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YORKSHIRE Geological and Polytechnic Society.

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1891—1894.

WITH TWENTY-FOUR PLATES.

EDITED BY

WILLIAM LOWER CARTER, M.A., F.G.S.

AND

WILLIAM CASH, F.G.S.

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ON THE PRESENT STATE OF OUR KNOWLEDGE OF THE YORKSHIRE CALAMITÆ. BY THOMAS HICK, B.A., B.SC., ASSISTANT LECTURER IN BOTANY, OWENS COLLEGE, MANCHESTER.

In matters of science, as well as in those of commerce and industry, it is well periodically to take stock of our possessions, estimate our gains and our losses, and endeavour to discover how and in what directions our success in the future may be greater than it has been in the past. In attempting to do this for the fossil plants known as the *Calamitæ*, I am moved by the hope that a fresh impulse may be given to Yorkshire Palæophytology, and as a result of this, that the gaps which at present exist in our knowledge of these plants may be speedily filled up.

It will be observed from the title of the paper that it is limited to the Yorkshire *Calamitæ*; but a further limitation will be found in the fact that I deal chiefly with those specimens which have their structure preserved in a more or less perfect condition, and which enable us to learn something of their anatomy and histology. I have no desire to mimimise the value of the casts and impressions of *Calamitæ* which are so abundant in the Coal Measures, for on many points their evidence is of the highest possible value. But however much they may teach us as to the external form of *Calamitæ* and the mutual relations of their various organs, the minute structure and internal organisation on which most questions of affinity depend, can only be learnt from those petrifactions in which such structure has been preserved. As in the past so in the future, *Calamitæ* with structure will be the safest guides to their affinities and organisation, while for the construction of the phylogenetic tree of the vegetable kingdom their aid will be absolutely indispensable.

As is usually done in dealing with recent plants, it will be well to consider the various members of the *Calamitæ* in their natural order, beginning with the roots and then passing on successively to the stems, leaves, and reproductive organs.

Roots and Rootlets.

Of the roots and rootlets of the *Calamitæ* little appears to be known. From statements made by Binney* it would seem that in the genus *Calamites* both roots and rootlets were present. Of the former he says, "the termination of the root of a Calamite is exactly of the same form as the terminal part of a Stigmaria, both being club-shaped"; and of the latter, that "they very much resemble the rootlets of Stigmaria, if they are not identical with them," and are "arranged in regular quincunical order."

Adventitious roots were given off from the nodes of the aerial stem; at the tapering basal part and from the figures given in the literature, they appear to have been slender, cylindrical, and sometimes branched structures, the branching being apparently dichotomous. According to Solms-Laubach† some species of *Calamitæ* had subterraneous rhizomes which likewise gave off roots from the nodes, often crowded together in tufts, and which when seen in impressions, had the form of long usually simple ribbon-like stripes.

Looking at those statements critically, one can scarcely avoid the suspicion that the quincunical arrangement of the rootlets mentioned by Binney requires further investigation. There is no case known among existing plants where such an arrangement of

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* Observations on the Structure of Fossil Plants found in the Carboniferous Strata. I. Calamites and Calamodendron, 1868, Palæontographical Soc.

† Fossil Botany. Eng. Ed., pp. 308, 309.

rootlets *on a root* is known to occur. On *Stigmaria* the rootlets have such an arrangement, but by many authorities it is maintained that *Stigmaria* is not morphologically a root.

It will be noted moreover that nothing is said of the structure of the organs called roots and rootlets, and so far as I can gather our knowledge on this point is a perfect blank. It is true that Renault* would have us believe that all the forms of *Astromyelon* are roots of *Calamodendron* and *Arthropitys, Astromyelon dadoxylinum* being the root of the former, and *Astromyelon Augustodunense* that of the latter. But in the Yorkshire forms of *Astromyelon* there is nothing characterestic of root structure, and we may therefore venture to reject this determination, as is done by Solms-Laubach, until it is supported by better evidence than it is at present.

THE STEM.

From the accounts given in the literature, ably summarised by Solms-Laubach,† it would seem, as already stated, that some species of *Calamites* possessed subterranean rhizomes which gave off two kinds of branches. The first of these remained beneath the ground, like the parent rhizome, to whose nodes they were attached by a broad base. The second were aerial shoots, which were inserted upon the rhizome like the preceding, but their bases were curved and narrowed into a conical form, and had a relatively large number of short internodes. It would seem, too, that these aerial shoots bore lateral branches, which were cylindrical and of the non-tapering kind. The aerial stems arising from the rhizome were frequently tufted, forming a group round a common centre, whence it has been concluded they were annual, like those of the gigantic Equisetums of the Trias.

The laws of branching of the aerial shoots have been at least partially worked out by Weiss,‡ who includes the number and arrangement of the branches among the characteristics of the four groups into which he divides the *Calamitæ*.

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* Nouvelles recherches sur le genre Astromyelon. Memoires de la Soc. des Sciences Naturelles de Saône et Loire, 1885.

† Fossil Botany. Eng. Ed., pp. 308, 309.

‡ Beiträge zur fossilen Flora III., Steinkohlen-Calamarien II.

According to Grand 'Eury* there were other species of *Calamitæ*, which, instead of being tufted like the above, grew singly, their narrowed and fusiform extremities passing vertically downwards, and giving off from the nodes close whorls of long, simple, descending roots.

Now it is a possible, if not a probable hypothesis, that these various kinds of shoots and branches should have a correspondingly variable internal structure, but we have no positive evidence by which this, or indeed any other hypothesis, can be tested. One would like to know too whether any of these, and if so which, were capable of unlimited growth, for although some of them were capable of secondary growth in thickness, it does not follow necessarily that they were perennial. Where branching occurred the branches were in some forms solitary and in others whorled, but we have nothing to show in what way these various habits were correlated with internal organisation.

As regards the structure of the aerial stems we are in a somewhat better position, as this is now tolerably well-known, at least in a general way. In saying this it must be remembered that I am speaking only of Yorkshire specimens with structure, all of which belong to the type now known as *Arthropitys*. Still it may be mentioned that the Lancashire specimens belong to the same type, so that as far as present knowledge goes, this is the only type found in the Yorkshire and Lancashire Coal Measures, with the structure preserved.

In a paper read by Mr. Cash and myself before this Society in 1883,† an account was given of the anatomy of the stem as it was then known, and attention was specially called to the light thrown upon the cortex by a specimen discovered by Mr. Spencer. I believe that specimen still remains the most perfect one hitherto described and published, but we are now in possession of others which afford additional information, not only upon the anatomy of the stem as a whole, but also on its development from the condition of a twig to that of a stout shoot. Unfortunately, a description of these cannot

* Flore Carbonifère du dépt. de la Loire et du centre de la France.

† Proc. Yorksh. Geol. & Polyt. Soc., N.S., vol. iii.

be published until we are in possession of longitudinal sections, without which the story told would be still incomplete, and on some points might even be misleading.

THE LEAVES.

The leaves of *Calamitæ,* as found in casts and impressions are mentioned by various Palæophytologists. Carruthers* describes them as "linear-acuminate," each whorl containing "from ten to twenty leaves." Renault† says, "leurs feuilles sont verticilleés, libres, ou tres faiblement soudées à la base, linéaires-lancéolées." Schenk‡ describes the leaves of *Calamitina varians* Weiss, as having well-preserved leaves, which are linear and lanceolate at the apex, with a distinctly contrasted, ovate, thickened basal part, traversed by a furrow. Solms-Laubach|| tells us that "the leaves of *Calamitæ* are unusually rare," and that "they are linear and not united laterally into a sheath." But I have nowhere found any definite statements regarding the leaves of our Yorkshire type, *Arthropitys,* nor any information on the internal structure of leaves that have been found attached to the stems of other forms. I conclude therefore that on these points little or nothing is known.

REPRODUCTIVE STRUCTURES.

Numerous accounts have been published, often accompanied by figures, of several kinds of spikes or Strobili which are regarded by their describers as the fruit of *Calamites.* One of these has been described by Williamson§ as the "true fructification of Calamites," and as the only one which at present is entitled to be so regarded. According to his description the fruit has an axis which repeats the structure of a Calamitean twig of the *Arthropitys* type, and from which, at intervals, nodal disks are given off which bear a number of free bracts at the margin. From the upper surface of each nodal disk sporangiophores arise which bear sporangia, but how the latter are attached he has not yet been able to discover.

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* On the Structure and Affinities of Lepidodendron and Calamites.

† Structure Comparée de quelques tiges de la Flore Carbonifère, p. 218.

‡ Die fossilen Pflanzenreste, p. 124.

|| Fossil Botany: Eng. ed., p. 295.

§ Philosophical Transactions, 1888.

The axial structure of this fruit seems sufficient to bring it into close relation with *Arthropitys,* as is confidently done by Williamson, but the insertion of the sporangiophores is so different from that of *Equisetum,* with which *Arthropitys* agrees in so many respects, that we cannot but wish that further specimens were forthcoming. Up to the present time only a few specimens have been discovered from the Lancashire Coal Measures, and we can therefore scarcely determine whether or not they represent the normal state of things. As *Arthropitys* is a Yorkshire as well as a Lancashire type, it is surely not extravagant to think that if our Coal Measures were carefully and persistently searched, the search would be rewarded with additional examples of this most interesting spike.

Our Yorkshire beds have, however, yielded numerous examples of the strobili, which are known under the name of *Calamostachys,* and which were dealt with at some length in a valuable paper contributed to the Proceedings of this Society by Mr. Cash in 1887.* In its general structure, and even in a large number of details, this spike approaches so closely to the sporiferous spike of *Equisetum,* that it might be said to be almost exactly similar to it. But to say this, would be to ignore the fact that its axis is not yet as fully known as it ought to be before such an assertion would be scientifically justified. In the paper referred to, the views of several authorities with respect to *Calamostachys* are carefully collated, and it is shown that they are widely at variance with one another. Prof. Williamson is quoted as being of opinion "that *Calamostachys Binneyana* has much closer affinities with *Asterophyllites* than with *Calamites,*" and elsewhere† the same authority has expressed his conviction that its true affinities are with the *Lycopodiaceæ.*‡ This determination it may be mentioned was based, in the main, upon the structure of the axis of the fruit, which may be regarded as the critical feature where its affinities are concerned. Recently, however, Williamson has seen reason to modify these views and in the "General

* Proc. of the Yorks. Geol. and Polyt. Soc., 1887, p. 444.

† Philosophical Transactions, 1881, p. 299.

‡ At the time this opinion was expressed, Williamson regarded *Asterophyllites* as Lycopodiaceous.

Index"* to his memoirs, has placed *Calamostachys Binneyana*, Schimp., among the *Calamarieæ*. At the same time he expresses a suspicion that under that name more than one species of fruit may be comprehended.

From a careful study of a number of preparations of this type of *Calamostachys* I have come to the conclusion that by this change Williamson has come nearer the truth as to its affinities than in his previous memoirs. It must not be overlooked, however, that to place some of the forms of *Calamostachys Binneyana*, Schimp., in the large group of *Calamarieæ* is not the same thing as to affirm that they are the fruits of some species of *Calamitæ*. That they are such is an opinion held by Carruthers, Binney, Schimper, and other palæophytologists, but to the best of my belief no specimen has hitherto been published whose axial tissues afford the evidence necessary to give this view a complete and irrefragable foundation. We are in this position then, that, as was pointed out by Carruthers long ago, *Calamostachys Binneyana*, Schimp., agrees in almost every detail with the sporiferous spike of *Equisetum*, and is, therefore, probably a fruit of some Calamitean plant. But the tissues of the axis which would clinch the argument for or against such a determination, are in all specimens hitherto described, so imperfectly preserved that their evidence is not decisive and cannot, therefore, be invoked on either side. I need scarcely say, that to a palæophytologist this is most tantalising, and if he is a Yorkshireman it is doubly so, for the remains of *Calamostachys Binneyana*, Schimp., are not infrequent in the Yorkshire Coal Measures, and the conviction lies near that if they were thoroughly overhauled, the missing link would be found and this important question settled once and for all. It is proverbially unsafe to prophesy unless you know, and I will avoid doing so. But I have an unusually strong suspicion that the axis of our Yorkshire specimens of *Calamostachys Binneyana* will yet prove to agree with the stem of some form of *Calamitæ*, and that in some cases at least, this "fruit" will turn out to be the spike of *Arthropitys*. Be this, however, as it may, the time appears to have

* Proc. of the Manchester Lit. and Phil. Soc, 4th Ser., vol. iv.

come when an effort should be made to give more completeness to our knowledge of the *Calamitæ* generally, and especially to clear up the points which are still doubtful in the organisation of *Arthropitys*.

THE MODE OF DEPOSITION AND PROPERTIES OF THE CARBONIFEROUS STRATA OF LEEDS AND ITS IMMEDIATE SUBURBS.

BY BENJ. HOLGATE, F.G.S.

It is well known that Leeds stands in an enviable position as regards its minerals, and owes its prosperity in a great measure to them. It is situated on the northern edge of the Yorkshire Coalfield, and consequently on the Lower Coal Measures, it is rich in coarse and fine-grained sandstones. Some of these are of the greatest durability when exposed to weather and other decaying influences, and are used for building and monumental purposes. Others are suitable for grindstones, the grains of silex not being so firmly bound together. These various kinds of stone are obtained on the north and east, within the Borough, and are well known to architects, engineers, and builders throughout the United Kingdom. The coals, of which there are no less than five good workable seams dealt with here, besides numerous others in the overlying strata, embrace almost every variety, and are used for every purpose to which coals are put. Firebricks and pottery made from the clays are exported to numerous foreign ports.

The carboniferous strata between the coarse millstone grit and the fine Elland flagstone, both alluded to above, have thinned out to the north of the town, and though the ganister measures and their included coals are all present, they are much thinner than in the districts to the south-west, in the neighbourhood of Halifax. The strata have an almost uniform dip towards the south-east, and have not been contorted notwithstanding their great age, although faults are numerous. Almost every cubic foot of the strata of the coal measures is made use of, the stones for building purposes, the coals for generating heat, the ironstone for making iron, the fireclays for making firebricks to withstand high temperatures, terra cotta and faience ware, the inferior fireclay for coarse pottery, and the remainder, consisting of black shale, blue bind, brown and grey binds, and soft stones, are used for making the ordinary common and pressed bricks, of which Leeds is principally built.

Open quarries are worked to the south and east of the town, some of which are 70 feet in depth. As they are always being worked they constantly present a fresh face for study. Commencing on the east side of the town some feet below the base of the workable coal seam known as the "Better Bed" (the one lying next above the Elland Flagstone), and going from quarry to quarry, we may follow in an upward direction an almost uninterrupted succession of measures as they are laid bare through a vertical depth of upwards of 300 feet. This is owing to the dip of the strata, the quarries being at an almost equal elevation above the sea. The conditions have been very varied under which these 300 feet of strata were laid down. There are few geological facts which are not here illustrated: land deposits and deposits made in almost still water or left by rapidly flowing streams, also plant and animal remains in immense quantities, though as far as can be made out of not many different kinds; an examination however leads us to suspect that the varieties have been much more numerous, the traces having been obliterated or altered by the numerous changes that have taken place during the immense period of time that has elapsed since their deposition, so that none but the most indestructible forms are preserved, unless they are embedded in modules. The land has been repeatedly elevated and depressed, the chemical action of water permeating through the mass, here taking up elements in solution and there depositing them under different conditions, or exchanging them for other elements has also had an important share in the change. To speak of all the phases of these changes would be a great though an interesting task. I must content myself with giving a table briefly describing the different kinds of strata, and will only enlarge upon a few typical ones.

Waters.—There are many soluble salts present in the shales and binds producing mineral waters of different kinds. The sandstones allow the water to pass freely through them with but little change, and serve only as a mode of conveyance from one stratum of shale to another, so that they do not retain the salts. We find different kinds of mineral waters at different horizons; some are medicinal, such as that known as the Holbeck Spa Water; others contain a large quantity of salt in solution, as do those immediately above the Beeston Bed Coal (See Tables Nos. 1 and 45.)

SEAT EARTHS.—These underlie each seam of coal however thin it may be, and are generally about 2 feet to 3 feet in thickness, from which we gather that this was the distance to which the coal measure trees rooted. Like the trees of the present day those of the coal measures contrived to exist upon different kinds of soil whatever their preferences might be, and we find some rooting in mud as in that beneath the Beeston Bed (Table No. 40.) Others in loamy sand (see Table No. 18) as is the Black Bed Seat Earth, and others (No. 27) again in a micacious bind. In the Better Bed Seat Earth (No. 2) which is the fireclay for which Leeds is celebrated, the roots completely destroyed all stratification, and made a soil just as trees do at the present day. In some, however, this has not taken place, and though the roots and rootlets are numerous we can distinctly see what the original deposit was like (See Table No. 27). In this case we find a micacious and bituminous bind.

On examination we are struck with the fact that the thickness of the coal seams do not appear to bear any proportion to the depth of, or the quantity of roots in the seat earth; a seam of coal 2 in. in thickness has as great a depth of seat earth and often as many roots as a coal seam having a thickness of some feet. If, however, we examine the overlying bed we shall see the reason of this, and shall find it to be for some feet in height, a shale, very black and bituminous. We shall also probably find stems of trees standing up in it. If we burn this shale it will give out a considerable amount of heat, and will lose a great deal of its weight, sometimes as much as two-thirds. From this we realise that the land was sinking at a greater rate than the trees and plants were growing, and that a coal seam does not represent the total amount of growth, but only that part of it which is made up entirely, or very nearly so, of vegetable matter. The trees and plants stood and grew for a long time after this, during which time mud was being brought down by streams and deposited in the spaces intervening between the plants. The time when the forest was quite destroyed is marked by a difference in the colour and in the nature of the deposits. The strata containing floated fronds of ferns and calamites are blue in colour, and not so dense or tough.

We also realise that even if our coals were to run short, we should still have beds of immense thickness which, though not so valuable as pure coals, might in case of need be made to render good service (See Table No. 20, 50, etc.)

The sharp line of demarcation between the coal and the overlying stratum has most probably been produced by such stratum sliding over the coal during the elevations and depressions that have taken place since they were deposited, and by the different distances apart at which the force producing lateral pressure has caused the strata to joint or cleave.

Sometimes we find that the trees actually took root under water and grew for some time whilst a considerable amount of mud was being deposited; that the mud afterwards ceased to be brought down and that consequently the coals are pure. We thus have an impure coal immediately above the seat earth and below the pure coal. This is what has taken place in the Beeston Bed (Table No. 41). For about two feet between the seat earth and the coal at present worked is a stratum which is left unworked at the present time. Years ago this was sold at a low price to the very poor under the name of "Doggies." It is a very heavy and dirty coal. At Churwell it is known as the "Churwell thick," and possesses the same properties. Here the Beeston Bed actually divides into two distinct coal seams, the distance between the upper and the lower part increasing from nothing up to a distance of ten yards, with intervening measures of shale, showing that at Churwell the forest was completely overwhelmed by the mud which had been brought down by the water, but that at Hunslet it was left free from mud to grow with greater purity. This it did, making a coal seam 8ft. in thickness but with several mud partings. It is interesting to know that the latter continued growing, whilst that at Churwell was being covered up with mud to the height above named and that the forest again extended itself over the Churwell area, the upper part of the Beeston Bed making the Upper Churwell thin coal. There are few coal seams that did not vary in character during growth, and that were not inundated with mud at various times; every parting in a coal seam represents such an inundation. The Beeston Bed coal has in some places as many as four such partings.

After what has been said about the mode of formation of coals, it is not difficult to understand why fish remains are often found in the roof of coal seams, and no doubt perished in numbers when the mud came down in large quantities. We find numerous though isolated fish remains in the overlying black shales. A reference to the Table will show that whatever may be the thickness of the coal the seat earth is about 3 ft. in thickness, and that all the coal seams have black shale immediately overlying them. We sometimes find cases in which the overlying shale, and even the coal has been subsequently washed away by river action; when this has been the case it has generally a sandstone roof, and is not to be depended upon for continuity or thickness. I do not, in this paper, deal with the properties of coal and pass on to the shale. From what has been previously said we should expect in all black shale to find numerous remains of plants, fishes and molluscs, and this is what we actually do find. Lepidostrobi, flattened, may be found by thousands in the black shale overlying the Black Bed; fish remains are also common, and it is chiefly about anthracosia that the iron has collected into the nodules from which the best Yorkshire iron is made; nodules of this kind often form about plant remains, but wherever they are so found they are never so rich in iron as when formed about those of animals, and consequently the best ironstone is found in the black shale. Next to the coals they contain the greatest number of plant and animal remains, this is proved by their losing so much weight when burnt.

Blue Bind—These deposits have evidently been made in very quiet places. The mud of which they are formed is very fine and must have been held in suspension long after any perceptible motion of the water had ceased. In it we find perfectly preserved fronds of ferns, but not in large quantities, Asterophylites, not flattened, but standing vertically with its frill of leaves perfectly preserved; leaves which, as far as I know, have not been named, and calamites are often found, as well as Stigmariæ, Sigillariæ, and other plant remains, the latter have generally decayed or have gone to form a nodule of very clayey ironstone. After repeated examination the idea forces itself upon one that it does not represent a forest growth with mud poured amongst it, but that it represents a quiet nook, with water plants growing and with stray leaves and bits of floating wood becoming water-logged and quietly sinking to the bottom, and that the whole was so gently done that the mud entombed the growing plants without disturbing them, and those which had sunk so as not to alter their form.

Ironstone nodules are numerous and lie in layers, sometimes they unite and make a continuous plate. The nucleus of these nodules is always animal or plant remains. The plants do not appear to have had the power of concentration which the animals have had, and are softer and do not contain so much iron, generally the remains have been damaged before the concretion has been formed, sometimes it is the frond of a fern, and if so it will be perfect; some have acted curiously, they have formed about the stigmariæ or lepidostrobus and have completely entombed it without injury, a sufficient quantity of carbonate of iron having filtered through the nucleus has sufficed to preserve every cell. Upon breaking the nodules into pieces we may take out the specimens and examine them under the microscope.

Brown and Grey Binds mark a period of transition from the state of things above named to one in which the course of the stream was altering, or that it was quickening in speed and bringing down more sand. Specimens are not well preserved in it; sometimes we find that the stream was actually running over it, and that as it receded it left its ripple marks and worm burrows which hardened, and when the next flood came, bringing with it sand even coarser than the last, it deposited it on the uneven surface and a cast was made of it which has remained to the present day.

Colour of strata is a good guide to the kind of fossils we shall find, as well as to the physical changes to which the strata have been subjected since they were deposited. Black hard shales contain the remains of fishes or molluscs and plants. Blue bind contains plant remains which are not numerous but well preserved. The stones contain only casts of plants, the passage of water through them as long since removed any vegetable remains there might be.

A noticeable feature in some of these strata is the way in which casts and ironstone nodules have been acted upon by lateral pressure. They have evidently been formed before the land was elevated, and the pressure has caused them to slide among the shales or sandstone and has caused a foliation to take place round the hard object. It has in fact produced a cleavage concentric with the tree or nodule of ironstone (See Table No. 26).

I would also point out particularly the rapid changes which took place in the beds numbered 47 to 51. In this case the animals, which would no doubt have gone on living and dying gradually as they have done in the other black shales, were brought to an untimely end, probably through the drying up of the arm of water in which they lived; this is the only way in which we can explain why there are so many fish remains and remains of anthracosia in this thickness of four inches. The shale is hardened, not by the deposition of carbonate of iron, but by the permeation of the oily matter from the animals. The corners adjacent to the two planes of cleavage are rounded as though water had taken away some of the matter in its passage along these planes. The surface clays have long ago been used for brickmaking, by surface clays I mean the original covering of drift, which consisted of shales and pebbles. These had been washed in water as they were being deposited, consequently had had all the hydro-carbonaceous matter washed out of them. In order to make bricks from this material it was necessary to give it plasticity by hydrating it, and for this purpose it was kept in a wet state for weeks, and repeatedly turned over.

N.B.—In the following Table of the Strata, No. 1 is the lowest in the sections, and each succeeding number represents the strata in ascending order :—

Patent Brickyard No. 1.

No.	Name or kind and colour of Deposit.	Original constituents. Animals and Plants.	Mode of Formation of Deposit.	Changes that have taken place since Deposition.	Present properties and uses.	Ft.	In.
1	Yellow Loamy Bind	Sand and Clay	A beach	Carbonate of iron about nuclei of vegetable matter	Yields Holbeck Spa water drained from strata above; contains sulphuretted hydrogen, carbonate of soda, sulphate of magnesia, &c. Water used for wool-washing	4	0
2	Fireclay ...	Micaceous Sand and Clay, like No. 1, but altered by roots of trees ramifying through it	Dry land of fine silicious loam	Ramified by roots and rootlets of plants which formed overlying coal, stratification destroyed by roots	Uses: terra cotta, faience, stoneware, and fire-bricks	3	0
3	Better Bed Clay	Spores and fish remains, as well as coal measure trees	Land sinking	... ...	Hard coal free from sulphur, coal and coke from it used in making best Yorkshire iron ..	1	3
4	Blue Bind ...	Fine mud gently deposited, plants not destroyed, floated fronds of ferns	Land sinking, deposit becoming coarser in grain, water almost motionless, out of the way of force of stream	... ...	Unctious to the touch, used in brickmaking, does not lose much weight when burnt ...	6	0
5	Micaceous Grey Bind	No plants in position, floated fern fronds fewer as stratum ascends	Centre of stream, gradually approaching water flowing more quickly, deposits becoming closer in grain	... ...	... ...	16	0
6	Fine Sandstone...	Sand	Direction of river still changing, quickening speed of river ...	... ...	... ...	0	9
7	Soft Micaceous Bind	Mud and mica	Ripple marked at top. Stream actually here, then again changed its course, leaving ripple marks dry	Left by water to harden, sand afterwards deposited upon it	Makes plastic clay ..	4	0
8	Hard Siliceous Stone	Siliceous sand	Stream again over dried sandstone, depositing white fine sand which takes cast at	... ...	Not used for brickmaking, will not cohere	0	6

						ft.	in.
		floated plants and ...	gently				
10	Soft Stone ...	Sand	Speed of water rather more rapid	... ...	Not used for brick-making	1	0

Patent Brickyard No. 2.

11	Black Shale ...	Mud with Anthracosia scales of fishes, and numerous water plants	Speed of water very slow ...	Carbonate of iron deposited about organic substances by perculating water making nodules of ironstone	Ironstone for iron making, shale loses much weight in burning, shale makes very plastic clay... ...	6	0
12	Micaceous Shale	Alternate layers of white micaceous sand and mud, containing matter, like 14 and 16	Quickening stream, plants diminishing in numbers ...	... ...	... ...	2	0
13	As 11, but gradually changing into above ...	... ...	... ...	... ...	... ...	22	0
14	As 12 and 16 ..	... ...	Ripple marks at top ...	Hardened in the air since deposition, next later deposit made upon it	... ...	18	0
15	Brown Stone ...	... ...	Stream more rapid, casts of ripple marks	... ...	... ...	2	0
16	Brown Bind ...	Like 14 and 12	Filling up, stream taking another direction	... ...	... ...	11	0
17	Soft Sandstone...	Sand	Stream over the place ...	... ...	... ...	3	4
18	Inferior Fireclay	Stratum below altered by ramification of roots	At surface of water	Originally like 17, but pierced in all directions by roots of the coal plants above ..	... ...	3	0
19	Black Bed Coal...	Plants, fish remains on the top	Land growth, but sinking area	Iron pyrites and other minerals deposited between interstices of cleavage	Inferior engine coal ...	2	6
20	Black Shale ...	For description see No. 20 Boyle's yard, in which it is included	... ...	Changed to a yellow by weathering	Two feet in thickness in this quarry... ...	—	

C

BOYLE'S BRICKYARD.

No.	Name or kind and colour of Deposit.	Original constituents. Animals and Plants.	Mode of Formation of Deposit.	Changes that have taken place siuce Deposition.	Present properties and uses.	Ft.	In.
20	Black Shale ... (continued from Patent Brick-yard No. 2)	Mud, numerous coal measure trees, lepidostrobi, fishes, and anthracosia	Sinking area trees continuing to live, very bituminous	Carbonate of iron formed into nodules about animal and vegetable remains	Mines sunk for ironstone nodules, from which are made best Yorkshire iron; great decrease in weight of shale when burnt ...	9	0
21	Shale not so black as No. 21	Similar fossils, but not as numerous	Many of trees of coals below have died off	Ironstone nodules, but not so numerous ...	Not used	9	4
22	Blue Bind ...	Mud, with floated fronds of ferns, perfect lepidostrobi and stigmaria	A quiet place, gradually filling up	Carbonate of iron and lime have first petrified the tissue of stigmaria and lepidostrobi, and have then formed a nodule about them leaving them loose	Bind used for brick-making; nodules useless	17	7
23	Seat Earth ...	Like that below, but pierced by stigmaria	Has been blue bind, but rootlets have broken stratification and have taken some fusible salts out of it	... ...	Suitable for superior bricks	2	5
24	Crow Coal ...	Plants, many of which are water plants	In the parting between coals are fine thread-like plant remains	Two lines of cleavage marks different pressure of elevation	No fish remains in the coal, a good house coal, very soft { Coal ...	0	4
					Bind ...	0	9
					Coal ...	1	1
25	Bituminous Shale	Fine mud, many lepidostrobi and anthracosia	Sinking land, very quiet, away from great water-way	Nodules of poor clay. Ironstone containing entire and uncrushed and perfectly preserved lepidostrobi, as are the	Makes bricks; decreases in weight when burnt	14	3

	Sandstone			Lateral thrust has foliated the rock in layers about the stems			
27	Seat Earth ...	Micaceous shale intersected by roots and rootlets, containing too many fusible salts to make good firebricks	Stream has left neighbourhood, allowing growth of coal measure trees	... ...	Inferior fireclay, used for making stone pottery	4	0
28	Thin seam of Coal	Growth of trees... ...	... ...	... ...	... ...	0	2
29	Black Shale ...	Mud, trees, fish remains ...	Sand continueing to sink; stream changing its direction and depositing mud	... ...	Burns well; very bituminous	0	4
30	Dark Shale ...	Trees from seat earth below still growing through coal and black shale, but not so numerously	Mud still brought down, but not in sufficient quantity to destroy plants	... ...	Loses much weight in burning	8	4
31	Blue Bind ...	Vegetable matter present, fronds of ferns and Lepidostrobus	Trees below now almost died off. A period of rest. Deposit only fine mud	Lepidostrobi well preserved as below	Does not shrink much in burning	5	6
32	Grey Bind ...	More micaceous ...	Plant remains almost absent ...	... ...	... ...	1	6
33	Red Stony Bind ...	Micaceous fine sand ...	... ...	... ...	... ...	3	0
34	Red Stone ..	Sand	Speed of water has been gradually increasing	... ...	... ...	1	0
35	Red Bind ..	Fine Sand	Speed diminishing	Colouring matter probably from above	... ...	3	0
36	Seat Earth ...	Roots and rootlets into sand, as below	Sand has been as below, but plants have rooted into it	... ...	... ...	1	7
37	DarkShale, nearly Coal	Coal measure plants; almost a coal	Sufficiently near surface for plants to grow, but not sufficiently free from mud to make coal	... ...	... ...	0	1
38	Yellow Clay ..	Has been black shale at one time	Like other shales	Yellow colour from percolation of water. This is not original drift clay	Brickmaking... ...	6	0

No.	Name or kind and colour of Deposit.	Original constituents. Animals and Plants.	Mode of Formation of Deposit.	Changes that have taken place since Deposition.	Present properties and uses.	Ft.	In.
39	Blue Bind ...	Fine mud, many calamites, very fine specimens; fronds of ferns	Stream receded; quiet depositions	Vegetable matter of calamites, have hardened casts and caused concretions	Makes good bricks and coarse pottery	20	0
40	Seat Earth ...	Like above, but intersected by roots	Sufficiently near surface for trees to root in it	... ...	Makes good bricks and coarse pottery, probably used by Leeds pottery in its early days	4	0
41	Beeston Bed Coal	Plants, animals, and trees, with mud in lower part	Upper part pure coal, parting layers of mud: bottom part very dirty. Trees have been growing with a proportion of each	... ...	Divided into layers by several partings, each layer of different quality. Bottom layer is doggies	8	0
42	Black Shale ...	Mud, with anthracosia and fish remains. Trees still growing	Area sinking faster than growth of trees. Much mud	... ...	Shrinks in burning ...	14	0
43	Blue Bind ...	Fine mud, ferns, calamites, terminal buds of coal measure plants changing to sand	A quiet place. Gentle deposition becomes coarser	Calamites form nodular concretions about them	Does not shrink much in burning	17	0
44	Sandstone ...	Fine sand	Stream over it; ripple marked and worm barrowed	... ...	... ...	0	9
45	Dark Shale ...	Much plant matter ...	Stream has again left here ...	Much chemical action has taken place; water has dissolved and re-deposited salts	Contains many salts, crystallised on side of quarry, water is salty	9	3

47	Coal	... ...	Sufficiently shallow for growth of plants	... ...	Not used	0	2
48	Soft Black Shale	Coal plants still living ...	Mud mixing with plants ...	... ...	Burnt as coal ...	0	4
49	Black Hard Shale	Fish remains & anthracosia	A lake	All fish and molluscs	As coal	0	6
50	Harder Shale ...	Fish remains & anthracosia	Lake dried up ...	killed and in one mass	Burnt as coal ...	0	4
51	Black Shale ...	As above	Again much mud	... ...	... ..	0	5
52	Hard Shale ...	Mud, plants, &c. ...	... ...	... ...	... ...	1	7
53	Blue Bind ...	Light mud	Stream further away ...	... ...	... ...	1	4
54	Soft Grey Stone...	Sand	... ...	... ...	... ...	0	6
55	Blue Bind ...	... ...	As other	... ...	... ...	3	0
56	Hard Stone ...	... .	... ...	... ...	... ...	3	5
57	Sandy Shale ...	... ...	Stream quicker	... ...	... ...	7	4
58	Seat Earth ...	Roots and Rootlets ...	Rooted in stratum below ...	... ...	... ...	2	6
59	Soft Black Smut	Dirty coal	... ...	... ...	... ...	1	0
60	Yellow Clay ...	Mud and plant remains ...	Has been black shale	Not the drift clay, which has been removed. Colour is yellow from percolation of water. Chemical action	... ...	5	4

ON THE UNDERGROUND WATERS OF LINCOLNSHIRE.

BY C. E. DE RANCE, ASSOC. INST. C.E., F.G.S., F.R.G.S., F.R. MET. SOC.,
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The County of Lincoln occupies an area of no less than 1,775,000 acres, or rather more than a million and three-quarters, and, with the exception of Yorkshire, is the largest county in England. It is drained entirely by streams flowing into the German Ocean, of which the Welland, the Witham, and the Ancholm are the most important; to the north-west a small tract drains into the Trent; and to the north-east small streams flow off the Wolds direct into the sea, or the north of the Humber.

The surface geological structure is largely modified by thick deposits of Glacial Boulder Clay, while below the strata range from the Keuper Marls, under the Trent on the west, to the Upper Cretaceous on the eastern margin, where they disappear below the overlying glacial drift, about 600,000 acres consist of porous rocks, but these are in part covered by impermeable Boulder Clay. The Witham drains no less than 176,000 acres of fen-land, the Welland 77,000 acres.

More than 80 per cent. of the land is cultivated; 35 per cent. of the whole area, or nearly half the cultivated area, grows corn crops, half the latter being wheat. Green crops occupy 12½ per cent. of the total area, and fallow and grasses and clover under rotation nearly 9 per cent. Permanent pasture is nearly 26 per cent., and towns, woods, gardens, and waste 19 per cent.

All water, whether visible in streams and rivers, or concealed beneath the earth's surface, being derived from rainfall. In Appendix I. I have tabulated the rainfall at four local stations from the returns furnished to Mr. Symons, F.R.S., and published by him in his annual volumes of "British Rainfall." In 26 years, at Lincoln, the rainfall has been 20 inches or less, no less than 9 times, and on 2 of these

9 years it fell below 16 inches, viz., in 1884 and 1887. In 22 years at Navenby the rainfall has been 20 inches, or less, no fewer than 6 times, on 2 of which it was below 17 inches. At Sleaford in 15 years, the rainfall fell below 20 inches on three occasions, viz., 1884, 1887, and 1890. At Pode Hole, Spalding, the rainfall in 21 years, was 20 inches, or less, in six different years, viz., 1870, 1873, 1874, 1884, 1887, 1890. Of these four were below 17 inches, and one below 16 inches ; that of the Jubilee year, 1887, in which only 15·13 inches fell.

An inspection of an Ordnance one-inch map, on which no geological features are coloured at once discloses the permeable or impermeable nature of the rocks and soils of which the area may be composed, by the absence or presence of stream lines indicated on the map, on any particular area that may be selected for observation. For convenience it is found useful to have " one-inch squares traced on tracing-cloth, each of which when placed over the map, covers an area of one square mile. If the area so covered contains no stream lines engraved, it may be safely assumed that, after deducting the proportion of the annual rainfall evaporated, the whole of the balance left will find its way into the underground stores of water below. If the stream lines are above a mile in linear extent, about a third of the rainfall will be evaporated, a third run off in floods, and a third absorbed. If numerous stream lines traverse the square inch in all directions, two-thirds of the rainfall will be run off in floods, and be only available in catchment reservoirs of large extent, capable of storing the rainfall of several months. The porous rocks vary much in degree of porosity, and still more in the rate at which they discharge water absorbed. The minimum supply of underground water in the county of Lincoln is therefore 5 inches per annum, or 200,000 gallons of water per square mile per day.

One inch of rainfall per annum gives 62 gallons of water per day per acre, or a supply for three persons from each acre were it all available, assuming evaporation to take a third of this quantity. The balance left for human consumption of the 5 inches percolating depends on the amount sucked up by vegetation ; this is an exceedingly variable quantity. After a long drought the first rainfall never passes a yard underground; it probably would average an inch and a quarter per acre, leaving a balance of three inches and three-quarters for drinking purposes, necessitating an area of one acre to give the quantity of water required by ten persons daily, so that looking to the acreage of the county of Lincoln it should be able to supply no less than six million persons from underground sources, whilst its population is under half a million. Its inhabitants therefore should be very amply supplied, but this is far from being the case through the underground stores being seldom utilized.

COLLINGHAM.

At South Scarle, nine miles S.W. of Lincoln, and half way between that city and Newark, on the Nottinghamshire side of the county boundary, an unsuccessful boring for coal gave very important results as regards the character of the strata and its water-bearing capacity.

A feeder of water was met with at a depth of 134 feet in the Keuper Sandstone, running 11 gallons per minute, and another occurred at 950 feet, running at 50 gallons per minute, in the same formation. The last is stated to have risen 52 feet above the surface. These artesian waters are separated from the water in the Bunter Sandstones beneath by intervening shales, but there is every reason to believe that the whole of the sandstones, from 958 feet to 1500 feet, are similarly charged with water, absorbed as rainfall, in the magnificent gathering ground between Retford and Worksop, an area capable of supplying millions of gallons of pure water daily, and at present practically untouched. The temperature taken in the Scarle bore-hole points to the free passage of water in the porous rocks beneath, rising from 69 deg. on the base of the Keuper marls to $69\frac{1}{8}$ deg. at the base of the Keuper sandstone, and to no less than 73 deg. in the water flowing off the top of the Permian upper marls. I have no information as to the diameter of this bore-hole at the surface, but at the termination it was only 0·9 of an inch. I presume it is not now available for waterworks purposes, and any future boring to reach the required depth, and give a proper supply, should not be less than 24 inches at the commencement.

GAINSBOROUGH.

Boring made by Messrs. E. Timmins & Sons, Bridgewater Foundry, Runcorn, for the Local Board, at the recommendation of myself, the site is six miles from the outcrop of the New Red Sandstone.

		Feet.
725	Keuper marls, with much gypsum to 350 feet ...	725
1201	New Red Sandstone, with red and white pebbles, at 750 feet and 960 feet in depth	375

The well is 58 feet deep, the bore-hole is lined with cast iron tubes of 19 inches internal diameter to 140 feet, of 15 inches to 212 feet, of 12½ inches to 335 feet (of wrought iron), of 10½ inches diameter (wrought iron), to 737 feet, and 10 inches internal diameter (wrought iron) to 1201 feet.

The water contains 32·20 grains per gallon of solid residue, at 212 F, and contains of combined chlorine 1·40 grains per gallon. Its hardness on Clarke's scale is 25·76, of which 16·31 is permanent; the water in the boring is mixed in the well with some upper waters, to which its hardness is due. This mixture was not due to any defect in the work done by the contractors under their instructions, and there is every reason to believe that, if the whole of the water were derived from the New Red Sandstone it would be found much softer. The quantity pumped is about 15,000 gallons per hour. The character of the underground waters from the New Red Sandstone of this district, where no admixture has taken place, is well seen in the analysis accompanying the following particulars of a recent boring at Worksop.

WORKSOP.

Hodsock Priory. Bored March, 1891. Surface 55 feet above Ordnance Datum. Depth of six-inch boring 94 feet. Permanent water level before pumping, three feet from surface; after pumping 150,000 gallons in 24 hours it fell to 18 feet below the surface, but recovered in a few minutes on stopping the pumps.

The boring commenced in six feet of surface soil, and was then carried through the Lower Mottled Sandstone, with numerous thin layers of marls. Water occurred throughout the boring.

Analysis given in grains per gallon:—

Total solid residue	18·48
Oxidizable Organic matter	·02
Chlorine	·90
Equal to Chloride of Sodium	1·48
Nitric Acid as Nitrates	3·85
Free Ammonia	·0005
Albumenized Ammonia	·001
Hardness—Clarke's scale	14

"Water was bright, clear, and free from colour and deposit . . . . . It is a beautifully pure supply for drinking purposes; it not being excessively hard makes it also serviceable for general domestic purposes."

The excellent character of the water derived from the New Red Sandstone, and its power of naturally filtering and purifying waters passing through its pores, was acknowledged by the Rivers Pollution Commission, and from this formation are derived at Liverpool six-and-a-half million gallons a day, and the whole of the supplies of Birmingham, Birkenhead, Southport, Wallasey, Crewe, Staffordshire Potteries, South Staffordshire Waterworks, Nottingham, Coventry, and Leamington, as well as a large number of smaller towns. The outcrop of these rocks lies sixteen miles westward of Lincoln, where they occupy a very large area between Worksop and East Retford, of dry sandy ground, absorbing a large proportion of the annual rainfall, which water is practically untouched. The eastward dip of the New Red Sandstone carries down that formation, and with it the underground stores of water contained in it below the Lias and Oolites of the Grantham, Lincoln, and Gainsborough districts, through which they have been touched at several points, and in some cases penetrated.

The Keuper Marls contain sandy beds, which at several localities have given local supplies, but they cannot be depended on for large public water supplies.

The Marlstone Rock Bed, lying between the Lower and Upper Lias Clays, is often of great value as a source of springs, but in the Lincoln district this is not the case.

In the two shafts and borings made at Kirkstead and Woodhall, near Horncastle, in 1819, in a futile search for coal, no water appears to have been met with, except the saline spring known as Woodhall Spa, which was met with at a depth of 530 feet, and is believed by Mr. Jukes Brown, of the Geological Survey, to have issued from the Inferior Oolite, but it is more probable that it came from the Lias. He thinks it probable that the beds passed through were as follows:—

Ft.	In.		Ft.	In.
10	0	Gravels and Boulder Clay	10	0
360	0	Kimeridge and Oxford Clays	350	0
		Kellaway Rock, Clays, Cornbrash ... }	140	0
500	0	Great Oolite, Upper Estuarine ... ... }		
640	0	Limestone Oolite and Northampton Beds ...	140	0
1020	0	Lias, Upper, Middle, and Top of Lower ...	380	0

The temperature of the water in 1883 was 59·6 Fah. In 1865 it contained:—

	Grains per Gal.
Chloride of Sodium	1215·17
,, Potassium	2 15
,, Magnesium	86·84
,, Calcium	105·00
Bromide of Sodium	5·14
Iodide of Sodium	2·73
Sulphate of Soda	30·62
Bicarbonate of Soda	45·76
Carbonate of Lime	9·38
,, Iron	0·27
Silica	0·33
Organic matter	Trace.

At Stamford, the Marquis of Exeter had a futile boring for coal put down, which commenced in the Kimeridge Clay, was discontinued at 500 feet, still in the Lias, as might have been expected.

The gorge of the River Witham, at Lincoln, has cut through the following rocks in descending order:—

g^5 { The Lincolnshire Limestone.
$g^{5'}$ { The Lower Estuarine series.
g^3 { Upper Lias Clay.
g^3 { Lias Marlstone.
$g^{2'}$ { Middle Lias Clay.
g^1 { Lias Clay and Limestone.

Except some small springs thrown out by an ironstone rock in the Middle Lias, at Bracebridge, at 45 feet above the sea level, no underground water is yielded by the Lias, and it may be regarded as an impermeable floor on which water absorbed on the porous rocks lying above it are supported, and carried by their dip beneath the sea level, from whence they are prevented from rising by the overlying impermeable Oolitic Clays.

Above the Lias Clays occur the inferior Oolitic Basement Beds, consisting of the Northampton sand, and the overlying clays, shales, and sands of the Lower Estuarine series, varying much in character in different parts of the district. From Navenby to Burton four to eighteen feet of massive ironstone beds occur; between Burton and Ingham clay and sands without ironstone replace the ironstone; but northwards, the Northampton sands are represented by the compact hard ironstone called "the Dogger;" the sands above at Ingham are also cemented into "pan," and associated with grey clay.

These ironstone beds occur at about 200 feet above the mean sea level below the Cathedral, and dip eastwards, and descend beneath the sea level at a point on the Witham, half-a-mile on the Lincoln side of Washingborough Station, or 200 feet in two miles, which is equal to an inclination of rather more than two degrees in that direction. Strong springs rise in a small combe about 200 yards south of the Wragby Road, and a little more than a mile E.N.E. of the Cathedral, which are due to the faulting of ironstone beds against the Lias. The structure of the ironstone varies from very compact to cellular, the latter being called "fire-stone" by the well-sinkers, who imagine the rock has been exposed to fire.

Northwards from the gorge of the Witham at Lincoln, these various beds, capped by the Lincolnshire Oolite, form a fine escarpment, often locally known as the "Cliff," ranging nearly north and south, while the beds dip gently eastward. Small springs are thrown out at various points along the outcrop, as at the Burton Mill spring, issuing from six feet of ironstone.

From the variable character, small outcrop, and the widespread presence of iron, I consider the Inferior Oolite Basement Beds to be of no value for water supply purposes. But the upper part of the Inferior Oolite or Lincolnshire Oolite is an important water-bearing stratum; it has a wide area of absorption, and is exceedingly porous, or, more correctly, it is much traversed by fissures, which afford a ready passage to rain water flowing over them from high levels, and readily discharging the same as springs at low levels.

The Lincolnshire Limestone, south of Lincoln, is remarkable for having, from its water-bearing properties given rise to two lines of villages, the one at its base or the foot of the escarpment, where the water is supported by the underlying impermeable Lias clay, the other on the east, where the porous limestone dipping under impermeable clays, leaves no escape for the contained waters, the rock being water-logged up to the top of the overlying clay, the overflowing springs being the water absorbed over the whole porous area.

The Lincolnshire Limestones of this area generally consist of:—

1. White Limestones.
2. Whitish or Buff Limestones, with Oolitic grains.
3. Hard Grey Limestones (hydraulic).

Seams and partings of calcareous marls crowded with fossils occur at various horizons, and have the effect of dividing up the water contained into several distinct sheets, but none of these shale beds are absolutely continuous, so that the various sheets of water intermingle at certain points. The upper beds are well seen at Blankney and Metherington, between which issue very powerful springs.

At Great Spring Head the line of permanent saturation occurs more than a mile west of the overhanging lip of impermeable rocks. The water issues from fissures in a pink limestone with fine sandy grains. These springs are derived from the rain falling over the area lying between Harmston and Coleby, Dunstan Pillar, and the

Green Man. Its breaking out at a higher level than most of the other springs appears to be due to the obstruction to the passage of water down the dip of the strata, caused by the N.W. and S.E. fault ranging between Dunston and Nocton.

At the Green Man, 154 feet above the mean sea-level, there is a well 25 feet deep with bore-hole, the water at time of visit (July, 1891) did not rise to bottom of well. A slimy pond by the roadside was used 40 years ago, and has a puddled bottom; no spring occurs.

At Warren House there is a double bucket well; the water flows strongly to the south-east. The water is lifted by horse-power. A quarter of a mile to the north is a deep dug combe, pointing to a seasonal variation in the level of the plane of saturation. This is also apparent in the park approaching Blankley Hall, where a combe has evidently been recently occupied by a stream, now (July) reduced to a single clear, rather shallow, pond.

Shallow wells, with ordinary pumps, supply the village of Blankney.

Traversing the same district along the strike of the Lincolnshire Limestone, from Lincoln southwards along Ermine Street, at the cottage 4½ miles south of the city, water stands at 35 feet from the surface, and yields a copious (cottage) supply. This is also the case at the cottage at the corner of bye-road just north of the monument; the water level is just 30 feet from the surface and varies about five feet. The Pillar is 198 feet above the mean sea level, so that the water level is 161 feet above the same. At the first cottage south of the monument a single bucket-pump reaches water, and a very small stream was flowing down the combe between. With the exception of the above well the whole of the facts observed south of Lincoln, in the Lincolnshire Limestone, point to less local irregularities of water level, and a more uniform eastern trend than is observable north of the city, where the limestone is broken up by hard bands, probably of ironstone. The aggregate thickness of the limestone, as measured by the Geological Survey at Washingborough, amounts to 65 feet, in which occur the following impermeable beds :—

	Ft.	In.
Marly, Rubbly Limestone	5	9
Hard Clay and Stony Marl	4	10
Ditto „	0	11
Marl	0	3
Clay	0	6
Marl	0	7
	12	10

Or about 13 feet in all, leaving 52 feet of porous material, of which half may be considered as permanently saturated with water, or 26 feet. Taking the width of outcrop between Coleby and Dunston at five miles, a pumping station placed beside the railway south of Dunston Station, draining the rock half-a-mile north and south respectively, might be expected to produce, in dry years, the daily quantity of 700,000 gallons of water.

The best site for a boring to obtain the waters in the Lincolnshire Limestone north of the city is Scothern, and after that Dunholme. In either case the boring should commence in the Oxford Clay, so as to have the cover of an impermeable material. Such borings would be of an artesian character. This has been proved on the west side of the village of Dunholme by a boring 106 feet deep, the water rising five feet above the surface, in a pipe 1½ inches in diameter, with a discharge of 20,000 gallons in 24 hours. This boring must penetrate the

Cornbrash	5 ?
Great Oolite Clay	25 ?
Great Oolite Limestone	15 ?
Estuarine Beds	35 ?
Lincolnshire Limestone	26 ?

The occasional presence of "swallow-holes" in the Lincolnshire Limestone, into which the streams are precipitated, the cracks and fissures that seem to accompany the outburst of springs, all tend to show that this rock is capable of holding a very large quantity of water. The chief motion of underground water takes place along cracks and fissures in underground defined channels, rather than through the pores of the rock. Two very adverse conditions arise from this: First, that when water passes through fissures, and not through pores of the rock, the natural process of filtration is not exerted. Second, that in works of this class (as will be seen in the chalk) there is an unsatisfactory element of chance as to whether any particular boring may intercept a fissure along which water is travelling or capable of travelling. In the case of the Lincolnshire Oolites, as they are carried by the dip under overlying Oolite and Cretaceous rock under the German Ocean, there is no probability of the beds appearing at the margin under the sea, and consequently the water is passing under the overlying strata, though fully charged with water previously absorbed, and an artesian pressure which varies in amount according to whether the head of water rises after rain or sinks after drought, as is seen in Dunholme Boring, which increases in flow after rain, the rain in question having been absorbed several miles to the west. This ready response to rainfall is a most unsatisfactory element in the Lincolnshire Oolite, and is well evidenced by the great variability in the springs gauged by Mr. Teagne, C.E., at Welton, running in—

August, 1878	105,000	gallons
June, 1887	168,000	,,
June 15, 1891, after heavy rainfall ...	2,800,000	,,
July 29, 1891	759,600	,,
Sep. 16, 1891	493,560	,,

The whole of the rainfall absorbed by the Lincolnshire Oolite is thrown out as springs, which act in direct response to the rainfall, and any wells or artesian boreholes to obtain a large supply will have to pump at a greater rate than the water can naturally flow out at the springs at the high level, and it is doubtful whether the pumps could do this, unless they should be fortunate enough to be placed in a line of natural fissure. Regarding the springs as interest and the water stored under the clay area as capital, it follows that no water can be permanently pumped beyond the capacity of the springs, and then only at their expense.

The Upper Estuarine Series is 35 feet in thickness at Lincoln, and thins northward to 15 feet at Ancholme Head. They consist of clays, sandy clays, and sands, that are generally impermeable, forming an impervious barrier between the waters of the Lincolnshire (Oolite) Limestone and the Great Oolite Limestone. A hard sand at the base of this series yields water at a depth of 49 feet below the platform at Potter Handworth Station, blue and red clays, with jet and bands of pyritous sandstone occurring above. The latter are a great feature of this series, and the decomposed pyrites produces an acidity of soil as deleterious to vegetation as to purposes of water supply. Strong clays of this age occur at Nettleham, Dunholme Lodge, and Gorse Cover, between Welton and Hackthorn, and support a sheet of water in the Great Oolite.

The Great Oolite Limestone is a compact shelly ragstone, its average thickness is 15 feet, though water-bearing, its small area and thickness render it of little importance for a public supply. The water rising to the surface near Dunholme Church in the Kellaway Rock, lying at the base of the Oxford Clay, may be derived from Great Oolite or Lincolnshire Limestone; both are penetrated by a boring 106 feet deep on the west of the village.

At Honeyholes Farm a pond receives the water from the roof of a large barn. It is situated on a soft sandy clay, doubtless belonging to the Boulder Clay Drift. The vegetation changes, and ditches are seen in the area overlaid by the Boulder Clay, and on the outcrop of Upper Estuarine series. Deep-set ponds occur south of Honeyholes, but they only contain surface water.

The Great Oolite Clay is an impermeable dark bluish deposit about 25 feet in thickness, and occasionally used for the manufacture of bricks, as at Metheringham Station.

The Cornbrash is a thin-bedded shelly limestone, of a rusty colour above and of a deep blue below, it is compact and crystalline and only five feet in thickness; for water supply purposes it is of no importance.

The Kellaway Beds consist of a few feet of black shales at the base, overlaid by the Kellaway sands, the junction being well seen in

Scothern Mill. In the sands occur the "Kellaway Rock." The shales support a small sheet of water of no sanitary importance.

Above occur the impermeable Oxford and Kimmeridge Clays, which are practically impermeable, and prevent the water in the porous strata beneath from rising to the surface, and therefore constitute an area of artesian pressure, both North and South of Lincoln.

The Geological sequence at Sleaford is similar to that of the Lincoln area, and for boring purposes, to obtain a water supply, the conditions are hardly as favourable as nearer Lincoln.

Cretaceous Rocks.—The Lower Cretaceous, or Neocomian Rocks, consist of the following strata in the Tealby district:—

	Ft.
Red Chalk	6
Upper Sands or Carstone	25
Tealby Clays, Limestones, and White Ironstones of Claxby	65
Spilsby Sandstone and Lower Sands	42

The Spilsby Sandstone is an extremely hard calcareous grey grit, passing horizontally into soft sandstone with mud from oxide of iron. Narrow outcrops, and shallow thickness alike, prevent the above being useful for purposes of public water supply, and were the conditions otherwise the presence of iron would seriously affect their quality.

The Carstone is a coarse grit, mixed with ferruginous clay, but never passes, like the softer portions of the Spilsby Sandstone, into a "running sand."

The Red Chalk is shaly and impermeable, and throws off springs at the base of the Lower Chalk, and a spring half-a-mile south of Stanton-le-hole is thrown out by the Carstone.

Upper Cretaceous.

Lower Chalk: This formation in Lincolnshire is marly, and cannot be relied on for a good supply of water.

Middle Chalk: For borings see end of Appendix II.

APPENDIX I.

Rainfall, from "Symonds' Annual."

	Lincoln. M.S. & L. Ry. Co. 25 feet above O.D.	Navenby. Rev. J. Hays.	Sleaford. Bloxholme. Mr. D. Lumsden 20 feet O.D.	Spalding. Pode Hole, Mr. H. Harrison 20 feet O.D.
1863	16·64	...	...	...
1864	...	...	...	...
1865	...	...	...	...
1866	22·62	..	...	...
1867	23·46	...	...	..
1868	19·64	...	...	...
1869	24·10	28·77	...	...
1870	16·29	18·82	...	16·88
1871	19·12	24·88	...	25·50
1872	32·15	36·14	...	32·50
1873	18·31	19·95	...	19·63
1874	16·58	18·38	...	16·22
1875	25·74	25·57	...	32·25
1876	29·79	30·83	32·92	31·00
1877	25·95	25·70	29·43	24·25
1878	28·04	28·40	30·18	25·63
1879	24·98	29·59	31·64	24·35
1880	30·68	22·93	32·59	37·13
1881	23·83	26·55	25·36	26·13
1882	32·96	33·08	33·71	30·50
1883	31·49	35·85	31·62	30·88
1884	15·43	16·25	16·92	16·75
1885	25·07	26·06	23·75	23·88
1886	24·57	27·21	27·34	30·25
1887	15·53	16·68	17·04	15·13
1888	20·34	23·62	22·39	21·46
1889	26·01	25·63	23·15	26·50
1890	18·20	17·31	18·29	20·12

APPENDIX II.

Lincolnshire Strata.

			Feet.
Cretaceous.	Chalk	Middle Chalk	164
		Lower Chalk	72
		Red Chalk 11ft., and Carstone 36ft. ...	47
	Tealby Beds.	Tealby Limestone	15
		Tealby Clay	50
		Claxby Ironstone	10
		Spilsby Sandstone	30

			Feet.	
Oolitic.	Upper	Upper Kimeridge Clay	800 (with Oxford Clay)	
	Middle	Oxford Clay		
		Kellaway Rock	10 ?	198
		Basement Clay	18 ?	
	Great Oolite Series	Cornbrash	5	
		Great Oolitic Clay	25	
		Great Oolitic Limestone	15	
		Upper Estuarine Beds	35	
	Inferior Oolite	Lincolnshire Limestone	60	
		Basement Beds (Northampton Beds)	30	
Liassic.	Lias.	Upper Lias	100	971
		Marlstone Rock-bed (represented by clay)	20	
		Middle Lias Clay	15 ?	
		Lower Lias	814	
		Rhætic	22	
Triassic.	Trias	Keuper Marls		725
		Keuper Sandstone	249	791
		Upper Soft Sandstone	206	
		Pebble Beds	113	
		Lower Soft Sandstone	223	
Permian.	Permian	Upper Marls	118	521
		Upper Magnesian Limestone	44	
		Middle Marls	140	
		Lower Magnesian Limestone	26	
		Marl Slates	193	
Carboniferous		Upper Coal Measures	10	

An examination of the table of the sequence of the rocks discloses that though there are no less than 15 water-bearing horizons, half of them are only 30 feet in thickness, or less, and though valuable for supplies to private dwellings are of no use for a public water supply. This can alone be afforded by the following:—(1.) The Middle Chalk, 164 feet; (2.) The Lincolnshire Oolite and Nottinghamshire Sands, together about 90 feet; (3.) The New Red Sandstone, in four horizons, together 791 feet.

Lincolnshire Wells and Borings.

Collingham, or Scarle.

This section was first described by Dr. Hull, F.R.S., late Director of the Geological Survey of Ireland; and subsequently by Mr. Dalton, F.G.S., late of the Geological Survey; and Mr. Wilson, F.G.S., of the Bristol Museum. It appears to have been as follows:—

Depth in feet.		Thickness, feet.	
21	Drift Deposits, river gravel	21	753
	Lower Lias Clay Limestone	29	
	Rhætic Shales and Limestone	15	
753	Keuper Marls (Gypsum)...	688	
958½	Keuper Sandstone, fine-grained and grey shales		205½
1164	Upper Soft Sandstone		205½
	Blue Shales ... ... (Pebble Beds)	1	113
	Reddish-Brown Coarse Sandstone (Pebble Beds)	73	
1277	Quartzite Conglomerate ... (Pebble Beds)	39	
1500	Lower Soft Sandstone, Marls in first 79 feet...		223
1618½	Permian Marls	118½	519
	Light Yellow Magnesian Limestone ...	43½	
	Red and Blue Marls and Gypsum... ...	138	
	Lower Magnesian Limestone	26	
	Dolomitic Limestone, Marl Slates... ...	58	
	Lost Cores	16	
2019	Thin-bedded Dolomites, Grey Shales, and Sandstone	118	
	Permian Basement Beds..	1	
2031	Deep Red Indurated Marls, with hæmatite nodules, Carboniferous		10

Newark.

Trent Brewery Well, No. 3, surface level 49 feet. Sunk by Messrs. Mather and Platt, Manchester, 1870.

Ft.	In.		Ft.	In.
325	6	Red and Blue Marls	160	0
		Gypsum and Hard Sandy Marl	30	0
		Red and Blue Marl, hard bands at 231 feet ...	125	6

Ft.	In.		Ft.	In.
576	0	Blue Flints (? hard rock)	4	0
		Pea Stone, hard bright red, soft sandstone ...	60	6
		Blue Clay	1	0
		Red "	4	0
		Red Stone (very hard)	14	6
		Brown Rock	7	0
		Brown Sandstone	18	0
		Stone Bind (hard sandy marl)	73	6
		Brown Rock (very hard sandstone)	2	0
		Stone Bind (hard sandy marl)	6	0
585	6	Brown "Granite" Rock (coarse sandstone) ...	75	0
		Stone Bind (very hard sandstone)	13	6
		Brown Rock	37	6
		Redstone	4	6
		Red Clay	9	0

Abstract of above:—

	Ft.	In.
Keuper Marls, with sandstones	325	6
Keuper Waterstones	190	0
Keuper Sandstone	69	6

Messrs. Warwick and Sons' Brewery, surface level 36 feet.

	Ft.	In.
Keuper Marls, with Gypsum	400	3

The water yielded contains six grains to the gallon of carbonate of lime, 84·93 grains of sulphate of lime, and 23·91 grains of sulphate of magnesia. The two latter are doubtless from the lower beds of the Keuper Marls, as the boring was only tubed down to 300 feet, those ingredients being suitable for brewing.

Owthorpe.

Boring for Coal, 1876-80. [Qr. Sheet, 71 S.E.] Information from Mr. Harrison.

Ft.	In.		Ft.	In.
12	0	Lower Lias	12	0
46	6	Rhœtic Beds	34	6
679	6	Keuper Marls (Gypsum)	633	0

Ft.	In.		Ft.	In.	Ft.	In.
772	6	Red Sandy Marl and Sandstones ...	15	0	93	0
		Red Sandy Marl	44	0		
		Reddish and White Gritty Sandstones, with pebbles	34	0		
804	6	Fine White Micaceous Sandstone ...	22	0	32	0
		White-pink Gritty Sandstone... ...	10	0		
941	6	Coarse-grained Gritty Sandstone, passing into coarse and fine conglomerate, of which the larger pebbles were quartzite	137	0	264	0
		Red Marl and White Marl	2	0		
		Sandstone and Conglomerate ...	56	0		
		Fine White Micaceous, sometimes gritty	36	0		
		Dark Red Coarse-grained Sandstone ...	16	0		
1068	6	Red and Grey Sandstone, conglomerate predominating	17	0		
1097	6	Red Marl, Banded Red and Grey Marl, Soft White Clay	14	0	29	0
		Red, Grey, and White Fine-grained Micaceous Sandstone	15	0		
1342	0	Coal Measures, with coal seams ..	244	6		

In abstract I classify the above section as follows :—

Ft.	In.		Ft.	In.
46	6	Lias and Rhœtic	46	6
679	6	Keuper Marls	633	0
772	6	Keuper Sandstones	93	0
804	6	Upper Soft Sandstones	32	0
1068	6	Pebble Beds	264	0
1097	6	Upper Coal Measures?	29	0
1342	0	Coal Measures	244	6

Boring east of East Retford, made by the Retford Coal Company in a futile search for coal. A plentiful supply of water was met with, but somewhat impregnated with iron. Communicated by the late Mr. Charles Tomlinson, C.E., of Rotherham, to C. E. De Rance, F.G.S.

	Ft.	In.		Ft.	In.
Keuper	29	6	Soft Red Marl and Sandstone ...	29	6
	60	0	Red and Grey Marlstone and Gypsum	30	6
Upper Mottled Sandstone	183	0	Red Sandstone	123	0
	186	0	Grey and Red Marl	3	0
	278	6	Red Sandstone	92	6
Bunter Pebble-beds	289	0	Red Sandstone and Gravel ...	1	6
	510	0	Red Sandstone	230	0
	511	6	Red Marl and Gravel	1	6
	654	0	Red Sandstone	142	6
	662	0	Pebbly Conglomerate	8	0
Lower Sandstone	733	0	Red Sandstone	70	0
	736	0	Red Marl	3	0
	805	0	Red Sandstone	69	0
Permian	904	6	Red and Grey Marl and Red and White Sandstone	99	0
	911	0	Red Marl and Limestone ...	7	0

Following the sub-divisions I have proposed above the abstract would be :—

Ft.	In.		Ft.	In.
60	0	Keuper	60	0
278	6	Upper Sandstones	218	0
662	0	Pebble Beds	383	6
805	0	Lower Sandstones	143	0
911	0	Permian	106	0

From Mr. John Bennett, Goole, per H. Franklin Parsons, M.D., F.G.S. Section of Trial Boring at Reedness, five miles east of Goole, made by the late Mr. Egremont in 1835 :—

From surface Ft.	In.				Thickness. Ft.	In.
1	6	1.	Dark Soil	Alluvial deposits	1	6
1	9	2.	Yellow Sandy Warp ...		0	3
9	3	3.	Dark Blue Warp ...		7	6
15	3	4.	Fine Blue Clay		6	0
21	3	5.	Blue Sandy Warp ..		6	0
30	3	6.	Light Grey Sand, with water		9	0
42	0	7.	Black Moor Earth, with some rotten wood		11	9

From surface. Ft.	In.				Thickness. Ft.	In.
45	3	8.	Strong Blue Clay ...	Drift	3	3
46	0	9.	Grey Sand, with water ...	Drift	0	9
56	3	10.	Black Gravel and Quicksand	Drift	10	3
57	8	11.	Red Sand	Drift	1	5
63	0	12.	Grey Sand and Gravel ...	Drift	5	4
66	4	13.	Red Sand	Drift	3	4
69	8	14.	Gravel and Sharp Sand ..	Drift	3	4
72	10	15.	Red Marl, metal with grey specks ...		3	2
80	11	16.	Red Sandstone, with gypsum and thin lists		8	1
90	1	17.	Strong Blue Stone, with thin white beds		9	2
108	4	18.	Dark Red Bind, with thin beds of gypsum		18	3
110	0	19.	Strong Blue Stone		1	8
120	3	20.	Red Bind, with beds of blue stone ...		10	3
125	1	21.	Blue Stone		4	10
133	7	22.	Red Bind, with thin white beds, and hard lists of blue stone ..		8	6
135	7	23.	Blue Bind		2	0
143	2	24.	Red Bind, with thin hard lists of blue stone and gypsum ...		7	7
151	10	25.	Red Stone		8	8
168	8	26.	Red Bind, with hard lists of stone and gypsum		16	10
173	0	27.	Blue Stone		4	4
190	11	28.	Red Bind, with thin beds of gypsum ...		17	11
192	8	29.	Blue Bind		1	9
199	4	30.	Red Bind, with thin beds of gypsum ..		6	8
199	6	31.	Blue Stone and white parting ...		0	2
219	2	32.	Red Stone, with blue lists		19	8
241	8	33.	Blue Bind, with thin beds of gypsum ..		22	6
241	2	34.	Blue Stone		5	6
251	2	35.	Blue Stone		4	0
257	8	36.	Red Bind, with hard list and white partings		6	6
263	2	37.	Red Sandstone, with thin white partings ...		5	6
269	8	38.	Blue Stone, thin beds, and blue bind partings		6	6
286	2	39.	Blue Bind, with thin beds of blue stone ..		16	6
297	2	40.	Red Bind, with thin bands of gypsum ...		11	0

From surface. Ft.	In.			Thickness. Ft.	In.
305	5	41.	Blue Bind, with soft beds of gypsum ...	8	3
337	10	42.	Dark Soft Red Bind	32	5
341	10	43.	Blue Stone	4	0
511	4	44.	Red Sandstone	169	6
513	4	45.	Red Bind	2	0
529	10	46.	Red Sandstone	16	6
533	4	47.	Red Bind, with lists of blue stone ...	3	6
766	10	48.	Red Sandstone	233	6
770	0	49.	Red Bind, with bright shining specks ...	3	2
772	10	50.	Dark Red Bind	2	10
784	4	51.	Red Sandstone	11	6
785	4	52.	Dark Red Bind	1	0
804	10	53.	Red Sandstone	19	6
807	1	54.	Red Bind	2	3
881	4	55.	Red Stone	74	3
882	4	56.	Red Bind	1	0
906	10	57.	Red Stone	24	6
910	8	58	Soft Red Bind	3	10
930	10	59.	Red Sandstone	20	2
931	10	60.	Dark Red Bind	1	0
955	10	61.	Red Sandstone	21	0
957	1	62.	Dark Red Bind	1	3
995	4	63.	Red Sandstone	38	3
998	4	64.	Light Red Sandstone	3	0
1029	0	65.	Red Sandstone	30	8
				1029	0

In abstract, the section will stand as follows :—

		Ft.	In.
Beds 1 to 14.	Drift	69	8
Bnds 15 to 43.	Keuper Marls, with hard bands and gypsum	272	2
Bed 44.	Red Sandstone	272	2
Beds 45 to 47.	Red Sandstone, with 5½ feet of red binds	22	0
Bed 48.	Red Sandstone	233	6
Beds 49 to 62.	Red Sandstone, with 16 feet 4 inches of red binds	190	3
Beds 63 to 65.	Red Sandstone	71	11
		1029	0

Out of 687 feet 2 inches of beds beneath the Keuper Marls, only 21 feet 10 inches consists of red binds, the rest being 665 feet 4 inches of red sandstone of similar physical character from top to bottom. They have been referred by Dr. Parsons to the Bunter.

In considering their age and character, it may be useful to compare this section with the borings for salt in the Middlesborough district, especially that of Saltholm Farm, on the Durham side of the Tees ("Sixth Report Underground Water"). I there suggest that "the limestones, thick salt beds, and gypsum are probably referable to the Permian; the intervening beds of red sandstone, 832 feet, are probably referable to the Waterstones and Lower Mottled Bunter, the Upper Mottled and Pebble Beds having thinned out." From more extended investigation, I think it more probable that the pebbly character of the middle portion of the Bunter has died away northwards, and that the Middlesborough section represents Waterstones and pebbleless Middle Bunter.

In the Lincolnshire area the valuable sections collected by Dr. Parsons throw light on this inquiry. He describes the beds below the Keuper Marls, in the surface sections, as "a loose red sand or friable semi-coherent red sandstone, often micaceous, with more coherent clayey bands, and with occasional partings or pockets of red, green, or yellow ochrey marl." *

Trial Boring for Water, Booth Ferry Road, Goole, made by Goole and Hook Parochial Sanitary Committee in 1876. From Mr. Tudor, Surveyor, Goole, per Dr. Parsons.

From surface. Ft.	In.		Thickness Ft.	In.
17	0	Warp, Peat, and Clay	17	0
25	0	Rough Gravel	8	0
28	0	Warp Clay, with a large pebble	3	0
34	0	Red Sand	6	0
58	0	Hard, Coarse, Light Red Sand	24	0
68	0	Red Marl	10	0
79	0	Hard Sand	11	0

* Proc. Geol. and Polyt. Soc. of West Riding of Yorkshire, 1877, p 216. From which several sections have been here reproduced for convenience of reference. C. E. R.

From surface. Ft.	In.		Thickness. Ft.	In.
82	0	Red Marl	3	0
108	0	Hard Sand	26	0
109	0	Red Marl	1	0
170	0	Hard Sand	61	0
173	0	Red Marl	3	0
176	0	Hard Coarse Sandstone, with small pebbles ...	3	0
260	0	Red Sandstone and Marl mixed	84	0
282	0	Red Sand	22	0
284	2	Stiff Red Marl	2	2
306	3	Marl and Red Sand	22	1
366	0	Red Sandy Marl	59	9
			366	0

In abstract, this section gives drift probably 28 feet, red sand 338 feet, of which 19 feet were marl, if the red sandy marl last penetrated be omitted, which added gives an entire thickness of marl of just 80 feet. The occurrence of the small pebbles at 176 feet and the thick marl are worthy of note in this section, and differ from those adjacent; they are probably referable to the Waterstones.

Helliwell's Brewery, Rawcliffe, from Dr. Helliwell, per Dr. Parsons. Well deepened in 1876.

From surface. Ft.	In.			Thickness. Ft.	In.
18	0	1.	Old Well	18	0
45	0	2.	Yellow Sand	27	0
47	0	3.	Blue Clay	2	0
47	6	4.	Peat	0	6
59	6	5.	Clay, with gravel	12	0
200	0	6.	Red Sand, with thin marl bed at 139 feet ...	140	6
				200	0

Artesian Well at Rawcliffe Halls, 1877. Details from Mr. Tudor, Surveyor, Goole, per Dr. Parsons.

From surface. Ft.	In.			Thickness. Ft.	In.
16	0	1.	Silty Stiff Red Warp	16	0
130	0	2.	Red Sand and Marl	114	0
250	0	3.	Coarse Loose Red Sandstone and Marl ...	120	0
				250	0

Well near Rawcliffe Station. Per Dr. Parsons, 1876.

From surface. Ft.	In.			Thickness. Ft.	In.
3	0	1.	Black Sand	3	0
8	0	2.	Brown Coarse Sand	5	0
16	0	3.	Mottled Brown Clay	8	0
		4.	Red Sand		

These soft red sands and loose sandstones would appear to be referable to the Keuper Sandstone, and are the representatives of the Cheshire Frodsham Beds, which have been observed eastwards by Mr. Aveline, F.G.S., and myself as far as Ashbourne in Derbyshire.

Trial Boring for Water at New Bridge, near Snaith, in ancient course of the River Don, made in 1876 by the Goole Local Board, From Mr. Tudor, Surveyor, Goole.

From surface. Ft.	In.		Thickness. Ft.	In.
46	0	Brown Warp, Peat, and Loam	46	0
51	0	Gravel, with magnesian limestone fragments ...	5	0
56	0	Coarse Reddish-brown Sand (decomposed rock?)	5	0
57	0	Light Green Marl	1	0
80	0	Red Marly Sandstone	23	0
87	0	Coarse Red Sandstone	7	0
130	0	Bed Marly Sand	43	0
133	0	Red Sand, with green marl	3	0
170	0	Red Marly Sand	37	0
173	0	Blue Marl	3	0
175	0	Red Marl	2	0
263	0	Red Marly Sand	88	0
265	0	Variegated Marl	2	0
309	0	Red Marly Sand	44	0
329	0	Coarse Red Sand	20	0
377	0	Red Marly Sand	48	0
379	0	Variegated Marl	2	0
403	0	Red Marly Sand	24	0
404	0	Variegated Marl	1	0
500	0	Red Marly Sand	96	0
			500	0

This section gives, in abstract, drifts probably 51 feet, and 449 feet of red sandstone, red sand, and coarse red sand, with 11 feet of intercalated marls, the whole of which may be regarded as one series, and compare well with the Goole section, and may be referred to the Keuper Sandstones, and might for their important thickness be called the Goole Beds.

It may be well to reproduce the section of the Selby Waterworks, obtained from Mr. Wetherill by Professor Green, F.R.S.

Surface level $20\frac{1}{2}$ feet above Ordnance datum; the water out of a 6-inch bore-hole rises to 16 feet from Ordnance datum.

From surface. Ft.	In.			Thickness. Ft.	In.
5	0	1.	Alluvial Soil	5	0
29	0	2.	Clay	24	0
30	0	3.	Sand charged with water that one man could pump	1	0
54	0	4.	Clay	24	0
75	0	5.	Quicksand. Strong spring of water at base ...	21	0
		6.	Red Sandstone	18	0
93	0	7.	Marl, resembling fuller's earth	0	1
		8.	Red Sandstone	10	3
103	3	9.	Grey Sandstone	0	1
		10.	Red Sandstone	64	9
		11.	Red Hard Sandstone	118	6
		12.	Very Hard Rock...	10	6
		13.	Red Sandstone	6	9
		14.	Very Hard Rock...	14	9
330	8	15.	Hard Rock	22	0
				330	8

Here there was 75 feet of drift, all the remainder being more or less hard red sandstone, without the intercalated marl beds observable in the Goole section, which are presumably above those penetrated at Selby, which may be referred to the Pebble Beds.

Boring at Donington, on west side of River Bain. Communicated by Mr. Edward Bogg, the Geol. Soc., London, "Trans. Geol. Soc." 1816.

		Ft.	In.
1.	Clay Soil	3	0
2.	Dark Coloured Clay	9	0
3.	Soft Grey Shale, with fossils	1	0
4.	Dark Agillaceous Stone	0	5
5.	Dark Coloured Clay	3	1
6.	Soft Grey Shale	1	0
7.	Laminated Clay, slightly indented	23	2
8.	Soft Grey Shale, slightly inflammable	5	3
9.	Ditto, darker coloured	5	3
10.	Indurated Clay, with white fossils	37	6
11.	Ditto, but harder and blacker	7	3
12.	Dark Coloured Bituminous Inflammable Shale ...	6	0
13.	Dark-blue Ironstone	0	3
14.	Laminated Indurated Clay, with fossils	33	0
15.	Ditto, harder fossil impressions in pyrites ...	10	4
16.	Dark Blue Clay (iron) stone	0	4
17.	Hard Indurated Laminated Clay	18	4
18.	Laminated Bituminous Shale, with fossils ...	1	10
19.	Dark Blue Ironstone	0	2
20.	Laminated Bituminous Shale, like 18	11	0
21.	Dark Blue Ironstone	0	1½
22.	Laminated Bituminous Shale, like 18 and 20 ...	18	10½
23.	Dark Indurated Clay, with fossils	3	6
24.	Laminated Bituminous Shale, like 18, 20, and 22...	9	0
25.	Dark Clay, like 23	5	0
26.	Laminated Bituminous Shale, like 24, &c. ...	4	6
27.	Dark Clay, indurated clay, like 25	30	3
28.	Grit	0	2
29.	Brown Laminated Clay	0	2
30.	Clay (iron) stone	4	10
31.	Hard Laminated Bituminous Shale	3	2
32.	Clay (iron) stone	2	0
33.	Hard Laminated Bituminous Inflammable Shale ...	2	4
34.	Inflammable Compact Shale	3	0
35.	Hard Laminated Shale, very inflammable ...	5	7½

		Ft.	In.
36.	Dark Blue Compact Shale, with bituminous bands	13	9½
37.	Very Inflammable Shale	0	2
38.	Hard, Dark, Blue, Compact Shale	3	8
39.	Clay (iron) stone	1	0
40.	Ditto, but not so hard	1	0
41.	Hard, Dark, Compact Shale, like 38	22	10
		309	0

Grantham.

Boring on Messrs. R. Hornsby & Sons, Iron Works, at Spittlegate.

Ft.	In.		Ft.	In.
832	0	Lower Lias	832	0
853	4	Rhœtic	21	4
		Keuper Marl	(+)	

Melton Mowbray.

Town Supply, boring 200 yards west of the North Station. Surface level 260 feet above the sea.

Ft.	In.		Ft.	In.
38	0	Drift Clays	38	0
268	8	Lower Lias Clays	230	8
285	0	Rhœtic	16	4
476	8	Keuper Marls	191	1
533	0	Keuper Marls, with sandstones	56	4

Water was yielded by gypsum beds in the marls, and by the sandstones below them, and rose to 120 feet below the surface, or 140 feet above the sea level.

Bourn.

Spretchley's Brewery for the Spalding Waterworks.

Ft.	In.		Ft.	In.
20	0	Fen Beds	20	0
28	0	Cornbrash	8	0
63	0	{ Great White Clay	35	0
75	0	{ Great Oolite	12	0
90	0	Green and Yellow Marl	15	0

Bracebridge, near Lincoln.

Trial bore-hole for Messrs. Bass & Co., by Messrs. Le Grand and Sutcliffe, London.

Ft.	In.		Ft.	In.
320	0	Lower Lias Clay	320	0

The water at that depth contained the following constituents —

	Grains.
Sodium Chloride	549·00
„ Bromide...	11·00
„ Carbonate	15·00
Calcium „	12·50
Magnesium „	4·58
Calcium Sulphate	1·13
Silica	0·35
Iron Oxide, Alumina, Phosphoric Acid	0·21
Suspended Matter	0·04
Total	593·81

As this boring commenced in the Lower Lias, near the top of that deposit, which is at least 800 feet thick, the saline water must either be derived from the Lower Lias, or must have flowed up along the plane of some fault or joint from the Keuper Marls below.

Scothern Grange Well.

Boulder clay	7 feet
Gravel, with water	(+)

Langworth.

Farm, 1¼ mile S.W. of Station.

ft.			ft.
30	Boulder Clay } Oxford Clay }	sunk	30
	Ditto do	bored	60
90	Kellaways Sand	... ...	(+)

The water rises nearly to the surface.

Sudbrook Holme.

Boring by Messrs. Legrand & Sutcliffe, London. Water rises to level of top of house. Yielded 7000 gallons per day of 10 hours.

Ft.	In.			Ft.	In.
2	0	Soil		2	0
7	0	Stone	Kellaways Beds	5	0
20	0	Grey Sand	Kellaways Beds	13	0
27	0	Blue Clay	Kellaways Beds	7	0
31	6	Stone	Cornbrash	4	6
43	0	Green Clay	Great Oolite Clay	11	6
57	0	Dark Clay	Great Oolite Clay	14	0
62	0	Stone 4 ft., Clay 1 ft.	Great Oolite	5	0
76	0	Shell Rock	Great Oolite	14	6
80	2	Green Clay	Upper Estuarine	5	4
85	6	Stone	Upper Estuarine	15	0
100	6	Clay		15	0
107	0	Stone	Lincolnshire Limestone	5	6

Grimsby Waterworks Co. Wells. Collected by C. E. De Rance from Messrs. Mather & Platt, Manchester. Boring west of Grimsby.

From surface. Ft.	In.		Thickness. Ft.	In.
21	0	1. Very Soft Clay, full of vegetable matter	21	0
24	6	2. Gravel and Sand	3	6
29	6	3. Clay	5	0
31	6	4. Rough Gravel and Small Flints	2	0
33	6	5. Fine Soft Clay and Small Flints	2	0
45	0	6. Rough Gravel	11	6
60	0	7. Fine Gravel	15	0
75	0	8. Chalk, very hard. Water then rose to 4 feet above the surface in large volumes	15	0
			75	0

Boring east of Grimsby, near Cleethorpes.

From surface. Ft.	In.		Thickness. Ft.	In.
84	0	Stiff Bluish Clay, with flakes of chalk	84	0
99	0	Sand and Gravel	15	0
224	0	Chalk, with flints in beds	125	0
			224	0

In the Cleethorpes boring the top of the chalk was very rotten and had to be tubed out down to 120 feet from the surface, or 21 feet from the top of the chalk. The yield from this boring is only about 180,000 to 192,000 gallons per day, and it is evident that the water is not entirely tubed out from the upper part of the Chalk, from the fact that, when this quantity is pumped, the water-level being 24 feet from the surface, the neighbouring wells and bore-holes all lose their supply of water, none of which do more than penetrate the top bed of the Chalk.

At Grimsby Docks there is a well in the Chalk 300 feet deep; the water is clear and palatable. Analysed by the Rivers Pollution Commission, was found to have a hardness of 22·1, of which 7·6 was permanent; chlorine was 5·00, in parts per 100,000.

NOTES ON SOME NEW OR BUT LITTLE KNOWN EOCENE POLYZOA FROM LOCALITIES. BY GEORGE ROBERT VINE.

Some time after my first paper "Notes on British Eocene Polyzoa,"* had been placed in the hands of the printer, I received from Mr. Alfred Bell another small packet of Eocene material for description. And quite recently (Feb., 1891), a few additions have been made by the same gentleman to the original stock, differing but little, however, from the first batch; so I think I shall now be able to describe, or incidentally refer to, all the Polyzoa known to me, from the several British Eocene horizons. The Polyzoan fauna that will be referred to further on, is altogether unlike the species already described, and so far as I am aware most of the forms are new to British rocks, some of the species at least being more closely allied to the Cretaceous Polyzoa of France, as described and illustrated by d'Orbigny, than to ordinary Tertiary forms, British or Continental. The locality whence most of the forms are derived, Fareham, Hants, is also new to me, consequently I asked Mr. Bell to draw up for the introductory part of this paper a brief synopsis of "Hants and its Fauna," which I give below in his own words:—

"In widening the railway near this place (Fareham) a short time back, a deposit, containing a peculiar assemblage of mollusca, was opened up, including a large number of Brachiopods, *Terebratula bisinuata, Lam.*, which at the time of publication of Dr. Davidson's Monograph of Fossil Brachiopoda, 1852, only two examples were known, collected from the Bracklesham beds and the Hampshire cliffs. I have since obtained other fragments from the Bracklesham sands.

The Fareham Brachiopods are very local, nearly all double, much crushed and distorted, and appear to have been destroyed by a sudden influx of mud or other matter. Polyzoa not being, so far as I can ascertain, associated with them as they are with some of the other shells.

* Proc. Yorksh. Geol. and Polyt. Soc., vol. xi., pp. 154-169.

The general *facies* of the fauna is not that of the ordinary London Clay, and it was not till I had seen the fine blocks in the Woodwardian Museum, Cambridge, obtained by Mr. H. Keeping, that I could understand the relegation of this deposit to the horizon assigned to them. I believe, however, that we have here a passage bed between the London Clay and the Bracklesham series.

The Polyzoa occur chiefly on *Turritella sulcifera, Fusus* (Strepsidura) *pyrus*, var. *bulbus* and *Voluta athleta*.

Usually the adherent Polyzoa in the Eocene beds generally are rather confined to the number of species to which they attach themselves; *Membranipora Lacroixii* seems to be an exception, as I have seen this species attached to *Cerithium, Cominella desertum, Fusus trilineata, . . . Murex minax,* and several *Voluta* species and other shells. *Biflusta eocena* is chiefly attached to stones."

The following species and varieties from the British Eocene rocks are all that are known up to date.

Sub-order, CYCLOSTOMATA, Busk.

1. Crisia sp. (eburnea?) London Clay.
2. Idmonea coronopus Def. London Clay and Bracklesham.
3. ,, gracillima? Reuss. London Clay, Sheppy.
4. Hornera (minuta) Vine.
5. ,, flabelliformis, Blainv.
6. ,, ramosa, d'Orbigny. Fareham, Hants.
7. Lichenopora mediterranea? Blainv. ,, ,,
8. Ditaxia variabilis, d'Orb. ,, ,,

Sub-order, CHEILOSTOMATA, Busk.

9. Dittosaria Wetherelli, Busk. London Clay.
10. Membranipora reticulum, Linn. ,, ,, Fareham.
    ,, = *M. Lacroixii*, Savg. (of authors.)
    ,, ? crassa, Desm. Thanet sands.
    ,, holostoma, Busk.
11. var. perforata, Vine. London Clay, Fareham.
12. Biflusta eocena, Busk. Bracklesham.

MEMBRANIPORELLA NITIDA, Johnston.

13. ,, var. eocena, Vine. London Clay, Sheppy.

MICROPORELLA VIOLACEA, Johnston.

14. var. (*a*) fissa, Hincks (and Waters), London Clay and Fareham.

15. var (*b*).

PORELLA CONCINNA, Busk.

16. var. eocena, Vine, London Clay, Fareham.

17. Eschara? Brongniarte, M. Ed., Bracklesham.

18. Cellepora petiolus, Lonsd., Bracklesham and Barton beds.

19. „ sp. (pumicosa?) „ „

20. Lunulites urceolata, Lamk. „ „

*21. [Diachoris intermedia, *Waters*] Bournemouth beds.

§ CYCLOSTOMATA, Busk.

This Sub-order is very poorly represented in British Eocene rocks, and in the Fareham Beds only three definable species have been brought to light, or at least to my knowledge, up to date:

1. Hornera ramosa, d'Orbigny.
2. Lichenopora sp. (Mediterranea? Blainv.)
3. Ditaxia variabilis, d'Orb.

1. HORNERA RAMOSA, d'Orb., sp.

1850-52. Reteporidea ramosa, d'Orb., Terr. Cret. v., p. 937, pl. 608, fig. 6-10, pl. 773, fig. 1-3.

1890. Hornera ramosa, d'Orb., (Pergens), Rev. des Bryoz. du Crétacé, Bull. de la Soc. Belge de Geol. Tome iii. p. 353.

Zoarium composed of free growing branches, circular or slightly flattened, but not, so far as I am aware, anastomosing. The diameter

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*[NOTE.—In my former list of Eocene Polyzoa (Proc. Yorksh. Geol. Soc., vol. xi., p. 158), I recorded "*Diachoris intermedia*, Hincks." In justice to Mr. A. W. Waters I append the following remarks, extracted from a letter to me, by way of explanation: "I notice that you give my *D. intermedia* as the same as Hincks, which is not the case. I first noticed the cast of *Diachoris* from the Bournemouth Beds, but from a cast in clay it is impossible to make a good species. I said something to the effect that if further specimens should be discovered, and better ones show that it is new, it might be called *D. intermedia*. You will find my remarks as a note to Starkee Gardiner's paper on the Bournemouth Beds in the Quart. Jour. of the Geol. Soc." With this explanation it will be far wiser to retain the name in the list, in the hope that something better may be brought to light.]

of the branches are variable, measuring from 1 to 2 mm. in the older parts of the zoarium. *Zoœcia* disposed in transverse groups (Idmonea like) on the sides of the branches, generally from three to four in a row, the rows separated from each other by cancellated interspaces, about ½ mm. apart. In the older parts of the branches, besides the lateral disposition of the zoœcia there are from two to three rows of cells longitudinally arranged, which decrease in number in the smaller portions of the branches which ultimately fade away in the still younger parts. This feature is faintly shown in d'Orb., fig. (pl. 608, f. 7). The orifices of the zoœcia are circular (0·08 m.m.) peristomes prominent. The rest of the surfaces of the branches, face, sides, and reverse, are occupied by intervening cavities *(cavités intersquelettiques,* Pergins, (op. cit., p. 311) similar to the cribriform features in ordinary Hornera species, fossil or recent.

Horizon: Senonian, France; Middle Eocene, Hants.

Localities: France, d'Orb., "à Royan, à Bougniaux-Charente Inferieure; à Meudon, pres de Paris; à Sainte-Colombe-Manche." — England; Fareham, Hants.

I do not think that there can be any doubt about the identity of this peculiar species, and its well established presence in British Eocene rocks. It is undoubtedly the most abundant polyzoon in the Fareham deposit. My first examples were embedded in masses of the dark Clay which I was allowed to soak, and pick out the fragments from the softened material, but I was unable to find other species of Polyzoa associated in the debris. In the debris, however, I was able to pick out several examples of Foraminifera, *Alveolina*, sp. (unique), and *Nummulites* similar to species found in the Isle of Wight; Miliolinæ, and other species similar to, but finer than the Rotaline species found in the London Clay of Sheppy. My later examples were both free, and embedded in much harder debris commingling with water-worn blackish pebbles. From the peculiar appearance of these conglomerate masses we may conjecture that in all probability some sudden inrushing of muddy gravel, broken shells and other material enveloped, and consequently destroyed the habitat of this beautiful species which was, apparently, a remnant of the old Cretaceous Polyzoan fauna. I doubt, however, whether the full grown

Zoarium was "cupuliforme" (T. C., p. 937, pl. 608, fig. 6, d'Orb), or similar, in any other sense than that already described, to d'Orbigny's beautiful species. There is no evidence, judging from the preservation of the fragments in my possession, that this polyzoon had ever been subjected to the wearing action of water for any length of time. The destruction of the peculiar habitat seems to have been sudden and complete, although in other places (*vide* remarks by Mr. Bell, ante) the destruction of the then living Brachiopods, though brought about similarly, may have been more marked than the destruction of the Polyzoan fauna. Such catastrophies are quite common in our British rocks, both Palæozoic and Mesozoic.

2. LICHENOPORA SP. (MEDITERRANEA? Blainv.)

It is impossible, both on account of its peculiar habitat and poor preservation, to completely identify this species of *Lichenopora*. The zoarium is wholly adnate, irregular in outline, without marginal lamina, but hollowed in the centre. Its measurement is quite 3 mms. in one direction and 2½ mm. in another. The zoœcial rays are partly uni, and partly multiserial in their arrangement, but on the outer edges of the zoarium the orifices of the zoœcia and the openings of the cancelli appear to be about equal in size, so that it is almost impossible to distinguish the one from the other. As this is the only true *Lichenopora* from British Eocene rocks that I have been able to examine, or in other words, the only species known to me, it would not do to pass it over, in spite of the difficulty of identifying it. On the fossil it is associated with a small colony of *Membranipora holostoma*, Busk (var. *perforata n.v.*), a few of the zoœcia of which obliterates, to some extent, the face of the *Lichenopora*.

Horizon and Habitat: Upper Eocene, Barton Clay; On *Voluta athleta*.

The only species known to me with which I can compare this Eocene form is the *L.* (Discoporella) *mediterranea*, Busk (Cat. Polyzoa. Brit. Mus III., p. 33, pl. 34, fig. 4), which the author identifies as follows :—

1844. Lichenopora mediterranea, Blainville Man. d'Actinol, p. 407.
1847. Actinopora mediterranea d'Orb., Prod. iii., p. 188.
1852. Unicavea mediterranea, *id. ib.*, p. 971.

Hab.: Mediterranean on shell (H.M.S. 'Porcupine;' Blainville, Michelin, d'Orbigny) Fossil; Miocene: Astezan, Asti, Vaucluse.

In his Bruccoli paper* Mr. A. W. Waters says, respecting *Discoporella mediterranea* (p. 18), "In the material collected by Dr. Fuchs from Bruccoli, there are a few fragments adnate and one stipate, and it would seem that the mode of growth should not be used as a generic character. This view would lead to the addition of Defrancia to Discoporella, and as this is a very variable species it seems possible that *Defrancia lucernaria, Sars* (see Busk Op. cit. Brit. M. C., pt. iii, p. 36, pl. 33, fig. 3), is only a variety. The cells of the rays are in some much raised, in others the rays are less distinct." A similar opinion is expressed by Mr. Waters in his remarks on the same species as found at Naples (Ann. Mag. Nat. Hist. (5 iii.), 1879, p. 277). Besides these references Dr. Pergens, in his papers on the (Pliocëne Bryozoën von Rhodos, p. 11., 1887, Bryozoa Nord-oüest Medt., p. 11, Bull. Soc. Roy. Malcol de Belg., 1889), partially describes this peculiar species, and Seguenza (Form. Terz. Reggio, pp. 330-372), refers to it twice.† Under present circumstances then, although I believe that the species may be placed here, it may be best to bracket the specific name, but I advise that a careful search should be made when comparing Barton Clay fossils for better examples than the one that has been so feebly described above.

British Horizon: Eocene, Barton Clay.

1851. Genus Ditaxia, Hagenow.

The genus *Ditaxia* was founded by Hagenow for the reception of the following peculiar species previously described by Goldfuss.

Ceriopora anomalopora, Goldf, "Petrifacta," p. 33, pl. 10, fig. 5.
,, compressa, ,, ,, p. 37, pl. 11, fig. 4.

Only the first of these is taken by Dr. Ed. Pergens‡ and accepted as the type of *Ditaxia;* the second is a *Mesenteripora.* The zoaria are in double layers simple and creeping, double and free, bearing on

* Bryozoa (Polyzoa) from the Pliocene of Bruccoli (Sicily). Proc. Manchester Geol. Soc., 1878-9.

† See Miss E. C. Jelly's "Synon. Cat. of Marine Bryoz., p. 136, No. 884.

‡ Rev. des Bryoz. du Cret., p. 337.

the surface both the orifices of the true zoœcia and the accessory cells ("cavites intersquelettiques"). Dr. Pergens in the grouping of the Cretacious Polyzoa places this genus in the family *Diastoporidæ*, and he remarks (Op. cit., p. 328) that "Dixatia comprises those species with 'cavities intersquelettiques' strongly developed. This difference between *Ditaxia* and *Diastopora* is however of little value, and perhaps some day anatomical researches will compel us to unite these genera into one." I cannot agree with this opinion in the present case, for after a careful study of the type species of Hagenow, *Ditaxia anomalopora*, there seems to me to be no relationship whatever between it and *Diastopora* as generally understood. I have no objection to the grouping of the following species however under the genus Ditaxia, as adopted by Dr. Pergens in his revision of d'Orbigny's labours (Op. cit., p. 337).

1. Ditaxia anomalopora, Goldf., d'Orb., Terr. Cret., p. 953.
2. ,, variabilis, d'Orb (= Semimulticlausa id.) l.c., p. 900.
3. ,, papularia, Mich. (= Reptomulticlausa id., d'Orb.) l.c., p. 901.
4. ,, nodosa, d'Orb. (= Seminodicrescis id.) l.c., p. 1067.
5. ,, tubulosa, d'Orb. (= Semicrescis id.) l.c., p. 1073.
6. ,, ramosa, d'Orb. (= Semimulticrescis id.) l.c., 1078.

3. Ditaxia variabilis, d'Orb.

1850-52. Semimulticlausa variabilis, d'Orb., Terr. Cret., vol. v., p. 900, pl. 767, figs. 5-10.

1890. Ditaxia variabilis, Perg. Revis. des Bryoz. du Cret., p. 337.

This species is represented by several examples which closely resemble d'Orbigny's figure, but as such a variety of forms are associated under the generic term *Ditaxia* by Dr. Pergens, I forbear making any remarks on the genus Ditaxia at present. Certainly *Semimulticrescis ramosa*, d'Orb. (pl. 800, figs. 15-17) in some of its features resembles the above, but the Eocene forms, when magnified, are more akin to *D. variabilis* than to *D. ramosa*.

Horizons and Localities: London Clay, Fareham; Cretaceous, 22nd stage, Villedien, Lavardin (Loir-et-Cher); Tours (Indre-et-Loire) d'Orb.

§ CHEILOSTOMATA, Busk.

Membranipora Lacroixii, (Busk., Geol. Mag., v. iii., p. 866, p. 2).
1826. Flustra Lacroixii, Savigny l'Egypt (Audouin), pl. 10, fig. 9.
1850. Membranipora Lacroixii, Busk, Cat. Pol. Brit. Mar., p. 60, fig. 1.
1880. ,, ,, Hincks, Brit. Mar. Pol., p. 129, pl. 17, 5-8.
1886. ,, reticulum, Pergens, Plioc. Bry., von Rhodos, p. 15.
1889. ,, ,, E. C. Jelly, Synon. Cat. Recent Bryozoa, species 1047, pp. 162-164.

Miss E. C. Jelly's valuable "Synonymic Catalogue of Recent Marine Bryozoa" has been published since I wrote my paper on "British Eocene Polyzoa,"* which was recently printed in this Journal. On referring to the synonymy of *M. Lacroixii*, Aud., I find that this name will, in all probability, have to give way to that of *Membranipora* (Millepora) *reticulum*, Linn. In Miss Jelly's "Catalogue," no fewer than 60 references under the head of "*Membranipora reticulum*, Linn.; Pergens" are given by her, so that ample opportunity is offered to those students who wish to debate the question as to who was the author of the species which I have called *Membranipora Lacroixii*, Aud. As the present material, however, really merits a most careful examination I shall make no apology for the length or characteristic minuteness of my descriptive sketches.

1. MEMBRANIPORA RETICULUM, Linn. (Pergens), E. C. Jelly, species No. 1047.

Membranipora Lacroixii, Hincks, Brit. Mar. Polyz., pp. 129-131.
,, ,, Vine, Proc. Yorksh. Geol. Soc., vol. xi., pt. ii., p. 159.

Zoœcia, oval, or slightly elongated at the proximal extremity, area occupying the whole front of the cell; margin rounded "granulated," rising so as to form a prominent ridge; occasionally in the more sheltered portions of the colony a few cells are preserved with

* Vine, Notes on British Eocene Polyzoa, Proc. Yorksh. Geol. and Polyt. Soc. vol. xi., pt. ii., p. 159.

the lamina, slightly calcified, intact, with a semicircular aperture at the top, triangular hollows immediately above the aperture. Communication pores: in rare cases three, especially in the Colwell Bay example; in the Fareham examples, two, placed in the side walls at the distal and proximal extremities of the cell.

Horizon: Oyster Beds, Colwell Bay, on oyster shells, (Prof. Judd), Bracklesham Bay; London Clay, Highgate (Busk); Walton-on-Thames (C. D. Sherborn); Fareham, on *Turritella*, *Voluta athleta*, Soland., and *Strepsidura pyrus*, var. *bulbus*; Portsmouth, *Natica hautoniensis.*

In all probability the present forms, when in their natural state, were furnished with delicate spines on the walls of the cell, of which the remaining beaded, or granulated, surface may be indicative. The species, however, must not be confounded with *Biflustra Lacroixii*, Smith, which Hincks gives as a synonym of *M. Lacroixii*, and Busk (Challenger Rep., p. 63) as probably synonymous with *Membranipora crassimarginata,* Hincks, variety *B. incrustans,* Busk (Chal. Rep. p. 63, pl. 15, fig. 5.)

2. Membranipora holostoma, Busk (Crag. Pol., p. 36, pl. 3, fig. 3) var. perforata, var. new.

Zoarium encrusting; irregular. *Zoœcia* oval, and occasionally pyriform; front of cell slightly arched; margins much raised and forming a line of separation between the margins of contiguous cells; surface of lamina coarsely perforated; orifice semi-orbicular; peristome not prominent; a circular pore much larger than the perforations on each side just below the orifice. *Avicularia* (?)

Locality, &c.: on *Voluta athleta*, Sol.; Barton Clay, adherent to *Lichenopora Mediterranea,* Blainville, which has already been described.

Membranipora holostoma is described by Busk from a fragment found on the inside of a small *Pectunculus glycimeris,* and the species seem to be somewhat rare in the Crag. Dr. Manzoni (Castrocaro, p. 14, pl. 1, fig. 12) describes and illustrates a fragment which he says is rare, but more like the Eocene form than that of the Crag. Reuss (Miocene d'Austria et Ungheria), also catalogues a species which he identifies with *M. hololostoma*, Busk.

The present variety, however, differs from the whole of the examples referred to in having the lamina perforated, but in the only fragment known to me I have not seen any avicularia.

3. MICROPORELLA VIOLACEA Johnston, var. (*a*) FISSA, Waters.

„ fissa, Hincks. Contrib. Gen. Hist. Marine Poly., Ann. Mag. Nat. Hist., ser. v., vol. iv., p. 381.

„ violacea, var. fissa, Waters. Quart. Journ. Geol. Soc., vol. xxxvii., p. 329, pl. 15, fig. 26; pl. 17, fig. 73.

„ violacea, var. fissa, Vine. Proc. Yorksh. Geol. and Polyt. Soc., vol. xi., p. 162.

The examples of this species are similar to those already described in my first paper.

Horizon: Bracklesham Beds; London Clay, Fareham, Hampshire.

4. PORELLA CONCINNA? Busk. Hincks Brit. Marine Poly., vol. i., p. 323, pl. 46.

var. EOCENA; var. new.

Zoarium encrusting, in irregular patches, the whole of a *Turritella sulcifera*. *Zoœcia* ovate, convex and punctured round the margins, but this feature is often obscured by an incrustation of pyrites. *Oœcia* globose and prominent.

Horizon: London Clay, Fareham.

The range of variation in recent *P. concinna* is so great that one naturally hesitates to increase the difficulties of the Palæontologist by suggesting new varietal terms. The Eocene form differs from all the figures given by Hincks (Brit. Marine Polyzoa, vol. ii., pl. 46). In a modified sense it comes nearest to fig. 11 of the same plate, excepting that the general character of the cell is rather less elongate or more like the bottom cell in the left-hand corner of the figure, and the small avicularian cell is only seen in the better preserved cells. I should like to leave the Eocene form here provisionally, trusting that better examples, less pyritised, may turn up in the future.

THE HYBODONT AND CESTRACIONT SHARKS OF THE CRETACEOUS PERIOD.

BY A. SMITH WOODWARD, F.G.S.

PLATES I. AND II.

The fish fauna of the Cretaceous period is of most interest as exhibiting the last survivors of many of the ancient Mesozoic types and the dawn of the great host of modern forms which characterise the Tertiary epoch. Among sharks the Hybodonts and Cestracionts are becoming extinct, *Cestracion* itself alone passing into the Tertiary beyond, while numerous representatives of the characteristically modern group of Lamnidæ suddenly make their appearance in the Gault, Greensand, and Chalk. Among other fishes the same kind of change is apparent, and it remains for future discoveries of intermediate forms to indicate the precise lines of evolution of which only widely separated terms are as yet well known.

The surviving Jurassic families and genera that become almost or quite extinct in the course of the Cretaceous period are thus worthy of special attention. It is instructive to compare them with their early representatives at a time when such forms were a dominant type of life. The materials are often unfortunately fragmentary, but many noteworthy facts are discoverable in the attempt at comparison, and it is the object of the following notes to deal with some of the Cretaceous Hybodont and Cestraciont fossils from this point of view.

Genus HYBODUS.

[Agassiz, Poiss. Foss., vol. iii., 1837, p. 41 ; A. S. Woodward, Cat. Foss. Fishes, Brit. Mus., pt. i., 1889, p. 250.]

As represented by its typical species in the Lias, the principal characters of the skeleton of the genus *Hybodus* are now well-known. The paired fins and the anal and caudal fins alone remain undiscovered. In shape the fish seems to have much resembled the existing Port Jackson Shark (*Cestracion*) or the typical modern Lamnidæ ; and the presence of two dorsal fins is proved by the frequent occurrence of the two spines with which they were armed. The mouth is deeply cleft and not quite terminal, while the teeth are relatively large and arranged in several series simultaneously in function. Each tooth is conical or cuspidate, the crown more or less striated, with one principal elevation, and one or more lateral prominences on either side diminishing outwards; the root is somewhat depressed, but not expanded in a plane at right angles to the cusps of the crown. The notochord must have been persistent, there being no traces of vertebræ; and the neural and hæmal arches of the axial skeleton do not appear to have been strengthened by calcified intercalary cartilages, such as exist in modern sharks. Ribs are distinct. The shagreen is sparse, consisting of small conical, radiately-grooved tubercles, sometimes fused into groups of three; and two large hook-shaped semi-barbed dermal spines, fixed on broad bases, occur above and behind the orbit. The dorsal fin-spines are marked with smooth longitudinal ridges and grooves, and bear a double series of downwardly curved hooklets along the middle of the posterior face. Both spines are somewhat arched, but the anterior is longer and more slender than the posterior.

Now, it is interesting to remark that teeth and spines identical with those of the genus *Hybodus* occur scattered through all Mesozoic formations as far upwards as the Gault and Upper Greensand. Hybodont teeth, indeed, though not the dorsal fin-spines, range as far as the Upper Chalk. It has thus for a long time seemed probable that typical members of the genus *Hybodus* lived throughout all the Mesozoic period, at least until the deposition of the Chalk. Hitherto, however, the actual proof of the circumstance has not been forthcoming, and the generic determination of the teeth and spines has necessarily remained provisional. On the present occasion the writer is able to announce that some of the long-desired evidence is at last available for discussion; and a glance at the following description, illustrated by plate I., will suffice to show that the characters of the teeth and associated spines are not altogether misleading.

Hybodus basanus, Egerton.

1845. Sir P. Egerton. Quart. Journ. Geol. Soc., vol. i., p. 167, pl. 4.
1889. A. S. Woodward. Cat. Foss. Fishes Brit. Mus., pt. i., p. 273, pl. 12, figs. 1-5.

Some of the finest fossil Elasmobranch heads yet discovered constitute the material on which this species is based, and the generic determination has been arrived at solely from the evidence of the teeth and associated ribbed dorsal fin-spines. Two other essential characters must be known before it is definitely proved that such a determination is correct, and they are the characters revealed by the new specimens now under consideration.

The fossils in question were lately obtained by the British Museum from the collection of the late Mr. S. H. Beckles, F.R.S., of St. Leonard's-on-Sea. They comprise numerous skulls and two portions of the trunk of the typical *Hybodus basanus* from the Wealden of the Sussex Coast, probably from Pevensey Bay. All the remains of heads require much extrication from matrix before they exhibit the various cartilages and teeth, but the portions of trunk are already as completely exposed as possible.

The two essential characters concerning which these specimens afford information are (i.) the presence of hooked cephalic spines, and (ii.) the occurrence of a vacant space between the neural and hæmal arches of the endo-skeleton, which must have been occupied by a persistent notochord. Moreover, the fossil shown in pl. I., fig. 1, seems to exhibit for the first time in *Hybodus* the great triangular basal cartilage by which each dorsal fin-spine is supported.

It is worthy of note that among the numerous heads of *H. basanus* at present in the British Museum, only a very small proportion display the cephalic spines. Indeed, as the same remark applies to the large series of known specimens of the typical species from the Lias, the writer is much inclined to think that the presence or absence of these spines will eventually prove to be a sexual character. However that may be, five or six of the Wealden skulls (*e.g.*, number P. 6356) exhibit the characteristic hooks in their usual position behind and above the orbit, and these are no smaller in size than those of the typical *H. reticulatus*. It is only to be observed that whereas in the earlier species the spines invariably occur in two pairs, there is no certain evidence of more than one pair in the fossils from the Wealden.

Cephalic spines of Hybodont sharks, *Sphenonchus* of the older authors, have long been known from the English Wealden. The discovery of these affixed to the heads of which they were the armature was thus to be expected sooner or later. More remarkable, however, is the proof of the persistence of the notochord afforded both by the original of pl. I., fig. 1, and by a smaller fossil, partly shown in pl. II., fig. 1. The genus *Notidanus*, it is true, has retained the primitive character of the axial skeleton of its trunk from the latter part of the Jurassic period to the present day; but examples of such lengthened persistence are few, and the range of the typical notochordal *Hybodus* from the Trias to the Upper Greensand is noteworthy. In Mr. Beckles' two fossils the series of elongated neural arches and spines (*n.s.*) is seen regularly arranged, though in part fragmentary; and in the smaller specimen, of which a portion is shown in pl. II., fig. 1, there are also distinct remains of the hæmal arches (*h*). All these cartilages are well calcified in tesseræ, as also are the basals of the dorsal fins; but the space between the neural and hæmal elements (*not.*) is quite destitute of calcifications of any kind. The dorsal fin-spines are somewhat displaced, the first (*d*1) being overturned and accidentally thrust behind the second (*d*2). Each is shown to have been supported in the usual manner of a dorsal fin-spine by a great triangular basal cartilage (*b.*) extending from its inserted end the whole length of the fissure on the hinder margin. At the distal border of the basal cartilage of the anterior fin, five small radials (*r.*) also occur, gradually increasing in length towards the hinder border; and there are traces of delicate filiform rays for the support of the fin-membrane.

Genus SYNECHODUS.

[A. S. Woodward, Proc. Geol. Assoc., vol. x., 1888, p. 288, and Geol. Mag. (3) vol. v., 1888, p. 496].

While it is now proved that a typical species of the genus *Hybodus* survived as late as the period of the Wealden, it is interesting to recall the fact of the occurrence even in the Chalk of another genus of Cestraciontidæ exhibiting but a slight advance upon the typically Liassic *Palæospinax*. So far as known, *Synechodus* only differs from *Palæospinax* in the more numerous cusps of its teeth, the articulation of the pterygo-quadrate cartilage with the postorbital region of the cranium, and the markedly asterospondylic character of its vertebræ. Like *Palæospinax* and *Cestracion,* this shark must have been destitute of cephalic spines ; and there can be no doubt that the dorsal fin-spines were smooth, without posterior denticles.

In connection with the striking resemblance between the Liassic and Cretaceous genera thus compared, a detached dorsal fin-spine from the Gault of Folkestone, recently presented by Mr. J. T. Day, F.G.S., to the British Museum, is worthy of special remark. This fossil is shown of the natural size in pl. II., fig. 2, and is precisely similar in form to that of the recent *Cestracion* and several Spinacidæ. Instead, however, of its inserted portion being coated by an even film of ganoine, the shining layer towards the base of insertion becomes subdivided into a cluster of rounded tubercles. This is a condition not infrequently met with in the spines of *Palæospinax,* but unknown, so far as the writer is aware, in the recent or extinct species of *Cestracion.* The new fossil may thus be referred to *Synechodus* with much probability of correctness, and in that case makes known another slight point of resemblance between this genus and its forerunner of the Lias.

SYNECHODUS ILLINGWORTHI (Dixon).

1850. *Acrodus illingworthi,* F. Dixon. Geol. and Foss. Sussex, p. 364, pl. 30, figs. 11-12, pl. 32, fig. 9.

1887-89. *Acrodus* (?) *illingworthi,* A. S. Woodward. Geol. Mag. [3], vol. iv., p. 104 ; Proc. Geol. Assoc., vol. x., p. 290 ; Cat. Foss. Fishes Brit. Mus., pt. i., p. 297.

1889. *Hybodus* (?) sp., A. S. Woodward. Cat. Foss. Fishes Brit. Mus., pt. i., p. 277.

A recent examination of the Upper Cretaceous teeth named *Acrodus illingworthi,* in company with Prof. H. G. Seeley, has convinced the present writer that they must be referred to the hinder part of the dentition of a large species of *Synechodus.* To the middle of each ramus of the jaw of the same species may also be assigned the small group of Hybodont teeth from the English Chalk entered in the British Museum Catalogue as very doubtfully pertaining to *Hybodus* (number 45,311). Some of the detached hinder teeth are shown of the natural size in pl. II., figs. 3-6; and six of the more cuspidate teeth from the group just mentioned are represented in figs. 7 *a—d.*

The species thus determined on the evidence of the dentition is characterized by the short, robust, and obtusely pointed form of the cusps in the principal lateral teeth, and the acute character of the longitudinal keel of the crown in many of the hinder teeth. The anterior prehensile teeth are unknown.

S. illingworthi has hitherto been obtained from undetermined horizons in the Chalk near Lewes, Sussex, and Dorking, Surrey; and from the Lower Chalk of Guildford and Dover.

Genus Cestracion.

[Cuvier, Régne Animal, vol. ii., 1817, p. 129].

In the "Catalogue of Fossil Fishes in the British Museum," pt. i., pp. 333-336, the writer expressed the opinion that the so-called *Drepanephorus* of Egerton is generically identical with the existing Port Jackson Shark (*Cestracion*), and that the detached Cretaceous teeth variously known as *Strophodus sulcatus, Acrodus cretaceus, A. polydictyos,* and *A. rugosus* may all be most appropriately referred to the same genus. Nothing subsequently discovered has tended to alter this determination. So rare, indeed, is the occurrence of Cestraciont remains in the Cretaceous formations, that every additional specimen is worthy of special consideration.

Cestracion rugosus (Agassiz).

1839. *Acrodus rugosus,* L. Agassiz Poiss. Foss., vol. iii., p. 148, pl. 22, figs. 28-29.

1889. *Cestracion rugosus,* A. S. Woodward Cat. Foss. Fishes, Brit. Mus., pt. i., p. 335.

More especially rare are the large tritoral teeth from the Chalk, provisionally named *Cestracion rugosus.* Until recently the writer was acquainted only with two English specimens, one from Lewes and the other from Charing, Kent; but the British Museum has now been enriched by a third example, the discovery and donation of Mr. G. E. Dibley. This tooth was obtained from the Lower Chalk of Warlingham, near Croydon, Surrey, and is shown of twice the natural size in pl. II., fig. 8. The specimen agrees precisely in specific characters with the other teeth already known, and its rugose coronal surface is in a fine state of preservation.

Explanation of Plates.

Plate I.

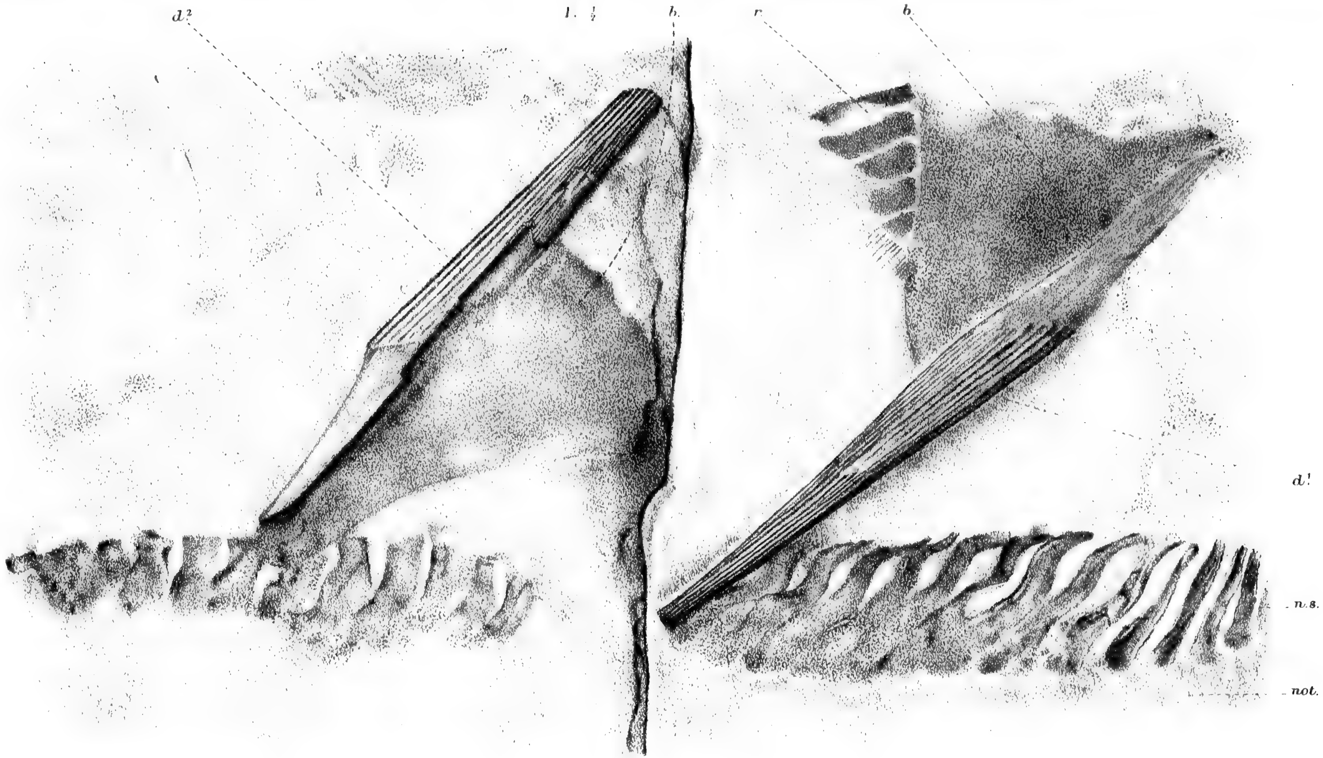
1. *Hybodus basanus*, Egerton; portion of skeleton of trunk, lateral aspect, one-half natural size. Wealden; Sussex Coast. *b.* basal cartilage of dorsal fin; d_1 d_2 dorsal fin-spines; *n.s.* neural arches and spines; *not.* position of notochord; *r.* radial cartilages. [Brit. Mus. No. P. 6357.]

Plate II.

1. *Hybodus basanus*, Egerton; portion of endoskeleton of trunk, lateral aspect, two-thirds natural size. Wealden; Sussex Coast. *h.s.* hæmal arches and spines; *n.s.* neural arches and spines; *not.* portion of notochord. [Brit. Mus. No. P. 6358.]
2. *Synechodus* (?) sp. dorsal fin-spine, natural size. Gault; Folkestone. [Brit. Mus. No. P. 6501.]
3. *Synechodus illingworthi* (Dixon); tooth, coronal (*a*) and inner (*b*) aspects, natural size. Chalk; Sussex. [Brit. Mus. No. P. 2148.]
4. Ditto; tooth, outer aspect, natural size. Chalk; Southeram, Sussex. [Brit. Mus. No. P. 5879.]
5. Ditto; tooth, coronal (*a*) and inner (*b*) aspects, natural size. Lower Chalk; Dover. [Brit. Mus. No. 37161.]
6. Ditto; tooth, coronal (*a*) and outer (*b*) aspects, natural size. Lower Chalk; Guildford. [Brit. Mus. No. 49858.]

7*a.d.* Ditto; group of six associated teeth, natural size. Chalk, England. [Brit. Mus. No. 45311.]

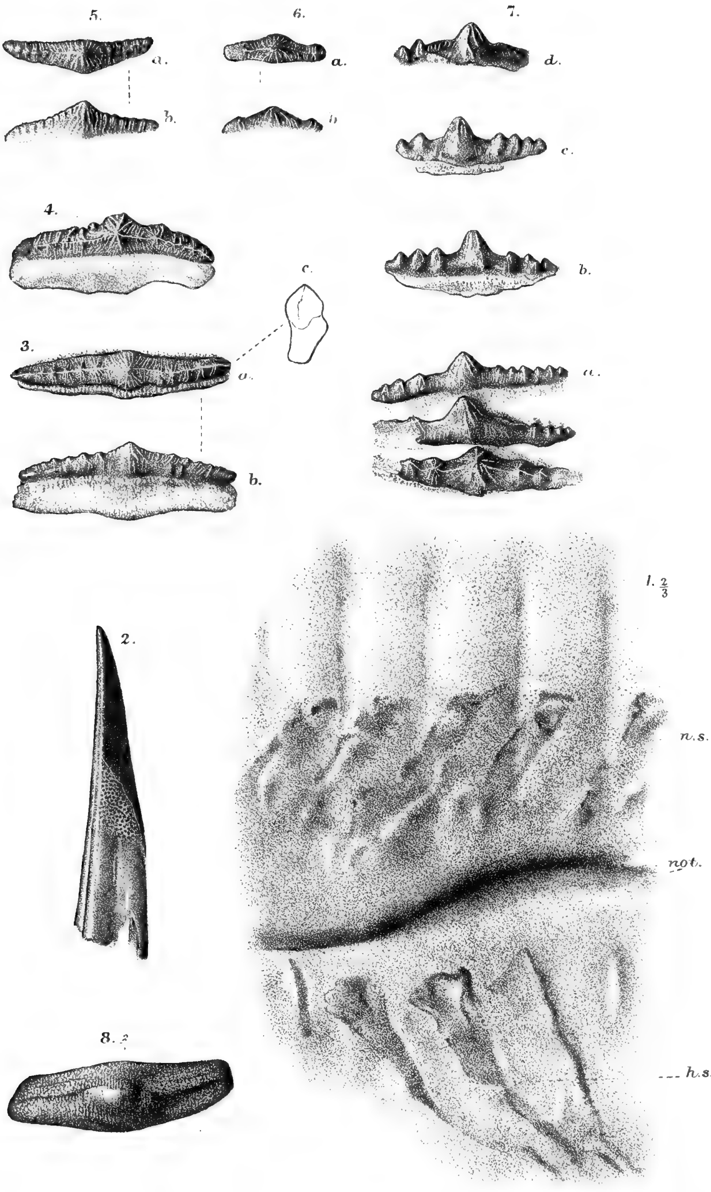
8. *Cestracion rugosus* (Agassiz); tooth, coronal aspect, twice natural size. Lower Chalk; Warlingham, Croydon. [Brit. Mus. No. P. 6489.]



G. M. Woodward del. et lith.

West, Newman, lith.

HYBODUS BASANUS.



G. M. Woodward del. et lith.

West, Newman, imp.

I, HYBODUS BASANUS. 2. SYNECHODUS.
3 - 7. SYNECHODUS ILLINGWORTHI.
8. CESTRACION RUGOSUS.

EVIDENCE OF GLACIAL ACTION NEAR LEEDS.

BY JAMES E. BEDFORD, F.G.S.

The object of this paper on the above subject is to direct the attention of geologists and others to some good sections recently exposed to view in the Meanwood valley. For many years a quarry has been worked by Mr. B. Rowley in the ganister beds of the lower carboniferous shales and grits at Headingley, in the valley below Meanwood. This quarry is in rather an uncommon position for such excavations, in so much as it lies in the valley bottom and not on the hill side as is usual in quarrying in this district. The stone only becomes visible when the superincumbent material is removed by excavating. The rock appears to the eye to be fairly horizontal, but there is a dip to the S.E. which causes the rock to come to the surface within three or four hundred yards from the quarry. A thin bed of coal is seen to underlie the upper bed of ganister. Resting immediately on the rock is a bed of shale 8 feet thick, black and friable in its lower portions, but becoming yellow and softer in its upper beds. This shale is overlaid by a true glacial moraine composed of sandy clay with patches of sand, irregular in shape, and which occur in "pockets" in the clay. The sand in these patches is not bedded horizontally, but often inclined at a considerable angle. The moraine material contains great quantities of sub-angular blocks of grit rock of all sizes, from 2 feet 6 inches in diameter downwards. These grits are quite local, and consist almost entirely of ganister from the beds which the material now overlies. The glacial *debris* is evidently the work of a tongue of ice which stretched across the valley N.E. from the direction of Moortown. The bed of ganister comes to the surface and forms a low escarpment in that direction. It is quite evident that the ice crossed this escarpment and broke away masses of rock at this point, and carried them before it and under it to their present position. The escarpment is not more than three or four hundred yards from the quarry. The appearance of the blocks in the moraine leads me to believe this to have been the source of the blocks from the sub-angular form they still retain. I also infer that the weight of ice has not been very great otherwise the blocks would have been crushed to a greater extent and more sand produced. The moraine deposit has not been reassorted by the action of water; the blocks are rammed into the clay in all positions and at all levels; they also in many cases rest on their smaller ends. There is no appearance of bedding with the exception of the pockets of sand above referred to. No rocks from a distance have been found in the deposit excepting a small piece of chert which I found some years ago. Further evidence of ice movement appears from the condition of the shales below. These beds are contorted and crumpled in a surprising manner. In addition to the folding and squeezing of the shales, portions of the black or lower portion have been torn up and rammed into the clays above, fully five feet higher than their natural position. These blocks are seen to be bent and twisted by the pressure. The contortions only occur in the upper layers of the shale, the two feet lying immediately on the ganister being unaffected at this point shown in the sections; the six feet above, underlying the moraine, being much disturbed. The layers are seen to be crushed into sharp angular bends. There is no faulting of the bed rock or in the shales to account for the movement, and in my opinion nothing but ice could have produced the effect referred to. There is sufficient evidence for the assumption that the ice in its movement has not followed the direction of the valley itself, *i.e.*, by the gorge in the Millstone grit at Meanwood Wood, for if it had done so we should certainly find large quantities of that material in the moraine torn away from the ridge formed by the fault which brings the grit to the surface at that point. The direction has been diagonally across the valley from the Plain of York. A glacier or ice sheet from the North Sea or from the Hambleton Hills would push local ice from the high ground about Moortown into the valley, although the main glacier itself may not have stretched so far at the time the deposit was found. The ice does not appear to have surmounted the escarpment of Woodhouse Ridge, where it may have had its direction turned down the valley; but there is no doubt that a tongue of ice passed round the N.W. of

Headingley Hill from the direction of Meanwood Wood, as proved by a section exposed a few years ago near the Pumping Station at Headingley. This consisted of eight or nine feet of yellow sand and clay, full of rounded blocks of Millstone grit; this deposit is on the Elland flagstone or the shales immediately below it. Patches of clay overlie large areas in this district although the elevation is considerably above the levels of the neighbouring valleys. This clay may have resulted from glaciation, but it has been so much disturbed by roots of trees, when the great forest stretched over it, and by subsequent rain-wash, that little now remains on which to base any theories.

A PERMIAN CONGLOMERATE BED AT MARKINGTON.

BY REV. J. STANLEY TUTE, B.A.

There is in the parish of Markington a small bed of Permian Conglomerate, the existence of which seems to be worth recording. It consists of waterworn pebbles of Carboniferous Limestone and Sandstone, with angular fragments of Magnesian Limestone, embedded in a matrix of harder Magnesian Limestone. The thickness of this bed, where it is exposed, is about a yard, and its width a few yards, as far as it is traceable. The difficulty of tracing it further arises from its position. It occurs a little below the top of a steep bank about 50 feet in height, overgrown with a rather dense plantation, in which two out-crops appear. This conglomerate bed and another well-marked bed, upon which it lies, reaches to the bottom of the valley; and upon its eroded surface there runs the Markington Beck, a great part of which shortly disappears in swallow-holes and crevices of the Limestone. After passing underneath the hill, which is between Markington and Bishop Monkton, the stream bursts out in the latter parish.

That this conglomerate bed once extended further to the west is clear from the occurrence there of boulders of this rock among the other boulders of the drift. There is clear evidence at hand that the loss by denudation has been very great, probably to the extent of 200 feet or more. The well-marked limestone I have mentioned is easily recognized amongst the other Permian beds, and consists of smoothed lumpy blocks of greyish-brown limestone, containing many sparry cavities, and probably represents the Lower Limestone of the county of Durham, the beds of which are described by Mr. Howse as "thin, hard, and knobby, and the entire thickness fissured and intersected with numerous perpendicular fissures or backs."* It occurs also half-a-mile to the east, near Wormald Green, in a very fine section 200 yards in extent, as a bottom bed; but I have failed to detect any traces of the conglomerate bed there. The section is

* A guide to the collections of Local Fossils in the Museum, Newcastle.

about 70 feet in thickness, and consists of the following strata :—
Boulder Clay from 5 to 15 feet thick.

Quarry Men's Terms.	Wormhole Beds	30	0*
	Crapley Beds	1	6
	White Bed, with a clay parting of 2in. ...	30	0
	Lumpy Bed	10	0

Where the outcrop of the conglomerate occurs this Lumpy Bed is certainly more than 50 feet in thickness. As no traces of the conglomerate are found in the quarry, I conclude that it is local in its origin ; and though the rocks contained in it have certainly been brought in Permian times from a distance at least of fifteen or twenty miles westward, the formation does not seem to have been glacial, but to have been the result of river gravel deposit cemented together by subsequent calcareous Permian deposits.

The Lumpy Bed seems to occur at Humbleton near Sunderland, and at Garforth near Leeds. In the latter place the beds abound with Axinus obsurus, which also occurs at the western edge of the lowest position of the Lumpy Bed, about a mile from the outcrop in Markington.

The so-called Crapley Bed is a marked feature in the Quarry, running through its whole length, at an angle of 6° N.E., and consists of a bed of White Limestone, separated from the beds above and below by thin beds consisting of broken fragments of limestone. the origin of which does not seem to be very clear.

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* To this I drew the attention of the Society at a previous meeting.

BRITISH PALÆOZOIC CTENOSTOMATOUS POLYZOA.

BY GEORGE ROBERT VINE.

(PLATES III. and IV.)

In the Annals and Magazine of Natural History for 1877, Dr. H. A. Nicholson and R. Etheridge, jun., published a paper on some peculiar parasitic organisms found in the Devonian Rocks of Ontario, and the Carboniferous Rocks of Scotland. The species described and illustrated were :—

1. Ascodictyon fusiforme, Nich. & Eth. jun., p. 463, pl. 19, figs. 7-8.
2. ,, stellatum, Nich. & Eth. jun., p. 464, pl. 19, figs. 1-6.
3. ,, radians, Nich. & Eth. jun., p. 465, pl. 19, figs. 9-11.

Of these species the authors say* (p. 466), " After a very careful examination of a considerable number of specimens of the singular organisms which we have grouped together under the name of *Ascodictyon,* and after taking the opinion of several of our fellow-workers, we are still unable to express a positive opinion of their precise zoological position and relationships." They then cite the opinions, respecting the peculiar organisms, of Dr. Strethell Wright,† " who was unable to throw any light upon their nature ;" of Professor Huxley, " who, after considerable hesitation, suggested that they might be protozoans ;" of " our friend Mr. H. B. Brady, who, after a protracted examination of both the Scotch and the American forms, arrived at the conclusion that they cannot be referred to this group." Through the kindness of Mr. John Young, of Glasgow, I have in my possession some of the examples which were submitted by him to Mr. Brady for examination. After this some of the American specimens " of *A. fusiforme* and *A. stellatum* were kindly submitted by Mr. H. B. Brady to the Rev. T. Hincks, who suggested that they were possibly allied to the recent *Anguinariæ.*" The authors would not

* On Ascodictyon, a new provisional and anomalous genus of Palæozoic Fossils, ser. 4, vol. xix., p. 465.

† Journ. Cincinnati Soc. Nat. Hist., vol, ii., p.

commit themselves to any definite opinion as to the systematic position of the fossils described, but they remarked (p. 467) "Our *A. fusiforme* . . . presents a close superficial resemblance to the creeping base of *Anguinaria* (Ætea) *spatulata*; but in the absence of any evidence in the fossils of the existence of erect cells with distinct apertures for the polypides, it would be hazardous to regard this suggestion as being more than a conjecture. The only other recent forms to which we can find any likeness with *Ascodictyon* are some of the Sertularians (*e.g. S. pumila*), there being a decided resemblance between the thread-like fibres which creep along the foreign bodies to which these organisms are attached, and which connect the polypiferous shoots and the netted stolons of *A. radians* and *A. stellatum*. In other respects, however, the structure of *Ascodictyon* is by no means Hydrozoal."

In one of Mr. E. O. Ulrich's earlier papers, amongst other descriptions of new genera and species of fossils from the Lower Silurian about Cincinnati,* the author founded a new genus, "Rhopalonaria," for the reception of an equally obscure organism encrusting *Streptelasma corniculum*, Hall. The species was placed in the family *Crisidæ*. Mr. Ulrich says (op, cit., p. 27) "on account of the great delicacy of the fossil, the fronds themselves are rarely found, but instead we find a series of impressions on the exterior coat of the *Streptelasma*, which very well represents the fronds and cells of the same." I have in my possession an example of Mr. Ulrich's species, and I find that it is well described and figured in the work already referred to (p. 26).

4. Rhopalonaria venosa, Ul. (op. cit., p. 26, pl. 7, figs. 24-24c.)

When Dr. Nicholson's and Mr. R. Etheridge's paper was published, I was already in possession of fine examples of Scotch Carboniferous forms encrusting crinoid stems derived from the Hairmyres Shales; later on these were added to, and just recently a very fine series of the Carboniforous forms from the Calderwood Shales have been given to me by Mr. John Young, so as to enable me to work out details which have been as yet only partially described.

* Journ. Cincinnati Soc. Nat. Hist., vol. ii., p. 26.

The evidence, however, on which I rely for more faithful determination is derived from the study of several hundreds of examples brought to light in my close and careful examination of the organic debris of the Wenlock Shales. I have already described many of the organisms found in Mr. Maw's washings*, but there still remains several groups to work out more carefully than I have yet been able to do, and in all probability this will form an initial paper of a far more elaborate series than I have previously attempted. The reason for this may be briefly stated. In the various States of America details of the Palæozoic faunas have been and are being published. Some of the Palæozoic horizons are similar to our own, especially the Upper Silurian and the Sub-carboniferous, and the Polyzoa or Bryozoa† of these horizons have been more systematically worked out, described, and illustrated by American authors than by us. From time to time, as the work progresses, I am kept supplied with typical examples of species of the Bryozoa for comparison with our own, and also with the literature of the subject whenever published. For this reason many of the Wenlock Shale Polyzoa have been re-studied and many apparently allied forms separated for comparison and description. The present group of organic forms, which I now place amongst the Ctenostomatous Polyzoa, as described by Hincks and others, is the outcome of matured knowledge and more careful selection. I am fully aware of the difficulties that I have to encounter in thus attempting to arrange systematically a series of fossils of such obscure types, especially when so many experts have failed. It may be well, therefore, to state briefly by what means I arrive at my present conclusions.

* See Geol. Mag., 1881, (Jan. and March) for remarks by Mr. Davidson and Mr. Maw.

† In all my own writings I prefer to use the term Polyzoa rather than Bryozoa, not that I have any prejudice against the use of the latter. Whenever I use the words in unison, as above, I do so in deference to the opinions of others who differ from me. With Continental authors, however, the words Polyzoa and Bryozoa are generally speaking synonymous, but American authors frequently include under the head line Bryozoa forms which Professor Nicholson and others describe as Monticulipora, &c., or Cœlenterata. In a modified sense, perhaps, American authors may be truer to nature than their British opponents.

In 1881 I published in the Quarterly Journal of the Geological Society* the names of two Silurian species as members of *Ascodictya*, as follows :—

Ascodictyon stellatum, var. Siluriense, Vine, p. 618.
„ radians ? Nich. and Eth. (Provisional) p. 619.

In Feb., 1882, in another paper, "Notes of the Polyzoa of the Wenlock Shales," I gave fuller details of Ascodictya species, with figures, as follows :—

5. Ascodictyon stellatum, var. Siluriense, Vine, p. 52, figs. 1-2.
6. „ radiciforme, Vine, p. 53, fig. 3.
7. „ filiforme, Vine, p. 54.

In 1884, in the Annals and Mag. Nat. History, I did my best to grapple with the systematic position of the fossils, which had by that time proved to be very abundant both as individuals, specific and varietal, in the Wenlock Shales. After reviewing the whole of the literature known to me up to date, giving the various opinions of authors already published, I ventured on a new departure on my own account. On page 87 I remarked, "There are not, so far as I am aware, any Cyclostomatous Polyzoa, which may be considered truly Stoloniferous. Some of the Hydrozoa are, but I know of none whose stolons are adherent to stone or shell, such as are found in these ancient rocks ; neither am I aware that the Stoloniferous Ctenostomatous Polyzoa are adherent to stone and shell, like *Ascodictyon* or *Rhopalonaria*. Yet it seems to me that we have in *Ascodictyon filiforme*,† at least, primitive representatives of Stoloniferous Vesiculariidie, such as *Vesicularia* or *Bowerbankia*, or possibly some member of the more humble race of the Entoprocta. Barrois‡ has already . . . spoken of a pro-Bryozoan race, composed of free swimming organisms. May [not] *Ascodictyon* be the attached or larval form of some of the as yet unknown pre-Upper-Silurian types of organic life, Polyzoan or otherwise ?"

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* Silurian Uniserial Stomatopora and Ascodictya. Nov., pp. 613-619.

† This species is fully described in the paper referred to, Ann. Mag. Nat. Hist., Aug., 1884, p. 78.

‡ On the Embryogeny of the Cyclostomatous Polyzoa, Ann. Mag. Nat. Hist., Nov., 1882, p. 402.

I thought at the time that these remarks would fare better if placed before the scientific palæontologist in a tentative, rather than in a positive, form, and in this spirit they seem to have been accepted by the late Mr. George Busk, for I find in his posthumous Challenger Report* the following paragraph :—

"No fossil forms belonging either to the Ctenostomata or the Ectoproctan Polyzoa have hitherto been identified, but Mr. Vine has thrown out a hint, in a paper on *Ascodictyon* (Ann. Mag. Nat. Hist. 1884), that perhaps *Ascodictyon filiforme* may be a primitive representative of the Stoloniferous Vesicularidæ, or possibly of the Entoprocta. That this latter order is of great antiquity is also confirmed by its embryonic history, for . . . . M. Barrois after the most careful and elaborate comparison of the larvæ of various Ectoproctan and Entoproctan groups, comes to the conclusion that the larvæ of Entoprocta represents the primitive type from which all the others are derived." Vol. xvii. p. 4.

Quite recently Mr. E. O. Ulrich, of America, in a paper on New Lower Silurian Bryozoa from the Trenton Shales of Minnesota,† proposed a new genus, *Vinella,* for the reception of some peculiar organisms found both in America and in England. The genus *Vinella,* Mr. Ulrich's remarks, is proposed "for an adnate form supposed to be a Ctenostomatous Bryozoon, with relation to *Vesicularia,* Thompson, and probably also to *Mimosella* Hincks. . . . As interpreted by me the fossils for whose reception this genus is proposed represents the stoloniferous part of the bryozoon only. The Zœocia I regard as having been deciduous and developed by budding from the creeping stolons at the parts now represented by small pores." In naming the genus in my "honor" Mr. Ulrich says that I "was the first to suggest the relation of *Rhopalonaria* and *Ascodictyon* to the Ctenostomatous Bryozoa."

My last reference is to Mr. Ulrich's synopsis of classification which prefaces his descriptions of the Palæozoic Bryozoa, in vol. viii. of the Palæontology of Illinois ‡ It is rather strange that indepen-

* Challenger Report, Polyzoa, pt. 2, vol. xvii., p. 4. 1886.

† Journ. Cincinnati Soc. Nat. Hist., March, 1890, p. 173.

‡ Geological Survey of Illinois, A. H. Worthen, Director ; vol, viii., Geology and Palæontology ; Text. "Bryozoa," E. O. Ulrich, pp. 285-728, pls. 29 to 78, June, 1890.

dently of each other we should have both arrived at similar conclusions respecting the peculiar group of organisms now under consideration, and although I may have been the first to suggest the relationship, the honour is due to him for first adopting the sub-order Ctenostomata into his elaborate synopsis, and afterwards to found a new genus for the reception of new types. The only family given by Ulrich (op. cit., p. 367) is Ascodictyonidæ.

Before venturing to give further details respecting the problematic affinities of the fossil forms now being described, it may be well to draw attention to the following remarks on recent Ctenostomata derived from a study of the species referred to by Mr. Hincks (Brit. Mar. Polyzoa, 1880).

The Sub-order Ctenostomata, Busk, is divided by Mr. Hincks into two distinct and characteristic groups.

Group (*a*) HALCYONELLEA, Ehrenberg (Brit. Mar. Polyzoa, p. 490).

Group (*b*) STOLONIFERA, Ehlers, (,, ,, p. 512).

Mr. Busk, however, in his Challenger Report,* accepts the first of these divisions, Halcyonellea, but re-establishes (in part) Johnston's name for the Stoloniferous group.

Division II. VESICULARINA (pars.) Johnston. (Challenger Report, pt. ii., p. 32).

I pass over group (*a*) because, at present, I have no knowledge of any fossil forms that could be referred to it, and I accept Mr. Hincks' divisions of group (*b*) on account of its fuller diagnosis.

II. STOLONIFERA, Ehlers (Hincks' Brit. Mar. Polyzoa, p. 512).

Zoarium, horny, or membranous. Zoœcia developed by budding from the *internodes* of a distinct stolon or stem. As the fossil forms appear to me to have relationship with some, at least, of the recent Ctenostomata, I select for remarks those families only, with their principal genera, where the relationship seems to be more superficially apparent.

Family IV., VESICULARIIDÆ.

Zoœcia, contracted below, not closely united to the stem at the

* Report on the Polyzon, Part II, 1886.

base, deciduous, destitute of a membranous area. Zoarium, *repent, or erect.** Hincks, p. 512.

In the Genus *Vesicularia*, the type of which is *V. spinosa*, Linn. (p. 533), the Zoarium is phytoid and rooted by a fibrous base. *The endosarc of this species consists of a slender thread*, running through the tubular stem from cell to cell, and communicating with each other through an orifice at the base. (See Hincks, p. 514, pl. 73).

In the Genus *Bowerbankia*, Farre (p. 518), the Zoœcia are *ovate, disjunct, clustered*, and the Zoaria are either repent or erect. In one species *B. caudata* Hincks the stem is creeping, the Zoœcia are elongate and sub-cylindrical. Five species of Bowerbankia are described and illustrated by Hincks, but four of these are of no importance for the elucidation of my present labours, but the student should refer to the description of them nevertheless for special information (pl. 73-75 and 76).

Family V. BUSKIIDÆ, Brit. Mar. Polyzoa, p. 531.

In this family the Zoœcia are contracted below, not continuous with the creeping stolon, *with no aperture* on the ventral surface. It may be well, however, to refer the student to the illustrations which show the peculiar stolon of *B. nitens* (p. 532), and also of the arrangement of the whole on the erect stem of *Hippuraria Egertoni*, (pl. 78, fig. 1), but beyond the mere similarity no real identity could be established between the fossil and recent species.

Family VI. CYLINDRACIIDA, p. 534.

In this family the Zoœcia are not contracted at the base, but they are closely united to the stem at the base, and they are not deciduous.

Family VALKERIIDÆ, p. 551.

The Zoœcia of the species of this family are contracted below, and they are also deciduous. In the genus Valkeria the Zoarium is both erect and repent, and the ovate Zoœcia are clustered together.

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* The italicised parts of sentences is for the purpose of drawing attention to special features.

In *Valkeria uva* the stem is *repent and adnate*, and what is more important, this repent stem is *jointed at intervals*, whilst in the filiform stem of *V. tremula* the Zoœcia are distributed upon it at certain intervals in groups. Between some of the foreign species of this genus and *Ascodictya* there appears to me to be a very close resemblance in the whorl-like structures both of Zoœcia and stem, but this will be referred to again further on.

Family IX. MIMOSELLIDÆ, p. 555.

The Zoœcia in this family are also contracted below, and are both movable and deciduous. The stem is erect in the beautiful *M. gracilis*, is confervoid, and of a light brown colour.

From this analysis it is very clear that it would be simply impossible to adopt any of the generic names of recent species under which fossil forms could be placed. Indeed the peculiarly horny or membranous texture of the one, is only faintly apparent in the other; and so far as the fossil forms can be interpreted by their remains it would be very hazardous, and even reckless from the evidence available, to say that any of the species had erect as well as creeping stolons or stems. The evidence of the deciduous character of the cells is likewise obscure ; yet it is impossible to interpret certain structural features of the fossil forms without supposing that the punctures or holes in some of my own examples of the Ascodictyomidæ as well as in the *Vinella repens* of Ulrich were bases of deciduous cells.

The structural features of one of the groups which I shall describe presently may be referred to here. On plate IV. I give magnified illustrations, both drawn with camera lucida and to the same scale, of (1) *Ascodictyon siluriense*, Vine; and (2) of the recent *Valkeria tuberosa*, Heller, dredged at Naples, mounted and presented to me by Dr. Pergens, of Belgium.

The *Ascodictyon* encrusted the outer portion of a very fine white shell, which, by careful manipulation, I have so reduced that when mounted in balsam, on glass, all the outlines of the cells, the ramifications of the stolons, and even the dark "endosarcal" matter in the stems are clearly defined and very transparent. It will be noticed that the number of cells in each of the whorls are most irregular, and some of those left out in the drawing* contain only two, three, and four cells. All the whorls are connected by hollow fiilimentous threads, the walls of which are about one-fourth the diameter of the thread on either side, whilst the central part, two-fourths of the thickness, contains the dark brown mass so frequently referred to in my various descriptions. Unless the cells are broken there is not so far as I can see, any other opening or aperture through which the polypide of these old-world organisms protruded. This evidence I regard as pretty conclusive that we are dealing with Ctenostomatous rather than with Cyclostomatous Polyzoan remains. In plate IV. I have shown several cells in process of formation, (really matured cells, belonging to Ascodictya, are almost if not wholly unknown to me), and if the readers will turn to vol. ii. of Hincks' British Marine Polyzoa, plates 74, 75, and 80, he will see illustrations of many of the recent Ctenostomatous Polyzoa likewise figured, showing matured as well as unmatured cells. There is no recent species of the Ctenostomata that I have studied more closely than the Mediterranean form, known as *Zoobotryon pellucida*, Ehrenb.† and as far back as 1879 I made drawings of the slowly growing stem of this Polyzoon, in the hope that I might be able to throw some little light upon the growth of buds on the stems of the Carboniferous *Ascodictyon Youngi*, but it was not till after my second British Association Report on Silurian Polyzoa was published that I ever dreamed of referring Silurian or Carboniferous species to the Ctenostomatous group. At that time I had a somewhat timid dread of "Authority," which, I am happy to say, is now slightly abated, and since then I have treasured up many fragments of shell and Crinoid stems from the Wenlock Shales, on which Ascodictya and Rhopalonaria were abundant. Had the forms which I have already referred to been found in a living, or even as semi-fossil remains, that is to say in any of the higher Tertiary formations, I really believe that the discoverer of anomalous organisms

* Altogether there were eight whorls, similar to those drawn, on the piece of shell which measured nearly a quarter of an inch square.

† Thanks to Mr. Waters, Miss E. C. Jelly, and Dr. Pergens, I have always been kept well supplied with this species preserved in alcohol.

like these would have been sorely tried if he was not allowed to place his treasures in the family Valkeriidæ at least. In *Valkeria tuberosa*, fig. 2, pl. IV., whorls of cells are similarly placed at intervals on a delicate hollow stolon, the walls and the central portions of which are like the stolons of *A. siluriense*, and the only difference between the two, so far as structure is concerned, is the Zoaria of recent *Valkeria* are free, whilst the Zoaria of Ascodictyæ are repent.

PALÆOZOIC CTENOSTOMATOUS POLYZOA

Genus VINELLA, Ulrich.

1. Vinella repens, Ulrich, Upper Silurians, Shropshire.
2. ,, ,, var. contorta, Vine. ,, ,, ,,

Genus ASCODICTYON, Nicholson and Etheridge, jun.

3. Ascodictyon filiforme, Vine, Upper Silurian, Shropshire.
4. ,, radiciforme, Vine. ,, ,, ,,
5. ,, siluriense, Vine ,, ,, ,,

MIDDLE DEVONIAN, Ontario.

?6. ,, fusiforme, Nich. & Eth. jun., and Carb. Shales Scotland.
7. ,, stellatum, Nich. & Eth. jun.

CARBONIFEROUS.

?8. ,, radians, Nich. & Eth., Carb. Shales, Scotland.
9. ,, Youngi, Vine, ,, ,, Hairmyres.

Genus RHOPALONARIA, Ulrich.

10. Rhopalonaria venosa, Ulrich, Low. Sil. Cincinnati Group.
?11. ,, botellus, Vine, Up. Sil. Shropshire.

DESCRIPTION OF SPECIES.

In the synopsis of classification which prefaces the description of Palæozoic Bryozoa in the Report already referred to,* Mr. E. O. Ulrich suggests the following arrangement. :—

Order GYMNOLEMATA, Allman.

Sub-order CTENOSTOMATA, Busk.

Family ASCODICTYONIDÆ, Ulrich.

* Geol. Survey of Illinois, Vol. viii. Geology and Palæontology, 1890, p. 367.

1. Genus ASCODICTYÆ, Nicholson & Etheridge.
2. ,, RHOPALONARIA, Ulrich.

But previously to the publication of the "Report" a new genus was founded for the reception of some very peculiar and primitive types of Polyzoa, found both in British and American Silurian rocks.

1890. Genus : VINELLA, E. O. Ulrich, Cin. Soc. Nat. Hist., March, p. 173.

Zoarium attached to foreign bodies, consisting of exceedingly slender ramifying thread-like tubes, occasionally arranged in a radial manner, surface of tubes often faintly-lined longitudinally; a row of widely-separated small pores along the centre of the surface of the tubes. Zoœcia unknown.

VINELLA REPENS, Ulrich, pl. III., figs. 1-4.

Zoarium repent. stolons thread-like or contorted, and where best preserved (see figs. 2-3) very small pores are arranged along the centre of the upper surface.

Locality and Horizon : Upper Silurian, Buildwas Beds of Wenlock Shales, Shropshire; Lower Silurian, Cincinnati and Chester Groups, U.S. America (Ulrich); Upper Silurian, Sweden (Lindstrom).

This is the most primitive of all the Wenlock species, and one of the most abundant. The forms are generally found on broken shells, but occasionally on crinoid stems. All the examples figured are British, and are in my own cabinet. As yet, though several hundreds of examples have passed through my hands, none of them have been found in any of the washings *above* the Buildwas beds. It will be seen that no essential difference exists between the British and the American forms, so that the specific name *V. repens* will apply to examples derived from Lower and Upper Silurian rocks alike. I have already given my opinion respecting these delicate thread-like organisms, and unless the forms find a resting place amongst the *Ctenostomata*, a new sub-order must be created for the whole of the species that will be described in this paper. I have not the least doubt but that the organisms are really Polyzoan, and I do not fear the criticisms of fellow-workers on recent Ctenostomata whenever the stoloniferous portions of the same are microscopically studied. The only objection to their proper recognition as members of this group, is that all the fossil forms known to me are "repent" and attached to foreign bodies, whereas the recent forms, generally speaking, are erect.

VINELLA REPENS, Ulrich., var. contorta, pl. III., figs. 5-7.

Zoarium repent, very much contorted, and occasionally the thread-like stolons cross each other at right angles so as to form radial prolongations. The stolons are marked on the surface by porous openings similar to *V. repens,* so that it is really difficult to keep the forms apart otherwise than for convenience of reference.

Locality and Horizon : Upper Silurian ; Buildwas Beds of the Wenlock Shales, Shropshire.

A reference to Mr. Ulrich's unmagnified figure of *V. repens* (op. cit.) which is attached to the "inner side of a thin variety of *Streptorhynchus filitextus,* Hall," will show that the species embrace forms very similar to the one separated to make the present variety. My reasons for the separation may be briefly stated. In Mr. Ulrich's figure (see op. cit., p. 174) the central point of attachment is very different from our own *V. repens,* and the branching of the rays are also different. Both the American and the British forms show structural features at this intersection, but the characteristic features of the British variety may be seen in figures 6, 6a, and 7, pl. III. I have not the least doubt but that several examples of these primitive organisms may be found in the cabinets of working palæontologists, and as these may be awaiting recognition or description, it would be advantageous to scientific investigation to know to which particular type they refer their examples. I anticipate some valuable hints in the future respecting the distribution in the Palæozoic rocks of the genera *Vinella* and *Ascodictyon,* hence my desire to fix the types of the species and varieties described.

Family ASCODICTYONIDÆ, Ulrich.

1890. Geological Survey of Illinois, vol. viii., p. 367.

Zoaria adnate, consisting of radially arranged filiform, fusiform, or bulbus Zoœcia: or of subfusiform uniserial cells. Substance, corneo-calcareous.

Genus ASCODICTYON, Nicholson & Etheridge.

1877. Ann. Mag. Nat. Hist., ser. 4, vol. xix., p. 463.
1882. Ascodictyon, Vine, Quart. Journ, Geol. Soc., Feb., p. 52.
1884. ,, Vine, Ann. Mag. Nat. Hist., Aug., p. 78.
1890. ,, Ulrich, Geol. Survey Illinois, vol viii:, p. 367.

Zoœcia consisting of radially arranged fusiform or bulbus Zoœcia, or filiform threads with periodic swellings.

The simple diagnosis which is given above is formulated by Mr. Ulrich for his Synopsis of Classification (op. cit., p. 367), and its adoption here will enable me to place in the genus the whole of the vesiculated Zoaria found in the Wenlock Shales. The type species, *A. fusiforme*, Nich. and Eth., of *Ascodictyon*, is derived from Middle Devonian rocks of Ontario (Hamilton formation).

ASCODICTYON FILIFORME, Vine, pl. III, figs. 8-15.

1882. *A. filiforme*, Vine, Quart. Journ. Geol. Soc., Feb., pp. 54-55.
1884. ,, ,, Ann. Mag. Nat. Hist., Aug., pp. 78-80.
1887. ,, ,, Yorksh. Geol. Soc., vol. ix., p. 183.

Zoarium filamentous, forming linear, contorted, or clustered threads, adherent to shells, stems of crinoids, fragments of trilobites, but rarely to corals. *Filamentous* threads, hollow, but surrounded by delicate calcareous walls; the hollows filled with a dark-brown granular mass. Lagenæ-like divergences developed on the sides of the threads, sometimes as single vesicles and occasionally as groups. Peculiarly clustered stellate fibres are also formed at irregular distances.

Localities and Horizon: Up. Silurian Wenlock Shales; Buildwas beds; generally distributed in the whole of the Buildwas washings but more abundant in the debris, numbered 36 and 38.

In the papers referred to under the headline *A. filiforme* I have dealt with this peculiar species, and all its variations, rather minutely. At the time of writing the last paper mentioned I was inclined to adopt the family name *Stomatoporidæ* (op. cit. p. 183), in which I could include both Ascodictyon and Rhopalonaria, chiefly on account of the problematic characters of some of the forms described. Since then I have pondered much over these anomalous organisms, and I have gathered together, for the purpose of comparative study, all the Ctenostomatous Polyzoa that was possible. The creation of the Genus *Vinella* by Mr. Ulrich for American forms has removed some of the difficulties that I had to encounter in my endeavour to group together systematically the peculiar forms which I have already described. Whether I am successful, or otherwise, in my endeavour remains to be seen.

Independently of this there is no other group of organic forms known to me, excepting the stoloniferous Ctenostomatous Polyzoa, with which *Ascodictyon* can be compared. I am not at all certain, however, that *A. filiforme*, *A. siluriænse*, or *A. stellatum* ever possessed deciduous cells, like *Mimosella*, *Valkeria*, or even *Vesicularia*, yet in other respects the resemblance between the Palæozoic and recent groups are most remarkable.

ASCODICTYON RADICIFORME, Vine.

1882. Ascodictyon radiciforme, Vine, Quart. Jour. Geol. Soc., Feb., 1882, p. 53, fig. 2.

1884. ,, radiciforme, Vine, Ann. Mag. Nat. Hist., Aug., 1884, p. 83, figs. 1, 2, 3 and 5 only.

1881. ,, radians, Vine (part), Quart. Jour. Geol. Soc. (provisional placement) p. 619, Nov., 1881, no figures.

1887. ,, radiciforme, Vine, Yorksh. Geol. Polyt. Soc., vol. ix., p. 183-4, pl. 12, fig. 5.

Zoarium, composed of elongated, root like processes, which vary in length from three quarters of a line, to a line. The radial processes are occasionally jointed, and unevenly developed around a common axis. The fusiform or tongue-like prolongations I have characterised previously as "vesicles" (Quar. Jour. Geol. Soc., 1882, p. 54), indicating by the use of the term a kind of cell, but I am not certain that these prolongations will bear that construction. In the free surfaces of some of these (vesicles?) "excessively minute closely approximated pores," referred to by Nicholson in his description of *A. radians* are present, and in parts where the stolon has broken away from the place of attachment, similarly minute pores are also visible. This feature is shown in fig. 9, pl. 12 (Yorksh. Geol. and Polyt. Soc. vol. ix.)

Locality and Horizon : Upper Silurian; Buildwas Beds ; Wenlock Shales, on stems of crinoids and broken shells.

Ascodictyon radiciforme, Vine, differs in many respects from *A. radians,* the carboniferous form described by Nich. and Eth., June (Ann. Mag. Nat. Hist., 1877, p. 465). In the Silurian species the peculiar pit-lke structure, so admirably depicted in *A. radians* (ibid. pl. 19, fig. 10), is absent in all the examples that I have studied, and the stolons connecting the root-like vesicles are different in both species. The filamentous threads of *A. radiciforme,* Vine, are similar to the threads or stolons figured in the carboniferous, *A. Youngi,* of the present paper (pl. 2, figs. 3-4).

ASCODICTYON SILURIENSE, Vine, pl. 2, fig. 1.

1881. Ascodictyon stellatum, Vine, Quart. Jour. Geol. Soc., p. 618.
1882. „ „, var. siluriense, Vine, ibid., p. 52, figs. 1-2.
1884 „ „, „ Vine, Ann. Mag. Nat. Hist. (August), p. 81.
1887. „ „ „ Vine, Proc. Yorksh. Geol. Soc., vol. ix., p. 184, pl. 12, fig. 6.

Zoarium composed of ovoid or fusiform vesicles, generally disposed in stellate clusters, and united in their colonial growths by hollow filamentous threads. Vesicles smooth and devoid of any special aperture or foraminated surfaces, similar to *A. stellatum,* as figured by the authors of that species,* The vesicles of the Silurian species vary in size from one-fifth to one-sixth of a line in length, whilst the vesicles of *A. stellatum,* derived from the Devonian rocks of Ontario, vary in length from one-third to one-fifth of a line in length. As certain special features referred to their species by the authors, are entirely absent in the Silurian fossils, this necessitates the removal of the word "variety" from my present revision of this peculiar group of organic forms.

Horizon : Upper Silurian ; Buildwas Beds of Wenlock Shales.

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* Ann. Mag. Nat. Hist., ser. 4, vol. xix., pl. 19, figs. 1-6.

The American forms described by Nicholson and Etheridge are the following :

Ascodictyon fusiforme, Nicholson and Etheridge, Jun.

1877. Ann. Mag. Nat. Hist., ser. 4, vol. xix., pp. 463-464, pl. 19, figs. 7-8.

Unfortunately this is the type species of the authors, and after the most careful investigation and study I am unable to locate the present form or quote it as an ally of any recent Ctenostomatous Polyzoa. The species is well described, and the authors felt their own difficulties when attempting to place it, even provisionally, as an ally of any known Polyzoon, either recent or fossil. "Our *A. fusiforme*," they say, (p. 467) "certainly presents a close superficial resemblance to the creeping base of *Anguinaria* (Ætea) *spatulata*, but in the absence of any evidence in the fossils of the existence of erect cells with distinct apertures for the polypides, it would be hazardous to regard this suggestion as being more than a conjecture." Certainly *A. fusiforme* in general outline closely resembles the stolons of *Ætea anguina*,* as figured by Hincks, and the Devonian fossil may be superficially compared with the Ætea group, but I do not think any real affinity between them could be established. Amongst some examples of the fossil, encrustations on the stems of Crinoids, already referred to as given to me by Mr. John Young, forms similar to those described by Messrs. Nicholson and Etheridge, may be detected, thus establishing a generic affinity between the American Devonian, and the Scotch Carboniferous forms, but beyond this I cannot go. The American species is described as rare and adherent to *Spirifera mucronata*, Conrad, Middle Devonian, Ontaria ; the Carboniferous forms are generally adherent to Crinoid stems from the Calderwood and Boghead Shales, Scotland.

Ascodictyon stellatum, Nicholson and Ethridge, Jun.

1877. Ann. Mag. Nat. Hist., ser. 4, vol. xix., pp. 464-465, pl. 19, figs. 1-6.

There is the closest resemblance between this and the Silurian species *A. siluriense*, already described, but as there are special

* Brit. Mar. Polyzoa, vol. ii., pl. 1.

features about the "ornamentation" of the vesicles of the Devonian forms that are not found in the Silurian, it will I think be far wiser to keep the two forms distinct. If, however, we accept the Silurian species as types of fossil Ctenostomata, *A. stellatum* must be accepted also as an ally, especially so as the authors say "the clusters are connected together by creeping filamentous tubes, the free surfaces of which are perforated by a single row of minute foramina, and which generally anastamose so as to form a network."

Not very rare in the Hamilton formation (middle Devonian) of Widder, Ontario. Adherent to *Spirifera mucronata*, Conrad, and *Cyrtina hamiltonensis*, Hall.

The following are peculiarly British Carboniferous species :

ASCODICTYON RADIANS, Nich. and Eth., jun.

1877. Ann. Mag. Nat. Hist., Ser. 4., vol. xix., p. 465, pl. 19, figs. 9-11.

As described and figured by the authors this species can only be accepted as a very doubtful ally of some of the fossil species of Ctenostomatous Polyzoa. Figures 9 to 11 are most perfect in their delineation and the description is exact; but there is one feature in fig. 10 so unlike any fossil belonging to this group that I have heretofore examined, which makes me hesitate to accept it. That is the central pit-like cavity which is well shown in the figure. It seems to me that this is the basal part of some, at present unknown, Carboniferous Polyzoa, possibly allied to the Ctenostomatous group. My own examples show exactly the same characters depicted by the authors, but it lacks the connecting hollow stoloniferous filamentous threads so frequently referred to in the descriptions of Ascodictyon and Vinella species in this paper.

ASCODICTYON YOUNGI, sp. n., pl. IV., figs. 3 and 4.

Zoarium composed of pyriform vesicles occasionally disposed in stellate cluster, similar to other species already described. These vesicles are connected together by filamentous, hollow, unornamented threads, which creeps along and undulate with the irregularities of the surfaces to which the forms are attached. The type species is adherent to a portion of a Crinoid stem (*Platycrinus*, sp.), and the stellate vesicles are not so abundant in their colonial growths as in the Silurian species.

Horizon and Locality : Low. Carboniferous Shales ; Hairmyres, Scotland.

This species is named in honour of Mr. John Young, of the Hunterian Museum, Glasgow, to whose kindness in supplying me with washed and unwashed Carboniferous shales, I owe so much. The form described I have only met with in the Hairmyres shales, where it is very rare. I have placed the clusters of vesicles of the fossil form of *A. Youngi* by the side of the recent *Valkeria tuberosa,* Heller, for the purpose of comparison. In the one case vesicles and filamentous threads (fig. 3) are magnified to about the same proportions as figs. 1 and 2 on the same plate ; the other (fig. 4) is magnified about 60 times. The abraided surfaces,however, shown in figs. 3 and 4, must not be regarded as normal features, but by means of this abrasion we may indicate that the vesicles were organically hollow, and the dark mass (pyrites ?) which exists below the outer covering probably represents the once existing animal matter in the several vesicles, but this suggestion must be regarded as a conjecture only. The type character of the vesicles are generally unlike all the other species that have been figured, and it seems to me that *A. Youngi* is more closely allied to the type vesicles of *Valkeria* than to other forms. Both figures 3 and 4 are drawn by the aid of the Camera lucida, only to different scales, which are indicated by the magnified portions of the parts of one hundredths of an inch.

Genus RHOPALONARIA, Ulrich.

1890. Geological Survey of Illinois, vol. viii., p. 367.

Derivation RHOPALON, a club.

Cells slender, fusiform, arranged in a single anastomising series. Cell mouths small, near one end of the cell. Type *R. venosa*, Ulrich ; range Trenton and Cincinnati.

As this is defined and limited to the type specimen, it will be impossible for me to include any of the British species in this genus. *Rhopalonaria venosa** is defined thus : " Cells uniserial, long, acutely

* 1879 Jour. Cincin. Soc. Nat. Hist., vol. ii., pl. 7, figs. 24-24a.

elliptical, and joined together at their contracted ends. . . . Cell mouths not clearly determined, but appear to be situated near the middle of the cell," and the author further says "the genus is related to *Hippothoa*, but in the form and arrangement of the cells they differ widely."

I have already described or referred to species found in the Wenlock shales, and some of the forms have been figured (Yorksh. Geol. and Polyt. Soc., vol. ix., pl. 12, figs. 11-12) as *Rhopalonaria botellus*, Vine, but I am unable to place any of the forms definitely in the Ctenostomatous group, neither am I able to add much more to the information that I have already given respecting these peculiar fossils. Mr. Ulrich places Rhopalonaria amongst the Ctenostomata, and in all probability he will be able, ere long, to illustrate and describe American forms, which are similar in some respects to our own.

LOWER SILURIAN, Cincinnati.

Rhopalonaria venosa, Ulrich.

1879. Jour. Cincin. Soc. Nat. Hist., vol. ii., pl. 7, figs. 24-24b.

Examples of the British species which I have used for the descriptions in the present paper, will be placed in the British Museum (Nat. Hist.), and in the Museum of Practical Geology, for reference, &c.

EXPLANATION OF PLATES.

PLATE III.

Figs. 1-4. Vinella repens, Ulrich.

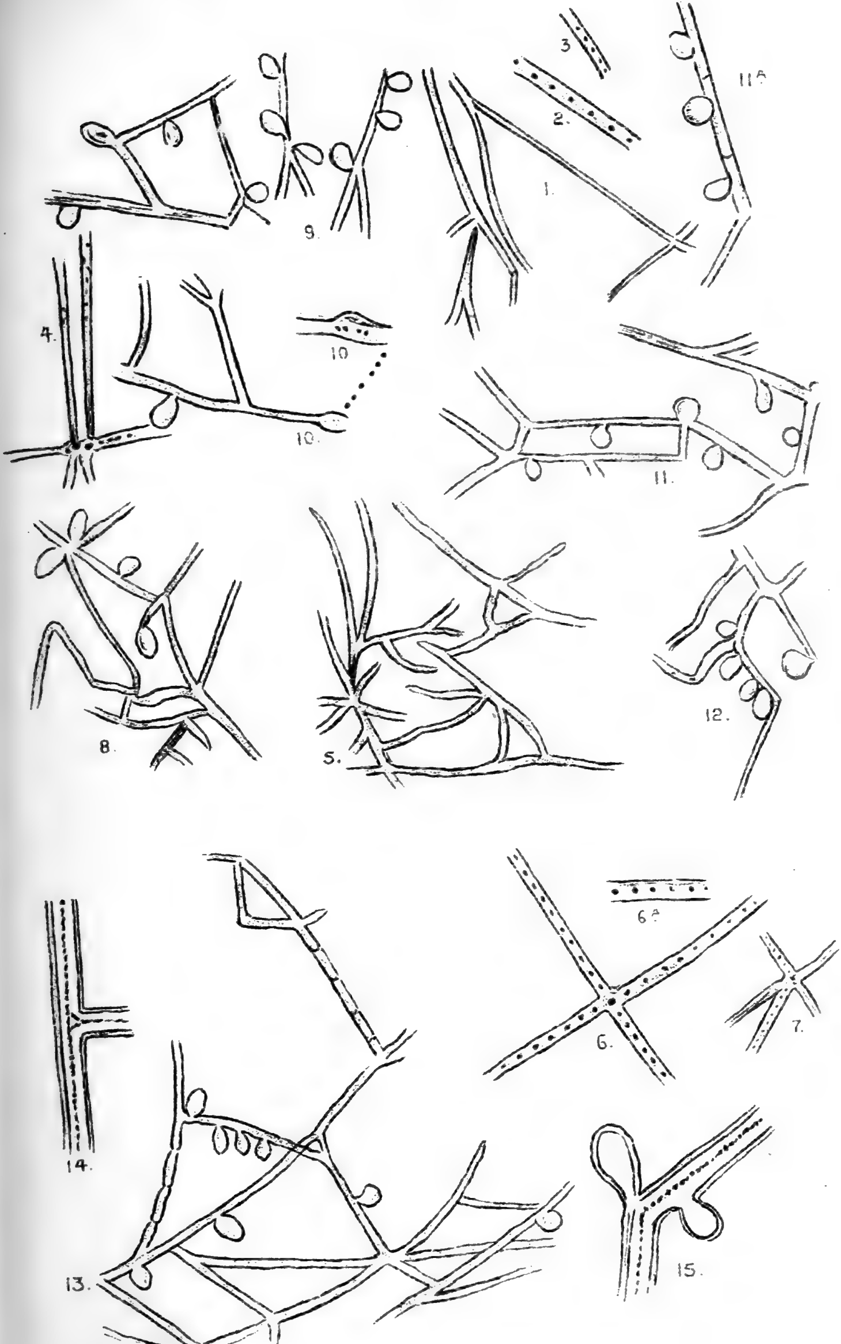
Shewing the different characters of the British Wenlock Shale examples.

Figs. 5-7. Vinella repens, var. contorta, Vine.

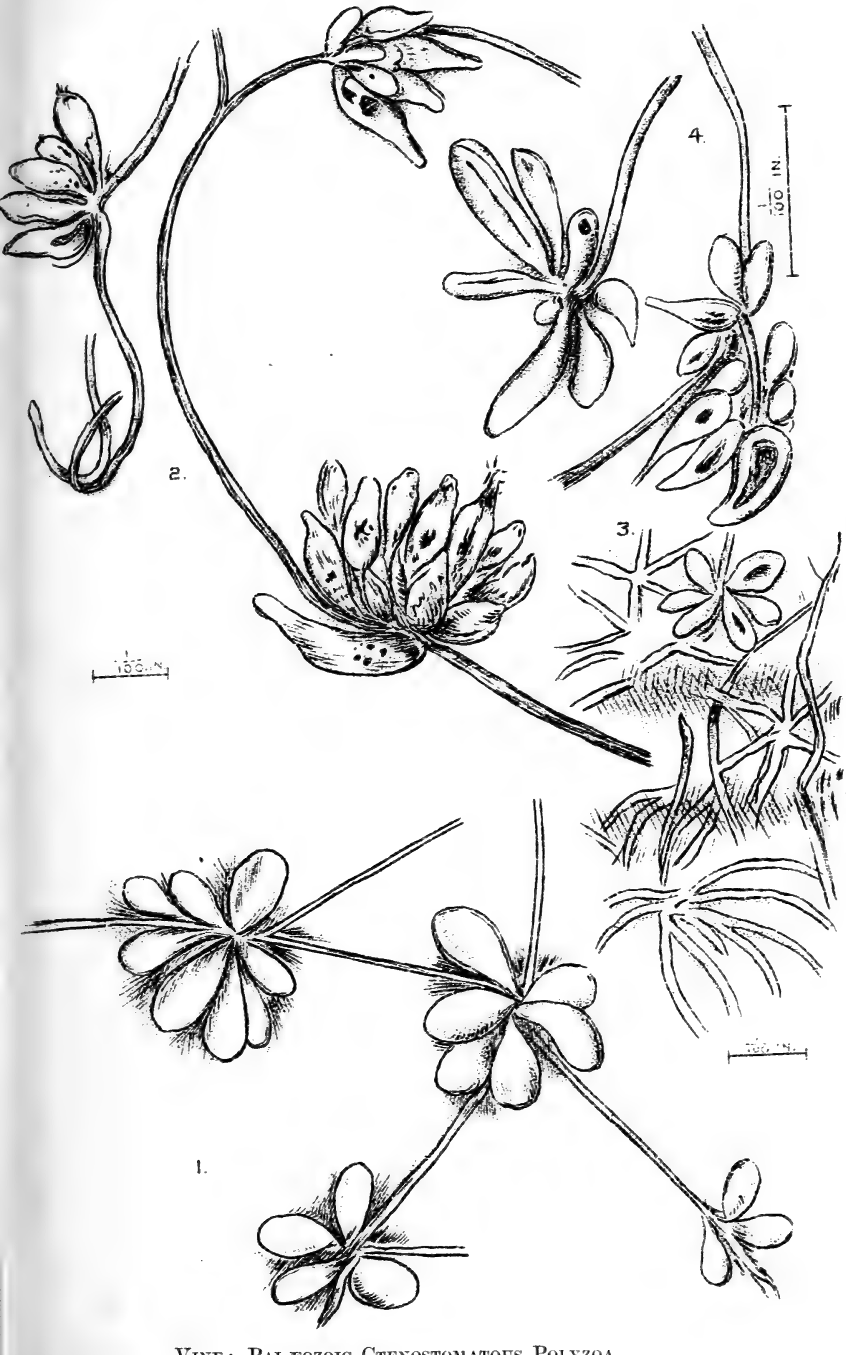
As the forms of this variety differ from the American V. repens, I have given the British examples a varietal name.

Figs. 8-15. Ascodictyon filiforme, Vine.

It appears to me to be impossible to break up the variations of this species for the purpose of placing them under distinct names.



VINE: PALÆOZOIC CTENOSTOMATOUS POLYZOA.



Vine: Palæozoic Ctenostomatous Polyzoa.

I have given illustrations of most of the varieties; some have very few vesicles, in others the vesicles are more abundant. As the colonies are unevenly scattered over broken shells, stems of crinoids, &c., I have been obliged to draw the figures by the eye only, and not by the *camera lucida*, but the characters of all may be relied upon as being true to nature.

PLATE IV.

Fig. 1. Ascodictyon siluriense, Vine.

This figure is drawn by the aid of the camera lucida from a transparent section of shell, on which the whorls were scattered, so that all the outlines are in proportion, and the fossil is magnified a little over twenty-five times.

Figs. 2-2A. Valkeria tuberoso, Heller.

This species is also drawn by the aid of the camera lucida, and it is magnified about the same, twenty-five times. This is a recent species, dredged by Dr. Pergens, in the Bay of Naples. It is placed here for the purpose of shewing the character of the Zoarium, the whorls of Zoœcia, and the connecting hollow filamentous thread by which the whorls of cells are connected together. The striking similarity between the living and the fossil forms are at once apparent.

Fig. 3 and 4. Ascodictyon Youngi, Vine.

Fig. 3 is a magnified fragment of Crinoid stem, on which colonies of this species covered the whole of the surface. On account of the undulations of the stem it is impossible to depict the continuous ramifications of the filaments, hence they appear in the sketch as broken threads. Only one cluster of vesicles is shown, and these and the filaments are magnified to about the same proportions as figs. 1 and 2.

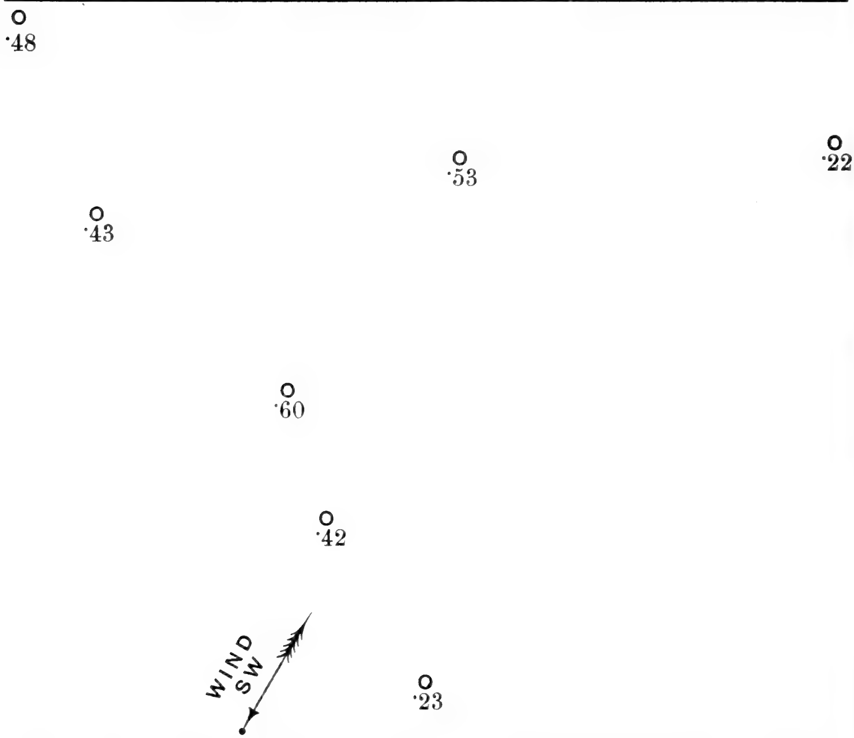
Fig. 4. Two separated clusters of vesicles drawn by the aid of the camera lucida magnified to about 60 diameter. Examples in my own cabinet.

STUDY OF "INTENSE" RAINFALL AT LEEDS, SUNDAY, JULY 19TH, 1891.

BY RICHARD REYNOLDS, F.C.S.

(Scale taken from Ordnance Map, 1in. to a mile.)

A violent thunderstorm, lasting not more than 40 min., gave the only rain of the 24 hours. Its maximum fall was at Woodhouse Cliff; in the first 25 min., ·23 in. fell; then 15 min. gave ·37 in., ceasing sharply. The latter record is at the rate of 1·5 in. per hour.



·23 in.	Museum	Mr. E. R. Waite.
·42 in.	Woodhouse Moor	Mr. T. Hewson, C.E.
·43 in.	Weetwood Reservoir	,,
·50 in.	Eccup Reservoir	,,
·60 in.	Woodhouse Cliff	Mr. R. Reynolds.
·48 in.	Lawnswood, Adel	Mr. C. S. Irvine
·53 in.	Allerton Hill	Mr. T. Fenwick, C.E
·22 in.	Elmete Hall, Roundhay ...	Mr. J. Hawthorne Kitson.

THE AFFINITY OF DADOXYLON TO CORDAITES.

BY JAS. SPENCER.

There is a large tree-like fossil occasionally found in sandstone rocks of the Carboniferous formation called Dadoxylon. The affinity of this remarkable plant has been generally supposed to be with the pine family; but recent discoveries have shown that it has more affinity with the Cycadeæ than with the Coniferæ. My paper deals with the various discoveries which have been made in connection with Dadoxylon, more especially with those of recent years. Many of the sandstone rocks of the Carboniferous age abound in fragments of a very curious fossil; occasionally they occur in their natural rounded form, but more frequently they are more or less flattened. They are characterised by having a series of somewhat irregular ring-like markings along the whole length of the stem; more commonly the markings somewhat resemble the rings of a ladder, and many of them are striated longitudinally. For a long time these singular fossils were thought to have been distinct plants, and were named Sternbergia by Artis, in honour of Count Sternberg, one of the founders of the Science of Fossil Botany. At about the same time, or a little before, Sternberg gave them the name of *Artisia transversa*; but in this country they have generally been known under the name of *Sternbergia transversa.* In the same sandstone quarries there occur along with *Sternbergia transversa,* but much more rarely, fragments of another fossil plant of a larger and more tree-like aspect. These specimens generally occur in the form of roundish stems, and of various thicknesses and lengths. When found *in situ,* in the quarry, they are usually enveloped in a thin layer of smudgy coal, which is probably the mineralized remains of the bark. In many places specimens have been found with portions of their original woody structure well preserved, and microscopic sections of this woody structure show that it closely resembled that of the Pine family. I have come across many specimens of this character in sandstone quarries, but for the purpose of tracing the history of the discoveries in connection with Dadoxylon it will perhaps be best to begin with those which have been made historical by the discoveries of the late Mr. Witham.

In the year 1826 a large tree trunk, 36 feet in length and 3 feet in diameter at the base, was discovered in the celebrated Craighleith Quarry, which is situated in the Calciferous Sandstone, a member of the Mountain Limestone series, near Edinburgh. In the year 1830 another large tree 47 feet in length and 5 feet in diameter at the base, tapering to one foot seven inches at the apex, was found in the same quarry. The structure of the wood of these two trees appears to have been identical, and it was named by Lindley and Hutton *Pinites Withami* after Mr. Witham, who appears to have been the first to study microscopic sections of the wood of fossil plants, and to introduce this most interesting branch of study to the scientific world. The next important discovery took place the year after (1831) in the same quarry, when a small stem with a branch was found; a thin section of the branch showed the annular rings of growth characteristic of the Coniferæ, as well as the pith, which was remarkable on account of its being much larger in proportion to the area of the woody zone than that of recent pines. The authors of the Fossil Flora named this specimen *Pinites medullaris* on account of its large pith. Two years previously a large tree trunk was found at Wide Open, near Newcastle, on the estate of the Rev. R. H. Brandling, in what Mr. Witham terms the "Grindstone Post," which was considered to be one of the highest members of the coal formation of that district. The wood of this fossil tree was named by Lindley and Hutton *Pinites Brandlingi*, after the owner of the quarry. The structure of the wood of all these fossil trees was regarded by Witham as being identical, and therefore they ought to have been named after the first discovered *Pinites Withami*. It is too late now to remedy the mistake, and the names are useful to denote certain peculiarities in the preservation of the structure and in the form of the pith. Thus *Pinites medullaris* refers to a very important characteristic feature found in all these supposed Pines, and that is the much larger relative proportion of the pith area than obtains in modern Pines; and the structure of the wood of *Pinites Brandlingi* is remarkable for its beautiful state of preservation, and also as being regarded by Prof. Renault and other French Fossil Botanists, as being identical with that of the wood of Cordaites, which they regard as belonging to the Cycadeæ.

The following extract from Witham's work on the "Internal Structure of Fossil Plants," will show that even Witham himself was well aware of some of the differences between Pinites and modern Pines. "These fossil trees," he says, "all present a texture very intimately allied to that of our present Coniferæ, but, as has been shown, differing in certain respects, namely, in most instances the want of concentric rings, and in all cases having reticulations or areoles in two or three series, on two opposite walls of the elongated cellules. In one or two instances the areoles approach very closely to those of the Pines. It is however certain that hitherto no structure precisely resembling that of the Coniferæ in every respect has been found in the Mountain Limestone Series or in the Coal formation."

Endlicher changed the name of the genus from Pinites to Dadoxylon (meaning pine or torch wood) by which it is now generally known, but it is also known under several other names, such as Araucarites, Araucarioxylon, &c., all denoting the resemblance of its woody structure to that of the Araucaria or Norfolk Island Pine, but the term Dadoxylon is preferable, because it leaves the question of its affinities an open one.

It is a singular fact that Dadoxylon does not appear to have grown in the same low-lying localites as the coal producing plants, although it is frequently found with them in the sandstone rocks and in the shales. After many years of patient research in coal ball material, in which the coal forming plants occur in a beautiful state of preservation, I have not succeeded in finding a single fragment of Dadoxylon. But in the nodules which occur in the marine strata overlying the Hard Bed Coal, the coal in which the coal balls occur, fragments of small stems and branches of Dadoxylon are occasionally met with embedded among marine shells, such as Goniatites, Nautili, Aviculopectens and many other sea shells.

These wood specimens are generally destitute of the bark, but when fragments of the bark do occur on the stems its tissues are generally so mineralized (changed into graphyte) that the structure cannot be recognized, although the woody portion of the stem may be in a good state of perservation.

These fragments of Dadoxylon appear to have been drifted from some neighbouring land into the sea and ultimately became enclosed in calcareous nodules along with marine shells. It is a curious fact that nearly all the specimens of Dadoxylon which have been found and described in this country of recent years, appear to have been drifted fragments enclosed in similar calcareous nodules along with marine shells. Such fragments appear to have been met with in many of the marine beds throughout the Carboniferous formation. I have found them in the calcareous nodules of the Yoredale strata, Milstone Grit and Coal strata of the Parish of Halifax. They have been met with in similar nodules and under similar conditions in many other places situated on the Carboniferous formation.

There is abundant evidence to show that most of the other common coal plants, such as Calamites, Lepidodendra, Sigillaria and ferns chiefly flourished in extensive mud flats or swamps near the sea level, where they formed those thick and extensive vegetable deposits which ultimately became converted into coal. But the Dadoxylons appear to have preferred the upland districts like many of the Coniferæ of the present day.

Storms and hurricanes appear to have periodically prevailed in those ancient forests, causing the uprooting of many trees and playing sad havoc with many others, and branches, leaves, and fruits, &c., were swept into the rivers and thence carried down to the sea, where many of them became embedded in the mud and sand at the rivers mouths, now composing the shales and sandstones, where their fossilized remains are now found, while many of the smaller fragments would be carried further out to sea, and becoming water-logged would sink to the bottom and become enveloped in those calcareous nodules in which they are now met with. The great majority of the drifted trunks and fragments would utterly perish, while a few only, here and there, would meet with conditions favourable to their preservation in a fossil state. In some beds of stone, trunks of trees are found standing more or less erect, in others they are flattened on the bedding of the stone; but the smaller twigs, leaves and fruitstones often occur in great abundance, and mingled promiscuously in the stone or shale, as the case may be. In many cases the fossils are imbedded in a smudgy coal which is evidently the mineralized remains of either the bark or cortical layer.

Besides the remains of Dadoxylon, the sandstones abound in beautiful specimens of other Carboniferous plants, such as Calamites, Lepidodendra and Sigillaria, ferns, &c., which plainly indicate that these coal plants were not solely confined to the low-lying swampy ground but overspread most of the Carboniferous lands, and this fact explains the rapidity with which they seized upon and overran the new lands as they uprose above the level of the sea, which must have been repeated again and again as often as there are beds of coals.

The numerous leaves bearing *stomata*, cardiocarpons, and other fruits found in coal balls, and now referred to the cycads, seem to indicate that the plants which produced them must have lived on the spot, but we must not overlook the possibility that these Cycadean fragments may have been brought into the coal swamps, from contiguous high lands or other areas where they may have grown, by winds or floods. Cases of this character are recorded by Lyell and other authors as having occurred in the Oolite and Tertiary stratas.

Sandstone casts, or even large stems, showing the structure of the wood, such as those of Craighleith and Wide Open, do not tell us the real character of the plant; something more than this is required before its relationship can be determined. It is necessary that the character of the pith, if it has any, and the cortical layer should also be known before its place in the vegetable kingdom can be assigned.

The next most important discovery, concerning this plant, was made by Prof. W. C. Williamson, of Owen's College, who obtained a small branch of Dadoxylon from Coalbrookdale, in a remarkably good state of preservation. At one end of the stem the pith was exposed and showing the transverse bars pertaining to Sternbergia. Thus the two fossils Sternbergia and Dadoxylon were found to belong to one plant, Sternbergia as its pith and Dadoxylon as its woody stem. The pith of Dadoxylon is composed of a number of flat saucer-like discs formed of cellular tissue, these in the fossil state form the transverse bars of Sternbergia. Although I have had the pleasure of examining Prof. Williamson's specimens and of reading his descriptions, yet having discovered some very good specimens myself it will be more convenient for me to describe the character of Dadoxylon from my own specimens.

DADOXYLON. TRANSVERSE SECTION.

In a transverse section of the stem the pith is seen to be much larger in proportion to the woody zone than that of recent pine stems. The hexagonal cells of the pith are clustered together in two or three portions of the pith area, so that nothing striking is seen in its character in a transverse section. The narrow woody zone is seldom marked by those concentric rings which are so conspicuous in modern pines, and the bark is rarely preserved.

LONGITUDINAL SECTION.

The Sternbergian character of the pith is very conspicuous in a long section. The pith is seen to be composed of a number of shallow disks formed of cellular tissue, and when these became compressed and the intermediate spaces filled in by calcite, &c., there is left the peculiar transverse markings of Sternbergia. The long section also shows us the character of the wood cells of the woody zone, and also that of the medullary rays and the areoles or the equivalents of the pitted ducts of the true pines, which occur in two or three rows on the long wood cells. It will be seen from the above description that a longitudinal section of a plant is as equally important in determining its structure as a traverse section.

It is a very rare thing to find a Dadoxylon enclosed in its cortical layer, and consequently very few fossil botanists even are acquainted with its real character. One of my sections which is about two inches in diameter, shows a small part of the outer portion of the bark, which is composed of very delicate cells, and if the whole area of the cortical tissue was composed of similar cells we need not wonder at the rariety of its preservation. This is the largest and thickest branch or stem that I have hitherto met with showing structure. The pith, which is of the usual discoidal character and occupies a relatively smaller area than that of any other of my specimens, ir rather more than a quarter of an inch in diameter. This is enclosed by the woody zone (composed of fine wood cells) of about half-an-inch in radius. This woody zone shows six or seven rings of growth, and appears to have been about as much above the normal proportion of area as the pith falls short of its normal proportion. In other words, the woody zone appears to have increased in area at the expense of the pith area. Surrounding the woody zone is a zone now occupied by calcite, which has evidently taken the place of the bark, of about a quarter-an-inch in diameter. Surrounding this zone there is a thin zone of very fine and thin walled cellular tissue, which appears to be either part of the bark or the inner edge of the epidermal layer, but the outer layer of that tissue is not represented in the specimen. Whether the zone of calcite and thin wall of cellular tissue represent the full width of the cortex cannot be determined from this section, but it shows us that the fundamental tissues occupied a large proportion of the area of the stem much larger than they occupy in the stems of recent or fossil pines.

In Witham's work on "The Internal Structure of Fossil Vegetables," there is a very good section of a cycad *(Cycas revoluta)* in which the fundamental tissues are seen to occupy a large part of the stem, while the woody tissue, which is of a very lax description, forms a narrow zone dividing the area of the large pith from the broad cortex.

Had Witham been acquainted with the full meaning of this peculiar feature of the structure of the Cycadeæ, as illustrated by his own section of *Cycas revoluta*, it is not improbable that he would have seen that his supposed pine stems were more nearly allied to the cycads than to the pines. But there were two facts in connection with Pinites, which he does not appear to have been acquainted with, namely, the discoidal character of the pith and the large area occupied by the cortex. Although the discoidal nature of the pith would not have aided him in fixing the affinity of the fossil plants, because it appears to be a structure dependent upon rapidity of growth, and is found at the present day in plants of widely different families, yet its large area taken into consideration along with that of the bark would have had a direct bearing upon the affinities of the plants.

The great height and girth of the fossil trees, taken along with a certain resemblance of their woody structures to those of the Pines, would have a tendency to bias his mind in favour of the Pine family; moreover, up to Witham's time, very little appears to have been done in the study of the internal structures of modern plants. The fact that some of the cycads had a woody structure more closely resembling Pinites than did that of the Pines, has been made known to us since Witham's day.

CORDAITES.

M. Brongniart, Prof. Renault, and other French Fossil Botanists have described specimens of fossil plants closely resembling, if not identical with, those of Dadoxylon, from the Coal-field of St. Etienne, under the name of Cordaites, which they affirm to be true cycads. In the same coal-field large quantities of fruits, leaves, and even flowers of cycads have been found and described by Brongniart, Renault and others. So remarkably well preserved are the fossils from St. Etienne that it is said the "broad leaves of Cordaites show their *stomata* and the fruits their polen grains." In this respect they resemble the Halifax leaves which show their *stomata* quite as well, while vast numbers of various kinds of fruits and spores, many with their pollen grains admirably preserved, abound in the Halifax material.

Cordaites attained a large size, and in almost every respect seem to be the Dadoxylon of the French Coal-field; the structure of its wood has long been known to be identical with that of *Dadoxylon* (Pinites) *Brandlingi*.

Some time ago Dr. Hovelacque, of Paris, sent me a piece of Cordaites from which I have cut and ground many sections, all of them shew the structure of the wood remarkably well, but no better than many of my sections of Dadoxylon from the Carboniferous formation. In comparing sections of Cordaites with similar sections of Dadoxylon I can detect no organic difference between them, and therefore I must regard them as being identical both in structure and external appearance.

There is one feature about Dadoxylon which has often struck me as being in singular contrast to what obtains in the higher cryptogams, such as the Sigillaria and Lepidodendra, and that is while in its woody structure it seems to be nearest allied to the Araucaria, which belongs to one of the lowest types of the Pine family ; on the other hand, the structure of its contemporaries, the Sigillaria and the Lepidodendra, shows us that they belonged to a far higher type of cryptogams than any living at the present day. The vascular cryptograms of the Carboniferous age had already reached their climax, both in growth and in organization, from which they have gradually dwindled down to their present lowly condition.

But if Dadoxylon was a true pine no such degradation has taken place in the Pine family, which must have remained very much in the same state of development from its first known appearance in the middle of the Devonian period through the vast length of the Carboniferous and Permian periods, and thence onwards through the great break at the end of the Carboniferous age into, and well nigh to the close of, the great Mesozoic ages.

This, however, seems to many Palæophytologists utterly incredible, and is opposed by most of the other known facts in connection with the life of the same periods ; and of late years a considerable amount of doubt has arisen in the minds of some of our best fossil botanists concerning the affinities of our Dadoxylon. The weight of the evidence seems to me to be now in favour of the opinion that Dadoxylon and Cordaites belong to the same family, the cycads, and that they represent the highest type of that family, which, like the vascular cryptograms, have gradually dwindled away both in size and in organization until they have reached the insignificant forms of the present day.

Those noble Cycadean trees, Dadoxylon and Cordaites, had already reached their climax in the Carboniferous age, and appear to have gradually died out towards the end of that period.

Walchia imbricata, the first of the true pines, did not make its appearance until towards the end of the Carboniferous period. The first recorded specimen, according to Mr. R. Kidstone, F.G.S., was found a few years ago in the Upper Coal Measures. It is closely related to the Araucaria, and first begins to hold a prominent position in the somewhat scanty flora of the Permian age. But during the Mesozoic ages the Araucaria held a similar predominant position in the vegetable kingdom that the Dadoxylons held in the preceding Palæozic ages. So long as Dadoxylon was regarded as a true pine it appeared to afford a strong argument against the theory of evolution, but now it has been shown that its supposed affinity with the pines is based entirely upon the resemblance of its wood to that of the Araucaria, and that the structure of the whole stem, pith, wood, and bark being taken into consideration, it is seen to have more affinity with the Cycads, as seen in *Cycas revoluta,* than with the Araucaria ; and it is found to occupy its natural place both in the vegetable kingdom and in the order of its appearance in geological time according to the theory of evolution.

EXPLORATION OF THE ELBOLTON CAVE. BY REV. E. JONES.

Exploration was continued until the end of December, 1890. The entrance to the Cave is through a shaft or pothole twenty feet in depth, situated at the foot of a small limestone scar on Elbolton, 1000 feet above sea level. The chamber, before the exploration commenced, was thirty feet long, and varied from seven to thirteen feet in width. The floor was fairly level with the exception of a heap of stones under the entrance On the surface nothing was observed but a few sheep bones of recent origin. The upper stratum, which varied in thickness from four feet at the east to seventeen feet at the west end of the chamber, is the only one wherein human remains have yet been found. It consisted of loose angular fragments of limestone, interspersed with large quantities of bones of the Celtic short-horn, the boar, dog, red deer, sheep, &c. The larger of the animal bones were split and broken, and were evidently used as food. Burnt bones and charcoal were found in three places. Three skeletons were discovered buried with the legs bent, and the knees close to the skull. The other human bones were more or less scattered. Most of the skulls were shattered, though two obtained from the east end are fairly preserved, and are good typical specimens of the long-head type. But the human remains obtained from the other end of the chamber and at a much lower level thirteen and fifteen feet below the floor (one lying but a few inches above the clay containing bones of the bear and reindeer) are not dolichocephalic but brachycephalic. The latter are more decayed than the others. Associated with the round-head was pottery of different character to that which was found in the other parts of the cave. It is thicker, ruder, and with a different ornamentation. The pottery found near the long-headed men was marked with straight lines, in some cases cutting one another and forming a diamond-shaped ornamentation, in others going in and out without intersecting, forming a "herring-bone" pattern. Others had impressions made by some rounded bone tool. But the pottery found near the remains of the round-head is ornamented with wedge-shaped characters made with an angular tool. Both kinds of pottery were made from clay similar to that found in the cave, and both kinds were hand-fashioned without wheel, and charred and burned from the inside. No flints or metal of any kind have been found in the cave. The only objects obtained have been bone pins and a few other worked bones. From the position where this brachycephalic skull was found and from the ruder kinds of pottery associated with it, it would appear that in Craven a round-headed race preceded the long-headed one.

Nearly all of the upper stratum containing human remains had been cleared away before August last, and the next layer had been worked for some distance, especially in the second shaft, at the west end of the chamber. So far this lower stratum was composed of stiff clay with angular fragments of limestone, and at times a thin bed of stalagmite. No human remains nor any of the animals associated with them have been found. These are replaced mainly by bears, both Ursus feros and Ursus arctos, and great numbers of Alpine hares and foxes The bones in this layer show no evidence of having been gnawed by other animals. They either perished in the fissure or their bones were washed down through pot holes into the cave. The bones from the lower layer are darker, much harder, and less porous than those from the upper one.

After the meeting of the British Association at Leeds, in 1890, efforts were first directed to the careful examination of the lower clay bed in the centre of the chamber. A pothole about ten feet deep and three in width was cleared out. This contained a few of the limb bones of a bear. A great part of the rock floor at the foot of the first ladder was blasted. It consisted apparently of a quantity of rock fallen from the roof and cemented by stalagmite. We were hopeful that underneath it we should find an old deposit. So far however it is solid. Further west the excavation was continued, the difficulty of working in the soft adhesive clay increasing. The percentage of bones was small, and in the next six feet not a single bone was found, The cave has now developed into a deep fissure and is from four to six feet in width at a depth of about forty-five feet from the original level of the cave floor. The attention of your Committee was next directed to find any possible entrance to the cave in addition to the present one; the floor was tested along the sides of the cave east of the first ladder, but the miners report that there the ground was all solid rock.

Between the barren clay section and the second ladder there is a quantity of unexplored material. Huge blocks of fallen rock are wedged in the fissure, and it was found unsafe to remove them as they underpin an immense overhanging side of the cave sixty feet in height. The second ladder was then descended and a level driven beneath the fallen blocks at a depth of forty-five feet from the first floor. For the first six feet this level proved as ossiferous as any of the material yet examined and of similar character, containing bones of the bear and the hare. Beneath was a barren clay, followed by beds of sharp quartz sand, until the level is barred by solid rock. In the descent two or three stalagmitic floors were pierced but the material continued the same above and below the stalagmite. The new chambers that were opened last year are extensions of this fissure. The miners have put a steel rod eight feet lower than present level, forcing it through another stalagmitic floor. While the east part of this level is sand containing no bones, the western part, and the passage up to the new chambers, is a brecciated mass of bones and stalagmite.

At the further extremity of the new chambers, and about sixty yards from the foot of second ladder, there was a deep pool into which the roof dipped. In the floor of the passage leading to the pool a hole eight feet deep was dug. The material was comminuted limestone. Here also bones of young bears were found; they had evidently been washed down from the first chamber. By means of this last excavation the pond was lowered four or five feet. A ladder was placed across it and an entrance effected into a further passage leading to a large natural chamber.

So far the cave has been interesting. What may be entombed in the unexplored depths of the fissure is a matter of pure conjecture. Whether a repetition of the finds in the fissure at Ray Gill and in the lower cave earth of the Victoria Cave with the addition of palæolithic man may be obtained, must be left for further exploration to determine.

SECRETARY'S REPORT.

The Society commenced the year with two hundred and seven members. During the year the number has been reduced by the death of four members. Lt.-Colonel Louis J. Crossley, J.P., of Halifax, was a Vice-President, and took much interest in the Society. His researches in Electrical Science are well known; his discoveries have been of great importance, and the value of some of them has been demonstrated by their universal adoption for commercial and other purposes. At the Annual Meeting at Halifax, in 1882, Colonel Crossley presided and afterwards entertained the members.

The members of the Society joined with those of the Geologists' Association of London, in an excursion on the Yorkshire Coast, extending over the greater part of a week, commencing on Monday, August 3rd, and continuing until Saturday, August 8th. The Societies met at Driffield, and from thence investigated the strata exhibited on the shore from Bridlington to Whitby.

The Annual Meeting of the members was held at the Philosophical Hall, Leeds, on Wednesday, November 4th, 1891. The President, the Marquis of Ripon, occupied the chair and gave an address. In addition to the ordinary business the following papers were read :—

Thomas Hick, B.A., B.Sc., "On the present state of our knowledge of the Calamitæ."

Chas. E. De Rance, F.G.S., of H.M. Geological Survey, "On the Underground Waters of Lincolnshire."

James E. Bedford, F.G.S., "On some Glacial Sections at Meanwood, near Leeds."

Rev. J. Stanley Tute, B.A., "On a Permian Conglomerate at Markington."

George R. Vine, "Notes on some new or but little known Eocene Polyzoa."

George R. Vine, "On the Palæozoic Ctenostomatous Polyzoa."

Rev. E. Maule Cole, M.A., F.G.S., "Notes on some Sands on the Wolds."

James Spencer, "On the Affinities of Dadoxylon and Cordaites."

B. Holgate, F.G.S., "On the mode of Deposition of the Carboniferous Strata, near Leeds."

Thomas Tate, F.G.S., "Yorkshire Petrology: the Cleveland Dyke."

Rev. E. Jones, "Report on the Investigation of Elbolton Cave, near Skipton."

A. Smith Woodward, F.G.S., "The Hybodont and Cestraciont Sharks of the Cretaceous Period."

As in previous years it is with pleasure that the indebtedness of the Society is expressed to those gentlemen who have acted as Local Secretaries. The following is a list of the Local Secretaries together with the districts which they represent:—

Barnsley	T. W. H. Mitchell, Barnsley.
Bradford	Thos. Tate, F.G.S., 5, Eldon Mount, Leeds.
Bridlington	G. W. Lamplugh, Bridlington Quay.
Driffield	Rev. E. Maule Cole, M.A., Wetwang, near York.
Halifax	Geo. Patchett, Junr., Halifax.
Harrogate...	R. Peach, Harrogate.
Huddersfield	P. Sykes, 33, Estate Buildings, Huddersfield.
Leyburn and Wensley-dale	William Horne, F.G.S., Leyburn.
Thirsk	W. Gregson, Baldersby, Thirsk.
York	W. M. Platnauer, The Museum, York.

This Society exchanges its proceedings for those of the Societies whose names are appended. The thanks of the Society are hereby tendered to those Societies for their respective contributions.

Essex Naturalists' Field Club.
Norwich Geological Society.
Memorias de la Sociedad Cientifica "Antonio Alzate," Mexico.
Warwickshire Natural History and Archæological Society.
Royal Society of Tasmania, Van Dieman's Land.
Royal Dublin Society.
Royal Academy of Science, Stockholm, Sweden.
Geological Association, Liverpool.
Royal Historical and Archæological Association of Ireland.
Geologists' Association, London.
Manchester Geological Society.
Literary and Philosophical Society, Liverpool.
Royal Institution of Cornwall.
Royal Geological Society of Ireland.
Midland Naturalist, Birmingham.

Academy of Natural Sciences, Philadelphia, U.S.A.
Naturhistorischen Hofmuseum, Wien, Austria.
Societie Imperiale des Naturalistes, Moscow.
United States Geological Survey of the Territories, Washington.
Boston Society of Natural History, U.S. America.
Hull Literary and Philosophical Society.
Connecticut Academy of Arts and Sciences.
Academy of Science, St. Louis, U.S. America.
Owens College, Manchester.
Meriden Scientific Association, Meriden, Conn. U.S.A.
Royal Society of New South Wales, Sydney, Australia.
Nova Scotian Institute of Science, Halifax, Nova Scotia, Canada.
Rochester Academy of Science, Rochester, N.Y., U.S.A.
Halle (Prussia) Imperial Academy of Naturalists.
Historical Society of Lancashire and Cheshire.
Geological Society of London.
Royal University of Norway, Christiana.
Sociètè-Geologique du Nord, Lille.
Royal Society of Edinburgh.
Royal Geological Society of Cornwall.
Geological Society of Edinburgh.
Royal Physical Society of Edinburgh.
Oversigt over det Konigelige Danske Videnskabernes Selskabs, Kjopenhavn.
Museum of Comparative Zoology, Cambridge, U.S.A.
Watford Natural History Society and Hertfordshire Field Club.
Birmingham Natural History and Microscopical Society.
Bristol Naturalists' Society.
Leeds Geological Association.
Patent Office Library, London.
Powis Land Naturalists' Club, Aberystwith.
American Philosophical Society, Philadelphia, U.S.A.
Comité Geologique de Russie, St. Petersburg.
Elisha Mitchell Scientific Society, Chapel Hill, U.S.A.
Elliott Society of Science and Art, Charleston, U.S.A.

The Fifth Annual Report of the Committee of the British Association appointed to ascertain and record the localities of the British Islands in which the evidences of the existence of pre-historic inhabitants of the country are found, was presented at the Meeting of the Association at Cardiff. It contained a list of the Ancient Lake-dwellings or Crannoges of the British Islands, and was compiled by Dr. Munro. The list is exhaustive, and must be useful if not indispensable to those who pursue the subject in the future. Your Secretary is the recorder of the Committee, and he desires to impress on the members of this Society the advisability of their preparing lists of pre-historic objects found in their own neighbourhood with a record of the locality.

During the past year the investigation of the Cave at Elbolton, near Skipton, has been proceeded with, and a report of the work done will be found on another page. A further grant of £25 has been made.

Another Committee of the British Association in which this Society is much interested is that for the Collection, Preservation, and Systematic Registration of Photographs of Geological Interest. Mr. Jas. E. Bedford is the Secretary, and has taken active interest in the work.

The Balance Sheet is appended, from which it will be observed that the financial position of the Society is sound. It is, however, very important that Members who have not paid their subscriptions should do so. In a Society whose Members extend over so wide an area as the County of York, it is impossible to make a personal appeal to every one, and the consequence is that many Members must necessarily be expected to forward their subscriptions by post. It is urged that they should be kind enough to do so during the early part of each current financial year.

A Photograph illustrating the junction of the Carboniferous Rocks with the Permian Sandstone at Knaresboro' will be issued with the Proceedings for the current year. The negative has been kindly provided by G. Bingley, Esquire, President of the Leeds Photographic Society, to whom the Society tenders its thanks.

Statement of Receipts and Expenditure of the Yorkshire Geological and Polytechnic Society, 1890-91.

Receipts.	£	s.	d.	Expenditure.	£	s.	d.
To Balance in hands of Treasurer, 31st Oct., 1890...	14	7	8	By Whitley and Booth—Printing, &c. ...	50	0	0
,, Subscriptions	56	2	3	,, Expenses at the Meetings, Postage, &c.	9	19	8
,, Interest on Halifax Corporation Bonds	11	1	10	,, Balance in hands of Treasurer, 31st Oct., 1891...	21	12	1
	£81	11	9		£81	11	9

CAPITAL ACCOUNT.

	£	s.	d.
To Halifax Corporation Bond	350	0	0
,, Cash in hands of the Treasurer, 31st Oct., 1891	31	13	11
	£381	13	11

WM. CASH, Treasurer.

Audited and found correct, 3rd November, 1891.

GEO. PATCHETT, Jun.

MINUTES OF MEETINGS.

Meeting of the Council at the Philosophical Hall, Leeds, March 26th, 1890.

Present, Messrs. Cheetham, Bedford, Tate, and Davis.

The minutes of last meeting were read and confirmed.

Resolved that a meeting be held on Wednesday, April 23rd, the place of meeting to be arranged by the Hon. Secretary, preference being given to Keighley, if convenient, and that Mr. John Brigg, J.P., be invited to preside.

Meeting of the Council, Museum, Leeds, August 20th, 1890, J. C. Bedford, Esq., in the chair.

Present, Messrs. Reynolds, Tate, Gray, and Davis.

Apologies were read from Messrs. Carter, Cheetham, and Eddy.

Minutes of the last meeting were read and confirmed.

Proposed by Mr. Tate, seconded by Mr. Gray, that a meeting be held at Halifax, on Wednesday, November 5th, at three o'clock p.m., the President, the Marquis of Ripon, to preside, and that papers be accepted from Messrs. Vine, Holgate, Cole, Lamplugh, and others.

Mr. Reynolds proposed, and Mr. Tate seconded, that the Council recommends to its successors that the proceedings of the Society be published half-yearly instead of annually.

Mr. Reynolds moved, and Mr. Bedford seconded, that the Hon. Secretary be requested to represent the Society at the meeting of the Corresponding Societies of the British Association at Leeds.

Annual Meeting, November 5th, 1890, Lecture Theatre of the Literary and Philosophical Society, Halifax.

Alderman James Booth, the Mayor of Halifax and a Vice-President of the Society, occupied the chair.

A letter was read from the Marquis of Ripon expressing regret that ill health prevented his Lordship being present.

The minutes of last general meeting were read and confirmed.

The Honarary Secretary read the Annual Report.

The Treasurer presented a Financial Statement. On the motion of the Chairman the Report and Balance Sheet were adopted.

The following gentlemen were elected members of the Society:—

Edmund Wilson, Red Hall, Leeds.

J. W. Stather, 226, Spring Bank, Hull.

J. Fletcher White, 24, St. John's, Wakefield.

J. Rawlinson Ford, 61, Albion Street, Leeds.

J. H. Grant Davis, Greetland, Halifax.

W. Akroyd, Halifax.

J. H. Howarth, Skipton.

On the motion of Mr. Rowley, seconded by Mr. Chatham, the Most Noble the Marquis of Ripon was re-elected President for the ensuing year.

On the motion of Mr. Reynolds, seconded by Mr. Parke, the Vice-Presidents were re-elected.

On the motion of Mr. Holgate, seconded by Mr. Seal, the Hon. Secretary and the Treasurer were re-elected.

On the motion of Mr. Bedford, seconded by Rev. E. Jones, the following gentlemen were elected members of the Council for the next year:—

J. T. Atkinson.

J. E. Bedford.

R. Carter.

W. Cheetham.

J. Ray Eddy.

T. W. Embleton.

Thos. H. Gray.

Professor A. Lupton.

G. H. Parke.

R. Reynolds.

W. Rowley.

C. Fox Strangways.

The Chairman gave an address.

The following papers were then communicated:—

W. E. Garforth, J.P., F.G.S., "On Mining at 1000 yards and deeper."

Mr. W. Rowley and Mr. J. Seal spoke thereon.

G. R. Vine, "Notes on the Polyzoa and Microzoa of the Red Chalk of Yorkshire and Norfolk."

Rev. E. M. Cole, M.A., "On the opening of the Great Tumulus at Duggleby."

T. Tate, F.G.S., "On the so-called Ingleton Granite."

J. R. Mortimer, "On the pre-history of Fimber."

J. R. Mortimer, "On the supposed Roman Camp at Octon."

G. W. Lamplugh, "On the Boulders of Flambro' Head."

Alfred Harker, M.A., "Petrological Notes on the Boulders at Flambro'."

J. R. Dakyns, "On the changes of the Lower Carboniferous Rocks in Yorkshire from N. to S."

B. Holgate, "On some physical properties of Coal," discussed by Rowley, Garforth, and Seal.

B. Holgate, "On the mode of deposition and properties of the Carboniferous Strata of Leeds and District."

Wm. Cash and J. Lomas, "On the structure of Lepidophloios."

A vote of thanks to the Chairman and Authors was proposed by Mr. Reynolds, and seconded by Mr. J. Ray Eddy, and carried.

The members afterwards adjourned to the White Swan Hotel and dined, the Mayor, Ald. James Booth presiding.

Meeting of the Council, Philosophical Hall, Leeds, July 8th, 1891.

Present, T. W. Embledon, Esq., in the chair.

Messrs. Carter, Gray, Tate, Reynolds, and Honorary Secretary.

The minutes of last general meeting were read and confirmed.

Resolved that if a suitable subject is found a photograph be issued with next year's proceedings.

That the Secretary write to the Geologists Association for information respecting their excursion to East Yorkshire, and if desirable, arrange that the members of this Society shall join in the excursion.

Joint excursion of the members of Geologists' Association of London with the members of this Society on the Yorkshire Coast, August 3rd to August 8th, 1891, conducted by Rev. Prof. J. F. Blake, J. W. Woodall, of Scarborough, and G. W. Lamplugh, of Bridlington.

3rd August. Mr. Mortimer's Museum was inspected. Visited Flamborough Head and North Shore of Bridlington Bay. Mr. Boynton's collection from Lake Dwellings at Ulrome was inspected.

4th. Visited Speeton, Red and White Chalk and the Speeton Clays, together with the Upper Jurassic Rocks of Filey Brig received attention.

5th. Scarborough Museum inspected; visited the Oolitic Rocks exhibited south of Scarborough, and the series comprising the Lower Kelloway Rocks on the north of the Castle Hill. Mr. J. W. Woodall's Steam Yacht and the Harbour Tug were placed at the disposal of the members.

6th. Visited the Peak, Blea Wyke, Cloughton, and the plant beds of Gristhorpe; thence to Hackness and Forge Valley, and returned to Scarborough.

7th. Peak Alum Quarries, Fault at Peak Steel, bringing Upper and Lower Lias into juxtaposition; Jetworks at Hawsker.

8th. Whitby Museum, Grosmount Ironworks, &c., and Quarries at Malton in Coralian Oolite and Calcareous Grit investigated.

Meeting of the Council at Philosophical Hall, Leeds, November 4th, 1891.

Present, R. Reynolds, Esq., in the chair.

The Marquis of Ripon, K.G., Professor A. Lupton and Messrs. Embleton, Gray, Parke, Horne, Bedford, Cheetham, Atkinson, Seal, and Secretary.

The minutes were read and confirmed.

Secretary's Report and Balance Sheet read and ordered to be presented to the Annual Meeting.

Mr. A. Smith Woodward's paper with two lithograph plates accepted, and ordered to be printed.

The photograph of a section of the junction of the Permian and Carboniferous Rocks at Knaresborough ordered to be printed by the Autotype Company, London.

Annual Meeting at the Philosophical Hall, Leeds, on Monday, 4th of November, 1891.

The President, the Marquis of Ripon, K.G., in the chair.

There was a large attendance of members.

The Hon. Secretary read the minutes, which were confirmed.

The Hon. Secretary presented the Annual Report, and read the Treasurer's Balance Sheet.

On the motion of the President, seconded by Mr. Mitchell, the Report and Balance Sheet were adopted.

Mr. J. T. Atkinson proposed, and Professor A. Lupton seconded, the re-election of the President, which was carried.

The Vice-Presidents, with the exception of L. J. Crossley, Esq., deceased, were re-elected.

On the motion of Mr. S. Seal, seconded by Mr. J. Ross, the Council, the Hon. Secretary, and the Treasurer, were re-elected.

Mr. Jas. W. Davis proposed, and Mr. J. E. Bedford seconded, that Mr. C. E. De Rance, F.G.S., of H.M. Geological Survey. &c., be elected an Honorary Member, carried.

Mr. Davis proposed and Mr. Bedford seconded, and it was carried, that the following gentlemen be elected members of the Society :—

J. H. Morton, Solicitor, Broad Street, Halifax.

J. C. Chambers, National Telephone Co., Manchester.

R. H. Longbottom, Mining Engineer, Wakefield.

Mr. W. Gregson proposed, and Mr. S. Seal seconded, that the following gentlemen be members, and it was carried :—

J. R. Brooke, Green End House, Melmerby, Thirsk.

Sir Matthew Dodsworth, Bart., Thornton Watlass, Bedale.

Christopher Furness, M.P., Brantford, West Hartlepool.

Rt. Hon. Lord Masham, Swinton Castle, Bedale.

Jno. T. Pearson, The Hall, Melmerby, Thirsk.

The following papers were read or communicated :—

T. Hick, B.A., &c., "On the present state of our knowledge of the Calamitæ."

C. E. De Rance, "On the Underground Waters of Lincolnshire."

J. E. Bedford, F.G.S., "On some Glacial Sections at Meanwood, Leeds.

Rev. J. S. Tute, "On a Permian Conglomerate at Markington."

G. R. Vine, "Notes on some new or but little known Eocene Polyzoa."

G. R. Vine, "On the Palæozoic Ctenostomatous Polyzoa."

Rev. E. M. Cole, "Notes on some Sands of the Wolds."

Jas. Spencer, "On the affinities of Dadoxylon with Cordaites."

B. Holgate, "On the mode of the Deposition of the Carboniferous Strata near Leeds."

Thos. Tate, "Yorkshire Petrology—the Cleveland Dyke."

Rev. E. Jones, "Report on the investigation of the Elbolton Cave near Skipton."

A. Smith Woodward, "The Hybodont and Cestraciont Sharks of the Cretaceous Period."

Votes of thanks concluded the meeting.

The members afterwards adjourned to the Queen's Hotel and dined together. The President presiding.

Bibliography, 1889-1890.

Abbs, H. Cooper. Presidential Address to the Tyneside Naturalists' Field Club on the Buttertubs between Wensleydale and Swaledale, a Shap Granite Boulder at Saltburn-by-the-Sea, and the Geology of Saltburn. *Nat. Hist. Trans. Northum. and Durham*, vol. viii., Part III., pp. 326-346.

Adamson, S. A. Scientific Aspects of Health Resorts. IX. Saltburn and District. *Research*, Jan. 1890, pp. 148-151, and woodcuts.

———— Scientific Research in Yorkshire (being an account of work and objects of the Yorkshire Boulder Committee, Fossil Flora Committee, Coast Erosion Committee, and Geological Photographs Committee). *Research*, March, 1890, pp. 200-202.

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METEOROLOGY OF BRADFORD FOR 1891.

Computed from daily observations made at the Exchange, Bradford, by John McLandsborough, M. Inst. C.E. retired., F.R.A.S., F.R.Met.Soc., F.G.S., and Alfred Eley Preston, M. Inst. C E , F.R.Met.Soc., F.G.S.
Latitude, 53deg. 47min. 38sec. N.; longitude, 1deg. 45min. 4sec. W. Height above mean sea level, 366ft.

Pressure of Atmosphere in Month.

Months.	Highest Reading of Barometer.	Date	Highest during 23 Years.	Mean of Highest of 23 Years.	Lowest Reading of Barometer.	Date	Lowest during 23 Years.	Mean of Lowest of 23 Years.	Range.	Corrected for Capillarity and Temperature: Mean	Corrected: Mean of 23 Years.
	Ins.	On	Ins.	Ins.	Ins.	On	Ins.	Ins.	Ins.	Ins.	Ins.
January	30·378	14th	30·544	30·181	29·012	23rd	28·070	28·693	1·296	29·664	29·525
February	30·356	4th	30·412	30·104	29·580	26th	28·462	28·835	0·776	30·016	29·540
March	29·858	3rd	30·476	30·128	28·990	16th	28·175	28·764	0·868	29·377	29·488
April	29·988	20th	30·501	30·060	29·186	6th	28·332	28·852	0·802	29·582	29·475
May	29·946	12th	30·382	30·049	28·948	1st	28·661	29·030	0·998	29·375	29·537
June	30·084	20th	30·360	30·025	29·350	30th	28·840	29·171	0·734	29·639	29·564
July	30·008	14th	30·305	29·972	29·200	7th	28·690	29·147	0·808	29·475	29·509
August	29·728	7th	30·242	29·989	28·990	27th	28·670	29·057	0·738	29·312	29·496
September	29·938	16th	30·332	30·081	28·884	1st	28·452	29·006	1·054	29·516	29·521
October	30·394	31st	30·394	30·132	28·610	13th	28·250	28·737	1·784	29·259	29·451
November	30·376	5th	30·376	30·058	28·060	11th	28·060	28·653	2·316	29·399	29·443
December	30·270	21st	30·358	30·120	28·588	10th	27·652	28·677	1·682	29·449	29·477
Means, or totals	30·105		30·376	30·073	28·950		28·364	28·887	1·155	29·604	29·502

Temperature of Air in Shade during Month.

Months.	In Each Month: Highest.	Date.	Highest during 23 Years.	Mean of Highest of 23 Years.	Lowest.	Date	Lowest during 23 Years.	Mean of Lowest of 23 Years	Range.
	Deg.	On	Deg.	Deg.	Deg.	On	Deg.	Deg.	Deg.
January	51·0	30th	57·2	52·9	12·0	19th	6·7	23·2	39·0
February	53·0	4th	69·8	53·4	27·6	26th	19·2	26·5	25·4
March	53·3	2nd	66·0	56·8	27·0	9th	17·4	25·8	26·3
April	54·6	27th	74·0	63·4	31·1	7th	27·4	31·4	23·5
May	72·9	13th	83·9	70·4	28·6	18th	28·6	34·9	44·3
June	74·1	27th	87·8	76·9	42·0	1st	38·0	41·9	32·1
July	78·0	18th	89·6	79·4	49·0	29th	42·0	46·5	29·0
August	69·5	19th	85·2	78·0	46·2	30th	38·6	45·2	23·3
September	79·9	12th	81·3	71·1	46·0	22nd	33·5	40·1	33·9
October	62·9	8th	69·9	63·2	36·0	25th	26·7	32·6	26·9
November	56·0	19th	61·5	56·4	28·6	28th	23·0	28·6	27·5
December	56·0	4th	57·8	53·1	16·1	25th	13·2	23·0	39·9
Means, or totals	63·4		72·8	64·6	32·5		26·2	33·3	30·9

Months.	Daily Mean, In Each Month: Of all Highest.	Mean of 23 Years.	Of all Lowest.	Mean of 23 Years.	Range: Mean.	Range: Mean of 23 Years	Of Dry Bulb: Mean	Of Dry Bulb: Mean of 23 Years
	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.
January	40·4	43·0	31·5	34·4	8·9	8·7	37·0	39·2
February	44·7	44·2	35·6	35·3	9·1	8·8	39·6	39·6
March	44·2	46·3	34·3	35·3	9·9	11·0	38·7	40·4
April	47·7	52·2	36·5	39·3	11·2	12·[illegible]	41·6	44·5
May	55·2	58·3	42·2	43·9	13·0	14·4	48·1	49·6
June	65·5	65·1	50·8	50·1	14·7	15·0	57·1	55·9
July	65·0	68·0	53·3	55·8	12·7	14·3	58·5	60·0
August	62·4	66·8	52·8	53·0	9·6	13·8	57·2	58·7
September	64·8	62·1	51·8	49·7	13·0	12·4	57·0	54·7
October	55·0	53·8	44·2	43·3	10·8	10·5	49·0	48·2
November	46·8	47·3	38·8	38·4	8·0	9·0	42·4	42·8
December	44·3	42·7	33·9	34·1	10·4	8·5	39·8	39·0
Means, or totals	53·1	54·2	42·1	42·6	11·0	11·6	47·2	47·7

Months.	Adopted Mean Temperature, Of Air: Mean.	Of Air: Mean of 23 Years	Of Evaporation: Mean.	Of Evaporation: Mean of 23 Years.	Dew Point: Mean.	Dew Point: Mean of 23 Years
	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.
January	36·4	38·8	34·6	37·1	32·0	34·8
February	39·6	39·5	38·0	37·7	35·9	35·4
March	38·5	40·1	36·2	37·7	33·1	34·7
April	41·1	44·5	37·9	41·1	33·9	3[illegible]·2
May	47·6	49·5	43·9	45·2	39·8	41·0
June	56·7	55·8	52·4	51·3	48·4	46·9
July	58·2	59·7	52·5	54·1	47·4	49·8
August	56·5	58·5	52·4	53·9	48·6	50·0
September	57·0	54·8	52·8	51·4	48·9	48·1
October	48·8	47·9	46·0	45·5	43·0	42·7
November	42·4	42·5	40·3	40·3	37·8	37·5
December	39·4	38·7	37·6	36·7	35·3	34·2
Means, or totals	46·9	47·5	43·7	44·3	40·3	41·0

Vapour.

Months.	Elastic Force: Mean	Elastic Force: Mean of 23 Years	In a Cubic Foot of Air: Mean	Mean of 23 Years	Short of Saturation	Mean of 23 Years	Mean Weight of a Cubic Foot of Air.	Mean of 23 Years
	Ins.	Ins.	Grs.	Grs.	Grs.	Grs.	Grs.	Grs.
January	·182	·204	2·1	2·4	0·5	0·4	554	549
February	·211	·208	2·4	2·4	0·4	0·4	557	548
March	·189	·203	2·2	2·3	0·6	0·5	547	547
April	·195	·22[illegible]	2·3	2·6	0·7	0·8	548	541
May	·246	·259	2·8	3·0	0·9	1·1	536	537
June	·341	·322	3·8	3·6	1·3	1·4	531	531
July	·328	·360	3·7	4·0	1·8	1·7	527	526
August	·343	·362	3·9	4·1	1·2	1·4	525	527
September	·346	·337	3·9	3·8	1·3	1·0	529	531
October	·278	·276	3·1	3·1	0·7	0·7	533	537
November	·227	·225	2·6	2·6	0·5	0·5	542	543
December	·206	·199	2·4	2·3	0·5	0·5	547	548
Means, or totals	·258	·265	2·9	3·0	0·9	0·9	540	539

Months.	Degree of Humidity (Complete Saturation = 100): Highest	Date	Highest during 23 Years	Mean of Highest of 23 Years	Lowest	Date	Lowest during 23 Years	Mean of Lowest of 23 Years	Mean	Mean of 23 Years
	0–100	On	0–100	0–100	0–100	On	0–100	0–100	0–100	0–100
January	98	2nd	100	97	4[illegible]	19th	34	65	85	88
February	100	20th	100	97	63	12th	42	65	87	86
March	96	11th	[illegible]	96	47	12th	28	56	82	83
April	97	4th	100	95	47	1[illegible]th	30	52	76	77
May	97	1st	99	92	4[illegible]	6th	30	44	7[illegible]	73
June	93	6th	100	93	47	11th	32	48	71	72
July	97	30th	99	91	37	17th	35	48	68	70
August	95	6th	99	92	48	18th	41	51	75	74
September	9[illegible]	6th	9[illegible]	96	40	10th	38	54	74	78
October	97	4th	[illegible]	97	[illegible]	[illegible]th	49	61	80	83
November	9[illegible]	1st	100	96	69	19th	43	61	84	83
December	97	25th	100	97	51	5th	41	64	80	84
Means, or totals	97		100	95	49		37	56	79	79

Bright Sunshine; Temp. of Air in Sun's Rays; Wind (Direction).

Months	Bright Sunshine: Greatest Daily Duration.	Date	Total of Month.	Per cent. of Possible Duration.	Temp. of Air in Sun's Rays: Highest.	Date.	Mean.	Direction: Relative Proportion of at 9 a.m.: N.	NE.	E.	SE.	S.	SW.	W.	NW.
	hr. min	On	hr. min.		Deg.	On	Deg.	No.	No.	No.	No.	No.	No.	No	No
January	2 45	23rd	12 50	5	73·0	28th	55·0	3	5	0	2	2	9	2	8
February	6 0	16th	21 20	8	84·0	12th	63·1	6	1	0	1	2	5	5	9
March	8 30	28th	79 30	22	99·0	30th	74·9	5	6	2	0	1	1	10	6
April	7 30	24th	60 20	14	98·0	15th	76·7	5	8	8	3	1	1	4	0
May	11 45	12th	104 55	21	107·0	30th	90·6	3	6	3	1	3	5	6	4
June	10 0	12th	95 5	19	104·8	22nd	100·2	5	5	6	2	1	6	2	3
July	11 0	28th	145 15	29	107·0	27th	101·1	4	1	0	0	4	6	11	5
August	9 15	19th	90 5	20	105·0	3rd	96·4	4	0	2	1	2	10	7	5
September	8 15	13th	110 5	29	107·0	13th	93·6	4	0	1	0	5	10	10	0
October	5 50	8th	62 0	19	99·4	1st	79·7	5	2	6	0	5	9	3	1
November	3 0	1st	12 55	5	76·0	1st	60·8	5	4	10	0	4	3	3	1
December	2 50	15th	11 16	5	70·0	6th	57·6	6	0	2	2	4	5	10	2
Means, or totals	7 13		805 35	18	94·2		79·1	54	38	40	12	34	70	73	44

Wind (Velocity and Pressure); Cloud.

Months	Velocity at 9 a.m.: Mean.	Highest.	Date	During 24 hours: Mean.	Highest.	Date	Total Registered in Month.	Pressure: Mean of all Daily Highest.	Mean of all Daily Hghst. of 8 Year	Highest.	Direction.	Date.	Mean of Highest of Month of 8 Years.	Mean Amount of Cloud
	Miles p'r hr.	Miles p'r hr.	On	Miles per d.	Miles per d.	On	Miles.	lb. per sq. ft.	lb. per sq. ft.	lb. per sq. ft.		On	lb. per sq. ft.	0–10
January	6·4	17·0	20th	144	348	27th	4464	1·88	2·89	7·50	S W	27th	12·09	8·1
February	3·2	11·8	1[illegible]th	94	246	12th	2643	1·31	2·64	10·75	S W	12th	9·62	9·3
March	8·7	24·0	5th	183	559	6th	5672	2·92	2·33	10·00	W	6th	9·75	7·5
April	6·9	12·0	3rd	132	218	3rd	3968	1·57	2·22	5·00	W	17th	7·72	8·2
May	5·9	12·4	2nd	130	228	2nd	4042	1·63	2·12	4·00	S W	2nd	7·41	7·1
June	6·9	14·4	27th	160	241	14th	4490	1·62	1·57	3·50	W	14th	6·28	7·1
July	6·5	10·4	15th	140	216	7th	4341	1·73	1·69	5·00	S W	7th	6·75	7·2
August	6·7	15·8	26th	148	493	26th	4603	2·34	1·67	13·50	S W	26th	7·59	8·2
September	8·3	19·8	[illegible]th	161	309	1st	4841	2·00	1·90	5·25	S W	2nd	6·19	6·3
October	6·1	17·3	14th	165	306	17th	5127	1·97	2·25	6·50	S W	16th	8·41	6·9
November	5·7	13·4	1[illegible]th	134	321	12th	4009	1·40	2·26	8·50	W	12th	9·34	8·2
December	6·2	18·0	3rd	165	326	11th	5115	2·20	2·48	8·00	S W	6th	9·62	8·2
Means, or totals	6·5	15·5		146	318		633·6	1·88	2·16	7·29			8·31	7·7

Rain.

Months	Number of Days it fell.	Greatest Daily Fall.	Date.	Amount Collected.	Mean of 22 Years	Mean of Seven Years ending with 1882, 65½ft. above surface of ground	Mean of 7 Yrs. endg. with 1882 at T'n Hall and Mid Ry Station on surface of ground.	Gr'ter fall on surface at Town Hall & Mid Stn than at 65½ft. above surface at Exch: Depth in Inches	Percentage of fall at Exch'ge
	No.	Ins.	On	Ins.	Ins.	Ins.	Ins.	Ins.	Per cent.
January	15	0·66	21st	1·53	2·62	2·209	2·474	0·265	11·2
February	0	0·00	—	0·00	1·74	2·609	2·972	0·363	11·4
March	17	0·23	16th	1·22	2·16	2·778	3·260	0·484	11·7
April	12	0·47	5th	1·61	2·05	2·516	2·835	0·319	11·2
May	22	0·29	24th	2·53	1·86	2·103	2·277	0·174	10·8
June	8	0·65	5th	1·03	2·21	2·837	3·011	0·174	10·6
July	16	0·29	2nd	1·80	2·89	3·401	3·641	0·240	10·7
August	22	0·65	18th	4·02	2·69	3·654	3·892	0·238	10·7
September	18	0·58	20th	2·04	2·61	2·894	3·229	0·335	11·2
October	21	0·64	14th	3·67	3·43	3·640	4·012	0·372	11·0
November	20	0·48	11th	2·96	2·91	3·421	3·828	0·407	11·2
December	20	1·02	10th	4·99	2·67	3·681	4·170	0·489	11·3
Means, or totals	190	0·50		27·20	29·84	35·741	39·601	3·860	11·08

METEOROLOGY OF BRADFORD FOR 1891.

Yearly Maximum and Minimum Atmospheric Pressure, Temperature, Humidity, Bright Sunshine, Wind Pressure, and Rainfall.

Year	Pressure. Highest. Reading of Barom during Year (Ins.)	Date	Pressure. Lowest. Reading of Barom during Year (Ins.)	Date.	Temperature. In Shade. Highest. R'ding of Maximum Thermom during Yr. (Deg.)	Date.	In Shade. Lowest. R'ding of Minimum Thermom during Yr (Deg.)	Date.	Last and First Frost of Seasons. Date of Last Frost.	Date of First Frost.
1869	30 290	Dec 6	28 500	Feb. 1	85·2	Aug 30	19 8	Dec 28	Mar. 27	Oct. 20
1870	30 264	Jan 19	28 308	Jan. 8	85 0	July 25	16 6	Dec 23	Mar 30	Nov. 9
1871	30 152	Mar 28	28 308	Jan. 16	84·0	Aug. 12	6·7	Jan. 1	April 11	Nov. 13
1872	30 166	April 6	28 070	Jan. 24	86·4	July 23	24 8	Mar. 27	Mar. 27	Nov. 19
1873	30 338	Feb. 18	28 022	Jan. 20	88·8	July 23	19 2	Feb. 24	Mar. 14	Nov. 5
1874	30·476	Mar. 6	28 276	Dec. 11	83·9	July 20	15·0	Dec. 31	Mar. 12	Nov. 11
1875	30 305	July 7	28 484	Nov. 10	83·0	Aug. 17	13 0	Jan. 1	Mar. 22	Nov. 26
1876	30 300	Jan. 15	28 070	Dec. 4	87 6	July 17	23·0	Jan. 9	April 15	Nov. 9
1877	30 358	Oct. 6	28 300	Nov. 29	80 0	June 19	20 0	Mar. 1	May 4	Oct. 18
1878	30 320	Mar 16	28 630	April 1	89 6	July 19	13 9	Dec 26	April 6	Nov. 9
1879	30 352	Dec. 13	28 600	Feb. 10	74·4	July 30	13·2	Dec. 7	May 10	Nov. 14
1880	30 332	Jan. 7	28 164	Nov. 16	81 3	Sep. 5	20 8	Jan. 20	Feb. 23	Oct. 20
1881	30 382	May 10	28 250	Oct. 14	83 3	July 6	12 0	Jan. 26	April 21	Oct 17
1882	30 544	Jan 18	28 452	Mar. 1	77 4	Aug. 12	18 6	Dec. 11	April 16	Nov. 12
1883	30 500	April 9	28 452	Sep. 2	76·2	July 3	19 8	Mar. 10	Mar 29	Nov. 12
1884	30 354	Oct. 5	28 376	Jan. 27	84·4	Aug. 12	26·5	Nov. 30	April 24	Nov. 24
1885	30 273	Mar 14	28 400	Jan. 11	82·2	July 27	22 1	Dec. 11	April 5	Nov. 16
1886	30 365	Nov. 24	27·652	Dec. 8	79 5	July 3	17 4	Mar. 7	April 30	Dec. 2
1887	30 412	Feb. 8	28 328	Nov. 3	82·8	July 9	21·1	Jan. 17	April 17	Oct 12
1888	30 333	Jan. 10	28 410	Mar. 28	80 4	June 27	19 2	Feb. 14	April 8	Oct. 2
1889	30·358	Dec. 5	28·460	Mar. 20	77·5	Aug. 1	21·3	Mar. 4	Mar. 22	Nov. 27
1890	30 376	Feb. 23	28 315	Jan. 23	76·4	Sept. 10	18 4	Dec. 22	Mar. 10	Oct 28
1891	30 394	Oct. 31	28 060	Nov. 11	79 9	Sept 12	12 0	Jan 19	May 18	Nov. 25
Means	30 345		28·295		81·9		18 0			

Year	Temperature. In Sun's Rays. Highest. Reading of Solar Thermom. during Yr. (Deg.)	Date.	Humidity (Complete Saturation = 100). Highest. Degree of Humidity during Yr (0–100)	Date.	Lowest. Degree of Humidity during Yr (0–100)	Date.	Bright Sunshine. Greatest Daily Duration (hr min)	Date.	Total of Year (hr. min)	Per cent of Possible Duration.	Wind Pressure. Highest (lb. per sq ft)	Date.
1869	127 7	Aug. 30	99	Feb 8	42	Sep 24						
1870	127 5	July 25	98	Jan 29	48	Mar. 8			...			
1871	128 7	July 17	98	July 7	43	Nov. 2	...	...	...		...	...
1872	124 8	Aug. 19	100	Mar. 22	46	Sep. 23	...	...	...	...	...	...
1873	124 5	July 23	100	Dec. 11	41	Mar. 26	...	...	...	...	...	...
1874	125 8	July 20	100	Feb. 6	42	May 18	...	...	...	...	...	...
1875	122 0	July 6	100	Jan. 23	43	July 6	...	...	...	...	...	...
1876	125 6	July 16	99	Oct. 4	46	May 5	...	...	...	...	...	...
1877	116 4	June 19	100	Oct. 29	35	May 23	...	...	...	...	...	...
1878	118 2	July 22	99	Jan. 13	53	Aug 9	...	...	...	...	...	...
1879	101 2	Aug. 13	100	Oct. 7	51	Dec. 12	...		...	...	...	...
1880	112 0	Aug. 13	99	Dec. 15	50	May 30	...	...	...	...	...	...
1881	116 5	June 1	98	Oct. 14	38	May 31	...	...	...	...		
1882	108·0	Aug. 9	99	Nov. 5	36	May 18	...	...	...	...	...	...
1883	107 6	May 17	99	Dec. 26	30	April 9	...	...	...	...	...	...
1884	107 8	Aug 9	98	Jan. 23	30	May 22	...	...	...	...	24 00	Jan. 24
1885	113 6	July 27	100	Jan. 23	32	June 4	...	...	...	...	15 25	Dec. 4
1886	108 8	July 5	99	Jan 12	32	May 4	11 45	July 6	851 48	19	18 00	Dec. 9
1887	107 6	July 9	100	April 21	35	July 9	12 40	July 3	1120 58	25	15 00	Feb. 4
1888	110 0	Sep. 15	99	Mar. 15	39	June 11	13 40	May 24	984 20	20	13 00	May 4
1889	115·2	June 23	99	April 22	39	June 26	12 15	July 8	827 45	18	12·00	Feb. 9
1890	111·0	June 16	99	May 11	31	May 29	14 25	May 25	824 5	18¼	14 0	Jan. 19
1891	107 0	July 27	100	Feb. 20	37	July 17	11 45	May 12	805 35	18	13 50	Aug. 26
Means	116 0		99		39		12 45		885 45	20	15·59	

Year	Rain. Total for Year (Ins.)	Mean Y'rly Rainfall at Town Hall and Mid Rly Stn on surface of g'nd (Ins.)	Gtr fall on srfce at Tn H'll & Mid Stn than at 65½ ft ab've surf at Exe. Depth in Inches (Ins.)	Percentage of fall at Exch'ge (Per cent)	Greatest Daily Fall during Yr. (Ins.)	Date.	Snow. Last and First Snow of Seasons. Date of Last Snow.	Date of First Snow.
1869						...	April 3	Oct 19
1870	24 120	...	...	...	0 820	June 18	Mar 24	Nov 15
1871	21·640	...	...	...	0 985	June 16	Mar. 15	Nov. 16
1872	42 060	...	...	...	2 490	June 19	May 11	Nov 13
1873	21 440	...	...	...	1 200	Aug. 4	April 25	Jan 3, '74
1874	23 560	...	...	...	0 740	Dec. 7	May 9	Nov. 26
1875	30 280	...	...	...	1 700	Nov. 15	Mar 12	Nov. 9
1876	35 270	39 788	4 518	11 28	1 810	Oct. 9	April 12	Nov. 8
1877	40 650	45 499	4·849	11 19	1 420	July 16	May 19	Oct. 15
1878	35 434	39 010	3 576	11 01	1 220	Aug 14	April 1	Nov 8
1879	28 017	30 298	2 281	10 82	1 020	June 8	May 7	Nov. 20
1880	35 690	39 616	3 926	11·10	1 710	Oct. 27	Mar. 2	Oct. 27
1881	35 434	39 892	4 458	11 26	1 435	Oct 13	April 20	Oct 29
1882	39·683	43 103	3 420	10 86	1 608	Dec. 6	Mar 21	Nov. 19
1883	34 396	...	...	...	1 338	Sep. 26	Mar. 24	Nov. 10
1884	27 657	...	...	...	1 170	Jan. 23	Feb 28	Nov. 23
1885	25 699	...	...	...	1 208	Sep 3	May 7	Dec. 9
1886	35 993	...	...	...	2 130	July 26	May 12	Nov. 6
1887	18 665	...	...	...	0 810	Oct. 9	May 21	Oct. 14
1888	25 646	...	...	...	1 050	Nov. 3	April 8	Oct. 1
1889	22·141	...	...	...	0 590	Mar. 9	Mar. 21	Nov. 25
1890	25 730	...	...	...	1 485	Jan. 22	April 13	Oct. 21
1891	27 303	...	...	...	1·020	Dec. 10	May 17	Nov. 26
Means	29 841	39·601	3 860	11·08	1 316			

EXPLANATION.

The observations are made at nine a.m., and, with the exception of maximum and minimum thermometer readings, again at three p.m.

The highest and lowest barometric readings for each month, also the monthly range, are given as recorded; while the mean pressure is deduced from bi-daily observations corrected for index error, capillarity, temperature, and diurnal range. To correct for altitude or reduce to sea level (the air temperature being 48 degrees and barometer 30 inches at sea level), add ·401 inch to the heights given.

A remarkable instance of barometric depression occurred on the 8th December, 1886, when at 8 40 p.m. the mercury of the Exchange barometer had fallen to 27·456 inches only—the lowest reading on record here. The cyclone indicated by this depression was the cause of great loss of life and property, extending over an unusually large district.

All thermometric observations and deductions are given in degrees Fahrenheit.

The adopted mean temperature of air is deduced from the dry bulb and the maximum and minimum readings; the temperature of evaporation from the dry and wet bulb and the maximum and minimum readings. The dew point, elastic force of vapour, humidity, &c., are deduced from bi-daily readings of the dry and wet bulb hygrometer, by Glaisher's Hygrometrical Tables, sixth edition.

Bright sunshine is recorded in hours and minutes by glass sphere on cards, known as Campbell's recorder, fixed on Professor Stokes' zodiacal frame.

The solar thermometer has a black bulb enclosed in a vacuum.

The direction, velocity, and pressure of wind are recorded as indicated by anemometers fixed 10½ feet above the ridge of roof of Exchange. The velocity per hour at 9 a m. is determined from anemometer readings made one minute and a half before and a like period after that hour, by multiplying the difference thereof by 20. The pressure is given in pounds avoirdupois per square foot.

The amount of cloud is estimated by a scale ranging from 0 to 10.

The rain gauge is fixed upon the top of central roof of the Exchange, at an elevation of 65½ feet above the surface of the ground and 395 feet above mean sea level. As rain gauges on the summit of buildings are generally found to collect less rain than when placed upon the surface of open ground adjacent thereto, steps were taken in 1875 to determine to what extent this was the case with the Exchange rain gauge, when two additional gauges were provided and fixed upon the surface of adjacent open spaces, one near to the Town Hall, the other near to the Midland Railway Station, between which the Exchange gauge is situate about midway, and the surface of ground about the same height. At both of these gauges, as well as at the Exchange gauge, daily observations were made from the commencement of 1876 to the end of 1882, a period of seven years, when the surface gauges were removed in consequence of the ground they occupied being no longer available for the purpose. The particulars of these gaugings are set forth in tables. The results show that the mean yearly rainfall on the surface of ground for the seven years ending with 1882 is 3 86 inches, or 11·08 per cent, greater than at the summit of the Exchange. The mean yearly rainfall recorded at the Exchange for the twenty-two years ending with 1891 is 29·841 inches. By adding 11·08 per cent. thereto the mean normal rainfall of central Bradford for such period is found to be 33 147 inches per annum. There are good grounds for concluding that the smaller amount of rainfall collected on the Exchange—and on buildings generally—than on the surface of ground is due to the varying direction and force of wind there producing different currents and eddies, which prevent due precipitation on the top or ridge of roof where the gauge is fixed. The rainfall of 1869 was collected by a gauge placed on the ridge of outer roof of Exchange, near to the north-west corner thereof. This position not being deemed quite satisfactory, the gauge was removed at the end of that year to the ridge of central roof—the place it has since occupied. To avoid risk of inaccurate results, the rainfall of 1869 is omitted from these returns.

The instruments with which the observations are made have been verified by comparison with the standards at Kew Observatory.

122/1922/collated OK.

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THE GEOLOGY OF THE COUNTRY BETWEEN GRASSINGTON AND WENSLEYDALE. BY J. R. DAKYNS, F.G.S., OF H.M. GEOLOGICAL SURVEY.

In my paper on "the changes of the Lower Carboniferous Rocks in Yorkshire from south to north," published in the Society's Proceedings for 1891, I gave a general sketch of the geology of the country between Skipton and Kettlewell. I wish now to extend and supplement that sketch with a few details.

It was pointed out in that paper that there are at Kettlewell upwards of 36 yards of measures between the Middle Limestone and the Millstone Grit. These measures form a series of alternating beds of limestone and plate; the details may be seen in the accompanying section, which was kindly given to me by Mr. John Place, of Kettlewell, the manager of the Providence Mine.

Section of measures met with in the Providence Mine :—

		Yds.	Ft.	In.
Millstone Grit.	Grit, Girdles, and Cover	10	0	0
	Plate and Coal	0	2	0
	Grit	10	0	8
	Girdles and Plate	8	0	0
	Grit	4	0	0
	Girdles and Shale	7	1	8
	Coal	0	2	0
	Plate	8	0	0
	The Bearing Grit	31	1	3

		Yds.	Ft.	In.
Limestone Shales or Yoredale Series.	Plate	12	0	0
	Limestone	2	0	0
	Plate and Lime Girdles	5	0	0
	Limestone	3	0	0
	Plate	1	0	0
	Limestone	2	2	0
	Plate and Girdles	6	0	9
	Limestone	2	2	8
	Plate	0	0	8
	Limestone	2	0	0
	Plate	1	1	6
	Limestone	1	0	8
	Plate	0	0	8
	Limestone	12	0	0
	Limestone	20	0	0
	Plate	6	0	0
	Limestone	16	0	0
	Dirt Pot Grit	3	0	0
	Plate	1	1	0
	Blue Grit and Plate	3	1	6
Carboniferous Limestone.	Limestone	1	2	6
	Plate	1	0	0
	Limestone	11	2	0
	Limestone	27	1	0
	Limestone, mussel or pipe-stopple	5	0	0
	White Limestone	7	0	0
	Dark Limestone, in thin posts	6	0	0
	White Limestone	11	0	0
	Clay Bed	0	0	4
	Grey Limestone	5	0	0
	Clay Bed	0	0	4
	Grey Limestone, thickness not given			
	Clay Bed	0	0	6
	Thick White Limestone			

There is no recognisable bed answering to either the Underset or to the Main Limestone, but these beds soon make their appearance as we go north. The latter forms a plateau at Coverhead, with a fine escarpment towards Wharfedale. It has a thin capping of chert over which comes the Bearing Grit.

I will now briefly describe the run of the Millstone Grits. The lowest beds, viz., the Grassington Grits, strike west from Grimwith Fell towards Grassington ; near this village they turn north and run by the mines across Grassington Moor, Black Edge, and Conistone Moor. They are thrown down to the north at Yarnbury by New Rake Vein, then up by Beaver Vein, and after several small breaks are finally thrown up to the north by the Bycliffe or Black Vein. This great vein runs from Bycliffe along Groove Gill, crosses Gateup Gill, where the fracture is seen, and thence crossing north of Wigstones it runs down Stony Groove to Merryfield ; and thence into the Craven Fault near Pateley Brig.

This vein is the most northern and greatest in throw of the many veins on Grassington Moor; they seem to be all more or less connected with the Craven Fault, with which they make but small angles or are roughly parallel.

The Red Scar Grit occupies the northern part of Appletreewick Moor and Hebden Moor. It forms a fine escarpment along the sides of Gateup. It is thrown up to the north by the Bycliffe Vein, so as to form the escarpment of Rather Standard. At the north end of this feature it seems to be thrown up on the west, so that the top of the rock which runs up Henless Beck is now found in Meugher Dike. This top is well-marked by the tesselated limestone, which is found both in Henless Beck and in Meugher Dike.

The rock forming Sand Haw seems from its position to be part of the Red Scar Grit; it is a peculiar rock, being a hard close-grained Siliceous Sandstone ; it is somewhat similar to the Red Scar Grit of Wolfry Crags, but is quite unlike the general character of that bed. It is used for making whetstones, for which purpose it is fetched a long way.

At Hunter Sleets (or Anter Sleets) the section of the Lower Grits is as follows :—

	Fths.	Yds.	Ft.	Ins.
Grit	—	8	—	—
Plate	—	1	—	—
Coal	—	—	—	6
Shale	—	—	—	5 to 10
Grit	about 20	—	—	—
Plate	about 3	—	—	—
Coal	—	—	1	—
Soapy Grit ...	2 or 3	—	—	—
Main Limestone ...	—	—	—	—

Further north, the Lower Coal lies on the Cherty top of the Limestone.

Above the Grassington Grits we have, under Whernside, something like 170 feet of Shales and Sandstone; then a thin Siliceous Grit at Pinlow Pike; another 140 feet of Shales and Sandstone takes us to the base of the Red Scar Grit. This Grit is here about 90 feet thick. Above it we have 160 feet of Grits and Shales extending up to the base of the Whernside Grit. This grit, which forms the summit of Great Whernside, has generally a base of flagstone; the upper part of this rock is a siliceous "Homerstone Grit. "Homerstone" is a local term applied to a grit that contains large pebbles of quartz. The Whernside Grit, which is supposed to be the same as the Lower Follifoot Grit, is the highest Millstone Grit known anywhere in Upper Wharfedale. The part of the country including Great Whernside and Coverhead is illustrated by one of the Geological Survey's Sheets of Horizontal Sections. In the upper part of Coverdale there are four Limestones cropping out, viz., the Main and Middle Limestones, and between them two other limestones. Of these latter the lowest is the limestone which occurs at Walden Head, above Fairy Scar (see below), and passes down Walden into sandstone. The limestone next above it is probably the Underset. Over it come irony shales, and over them the Main Limestone. This bed, as was long ago pointed out by Phillips, is thicker on the north-west side of Coverdale than it is on the south-east. The following is a general table of the strata at Coverhead, and hard by, the beds below the top of the limestones only appearing in Wharfedale :—

		Ft.
	Sandstone	90
	Shale	110
	Sandstone	50
	Shale	90
	Thin-tesselated Limestone	
Red Scar Grit	Grit } = Upper Kinder Scout Grit	25
	Coal	
	Grit	25
	Shales	125
	Sandstone, hard siliceous rock of Pinlow Pike ...	25
	Shale, with thin variable sandstones	140
	Coal	
	Sandstone and Shale	50
	Sandstone } Lower Kinder Scout Grit	35
	Coal	
	The Bearing Grit	120
	Coal	
	Cherty Beds	0 to 50
	Main Limestone	95
	Flags	25
	Plate	75
	Limestone, probably = Underset	20
	Plate	25
	Sandstone and Chert	17
	Plate	23
	Limestone	30
	Plate	10
	Middle Limestone	120
	Plate	22
	Simonstone Limestone	90
	Dirt Pot Grit	25
	Carboniferous Limestone, over	700

The cherty beds between the Main Limestone and the Millstone Grit are first seen, as one goes north, in Lord's Gill.

At the head of Coverdale the grits of Grassington Moor are in full force, but they rapidly deteriorate down dale into a mass of sandy shales and thin poor sandstones. This change sets in immediately east of Crab Gill. It is quite possible that these degenerate representatives of the Lower Millstone Grits are, in Wensleydale, equivalent to the beds known as the "Ten Fathom Grits." If so, this will be an additional and very strong argument in favour of my view, that the proper line to take as the base of the Millstone Grit is the top of the Little Limestone.

The most important bed in Coverdale, above the Grassington Grits, is a thin but hard siliceous sandstone, like ganister. This rock forms a feature at the south-west end of Little Whernside. It is probably the same rock as that seen at Pinlow Pike south of Great Whernside.

The next important rock is the Red Scar Grit. This bed retains its character of a coarse felspathic grit. It has also in Coverdale as in Wharfedale a coal associated with it. In Wharfedale the coal lies in the middle of the grit, which is a double rock. In Coverdale the coal lies near the top of the lower or felspathic part of the rock ; the upper part is a white siliceous ganister-like grit with rootlets, over which comes the tesselated limestone. It is remarkable how often limestones (generally thin) are connected with coals or seat-earths.

The Limestone is overlaid by Shales containing a thin Sandstone, and the Shales are succeeded by a Grit forming bold crags on Gateside Fell. It is overlaid by Shales and Sandstone, and these by a Grit forming another set of bold crags. This rock is a coarse Grit overlaid by white siliceous close-grained Sandstone, like Ganister, containing Stigmaria. Fragments of Sandstone containing shells are strewn about on the moor. These are doubtless fragments of the Shell-bed. The frequent occurrence of Ganister above the Red Scar Grit is important, and it is noteworthy that even as far south as Derbyshire beds of Ganister are apt to occur about this horizon, *i.e.*, above the Kinder Scout Grit. In Coverdale these Ganisters become numerous and characteristic of the beds. It will be borne in mind that these beds all lie below the horizon of the so-called Third Grit of Lancashire or the Middle Grit of South Yorkshire. A section across Scrafton and Colsterdale Moors gives the following thickness of beds above the Red Scar Grit Coal :—

	Ft.			Ft.
Shale	30			
Lower Follifoot Grit ..	50			
Measures	135	=	Shale ...	30
			Sandstone ...	35
			Shale ...	25
Sandstone.. ...	45	=	Caponstone ...	75
Shale	35	=	Shale ...	40
Grit	20 or 30	=	Grit ...	30
Coal				

The little Limestone above the Red Scar Grit is seen below Braithwaite Moor. It is here quite different in character from what it is to the south. It is a coarse encrinital grey Limestone, containing rolled fragments of encrinites, and it is false-bedded, the dip of the false bedding being to the north-east. The section of the beds in connection with it is as follows :—

	Ft.	Ins.
Limestone ... ... (seen)	3	0
Flaggy Siliceous Sandstone	3	0
Grey Clayey Shale	3	0
Coal	0	3 to 4
Grey-seat Earth, Clay and Stone	2	6
Soft Red and White Felspathic Grit	3	0
Hard White Calliard		

A coal pit on Braithwaite Moor gives the following section :—

	Ft.
Gravel	30
Grit and Girdles	21
Grit Rock	18
Grit and thin beds	30
Blue Plate	12
Middle Grit Rock	42
Plate	48
The Capon Hardstone	36
Coal (4 inches)	
Hardstone (4 feet)	

	Ft.
Plate	36
Limestone (3 feet)	
Grit (3 feet)...	
White bed	
Girdles	
Coal...	

A section drawn across the outcrop of the beds gives the following approximate thicknesses :—

	Ft.
Red Scar Grit...	60
Shale	35
Sandstone	15
Shale	95
Sandstone	15
Shale	50
Grit	65
Shale	55
Main Limestone	

I will now describe the adjoining dales, Walden and Bishopdale. The lowest rock seen is a Sandstone in the bed of the stream below Blue Bridge, on the north side of West Burton. This Sandstone is also said to have been reached in mining just below the foss of Bow Bridge, near Thoralby. A sandstone, which is probably the same as the above, occurs in the bed of the Yore, at Redmire Foss, overlaid by Limestone.

At West Burton the section is—

Hardra Scar Limestone, 2 to 3 fathoms.
Grit, 2 to 3 yards.
Plate, 1 fathom.
Limestone, 10 fathoms.
Grit, seen in stream below Blue Bridge.

At the bridge a powerful vein crosses which throws down the beds on the south.

The upper limestone of the above section is that on which Swinethwaite stands, and which we identify with the Hardra Scar Limestone. Above the Swinethwaite Limestone come measures consisting mainly of sandstone, and above these the limestone on which West Witton stands. This we identify with the Simonstone Limestone. Above it come measures consisting of shale and sandstone, the latter being particularly developed round the gable end between Bishopdale and Walden, where it lies immediately on the limestone. Above these measures comes the Middle Limestone. This limestone is between West Burton and West Witton far thicker than usual, being as much as 250 feet thick. It generally has a sandstone about 10 feet thick at its base. The Middle Limestone is overlaid by a series of sandstones and shales with thin limestones. The sandstones generally predominate, but they thin away up Walden, and a little limestone overlying them swells out into a bed of respectable thickness, which entirely replaces the sandstone at Walden Head. The shales connected with these beds, and lying immediately above the Middle Limestone, are highly ferruginous.

Above the Sandstone-Limestone Series come shales and then the Underset Limestone. This is a very variable bed in this part of the country ; it is sometimes absent altogether or too thin to be seen ; at other times it is an important rock nearly equal to the Main or Middle Limestones. It sometimes has a workable coal seam below it, and in the lower part of Walden there occurs above it a hard ganister-like sandstone with rootlets, which has been found useful for walling and other purposes. The limestone itself is sometimes impure towards the top

Over these beds come shales, and then the Main Limestone usually with a sandstone base.

The limestone consists of two parts, a lower part of pure limestone, and a cherty part, above which come the sandstones and shales of the Millstone Grit Series.

At or near the base of the Millstone Grit is a workable seam of coal, which has been got at Petticoat Rake, adjoining Fleensop. The coal was nine inches thick. It is not persistent, however, for it lies in "pools and gutters" between "rigs of chert." It is in places three feet thick ; then deteriorates and "nips out." The cherty beds consist of dun limestone, grit and chert.

The highest bed of Millstone Grit occurring west of the Cover is that forming the top part of Penhill. This we correlate with the Red Scar Grit, or the upper part of the Kinderscout Grit.

Horizontal sections drawn across Wasset Fell give the following thicknesses of the beds in this district below the Millstone Grit:—

	Bishopdale. Ft.		Walden. Ft.
Millstone Grit			
Main Limestone	90	to	160
Measures, mostly Shale... ...	90	,,	70
Sandstone ... about	10	,,	10
Underset	50	,,	50
Sandstone	20	,,	30
Measures	160	,,	140
Middle Limestone	90	,,	100
Sandstone	10	,,	—
Sandstone, Shale, and thin Limestone	90	,,	80
Limestone of West Witton ...	30	,,	35
Sandstone and Shale	50	,,	50
Hardra Scar Limestone ...	50	,,	40
Sandstone	50	,,	—
Carboniferous Limestone ...	300 feet seen		

With this may be compared a section across the beds above West Witton, which gives the following thicknesses:—

	Ft.
Cherty Beds	140
Main Limestone	75
Shale and Sandstone	150
Limestone	10
Shale	50
Limestone	30
Sandstone	40
Middle Limestone	250
Sandstone	10
Shale	50
Limestone	20
Shale	30
West Witton Limestone	

The lowest Millstone Grit or the Grit of Grassington Moor continues in force as a massive coarse grit all down Walden, but on Burton Moor it has the form of a massive well-jointed sandstone, and then rapidly deteriorates northwards into a mass of sandstones and shales. The sandstones however forms excellent flags, for which purpose they are extensively quarried on the northern face of Penhill.

The following parallel sections represent the beds on the south-west and north sides of Penhill; and the Millstone Grit portions of these sections may be superposed over the section given above to get a complete series from West Witton to the summit of Penhill.

	North Side. Ft.		South-west Side. Ft.
Coarse Grit = Red Scar Grit...	75 seen		75 seen
Thin Shale	10		10
Massive Sandstone	40		30
Shale	95		85
Sandstone	10		20
Shale	20		10
Sandstone	20		30
Shale	20		40
Sandstone	20	The Grassington Grits	140
Shale	30		
Sandstone	50		
Shale	60		20
Cherty Beds	80	The Main Limestone	130
White Limestone	70		

Black Scar, on Penhill, formed of the topmost beds of the above section, gives the following sequence of rocks:—

5. Coarse felspathic grit forms the summit plateau, with ganister lying about.

   Thin shale.

4. Massive sandstone: very variable; in places calcareous; dies out eastward.

   Shale: sandy micaceous and blue.

3. Sandstone: calcareous; seen on the road at the east end of Black Scar, about 50 yards from the elbow, just above the 1,500 contour line; it runs to the spring on the east side of the road.

Shales : sandy micaceous ; concretionary and jointed, bluish in colour.

2. Sandstone : calcareous ; dies out or thins eastward.

Shale.

1. Sandstone : calcareous ; dies out or thins eastward.

On the zigzag road leading to the top of the hill, east of Black Scar, the beds are well shown. No. 3 is a flaggy micaceous sandstone. In the overlying shales a sandy band occurs from which water issues, and sinks in No. 3.

The topmost grit is the Red Scar Grit. Ganister is found above it.

In the above paper, taken in conjunction with the previous one, I have endeavoured to describe, without going into minute details, the chief changes which the rocks undergo from south to north. These may be summed up as follows :—

1. The Yoredale type of beds can hardly be said to exist south of Kettlewell. From Grassington northwards the Carboniferous Limestone becomes split up with beds of sandstone and shale ; and north of Kettlewell important rocks, to wit the Underset and Main Limestones, set in ; so that finally we have in Yoredale the well-known type of beds that goes by that name.
2. In the southern part of its course the Main Limestone is immediately overlaid by the Millstone Grit ; but northwards a set of cherty beds comes in between the pure limestone and the grit ; at first, as at Coverhead, this is merely a thin cherty top to the limestone, but this gradually develops into a series of cherty beds, sandstones, and shales.
3. Owing to the deterioration of the lowest Millstone Grit in Coverdale and on the slopes of Penhill, it is somewhat uncertain what line further north should be taken as the Millstone Grit base. I have suggested the top of the Little Limestone so as to keep on one horizon.
4. It is important to notice that the siliceous grits and ganister-like rocks that occur in the Millstone Grit Series above the Kinderscout Grits, become more pronounced northward, so that at length they are regular ganister measures, similar to the ganister measures of the lower part of the coal measures,

THE FLAMBOROUGH DRAINAGE SECTIONS. BY G. W. LAMPLUGH, F.G.S.

During the past winter the village of Flamborough has been thoroughly drained, and the deep trenches cut for this purpose revealed some excellent sections of the drift deposits which cover the chalk over the greater part of the headland.

The village stands on slightly undulating ground, from about 120 to 150 feet above the sea-level, and is nearly a mile from the nearest point of the sea-coast. In a recently-published description of the drifts of the headland* I have traced the course of a well-marked chain of gravel mounds for four miles south-eastward, along the northern edge of the promontory from Speeton to Thornwick, and thence southward across the headland into Bridlington Bay. This chain, which seems to have had its origin at the margin of the ice-sheet, is generally found to lie not far within the edge of the area covered by the glacial deposits; and while the drifts to the seaward of the mounds almost everywhere overspread the old chalk surface in thick masses, obliterating its minor inequalities, they form to the landward only a thin superficial covering, which soon thins out and entirely disappears. Flamborough lies in the bend of this chain of mounds, and consequently, as the drainage sections showed, the drifts thin away rapidly to the westward, but thicken in every other direction from about the centre of the village. Windmill Hill at the north end of the village, and Beacon Hill at the opposite extremity, form parts of this chain.

In describing the drainage sections I will commence at the outfall, and follow the line of the main drain to its termination, noticing the branches on either side in passing their points of junction.

The outfall is on the south side of the headland, in a short shallow ravine known as Hartendale Gutter, which runs back from the cliff about half-way between Danes Dykes and South Sea Landing. The cliff section at this place is described (though not figured) in the paper already referred to (p. 397). The drainage-trench, averaging 4 feet in depth, ran for some distance in the ravine, and then along the south-western rim of Beacon Hill, the great sand and gravel mound which forms the most conspicuous feature of the south side of

* Quart. Journ. Geol. Soc., vol. xlvii., p. 384 (August, 1891).

the Head. From this point its course is shown in the accompanying ground-plan of the village. (Pl. v.)

I was not aware of the commencement of the work until the trenches had been filled in between the outfall and the village, but from the description given to me by the engineer, and from the heaps of excavated material it would appear that this section was cut almost entirely through sand and gravel, evidently the continuation of the Beacon Hill deposit, though there may have been a thin capping of red earthy boulder clay in places.

The branch which strikes off to the right through Beacon Farm Lane and thence northward to the Church, was also excavated to a depth of from 5 to 7½ feet, chiefly drift-gravel and sand, the finer gravel sometimes containing a few crumb-like fragments of marine shells, such as are found in similar gravels in the Cliff Sections. Towards the termination of this branch the upper portion of the gravel underlying the surface soil became very clayey and contained numerous large sub-angular erratics. It resembled, in fact, a much-weathered boulder clay, and probably marks the edge of the Upper Boulder Clay which is seen in most of the sections further west.

Following the line of the main drain, gravels, sometimes consisting mainly of large flat pebbles of chalk and sometimes mainly of erratic pebbles, continued to predominate as far as the corner of the Bridlington Road; and the shallow branch (averaging 6 feet) which struck westward along the road was also laid in similar gravels. In the opposite direction, however, along Church Street, the main drain passed through a constantly increasing thickness of red boulder clay immediately under the surface, with irregular beds of sand and gravel below, the depth of the sections being about 8 feet.

At the corner of Tower Street, in a section of 10 feet in depth, the sandy beds had dwindled to an intermittent seam of less than one foot in thickness, covered by about 6 feet of tough red boulder clay. Below the sandy seam rubbly chalk was found passing downward into solid white chalk without flints. I had not suspected that the chalk at this point lay so near the surface, though the presence of an old disused chalk pit in Carter Lane, 300 yards to the north-west, proved the rapid rise of the top of the rock in that direction.

From this point the trenches, from 13 to 17 feet deep, reached the chalk almost uninterruptedly throughout the whole length of Tower Street. Its surface was, however, very irregular, occasionally rising and sinking suddenly from within 5 feet of the road level to a depth of 12 feet or more. The drift deposits, still consisting in their lower part of sandy material with tough red clay above, filled up all these inequalities and presented a level surface.

The first short branch which passed out from Tower Street on the right did not reach the chalk in a depth of 14 feet, and showed a rapid thickening in that direction of the gravelly portion of the drift.

The shallow branch to the left, 5 to 10 feet deep, along Carter Lane on the other hand, reached the chalk after passing through only three or four feet of red boulder clay, thus proving the rapid attenuation of the glacial beds in that direction. The clay in this section contained many large boulders of basalt, sandstone, carboniferous limestone, etc.

The main drain turns sharply to the right through Cross Street. Here the chalk sank gradually out of reach, and the drifts proportionately thickened.

In the southern part of North Street the trenches, 15 feet deep, were filled in before I had an opportunity to examine them, but they have been described to me as consisting of an irregular mixture of boulder clay and sandy gravel, the different patches of gravel varying much in appearance, as is so commonly the case in these deposits. The two shallow branches to the right, along Allison Lane and through School House Lane (both ending with a depth of five feet), passed through the red Upper Boulder Clay into stratified beds of drift beneath it, and in both instances in going eastward the clay disappeared, and gave place to rough clayey water-yielding gravels.

Following the main drain, one of the deepest portions of the trenches was reached at the corner near the "Rose and Crown," where a branch leads off to the north side of the North Mere. Here the excavation was carried to a depth of $16\frac{1}{2}$ feet, and was wholly in the glacial deposits. The lowest bed was a mass of very dark earthy boulder clay containing many small pebbles of chalk. It resembled in every respect the Basement Clay of the cliff sections, and I have no hesitation in identifying it as an inland prolongation of that deposit. Its occurrence at this point is interesting as showing the presence of the division to within a short distance of the edge of the drift-covered area, and beyond the range of the gravel mounds.

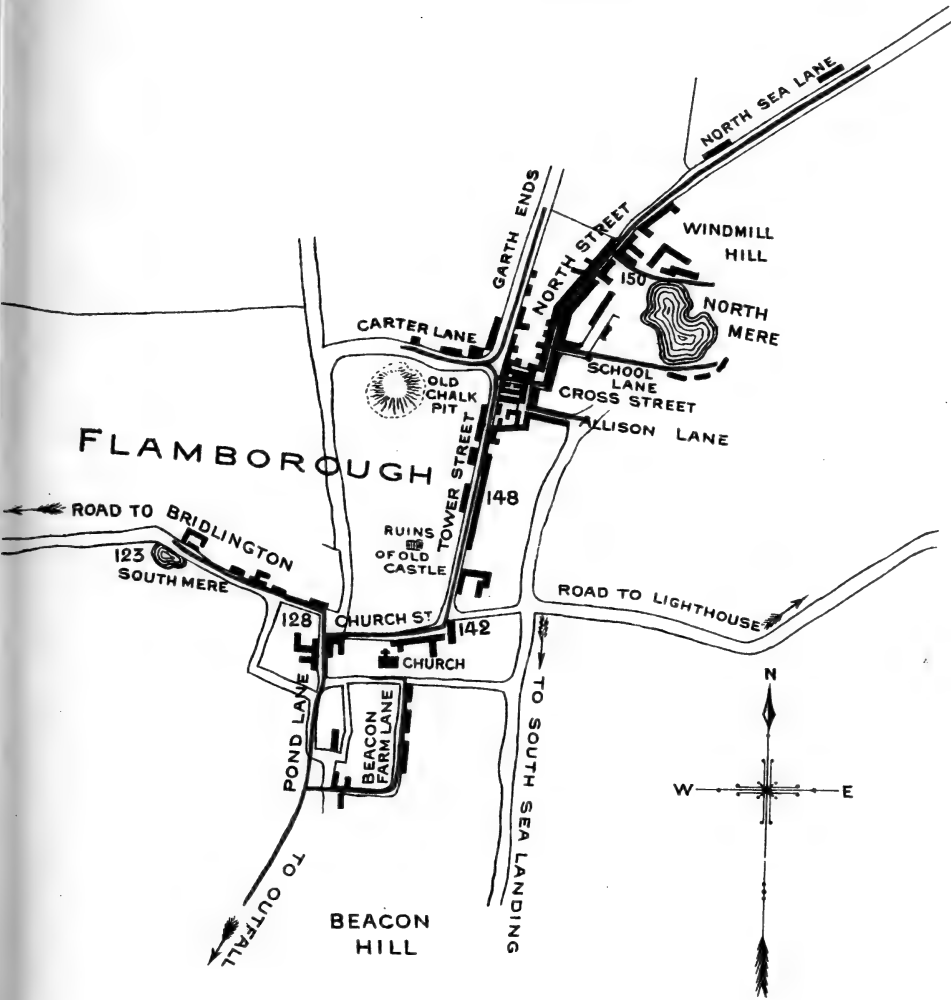
The Basement Clay was seen for only a few yards and then lost through the rise in the bottom of the trenches, which from this point became rapidly shallower, both along the line of the main drain and in the above-mentioned branch. This branch, like all the other trenches leading eastward, terminated in earthy gravel with much water. The main, along North Sea Lane, was laid at an average depth of only 9 feet, and towards the end of the drainage system revealed nothing except the Upper Red Boulder Clay. As already mentioned numerous far-travelled boulders, chiefly carboniferous rocks and basalts, were thrown out during the excavations. Some of these were of large size, the largest being a block of basalt lying in the upper clay in Carter Lane, whose full dimensions were not ascertained, as it was found easier to pass the pipes beneath it than to remove it. The portion exposed measured about 5 feet $\times$ $2\frac{1}{2}$ $\times$ 3.

To conclude these notes I will recapitulate the points on which these sections seem to me to have yielded useful information.

1. They show the rapid attenuation of the drift in a westerly direction from the sea-coast.
2. They prove the extension of the Basement Clay inland over some portion of Flamborough Head.
3. They indicate that the Basement Clay is overlapped by the Intermediate Stratified Series,* which in some places rests directly upon the Chalk.
4. They yield further evidence of the close connection existing between the Intermediate Stratified Series and the Upper Boulder Clay.

My best thanks are due to S. Dyer Esq., of Bridlington Quay, under whose directions these works were carried out, for his kindness in allowing me to examine his plans, and in supplying me with measures and with much information with regard to some of the sections which I was unable to examine.

* Vide supra cit. pp. 400 and 404.



GROUND-PLAN OF FLAMBOROUGH

Scale, SIX INCHES TO ONE MILE.

FOSSIL POLYZOA: FURTHER ADDITIONS TO THE CRETACEOUS LISTS.

BY GEORGE ROBERT VINE.

When, years ago, I began the study of the Fossil Polyzoa of the British rocks, and commenced the serial descriptions published in the Proceedings of this Society, really good collections were almost unknown to science. Lists of species derived from different horizons were also difficult to get at. McCoy in his various Palæontological works; Professor Phillips' in the Geology of Yorkshire (Carboniferous part), and also in his "Devonian Fossils"; described and illustrated species derived from Carboniferous and Devonian Rocks. Lonsdale, in Murchisson's Siluria, added considerably to our knowledge of forms found in the still lower rocks; then, in 1854, Professor Morris catalogued all the species known to science found in British Palæozoic Rocks, and his lists were constantly referred to whenever new additions had to be made. Since then, but still within the limits of 20 years, very great additions have been made to Palæozoic lists by the Messrs. Young, of Glasgow, by Mr. Robert Etheridge, jun, and by myself. The Permian Polyzoa, however, had been ably dealt with by Professor King in his Monograph of Permian fossils, and also by Mr. Kirkby. (Permian of S. Yorkshire, Quart. Journ. Geol. Soc., vol. xvii., p. 287). The Polyzoan Fauna of the Mesozoic and Tertiary Rocks have also been catalogued by Morris, and separate memoirs on the Polyzoa of two horizons have been published, namely, the Bryozoa of the Jurassic Formation, by Jules Haime, (1854) in which British examples are mentioned; and the Polyzoa of the Crag, (1859) by Mr. George Busk. In Dixon's Geology of Sussex, (1850) two plates are devoted to the delineation of Cretaceous "Bryozoa," and elaborate descriptions of the same are given by Mr. Lonsdale; and a few Cretaceous forms are briefly described and illustrated in Dr. Mantell's Medals of Creation (1845).

Since the publication of Morris' Catalogue of British Fossils, however, great advances have been made in the study of this group of organic forms, so much so that what might well have been characterised, ten or twelve years ago, as a difficult group to handle, is now one of the most popular and fascinating of the many palæontological specialities. But even now, in spite of the many who are engaged in the work, the lists of Upper Cretaceous Polyzoa have been added to but little since 1854. Even up to 1885 (Phillips' Manual of Geology, pp. 589-590, and Professor Prestwich's Geology, 1888), the lists of Upper Cretaceous forms are given by the authors as 61 or 62 species. In my forthcoming British Association Report on Upper Cretaceous Polyzoa I shall catalogue nearly 130 species and varieties found in one locality; and the end is not yet.

In this paper I shall describe and illustrate forms, which may be considered as additions to the lists of Cretaceous Polyzoa which have been already published in the Proceedings of this Society.

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§ I. The Red Chalk of Hunstanton.

In November, 1891, I received from Mr. Jesson a small box containing about thirty specimens of well-preserved Red Chalk fossils, some of which were derived from the top bed of the Hunstanton Red Chalk. Many of the forms have been previously described in full,* whilst other fossils were encrusted by much finer examples of Polyzoa than were available for my work at the time I wrote: a few species were altogether new.

I. Stomatopora variabilis, pl. VI., figs. 1 and 1b.

I have a great objection in creating new specific names for mere fragments, but the forms placed here are so well preserved and peculiar that I cannot help breaking a rule that must not be too strictly kept. The fragment (1a) was adherent to shell (*Inoceramus*) and the two cells measure three-twentyfourths of an inch in length, one cell rather larger than the other. The cells of fig. 1a, pl. VI., and fig. 1b, vary in their measurement from one-twelfth to one-sixteenth of an inch in length.

Horizon: Examples of fig. 1a Red Chalk, Hunstanton = F gs. 1 and 1b, from the top beds of Hunstanton Red Chalk.

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* Polyzoa of the Red Chalk, &c. Quart. Journ. Geol. Soc., vol. xlvi., 1890.
,, ,, Proc. Yorksh. Geol. Soc, vol. xi., 1890.

II. Stomatopora ramea, Blain. (Quart. Journ. Geol. Soc., p. 465, Yorksh. Geol. Soc., p. 371).

In the two papers referred to above I remark that examples of this species are rare in the Red Chalk. From the top bed two colonial growths of very variable habit were found encrusting *Terebratula biplicata.* The Zoœcia are elongate, about one-sixteenth of an inch in length, but tolerably even as to breadth.

III Proboscina dilitata, d'Orb.
Var. Cantabrigensis, Vine.

1889. Further Notes on the Polyzoa of the Cambridge Greensand. Proc. Yorksh. Geol Soc., vol xi., p. 263.

In my Red Chalk papers, (1890) I remark that I found on my material a cast only of this beautiful variety of *P. dilitata.* In the new material submitted to me by Mr. Jesson was a well-preserved example of this species encrusting *Inoceramus,* but not quite so large as the figured example (Cam. Greensand Paper, pl. xii., figs. 3-4). Zoarium branching with two, three, and four rows of cells in the branch. Fig. 3, pl. A, represents a very young example of the species.

Horizon : Red Chalk, Hunstanton.

IV. Proboscina inornata, sp. n., pl VI., fig. 4.

I have not previously noticed a Red Chalk Polyzoon similar to the one now depicted. The Zoarium was found coiling round the stem of a *Belemnite.* The Zoœcia, which are alternately placed to the right and left, vary from one, to three in a row, and are large and bulky, passing from uni- to multiserial in their arrangements. On the same stem is a course variety of *Stomatopora linearis,* d'Orb (Yorksh. Geol. Soc., 1890, pl. 17, fig. 5) only that the Zoœcia are rather more stunted than those previously figured.

Horizon : Top Bed Hunstanton Red Chalk.

Besides the above there were in the new material from the Red Chalk much better examples of the following species all from the top bed :—

Zonopora variabilis, d'Orb. (Quart. Journ. Geol. Soc., p. 482; Yorksh. Geol. Soc., p 384).

Ceriopora micropora, Goldf. (Quart. Journ. Geol. Soc., p. 480; Yorksh. Geol. Soc., 382).

Multicrescis variabilis, d'Orb. (Quart. Journ. Geol. Soc., p. 482; Yorksh. Geol. Soc., p. 384).

This last species was well represented by several free examples, some of which closely resemble the *Thalamopora Michelini* from the Essen Greensand, described by Simonowitsch (Beiträge zur Kenntwiss der Bryoz. des Essener Grünsandes, 1872). See pl. VI., figs. 13-14.

V. ZONOPORA UNDATA ? d'Orb. (or variety of the same), pl. VI., figs. 8 and 9.

D'Orb. sp. Terr. Cret. p. 932, pl. 771, figs. 14-15.

The Zoarium of this species is disposed in cheese-like zones, but rather more compressed than in d'Orbigny's figure. *Zonopora undata* is a Senonian fossil with well-marked characters, and this, in common with all those species which have true zoœcial apertures separated by smaller pores (" les cavités intersque lettiques,") Dr. Pergens relegates to the Heteropora group. I have given the nearest affinity possible for this rather rare British Polyzoon, and in placing it as a variety, any misconception as to its zonal position will be avoided.

Horizon : Top Beds Red Chalk, Hunstanton.

VI. REPTOMULTICAVA COLLIS, d'Orb. Pl. VI., figs. 10-12.

See Quart. Journ. Geol. Soc., 1890, p. 481.

See Proc. Yorksh. Geol. Soc. 1890, p. 382.

D'Orbigny Terr. Cret., p. 1036, pl. 792, figs. 1-3.

The examples illustrated on pl. VI are finer and much better preserved than those referred to in the two papers indicated above, and are also larger than d'Orbigny's figure. The largest example (fig. 11, pl. VI.) is fully a quarter of an inch in diameter without the extended basal lamina, which generally projects beyond the raised portion of the Zoarium. Figs. 10 and 12 represent examples from the top bed of the Red Chalk, and as regards height are slightly different from fig. 11; otherwise they were about the same dimensions at the base.

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§ II. Gault Polyzoa.

Neither in the Catalogue of British Fossils by Professor Morris, ed. 1854, nor in the Catalogue of Cretaceous Fossils in the Museum of Practical Geology, 1878, is there any mention of Polyzoa derived from the horizon of "what is ordinarily characterised as Gault.' The only reference known to me will be found in Phillips' Manual of Geology, ed. 1885, pp. 589-590. The Palæontological lists of Cretaceous Fossils, including the Polyzoa, were compiled by Mr. Etheridge, and three Gault species are recorded, but unfortuately the British specimens cannot be traced.*

The species indicated in the list are as follows, the names are supplied to me by Mr. Etheridge himself :—

1. Berenicea Clementina d'Orb. Pal. Fr., vol. v., p. 865, pl. 636, figs. 1-2.
2. ,, polystoma Röm. 1839. "Ool." pl. 17, fig. 6 and Kreide, p. 19.
3. Ceriòcava ramulosa, d'Orb. Pal. Fr., vol. v., p. 1017, pl. 788, figs. 11-12.
   = Chœtetes ramulosus, Mich. Icon. Zooph., p. 202, pl. 51, fig. 5.

The material on which I now rely was derived from Gault in situ, from two localities, Barnwell, Cambridge, and Folkestone. "At Cambridge Station and along the East Road the Gault is shown to be 120 to 130 feet thick in wells, but at Barnwell it is said to be 140 to 150 feet. Any one who stands on the surface of the Gault at Barnwell will have little doubt about its being higher than the Coprolite bed at Coldham Common, and will see that the slope south-eastwards is much greater than can be accounted for by dip alone. Coldham Common, in fact, owes its formation to the existence of a hollow in the surface of the Gault, which is here only between 110 and 120 feet thick."†

I have already, in two papers which were published in the Proceedings of this Society, ("Polyzoa of the Cambridge Greensand,"

* See Report on the Cretaceous Polyzoa (Vine), Brit. Association Reports, 1890-91, p. 287.

† Messrs. W. H. Penning and A. J. Jukes-Brown, in Geology of the Neighbourhood of Cambridge, p. 19, Mem. Geol. Survey.

vol. ix., and "Further Notes," vol. xi.) described some of the Microzoa derived from the Coprolite bed at Coldham Common, and as I have no fresh material from this peculiar horizon the student is referred to those papers for special details of the groups described:—Polyzoa, Entomostraca, and Foraminifera. So far as I am aware species of Polyzoa derived from the Gault of Folkestone are very rare.

I. PROBOSCINA CLEMENTINA, sp. n., pl. VI., fig. 5.

Not *Diastopora Clementina*, d'Orb, pl. 636, figs. 1-2.

The figure of *D. Clementina*, given by d'Orbigny, is really a *Proboscina*, but as I reserve the term *Diastopora* for another form which is described below, it may be well to direct the attention of the Palæontologist to these pecularities of Zoarial growth.

Zoarium adnate, flabelliform. Zoœcia generally adherent by their whole length, but occasionally raised towards the distal extremity, more particularly in the earlier cells of the Zoarium; the surface of the Zoœcia are either slightly rugose or marked with transverse lines. Apertures small, peristomes prominent.

Locality and Horizon: Gault in situ, Barnwell, Cambridge.

II. DIASTOPORA CLEMENTINA, d'Orb.

Berenicea Clementina, d'Orb., Terr. Cret., p. 865, pl. 636, figs. 1-2.

In his description of this species d'Orbigny says "discoidale ou flabelliforme," and in all probability the author had satisfactory evidence of this fact. I have a very large Zoarium of this species derived from the Folkestone Gault which is really disciform. In other respects I cannot see that the British example, except in size, differs in any material particular from the French. The cells of the central portion of the Zoarium are however more closely compacted together than in the outer portion, where the cells are well separated and the transverse lines are not so distinct as in the earlier stages of growth. The Zoarium is about three-eights of an inch in length and breadth.

Habitat: On the beak of a *Terebratula*.

III. MEMBRANIPORA GAULTINA, Vine, pl. VI., fig. 15.

1890. Quart. Journ Geol. Soc., vol. xlvi., p. 484.

Proc. Yorksh. Geol. Soc., vol. xi., p. 385

Zoarium simple and uniserial. Zoœcia elongate, sub-ovate produced or attenuated below; area oval or circular, occupying nearly the whole front of the cell; area walls smooth or slightly crenulated when aged; the produced portion of the wall below the area folded or puckered (see fig. 15). Zoœcia generally linked together in linear series, branching laterally sometimes from every cell, but in the figured example (fig. 15, pl. VI.) the mode of branching is most peculiar, this however is an exceptional feature. The lengths of the cells, including the attenuated portions, vary considerably, but generally speaking the measurement is from about one-tenth to one-sixteenth of an inch in length.

Locality and Horizon: Gault in situ, Barnwell, Cambridge. The forms described from the Red Chalk of Hunstanton, are destitute of the "puckering" of the cell wall just below the area.

Since I wrote the description of this species, as published in my "Red Chalk Paper" (Quart. Journ. Geol. Soc., vol. 46, p. 484), I have examined many allied forms derived from the British Upper Chalk of Chatham, Salisbury, and also from Norfolk; and as these forms have been characterised by Marsson (*Hippothoa dispersa* = *Cellepora dispersa*, Hagenow, 1839), it may be well to keep the Upper Chalk forms distinct.

IV. MEMBRANIPORA FRAGILIS, d'Orb. Var?

1851. Flustrellaria fragilis, d'Orb. Terr. Cret. p. 515, pl. 723, figs. 3-9.

Zoarium very irregular. Zoœcia irregularly disposed, sometimes in linear series with two or three rows of contiguous cells, but more frequently in single series, but these continually twist and twirl in a variety of ways, which for the purposes of description are most confusing; the disposition and habits of the cells generally may be described as oval, with large area occupying nearly the whole of the front. The cells of this species are more closely allied to the ***Flustrellaria fragilis***, d'Orb. (l. c., pl. 723, figs. 6 and 8) than to any other species known to me. The Zoarium of the British example is more than half an inch in width and breadth, and from some portions it would be quite possible to construct a drawing similar, ovicell and all, to that of d'Orbigny's figures (6 and 8, pl. 723).

Habitat: On Broken Shell embedded in Blue Clay.

Horizon and Locality: Gault, Folkestone.

V. Hippothoa?

On the outer surface of a small bivalve shell in my possession are several peculiar organisms, which closely resemble in some of their *Zoœcia* at least, *Hippothoa simplex* d'Orb. (Terr. Cret. pl. 711, fig. 6), but the habit of the *Zoarium* is more tortuous than the fragments depicted. In other respects the Gault forms are more like the creeping stolons of species of *Aetea*, similar to those depicted by Hincks' (British Marine Polyzoa, pl. 1, figs. 8 and 12). I can only indicate the existence of this peculiar polyzoon in the hope that better examples may be found.

Horizon: Gault, Barnwell, Cambridge.

D'Orbigny, in one of the appendices to his work on Cretaceous Bryozoa (p. 1082) divided the then known French Geological Formations into several minor divisions, or stages, to each of which he gave a characteristic name. In some of these French divisions, previously to the commencement of d'Orbigny's labours, Polyzoa, or Bryozoa had been recorded, and these are fully referred to in the "Prodrome de Paléontologie" by the same author. In the Palæozoic formations 66 species had been described. In the Jurassic rocks 93 species; and in the Cretaceous formation, which was divided into the following stages, 17 Neocomian, 18 Aptian, 19 Albian, 20 Cenomanian, 21 Turonian, 22 Senonian, and 23 Danian. D'Orbigny, after the completion of his labours on the Bryozoa, catalogued about 1073 species. Of course a number of these were ficticious, but as the whole are well described and illustrated we owe to the illustrious author a debt of gratitude for his painstaking and discriminating labours on the Cretaceous Bryozoan Group.

In the "Albian" division (No. 19) only 22 species are recorded by d'Orbigny, but the number which were really proper to the French Albian rocks were only 16, the other 6 species are otherwise accounted for. In this paper I have given descriptions of 4, probably 5, species found on the British Gault, and in the hope of stimulating enquiry in this direction I append the names and references to the plates and figures in the Atlas of the whole of d'Orbigny's Albian, or Gault Polyzoa in the order in which the author refers to them.*

1. Mèlicertites Haimeana, d'Orb., Atlas, pl. 617, figs. 11-13.
2. Elea triangularis, d'Orb. = *Escharae* of Atlas, pl. 602, figs. 4-5, and pl. 737, figs. 17-20.
3. Reptelea acteon, d'Orb.=*Escharina* of Atlas, pl. 604, figs. 5-6.
4. Multelea gracilis, d'Orb., Atlas, pl. 739, figs. 1-3.
5. Entalophora angusta, d'Orb. = *E. gracilis*; Atlas, pl. 617, figs. 1-4.
6. Diastopora Dutemplena, d'Orb., Atlas, pl. 617, figs. 8-10.
7. Reptomultisparsa Dutemplena, d'Orb., Atlas, pl. 761, figs. 8-10.
8. Zonopora lævigata, d'Orb., Atlas, pl. 771, figs. 7-8.
9. Laterocavea Dutemplena, d'Orb., Atlas, pl. 772, figs. 7-10.
10. Sparsicavea irregularis (Entalophora), d'Orb., Atlas, pl. 617, figs. 5-7.
11. Semimulticavea Landrioti, d'Orb. (Radiopora), Atlas, pl. 648, figs. 5-7.
12. Echinocavea Raulini, d'Orb., Atlas, pl. 788, figs. 7-8.
13. Semimulticavea cornuta, d'Orb., Atlas, pl. 791, figs. 1-2.
14. Heteropora Constantii, d'Orb., Atlas, pl. 799, figs. 6-7.
15. Multicrescis Michelini, d'Orb., Atlas, pl. 799, figs. 14-15.
16. ,, mamillata, d'Orb., Atlas, pl. 800, figs. 1-2.

Fifteen of these species, says the author, are peculiar to the sandstone of Grandpré, and of Novian in the Ardennes and the Meuse belonging to the Anglo-Parisian basin; and one (No. 11) is found in the same basin, and in the deposits of St. Croix in the Canton of Vaud (l. c., p. 1092).

Quite recently, however, the "Bryozoa" in the d'Orbigny collection, now preserved in the Paris Museum, have been carefully examined, and the Cyclostomatous species revised by Dr. Pergens† of Belgium. The result of this critical investigation is that at least ten of the above-named species are either lost or are rendered useless for the purpose of the revision, and only six species are satisfactorily accounted for. The numbers as given above are again used in this

* Palæontology, France: Terr. Cret., vol. v., p. 1092.

† Revis des Bryozoaries du Cretacé, figures par d'Orbigny, Brussels, 1890.

amended list, and by their aid the student of Fossil Polyzoa will learn the new generic names which have been given to the forms retained by Dr. Pergens.

9. Idmonea Dutemplena, d'Orb., Terr. Cret. pl. 772, figs. 7-10.
8. Heteropora arborea, Kock and Dunker, Perg. p. 312, fig. 6.
15. ,, Michelini, d'Orb., Terr. Cret. pl. 799, figs. 14-15.
11. Lichenopora Landroiti, Mich. ,, pl. 648, figs. 5-7
12. Echinocavea Raulini, d'Orb. ,, pl. 788, figs. 7-8.
2. Elea triangularis, Mich. ,, pl. 737, figs. 17-20.

Some of these species occur in British Rocks but in other horizons of the Cretaceous Series.

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§ III. Polyzoa of the Lower Chalk.

Professor Morris, in his Catalogue of British Fossils, gives a list of six species of Polyzoa derived from the chalk detritus of Charing. The names of these are :—

1. Pustulopora echinata, Reuss. Böhm Kreide, pl. 14, fig. 4.
2. ,, madreporacea, Goldf. ,, ,, 14, fig. 5.
3. Hornera carinata, Reuss. ,, ,, 14, fig. 6.
4. Cricopora annulata, Reuss. ,, ,, 14, figs. 2-3.
5. Vincularia Bronni, Reuss. ,, ,, 15, fig. 30.
6. Escharina dispersa, Reuss ,, ,, 15, fig. 26.

From material supplied to me by Professor T. Rupert Jones, derived from the same horizon (The Harris Collection), I have picked out and identified the following additional species,* besides others at present unnamed.

Entalophora lineata, Beissel. Proc. Yorksh. Geol. Soc., vol. xi., p. 261.
,, ,, var. striatopora, Vine. Proc. Yorksh. Geol. Soc., vol. xi., p. 261
,, proboscidea, var. elegans, Vine. Proc. Yorksh. Geol. Soc., vol. xi., p. 260.
,, ,, ,, raripora, ,, ,, ,,
,, ,, ,, delicatula, Vine
Filisparsa ornata, Reuss.

* See British Association Report on Cretaceous Polyzoa, p. 292 (Mihi.) 1890-91.

Umbrellina paucipora, Vine. Proc. Yorksh. Geol. Soc., vol. xi., p. 270.
Osculipora plebea, Novak ,, ,, ,, ,,

In the Catalogue of the Museum of Practical Geology, 1878, the following are recorded from the Lower Chalk. One species, *Spinopora Dixoni*, Lonsdale, is present also in the Upper Chalk of Chatham, but I do not include this species in the Polyzoan Group:—

Membranipora (Flustra sp.?) fragilis, d'Orb. (See Museum Catalogue, p. 83.)

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§ IV. Polyzoa from the Chalk Marl.

The species now to be described are from the Chalk Marl derived chiefly from the Marl Bed which overlies the Red Chalk of Hunstanton. Most of the fossils encrusted by Polyzoan remains were submitted to Mr. Jukes-Browne for examination, who kindly handed them over to Mr. William Hill for special localisation if possible. After pointing out the difficulty of doing as I wished without sectioning the fossils, Mr. Hill says, "I think you may take it that all come from the Chalk at an horizon not higher than the Totten hoe Stone."

This very peculiar horizon is well shown in the diagram sections which accompany the very elaborate paper on the "Lower Beds of the Upper Cretaceous Series in Lincolnshire and Yorkshire," by Mr. William Hill, F.G.S. Quart. Journ. Geol. Soc., vol. xliv., pp. 320-366, 1888.

I. Stomatopora pedicellata, Marsson, pl. VI., fig. 2.

Die Bryoz. der Weissen Schreibk. der Insul Rügen, p. 14, pl. 1, fig. 1.

Encrusting several Echinoderms is a very delicate Stomatopora with long and slender Zoœcia, which closely resembles the *S. pedicellata*, Marsson. I have in my cabinet a species from the Upper Chalk encrusting Micraster cor-anguinum, which corresponds more closely with Marsson's figure, and the Chalk Marl form differs but slightly from it. I place it here provisionally.

Horizon: Chalk Marl above Red Chalk, Hunstanton, and on *Holaster sub-globosus*, in Mr. Hill's Cabinet.

II. STOMATOPORA LONGISCATA, d'Orb., pl. VI., fig. 1.

S. longiscata, d'Orb., Terr. Cret. v., p. 839, pl. 629, figs. 9-11.

For other references and remarks see Proc. Yorksh. Geol. Soc., vol. xi., p. 372, and Quart. Journ. Geol. Soc., vol. xlvi., p. 465.

Excepting that the Zoœcia in parts of the branch are very slightly curved, the Chalk Marl form is identical with those referred to in the above papers.

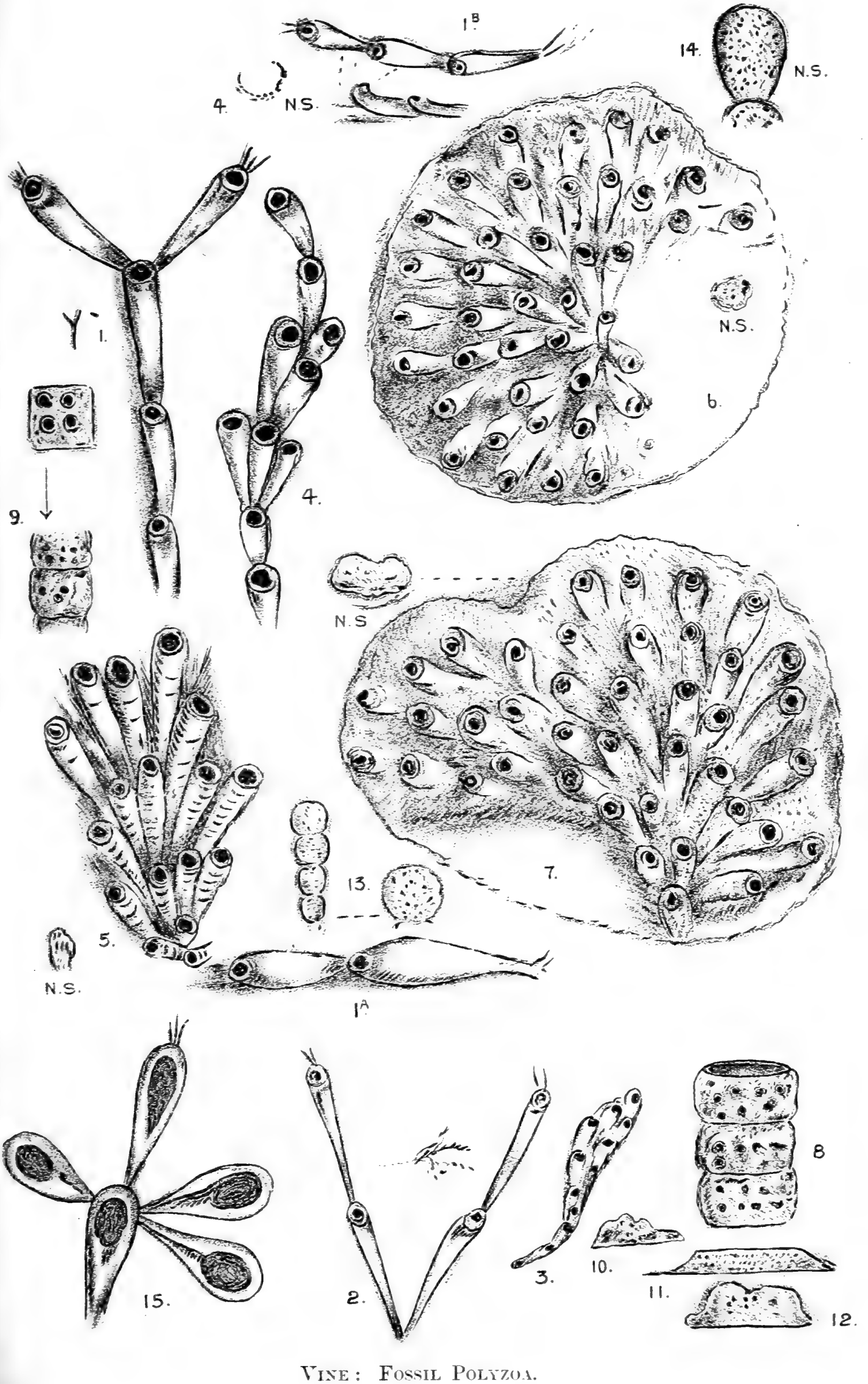
Horizon: Chalk Marl; my own Cabinet; No. 2 from Chalk Marl above Red Chalk, Hunstanton.

III. DIASTOPORA REGULARIS, d'Orb., pl. VI., fig. 6-7.

1850. Diastopora regularis, d'Orb., Terr. Cret. pl. 636, figs. 9-10.
,, ,, densata, d'Orb., l.c., pl. 637, figs. 1-2.
,, ,, orbicula, d'Orb., l.c., pl. 637, figs. 3-4.
1852. Berenicea regularis, d'Orb., Terr. Cret., p. 865.
1890. Diastopora regularis, d'Orb. Revis. des Bryoz. Pergens, p. 334.
1890. ,, ,, Vine. Quart. Journ. Geol. Soc., vol. 46, p. 476.
1890. ,, ,, Vine. Proc. Yorksh. Geol. Soc., vol. xi., p. 380.

In looking over the figures of d'Orbigny on plates 636 and 637, as given in the synonymy above, one would be inclined to keep all the forms distinct. *Diastopora regularis*, pl. 636, figs. 9-10, has a proboscina-like zoarium with distinctly separated cells, and with interspaces between; whilst in *D. densata*, pl. 637, figs. 1-2, the originating cells are central, the intervening spaces less distinct, and the zoarium is really discoid. In 1852, however, d'Orbigny felt constrained, after examining a large number of examples to place the three species under one name, taking the *D. regularis*, pl. 636, fig. 7, as the type of the whole. In my Red Chalk Paper (Quart. Journ. Geol. Soc., 1890, p. 476) I described a form, unique in that horizon.

Zoarium fixed, discoid or slightly flabelliform, composed of distinct cells, arranged in lines or alternately placed; adherent by their whole length, separated by interspaces, which are either smooth or partially punctate (?) In fig. 6 the zoarium is discoid with central



VINE: FOSSIL POLYZOA.

cells like *D. densata*, and although the Zoarium of d'Orbigny's species is about the same natural size as the British the latter contains a less number of cells. The form depicted in fig. 7 partakes more of the character of *D. orbicula*, it contains a less number of cells than the French form. Under present circumstances, on account of my limited knowledge of Chalk Marl examples of Polyzoa, it is impossible to indicate to what extent the British forms vary. The material already examined show in some few cases a resemblance between species found in the British Cenomanian horizons and those described and illustrated by d'Orbigny, Reuss, and Novak, from French and Bohemian, Cenomanian Rocks. I throw out the hint in the hope that other workers on the lower beds of the British Upper Cretaceous Rocks will examine the fossils in their possession to see what Polyzoan encrustations are to be found on them. Mr. Hill, however, has already informed me that Polyzoa are very rare on his Chalk Marl Fossils, so that no great harvest is anticipated.

Horizon: Lower Chalk on *Holaster Sub-globosus*, in Mr. Hill's Cabinet; Chalk Marl above Red Chalk, Hunstanton.

Explanation of Plate.

Figs.

1. Stomatopora longiscata, d'Orb.

1A-1B. „ variabilis, Vine.

2. „ pedicellata, Marsson.

3. Proboscina dilitata, var. Cantabrigensis, Vine. A young colony.

4. „ inornata, Vine.

5. „ clementina, Vine.

6-7. Diastopora regularis, d'Orb.

8-9. Zonopora undata? d'Orb. Variety.

10-12. Reptomulticava collis, d'Orb. Varieties. (See text).

13-14. Multicrescis variabilis, d'Orb.? *Thalamopora Michelini*, Simonowitsch.

15. Membranipora Gaultina, Vine.

THE VOLCANOES OF ICELAND. BY TEMPEST ANDERSON, M.D., B.SC.

The author visited Iceland in the summer of 1890, with the especial object of examining and photographing the volcanic phenomena with which the country abounds.

Iceland is an island about the size of Ireland, situated just outside the arctic circle. The inhabited, or habitable, portion is confined to a narrow belt round the shore, the centre portion being occupied by volcanic mountains, extensive lava deserts, sandy plains, and snow mountains mostly flat-topped, called "Jokuls." The interior is traversed by a few desert tracks, seldom used, and becoming less so since the establishment of a regular service of steamers round the north coast. The north coast is much broken up into promontories and fjords, or deep bays, at the ends of which most of the villages—they scarcely deserve the name of towns—are situated. The south coast, on the contrary, does not boast a single harbour where a steamer can lie in safety, between Reykjavik and Hafnafjord on the west, and Berufjord on the east, for, though it is true that the small trading station of Eyra Bakki is situated here, and small sailing vessels find some shelter from the Atlantic swell behind a reef of rocks, the entrance is narrow and dangerous for any ordinary craft in which a landsman would like to trust himself. Add to this, that many large rivers, quite disproportionate to the size of the island, come from the desert interior and here flow into the sea; that they are mostly broad, swift, and icy cold, and often with quicksands in their bottoms; and we see at once the reason that this part of the island is seldom visited by travellers, and that the inhabitants enjoy fewer of the necessities, to say nothing of the luxuries of life than in other parts. Yet in this part are situated the great volcanoes of Kotlugiâ and Skapta Jokul, which it was the author's object to explore on his visit to the island in 1890.

Reykjavik, the capital of Iceland, is a straggling village or small town of 2,500 inhabitants. The chief buildings are the governor's house, a plain whitewashed building apparently of about a dozen small rooms, a Church or Cathedral, also whitewashed, capable of holding probably 400 people, and the parliament-house, a building of very moderate dimensions, yet accommodating a free library on the ground-floor, the Parliament Chamber on the first floor, and the National Museum in the attics. The Latin school, and one or two Elementary schools complete the sum of the public buildings, except the gaol, which has twelve cells, generally empty.

In the more remote parts, such as the Skaptadair, many articles of bone and stone are still in use, which, in more accessible districts, have been replaced by metal or earthenware. The inhabitants still use a wheelbarrow with a stone wheel, a steelyard with a stone weight, a hammer with a stone head, and a net with bone sinkers. At the same farm a quern, or stone hand mill, was in use, also horn stirrups, and harness fastenings of bone instead of metal buckles, to say nothing of bone pins and rude bone dice. At a neighbouring farm was a basin formed of the cup joint of a basalt pillar. Truly we still have a survival of the Stone Age. Less remote than this is the meeting place of the County Council of the district, consisting of a spacious cave in the lava. It would be difficult to find anything more appropriate to such a primitive land.

The roads, such as they are, are merely bridle tracks. Where they traverse stony moors and lava streams, they are mended by taking off the largest stones, leaving the smaller to be trodden down; where they cross bogs they are occasionally carried on artificial embankments. Bridges are almost unknown. In the few cases where new roads have been made, they have evidently been laid out by unskilled persons, and the work has often been begun in the middle; then, before the road has been finished, the plan has been changed, and the whole abandoned. I saw several large pieces of road out in the wilds leading nowhere, and which will never be used. It is only fair to say, however, that near Reykjavik there is about twenty miles of new road beautifully engineered by men who have recently returned from learning road-making in Norway. Even in these roads, however, there are gaps left unmade at intervals. This, I was told (let us hope falsely), is to prevent people spoiling them by using wheeled carriages or carts on them.

The numerous hot springs constitute one of the chief wonders of Iceland. They are very numerous, and as various in their volume as in the composition of their waters and the products deposited from them. The great Geyser, which has been so often described, spouts its mighty volume of water, only slightly charged with silica, and deposits a silicious sinter called Geyserite; and several other springs, such as at Reykjanæs, deposit similar formations; others are so charged with ferruginous and sulphurous mud, that they appear like boiling cauldrons of red and blue paint. Some of the Reykjanæs springs, and many of those at Krisuvik, are of this kind, as are the more celebrated mud Geysers of Krabla, in the north of the island.

At Krisuvik, and some other places, but connected with the springs, are fumaroles, from which some sulphurous vapour and steam escapes. This has given rise to deposits more or less extensive of sulphurous earth or mud, on the top of which a crust forms on which it is possible to walk; care is however necessary, for if the traveller should happen to go through the crust, he will be precipitated into a mass of boiling sulphurous mud. It has been proposed to work these deposits for shipment to England, and a company was formed which came to an untimely end. We visited the house built for the manager at the springs; it was built of galvanised iron. Could any one have conceived a material less likely to resist sulphur fumes? There were many difficulties which operated to prevent success. The natural idea would have been to burn the crude sulphur in *calcaroni* or kilns, like those used in Sicily. The heat produced by the burning of part of the sulphur melts the remainder, and runs out in a refined state into moulds. But in Sicily the deposit is dry, here it was liquid mud; there was no means of drying it. Krisuvik is near the sea, and this was conspicuously marked on the map published at the time; but the coast is rocky, and there is no landing-place. In reality, the sulphur had to be carried on ponies for many miles over the mountains to Hafnafjord. We were told that about seventy horses died one year, and the attempt was then abandoned. No wonder the venture was unprofitable to the shareholders.

The rivers of Iceland are large and out of all proportion to the island, and are especially large and dangerous in the southern part, as it is here that most of the great rivers draining the desert interior of the island, and especially the glacier streams proceeding from the Myrdals, Skapta, and Vatna Jokuls discharge themselves into the sea. They constitute, in this district at any rate, a most serious hindrance and occasionally a positive danger to the traveller. Most of the worst are broad and swift rather than very deep, a common size being a quarter of a mile or more wide, the depth in the fordable parts perhaps four feet, and the rapidity sufficient to make the icy cold water surge and foam up against the traveller's saddle and water boots. It is no wonder that a stream of these dimensions, flowing over a sandy and gravelly bottom, constantly shifts its course, and that quicksands are common. A place may be safely fordable to-day, and deep water next week. Hence the necessity of always taking a local guide from the nearest farm. Where the river comes from a lake the water will be pretty clear, so that the bottom is partly visible; but if from a glacier it will be loaded with mud, which prevents a view of the bottom, and this with its icy coldness adds greatly to the difficulty and danger of crossing. Deaths occur not infrequently from horse and rider being carried away. Sometimes a river spreads itself out into many parallel arms, and the guide in search of a ford seeks by preference such a part. If the river is not fordable at present he must seek a ferry at a narrow part where the banks are good. This is always a tedious undertaking. First the ferryman must be found, which is sometimes difficult even if he lives on the near side of the river, but the difficulty is much worse if he and the boat are on the opposite. Then all the horses are unsaddled, and the saddles, pack boxes, and gear are put into the rickety boat, and the horses, with much shouting and cracking of whips, are driven unwillingly into the stream. As soon as they are well swimming and too far out to turn back, the travellers and guides hurry across in the boats as quickly as possible. By the time they are across the horses have all landed, and feeling cold have started off at a canter. A guide runs after them, and with some trouble catches one which he mounts and pursues the others, and eventually drives them all back to the ferry. Then the whole cavalcade has to be resaddled and the packs adjusted, so that before the caravan is fairly on its way again at least an hour, but often more, has been wasted. What wonder that the guide always prefers to ford if possible.

The main object of our visit was to examine the great volcanoes of Kotugiá and the Skaptá Jokul, the former of which appears not to have been visited this century, while the crater of the latter had, we were assured, never been reached since its formation in 1783.

The crater of Kotugiá is a vast fissure situated high up among the glaciers of the Myrdals Jokul, and is now so filled with snow and ice that our distant view of it did not promise much from a nearer inspection. Moreover, the weather being abominable, and the snow in bad condition, we were reluctantly compelled to abandon the attempt. One peculiarity of the eruptions arises from its position under a glacier of snowfield, viz., that when the incandescent gases and lava escape, the snow and ice are suddenly melted, and a vast outpouring takes place of mingled boiling water, ice, volcanic mud, pumice stones and ashes. This rushes with great velocity to the sea, devastating everything. We rode across a plain about twenty miles wide which marks the track. The last eruption took place in 1866. Scarcely a blade of any kind of vegetation has yet begun to appear on all this vast area. Certainly the volcano deserves its name of Kotugiá, the Kettle crater.

The second main object of our journey was to explore the lava fields of the Skaptá Jokul, mentioned in all the books on vulcanology as being among the largest known. The great eruption of this volcano in 1783 is well described by Lord Dufferin in his "Letters from High Latitudes," and especially by Henderson, a missionary who visited the island in 1814, when the facts were fresh in living memory. Two great streams of lava issued from the desert interior of the island, one descending the valley of the Skaptá River, and another, that of the Hervisflot, the first being about fifty miles long, and the latter perhaps forty. Both appear to have issued from the same great fissure on which a line of craters has been thrown up. We determined to endeavour to reach the craters by the former valley. We slept at the last farm in the valley, and were fortunate in obtaining the old farmer as guide. He at once told us that, though he had taken several parties of travellers far up the course of the lava, none had ever reached the crater; but he was quite willing to make the attempt. We therefore started next morning, keeping at first some distance from and then close alongside the lava. At last we found it necessary, in order to get to a set of cinder heaps which promised a passable road, to cross the main stream, and had some difficulty in getting our clever little nags across; but perseverance prevailed, and going further on we encamped in the evening at the last patch of grass at the edge of the desert. Next morning, after a hard frosty night, the weather proved good, in fact, the only good day for many days, and by riding as far as possible into the desert and then leaving the horses and going forward on foot, the craters, the objects of such a long journey, were at last reached. They extend in a line for several miles along a great fissure, which is still in many places clearly visible. At the lower end are two or three dwarf craters, then the two or three main orifices from which most of the lava has poured out in billows of fire, now solid and black, it is true, but retaining their shape perfectly; and, further on, several others from which the gases and steam evidently chiefly escaped.

The higher craters, from which the steam and vapours escaped, are roundish or oval; and the fissures can still be seen along their bottoms in places of a width of several feet. Traces of it are also visible going under the heaps of scoriæ which separate adjacent craters, and here constitute their walls. The outer slopes of the craters are gentle, the inner nearly precipitous, this conformation being apparently due to the scoriæ having been ejected in a pasty condition, so that they stuck where they fell; and thus, while those which fell again directly into the fissure would be blown out again, those which fell out of the direct line attached themselves and did not roll back to fill up the vent, as we so often see in ash cones. These craters also illustrate most strikingly the fact that water, except as running streams, has scarcely any eroding power. Though they have been erupted over 100 years their edges are as sharp and perfect as the day they were formed, the explanation being that the scoriæ are so porous that the rain as it falls, and the snow as it melts, instantly soaks in, and never appears on the surface as a stream.

The lava near the craters is almost all of the corded or "*pahoheoe*" type, while lower down the valley immense fields of scoriaceous lava, or "*aa*," of the most bristling character are seen. The most probable explanation being that the lava, at the commencement of the eruption, contained much imprisoned steam and vapours which escaped in fiery froth, and solidified into the rough "*aa*," and was carried down the valley on the surface of molten lava, which, in places, is as much as 600 feet thick. The eruption was a prolonged one, and consequently the later lava had a prolonged simmering in the chimney or fissure during which it parted with most of its vapour, and when finally it flowed out it had little left, not sufficient to form a layer of froth, but only a few "giant's children" or blow-holes, of which some very fine examples occur near the craters. This sequence of events does not appear always to obtain. Near Hekla we saw a stream of lava, scoriaceous on the steep slope near its point of eruption, but corded with most beautiful regularity in parts where it had flowed tranquilly on the plain after parting with most of its vapour, and escaping from under the crust higher up.

We returned from the Skapta by way of the Fjallabaksvegr, a desert route of about ninety miles from the last house on the one side to the first on the other, and thence by Hekla, the Geysir, and Thingvalla; but these have often been described, and space is wanting.

It is currently believed in Iceland, and was stated in some of the public prints at the time, that a volcanic eruption or earthquake had taken place at Cape Reykjanæs in October, 1887, by which a large new *giâ* or chasm had been formed, separating a large rocky promontory, almost deserving the name of a mountain, from the main cape on which the lighthouse stands. This chasm, at least fifty feet wide, was pointed out to the author from a passing steamer, the captain declaring that he remembered the rocks before they were rent asunder. Here, then, appeared to be a case of the formation of one of the giás or chasms which form such a characteristic feature of Icelandic geology. There are several such on the Reykjamæs peninsula, huge chasms several feet wide and of unknown depth, stretching for miles across the lava desert of which the district is composed. In this district they usually, though not always, have a throw of a few feet or yards, but one of these at Thingvalla, more in the centre of the island, the Allmanagiá, has a throw of about 100 feet. In this case, the author is satisfied that the *giá* is due to the unequal settling of a crust of lava formed on the surface of a still fluid mass, which had found an outlet and flowed out after the solidification of the surface. He is not prepared however to say that this explanation will hold good in the case of all the rifts on the Reykjanæs peninsula. It certainly would not in the case of the great fissure from which the Skapta lava was erupted. Consequently any clear case of the formation of a new *giá* in strata long cooled and solidified would have been well worth investigation.

From a careful examination of the locality it appeared that no fresh formation of a *giá* has taken place, but that certain small portions of the rock on which the lighthouse stands had been loosened partly by ordinary denudation and partly by earthquakes, which are frequent here, and had fallen on to the beach. The strata of partly consolidated volcanic ashes and lava are quite continuous at the end of the small cove or recess between the two large rocks above referred to.

ON SOME SECTIONS IN THE LIASSIC AND OOLITIC ROCKS OF YORKSHIRE.

BY JAMES W. DAVIS, F.G.S., F.S.A., ETC., HONORARY MEMBER OF THE NEW ZEALAND INSTITUTE.

The upheaval of the Penine Anticlinal separating Lancashire and Yorkshire in a direction north and south; and the dislocation of the strata caused by the Great Craven Faults running east and west, have not only influenced the physical features of the West Riding of Yorkshire, but have also been instrumental in moulding the character of the country towards the eastern boundary of the County. The Carboniferous series were forced into a semi-circular basin, with a general depression towards the south-east, the Coal Measures were crushed and fractured in every direction, and innumerable faults exist as the result of this action. A long period of depression followed, and the several beds of the Millstone Grits and Coal Measures were denuded to a more or less regular surface, over which the Magnesian Limestones and other members of the Permian Series were unconformably deposited. They dip towards the east and disappear under the Keuper and Bunter Sandstones and Marls. The latter are in turn hidden beneath the thick glacial beds and river deposits which form the surface of the extensive plain of the river Ouse.

On the eastern side of the plain of the Ouse, the physical conformation of the country assumes a lofty character; the Liassic series of the North Riding, surmounted by the sandstones of the Inferior Oolites, give rise to an extensive area of undulating moorlands reaching from Saltburn, in the north, to Emsley, Pickering, and Goathland Moors, in the south; towards Cloughton and Scarborough the sandstones are obscured by thick deposits of Boulder Clay and Gravel. Separating this upland area from the Vale of Pickering is a long range of tabular hills of the Coralline Oolites, extending from Hambleton to Scarborough; they form a bold escarpment to the northwards, under the base of which dip the sandstones of the Inferior Oolites. South of the Pickering Valley, filled with Post Glacial Gravels and Alluvium, extends the long line of escarpment of

Chalk Wolds. The Chalk has a general dip to the south-east of two to five degrees, but in several places this is interferred with by lines of faults, and contortions. The Chalk escarpment, after extending eastwards from Flamborough Head to North Grimston and Achlam Brow, takes a southerly direction to the Humber, enclosing the luxuriant plains of Holderness, a basin-shaped hollow filled with glacial and more modern deposits. It is thus seen that, as has been found to be the case in the primary rocks of the western uplands of Yorkshire, the Wolds and hills of the easterly portion of the County exhibit the highest or most recent strata occupying the inner margins of the basin; these are surrounded by the older series which successively rise from underneath, and occupy constantly enlarging circles, the lowest, the Lias, underlying and surrounding the whole. Whilst this general conformity can be traced throughout the series of strata, there are several foldings and dislocations which interfere with it, notably in the lower beds of the Lias and in the Chalk. The principal lines of disturbance in the Chalk have generally an east and west direction. One of the finest exhibitions of distorted strata occurs at Scale Nab, in the Bempton Cliffs, half way between Flamborough Head and Speeton. The cliffs are 250 feet in height, and the Chalk is folded repeatedly. Photographs of this magnificent section were issued to the members of the Society in the year 1885, and a brief description was printed in the Proceedings of the same year. The line of disturbance is indicated on the map of the Geological Survey as proceeding due west a little north of Wold Newton and Foxholes, and about midway between Sherborn and Weaverthorpe. In the railway cutting near Hunmanby the Chalk is brought by a fault into juxtaposition with the Neocomian beds of Speeton.

The general dip of the beds is towards the south, but there are variations. Southwards from Robin Hood's Bay the rocks have the normal dip, but about the middle of the Bay they are observed to form an anticlinal and roll over with a strong northerly dip. The anticlinal extends inwards from the coast through the middle of Eskdale; evidence of it may be seen in the Lower Lias Shale on the south bank of the river in the Blue Scar. The anticlinal crosses the

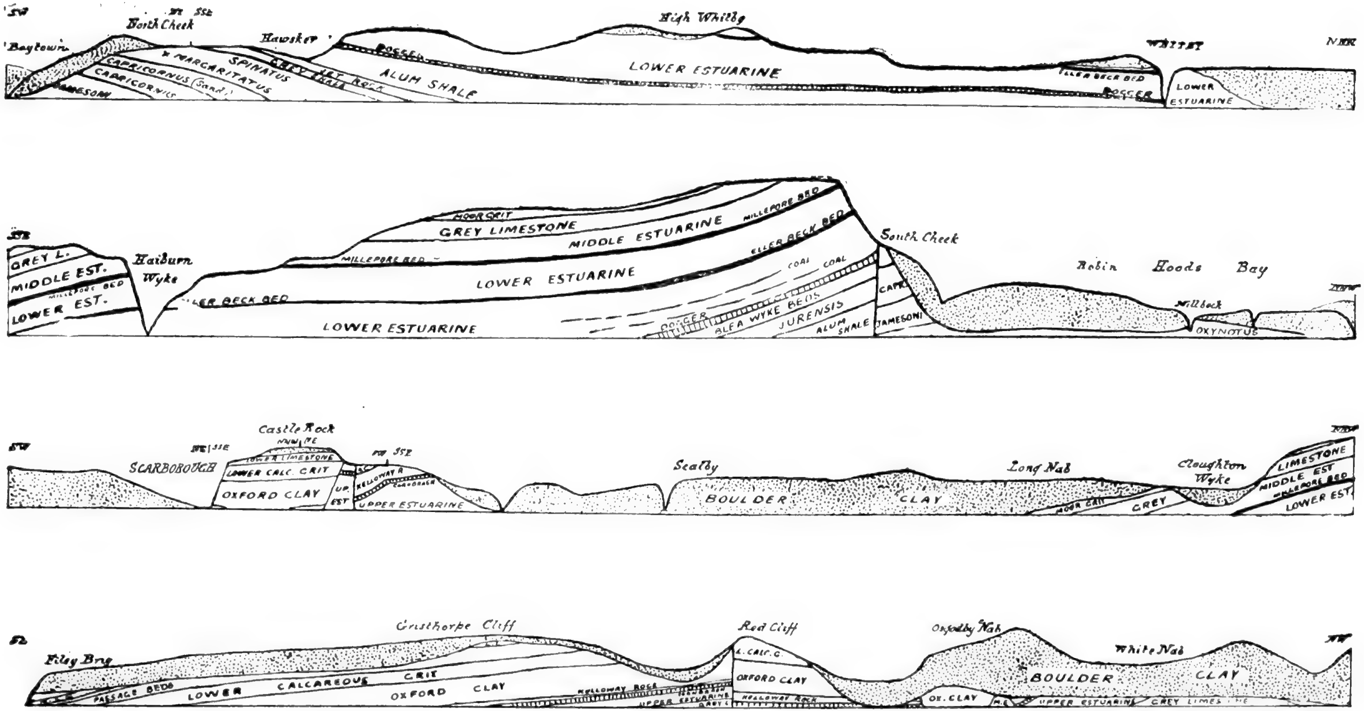


FIG. 1.—SECTION SEEN ALONG THE COAST OF YORKSHIRE FROM WHITBY TO FILEY BRIG.

river diagonally, and this causes a peculiar effect, the beds dip east in the eastern half of the dale and west in the western half. At the southern extremity of Robin Hood's Bay is the Peak Fault, by which the base of the Middle Lias is brought into a line with the top of the Upper Lias, indicating a throw of more than 400 feet. The indication of the fault inland is shown under Crag Hall, where the Dogger abuts against Grey Limestone. The country south is buried in Boulder Clays and the fault is difficult to trace. There are indications of it between Pye Rigg and Bell Hill, and southwards it runs west of Cloughton, where the Moor Grit, which crops out in the village, is also seen 100 feet higher, capping Ripley's Bank. The country south of Cloughton is covered with Boulder Clay, but it is probable that the faults occurring at Scarborough Castle may be a continuation of the same line of disturbance. At Hayburn Wyke there is an anticlinal which may indicate a branch of the Peak Fault, but its connection is by no means very clear. South of Scarborough the coast section exposes great thicknesses of Boulder Clay with the Estuarine Series and the Oxford Clay beneath, at White Nab and Osgodby Nab. At Red Cliff the fine section exposing the series from the Cornbrash up to the Lower Calcareous Grit is cut off by a fault which brings the Estuarine Series again into view at the northern extremity of Gristhorpe Bay. The Gristhorpe Cliffs, further south, afford a magnificent section of the strata between the Cornbrash and Kelloway Rock and the Lower Calcareous Grit. The section is continuous to Filey Brig, where the Passage Beds and probably the equivalent of the lower beds of the Coralline Oolites are exposed. South of Filey the Boulder Clays fill up the coast of the Bay, enveloping the Kimmeridge Clay (*see* fig. 1).

The drainage of the northern portion of the district is conveyed by the River Esk to the sea at Whitby. South of the valley of the Esk the River Derwent and its tributaries run into the Ouse; and the whole of this district is drained westwards, away from the coast, and eventually reaches the sea by way of the Humber. The Esk and its tributaries form a series of dales, of which the most important, Glaizedale, Fryup, Danbydale, and Westerdale are cut through the Oolitic Sandstones deep into the Liassic Rocks; about one hundred feet of Lower Lias is exposed, and the symmetrical terraces formed by the sandy beds of the Middle Lias, and the jet rocks of the Upper, form marked features in the valleys, especially on the southern slopes.

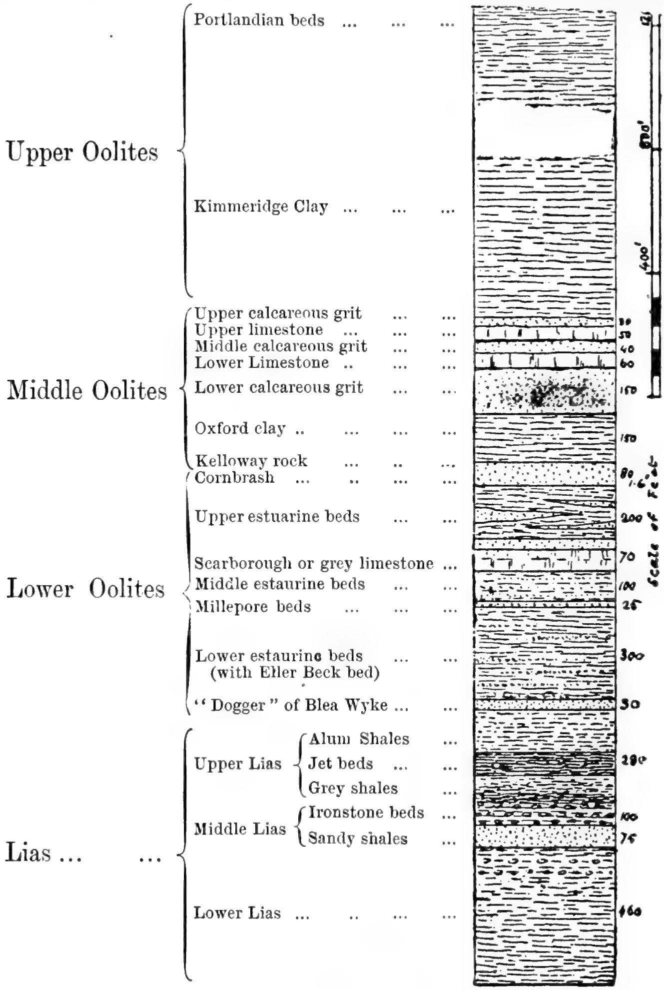


FIG. 2.—VERTICAL SECTION OF LIASSIC AND OOLITIC SERIES.

The moorlands, which form the watershed between the Esk and the tributaries of the Derwent, are coincident with an anticlinal, the rocks on the north having a northerly dip, whilst those on the south dip in a southerly direction. The streams draining southwards have cut through the sandstones and intervening shales in a similar manner to those falling to the Esk, and deep dales exhibit the Liassic beds in a very instructive manner; they are Rosedale, Bransdale, Farndale and Bilsdale. Further south the streams have deeply indented the Coralline Oolites of the Tabular Hills, and carved their way through them to the Vale of Pickering beyond, where the streams are known as the Rye, Dove and Severn, their combined waters join the Derwent a few miles above Malton.

It is proposed to describe with more or less detail three sections which serve to illustrate the whole series of the Liassic and Oolitic Rocks which occur in Yorkshire. First: the section exposed in Robin Hood's Bay and Peak, which comprise the Lower, Middle, and Upper Liassic Strata, the Dogger Beds and the Estuarine Series of the Lower Oolites, as high as the Grey Limestone Series. Second: the section exposed in the Gristhorpe Cliffs which includes all the beds between the Millepore beds of the Middle Estuarine Series, and the base of the Coralline Oolites; and third, the Scarborough Castle and Hackness sections which expose the Middle Oolites from the Cornbrash and Kelloway Rock to the Upper Calcareous Grits

I.—SECTIONS AT ROBIN HOOD'S BAY AND PEAK.

The LIASSIC BEDS are well developed in Robin Hood's Bay and the Cliff between Blea Wyke and Peak Steel. The oldest beds occur only in the scars furthest from the shore, about the middle of the Bay (fig. 3). Succeeding beds higher in the series occur in the scars of the Bay and in the Cliffs. They give place to the Middle Lias, the Marlstone of Prof. Phillips. The Middle Lias consists of two parts, the Lower or Sandy Series, well exposed at the North Cheek of the Bay and on the west side of the Peak Fault. The Upper part, named the Ironstone Series, forms the triangular mass of rock between the forks of the Peak Faults; a complete section is also exposed in the cliff at Hawsker Bottom (fig 5). The Upper Lias consists of three divisions. The Lowest, a soft grey shale; the Middle, a hard dark shale with doggers: and the Upper, the Alum Shale, with beds of hard jet rock at its base. These beds of the Upper Lias may be studied in the cliffs west and east of the Fault; on the west, high up in the cliffs at and near the Peak Allum Works; and on the east, thrown down to the foot of the cliff and the scars at Peak Steel. It is proposed to give a description of the several beds, which are admirably exposed for observation, perhaps nowhere else so well, in Robin Hood's Bay and Peak.

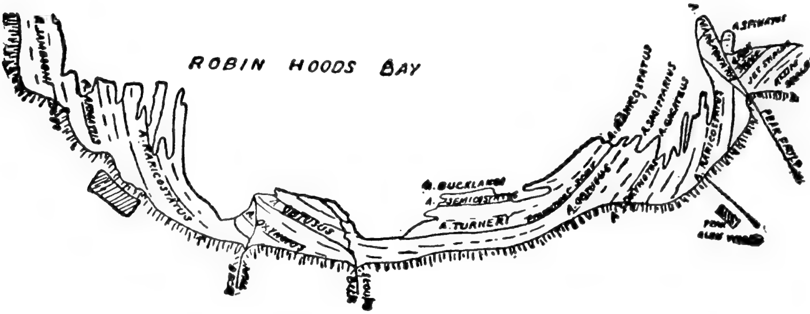


FIG. 3.—SHORE-PLAN IN ROBIN HOOD'S BAY, SHOWING THE POSITION OF THE LIAS-ZONES.

The Lower Lias is more extensively exposed in the scars and cliffs of Robin Hood's Bay than elsewhere in Yorkshire. The lowest beds containing *Ammonites planorbis* do not occur in Yorkshire, but, as Professor Blake has pointed out, it probably occurs in the bottom of the North Sea, because hard calcareous nodules are constantly being washed upon the shore, which contain that fossil in excellent preservation. The next zone, *Am. angulatus,* is exposed at Redcar, and the succeeding beds, in the district under consideration. The rocks here consist of argillaceous shales, slightly sandy and of a dark colour, with bands of hard marl in the lower part. The Lower Lias may be divided into the following beds, each characterized by a distinct fauna.

B. Soft shales with rows of ironstone doggers and pyritous nodules. 320ft.

- *d.* Soft shales with rows of ironstone doggers.
  (Zone of Am. Capricornus) *Gryphæa obliquata.*
- *c.* Soft shales with rows of pyritous nodules.
  (Zone of Am. Jamesoni) *G. obliquata, Pinna folium.*

A. Soft shales with a succession of sandy and marly bands. 140ft.	*b.* Shales with hard sandy bands, the upper parts covered by fucoidal markings. (Zone of Am. oxynotus) *Gryphæa incurva, Ammonites* abundant. *a.* Shales with marly calcareous bands, generally very shelly. (Zone of Am. Bucklandi) *Gryphæa incurva, Hippopodium ponderosum* in bands, *Am. semicostatus.*

The zone of *Ammonites Bucklandi* (*a*) forms a series of outer scars in the Bay parallel with the coast line, and dipping at an angle of 4° to the S.S.W. The outcrop is about 300 yards in extent, and the rock consists of soft grey shales with harder calcareous sandstones interspersed. They are only exposed at low spring tides, and are rendered difficult to investigate by the quantities of seaweeds which is attached to the beds. It is only after the hot summer weather has to some extent destroyed the weed that they can be examined satisfactorily.

The following is a list of the principal fossils found in these beds :—

Gryphæa arcuata, Lam.
Lima Hettangiensis, Terg.
Monotis inæquivalvis, Sow.
Pecten calvus, Goldf.
,, Thiollierei, Dumort.
,, textorius, Schloth.
Perna infraliassica, Quenst.
Cardinia hybrida, Stutch.
Protocardium oxynoti, Quenst.
Hippopodium ponderosum, Sow.
Leda galathea, D'orb.
,, Renevieri, Opp.
Lucina limbata, T. & B
Modiola lævis, Sow.
Nucula navis, Piette
Pholadomya glabra, Ag.
Chemnitzia trivia, Tate.
Cerithium sp.
Dentalium etalense, Terg. & P.
Ammonites Bucklandi, Sow.
,, semicostatus, Y. & B.
,, Turneri, Sow.
Belemnites acutus, Miller.
Pentacrinus tuberculatus.

The *Ammonites Oxynotus* Zone (*b*) is about 110 feet in thickness. it consists of alternating layers of soft shale and bands of sandy marl, the latter being remarkable for impressions of fucoids which are rendered visible by exposure to sea-water. Fossil ammonites are

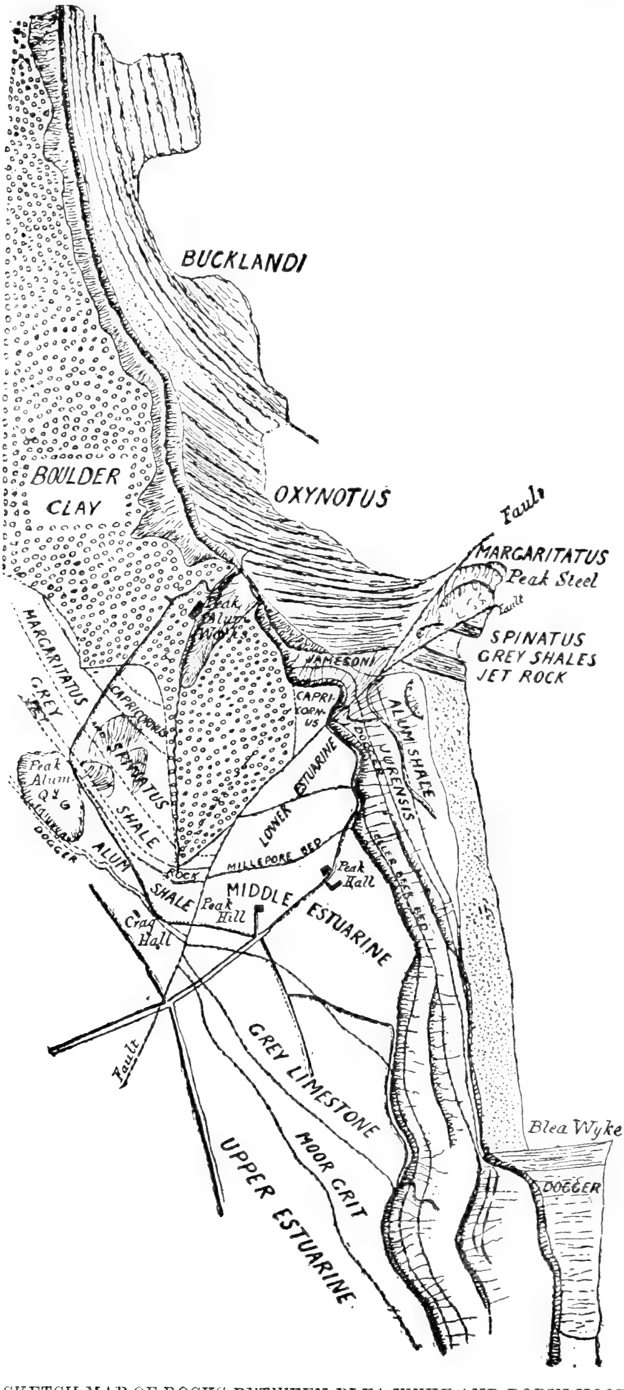


FIG. 4.—SKETCH MAP OF ROCKS BETWEEN BLEA WYKE AND ROBIN HOOD'S BAY

abundant in these beds and at the same time are restricted to definite lines. The highest beds with *Am. armatus* form the scar opposite Bay Town, where the dip is nearly due north; thence they rise into the cliff, and about the middle of the Bay they reach an altitude of 90 feet above sea-level, and the dip of the beds is nearly west. The strata again descend and form part of the scar opposite Peak Fault, about 100 yards seawards from the foot of the cliff, and the dip is southwards. The cliff section is interesting, and the following beds may be traced without difficulty :—(*see* fig. 3).

	Ft.	In.
Soft dark shales, resting on hard sandy calcareous bed, with fucoidal markings; *Gryphæa and Belemnites* ...	1	0
Soft sandy shales: *A. armatus*, *A. raricostatus*, *A. dudresseri*, *Gryphæa obliqata*	5	6
Sandy bands, *Rhynchonella variabilis*	5	6
Hard calcareous sandy band, *Modiola scalprum* (forms the second well-marked scar)	2	0
Sandy shale, with discs of ironstone resting on crinoidal remains; several species of *Ammonites* in hard nodules	8	6
Hard shales, with *A. obsoletus* at base	5	0
Sandy shale: *Belemnites* and *Gryphæa incurva* ...	5	6
Soft shale	0	2
Hard sandy band	0	10

(The three last beds form a double line in the cliff, and a small terrace at the mouth of Mill Beck, where a considerable number of fossils may be obtained on the top of the terrace or ledge).

Sandy shales	20	7

(These contain two lines of small doggers or nodules in most of which *A. gagateus* occurs; they also contain *A. densinodus, A. raricostatus, A. impendens, A. Simpsoni, A. oxynotus*).

Hard calcareous bed, covered with fucoidal markings, crosses the mouth of Mill Beck; *Pseudoglyphæa* ...	1	3
Soft shale: *Homomya ventricosa*	0	3
Hard calcareous band	0	9

(The last three beds make a strong scar and well-marked line in the cliff).

Shale, with remains of *Pentacrinus tuberculatus, Belemnites acutus, Modiola acutus.* At the base is a row of small doggers containing *A. gagateus* in great numbers, also *A. oxynotus*	7	3
Shale, soft and dark, with fossiliferous nodules ...	6	0

Below this the beds are not easy to trace; there are probably about 40 feet of shales with harder bands.

The zone of *Ammonites Jamesoni* (*c*) is composed of similar strata to those already mentioned. Their upper boundary is marked by the disappearance of *Pinna folium* and *Am. Jamesoni.* A pecularity of this zone is that the lines of doggers, especially in the lower beds, are replaced by bands of iron pyrites in imperfect tetrahedra; many of the fossil Ammonites are composed entirely of iron pyrites. The beds form a large flat expanse of scars north-east of Baytown; fossils occur in them either singly or more frequently in small conical heaps consisting of the shells of *Pecten, Belemites* and *Gryphæa,* a feature which characterizes this part of the Lower Lias. *Pinna folium* occurs throughout the series; *A. Jamesoni* and *A. brevispina* occur chiefly in the upper beds; and *A. armatus* and *A. densinoides* are common in the lower, in addition to *Lima pectinoides, Inoceramus dubius, Pleuromya galethea,* &c. The thickness of the strata of this zone is about 186 feet. Besides the location already given they may be studied in the base of the high cliff of the north-west side of the great Peak Fault. The strata is also exposed in the sides of the small streams flowing to Robin Hood's Bay, such as Mill Beck.

The upper bed of the Lower Lias, the *A. capricornus* zone (*d*), consists of 140 feet of grey micaceous shale, light coloured and sandy in the upper part, in the lower darker coloured and more argillaceous. A characteristic feature is the occurrence of bands of septariated doggers containing zinc blende at intervals of a few feet. In many horizons the Ammonites are casts entirely composed of zinc blende, and can be traced for considerable distances. Two of these bands, about fifty feet below the top of the Lower Lias, may be traced in the beds at Staithes and followed thence to Saltburn; the upper one contains *A. fimbriatus,* while the lower is a thin seam of clay-ironstone, speckled white, with a layer of small Belemnites and Pectens at the base. A complete section of these beds may be examined on the shore and cliffs at the North Cheek of Robin Hood's Bay. They show the junction with the beds of *A. Jamesoni* (*c*) below; and the upper beds, hard, sandy, and micaceous, and regularly jointed, gradually join up to those of the Middle Lias. In consequence of the jointed character of the upper rock, it falls and accumulates in large blocks on the shore; such an accumulation may be seen on the north-west side of Peak Fault, fallen from an inaccessible position, containing more or less abundant specimens of *A. capricornus,* accompanied by small ferruginous doggers, sometimes formerly mistaken for cannon balls. These beds are exposed in Tan Beck, above the Peak Alum Works, their junction with the Middle Lias Beds is also exposed in the same section. They may also be examined in Mill Beck and a gorge in Butcher Close Wood.

The following section of the A. capricornus Beds is exposed half way between Baytown and North Cheek:—

	Ft.	Ins.
Thick band of *Gryphæa*, &c., the base of the Middle Lias		
Sandy shale, rather hard, with small doggers, enclosing *A. capricornus*	9	0
Shales, with occasional bands of doggers...	37	0
Shale, with *A. fimbriatus, A. capricornus,* &c. ...	8	0
Shale, with nodular band, showing cone in cone structure near its base	11	0
Shale and thin dogger bands, with *Gryphæa, Belemnites, A. fimbriatus, A. Henleyi,* &c.	40	6

Messrs. Tate and Blake give the following list of fossils obtained from the beds in the district cited above:—

Fossil Wood.
Gryphæa cymbium, Lam.; var. depressa, Phill.
Monotis inæquivalvis, Sow.
Crenatula (Inoceramus) ventricosus, Sow.
Modiola numismalis, Oppel.
Modiola scalprum, Sow.

Pholadomya Beyrichii, Schlönb.
Ammonites capricornus, Schloth.
A. fimbriatus, Sow.
A. striatus, Rein.

The Capricornus Beds at Huntcliff, near Skinningrove, and Colburn Nab, Staithes, contain a much greater variety of fossils than the section now considered.

The MIDDLE LIAS may be divided into two parts. The Lower consisting of sandstones and hard shales, called the "Sandy Series"; and the Upper made up of shales with bands of ironstones of variable thickness, denominated the "Ironstone Series." The sandstones of the Lower Series have a blueish tinge when newly broken, but this is lost by exposure. The fractured surface is often found covered with casts of shells, principally *Cardium truncatum, Gryphæa, Cymbium, Pecten,* and *Avicula.* The beds are remarkable for the great abundance of fossils they contain; they are between 50 and 60 feet in thickness. Several exposures occur in the district. On the west side of the Peak Fault the cliff is capped by sandstone and sandy shales. They are seen on the left of the footway with an abundance of fossils: *A. margaritatus, Hippopodium ponderosum, Cardium truncatum, Gryphæa,* and *Dentalium,* not generally very well preserved. From thence the sandstones form a well-marked terrace round the south-east side of the Bay, and disappear under the Boulder Clay below the Brow Alum Quarry. The Middle Lias rocks form a fine succession of curving terraces systemmatically arranged round this part of the bay; and in Tan Beck, and less perfectly in other streams, good sections of the series may be obtained. The best section of the Middle Lias beds is obtained a short distance north of North Cheek of Robin Hood's Bay at Castle Chamber, the following is the section in descending order—

	Ft.	In.
Thin calcareous sandy band forms top of Dobson Nab: layers of *Cardium truncatum,* &c.	0	10
Hard sandy shale	4	0
Calcareous sandy shale: *Dentalium giganteum, Gryphæa, Cardium truncatum,* &c., abundant ...	5	0

Close-grained sandstone, ferruginous and calcareous, containing four distinct bands of *Gryphæa, Cardium,* &c. (forms the roof of Castle Chamber, a small hollow in the cliff at high-water mark) ...	3	0
Hard sandy shale: *A. margaritatus, Pecten,, Belemnites,* &c., in bands	2	4
Dogger band	0	4
Hard sandy shale, with an 8-inch fossiliferous nodular band at the base	3	0
Hard shale, darker than above: *Pecten, Belemnites,* &c.	5	4
Calcareous and ferruginous Dogger Band. *A. capricornus*	0	6
Hard Shale	0	6
Very hard ferruginous sandstone, containing layers of fossils: *Dentalium giganteum* being abundant in the uppermost; *A. capricornus, Bel. clavatus, Gryphæa cymbium,* &c., abundant; *Cardium truncatum* found occasionally (forms the floor of Castle Chamber)	4	6
Sandy shale, with doggers and fossil wood ...	15	1
Shale, with septariated nodules at base	1	0
Shale, with dogger at base, very fossiliferous ...	7	5
Thin sandy laminæ, passing into a calcareous band, composed of *G. cymbium* and *Avicula inæquivalvis,* accompanied by *A. capricornus, Encyclas undatus, Rhynchonella calcicostata, Belemnites,* &c.	1	6
Total ...	54	4

The *Ironstone Series,* the upper division of the Middle Lias, consists of shales with thin bands of ironstone. The shales are soft and clayey in the upper and middle portions, hard and sandy in the lower; the whole is very fossiliferous. At Peak Steel this series forms a hard triangular piece of rock between the two branches of the fault. Its equivalent is on the other side of the east branch of the fault, 360 feet higher up in the cliff. A couple of miles westward, in the narrow gorge of Howedale Beck, there is a section of the Ironstone Series to a depth of 80 feet, in which it is observed that the thick beds of ironstone of the district further north have disappeared and are represented by bands of nodules. The shales are more clayey and decidedly less sandy than in other sections. The outcrop from this point is lost under the Boulder Clay until Hawsker is reached. At Hawsker Bottoms a very complete section about 100 feet thick is obtained (fig. 5).

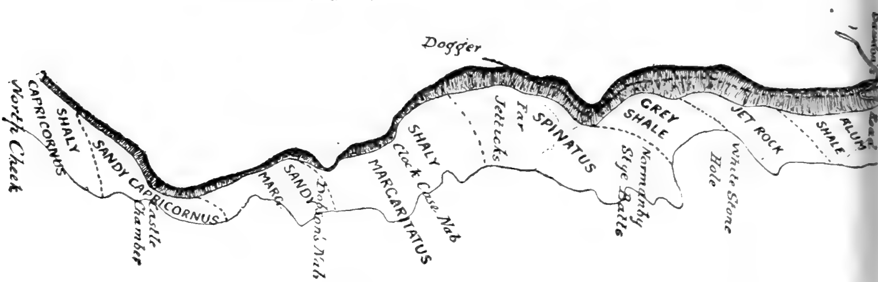


FIG. 5.—SHORE PLAN FROM HAWSKER TO ROBIN HOOD'S BAY.

The Upper Lias comprises thick beds of argillaceous shale, in the upper part grey in colour changing to nearly black in the lower; it has a nearly constant thickness of 240 feet. It may be roughly divided into three parts :—

1. Soft grey micaceous Alum Shale (with *Ammonites communis*, *A. elegans*, *A. bifrons*, &c., and *Leda ovum*), the Jet Rock is at the base.
2. Hard dark shale, with pyritous doggers; the characteristic fossils being *A. serpentinus* and *Inoceramus dubius*.
3. Soft or grey shale, with the very restricted *A. annulatus*.

The *Grey Shale* rests immediately on the ironstone series of the Middle Lias, and consists of shale which weathers soft and grey. Two bands of impure earthy ironstone occur close together about the the middle of the bed, enclosing *A. annulatus*, the characteristic fossil, in great abundance. *Belemnites cylindricus* occurs on about the same horizon as well as many other fossils; otherwise these beds are remarkable for the paucity of their fossils. These shales occur on the east side of the fault at South Cheek on Peak Steel. The extreme point is a mass of the ferruginous Ironstone Series dropped 100 feet by the fault. Above this are the Grey Shales, which, being soft, have been washed away by the tides, leaving a hollow since filled up with blocks of oolitic sandstone from the cliffs above, and always more or less under water.

Above the Grey Shales the JET ROCK can be seen almost hidden by detritus at the foot of the cliff. It is thence thrown by the fault to a position on the hills above, immediately below the Peak Alum Works, where it has been extensively mined along the face of the hill. It has also been much worked at Howedale, further north; from thence it is hidden by Boulder Clay, but reappears at the North Cheek of the Bay, forming the summits of Far and High Jetticks. Its position in the cliff face is indicated by the terrace, where the jets have been dug away, till it reaches the shore with a northerly dip at Hawsker Bottom, where its thickness is about 25 to 30 feet. "The long white line of breakers that extends at almost all tides from Black Nab to Saltwick is caused by the top of this rock; the lenticular doggers of calcareous and ferruginous shale being here very hard and of enormous size. At very low tides the breakers caused by this bed can be clearly seen from the top of the cliffs in the form of a curve stretching west till it is due north of the old Abbey."*

The Jet Rocks are remarkable for their even laminated bedding and for the abundance of their fossils. They are of a dark colour and interspersed are rows of doggers of blue cement stone with a pyritous covering. The doggers contain *A. serpentinus* and *Inoceramus dubius.* The former is often filled with liquid bitumen, and the doggers themselves smell of mineral oil. At the top of the Jet Rock is a continuous band of large doggers, as much as 15 feet in diameter, very hard, composed of laminated sandy shale, cemented together by carbonate of lime and iron. This continuous dogger band forms the roof of all the workings for hard jet, which occurs in greatest quantity for about 10 feet below the band. The huge, flattened, lenticular doggers may be seen on the shore at Saltwick at low tides, and also at South Cheek, between Peak Steel and Blea Wyke, where they are

* Geology of the Country between Whitby and Scarborough, Memoir Geol. Survey, 1822, p. 21.

elevated above the general level on cones of shale, which has been washed away all round them. The jet is probably formed of water-logged coniferous wood,* in some specimens the structure is preserved, in others entirely obliterated. A different opinion is expressed by Tate and Blake,† who trace the origin of jet to the bitumen occurring in the rocks. "It is the result of the segregation of the bitumen in the intervals of the shales which, allowing to a certain extent the access of air, has hardened it into jet, a process which may undoubtedly be now going on. So in cases where it is embedded in a nodule it remains unhardened. There seems to be no reason whatever for connecting it with wood, beyond its having a remotely similar composition, though, of course, we have thrown no light on the cause of the presence of bitumen itself." It is further assumed that the bitumen is derived from the decayed vegetables of the period.

The Jet Rock is, palæontologically, especially interesting from the large number and variety of the fish and saurian remains found in it. The "scale fish" as it is locally termed, *Lepidotus semiserratus*, is the most common; examples of other genera are also found, *Ptycholepis, Leptolepis, Pachycormus* and *Gyrosteus.* Of the saurians examples of the *Ichthyosaurus* and *Plesiosaurus* have been found in the Jet workings. A number of Cephalopods, including the Aptychi, as well as other mollusca occur, which are not commonly found in other Liassic strata. The characteristic ammonite being *A. serpentinus.*

Messrs. Tate and Blake give the following list of fossils from the Jet Rocks (zone of *Am. serpentinus*) :—

Steneosaurus brevier.	Belemnites subtenuis, Simp.
Ichthyosaurus tenuirostris.	B. subaduncatus.
Plesiosaurus longirostris.	B. tripartitus, Schloth.
P. propinquus.	Ammonites heterophyllus, Lon.
Gyrosteus mirabilis, Ag.	A. levisoni.
Æchmodus ovalis.	A. gracilis.
Lepidotus semiserratus.	A. crassescens.

* Op. cit. Memoir Geol. Survey, p. 23.
† The Yorkshire Lias, p. 178.

L. rugosus.
L. pectinatus.
Pachycormus curtus.
P. latirostris.
P. gracilis.
P. latus.
P. macropterus.
P. acutirostris.
P. latipennis.
Ptycholepis bollensis.
Leptolepis saltviciensis
Aspidorhynchus anglicus.
Belonostomus acutus
Beloteuthis subcostatus.
B. Leckenbyi.
Groteuthis coriaceus.
Teudopsis cuspidata.
Belemnites tubularis.
B. inæquistriatus.
B. dorsalis
B. crossotelus.
B. voltzii, Phill.
B. breviformis.
B. striolatus.
B. lævis.
B. acuminatus.
B. scabrosus.
A. elegans, Sow.
A. aalensis
A. serpentinus, Rein.
A. exaratus.
A. cæcilia.
A. subconcavus.
A. lineatus.
A. cornucopia.
A. erratus.
Natica buccinoides.
Discohelix minutus.
Inoceramus dubius, Lon.
I. Simpsoni.
Tancredia dubia.
Posidonomya Bronni, Voltz.
Pecten pumilus.
Monotis substriatus.
Pleuromya bituminosa.
Ceromya exarata.
Modiola Simpsoni.
Protocardium substriatulum ?
Discina reflexa
Extracrinus briareus.
E. dichotomus.
Pachyphyllum peregrinum.

The ALUM SHALE, the uppermost of the Liassic Series, is first seen rising from the bed of the sea at Blea Wyke, capped by some soft sandy shale. The thickness is about 150 feet. The upper 100 feet is a soft grey micaceous shale, which weathers to small crisp fragments with yellow edges. This is the source of the alum. The rocks are characterized throughout by the presence of *A. communis* and *Leda ovum*. The lower 50 feet are harder and darker bituminous shales, not used for alum, in which ammonites of the serpentinus type predominate. The Alum Shales form the lower part of the cliffs at the east side of the Fault. On the west side of the Fault these shales are constantly exposed, especially at the great works, long since abandoned, at Peak and Brow. At Howedale the entire series may be examined and measured. Other small exposures occur in the neighbourhood; from Maw Wyke to Whitby the base of the cliff and the scars consist of this portion of the Upper Lias.

The manufacture of alum was some years ago a large industry. The shales of this neighbourhood were the only source of alum, and though the disadvantage of want of fuel was great, the trade flourished. About 45 years ago a process was discovered by which a great proportion could be extracted from coal shale, and since then the ammoniacal liquor from the manufacture of gas has been utilized, and the Whitby alum was driven out of the field. The alum made in this district was potash alum, and it was manufactured as follows. The shale was first calcined, this was done by placing about 4 feet of shale over brushwood, setting it on fire, and repeatedly adding shale, the temperature being regulated so that the sulphur was not sublimated. This operation lasted one or two years. The calcining floors may be seen at any of the old works. The calcined shale was then washed and the aluminium sulphate dissolved out. This was done in a series of cisterns, and the liquid was conveyed to the boiling house, the shale being now thrown aside in heaps. The liquor was evaporated, the potash sulphate or chloride added, which precipitated the alum. This was again dissolved in boiling water, and crystallized out in the form known to commerce.

The fauna of the Alum Shales is even more rich than that of the jet rocks in large Saurians; they are abundant both in species and numbers, and are the largest known. In addition to the Ichthysaurians and Plesiosaurians there are the Teleosaurians. In the Lias of Lyme Regis and the South of England the Saurians come from the lower beds of the Lias, but in Yorkshire they occur in the upper beds. The profusion of Ammonites and Belemnites is greater in these beds than in any others, though the number and variety of the species is not so great.

Above the Alum Shale, Tate and Blake consider that a series of shales form a passage bed to the Dogger Oolites. These authors attribute to them a thickness of about 80 feet.* The Geological Survey reckon this an over-estimate, and represent the series as 30 feet thick. The beds occur at the foot of the cliff below Peak, extending seawards on the shore. The shore sections are completely hidden by *débris* from the oolites, and there is thus very little opportunity to study them. They consist of four beds of sandy micaceous shale, separated by irregular bands of nodules, the latter containing fossils of which *Ammonites jurensis* is most characteristic. The fauna is a mixed one, part of the fossils, such as *Discina reflexa*, *Venus tenuis*, *Pecten disciformis*, *Dentalium elongatum*, &c., are upper Lias forms; others are Oolitic. The beds exhibit the last remnants of Liassic life and the first dawning of the Oolitic.

The Oolites.

The Peak Cliffs south of Robin Hood's Bay attain a height of more than 600 feet, and exhibit a magnificent section not only of the Upper Lias Beds but especially those of the Inferior Oolite. The two series are brought into juxtaposition by the great fault, with a downthrow to the south of 400 feet. Near the extreme headland, the Peak Steel, a second fault branches to the eastwards, and between the two is the hard triangular mass of rock of the Ironstone Series already described (see fig. 6). A most instructive method of visiting these sections is to descend the circuitous footpath from the top of the cliffs above Blea Wyke to the Dogger Beds at the base. The path, which descends from a position near the Peak Railway Station, winds down one of the most beautiful and majestic amphitheatres of rocks in the country. The several strata extend in semicircles, and form a section of great interest and no little grandeur; thence along the cliff base to the Peak Steel, and again ascend by the path which is immediately over the line of fault.

The Lower Oolites are developed between Blea Wyke and Scarborough, the upper beds forming the lower part of the North Cliff, whilst the lowest beds occur at Blea Wyke. The latter offer an admirable section, and it is possible to examine every bed; they are more extensively developed here than elsewhere, and between the

* Yorkshire Lias, p. 19.

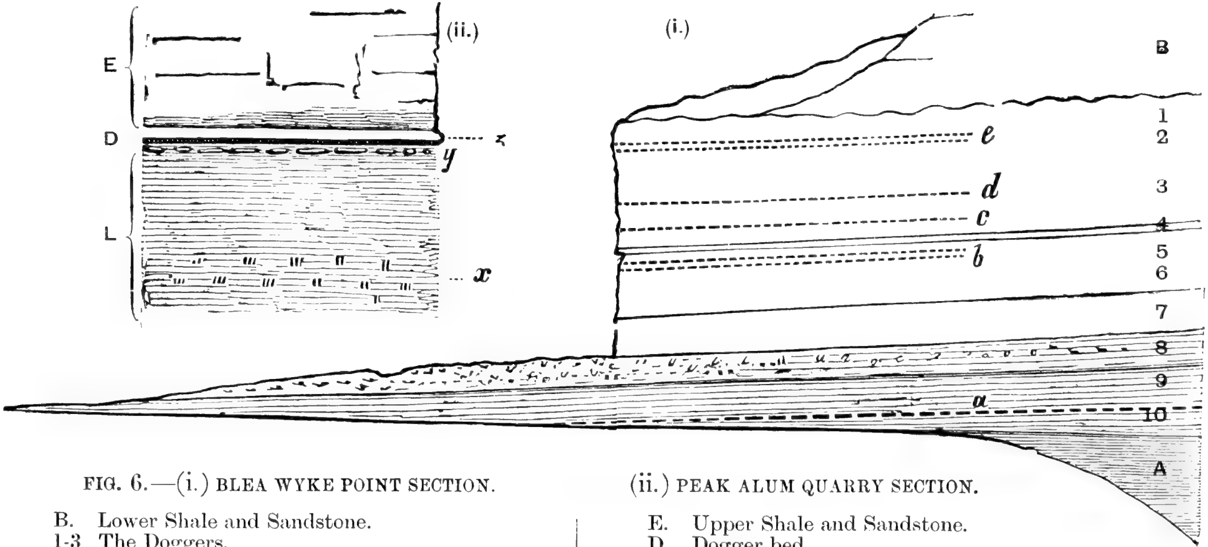


FIG. 6.—(i.) BLEA WYKE POINT SECTION.

B. Lower Shale and Sandstone.
1-3 The Doggers.
e. Nerinea bed.
d. c. Lines of Nodules.
4-6 Ferruginous and Yellow Sandstones.
b. Terebratula bed.
7-9 Grey Sandstones and Shales, with *Vermetus bed.*
10 Soft Grey Shales with Doggers.
a. Lingula bed.
A. Ammonites Jurensis Zone.

(ii.) PEAK ALUM QUARRY SECTION.

E. Upper Shale and Sandstone.
D. Dogger bed.
z. Nodule bed at base.
L. Alum Rock of Upper Lias.
x. Leda Ovum bed.
y. Line of Ironstone Nodules.

base of the Grey Limestone Series and the top of the Upper Lias there is a thickness of nearly 500 feet, whilst at Hawsker the entire thickness is less than 300 feet. The section following is extracted from the memoirs of the Geological Survey (Quarter Sheet, 95 N.W.), and the whole of the series to the base of the Oolites is exhibited in the section :—

SECTION OF THE CLIFFS AT AND NEAR BLEA WYKE.

		Ft.	Ins.
Moor Grit	Massive false-bedded sandstone, resting on flaggy sandstone	40	0
Grey Limestone Series.	Sandy and calcareous shale, resting on bands of impure limestone ...	100	0
Estuarine Series	Shales and false-bedded sandstone, with occasional beds of fire clay and a thin seam of coal in the lower part ...	100	0
Millepore Bed	Nodular bands, with calcareous and ferruginous sandstone below	8	0
Estuarine Series with Eller Beck Bed.	Great masses of false-bedded ferruginous sandstone resting on shale, with bands of carbonaceous matter	110	0
	Thin flaggy sandstone, resting on a few feet of soft shale, enclosing thin bands of ironstone. (*Eller Beck Bed.*) ...	15	0
	Principally carbonaceous shales, with thin coal seams in the upper part, false-bedded sandstone in the lower ..	150	0
Dogger Beds.	Sandstone, oolitic in parts, with layers of small pebbles, and weathering into rounded blocks with ferruginous casings, soft sandstone below graduating into the shales of the Upper Lias ...	95	0
	Total	633	0

The DOGGER receives its name from its weathering into roundish lumps or doggers enclosed in a ferruginous casing. The lowest bed of the Oolites consists usually of reddish ferruginous sandstone, slightly calcareous, and is a littoral formation with numerous nodules. At Blea Wyke it may be seen on the beach rising from the sea level, and the following series of beds may be traced :—

SECTION IN DOGGER BEDS AT BLEA WYKE.

		Ft.	Ins.
1.	Dogger sandstone, hard, red, and ferruginous, with small projecting masses of oxide of iron; pebbles scattered throughout	10	0
2.	Ferruginous band, composed entirely of shells, the lime nearly all replaced by iron; the *Nerinæa Band* ...	1	6
3.	Greenish dogger sandstone with pebbles, scattered and in bands	25	0
4.	Ferruginous shaly micaceous bed; very few fossils ...	1	2
5.	Brown sandstone, crowded with *Terebratula trilineata*	2	0
6.	Soft brown sandstone, becoming yellow in lower parts; fossils in nests, calcareous casts of large alveoli of *Belemnites*; pebbles scattered throughout ...	25	0
7.	Soft grey sandstone, forming a back to the scar; fossils in nests. *Vermetus Bed*	10	0
8.	Soft sandstone and hard grey sandy shale; fossils in nests, fossil wood, *Belemnites*, &c.	25	0
9.	Soft grey sandy shales	7	0
10.	Soft dark grey shales with doggers; the uppermost dogger band being almost composed of *Lingula Beanii*; the thickness doubtful.		

The Dogger Sandstones (1) is the same as seen in other parts of the district, but the beds (2-9) are not, for the most part, known to occur elsewhere. The Nerinæa band (2) is readily distinguished by its dark red colour, immediately above the doggers, and may be seen rising from the sea level to a height of 15 or 20 feet in the north end of the cliff, it is replete with fossils of undoubtedly Oolitic *facies*. The following list is recorded in the Memoirs of the Geological Survey (Sh. 95, N.W., p. 27). .—

Rhynchonella obsoleta, Sow.
Terebratula perovalis, Sow.
Hinnites relatus, Goldf.
Gervillia tortuosa, Sow.
Pteroperna striata, Bean.
Opis Phillipsii, D'Orb.
Astarte elegans, Sow.
Ceromya Bajociana, D'Orb.
Gresslya adducta, Phill.
Natica adducta, Phill.

Modiola cuneata, Sow.	Cardium punctura, Bean.
Cucullæa cancellata, Phill.	Chemnitzia lineata, Leck.
Macrodon Hirsonensis, D'Orb.	Neiinæa cingenda, Bronn.
Trigonia denticulata, Ag.	Cerithium (2 species).
,, var. costata, Lycett.	Alaria Phillipsii, D'Orb.
,, spinulosa, Y. &. B.	Onustus pyramidatus, Phill.
Cypricardia acutangula, Phill.	Nerita lævigata, Phill.
Tancredia axiniformis, Phill.	Trochotoma sp ?
Cardium striatulum, Sow.	Actæonina sp ?

The Terebratula Bed (5) consists of two feet of soft brown or yellowish sandstone, full of fine casts of *Terebratula trilineata*, Y. and B., other fossils being small and mostly found in nests. This appears to be the lowest bed found in any other locality, and the remaining strata are unique in this section. *Trigonia* and other fossils are associated with the *Terebratula*. At the base of No. 9 is a thin stratum of sandy nodules, almost composed of *Lingula Beanii*, and known as the "Lingula Band" (10). They are readily observable at the foot of the cliff at its northern extremity at Blea Wyke, and other bands of a similar nature occur lower down. They are the uppermost beds of the Lias. The lower beds are not easy to observe, because they are under water except at unusually low spring tides. From the occurrence of *A. striatulus* and *A. Jurensis* in these shales they have been variously named the "*A. striatulus beds*" and the "*A. Jurensis shales.*" The whole of the Dogger Series thin away very rapidly towards the Peak, and their course is stopped by the great Peak Fault (fig. 6). The ferruginous beds with the characteristic doggers again appears in the Peak Alum Works, from whence its outcrop may be traced to Howedale Beck, after which it is covered by the Boulder Clay.

The Lower Estuarine Beds are of freshwater origin, and at Blea Wyke consist of alternating beds of shale and sandstone, with three beds of thin coal attaining a thickness of 160 feet. A bed of soft ferruginous sandstone occurring at a height of 50 or 60 feet from the base of the series contains vertical stems of plants often five feet in height, which are probably the remains of *Equisetites*. At the summit of the Lower Estuarine Series is the Eller Beck Bed, so named from its development at Eller Beck, near Goathland. It is of marine origin, and may be traced at the top of the undercliff between Hayburn Wyke and Blea Wyke (fig. 4), and thence after following the coast line turning inland and abutting against the fault. The beds are about 17 feet thick, and consist of the following strata :—

ELLER BECK BEDS AT PEAK.

	Ft.	Ins.
Sandstone, close-grained in upper part and flaggy, with streaks of dense ironstone near the base ...	12	0
Thin Band of Ironstone, with *Nucula, Astarte minima,* in great numbers ; also *Gervillia acuta, Arca sp. Corbula, Tancredia,* and *Littorina* ...	0	3
Shales, well-bedded and ferruginous	3	0
Thin band of ironstone, unfossiliferous	0	3
Shales, similar to the above	1	6
Ironstone	0	3

Between the Eller Beck marine beds and the marine Millepore Bed, the Estuarine Series consists mainly of two parts, the lower being mostly shales, and the upper consisting of a massive false-bedded ferruginous sandstone 60 feet thick. At Peak these beds are for the most part hidden by talus from the cliffs above.

The *Millepore Beds,* about 12 feet in thickness, may be seen at the top of the cliff at the gardens of Peak Hall, from this point they take a direction at right angles to the cliff until they are stopped at the fault. From Peak Hall a footpath leads down the cliff towards Foxholes, and the following section is exposed :—

	Ft.	Ins.
Hard yellow sandstone	5	0
Soft yellow calcareous sandstone, with fossils ..	0	2
Hard ferruginous band, many small fossils ...	0	4
Flaggy sandstone, speckled white	1	6
Flaggy sandstone	3	0
Dogger band, speckled white	0	6
Soft white sandstone, with few casts of fossils ...	2	0
Total	12	6

Beyond the Fault the Millepore Bed may be seen at the top of High Moor over the Peak Alum Works.

The Millepore Beds take their name from the small Polyzoan, *Spirapora (Millepora) straminea*, Phill, the remains of which in some places occur in great numbers, weathered on the surface of the rock.

The MIDDLE ESTUARINE SERIES are 80 to 100 feet in thickness and consist of shales, with three or four well-marked beds of sandstone, containing a great abundance of plant remains. The sandstones are rarely persistent, and frequently die out in short distances. It is in this series that the soft jet used to be worked. East of the Peak Fault these rocks have an expanse to the cliff towards Blea Wyke where they include a coal seam 10 inches in thickness. The section exposed in the cliff is :—

	Ft.	Ins.
Dark shale, coaly at base	2	6
White rubbly false-bedded sandstone, with shale partings	40	0
Hard white sandstone, with Equisetites	3	0
White shale, with carbonaceous band at top ...	20	0
Coal seam	0	10
Shale	3	0
Sandstone, hard and white	3	0
Millepore bed at base		
Total	72	4

Above the Middle Estuarine Series there are the Scarborough and Grey Limestone Series, the Moor Grit and the upper Estuarine Beds.

The Scarborough or Grey Limestone Series is the most important of the marine beds of the Middle Oolites. In the district now under consideration it varies up to 90 feet in thickness. It consists of calcareous and siliceous bands with partings of shale. A fine section is exposed at Cloughton Wyke, and it has a regular outcrop northwards to the Peak Fault. At Blea Wyke it appears to attain its greatest thickness, and forms the uppermost bed of the amphitheatre already mentioned. Above the Point the following section is exposed :—

SECTION AT BLEA WYKE POINT.

	Ft.	In.
Flaggy sandstone with *Myacites* in great numbers along the lines of bedding: *Avicula Braamburiensis* and a small Pecten abundant in the lower part: *Pholadomya Sœmanni ?* occasionally found ...	15	0
Sandy shales rather hard at top, with small ironstone nodules containing *Avicula braamburiensis*, becoming soft and calcareous in the middle, and harder and more calcareous towards the base; *Belemnites giganteus* occurs somewhat plentifully in this series	55	0
Calcareous sandstone which weathers into blocks with a rounded outline, the outer face often covered with stalactite; many small fossils	5	0
Band of flaggy limestone which weathers easily away: *A. Braamburiensis*, *Pecten lens*, and *Gervillia acuta* very abundant	2	0
Hard calcareous shales, with nodules of close-grained limestone almost composed of shells	10	0
Band of flaggy limestone having the appearance of hard calcareous mud	2	0
Thin flaggy sandstone with *Myacites* along the bedding planes, passing gradually to a sandy shale; casts of a small Pecten are very abundant near the base	15	0
Total ...	89	0

From the cliff the limestones extend westwards and abut against the fault near Cragg Hall.

The Moor Grit, the lowest bed of the Upper Estuarine Series, rests on the Scarborough Limestone. The whole series of the Upper Estuarines have a thickness of about 200 feet, and have a wide expanse over the moors of the North Riding. Above the Moor Grit, which is a massive, jointed sandstone, the Upper Estuarine Series consists of shale, with an occasional bed of sandstone. The Moor Grit forms a conspicuous feature along the hills above Robin Hood's Bay, and extends to Staintondale and Cloughton ; at the latter place it is quarried for building purposes. It forms the summit of the extensive Fylingdales Moor, dipping southwards under the Cornbrash and Kelloway's Rock of Hackness, Wykeham, and Pickering Moors.

In this district the Lower Oolites are principally of estuarine formation ; in the South of England they are exclusively marine. It is evident that whilst in the Oolitic areas of the Middle and South of England the strata were deposited under marine conditions, at the same time in the north for a long period there were alternations of marine, estuarine and terrestrial conditions. The thin bands of the Millepore and Scarborough Limestones being deposited in the sea. The beds of coal and leaf beds of the middle estuarines indicating a terrestrial surface.

II. The Gristhorpe and Filey Sections.

The Lower Oolites have been traced from their junction with the Liassic Beds at the foot of Peak to the summit of the escarpment at Blea Wyke, and this incomparably fine section comprises all the series from the Dogger's to the Upper Estuarine sandstones and shales. To continue the series a profitable and most interesting series of sections are exposed on the coast between Scarborough and Filey. At Gristhorpe, midway between the two, the cliffs and scars exhibit the rocks between the Estuarine Series and the Lower Calcareous Grit. The lowest rocks are part of the *Lower Estuarine Series,* and consist of irregular but massive sandstones ; they form the lowest part of the scars or reefs opposite Yons Nab, the northern extremity of Gristhorpe Bay. They appear to have become much harder than at Peak ; they are only exposed at very low water. Above these sandstones the *Millepore Beds* form a reef of rocks extending from Yons Nab south-eastwards completely across the bay to the Old Horseshoe Rocks. The beds are composed of a very hard siliceous calcareous sandstone with ferruginous partings. It is false-bedded and full of the remains of crinoids, and has every appearance of having beon deposited during a slight subsidence of the estuarine beds beneath the sea, in shallow water. The true Millepore beds are about 15 feet in thickness. Resting on them at Yons Nab are 25 feet of strata, which from the contained fossils are evidently of marine origin, and must be associated with the Millepore Beds. They are of very local extent, and the following section of them is exposed on the Cayton Bay side of the Nab :—

	Ft.	In.
Ferruginous sandstone : *Trigonia signata, Avicula, Myacites*, &c.	4	0
Sandy shale, with an ironstone band near the base ...	4	6
Ferruginous band : *Pecten clathratus, P. articulatus. Avicula Braamburiensis, Pholadomya Heraultii, Ostrea*, &c.	1	0
Sandy shales, with fossils in upper part, and ripple marks about half way down : *Trigonia* abundant, *Aviculæ*, spines of *Pseudodiadema*, and remains of plants	7	0
Indistinct marly shales, about	8	6
Millepore sandstone		
Total	25	0

The following list of the most characteristic fossils from the Millepore Beds has been prepared by Mr. R. Etheredge :—

Spiropora (Millepora) straminea, Phill.

Pygaster semisulcatus, Phil.	Trigonia recticostata, Lyc.
Stomechinus germnians, Phil.	T. conjungens, Phil.
Pecten demissus, Phil.	Pholadomya Heraultii, Ag.
Pinna cuneata, Bean.	P. Sæmanni, L. and M.
Lima duplicata, Sow.	Ceromya Bajociana, D'Orb.
Gervillia lata, Phil.	Natica adducta, Phil.
Modiola imbricata, Sow.	Chemnitzia vetusta, Phil.
Unicardium gibbosum, Lyc.	Actæonina glabra, Phil.
Goniomya literata, Sow.	Cerithium Leckenbyi, Wr.

Immediately above the Millepore Beds are the *Middle Estuarine Series,* consisting of thin bands of sandstone and shale with thin coals. They occupy most of the cliff and foreshore on the east side of the Nab, where they are more than 50 feet in thickness. On the west side of the point or Nab at Low Red Cliff they have diminished to 34 feet. The section in Gristhorpe Bay, on the east side of the Nab, is :—

	Ft.	In.
Sandstone with fine black laminations, very characteristic	5	0
Shale	8	0
Black coaly shale	0	3
Soft white sandstone with rootlets	1	0
Grey shale	5	0
Sandstone and shale with carbonaceous markings and some sulphur	3	6
Black shale	1	6
Finely-laminated shale, with irregular patches of coal and fossil plants (The Gristhorpe Plant Bed) ...	6	0
False-bedded sandstone, with pyrites and carbonized wood, passing into hard sandstone towards the base, which may belong to the Millepore series, but no fossils have been found in it	21	0
Total... ...	52	9

The plant bed at Gristhorpe has yielded the following plants, many of which have been figured by Phillips in the Geology of the Yorkshire Coast, and also by Leckenby.*

Taxites laxus, Phil.
Walchia Williamsonis, Brong.
Tæniopteris vittata, Brong.
T. major, Lindley.
Hymenophyllites Williamsonis, Brong.
Sphænopteris Phillipsii, Brong.
Glossopteris Phillipsii, Brong.
Phlebopteris polypodioides, Brong.
P. Phillipsii, Brong.
Pecopteris dentata, Lindley.
P. lobifolia, Phil.
Ctenis falcata, Lindley.
Odontopteris Leckenbyi, Tign.
Otoxamites Beanii, Lindley.
Pterophyllum pecten, Lindley.
P. comptum, Lindley.
Equisetites columnaris, Brong.

In Gristhorpe Bay the Middle Estuarine Series is succeeded by the *Scarborough or Grey Limestone Series.* At Blea Wyke these rocks had a thickness of 19 feet (see section, p. 196), from that locality southwards they become more and more attenuated, and at Gristhorpe Bay they are only from 3 to 7 feet in thickness, and are represented in the cliff by—

* Quart. Journ. Geol. Soc., vol. xx., p. 76.

	Ft.	Ins.
Hard grey ironstone	0	10
Shale, with fossils	1	6
Hard ironstone, with fossils	0	6
Shale, full of fossils	4	0
Total	6	10

From the shales are obtained *Avicula Braamburiensis, Ostrea flabelloides*, and other fossils. The beds are devoid of limestone, and as they sink from the cliffs to the beach would be extremely difficult to follow but for the characteristic sandstone of the Middle Estuarine Series. This is finely laminated and beautifully interstratified with thin black carbonaceous seams, while immediately under, lies the Scarborough Series. It extends in long well-marked reef across the bay, midway between the cliffs and the outer reef of the Millepore bed.

In Cayton Bay the bed is again seen at a point east of the great fault at Red Cliff. (Fig. 7.) In the Bay it forms the outermost portion of the island of Calf Allen Rocks.

The *Upper Estuarine Series* succeed the Scarborough beds, and consists of an irregular mass of sandstones and shales, with a few thin ironstone bands and much carbonaceous matter. The beds rise from the shore into the cliffs, and form a bold face at Gristhorpe Bay; at the north-western end of the Bay there is the following section exposed :—

	Ft.	Ins.
Shale, with two bands of thin sandstone	50	0
Strata, probably shale, but much obscured by land-slips	38	0
Beds, mostly sandstone, forms the first reef in the Bay	15	0
Granular ironstone band	1	0
Sandstone, with coaly streaks and sulphur ...	20	0
Total	124	0

The sandstones predominate mostly in the lower part, and are very false-bedded and lenticular. The granular Ironstone Band, one foot in thickness, forms a well-marked band of nodules exposed along the shore at Gristhorpe. The series forms the base, and extends far up the face of the cliff, gradually dipping to the south-east towards Cunstone Nab, where it disappears beneath the Cornbrash, the uppermost bed of the Lower Oolites, and the Kelloways of the Middle Oolites.

The *Cornbrash*, though a comparatively thin rock, being only a few feet in thickness, is a very persistent one, and highly charged with fossils. Its base is a rubbly limestone with a grey colour, occasionally oolitic or ferruginous; above this are about 6 feet of shales, finely laminated and bluish grey in colour, containing *Avicula echinata, Gryphæa stricklandi,* and other fossils. The blue colour of the shales and ferruginous aspect of the limestone are useful in tracing the beds. The shale or "Clays of the Cornbrash" as they are sometimes termed pass gradually up into the yellow argillaceous base of the Kelloways Rock.

The Cornbrash first makes its appearance at the base of the cliff at Wyke, an indent of the coast south-east of Gristhorpe Bay; and may be traced, if not hidden by the *débris* of the stupendous cliffs above, along the Gristhorpe cliffs for some distance. At Redcliffe it is thrown down by the fault, and appears on the shore a little below high water mark. (Fig. 7.) It is very fossiliferous, the following list representing some of the most characteristic:—

Echinobrissus orbicularis, Phil.	Avicula echinata, Sow.
Holectypus depressus, Lam.	Pinna cuneata, Bean.
Rhynchonella concinna, Sow.	Modiola cuneata, Sow.
Waldheimiala obovata, Sow.	Trigonia Scarburgensis, Lyc.
W. ornithocephala, Sow.	T. elongata, Sow.
Ostrea flabelloides, Lam.	T. cassiope, D'orb.
Pecten lens, Sow.	Cardium cognatum, Phil.
P. demissus, Phil.	Unicardium depressum, Phil.
P. vagans, Sow.	Pholadomya angustata, Sow.
Lima duplicata, Sow.	Homomya crassiuscula, Lyc. & Mor.
Goniomya v. scripta, Sow.	Bulla undulata, Bean.
Myacites decurtata, Phil.	Chemnitzia vittata, Phil.
Gresslya peregrina, Phil.	Littorina punctura, Bean.
Actæonina Scarburgensis, Lyc.	Ammonites Herveyi, Sow.
Amberlya armigera, Lyc.	

Further north the Cornbrash may be seen at the base of the Kelloways Rock, in the valleys at Hackness, and on the sides of the Langdale Gorge and in other localities. An outlier occurs on the moors of Fylingdale at Blea Hill. An outlying piece of the rock may be seen along the north cliff at Scarborough.

The *Kelloway Rock* is a thick bedded sandstone, soft and of a brownish-yellow colour, due to iron; except a red calcareous band in its upper beds with fossils, the Kelloways are generally unfossiliferous. Towards the base the beds become more argillaceous, and pass insensibly and without break into the blue clays of the Cornbrash below. The Kelloway Sandstone first appears and forms a projecting reef at low water at Newbiggin Wyke. In this locality it is scarcely 6 feet in thickness, but it rapidly expands northward, and a short distance further on, in Gristhorpe Cliff, the beds have attained a thickness of 30 feet, and in the North Cliff, at Scarborough, they are 75 feet. After forming a distinct feature in the south-west end of Gristhorpe Bay the Kelloways are hidden by the boulder clay of the coast, until they again appear high in the cliff on the eastern side of the fault in Red Cliff. Further north, it can easily be traced by the projecting feature it makes on the sides of the hills west of Scarborough. It has been quarried at several places, and has been used in the erection of the Scarborough Museum, and also the one at York. It is a very durable stone and hardens with exposure. In the valleys westward from Scarborough, about Hackness and district, surmounted by the Calcareous Grit, this rock usually forms a prominent feature about half-way down the escarpment. It comes to the surface northwestwards, and forms moorlands reaching a height above the sea level of 950 feet.

The following fossils have been obtained from the red calcareous band referred to above:—

Rhychonella Thurmanni, Voltz.
R. socialis.
Waldheimia ornithocephala, Sow.
Ostrea flabelloides, Lam.
Gryphæa dilatata, Sow.
Pecten fibrosus, Sow.
Goniomya liberata, Sow.
Myacites recurvus, Phil.
Myacites calceiformis, Phil.
Gresslya peregrina, Phil.
Pleurotomaria guttata, Phil.
Ammonites modiolaris, Sherid.

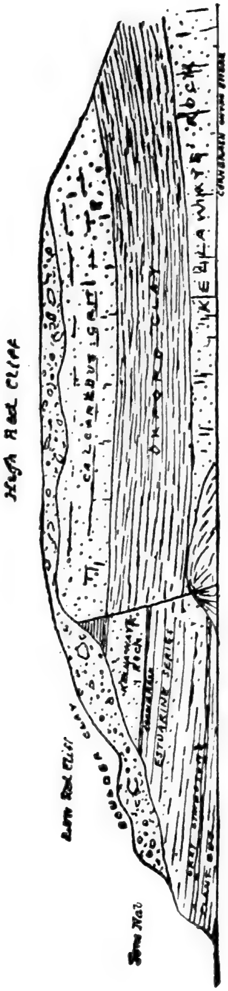


FIG. 7.—DIAGRAMMATIC SECTION SHEWING THE POSITION OF THE BEDS ON EACH SIDE THE FAULT AT RED CLIFF, NEAR GRISTHORPE.

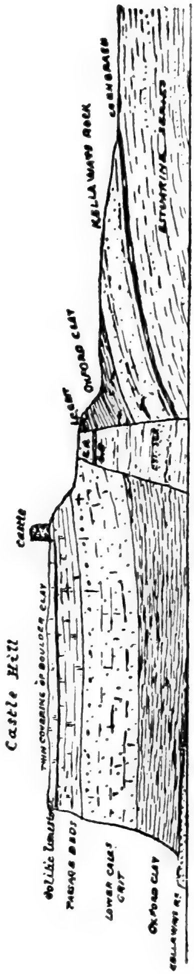


FIG. 9.—DIAGRAMMATIC SECTION OF THE STRATA AT CASTLE HILL AND NORTH CLIFF, SCARBOROUGH.

Avicula inæquivalvis, Sow.	A. Kœnigi, Sow.
Modiola bipartita, Sow.	A. athleta, Phil.
Modiola pulchra.	A. alligatus, Bean.
Trigonia paucicostata, Lye.	A. Gulielmi, Sow.
Trigonia ruppellensis	A. Gowerianus, Sow.
Cardium cognatum, Phil.	A. lunula, Zeit.
Anatina undulata, Sow.	Belemnites Oweni.

Resting on the Kelloway Rocks is the *Oxford Clay*. It is difficult to draw a dividing line between the two formations, so gradually and imperceptably do they merge one with the other. The Oxford Clay at Gristhorpe is a grey sandy shale, and, together with sandstone above and below, forms one of the grandest sections on the Yorkshire coast. The shales may be traced along the coast eastward to a point less than a mile from Filey Brig, where they may seen at the base of the cliff. At the opposite end of Gristhorpe Bay the Oxford Clay again makes its appearance in Red Cliff, occupying about half the height of the cliff. (Fig. 7.) The thickness along the coast varies between 120 and 150 feet, but inland it rapidly diminishes and in some places is scarcely recognisable. It can however be generally identified in association with the calcareous grits above by its throwing out the water.

The *Lower Calcareous Grit*, as already stated, forms the uppermost part of the cliff section exposed at Gristhorpe. Its massive structure and the hardness of some of its beds have rendered it one of the most important elements in the scenery of this part of the country. The bold escarpment of the Derwent valley at Langdale, Troutsdale, and Hackness are due to this rock ; and the fine series of cliffs between Filey Brig and Cayton Bay also owe much of their grandeur to its protective influence. It consists of a yellow calcareous sandstone, gradually changing downwards to a sandy shale. It has probably a maximum of 150 feet in thickness. In the cliff north-west of Filey Brig about 80 feet of the Lower Calcareous Grit occurs, but further on in the Gristhorpe cliffs the grit is thinner, a portion of it having been removed by denudation. At Redcliff in Cayton Bay there is a good section in this rock, but from this point the outcrop extends inland to Oliver's Mount ; an outlier of the rock occurs at Scarborough Castle. (Fig. 9.) It is extensively quarried along the inland escarpment, and forms a good building stone which hardens with exposure. The Lower Calcareous Grit is richly fossiliferous, and the beds at Filey are comparatively full of fossils. At Gristhorpe Cliff there occurs huge fossils of the genus *Ammonite,* and also a very large starfish, *Astropecten rectus,* usually found embedded in a calcareous sparry matrix.

The following list of fossils is given as common to the lower portion of the Coralline Oolite and the Lower Calcareous Grit by Mr. Fox Strangways, in the Memoirs illustrating this part of the district:—

Echinobrissus scutatus, Lam.
Holectypus depressus, Lam.
Rhynchonella Thurmanni, Voltz.
Exogyra nana, Phil.
Gervillia aviculoides, Sow.
Gryphæa dilata, Sow.
Ostrea flabelloides, Lam.
Ostrea solitaria, Sow.
Pecten subfibrosus, D'orb.
Pinna lanceolata, Sow.
Astarte Duboisiana, D'orb.
Isocardia tenera, Sow.
Lucina obliqua, Buvig.
Modiola bipartita, Sow.
Pholadomya angustata, Sow.
Sowerbya triangularis, Sow.
Alaria bispinosa, Phil.
Cylindrites elongatus, Phil.
Dentalium entaloideum, Desh.
Ammonites cordatus, Sow.
A. perarmatus, Sow.
A. plicatilis, Sow.
Belemnites abbreviatus, Mill.

Following on the series of the Lower Oolites exhibited in the magnificent amphitheatre of Blea Wyke, the Upper series of the Lower Oolites from the Millepore Bed to the Cornbrash have been traced in the scars and cliffs of the northern portion of Gristhorpe Bay and round the headland to Red Cliff in Cayton Bay, where the Cornbrash is exhibited on the shore. Superceding the Lower Oolites, the rocks of the Middle Oolites successively crop out of the sea-bed along the cliffs between the north of Filey Brig and Gristhorpe Bay, forming an imposing succession of ever-increasing magnitude and magnificence. Above the Lower Calcareous Grit is a series of beds considered as passage beds. At Filey Brig, where a good sequence is exhibited, they are called the Greystone Beds. These rocks in the central part are composed of a calcareous sandstone, exhibiting much false bedding and varying considerably in different localities. The sandstones are 25 feet to 30 feet in thickness, and change in their lower part to a loose sand, the lime having been dissolved out. The upper beds, on the contrary, become more calcareous and assume an oolitic structure as they approach the beds of the Coralline Oolites. These rocks are represented to some extent in the accompanying figure, which represents a section at Carr Naze, west of Filey Brig. The passage beds are represented resting on the Lower Calcareous Grit, which is replete with large doggers called the Ball beds, and

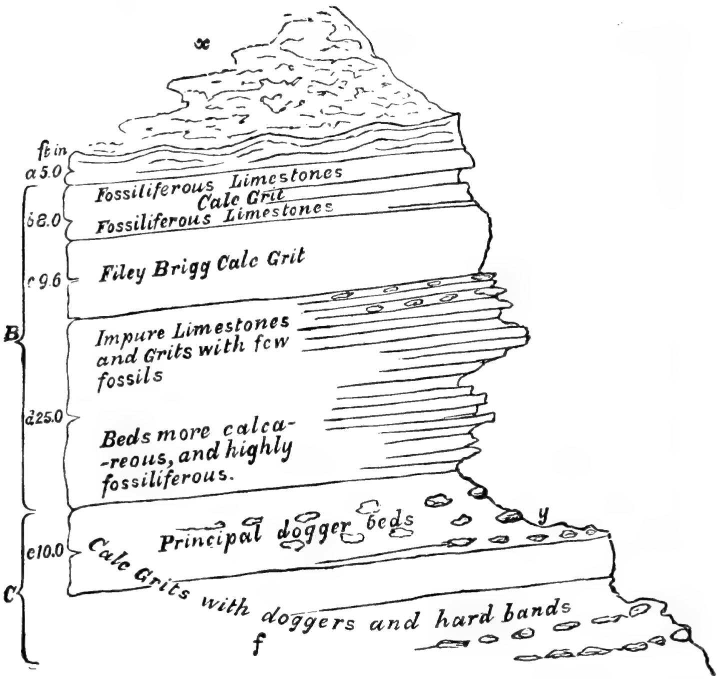


FIG. 8.—SECTION ACROSS PART OF THE CARR NAZE, FILEY BRIG.

contain numerous fossils. The lower beds form a series of brown and grey grits. The connection of these beds with the passage beds exhibited in other localities, as for example at Scarborough Castle or Hackness, is much obscured, and it is only on the evidence of the fossils that their identity can be established. The whole of the sequence has been measured by the Survey with the following result:—

Section at north side of the Carr Naze, Filey.

		Ft.	Ins.
	Boulder clay, resting on a denuded surface		
Upper Limestone? Oolitic Limestone	Irregular rubbly oolitic limestone ...	15	0
	White shelly limestone, partly oolitic, with *Ostrea mima, O. duriuscula, Pecten vagans*	2	0
	Fissile slabby beds	3	0
Middle Calcareous Grit or Filey Brig Grit.	Massive sandstone, with fucoids at top...	2	0
	Shelly band, containing *Serpula, Gervillia aviculoides, Pecten subfibrosus, Ostrea mima, Gryphæa dilatata, Chemnitzia Heddingtonensis*	0	7
	Hard massive sandy grit, with *Gervillia aviculoides* and *Pecten subfibrosus*, along certain lines	9	0
	Brown and yellow nodular grit ...	1	3
Grey Grits.	Hard grey grit with irregular top, containing *Serpula, Vermicularia, Avicula, Trigonia*	0	6
	Grits, hard, brown, yellow, or grey ...	3	8
	Nodular bed, with comminuted shells ...	0	10
	Cherty oolitic bed, almost pisolitic with fossils, *Trichites Plottii*, &c. ...	0	10
	Oolitic bed, with *Serpula, Ostrea mima*, &c.	1	3
	Grey gritty bed, with *Serpula*, and lower *Gryphæa dilatata*	3	8
Passage Beds. Brown and Grey Grits.	Brown sandy bed	2	6
	Grey grit, with *Rhynchonella Thurmanni*	4	6
	Grey grit, with *Gervillia aviculoides* ...	1	6
	Brown sandy grit, with *Gryhhæa dilatata*	2	9
	Brown sandy grit, with *Pecten snbfibrosus, Ostrea mima, Gervillia aviculoides* ...	2	6

		Ft.	Ins.
Spongy Porous Grits.	Rhynchonella bed with fucoidal base, containing *Pecten subfibrosus, G. aviculoides*	2	6
	Rhynchonella bed, with *R. Thurmanni* very abundant	1	0
	Spongy beds, shaly at base, with a band of *G. aviculoides. Gryphæa dilatata* ...	1	6
	Gervillia beds, *G. aviculoides* very abundant	2	0
	Hard grey grit, with *P. subfibrosus* and *G. aviculoides*	2	0
	Grey gritty bed, full of *Serpula, Ostrea mima, Pecten subfibrosus,* and plant remains...	1	0
	Soft sandy beds in three or four divisions, with large sponge doggers, *Serpula lacérata, P. subfibrosus, G. dilatata, Ostrea mima*	10	0
Lower Calcareous Grits.	Hard gritty sandstone with doggers ...	2	0
	Massive sandstone, passing down into sandy sandstone .. ... about	50	0

The upper beds of this series as they are traced along the cliff section towards Gristhorpe crop out and rapidly disappear, and both the Upper Limestone and the Filey Brig Grit have disappeared close to Filey Spa.

III. The Scarborough and Hackness Sections.

The Passage Beds are very accessible on the north side of the Castle Hill at Scarborough, and about seven feet below the Lower Limestone Beds the series is so full of *Gervillia* as to have given the name of "Gervillia Beds" to the group.

Section on the north side of Castle Hill, Scarborough.

		Ft.	Ins.
Lower Limestone.	Oolitic Limestone in several beds, with *Echinobrissus scutatus, Ostrea mima, Gervillia aviculoides, and Trigonia* ...	26	6

			Ft.	Ins
Passage Beds.	Grey Gervillia Beds.	False-bedded Grit, with small projections weathering black	4	0
		Soft sandy stone, with ferruginous nodules	1	6
		Parting, with *Pecten subfibrosus*		
		Irregular spongy grits, with *Cylindrites*	1	0
		Soft bed, with uneven base	0	6
		Fine-grained grey spongy grit, with *Gervillia aviculoides*	2	0
		Fine-grained hard grey grit, with *G. aviculoides* and *Gryphœa dilatata* ...	3	0
	Yellow Foxy Grits.	Yellow sand and sandy grit, passing down into white massive spongy grit, with *Gervillia, Ostrea, Pecten*	9	6
		Yellow grit, with *Gervillia*	2	0
		Hard band of grit	1	0
		Shaly band, with *Pecten subfibrosus, Ostrea mima*	1	0
		Solid bed of grit	2	0
		Six or seven courses of sandy yellow spongy rock, with *Rhynchonella, Pecten subfibrosus, Trigonia, Ammonites cordatus*	7	0
		Yellow sandy grit	2	6
		Bright yellow soft sand, with siliceous balls	18	0
		Hard massive grit, evenly jointed, and with a spongy line on top	3	0
		Massive sandstone, passing down into shaly sandstone of the Lower Calcareous Grit		

The *Greystone* is a siliceous rock, very hard and false-bedded, and is quarried inland for building walls and repairing roads. The rock is about 25 feet thick, and expands in some localities, as the one N.W. of Sawdon, over considerable localities. In Thorntondale this rock has a massive character, and frequently stands out in lines of bold crags. In this district it is readily distinguished from the Coralline Limestone above, but the distinctive features disappear to a large extent eastwards. In the neighbourhood of Hackness where these beds are largely quarried they are known as "Wallstones."

Beyond Bickley the Greystone or Wallstone passes into a true grit with an occasional lenticular-shaped patch of fossils. This grit is much liable to weathering, and there are several detached blocks on the surface of the moor. Above Staindale are a number of them, one of which is 16 feet high and measures 80 feet in circumference. The Bride Stones are an example of this action; the particles of sand are cemented together by silica, and to this is due no doubt its power of resistance as compared with the surrounding rock which has disappeared.

The remaining portion of the Middle Oolites are best represented in the district about Hackness. The River Derwent and its tributaries have formed a series of deep valleys which are not only interesting geologically, but constitute some of the finest inland scenery in the country. One of the hills on the east side of the Lowedale Beck, and about half a mile north of the village of Hackness, exhibits a very complete series of beds between the Kelloway Rock and the Upper Calcareous Grit. The former rock may be seen at the base in the valley; above it, rising in the hill, is the Oxford Clay, considerably diminished in thickness. The succeeding series of strata are exposed in a disused path, which is half water-course after heavy rain. It is reached by a road opposite St. Peter's Church, which passes Silpho. After proceeding a short distance the path is seen branching off to the left, whilst the road by zig-zag turns ascends the hill. The Lower Calcareous Grit succeeds the Oxford Clay and is exposed in the lower part of the path, gradually changing in its upper strata to the Passage Beds, and they in turn giving place to the Lower Oolitic Limestone, with the Coral Rag at the base. Still exposed on the hill-side is the Middle Calcareous Grit, and forming the summit of the escarpment is the Upper Oolitic Limestone, with Coral Rag at the top. The latter extends over the surface of the hill for some distance. The last in the series is a small detached outlier of the Upper Calcareous Grit, the uppermost bed of the Middle Oolites.

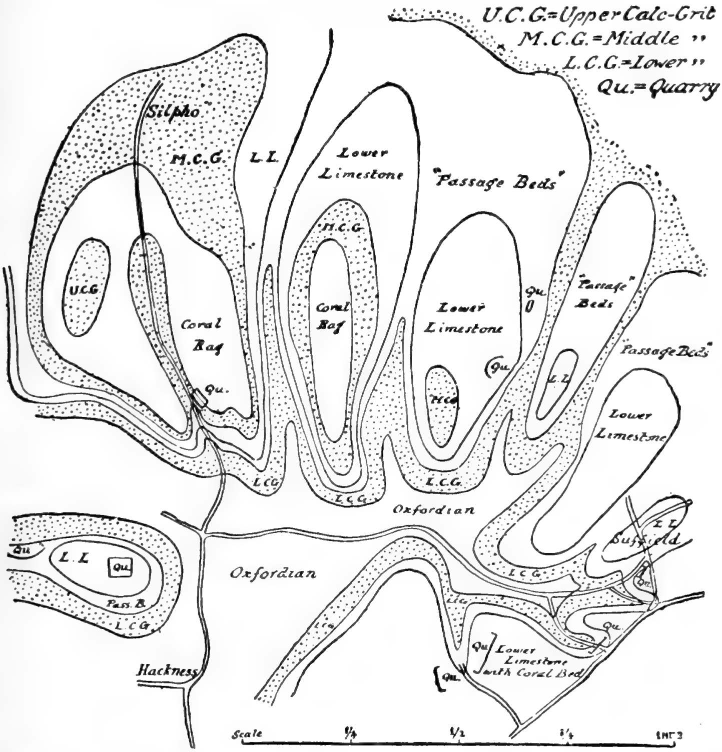


FIG. 10.—GEOLOGICAL SKETCH-MAP OF THE DISTRICT AROUND HACKNESS.

The following is the sequence of the beds above the Lower Calcareous Grits in the Hackness section below Selpho Heights:—

		Ft.	Ins.
1.	Upper Calcareous Grit. Partly *in situ,* partly disintegrated on surface		
2.	Upper Coral Rag. A crystalline limestone made up of roundheads of *Thamnastræa concinna* and borings of *Lithodomi*	12	0
3.	The Upper Limestone or Bell-Head Limestone. Massive oolite limestone in several beds, very fossiliferous with *Astarte, Nerinea, Chemnitzia,* &c., in upper part; near the centre a strong band of shelly bed, with *Thecosmilia, Phasianella, Cidaris,* &c.	25	0

		Ft.	Ins.
4.	Middle Calcareous Grit. Soft thin sandy beds or gritty limestones, with *Modiola, Pecten*, and *Terebratula*	20	0
5.	Lower Oolitic Limestone. Flaggy limestone at top, changing to small-grained oolites towards the centre, and thick-bedded fossiliferous limestones forming the base, with *Gervillia, Ostrea*, and *Gryphœa*, This series is quarried for lime ...	20	0
6.	Lower Coral Rag. A hard brown ferruginous coral limestone, very fossiliferous, mainly composed of corals	8	0
7.	Passage or Basement Beds. A series of impure siliceous flaggy limestones, very ferruginous, and in some cases composed of comminuted shells, with *Gervillia, Exogyra*, &c.	25	0
	Lower Calcareous Grit		

The Upper Oolitic Limestone, with the superincumbent Coral Rag, is much more fossiliferous than the Lower Limestones. At Ayton, a few miles south-east of Hackness and four miles from Scarborough, fossils are very abundant in this rock. From these districts the following fossils have been obtained :—

Thecosmilia annularis, Flemg.
Cidaris florigemma, Phil.
C. Smithii, Wright.
Echinobrissus scutatus, Lam.
Hemicidaris intermedia, Flem.
Holectypus depressus, Lam.
Pseudodiadema versipora, Phil.
Natica arguta, Phil.
Cerithium inornatum, Buvig.
C. limæforme, Röm.
C. Humbertinum, Buv.
Nerinæa fusiformis, D'Orb.
N. fasciata, Voltz.
Littorina muricata, Sow.
Turbo fumiculatus, Phil.
Astarte ovalis, Sow.
A. Aytonensis, Lyc.
Chemnitzia Heddingtonensis, Sow.
Pecten vimineus, Sow.
P. fibrosus, Sow.
P. lens, Sow.
Hinnites velatus, Goldf.
Lima fragilis, Röm.
L. rudis, Sow.
L. rigida, Sow.
Perna mytiloides, Lam.
Arca quadrisulcata, Sow.
A. pectinata, Phil.
Cucullæa elongata, Phil.
Myoconcha texta, Buv.

T. corallensis, Buv.
Trochus Aytonensis, B. & H.
Delphinula muricata, Buv.
Phasianella striata, Sow.
Trochotoma tornata, Phil.
Bulla Beaugrandi, De Lor.
Ostrea duriuscula, Phil.
O. gregaria, Sow.
Exogyra nana, Sow.
Anomia? sp.
Modiola inclusa, Phil.
M. Lycetti, Whit.
Myacites? sp.
Terebratula insignis, Schub.
Pseudomelania striata.
Cylindrites Lindii.
Ammonites cordatus, Sow.
A. plicatilis, Sow.
A. varicostatus, Buckl.

Succeeding the Coralline Oolites, the uppermost beds of the Middle Oolites, are the Kimmeridge Clays, estimated by Mr. Fox-Strangways at more than 500 feet in thickness. These clays form the lower beds of the Upper Oolite Series. They are nowhere in the eastern part of the district exposed so as to show their relationship with the Coralline Oolites, they only actually come to the surface in the hills above Pickering, on the steep slopes of Thorpe Basset Wold and west of Brompton. These clays, however, occupy the large depressed area between Hemsley, Pickering, Malton and Filey; and between Filey and Speeton they occupy the shore line, but are so deeply enveloped by glacial deposits that only a few small and doubtful sections can be observed. Occasionally they are exposed on the foreshore of the Bay under exceptionally favourable circumstances of wind and tide. Apparently they consist of dark-coloured shale with septaria, and thin fossiliferous bands of limestone. Besides the Kimmeridge Clay, the Upper Oolites comprise the Portlandian Beds, which are represented in this area by a band of Coprolites with Saurian remains, below which are a few feet of dark-coloured clays containing *Ammonites gigas, Zeit, A. Gravesiansis, D'Orb,* which are characteristic of the series. Their position is marked by the old coprolite workings, and the shales are occasionally seen near or on the shore.

For more extensive information respecting the geological structure of the area under consideration the student is referred to the works below, to which I am indebted for much of the information in this paper:—

J. Phillips. Illustrations of the Geology of the Yorkshire Coast, 3rd edition. Edited by R. Etheridge, 1875.

W. H. Hudleston. The Yorkshire Oolites. Proc. Geol. Assoc. 1874.

R. Tate and J. F. Blake. The Yorkshire Lias, 1876.

J. F. Blake and W. H. Hudleston. The Corallian Rocks of England. Quart. Journ. Geol. Soc., vol. xxxiii., pp. 260-405, 1877.

J. F. Blake. The Geological History of East Yorkshire. Proc. Yorksh. Geol. and Polyt. Soc. n.s., vol. vii., pp. 15-29, 1879.

C. Fox-Strangways. The Geology of the Oolitic and Cretaceous Rocks south of Scarborough. Mem. Geol. Survey and Map, 95 S.W., 1880.

C. Fox-Strangways. The Geology of the country between Whitby and Scarborough. Mem. Geol. Survey and Map, 95 N.W., 1882.

W. H. Hudleston. Contributions to the Palæontology of the Yorkshire Oolite. Geol. Mag., dec. iii., vol. i., 1884, and vol. ii., 1885.

E. M. Cole. On the Physical Geography and Geology of the East Riding of Yorkshire. Proc. Yorksh. Geol. and Polyt. Soc. n.s., vol. ix., pp. 113-123, 1886.

⁂ The Author desires to express his indebtedness to the following gentlemen who have kindly allowed *clichés* to be taken from blocks which have been previously used in illustration of their works:—To Professor J. F. Blake, F.G.S., for figures 1, 4, 5 and 10; to W. H. Hudleston, F.R.S., Pres. G.S., for figures 6 and 8; to C. Fox-Strangways, F.G.S,, for figures 2, 7 and 9; and to G. Barrow, F.G.S., for figure 3.

AN ACCOUNT OF THE OPENING OF THE TUMULUS "HOWE HILL," DUGGLEBY. BY J. R. MORTIMER.

This large flat-topped circular barrow (pl. vii.) was opened by the present Sir Tatton Sykes, Bart., of Sledmere, during July and August, 1890. It stands on the sloping hillside, about 13 chains length S.S.E. of the village of Duggleby, in and near which rise the springs which form the Gypsey Stream. It resembled in size and circular form two other large barrows on the neighbouring chalk wolds; one, Mickle Head, about nine miles S.W. of Duggleby, at the foot of Garrowby Hill;* and the other near Wold Newton, named "Willy Howe," eleven miles distant, in an easterly direction. The latter has been similar in size (about 125 feet in diameter) to the Duggleby barrow, and it also stands on the foot of the southern side of the same midwold valley, and about the same distance south of the Gypsey stream. In short the two barrows are in every respect so much alike that their resemblance would seem to be more than accidental. They may be the monuments of two neighbouring and kindred chiefs held in equal honour, and over whose remains similar monuments were raised. Of the three barrows the Garrowby one is far the largest, having a diameter of 250 feet at the base, and an elevation of about 50 feet. This mound does not appear to have been opened, but "Willy Howe" has been twice examined; once by the late Lord Londesborough in 1857,† and again by Canon Greenwell in 1887. The latter search was made within the limits of the former opening, with a view to discover the primary interments which might have been passed over by the previous explorers. On neither occasion was there observed any indication of a body.

* This mound is not marked as a tumulus on the ordnance maps; the writer, however, believes it to be artificially formed.

† This opening, which was east and west through the centre, was not more than 18 feet wide at the bottom, and probably not more than 16 feet. Therefore the experience gained in opening "Howe Hill," Duggleby, renders it possible that the primary burial in "Willy Howe" yet remains undiscovered, probably near to the north side of the opening made by the late Lord Londesborough. Had the excavation in "Howe Hill," Duggleby, been no wider than that made in "Willy Howe," the two graves containing the primary interments would not have been discovered.

Owing to the sloping nature of the ground on which Duggleby Howe had been raised, its elevation appeared much greater viewed from the north side than it did from the south. Its diameter at the base was about 125 feet, and its flat top was 47 feet in diameter. By drawing a line east and west across the centre of the barrow its elevation was found to be 22 feet on the east side, and 19 feet on the west. In all probability this mound was originally 8 to 10 feet higher, measured along the same line. It is said that the Duggleby barrow was opened by the late Rev. Christopher Sykes,* brother to the late Sir Tatton Sykes, of Sledmere, not more recently than the year 1798 or 1799, as he left Sledmere in 1800. I believe there is no written record of this opening, and there is no tradition of any thing having been found.

On July 21st, 1890, a commencement was made by the writer and a number of experienced workmen. An area of 40 feet square over the centre of the barrow, and a portion of the east side of the mound, were removed. From the central area and mainly from the filled in excavation (which was small for so large a mound, and did not reach within 12 feet of the base of the mound), made by the previous explorers, the following articles of iron were found, namely, a few nails and flat bits much corroded, and one side of a pair of small shears, probably Anglo-Saxon ; there was also the pointed end of a bone pin, and a piece of bone apparently from the side of an Anglo-Saxon comb.

Twenty-five flint flakes were found, some of which were variously shaped by secondary chipping ; a punch-shaped tool $2\frac{1}{2}$ inches long ; a portion of a toothed double-edged flake saw ; and a sharply-pointed triangular knife 2 inches in length, and 1 inch broad at the base, made of a very thin flake of light-coloured native

* Mr. Sykes explored other barrows in the neighbourhood ; and it is recorded, in the preface to the eighth edition of the hand-book of the Antiquities in the York Museum, that the Rev. Christopher Sykes was the first donor to the Museum. The gift was a small number of Anglo-Saxon cinerary urns from a cemetery on the Wolds.

A short paper, by Mr. Sykes, on the finding of a bracelet on the wrist of a skeleton found by the road side in Wetwang field, was read May 15th, 1794, at a meeting of the society of Antiquaries of London. It is therefore to be hoped that some account of Mr. Sykes' explorations of the Duggleby and other barrows may yet exist.

flint. One side of this knife shows a portion of the rough drab-coloured skin of the block from which it has been struck ; four large flakes most skilfully removed from the side of the knife leave, without the usual finer chipping, an edge almost as sharp as a razor ; whilst its back has been formed by removing numerous small chips, mainly from the same side of the knife, leaving the back only about one-eighth of an inch in thickness. The other side of this knife has been left flat as struck from the core, with the exception of a short distance along the back where it is slightly chipped. There was also a large rejected core (pl. ix. fig. 1) of black flint, from which four large flakes had been struck from opposite sides, probably used as a hammer. About 250 pot-sherds were found, among which was one small bit of British ware ; a few fragments of Roman and Anglo-Saxon vessels ; and many portions of vessels of a more recent period, some glazed and some unglazed. There were also several pieces of gritstone, a few inches in diameter, all more or less reddened by the action of fire. In addition, the remains of the following animals were collected, viz.:—Bones and fifteen teeth of the horse ;* bones and five teeth of the ox ; part of the under-jaw with teeth of the goat or sheep ; two under-jaws with teeth of a small dog or fox ; teeth and portions of the antler of the red deer. There was also three quarters of a human under-jaw, probably of a female ; several other pieces of human bone, most notably a portion of a very large femur, and another portion of a rather small femur, both of which had been deeply cut with a sharp instrument, probably belonging to some of the workmen engaged in the previous opening. These human bones indicate the removal of at least two adult bodies, most likely secondary Anglo-Saxon interments, which had been buried in the upper part of the mound. The great quantity of various kinds of pottery found in the upper and disturbed part of the mound is interesting and very unusual. It corresponds, in quantity and variety, with the pottery which the writer has obtained from three other mounds, one at Fimber, one at Wetwang, and one at Cowlam. But in each of these cases it was found either in, or connected with,

* The teeth of this animal were found only in disturbed ground, at the summit of the mound, caused by secondary interments, and by the digging of the cross-formed trench in, most probably, Anglo-Saxon times.

large cross-formed trenches which had been cut north and south, east and west, through the centre of the mounds, and into the rocks below, to a depth of from 8 to 9 feet. Probably these sherds are the remains of pottery used and broken at the opening and other ceremonies connected with these excavated crosses. From the finding of so large an amount of pottery in this instance, we were led to believe that an excavated cross, similar to the three named above, and serving a similar purpose (probably as a sacred Moot-hill symbol) had once existed on the summit of the Duggleby Howe, and that, when the present Sir Tatton Sykes, in 1870, placed a wooden cross on the summit of this mound he was unconsciously replacing an old symbol, of a similar import, which had been removed by the excavations made by the late Mr. C. Sykes three quarters of a century before. The symbol of an excavated cross dates back, probably, from the 5th to the 7th century, when the top of the mound was made flat, and in other ways fitted for a Folk Moot, for which purpose it most likely served for many centuries. Whether or not "Willy Howe" had a flat top at the time it was first opened seems somewhat uncertain; but the mound "Mickle Head," at the foot of Garrowby Hill, has a flat top 60 feet in diameter, and several other large mounds in other parts of Yorkshire possess this feature. As the excavation proceeded, and the central opening had reached a depth of 9 feet, it was observed that portions of the old opening made by the late Rev. C. Sykes, as well as the bottoms of the southern and eastern arms of the excavated cross, extended nearly to this depth. The undisturbed portions of the two arms of the cross contained about 18 inches of pure clay at the bottom, as well as a block of grey limestone, worked into the form and about the size of an ordinary building brick; and a piece of grit-stone which seems to have had a circular hollow cut into the middle of it, which may be a portion of the bottom stone of a primitive handmill. In addition to those found in the upper portion of the mound we took from the material filling the old opening, and in the disturbed portion of the arms of the cross, a few more pieces of the two disturbed human bodies; portions of the heads and other bones of two large dogs; the right side of a hoof, and other bones of an ox; four teeth of the horse and two pieces of burnt animal bone. One portion of the broken leg bone of an ox has had a round hole about half an inch in diameter bored through it, probably to fit it for some tool. There was also a portion of another iron knife, seemingly Anglo-Saxon, nine rusty nails and other bits of iron ; fifty-nine pieces of pottery of the same kinds (except British) as previously found, and twelve chips of flint. Seven cremated interments were taken from a small area on the north side of the central excavation. They were all laid on the same plane, fourteen feet from the level of the flat top of the barrow. Their horizontal position, all under the arched bed of Kimmeridge clay, are numbered on the plan (plate viii.) A portion of a bone pin (pl. x., fig. 6) was found with No. 4, and one of the workmen picked up an instrument of flint (pl. ix., fig. 3) chipped to a very sharp point. It was found about three feet north of the deposit No. 3, and on the same level. It was found that there was an inner mound, the centre of which did not, as shown in the plan (pl. viii.,) quite correspond with the centre of the completed mound. This may have happened from the chalk material that formed the upper portion of the mound having been quarried from the rising ground to the south, and consequently piled more on this side than on the north and distant side of the mound. A section (pl. vii.) which was obtained from measurements of the southern and eastern radius shows this inner mound to have a diameter of 75 feet, and to measure 11 feet in height, the upper ten to fourteen inches being almost pure Kimmeridge Clay containing no remains, under which was 4½ feet of small chalk grit, in which most of the cremated interments were found ; and below the chalk grit was a core of clayey soil of a hazel colour, mixed with a little chalk grit 5½ feet high in the centre, obtained from the adjoining ground. This core was afterwards found to rest on the old turf line, and to contain or cover all the inhumed primary interments, also a few of the cremated ones. A large heap of chalk lying on the south side of the centre grave, from which it had been cast, still remained on the old surface line. Fifteen additional deposits of burnt bones were found in the same central area in which the seven previously named deposits were taken, but at a lower level of from two to six feet, reaching downwards from the lower portion of the chalk layer to near the base of the core of clayey soil. Except a few burnt portions of a bone pin with No. 20, and a piece of the lip of a food-vase with No. 12, no relic accompanied any of the deposits. Near the deposit No. 19 and about two feet from the base of the mound, was found the greater half of the under-jaw of a young person having the back molar just rising from its socket. Two more cremated deposits (Nos. 21 and 22) were found. Just to the east of No. 21 were the much decayed unburnt remains (marked A) of a very young child, and ten inches lower was the inhumed body (marked B) of a youth from six to ten years of age, on the right side, knees up and head to the east. A femur and tibia measured 13 and 10½ inches respectively. This body was 19½ feet from the apex of the mound, and one foot from its base. No relic accompanied this body, but about two feet to the south and two feet higher in the mound was a stag's-horn pick (pl. x., fig. 4) with the point broken off; and about one foot above this and a little further south was another pick (pl. x., fig. 5) also of stag's-horn, with the point much worn. Only one deposit of burnt bones (No. 23 on the plan) was found, at a depth of 17 feet from the apex of the mound; but in a shallow grave, only nine to ten inches below the ancient turf line, and at the depth of 22½ feet from the flat top of the mound, vertically under the body marked "B," lay a body marked "C" on its left side, head to N.N.E., both hands near the face, and the knees brought up to a right angle with the trunk. A femur measured 16¾ inches, a tibia 13½ inches, and the right and left humerus 13 inches respectively. These are of medium strength. The skull is dolicocephalic, the bones of great thickness, and belonged to a person about 50 years of age with fine features. A fine bone pin (pl. x., fig. 3) 9¼ inches long, lay about three inches behind the back of the body, with the point to the hips. A little way behind the shoulders lay several flint flakes, also worked flints, as well as several tusks of the boar. A similar deposit lay a few inches behind the hips. In all there were thirteen flakes and six worked flints (pl. ix., figs. 2-6) all of dark-coloured foreign flint. There were also two incisor teeth of the beaver (pl. ix. fig. 10); and the number of boars' tusks was twelve, pl. ix., fig. 8, being one; and pl. ix., fig. 9, is another which has been cut into an instrument of uncertain use. A little above the body we found the neck vertebræ of an ox and other pieces of animal bone. On the western edge of this shallow grave (marked "A" on the plan) were the inhumed remains of an adult, about 70 years of age (marked "D"), of large stature, with head to west and over the eastern edge of the centre grave (marked "B"), into which it had settled some 10 inches. It lay on its right side in the position shown on the plan. Femur and tibia measured 20 inches and $17\frac{1}{2}$ inches respectively. In front of the face of the body lay a beautiful knife (pl. x., fig. 2) of almost transparent glass-coloured flint. It is of a rare type* and very thin, having been ground down on both sides to not more than $\frac{1}{16}$ of an inch in thickness. The length of this beautiful specimen is $2\frac{3}{8}$ inch., and breadth $1\frac{3}{16}$ of an inch. Its smoothly rounded ends are so formed that it might be used equally well either as a knife or a spoon. A deposit of burnt bones was found in the position numbered 24 on the plan, and about the same depth in the mound as Nos. 1 to 7. Nothing with it. Over the centre grave (marked "B" on the plan) and about 3 feet above the base of the barrow lay the much decayed body of a child, marked "E;" and about two feet under it was the body of a youth 8 to 12 years of age, marked "F," on the left side, head to S.W., knees pulled up, and hands in front of face. Femur and tibia measured 14 inches and $11\frac{1}{2}$ inches respectively. No relics. About two feet lower than the last body and about one foot into the grave "B," was an adult male, marked "G," who probably reached the age of 60, laid on its right side in a flexed position, and head to N.E. Femur and tibia measured 18 and 14 inches respectively. This body was distorted by the unequal settling of the grave below. In front of its chest lay a hammer head made of the root end of a shed antler of the red deer, and near it was a diamond-shaped arrow-head (pl. xi., fig. 2) of dark-coloured flint, which unfortunately had lost its point. There was also a most beautiful axe (pl. x., figs. 1-1A) made of drab-coloured flint, resembling such as might have been obtained with careful selection from the neighbouring beds of chalk, $9\frac{1}{2}$ inches long, lying with its

* The writer only knows of one similar knife, which was found by him in a barrow on the "Aldro Farm."

broad cutting edge towards the knees of the body. The hammer-head was laid on its edge, showing that it had at the time of interment been held in that position by a shaft, most probably of wood, which had finally gone to decay. The bottom of the central grave "B" was next reached, and other parts of the excavation lowered. In proceeding downwards, at a depth of three feet, the flexed body of a child marked "H" was found. It appeared to have been about two to three years old, on its right side, and the head to the east. No relic. This body lay at the bottom of a boat-shaped mass of clayey matter, in the centre of the grave; all round the outsides at this horizon being gritty chalk. About two feet below the last body was an adult, marked "I," probably a male of about 60 years of age, in the same flexed position, but considerably contorted by the unequal settling in the grave, with the head placed to the east. Femur and tibia measured $17\frac{2}{3}$ and $14\frac{1}{2}$ inches respectively. Nothing accompanied this body; but near its feet lay the skull (marked "J") of a young person about 20 years of age, with back upper left molar fully grown, minus under-jaw; and there is a large suspicious-looking circular hole in the left parietal bone. At a depth of nine feet from the base of the barrow we reached the firm undisturbed floor of this grave which, at about half its depth, measured 11 feet east and west, and 10 feet north and south; and at the bottom 7 feet east and west, and $5\frac{1}{2}$ feet north and south. On the bottom of the grave lay an adult body (marked "K") on its back, head to east. knees drawn up, right arm bent over the chest, and hand on the left shoulder; the left arm bent at a right angle over the abdomen, with the hand near the right elbow. Femur, tibia, and humerus measured 19, 15, and 13 inches respectively, and were of strong make. Master Mark Sykes, of Sledmere, much interested, assisted the writer to uncover this body. At the knees lay the irreparably crushed remains of a semi-globular food-vase, of which a restoration is given (pl. xi., fig. 3). It was made of dark-coloured Kimmeridge clay, obtained in the neighbourhood. Near the vase nine small flint flakes were found, some of which were slightly knotched on one edge as if intended for saws; there were also two cores from which a few flakes had been struck; all were of dark-coloured flint. These flints were very poor specimens, none of them seemed suitable even for the most inferior tool. Probably they were placed there during some superstitious burial ceremony as a charm. Much decayed wood and several thin patches of ferruginous matter (not the residue of any oxidized iron implements) were in contact with the body, over and under it. At various depths in the body of the mound, a little to the south of the grave, there were thirteen more deposits of burnt bones, denoted on the plan by the Nos. 25 to 37 both inclusive, and with No. 30 there was a bone pin (pl. xi., fig. 4).

About three feet above and near the outside of the southern edge of the large grave ("B" on the plan) were the distorted remains (from unequal settling) of a young person (marked "L") having only two molar teeth on each side of each jaw, and there was no appearance that there ever had, or would have been, a third molar, which originally had been placed with its head to the north, knees pulled up, right arm crossed over the body, and the left arm doubled, with hand brought to the shoulder. Femur and tibia measured 16¼ and 13½ inches respectively. This body seemed to have been interred with its head and shoulders considerably raised, and probably was protected by a cist-formed receptacle of wood, this being sufficiently durable to allow the flesh to decay, thus allowing the under-jaw to fall some distance from the head, the head to roll over, and other bones to fall into the unnatural position in which they were found. A small deposit of cremated bones lay close to the hips of this body, but no relic accompanied it. About sixteen feet south-east of the centre of the large grave, and one foot above the base of the barrow, lay a body (marked "M") on its back, head to south-west, with knees pulled up and head pressed over to the north-west. Femur and tibia measured 18 and 14 inches respectively. The right humerus measured 13 inches, whilst the left measured 12½ inches only. Over this body were the greatly decayed remains of two very small infants, the positions of which could not be made out. About 20 feet west of these and about three feet above the base of the mound and in the bottom bed or core of hazel-coloured clayey soil were most of the bones of one leg of a fox,* the flesh of which had probably been

* Determined by Prof. Newton.

consumed by the mound builders, and the bones dropped where they were found. The total number of cremated interments, which were found in disc-formed circular heaps six to eighteen inches in diameter, and one to six inches in thickness, was raised to fifty-three,* of which nine or ten were found in the core of hazel-coloured clay, and the remainder in the layer of gritty chalk close above. Excepting portions of burnt bone pins with Nos. 4, 10, 30, previously alluded to, nothing accompanied any of them. It is remarkable that not one of this very large number of burnt bodies had been placed in a cinerary urn. This large mound is also remarkable for the almost entire absence of British pottery and pot-sherds. Excepting the crushed vase with the body at the bottom of the grave, four very small sherds from the substance of the mound, and a very small fragment of a food-vase with the cremated deposit No. 12, no other pottery was found (W).

EXPLANATION OF PLATE VII.

W. Is the inner mound of a clayey or earthy matter $5\frac{1}{2}$ feet in thickness.

X. A bed of small chalk grit $4\frac{1}{2}$ feet thick, in which were most of the cremated bodies.

Y. Blue Kimmeridge clay, 12 inches in thickness, sealing up all the inhumed bodies, as well as the cremated interments which were found at various elevations as shown by the small circles; but only a few were vertically over the grave.

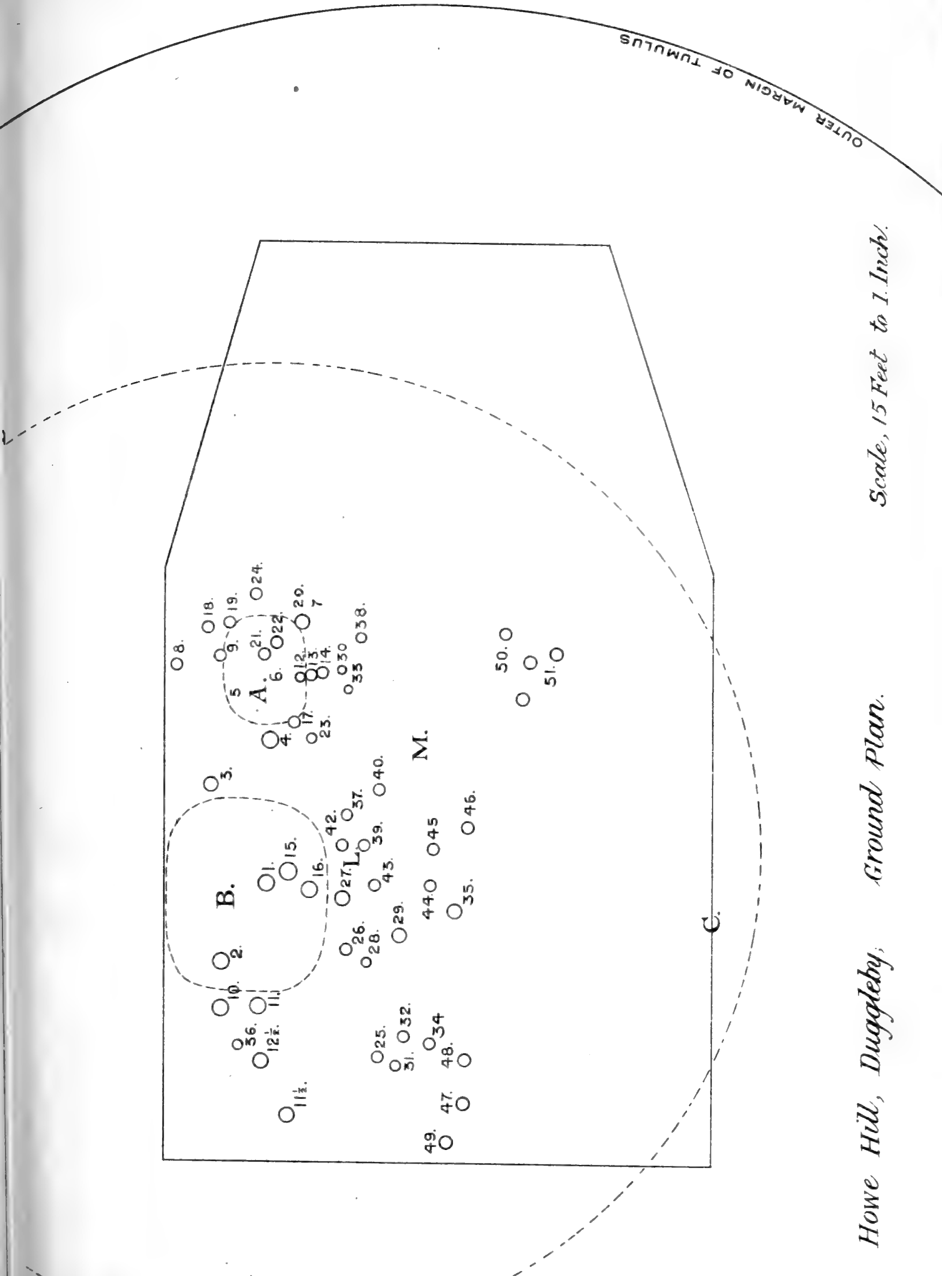
Z. Roughly quarried chalk, $9\frac{1}{2}$ feet in thickness in the centre of the mound.

* Marks the assumed original height of the barrow, which was probably 8 to 10 feet higher than the present flat top.

O. Indicates cremated interments.

---

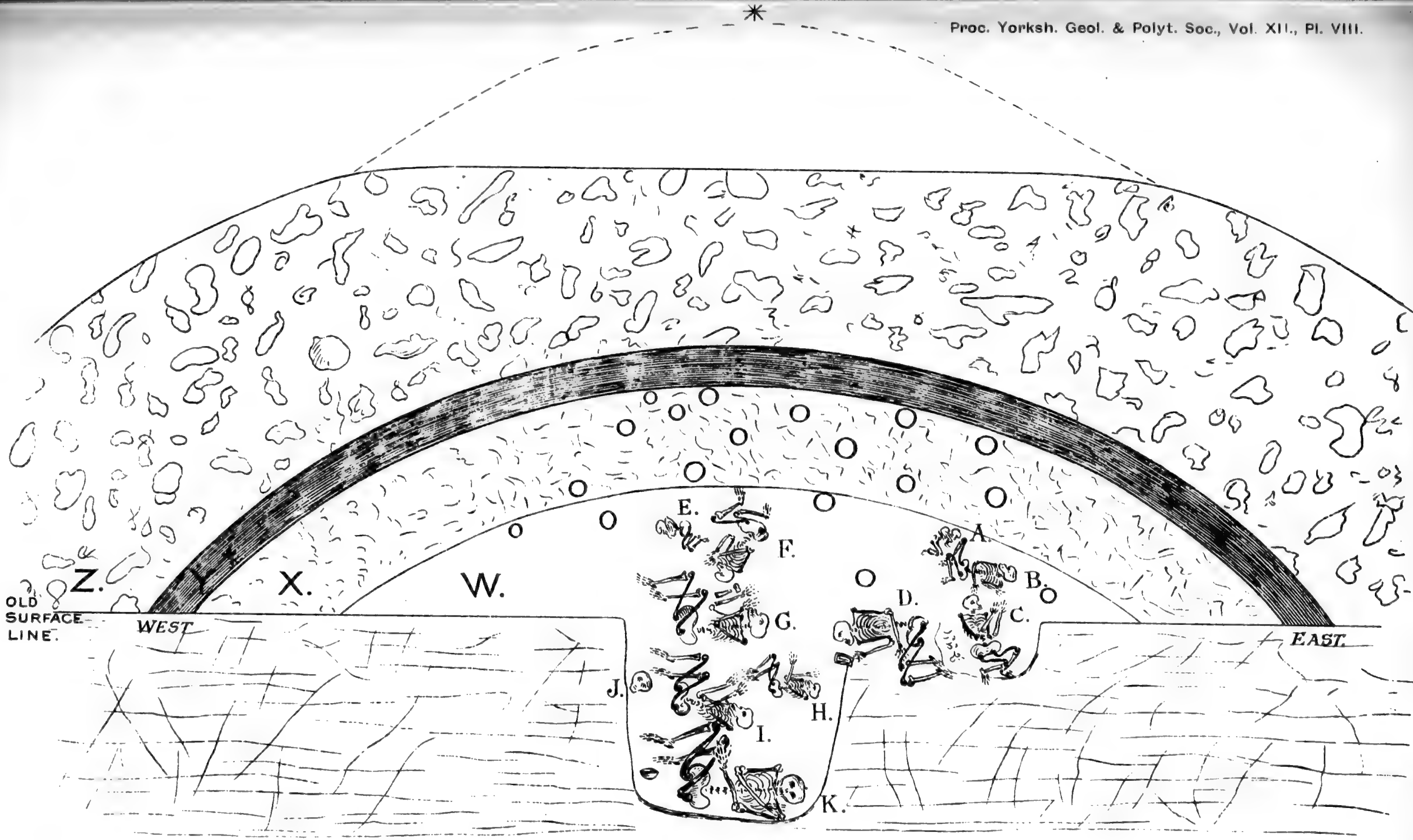
* It will be observed from the plan (pl. viii.) that most of the cremated deposits are at the south side of the grave, and that they are sparingly distributed vertically over the grave. Had our excavation reached as far beyond the north side of the grave as it did on the south side very probably many cremated deposits would have been found on that side of the grave also. Therefore, possibly, the number of burnt bodies remaining in the unexplored portion of the mound might be nearly as great as the number discovered.



Howe Hill, Duggleby; Ground Plan.

Scale, 15 Feet to 1 Inch.

MORTIMER: DUGGLEBY TUMULUS.



MORTIMER: HOWE HILL, DUGGLEBY. VERTICAL SECTION SHEWING INTERMENTS.

Scale, 10 feet = 1 inch.

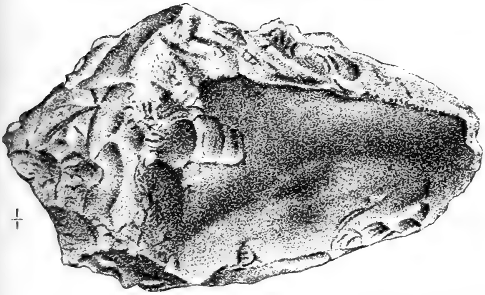


FIG. 1.

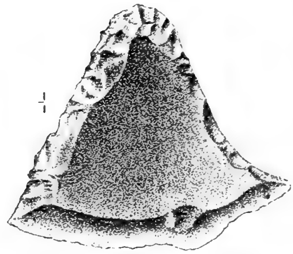


FIG. 2.

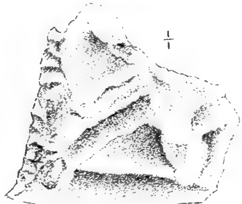


FIG. 6.


FIG. 7.

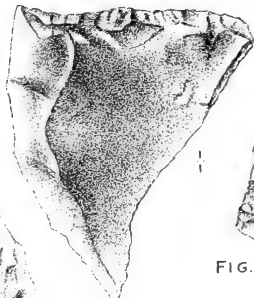


FIG. 4.


FIG. 5.


FIG. 3.

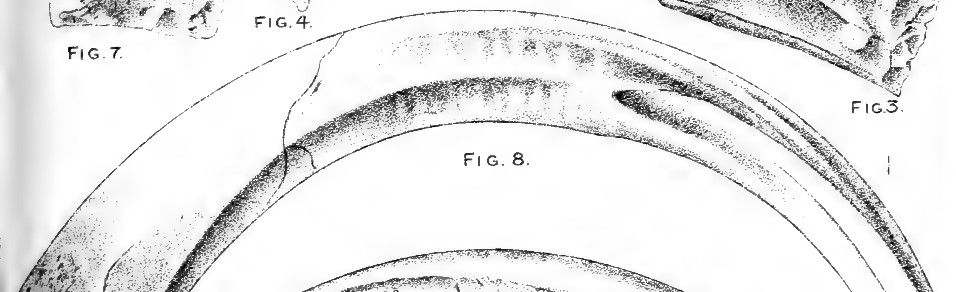


FIG. 8.

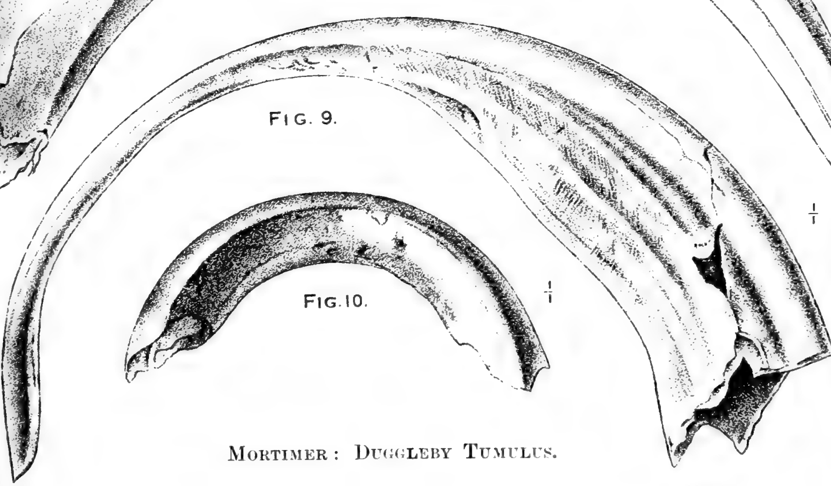
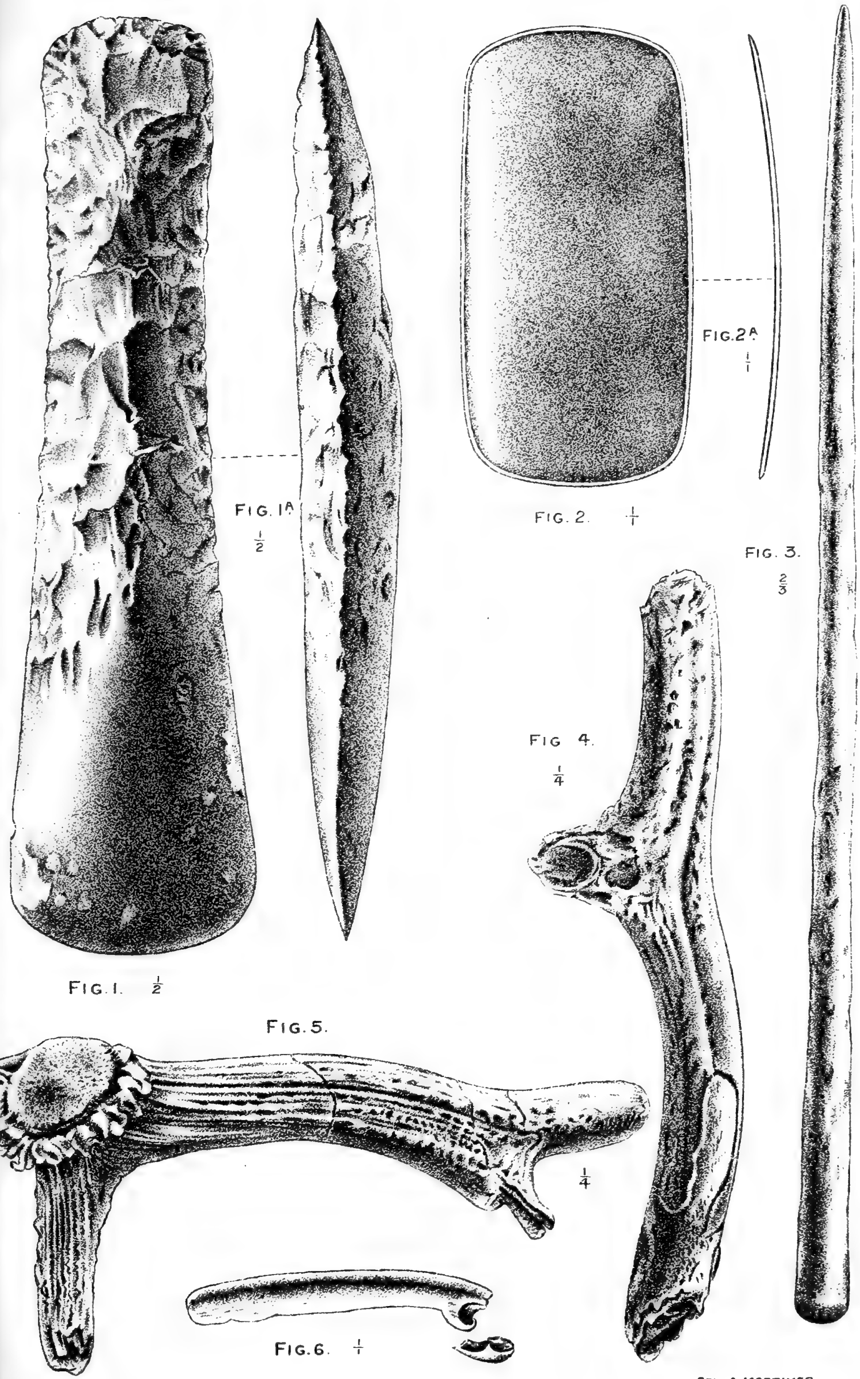


FIG. 9.

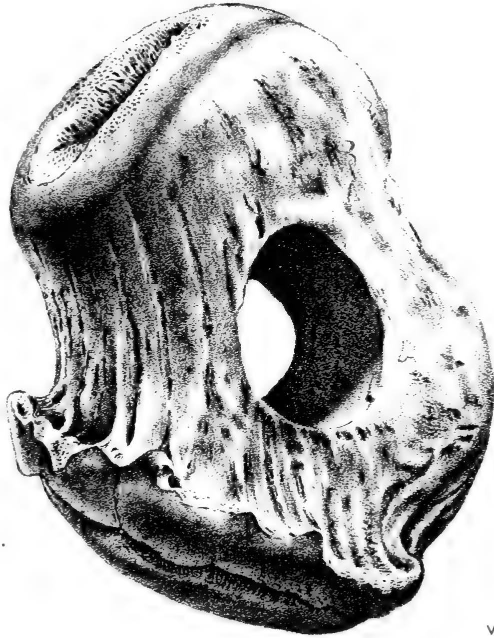
FIG. 10.

MORTIMER: DUGGLEBY TUMULUS.

DEL. A. MORTIMER.

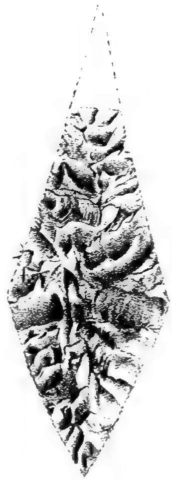


MORTIMER: DUGGLEBY TUMULUS.



1/1

FIG. 1.



1/1

FIG. 2.

WITH BODY "G."

1/3

FIG. 3.

RESTORED VASE WITH BODY "K."

1/1

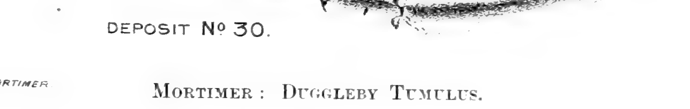


FIG. 4.

DEPOSIT No. 30.

DEL, A. MORTIMER

MORTIMER: DUGGLEBY TUMULUS.

Plate VIII.

A. Small grave.

B. Large grave.

C. Encloses the area cremated.

L.M. Denote positions of bodies in the body of the mound, a little above its base.

D. Marks the margin of the inner mound.

Plate IX.

Fig. 1. Flint. Found in the body of the mound.
7. ,, ,, ,, ,,
2-6. Flints. Found with body marked "C," Plate VII.
8-9. Boar's tusks ,, ,, ,,
10. Beaver's tusk ,, ,, ,,

Plate X.

1. Axe-head in flint. Found with body "G," Plate VII.
2. Flint. ,, ,, "D," ,,
3. Bone pin ,, ,, "C," ,,
4-5. Stag's horns. Found over the grave.
6. Found in deposit No. 4, Plate VIII.

Plate XI.

1. Bone implement. Found with body "G," Plate VII.
2. Flint ,, ,, ,, "G," ,,
3. Earthenware vase ,, ,, "K," ,,
4. Bone implement. Found in deposit No. 30, Plate VIII.

PROCEEDINGS OF THE YORKSHIRE

Geological & Polytechnic Society.

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WITH TWO PLATES.

EDITED BY JAMES W. DAVIS, F.S.A., F.G.S.

1893.

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1893.

VOL. XII.] [PART III.

PROCEEDINGS

OF THE

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GEOLOGICAL AND POLYTECHNIC SOCIETY.

EDITED BY JAMES W. DAVIS, F.S.A., F.G.S., &c.

1893.

ON THE CRANIA AND OTHER HUMAN REMAINS FOUND IN THE BARROW AT HOWE HILL, DUGGLEBY. BY J. G. GARSON, M.D.,

Corresp. Mem. Anthrop. Soc., Paris and Berlin; Lecturer on Comparative Anatomy, Charing Cross Hospital.

The specimens from Howe Hill Barrow which have been placed in my hands for examination by Mr. J. R. Mortimer, of Driffield, consist of the skulls belonging to the skeletons he has designated in his paper on the exploration of the barrow, by the letters C, D, F, G, H, I, J, K, L, and M, and some of the long bones of the extremities of D, I, and K. (p. 224, pl. viii.) He has also been good enough to furnish me with the measurements of some of the long bones, which have unfortunately not been preserved, belonging to C, D, G, I, L, and M, together with his notes and diagrams relating to the exploration of the barrow, which have been of the greatest assistance to me. The skulls and bones are in a very fragile condition, and many of them are very incomplete, notwithstanding that Mr. Mortimer has bestowed much time and patience in restoring them as far as was possible.

Eight of the specimens belonged to adult males, and two to children of about six and ten years of age respectively. No female's bones appear to have been found in the barrow. According to the usual rule, the description of the specimens I am about to give will only include the adults of the series.

Stature.—As is generally the case with human remains from ancient barrows, the stature of the persons whom the skeletons represent can only be determined by calculation from the long bones of the extremities. Of these I have personally only measured the right femur of D, the right and left femora and tibiæ of I, and the two femora, the right humerus, and left tibia of K. The measurements of the other bones which I have given in the "Table of Measurements of the Long Bones," were made by Mr. Mortimer, on whose accuracy in measuring I must entirely rely. It is necessary to state that his measurements were not made with instruments of such precision as were at my disposal for measuring those of the bones submitted to me, and although I have found some differences between his measurements and my own in the bones of D, I, and K, which we have both measured independently, I have little doubt that his measurements of the bones of the other skeletons which I have not measured, are sufficiently correct for comparison with measurements taken before such rigid accuracy as is now required was practised in anthropological research. The measurements made by Mr. Mortimer were supplied to me in inches and parts of inches, but for convenience I have carefully converted them into their equivalent in millimetres. By taking my own and Mr. Mortimer's measurement together I have been able to calculate the probable stature of seven of the adults, no long bones being found with the eighth adult skull (marked J). In doing this I have used the following formulæ given by Topinard in his *Eléments d' Anthropologie*:—

$$\frac{\text{Femur} + \text{Tibia} \times 100}{49{\cdot}4}; \quad \frac{\text{Femur} \times 100}{27{\cdot}1}; \quad \frac{\text{Tibia} \times 100}{23{\cdot}3}; \quad \frac{\text{Humerus} \times 100}{20{\cdot}7};$$

As in my opinion the best and most reliable estimate of stature is obtained from the lengths of the femur and tibia added together, I attach most importance to the results yielded by the first of these formulæ. Having the measurements of both these bones in each of the seven skeletons, I have been able to estimate the stature in this way in each instance, and find that the average of the series is 1 m. 661, or 65·4 inches. Estimated from the length of the femur alone, the average is 11 mm. more, namely 1 m. 672, or about 66 inches, while from the length of the tibia it is 1 m. 575, or about 62 inches.

The tallest individual was that to whom the skeleton D belonged. His stature estimated from the femur and tibia is 1 m. 927, from the femur alone 1 m. 874, and from the tibia 1 m. 905, or 75·9, 73·8, and 75 inches respectively. It is fortunate that I am able to place before you the right femur of this skeleton and to demonstrate its length to you as 508 mm., otherwise you might think that there was some mistake regarding its measurement, on account of its being so unusually long. The two shortest skeletons are those marked C and L, each of which have an estimated stature from the femur and tibia of 1 m. 555, or 61·2 inches. From these figures it will be seen that there is a considerable degree of variation in this small series. The occurrence of D measuring 9 inches more than the tallest of the other six, without there being any skeleton correspondingly short, gives an erroneous idea of the average stature of the series. I have, therefore, had resource to Mr. Galton's method of arranging the different specimens according to their centesimal grades, by which means we get rid of the disturbing effects of the extremes at each end of the series, and so obtain the mean of the group. When treated in this way the actual mean stature of the series is 1 m. 628 (64·1 inches). For the information of those who are unacquainted with this method of dealing with statistics, I may state that at the 25th centesimal grade the stature is 1 m. 564 (61·6 inches), the 50th, 1 m. 616, and at the 75th, 1 m. 692 (66·6 inches); the value of Q, therefore, is 64 mm., giving a corrected mean for the series of 1 m. 628. This height indicates as nearly as possible, I consider, the mean stature of the persons represented by the skeletons we have to deal with. It is considerably lower than the mean stature of the male population of this country at the present time, which, at prime of life between the ages of 23 and 51, is 1 m. 715 (67·5 inches), according to the extensive observations of the Anthropometric Committee of the British Association* (See Reports for 1882). The tibio-femoral index, which shows the relative length of the tibia to that of the femur, varies from 77·7 in G and M to 87·4 in D, and averages in the whole series 81·1, but excluding D, in which the index is very

* When these observations, as tabulated, are treated by Mr. Galton's method of centesimal grades, the corrected mean stature is 1 m. 703 (67 inches).

high, it averages 80 in the six other skeletons, which is almost the same as that given by Broca, Topinard, and Rollet for Europeans. Although in persons of tall stature Topinard found that the index is somewhat higher than in short persons (averaging 81·1 in males with statures between 1 m. 70 and 2 m. 06, and 79·7 in those with statures varying from 1 m. 43 to 1 m. 60) the index is so high in D as to lead us to suspect that some error has occurred in recording the length of the tibia in that skeleton.

The index of Platycnemism, or the relation between the transverse breadth of the tibia to its antero-posterior diameter was ascertained only in the two specimens K and I which were measured by me; in the former it is 64·9, and in the latter 67·6, giving an average of 66·3 for the two specimens. The measurements for this index were taken by Busk's method about 4 cm. below the nutrient foramen of the bone. The average index in English people is 73, so that the specimens from Howe Hill Barrow, are markedly platycnemic as compared with the existing inhabitants.

To trace the relations of the people represented by these skeletons, it is necessary to study, as far as materials will permit, the characters and dimensions of those of the earlier races who have successively inhabited various parts of England. For this purpose, I have calculated the stature of all the Barrow specimens of adult males described in the "Crania Britannica" by Dr. Barnard Davis. As, however, he only gives the dimensions of the femur, I have only been able to do so from it, and not from the femur and tibia, as I would have preferred to do. The results are as follows:—The average stature of eight Long Barrow skeletons is 1 m. 698 (66·8 inches), the average length of the femur being 460 mm., while that of twelve Round Barrow skeletons is 1 m. 793 (70·6 inches).

Between the average stature, estimated from the femur, of the Howe Hill series, which I have previously stated, is 1 m. 672, and that of the Long Barrow specimens, the difference is only 26 mm.; while between the former and Round Barrow series it is 118 mm. It is therefore clear that the skeletons from Howe Hill correspond very closely to Dr. Barnard Davis's Long Barrow series, which, I may mention, includes specimens from Yorkshire, Staffordshire, Gloucestershire and Wiltshire, from which counties also the Round Barrow specimens were likewise obtained. The tallest Long Barrow skeleton in the "Crania Britannica" series has an estimated stature of 1m. 874, his femur being 508 mm. long, which is exactly the same length as the longest femur from Howe Hill; the shortest man has an estimated stature of 1 m. 546, which is also exactly the same as that of the shortest skeleton from Howe Hill. The range of variation in stature of both series is practically the same; in both there is a disturbing element owing to the presence of an usually tall individual, which raises the average stature of each group to a figure higher than it should be. To get at the true mean stature of the groups, I have again employed Mr. Galton's graphic method, which shows that the stature at the 25th and 75th centesimal grades is respectively 1 m. 585, and 1 m 715 in the Howe Hill specimens, and 1 m 652, and 1 m. 730 in the Long Barrow series, the respective values of Q, (*i.e.*, half the difference between the statures at each of these two grades), are 65 and 39 mm., giving to the former series a corrected mean stature at the 50th grade of 1 m. 650, and the latter of 1 m. 691, the observed mean of the former being 1 m. 653, and of the latter 1 m. 702.

On the other hand, the tallest Round Barrow skeleton in the "Crania Britannica" has an estimated stature of 1 m. 920, (75·6 inches), and the shortest of 1 m. 686 (66·3 inches) while the rest of the series range themselves regularly between these extremes.

In the Memoirs of the Anthropological Society of London, Vol. III, p. 41, Dr. Thurnam gives the length of the femur of twenty-five males from Long Barrows as 457 mm. which gives an estimated stature of 1 m. 686, while the femur in twenty-seven males from Round Barrows averaged 477·5 which gives an average stature in them of 1 m. 761.

The Howe Hill specimens may also be compared with skeletons obtained by General Pitt Rivers, from Rotherley, Woodcuts, and Winklebury. The medium stature of eleven skeletons found at Rotherley was 1 m. 562 (61.5 inches), and of seven from Woodcuts which were rather more mixed in type, 1 m. 644 (64·7 inches).

The general conformation of the skulls obtained from these two places agrees with that of the Howe Hill series in being, as we shall afterwards see, markedly dolichocephalic. On the other hand, the medium stature of twelve Anglo-Saxon skeletons from Winklebury was 1 m. 700. Thus, we see that the stature of the Howe Hill Barrow series agrees very closely with that of the dolichocephalic race in the Pitt Rivers series, and is considerably less than that of the Anglo-Saxons in the same collection. The tibiæ of the Rotherley specimens are somewhat platycnemic, the average index in these being 70·2.

SKULL—*Characters of the Calvarial portion.*—The ridges for muscular attachments on the cranial vault are of very moderate size, but in one or two instances are fairly well developed in the stephanic region. The under surface, however, presents a marked contrast to the upper in this respect, the superior curved line of the occiput being in some cases very strongly developed ; a well-marked torus is present in three specimens, and a smaller one on a fourth ; the other muscular attachments on the base are well-marked except the mastoid processes, which are only moderately large. The bones forming the calvarial vault, are thick and heavy, and in one instance might be called massive. The sutures are moderately closed in some specimens and obliterated in others ; stenosis of the sagittal suture is present in a greater or less degree in the majority of cases. Where the sutures can be traced their character is simple. In only one instance are worm-eaten bones present, these are of small size and situated in the lambdoidal suture. The antero-posterior outline or curve of the calvaria is regular ; in one case the forehead is vertical, in several it is low, and in others its curve is medium. Occipital elongation occurs only once, and in that instance it is probably more apparent than real, owing to post-mortem distortion. I may mention here that post-mortem distortion of some kind is noticeable in almost all the specimens, but varies in character ; sometimes affecting the right and sometimes the left side. When viewed from above, the outline of the calvaria is seen to vary considerably ; in four cases it may be described as extremely long and narrow, the forehead rounded, narrow, and with the orbital processes little marked ; the sides straight, and the occiput elongated ; in three specimens it is somewhat shorter and broader, and more or less pear-shaped in form, or, as it has been termed by some writers, "coffin-shaped." In one of these latter (L) the forehead is very rounded, the frontal bosses are well-marked, and the occipital region terminates very abruptly, so as to give a truncated appearance to the back of the head. The fourth specimen (G) presents characters intermediate between these two kinds; it agrees with the first four in being long and narrow, but in the details of its outline it agrees with the second three. When the skulls are placed in a row and viewed from the front, the form of the arch of the cranial vault is observed to be very characteristic, being pointed in the first four specimens, while it is flat in the other four. These varieties in the form of the cranial arch are equally observable when the skulls are looked at from behind. As the differences mentioned seem to me to be no mere accidental variations, but probably racial, I have divided the series into two groups, the first of which is composed of the specmens C, D, I, and K, while the second includes G, L, J, and M. It will be noted that the skull of the primary interment belongs to the first group. The immature specimens F and H belong to this group.

On each parietal bone of J, just above the parietal boss, a rounded opening occurs, that on the left side being 35 mm., and that on the right 20 mm. in diameter, the edges are bevelled inwards, and from them stellated fracture rays extend. There is little doubt that these holes are the result of sharp and quick blows delivered with considerable force, and would have been sufficient to have caused the death of the person. The skull was found by itself without the rest of the skeleton, in the middle of the grave below the centre of the barrow.

Characters of the facial portion.—The broken condition of the facial portion of the skull renders it impossible to give anything like a satisfactory description of the characters of the face, but it appears to be longer in proportion to its breadth in the first group than in the second. As a rule the facial bones harmonise with those of the calvaria, except in L, in which the weakness of the former presents a marked contrast to to massiveness of the latter.

The glabella and superciliary regions vary from being almost quite flat in some specimens to be moderately or even markedly developed in others. In the case where it is most developed (I), the superciliary bosses and the glabella form a continuous ridge across the forehead. The orbits appear to be set at about the same angle with the horizontal in each case, and their upper margins are thin; in form they are broadened rectangular to nearly square in the specimens complete enough to admit of their shapes being determined.

The nasal spine is small, the lower margins of the nasal openings are sharp and well-defined, the outline in profile of the nasal bones appears to vary within the outlines of Nos. 1, 2, and 3 of Broca's nasal curve. The profile of the upper jaw is straight or nearly so, there is therefore no tendency to prognatism. The direction of the incisor teeth is vertical. In the majority of cases, the teeth are moderately worn, but in one case (I) they are much worn, and in two (K and J), they are little worn. The last molar is sometimes absent through not being developed. The form of the palate, or rather the outline of the upper alveolar arch, is somewhat parabolic. The chin is narrow and pointed in the majority of cases, but it is more rounded and less pointed in M.

Measurements.—Turning to the measurements of the skull and comparing them, as far as possible, with the characters observed by inspection, we find that while some of these do not vary much in the two groups, others are markedly different. The measurements of G show that in some respects it agrees with those of the first group, but in the majority it resembles those of the second, among which it has been placed from its general characters.

The cephalic index of the series ranges from 65·5 to 79·6; five of the crania are hyperdolichocephalic, one is dolichocephalic, and two are mesaticephalic. All of the specimens belonging to the first group, and G, belonging to the second group, are hyperdolichocephalic. The higher cephalic index in the other specimens is due not only to their breadth being greater, but also to their length being less than those of the first group. The cephalic index of L being considerably higher than the others (79·6) is probably due to irregular or premature closure of some of the sutures, which has caused abnormal bulging of the parietal regions, its biauricular or base breadth being only 100 mm., or no less than 20 mm. less than any of the other specimens, so that it cannot be considered quite normal.

The height measurement and the height to length index are slightly less in the first group than in the second. The appearance of greater height imparted to the eye in the former is therefore due to the want of filling out of their lateral walls, and the acuteness of the arch formed by the upper and curved parts of the parietal bones, as it will be seen that there is little variation in the biauricular diameter in the whole series, except in L, which is unusually narrow in this region. Only in K does the height exceed the maximum breadth. Owing to the imperfect condition of the specimens it was not possible to measure the cranial capacity, but as estimated from the cephalic module of Schmidt it is a little larger in the second group than in the first, though the antero-posterior or sagittal, the horizontal, and the traverse circumferences of the cranium are practically similar in both groups.

The narrowness of the cranium in the first group is not confined to the maximum breadth only, but extends to the minimum, and the maximum (bistephanic) diameters of the frontal bone, and also to the external biorbital and bizygomatic diameters, all of which are less than in the second group. This shows that the upper part of the face is quite in harmony with the width of the calvaria in each group. The minimum traverse diameter of the maxillary bones, that is, the maximum alveolar breadth, is if anything, less in the second group than in the first, while the bigonial diameter of the mandible averages 6 mm. less in the former, showing that the lower part of the face is narrower in them than in the latter, thus reversing the conditions present in the upper part of the cranium. This narrowing of the lower part of the face in the second group appears more accentuated on account of the greater breadth of the upper part, and gives a somewhat wedge-shaped appearance to the face. Details of the characters of the nose, orbits, &c., from the measurements is unfortunately impossible.

The skulls are in all respects similar to those of Long Barrow specimens which have passed through my hands from different parts of the kingdom, but I have never examined a series of skulls in which there were such a large proportion of hyperdolichocephalic specimens. The two types found in this series I have long been familiar with among Long Barrow skulls. That which I have distinguished as group 2 may be thought from the description to be somewhat like the skulls of the Round Barrow period. but this is not the case, as although somewhat coffin-shaped they are quite distinct from them. It is very unfortunate that in the exploration of this barrow the importance of preserving most carefully every bone of each skeleton found was not understood, as the anatomy of the two types which existed in that remote period has not been worked out yet. As far as I am able to see, there does not seem to be any difference in stature between the two groups, nor was there preference apparently as to the places of interment given to the one type more than the other, which were thoroughly mixed together, some of each group were in the grave with the primary interment, and some of both kinds were found outside it.

Let us now turn to the skulls from Long Barrows described in the Crania Britannica and by Dr. Thurnam in the Memoirs of the Anthropological Society of London, Vol. III., and to the specimens figured by General Pitt Rivers from Rotherley and Woodcuts. The cephalic index of 17 Long Barrow skulls, including the nine specimens whose height has been estimated from the femur, previously discussed from the Crania Britannica, varies from 67 to 75 ; three are hyperdolichocephalic, 13 dolichocephalic, and 1 mesaticephalic. The measurement of length from which Dr. Davis calculated the index was that from the ophryon to the occiput which generally is a little shorter than the maximum length measured from the glabella, as now universally done, consequently the cephalic index calculated from the former is somewhat higher, and it is probable that several of the 13 dolichocephalic specimens would have fallen within the limits of the first group had Dr. Davis measured their length from the glabella, many of them having indices according to him of 70, 71, and 72. In a more recent paper Dr. Thurnam* gives the cephalic index of 48 Long Barrow skulls as varying from 65 to 75. Of these 16 are hyperdolichocephalic, 29 dolichocephalic, and 3 mesaticephalic ; their length averaged 195, the breadth 139 mm., the height 143, the face length (probably from the ophryon to the chin) 111 mm., face breadth 128 mm. ; the cephalic index of the series averages 71 and the altitudinal index 73. Coming to the same race in post-Roman

* "Memoirs Anthrop. Soc. Lond.," vol. iii., p. 41.

times we find that the cephalic index in the specimens from Rotherley varied from 68·9 to 82·6; and that 3 were hyperdolichocephalic, 6 dolichocephalic, 3 mesaticephalic, and 1 brachycephalic. The Woodcuts specimens are not so markedly dolichocephalic and not so pure in character.

Arranged in tabular form, the cephalic index in these series are as follows:—

	Hyperdolicho-ceph.	Dolichoceph.	Mesaticeph.	Brachyceph.
Howe Hill Barrow	5	1	2	0
Long Barrows *Cran. Britann.*	3	13	1	0
" " Dr. Thurnam...	16	29	3	0
Rotherley, Gen. Pitt Rivers ...	3	6	3	1
Woodcuts	0	5	7	1

From this it is evident that the general form of the Howe Hill Round Barrow skulls agrees entirely with the Long Barrow skulls of Davis and Thurnam. In neither group of the Howe Hill skulls, if we except L, which, as I have already said, is an abnormal specimen, have we any approach towards the brachycephalic type, as the only other mesaticephalic specimen is at the lowest end of the group, four above the dolichocephalic group. As it is very imperfect in the posterior part of the base, as it is shorter than any of the others, it is not unlikely that in drying, the unsupported part of the occipital may have curved inwards somewhat and so reduced the length, in which case it would also fall into the dolichocephalic group.

I have not been able to compare these specimens from Howe Hill with any of the actual specimens described by Drs. Davis and Thurnam, but I have done so with drawings of them. On plate 33 of the Crania Britannica is an engraving and on the opposite page of the letter-press are some woodcuts of a skull from West Kennet Barrow in Wiltshire, of which the cephalic index is 67·0; both of these specimens resemble the skull C from Howe Hill. Again on plate 59 we have an engraving of a skull from the Long Barrow of Rodmarton, Gloucestershire, with a cephalic of 72 which agrees in its characters with M of our series. The skull depicted on plate 5 from the Long Barrow of Ulley, Gloucestershire, fairly represents D, I, and K of our series. In the Crania Britannica, therefore, we have specimens from the Long Barrows which represent very accurately both groups of our series from Howe Hill Barrow. I need scarcely occupy time in comparing them with the Round Barrow skulls described by Drs. Davis and Thurnam, as these are all brachycephalic and of very different type, except in cases where crossing has occurred.

Having established the fact, sufficiently clear I hope, of the identity as regards the physical characters of the Howe Hill specimens with the Long Barrow race, there remains to be considered the question of the Archæological evidence of their affinities. For this we have to refer to the abstract of Mr. Mortimer's notes which I made previously to examining the skeletons, so as to do away with the chance of any bias being produced on my mind by the specimens. In the outer layer of the barrow we find flint, bone, and *iron* implements; British, Roman, and Anglo-Saxon pottery, and some of more recent date; of animal remains those of dog, red deer, ox, and horse. There were well marked traces of this outer layer having been used for secondary interments, but neither these nor the various explorations which had been previously made had extended beyond this layer. Next there is a layer of Kimmeridge clay one foot in thickness, in which no relics were found, which, as it were, cemented in the interior mound containing the interments, which may be considered as the *raison d'être* of the barrow. The inner mound consisted of two layers, in which there were seven deposits of burnt bones, with flint and bone implements and pieces of food vase. In the inner or core of the barrow were numerous cremated deposits extending to half its thickness, but fewer in number below that. Towards the base line of the barrow and in the central grave we have the skeletons placed in different directions, chiefly lying on one or the other side, with the limbs drawn up towards the body. With them were found in this deeper part of the core, flint implements carefully manufactured, worked flints and flakes, bone pins, some of which were burnt. With K, the primary interment at the bottom of the grave, was a semi-globular vase of Kimmeridge clay, but no cinerary urns were anywhere found; the animal remains found in connection with the skeletons were those of fox (identified as such by Professor Newton), ox, deer, boar, and beaver. It is a matter of regret that the pieces of bones from the cremated deposits so numerous in the barrow, were not preserved, as it might have been possible to determine from them whether they were human or belonged to domestic or other animals. From these data I think we have undoubtedly to deal with the remains of a Neolithic people interred in an age before metal had been introduced among them. The bronze age, which succeeded the stone period, is totally unrepresented in the barrow, from which I think we may conclude that a considerable interval of time elapsed between the primary interments in the inner mound and the secondary ones in the outer layer. Although the various flints and other articles found have not, as far as I am aware, been submitted to the examination of a well-known acknowledged expert, the full description which Mr. Mortimer has given us of them leads me to the couclusion that the Archæological evidence corroborates the conclusions I have arrived at from my examination of the skeletons, and shows that the people interred in this barrow are identical with the Long Barrow people.

NOTE.—Since this paper was written I have calculated the stature of the skeletons by Rollet's formulæ for the *femur* and *tibia*, which are almost identical with Topinard's latest for these two bones. The stature from the *humerus* is calculated from Topinard's latest revised formula.

	Humerus × L.	Femur × L.	Tibia × L.	Fem. & Tib.	H. F. & T.
	20·0	27·3	22·0	49·3	...
C ...	1,650	1,556	1,559	1,558	1,588
D ...	...	1,861	2,018	1,931	...
I ...	...	1,608	1,577	1,594	...
K ...	1,710	1,707	1,700	1,703	1,706
G ...	...	1,677	1,618	1,651	...
L ...	...	1,535	1,586	1,558	...
M ...	1,625	1,677	1,618	1,651	1,640
	4,985	11,621	11,676	11,646	4,934
	1,662	1,660	1,668	1,664	1,645
	Average excluding D.				
	1,662	1,627	1,610	1,619	

As the length of the tibia in D is quite out of proportion to that of the femur, I am inclined to think that some error has occurred in recording its measurement. The above formulæ appear to give better results than the earlier ones of Topinard used in the paper, as the estimates from the femur and tibia more closely correspond to one another. The earlier formulæ are those used by General Pitt Rivers in his works on "Excavations in Cranborne Chase;" the formulæ used in the paper for the estimate of stature from the lengths of the femur and tibia added together is almost the same as that just given, and the difference between using the one or other is only 3mm. on the indicated stature, that is to say, when the divisor 49·4 is used the stature indicated by the answer is 3 mm. less than when 49·3 is used as the divisor.

The length of the humerus in these specimens being longer than usual, possibly from the longest bone having been measured instead of the mean of the two, Topinard's last formulæ has been given in this additional note in preference to that of Rollet's which would have given a still higher estimate, and therefore differed more from the results given by the other bones.

	Maximum length.	Maximum breadth.	Basio-brymatic height.	Minimum frontal breadth.	Stephanic breadth.	Horizontal circumference.	Frontal curve length.	Parietal curve length.	Occipital curve length.	Antero-post. curve length (nasion to opisthion).	Length of foramen magnum.	Basio-nasal length.	Total longitudinal circumference.	Auriculo-brymatic curve length.	Bi-auricular breadth.	Nasio-mental length.	Nasio-alveolar length.	Basio-alveolar length.	External bi-orbital breadth.
	(1)	(2)	(3)	(4)	(5)	(13)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(14)	(15)	(16)	(17)	(18)	(19)
C	200	133	—	100	118	536	145	140	113	398	—	—	—	315	c110	120	70	—	104
D	202	139	132	87	c116	540	132	147	130	409	—	—	—	314	118	—	—	—	—
I	194	132	—	94	c111	c500	132	127	—	—	—	—	—	c290	c116	130	73	—	101
K	198	131	135	—	—	531	sutures obliterated.			371	41	114	526	312	121	96	—	—	—
Total... ...	791	535	267	281	345	2,107	409	414	243	1,178	41	114	526	1,231	465	346	143	—	205
Average ...	198·5	133·7	133·5	93·7	115	527	136·3	138	121·5	383	41	114	526	310·2	116·2	115·3	71·5	—	102·5
G	205	142	140	106	122	555	133	145	123	401	—	—	—	311	120	124	75	—	114
J	186	140	—	100	c120	c513	260		—	—	—	—	—	—	—	—	—	—	c116
L	191	152	140	103	125	549	143	146	114	394	—	—	—	341	100	—	—	—	c102
M... ..	194	145	133	100	129	540	126	139	114	379	42	103	523	309	121	114	64	97	109
Total... ...	776	579	413	409	496	2,157	402	430	351	1,174	42	103	523	961	341	238	139	97	441
Average ...	194	144·7	137·7	102·2	124	539	134	143	117	391	42	103	523	310	113·7	119	69·5	97	110·2

	Bizygomatic breadth.	Maximum breadth of maxillæ.	Minimum breadth of maxillæ.	Bigonial breadth.	Interorbital breadth.	Orbital breadth.	Orbital height.	Nasal length.	Nasal breadth.	Palato-maxillary length.	INDICES. Cephalic.	Height.	Sup. facial.	Total facial.	Nasal.	Stephano-zygomatic.	Gnathic.	Orbital.
	(20)	(21)	(22)	(23)	(24)													
C	124	88	60	104	—	—	33	c50	c23	53	65·5	—	56·4	103·3 / 96·8	46·9	95·2	—	—
D	—	—	—	—	—	—	—	—	—	—	68·8	c65·3						
I	c128	102	60	c100	26	38	33	54	c25	54	68·0	—	—	—	46·3	85·9	—	86·8
K	—	—	60	103	—	—	—	—	—	—	66·2	68·2	—	—	—	—	—	—
Total... ...	252	190	180	307	26	38	66	104	48	107	268·5	133·5	56·4	96·8	93·2	181·1	—	86·8
Average ...	126	95	60	103·3	26	38	33	52	24	53·5	67·1	66·7	56·4	96·8	46·6	90·5	—	86·8
G	132	—	61	98	—	—	—	56	c22	—	69·3	68·3	56·8	106·4 / 93·9	39·3	92·4		—
J	—	—	57	—	—	—	—	—	—	—	75·3	—	—	—	—	—	—	
L	—	—	54	88	—	—	—	—	c23	—	79·6	c73·3	—	—	—	—		
M... ..	134	100	63	105	c23	40	33	52	24	54	74·7	68·6	47·8	117·5 / 85·1	46·2	96·3	94·2	82·5
Total... ...	266	100	235	291	23	40	33	108	69	54	298·9	210·2	104·6	179·0	85·5	188·7	94·2	82·5
Average ...	133	100	59	97	23	40	33	54	23	54	74·7	70·0	52·3	89·5	42·7	94·3	94·2	82·5

MEASUREMENTS OF THE LONG BONES, AND STATURE ESTIMATED FROM THEM BY FORMULÆ STATED IN PAPER.

	Humerus.	Femur.	Tibia.	F. and T.	From humerus.	From femur.	From tibia.	From F. and T.	From F. T. and H.	Tibio-femoral Index.
C	†330	425	343	768	1,594	1,568	1,472	1,555	1,545	80·7
D	—	*508r	444	952	—	1,874	1,905	1,927	—	†87·4
I	—	*439	*347	*786	—	1,620	1,489	1,591	—	79·0
K ..	*342r	*466	*374l	*840	1,652	1,719	1,605	1,700	1,659	80·2
G ...	—	458	356	814	—	1,690	1,528	1,648	—	77·7
L ...	—	419	349	768	—	1,546	1,498	1,555	—	84·9
M .	325	458	356	814	1,570	1,690	1,528	1,648	1,596	77·7
Total	997	3,173	2,569	5,742	4,816	11,707	11,025	11,624	4,800	5,676
Average	332	453	367	820	1,605	1,672	1,575	1,661	1,600	81·1

* Means measured by myself: when only one bone has been measured it is marked *r* or *l* as it was right or left:—Femur, *r* 438, *l* 440; Tibia, *r* 348, *l* 346; Femur, *r* 467, *l* 463 worn. All measurements unmarked have been supplied to me by Mr. Mortimer.

† The relation which the length of the tibia bears to that of the femur shows that probably some error has occurred in measuring, as the record of the measurement of the tibia in D. The average tibio-femorl index of the six specimens, omitting D, is 80·0.

EXAMINATION OF THE BONES OF ANIMALS FOUND IN THE TUMULUS.

BY E. T. NEWTON, F.G.S., OF H.M. GEOLOGICAL SURVEY.

Four parcels of disjointed and splintered bones scattered in the body of the mound, and found under the dome-shaped bed of blue clay, have been submitted to Mr. Newton, who has supplied me with the following list of the animals, which he has been able to identify.

Parcel No. 1, containing the bones found immediately over the grave B, comprised :—

Bos taurus, probably var. longifrons.
Capreolus caprea (Roebuck).

Parcel No. 2, taken from the soily material at the base of the barrow, contained :—

Homo sapiens (human).
Cervus elephas (red deer).
Bos taurus (calf) ? var. longifrons.
Canis vulpes (fox).
Sheep or goat.
Gnawed bones.

Parcel No. 3. The bones were removed from the body of the mound at depths varying from 13 to 18 feet, and consisted of .—

Homo sapiens.
Bos taurus ? var. longifrons.
Sus scrofa (pig).
Canis vulpes (fox).
Sheep or goat.

Parcel No. 4, taken 3 feet below the bed of blue clay, included the bones of :—

Canis vulpes (fox).
Capreolus caprea (Roebuck).

FURTHER OBSERVATIONS ON THE CONTENTS OF THE HOWE TUMULUS.

BY J. R. MORTIMER.

I trust that a few additional remarks on the facts recorded in the former description of this barrow may be of some interest, and may help to further illustrate the history of this important barrow. Referring to Dr. Garson's descriptions of the skeletons it will be observed, probably with some surprise, that he had met with no female bones, the eight adult specimens all belonging to males. The height of the tallest he calculated to have been about 6 feet 3 inches, and the shortest about 5 feet 1¼ inches. It will also be noticed that their average height and cranial measurements correspond very closely with those usually found in long barrow interments, and are very different in type from other round barrow specimens with which Dr. Garson has compared them. But according to the prevalent theory the round barrows were raised by a round skulled race, and the long barrows by men with long skulls. A theory which is decidedly negatived by the evidence obtained from this round barrow, and also from numerous other examples which have come under my observation. It is to be regretted Dr. Garson has omitted giving the approximate ages of the eight adults. From my own examination of the teeth at the time when I was engaged in repairing the crania, I was led to believe the ages of the adults varied from 18 to 70, or even more, whilst those of the children extended down to the period of infancy. From this it would seem that in the grave and immediately above it there must have been the representatives of three generations who had, from some cause or another, been buried at the same time. As there was no break in the layers of soil covering the grave, this must be taken as affording a proof that no intrusive interment had taken place at any subsequent period.

As a specialist Dr. Garson naturally attaches the greater importance to the collecting of the osseous remains. But then an ordinary archæologist probably considers the collecting of other relics somewhat more important than merely securing the bones, for these are, except in the hands of a specialist, comparatively useless. Yet I possess nearly two cart loads of these crania and other portions of the human skeleton (properly labelled and stored away) which have been collected at various periods from British barrows during the last 25 years.

I have hitherto during all these years sought in vain for the assistance of an expert to describe these bones. Dr. Garson being the first and only one from whom I have been favoured with any reply to my enquiries since the death of Dr. Barnard Davis. Nevertheless, I have continued to collect the crania and such long bones as were thought suitable for description, believing the time would arrive when they would be of greater interest.

From a more recent examination made of no less than forty of the cremated deposits (now in my possession) obtained from Howe Hill, I found them to consist of about twenty-five per cent. of infants and young children, and about sixty-five per cent. whose ages appeared to range from boyhood to manhood; whilst there did not seem to be more than ten to fifteen per cent. assignable to very old persons judging from the closed sutures observed in the fragments of the skulls.

It is difficult to avoid speculating as to the meaning of such a large number being met with in the mound. Why were they burnt and dispersed in the manner and in such abundance as that in which we found them? Were they the remains of slaves or servants, who, with their families, (as they were evidently of all ages) had been sacrificed and interred during the raising of the mound?

The absence of any cinerary urn, food vase, or flint instruments with these cremated deposits is significant, and would seem to imply that very little respect or care was bestowed on their disposal. They appear to have been placed merely in small heaps, occasionally comprising more than one body, as the mound was being raised. If these deposits were not the remains of cremated attendants they may have been those of prisoners taken during a war with some hostile clan.

The disjointed and fractured bones found during the excavations most probably represented the animals that were slaughtered and eaten by the builders of this mound. Their presence in this instance can scarcely be otherwise accounted for. The bones of the fox having been taken from each division of the mound under the blue clay show that these animals were then numerous and used as food. As regards the human bones, two of which are the lower ends of the humerus belonging to adult persons, the larger is blackened in consequence of having been scorched, probably in cooking, show the sharply jagged fractures* similar to those observed on the splintered animal bones, with which they were associated.

These human bones had been broken at the same time in a similar fresh condition, and might also have been the remains of feastings. Cannibalism has undoubtedly existed at one time or another all over the world, and probably this repulsive practice would long survive, especially at great funeral gatherings or other religious ceremonies. As before stated, very few bones were found in the large mass of rough chalk forming that portion of the mound above the bed of blue clay, with the exception of those met with in the disturbed portion at the apex of the barrow. These, as already mentioned, (p. 217) were detached and broken bones of the ox, the dog, and the horse, also a few human bones. The remains of the horse were not found below this disturbed portion of the mound. All these were evidently of a secondary character, belonging to an unknown but comparatively recent period ; probably they were Anglo-Saxon interments. These bones were not included in the collection submitted to Mr. Newton for determination.

In conclusion it can only be stated that in spite of the devoted efforts of this ancient race to perpetuate the memory of their illustrious dead, how scanty is the record which reaches us, and how great are the blanks which still remain in our knowledge of their lives and their customs even after we have, by careful search, exhausted their burial mound of its evidence ! But the little we have been able to gather, and now place upon record, will, we trust, remain as in some degree a memorial, even though vague, of the savage customs and low culture under which this ancient race lived and struggled.

* Bones which have been buried for a long time lose their gelatine, and consequently break short like the rotten decayed branch of a tree without showing any splintering.

ON SOME SINGULAR NODULES IN THE MAGNESIAN LIMESTONE.

BY REV. J. STANLEY TUTE, B.A.

In the quarry of Magnesian Limestone near Wormald Green there occur some singular nodules of an impure silicate of lime, which appear to be of sufficient interest to be worth putting on record. They seem to form a connecting link between the Permian beds of Yorkshire and those of Durham. I am informed by Mr. R. Howse, of Newcastle, that simular nodules are found at South Shields, and at Fulwell, near Sunderland, an analysis and description of which appeared in the Transactions of the Tyneside Naturalists' Field Club, by Mr. Robert Calvert Clapham, and read Dec. 23, 1861.* The following is a copy of the analysis of the nodules from the Trow Rocks :—

Silica	78.00
Alumina	1.50
Peroxide of Iron	—
Carb. Magnesia	9.20
,, Lime	11.10
Total	99.80

Upon this he remarks " It is therefore not a flint (properly so called), but a mineral consisting of silica, and carbonate of lime and magnesia, which may yet require to be named. It is possible that it may have existed as some organic substance, of which the present mineral may retain some of the original form.

" Another specimen of a similar substance, but much more flinty in its appearance, found at Fulwell, and sent me by Mr. J. W. Kirkby, approaches much more nearly to the composition of flint in the quantity of silica, but contains a greater percentage of other matters than that mineral. It is composed as under :—

Silica	96.5
Alumina and Iron	1.2
Carb. Lime	1.6
Magnesia	trace
Total	99.3

* See Vol. v., Part 2, page 124, xxiii.

The nodules at Wormald Green occur in the lowest beds of the middle Permian Limestone, which are yellow, and much fractured. The nodules themselves are nearly white, in section have frequently a regular oval form, with dark central markings, either oval or approximately oval, as if some round organic substance like sea-weed had formed the nucleus of a deposit, and had been occasionally crushed into a flattened form.* The dark portions seem to indicate the presence of carbonaceus matter.

Other nodules occur, more spread out, and flatter, which exhibit faint parallel bands, which probably mark the successive deposits of silicate of lime.

* Op. cit. II., III), 4, 5, 6. III., 1, 2; iv.

THE OCCURRENCE OF A TOOTH OF A MASTODON IN THE GLACIAL DRIFT.

BY REV. J. STANLEY TUTE, B.A.

Mr. Bullivant, the schoolmaster of South Stainley, has showed me the Tooth of a Mastodon, which he found in a pit of Glacial Drift, on the road-side, about a mile from Ripley. The tooth was about six feet from the surface, in a bed of clay, grit, water-worn stones, and sharp angular rocks. About a foot above the tooth was a layer of sand. The drift is a portion of the brown glacial stream from the N. W., which spreads out eastward into the vale of York, it is cut off on the west by Cayton Gill, and on the south by the river Nidd. Near the river Laver, at Aldfield, it overlies an older bed of dark-coloured drift.

NOTES ON THE POLYZOA, STOMATOPORA, AND PROBOSCINA GROUPS, FROM THE CORNBRASH OF THRAPSTON, NORTHAMPTONSHIRE.

BY GEORGE ROBERT VINE.

In his illustrations of the "Geology of Yorkshire,"* Mr. John Phillips referred only one species of Polyzoa to the "Zoophyta" group, which he found adhering to fossils derived from the Cornbrash Rocks of the Yorkshire coast. This species Phillips named *Cellaria Smithii*. "It seems," the author says, "to belong to the genus hippothoa, Lamx., see his Expos. Meth. t. lxxx., fig. 16, Scarborough, attached to cardium citrinoideum." Phillips.

In Mons. Jules Haime's description of the "Fossil Bryozoa of the Jurassic formation,† the author only cites one species (p. 180), *Berenicea lucensis*, as found in the Great Oolite, Hampton Cliffe, and also in the Bradford Clay and Cornbrash.

From material, at that time in my possession, and also from a careful study of the Polyzoan fauna preserved in the cases of the Museum of Practical Geology, Jermyn Street, I was able to record, and partially describe, in my third "Report on Fossil Polyzoa,"‡ the following Cornbrash examples :—

1. Stomatopora Waltoni, Haime Cornbrash, Stanton.
2. „ dichotoma, Lamx „ „
3. Terebellaria ramosissima, Lamx „ „
4. Diastopora microstoma, Mich (?) „ „

In another paper on the "Jurassic Polyzoa found in the neighbourhood of Northampton"‖ I also described amongst others, and partly illustrated, the following species :

1. Stomatopora Waltoni, Haime, Cornbrash, Bedford.
2. Diastopora Oolitica, Vine „ „
3. „ Davidsoni, Haime „ „
4. Terebellaria ? increscens, Vine.

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* Ed. 1229, p. 143, pl. vii., figs 7, 8. † Geol. France, 2r. ser., tom. v., 1854.
‡ Brit. Assoc. Reports, 1882-3. ‖ Jour. Northampton Soc. Nat. History, 1886. The species described are preserved in the Northampton Museum.

Since these papers were written I have been allowed to examine, study, and select, from more than six hundred fossils, a certain number on which Polyzoan encrustations were found. The whole of these fossils belonged to Mr. Thomas Jesson, F.G.S., to whose previous kindness, by way of loans and gifts, I owe so much. Altogether, on the 600 fossils, there were considerably more than 1,200 colonial polyzoan growths ; and the whole of these were of such varying habits that I almost despaired of ever being able to fix the types for serial description. However, rather than further delay the publication of notes on the Cornbrash Polyzoa, I make a provisional selection of two groups, Stomatopora and Proboscina, in the hope that at some future time I may be able to add to the present list of species.

Before I give a detailed examination of the Cornbrash Stomatopora and Proboscina, I think that it will be both wise and useful to future students if I give preliminary studies of the peculiarities of the Jurassic forms already described, especially as regards British rocks.

The Genus *Stomatopora*, Bronn. (1825), may be considered as equal to the Genus *Alecto* (1821), previously described by Lamouroux ; the reason assigned for the change of name was, that Leach (1815) had already used the term *Alecto* for an altogether different group of fossils. In his "Petrifactions of Germany" Dr. Goldfuss employed the word *Aulopora* for Jurassic species, properly belonging to the *Stomatopora*, or "Alecto" group. Up till 1848 the whole of these generic terms were indifferently used by authors. Milne Edwards, Johnstone, and d'Orbigny (Prodr. de Palæont.) used the word *Alecto*, and Reuss (Foss. Polyp. der Wiener.) employed the term *Aulopora*. In his Palæont. Française, Terrains Crétacés (1852) d'Orbigny used the word *Stomatopora* for all those uniserial species which were found encrusting foreign bodies, not only in the Cretaceous rocks of France, but in other horizons as well. Altogether twenty-two species are accounted for, and as the synopsis which prefaces the descriptive text of the author gives the status of our knowledge of this group up till 1852, including the Cretaceous species, it may be useful to insert the list here, in d'Orbigny's own phraseology :*

* Op. cit. p. 834, Ed. 1852.

10a	Stage Bajocian	...	2	Species	(Jurassic series.)
11	„ Bathonian	...	2	„	(„ „)
14	„ Coralliėn	...	3	„	(„ „)
17	„ Néocomien	...	3	„	(Cretaceous„)
20	„ Cénomanien	...	5	„	(„ „)
22	„ Sénonien	...	3	„	(„ „)
24	„ Suessonien	...	1	„	(Tertiary series)
26	„ Falunien	...	3	„	(„ „)

Since this synopsis was drawn up, Uniserial Stomatopora have been described in the Quarterly Journal of the Geological Soc., and Transac. of Yorkshire Geol. Soc. by myself, where full references will be found of species derived from the Wenlock shales of Shropshire, and from American Silurian and Devonian Rocks, by Mr. E. O. Ulrich, Prof. H. A. Nicholson, Mr. Hall, and other American writers.

M. Jules Haime's monographical description of the "Bryozoaries Fossiles de la Formation Jurassique,"* the author described and illustrated seven species of Uniserial Stomatopora; but as I wish now to deal with British forms only, I give the names and references to those British species, examples of which Haime had before him when he wrote.†

1. Stomatopora dichotoma (Op. cit. p. 160, pl. vi., fig. 1, a to d)
2. „ Waltoni („ „ p. 162, „ „ „ 3, a to b)
3. „ dichotomoides („ „ p. 163, „ „ „ 7)

In my third British Association Report (1882-3), as previously referred to, I was able to add to the British list, two new names:

4. Stomatopora antiquata, Haime (Juras. Bryoz. pl. vi., fig. 7).
5. „ dilatans montlivaltiformis (B. A. Rep., p. 251).

In a paper "On Some Polyzoa from the Lias (Quart. Jour. Geol. Soc., vol. xliii., p. 636, pl. xxv., fig. 10), Mr. E. A. Walford described, from the Middle Lias, King's Sutton, a Stomatopora sp., but in a footnote he says "I have found the same species in the Inferior Oolite of Dorset," and for this reason he was induced to name the Lias form:

6. Stomatopora elongata, Walford (Q. J. G. S., 1887, p. 636).

In another paper (on some "Bryozoa" from the Inferior Oolite of

* Ed., 1854, Paris.

† All the British type examples of Haime are preserved in the Walton Collection of Jurassic Polyzoa in the Woodwardian Museum, Cambridge.

Shipton, Dorset (Q. J. G. Soc., vol. xlv., 1889, pp. 561—574), Mr. Walford described several species and varieties of Stomatopora, of which the following are new:

7. Stomatopora spirata (op. cit. p. 564, pl. 18., figs. 6, a. b.).
   ,, dichotomoides d'Orb.
8. ,, var. attenuata (op. cit. p. 564, pl. xviii., f. 91).
9. ,, porrecta (op. cit. p. 565, pl. lxviii., f. 7 & 8.)

These nine species, then, represent the whole of the Uniserial Stomatopora known to me, up to date (1892), which have been recorded or described from the British Jurasic Rocks.

The Cornbrash Uniserial Stomatopora, which will now be described in full, were adherent to a variety of fossils, including species of Echinodermata, Terebratula, Ostræ, and other fossils. On the Ostræ some of the forms were found on the insides of the valves (dead shells), whilst other examples luxuriate in the folds of the outer portions of the same or similiar shells.

Sub-Order CYCLOSTOMATA, BUSK.

Division Parallelata, Waters.

Genus STOMATOPORA.

1825. Stomatopora, Bronn., Pflanzenth, p. 27.

1. Stomatopora, Phillipsii, sp. n., pl. (XII.), figs. 1, 1a, 2, 2a, 3, 3a.

Zoarium encrusting, linear or branched; branches diverging from the distal extremity of the cell, generally in a line with the oral aperture, and not from the sides of the parent cell, like ordinary *Hippothoa* species. *Zoœcia* pyriform, smooth, slightly prolonged at the base, middle portion raised or inflated towards the distal extremity, by which the oral aperture is occasionally obscured; each zoœcium measures about $\frac{1}{50}$ of an inch in length.

Horizon and Locality: Cornbrash, Thrapston.

Habitat: On Terebratula obovata.

In all probability the above may be considered as identical with Phillips' *Cellaria Smithii*, Geol. Yorksh., p. 143, pl. vii., but in the absence of positive evidence, I dedicate the species to the memory of the author of the Geology of Yorkshire. I do not think, however, that there can be any doubt about the Cyclostomatous character of *Stomatopora Phillipsii.* Forms of both fossil and recent polyzoa, in some respects similar to the present one, have been placed in the Genus *Terebripora* d'Orb, or *Hippothoa* Lamx., indeed, Philips suggests that his species may be a member of the Hippothoa group, and Mr. Hincks,* though doubtfully, places the *Terebripora* d'Orbigny as a synonym of *Hippothoa.* D'Orbigny suggested,† and Mr. Hincks repeats in a note "that members of the genus burrow in the shells of certain Molluscs," and "our common *H. divaricata* erodes to some extent the surface to which it is attached; and the position of its cells, after their removal, is often marked by a very distinct depression" (p. 286). On account of their burrowing habits, Dr. Fischer‡ referred four Jurassic species to the perforating group, as follows :—

Terebripora	propinqua Fischer.	Oxford Clay :	Ardennes.
,,	arachne ,,	,,	Calvados.
,,	producta ,,	Kimmeridge :	,,
,,	Michelina Terq. sp.	Infra-lias, Hettange.	

In his remarks, however, on a new species of this Genus *Terebripora capillaris,* Dr. Dollfus|| has reviewed the whole of the literature of the subject, and the student is referred to that paper for special details. As regards the present form I have no evidence that *S. Phillipsi* burrows in, or even erodes the shell to which it is adherent, and the peculiar character of the Zoœcia, the mode of branching, and the absence of the long caudate appendages, appear to me sufficiently characteristic to seperate both *Cellaria Smithii* and *S. Phillipsi* from either *Hippothoa* or *Terebripora,* as described by d'Orbigny, Fischer, Dollfuss, and Hincks. The position assigned to *Cellaria Smithii* by Haime is in the Fam. Escharidæ, as follows :—

Hippothoa Smithii, Haime. Juras. Bryoz., p. 217.
= Celleria Smithii, Phill. ; Hippothoa Smithii, Morris, Cat. Brit. Foss.

Alecto Smithii, d'Orb. Prodr. de Palæont., t i., p. 317, 1850.
Terebripora antiqua, d'Orb. Prodr. de Palæont., t i., p. 318,

* British Marine Polyzoa, p. 286. † Terr. Cret. vol. v. p. 424.

‡ O. Fischer de Bryoza perforants ; Nouvelles archives du Mus., t ii., 1886.

|| 1877, Bryozoare Nouveau du Terr., Dévonien du Cotentin Bulletin de la Soc. Linn., 3rd ser. vol. i., pp. 1-16, pl. i., f. 3.

1850, is the only other Jurassic form placed in the Family Escharidæ by Haime.

2. Stomatopora intermixta, sp. n., pl. (XII.), figs. 4 to 4b.

Zoarium adnate, creeping, forming a series of reticulations by the anastomosis of the short branches, which are characteristic of this species. The *Zoœcia* are unlike ordinary Stomatoporæ. To the naked eye the cells seem to be much inflated, basally, but under the microscope this deceptive feature is soon resolved ; the short tubular Zoœcia are then found to be of the ordinary uniserial Stomatopora type, beneath which there is a basal lamina similar in substance to the cell itself, and upon which the cell rests ; peristomes raised, aperture orbicular. Occasionally two or three cells run in parallel lines, giving to the Zoarium a most peculiar Proboscinæ feature.

Horizon and Locality: Cornbrash, Thrapston.

Habitat: On Ostreæ.

In general habit *S. intermixta* resembles *Aulopora intermedia* Goldfuss (Petrifac., p. 218, t 65, f. i.), but it differs from that species by the possession of the basal lamina already referred to.

3. Stomatopora dichotoma, Lamx.

1821. Alecto dichotoma, Lamx. Exp. meth. des generes des Pol. p. 84, pl. lxxxi., figs. 12, 13, 14.

1822. „ „ W. D. Conybeare and Wm. Phillips. Outlines of the Geology of England and Wales, p. 214.

1854. Stomatopora dichotoma, Haime. Descr. des Bryozoaries Foss. de la Form. Juras. p. 160 ; pl. vi., f. 1.

1889. „ „ E. A. Walford. Quart. Jour. Geol. Soc., vol. xlv., p. 563. Under the last two references the whole bibliography of the species is given up to date.

The true *S. dichotoma* as given, and so ably described by Haime, is not abundant on the fossils of the Thrapston horizon. I have, however, good typical examples encrusting *Terebratula maxillata*, from the Great Oolite, Kidlington, Oxon, which conforms, in every particular, to that which Mr. Walford (op. cit. p. 563) speaks of as agreeing with Haime's figures (Juras. Bryoz. pl. vi., fig. 1). The Cornbrash examples are like the shorter form "as figured by Reuss." It is this shorter variety, which I referred to in my Caen and Ranville Paper,* and I found that the species varied accordingly with the habitat which formed the home of the colony. The robust forms were adherent to *Terebratula* ; the slighter ones to *Heteropora.*

Horizon and Locality : Cornbrash, Thrapston.

Habitat : on Terebratula and Ostreæ.

4. Stomatopora Waltoni, Haime. Pl. (XII.), figs. 5—5c.

1854.	S. Waltoni, Haime.		Desc. des Bryoz. de la form. Juras. pl. vi., figs 2 and 3.
1882-3.	,, ,,	Vine.	Report on Fos. Polyzoa, Brit. Assoc. Rep. 1883, p. 3 of Report.
1884.	,, ,,	Vine.	Quart. Jour. Geol. Soc., p. 787.
1888.	,, ,,	Vine.	Notes on the Caen & Ranville Polyzoa, Northampton Journ. Soc. Nat. Hist., p. 13.

There are several examples of this species in the collection of Mr. Jesson, some of which are of the ordinary type, whilst a few of them approach nearer to *Stomatopora dichotomoides, D'Orb.*

Horizon and Locality : Cornbrash, Thrapstone.

Habitat : On Ostreæ generally.

5. Stomatopora ? (Proboscina) Desoudini, Haime.

1854. Stomatopora Desoudini, Haime, Des. des. Bryoz. de la Form. Jurassique, p. 165, pl. vi., f. 5, a, b.

This species Haime places doubtfully amongst the Stomatopora group. Both in the peculiarity of the Zoarium and in the arrangement of the cells it may be regarded as a kind of duplex form, partly a *Proboscina* and partly a *Tubulipora.* The form described by the author is from the inferior Oolite of Longwy. One very small example is all that I have found encrusting Cornbrash fossils (Echinoderm) ; but without other examples to judge from it will be better to leave the species, the last of the Stomatopora group described by Haime, just where the author left it. See his remarks (op. cit. p. 165).

* Vine, Journ. Soc. Nat. Hist. Northampton, vol. v., p. 12, 1888

Localities: Inferior Oolite, Longwy (Terquem); Cornbrash, Thrapston, Northamptonshire.

Genus PROBOSCINA.

1826. Proboscina, Audouin, 1838: Criserpia, Edwards, 1847; Idmonea, d'Orbigny, 1852; Proboscina, d'Orbigny. Palæont. Française, vol. v., p. 844.

The species of this genus may be regarded as so many passage forms, which conveniently link together uniserial Stomatopora on the one side, and Diastopora on the other. By many modern workers on the Polyzoa group the genus is disallowed. Mr. George Busk in the III. British Mus. Catalogue (1875), and Mr. Hincks in the British Marine Polyzoa (1880), unite under one head, uniserial and multiserial forms. Neither Mr. A. W. Waters, in his various papers on Australian Fossil "Bryozoa," nor Dr. Pergens, in his revision of d'Orbigny's Cretaceous "Bryozoa," make any distinction in the grouping of the forms generally characterised as Stomatopora and Proboscina. The use, however, of the two generic names has its advantages, especially when dealing with Jurassic species, and for its adoption I make no further apology. Mons. d'Orbigny, in the Palæontologie Française, vol. v., Terr. Cret., pp. 844-147, has given a very full diagnosis of this genus, one of the distinguishing features of which is that species which are referred to the Proboscina group, commence their zoarial growth from an "egg-cell" (*cellule œuf*). The Rev. T. Hincks, in his history of "British Marine Polyzoa" (1880), remarks (p. 425) that "*Stomatopora* is distinguished by its linear, adpressed, dichotomously branched Zoarium, in which the cells are generally immersed for a great portion of their length, and are not divergent, except in a very slight degree, and then almost exclusively towards the very extremity of the branches. The most marked variation within the limits of the genus is found in the forms which have the Zoarium partially free and erect. They constitute the sub-genus *Proboscina* of Smitt." The type species of the sub-genus, however, both of Smitt and Hincks' *Stomatopora incrassata*, Smitt (Brit. Mar. Polyzoa, pl. 59. fig. 2) differs from the ordinary *Proboscina* species found in the Cornbrash rocks. A much better idea of the group can be obtained by a careful study of the figure and text of *Stomatopora dilatans* (Brit. Mar. Polyzoa, p. 420, pl. lvii., figs. 3, 3a), in which the position of the "egg cell" is a very characteristic feature of the species.

The British Jurassic species of *Proboscina* heretofore described are few in number. Up till 1852 only four Jurassic forms were referred to the genus by d'Orbigny. Jules Haime, in his Monograph of the Jurassic Fossil Bryozoa, only records five species as legitimate members of the group ; the four species of d'Orbigny are placed in the doubtful list, but only one of the species described by Haime is placed on the British list.

1. Proboscina Davidsoni Haime (op. cit., p. 167, pl. vi., fig. 11, a, b).

Mr. E. A. Walford, in his valuable paper "On some Bryozoa from the Inferior Oolite, &c., of Dorset," (Quart. Jour. Geol. Soc., Aug., 1889) adds considerably to our knowledge of British forms, both specific and varietal.

2. Proboscina spatiosa, Walford (op. cit., p. 566, pl. xvii., figs. 1-3.)
3. ,, ,, var. brevis, Walford (op. cit., p. 567, pl. xviii., figs. 1-2.)
4. ,, ,, ,, brevior, Walford (op. cit., p. 567, ,, ,, figs. 3-5.
5. ,, inconstans, Walford (op. cit., p. 567, pl. xvii., figs. 4-6.)

The following Cornbrash species must now be added to this meagre Jurassic list :—

1. Proboscina obscura, sp. n., pl. (XIII.), figs. 7-7b.

Zoarium zigzag or serpuliform, wholly adherent by the base, but slightly raised in the middle portion. *Zoœcia* stunted, or partially obscured in certain portions of the zoarium, or developed, Idmonea like, on other portions; irregularly disposed and occasionally elongated; surface transversely banded or punctured, aperture circular, placed at the extremity of the cell ; peristome thin. *Oœcium?* Lepralia like, slightly distended in the central portion, and punctured in transverse lines across the surface.

Horizon: Cornbrash, Thrapston.

The example is unique, and it differs in many respects from all the other species met with in my Cornbrash material ; but more especially in the Lepralia-like form of the *Oœcium*.

2. Proboscina divisa, sp. n. Pl. (XIII.), figs. 8, 8a.

Zoarium fenestrate, much branched, narrow; branches anastomosing at frequent intervals. *Zoœcia* elongated, or stunted, generally from two to three, on the surface of the branches; but occasionally the cells are irregularly clustered together in places where the branches divide, and form a fenestrule.

Locality and Habitat: Cornbrash, Thrapston.

The examples of this species are by no means abundant, and though I have frequently met with fenestrated Proboscinæ in other horizons of the Jurassic rocks, forms similar in any sense to the one described above are extremely rare, even in the Cornbrash rocks of Thrapston.

Proboscine clementina, Vine. (Proc, Yorksh. Geol. Soc., vol. xii., p. 154, pl. vi., fig. 2.)

3. ,, var. minuta, var. n., Pl. (XIII.), 9, 9a, 9h.

Zoarium, fan-shaped, or flabellate, delicate, originating from an "egg-cell." *Zoœcia*, contiguous, adherent by their bases only, the upper parts of the cells slightly elevated and rounded; partially free towards the orifices, the peristomes turned upwards; surfaces of Zoœcia striated transversely. The basal part of the cells occasionally distended, or pointed, just above the aperture, (Pl. (XIII.), fig. 9b.)

Horizon and Locality. Cornbrash, Thrapston, Northampton.

Except in the size of the colony, these two Cornbrash *Proboscinæ* closely resemble the Gault forms already described by me in a former paper (Proc. Yorksh. Geol, Soc., vol. xi., pl. ii., p. 154). The distinguishing feature in the Zoœcia of the Jurassic forms, however, merits recognition and description.

Proboscina clementina. Vine.

4. ,, Var. depressa, var. n.

The beautiful and delicate variety described above (*P. clementina*, var, *minuta*), is the form more generally met with encrusting Cornbrash Fossils; but there are several other varieties which would merit distinction if a more critical diagnosis were adopted. One peculiar example, however, in my possession, has the Zoœcia rather more robust and depressed than in the var. *minuta* (No. 3, ante.). This may be the result of habitat only, but even this difference may be recognised advantageously.

Locality and Habitat : on Echinoderm.

5. Proboscina ornata, sp. n., pl. (XIII.), figs. I0, 10a, 10b.

Zoarium flabellate. or very irregularly disposed ; some portions of the Zoarium apparently thickened by a secondary growth of cells. *Zoœcia* contiguous, rather larger than the ordinary cells of the *Proboscina* species previously described ; cells thickly and minutely punctate, aperture circular. *Oœcia* very conspicuous and frequent, generally having a globular outline. In some portions of the Zoarium there are occasional cells, which differ considerably from the ordinary ones ; these are short or stunted, very broad across the central portion, but with apertures similar to the regular cells ; surface (smooth when worn), but normally the cells are finely punctate.

Locality and Horizon: Cornbrash, Thrapstone ; generally on the shells of Echini.

This beautiful species is not altogether rare, but examples showing the peculiar *Oœcia* are not abundant. The example selected for diagnosis have at least four, and associated with these are several of the modified oœciel cells referred to in the text. The colonial growths of the Zoaria are similar in some respects to the *Zoaria* of the next species which I shall describe, but the Zoœcia are more depressed, and when superficially examined by a hand-glass somewhat pellucid. On account of this peculiarity I referred to the forms in my original MS. notes as *Probiscina pellucida,* when returning the greater bulk of the fossils to Mr. Jesson.

6. Proboscina Thrapstonensis, sp. n. Pl. (XII.), figs. 6-6d.

Zoarium flabelliform, fan-shape, lobulate or irregular, forming large and small patches, or colonial growths, and wholly adherent to a variety of fossils : *Ostreæ, Terebratula* species, and *Echinoderms* especially. *Zoœcia* depressed, contiguous by their whole length, and nearly of equal breadth throughout : surface of the cells flat, occasionally slightly rounded in the upper portions, especially in the newer cells, on the margins of the zoariums ; aperture circular, with a thin peristome placed at the extremity, depressed, or very slightly raised upwards just below the orifice. In the younger cells the surface is densely punctate ; in the older cells this feature is obscured by a thin coating of calcareous matter.—Ovicells ?

Locality : Cornbrash, Thrapston.

This is by far the most abundant species of all the Cornbrash Polyzoa.

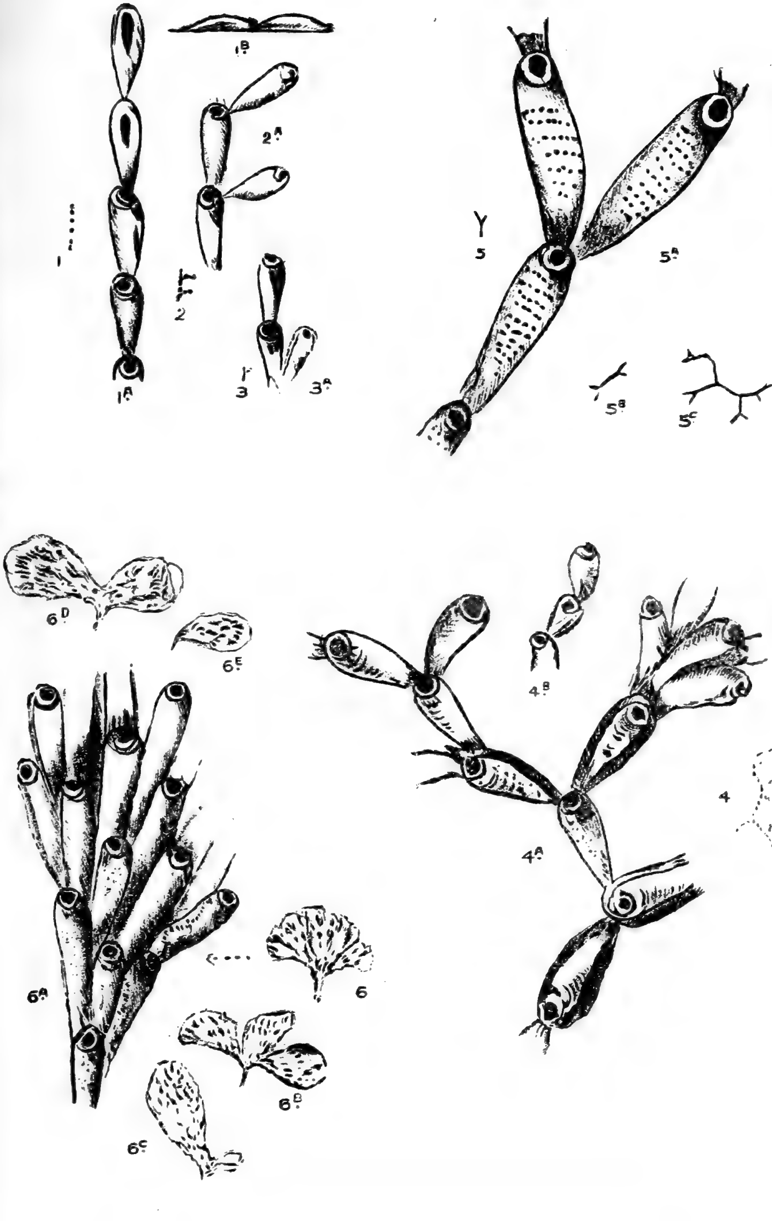
Description of Plates A and B.

Plate XII.

Figs.	1-1*a*.	Stomatopora	Phillipsi, Vine.	The largest colony found.
,,	2-2*a*.	,,	,, ,,	Another colony.
,,	3.	,,	Phillipsi ?	slightly varying from the above.
,,	4.	,,	intermixta, Vine,	natural size.
,,	4*a* & *b*.	,,	,, ,,	enlarged.
,,	5*b*-5*c*.	,,	dichotoma, Lamx.,	various colonies.
,,	5 & 5*a*.	,,	,, ,,	enlarged.
,,	6-6*a*.	Proboscina	Thraptonensis, Vine	type.
,,	6*b* to 6*d*.	,,	,,	various colonies.

Plate XIII.

,,	7-7*b*.	Proboscina	obscura, Vine.	
,,	7*a*.	,,	,,	Oœcium (?)
,,	8-8*a*.	,,	divisa, Vine.	
,,	9-9*b*.	,,	clementina, Var. minuta, Vine.	
,,	10.	,,	ornata, Vine.	Colonial growth of Zoarium marked *a* and 10*b*, showing two sets of Oœcia.
,,	10*a*.	,,	ornata.	Oœcial chambers from the left-hand side of the fig. 10, marked *a*.
,,	10*b*.	,,	ornato.	Oœcial chambers from the right-hand side of the colony, marked 10*b*.



VINE: POLYZOA FROM THE CORNBRASH OF THRAPSTON. A.

VINE: POLYZOA FROM THE CORNBRASH OF THRAPSTON. B.

RECORD OF A REMARKABLE SHOOTING STAR, APRIL 2ND, 1892.

BY R. REYNOLDS, F.I.C.

On the evening of April 2, 1892, at 7.30, when passing through my garden at Cliff Road, Leeds, my attention was arrested by a meteor of extraordinary size and brilliancy. I made a note of the particulars, and forwarded them, with some monthly returns of meteorology to the Editors of "The Natural History Journal," York.

The direction of the meteor was from N.E. to N. Its elevation appeared to be from 60° to 30°, the angle of its fall being 45°. The impression left upon my mind was that the colour was pale green, and the form pear-shaped, the last view of its extremity giving a brilliant red colour. I estimated its duration at from two to three seconds.

The Editors of the "Natural History Journal" received independent reports of the same meteor from Mr. T. W. Backhouse, F.R.A.S., Sunderland, and Miss H. S. Lean, Wigton; and placed the whole of the evidence in the hands of Mr David Booth, of Leeds, who has published in their issue of November 15 the following report, which the Editors kindly permit me to reproduce. The distance between the stations of observation seems to confer a special interest on the case.

"A spectacle of a somewhat extraordinary character presented itself to many individuals residing in various parts of the North of England, at 7h. 29m. G. M. T., on April 2nd of the present year. A shooting star of unusual dimensions, and great brilliancy, was observed to travel across a portion of the heavens, whilst the twilight was yet sufficiently strong to overpower the light of all except the brightest stars. The meteor had a long train of light following, and in close proximity to the head, the whole moving rather slowly downwards to its fall towards the earth.

From the observations which have been collected and discussed for the purpose of computation, T. W. Backhouse, F.R.A.S., Sunderland, and H. S. Lean, Wigton, "May N. H. J." appear to have been the most accurate. These two stations being remarkably well placed for comparison, we append notes concerning the flight of the meteor through the atmosphere at a great altitude between these two places.

Mr. Backhouse, an experienced observer of this class of phenomenon, states that the meteor appeared many times brighter than Venus, shining at the moment in the south western sky, and thus most favourably placed for comparison with the fireball as seen from Sunderland. There was little or no train seen from this point of observation, but this is accounted for by the fact that the place was "brilliantly lighted up with gas, the sky hazy, and the atmosphere of the town smoky," all being items which would help to obscure any appendage. Yet Mr. Backhouse describes it as one of the brightest meteors which he has ever recorded.

The point of the path first noted at Sunderland was at R.A. 4h. 55m., Dec. + $43\frac{1}{2}°$, which was at the time in Azimuth 93° and and altitude 55°. The meteor appeared to become extinguished at R.A. 1h. 44m., Dec. + 37°, the Azimuth of which was 118° and altitude 25°. The Azimuth is reckoned from the South point westwards in degrees of a great circle.

Miss H. S. Lean, Wigton, also saw and recorded the meteor, and describes its path as appearing from her station to be from the S.E. to N.E. at an altitude of about 40° ; finishing its track a few degrees past and below the tail of the Great Bear, the flight lasting about $2\frac{1}{2}$ seconds. The meteor had a long train of light, and the last that was seen of it was a red glow near the place of its extinction.

Mr. R. Reynolds, Leeds, appears from his description to have got the true direction of the track of the fireball. From this station it seemed to move from the N.E. to the N. quarter of the heavens, being, according to the description of the observer, 'projected upon a starless sky.' It would seem that Mr. Reynolds saw an earlier part of the track of the meteor than the Wigton and Sunderland observations shew. Mr. Backhouse only saw a later portion of the flight, as, he reports, that an observer in the Northern suburb of Sunderland saw it begin from his station in the E.S.E. This commencement thus agrees with that of Mr. Reynolds. But further confirmation and an accurate description carefully made instrumentally, would seem necessary before accepting this eastern point of commencement of the track. It appears from projection that it is hardly possible that the track could be much further prolonged backwards than the South point, as seen from Sunderland, unless some abnormal record had been made—abnormal with respect to the generality of meteor tracks. The path as seen from Wigton and Sunderland, conforms most closely to the requirements of computation, and it is from their observations that the data for the foregoing remarks have been collected.

All the observers agree that the bolide was travelling in a direction from the S.E. to the N.W. Probably passing from over the borders of Yorkshire and Durham, near Darlington, across the latter county and then Northumberland, terminating over the Cheviot Hills a little E. of Cumberland. The mean heights from these two observations give an elevation of 43 miles as it passed over the borders of Durham and Northumberland, and 25 miles at its point of extinction, over the borders of the latter county and Scotland ; or 75 miles in $2\frac{1}{2}$ secs.

An observer stationed at Falkirk should have seen the meteor in the S.E. portion of the sky, and it would have appeared as an almost stationary ball of light suspended at an altitude of a little over 25°.

The radiant of the meteor appears to have been in Sextans at 161° — 4°, which was in Azimuth 320° and altitude 25° at the time of observation."

SECRETARY'S REPORT.

The Society during the current year has been able to carry out the resolution of the Council of the 20th August, 1890, that the Proceedings of the Society be published half-yearly instead of annually. Part II. of Vol. XII., with seven plates, was issued to the members during July of this year, and the papers to be read to-day will be printed and issued to the members as early as possible in January next. Hitherto there has been a strong objection on the part of authors to contribute papers early in the year, which would not be printed and issued to the members until nearly a year afterwards; it is hoped that this objection will disappear with the publication of the Proceedings half-yearly.

The members met at York under the chairmanship of Tempest Anderson, Esq., M.D., on the 18th May, 1892, who gave an address on "Icelandic Volcanoes," illustrated by Photographs and the Oxy-hydrogen Lantern.

The following papers were also read:—

J. R. Mortimer, "On the Excavation of Duggleby Howe."

G. W. Lamplugh, "Notes on some Drainage Sections at Flamborough."

J. R. Dakyns, F.G.S., of H.M. Geol. Survey, "The Geology of the Country between Grassington and Wensleydale."

James W. Davis, F.G.S., &c., "On the Lias and Oolites of the Yorkshire Coast."

Geo. R. Vine, "Fossil Polyzoa: Further additions to the Cretaceous Lists."

The Annual Meeting was held at Leeds on December 14th, 1892. In the absence of the President, the Marquis of Ripon, Mr. Richard Carter occupied the chair. The following papers were communicated:

J. G. Garson, M.D., "On the Crania exhumed from the Duggleby Howe."

E. T. Newton, F.G.S., "Enumeration of the Bones found in the Tumulus."

J. R. Mortimer, "Additional notes on the Howe, Duggleby."

Rev. J. Stanley Tute, B.A., "On some singular nodules in the Magnesian Limestone."

Rev. J. Stanley Tute, B.A., "On the occurrence of the tooth of a Mastodon in the Glacial Drift."

G. R. Vine, "Notes on the Polyzoa—Stomatopora and Proboscina groups—from the Cornbrash of Thrapston, Northamptonshire."

R. Reynolds, F.C.S., "Record of a remarkable Shooting Star, April 2nd, 1892."

The Local Secretaries remain the same as last year, with the exception that W. Lower Carter, Esq., has accepted the office for the Leeds district.

This Society continues to exchange its proceedings with the Associations, Societies, and Institutions whose names are given below. This opportunity is taken to accord to all those Societies, &c., the warm and hearty thanks of this Society for their respective contributions.

Essex Naturalists' Field Club.
Norwich Geological Society
Memorias de la Sociedad Cientifica "Antonio Alzate," Mexico.
Warwickshire Natural History and Archæological Society.
Royal Society of Tasmania, Van Dieman's Land
Royal Dublin Society.
Royal Academy of Science, Stockholm, Sweden.
Geological Association, Liverpool.
Royal Historical and Archæological Association of Ireland.
Geologists' Association, London.
Manchester Geological Society.
Literary and Philosophical Society, Liverpool.
Royal Institution of Cornwall.
Royal Geological Society of Ireland.
Midland Naturalist, Birmingham.
Yorkshire Naturalists' Union, (Percy H. Grimshaw, 8, Elm Grove, Burley-in-Wharfedale, Leeds.)
Wisconsin Academy of Sciences, Arts and Letters (Madison, Wisconsin, U.S.A.)
Geographical Society, Manchester.
Academy of Natural Sciences, Philadelphia, U.S.A,
Naturhistorischen Hofmuseum, Wien, Austria.
Sociètè Imperiale des Naturalistes, Moscow.

United States Geological Survey of the Territories, Washington.
Boston Society of Natural History, U.S.A.
Hull Literary and Philosophical Society.
Connecticut Academy of Arts and Sciences.
Academy of Science, St. Louis, U.S.A.
Owens College, Manchester.
Meriden Scientific Association, Meriden, Conn , U.S A.
Royal Society of New South Wales, Sydney, Australia, (F. B. Kyngdon.)
Nova Scotian Institute of Science, Halifax, Nova Scotia, Canada.
Rochester Academy of Science, Rochester, N Y., U S A.
Halle (Prussia) Imperial Academy of Naturalists.
Historical Society of Lancashire and Cheshire.
Geological Society of London.
Royal University of Norway, Christiana.
Sociètè-Geologique du Nord, Lille.
Royal Society of Edinburgh.
Royal Geological Society of Cornwall.
Geological Society of Edinburgh.
Royal Physical Society of Edinburgh.
Oversigt over det Konigelige Danske Videnskabernes Selskabs, Kjopenhavn.
Museum of Comparative Zoology, Cambridge, U.S.A.
Watford Natural History Society and Hertfordshire Field Club.
Birmingham Natural History and Microscopical Society.
Bristol Naturalists' Society.
Leeds Geological Association.
Patent Office Library, London.
Powis Land Naturalists' Club, Aberystwith,
American Philosophical Society, Philadelphia, U S.A.
Comité Geologique de Russie, St. Petersburg.
Elisha Mitchell Scientific Society, Chapel Hill, U.S.A.
Elliott Society of Science and Art, Charleston, U.S.A.

The Treasurer's Balance Sheet is appended, and is satisfactory. It will be observed that a sum of £32 0s. 0d. has been temporarily transferred from the capital to the general account; this was done to pay off the balance due to the printers for the History of the Society. At present there are no outstanding amounts against the Society, and it is expected that at no very distant date the sum named above will be re-transferred to the capital account.

In conclusion the attention of the Society is called to a resolution passed by the Council on the 16th November last, viz.: "That the Society be recommended to undertake the exploration of certain prehistoric remains in Upper Wharfedale; that a special subscription be raised for the purpose; and that the following gentlemen, with power to add others to their number, be appointed a Committee of Investigation, viz. :—Professor W. Boyd Dawkins, Messrs. Tiddeman, Davis, Eddy, Wilkinson, Hartley, Cheetham, W. Morrison, M.P., Cudworth, Mortimer, W. L. Carter, Tate, Horne, and E. E. Speight as Honorary Secretary."

Statement of Receipts and Expenditure of the Yorkshire Geological and Polytechnic Society, 1891-92.

Receipts.

	£	s.	d.
To Balance in hands of Treasurer, 31st Oct., 1891	21	12	1
,, Transfer from Capital Account ...	32	0	0
,, Subscriptions	67	18	2
,, Interest on Halifax Corporation Bonds	10	9	0
	£131	19	3

Expenditure.

	£	s.	d.
By Whitley and Booth—Printing, &c. ...	102	0	0
,, Expenses at the Meetings, Postage, &c.	4	2	4
,, Autotype Co., Woodward and West...	16	5	3
,, Balance in hands of Treasurer, 30th Nov., 1892	9	11	8
	£131	19	3

CAPITAL ACCOUNT.

	£	s.	d.
To Halifax Corporation Bond	350	0	0
,, Cash at Halifax & Huddersfield Union Banking Co., Ltd., Halifax, 30th Nov., 1892	38	19	3
	£388	19	3

WM. CASH, Treasurer.

Audited and found correct, 30th November, 1892.

GEO. PATCHETT, Jun.

LIST OF MEMBERS.

Life members who have compounded for their annual subscriptions are indicated by an asterisk (*)

HONORARY MEMBERS.

Bodington, Principal N., M.A., &c., The Yorkshire College, Leeds.
De Rance, Chas. E., C.E., F.R.M.S., Alderley Edge, near Manchester.
Hughes, Prof. T. McK., F.R.S., &c., Cambridge.
Judd, Prof. Jno. W., F.R.S., Science Department, South Kensington, London.
Williamson, Prof. W. C., F.R.S., Owen's College, Manchester.
Woodward, Henry, Esq., LL.D., F.R.S., British Museum, (Natural History), London, S.W.

---

*Abbot, R. T. G., Whitley House, Malton.
Atkinson, J. T., F.G.S., Hill Field House, Selby.
*Ackroyd, W., F.I.C., Borough Analyst, Halifax.

Balme, E. B. W., J.P., Cote Hall, Mirfield.
Bartholomew, Chas., Castle Hill House, Ealing, Middlesex.
*Bartholomew, C. W., Blakesley Hall, near Towcaster.
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Beaumont, Hy., Elland.
Bedford, James, Woodhouse Cliffe, Leeds.
Bedford, J. E., F.G.S., Clifton Villa, Cardigan Road, Leeds.
Binns, J. A., 11, Oak Lane, Manningham, Bradford.
Binns, Thomas, Sawley Hall, Ripon.
*Booth, James, F.G.S., Spring Hall, Halifax.
Bould, Chas. H., Halifax Old Road, Huddersfield.
*Bowman, F. H., D.Sc., F.R.A.S., F.C.S., F.G.S.
Brierley, H. G., Glen View, Huddersfield.
*Brigg, John, J.P., F.G.S., Keighley.
*Briggs, Arthur, J.P., Cragg Royd, Rawden, Leeds.

Brooke, Ed., jun., F.G.S., Fieldhouse Clay Works, Huddersfield.
Brooke, J. R., Green End House, Melmerby, Thirsk.
Brooke, Lieut.-Col. Thos., J.P., Armitage Bridge, Huddersfield.
Brownridge, C., C.E., F.G.S., 256, Burley Mount, Leeds.
*Buckley, George, jun., Waterhouse Street, Halifax.

Carter, Jas., Burton House, Bedale.
Carter, R., C.E., F.G.S., Spring Bank, Harrogate.
Carter, W. Lower, Meanwood, Leeds.
*Cash, W., F.G.S., Elmfield Terrace, Halifax.
*Chambers, J. C., National Telephone Co., Manchester.
*Charlesworth, J. B., J.P., Stradsett Hall, Downham Market.
Cheetham, W., Horsforth, near Leeds.
Child, Hy. Slade, Mining Engineer, Wakefield.
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Davis, J. H. Grant, Greetland, Halifax.
Dawson, Oswald, Caledonian House, Leeds.
*Denham, Charles, London.
Dewhurst, J. B., Aireville, Skipton.
Dobson, M. G., Stannary Hall, Halifax.
Dodsworth, Sir Matthew, Bart., Thornton Watlass, Bedale.
Dolan, T. M., M.D., Horton House, Halifax.
Drury, Ed., Halifax.
*Duncan, Surr W., Horsforth Hall, Horsforth, near Leeds.
Durnford, W. St. John, Tankersley, near Barnsley.

Eddy, J. Ray, F.G.S., Carlton Grange, Skipton.
Effingham, Earl of, Tusmore House, Bicester.

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EMMOTT, W., The Square, Halifax.

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FIELD JOSEPH, West Parade, Huddersfield.
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GREGSON, W., Baldersby, Thirsk.

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MITCHELL, JOSH., F.G.S., Worsbro' Dale, Barnsley.
MITCHELL, T. CARTER, F.S.A., Topcliff, Thirsk.
MITCHELL, T. W. H., Barnsley.
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ORMEROD, HANSON, Boothroyd, Brighouse.

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PAWSON, A. H., Leeds.
PEACH, ROBERT, Harrogate.
PLATNAUER, H. M., F.G.S., The Museum, York.
POCKLINGTON, HENRY, F.R.M.S., Park Row, Leeds.
POLE, CHARLES, Halifax.
POLE, M., H.M. Inspector of Schools, Sowerby Bridge, Halifax.
PRESTON, ALFRED ELEY, C.E., F.G.S., The Exchange, Bradford.
PEARSON, JOHN T., The Hall, Melmerby, Thirsk.

*RAMSDEN, Sir J. W., Bart., M.P., Byram Hall, near Pontefract.
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*RHODES, JOHN, Snydale Hall, Pontefract.
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ROSS, JAMES, Harrogate.
ROWLEY, BROOK, Weymouth Street, Halifax.
*ROWLEY, WALTER, F.G.S., Albion Street, Leeds.
*RYDER, CHARLES, Westfield, Chapeltown, Leeds.

Scarborough Philosophical Society, J. H. PHILLIPS, (Scarborough).
SCRATCHERD, T. H. C., Halifax.
SEAL, HENRY, Vale Head, Knottingley.
SEAL, STEPHEN, F.G.S., Darfield Quarries, Barnsley.
SHAW, JOHN, Darrington Hall, Pontefract.
*SIMPSON, W., Halifax.
SLATER, E., Ashville, Stanningley, Leeds.
SLATER, M. B., Malton.
SLINGSBY, W. C., Carleton, near Skipton.
SMITH, F., Huddersfield Road, Halifax.
SORBY, H. C., D.C.L., F.R.S., F.G.S., Broomfield, Sheffield.
SPEIGHT, ERNEST E., Ardyngnook, Baildon.

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*Stansfeld, A. W., Skipton-in-Craven, Yorkshire.
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*Stockdale, T., Spring Lea, Leeds.
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Sugden, Richard, ye Farre Close, Brighouse.
Swallow, D., Gas Works, Bradford.
Sykes, Peace, 33, Estate Buildings, Huddersfield.
Sykes, Sir Tatton, Bart., Sledmere House, near York.

Tate, Thomas, F.G.S., 5, Eldon Mount, Leeds.
Taylor, John Henry, Borough Surveyor, Barnsley.
Tetley, Mrs., Foxhills, Weetwood, Leeds.
Tetley, C. F., M.A., Spring Road, Headingley, Leeds.
*Tew Thomas W., J.P., Carleton Villa, near Pontefract.
Travis, Rev. W. Travis, M.A., Ripley.
Thompson, J. C., Selby.
Thompson, R., Dringcote, The Mount, York.
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Utley, William, Halifax.

Vine, George R., 112, Hill Top, Attercliffe, Sheffield.

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Wharncliffe, Earl of, Wortley Hall, Sheffield.

WHEATLEY CHARLES, Sands House, Mirfield.
WHITE, J. FLETCHER, F.G.S., 24, St. John's, Wakefield.
*WHITELEY, FREDK., Clare Road, Halifax.
WILKINSON, J. J., Skipton.
WILSON, EDMUND, Red Hall, Leeds.
WILSON, E. J., M.A., 6, Whitefriars' Gate, Hull.
WOODALL, J. W., J.P., F.G.S., Old Bank, Scarborough.
WOODHEAD JOSEPH, M.P., J.P., Longdenholme, Huddersfield.

*** It is requested that Members changing their residence will communicate with the Secretary.

METEOROLOGY OF BRADFORD FOR 1892.

Computed from daily observations made at the Exchange, Bradford, by John McLandsborough, M. Inst. C.E. retired., F.R.A.S., F.R.Met.Soc., F.G.S., and Alfred Eley Preston, M. Inst. C.E., F.R.Met.Soc., F.G.S.
Latitude, 53deg. 47min. 38sec. N.; longitude, 1deg. 45min. 4sec. W. Height above mean sea level, 366ft.

PRESSURE OF ATMOSPHERE IN MONTH.

Months.	Highest Reading of Barometer.	Date	Highest during 24 Years.	Mean of Highest of 24 Years.	Lowest Reading of Barometer.	Date	Lowest during 24 Years.	Mean of Lowest of 24 Years.	Range.	Corrected for Capillarity and Temperature: Mean	Mean of 24 Years.
	Ins.	On	Ins.	Ins.	Ins.	On	Ins.	Ins.	Ins.	Ins.	Ins.
January	30 080	25th	30 541	30 176	28 904	6th	28 070	28 702	1 176	29 39	29 5·0
February	30 220	13th	30 11[illegible]	30 108	28 659	2nd	28 4 2	28 827	1 582	29 342	29 532
March	30 256	30th	30 4[illegible]6	30 133	28 892	15th	28 175	28 788	1 364	29 [illegible]4[illegible]	29 4[illegible]5
April	30 126	1st	30 50[illegible]	30 062	29 178	27th	28 332	28 866	0 948	29 612	29 480
May	30 240	17th	30 [illegible]52	30 0[illegible]7	29 180	16th	[illegible]8 66[illegible]	29 036	1 060	29·571	29 539
June	30 102	8th	30 300	30 129	29 [illegible]60	2nd	28 840	29 174	0 862	29 565	29 5[illegible]4
July	30 096	24th	30 305	29 977	29 168	19th	28 690	29 148	0 9[illegible]8	29 608	29 513
August	29 938	10th	30 2[illegible]2	29 968	29 046	30th	28 670	29 057	0 892	29 469	29 495
September	29 966	6th	30 232	30 076	29 052	30th	28 452	29 008	0 914	29 499	29 520
October	29 970	18th	30 [illegible]34	30 125	28 784	29th	28 250	28·739	1 186	29 [illegible]05	29 445
November	30 678	22nd	30 376	30 059	29 214	3rd	28·080	28 676	0 864	29 608	29 450
December	29 902	16th	30 458	30 111	28 800	11th	27 [illegible]62	28 686	1 102	29 538	29 479
Means, or totals	30 080		0 376	30 073	29 017		28 354	28 892	1 063	29 612	29 503

TEMPERATURE OF AIR IN SHADE DURING MONTH.

Months.	In Each Month: Highest.	Date.	Highest during 24 Years.	Mean of Highest of 24 Years.	Lowest.	Date	Lowest during 24 Years.	Mean of Lowest of 24 Years.	Range.	Daily Mean, In Each Month: Of all Highest.	Mean of 24 Years.	Of all Lowest.	Mean of 24 Years.	Range: Mean	Mean of 24 Years.	Of Dry Bulb: Mean	Mean of 24 Years.
	Deg.	On	Deg.	Deg.	Deg.	On	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.
January	5[illegible] 0	30th	57 2	52 8	21 8	16th	6 7	23 1	29 2	40 2	42 9	32 3	34 3	7·9	8 6	36 8	39 1
February	50 4	8th	59 8	53 2	18 8	19th	[illegible]8 8	26 1	31 6	42 0	44 1	34·0	35 2	8 0	8·8	37 4	39 5
March	59 8	19th	66 0	56 9	21 2	12th	17 4	25 6	33 8	42 8	46 2	3[illegible] 8	35 2	11 0	11·0	37 2	40 3
April	64 5	3rd	74 0	63 5	25 0	19th	25·0	31 1	39 5	52 6	52 3	37 0	39 2	16 6	13 0	42 7	44 5
May	68 8	31st	83 9	70 4	34 7	1st	28 6	34 9	34 1	58 3	58 3	43 4	43 9	12 9	14 4	51 8	49 7
June	76 6	1st	87 8	76 9	39 4	18th	38·0	41 8	37 2	6[illegible] 3	65 0	49 0	50 1	13 3	14 9	54 6	55 8
July	76 0	6th	89 0	79 3	4[illegible] 1	18th	42·0	46 5	30 6	63 3	67 8	51 7	53 7	11 6	14 1	56 6	59 8
August	77 0	24th	85 2	77 9	44 2	10th	38 6	45 2	32 8	65 6	66 8	51·5	53 0	12 0	13 7	58 4	58 7
September	65 4	11th	[illegible] 3	70 9	42 9	29th	33 5	40 2	22 5	60 0	62 0	48 7	49 7	11 3	12 3	53 7	54 7
October	58·2	29th	69 9	63 0	28 6	28th	26 7	32 4	29 6	50 3	53 7	39 9	43 2	10 4	10 5	44 6	48 1
November	56 5	15th	61 6	56 4	30 0	2nd	23·0	26 6	26 5	48 1	47 4	40 1	38 4	8 0	8 9	44 1	42 8
December	52 6	19th	57 8	63 1	19 0	26th	15 2	22 9	33 6	40 3	42 6	3[illegible] 8	34 0	8 5	8 5	36 4	38 9
Means, or totals	63 1		72 8	64 5	30 9		26 0	33 2	32 2	52 2	54 1	4[illegible] 3	42 5	10 9	11 6	46 2	47 7

Adopted Mean Temperature. — VAPOUR.

Months.	Of Air: Mean	Mean of 24 Years.	Of Evaporation: Mean.	Mean of 24 Years.	Dew Point: Mean	Mean of 24 Years.	Elastic Force: Mean	Mean of 24 Years.	In a Cubic Foot of Air: Mean	Mean of 24 Years.	Short of Saturation.	Mean of 24 Years.	Mean Weight of a Cubic Foot of Air.	Mean of 24 Years.	Degree of Humidity (Complete Saturation = 100): Highest	Date	Highest during 24 Years.	Mean of Highest of 24 Years.	Lowest	Date	Lowest during 24 Years.	Mean of Lowest of 24 Years.	Mean	Mean of 24 Years.
	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Ins.	Ins.	Grs.	Grs.	Grs.	Grs.	Grs.	Grs.	0–100	On	0 100	0 100	0 100	On	0 100	0 100	0 100	0 100
January	36 5	38 7	34 8	37 0	32 3	34 7	184	203	2 1	2 3	0 4	0 4	649	549	94	12th	100	97	60	7th	34	65	86	88
February	37 5	39 4	36 0	37 7	34 0	35 4	195	208	2 3	2 4	0 4	0 4	547	548	98	24th	100	97	57	18th	42	65	87	88
March	36 8	39 9	34 0	37 6	30 0	34 5	167	201	1 9	2 3	0 7	0 5	654	547	96	28th	99	96	35	31st	28	66	78	82
April	43 0	44 4	39 7	41 1	35 7	37 2	2[illegible]0	224	2 4	2 6	0 8	0 8	546	542	97	18th	100	95	32	3rd	30	51	78	77
May	51 0	49 5	47 4	45 3	43 6	41 1	285	260	3 2	3 0	1 0	1 1	536	537	96	16th	99	92	44	31st	30	44	76	73
June	54 2	55 7	50 0	51 3	45 9	46 9	308	322	3 5	3 6	1 3	1 4	534	531	97	16th	100	93	42	8th	32	48	73	72
July	56 1	59 6	51 9	54 0	47 9	49 8	336	3[illegible]9	3 8	4 0	1 3	1 7	5[illegible]1	526	96	5th	99	91	49	8th	36	48	74	70
August	58 1	58 5	54 1	53 9	50 5	50 0	368	362	4 1	4 1	1 3	1 4	526	527	94	18th	99	92	4[illegible]	4th	41	51	78	74
September	53 4	54 8	50 1	51 4	46 8	48 0	320	336	3 8	3 8	1 0	1 0	532	531	94	19th	99	95	56	17th	48	54	78	78
October	44 4	47 7	41 8	45 3	38 7	42 5	·236	274	2 7	3 1	0 6	0 6	534	537	98	9th	99	97	64	13th	49	61	80	83
November	43·0	42 5	41 9	40 3	39 6	37 6	·244	226	2 8	2 6	0 6	0 5	545	543	98	21st	100	97	65	29th	44	61	85	83
December	36 2	38 6	34 4	36 0	31 7	34 1	180	·198	2 1	2 3	0 5	0 5	5[illegible]2	548	97	22nd	100	97	52	28th	44	63	84	84
Means, or totals	45 9	47 4	43 0	44 3	39 7	41·0	253	264	2 9	3 0	0 8	0 9	541	539	97		100	95	50		37	58	79	79

BRIGHT SUNSHINE. — TEMP. OF AIR IN SUN'S RAYS. — WIND: Direction: Relative Proportion of at 9 a.m.

Months.	Bright Sunshine: Greatest Daily Duration	Date	Total of Month	Per cent of Possible Duration	Temp. of Air in Sun's Rays: Highest	Date.	Mean	N.	NE.	E.	SE.	S.	SW.	W.	NW.
	hr. min.	On	hr. min.		Deg.	On	Deg.	No.	No.	No.	No.	No.	No.	No.	No.
January	4 50	4th	24 10	10	74 5	25th	55·2	5	1	4	3	1	4	11	2
February	5 15	4th	37 50	14	84 0	12th	64 1	6	4	3	1	1	4	7	3
March	6 30	20th	48 0	13	95 2	19th	73 2	12	4	4	1	3	0	4	[illegible]
April	9 45	11th	111 25	27	104 2	24th	88 3	11	6	1	0	1	3	4	4
May	12 30	12th	109 55	22	105 0	13th	96 0	3	4	1	1	3	5	10	4
June	12 0	7th	141 15	28	10[illegible] 6	8th	101·2	6	4	3	2	5	4	0	6
July	1[illegible] 30	8th	99 50	20	1[illegible]7 5	23rd	94·4	2	10	6	2	1	4	5	1
August	10 30	4th	110 30	24	107 5	21st	97 5	3	0	1	1	4	12	7	3
September	9 45	25th	94 3	25	107 0	4th	9[illegible] 6	5	1	0	0	4	8	10	2
October	6 30	24th	66 30	20	91 0	13th	77·3	5	4	0	1	2	4	10	5
November	3 20	1st	12 0	5	81·0	6th	63·5	0	1	1	5	6	15	2	0
December	4 35	5th	13 26	6	63·0	1st	54·0	4	5	1	5	2	6	5	3
Means, or totals.	8 12		866 53	19	93 8		79 8	62	44	25	22	33	69	76	36

WIND: Velocity. — Pressure.

Months.	At 9 a.m.: Mean	Highest	Date	During 24 hours: Mean	Mean of 6 years.	Highest	Date	Highest of 6 years.	Total Registered in Month	Mean of Monthly T't'l of 6yrs	Highest Monthly T't'l of 6yrs	Pressure: Mean of all Daily Highest	Mean of all Daily Highest in 9 Years	Highest	Direction	Date	Mean of Highest of Month of 9 Years
	Miles p'r hr	Miles p'r hr	On	Miles per d	Miles per d	Miles per d	On	Miles per d.	Miles	Miles	Miles	lb. per sq. ft	lb. per sq. ft	lb. per sq. ft		On	lb. per sq. ft
January	7 0	21 4	30th	156	158	439	30th	439	4837	4915	6724	2 77	2 88	9 00	W	30th	11 75
February	7 2	17 4	1st	163	159	519	2nd	462	4717	4522	5488	2 30	2 51	8 00	W	2nd	9 44
March	5 9	13 3	17th	143	162	523	18th	559	4435	5029	5803	1 41	2 23	5 00	S S W	18th	9 22
April	5 6	12 [illegible]	28th	116	151	247	28th	359	3486	4528	556[illegible]	1·91	2 19	10 00	N	28th	7 97
May	6 9	18 0	20th	168	151	287	4th	37[illegible]	5218	4679	5349	3 31	2 25	8 00	W	17th	7 47
June	5 9	12 0	3rd	127	137	262	27th	262	3800	4086	4764	2 36	1 65	4 00	W	27th	6 03
July	6 6	24 0	8th	147	139	359	8th	359	4543	4305	4771	2 55	1 78	10 00	N W	9th	6 22
August	7 1	12 2	30th	136	131	291	31st	493	4222	4050	4603	2 70	1·79	7 65	S W	31st	7 53
September	7 6	19 8	27th	162	138	279	2nd	309	4873	4135	4873	2 80	2 00	6 00	S W	2nd	6 17
October	5 7	12 8	28th	104	150	290	10th	390	3223	4633	5 27		—	—	—		
November	3 9	13 0	26th	91	147	262	30th	490	2719	4402	7853	—	—	—	—	—	—
December	4 0	14 8	18th	99	133	231	19th	354	3066	4122	5116	—	—	—	—	—	—
Means, or totals.	6 1	15 9		134	146	[illegible]91		404	49139	53406	5503	—	—	-			

RAIN.

Months.	Mean Amount of Cloud	Number of Days it fell	Greatest Daily Fall	Date.	Amount Collected	Mean of 23 Years	Mean of Seven Years ending with 1892, 65½ft. above surface of ground	Mean of 7 Yrs. ending with 1892 at T'n Hall and Mid Rd. Station on surface ground	Gr'ter fall on surface at Town Hall & Mid Stn. than at 65½ft. above surface at Exch.: Depth in Inches	Percentage of fall at Exch'ge
	0 10	No.	Ins.	On	Ins.	Ins.	Ins.	Ins.	Ins.	Per cent
January	7 7	19	0 39	11th	1 95	2 59	2 209	2 474	0 265	11 2
February	7 5	19	0 83	15th	2 82	1 7[illegible]	2 109	2 972	0 363	11 4
March	7 2	13	0 31	16th	0 [illegible]7	2 11	2 776	3 260	0 484	11 7
April	6 8	14	0 31	28th	1 11	2 01	2 516	2 835	0 319	11 2
May	6 5	18	1 17	28th	3 [illegible]1	1·92	2 103	2 277	0 174	10 8
June	6 7	20	1 08	2[illegible]th	3 50	2 2[illegible]	2 817	3 011	0 174	10 6
July	7 5	10	0 40	16th	1 56	2 83	3 401	3 041	0 240	10 7
August	7 1	16	0 80	30th	2 57	2 68	3 664	3 892	0 238	10 7
September	7 3	18	0 35	30th	1 87	2 58	2 894	3 229	0 335	11 2
October	6 4	21	2 72	15th	6·92	3 59	3 640	4 012	0 372	11 0
November	7·8	14	0 54	5th	1·76	2 86	3 421	3 828	0 407	11 2
December	7·6	11	0·17	9th	0 74	2 58	3 681	4 170	0 489	11·3
Means, or totals.	7 2	193	0 76		28 88	29 80	35 741	39 601	3 860	11 08

METEOROLOGY OF BRADFORD FOR 1892

Yearly Maximum and Minimum Atmospheric Pressure, Temperature, Humidity, Bright Sunshine, Wind Pressure, and Rainfall.

Year.	Pressure. Highest: Reading of Barom during Year	Pressure. Highest: Date	Pressure. Lowest: Reading of Barom during Year.	Pressure. Lowest: Date	Temperature. In Shade. Highest: R'ding of Maximum Thermom during Yr.	Date	Temperature. In Shade. Lowest: R'ding of Minimum Thermom during Yr	Date	Last and First Frost of Seasons: Date of Last Frost	Date of First Frost	In Sun's Rays Highest: Reading of Solar Thermom. during Yr.	Date
	Ins		Ins		Deg		Deg				Deg	
1869	30 290	Dec. 6	28 500	Feb. 1	85·2	Aug. 30	19 8	Dec. 28	Mar. 27	Oct. 20	127 7	Aug. 30
1870	30 284	Jan. 19	28 308	Jan. 8	85·0	July 25	16 6	Dec. 23	Mar. 30	Nov. 9	127 5	July 25
1871	30 152	Mar 28	28 308	Jan. 16	84·0	Aug. 12	6 7	Jan. 1	April 11	Nov. 13	128 7	July 17
1872	30 156	April 6	28 070	Jan. 24	86·4	July 23	24 8	Mar. 27	Mar. 27	Nov. 19	124 8	Aug. 19
1873	30 338	Feb. 18	28 022	Jan. 20	88·8	July 23	19 2	Feb. 24	Mar. 14	Nov. 5	124 5	July 23
1874	30 476	Mar 6	28 276	Dec. 11	80·9	July 20	15 0	Dec. 31	Mar. 12	Nov. 11	125 8	July 20
1875	30 305	July 7	28 484	Nov. 10	80·0	Aug. 17	13 0	Jan. 1	Mar 22	Nov. 26	122 0	July 5
1876	30 300	Jan. 15	28 070	Dec. 4	87 6	July 17	23·0	Jan. 9	April 15	Nov. 9	126 6	July 16
1877	30 358	Oct. 6	28 300	Nov. 29	80 0	June 19	20·0	Mar. 1	May 4	Oct. 18	116·4	June 19
1878	30·320	Mar 16	28 630	April 1	89·6	July 19	13 9	Dec. 26	April 6	Nov. 9	118 2	July 22
1879	30 362	Dec 13	28 500	Feb. 10	74·4	July 30	13 2	Dec. 7	May 10	Nov. 14	101 2	Aug. 13
1880	30 332	Jan. 7	28 154	Nov. 16	81 3	Sep. 5	20 8	Jan. 20	Feb 23	Oct. 20	112 0	Aug. 13
1881	30 382	May 10	28 250	Oct. 14	63 3	July 6	12·0	Jan. 26	April 21	Oct 17	116·5	June 1
1882	30 544	Jan. 18	28 452	Mar. 1	77·4	Aug. 12	18 6	Dec. 11	April 16	Nov. 12	108·0	Aug. 9
1883	30 500	April 9	28 452	Sep. 2	76·2	July 3	19 8	Mar. 10	Mar 29	Nov. 12	107 6	May 17
1884	30 354	Oct. 5	28 376	Jan. 27	84·4	Aug. 12	26 5	Nov. 30	April 24	Nov. 24	107 8	Aug. 9
1885	30 273	Mar 14	28 400	Jan 11	82 2	July 27	22 1	Dec. 11	April 5	Nov. 16	113·6	July 27
1886	30 355	Nov. 24	27 652	Dec. 8	79·5	July 3	17 4	Mar. 7	April 30	Dec. 2	108 8	July 5
1887	30 412	Feb. 8	28 328	Nov. 3	82·8	July 9	21·1	Jan. 17	April 17	Oct 12	107 6	July 9
1888	30 333	Jan. 10	28 410	Mar. 28	80 4	June 27	19 2	Feb. 14	April 8	Oct. 2	110 0	Sep. 15
1889	30 368	Dec. 5	28·460	Mar. 20	77·5	Aug. 1	21·3	Mar. 4	Mar. 22	Nov. 27	115·2	June 23
1890	30 376	Feb. 23	28 315	Jan. 23	76·4	Sept. 10	16·4	Dec. 22	Mar. 10	Oct 28	111·0	June 16
1891	30 394	Oct. 31	28 060	Nov. 11	79 9	Sept 12	12 0	Jan. 19	May 18	Nov. 25	107 0	July 27
1892	30 156	Mar 30	28 638	Feb 2	77 0	Aug 24	18 8	Feb 19	April 19	Oct. 25	107 5	July 23
Means	30·342		28·309		81·7		18·0				115 6	

Year.	Humidity (Complete Saturation = 100). Highest: Degree of Humidity during Yr	Date	Humidity. Lowest: Degree of Humidity during Yr.	Date	Bright Sunshine: Greatest Daily Duration.	Date.	Total of Year	Per cent. of Possible Duration	Wind Pressure: Highest.	Date
	0 100		0—100		hr. min.		hr. min.		lb. per sq. ft.	
1869	99	Feb. 8	42	Sep. 24	......	.....	.....	......		......
1870	98	Jan. 29	28	Mar. 8						
1871	98	July 7	43	Nov 2						
1872	100	Mar. 22	45	Sep 23						
1873	100	Dec. 11	41	Mar 26						
1874	100	Feb. 6	42	May 18						
1875	100	Jan. 23	43	July 6						
1876	99	Oct. 4	46	May 5						
1877	100	Oct. 29	35	May 23						
1878	99	Jan. 13	53	Aug 9						
1879	100	Oct 7	51	Dec. 12						
1880	99	Dec. 15	50	May 30						
1881	98	Oct. 14	38	May 31						
1882	99	Nov. 5	36	May 18						
1883	99	Dec. 26	30	April 9						
1884	98	Jan. 23	30	May 22					24 00	Jan 24
1885	100	Jan. 23	32	June 4					15 25	Dec 4
1886	99	Jan 12	32	May 4	11 45	July 6	851 48	19	18 00	Dec. 9
1887	100	April 21	35	July 9	12 40	July 3	1120 58	25	15 00	Feb 4
1888	99	Mar 15	39	June 11	13 40	May 24	584 20	20	13 00	May 4
1889	99	April 22	39	June 26	12 15	July 8	827 46	18	12·00	Feb 9
1890	99	May 11	31	May 29	14 25	May 25	824 5	18½	14 0	Jan 19
1891	100	Feb. 20	37	July 17	11 45	May 12	806 35	18	13 50	Aug. 26
1892	99	Jan 12	32	April 3	12 30	June 7	866 53	19	10·00	April 28
Means	99		39		12 43		883 3	20	14·97	

Year.	Rain: Total for Year	Mean Y'rly Rainfall at Town Hall and Mid Rly Stn on surface of g'nd	Gtr fall on srfce at Tn H'll & Mid Stn than at 65½ ft ab've surf at Exc: Depth in Inches	Percentage of fall at Exch'ge	Greatest Daily Fall during Yr	Date	Snow. Last and First Snow of Seasons: Date of Last Snow	Date of First Snow
	Ins.	Ins.	Ins	Per cent	Ins			
1869	....	....				....	April 3	Oct 19
1870	24 120				0 820	June 18	Mar 24	Nov 15
1871	21 640				0 985	June 16	Mar 15	Nov 16
1872	42 060				2 490	June 13	May 11	Nov 13
1873	21 440				1 200	Aug 4	April 25	Jan 3, '74
1874	23 560				0 740	Dec 7	May 9	Nov 26
1875	30 280				1 700	Nov 15	Mar 12	Nov 9
1876	35 270	39 788	4 518	11 28	1 810	Oct 9	April 12	Nov. 8
1877	40 650	45 499	4 849	11 19	1 420	July 16	May 19	Oct 15
1878	35 434	39 010	3 576	11 01	220	Aug 14	April 1	Nov 8
1879	26 017	30 298	2 281	10 82	1 020	June 8	May 7	Nov 20
1880	35 690	39 616	3 926	11 10	1 710	Oct 27	Mar 2	Oct 27
1881	35 434	39 892	4 458	11 26	1 435	Oct 13	April 20	Oct 29
1882	39 683	43 103	3 420	10 86	1 608	Dec. 6	Mar 21	Nov. 19
1883	34 396				1 338	Sep 26	Mar 24	Nov 10
1884	27 657				1 170	Jan 23	Feb 28	Nov 23
1885	25 699				1 208	Sep 3	May 7	Dec 9
1886	35 993				2·130	July 26	May 12	Nov. 6
1887	18 665				0 810	Oct 9	May 21	Oct 14
1888	25 646				1 050	Nov. 3	April 8	Oct 1
1889	22 141				0 590	Mar [illegible]	Mar. 21	Nov. 25
1890	25 730				1 485	Jan 22	April 14	Oct 21
1891	27 303				1 020	Dec. 1[illegible]	May 17	Nov 26
1892	28 681				2 720	Oct 15	April 28	Oct 24
Means	29 799	39·601	3 860	11·08	1·377			

EXPLANATION.

The observations are made at nine a.m., and, with the exception of maximum and minimum thermometer readings, again at three p.m.

The highest and lowest barometric readings for each month, also the monthly range, are given as recorded; while the mean pressure is deduced from bi-daily observations corrected for index error, capillarity, temperature, and diurnal range. To correct for altitude or reduce to sea level the air temperature being 48 degrees and barometer 30 inches at sea level), add 401 inch to the heights given

A remarkable instance of barometric depression occurred on the 8th December, 1886, when at 8 40 p m the mercury of the Exchange barometer had fallen to 27 466 inches only the lowest reading on record here. The cyclone indicated by this depression was the cause of great loss of life and property, extending over an unusually large district

All thermometric observations and deductions are given in degrees Fahrenheit.

The adopted mean temperature of air is deduced from the dry bulb and the maximum and minimum readings; the temperature of evaporation from the dry and wet bulb and the maximum and minimum readings. The dew point, elastic force of vapour, humidity, &c., are deduced from bi-daily readings of the dry and wet bulb hygrometer, by Glaisher's Hygrometrical Tables, sixth edition.

Bright sunshine is recorded in hours and minutes by glass sphere on cards, known as Campbell's recorder, fixed on Professor Stokes' zodiacal frame.

The solar thermometer has a black bulb enclosed in a vacuum.

The direction, velocity, and pressure of wind are recorded as indicated by anemometers fixed 10½ feet above the ridge of roof of Exchange. The velocity per hour at 9 a m is determined from anemometer readings made one minute and a half before and a like period after that hour, by multiplying the difference thereof by 20. The pressure is given in pounds avoirdupois per square foot.

The amount of cloud is estimated by a scale ranging from 0 to 10.

Rainfall includes melted snow and hail.

The rain gauge is fixed upon the top of central roof of the Exchange, at an elevation of 65½ feet above the surface of the ground and 395 feet above mean sea level. As rain gauges on the summit of buildings are generally found to collect less rain than when placed upon the surface of open ground adjacent thereto, steps were taken in 1875 to determine to what extent this was the case with the Exchange rain gauge, when two additional gauges were provided and fixed upon the surface of adjacent open spaces, one near to the Town Hall, the other near to the Midland Railway Station, between which the Exchange gauge is situate about midway, and the surface of ground about the same height. At both of these gauges, as well as at the Exchange gauge, daily observations were made from the commencement of 1876 to the end of 1882, a period of seven years, when the surface gauges were removed in consequence of the ground they occupied being no longer available for the purpose. The particulars of these gaugings are set forth in tables. The results show that the mean yearly rainfall on the surface of ground for the seven years ending with 1882 is 3 86 inches, or 11 08 per cent., greater than at the summit of the Exchange The mean yearly rainfall recorded at the Exchange for the twenty-three years ending with 1892 is 29·799 inches By adding 11·08 per cent. thereto the mean normal rainfall of central Bradford for such period is found to be 33 101 inches per annum There are good grounds for concluding that the smaller amount of rainfall collected on the Exchange and on buildings generally than on the surface of ground is due to the varying direction and force of wind there producing different currents and eddies, which prevent due precipitation on the top or ridge of roof where the gauge is fixed The rainfall of 1869 was collected by a gauge placed on the ridge of outer roof of Exchange, near to the north-west corner thereof. This position not being deemed quite satisfactory, the gauge was removed at the end of that year to the ridge of central roof the place it has since occupied To avoid risk of inaccurate results, the rainfall of 1869 is omitted from these returns.

The instruments with which the observations are made have been verified by comparison with the standards at Kew Observatory.

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WITH THREE PLATES AND A MAP.

EDITED BY

W. LOWER CARTER, M.A., F.G.S., AND WILLIAM CASH, F.G.S.

1894.

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EDITED BY JAMES W. DAVIS, F.S.A., F.G.S., &c.

1893.

CALAMOSTACHYS BINNEYANA, SCHIMP.

BY THOMAS HICK, B.A., B.SC., ASSISTANT LECTURER IN BOTANY, OWENS COLLEGE, MANCHESTER.

Our knowledge of the structure and characteristics of the sporiferous spike or strobilus now known as *Calamostachys Binneyana* is almost entirely based upon the descriptions and figures published by Carruthers,* Binney,† and Williamson.‡ By Carruthers it was named *Volkmannia Binneyi*, by Binney *Calamodendron commune*, and by Schimper *Calamostachys Binneyana*, a name which has been generally adopted by later writers.

The specimens described by these authors being in no case perfect, it is not surprising that on some important points our knowledge of the fossil is anything but complete, while it is well-known that as regards its affinities Carruthers and Williamson came to widely different conclusions.

Under these circumstances I propose to review its structure and affinities in the light of a series of preparations lately placed in my hands by W. Cash, Esq., of Halifax. They consist of a number

* Journal of Botany. December, 1867.

† Observations on the Structure of Fossil Plants found in Carboniferous Strata, Part I., Calamites and Calamodendron. Palæontographical Society, 1868.

‡ On the Organisation of the Fossil Plants of the Coal Measures. Philosophical Transactions, 1871-1891.

of sections cut by Mr. James Binns, of the same town, in which the structure of the spike is so well preserved as to give much additional information on important points of detail, clear up others that have hitherto been doubtful, and at the same time throw considerable light on the question of affinities.

The general structure of *Calamostachys Binneyana*, as hitherto described, may be summarised as follows :—

The axis of the spike consists of a series of nodes and internodes, the former of which bear alternately whorls of sterile bracts and sporangiophores. The nodes bearing bracts are extended outwards to form what Williamson has termed the "nodal disks." From the margin of each disk, the bracts, usually twelve in number, are given off, and these turning upwards ascend beyond the bases of the members of the next higher whorl, with which they alternate. The sporangiophores are placed about midway between the "nodal disks," and stand at right angles to the axis. Their distal ends are dilated into peltate heads to the inner surface of which the sporangia are attached, of which each carries four. Hence, as has often been pointed out, the spike bears a strong resemblance to that of *Equisetum*, the chief difference being the intercalation of a "nodal disk" with its sterile bracts between the successive whorls of sporangiophores.

As regards the histology of the strobilus the authorities referred to were not in a position to obtain final and decisive results, and hence perhaps their divergent views. In dealing with it, it will conduce to clearness if we first epitomise the statements already published, and then present the results obtained by a study of the fresh material.

The Axis of the Strobilus.

Carruthers in the paper already referred to writes of the axis as follows :—"The axis of the strobilus has a bundle of fine scalariform tissue in its center, forming about a third of its diameter, and generally appearing free from the surrounding cellular tissue which is composed of somewhat elongated cells."*

* Loc. cit., p. 350.

On the accompanying plate he gives a figure (fig. 3) which is referred to as illustrating this structure, but the section it represents is an oblique one, and the figure is not conclusive as to the central position of the vascular tissue.

Binney in his account of the axis is somewhat lacking in precision.* Without quoting his exact words it will suffice to say that from his description and figures there can be little doubt that he regarded the central part of the axis as being composed of vascular tissue of the scalariform type. His figures which were admirably drawn by Fitch, represent two transverse and four longitudinal sections. In the former, the elements in the center of the axis remind us much more of parenchyma than of vascular tissue, while the latter not being exactly radial, are certainly not decisive of the vascular nature of the central part of the axis.

Williamson has dealt with the minute structure of the axis in several of his memoirs on carboniferous plants. In Part I.,† without entering into details, he insists that the axis differs widely from the stem of *Calamites*, stating that "the vascular tissues are all found in the central part." In Part V.,‡ the strobilus is subjected to a detailed description, as a result of which the center of the axis is said to be "composed of a cluster of barred vessels," and an enlarged figure of part of a transverse section of the axis is given to illustrate this feature. In Parts IX.‖ and X.§ the same view is maintained, and in the latter we have additional figures, both longitudinal and transverse, in the former of which the central tissue is drawn as consisting of elongated vascular elements with scalariform markings. In Part XV.¶ however a change is made in the mode of description, and the central part of the axis is spoken of as containing a "quasi-medullary cellular parenchyma." Finally, in the first part of an index to the Memoirs,** a foot-note is inserted stating that "there has been much difficulty in defining the structure of this axis which varies much in different specimens." At the same time it is added that the center

* Loc. cit., pp. 23-27. † Op. cit., Part I., 1871, p 501.
‡ Op. cit., Pt. v., 1874, p. 61. ‖ Ibid., Pt. ix., 1878, p. 334.
§ Ibid., Pt. x., 1880, p. 503. ¶ Ibid., Pt. xv., 1889, p. 160.
** Proceedings of the Manchester Literary and Philosophical Society, 1890-91. Reprint, p. 14.

of the specimen described in Part V. is "probably cellular, not vascular, as described in the Memoir." Other undescribed specimens are also referred to as showing a "central medulla" which is "distinctly cellular."

As regards the vascular bundles which in some cases surround the center of the axis, nothing is said by Carruthers and Binney, and our present knowledge of them is entirely due to Williamson. Unfortunately, however, Williamson's description of them was dominated by the idea that they enclosed a strand of vascular tissue, and this led him to compare them with the *secondary* vascular bundles of the plant he then termed *Asterophyllites*.*

From all this it is clear that much confusion exists respecting the histological composition of the axis of *Calamostachys Binneyana*, and until it is cleared up no serious attempt can be made to remove the equally prevailing confusion which obscures its affinities and systematic position.

Turning now to the new material, it may be well to state at the outset that after a careful and prolonged study of it, I have come to the conclusion that *Calamostachys Binneyana* is not only characterised by a parenchymatous pith in the center of the axis, but also by a ring of *primary* vascular bundles round that pith, which have the characteristics of those of *Calamites*.

Among the transverse sections are several which have been well preserved, and are more than usually perfect so far as concerns the axis at least. In these the parenchymatous character of the central tissue is indicated not only by the appearance and arrangement of the elements, their irregularities of size and shape, and the presence of intercellular spaces, but also by the fact that neither the side walls where inclined to the vertical, nor the transverse walls where visible, show any traces of scalariform or other vascular markings. For demonstrative evidence, however, we must go to the longitudinal sections, one of which is represented in figs. 2, Pl. I., and 3, Pl. II. This is a magnificent specimen whose axis is practically perfect, and both in this and other respects seems much superior to those previously published. Both extremities appear to be wanting, but the part pre-

* Now known to be *Sphenophyllum*.

served measures 13 cm. in length, carries 11 "nodal disks," and has its axis cut nearly radially throughout its entire length. As here displayed the central tissue is found to be made up of cells which are longitudinally elongated, with end walls often but not universally rectangular, figs. 2, Pl. I., and 3, Pl. II. The cell-walls are for the most part thin except at and in the neighbourhood of the "nodal disks" where they are thicker, and the cells themselves somewhat shorter.

In the last quotation from Williamson* it will be noted that the central tissue is said to vary very much in different specimens. Some variation is shown by the preparations under consideration, but it only affects the wall thickenings, the size of the elements, the completeness of the tissue, and other minor matters. In no case is the center found to be occupied by vascular tissue when cut exactly in the radial and longitudinal direction.

Primary Vascular Bundles.

Returning to the transverse sections, there is another feature to be noticed which is a still more significant one. This consists of (usually) three empty spaces in the tissue which abuts on the periphery of the pith. They vary in size in different specimens, and are sometimes irregular at the margin as if the tissue round them had been torn. These cavities when well preserved at once recal the intercellular passages met with in the primary vascular bundles of *Equisetum* and *Arthropitys*, and there can be no doubt that they are strictly homologous with them. In other words, they are the carinal canals of the primary vascular bundles of the axis, and their presence affords positive proof that the bundles are of the Calamitean type. Singularly enough, one or more of these canals are vaguely indicated in some of the figures of transverse sections previously published, but no one has recognised them as characteristic structures. Williamson certainly mentions them in his tenth Memoir,† where he describes them as "small vacant spaces which . . . . . doubtless transmitted vascular bundles to the sporangiophores," but he failed to identify them as the intercellular canals of imperfect bundles, and so missed their significance and homologies.

* Ante, p. † Op. cit., Pt. x., 1880, p. 503.

In fig. 1, Pl. I., these canals are well and distinctly shown at *a*, but they appear to have been enlarged by the tearing of the peripheral tissue, as they are smaller in all the other sections. At the margin we observe small elements, *v*, somewhat different from the rest, projecting into the open space, which forcibly remind us of what is found in the carinal canals of *Equisetum*. This and other similar sections are of themselves almost conclusive of the nature of these open spaces, but the longitudinal one shown in figs. 2, Pl. I., and 3, Pl. II., is absolutely demonstrative. Here we have one of the canals cut longitudinally, *c*, and at various points along its course we find, adhering to its sides, fragments of annular, and spiral vessels almost exactly as they are seen in longitudinal sections of the stems of living *Equiseta*, fig. 3, *v*. Pl. II. There are remnants too of the tissue which originally interrupted the continuity of the canals at the "nodal disks," one of which is shown at *d*.

I am convinced then that we have here structures which are strictly homologous with the carinal canals of *Equisetum* and the extinct *Arthropitys*. Taking the view of Count Solms, that in these two genera the canals represent the initial tracheal strands of vascular bundles, we reach the conclusion already stated, that in these specimens of *Calamostachys Binneyana* the axis not only had a parenchymatous pith, but that the primary vascular bundles were of the Calamitean type.

An examination of numerous other sections, while confirming these conclusions, reveals one or two points of difference which it may be well to mention. In some the pith has a triangular rather than a circular section, and in these cases the carinal canals are situated at the angles. The angles however are usually truncated, and are not always of the same breadth tangentially. Sometimes indeed they give the impression that they are about to bifurcate, the carinal canals dividing, so to speak, at the same time. Obviously we have here an increase in the number of the primary bundles, and in this way the number of canals may be increased to six, a number actually found in two sections belonging to Mr. Lomax, of Radcliffe, which he permitted me to examine. In another case, five transverse sections have been cut from the same strobilus, four of which have three carinal canals, while the fifth has four. As the sections cannot have been far apart in the uncut strobilus, this would seem to show that the number of carinal canals, *i.e.*, of primary vascular bundles, may vary in different parts of the axis.

SECONDARY XYLEM.

Taking the carinal canals to be the representatives of the primary vascular bundles, fig. 1 shows that in some examples of *Calamostachys Binneyana* no secondary thickening is met with, though its subsequent appearance is not precluded. In others, however, secondary xylem, composed of scalariform tracheids is met with, and there as in the stem of *Arthropitys*, the development begins at the carinal canals. Thus three wedge-shaped masses are usually produced, whose elements spread out in radiating rows and in a fan-like manner from the carinal canals, while a little later intermediate xylem is developed in the intervening areas. In this way a narrow but complete zone of secondary xylem is formed. The three bands of intermediate xylem are usually convex towards the pith, which thus takes the triangular shape with concave sides so often noticed by previous writers. All this however has been so well described and illustrated by Williamson in his fifth* and tenth† Memoirs that it need not further detain us.

THE CORTICAL TISSUES.

The tissue which immediately surrounds the primary vascular bundles or the secondary xylem when such is present, is usually absent from the petrified strobili, and only one section has been published in which it is preserved. This we owe to Williamson, who in his account of it tells us‡ that "the vascular axis is closely surrounded by a dense cellular layer," which "passes into a more open and delicate cellular tissue in which there are large lacunæ . . . . probably due to partial desiccation." Fig. 1, Pl. I., represents a section in which the cortical tissues apparently still retain their original form unchanged, In it the inner parenchyma (i.p.) is seen to be composed of cells of relatively large size, with delicate

* Op. cit., Pt. v., 1871, p. 72, fig. 38. † Op. cit., Pt. x., 1880, p. 504, fig. 16.
‡ Op. cit., Pt. x., 1880, p. 503.

thin walls, a circumstance which readily accounts for the frequency with which it disappears in the process of fossilisation. On the outside of the inner parenchyma we have the hypoderma, *h*, which is thickwalled, and whose elements are somewhat uniform in size, and in some cases have apparently possessed copious contents. In different specimens and probably in different parts of the same specimen the character of the hypoderma varies a little, especially in the wall thickening and the density of the cell contents. As has been shown by previous authors, the hypodermal elements are elongated longitudinally and are prosenchymatous.

In none of the sections is there shown a distinct epidermis, but in one or two instances hairs are met with between the sporangia which seem to have been connected with an epidermal layer.

The Nodal Disks and Bracts.

According to Carruthers* the disks are composed of large roundish cells and the bracts of smaller and more elongated elements, while a slender vascular bundle enters each bract from the axis. Williamson† describes the disk as consisting of "two kinds of coarse thick-walled cellular tissue," broad lines of cells elongated in the plane of the disk leading from the axis to the base of each bract, while the intermediate triangular areas are occupied by a coarse parenchyma. In a later Memoir‡ he tells us that the prosenchymatous cells are found only on the upper surface of the disk, and that "the bundle of small spiral vessels" runs "along the center of the lines" they form. To these statements we are in a position to make one or two important additions. The disks of one of the best preserved specimens have a thickness of 0·559 mm., and the vascular strands run about midway between the upper and lower surfaces. But near the periphery a layer of cells is differentiated beneath the vascular strands which neither Carruthers, Williamson, nor any other writer appears to have noticed. It consists of large elements of variable size, whose walls are thin and whose lumina are occupied by dense masses of some black substance which is probably carbonaceous.

* Loc. cit., p. 350. † Op. cit., Pt. v., 1871, p. 60.

‡ Op. cit., Pt. x., 1810, p. 503.

The histology of the bracts has scarcely received the attention it seems to deserve, and is certainly more complex than has hitherto been made apparent. A reference to fig. 4, Pl. II., which represents a transverse section, will show that the tissues are well differentiated. At *e* we have the epidermis, which can often be followed round the whole section ; at *b* is seen the sclerenchyma or prosenchyma which is in continuity with that of the nodal disk ; and at *v* the delicate strand of vascular tissue. Attention should be specially directed however to a layer of much larger elements *g* which occupy the lower half of the bract, and form one of the most conspicuous of its features. Some of these elements are unusually large, while their walls are comparatively thin, and their contents dense and carbonaceous. They appear to be united without intercellular spaces, and at some distance from the wall a thin pellicle is usually present in each cell, which may represent the primordial utricle. The carbonaceous mass is within this pellicle, and in most cases there is an interval between them, while in others they are in contact with one another. Occasionally both are in contact with the cell wall.

This layer of tissue I have come to regard as an important one. It is a constant character of the bracts when perfect, and has been found of great practical value in the recognition of fragments of bracts when detached and in other ways. It appears, however, to have been easily destroyed, as many bracts are met with in which it is wholly or partially lost. It scarcely needs to be said that it is a continuation of the similar layer mentioned above as making its appearance at the periphery of the nodal disk.

Longitudinal actions of the bracts are hardly ever met with in a form suitable for illustration. Still by carefully studying the numerous fragments that occur in most preparations of the strobilus it is easy to make out that the elements beneath the upper epidermis are really sclerenchymatous, and that the layer with the black contents is made up of somewhat elongated cells with rectangular or oblique ends.

The Sporangiophores.

The sporangiophores consist of a pedicel and a peltate head or scutellum, and, as shown by Carruthers and Williamson, their histology is relatively simple. Cellular in the main, the peripheral tissue of the pedicel, is apparently sclerenchymatous, while a vascular strand runs up the center. The sclerenchyma is continued on the underside of the scutellum, while the vascular strand divides into four smaller strands, which diverge to the four sporangia. The conical mass of tissue which lies between these diverging strands and the external surface of the scutellum appears to have been of a delicate nature, as it is frequently wanting when the other tissues are well preserved. The superficial cells of the external surface constitute a well-developed epidermis whose elements are large and elongated vertically to the surface, but their walls are not thickened as in *Equisetum.* This last character is no doubt to be correlated with the fact that they are protected by the bracts from the nodal disk below.

It does not appear to have been previously made known that the annular or spiral tracheæ which form the vascular strands of the sporangiophores are accompanied by elongated, thin-walled, narrow cells, which have some of the appearances of a phloem tissue. This is especially evident where the vascular tissue approaches the point of attachment of the sporangia. So distinct and perfect are these cells at this point in one of the sections, that in some of them structures are seen that almost compel the belief that they are nuclei!

Professor Williamson has shown* that the sporangia are not connected with the scutellum by the entire base as in *Equisetum,* but by a narrow neck of cellular tissue attached a little within the overhanging margin. One of these peduncles is seen in fig. 5, Pl. II. This mode of attachment of the sporangia seems to be an important feature of this species of *Calamostachys,* as it appears to indicate that the archesporia were developed in special lobes of the scutellum.

The Sporangia.

The form and structure of the sporangia has been so well described already that they need not be dealt with here. One feature however may be mentioned as it does not seem to have been previously brought forward, or at all events sufficiently emphasised.

* Op. cit., Pt. xi., 1881, p. 298.

An examination of fig. 5, *a*, Pl. II., will show that the thin-walled tissue of the peduncle is continued into the sporangium where it forms a non-sporogenous tissue, filling up the somewhat conical base In other sections a thin layer of this tissue may be traced all round the interior of the sporangia, where it bears some resemblance to the compressed cells which, as a tapetum, surround the archesporium of some of the Vascular Cryptogams. Moreover this layer is often found separated from the outer wall of the sporangium, and then the spores seem to be contained in a delicate bag, quite distinct from the wall itself. That this condition is one which preceded the full maturation of the spores seems probable from the fact that in the specimens where it occurs the spores are still grouped more or less in tetrads, and enclosed in the mother cells, and I incline to the opinion that the separation was brought about during the process of fossilisation.

The Spores.

As in the case of the sporangia the spores have been carefully described by previous writers, and I have no additional details to bring forward. As to their character, it may be noted that in none of the sections studied has any indication been found that this species of spike was heterosporous. Slight differences of size and appearance are sometimes met with, even between spores in the same sporangium, but these are not greater than those that occasionally arise in the homosporous sporangia of recent plants. So far then as is known up to the present time this species of *Calamostachys* is homosporous.

Systematic Position.

If the preceding description has not failed in its object it will have convinced the reader that in *Calamostachys Binneyana* we have a sporiferous spike whose structure has many points of resemblance with that of *Equisetum*. The resemblance is so close and involves so many details that it is impossible to do otherwise than conclude that it is the strobilus of some carboniferous plant whose affinities are more or less close with the existing genus *Equisetum*. Such a plant we have in *Calamites*, and hence Carruthers* did not hesitate to

* Loc. cit.

describe *Calamostachys Binneyana* as the fruit of *Calamites* in 1867, although the structure of the axis was in some respects misinterpreted and in others but imperfectly known.

Binney* in making it the fruit of his *Calamodendron commune* was in practical agreement with Carruthers, since the plant so named by him is nothing else than a form of *Calamites*, and on the continent, with some exceptions, this view of its relations has generally prevailed. But this determination ignored the fact that, as then interpreted, the central part of the axis of the spike was vascular, and in that respect differed so much from the stem of *Calamites* that it was not easy to see how the one could be continued into the other.

Realising the importance of this difficulty, Williamson from an early period rejected the Calamitean view of the affinities of the spike, and in several of his memoirs has contended that they lie rather with the *Lycopodiaceæ*.† Not only so, but in 1869 he described a spike‡ which differs in important points from *Calamostachys*, as "the only British strobilus, of which the internal organisation has hitherto been described, that has any claims to be regarded as the fruit of *Calamites*," and in a re-description of it from fresh material in 1888,|| the same view is substantially maintained. Thus, both on positive and negative grounds, *Calamostachys Binneyana* was shut out from all relationship with *Calamites*. How persistently Williamson has maintained this position was shown by Mr. Cash in a paper contributed to the Proceedings of this Society in 1887,§ and there is no need to repeat the quotations from Williamson's memoirs there given.

Looking at the matter in the light of the new evidence brought forward in what has preceded, it will probably be conceded that the establishment of the existence of a parenchymatous pith in the axis of the spike removes the chief ground for Williamson's suggestion of

* Loc. cit.

† Op. cit., Pt. v., 1871, p. 65; Pt. x., 1880, p. 504; Pt. xi., 1881, p. 299.

‡ Proceedings of the Literary and Philosophical Society of Manchester. Series 3, vol. 4.

|| Williamson, Op. cit., Pt. xiv., pp. 47-48.

§ Proceedings of the Yorksh. Geol. and Polytechnic Soc., vol. ix., 1887.

affinities with the *Lycopodiaceæ*. On the other hand the demonstration of the existence of primary vascular bundles with *carinal canals*, affords positive proof of the closeness of its relationship with the *Calamitæ*. Hence taking the whole of the evidence as it stands, both old and new, it seems to me to fully establish the conclusion at which Carruthers arrived in 1867, viz., that *Calamostachys Binneyana* is the fruit of some form of *Calamites*.

Now the genus *Calamites* is not very well defined, and under it have been included several series of fossils which are distinguished by important differences. This is especially the case with those which are merely the casts of the pith cavity, and which Weiss has provisionally distributed into four groups. But there are differences also in the specimens that show structure, although a critical study of these differences can scarcely be said, as yet, to have been made. Hence the question naturally arises whether it is possible to bring *Calamostachys Binneyana* into relationship with any of the Calamitean stems whose structure is to some extent already known. In reply it may be admitted that this cannot be done with certainty at present, but that there is some probability that it is the spike of a *Calamites* of the type of *Arthropitys*. The evidence which points to this conclusions, if it does not actually prove it, is as follows. :—

Up to the present time only two types of *Calamites* with structure appear to be known, viz., those included in Göppert's genera *Arthropitys* and *Calamodendron*. The geological range of the two types is different,* the latter being found in the Upper Coal Measures and the Rothliegende, and the former in the Lower Coal Measures. Now all the *Calamites* with structure hitherto found in Yorkshire and Lancashire are from the Lower Coal Measures and are of the *Arthropitys* type. In the same beds with them, and often in the same nodules, we find *Calamostachys Binneyana*, so that the two fossils are intimately associated together. Of itself, this fact is not perhaps of great weight as an argument that both belong to the same plant, but on the other hand it can hardly be maintained that it is of no value at all.

In the next plaee there are certain anatomical structures met

* Solms-Laubach: Fossil Botany, p. 299.

with in the stems and leaves of *Arthropitys* as well as in the bracts of *Calamostachys Binneyana* which seem to me significant of their close relationship. In a paper published by Mr. W. Cash and myself in the Proceedings of the Yorkshire Geological and Polytechnic Society* in 1883, attention was called to a layer of tissue outside the zone of xylem in the stem of *Calamites* (*Arthropitys*), which presents several peculiarities. Two of these are the presence of a number of large elements among others of smaller size, and the presence within some of the former of black and apparently carbonaceous masses. Since that time a large number of young stems have come under observation, and they all exhibit this layer as a characteristic mark of their anatomy. It is practically continuous round the whole stem, and is sharply distinguished by its open texture, so to speak, and the black contents from the tissues on the inside and the outside. In its histological details it bears the closest possible resemblance to the layer of large elements described in this paper† as commencing at the periphery of the nodal disks of *Calamostachys Binneyana*, and as forming the lower half of the transverse sections of the bracts. In other words, while having the same general appearance, it presents the same variability in the size and shape of its elements, which are united without intercellular spaces, and in many cases have similar black contents.

But this is not all. In a large series of preparations of *Arthropitys* which Mr. W. Cash has placed in my hands, small stems are found associated with leaves in a manner which is demonstrative that they belong to the same foliage shoot. Mr. Lomax too has kindly allowed me to examine several preparations from his cabinet, which likewise show small stems and leaves in such positions as to prove that they belong to one another. Now in all these preparations the leaves of *Arthropitys* are characterised by a layer of tissue which is histologically the same as that just described in the stem, and which is so conspicuous a feature in the bracts of *Calamostachys Binneyana*. Thus a tissue which is characteristic of the bracts of the sporiferous spike with which we are dealing is characteristic also

* Vol. xix., 1883, pp. 85-92.

† Ante, pp. 286-287.

Fig. 1.

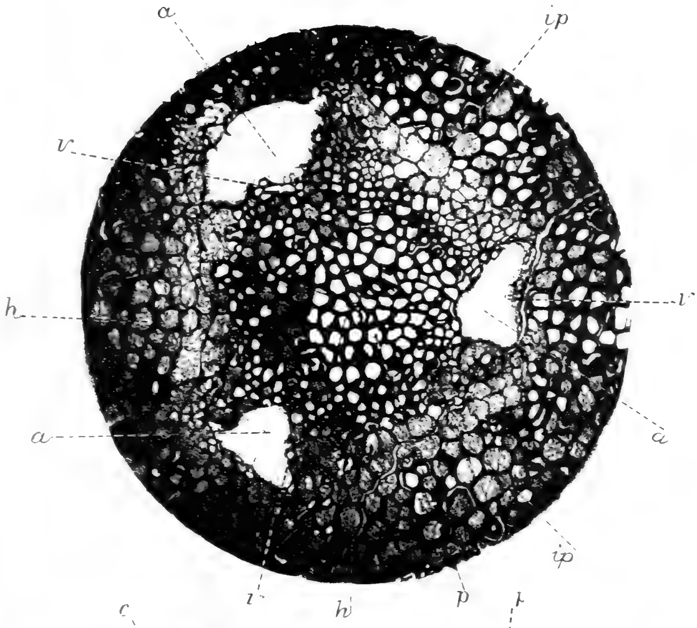


Fig. 2.

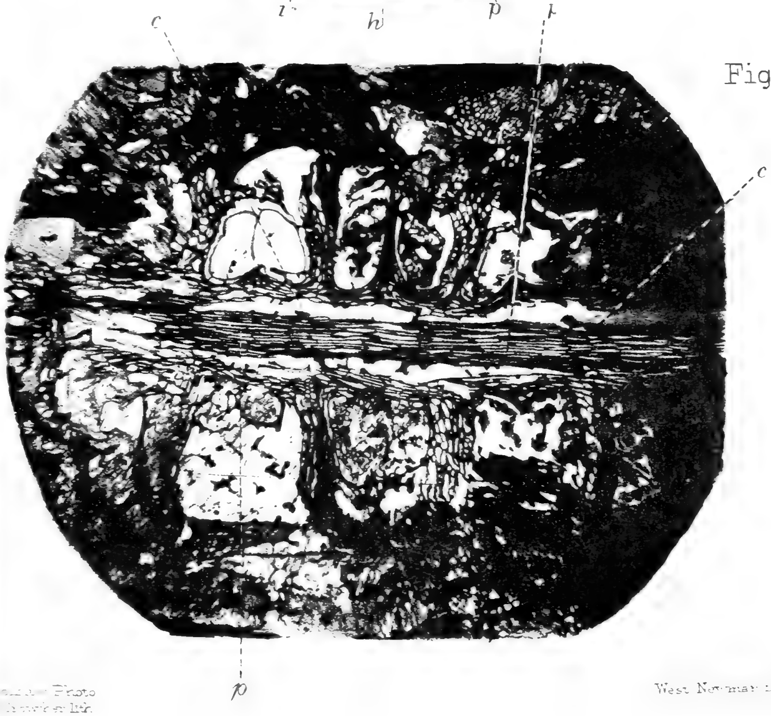


Photo
W.H. ... lith.

West Newman imp.

CALAMOSTACHYS BINNEYANA *(Schimp)* Pl. 1.

Fig. 3.

Fig. 5.

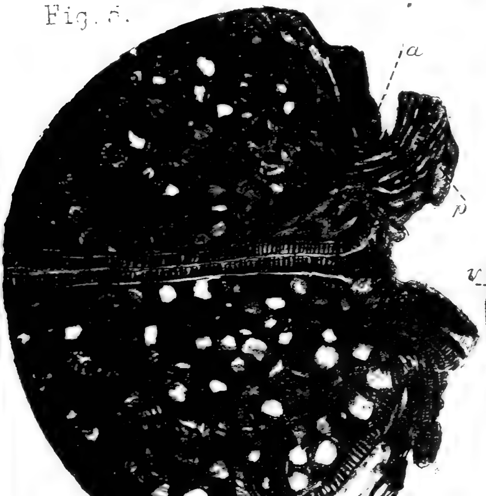
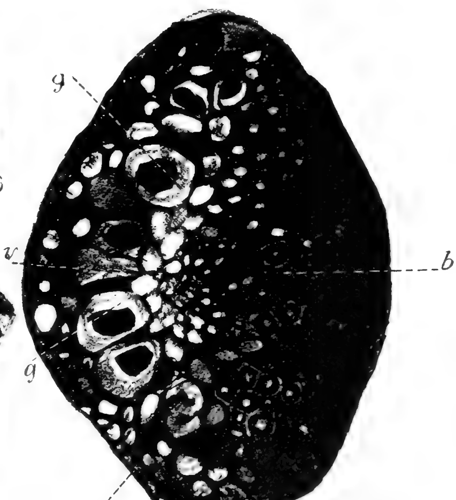


Fig. 4.



J. Lomax Photo
W. H. Crowther lith

West, Newman imp.

CALAMOSTACHYS BINNEYANA *(Schimp).* Pl. II.

of the leaves of *Arthropitys* as well as of its stem. Hence it would seem to be a legitimate inference that there is a close relationship between *Calamostachys Binneyana* and that type of *Calamites* which is known as *Arthropitys*. We might, perhaps, without much risk of error, go further than this, and conclude that the one is actually the spore-bearing shoot of the other, but in a case of this kind it is better to keep our inferences well within the range of the facts on which they are based.

Explanation of the Figures.

Plate I.

Fig. 1. Transverse section of the axis of Calamostachys Binneyana.

a. Carinal Canals. *i.p.* Inner parenchyma of Cortex.

v. Small vessels at the margin of the same. *h*. Hypoderma of Cortex.

p. pith.

,, 2. Longitudinal section of Axis.

p. pith. *c*. Carinal Canals.

Plate II.

,, 3. Part of the same enlarged.

p. pith. *c*. Carinal Canals.

v. Vessels. *d*. Fragment of nodal tissue which is here vascular.

,, 4. Transverse section of Bract.

e. Epidermis. *b*. Sclerenchyma.

v. Small vascular bundle. *g*. Large cells with black contents.

,, 5. Sporangia with spores.

p. Peduncle. *a*. Non-sporogenous tissue.

A SKETCH OF THE GEOLOGY OF NIDDERDALE AND THE WASHBURN NORTH OF BLUBBERHOUSES. BY J. R. DAKYNS.

In my former communications to this Society on the Carboniferous Rocks of the West Riding, I have said next to nothing about the geology of that part of the country east of Wharfedale, which drains into the Rivers Nidd and Washburn. I propose now to give a short sketch of the geology of this area; but, in justice to Mr. J. Lucas, I must say that much of my knowledge of its geology, especially as regards the thickness of the beds, is derived from his patient and careful investigations.

In the basin of the Washburn and in Nidderdale the Millstone Grit consists of the following members, which are lettered for convenience of reference, as given in the annexed list.

				Average thickness in Feet.
	Shale	...	... ...	50
	Sandstone *k*	...	... ...	45
	Shale	...	... ...	75
	Sandstone *h*	...	... ...	30
	Shale	...	... ...	35
Brimham Rock *g*	Sandstone g^4	...	... ...	50
	Shale	...	... ...	20
	Sandstone g^3	...	... ...	75
	Shale	...	... ...	22
	Sandstone g^2	...	... ...	97
	Shale	...	... ...	47
	Sandstone g^1	...	... ...	77
	Shale	...	... ...	89
The Shell Bed *f*	Shell Bed f^2	...	40	= 85, but averaging 55
	Shale	...	20	
	Shell Bed f^1	...	25	
	Shale	...	... ...	33
Upper Grit of Follifoot Ridge	Sandstone *c*	...	... ...	38
	Shale	...	... ...	45

			Average thickness in Feet.
	Brought forward	...	883
Lower Grit of Follifoot Ridge	Sandstone *d*	..	74
	Shale ... ... Flagstone, occasional ... Shale	= Shale	90
Kinder Scout Grit	Sandstone c^3 ... ... Shale ... ... Flagstone, occasional ... Shale ... ... Sandstone c^2 ... ... Shale ... ... Sandstone c^1	= Sandstone *c*	120
	Shale ... ... Sandstone, thin ... Shale	= Shale	90
	Sandstone *b*	...	58
	Shale	...	230
	Sandstone *a*	...	176
Total	.. ..	...	1721

The thicknesses given above have been obtained by taking averages of several measurements in different places.

The annexed section was also kindly given to us by Mr. Newbold, of Eagle Hall, Pateley Bridge. It seems to be identical with one given by Professor Phillips in his "Geology of Yorkshire," which we got from Mr. Newbold's grandfather.

		Feet.
Grit, supposed to equal bed *c* ..	... ...	30
Ellen Scar Plate, so called by Phillips	... ...	150
Sandgill Grit ,, ,,	... ...	48
Grey Beds	... ...	36
Fine Grit	... ...	21
Underset Plate	... ...	141
Limestone	... ...	8
Plate	.. ...	6

	Feet.
1st Underset Grit	96
Plate	6
2nd Underset Grit	48
Plate	3
Coal	2
3rd Underset Grit	21
Lime Plate	8
Greenhow Limestone, thickness not known.	

This section was given to us as representative of the measures met with in the workings of the Greenhow Hill Lead Mines. Perhaps the best section of these measures is to be seen in Cock Hill Level. I examined both this level and also the California level under Grimwith Fell, and found great similarity in the grit beds of the two levels; but the limestone shales have almost vanished in Cock Hill, being only eight feet thick.

The thin limestone which lies a little above the top of the Underset Grits reminds one of the little limestone met with just above the Grassington Grits in the shaft in Gateup. There can be no doubt that the Underset Grits of Cock Hill correspond in part, if not altogether, to the Grassington Grits. The coal too is certainly the same as one of those met with in the mines on Grassington Moor. I will now point out the position and run of the chief beds.

The three beds of Kinder Scout Grit, lettered *a*, *b*, *c*, in the above list, run along the northern edge of the one-inch ordnance map, 92° S.E., with a northerly dip; but between Beamsley and Blubberhouse Moor, the top turns, owing to the Beamsley anticlinal, and runs north-east, so that the three beds occupy the Washburn Valley from Moyington House to the dams a mile above Blubberhouses. A dirty coal, eight inches thick, was seen near the top of *a*, at the head of the Deep Gill, along which the Kex Gill or Skipton Road runs, about two miles west of Blubberhouses. Thence the top runs north of Kex Gill Road, and bending round runs north by Rocking Hall to the Washburn above Hoodstorth and east of Pockstones; thence up the valley and across Kitty White's Allotment to the Craven Fault. A thin bed of sandstone overlies it on Kitty

White's Allotment. Elsewhere in the Washburn basin it is succeeded in order by the lower and upper grits of Follifoot Ridge, the Shell Bed and two beds of the Brimham Grits, viz., the flags and the Brimham Rock proper.

A coal has been worked in the Lower Follifoot Grit near Thornthwaite, where the section of the rock is as follows:—

	Ft.	Ins.
Hard Stone and Shale	75	
Coal		6 to 8
Hard Grit	55	
Rotten Stone		
Stone		

The upper part of the Kinder Scout Grit appears as an inlier at Thornthwaite, and also immediately west of Dacre and again around Long Scales.

The Shell Bed gives an excellent and invaluable horizon. Its course can be easily seen by reference to the engraved six-inch Geological Maps, for wherever it occurs the words "shell bed" have been printed on the map; but I may shortly state that, running along the upper part of Redshaw Gill, it turns north by Black Sike, runs under Ravenstones Plantation, and thence by the farmhouses Hay Slack, Hoodstorth, Padside Hall and Padside Green, all of which stand on it. It occurs on the south-east side of the Beamsley anticlinal in several inlying and outlying patches, particularly north of Fewston, where there are two shell beds.

The greater part of the Forest Moor is formed of Follifoot Grits, surrounding islands of the shell bed; and east of Blubberhouses an inlier of the Brimham Rock appears.

Immediately south of the Craven Fault we have a regular series of the beds in a synclinal trough, up to the third bed of the Brimham group.

North of the limestone axis of Greenhow Hill the beds of the Kinder Scout Grit occupy the northern slope of Beamsley Moor. Hardcastle and Cross Gill Moors are occupied by the Follifoot Grits. The top of the Kinder Scout Grits runs up from Ashford Side Beck to the Henless Beck, where it is marked by the tesselated limestone.

An outlier of the Follifoot Grits occurs on Heathfield, Gouthwaite and Raygill House Moors, forming a bold escarpment along Henstone Band. A small outlier of the Lower Follifoot Grit occurs on Mengher. The various gills descending from the above-mentioned moors into Nidderdale are occupied by tongues of Kinder Scout Grit.

On the north-east side of Nidderdale there is a regular succession of beds from the Kinder Scout Grit to the bed lettered *k* in the list. This is the highest bed of Millstone Grit present in this part of the country. The greater portion of the country north and east of Pateley Bridge is occupied by the beds *h* and *g*, the latter having as many as five sub-divisions.

As the country south of the Craven Fault is much complicated by the fact of the beds forming a series of rolls, it will be as well to point out the position and direction of the anticlinal and synclinal axes. We have then firstly the broken anticlinal of Greenhow Hill, which running across Appletreewick Pasture and north of Burnsall is continued to the south-west across the limestone hills, Elbolton and Butter Haw. This is succeeded on the south by a synclinal trough, which runs from Wilsill near Pateley Bridge in a roughly parallel direction, north of Pockstones by Skyreholme to the Wharfe. This is succeeded by the Simonseat anticlinal, which runs out of the great Beamsley anticlinal a mile north of Dacre Banks. It runs roughly parallel to the other axes by Palley Crags and Pockstones to Simonseat, where the beds bend round in a gable. This is succeeded by a synclinal, which, starting from the same part of Nidderdale, runs south-west across Whitmoor to Kex Gill. This is succeeded by the Beamsley anticlinal. This important axis may be considered the continuation of the Skibeden anticlinal after a broken fashion. It runs a little north of the beacon across the moor to Round Hill, and thence crossing the outcrops of the Kinder Scout Grit in the Washburn it runs through Thornthwaite a mile west of Dacre, crosses Nidderdale a mile above Dacre Banks, and thence by the Brimham Rocks across the moor by Sawley to Aldfield, where it runs under the Permian. It is succeeded on the east by a synclinal running along Darley Beck, and this by an anticlinal which running along Delves Ridge crosses the Nidd at New Bridge above Birstwith

Station, and thence runs into Thornton Beck below Shaw Mill. It is succeeded by a synclinal running from Blubberhouse Moor by Fewston, and thence by John of Gaunt's Castle down the gill in Haverah Park. This is succeeded by an anticlinal which branches out of the Beamsley one at Round Hill, and thence skirting the edge of the ordnance map 92° N.E. runs on to Harrogate.

GLACIAL PHENOMENA OF WHARFEDALE BETWEEN BOLTON ABBEY AND KETTLEWELL. BY J. R. DAKYNS.

With one singular exception the glacial drift in the basins of the Rivers Wharfe and Nidd, among the Carboniferous Rocks, contains no stones but such as may have come from the rocks cropping out at the surface in those basins. There are no foreigners. We know that the drift material has travelled southward and eastward, because boulders of Carboniferous Limestone are found to the south and east of any outcrop of that formation. Thus in the adjoining area boulders of Carboniferous Limestone have been carried southward across the Aire to the higher part of the Worth valley, and such have also travelled eastward down the Aire valley towards Leeds. There are very few glacial striæ in Upper Wharfedale, because there are not many hard compact rocks fitted for retaining striæ. Limestone is hard and compact enough, but it disappears so rapidly at the surface under the influence of rain water and becomes so fretted into fantastic shapes, that it does not long retain superficial markings except when protected from the weather by a covering of clay. One very good instance of this sort occurs between Conistone and Kettlewell. There I found, under a bed of boulder clay, Limestone Rock, beautifully grooved; the grooves trended along the hillside bounding the valley of the Wharfe. The only other scratches I got in this district were on Millstone Grit, on the southern part of Hebden Moor; there I found scratches trending N.W. and S.E., and close by some doubtful ones pointing E.N.E. The valley of the Wharfe is crossed at Grasswood, a mile above Grassington, by a barrier of limestone, through which the river runs in a narrow channel. Above the barrier stratified sand and gravel is found. There is all the appearance of this rock barrier being the lower tip of a rock basin filled in with drift and alluvium. It is difficult to say how much of the sand and gravel is of the glacial period and how much is ordinary river gravel. The river gravels probably run back to glacial times. A similar barrier, of coarse gritsone, crosses the valley at the elbow in the stream near Drebley. The hills on either side of the river formed by this rock are called Herd's Hill and Heugh. Herd's Hill has a distinctly glaciated look as seen from a distance, but I could find no scratches for the retention of which the rock is in fact too coarse. I found, however, something like grooves running N.N.E. and S.S.W. This hill, along with the Heugh on the opposite side of the river, forms a prominent bank of grit, stretching across the valley, which it would dam up but for the narrow passage which the river has cut for itself. The drift is piled up against the high side of this dam. Gravel mounds enclose the Heugh on the north-west. These mounds gave no section; externally they have an Esker-like look, as they are moundy and enclose hollows. They reach an altitude of 600 feet above the sea level.

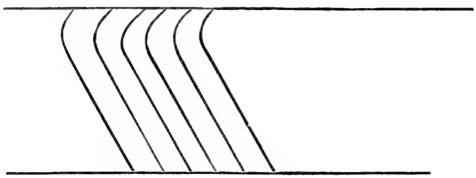
In constructing the puddle trench of the Barden Reservoir for the Bradford Corporation Waterworks, a total thickness of 65 feet of drift was met with. The section, as kindly communicated to me by the resident engineer, was as follows :—

	Ft.
Yellow Clay	10
Blue Clay, sandy and strong .. .. }	13
Sand and Gravel ... . }	
Blue Clay, containing limestone boulders and great blocks of grit; hard and water-tight	42

The yellow clay is doubtless merely the weathered part of the blue.

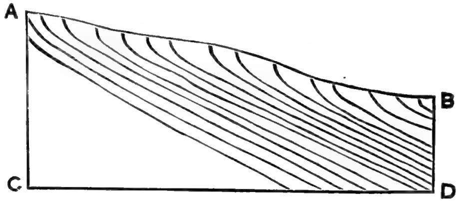
As both grit and limestone occur in place in large masses in this district, it is of no importance finding boulders of one rock lying on the other ; but I may mention that the limestone ridge above Fancarl House, though free from drift and generally bare, is strewn with boulders and blocks of coarse Millstone Grit. I found too a block of limestone on the Kinder Scout Grit Escarpment at the southern end of Crooksior Crags on Embsay Moor, more than 1,200 feet above sea level. The curious round hills forming the Millstone Grit Escarpment south of Barden, between the River Wharfe and the Pateley Bridge road, have limestone boulders on them.

At Gill Bank, near Storriths, beds of flaggy grit, dipping at 60° to the S.E., presented the appearance, shown in the figures, as if the beds had been turned over southwards and broken. Ice moving from the north might have done this.



This is similar to what has so often been observed by Messrs. Tiddeman and Green in the country described in the Geological Survey Memoir "On the Burnley Coalfield."

The only other case of bending over of the ends of the beds that I am acquainted with in this locality, presents some difficulty. It occurs on the northern slope of hills forming the south part of Barden Moor. In a quarry near Hutchen Gill Gate the beds, which consist of flagstone, are dipping down hill, *i.e.*, to the north at 25°. The top layers are turned over as if by a force acting down hill, *i.e.* from south to north. The slope of the ground does not seem sufficiently great for this bending over to be due to the "weight of the hill," as it is called. On the other hand, it is quite certain that the great mass of ice moved southward. The annexed figure represents what is seen:—



A B represents the slope of the ground; C D is a horizontal line. If this bending over was caused by ice it must have been by quite local ice; for the general movement of the ice of the country was from B to A, not from A to B. As regards the drift material, it is of two sorts, well rounded and bedded sand and gravel, and ordinary boulder drift. This last is the most frequent; it cannot always be called boulder *clay*, and in the higher part of the dale can seldom be so called except by courtesy, for it often consists of a mass of both rounded and angular stones, of all shapes and sizes, with very little clayey matter at all. The difference between it and boulder *clay* is, however, merely one of degree. When the drift is derived from hard rocks like grit and limestone, there will be a stony deposit with but little clay; when it comes from shale, there will be much clay.

It is quite impossible, as a rule, to separate the boulder beds from the sand and gravel. The boulder beds, when stony, approximate to gravel in such cases as those in which the contained stones are well rounded; and, moreover, as the section of the Barden Reservoir shows, the sand and gravel is sometimes intercalated in the midst of boulder clay, consequently no general sequence can be made out; but near Linton Mill the gravel certainly lies on the top of boulder clay, for there is a steep bank, the upper part consisting of dry gravel, and the lower of wet clay, which throws out the water percolating the first; but as there is no section it is impossible to tell whether the gravel is a scratched boulder gravel or a water-washed gravel. Near Park Bridge, over the Wharfe, there is above the alluvial flat a bank of coarse gravel: though very rough and unstratified in places, it is on the whole distincely stratified. It contains subangular blocks of Millstone Grit about 3 feet in diameter. This gravel continues some way up stream.

Opposite Lud Stream Islands there is a gravel in a similar position and apparently of a similar character, but the section is not clean cut. It is surmounted by another bank of gravel (section also not good) apparently of the same general character, but containing much larger subangular blocks of grit. The top of this gravel bank is 75 feet above the river, and from its edge there stretches a gently rising and undulating surface for about one sixth of a mile to the foot of the hill called South Nab. This plateau may be entirely of gravel.

On the left bank of Posforth Beck, a little below the first bend in the stream above its junction with the Wharfe, there is a section in true glacial drift. The material consists of angular *debris* of grits and limestones, and the blocks of the latter are well glaciated. It contains also fine stratified sand, beautifully false-bedded. The boulder-bearing drift seems to wrap round the sand, but the section is not clear. Further down stream there is a similar angular deposit. There are plenty of rounded stones ; but the characteristic feature is angularity.

Pickles Gill, above its junction with Tom Taylor Dike, is full of drift, consisting of angular blocks and pebbles of grit and limestone. The pebbles are mostly of limestone ; and the limestones are glaciated and scratched, particularly the pebbles

It is not necessary to give any more details of sections, as it would merely be a repetition of what has been already said. The general result is that the boulder beds vary from a true boulder clay to a stony mass, which consists sometimes of a heap of angular fragments, while at others it contains a large number of pebbles ; and that in the latter case, on the Millstone Grit area in the south, the larger proportion of the pebbles are of limestone, and that the limestones are generally scratched, the grits but rarely so. Evidently the reason why most of the pebbles are of limestone is that the limestones have come the greater distance.

Further, the true glacial boulder beds are mixed up with finely stratified sand and gravel. Lastly, well water-worn gravels, containing large boulders and angular blocks, line the valley sides in terraces, like ordinary river terraces. This makes me think that there is no real distinction to be drawn between the older river gravels and the water-worn gravels with boulders, which are generally set down to the glacial period as something quite *sui generis*. I believe on the contrary that the ordinary river gravels run back to glacial times, and gradually merge into the glacial deposits.

I will now consider the solitary case of foreign blocks occurring in the valley of the Wharfe. These consist of Silurian Grits like some of the Silurian Rocks that occur in places in Ribblesdale. In Wharfedale these Silurian boulders are confined to the portion of the valley between Chapel House Lodge and Burnsall, that is, all that I have met with are below Chapel House Lodge and above Burnsall. They are most plentiful about Linton and Threshfield. The greater number of them have long since been cleared off the ground and built into the walls for "throughs," where their remains may still be seen; but some few I found still lying about on the surface of the land, and some may be seen in the drift cut through by becks descending from Threshfield Moor. I could find none above the general level of the drift of the more open country, which near Threshfield reaches about the height of 800 feet above sea level. I examined the country lying between the site of the boulders and the outcrop of Silurian Rocks in Ribblesdale; but though there are plenty of Millstone Grit boulders lying on the bare surface of the limestone, not a single Silurian boulder was to be found. It was quite clear that these Wharfedale boulders had not come over the fells from Ribblesdale. Whence and how then did they come? It may be thought at first sight that they came on floating ice discharged from a glacier debouching at the mouth of Ribblesdale near Settle. But there are great difficulties connected with this view, the chief of which is this: if these boulders drifted eastward from Settle on floating ice, when the sea level was but little higher than the present 800 contour line, and Wharfedale was a fjord, whether filled with ice or water, how did they surmounting the rock barrier at Nether side manage to travel *up* the dale or fjord towards Chapel House? for assuredly ice, or water carrying ice, was flowing down Wharfedale all the while. This is an insuperable difficulty to the floating ice theory.

I believe that the true explanation is this: At the foot of Kilnsey Crag strong springs break over from the limestone rock, just above the level of the alluvium; and also in Littondale strong springs break out at the foot of the limestone scars, the hillside below being formed of a mass of detritus, which as completely conceals the underlying rocks as the alluvium at Kilnsey does. Now, seeing that strong springs break out at the foot of scars formed by limestone of great thickness, and that it is only a little way below the springs that we find Silurian boulders in the dale, it seems likely that the springs are thrown out by Silurian rocks in places in the bottom of the valley, hidden from sight by superficial detritus, drift and alluvium, and that our boulders were thence derived. This makes everything simple; and the thickness it allows to the limestone is quite equal to the thickness of the limestone in Ribblesdale.

In conclusion let me say that thus far the drift phenomena of Wharfedale lend no support to the theory that the whole country was once overridden by an ice cap descending from the pole. There is no evidence here of foreign ice; but everything is in favour of huge confluent glaciers, or ice-sheets if you like, of home-made ice. Nidderdale, too, supports the same conclusion. There are no foreigners there at all.

THE GLACIATION OF YORKSHIRE. BY PERCY F. KENDALL, F.G.S., LECTURER ON GEOLOGY AT THE YORKSHIRE COLLEGE.

The address, of which the following is a rather free rendering, was delivered at very short notice. In its present form it is designed rather with a view to directing the attention of geologists to some of the larger problems connected with the glacial phenomena of Yorkshire than as an attempt to offer a full or final solution of them.

I have elsewhere* stated, somewhat at length, the grounds upon which I have been led to reject the theory of a great submergence of England and Wales during the glacial period, and to ascribe the phenomena to the operation of great glaciers with their concomitants of sub-glacial rivers, extra-morainic lakes, &c., acting upon a land-surface standing at about, and certainly not *below*, its present level.

I have also specified the course, general effects and approximate limits of the glaciers so far as I had been able, either by a study of the literature of the subject, or in the field, to determine them. I may, however, briefly recapitulate the points germane to the present enquiry.

The gradual approach of the ice-age produced at first small valley-glaciers in our great hill clusters, *e.g.* the Highlands and Southern uplands of Scotland, the Lake District, North and South Wales, the mountainous parts of Ireland, and perhaps some few valleys of the Pennine Chain.

With the accentuation of the cold these glaciers grew, coalesced, and extended out upon the low grounds or into the sea according to situation. Such as reached the sea detached icebergs from their fronts, and these drifting hither and thither in the random fashion so characteristic of ice floating in a tideway, would scatter their loads of boulders in a very erratic and irregular fashion over the sea floor. A further stage of refrigeration would bring about further confluences of the ice streams, and such as debouched into such

* Man and the Glacial Period (Internat. Scient. Series) pp. 137-181, and Geol. Mag. Nov., 1892, p. 491.

shallow waters as the Irish Sea and the Frith of Clyde would be unable now to find free flotation for the bergs. The condition of the Irish Sea powerfully affected that of Yorkshire, and indeed was one of the greatest factors in determining the nature and mode of glaciation of this county, and we may now consider what would be the state of affairs there as the Glacial Period approached its climax. We know from the unimpeachable testimony of striæ upon rock surfaces that there was a general convergence of glaciers of immense size upon the northern portion of the Irish Sea from almost every point of the compass. The glaciers of Kirkcudbrightshire and adjacent Scottish counties poured into it from the northward,* those of the Lake District, radiating from a centre about Great End,† came in from the north-east, and others from the Fells of Yorkshire and Lancashire from the east.‡ North Wales sent its quota from the south, and, finally, the great central basin of Ireland sent a portion of its surplus in from the westward. Now, in view of the fact that the depth of the Irish Sea rarely exceeds 50 fathoms and that glacial striæ are found on hills quite close to the coast at altitudes exceeding 1,000 feet above sea level, it will to many people not be surprising to find that this great influx of ice completely displaced the sea and converted the area into a huge ice-basin, in many particulars resembling that of Greenland. Of the depth of the ice we have a criterion, though an imperfect one, furnished by the fact that the highest point of the Isle of Man (Snaefell, 2,034 feet) was completely buried beneath the ice, and, along with its companion hills, was glaciated from top to bottom. Under these conditions new directions of flow would be taken, some of which might have been predicted *a priori* had we not previously determined them *a posteriori*. Three obvious outlets from the Irish Sea suggest themselves : one through the St. George's Channel between the Wicklow Mountains and the Snowdonian massif ; one by way of the broad low valley between the Pennine Chain and the Welsh hills ; and a third through the North Channel between the Antrim Coast and the Rinns of Galloway. The first and second of these routes we find by the evidence of striæ, boulder-

* Geol. Surv. Mem. † Ward, Q. J. G. S., vol. xxxi.

‡ Tiddeman, Q. J. G. S., vol. xxviii. ; Goodchild, op. cit., vol. xxx.

transport, and *all* the other indications of the direction of ice-movement to have been adopted. A glacier-lobe, upwards of 50 miles wide, flowed between Ireland and North Wales (the breadth almost exactly that of the Humboldt, the greatest of the Greenlandic glaciers), and terminated apparently somewhere to the southward of St. David's Head, which it overflowed ;* another lobe of about the same breadth drove in upon the plains of Lancashire and Cheshire, sweeping all the local glaciers round into conformity with its direction. Its left bank was composed of the outer line of the Pennine Chain against which it abutted at altitudes of 1,000 to 1,400 feet, while its right was the corresponding Carboniferous range of the Welsh Border upon which we find its lateral moraine at altitudes similar to these reached upon the Pennine Chain. The southerly termination of this mass was about Bridgenorth, where a great series of morainic hills was accumulated.

The third natural outlet of the Irish Sea, that through the North Channel, was not available, for we have evidence in the striæ on the Mull of Galloway, and the abundant erratics from the Clyde found in the Isle of Man that some of the ice from the Scottish Midland Valley came through to increase the congestion of the Irish Sea. There was, however, another avenue of escape for the surplus ice that would never have been suggested *a priori*, viz. by way of the Solway Frith and across the northern end of the Pennine Chain. During the early stages of the glacial period the ice-flow from the western sides of the Lake District and the Vale of Eden was down towards the Solway, and we find testimony to this in a northerly sprinkling of erratics of Shap granite and other rocks, besides the survival of a few striæ, going in the same direction ; but there is evidence, clear and unimpeachable, that has never been challenged, that the ice-flow was completely reversed. An ice-lobe, then, came up the Solway bringing with it Scottish granites and the characteristic rocks of the western side of the Lake District, and pressed in until it abutted against the Cross Fell escarpment, here it divided into two lobes, one of which proceeded in a due easterly direction, and, as I have determined from personal observations, carried its characteristic

* Hicks Brit. Assoc. Report, 1891, and *Glacialists' Magazine*, April, 1894.

erratics across the watershed and down the Valley of the Tyne.* The other lobe was forced up the Vale of Eden, at the head of which the easterly motion of the Lake District ice began to tell, and gradually forced it over the crest of the escarpment and over into Yorkshire. The point at which this passage took place can be fixed with a fair degree of accuracy. Two comparatively low passes occur in the neighbourhood of Brough, respectively the higher, and the lower, passes of Stainmoor. The lower of these, that by which the North-Eastern Railway crosses, is only 1,278 feet above sea level, but this was pre-occupied by ice flowing from Wilber and Howgill Fells, and there was no alternative but to force the higher pass nearer to Roman Fell. The striæ show a deflection in this direction, but the clearest testimony is afforded by the distribution of erratics. Blocks of Shap granite are found in abundance over the watershed, even at altitudes considerably above the highest point of the parent crag, and they are accompanied by erratics of Brockram and the so-called Dufton "granite," besides other well-known rocks of the Lake District and some few Scottish rocks. It has been remarked by Mr. Gunn† that the Shap erratics descend into Deepdale, Balderdale and Lunedale, but have never been found in the lateral valleys, and the Rev. W. R. Bell‡ has remarked that the stream of these erratics strikes the river Tees at its confluence with the Lune and no stragglers occur to the northward.

I have entered somewhat at length into these preliminaries as, without them, it is impossible to form any definite conception of the state of Yorkshire during the Ice Age; indeed the most important ice-flows in the county had their source and origin without its bounds.

Having brought the Shap granite over the Pennine Chain, I may now proceed to trace its distribution here. Down Teesdale it extends in an easterly direction right down to the sea, then we can trace it in the drift deposits which fringe the seaward margin of the county, past Whitby, Scarborough, Filey, Flamborough, Bridlington, Withern-

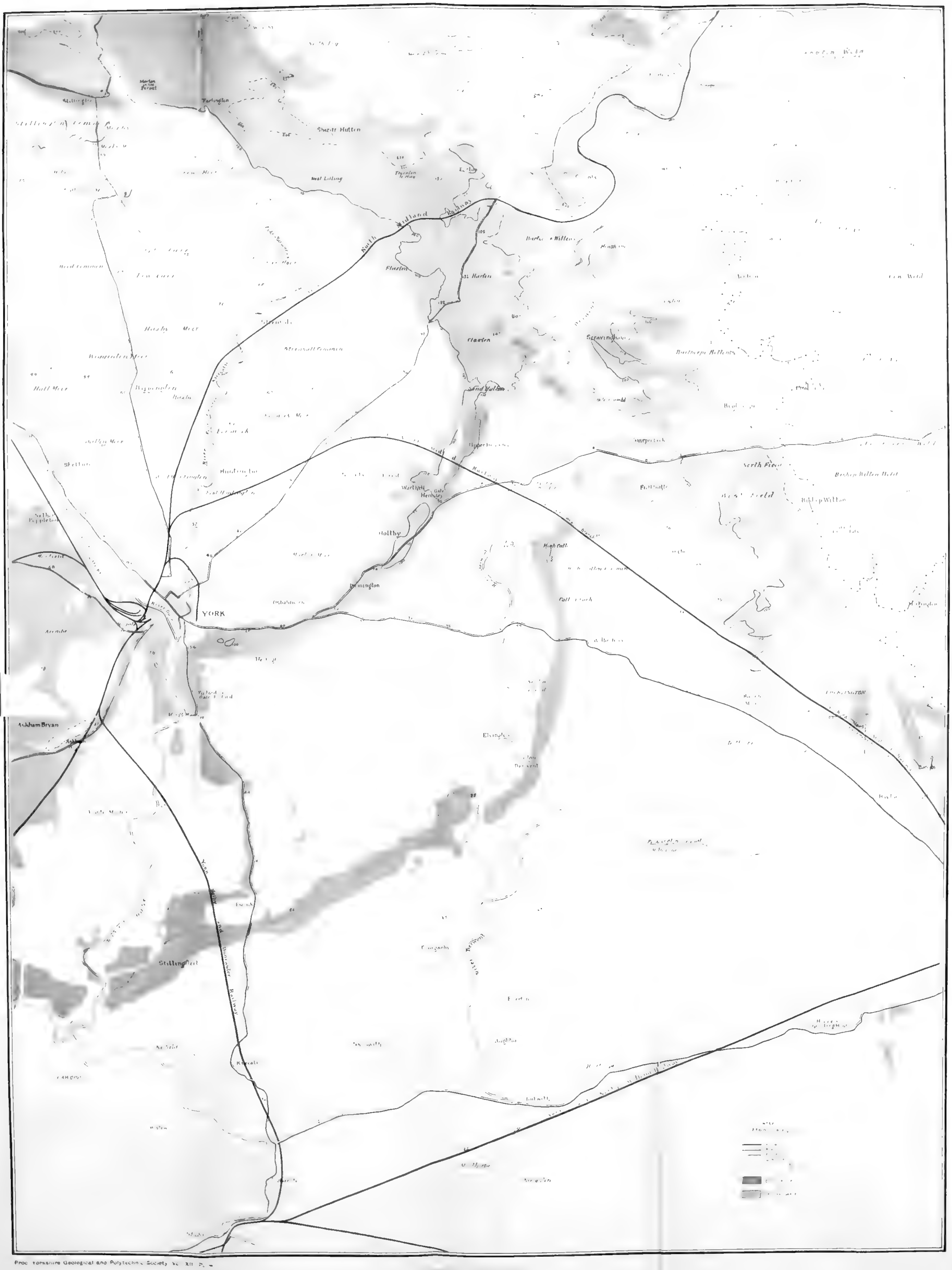
* I find that in this observation I was anticipated by the late Thomas Belt. (See Quart. Journ. of Science, July, 1876.)

† Geol. Mag. 1879, p. 384. ‡ Brit. Assoc. Report on Erratic Blocks, 1893.

sea, and down almost to Spurn Point. Beyond this it has never been found. Now besides this, which we may call the natural flow, inasmuch as it follows the existing line of drainage as far as the sea, there is an inland distribution which crosses one of the most important though one of the least elevated watersheds in the county, viz.: that which separates the Tees drainage from that of the Ouse. The precise point at which the southerly flow commenced has not been determined, but down the central and eastern portion of the Vale of York Shap erratics are found in some abundance, and continue as far as the City of York, where considerable numbers have been found from time to time. The maps of the Geological Survey mark in the neighbourhood of York a series of features without compare in the whole of the British Isles, and the fact that the surveyors made no attempt in the explanatory memoir to point out their significance is, I think, probably to be ascribed to a desire to do fuller justice to them in a general treatise upon the Drift Geology of Yorkshire, rather than to any inability to interpret them. Be the cause what it may, it was reserved to the late Professor Carvill Lewis to acquaint the world with the fact that York was built in the centre of a magnificent crescentic terminal moraine, one of whose horns rested upon the oolitic hills about Barton Hill, while the other merged in a confused congeries of drift hills to the west of the city. This he correctly pronounced to be the terminal moraine of the Teesdale glacier.

My own observations at York and in the neighbourhood show that this is not the only terminal moraine in the district. About five miles southward a second magnificent crescent sweeps round in almost precise parallelism with the first, and has an arc of about the same chord and radius. I do not for one instant doubt the accuracy of Lewis's determination of the first to be a terminal moraine, and exactly the same reasoning applies to the second. Each is a long crescentic ridge or series of knolls, rising to a height in some parts of 70 or 80 feet about the surrounding dead-level of "warp" clays, sands, or gravels. The ridges are mapped by the Geological Surveyors as boulder-clay, sand, and gravel, and sections show many of the characteristics of the moraines of great glaciers. Dr. Parsons

MAP OF THE YORK MORAINES.



Proc. Yorkshire Geological and Polytechnic Society, Vol. XII. Pl. [illegible]

in a valuable paper* gave some details of the section in the more southerly moraine at Escrick, and mentioned that the beds of sand, gravel, &c., dipped strongly to the south-west.

A section in the more northerly moraine, seen by myself, just to the north of the village of Bilbrough, displayed a series of sands and gravels dipping somewhat east of south. In the village I found a boulder of Shap granite. A general examination which I made of the boulders at this place agreed closely in its results with those yielded by my studies of sections in and about York. There was a great preponderance of boulders of various rocks from the Carboniferous series, especially Mountain Limestone.

One feature in the general disposition of the drift deposits at York deserves mention. The two moraines, that of York and that of Escrick, are joined together by a high ridge of coarse gravel, which from its position and relation to the flow of the glacier may be safely pronounced to be an esker.

So far all has been straightforward and simple, but I have now to propound the first problem :—Which moraine is the older, that upon which York stands, or the more southerly one at Escrick? The first impulse would, I have no doubt, be to declare the proposition self-evident, the Escrick moraine being further from the source of the glacier would be the older, and the York moraine would be a "moraine of retrocession." There are some facts, however, which seem to me to be worthy of consideration, which might lead one to the opposite conclusion, and these I put forward in a note communicated to the Glacialists' Association on September 24th, 1892.

An examination of the Geological Survey Maps shows that each of the two great moraines consists of a central strip of sand and gravel flanked by outcrops of boulder clay. Now, so far as I am aware, tough stony clay has never been observed amongst the materials discharged upon the free edge of a modern glacier so as to form the substance of its terminal moraine; and, indeed, the rarity of the occurrence of boulder clay in association with modern glaciers or their deposits, has led many geologists to deny the *direct* glacial origin of the material and to ascribe to it a marine origin,† but,

* Proc. Yorks. Geol. and Polyt. Soc., 1877.
† Dawkin's Early Man; Bulman, Geol. Mag. 1893.

while I am not, in view of Holst's observations upon the glaciers of Greenland, prepared to endorse this view I still recognise that the improbability of such a material being laid down in front of a glacier is very great, and therefore I am impelled to regard boulder clay as a *sub-glacial* deposit. If this be so then it will follow that the ice of the great glacier overrode both the moraine at York and that at Escrick, plastering their inner and outer faces with clayey ground-moraine. However we interpret the maps—admitting the premise that boulder clay is not laid down upon terminal moraines outside the edge of the ice—the conclusion must follow that these two moraines were over-ridden. If the median strip of sand and gravel were the crest of a ridge against which the boulder clay was, as I have suggested, banked, then the ice must have passed over this ridge to lay down the clay on the outer face of the moraine. If, on the other hand, we were to regard the sands and gravels as superposed upon the boulder clay, then we should be compelled to regard the great rampart of boulder clay upon which they rested as a terminal moraine which had been completely mantled by ground moraine, and subsequently capped upon a retreat of the ice by a second gravelly moraine. Which of these views is the correct one I am not in a position to say, but my impression is that the former better accords with the facts, as I have seen several sections in which boulder clay rested on the gravels, and one was quite on the summit of the moraine at "The Mount," York.*

I am well aware that objection will be taken to my explanation on the grounds of the inherent improbability of a glacier over-riding a moraine without levelling and redistributing it, and adverse negative evidence may be produced from the Alps and Norway; but I submit that there is no parity between the small torrentiform glaciers of the Alps and such a mighty ice-river as laid down the York moraine. A comparison would be more appropriate with the great Muir glacier of Alaska (though even there the gradient from the snowfields was immensely greater than that of the case we are considering), and here we find that the ice has actually passed over

* I would, however, remark that this material was much more stony and sandy than the generality of boulder-clays, and much more like ordinary moraine-stuff.

great beds of sand and gravel without disturbing the bedding, or even overturning the standing trees which had been smothered on the original advance of the ice. Even in the Alps, however, cases are not unknown of glaciers moving over their own terminal moraines. When we come again to the question which is the older, the York or the Escrick moraine, I confess myself unable to decide. I think both may have been overridden by oscillations of the ice-front, but whether by halts in the advance or of the retreat I am unable to say. These are points which might fitly receive the attention of the geologists of the county, and I am content to have suggested that the relative positions of two moraines are not absolute criteria of relative age. Another problem connected with the Vale of York glacier concerns its furthest extension. Shreds of boulder clay are mapped along the Wold escarpment for a long distance south of the Escrick moraine, and here and there great patches of gravel as at Heck rise out of the monotonous expanse of "warp." Are these relics attesting a great extension of the glacier to the southward, or are they, as seems to me very improbable, the deposits of an extra-morainic lake? I am not in possession of facts enabling me to attempt a full explanation of their occurrence, but I shall say something more regarding them on a later page.

I must now apply myself to the discussion of the causes which modified the ice-flows so as to effect the distribution of Shap erratics in the two southerly streams, viz., those down the Yorkshire Coast and the Vale of York respectively. The former of these shows that the Stainmoor glacier had a free outlet to the sea at one time, and one would in that case expect that it would keep to the Valley of the Tees and not encroach to any great extent upon the Vale of York. Mr. Lamplugh has, however, described some peculiarities in the vertical distribution of erratics through the drift series of the coast, which suggest, or perhaps prove, that the mouth of the Tees during some portion of the glacial period was obstructed so as to prevent the escape of the glacier in that direction. The occurrence of great numbers of erratics of Scandinavian origin in the drift of the east coast, from Whitby to Cromer, raises a strong presumption in favour of the extension to the British shores of that great ice-sheet which had its radiant point in Finland, and this mere probability becomes a well-grounded induction when we observe the way in which the striæ down the whole eastern coast-line of the British Isles are deflected, and in some cases our native streams were actually turned in upon the land as in the classic case of Caithness. Even on the remote Shetlands we find a similar effect, and those islands have been shown by Messrs. Peach and Horne to have been buried beneath a moving sheet of land-ice which bore down upon them from the east. On the Yorkshire Coast the evidence of striæ is remarkably scanty, one single striated surface having been found by Mr. Lamplugh* at Filey Brig coming in from the N. 20° E., but curvature of the bed-rock due to glacial pressure, has been noted by the same acute observer at Flamborough Head, and the occurrence of huge transported masses of friable secondary rocks at various places to the southward of their native outcrops, and of a great moraine along the coast for many miles would suffice, I think, to convince most investigators that an ice-sheet had pressed in against the coast with a strong northerly component of motion.

Mr. Lamplugh has suggested that probably the Teesdale (Stainmoor) glacier had not, up to the time of the onset of the Scandinavian ice, reached the sea, but that as the glacial period approached its culmination the great accumulation of snow and ice in the British Isles caused a relative desiccation of the region lying to the eastward, which would, of course, obtain their precipitation from the westerly winds which had already traversed the British area. He supposed that as the British glaciers waxed there would be a dwindling of the Scandinavian ice-sheet, and our native ice-stream of Stainmoor would at last succeed in reaching the sea, would there be deflected when it abutted against the front of the Scandinavian ice, and would be driven to the southward, rasping the faces of the cliffs, tearing off great masses of our soft secondary beds, and bearing them along to be stranded further south, sometimes at higher levels than the parent masses, scattering its burden of Shap boulders, and leaving a great line of morainic hills along the sea-board.

This explanation is, I think, a feasible one, but I am still disposed to think that the order of events was not quite the same

* Brit. Assoc. Rep., 1890.

as that suggested by Mr. Lamplugh, and I trust I shall escape the imputation of presumption in venturing to dissent from the opinion of so high authority, if I point out that, though I cannot claim a minute knowledge of the drift-beds of the Yorkshire coast such as Mr. Lamplugh possesses, I have paid a good deal of attention to the glacial phenomena of Northumberland, Durham, and the inland districts of Yorkshire, besides possessing a rather more than cursory acquaintance with the coast.

I incline to the opinion that at the first onset of the Scandinavian ice the Teesdale glacier had already made its way to the sea, and the comparative rarity of rocks from Teesdale in the Basement Clay may have been due to the fact that the Norse sheet at first bore straight on to our coast and thus ice coming to Holderness would not have crossed the path of the Shap stream. When the obstruction of our bold cliffs was encountered the foreign ice would pile up and thicken and gradually adopt a new course, which, since there were no native glaciers to be encountered to the south of the Tees, would be mainly southerly. Some of the Shap blocks which lay off the mouth of the Tees would now be involved in the ground moraine of the ice-sheet and carried with it, at an excessively slow rate, and laid down at intervals along the coast upon the Basement Bed. There is an area, known as the Rough Ground, a few miles from the mouth of the Tees, from which many boulders, some of Shap granite, are dredged from time to time by the trawlers, and this I regard, in common with the late Professor Carvill Lewis, as the site of the terminal moraine of the Stainmoor glacier. It might be objected that this terminal moraine would be entirely obliterated by the movement of other ice over it, but I would point out that the scour of marine currents may be continually exposing the boulders of a moraine that had been simply levelled. It is very improbable that on a low slope the terminal moraine of a great glacier could be wholly destroyed and all its materials carried away, especially by ice flowing along its length.

Now to consider the York branch of the Stainmoor stream. The same cause that obstructed the mouth of the Tees would oppose front to front the glacier which debouched there. Some piling up would take place, and a new line of flow would have to be found. Comparatively small glaciers descended the dales south of Teesdale, consequently the Vale of York would be open to any glacier in want of a passage, and I believe that it was under these conditions that the Vale of York became occupied, not so much, as I have previously and inaccurately expressed it, by *a branch* of the Teesdale glacier as by the glacier itself. There are many facts within my knowledge strongly corroborative of this opinion ; for example, I have found many flints in the drift of Stockton-upon-Tees, and these, I think, can only have come from the eastward. Again, I made a careful examination of the cliffs to the north of the mouth of the Wear, near Sunderland,* in the hope of obtaining a solution of some difficulties regarding the glaciation of Northumberland and Durham.

To my great surprise and perplexity I found that the large boulders had their long axes in an east and west direction, and the sharp ends pointed to the west, which would be taken to imply an ice-flow from the eastward. I began to doubt the safety of generalising from the position of boulders, but a fortunate exposure of a glaciated surface exhibited striæ unmistakably running from *east* to *west*, so that it is clear that on this low coast-line the eastern ice actually made its way in upon our country. These observations are a striking confirmation of the theory put forward many years ago by Mr. Richard Howse, who accounted for the occurrence of flints in the upper part of the drift of the coast of Northumberland by reference to an invasion of Scandinavian ice. If, as seems to have been the case, the foreign ice made its way in, then the deflection of flow of the Teesdale glacier is at once explained, and we may perhaps also explain the anomalous occurrence of a boulder of Shap granite at Lindrick Farm, two miles west of Ripon,† by supposing the thrust of the Scandinavian ice to have driven the York glacier over towards the western side of the vale. I would suggest an examination of the contents of the drift-beds between the Cleveland hills and the Tees,

* These observations were announced at a meeting of the Glacialists' Association, 1893.

† W. Gregson. Brit. Assoc. Rept. on Erratic Blocks, 1893.

and round the north-westerly slopes of the Cleveland hills, as a piece of work likely to throw much light upon this question, for it is quite conceivable that some ice from seaward may have made its way in.

The condition of the Vale of Pickering at this time offers another problem of great interest for solution, and it is to be hoped that some one may be stimulated to grapple with it. A very cursory glance at the map would suffice to show that some radical change in the drainage had been brought about at a geologically recent period. The broad opening seaward and the extremely flat and swampy condition of so much of the Vale must mean that the natural outlet was towards the sea, but that the line of morainic hills extending across the eastern end had obstructed and reversed the drainage which is now carried off to the westward by the River Derwent, which flows through a very steep and obviously recent gorge.*

So much of the low ground within the Vale is covered by "warp" and other like materials that it is exceedingly difficult to determine whether or not any ice penetrated from the eastward, but from what I have already said it might be inferred that I regard this as far from improbable. Several patches of boulder clay are mapped in the western portion of the Vale of Pickering, but I should regard these with a good deal of suspicion until some account had been given of the precise nature and contents of the alleged boulder clay. It appears to me probable that when the Scandinavian ice closed the natural outlet the Vale of Pickering was converted into a great extra-morainic lake, into which muddy water would flow from the melting ice-front, and the precipitation of this mud would form those clays called "warp." Bergs would break from the ice and raft out boulders which might be ultimately entombed in any deposits forming on the bed of the lake. From the oolitic hills and the chalk wolds streams would descend producing delta deposits round the margin of the lake, and the surplus water would overflow through a notch which would be gradually deepened and cut back to produce the existing gorge of the Derwent. This is what one would expect ; and it has yet to be shown how far the facts accord.

* A reference to the Geol. Surv. Mem. on the Jurassic Rocks of Britain, Vol I., Yorkshire, by Mr. C. Fox-Strangways, shows that the problem has been considered by an able observer, who has, however, left many questions still unsettled.

The condition of low grounds south of the York glacier is another of the problems calling for solution. I do not think there can be much doubt but that a very large lake existed, the Lake Humber of Carvill Lewis, in much of the region between York and the Trent valley, running up into the tributary valleys on the one side and penned by the ice on the other, but what its limits were, and to what height it rose, I do not think we are at present in a position to say. Much of the "warp" of the lower part of the Vale of York is, I think, clearly the deposit of such a lake, and in a cutting near Selby I saw, some few months ago, several large blocks of Jurassic sandstone which had been dug out of it, and which I should explain by the drifting of small icebergs from the York glacier. I would point out that this deposit is just such an one as might be expected to be laid down in water receiving the grindings of glaciers, and is very like the Clyde Clays, but wholly different from Boulder Clay. The anomalous occurrence of boulders of Shap granite and of drift deposits at Royston, near Barnsley, may perhaps be similarly explained.

The valleys of the Pennine Chain, from Swaledale southward to Airedale, appear to have been occupied by glaciers, some of which were confluent with that of the Vale of York, but towards the southern end of the Chain they finished as simple valley-glaciers, and lobes of the great extra-morainic lake may have ascended a short distance but all details are yet wanting, and I merely mention these points in order that they may not be lost sight of in any attempts to solve the problems which I have put before the Society.

Map.—The geological information is transferred from the Drift edition of the official maps, and I have added merely the 100, 200, and 300 feet contours.

Sincerely Yours
James W. Davis

Obituary.

JAMES WILLIAM DAVIS, F.G.S., F.L.S., F.S.A.

It is now more than a year since the Yorkshire Geological and Polytechnic Society lost, by the rude hand of death, its talented and highly esteemed Honorary Secretary, James William Davis, F.G.S., F.L.S., F.S.A. No member of this Society ever left so enduring an impress on its character and development, and indeed time only deepens our sense of obligation and irreparable loss.

Several excellent memoirs have already appeared of our friend, notably those published in the Quarterly Journal of the Geological Society of London, No. 198, May 1st, 1894; the Geological Magazine, September. 1893; and the Yorkshire "Naturalist." Whilst these have given admirable sketches of the character and general work of Mr. Davis, there still remains to be recorded the story of his special relations to our own Society, of which he was so distinguished an ornament.

The subject of our memoir was born near Leeds, on 15th April, 1846, and from his earliest years his abounding energy, his thirst for knowledge, his taste for Natural History pursuits, his keen love of nature, from both æsthetic and scientific stand points, were strongly marked. When a mere boy he regularly kept a diary, in which he entered notes on various subjects of interest, and laid down for himself an extended course of study, embracing Science, English Literature and Languages; and, ever an indefatigable worker he contrived, whilst neglecting no business duty, to use wisely every available spare hour for the cultivation of both body and mind. He had a rare gift of attracting the friendship and goodwill of any intellectual mind he came in contact with, and the force of his personal character usually placed him in the front rank as a leader in any scheme with which he became connected.

About 1864 he removed from Leeds to Halifax, and entered himself a student at the Haley Hill College (founded by the late Colonel Akroyd, who was an earnest educationalist, at a time when it was not so popular a rôle as it is to-day), he competed successfully in the Society of Arts Examination for the Chemistry prize, and carried off the silver medal for his year. In connection with the college a small band of students met together to read and discuss papers on various scientific subjects, and it was here that the present writer had the good fortune to make Mr. Davis' acquaintance, and to commence a lifelong friendship which deepened in mutual respect as years passed on, and with never a shadow of coolness or misunderstanding to mar it. Very shortly afterwards we were joined by Mr. Percy Sladen, F.L.S., and removing the scene of our studies to the Halifax Museum we entered upon a course of practical comparative anatomy, in which we were ably assisted by the resident Curator, Mr. Alexander Campbell, who in his youth had been associated with Professor Jamieson, of Edinburgh, and who possessed a sound knowledge of Osteology in all its branches. Here were dissected with youthful enthusiasm types representative of the chief classes of the animal kingdom. Parrots, crocodiles, serpents, apes, and last, but not least, a chimpanze were procured from a Liverpool dealer in foreign animals. At this time Mr. Davis excelled in the preparation of the skeletons of fishes, and no doubt acquired much skill and knowledge, which afterwards proved invaluable to him when he took up as a speciality the study of the Carboniferous fish remains. This Society became ultimately merged into a select company, meeting at the residences of its members in later years, and was joined by C. P. Hobkirk, F.L.S., J. Stubbins, F.R.M.S., and the late George Brook, Jun., F.L.S. Month by month the friends met in delightful intercourse to discuss new points of scientific interest as they arose from time to time, and to spend together in invigorating converse and genial fun cheerful hours, which doubtless are treasured up as precious memories by the survivors.

The visit of Professor Sollas, F.R.S., to Halifax, to lecture on Geology in connection with the University Extension Scheme, led to an intimate friendship which tended to strengthen Mr. Davis' growing partiality for Geological and Palæontological studies, as was evidenced by his forming the Halifax Geological Field Club, a Society which has flourished for more than twenty years, and still does excellent local work under the title of the Halifax Scientific Society. This, however, was not sufficient for the energetic personality of our friend, who began to add to the verification of the facts contained in Geological Text Books and Manuals, the practical study in the field of the phenomena presented by the cliffs, hills, mountains, and dales of his own county. For several years scarcely a week passed without journeys to one part or another of the county, observing, taking notes, making diagrams and sketches, and the whole culminated in the publication of his Geology and Botany of West Yorkshire, the Botanical portion of the work being written by Dr. F. Arnold Lees.

When the British Association held its annual meeting at Bradford, Mr. Davis became a member, and came into contact with the late Professor Philips, Dr. J. Gwyn Jeffreys, and other distinguished scientists, who fanned the flame of his increasing ardour for scientific work. From this time forward he attended most meetings of the Association, where he gathered around him a genial and friendly company of those like-minded with himself; he contributed papers almost yearly, and became an active member of Section C. The following year at the Belfast meeting he made the acquaintance of the late Lord Enniskillen and the late Sir Philip Egerton, who were attracted by his enthusiasm for their own special branch of palæontology, and who showed their friendly regard by laying open their rich cabinets for his study and heartily encouraging him in his work, and thus helped to confirm him in those Ichthyological researches which became his special department of scientific investigation.

What he managed to accomplish in this kind of work, notwithstanding scant leisure and amid a crowd of business, social, educational, and municipal engagements, is permanently recorded in his numerous contributions to the British Association Reports; the Proceedings of the Yorkshire Geological and Polytechnic Society; the Journal of the Geological Society of London; and particularly in the monographs published by the Royal Society of Dublin, viz., "On the Fossil Fishes of the Mountain Limestone of Great Britain" (1883); "On the Fossil Fishes of the Chalk of Mount Lebanon and Syria" (1887); and "On the Fossil Fishes of the Tertiary and

Cretaceo-Tertiary Formations of New Zealand" (1883). Even the dark days which slowly heralded the end of his labours were largely devoted to his beloved studies, and to the commencement of what promised to become the most brilliant of all his publications, a Monograph of "The Carboniferous Fishes," doubtless a vast undertaking, but we venture to think one which his enthusiasm, his energy, and large experience would have successfully grappled with had he been spared a few years longer. For it must be remembered that his own collections of the necessary material were very extensive, and that his knowledge of the specimens contained in the public and private collections of our own country was supplemented by a wide knowledge of the types to be found in almost every European Museum, and in many foreign private cabinets.

The objects for Mr. Davis' geological study were many of them collected by himself personally, in the field, for he was no mere closet and library geologist, but delighted to ramble, hammer in hand, wherever sections of the strata could be found, either in cliff, mine, quarry, railway cutting, hill or mountain side; and this brought him into contact with the shrewd and intelligent working men of his own county, and especially with the miners of the West Riding. He was always popular with the miners, who delighted to help him in his work, and to whom his genial, frank, manly nature strongly appealed, and to-day the mention of his name will evoke a spark of pleasurable recollection in the eyes of many a humble friend of his among the toilers in mine and quarry.

Our late Secretary was emphatically a Yorkshire geologist, of which profession two permanent records exist; first, his "West Yorkshire;" and second, his numerous annual contributions to our own Journal. Only those who were intimate with Mr. Davis have the faintest conception of the time, careful thought, and personal expenditure which he devoted to the interests of the Yorkshire Geological and Polytechnic Society. He was Secretary, Editor, Contributor, Whip, in short the very soul of it. Untiringly, continuously, he wrote papers, stimulated the younger members, persuaded whomsoever he came across who showed the least interest in geology to join the Society, corresponded freely with the honorary and permanent officials, whipped up the attendance at the meetings, sought out contributors and contributions, revised proofs, travelled the length and breadth of the county to find suitable objects for photographs, superintended the preparation of the plates, talked and wrote about the work to and for "all sorts and conditions of men," and, as it has been well expressed, "changed the state of affairs when some twenty years ago it was on the verge of dissolution, and by dint of enthusiasm and perseverance raised it to a prosperous and useful condition, and nearly quadrupled the number of its members."

Another admirable record of his energy is the "History of the Yorkshire Geological Society, 1837-1887," the jubilee volume, a work of nearly 500 closely printed pages, the sole work of his own hands, where, modestly writing little about his own efforts and sacrifices, he sketches the labours of the founders and the work of his contemporaries with generous recognition, and preserves to us in the character sketches much valuable information which must otherwise have inevitably perished.

At a general meeting of the members of the Society, held at Barnsley on April 27th, 1876, Mr. Jas. W. Davis was elected honorary secretary in place of Mr. L. C. Miall, who resigned. At the annual meeting following this election, held in October, 1876, the Secretary reported that the number of members had been increased to 115, and a debt for printing of more than £20, which had accumumulated up to the year 1870, had been paid off, and that a summary of the geological literature relating to the West Riding of Yorkshire had been prepared. In this year the Secretary organised a successful and interesting excursion to the Victoria Cave, near Settle, under the leadership of Mr. R. H. Tiddeman, M.A., F.G.S., who conducted the party to the cave, and explained its history and the important results obtained by its investigation, after which the large collection of prehistoric remains from the cave, which are deposited in the Giggleswick Museum, was visited. In 1877 Mr. Davis, in addition to his secretarial duties, read a paper on the unconformability of the Permian Limestone to the red rocks west of its escarpment in central Yorkshire, and every succeeding annual volume of our Proceedings has been enriched by one or more papers from his pen. At the meeting held at Huddersfield in October, 1877, he proposed and carried a resolution that the sphere of the Society's operations should be extended from the West Riding so as to embrace the whole of the county, and that the future title of the Society should be "The Yorkshire Geological and Polytechnic Society."

During 1878 the number of members was increased by 30 per cent. Meetings were held at Selby, Scarborough, and Wakefield; ten papers were contributed, and five additional local secretaries were appointed.

In 1879 the number of members reached 207. Three meetings were held, viz., at Barnsley, North Grimston, and Skipton. This year the Secretary obtained an addition to Rule vi. of the Society, viz., "That members may compound for their annual subscriptions, and become life members on payment of six guineas." The wisdom of this alteration is demonstrated by the response with which it has been met, and by the fact that the Society has now a capital sum of £350 safely invested as a provision against unexpected contingencies.

Perhaps the most notable excursion of this year was the one to Raygill to inspect a fissure in a limestone quarry, from which the bones of elephant, rhinoceros, bison, urus, hyæna, &c., had been obtained. At a succeeding meeting of the Council it was considered desirable that steps should be taken to secure a thorough investigation of the Raygill fissure and its contents, and Professors Green and Miall, with Messrs. Brigg and Davis, were appointed a committee, and empowered to collect subscriptions, to make necessary arrangements, and to carry out the exploration.

In 1880 four general meetings were held, viz., at Halifax, York, Middlesborough, and Leeds. At the annual meeting the Secretary had to report the number of members at 234.

During 1881 two meetings were held, one at Bradford, and one at Hull, from the latter place an excursion was made to Withernsea, when Prof. James Geikie explained the glacial phenomena of the district.

The three 1882 meetings were held, one at Dewsbury, one at

Harrogate, and one at Pontefract. The feature of the Harrogate meeting was a week's excursion in conjunction with the Geologists' Association of London, under the guidance of Mr. Huddleston, M.A., F.R.S., and Mr. Davis, when the geological features of interest in the neighbourhood of Harrogate, Knaresbro' and Plumpton, Skipton, Bolton Abbey, Malham, Gordale, Victoria Cave, Settle, Giggleswick, Clapham, Norber, and Horton in Ribblesdale were explored.

The Society's meetings in 1883 were held at Hull, Leeds, Ripon, and Halifax; the Hull meeting comprised a three days' excursion to Kilnsea, Spurn Point, Hornsea, and Skipsea. The examination of an ancient lake-dwelling was the chief point of interest, which is admirably described in a communication thereon by Mr. Davis in our Proceedings for that year.

Leeds and Harrogate were the centres at which the 1884 meetings were held. 1885 was marked by three meetings; held at Malton, York, and Leeds.

An excursion to Leyburn in Wensleydale, a meeting at Barnsley, and the Annual Meeting at Wakefield were held in 1886.

At the first General Meeting of 1887, held at Halifax, at the Hon. Sec.'s instigation a sum of Ten Pounds was devoted to the purpose of investigating a preglacial deposit near Bridlington, from which portions of a skeleton of Elephas had been obtained, the superintendence of the necessary excavation being entrusted to Messrs. Davis, Lamplugh, and Boynton.

During the summer an excursion was organised to Bridlington Quay, Sewerby, Speeton, Bempton, and Flamborough.

1887 was the 50th Anniversary of the formation of the Society and was celebrated by a Jubilee Meeting, which was held at the Town Hall, Ripon, on Saturday, the 22nd October, when the members of our Society expressed their high appreciation of the valuable and disinterested services rendered for many years by their Hon. Secretary by presenting to him a handsome Binocular Microscope, along with the accessory appliances suitable to the proper equipment of a geological worker.

The President, the Marquis of Ripon, K.G., LL.D., &c. occupied the chair and was supported by Prof. J. W. Judd, F.R.S., President of the Geological Society, London, Prof. A. H. Green, F.R.S., Prof. L. C. Miall, F.R.S., Prof. N. Bodington, M.A., and other distinguished scientific gentlemen, and was attended by most of the geologists of our county.

The Address, which accompanied the presentation, was as follows :—

To James W. Davis, Esq., F.G.S., &c., Chevinedge.

Dear Sir,—We, the undersigned members of the Yorkshire Geological and Polytechnic Society, have much pleasure in presenting you with a first-class large compound binocular microscope, with all necessary accessories, as a mark of the esteem in which we hold you personally, and as some little acknowledgment of the great services which you have rendered to the Society as Honorary Secretary and Editor of the Annual Proceedings during a period of twelve years ; to the ability and zeal which you have shown in this labour of love, as well as your personal efforts in generally promoting the welfare of the Society, and your uniform courtesy to the members, much of its present prosperous condition must be attributed ; and in the hope that you may long be spared to continue your labours, and enrich the Proceedings by your own valuable researches,

We subscribe ourselves,

October, 1887. (Signed) Ripon, President.

Three meetings were held in 1888, the first one at Leeds, where Professor A. H. Green, F.R.S., presided. After this meeting the Society had the pleasure of entertaining Professor Green at dinner at the Great Northern Hotel, on the occasion of his leaving the Yorkshire College to accept the chair of Geology at the University of Oxford. The second was a combined meeting and excursion. On August 29th the members of the Skipton Naturalists' and Scientific Association joined the members of our Society, who then proceeded by way of Thorpe to visit Elbolton Cave, afterwards to Burnsall, and returned by Barden Tower and Bolton Woods to Skipton. At the third meeting, held at Halifax, the Secretary reported that the Proceedings and Memoirs of some forty societies situate in various towns and cities of Europe, America, and even Australia, had been received in exchange for our Proceedings.

In 1889 three meetings were held at Malton, Hickleton, near Doncaster, and Leeds, at the latter meeting a grant of £5 was voted from the funds of the Society to Mr. G. R. Vine, to enable him to pursue his researches on the Fossil Polyzoa.

In 1890 our Hon. Secretary exerted himself successfully in promoting a subscription for funds to form a Memoral to the late Mr. S. A. Adamson, F.G.S., who had held the position of Local Secretary of our Society for the Leeds district. The Annual General Meeting of the Society was held at Halifax. At the British Association for the advancement of science which was held that year in Leeds Mr. Davis took an active part in the leadership of the geological excursions, particularly those to Flamborough and Bridlington.

In 1891 a united excursion of the members of the Geologists' Association, of London, with the members of this Society was made to the Yorkshire Coast, and extended from the 3rd to the 8th of August: the places of interest visited included Flamborough Head, Mr. Mortimer's Museum, Mr. Boynton's Ulrome Collections, Speeton, Filey Brig, Scarborough Museum, Castle Hill, Peak, Blea Wyke, Cloughton, Gristhorpe, Hackness, Hawsker, Whitby, and Malton. The Annual Meeting was held at Leeds. During this year Mr. Davis was elected a member of the Council of the Geological Society of London.

The printed records of our Society terminate with the volume for 1893, in which the Secretary's report concludes with an account of the business of the year 1892. Two meetings were held, the first at York, and the second, the Annual Meeting, at Leeds, on 14th December, 1892, when Mr. Davis strongly urged the claims of the Upper Wharfedale Exploration and particularly drew the attention of the Society to a resolution of the Council to this effect, viz., "That the Society be recommended to undertake the exploration of certain prehistoric remains in Upper Wharfedale; that a special subscription be raised for the purpose." This meeting was, I believe, the last General Meeting of our Society which our late Hon. Secretary attended. At this time the first premonitions of the coming trouble had been given, but it was hoped that by care and rest from some of the many varied and heavy duties which had fallen to his lot, and perhaps by change of scene and travel he would soon regain his wonted vigour. Mr. Davis spoke quite cheerfully about himself, and in his usual genial and jocose fashion made light of his own ailments.

The very brief sketch we have given of the Society's work during the many years that Mr. Davis held the Secretaryship, will indicate to some extent his versatility, his splendid organising power, and his great personal influence. That he was a man of broad views and many-sided gifts his numerous papers, written between 1874 and 1893, will show. They are not restricted to Fossil Fishes, for in perusing the long list of 60 contributions, which we append at the close of this memoir, it will be seen that his attention was given to such subjects as Physical Geology, Glaciation, Palæobotany, Cave Exploration, Prehistoric Man, Archæology, Lake Dwellings, &c.

In 1892 our friend, who had hitherto enjoyed splendid health and whose magnificent physique and active habits gave promise of a long and prosperous life, began to feel a diminution of energy, and symptoms of insomnia began to present themselves ; in spite of the wishes of his medical adviser and those of his most intimate friends he in his generous ardour for the public good pushed aside all mere personal considerations and accepted the Mayorality for a third time; doubtless his intense desire to see the completion of the Halifax Technical School for which he had laboured consistently, enthuiastically and persistently for several years, had much weight in determining this decision,—indeed his last visit to Halifax was paid in order to visit the school. A visit to Paris in May failed to give him the relief he sought for, he returned home, and afterwards spent some weeks at Grassington, where he seemed to somewhat recover his health ; leaving Grassington he removed to his favourite sea-side residence at Bridlington, and still feeling better he visited Halifax in July, where he stayed a day or two attending to various business and municipal duties, returning to Bridlington on the evening of Tuesday, the 19th July, on arriving there he wrote and posted some letters and then laid down on the couch, on his awaking from a short sleep it was found that he had lost the power of speech; rupture of a vessel in the brain was followed by paralysis, and after this, in spite of every effort of the best medical skill, the patient gradually became weaker and though retaining consciousness to the last was unable to hold any communication with his family or friends beyond what could be expressed by the language of the eyes; early on the morning of Friday, at about 3 o'clock, the end came, and a brave and noble presence passed from our midst. The sad news cast quite a gloom over Halifax, and, when it was known that its Mayor was no more, expressions of profound sympathy poured in from all sides. The President of our own Society, The Marquis of Ripon, the senior member for Halifax, the Right Hon. James Stansfeld, M.P., and the chief representatives of the numerous public and scientific institutions with which Mr. Davis had been associated hastened to condole with the bereaved family, and to testify to the deep-felt and wide-spread esteem and affection in which the memory of the deceased was everywhere held. As was fitting, a public funeral was accorded; one of the largest and most imposing ever seen in Halifax. The order of the procession was as follows:—

The Chief Constable, Mr. Pole.

The Police.

Workpeople from the Greetland Dyeworks.

Tradesmen and Burgesses.

Clergy and Ministers.

Trustees and Directors of the Halifax Equitable Benefit Building Society.

Members of the Halifax Mechanics' Institute.

Members of the West Vale Mechanics' Institute.

Members of the Halifax Board of Guardians.

Members of the Halifax School Board.

Members of Various Local Boards.

Elland Division Liberal Association.

Governors of Heath Grammar School.

Governors of the Crossley Orphanage.

Halifax Technical Institute Committee.

Halifax Literary and Philosophical Society.

Representatives of the Geological Society.
Leeds Geological Society.
Leeds Field Naturalists' Club.
Yorkshire Geological and Polytechnic Society.
Yorkshire Naturalists' Union.
Leeds Astronomical Society.
Governors of the Yorkshire College, Leeds.
Freemasons—Lodge of Probity (61) St. James' and other Lodges.
Halifax Chamber of Commerce.
Corporation Officials.
County and Borough Magistrates.
Members of Parliament.
Councillors.
Aldermen.
Deputy Mayor and Borough Treasurer.
The Mace.
The Hearse.
Mourners' Carriages.
Other Carriages.

The last ceremony took place at Salterhebble Church, and was most impressively conducted by Archdeacon Brooke, Canon Warneford, and Rev. G. T. Jowett.

The broad sympathetic frank genial nature of Mr. Davis everywhere won him friends; the silent reverent respect with which the crowds of people who lined the streets as the sad procession passed along bore evidence of this, and this feeling was manifested in various ways by all classes.

Only the briefest reference can here be given to his position as a public man apart from his career as a geologist. As an educationalist he was unwearied; he was for some years Chairman of the Scientific Committee of the Halifax School Board, and the chief promoter of the Halifax Technical School, in which to the last days of his useful life his active interest was intense; he introduced the Gilchrist Lectures to Halifax; he was for a time Secretary of the Yorkshire Fine Art Society; an active member and Chairman of Committee of the Yorkshire Naturalists' Union; held in due course the Chairmanship of the Halifax Literary and Philosophical Society, and of the Halifax Scientific Society; was a Governor of the Yorkshire College; and was thrice elected Mayor of Halifax; and in all these spheres of usefulness he has left a void which will not too easily be filled, but, of them all, none (except his own family) will feel his loss more keenly than our own Council and members, and none will longer miss than the writer

"The touch of a vanished hand
And the sound of a voice that is still."

WILLIAM CASH.

LIST OF MEMOIRS, PAPERS, &c., BY JAMES WILLIAM DAVIS, F.G.S.

1. Monthly analytical examination of the Harrogate Spas, 1872 [1873]. Pharmaceut. Journ. vol. iv. (1874), pp. 481, 482.
2. On a bone-bed in the Lower Coal-measures, with an enumeration of the Fish-remains of which it is principally composed. Quart. Journ. Geol. Soc. vol. xxxii. (1876), pp. 332-340.
3. West Yorkshire, by J. W. Davis and F. A. Lees. An account of its Geology, Physical Geography and Botany. Maps and plates, 8vo, London, 1878.
4. The Ichthyography of the Northern portion of the West Riding Coalfield. Proc. Mid. Inst. of Min. C. and M. Engineers, vol. vi. pt. xlii. p. 1. 1878.
5. The physical forces which have caused the present configuration of the Valley of the Calder in Yorkshire. GEOLOGICAL MAGAZINE, Dec. II. vol. v. (1878), pp. 500-508.
6. On the Occurrences of certain Fish-remains in the Coal-measures, and the evidence they afford of their fresh-water origin. Brit. Assoc. Rep. (1878), p. 539; Proc. Yorkshire Geol. Soc. vol. vi. (1879), pp. 40-52.
7. Erratic Boulders in the Valley of the Calder [1875]. *Ibid.* vol. vi. (1879), pp. 93-100.
8. The Stems and Roots of Fossil Trees in the Lower Coal-measures at Wadsley, near Sheffield [1876]. *Ibid.* vol. vi. (1879), p. 79.
9. Unconformability of the Permian Limestone to the Red Rocks west of its Escarpment in Central Yorkshire [1877]. *Ibid.* vol. vi. (1879), pp. 280-308.
10. Notes on *Pleurodus affinis*, sp. ined., Agassiz, and description of three spines of Cestracionts from the Lower Coal-measures [1878]. Quart. Jour. Geol. Soc. vol. xxxv. (1879), pp. 181-187.
11. On *Ostracacanthus dilatatus*, gen. et. sp. nov. . a Fossil Fish from the Coal-measures S.E. of Halifax, in Yorkshire. Brit. Assoc. Rep. (1879), p. 343; Proc. Yorkshire Geol. Soc. vol. vii. (1881), pp. 191-195.
12. On the source of the Erratic Boulders in the Valley of the River Calder, Yorkshire. GEOL. MAG., Dec. II. vol. vi. (1879), pp. 313-321; Proc. Yorkshire Geol. Soc. vol. vii. (1881), pp. 141-145.

13. Description of a New Species of Fossil Fish-spine, *Ctenacanthus minor*, from the Lower Coal-measures of Yorkshire. GEOL. MAG., Dec. II. vol. vi. (1879), pp. 531, 532.

14. On the Fish-remains found in the Cannel Coal, in the Middle Coal-Measures of the West Riding of Yorkshire, with the Descriptions of some Now Species (1879). Quart. Journ. Geol. Soc. vol. xxxvi. (1880), pp. 56-67.

15. On the Teleostean Affinities of the Genus *Pleuracanthus*. Ann. Mag. Nat. Hist. ser. 5, vol. v. (1880), pp. 349-357.

16. On a New Species of *Gyracanthus*, a Fossil Fish from the Coal-measures (*Gyrac. denticulatus*). *Ibid.* ser. 5, vol. vi. (1880), pp. 372, 373.

17. On the genus *Pleuracanthus*, Agass., including the genera *Orthacanthus* Agass. and Goldf., *Diplodus*, Agass., and *Xenacanthus*; Beyr. Quart. Journ. Geol. Soc., vol. xxxvi. (1880), pp. 321-336.

18. On a Group of Erratic Boulders at Norber, near Clapham, in Yorkshire [1880]. Proc. Yorkshire Geol. Soc. vol. vii. (1881), pp. 266-273.

19. On the Distribution of Fossil Fishes in the Yorkshire Coal-fields [1880]. *Ibid.* vol. vii. (1881), pp. 228-241; Proc. Geol. Assoc. vol. vi. (1881), pp. 359-370.

20. Report of the Raygill Fissure Exploration Committee [1880]. Proc. Yorkshire Geol. Soc. vol vii. (1881), pp. 300-305.

21. On the Exploration of a Fissure in the Mountain Limestone at Raygill. Brit. Assoc. Rep. (1881), pp. 645, 646.

22. On *Palæospinax priscus*, Egerton. Ann. Mag. Nat. Hist. vol. vii. ser. 5 (1881), pl. xx. pp. 429-432.

23. On the genera *Ctenoptychius*, Agassiz; *Ctenopetalus*, Agassiz; and *Harpacodus*, Agassiz. Ann. Mag. Nat. Hist. ser. 5, vol. viii. (1881), pp. 424-427.

24. Notes on the Fish-remains of the Bone-bed at Aust, near Bristol; with the Description of some New Genera and Species. Quart. Journ. Geol. Soc. vol. xxxvii. (1881), pp. 414-425.

25. On *Anodontacanthus*, a New Genus of Fossil Fishes from the Coal-measures; with Description of three New Species [*A. acutus, obtusus, fastigiatus*]. *Ibid.* vol. xxxvii. (1881), pp. 427-429.

26. On the Fossil Fish-remains from the Armagh Limestone in the Collection of the Earl of Enniskillen. Proc. Geol. Soc, vol. xxxviii. (1882), pp. 12, 13.

27. On the Fossil Fishes of the Carboniferous Limestone Series of Great Britain [1882]. Trans. Roy. Dublin Soc. Sci vol. i. (1883), pp. 327-600, plates xlii-lxv.

28. Notes on the Occurrence of Fossil Fish-remains in the Carboniferous Limestone Series of Yorkshire [1882]. Proc. Yorkshire Geol. Soc. vol. viii. (1884), pp. 39-63.

29. Description of a New Species of *Ptycholepis* from the Lias of Lyme Regis. Ann. Mag. Nat. Hist. series 5, vol. xiii. (1884), pp. 335-337, pl. x.

30. Biographical Notices of Eminent Yorkshire Geologists. i. John Phillips. Proc. Yorkshire Geol. Soc. vol. viii. pp. 3-20 (1882).

31. Description of a New Genus of Fossil Fishes from the Lias. *Ibid.* ser. 5, vol. xiii. (1884), pp. 448-453, pl. xvi.

32. On some remains of Fossil Fishes from the Yoredale Series at Leyburn in Wensleydale. GEOL. MAG., Dec. III. vol. i. (1884), pp. 91, 92.

33. On some Sections exposed during the Formation of the Line of Railway between Upton and Kirk Smeaton [1882]. Proc. Yorkshire Geol. Soc. vol. viii. (1884), pp. 107-113.

34. On a New Species of *Heterolepidotus* from the Lias. *Ibid.* vol. viii. (1884), pp. 403-407, pl. xxii.

35. On the Contortions of the Chalk at Flamborough Head. *Ibid.* vol. ix. (1885), pp. 43-49.

36. Note on *Chlamydoselachus anguineus*, Garman. *Ibid.* vol. ix. (1885), pp. 98-113, pl. xi.

37. On the relative age of the remains of Man in Yorkshire. *Ibid.* vol. ix. (1886), pp. 201-214.

38. On some remains of Fossil Trees in the Lower Coal-measures at Clayton, near Halifax. *Ibid.* vol. ix. (1886), pp. 253-256.

39. On the Exploration of the Raygill Fissure in Lothersdale. *Ibid.* vol. ix. (1886), pp. 280-281.

40. On some Fish-remains from the Tertiary Strata of New Zealand. Geol. Mag., Dec. III. vol. iii. (1886), pp. 93, 94.

41. Notes on a Collection of Fossil Fish-remains from the Mountain Limestone of Derbyshire. *Ibid.* vol. iii. (1886), pp. 149-157.

42. The Fossil Fishes of the Chalk of Mount Lebanon, in Syria. Trans. Royal Dublin Soc. vol. iii. (ser. ii.) 1886, pp. 467-636, pls. xiv.-xxxviii.

43. On *Chondrosteus acipenseriodes*, Ag. Quart. Journ. Geol. Soc. vol. xliii. (1887), pp. 605-616, pl. xxiii.

44. On the ancient Flint-users of Yorkshire. Proc. Yorkshire Geol. Soc. vol. ix. (1887), pp. 411-425.

45. Note on a Fossil Species of *Chlamydoselachus*. Geol. Mag., Dec. III. vol. iv. (1887), pp. 392, 393. Proc. Zool. Soc. Lond. (1887), pp. 542-544

46. Note on a Species of *Scymnus* from the Upper Tertiary Formation of New Zealand. Geol. Mag., Dec. III. vol. v. (1888), pp. 315, 316.

47. On Fossil Fish-remains from the Tertiary and Cretaceo-Tertiary Formations of New Zealand. Trans. Royal Dublin Soc. ser. ii. vol. iv. (1888), pp. 1-48, pls. i-vii.

48. History of the Yorkshire Geological and Polytechnic Society, 1837-1887. Proc. Yorkshire Geol. Soc. vol. x. (1889), pp. i-ix., 1-479.

49. The Lake-Dwellings of East Yorkshire. *Ibid.* vol. xi. (1889), pp 101-113.

50. Summary of Geological Literature relating to Yorkshire published during 1888. *Ibid.* vol. xi. pt. i. (1889), pp. 128, 129.

51. On the Fossil Fish of the Cretaceous Formations of Scandinavia. Trans. Royal Dublin Soc vol. iv. ser. ii. (1890), pp. 363-434, pls. xxxviii.-xlvi.

52. Fossil Fish-remains from Carboniferous Shales at Cultra, co. Down, Ireland. Proc. Yorkshire Geol. Soc. vol. xi. pt. ii. (1890), pp. 332-334.

53. Summary of Geological Literature relating to Yorkshire published during 1889. *Ibid.* vol. i. pt. ii. (1890), p. 344.

54. On the Dentition of *Pleuroplax* (*Pleurodus*) A. S. Woodw. Ann. Mag. Nat Hist. ser. vi. vol. v. (1890), pp. 291-294, pl. xiii.

55. On *Cœlacanthus Phillipsii*, Agassiz. Geol. Mag., Dec. III. vol. vii. (1890), pp. 159-161.

56. Yorkshire Naturalists' Union at Bretton Park. Naturalist, (1890), pp. 223-227.

57. On a New Species of *Coccodus* (*C. Lindströmi*, Davis). Quart Journ. Geol. Soc. vol. xlvi. pp. 565-568, pl. xxii.

58. On the Discovery of a New Species of Fossil Fish (*Strepsodus Brockbanki*) in the Upper Coal Measures Limestone of Levenshulme, near Manchester. Mem. and Proc Manchester Lit and Phil. Soc. [4] vol iv. 1891 (reprint paged 1-3), Geol. Mag., Dec. III. vol. viii. (1891), p. 465.

59. On some Sections in the Liassic and Oolitic Rocks of Yorkshire. Proc, Yorkshire Geol. Soc vol. xii. part ii. (1892), pp. 170-214.

60. On the Fossil Fish-remains of the Coal Measures of the British Islands. Part i. *Pleuracanthidæ*. Trans. Royal Dublin Soc. Sci. [2] vol. iv. (1892), pp. 703-748, plates lxv.-lxxiii and Geol. Mag., Dec. III. vol. x (1892), pp. 72-75.

POSTHUMOUS—On the Fossil Fish-remains of the Coal-measures of the British Isles, Part II; Acanthodidae. Dublin (Trans. Roy. Soc.) 1894. 4. 10 pg. w. 3 plates.

THOMAS WILLIAM EMBLETON.

Thomas William Embleton was the son of Thomas Embleton, and was born at Newcastle-on-Tyne, October 4th, 1809. He was educated at the Witton-le-Wear Grammar School, afterwards entering the University of Edinburgh. He served an apprenticeship to his uncle, Mr. George Hill, of Kenton, who had an extensive practice as Mining Engineer to the Gosforth and other collieries. At the early age of twenty-one years, in 1830, he succeeded Mr. Blenkinsop in the management of the Brandling Collieries, at Middleton, near Leeds, a position which he retained until 1865. Blenkinsop was from the North, and earnestly devoted himself to the problem of mechanical haulage, in 1811 patenting a locomotive engine with two double-acting cylinders and working on a toothed rail. The operations of these engines at the Middleton Collieries were for many years a source of much interest and wonder to the public, as they were the first instances of the regular employment of locomotive power for commercial purposes. Mr. Embleton made several improvements in the engines, and was the first to turn the steam into the funnel, with the result of increased draught and greater development of power.

In 1865, Mr. Embleton's connection with the Middleton Collieries ceased, and in the following year he took charge of the extensive collieries belonging to Messrs. J. and J. Charlesworth, retaining this engagement until 1888. During this period he was responsible for the sinking of several new shafts to different seams. As a Consulting Engineer he acted for the Earl of Mexborough, Mr. George Lane Fox, and the Wharncliffe Silkstone Colliery. He was also a partner in the Monkbretton Colliery, and directed the sinking of its pits. In difficulties connected with colliery management his advice was much sought, and where questions of trespass, damage from subsidence, &c., arose, his opinion was always received as coming from one who spoke with great experience and authority. In the terribly trying times when explosions claimed their holocaust of victims, Mr. Embleton's advice was especially valued. Thus, after the explosion at the Oaks Colliery, Barnsley, on December 12th, 1866, he was called in, with other eminent mining engineers, to control the recovery of the workings. He contributed to the Midland Institute of Mining Engineers a very interesting paper on the steps adopted for this end, with registers of the readings of the barometers, thermometers, and pressure gauges during a period of ten months. Mr. Embleton was a member of the North of England Institute of Mining and Mechanical Engineers, from the year 1855, contributing various papers to its Transactions.

Mr. Embleton's connection with the Yorkshire Geological and Polytechnic Society forms a thread which begins with the organization of the Society and runs without interruption for fifty-six years. In the History of the Society by the late Hon. Sec., Mr. J. W. Davis, published in 1889, the author acknowledges his indebtedness to Mr. Embleton for the most important facts connected with its earliest years. It was his habit to preserve particulars of Meetings of the Council and of the Society, and it was from notes taken by him that reports of its earlier gatherings were furnished to the newspapers. It was on the proposition of Mr. Embleton that a preliminary meeting of Coalowners, held at Wakefield, on December 1st, 1837, adopted the initial steps for founding "The Geological Society of the West Riding of Yorkshire." The late Mr. Thomas Wilson, M.A., was the first Hon. Sec., and he received from Mr. Embleton the most cordial co-operation in the details of organization. The Society's object was declared as "Collecting and methodising Geological and Mechanical Information in connection with the Coal Fields of Yorkshire."

At about this period Mr. Embleton conducted several of his colleagues in expeditions in the Middleton coal pits, under his management, and in other collieries. The result was the discovery of fossil remains of fishes, &c. The head of Megalichthys Hibberti had been found at Low Moor a few years earlier. This classical specimen was described by Professor Louis Agassiz, after it came under his notice during the visit which he paid with Professor Buckland, in 1824, to the Museum of the Leeds Philosophical and Literary Society.

Amongst geologists outside Yorkshire who watched with interest the birth of the new Society, none offered more hearty co-operation than Professor Johnston, of Durham. His name had been added to those of Dr. William Smith and Professor John Phillips as Honorary Members. Professor Johnston held the view of the need of enlarging the scope of the Society so as to embrace whatever concerned the operations of mining, and he adopted the term Polytechnic to describe this branch of knowledge.

By correspondence with Mr. Embleton and other friends in Yorkshire, Prof. Johnston was enabled to complete his materials for a lecture representing the existing conditions of the industry of Coal-mining. This was delivered at the second meeting of the Society, held at Wakefield, in June, 1838, being subsequently printed as a pamphlet and circulated amongst the Members. Mr. Embleton's letters to the lecturer are published, and are very interesting and suggestive on such points as the relations of the Middleton, Lofthouse, and Haigh Moor beds, and on the varying behaviour of candle-flame in air charged with fire-damp. Mr. Embleton described to the Society the resinous mineral Middletonite, discovered at Middleton Colliery about 1831. He brought this substance under the notice of the British Association at its meeting in Newcastle-on-Tyne, in 1838.

At the meeting of the West Riding Geological Society, held March, 1839, Mr. Embleton read a paper on "The Strata between the Bradford Rock and the Forty Yards Coal at Middleton," illustrated by a number of specimens of the rocks passed through in sinking a shaft from the surface to the first workable coal in the Middleton Colliery. Much importance was attached by the author to the careful observation and comparison of any fossils found in the roof of the coal. At the meeting held in May, Mr. Embleton and another Member were requested to confer with the Lancashire Society on the scales to be adopted for sections and plans. In June, he called the attention of a meeting at Sheffield to the need for a Geological Survey of the County on a large scale, moving the adoption of a petition to the House of Commons for a new Ordnance Survey of the Northern Counties on a scale of six inches to the mile. The petition was adopted.

In December, the Society met in Leeds, under the presidency of the Vicar, the Rev. W. F. Hook, D.D., who had been invited through Mr. Embleton to occupy that position. Dr. Hook gave an unhesitating and most cordial approval to the objects of the Society. Mr. Embleton's paper dealt with the succession of the strata in the Northern Yorkshire Coal Field, as represented in the seams of coal in the Townships of Whitwood, Methley, Stanley, Wrenthorpe, Lofthouse, Ardsley, Middleton, and Beeston. The paper was loaded with information. One interesting fact from the colliery under Mr. Embleton's personal supervision may be reproduced, as showing the thinning away of sandstone strata. Two of the Middleton pits are 300 yards apart; in one the quarry-stone or rock is 16 yards thick, in the other only two yards, although the depth from the surface to the first seam is the same at both pits.

In January, 1840, Mr. Embleton and two colleagues attended as delegates a meeting of the Manchester Geological Society, and were elected Honorary Members of the Society. The meeting discussed and finally accepted, on the proposition of Mr. J. Hawkshaw, a scheme for sections of the Lancashire and Yorkshire Coal Fields. The decision upon the line of Yorkshire section demanded and received very careful balancing of not less than three alternatives, the ultimate selection giving a section 25 miles in length and comprising between 3000 and 4000 feet of strata. It commenced at Northowram and finished in the Barnsley district. The portion relating to Bretton, Crigglestone, and Woolley was undertaken by Mr. Embleton and Mr. Morton. In December 1842, these gentlemen had completed their self-imposed labours, and the reports of other observers showed that more than one-third of the whole section had been finished. The construction of the North Midland and the Lancashire and Yorkshire Railways about this period afforded rare opportunities for the inspection of the geological features of various cuttings, and many excursions were made for this purpose. How greatly this voluntary labour was in advance of the action of the State is seen in the long interval before the Geological Survey of the West Riding Coal Field was systematically commenced (1866-7) under the able superintendence of Professor A. H. Green, whose complete report was issued in 1878, and cordially acknowledges the valuable assistance derived from the information given by colliery owners and other earlier observers.

The year 1844 saw a transference of the Society's Museum from Wakefield, where the cost of its separate maintenance had been found too onerous for the finances, to the custody of the Leeds Philosophical and Literary Society, in whose Museum the specimens were deposited. By the arrangement mutually concluded between the two Societies, the joint curatorship was vested in Mr. J. G. Marshall and Mr. Embleton.

At the meeting held in March, 1865, Mr. Embleton introduced the new hydraulic coal-cutting machine, invented by Messrs. Carrett, Marshall & Co., of Leeds, which had given some encouraging results in trials made at Kippax Collieries. In 1866, the Annual Meeting was held at Wakefield, under the chairmanship of Mr. Embleton, who delivered an address on "The History of Ancient Coal Mining," which will be found printed in the Proceedings.

In 1869, Mr. Embleton was elected President of the Midland Institute of Mining, Civil, and Mechanical Engineers, an office which he filled on three occasions. In 1891, he was called to the post of President of the Federated Institution of Mining Engineers. When the Coal Mines Regulation Act of 1872 was passed, Mr. Embleton was appointed one of the three Examiners for the Yorkshire and Lincolnshire Mining District, and he continued most assiduously to perform the duties of this important office.

After entering upon his seventy-first year, Mr. Embleton was initiated a Freemason, and passed through many degrees of the craft. He was a munificent donor to the Masonic charities.

Mr. Embleton died at his residence, The Cedars, Methley, near Leeds, on November 8th, 1893, aged 84 years. Thus passed from our midst a familiar and venerable figure, endowed with a vigorous intellect and will, and the repository of large stores of ripe professional experience. He was such a link between the past and present as we seldom meet with, for he had been engaged on practical improvements in locomotive engines at the date of the opening of the Liverpool and Manchester Railway. As regards loyalty to the Yorkshire Geological and Polytechnic Society, Thomas William Embleton was as constant in his support when answering the summons to its Council Meetings in 1893, as when, in 1837, he moved the resolution which resulted in its foundation. R. REYNOLDS.

Statement of Receipts and Expenditure of the Yorkshire Geological and Polytechnic Society, 1892-93.

Receipts.	£	s.	d.	Expenditure.	£	s.	d.
To Balance in Treasurer's hands, 30th Nov., 1892	9	11	8	By Whitley and Booth—Printing Account	20	0	0
,, Subscriptions	48	6	10	,, Secretarial and Sundry Expenses to date	12	8	10
				,, Balance in Treasurer's hands, 31st Dec., 1893.	25	9	8
	£57	18	6		£57	18	6

CAPITAL ACCOUNT.

	£	s.	d.	
To Halifax Corporation Bond	350	0	0	Audited and found correct, 30th December, 1893.
,, Cash at Bank, 31st Dec., 1893 ...	39	17	4	GEO. PATCHETT, Jun.
	£389	17	4	

WHARFEDALE EXPLORATION FUND.

	£	s.	d.		£	s.	d.
To Subscriptions to 31st Dec., 1893 ...	47	2	9	By Stanford (Maps)	1	9	6
				,, Expenses of Excavating Wages, &c.	22	8	6
				,, Balance in hands of Treasurer, 31st Dec., 1893	23	4	9
	£47	2	9		£47	2	9

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*** It is requested that Members changing their residences will communicate with the Secretary.

METEOROLOGY OF BRADFORD FOR 1893.

Sheet 1.

Computed from daily observations made at the Exchange, Bradford, by John McLandsborough, M. Inst. C.E. retired., F.R.A.S., F.R.Met.Soc., F.G.S., and Alfred Eley Preston, M. Inst. C.E., F.R.Met.Soc., F.G.S.

Latitude, 53deg. 47min. 38sec. N.; longitude, 1deg. 45min. 4sec. W. Height above mean sea level, 366ft.

Months.	Pressure of Atmosphere in Month.											Temperature of Air in Shade during Month. In Each Month.									Daily Mean. In Each Month.				Daily Mean. Range.		Daily Mean. Of Dry Bulb.	
	Highest Reading of Barometer.	Date.	Highest during 25 Years.	Mean of Highest of 25 Years.	Lowest Reading of Barometer.	Date.	Lowest during 25 Years.	Mean of Lowest of 25 Years.	Range.	Corrected for Capillarity and Temperature. Mean.	Corrected. Mean of 25 Years	Highest.	Date.	Highest during 25 Years.	Mean of Highest of 25 Years.	Lowest.	Date.	Lowest during 25 Years.	Mean of Lowest of 25 Years.	Range.	Of all Highest.	Mean of 25 Years.	Of all Lowest.	Mean of 25 Years.	Mean.	Mean of 25 Years.	Mean.	Mean of 25 Years.
	Ins.	On	Ins.	Ins.	Ins.	On	Ins.	Ins.	Ins.	Ins.	Ins.	Deg.	On	Deg.	Deg.	Deg.	On	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.
January	30 059	4th	30 544	30 171	29 078	29th	28 070	28 717	0 972	29·631	29 524	51·3	31st	57·2	52 8	19 0	5th	6 7	23·0	32·3	40 8	42 8	33 7	34 2	7 1	8 6	38 0	39 1
February	29 994	6th	30·412	30 104	28·300	26th	28 360	28 806	1 694	29·209	29 5·9	56·5	20th	59 8	53 4	26 9	28th	18·8	26 2	29 6	45 3	44 1	36 2	35·3	9 1	8 8	40·2	39 6
March	30 104	26th	30 476	30 137	29·034	1st	28·175	28 798	1 070	29·640	29 501	62 0	13th	66 0	57 1	27 2	19th	17·4	25 7	34 8	52 5	46 4	38·0	35 3	14 5	11·2	44 5	40 5
April	30 234	8th	30 500	30 069	29 560	29th	28 332	28 894	0 674	29 786	29 492	70·0	25th	74·0	63 7	31 2	12th	25·0	31·1	38 8	59 2	52 5	40 8	39 3	18 4	13 3	47 8	44 6
May	30·130	6th	30 382	30 060	29 192	18th	28 661	29 043	0 938	29·660	29 544	70 2	5th	83·9	70 4	40·4	7th	28·6	35·1	29 8	62 5	58 5	47·3	44·1	15·2	14 4	53·8	49·9
June	30 044	7th	30 300	30 031	28 928	23rd	28 840	29 115	1 166	29·694	29 565	83 8	19th	87 8	77 1	46·2	1st	38·0	41·9	37·6	66·5	65·0	51·8	50·2	14·7	14·9	58·2	55·9
July	29·922	28th	30 305	29 975	29 180	20th	28 690	29 149	0 742	29·485	29 512	80 5	9th	89 6	79 3	49 6	16th	42·0	46 6	30·9	67 8	67·8	54·5	55·7	13·3	14·1	59 8	59 8
August	30 012	19th	30 232	29 970	29 136	21st	28 670	29 060	0 876	29·574	29 498	85·0	19th	85 2	78 2	46·2	6th	38·6	45·2	38 8	70·6	66 9	56·7	53 2	13 9	13 7	62·9	58·9
September	29 992	12th	30·232	30 073	28·824	29th	28 452	29 009	1 168	29·418	29 516	71 9	6th	81 3	70 9	40·0	23rd	33 5	40·2	31 9	61 6	62 0	50 0	49 7	11 5	12 3	56 4	54 7
October	30·096	23rd	30 394	30 124	28 708	4th	28 250	28·737	1 388	29 426	29 445	64·1	16th	69 9	63 0	31 2	31st	16·7	32 4	32 9	55 9	53 8	45 1	43 3	10 8	10 5	49 8	48 2
November	30 148	21st	30 376	30 062	28 540	17th	28·060	28 670	1·608	29 587	29 456	55 0	4th	61 5	56 4	29 6	19th	23·0	26 7	25 4	46 5	47 3	37 6	38 4	8 9	8 9	41 9	42 8
December	30 358	30th	30·358	30 120	28 410	13th	27·652	28 675	1 948	29 429	29 477	52 8	14th	57 8	53 1	25 0	2nd	13 2	22 9	27·8	46 5	42 7	37 7	34 2	8 8	8 6	42·6	39 0
Means, or totals	30 095		30 376	30 074	28 908		28·346	28 893	1 187	29 537	29·504	66 9		72 8	64 6	34 4		26 0	33 2	32·5	56 3	54 2	44 1	42 6	12 2	11 6	43 6	47 8

Months.	Adopted Mean Temperature. Of Air.		Of Evaporation.		Dew Point.		Vapour. Elastic Force.		In a Cubic Foot of Air.				Mean Weight of a Cubic Foot of Air.	Mean of 25 Years.	Degree of Humidity. (Complete Saturation 100.)									
	Mean.	Mean of 25 Years.	Mean.	Mean of 25 Years.	Mean.	Mean of 25 Years.	Mean.	Mean of 25 Years.	Mean.	Mean of 25 Years.	Short of Saturation.	Mean of 25 Years.			Highest.	Date.	Highest during 25 Years.	Mean of Highest of 25 Years.	Lowest.	Date.	Lowest during 25 Years.	Mean of Lowest of 25 Years.	Mean.	Mean of 25 Years.
	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Ins.	Ins.	Grs.	Grs.	Grs.	Grs.	Grs.	Grs.	0 100	On	0 100	0 100	0 100	On	0 100	0 100	0 100	0 100
January	37 5	38 7	35 8	37 0	33 5	34 7	·192	·203	2 3	2 3	0 4	0 4	5 2	549	98	9th	100	97	65	31st	34	55	86	88
February	40 2	39 4	38 3	37 7	35 8	35 4	·211	·208	2 4	2 4	0 5	0 4	511	548	97	20th	100	97	55	19th	42	66	85	86
March	44 4	40·1	41 1	37 7	37 3	34 7	·222	·202	2 6	2 3	0 8	0 6	545	547	98	1st	99	96	41	28th	28	55	75	82
April	48 1	44·6	43 8	41 2	39 1	37 3	·238	·225	2 7	2 6	1 1	0 8	544	542	94	[illegible]	100	96	37	25th	31	51	71	77
May	53·5	49 7	48·9	45·4	44 3	41·3	·292	·261	3·3	3·0	1·3	1·1	535	537	89	17th	99	92	40	10th	30	44	71	73
June	57·8	55·8	52 9	51·3	48·5	46·9	·341	·322	3 8	3·6	1·6	1·4	529	531	93	3rd	100	93	43	16th	32	47	71	72
July	59·5	59 6	54·7	54·1	50·4	49 8	·367	·359	4 1	4·0	1·6	1·7	525	526	96	25th	99	91	47	7th	36	48	72	70
August	62 5	58 6	56 7	54·0	51·7	50·1	·385	·363	4·3	4·1	2·0	1·6	524	526	97	3rd	99	92	46	21st	41	51	69	71
September	54 9	54 8	50 9	51 4	47 1	48 0	·323	·336	3 7	3 8	1 2	1 1	529	531	91	18th	99	95	43	12th	38	54	75	78
October	49 6	47 8	46 3	45 4	42 8	42 5	·276	·274	3 1	3 1	0 9	0 7	535	537	94	4th	99	97	58	5th	49	61	77	82
November	41·8	42 5	39 5	40 3	36 6	37 6	·219	·226	2 5	2 6	0 6	0 5	547	544	95	18th	100	96	61	16th	43	63	83	83
December	42 3	38 7	40 3	36 8	37 9	34 3	·228	·199	2 6	2 3	0 5	0 5	543	548	98	25th	100	97	66	2nd	44	63	85	84
Means, or totals	49 3	47 5	45 8	44·4	42 1	41·0	·274	·265	3 1	3 0	1 0	0 9	537	539	95		100	95	51		37	56	77	79

Months	Bright Sunshine. Greatest Daily Duration.	Date.	Total of Month.	Per cent. of Possible Duration.	Temp. of Air in Sun's Rays. Highest.	Date.	Mean.	Wind. Direction: Relative Proportion of at 9 a.m. N.	NE.	E.	SE.	S.	SW.	W.	NW.
	hr min	On	hr min		Deg.	On	Deg.	No.	No.	No.	No.	No.	No.	No.	No.
January	0 60	16th	2 15	1	67 5	31st	56 3	3	3	3	2	1	6	7	6
February	3 45	9th	21 45	8	82 0	20th	63 7	2	1	3	3	3	10	3	3
March	7 40	13th	43 5	13	101 6	13th	79 2	5	0	2	1	1	5	12	5
April	11 25	23rd	150 0	36	104 5	3rd	90 7	2	8	7	3	1	2	5	2
May	13 0	10th	132 45	27	109·0	23rd	98·6	2	6	6	1	1	7	5	3
June	12 20	19th	123 25	24	109 0	17th	97·2	2	8	4	2	1	4	3	6
July	10 40	6th	123 6	24	105·0	2nd	98·8	5	4	4	3	1	4	7	3
August	11 0	22nd	163 10	36	117 8	19th	104·[illegible]	2	1	1	1	3	9	11	3
September	7 20	22nd	48 5	26	104·8	6th	91·7	3	2	0	0	6	7	8	4
October	7 45	1st	50 50	28	100·0	1st	79·0	0	1	0	0	0	19	8	3
November	4 0	1st	22 40	9	77 0	5th	63·0	7	4	3	1	0	7	4	4
December	2 10	2nd	6 30	3	66·0	17th	58·0	0	1	1	3	4	8	11	3
Means, or totals.	7 40		980 36	22	95·4		81·7	33	39	34	20	22	88	84	46

Months	Wind. Velocity. At 9 a.m. Mean.	Highest.	Date.	During 24 hours. Mean.	Mean of 7 years.	Highest.	Date	Highest of 7 years.	Total Registered in Month.	Mean of Monthly T't'l of 7 yrs.	Highest Monthly T't'l of 7 yrs.	Pressure. Mean of all Daily Highest.	Mean of all Daily Highest in 10 Years.	Highest.	Direction.	Date.	Mean of Highest of Month of 10 Years.	Mean Amount of Cloud.
	Miles p'r hr	Miles p'r hr.	On	Miles per d.	Miles per d.	Miles per d.	On	Miles per d.	Miles.	Miles	Miles.	lb. per sq. ft.	lb. per sq. ft.	lb. per sq. ft.		On	lb. per sq. ft.	0—10
January	6·5	15 6	26th	134	155	263	31st	439	4151	4806	6724	1·25	2·72	4·6	W N W	21st	11 02	7·8
February	7 6	19·2	10th	174	161	353	10th	462	4662	4570	5488	3 67	2 63	13 0	W	8th	9 80	7·0
March	5 8	13·3	17th	134	158	317	2nd	559	4156	4904	5803	2 64	2·27	10 2	W	2nd	9 32	6 7
April	3·7	13·3	30th	96	143	282	30th	359	2876	4292	5569	1·17	2·08	4·0	W S W	30th	7 57	4 2
May	6·2	12 2	1st	115	146	214	8th	376	3572	4521	6349	1·62	2 18	4 3	W	1st	7 15	5 7
June	4·8	15·0	28th	105	132	282	29th	282	3159	3954	4764	1 34	1·62	4·3	S W	29th	5 85	5·8
July	6·0	11·4	17th	127	137	250	18th	359	3924	4251	4771	1·73	1·78	6 6	S	10th	6·16	6·8
August	6 2	14 8	21st	138	132	306	22nd	493	4276	4082	4603	2 31	1·53	5 2	S W	22nd	7 29	5 5
September	5·9	15 2	19th	132	137	381	29th	381	3965	4111	4873	2·06	2·01	8 0	W S W	14th	6 35	6 2
October	6·4	14·2	26th	139	148	328	26th	390	4301	4586	6127	2·45	2·27	12·6	W S W	29th	8·83	5 5
November	7 4	18·8	18th	187	152	490	19th	490	5449	4551	7853	4 06	2 41	13 2	W N W	19th	9·73	7·5
December	8·3	20 6	8th	175	139	370	25th	370	5440	4310	5440	3 67	2 58	9 2	W	14th	9 58	7·4
Means, or totals.	6·1	15·3		138	145	320		413	50131	52938	5530	2 33	2 20	7·8			8 22	6·3

Months	Rain. Number of Days it fell.	Greatest Daily Fall.	Date.	Amount Collected.	Mean of 24 Years.	Mean of Seven Years ending with 1882, 65½ft above surface of ground	Mean of 7 Yrs endg. with 1882 at T'n Hall and Mid. Ry Station on surface of ground.	Gr'ter fall on surface at Town Hall & Mid. Stn than at 65½ft. above surface at Exch. Depth in Inches.	Percentage of fall at Exch'ge
	No.	Ins.	On	Ins.	Ins.	Ins.	Ins.	Ins.	Per cent
January	9	0 23	7th	0·66	2·51	2 209	2 474	0 265	11·2
February	21	0 77	10th	3·25	1 85	2 609	2 972	0 363	11 4
March	7	0 37	1st	0.97	2 06	2 776	3 260	0 484	11·7
April	5	0 26	2nd	0·61	1·86	2 516	2 835	0 319	11 2
May	11	1·18	18th	2 10	1·92	2·103	2 277	0 174	10 8
June	11	0·66	27th	1·82	2·24	2 837	3 011	0 174	10 6
July	17	0 67	12th	3·01	2·84	3·401	3 641	0 240	10 7
August	16	0 28	10th	1 37	2 63	3 654	3 892	0 238	10 7
September	15	0·51	27th	1·73	2·54	2 894	3 229	0 335	11 2
October	16	0·57	5th	1·94	3 52	3 640	4 012	0 372	11·0
November	22	0·31	2nd	1·31	2·79	3 421	3 828	0 407	11·2
December	23	1 04	13th	3·92	2·64	3 881	4 170	0 489	11·3
Means, or totals.	173	0·57		22·67	29·50	35·741	39 601	3 860	11·08

METEOROLOGY OF BRADFORD FOR 1893.

YEARLY MAXIMUM AND MINIMUM ATMOSPHERIC PRESSURE, TEMPERATURE, HUMIDITY, BRIGHT SUNSHINE, WIND PRESSURE, AND RAINFALL.

Year.	PRESSURE. Highest. Reading of Barom during Year	Date	PRESSURE. Lowest. Reading of Barom during Year.	Date.	TEMPERATURE. In Shade. Highest. R'ding of Maximum Thermom during Yr.	Date.	In Shade. Lowest. R'ding of Minimum Thermom. during Yr.	Date.	Last and First Frost of Seasons. Date of Last Frost.	Date of First Frost.	In Sun's Rays. Highest. Reading of Solar Thermom. during Yr.	Date.	HUMIDITY. (Complete Saturation = 100) Highest. Degree of Humidity during Yr.	Date.	Lowest. Degree of Humidity during Yr.	Date.	BRIGHT SUNSHINE. Greatest Daily Duration.	Date.	Total of Year.	Per cent of Possible Duration.	WIND PRESSURE. Highest.	Date	RAIN. Total for Year	Mean Y'rly Rainfall at Town Hall and Mid Rly Stn on surface of g'nd	Gr'tr fall on srfce at Tn H'll & Mid Stn than at 65½ ft ab've surf at Exc. Depth in Inches.	Percentage of fall at Exch'ge	Greatest Daily Fall during Yr	Date.	Snow. Last and First Snow of Seasons. Date of Last Snow	Date of First Snow.
	Ins		Ins		Deg.		Deg.				Deg.		0—100		0—100		hr. min.		hr. min.		lb per sq. ft.		Ins.	Ins.	Ins.	Per cent	Ins.			
1869	30 290	Dec. 6	28 600	Feb. 1	85 2	Aug. 30	19·8	Dec. 28	Mar. 27	Oct 20	127 7	Aug. 30	99	Feb. 8	42	Sep. 24	......	......	......	......	......	......		......	......	......	......	......	April 3	Oct. 19
1870	30 284	Jan. 19	28 308	Jan. 8	85·0	July 25	16·6	Dec. 23	Mar. 30	Nov. 9	127 5	July 25	98	Jan. 29	28	Mar. 8	......	......	......	......	......	......	24 120	......	......	......	0 820	June 18	Mar. 24	Nov. 15
1871	30 162	Mar. 28	28 308	Jan. 16	84·0	Aug. 12	6·7	Jan. 1	April 11	Nov. 13	128 7	July 17	98	July 7	43	Nov. 2	......	......	......	......	......	......	21 640	......	......	......	0 985	June 16	Mar. 15	Nov. 16
1872	30 166	April 6	28 070	Jan. 24	86 4	July 23	24·8	Mar. 27	Mar. 27	Nov. 19	124 8	Aug. 19	100	Mar. 22	45	Sep. 23	......	......	......	......	......	......	42 060	......	......	......	2 490	June 19	May 11	Nov. 13
1873	30 338	Feb. 18	28 022	Jan. 20	88·8	July 23	19·2	Feb. 24	Mar 14	Nov. 5	124 5	July 23	100	Dec. 11	41	Mar. 26	......	......	......	......	......	......	21 440	......	......	......	1 200	Aug. 4	April 26	Jan. 3, '74
1874	30 476	Mar. 6	28·276	Dec. 11	80 9	July 20	15·0	Dec. 31	Mar. 12	Nov. 11	125·8	July 20	100	Feb. 6	42	May 18	......	......	......	......	......	......	23 560	......	......	......	0 740	Dec. 7	May 9	Nov. 26
1875	30 305	July 7	28·484	Nov. 10	80·0	Aug. 17	13·0	Jan. 1	Mar 22	Nov. 26	122·0	July 5	100	Jan. 23	43	July 6	......	......	......	......	......	......	30 280	......	......	......	1 700	Nov. 15	Mar 12	Nov. 9
1876	30 300	Jan. 15	28 070	Dec. 4	87 6	July 17	23 0	Jan. 9	April 15	Nov. 9	125 6	July 16	99	Oct. 4	46	May 5							35 270	39 788	4 618	11 28	1 610	Oct 9	April 12	Nov. 8
1877	30 358	Oct 6	28 300	Nov. 29	80 0	June 19	20·0	Mar 1	May 4	Oct. 18	116 4	June 19	100	Oct. 29	35	May 23							40 650	45 499	4 849	11 19	1 420	July 16	May 19	Oct. 15
1878	30·320	Mar. 16	28 630	April 1	89 6	July 19	13 9	Dec. 26	April 6	Nov. 9	118 2	July 22	99	Jan. 13	53	Aug. 9	......	......	......	......	......	......	35 434	39 010	3 576	11 01	1 220	Aug. 14	April 1	Nov 8
1879	30·352	Dec. 13	28·500	Feb. 10	74·4	July 30	13·2	Dec. 7	May 10	Nov. 14	101·2	Aug. 13	100	Oct. 7	61	Dec. 12	......	......	......	......	......	......	28 017	30 298	2·281	10 82	1·020	June 8	May 7	Nov. 20
1880	30 332	Jan. 7	28·164	Nov. 16	81·3	Sep. 6	20·8	Jan. 20	Feb. 23	Oct. 20	112 0	Aug. 13	99	Dec. 15	50	May 30	......	......	......	......	......	......	35 690	39 616	3 926	11·10	1 710	Oct. 27	Mar. 2	Oct. 27
1881	30 382	May 10	28 250	Oct. 14	63 3	July 6	12·0	Jan. 26	April 21	Oct. 17	116 5	June 1	98	Oct. 14	38	May 31							35 434	39 892	4 458	11 26	1 435	Oct 13	April 20	Oct. 29
1882	30 544	Jan. 18	28 452	Mar. 1	77 4	Aug. 12	18 6	Dec. 11	April 16	Nov. 12	108 0	Aug. 9	99	Nov. 5	36	May 18							39 683	43 103	3 420	10 86	1 603	Dec 6	Mar 21	Nov 19
1883	30 500	April 9	28 452	Sep. 2	76 2	July 3	19·8	Mar. 10	Mar 29	Nov. 12	107 6	May 17	99	Dec. 26	30	April 9							34 396				1 333	Sep. 26	Mar. 24	Nov 10
1884	30 354	Oct. 5	28 376	Jan. 27	84 4	Aug. 12	26·5	Nov. 30	April 24	Nov. 24	107 8	Aug 9	98	Jan. 23	30	May 22					24 00	Jan. 24	27 657				1 171	Jan. 2?	Feb. 28	Nov. 23
1885	30 273	Mar 14	28 400	Jan 11	82 2	July 27	22 1	Dec. 11	April 5	Nov. 16	113 6	July 27	100	Jan. 23	32	June 4	....				15 25	Dec. 4	25 699				1 238	Sep. 3	May 7	Dec 9
1886	30 355	Nov. 24	27 652	Dec. 8	79 5	July 3	17 4	Mar. 7	April 30	Dec. 2	108 8	July 5	99	Jan 12	32	May 4	11 45	July 6	851 48	19	18 00	Dec. 9	35 993				2 1?0	July 26	May 12	Nov. 6
1887	30 412	Feb. 8	28 328	Nov. 3	82·8	July 9	21·1	Jan. 17	April 17	Oct 12	107 6	July 9	100	April 21	35	July 9	12 40	July 3	1120 58	25	15 00	Feb. 4	18 665				0 811	Oct. 9	May 21	Oct. 14
1888	30 333	Jan. 10	28 410	Mar. 28	80 4	June 27	19 2	Feb. 14	April 8	Oct. 2	110 0	Sep. 15	99	Mar 16	39	June 11	13 40	May 24	984 20	20	13 00	May 4	25 646				[illegible]	Nov. 3	April 8	Oct. 1
1889	30 358	Dec. 5	28·460	Mar. 20	77 5	Aug 1	21·3	Mar. 4	Mar. 22	Nov. 27	115 2	June 23	99	April 22	39	June 26	12 15	July 8	827 45	18	12·00	Feb. 9	22 141				0 690	Mar 9	Mar. 21	Nov. 25
1890	30 376	Feb. 23	28 315	Jan. 23	76·4	Sept. 10	18 4	Dec. 22	Mar. 10	Oct 28	111·0	June 16	99	May 11	31	May 29	14 25	May 25	824 5	18½	14 0[illegible]	Jan 19	25 730				1 435	Jan. 22	April 13	Oct. 21
1891	30 394	Oct. 31	28 060	Nov. 11	79 9	Sept 12	12 0	Jan 19	May 18	Nov. 25	107 0	July 27	100	Feb. 20	37	July 17	11 45	May 12	805 35	18	13 50	Aug. 26	27 303		......		[illegible]	Dec. 1?	May 17	Nov 26
1892	30·266	Mar. 30	28 638	Feb. 2	77 0	Aug. 24	18 8	Feb. 19	April 19	Oct. 26	107 5	July 23	99	Jan. 12	32	April 3	12 30	June 7	866 53	19	10·00	April 28	28 881	......			2 720	Oct 15	April 28	Oct. 24
1893	30·358	Dec 30	28·360	Feb. 26	85·0	Aug. 19	19·0	Jan 6	April 12	Oct 31	117·8	Aug. 19	98	Mar 1	37	April 25	13 0	May 10	980 36	22	13 20	Nov. 19	22·667				1 180	May 18	Mar 17	Nov. 6
Means	30·342		28·309		81 8		18 1				115 7		99		39		12 45		896 15	20	14·80		29·002	39 601	3 860	11 08	1 363			

EXPLANATION.

The observations are made at nine a.m., and, with the exception of maximum and minimum thermometer readings, again at three p.m.

The highest and lowest barometric readings for each month, also the monthly range, are given as recorded; while the mean pressure is deduced from bi-daily observations corrected for index error, capillarity, temperature, and diurnal range. To correct for altitude or reduce to sea level (the air temperature being 48 degrees and barometer 30 inches at sea level), add ·401 inch to the heights given.

A remarkable instance of barometric depression occurred on the 8th December, 1886, when at 8.40 p.m. the mercury of the Exchange barometer had fallen to 27·456 inches only—the lowest reading on record here. The cyclone indicated by this depression was the cause of great loss of life and property, extending over an unusually large district.

All thermometric observations and deductions are given in degrees Fahrenheit.

The adopted mean temperature of air is deduced from the dry bulb and the maximum and minimum readings; the temperature of evaporation from the dry and wet bulb and the maximum and minimum readings. The dew point, elastic force of vapour, humidity, &c., are deduced from bi-daily readings of the dry and wet bulb hygrometer, by Glaisher's Hygrometrical Tables, sixth edition.

Bright sunshine is recorded in hours and minutes by glass sphere on cards, known as Campbell's recorder, fixed on Professor Stokes' zodiacal frame.

The solar thermometer has a black bulb enclosed in a vacuum.

The direction, velocity, and pressure of wind are recorded as indicated by anemometers fixed 10½ feet above the ridge of roof of Exchange. The velocity per hour at 9 a.m. is determined from anemometer readings made one minute and a half before and a like period after that hour, by multiplying the difference thereof by 20. The pressure is given in pounds avoirdupois per square foot.

The amount of cloud is estimated by a scale ranging from 0 to 10.

Rainfall includes melted snow and hail.

The rain gauge is fixed upon the top of central roof of the Exchange, at an elevation of 65½ feet above the surface of the ground and 395 feet above mean sea level. As rain gauges on the summit of buildings are generally found to collect less rain than when placed upon the surface of open ground adjacent thereto, steps were taken in 1875 to determine to what extent this was the case with the Exchange rain gauge, when two additional gauges were provided and fixed upon the surface of adjacent open spaces, one near to the Town Hall, the other near to the Midland Railway Station, between which the Exchange gauge is situate about midway, and the surface of ground about the same height. At both of these gauges, as well as at the Exchange gauge, daily observations were made from the commencement of 1876 to the end of 1882, a period of seven years, when the surface gauges were removed in consequence of the ground they occupied being no longer available for the purpose. The particulars of these gaugings are set forth in tables. The results show that the mean yearly rainfall on the surface of ground for the seven years ending with 1882 is 3 86 inches, or 11·08 per cent., greater than at the summit of the Exchange. The mean yearly rainfall recorded at the Exchange for the twenty-four years ending with 1893 is 29·502 inches. By adding 11·08 per cent. thereto the mean normal rainfall of central Bradford for such period is found to be 32 771 inches per annum. There are good grounds for concluding that the smaller amount of rainfall collected on the Exchange—and on buildings generally than on the surface of ground is due to the varying direction and force of wind there producing different currents and eddies, which prevent due precipitation on the top or ridge of roof where the gauge is fixed. The rainfall of 1869 was collected by a gauge placed on the ridge of outer roof of Exchange, near to the north-west corner thereof. This position not being deemed quite satisfactory, the gauge was removed at the end of that year to the ridge of central roof—the place it has since occupied. To avoid risk of inaccurate results, the rainfall of 1869 is omitted from these returns.

The instruments with which the observations are made have been verified by comparison with the standards at Kew Observatory.

VOL. XII.] [PART V.

PROCEEDINGS

OF THE

YORKSHIRE GEOLOGICAL AND POLYTECHNIC SOCIETY.

EDITED BY W. LOWER CARTER, M.A., F.G.S.,
AND WILLIAM CASH, F.G.S.

1894.

THE MINERAL WATERS OF ASKERN IN YORKSHIRE.

BY C. H. BOTHAMLEY, F.I.C., F.C.S.

(*Read January 16th, 1894.*)

The West Riding of Yorkshire is remarkable in possessing, at Harrogate and Askern respectively, two groups of Sulphuretted Waters, each of which, in its own way, is unique in the United Kingdom. The Harrogate Waters have been somewhat frequently examined, but no analyses of the Askern Waters have been made since those of Lankester and West in 1840,* although since that time structural alterations have been made in some of the wells, and the reputation of the waters in the treatment of skin diseases and chronic rheumatism, has steadily increased.

It seemed very desirable that these waters should again be carefully examined, and, whilst at the Yorkshire College, I undertook an investigation which comprised the estimation of the dissolved constituents in each of the waters, and also the determination of the more important of them, and especially of the sulphuretted hydrogen, at various seasons of the year. The results have been communicated to the Chemical Society, but it seemed appropriate that they should also be brought before a society which is specially interested in all scientific matters relating to the West Riding.

* I am indebted to Mr. Richard Reynolds, of Leeds, for calling my attention to this fact.

History and Previous Analyses.

Askeron is mentioned in *A Natural Experimental and Medicinal History of the Mineral Waters of Derbyshire, Lincolnshire, and Yorkshire,* published in 1734 by one Dr. Short, who speaks of one spring only, describes its reactions, which were those of a sulphuretted water containing calcium compounds, and says, "The farmers find it of notable service to them in curing chafed feet, saddle galling, horses or oxen galled in the yoke, or by loading, etc., mangy dogs, scabbed horses, etc. It has done some notable cures in inveterate strumous and other ulcers, scab, leprosy, &c."

Many years later the water, which in the meantime had gradually increased in reputation, was analysed by Mr. Le Gay Brewerton, of Bawtry, who describes his results in a *Treatise on the Mineral Waters of Askern,* published in 1817. He states that the water contains "in four wine pints" the following dissolved gaseous and solid constituents :—

	Cubic inches.
Sulphuretted Hydrogen	3·32
Carbonic Acid	2·
Oxygen	·13
Nitrogen	1·53
	6·98

	Grains.
Sulphate of Lime	36·66
Sulphate of Magnesia	4·5
Carbonate of Lime	13·16
Carbonate of Alumina	·43
Muriate of Lime	·19
Muriate of Magnesia	1·45
Fetid Resin of Sulphur	1·35
	57·74

In July, 1821, a Mr. Murray published, in the *Doncaster Gazette,* an imperfect and obviously inaccurate analysis. He states that the water contains alum, muriate of soda and magnesia, and carbonate of lime, sulphuretted hydrogen, "sulphuretted azote," and atmospheric air.

After the publication of Mr. Brewerton's book five new wells were opened ; and in his treatise, *An Account of Askern and its Mineral Springs, together with a Sketch of the Natural History and a brief Topography of the immediate neighbourhood,* published in 1842, Dr. Edwin Lankester speaks of six wells, five of which he examined with the aid of Mr. West, of Leeds, the analyses seemingly being made in 1840.

The dissolved gaseous constituents in cubic inches of gas per imperial gallon of the water were as follows :—

	Sulphuretted Hydrogen.	Carbonic Acid.	Nitrogen.
Manor Well ...	8	$5\frac{1}{4}$	8
Terrace Well ...	$8\frac{1}{4}$	$14\frac{3}{4}$	12
Charity Well ...	$6\frac{1}{2}$	$8\frac{3}{4}$	$11\frac{1}{4}$
South Parade Well	6	8	11
Madder Close Well	14	13	11

The dissolved solid constituents in two of the wells were as follows, the results being stated in grains per imperial gallon :—

	Manor Well.	Charity Well.
Sulphate of Magnesia	34	18
Chloride of Calcium	3	4
Sulphate of Lime	110	104
Carbonate of Lime	6	12
Carbonate of Soda	26	26
	179	164

The quantity of dissolved solid matter in the case of the Terrace Well is said to be 144 grains ; in the South Parade Well 140 grains ; and in the Madder Close Well 100 grains, its composition, in all cases, being similar to that in the Manor and Charity Wells.

It may be noted that according to these results the waters contain a somewhat large quantity of sodium carbonate, but as a matter of fact the waters and the residues obtained from them are not alkaline ; and the conclusion that this compound was present arose, doubtless, from the manner in which Lankester and West combined the acids and bases when working out the analytical data. There is no evidence of the presence of this salt in the waters.

The Present Wells.

Askern stands on the edge of an extensive peat bog, which is, as a rule, imperfectly drained, the greater part being as yet uncultivated. It is built on Permian strata, with hills of magnesian limestone rising close behind the village, and red Permian marls containing gypsum are found in the immediate neighbourhood.

There are at present four wells, each with a pump room and suite of baths, and they are situate close to the western and south-western edges of the Pool, a comparatively shallow sheet of water, about six acres in extent, lying to the east of the high road between York and Doncaster, which runs through the village.

The Manor Well Baths are on the eastern side of the Pool, in lat. 53° 36′ 54″ N., and long. 1° 8′ 55″ W., but the water as actually used is supplied partly from the well at the south-west corner of the Pool, which also supplies the Charity Baths. This water is carried through the Pool in an iron pipe with flanged joints, and is allowed to mix, in a puddled well, with water derived from an old well that is under the building.

The Terrace Baths are on the opposite side of the Pool, the well by which they are supplied being dug in the peat about 40 yards to the south of the Pump Room, between a row of dwelling-houses and the edge of the Pool, in lat. 53° 36′ 52·4″ N., and long. 1° 9′ 0″ W. The well is constructed of brick with an outer lining of puddled clay, and the water is conveyed to the Pump Room through a lead pipe which has been in use for many years.

The Charity Baths, near the south-west corner of the Pool, are supplied by a well which is about 40 yards distant from both the Pump Room and the Pool. This well is in the form of a large brick tank, built in the peat, with an outer casing of puddled clay. Although it is covered in it is doubtful whether the entrance of surface drainage is entirely prevented, and this fact detracts somewhat from the scientific interest of this water.

The Town End or South Parade Baths are on the high road at the south end of the village, some little distance from the Pool. They are supplied by the Madder Close Well, the position of which is shown on the 6-inch Ordnance Survey Map. It is about 120 yards south of the Pump Room, in lat. 53° 36′ 41·7″ N., and long. 1° 9′ 1·5″ W., and is simply a large tank cut in the peat, without any lining of any kind, but is securely covered in. The water can be drawn from the well by means of an ordinary pump placed just over it, and is conveyed to the Pump Room through a pipe embedded in the peat. The sample for analysis was of course taken from the pump over the well.

It is obvious that this water, coming directly out of the peat and passing through a few feet only of lead pipe that has been in use for many years, represents most nearly of all the four the water as it actually occurs in the peat. For this reason special attention was paid to it in the course of the investigation.

ANALYSES.

The samples of water were collected with all the usual precautions, and as the methods of analysis adopted differed but little from the ordinary routine it is unnecessary to enter into details.* The results are given in Table A.

TABLE A.—*Dissolved Solid Matter in Parts per* 100,000.

	Mather Close Well.		Terrace Bath.		Charity Bath.		Manor Bath.	The Pool.
	Sep. 28, 1889.	July 12, 1890.	Sep. 27, 1889.	July 12, 1890.	Sep. 28, 1889.	July 12, 1890.	Sep. 27, 1889.	Sep. 27, 1889.
Specific gravity at 20° ...	1·0017	—	1·0017	—	1·0021	—	1·0020	—
Total solid residue at 120° ..	189·85	201·66	190·84	195·87	229·39	229·52	236·12	217·60
Sulphuric acid (SO_4) ..	70·51	90·78	66·87	76·84	96·40	109·94	94·71	131·5
Chlorine ...	2·10	—	3·97	—	7·21	—	7·30	—
Silicic anhydride (SiO_2) ...	1·46	—	1·36	—	2·30	—	2·33	—
Iodine	trace	—	trace	—	—	—	—	—
Calcium	49·92	49·64	46·79	50·20	43·25	42·71	43·39	52·62
Magnesium ..	7·84	7·98	8·68	6·98	14·53	14·34	13·82	6·25
Sodium	2·74	—	3·28	—	6·81	—	6·67	—
Iron	0·24	—	0·50	—	0·14	—	0·20	—
Lithium	trace	—	trace	—	—	—	—	—
Strontium ...	—	—	trace	—	—	—	—	—
Hydrogen sulphide in volumes per 100,000 ...	5670	5500	4950	5400	3480	2640	3730	None

* Reference may be made to the Transactions of the Chemical Society, 1893, p. 685.

TABLE B.—*Proximate Composition of the Dissolved Matter.*

In grams per litre.

	Mather Close.	Terrace.	Charity.	Manor.
Calcium carbonate	0·8417	0·8232	0·6825	0·6698
Calcium silicate	0·0281	0·0262	0·0443	0·0449
Calcium sulphate	0·5222	0·4434	0·4938	0·5151
Magnesium sulphate	0·3874	0·4288	0·7184	0·6834
Sodium chloride	0·0346	0·0989	0·1190	0·1205
Sodium sulphate	0·0426	0·0220	0·0659	0·0599
Total	1·8566	1·8425	2·1239	2·0936
Hydrogen sulphide (in cubic centimetres	56·7	49·5	34·8	37·3

In grains per gallon.

	Mather Close.	Terrace.	Charity.	Manor.
Calcium carbonate	58·92	57·62	47·78	46·89
Calcium silicate	1·97	1·85	3·10	3·14
Calcium sulphate	36·55	31·04	34·57	36·06
Magnesium sulphate	27·12	30·02	50·29	47·84
Sodium chloride	2·42	6·92	8·33	8·44
Sodium sulphate	2·98	1·54	4·61	4·19
Total	129·96	128·99	148·68	146·56
Hydrogen sulphide (in cubic inches)	15·73	13·74	9·66	10·35

Apart from the dissolved organic matter, to which reference will be made presently, the only important solid constituents are magnesium sulphate and calcium carbonate and sulphate.

In Table B, the acids and bases are arranged in the form of compounds, the arrangement being made on the following basis:—All the chlorine is regarded as occurring in the form of sodium chloride, and the remainder of the sodium is calculated to sulphate; all the magnesium is calculated to sulphate; and the rest of the sulphuric acid and the silica are considered to be united with calcium; the remainder of the calcium being calculated to carbonate.

The experimental evidence in support of this view as to the distribution of the acids and bases is given in detail in a *Note on the Distribution of Acids and Bases in a solution containing Calcium,* *Magnesium, Carbonic Acid and Sulphuric Acid, and on the Composition of Mineral Waters,* published in the Transactions of the Chemical Society, 1893, p. 696. Apart from chemical evidence, I am informed by Dr. J. G. Cassels, of Askern, that the presence of magnesium sulphate is indicated by the therapeutic action of the waters.

Examination for constituents usually present in minute quantities, was made on the residue from 44 litres ($9\frac{3}{4}$ gallons) of the water from the Mather Close Well and the Terrace Baths Well respectively, with the following results :—

Lithium was present in spectroscopic traces in both waters.

Strontium was present in spectroscopic traces in the Terrace water, but not in the Mather Close water.

Iodine was present in both waters, but bromine was present in neither.

Barium, which is so remarkable a constituent of some of the Harrogate waters, is not present in the Askern waters.

Potassium, calcium, rubidium, aluminium, and phosphoric acid were not detected in either of the waters.

The absence of bromine is of interest, but it is noteworthy that chlorine is present in small proportion only. The absence of potassium is probably explained by the observation of Berthelot and André, that this element is precipitated from dilute solutions of its salts when brought in contact with large quantities of humic acid.

It will be seen that the Askern waters are shallow spring waters, if not actually surface waters, the chief dissolved constituents being magnesium sulphate and calcium carbonate and sulphate, with an unusually large proportion of organic matter and a considerable volume of sulphuretted hydrogen. No other substances are present in any noteworthy proportion. The organic matter and the sulphuretted hydrogen may be regarded as the characteristic constituents of this group of waters.

The Organic Matter.

The water from all four wells is highly charged with dissolved organic matter derived from the peat through which the waters percolate. This organic matter is very unstable and is nitrogenous ;

when the water is distilled with a small quantity of sodium carbonate ammonia is evolved in relatively large quantity.

In view of these facts it would be useless to examine the organic matter left in the residue obtained by evaporation in the ordinary way, or to examine the products obtained by the distillation of the water at the ordinary temperature and pressure. The only method of ascertaining the real nature of the dissolved organic matter would seem to be to evaporate a large quantity of the water in a vacuum at the ordinary temperature. I was unable to carry out this investigation before leaving Yorkshire for the south of England, but I am of opinion that it might lead to results of considerable value.

The oxygen absorbed by the organic matter, as estimated by means of an acidified solution of potassium permanganate at the ordinary temperature, and after making the correction necessitated by the presence of sulphuretted hydrogen, was as follows:—

Oxygen absorbed by 100,000 parts.

Mather Close.	Charity.	Terrace.	Manor.	Pool.
5·78	4·92	4·78	4·24	0·015

The contrast between the organic purity of the water of the Pool and the large quantity of dissolved organic matter in the waters of the adjacent wells is very remarkable. A reference to Table A will show that the Pool water contains a large proportion of calcium sulphate, and it is probable that this compound precipitates the organic matter.

The Sulphuretted Hydrogen.

The whole of the hydrogen sulphide is present in the form of dissolved gas, and can be expelled by passing a current of an indifferent gas through the water for some time.

Neither sulphides nor thiosulphates are present in the waters. After complete removal of the hydrogen sulphides, the water discolourises a not inconsiderable quantity of iodine solution, but this absorption of iodine is due to the organic matter, and has, of course, to be allowed for when estimating the sulphuretted hydrogen.

The variations in the quantity of hydrogen sulphide are of much scientific and practical interest. The following table shows the quantity of sulphuretted hydrogen in cubic centimetres per litre, and of the sulphuric acid radical (SO_4) in grammes per litre in the four waters at various times of the year :—

		Mather Close.	Charity.	Terrace.	Manor.
1889. Sept. 27 and 28	Sulphuretted hydrogen	56·7	34·8	49·5	37·3
	Sulphuric acid (SO_4) ...	0·7063	0·9660	0·6698	0·9490
1890. July 12	Sulphuretted hydrogen	55·0	26·4	54·0	...
	Sulphuric acid (SO_4) ..	0·9093	1·1017	1·7697	...
Nov. 1	Sulphuretted hydrogen	42·3	31·7	23·6	36·1
	Sulphuric acid (SO_4) ...	0·7018	0·9099	0·7978	0·9956
1891. Jan. 17	Sulphuretted hydrogen	22·5	..	...	...
April 18 ..	Sulphuretted hydrogen	49·6	...	55·3	21·9
	Sulphuric acid (SO_4) ...	0·7023	...	0·7268	0·6359
July 29	Sulphuretted hydrogen	52·0	38·4	46·2	34·2

It will be seen in the first place, that the volume of sulphuretted hydrogen varies in one and the same water with the time of year. This comes out very distinctly in the Mather Close water, which was the most frequently examined :—

July.		September.		November.		January.		April.		July.
55·0	...	56·7	...	42·3	...	22·5	...	49·6	...	52·0

The proportion of this gas is lowest in mid-winter; increases as the weather becomes warmer; attains a maximum in summer and autumn, and then again decreases as the weather becomes colder. At the same time it is clear that the quantity of sulphuretted hydrogen present in the waters from late spring to early autumn, or in other words, during the time for which they are chiefly used for medicinal purposes, is practically constant, and, moreover, varies but little from year to year. This is a point of considerable practical importance.

Only indirect evidence can as yet be offered as to the origin of the sulphuretted hydrogen. The following facts are, however, important in this connection :—The quantity of sulphuretted hydrogen varies in the different wells at the same time of the year, and varies in the same well at different times of the year, the variations being periodic and in close relation with the season of the year. It has no relation to the quantity of sulphates present in the waters, and its variations have no relation to the variations in the quantity of the sulphates. It has also no relation to the chemical reducing power of the waters, as measured by means of acidified (potassium) permanganate solution.

There can, of course, be practically no doubt that the sulphuretted hydrogen is a product of the reduction of the sulphates present in the water. In all probability the magnesium or calcium sulphate (or perhaps both) is first reduced to sulphide and the latter is decomposed by the water and carbonic anhydride, with liberation of sulphuretted hydrogen. It is well known that sulphates can be reduced to sulphides by contact with water and organic matter if all air or oxygen is excluded, but we are still in the dark as to the precise manner in which the reduction is brought about.

Sulphuretted water is by no means uncommon in the peat bog in which the Askern waters are found, but it seems to occur in quantity only in the neighbourhood of the wells now in use. Its distribution is very local, and I am informed that sometimes a shallow well, cut in the peat, will yield sulphuretted water, whilst a similar well only a few yards away will yield non-sulphuretted water. Anyone going carefully over the district cannot fail to notice evidence of the occurrence of sulphuretted hydrogen in the surface water at isolated points.

I was informed that during very hot weather sulphuretted hydrogen sometimes appears in one or two of the deeper hollows or pits in the Pool, but during my own visits, made at intervals over more than two years, including some hot summer months, I never saw any evidence of the occurrence of sulphuretted hydrogen in the water of the Pool at any point.

There seems to be no sufficient reason for connecting the formation of the sulphuretted hydrogen with the confervoid growth to which reference is made by Dr. Lankester in his book, for these growths are abundant enough in places where there is no sulphuretted hydrogen, although the general character of the water is in other respects the same. At the same time all the evidence points to the conclusion that the reduction of the sulphates, with production of sulphuretted hydrogen, is brought about by some particular kind or kinds of organic matter, and probably by some specific *living organism* or organisms, irregularly distributed in the peat. In this connection it is important to note that the quantity of sulphuretted hydrogen in the waters is highest during those seasons of the year when the growth of all kinds of organisms shows its maximum activity. The problem, however, is one which only a competent biologist can solve.

The following comparison between the Askern and Harrogate waters is quoted from my paper in the Chemical Society's Transactions:—

Askern Waters and Harrogate Waters.

"The sulphuretted waters of Askern differ from those of Harrogate in several respects. The Harrogate waters (Trans., 1881, 39, 497) rise from a considerable depth, are almost entirely free from organic matter, and, in addition to hydrogen sulphide, contain a large quantity of dissolved carbonic anhydride. The Askern waters are surface waters, or at any rate rise from very slight depths, are highly charged with organic matter, and contain comparatively little free carbonic anhydride. The Harrogate waters contain a very large quantity of dissolved solid matter, amounting in the case of the Old Sulphur Well to 1480 parts per 100,000, and in the case of the Montpellier Strong Sulphur Well to 1450 parts per 100,000, whereas the Askern waters contain only about 200 parts of solid matter per 100,000. The difference in the nature of the solid constituents is as striking as the difference in their amount. The Harrogate waters contain chiefly chlorides and carbonates, and are free from sulphates, whilst the Askern waters contain chiefly sulphates and carbonates, and are almost free from chlorides. The quantity of sodium chloride in the Old Sulphur Well amounts to 1262 parts per 100,000, and in the Montpellier Strong Sulphur Well to 1223 parts per 100,000, whilst in none of the Askern waters does the quantity of this constituent exceed 12 parts per 100,000; and this fact is of great importance in connection with the use of these waters in the external treatment of skin diseases."

The Therapeutic Action of the Askern and similar Waters.

The medicinal effects of these waters are usually attributed chiefly if not solely to the sulphuretted hydrogen that they contain.

The quantity of iodine that the waters contain is so minute that it can scarcely be regarded as an active agent. There is, however, very good reason for supposing that the dissolved organic matter plays an important part, especially in the case of skin diseases, and this point is at any rate worthy of the careful attention of any one who in the future may investigate the therapeutic action of the Askern waters.

In a very curious and interesting old treatise (the existence of which seems to have been overlooked), entitled *A Methodic Synopsis of Mineral Waters, comprehending the most celebrated Medical Waters, both cold and hot, of Great Britain, Ireland, France, Germany, Italy, and several other parts of the World*, by John Rutty, M.D., 4to, London, 1757, an account is given of the medicinal use of the bog waters of Ireland, and especially of the waters of Lough Neagh and of Loch Sheighs, in the County of Cavan, "which have acquired no small reputation in the cure of scrophulous sores and cutaneous disorders." They are described as very soft waters, containing little saline matter, but a considerable quantity of dissolved peaty matter, which on evaporation is left as a brown or black unctuous and inflammable residue. Of the water of Lough Neagh, Dr. Rutty states, "The Appendix to Boate's Natural History of Ireland mentions the first occasion of introducing it into practice to have happened in King Charles the Second's time, in a young man who, having scrophulous ulcers running on him, used all imaginable means for his recovery without effect; at length, on eight days bathing every day in this Lough, all his sores dried up, and he was restored to health and strength; and this so remarkable a cure brought many others who had running sores upon them, who were also cured in a little time; and of late years the use of this water has been revived in the same cases, with good success in many instances."

* * * * *

"The water of Lough Sheighs, however, in the year 1736 was resorted to from all parts of this kingdom, and even from England, as an infallible remedy in cutaneous eruptions and ulcers, and the very mud of it was exported for these purposes. . . ."

"This water is said to have been first used for curing horses and dogs of the mange, and from all the observations I could make on the numerous sick who resorted thither, I could not but be convinced of its cleansing and healing quality in divers inveterate and rebellious eruptions on the skin; and in some scald heads; and in many old stubborn ulcers, which had baffled the common methods of use."

This account of the Irish bog waters has a curious resemblance to Dr. Short's account of the Askern water. The Irish waters probably contain a higher proportion of peaty matter than the Askern waters, but are free from sulphuretted hydrogen, and contain only very small quantities of calcium and magnesium salts.

A Pool that never Freezes.

About 120 yards to the south of the Askern Pool is an irregularly shaped piece of water about 100 yards long and 55 yards across at the widest part. It is known locally as the Mather or Madder Pool or Pits, and is shown under that name on the 6-inch Ordnance Survey Map. So far as I could learn it is of no great depth, and it communicates by narrow drains with the large drains that intersect the Common.

This pool has never been frozen over in the memory of anyone living in the neighbourhood, and there is a local tradition that it never has been frozen.

During the severe winter of 1890-91 the Askern Pool was covered with a thick sheet of ice, but the Mather Pool, although close by, showed no traces of ice even in the shallow water at the edge. On January 17th, 1891, after the frost had continued unbroken for weeks, the temperature of the air was 1·5° C. (29·3 F.), and the Pool, as already stated, was covered with a thick sheet of ice and had been so covered for days, and the temperature of the water drawn from the Mather Close Well was 4·8° C. (40·6 F.), yet the temperature of the water of the Mather Pool, about three feet from the edge and where it was still quite shallow, was as high as 9·0° C. (48° F).

This water contains magnesium and calcium sulphates and calcium carbonate, together with dissolved peaty matter, but without any sulphuretted hydrogen. There is nothing in the position or surroundings of the Mather Pool to explain its peculiar behaviour, and it would probably repay investigation.

I cannot conclude this paper without expressing my great indebtedness to my friend Dr. J. G. Cassels, of Askern, for his ever ready assistance. both in the work at the wells and in the enquiry into the history of the spring. I am also indebted to the proprietors of the various Pump Rooms for the facilities they so readily gave me for collecting the samples of water and making experiments at the wells.

THE EFFECT OF FAULTS ON THE CHARACTER OF THE SEASHORE.

BY THEO. T. GROOM, F.G.S.

(Read January 16th, 1894.)

If the shore-line extending from Westward Ho near Bideford to a point situated about a mile to the south-west, and forming the central strip of Barnstaple Bay, be viewed broadly, it will be seen to take a tolerably even and unbroken course ; when examined in detail, however, it is found to be broken up at all levels of the tide into a series of small bays and promontories, or islands (figs. 1 and 2). From the cliffs which bound the shore abruptly on the inland side a rocky platform, generally from two to three hundred yards wide, slopes gently down to the irregular low-water line. The cliffs usually vary in height from 15 or 20 feet above high-water level to perhaps five or six times that height, and show at a relatively small height above high-tide mark (20 feet or so) the remains of an old pebble-beach ; this, so far as it is preserved, shows no trace of the differential movements which have affected the rocks of the intertidal platform. The facts given above indicate that since the elevation which raised the old beach the land here has remained stationary for a period long enough to allow of the formation of a considerable indentation of the profile along the shore-line, and that, as might be expected, the differential movements which have affected the platform and which will be referred to later, are of earlier date than the formation of the old beach.

The rocks forming the platform and the cliffs are a series of shales, sandy shales, flags and sandstones, belonging apparently to the Morchard and Exeter types recognised by Mr. W. A. E. Ussher* in the Culm Measures. These, as is well known, have been affected by folds running chiefly E. and W., so that the rocks strike nearly straight out to sea. In the area examined they dip sometimes to

* The Culm Measures of Devonshire. Geol. Mag., vol. iv., 1887. The British Culm Measures. Proc. Somerset Archæological and Natural History Society, vol. xxxviii., 1892.

the north, and sometimes to the south, at an angle of about 60° or more (figs. 1 and 2). A first glimpse of the platform from the summit of the cliff shows in some places what appears to be a jumble of high jagged barnacle-covered rocks, interspersed with smooth and flat areas often covered with fucoids. As one walks along the cliff a grouping of these elements becomes very evident; the higher and more rocky portions are seen to form bands or blocks separated by wider zones of the smoother rocks (figs. 4 and 5).* A striking feature which soon becomes apparent is that numerous definite channels intersect in a conspicuous manner these rocks in all directions, the main ones crossing or bounding rough and smooth areas alike (figs. 1, 3, 3a, 4). These channels are so prominent that many of them have been mapped by the Survey, and are well shown on the six-inch maps of the district. They are either permanently or temporarily filled with water. Some are clearly related to the direction and configuration of the coast (cf. figs. and maps). Upon examination they are seen in most cases to mark lines of faulting. The appearances at once suggested comparison on a small scale with the state of things described by the Scandinavian geologists along the coast of Norway, where the fjords have been shown, notably by Kjerulf and Brögger,† to have a close relation with the faults of the district. Fig. 1 shows the fjord-like character of many of the small inlets of a portion of the coast. I became wishful, therefore, to ascertain whether the configuration of the coast in this locality was due at all directly to crust-movements, or solely to denudation, and to trace the effect of faulting on the character of the shore, more especially since this is not mentioned by De la Beche in his account of the denudation of this coast.

If the smoother and lower and the relatively elevated and rocky portions of the platform be compared, it is found that the former consist of blue shales and flags, whilst the latter are composed of hard bands of well-jointed greyish-blue compact sandstone. The sandstones and flags are everywhere more or less divided up by isolated bands of shale, and the shales by thin bands of sandstone. The

* I am indebted to the kindness of my brothers, Messrs. P. and W. Groom, for the photographs reproduced in this paper.

† Die Bildungsgeschichte des Kristianiafjordes. Nyt Magazin for Naturvidenskaberne xxx., 1886.

included shale bands tend to form channels, and the sandstones minor ridges of varying breadth and distinctness, running out to sea. Observation makes it clear that the existence of the relatively more and less elevated portions of the platform is due simply to the different rates at which denudation has taken place (the softer irregularly-broken beds being reduced to a lower level), and not in any way to the elevation or depression of faulted-blocks; this will also be evident from a consideration of the nature of the dislocations.

The channels, which intersect the rocks at varying angles are of some interest from the light thrown by them upon the effect of faults in facilitating marine denudation, and in modifying the configuration of the coast. When they are examined in detail they are seen to traverse nearly the whole of the platform between tide-marks; towards high-tide mark they generally become less marked or slight, and the fault itself is often distinguishable only by a careful examination of the disposition of the strata on either side; towards the sea they become wider and deeper, and form conspicuous fjord-like inlets (figs. 3, 3a), the lower parts of which are permanently filled with water. Still farther out to sea, they cut up the elevated sandstone reefs into small islets, separated from one another, and from the main land by channels of some depth (fig. 4). The channel-forming faults occur both as dip and strike faults, but faults crossing the outcrop of the beds obliquely are by far the most important. By the combined action of these faults the whole of the inter-tidal platform is cut up into a pavement, or mosaic, of angular blocks, the sandstone portions of which project above the level of the rest as ridges, blocks, or islets.

The smallest faults are planes of slight dislocation, along which the sea-water with its particles of sand can erode. In many cases the erosive action is facilitated by the irregular bending of the folia of the shale at the margin of the fault, so as to produce an easily-removed fringe of material. In the case of the larger faults the dragging action due to the horizontal displacement has produced, not a simple fringe, but a fringe traversed by lines, along which shearing or fracture parallel to the direction of the fault, has occurred. In many cases no definite fringe is formed, but planes of separation, parallel to the fault, and extending to a distance of a foot or several feet from the fault, can be detected. In the larger dislocations large blocks of limestone or shale may be broken off and jammed up at various angles, together with more triturated material, between the lips of the fault. The portion of rock mechanically affected has not the appearance of being greatly altered chemically, but the shear and fault planes, which generally cross the bedding and joint planes at an angle, have divided up the rock into a mass of rhombohedral or irregularly-shaped fragments, forming a kind of loose breccia lining the sides of the fault, the fragments of which, however, have not been cemented together by subsequent infiltration into a hard rock. This material is accordingly easily removed by the waves, and thus channels are eroded along lines of faulting. The fractured margins of even the most important faults, however, do not generally extend to more than a foot or so from the fault itself, so that though mechanical disruption greatly aids the denudation of the fault in a vertical direction, the widening must be accomplished mainly by the abrading action of the sea-water.

Where two faults meet, or are only at a short distance apart, still more of the rock may be removed, and in this way permanent pools, or v-shaped inlets are produced.

Prof. T. McKenny Hughes, whose experience of field geology is well-known, informs me that he has observed many facts similar to those described above. He says—"I have seen many cases quite confirmatory of the view you maintain. Along the coast S. and W. of Torquay for instance there are many examples, and also round Ilfracombe. Some good examples may be seen on the coasts of Cardiganshire, south of Aberystwith. But better still are seen on the south coast of the Isle of Man. There are some on the shelving limestone shore at Biarritz. Cases of weathering along joints are as well illustrated in the Lower Greensand at Hunstanton as anywhere. The rock perishes along the joints, and large portions disappear altogether, leaving a series of cushions of rock, delightful to small boys, who jump from one to the other with leaping poles. From the cliff above these are seen to be only the more weathered portions of the jointed rock that forms the whole shore. The Clints or bare limestone plateaux round the base of Ingleborough here and there show, in addition to the effect of weathering along joints, a greater gash, due to a fault. Indeed in the cases you are describing there seems to be a close connection between the faults and master-joints. Salter has, I think, called attention to this. At Hunstanton one may see good examples of the characters you describe along the margin of the faults, complicated by the very frequent hardening of the rock by *setting* of the iron oxides along bands, as described by Judd in the case of the Northamptonshire ironstone."

The longest and usually the most important faults are those belonging to the north-east series. They cut off, and have apparently dislocated some of the faults belonging to the N.W. system, as may be seen in the N.E. part of fig. 2: they are themselves cut off, in other cases, by N.W. faults; thus the N.E. faults seen in fig. 2 terminate against the large, curved N.W. fault at the S.W end of the map. The blocks bounded by the N.E. faults are themselves traversed by faults or fissures running either in a N.W. or N. direction : these faults are limited to the blocks, the boundaries of which they occasionally fail to reach (fig. 2).

It is difficult to state exactly in what order the various faults and dislocations originated, but the circumstance that the continuation of a fault can rarely, if ever, be detected on the two sides of another which cuts it off, suggests that the majority of the faults belong to a single period, the large blocks bounded by the chief faults being broken up into smaller sections, the faults bounding which either terminated against the larger faults, or failed to reach them.

The down-throw of the N.W. faults was very commonly, but not quite universally, on the N.E. side (fig. 1); that of the northerly faults (fig. 2) to the W., whilst in the case of the N.E. faults the throw was usually to the S.E. fig. 2). The N.E. faults, as far as could be observed, were ordinary ones ; and the hade of the last-mentioned series was high to the S.E.

It will be seen that the facts given lend no support to the view that the marine depression to the N.W. of the Devonshire (and Cornish) coast is directly due to crust movements, the throw of the N.E. faults, which are parallel to the general direction of this coast from Morte Point to Land's End, being the reverse of that required by this hypothesis.

The occurrence of series of faults intersecting one another at right angles is a common phenomenon, and has been particularly pointed out by De la Beche* in S.W. England. One series of faults in these cases is usually approximately parallel to the strike, and the other to the dip of the beds. Such is generally the case in Cornwall and South Devon, as may be seen from the maps and description of De la Beche and Asher. The normal strike of the beds in these regions is approximately E. and W., but in the neighbourhood of the granite it becomes modified, and the faults, mineral veins, and elvans show in many places a deflection more or less parallel to the general trend of the granite masses; the fissures, however, preserve their relations to the strike and dip of the beds. We cannot, accordingly, explain the N.E. and N.W. direction of the main faults near Westward Ho, as a deflection of the fault corresponding to the N. and W. faults of other parts of Devonshire and of Cornwall, since the former cross the strike obliquely; moreover, the latter series is represented in the district, as seen above†, though only to a small extent. The cause of this direction does not seem to be perfectly clear, and may have relation to the direction of the high ground and granite bosses, or be due to merely local conditions, such (as Mr. Ussher suggests to me) as the local development of grits in the Culm Measures of the region.

In conclusion we may say, firstly, that everything points to the view that the present configuration of the shore in this region is due solely to denudation acting on a tilted and faulted series of rocks of varying hardness; and secondly, that a fjord-like structure may be produced on a small scale by marine denudation acting along a series of faults and fissures.

Explanation of Figures.

Fig. 1. Portion of the sea coast between tide-marks about a mile to the S.W. of Westward Ho, showing the channels which have been excavated along lines of faulting. The faults themselves are

* Report on the Geology of Cornwall, Devon, and West Somerset, 1839.

† De la Beche describes a well-marked N-S. fault at Cornborough, which lies one-third of a mile to the E. of the area shown in fig. 1.

not shown in the map, but their effect in displacing the strata is visible. As far as can be judged from the survey-maps the prevalent direction of the channels in the strip of coast immediately to the S.W. is likewise N.W. The same may be said of the portion of the coast between that represented in figs. 1 and 2, as observed in the field.

Fig. 2. Map showing the principal faults which have effected the Culm Measures exposed in the intertidal platform about two-thirds of a mile W. of Westward Ho. The further continuation of the map to the N.E. would show a number of other faults running respectively N.E. and N.W. ; the survey map, for instance, shows about six N.E. channels, most of which traverse the whole breadth of the rock exposed.

Fig. 3. View at low water from the summit of the cliff of a portion of the shore between those represented in figs. 1 and 2, showing one of the larger N.W. faults, with a northerly one abutting against it. To the right is seen a second smaller N.W. fault. The small sandstone ridge to the left is separated from the shales to the extreme left by a strike fault. (From a photograph by Mr. Percy Groom.)

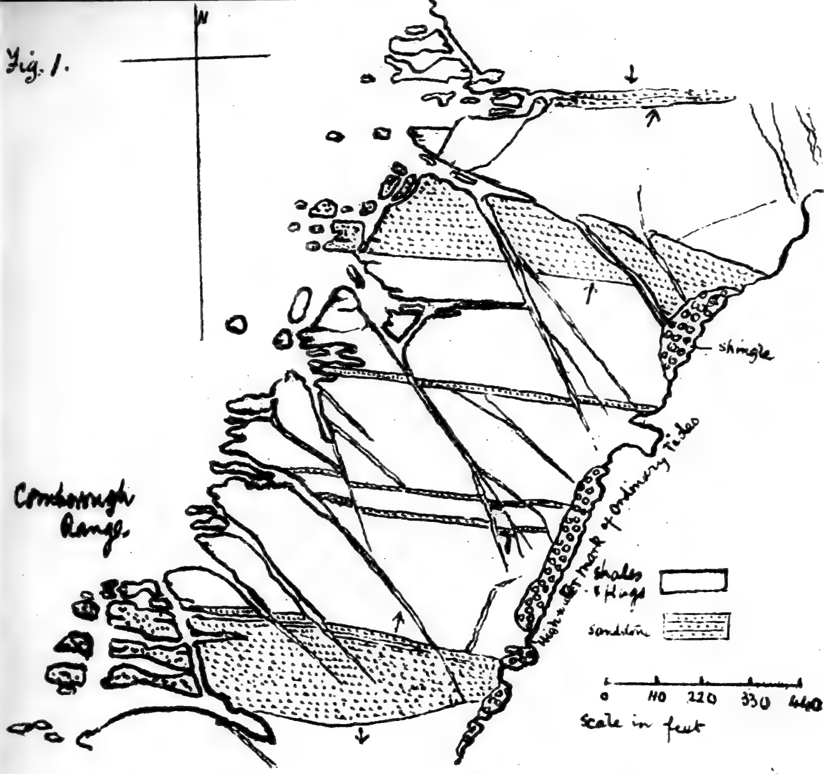
Fig. 3a. View at low tide from the top of the cliff of a portion of coast immediately to the N.E. of that shown in fig. 3 ; the same faults are shown together with other small ones, belonging to the N.W. and N.E. systems. (From a photograph by Mr. Percy Groom.)

Fig. 4. View from summit at cliff of part of the coast shown in fig. 2, immediately to the N.E. of the curved N.W. fault towards the S.W. of that map. The tide is partly up, and the small promontory to the N. of the fault is converted into a number of reefs traversed by two N.E. and one N. fault. The more north-westerly-situated of the two long N.E. faults. shown in the map, is seen filled with water near the upper right-hand corner, whilst portions of the two southern branches of the westernmost of the three N. faults are seen in the fore-ground. The N.W. curved fault itself is marked by the channel crossing the sandstone ridge to the left. (From a photograph by Mr. Percy Groom.)

Fig. 5. View from summit of cliff of part of coast ; on the left

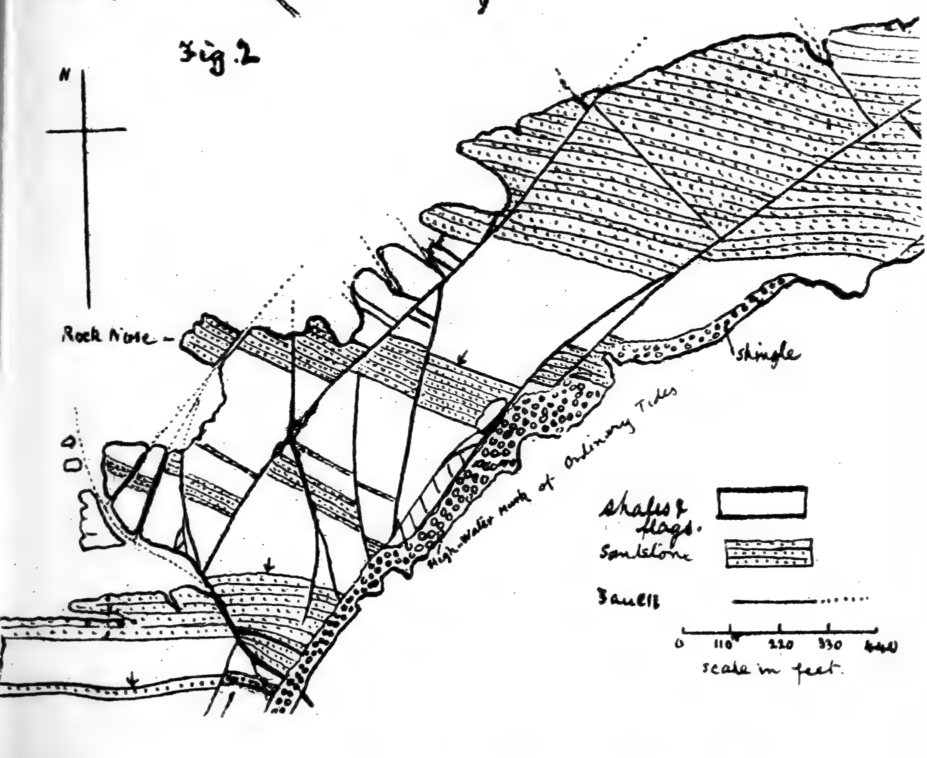
is seen the sandstone band indicated in the middle of fig. 2, and terminating seawards in Rock Nose; this band is traversed by three of the N.E. faults, one at the edge of the pebble-beach, a second in the fore-ground, and a third in the distance. The somewhat rocky portion of the fore-ground is a portion of the sandstone band displaced to the N.E. along the middle N.E. fault traversing the "Mermaids' Pool." Just beyond this is the flat area of shales occurring immediately to the N.N.W. of the sandstone band. On the right-hand side is seen the uppermost part of the broad sand-sandstone band occupying the N.E. portion of the map (fig. 2). Seawards appear small inlets excavated along two of the N.W. faults. (From a photograph by Mr. Wilfrid Groom.)

Fig. 1.



N
Cornborough Range.
shingle
High-water mark of Ordinary Tides
Shales & Flags
Sandstone
0 110 220 330 440
Scale in feet

Fig. 2



N
Rock Nose
shingle
High-water mark of Ordinary Tides
Shales & flags.
Sandstone
Faults
0 110 220 330 440
scale in feet.

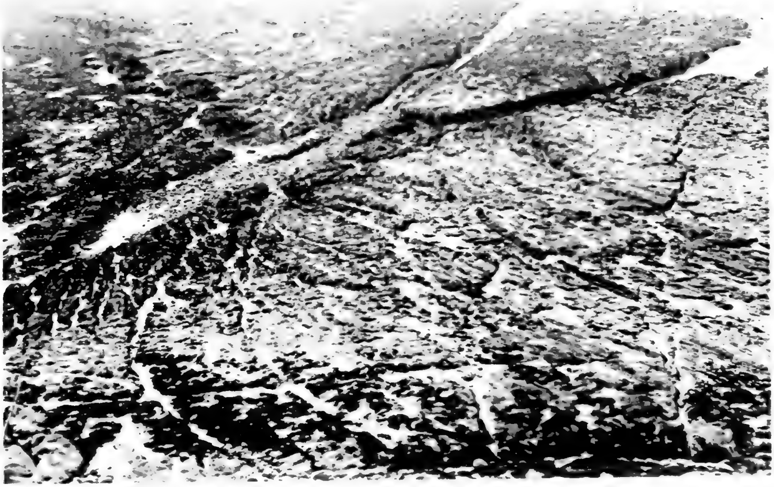


FIG. 3.

FIG. 4.

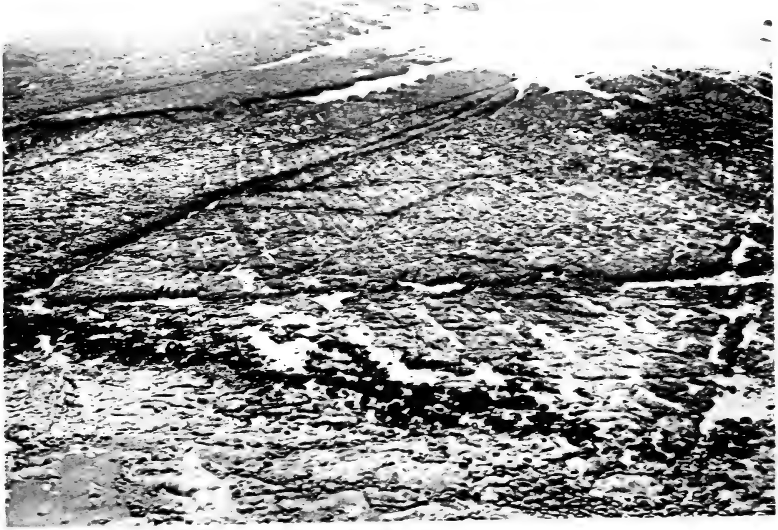


FIG. 3A.

FIG. 5.

ON THE GEOLOGY OF CALDERDALE. BY JAMES SPENCER.

(*Communicated January 16th, 1894.*)

After describing the general aspects of the country through which the Calder flows, the author enumerates the formations found in Calderdale. The strata of this valley and its tributary dales belong to the Carboniferous System, the Coal Measures, Millstone Grit, and Yoredale Beds being alone exposed, whilst the Mountain Limestone underlies the valley at no great depth. The total thickness of these strata exposed in Calderdale is from 4,000 to 5,000 feet.

In order to obtain some idea of the physical geography of the Carboniferous period it is advisable to consider the condition of things at the beginning of the Devonian period. Then the area now occupied by the British Isles was girdled by a broad belt of Archæan, Cambrian, and Silurian rocks, which stretched from Scandinavia round the western coasts of Scotland, Ireland, and Wales. From this ancient north-western continent three elevated tracts of land stretched across what is now England and Scotland. The northern range ran across the Lake District, the middle tract across Shropshire and Leicestershire, and the southern range passed in an easterly direction from the Bristol Channel, then turning southwards and crossing the English channel, was probably continuous with the Ardennes Mountains. These high lands were acted on by extensive denudation, and the enclosed low-lying ground was filled up in the Old Red Sandstone period by thick beds of conglomerate, sandstone, shales, and volcanic ashes and lavas, in some places amounting to 10,000 feet in thickness. The denudation of these strata probably furnished much of the material of the Calderdale rocks. At the close of the Old Red Sandstone period the whole area began to subside, and this downward movement continued, but with occasional pauses and slight upheavals, during the whole of the succeeding period. At the beginning of the Carboniferous period the sea extended from the middle of England through Derbyshire, Lancashire, and West Yorkshire, up to Central Scotland, but Northern Scotland was dry land and probably connected with the great Brito-Scandinavian continent. Two or more great rivers came down from this ancient continent loaded with sediment, and emptied themselves into this sea in which the Carboniferous Limestone was being deposited. In Derbyshire this limestone is about 5,000 feet in thickness, but as we trace it northwards it gradually becomes thinner, until in Northumberland and Central Scotland thick beds of shale, sandstone, and coal are interbedded in the limestone; showing that clear water prevailed in the south whilst the northern areas were invaded by mud-bearing currents, and minor elevations permitted the formation of land surfaces. These alterations of land and water conditions continued throughout the time during which the Mountain Limestone of Derbyshire was being deposited. At length the great rivers from the north-west and north-east extended their deltas down to Central England, covering up the Mountain Limestone with the Yoredale strata and Millstone grits. The Rough Rock, the uppermost bed of the Millstone Grit Series, near Halifax, consists of two members, an upper thick-bedded coarsely-grained, and false-bedded rock, from 70 to 100 feet in thickness. At the base of this series, in the neighbourhood of Halifax, there are eight to ten feet of fine-grained flagstone, which sometimes lies under the grit without any parting of shale, and at others has an intervening bed of shale of varying thickness. This lower flag-rock occurs at Moor End and Oxenhope Quarries without any covering of Rough Rock, where it is described by the Geological Surveyors as the Second Grit Rock.*

The structure of Ringby Hill affords a good example of the strata composing the Millstone Grit and Coal Measures. Ringby Hill forms a portion of the semi-circle of high-ground, forming the outcrop of the Lower Coal Measures, which extends from Swill Hill (1,300) and Ringby Hill (1,100) on the north, to Beacon Hill (850) on the east, and which stands up boldly from 500 to 600 feet above the Rough Rock upon which the town of Halifax stands. Overlying the Rough Rock at the base of the hill is a bed of seat earth upon which reposes a thin bed of coal, overlaid by 40 to 50 feet of shales.

* The Author has endeavoured to show (Trans. Man. Geol. Soc., vol. xiii., p. 107) that this flagstone is a necessary part of the Rough Rock, and after re-examining the exposures sees no reason to alter this opinion.

In the neighbourhood of Denholme these shales partly give place to a thick-bedded sandstone which is very rich in fossil plants (casts). Then we have more shales followed by the Soft Bed Coal (16 in.) with a roof which yields a few fish remains, but in which fossil plants are rare. Then follows about twelve feet of grey shales, upon which are three beds of Anthracosia, which are separated from one another by two thin beds of black shale, which contain quantities of Spirorbis carbonarius. In the Low Moor Coal series there is a bed several feet in thickness almost entirely composed of these small coiled shells.

Twenty-five yards above the Soft Bed Coal the Hard Bed Coal is reached; halfway between them is the Middle Band Coal, about ten inches in thickness, which is worked about Halifax in connection with the fireclay upon which it rests. Below the latter is a fine-grained sandstone from three to five feet in thickness.

The Halifax Hard Bed Coal is overlaid by a bed of marine shells consisting mainly of Aviculopectens. Immediately above this bed come six to twelve feet of shale, containing a large number of calcareous balls, locally known as "baum pots," which contain marine shells, Goniatites Listeri being especially common.

In the Hard Bed Coal itself there are other balls, generally coated with pyrites, but containing fossil plants showing the vegetable structure as well as the form. No less than nine species of Lepidodendron, six species of Sigillaria, ten of ferns, as well as Calamites, Astromyelons, and many other coal plants are thus preserved, and even the parasitic fungi which preyed upon them are found in a beautiful state of preservation. When cut into thin slices the tissues of the plants can be examined under the microscope almost as easily as those of living plants.

These Goniatite Beds are followed by thirty yards or more of "hard bands," a ragstone, composed of thin layers of stony shale, containing a large percentage of silica, forming a thin-bedded but very hard rock. This is followed by three to six feet of seat earth, upon which reposes the 36 Yards Band Coal, six to eight inches in thickness. Upon this coal rests about twelve yards of shale or "bind," followed by the 48 Yards Band Coal, six to ten inches in thickness; in some places there are two beds of coal with a foot of seat-earth between them. Thirty yards higher is the 80 Yards Band Coal, about four inches in thickness, and this is followed by about 200 feet of shale, rag, and thin beds of stone ; thus making, altogether, nearly 600 feet of strata between the Rough Rock at the base, and the flagstone which crowns the summit of Ringby Hill. This flagstone is here 70 feet in thickness, and consists of thin slaty beds of stone, reposing upon thicker beds of stone, rag, and shale in its upper part, with thick beds of ashlar and flags at the base ; it occupies an extensive area from Ringby and Swalesmoor to Queensbury, Northowram, and Southowram, where it is extensively quarried. The late Professor Phillips gave it the name of Flagstone Rock, but the Geological Surveyors re-named it the Elland Flagrock, because in working up from the south they first met with it in the neighbourhood of Elland. This rock has yielded a large number of fossil plants in a beautiful state of preservation (casts) ; Anthracosia also occurs in certain beds in the upper part of this rock, and worm tracks frequently occur on the bedding planes.

Besides the well-known Ganister rock which occurs under the Hard Bed Coal there is a similar fine-grained siliceous rock met with above that coal, and the same kind of rock is also found in the Low Moor Coal Measures.

A bed of similar rock, about nine yards in thickness, occurs in the Third Grits at Skip Mount, Wadsworth, near Hebden Bridge, and has been traced by the author along the edges of the moors on each side of the Calder Valley from Hebden Bridge to Sowerby Bridge, and on each side of the Luddenden Valley from Castle Carr to Luddenden. It is composed of nearly pure silica, in very fine, but sharp, angular grains, rendering it difficult to cut and grind into sections for the microscope. This galliard rock appears to have been derived from grit rocks, the disintegrated grains of which formed extensive shoals of fine sand, and afterwards were cemented together by silica. The shales vary considerably in character from soft clayey layers to others hard as sand rock, and range in colour from nearly white seat-earth to black carbonaceous shale. The "hard bands" or "binds" of the miner, are composed of a series of thin layers, which vary from one sixteenth of an inch to an inch or more in

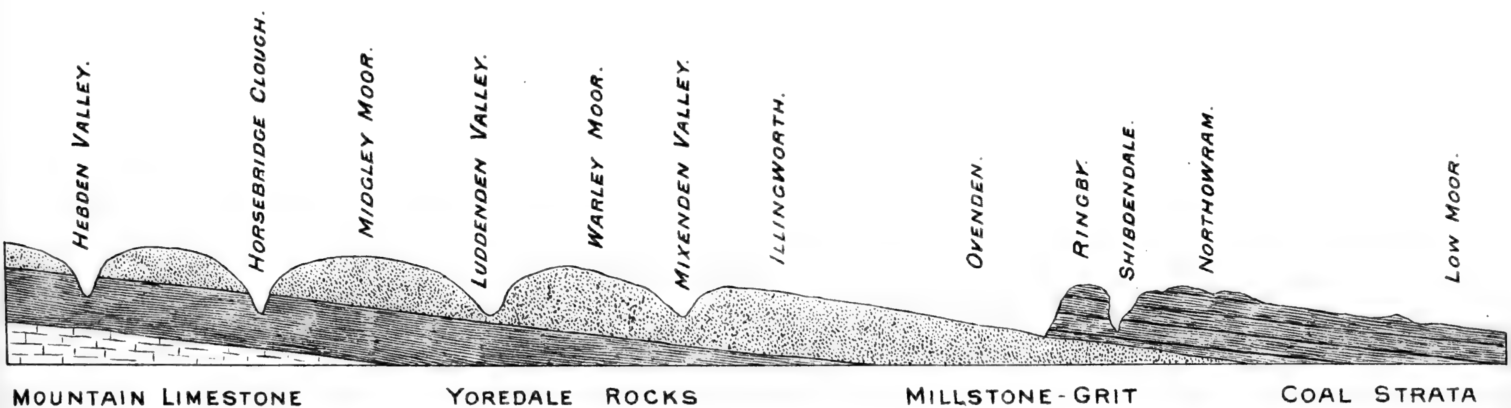


DIAGRAM · OF · THE · STRATA · OF · CALDERDALE.

Proc. Yorksh. Geol. & Polyt. Soc., Vol. XII., Pl. XXI.

thickness, and are chiefly composed of quartz grains ; sometimes they graduate into lenticular beds of sandstone similar to some of those in the Third Grits.

The author concludes with a resumé of the physical changes which have produced the existing contours of the surface.

UPPER WHARFEDALE EXPLORATION COMMITTEE.

FIRST ANNUAL REPORT (1893), BY E. E. SPEIGHT, B.A.

(Communicated January 16th, 1894.)

For many years back the existence of certain ancient remains in Upper Wharfedale has been known to a few inhabitants of the district and to interested visitors, but until quite recently no examination had been carried out. The character of most of the remains is now better understood, and, as far as can be predicted from surface signs, they consist mainly of barrows, enclosed settlements, defensive works and rude monuments. By far the most interesting and extensive are the settlements, five of which are situated within three miles of Grassington village, and which are of similar construction in their details. The district along both banks of the Wharfe for a stretch of three miles, between Grassington and Coniston, seems to have been at some early period one great dwelling and hunting ground, ranged over by a people hardy and cunning. The wooded knolls and the cleared patches on both sides the river bear evident marks of former occupation: traces of long since useless walls literally abound, and from the earth itself are constantly appearing relics of war and the chase.

In the Summer of 1892 one of the barrows near to Grassington was excavated under the direction of Rev. B. J. Harker, whose account appeared in contemporary journals and in the *Antiquary*. The success of this first attempt was marked, and had its due effect in promoting further investigation into the nature of other suspected sites in the neighbourhood.

After consultation with Prof. W. Boyd Dawkins, of Manchester Mr. Wm. Horne, of Leyburn, and Mr. Wm. Cudworth, of Bradford, I entertained the idea of forming a small Committee for the purpose of making a careful examination of the chief of the ancient remains. In November, 1892, I met Mr. J. W. Davis, who promised to assist in the formation of a Committee; also to bring the matter before the Council of the Yorkshire Geological and Polytechnic Society, and if possible to affiliate the Committee with that body. This was duly brought about, and with promises of other assistance, the end of 1892 saw a Joint Committee formed under the presidency of the Duke of Devonshire, and consisting of Ven. Archdeacon Boyd, Sir M. W. Wilson, Prof. W. Boyd Dawkins, and Messrs. W. L. Carter, W. Cheetham, W. Cudworth, J. W. Davis, J. R. Eddy, E. T. Hartley, W. Horne, Walter Morrison, J. R. Mortimer, W. A. Proctor, C. S. Roundell, M.P., Edwin Speight, T. Tate, R. H. Tiddeman, and J. J. Wilkinson, with E. E. Speight as Honorary Secretary. In response to an appeal for subscriptions, issued by Mr. Davis, the sum of £80 was promised, including £10 from the Duke of Devonshire, and a similar sum from Mr. Walter Morrison, whilst General Pitt-Rivers was one of the first donors, sending £5.

Meanwhile, permission to excavate in Upper Wharfedale was freely granted. As early as October, 1892, the Duke of Devonshire had generously consented to work being conducted in the extensive Grass Woods: a month later Sir Matthew Wilson wrote giving us power to make any examination we liked upon his property, and expressed his interest in the work. Mr. Wm. Proctor, of Rylstone, was equally kind, the land owned and tenanted by him including the Norton Tower district and much of Bordley Moor; and verbal permission having been readily accorded by various landowners on whose property were situated interesting remains, we had almost the whole district under our charge by the date of the first Committee Meeting, March 26th, 1893.

On that day, after carefully inspecting the remains close to the village of Grassington, a short conference was held under the chairmanship of Prof. Boyd Dawkins, at which it was decided to commence work as soon as possible, the first operations to consist of the examination of certain mounds and the making of various plans.

Accordingly, on April 5th was commenced the further examination of a barrow which I had relieved of its central interment the previous summer. This mound is situated in one of the higher pastures of the Coniston Liberty, named the Capstick Back Pasture (1891 Ord. Map, sheet cxvi. 13, in parcel 64, just to right of Old Lime Kiln). It is circular, with a diameter of 62 feet and a height of 1-3 feet above the original surface. The materials of construction consist of rolled limestone pebbles, large boulders, and earth, and the barrow is partly natural, being raised upon a hillock at the junction of two mineral veins.

At the previous examination, before the formation of this Committee, an entry was made into the centre of the mound, where was a rectangular grave, 7 feet by 3 feet, in the N.E. corner of which lay a human skeleton, under rough blocks of decomposed limestone, 4 feet below the surface of the mound. The body was laid on the left side, with the legs doubled up, the head-direction being due E. From the earth dug out of this central grave were taken fifteen human teeth, in addition to twelve found with the jaw; a third thigh bone, indicating a double interment, an iron knife (blade and haft), 4 inches long and ½ inch broad, part of an iron pin or nail, and a piece of worked bone with an iron rivet.

Twelve feet S. from the centre was a hollow 5 feet E-W. by 2½ feet N-S., sunk a few inches below the surface; this contained only the ordinary material of the barrow with a few human teeth. From here I dug a trench through to the centre with a width of 3 feet. 10 feet S. from the centre were a flint scraper and a flint chip (the only fragments of that material found in this barrow), just beneath the sod, while scattered about this portion were calcined bones of animals, pieces of charcoal and 30 human teeth. Here also I found a circular doubly-perforated button or pendant of jet or Kimmeridge shale, near which were pieces of chevron-marked pottery, including part of the rim of a vessel. 8 feet S. of the centre were portions of a bone-pin and of a bone-handle.

As the Exploration Committee had decided upon completing the examination of this mound, a trench was driven through from W. to E. This laid bare portions of the rude limestone boulder wall which entirely surrounds the barrow, 3 feet in thickness and 1 or 2 feet in height. Remains of another interment were found 15 feet E. from the centre, under a large limestone slab, and near to the skull was an iron nail. 6 feet nearer the centre was a bronze ring 1 inch in diameter, which, according to Prof. Dawkins, probably formed part of a ring-brooch. In the S.E. section of the mound, 12 feet from the centre, were found portions of skull and several phalanges, with many remains of the rat ; and at the same distance from the centre N.N.W. were found similar fragments of a skeleton, with a portion of gnawed antler and part of a bone comb.

In this barrow, as in the others examined, all human remains were much decayed and broken, this being due to the fact that the material of construction of the barrows in this district is mainly stone, the upper parts of which have in most cases been removed for later walling purposes. This has delayed the process of reconstruction of the bones, thereby preventing at present the issuing of detailed measurements. Examination of the fragments, however, has resulted in several observations, namely, that the skulls show strongly-marked superciliary ridges united by frontal bars, and low foreheads, and that the leg and thigh bones are strongly ridged, the tibiæ being platycnemic.

The animals represented in this barrow were the ox, sheep or goat, stag, hog, dog, fox and rat, of which last-named the jaws were abundant near any human remains.

The next work done was the excavation of a suspicious-looking mound, situated at the N. end of Lea Green Pasture (sheet cxxxiv. 1, parcel 368, N.E. end), one mile N. of Grassington. This was commenced on April 12th, 1893, a trench being run through from S. to N. The barrow is built at the summit of a natural mound, and consists of an outer wall enclosing an inner wall, the materials of construction being limestone pebbles and rubble. The diameter of the circle enclosed by the outer wall is 40 feet, that of the inner circle 16 feet, the inner wall being distant 7 feet from the outer wall at the N. end and 17 feet at the S. end. In the centre of the inner circle was a circular grave 5 feet in diameter and 3-4 feet deep, within which, under limestone slabs, was a human skeleton, laid on the right side, the head-direction W., the legs doubled up at right angles to the spine, and the hands near the head. Above the body was a pointed bone awl or netting implement (?) 3 inches in length. At the end of the N-S. trench, close under the outer wall, were portions of a human skull 5 feet from the centre S.E. were human remains interred just beneath the present surface, the skull being very thin, the head pointing due W., the skeleton on the right side. Near the head was a bronze-ring-brooch, similar to, but smaller than that found in the Capstick Pasture Barrow. 8 feet due E. from the centre of the N-S. line were found eleven human teeth. Nothing whatever was obtained from the west side of the N-S. trench. The skull from the central interment is of the same type as that of the central interment of the Capstick Pasture Barrow, with low forehead. Two measurements were obtainable, length 6·85 inches, and parietal breadth 5·70 inches. One femur from this interment is much rat-gnawed.

About sixty yards S. of this hill, and separated from it by a water-worn dip, is a curious place which I first noticed some six years ago, and which several members of our committee had examined and thought worthy of trial. A massive limestone wall surrounds a series of nearly twenty small enclosures, all irregularly constructed and arranged, the shape of the whole being an imperfect oblong, 80 yards by 50 yards. Before excavation, the walls, which are not easily distinguishable from the surrounding outcrops of limestone, were not more than 1 foot in height, but the digging has made them 3 feet normally, whatever their original height was. Two of the smaller enclosures contained rudely-constructed fireplaces in the S. corners ; in almost all was found charcoal or turf-ash, the remains of past fires made in the sheltered parts. Animal bones, mainly burnt, were most abundant, and were found in seventy-one out of the seventy-two holes and trenches made. The finds were as follows :—

I. Pottery. (Prof. Boyd Dawkins' List).

1. Lathe-turned ; grey ; ornamented with lines of square stick-marks ; glazed yellow-green ; similar to some unglazed Roman ware found near Maidstone.
2. Coarse, thick red ware, with flat bottom ; fragments glazed yellow-green ; without sanded paste.
3. Thinner ware ; also without sand.
4. Thin red ware, with sand ; outer surface with polished grains.
5. Fine red ware ; possibly pseudo-Samian.
6. Coarse, black ware ; with sand.

II. Stones.

8 Portions of millstones ; lowerstones, of Roman pattern.
16 Whetsones, of various shapes.
2 Small primitive-looking mortars.
1 Finely-drilled stone, possibly for hanging weight.
32 Flint flakes and chips, several worked.
Small portion of cut volcanic compact stone.

III. Iron.

Portions of a vessel.
8 Knives, of similar type to that found in Capstick Pasture Barrow.
One pin, one wedge, and one gouge.

Besides these were found a bronze pin, with flat, perforated (5 holes), coin-shaped head, along with a small pointed bronze sheath (?) 2 inches long, and ornamented with criss-cross pattern. These were taken from a hole 4 feet deep in the N.W. end of the settlement. There were also found a perfect bone spoon, a bone pin, and part of one of the dorsal vertebræ of a young animal, perforated as for a pendant. Though a fairly extensive examination was made of the interior of all smaller enclosures, yet the greater part of the ground within the larger walls is still untouched. A plan of the place, as so far excavated, has been prepared, but need not be published until a complete examination has been made.

On June 13th, 1893, a rock interment in one of the pastures E. of Lea Green was opened. This, too, is situated on a natural hillock, but, though signs of a grave were seen, only two small portions of human skull were found, the place having obviously been disturbed and the upper stones of the cairn removed.

After a stoppage of two months, further work was carried out, this time still on Lea Green, but nearer and within sight of Grassington itself. On a commanding ridge of this extensive pasture stands a strange pile of loose shuttered limestone, which, before we opened it, resembled, more than anything else, the mouth and surrounding surface mound of a pit. At the instance of Prof. Dawkins, who discredited the local opinions as to its formation, an examination was made during the last week of August, 1893, with the result that the pile turned out to be a barrow with similar contents to the others examined. The diameter was 66 feet N-S. and 76 feet W-E., and the central portion had fallen in, making a dip 4 feet lower than the surrounding ridge, which formed a ring whose diameter was 27 feet. Commencing from the interior, a careful examination of that part and of the encircling mound was made. A depth of 4 feet of limestones at the centre of the hollow was underlaid by a stratum of clay 3 inches in depth, below which was the limestone. The whole mound was constructed simply of stones, chosen at random and placed together without divisions or walls. Our finds were :

1. 7 feet E.N E. of the centre, at a depth of 5 feet from the surface of the hollow, the remains of a giant skeleton, much broken, as usual. Head-direction due S., body straight out, laid on its back, one hand near the head, the other among the vertebræ.
2. 6 feet N.N.E. of the centre, human remains consisting of seven well-preserved teeth, five phalanges, portions of lower jaw and of the skull.
3. 12 feet S.E. of centre, remains of skeleton ; head due W., straight out on left side ; skull fragmentary, lower jaw complete.
4. 16 feet N.W. of centre, among the dry outside stones of the encircling mound, remains of skeleton, with which was the first skull we found with frontal bones present and the upper jaw preserved ; certain phalanges and portions of limb bones also present.
5. 7 feet N. of No. 3, fragments of skull and jaw, with several teeth and phalanges.
6. 8 feet S. of centre on N.E. line, skeleton, much decayed ; head due W., legs doubled up, feet S.W.
7. 9 feet S.W. of No. 1, many phalanges with a few fragments of skull.
8. Four knives, similar to those previously found ; a small bronze pin ; part of a spiral bone pin ; and a sharpened bronze blade-implement perforated at one end.

This concluded the active work of the season, but I should mention that the result of a constant search by various helpers, amongst whom we are especially beholden to Parker Birch and his nephew James, has been the finding of many interesting flint implements, mainly arrow-tips and thumb-flints. These flints are of East Yorkshire origin, and are numerous on the higher parts of the river slopes; near the ancient remains they exist in great profusion, and they have recently been discovered in the enclosures at the low part of Grass Woods.

On July 29th, 1893, by kind permission of Mr. E. T. Hartley, a second Committee Meeting was held at the Skipton Grammar School. Mr. R. H. Tiddeman occupied the chair, and among the propositions carried were the following .

1. That Rev. E. Jones, Rev. W. Shuffrey, Rev. T. Nowell, Rev. B. J. Harker, and Mr. W. Cash be elected Members of the Committee, subject to their consent.
2. That Messrs. J. Ray Eddy, E. T. Hartley, and J. J. Wilkinson be appointed as Legal Representatives of the Committee, with a hold on the finds.

With regard to the former of these resolutions, Messrs. Jones, Shuffrey, Harker and Cash have signified their willingness to serve on the Committee. In contrast with these powerful acquisitions, the Committee has suffered a very severe loss by the death of three of its members, Archdeacon Boyd, Mr. W. Cheetham, and Alderman J. W. Davis.

To Mr. Davis almost alone is due the formation of this committee, in addition to which he was present at Grassington the greater part of the time during which the preliminary excavations were carried on ; when, though unfortunately prevented by illness from regularly visiting the workings, he nevertheless took the greatest interest in the explorations, and was ever ready with advice and assistance. In Archdeacon Boyd too, the work had a firm supporter, and though neither he nor Mr. Cheetham was able to attend the meetings owing to failing health, both gentlemen readily accorded their support, and expressed their interest in the proceedings. The members of the committee desire to place on record their appreciation of the past services rendered by such right earnest workers as Dr. Boyd, Mr. Davis, and Mr. Cheetham, and to express their keen sense of personal loss inflicted by their death.

It is a matter of much gratification that at this critical point of time the Committee should have acquired the hearty support and welcome advice of Mr. J. Ray Eddy, of Carleton, whose influence in the whole region of our explorations is unique. This gentleman has visited the workings on several occasions, and, in addition to subscribing liberally, has taken an active part in the management of the Committee.

Such is the account of our first years' work, and though the results are promising, it is to be remembered that what is already done is very little compared with the amount of work before the Committee. So far only the least likely and least important sites have been examined, whereas there is still four or five years' full digging in hand, together with much planning and photographing of remains. Under these circumstances the Committee feel justified in asking the 1893 donors to become annual subscribers, and in appealing to those interested in our branch of research for further subscriptions.

In conclusion, I have great pleasure in conveying the following gratifying news to members and subscribers. At a Council Meeting of the Society, held on Feb. 17th, 1894, it was decided :

1. That Mr. Percy F. Kendall, F.G.S., and Mr. Godfrey Bingley be elected Members of the Exploration Committee.
2. That a photographic camera and outfit, not to exceed £10 in cost, be purchased by the Society, and loaned to the Upper Wharfedale Exploration Committee.

NOTE.—Since the above Report was written there is a further record of work to be rendered. With the return of Spring last year, a move was made to the Grass Woods, for the purpose of examining certain remains which had for long interested visitors to Upper Wharfedale. At the highest point of the Woods, on a knoll overlooking for many miles the surrounding country, is a series of enclosures resembling those existing in other parts of the valley, but densely covered with brushwood. The kindness of the Duke of Devonshire enabled us to proceed quickly with the work, and extensive trials were made in every part of the ruins, but to no end, as the natural limestone was soon reached, and nothing but a few fire-marked stones was obtained. However, failure on the height was more than compensated by success in the recesses of the wood below, and, after the repairing of damage done on the summit of Far Gregory, work was continued for two months near the Park Stile, with daily discoveries. Here a naturally defended glade, running up the hill-side into the heart of the wood, has been further fortified by the raising of a boulder-wall on the north side. Between this wall and the limestone cliff on the south, was a row of circular enclosures, through the middle of which the present path has been cut. At the base of the wood, running south, were more enclosures, bounded by a continuous wall irregularly arranged; and on the north side were other walled-in divisions. In this portion of the field of exploration our finds were of a similar nature to the previous ones, but yielded us richer results. Especially noteworthy was the large quantity of British and Romano-British pottery discovered, some of the enclosures being littered with fragments of many varieties of ware, about 400 specimens of which have been removed to the show-room at Grassington. Several portions of antler were obtained, some evidently intended for use, a fact made more probable by the later finding of a perfect little knife, whose blade (similar to those haftless knives found in Lea Green) was fitted into an antler-tip. Mill-stones, potboilers, crushers, and other stones of use were unearthed and removed to a place of safety; and one of the last, though certainly not the least important, discoveries was that of our first coin, a bronze Constantinopolis of Constantinus Magnus. The date of the Grassington remains had been provisionally fixed by Prof. Boyd Dawkins as *circa* 350 A.D., the coin found being struck a few years before that date; hence, and from the similar nature of all the remains excavated, we may fairly accurately fix their historical position. It will be noted that the rare occurence of actual Roman articles, and the primitive nature of the remains in general, preclude the idea of Roman *occupation* of the district. This point was firmly insisted upon at the outset by Prof. Dawkins, and one result of the excavations has been to emphasize his conclusions.

I have a real pleasure in recording the value of the services rendered by our two workers, Mr. Wm. Hill and James Birch, who have proved themselves most capable and enthusiastic explorers. To Mr. Hill the thanks of the Society are especially due, as much of the work has been carried on under his sole oversight, always with unceasing care and intelligent direction ; to his young companion we are indebted for an activity and diligence which has been the means of preserving many little objects of interest which might easily have been overlooked. It is to be hoped that in the future explorations the experience of these tried helpers and speedy workers may be always utilized.

There only remains now the task of bidding farewell to the work which during two Summers gained for me so many friends. Unlooked for changes have brought about that I enter a new sphere of life, and I feel true regret in leaving at its commencement a task of such promise and one which I have certainly found "large and health-giving." I can only wish that the Society may enjoy complete success in all future operations, and I heartily thank all those members and distant subscribers by whose aid so much has already been achieved towards an explanation of an important phase of our northern early history.

ERNEST E. SPEIGHT.

Oxford, March, 1895.

THE MICROSCOPIC STRUCTURE OF THE ZONES OF THE CHALK.

BY A. J. JUKES-BROWNE, B.A., F.G.S.

Read April 11th, 1894.

INTRODUCTORY.

It is somewhat curious that such diverse views should be held by different geologists respecting the origin of the formation known as the Chalk, and regarding the conditions under which it was accumulated. This difference of opinion is probably owing to several distinct causes, and I think that before anyone can hope to arrive at a just and sound conclusion on this much debated question, he should fully and fairly consider the reasons why previous investigators have been led to take such different views. There are at least four causes which have conduced to this divergence of opinion.

(1) The minute structure of the Chalk has not been sufficiently investigated. The Chalk is not a simple formation of moderate thickness and extent like many other limestones, nor is it of similar composition throughout. Its thickness is great, 1,700 feet in the Isle of Wight, and its component strata are found to differ much from one another when they are examined with the microscope, though to the eye they may seem to have a very similar structure. Consequently, the inspection of a few slides of Chalk will not reveal the history of its formation, and no one ought to discuss the origin of the Chalk, as a whole, unless he has examined a large series of slides from different horizons and from different areas of Chalk.

(2) When any kind of Chalk is compared with modern deposits, either chemically or microscopically, it should be remembered that certain chemical and minerological changes must have taken place during the consolidation and upheaval of the formation. Some of these changes probably occurred while the formation was still below the Cretaceous Sea, and others were accomplished by the percolation of subaerial water through the mass. Some ingredients, such as the organic silica, the oxides of iron and manganese and the alkalis, have been dissolved and re-distributed or concentrated into concretions.

(3) It must also be remembered that the original structure of some parts of the Chalk may have been different from that of any deposit which could be formed at the present time. Chalk is mainly of organic origin, and the organisms of the Cretaceous period were different from those which now exist, and, as some of the Chalk-builders belong to extinct genera, we cannot be sure that their habits and habitats were similar to those of their nearest living allies. This is especially the case with the Mollusca. The Foraminifera, and especially the arenaceous forms, are more likely to have been similar in these respects to their modern congeners.

(4) Some of those who have discussed the origin of the Chalk, as a whole, have been more or less biassed by preconceived views regarding the permanence of continents and ocean basins, and have therefore sought to minimise the resemblances which some parts of the Chalk present to modern deep-sea deposits ; while their opponents have naturally made the most of these resemblances. The problem of the Chalk should be considered by itself, and the evidence must be balanced by a mind which is free from the bias of any previous theoretical views regarding the origin and growth of oceans and continents.

In the present communication I propose to follow one line of investigation only, and to point out the inferences which may be deduced from the facts so far as they are at present known to me. This branch of the subject is the minute structure of the successive zones of the Chalk as revealed by the microscope. Most of my information on this subject is derived from the work of my friend, Mr. W. Hill, published in several papers and in the Journal of the Geological Society of London, but an important contribution has recently been made by Dr. W. F. Hume, in his essay, entitled "Chemical and Micro-minerological Researches on the Upper Cretaceous Zones of the South of England," 1893.

2. Constituents of Chalk.

Before entering into particular descriptions it will be desirable to give some account of the general structure of Chalk and of its principal constituents. Most kinds of Chalk have a matrix of more or less fine-grained material, which encloses a greater or less number of larger particles, such as fragments of shell or Foraminifera. Sometimes the matrix forms the greater portion of the material; sometimes the definite organic and inorganic particles are in larger quantity. The matrix may be either wholly calcareous or may include some very fine argillaceous matter, and occasionally the mass is bound together by a cement of crystalline calcite.

The larger particles may be classified under four heads—Shell Fragments; Perfect Shells; Sponge Spicules; Mineral Grains.

(1) *Shell Fragments.* These are small angular fragments of the calcareous shells and spines of various marine animals. The most abundant are pieces of *Inoceramus* shell, varying in size from what may be called a large piece, under the microscope, down to single detached and broken prisms. Next to these in abundance, at some horizons, are fragments of the plates and spines of Echinid shells. Portions of the shells of Terebratula, Rhynchonella, Ostrea, and other genera can sometimes be distinguished. Broken Foraminifera are also common.

(2) *Perfect Shells.* Of these the most universally diffused are very small hollow spheres, which have often been mistaken for the detached or primordial cells of some kind of Foraminifera. Dr. G. J. Hinde, however, informs me that he has no doubt they are perfect shells and not detached cells; they occur also in modern oozes, but it is not known to what organism they belong.

Foraminifera are sometimes common, but are never so abundant as to occupy much space in the field of a slide. Both arenaceous and porcellanous forms occur. Entomostraca occur in some beds, and both they and Foraminifera may have contributed largely to the material of the fine calcareous dust of the matrix.

(3) *Sponge Spicules.* These are frequently present and are sometimes abundant, but are not always in their original condition, being often entirely replaced by calcite.

(4) *Mineral Grains.* These are partly such as have been formed on the sea-floor, and partly mineral fragments derived from terrestrial sources. Glauconite is the most common mineral; it generally occurs in grains of rounded outlines, and as it is often seen filling

the chambers of Foraminifera and the axial canals of Sponge Spicules there seems no reason to doubt that the loose grains have been formed in such situations. Of detrital minerals quartz is the commonest, but minute grains of other minerals also occur in some parts of the Chalk and in some districts; among those observed are Zircon, Tourmaline, Hornblende, Felspar, Rutile, and Apatite.

Next let us consider the physical conditions which these constituents may serve to indicate. Little can be learnt from the shells or shell-fragments because most of them belong to extinct species, and we know nothing of their habits. The Foraminifera, however, do furnish some evidence, for many of these seem to be identical with species now living, and the bottom-living arenaceous forms may perhaps be relied on as giving some indication of the depth of water.

The glauconite grains are more definite indicators of certain physical conditions. In modern deposits glauconite is formed inside Foraminifera shells at various depths down to 1,000 fathoms, but is most abundant where the deep water begins, that is from 100 to 400 fathoms. It does not occur where large rivers enter the sea, but only along tracts off bold coasts where the water is comparatively clear. From these and other facts mentioned in the Challenger Reports, it appears that glauconite is formed in areas where deposition goes on slowly, where the amount of land-derived sediment is small, and where, consequently, it lies exposed for a long time to the decomposing action of sea-water. An extensive deposit of glauconite sand or marl will, therefore, indicate clear water of from 100 to 500 fathoms, and within 200 miles of an extensive coast-line. Moreover, if the accompanying quartz-grains are small it is likely to have been formed nearer to the 500 fathom than to the 100 fathom-line.

The detrital minerals, quartz, felspar, zircon, &c., have generally been derived from the erosion of the land, and their presence in any quantity may usually be taken as proof of the deposit having been formed within 200 miles of land. Such particles, especially of the heavier minerals, are generally absent from the deeper oceanic deposits. In some regions, however, small particles of quartz do occur in oceanic oozes at great distances from land, and these can always be traced to wind-blown sands, so that the presence of minute quartz-grains does not prove the deposit to have been formed within the influence of shore currents. Again fine volcanic dust, containing recognisable particles of felspar, augite, hornblende and olivine, is often carried to great distances from land by the wind currents in the higher regions of the air.

3. Structure of successive Zones of the Chalk.

We now come to a consideration of the composition of the different zones into which the Chalk can be divided. Much more work is required before any such account can be considered complete, and the following statements only apply to portions of that part of England which lies to the east of a line drawn from the Wash to the South Coast at Weymouth. The Chalk of Yorkshire has not yet been sufficiently studied either in its zonal or structural aspects.

The Chalk Marl, or Zone of *Ammonites varians*, exhibits great differences in minute structure as it is traced from Norfolk to Dorset. In the N.W. of Norfolk the beds, which represent the Chalk Marl, are hard and highly calcareous; some are of fine some of coarser grain, according to the relative abundance of shell-fragments, but glauconite is absent except in one bed (the so-called "*Inoceramus Bed*,") and the quartz grains are few and small. As the zone is traced southwards, through Norfolk and Suffolk, beds of soft marl come in between the harder layers, and particles of quartz and glauconite become more frequent throughout. When traced further south these grains become rather larger, as well as more numerous, till in Berks and Wilts, where the zone attains its greatest thickness, the material is at its coarsest. Wiltshire Chalk Marl consists mainly of shell fragments, quartz particles, glauconite grains, and sponge spicules in varying proportions; and some beds contain much globular colloid silica. Near the base the grains of quartz are of comparatively large size, gradually becoming smaller in the higher beds. On the South Coast the following minerals have been found in Chalk Marl:—Quartz, Felspar, Zircon, Tourmaline, Apatite, Hornblende, Rutile and Garnet.

The Chalk Marl of the Isle of Wight, and to a less extent that of Folkestone, is characterised by the abundance of arenaceous Foraminifera, especially species of *Tritaxia, Textularia* and *Bulimina.*

The Grey Chalk or zone of *Holaster subglobosus* has the Totternhoe Stone at the base over a large area; this stone is a shelly Chalk, containing much glauconite and some quartz. The Chalk above it consists of fine calcareous dust in which there are some shell fragments and a little glauconite. In the highest part of the zone, from Norfolk to the Thames Valley, there is no visible glauconite or quartz, but south of the Thames both minerals occur sparingly up to the very top; the grains are, however, small, and other minerals are very rare.

Arenaceous Foraminifera are abundant in some localities, or at certain horizons, especially at Folkestone, and resemble those in the Chalk Marl. Calcareous spheres are also very abundant in the upper half of the zone.

In the *zone of Belemnitella plena* the material of the marls resembles that of the Grey Chalk, except that the amount of fine clay in it is much larger, and that the arenaceous Foraminifera belong chiefly to the genera *Ammodiscus* and *Haplophragmium.* Glauconite grains are very rare even on the south coast.

The Melbourn Rock is a very pure limestone; its whiter portions consist almost entirely of a fine calcareous paste, through which calcareous spheres are abundantly distributed, but the marly veins between the white lumps are full of shell fragments. No minerals have yet been recorded from it.

The Melbourn Rock passes up into the *zone of Rhynch. Cuvieri* or *Inoceramus mytiloides,* both fossils being common in it, and broken Inoceramus shells being so distributed through it as to give it a gritty character. The Chalk itself, however, is largely made up of calcareous spheres, shell fragments becoming less and less abundant as a microscopic constituent. The most remarkable point is the recurrence of mineral grains in the South of England and North-east of France; whether they occur in this zone further north is not yet known. The quantity is very small, less than 0·3 per cent. of the mass; the grains are mostly quartz and felspar, and are generally of decidedly rounded outline, but are sometimes large. Glauconite seems to be absent, for none has been observed.

The zone of Terebratulina gracilis is everywhere a purely calcareous deposit, consisting of a fine calcareous matrix crowded with minute calcareous spheres, and including a few scattered shells of large Foraminifera (*Globigerina*, *Rotalia*, &c). The insoluble residue consists almost entirely of very fine light-brown clay, coloured by hydrous oxides of iron. Mineral grains are very rare, but Dr. Hume found a few small particles of quartz in one sample from the Isle of Wight.

The Chalk Rock has a remarkable structure. It always contains a great variety of organic fragments derived from the shells of Echinoderms, Lamellibranchs and Brachiopods, with remains of siliceous sponges. Glauconite is abundant in the south central counties, but the grains become fewer and smaller to the north and east, and detrital minerals have only been found in the Chalk-rock of the southern counties. Quartz is there common in small angular grains, and sometimes in large rounded grains. Dr. Hume has also observed Augite, Hornblende and Tourmaline in the rock of the Isle of Wight.

The Chalk of the *Micraster breviporus and cortestudinarium* zones is generally rough and shelly; it consists of a fine calcareous matrix, enclosing shell fragments and large Foraminifera in varying amounts. In the South of England detrital minerals appear in the insoluble residue; these include Quartz, Apatite, Felspar and Tourmaline, the quartz grains being of various shapes "from perfectly rounded to strikingly angular" (Hume), and some of it is granite quartz. Glauconite is either absent or in very small quantity. No arenaceous Foraminifera have been observed.

The *Micraster coranguinum* Chalk resembles that of the *cortestudinarium* zone in general structure, but the insoluble residue is almost entirely fine clay, containing minute spherules and rods of Glauconite. Only a few very minute particles of quartz have been found.

The Chalk of the *Marsupite zone* is purer than any of the lower zones, the amount of insoluble residue being generally under one per cent., and the greater part of this being fine clay; but, by washing, a small residue is obtained, which includes minute angular fragments of quartz, grains of brassy iron pyrites, and of a reddish limonitic mineral, and rarely of glauconite, all very minute.

The zone of *Belemnitella mucronata* has the same characteristics, generally under one per cent. of clay, no glauconite, and detrital minerals very rare. The material is a fine calcareous dust or paste, in which small calcareous spheres and a few small Foraminifera and shell fragments are distributed.

4. Inferences.

There is one fact which seems clearly proved by the preceding details, and this is that the inorganic constituents of Chalk are most abundant in the South of England. There seem to be several zones in which the amount of quartz and glauconite increases as they are traced southward. From this we may infer that the main mass of land lay somewhere in a southerly direction.

I may here mention that the evidence of the French Chalk shows that this land lay to the east of France, and consequently to the south-east of England. At the same time there are indications of land to the south-west and good reasons for believing that this was a large island which presented a rocky shore to the east, its rivers draining toward its western coasts.

With respect to the depth of the Chalk sea we know that the period was one of great and extensive subsidence, but there is evidence that this subsidence was at any rate in one area interrupted by upheaval. It is obvious that if we can form an opinion as to the depth in which the Chalk Marl was formed, we shall have a basis from which to trace the subsequent changes.

We must remember that the Chalk Marl is not the base of the Upper Cretaceous series. The beds beneath it are not shore sands but marly clays and greensands, which seem to have been formed in water that was not less than 100 fathoms in depth, and may have been much more in the central part of our area. There is every reason to suppose that the Chalk Marl was formed in deeper water than the Gault, but the large amount of sand and glauconite which it contains, especially in the southern counties, makes it probable that no part of this southern area was more than 200 miles from land.

Two lines of evidence lead to the conclusion that the Chalk Marl was formed in water of from 300 to 500 fathoms. One is the general similarity of the deposit to that now forming in certain parts of the Gulf of Mexico and the Florida Straits, and especially in depths of from 200 to 500 fathoms, according to Dr. J. Murray.* Again, the assemblage of arenaceous Foraminifera is best matched in depths of from 350 to 300 fathoms at the present time.† If this conclusion is correct we may safely assume that the rest of the Lower Chalk was formed in rather deeper water, probably from 400 to 600 fathoms.

The Melbourn Rock and zone of Rhynchonella Cuvieri do not afford much positive evidence. The absence of glauconite suggests distance from land, but the presence of large quartz grains is puzzling. The stratigraphical and palæontological evidence connected, the Belemnite Marls and Melbourn Rock indicate the occurrence of considerable geographical changes at this time, affecting the direction and strength of the marine currents and largely altering the fauna. All the facts harmonize with the inference that these changes were brought about by continued subsidence.

Conditions then seem to have settled for a time, and the structure of the central part of the Middle Chalk seems to indicate the quiet deposition of purely calcareous ooze in deep water at some distance from land. The almost entire absence of mineral particles in the Ter. gracilis zone is a striking fact, for there are few modern oozes which are so free from minerals. The absence of pumice and the extreme rarity of augite and olivine is proof that no active volcanos existed within many hundred miles of our area, and it is the absence of this volcanic material which makes the Chalk seem so much purer than modern Globigerina ooze. The mass of the Chalk of the Ter. gracilis zone seems to be entirely made up of fine powder derived from the shells of Foraminifera, Calcareous spheres, Deep-sea Echinoderms, certain Mollusca and Brachiopoda, and Coccoliths.

The Chalk Rock presents a great contrast to this; the recurrence of glauconite and of quartz in Southern England suggests a partial re-elevation of land, and there are other reasons for thinking that there was an upheaval of the western island at this time. The character

* Bull. Mus. Comp. Geol., Harward Coll., U.S., vol. xii., p. 52.

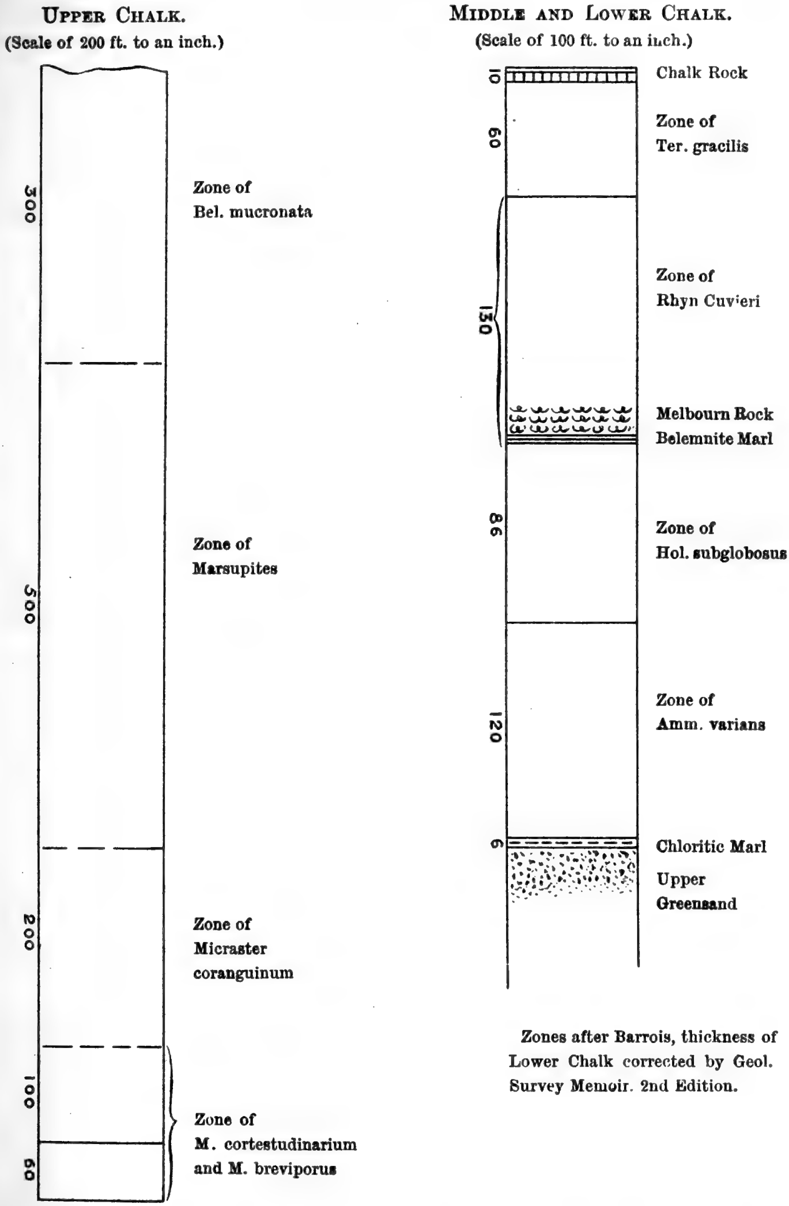
† W. F. Hume, Op. Cit., p. 81.

of the Chalk Rock fauna confirms the above inference, for it abounds in Gasteropoda and recalls that of the Chalk Marl. If the depth of the water over Hampshire had increased to 700 or 800 fathoms during the epoch of the Ter. gracilis zone an uprise of the south-western land may have brought its coast line within 100 miles without decreasing the depth of water by more than 100 or 150 fathoms, and without bringing the eastern shore of the Cretaceous Ocean any nearer our area because the upheaval may have been a tilting movement only lifting the western islands.

From this time we seem to be following the progress of a great and extensive subsidence. The grains of glauconite become smaller and fewer and eventually die out altogether; the same may be said of the detrital minerals, only a few minute angular particles of quartz being found in the higher beds of the Upper Chalk, quite invisible in a slice even under a half-inch lens. Arenaceous Foraminifera are also absent except Ammodiscus incertus.

The mere thickness of deposit above the Chalk Rock amounts to 200 fathoms in the Isle of Wight, and the fineness of the material shows that its accumulation was very slow. Its other characters indicate distance from *Continental* land and a considerable depth of water. At the same time the deposit is purely calcareous and shows no tendency to pass into a Red Clay; this however is due to the absence of volcanic material and is not a reliable indication of depth, for Globigerina oozes, with over 90 per cent. of Calcium Carbonate, occur in the South Atlantic at depths of about 2000 fathoms. It is, therefore, quite possible for a purely calcareous deposit to be formed at that depth.

It has been asserted that Coral-mud is more like Chalk than any other modern deposit, but the resemblance is probably quite superficial. Dr. J. Murray describes Coral-mud as always containing the debris of *reef-forming* organisms, such as Corals, Calcareous Algæ, Echinoderms, Alcyonaria, Pteropoda, small Gasteropoda, and other Mollusca. I need not say that such an assemblage is not to be found in any part of the Chalk. The only bed which presents any approach to such a structure is the Chalk Rock, but few corals and no Alcyonarians or calcareous Algæ have yet been observed in that. Prof.



A Diagram of the Zones of the Chalk as developed in the Isle of Wight.

Agassiz, who has examined both Chalk and Coral-mud, has no hesitation in saying that "Chalk is certainly not derived from the disintegration of Coral-reefs."*

The White Chalks agree with the Globigerina and Pteropod oozes in containing Coccoliths and calcareous spheres; they differ from both in containing fewer perfect shells. The most highly calcareous Globigerina oozes of the present day are crowded with, and often almost entirely made up of, Globigerina shells, while the more purely calcareous Chalks consist mainly of fine calcareous dust, and the single calcareous spheres are always more abundant than the Globigerinæ. This difference, however, may be due to the fact that we only possess samples of the highest layer of the modern oceanic ooze, this layer naturally consisting largely of fresh Globigerina shells. In deeper layers the fine material resulting from the decay and disintegration of the shells is likely to be more abundant, and such a deposit would greatly resemble Chalk.

While, therefore, no exact modern counterpart of Cretaceous Chalk has yet been discovered, yet it is a fact that certain varieties of Globigerina ooze resemble Chalk more than any other modern deposit, and I think we may reasonably infer that this similarity implies the existence of similar physical conditions.

* Three Cruises of the "Blake," vol. i., p. 148.

SOME NEW SECTIONS IN THE HESSLE GRAVELS.

BY F. FIELDER WALTON, F.G.S.

(Read June 8th, 1894.)

INTRODUCTORY.

Some excavations recently made at Hessle have exposed several sections of considerable interest, especially to those geologists who are studying the glacial deposits of East Yorkshire.

The sections uncover a series of gravel and sand in which mammalian bones are found; this gravel is banked up against a very steep face of chalk, the whole being overlaid by a layer of boulder clay, which covers up both the chalk and the gravel, so that upon the surface there is no indication of the strata below.

Before describing the new sections it would be well to mention what has been said about the Hessle gravels by previous writers. In the memoir of the Geological Survey these beds are placed and described among the interglacial beds of Holderness. By Professor Phillips they were thought to be pre-glacial and much older than the marine beds. Their exact place has not yet been satisfactorily determined except at a point a little to the North of Bridlington, where the buried cliff of chalk joins the present coast line. The deposits found banked against this cliff were here proved by Mr. Lamplugh to be pre-glacial. The Geological Memoir says :—" Leaving Bridlington the deposits banked against the old cliff are entirely unknown until we reach the Humber. Here, at Hessle, is the well-known gravel originally described by Professor Phillips, and considered by him to be pre-glacial. The most striking feature of this neighbourhood is the steep slope of the chalk towards the Humber, forming what is commonly called Hessle Cliff; though it is by no means vertical. On this lies irregularly the mammaliferous gravel, covered and overlapped by boulder clay." Then two sections are given, one just west of Hessle Station showing Purple Boulder Clay, 10 feet; below this bedded sand with chalk, looking very like an old run of the hill, with chalk at the base. The other, which is one hundred yards north and close to the line, shows about eight feet of boulder clay lying upon six inches of bedded sand ; below the sand is four feet of chalk rubble, then chalk. It is to be noted that the thickness of the gravel and sand on this south slope of the Chalk is only a few inches, perhaps a little more in places. The bones mentioned by the Geological Survey belong to Elephas primigenius, Rhinoceros, Cervus, Bos, and Equus caballus. The Memoir mentions that "there is not only a north and south slope of the Chalk but also an east and west irregularity, probably an old channel connected with the Humber."

THE OLD CHALK CLIFF.

It is with the deposits banked against this east and west slope of the Chalk, together with the slope itself, that we are concerned at present, and I hope to show that they are of very great importance in arriving at a correct knowledge of the Hessle gravels ; in fact I think they go a long way to prove that the Hessle gravels are the deposits that were banked up against the Humber end of the old cliff which formed the boundary of the Bay of Holderness in pre-glacial times ; and that the east and west irregularity of the Chalk mentioned by the Geological Survey was in reality the old buried cliff. The accompanying map shows that portion of Hessle lying a little to the west of the village, and with the Humber on the south. The surface rises from the water towards the north to a little over one hundred feet. The south edge of the gravel is about twenty-five feet above high-water mark. The bridge crossing the railway in Wold Field Lane is fifty feet.

The point marked A is about ninety feet. The one hundred feet contour passes from the N.W. corner of the field in which A is marked through the N.W. corner of the Town's Pit. From this contour line the land falls towards the E.S.E., so that the twenty-five feet contour lies just to the east of the road leading from the Station to the Village. For some miles further to the east the land is a low level, being only a few feet above the water line. The position of the Chalk is shown on the map, the actual exposures being also marked. There is an old pit just south of the railway showing about thirty to thirty-five feet of Chalk ; it can also be seen in the railway adjoining. This section is on the south slope of the hill.

The Chalk does not come quite to the surface, but is covered by eight to ten feet of boulder clay. It is in this locality that the sections mentioned by the Geological Survey were seen.

A little further to the north is a large pit (Hearfield's Pit) entirely in Chalk. This is excavated to a depth of seventy to eighty feet. On the north side of the Ferriby Road is the Old Town's Pit, showing from twenty to thirty feet of Chalk. In the pit marked A, about ten to twelve feet of Chalk can be seen. It has also been exposed where the two dots are placed on the line AB. All these exposures are in the *Middle Chalk*, and show well-marked lines of large flints of a rather light colour. The dip of the Chalk is a little to the east of south, and is only a few degrees in amount. The Upper Chalk without flints is entirely absent. In all the sections north of the railway the Chalk comes close up to the surface, being only covered by a thin layer of boulder clay. The upper layers of the Chalk are broken up by weathering into a coarse rubble, the finer material being near the top, and gradually becoming more massive in descending. The weathering generally extends to a depth of two or three feet, in places a little more. In the pit marked A it is checked rather abruptly by a thick band of flint.

The exposures just described are, I think, sufficient to justify me in marking the position of the Chalk as I have done on the map. I must now state that to the eastward of the line which shows, I believe, the position of the Old Chalk Cliff, the Chalk is at least from thirty to sixty feet below the surface; probably sixty feet is the most nearly correct. The amount and direction of the dip will not account for this sudden disappearance of the Chalk. Of course it might be said that this would indicate a line of fault, but as the existence of the line of cliff is known to the north of Bridlington, I cannot help but think that this is the Humber end of the same cliff, more especially as there are no other indications of any great dislocation in the Chalk, although local contortions and small faults do exist, but these are more common in the Lower Chalk. Even if it does show a line of fault, it might at the same time have formed the old cliff provided that it was at least as old as Pliocene times. At a point along the line AB there is a narrow trial pit about seven to eight feet deep, where the Chalk can be seen, with a line of flints about three feet six inches from the surface, and other irregular lines lower forming the west end of the pit, while the east end shows sandy gravel (a large proportion of sand). This is, I think, the face of the Chalk cliff itself. The actual junction shows tongues of sand between the layers of chalk rubble ; these tongues of sand are irregularly wedge-shaped, and are, where exposed, from one foot to eighteen inches in length, and from seven to ten inches in perpendicular thickness at the base of the wedge. The face of the Chalk in this pit is only about ten or twelve degrees from the perpendicular ; this measurement cannot be regarded as quite accurate, but only gives an approximate estimate of the slope of the Chalk downwards. For a distance of two miles north of this map (I have not looked further) there are several chalk pits between the one hundred and one hundred and twenty-five feet contour lines, but there is not one below and to the east of the one hundred feet line.

THE GRAVELS.

The deposits banked up against the cliff of Chalk consist of a great thickness of sand and gravel covered up by boulder clay. On the west the gravels are banked up against the Chalk cliff, but do not overlap it ; if ever they did so the boulder clay has planed it away so that it just equals the height of the cliff. The old cliff line, therefore, exactly maps out the western limit of the gravels. The southern boundary of the gravels can be divided into two portions, the western part lying on the slope of Chalk, and the eastern portion, which can be traced in the fields south of the railway and next the Humber, where they show a well-marked and rapid slope. The eastern bounda-y is not so well defined, but seems to follow near the twenty-five feet contour line. To the north they have been found in building, draining, and similar works, but there is no exact record of any sections. They can be seen, but not very well, in the railway cutting in which the station is placed, and extending as far west as the bridge which carries Wold Field Lane across the railway. The bridge itself, built on Chalk, is placed close to the point where the old cliff line joins the Humber. There are some waterworks in the cutting used for supplying the railway with water. The bores, which are at the bottom of a well twenty feet deep, are respectively one hundred and twelve and one hundred and fifteen feet deep, and are entirely in Chalk, and supply about seventy thousand gallons of water per hour. It must be remembered that about thirty feet of sand, gravel and clay have been removed in making this cutting. A considerable thickness of sand can be seen in the cutting at the present time.

The new sections in the gravels are situated between Southfield and the Ferriby Road, and bounded on the west by Wold Field Lane. The sections are artificial ones, and have been dug for the purpose of getting sand and gravel. The largest of them is in the field just north of the houses in Southfield, and, together with several trial pits, forms an almost continuous section along the line marked AB on the map; reaching from the seventy-five feet contour at the east end to a height of about ninety feet above sea-level, in a direction from W.S.W. to E.N.E., another large pit is situated on the north side of the field adjoining, and just south of the corner of the Town's Pit on the Ferriby Road. The southern of these pits, the largest, is an oblong excavation measuring one hundred and fifteen feet by seventy feet, and is dug out to a depth of twenty-five to thirty feet. At the eastern end a bore was made for another twelve or thirteen feet, without reaching the solid Chalk. This gives a proved thickness of at least thirty-seven feet for the gravels, not taking into account the boulder clay covering it. The northern pit measures ninety-six by sixty-three feet, and is dug to a depth of about twenty feet. These pits exhibit a general succession of sand and gravel roughly stratified, the sand being the lowest, the whole being overlaid by boulder clay. The lines of gravel, etc., can be traced easily along the whole length of the pit. The west end of the large pit shows the following section:—

	Feet.
Boulder Clay	4
Sand with only a little Gravel	12
Gravel and Sand mixed	7
	23

This section shows a large preponderance of sand over the gravel. These sands dip in the direction of N. 55° E., at a considerable angle; the gravels above following a similar direction, although the dip is variable in amount. They appear to be banked up against the Old Cliff.

The north side shows:—

	Ft.	In.
Boulder Clay	3	9
Contorted Gravel	5	4
Gravel	8	7
Sand	2	0
Sandy Gravel	1	0
	20	8

The east end shows:—

	Ft.	In.	
Boulder Clay	4	3	
Contorted Gravel	18	0	
Gravel	3	0	
Sand	2	0	
Sandy Gravel	0	6	
	27	9	base not seen.

The sand in the southern part of the pit is much thicker, in fact there is very little gravel above it. At the base of the sand the beds of gravel become rather clayey, and it is just about this horizon that most of the bones have been found in this pit.

The Contorted Gravels.

The most interesting feature of these sections is the well-defined contorted position of the upper part of the gravel; at the west end of this pit the contorted gravel is about five or six feet in thickness, but at the east end it can be traced in the gravel to a depth of eighteen feet. The contortions show tongues or wedges of gravel, &c., with the thickest portions, in a direction a little South of East to S.E.; where this section shows its greatest thickness on the east end of the pit irregular patches of clay are also seen intruded into the gravel. In the north pit the same contorted appearance of the gravel can be seen, varying in thickness from west to east from four to eight feet, but there is this difference—immediately below the contorted part the beds are composed of sand with thin lines of gravel dipping at an angle of about 15°, and the upper part of these beds of sand and gravel has been removed so that there seems to be a well-marked line of erosion where the contorted gravel lies on the sand. This contorted gravel seems to show that the gravels are older than the boulder clay; that the direction of approach of the ice was from the eastward; and that the ice could rise upon the slope of the gravels and so surmount the abrupt face of the buried cliff without disturbing them, except in a few places, to any great depth. That the gravels are older than the boulder clay is, I think, also proved by the relative composition of the gravels and the clay with its contained boulders.

Details of the Sand and Gravel.

After many hours careful search on different occasions I have been unable to find a single particle of any shell (except Chalk fossils) in either the sand or gravel; there are no fragments showing any pholas or other borings; and with the exception of one rounded pebble of quartzite no stones, except chalk or flint, have been found in either the sand or the gravel. The pebble of quartzite I myself found near the east end of the pit, about 20 feet from the surface, and a little below the reach of the contorted part. Since writing the above Mr. Sheppard has given me two small fragments of quartzite which he found. The workmen have shown me one or two more small quartzite pebbles which, they said, were found in the sand low down, but as there had recently been a fall of boulder clay in that part of the pit I do not think it wise to record them.

The microscopic examination of the sand shows that it is composed principally of clean rounded grains, with some platy and angular fragments. In fact on putting some of the blown sand from the Bridlington Cliff at the other end of the slide and comparing the two, I could not tell the slightest difference.

The gravel is found both in distinct layers and irregularly mixed with the sand; in several places, especially in the west and south of the large pit, and in one or two of the small trial pits adjoining, the sand forms almost the entire thickness of the strata, and contains only a very few fragments. The layers of gravel always have a large amount of sand mixed in with it.

The gravel is composed entirely of fragments of chalk and flint, it is generally small in size, but a few large pieces of flint are found.

Both the chalk and flint are sharp and angular ; they show hardly any signs of the action of water; such roundings of the edges as is seen on the soft chalk fragments might easily be accounted for by the percolation of water from the surface. These facts seem to indicate that these gravels were formed in some other way than under water, and are in this respect, and also in the absence of foreign boulders, quite different from any of the other gravels of South-east Yorkshire.

Mammalian Remains.

Mammalian bones have been found in these pits in the gravel. Most of them have been found in the bed of clayey gravel and sand, just below the principal stratum of sand and at a depth of 20-24 feet from the surface. They were not all together, but were scattered over the whole length of the pit. They have been examined by Mr. Platnauer, of York Museum, who refers them to the horse, Equus caballus, and the ox. There are not many places where mammalian bones are found in gravel and covered by boulder clay, their exact record is therefore a matter of some importance.

The following table shows what bones have been found and the particulars.

Animal.	Part.	Locality.	Depth.	Stratum.
Equus caballus	Teeth from upper jaw	West end of pit	16ft.	Clayey layer
Do.	Metatarsal, right, upper end	South pit	About 20ft. ?	Gravel
Do.	Haunch, right, 2 fragments	South pit	?	Gravel
Do.	Tibia, left, lower end	East end of South pit	22ft. 10in.	Sandy gravel
Do.	Cannon, lt., lower end	South pit	About 20ft.	Gravel
Do.	Metatarsal, right, perfect	South pit	18ft.	Gravel
Do.	Radius and Ulna, left, perfect	South pit, West end	15ft.	Top of clayey layer
Ox	Left Radius, upper end	South pit	12ft.	Gravel
Do.	Right Tibia, perfect	North pit, Ferriby Road	Not far down	Sand
Do.	Right Tibia, almost perfect	North pit, Ferriby Road	Not far down	Sand
	Several other uncertain fragmts.			

The Boulder Clay.

The layer of boulder clay covers over both the gravels and the Chalk, so that there is no indication on the surface of what is found below. Over the Chalk it is only a few inches thick, but its thickness increases towards the east, so that at the east end of the large pit it shows four or five feet. Still further eastward, towards the lower ground, I am told that in draining, etc , it has been found to be from ten to twenty feet. On the south slope towards the Humber it also thickens out considerably, being at least from eight to ten feet. The base of the boulder clay at its junction with the contorted gravel, as seen in the section, is well defined, and is a slightly wavey but almost straight line. Where the boulder clay has been removed by the workmen, previous to digging out the gravel, the upper surface of the contorted layer is very rough and uneven, this uneven appearance being probably due to some extent, but not altogether, to the irregular solution of the underlying gravel by percolating water. The boulder clay is a somewhat sandy clay, reddish brown in colour ; it is weathered and shows no well-defined jointing. The lower portion is more sandy than the upper part. No trace of any shell-fragments has been found, and there are no lenticular patches of gravel or sand in the clay itself.

The Boulders.

The stones contained in the clay are not very numerous, their average size being below four or five inches in diameter ; but a few larger ones of about twelve or fifteen inches have been found. On the eastern side of the excavations there are some local flints and small fragments of chalk all angular. The proportion of chalk and flint increases very rapidly towards the west, until where the clay overlaps the Chalk it is quite full of them, the distance being only two hundred to three hundred feet. The other stones in the clay *are all well-rounded and waterworn*, especially the smaller ones. They lie irregularly in the clay ; one or two at the east end of the section were lying with their long axes from E. to S.E. and W. to N.W. and with the highest ends towards the S.E. They are not much scratched or grooved, only one or two so marked have been seen, and those had all been moved from their original position in the clay. The rounded boulders show that they have travelled a long distance ; one, a porphyrite, I have shown to Mr. P. F. Kendall. He says, "it might be from the Cheviots or from Scandinavia ; it reminds me (Mr. Kendall) of some from Fredericsvaar, especially in the zoning of the Felspars."

Among the boulders may be mentioned :—

Local Flint and Chalk.	Quartzites.
Oolitic Limestone (1 piece).	Chlorite Schists.
Limestones.	Mica Schist.
Sandstones (several varieties).	Gneiss.
	Granite.
	Syenite.
	Porphyrites.
	Dolerites.

The boulders require further examination to make the account of them complete.

Other Gravels at Hessle.

At the large chalk pits, on the Humber side, a section of some interest is exposed. This section shows that the boulder clay lies directly on the Chalk, except in a few places, where there are large hollows in the surface of the Chalk ; these hollows are filled with gravel mixed with a little clay. The stones in this gravel are rounded by the action of water, and there are many far-travelled stones mixed with those of local origin, the whole being covered with boulder clay. It will be seen that these gravels are undoubtedly of glacial origin, and belong to the boulder clay above : they are quite different from those I have described in the other sections, and must not be confounded with those described by the Geological Survey in which mammalian bones have been found.

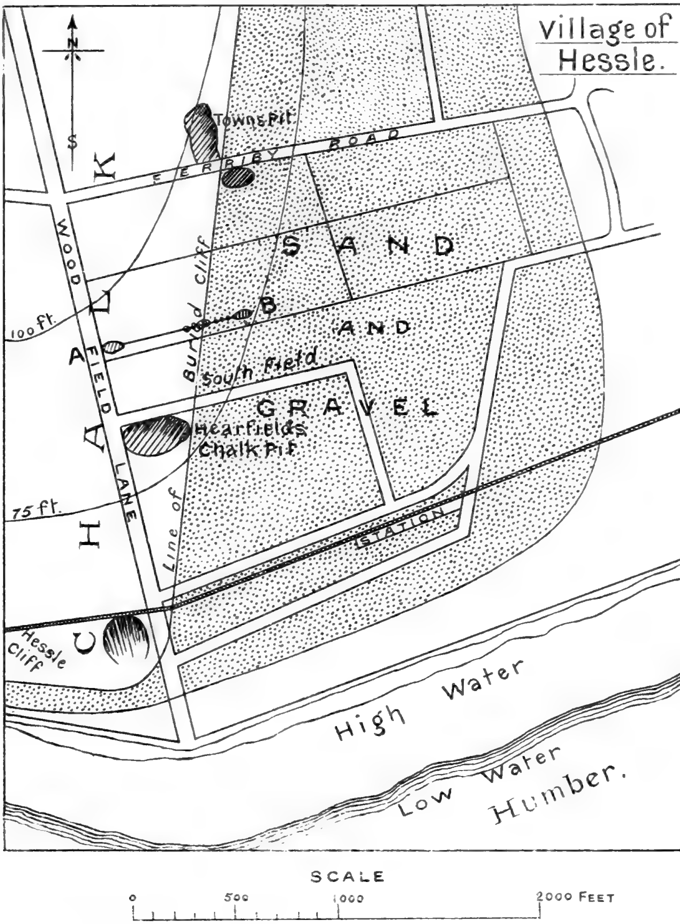
The only other deposits in this district resembling the Hessle gravels that I have seen are found on the lower slopes of the Wolds, and are nothing but chalk and flint fragments washed down from the higher ground and are only of very local extent. An example of this is at Drewton Stray South Cave, where I have seen about three feet of chalk wash and debris, lying upon the Kelloway Sands.

Conclusion.

It is to be hoped that further working of the pits will afford more information about the deeper parts of the gravel and Chalk cliff. The evidence of the angle of the Chalk face and the depth to which the cliff reaches also requires more investigation.

With respect to the age of the gravels they may be glacial, in which case they must have been formed by some very local action, but the absence of foreign boulders, and the presence of what seems to be blown sand below the gravel, seems to me to point very strongly to the conclusion that the Hessle gravels are of the same age as the pre-glacial deposits banked up against the buried cliff near Bridlington.

In conclusion I should like to express my thanks to Mr. Cook, the owner of the pits, for the facilities he has so willingly given me for examining the sections.



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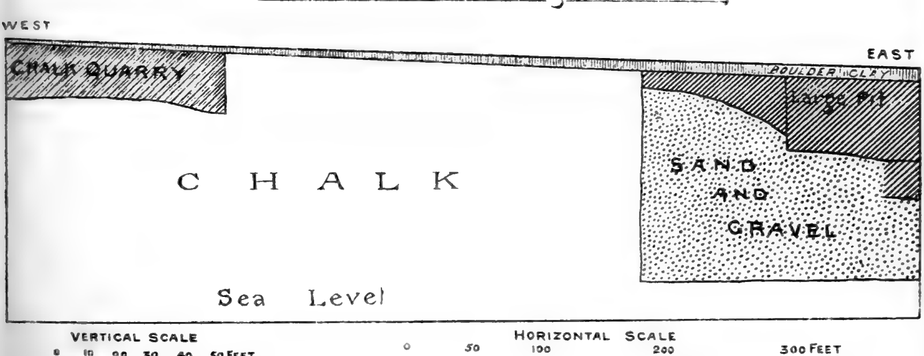

NOTE.—The dark-shaded portions show the extent of the present Excavations (1894).

NOTES ON THE STRATA AND DEPOSITION OF THE MILLSTONE GRITS.

BY WILLIAM SIMPSON, F.G.S.

In giving a paper upon this series of rocks, it is not my purpose so much to go into any detail, as to present, in as short a manner as possible, some of the broad facts of observation and generalization, and such deductions therefrom as may be useful to those of our members not so favourably situated for their personal study, or to those who, having confined their attention to the more commercially valuable Coal Measures, may still desire to have a fair theoretical acquaintance with this series, so intimately associated with, and immediately underlying, our lower coal-field.

Without having anything new to offer, I have still endeavoured to gather together, in presentable form, a few threads of information scattered over various memoirs and works of reference, supplemented by some little personal observation and speculation.

The Millstone Grits are not a particularly interesting series, and offer comparatively small inducement or reward to close investigation. The sandstones, flags, and grits are extensively quarried. The occasional small beds of coal have in some places been worked, but are generally of no value; and, save in one or two inconstant horizons, there is little to induce the fossil hunter to break the rock or part the shale. The Millstone Grit Beds, however, in their outcrop, cover a greater area in the West Riding than any other formation, and, as marking a period of change from the quieter infilling of the Yoredale shales and sandstones, and the constant shoaling and swampy growths of the Coal Measures, they are worthy of our attention.

Dividing and margining the important coal-fields of Staffordshire, Lancashire, and Yorkshire, the beds of the series extend from the borders of Derbyshire and Cheshire along the course of the Pennine Chain, westward and northward. They occupy the summits of, and form outliers on, the high hills above the Mountain Limestone and Yoredales, while eastward they stretch to the Permian Escarpment from the neighbourhood of Richmond to that of Leeds. A little to the north of Leeds the southern boundary of this easterly extension dips under the Coal Measures ; north from Richmond the grits extend in outliers, and again margin, on the west, the Durham and Northumberland Coal-fields.

It would be impossible, even in so general a manner as I propose, to consider them otherwise than as they may be studied in our own more immediate neighbourhood.

It is in our own neighbourhood, that is in Lancashire and South Yorkshire, that the Millstone Grit attains its greatest development : with the associated shales the thickness varies from about 1,500 to nearly 5,000 feet, and from this central tract the beds thin away in every direction ; most rapidly towards the north, north-west, south-west, and south-east ; less rapidly towards the south and east.

In the extreme north, that is in Cumberland and Northumberland, the grits are not only thin but fine in texture, and more like, if not actually finer, than our Lower Coal Measure sandstones. In considering this succession of sandstones and shales, which we call the Grit Series in our West Yorkshire district, with survey maps perhaps for guidance, one is confused by the divisions and nomenclature generally adopted.

Where the series was first mapped, that is in Derbyshire, the beds conform to a broad general classification into four grits, with their dividing shales. These sandstones were therefore named downwards, *the First, Second, Third, and Fourth Grits*, the first being further known as the "Rough Rock," and the fourth as the "Kinderscout," so named from the precipitous ridge on the west side of the Peak of Derbyshire.

Following the series northwards, however, whilst there was no difficulty in recognising the Rough Rock or the Kinderscout, the Second and Third Grits grew increasingly confusing and complicated, and difficult to correlate with the Derbyshire members.

In our Halifax district we get at least four important sandstones, with their shales, constituting a considerable thickness, which we attempt to correlate with the Third Grit ; whilst the one we call the second has become almost unrecognisable as a separate sandstone, being rarely parted from the Rough Rock.

Further north, towards Keighley and Skipton, the beds classed as Third Grits are 1500 feet thick, with *six* sandstones, including the Addingham Edge Rock. Seeing there is really no consistent datum line between the Rough Rock and the Kinderscout that can be followed with any real accuracy, would it not be much better if we ceased to attempt any such arbitrary classification, merely calling all between the two, *Middle Grits?*

I should scarcely have dared to advocate this myself, although I have many times felt the difficulty, had I not since found that so eminent an authority as Professor Green, in the "Memoirs of the Yorkshire Coal Field," finds himself constrained to recommend this simpler classification.

They would thus be divided so far as the Derbyshire, Lancashire and Yorkshire areas are concerned, as follows :

1. Rough Rock or Topmost Grit.
2. Shales.
3. Middle Grits { A group of Sandstones, Gritstones, and Shales, very variable in numbers, thickness, and character of the Sandy Beds.
4. Shales.
5. Kinderscout or Lowest Grits.

All below the rough conglomeratic and characteristic Kinderscout would then be Yoredales; all above the persistent and easily recognisable Rough or Top Grit, Coal Measures.

With these two well recognised datum lines bounding the series, and acknowledging the inconstancy of intermediate beds we may, I think, rest content to class them generally, however we may do locally, as Middle Grits.

In attempting to grasp the sequence and significance of the various beds of the Grit series, we must be prepared for great variations and inconstancy; with the exception, perhaps, of the Rough Rock at the top, and, in part, the Kinderscout at the base, nothing is so constant as their inconstancy. The sandstones are frequently lenticular beds, laid down in hollows and depressions, very variable in thickness, appearing, thinning out, and giving place to shales, or thickening into several beds with shale partings, within very short distances; so that it is frequently difficult to get anything like corresponding sections from the two sides of one hill.

To understand this apparent disorder requires some knowledge of the probable mode and conditions under which they were laid down. This I shall attempt to describe shortly. For the present I shall give a short description of the beds as they appear in our locality, merely premising this, that the period of the Millstone Grit deposition was in all probability preceded by important changes of elevation and depression, unequal and local, doubtless, but still sufficient to give a distinctive lithological character to the beds of the series; these oscillating earth movements, were not in all probability confined to the sub-aqueous areas, but affected also the adjacent land areas, elevating them into regions where the mechanical and chemical forces of disintegration and denudation had more effect, giving more rapid stream and current action, with consequent ability to carry along coarser detritus and distribute it over more extended areas.

The lowest beds of the series illustrate *this unequal subsidence*, as they are laid upon a most uneven bottom and are extremely variable in thickness, and in the relative distances below the more evenly laid Rough Rock.

In the Survey Memoirs of the Yorkshire Coalfield, a diagrammatic section, extending from Ashover, in the south, *via* Chatsworth and Grindleford Bridge, on through Midhopstones and Marsden, west of Halifax and Huddersfield, and northward to Keighley and Skipton, admirably illustrates this uneven floor and explains the variability in thickness and overlap of members of the series.

In the south, from Ashover to Chatsworth, we get a fairly even bottom and constant beds; then there commences a gradual depression with its maximum depth around Rood Hill, from whence northward there is a gentle rise to south of the district between Penistone and Marsden; a fairly even floor with sinking tendency to west of Huddersfield and Halifax, from whence northward the depression deepens considerably towards Keighley and Skipton.

It is probably, then, to these depressions and their gradual infilling we owe the great variations in thickness of the series; variations which are evident mostly in the lower members, as the Rough Rock was laid upon a comparatively even floor.

The thickness of the Kinderscout sandstones and shales, then, varies *most considerably* in the different districts from 200 feet or so to over 1,000 feet. Between Bamford Edge and Rood Hill we get an average thickness of Kinderscout of 900 feet, with southerly thinning away ; west of Halifax and Huddersfield about 350 to 500 feet ; in the Keighley and Skipton districts probably over 1,200 feet.

Lithologically the Kinderscout grit is generally exceedingly coarse and very massive, frequently quite conglomeratic, with pebbles of vein quartz, rounded or sub-angular, of all sizes up to nearly two inches in diameter ; there are occasional beds of flagstone, and where it is most largely developed it is in two or more beds, with shale partings. This grit is well exposed in the valleys west of Halifax, and along the summit of the Pennine Chain, on the Cononley and Skipton Moors, and will be familiar to all, as the rock of the Strid at Bolton Woods.

It is, however, in the Middle Grits, known generally as the Second and Third Grits, that we meet with most variation. They are the most inconstant members of the series, and it is in the difficulty of properly correlating these that I should advocate the simpler classification of Middle Grits.

In Derbyshire, as I said, there are two clear, distinct beds of sandstones between the Rough Rock and the Kinderscout. In Yorkshire this clear division ceases, the uneven bottom of the Kinderscout had not yet been levelled up, and the Middle series thicken out, and occur as large lenticular beds in the old hollows.

In the Halifax district, if we include the flag rock at the base of the Rough Rock, which is usually classed as the Second Grit, we get five fairly important beds to represent the two of Derbyshire, whilst at Keighley they have further increased to six or seven. The sandstones are, in our district, usually less gritty and finer than either the Kinderscout or Rough Rock, though still very variable in lithological character. In the shales of this Middle series are three or four inconstant, unimportant coal bands, thin and poor in quality, and of small commercial value, though they have been occasionally worked. A seam, a foot or two in thickness, has been worked near Meltham ; and one under the Addingham Edge Rock has been worked and found as thick as five feet, but the instances are few where the beds of the series have been worth mining. Some of the beds have an accompanying hard siliceous seat-earth, very like the ganister both in composition and appearance, as it is permeated with stigmarian rootlets ; it is known locally as *Calliard* or *Galliard.* There are also one or two good fossiliferous zones with marine shells and nodular bands in the shales, containing Goniatites, Aviculopectens, Posidonomya, Nautili, &c., and occasional fish remains.

The shales known as "binds" are of all kinds, *blue or black*, where they contain more or less carbonaceous and organic matter ; with a greater admixture of arenaceous matter they become *stone binds* ; or softer and more shaley, they are called *soft binds.*

The Rough Rock is in the Halifax district immediately underlaid by, and almost inseparable from, beds of flagstones. These are the Second Grit of the Memoirs and are extensively quarried for flags, though they are often much false-bedded. This rock is probably the equivalent of the Haslingden flags of Lancashire.

About Keighley, the rock correlated with this flagrock, puts on a peculiar form, and is known locally as *the blues.* It is found as a band of hard, blue, closely-grained rock, and is used for road mending. These Middle Grits occupy the tracts of high lands west of Halifax, from Sowerby Bridge to Blackstone Edge. The deep valleys of Calderdale, Luddenden, and others are cut through the rocks of this group. Some of the flagstones display good worm tracks and castings, ripple markings, and other indications of the littoral nature of these deposits.

Northwards, the Oxenhope and Haworth Moors, attaining to a height of over 1,400 feet, are on these Middle Grits, with a sequence gradually changing from that of the Halifax neighbourhood to the one more characteristic of Skipton and Keighley. Keighley itself is partly built on the rocks of this group. From Silsden Moor the Addingham Edge Grit, a coarse massive member of the Middle Grits, may be traced round the flanks of Rombald's Moor to Ilkley, where it forms the picturesque and well-known Cow and Calf Rocks. Further in the same direction it is the rock of Otley Chevin, Arthington

Bank, and Harewood Park. At Harewood Castle it makes a curve northwards, thence dips to the east and south-east, disappearing under the Permian Limestone at East Keswick.

The only remaining member of the series necessitating a short description is the Rough Rock, the uppermost bed of the Millstone Grits. This is naturally found encircling, as it immediately underlies, the Coal Measures from the southern boundaries of Yorkshire with Derbyshire, northward and westward, near Huddersfield and Halifax, and thence eastward a little north of Leeds, finally disappearing under the Permian escarpment. It nowhere attains a greater breadth of outcrop than four or five miles.

Halifax is built on the top of this rock, the rise from the Station westward being practically on its dip slope. From the heights above the town, westward, it has been denuded until near Mount Tabor the flag rock below is quarried at the surface. This Rough Rock and its accompanying flag rock are extensively quarried along their outcrop for building and paving stones.

Lithologically this Rough Rock may be termed a coarse, gritty, *felspathic* sandstone, with frequent pebbles of vein quartz and occasionally of felspar, but generally consisting of rough, angular grains of quartz in a matrix of felspar. It weathers on exposure, the felspar decomposing quickly under sub-aerial influences, and forms picturesque crags on the heights above the valleys. The Rough Rock may have about an average thickness of 80 to 100 feet, or with its accompanying flags of nearly 150 feet.

The peculiarity of this rock is its persistence over extensive areas, both in thickness and lithological characters. Although it extends over hundreds of square miles, it is fairly uniform in thickness throughout, and the cases where it becomes finely-grained or thins away are few and far between. It is difficult to realise how such a result could have been brought about by ordinary stream, estuarine, or littoral conditions, or even to explain how the constituent quartz grains are so angular and crystalline, showing frequently few traces of the necessary attrition, whilst at the same time the enclosed vein quartz pebbles are generally rounded or sub-angular.

These are problems necessitating consideration of the probable mode of deposition, in the light of which we may grasp the phenomena better. Let us first just pass in review again the class of sandstones comprising the series. They range from the extremely coarse and conglomeratic gritstone to the finest grained and most compact sandstone. The rougher examples are generally thickly and most irregularly bedded, whilst the finer ones are minutely and most evenly laminated. Most of them, however, coarse and fine alike, show traces of current-bedding. Where they are unweathered they are generally blue or grey, and contain iron as ferrous carbonate. Where they are exposed they are of various shades of ruddy-brown or yellow, the change being produced by the action of the air and water on the ferrous salt ; the carbonate becomes changed into one of the ferric hydrates, and the exact colour, in all probability, depends on the proportion of combined water. In all the sandstones, however, the constituents may generally be said to be alike, viz., quartz, felspar, and mica. The mica is displayed along the planes of lamination of the finer sandstones very plentifully, and is naturally more rarely seen in the coarse grits.

Dr. H. C. Sorby, who has made careful examination of these rocks, is of opinion that the felspar has, in the first place, been present in grains, crystals, or pebbles, as a felspar sand ; has been decomposed after deposition, re-deposited as a paste, and squeezed by pressure into the interstices between and round the quartz grains.

Dr. Sorby describes, in another paper read before the Microscopical Society, instances of the repairing of sand grains by a process of secondary crystallization. Whilst doubtless the angularity of many of the quartz grains in the grits is original (as sand grains being smaller than pebbles would not be subject to so much attrition and thus not so rapidly rounded) ; I have still been inclined to think, although without actual knowledge, that we may owe the extreme angularity of some of the grains to a process of secondary crystallization ; decomposing felspar would furnish the necessary silica, which might have been partially used thus in the repairing of the crystals.

I mentioned before that the Grit series is interesting as illustrating a physical change in the relative conditions and distribution of land and water areas, that must have taken place about the close of the Yoredale period. In a physical history of the Carboniferous period the Grit series would necessitate a new chapter, as I think there is strong evidence in support of the theory that they were laid down under somewhat different conditions from the preceding Yoredale group. Several eminent geologists have described the probable physical and geographical features of this period, and although there are naturally differences of opinion as to special land and water areas, there is sufficient general agreement to justify us in taking their geographical restorations as on the whole warranted by the data obtainable.

Jukes-Browne in his "Building of the British Isles," publishes a map covering the present British area, showing the probable relations of land and water of the Carboniferous period, and in the light of what is known up to the present, we may take it as probably the best that can be done.

He shows a large continental area to the north, embracing parts of the West and North of Ireland, stretching in a north-easterly direction across the middle of Scotland, until it joins a considerable prolongation of the present Scandinavia, an extension of that country stretching, with probably several important bays, down the present North Sea area, almost to our eastern coast of to-day, and with its southern coast line running easterly at about the latitude of our present Humber.

In the south, land is shown about a hundred miles south of Ireland, taking in part of Cornwall and stretching across to Brittany. These continental areas partially enclose a sea, which, with the exception of a large central and sundry smaller islands, covers the whole of England, the southern half of Scotland, and the whole of central and southern Ireland.

The large island in the middle of this Carboniferous sea is roughly L-shaped, with its longer north and south axis stretching from the Mull of Galloway to Pembrokeshire, embracing parts of the east coast of Ireland, the north of the Isle of Man, a small portion of Anglesea, and practically almost the whole of the western and southern portions of the Irish Sea ; the eastern prolongation takes in a good portion of Central Wales and the English Western Counties, and extends as far as and embraces Leicestershire.

This sea, which covered so much of what is now the British Isles, stretched eastwards through the north-east of France, Belgium, Germany, Poland, and Russia, covering, indeed, a great part of the present continent of Europe, and extended toward the North Pole, by way of Bear Island and Spitzbergen. It appears to have been bounded on the south by a more or less continuous belt of land through France, Switzerland, Bavaria, Bohemia, and Hungary.

It seems clear says the author,* "that the sea in which our Carboniferous beds were deposited was not an open sea or ocean, but a land-locked sea, comparable to some extent with the Mediterranean or Caribbean Sea of the present day; it was probably the most westerly embayment of a large European sea; its coast line formed a series of gulfs and promontories, and it was studded with islands of various sizes."

Professor Green, in the Memoirs of the Yorkshire Coal-field,† says, "this Mediterranean Sea had a fringe of shallow water round its margin, and deep depressions in its central portion. Round its edges deposits were formed, mainly of mud and sand, though every now and then calcareous animals established themselves in sufficient numbers to give rise to beds of limestone; at a certain distance from the shore all the sediment sank down to the bottom, and beyond that limit the water was bright and clear, and the only deposit found consisted of accumulations of the hard, calcareous parts of marine animals, which are now pure limestone. In the deep hollows, the deposits of limestone reached a great thickness; over the ridges, which parted the hollows, it was not so thick," thus explaining why the Carboniferous Limestone shows such varying thicknesses in different places. "The growth of limestone gradually filled up the deeper parts of the sea, and at last the area became as shallow throughout as it had been originally only at its edges. The mixed deposits of sandstone, shale, and impure limestone which had at first been confined to the neighbourhood of the shore, now extended themselves over nearly the

* Jukes-Browne, Building of the British Isles, pp. 131-2.

† Geology of Yorkshire Coal-field, p. 23.

whole marine tract, and the deposition of the Yoredale rocks began."

Thus we are brought up to the Millstone Grit period, when it is evident important changes took place. We speak of the Carboniferous period as one when sub-aqueous areas were almost constantly, though intermittently sinking, the downward movement about keeping pace with the deposition of mechanical sediment. But simple depression does not explain the phenomena of the Grits ; we require something more, positive oscillations of level, alternating elevations and depressions, and it is highly probable that movements of both kinds occurred just prior to and during the deposition of the Grits.

In the first place, we have this unequal bottom on which the Kinderscout is laid, and the fact that the district in which the Grits are thickest, that is, in Derbyshire, Lancashire, and the south of Yorkshire, is also that in which the Yoredales attain their maximum development. This unequal bottom is shown by the overlap against what were doubtless elevated Yoredale areas, of the higher members of the Kinderscout ; the lower beds were deposited in the hollows, and abut unconformably against elevated Yoredale beds, and it was not until further subsidence occurred, submerging these elevations, that the higher Kinderscout beds were laid over the whole area. Then we must also consider the great change in the nature of the Grit deposits from those of the preceding series.

The Kinderscout, especially, is exceedingly coarse, and succeeds, generally, beds of shale and much finer sandstone. It is also very persistent, and does not shade away as might be expected into finer grained sandstone, away from the source of supply, so that in addition to the unequal subsidence of sub-aqueous areas, we are almost forced to assume that there was considerable upheaval of the land over areas from which the supply of material was derived. Jukes-Browne, discussing this, says :—*" I see only one way in which such a change could be brought about, and that is by a general and considerable elevation of the area, raising the central parts of the island into those atmospheric regions where rain, frost, and wind are most vigorous and incessant in their action" ; and he adduces actual evidence in favour of this from Flintshire, where, near Mold, the Grit is of small and

* Building of the British Isles, Jukes-Browne, p. 140.

variable thickness, and for a certain space is entirely absent, the Lower Coal Measures overlapping westward on to the limestone. This upheaval was of a general nature, affecting a considerable region, giving the rivers a greater velocity, and a capacity for carrying coarse sand much greater distances.

Further evidence is, I think, furnished by the change in the life of the Grit series. Whilst the Carboniferous Limestone and the Yoredales were undoubtedly deposited in marine areas, the palæontology of the Grit series is that of brackish water, estuarine, or lagoon type, with only occasional marine horizons. The upheaval was probably responsible for shutting off a great shallow water basin from communication with the outer ocean, interposing barriers which it would appear were still occasionally broken down. That this movement of upheaval gradually exhausted itself prior to the deposition of the Coal Measures is evidenced in the gradational changes in the texture of the sandstones from the Millstone Grit upwards.

The Grits are, in the most important beds, not only coarse and massive, but show considerable persistency over large areas, whilst the Coal Measure sandstones are generally much finer grained, more variable in thickness, and less persistent, and were evidently deposited in a more regularly subsiding area.

The shallow water conditions that favour accumulation of sandstones must have been of longer duration in the Grit period, and the shoaling necessary for coal growth more rare, and for the most part local, and of comparatively short duration ; in other words, the period was mainly one of steady subsidence of the sub-aqueous area, the pauses being few and far between.

The Middle Grits however have much in common with the Coal Measure type, and show frequent traces of littoral conditions in ripple markings, worm trails and casts, rain-prints, etc., and evidence similar delta, lagoon, and swamp conditions. A shallow water area, receiving supplies of mechanical sediment from various sources. At times portions shoaled, and the streams and currents cut changeable channels in all directions in these shoal banks, channels that on furthur subsidence, perhaps received deposits of different texture, and so give us confusing abutments of sandstone and shale, and fault-like sections, where the beds above and below are unbroken.

The Rough Rock in its persistence over a really large area and consistency of texture, can scarcely be accounted for by ordinary stream or estuarine conditions. It was probably first piled in bars or banks of sand by the laden streams, and afterwards, either by changing currents or further subsidence, washed down and redistributed over the extensive area it covers.

It would be extremely interesting if we had more direct evidence as to the ancient rocks that furnished the material for our grits. It is hard in the very nature of the case to get any reliable evidence from the current bedding as to the directions of the streams ; in such shoaly tracts the currents were almost necessarily in all and variable directions. Jukes-Browne adduces evidence that some, at any rate, of the materials were derived from the central island he delineates.

Dr. Sorby, in a pamphlet on the structure and origin of the Millstone Grit of South Yorkshire, says, "I have made an extensive series of observations of the direction of the currents present during the deposition of the Millstone Grit, as indicated by the drift-bedding over a district twenty-five miles long in South Yorkshire and North Derbyshire, and I find that on an average the current was from the N.E. This also agrees with the direction in which the sandstone beds grow thicker and coarser ;" and, in further proof of his deductions, Dr. Sorby describes the finding of undoubted granitic pebbles, which, on comparison, are extremely like some of the Scandinavian rocks whilst unlike those of any British area.

Professor Bonney has examined a piece of Carboniferous grit from near Cleveden (Somersetshire), and from the quartz grains and fragments of fine-grained micaceous schist was inclined to trace its origin to the minutely crystalline schists of Anglesea.

It is highly probable that both the rivers of the continental area to the north and east, and the streams from the central island in the west and south of our district, helped to swell the mass of mechanical sediment composing the rocks of this series.

It would have been extremely interesting too, to have considered the later earth movements that have so uplifted, broken, and faulted these rocks, and that have resulted in exposing as our surface rocks measures that must at one time have been covered by some thousands of feet of Coal Measure strata.

Publications Consulted.

Geology of the Yorkshire Coal-field ...	Survey Memoirs.
„ „ Neighbourhood of Halifax, Huddersfield and Dewsbury	Survey Memoirs.
„ „ North Derbyshire ...	„
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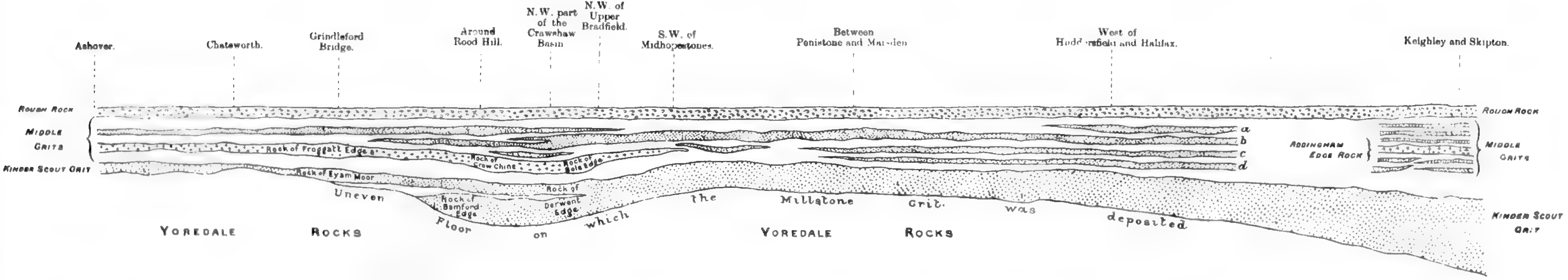
The Structure and Origin of Millstone Grit of South Yorkshire	H. C. Sorby, F.R.S., &c.
Trans. R. M. Soc., March 1st, 1887 ...	„
Proc. Brit. Assoc., 1886, p. 9	Prof. Bonney.
West Yorkshire	Davis and Lees.
Trans. Manchester Geol. Soc., Feb. 22nd, 1870	Jas. Spencer.
Do. do. Mar. 26th, 1874	do.

DIAGRAMMATIC SECTION OF THE MILLSTONE GRIT OF DERBYSHIRE AND THE WEST RIDING OF YORKSHIRE.

Reduced from the Survey Memoirs, Geology of the Yorkshire Coalfields
By permission of the Director General of the Geological Survey

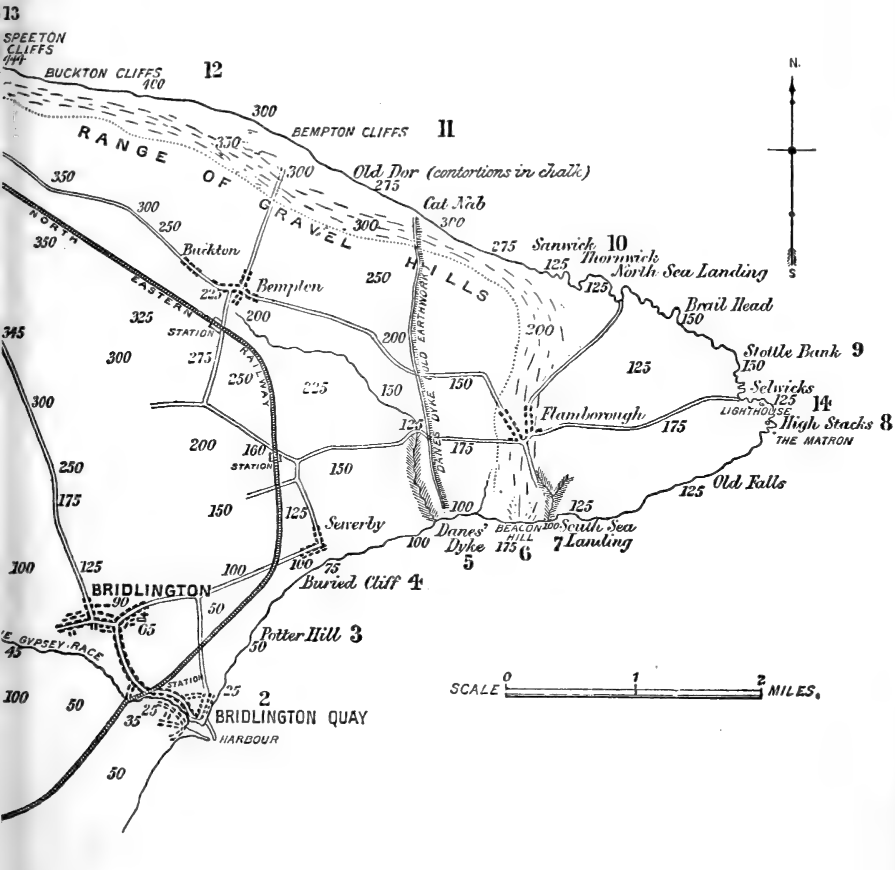
Horizontal Scale, 4 miles to an inch
Vertical Scale, 1,600 feet to an inch



NOTES ON THE FIELD EXCURSION FOR THE EXAMINATION OF THE COAST BETWEEN BRIDLINGTON AND FILEY.

BY W. LOWER CARTER, M.A., F.G.S.

In connection with the General Meeting at Bridlington a Two-day's Field Excursion was arranged for the examination of the coast sections between Bridlington and Filey, on Friday and Saturday, June 8th and 9th. The party was under the leadership of the Rev. E. Maule Cole, M.A., F.G.S., and Messrs. P. F. Kendall, F.G.S., and J. W. Stather, F.G.S.



On the arrival at Bridlington of the trains from Hull and Scarborough, a start was made along the beach, and the Glacial and Chalk beds up to the South Landing were examined. A special halt was made there in order to allow of a search for the bed containing arctic shells, identifiable fragments of which were obtained. The road was then taken to Flamborough where a West Riding contingent was added to the party, and, after luncheon, the journey was resumed to the Lighthouse in wagonettes. There a prolonged examination of the large boulders of Speeton and Kimeridge Clay, and Red Chalk, was made, and the remarkable crater-like hollows, formed by the falling-in of sea-caves, were duly admired. A rapid walk was then taken along the cliffs to Bempton, the notable example of denudation at North Landing being of special interest. Fragments of chalk were found along the cliff top, having been torn off and carried up by the wind in recent heavy gales and strewn over the fields for considerable distances inland. After a rest to view the contortions of the Chalk at Old Dor, and the pranks of thousands of guillemots, a cross-country cut was taken for Bempton Station, where the train was stopped to take up the party.

The second day rose dull and threatening, a thick grey fog overhanging the sea, whilst a gentle downpour did its best to damp the ardour of the geologists. But in vain. The party proceeded from Bridlington by the 9-22 train for Filey, where they were reinforced by a contingent from Hull, which included two courageous ladies. The outlook from Filey Station was anything but cheering, the rain falling heavily ; but the members faced the programme with geological resolution, and, making their way to the shore, commenced the beach walk to Speeton. For the first four miles nothing was to be seen but sloping cliffs of tenacious purple boulder clay, which were scored by the rain-wash, which had brought down the results of this denudation on to the beach in the form of deltas of mud. At intervals instances of rough stratification were seen in these clay deposits, at one point there being a considerable mass of well-laminated muds. The sea had excavated several caves which were overhung by clay roofs, firm as solid rock, showing to what a tremendous consolidating influence these deposits must have been subjected. These glacial deposits form a huge embankment across the seaward end of the Vale of Pickering, and are the cause of the present westward flow of the drainage of that area. They also fill up a considerable area to the south of Filey, obscuring what was a pre-glacial bay with a very much sharper curve inland from Filey Brigg than is the case with the present bay at Filey. As in the case of the much larger Bay of Holderness, the sea is now gradually recovering its own, and clearing away the deposits left by the great ice-sheet. The shore was strewn with boulders largely derived from this glacial clay, many characteristic Scandinavian rocks being noted, as well as well-known rocks from Northern Britain. Amongst these were stigmaria from the Coal Measures, Carboniferous Limestone with corals, Millstone Grit, Brockram from the Eden Valley, a minette from the western side of the Pennine Chain, large boulders of Lias with fossils, and specimens from the Armboth and Helvellyn dykes. The process of manufacture of clay balls on the shore was noted with interest, and the way in which, by rolling, they received a protective coating of small pebbles and sand. Our leader, however, gave the timely caution that the presence of these clay balls in a deposit was not to be taken as conclusive evidence of its marine origin, as such balls had been found in running streams. The absence of chalk and flint fragments in the clay was noteworthy, as compared with their frequency in the Bridlington drift, being additional evidence of the southward flow of the ice-sheet. The inclement nature of the weather, and the obscuration of the sections by slipped material, made the examination of the sections of Kimeridge and Speeton Clays very unsatisfactory, but many characteristic fossils were obtained. After Speeton Gap was passed, the weather improved considerably, though the fog did not rise, and the excellent sections now exposed of the Red Chalk and Lower White Chalk were examined in comfort, and good bags of fossils obtained. The cliffs were then surmounted, and their crowning moraines noted, before tracks had to be made for Speeton Station, where the train was stopped for the party by the kindness of the North-Eastern Railway Company.

The following notes of the geology of the Flamborough Coast were provided for the members by the kindness of Mr. G. W. Lamplugh, F.G.S., of H.M. Geological Survey. They form a valuable summary of the geology of the district under examination.

NOTES ON THE COAST BETWEEN BRIDLINGTON AND FILEY.

BY G. W. LAMPLUGH, F.G.S., OF H.M. GEOLOGICAL SURVEY.

I will presume that the party on reaching Bridlington make their way to the North Cliff, and walk thence along the shore to the beginning of the Chalk-cliffs at Sewerby. They will notice that the sections under the town are now wholly hidden by sea-defences, the need for which is well brought out by the present contour of the coast-line, a definite projection now marking the protected portion, especially on the south side of the town. This projection will doubtless become in time more marked, as the sea gradually develops its flank attack.

The details of most of the sections now concealed have been recorded, with illustrations, in the past volumes of the Society, and may be consulted by any member requiring information regarding them. (See Vol. VII. (1881), p. 383 ; Vol. VIII. (1882), p. 27, and (1883), p. 240 (with map of neighbourhood) ; and Vol. XI. (1889), p. 275).

One of the most interesting points thus hidden is the existence in the lowest (Basement) Boulder Clay ot transported masses of shelly sand and clay, containing a rich molluscan fauna with well-marked Arctic characteristics. These masses constitute the deposit formerly known as the "Bridlington Crag." A fine collection of their contents has been made during favourable opportunities by Mr. W. B. Headley, of Bridlington Quay. A shred of similar composition, containing a few shells, may be seen in the drifts above the chalk-cliff at Flambro' South Landing, three miles distant, in a rather inaccessible position. My view of these shelly patches is that they were torn from the sea bottom, and carried forward into their present position by the great ice-sheet in its advance upon our coast.

As the members walk along the cliffs towards Sewerby they will notice that the sections, though much obscured by slipping, show two and sometimes three distinct bands of boulder clay, separated by irregular deposits of stratified material, and that the cliff top is held by a considerable thickness of chalky gravel (*The Sewerby Gravels*). The different bands of boulder clays probably mark oscillations of the margin of the ice-sheet, and the overlying gravels seem to have been spread out by a body of fresh water, draining from the Wolds, and arrested here either by higher land now swept away by the sea, or by the edge of the decaying ice-sheet. The stratified sands and warps (*Hilderthorpe Series*), so well exposed in the cliffs south of Bridlington Quay, can be well explained as the sediment of the same flood in its quieter, deeper waters.

One of the most interesting sections of the whole coast-line is that which will confront the members at the commencement of the Chalk, though probably they will find its most important elements somewhat obscured by slipped material. An ancient sea-cliff of Chalk, buried and obliterated under glacial deposits, is here revealed. In 1887 and 1888, by means of a grant from this Society and from the British Association, we excavated the material banked against this buried cliff, and in doing so obtained a large collection of fragmentary remains of mammals, fish, and birds, which are now preserved in the Museums of York and Jermyn Street. *Elephas antiquus, Rhinoceros leptorhinus, Hippopotamus amphibius, Bison sp., Hyæna, Arvicola amphibius, Gadus morrhua,* were among the species identified. At the base of the cliff we found a sea-beach of rolled chalk pebbles, and overlying this a clayey land-wash with some small land-shells, passing up into an ancient blown sand which was piled quite to the top of the old cliff, and had helped to preserve it during the rigours of the subsequent glaciation. (Further account of this interesting section will be found in *Proc. Y. G. & P. Soc.*, Vol. IX., pp. 381—92). I regard these "Buried-Cliff-Beds" as older than any of the glacial deposits of East Yorkshire, and they are very valuable to us as an indication of the physical conditions of the area before the great glaciation. We can be sure that at that time Holderness formed a wide bay, with the sea running quite up to the foot of the Wolds, its shore-line approximating to the present course of the railway from Hull to Bridlington.

The locality deserves further investigation, and I hope the Society will again undertake it when the sea by removing the overhanging material which stopped our work enables this to be done in safety.

I shall presume that the chief attention of the members in their further progress north-eastward will now be directed to the Chalk. They might however still profitably give an eye now and again to the capping of drifts, of which a detailed description, with figures, will be found in *Q. J. G. S.*, Vol. XLVII., pl. xiii., p. 384.

With regard to the Chalk, there is still much work to be done in working out its subdivisions and thickness. I had made some progress in this direction before leaving the neighbourhood, and had intended to do more. Possibly I may find it practicable before long to sum up for this Society the information already obtained, in the hope that it may be of use to future workers.

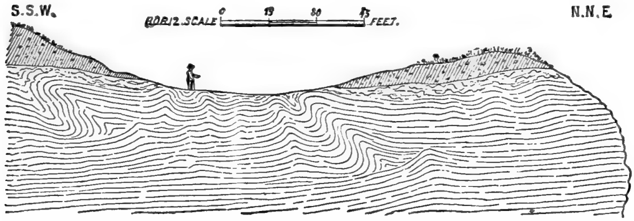
The fossil Sponges, for which the Chalk of Flambro' Head is celebrated, will be found most plentifully between Sewerby and Danes Dyke, being quite rare to the eastward of the latter place. *Marsupites ornatus,* another interesting fossil, is abundant, though usually in an imperfect condition, in a band which rises into the cliff two or three hundred yards west of Danes Dyke. Up to the South Sea Landing there is a steady rise of the Chalk northward, but beyond it the strata lie more nearly horizontally, partly owing to the cliffs here being nearly along the strike of the beds; and in going thence to the extreme point of the headland we pass very little lower in the series.

The numerous small faults which break the Chalk may be noted in passing. I measured a large sequence of them, under the impression that they might prove in the aggregate to represent a considerable throw in one direction; but the investigation showed that they frequently nullify each other, and that they probably mask what in less jointed beds would take the form of low undulations of the strata,

No flint occurs in the Upper Chalk, but nodules of this substance make their appearance on the shore at High Stacks, a little south of the Lighthouse, and thence are brought rather rapidly to the cliff top at the Fog-gun House by the renewed rise of the Chalk consequent upon the alteration in the trend of the cliff-line.

If the members have time to visit this locality they will find many points of interest. An ancient ravine in the Chalk has been buried under the drifts here (such as may be noticed also at South Sea Landing and at Danes Dyke), and has given rise to a curious conformation, the sea having penetrated into it by two caves, through which the loose material has been withdrawn, so that two large pit-like " blow-holes " have opened up near the edge of the cliff. There is a fault in the Chalk, accompanied by much contortion and the formation of veins of calcite in the shattered rock, in the centre of Selwicks, a northerly downthrow bringing, for a short distance, the flintless Chalk once more into the cliffs. (See *Y. Geol. and Pol. Soc.*, Vol. VII. (1880), p. 242, for further description). The lower part of the drifts around Selwicks is largely composed of re-arranged Speeton Clay ; and fragments of the characteristic fossils of that formation are quite plentiful here, as are also transported fragments of marine arctic shells.

FIG. 2.—SECTION AT THE TOP OF THE CLIFF AT COMMON HOLE, SELWICKS, SHOWING SURFACE-CONTORTIONS IN THE CHALK. (G. W. LAMPLUGH).

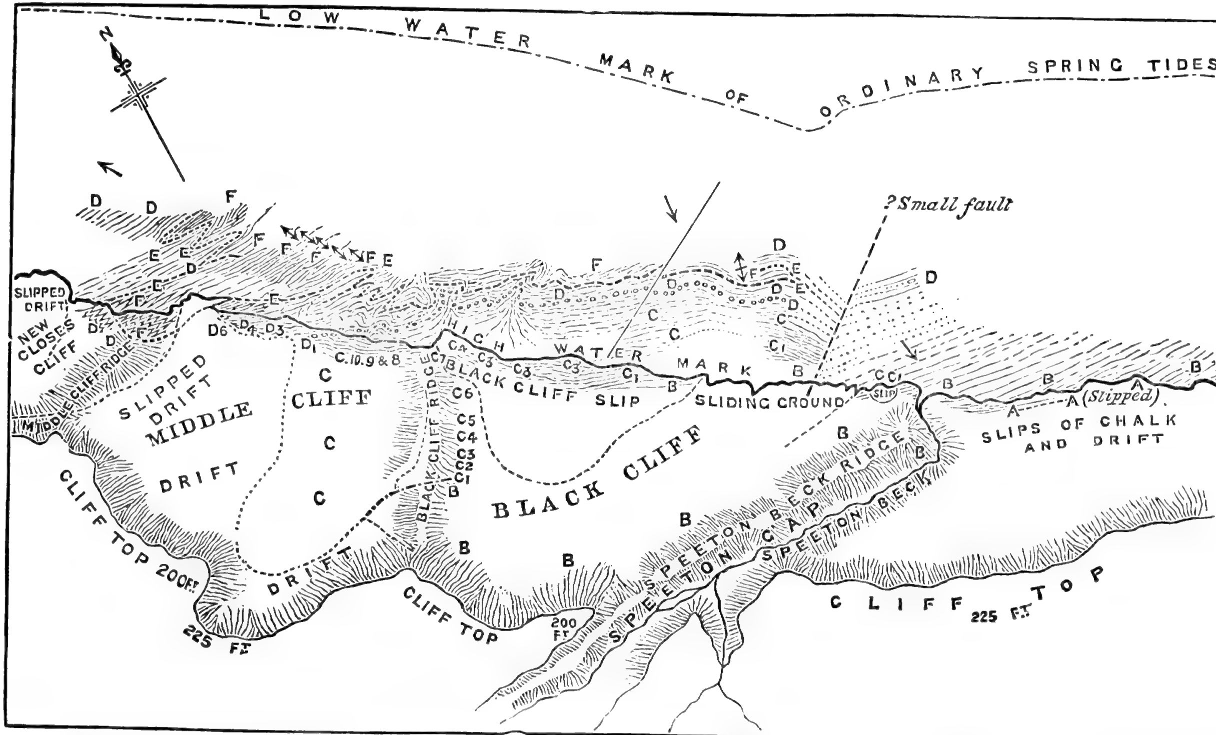


The wavy lines represent the bedding-planes of the Chalk-with-flints: top layers broken into rubble. Above is seen the dark 'Basement' Boulder-clay.

From Selwicks to the high cliffs of Buckton, the sections are made up entirely of flinty Chalk, with a variable capping of drifts. To the hardness of the rock, as much as to the tumultuousness of the sea, is due the fantastic and picturesque outlines into which this part of the coast is broken.

At Old Dor, opposite to Bempton, the beds are magnificently contorted, being thrown into sharp folds from the top to the bottom of a cliff 275 feet high. Photographs of this fine section were issued to the members in 1882, and a photograph of Little Thornwick Bay, two miles to the south-eastward, in 1885 ; and in each case a brief description of the locality will be found in the annual volume.

FIG. 3.—GROUND PLAN OF THE COAST AT SPEETON, SHOWING THE COURSE OF THE BEDS ON THE SHORE AND IN THE FOOT OF THE CLIFF. (Scale, 9 inches to 1 mile). G. W. LAMPLUGH.



A. Marly Clays, with *B. minimus, &c.* (slipped).
B. Clays of zone of *B. brunsvicensis.*
C. Clays of zone of *B. jaculum*, Phil.
D. Clays of zone of *B. lateralis*, Phil.
E. Coprolite-bed.
F. Bituminous shales with B. Owenii. *(vars.)*

The lines show the strike; where continuous, the beds have been actually observed; where broken, they are suppositious.

Under Buckton the softer flintless Lower Chalk rises into the base of the cliff, which then becomes less nearly vertical. The details of this portion of the Cretaceous series have been carefully worked out by Mr. W. Hill (see *Q. J. G. S.*, Vol. XLIV., pp. 320—366), who shows that the equivalents of the *Grey Chalk* and *Chalk Marl* of the southern counties may be recognized in it. Several pink bands occur in it, and it is in some parts fairly well supplied with fossils. Its thickness is about 130 feet. At its base we have the Red Chalk proper, or Hunstanton Limestone (the equivalent of the Upper Gault of the south of England), which may generally be found on the foreshore and at the foot of the broken cliff at Speeton, just where the Chalk escarpment leaves the coast-line. A search in this bed never fails to bring to light *Belemnites minimus* and *Terebratula semiglobosa*, with perhaps *Avicula gryphæoides ;* and beyond this numerous other fossils will reward the patient collector.

Of the Speeton Clays which come out from under the Chalk escarpment at Speeton, and form for about a mile a low broken undercliff, it is to be hoped that the members will not see too good a section, since this can usually be obtained only during stormy weather, when the beach and the foot of the cliff have been freshly scoured by heavy seas, and the slopes swilled by rain. At other times the hardened mud-streams and slipping drift-cap make a picture of disorder, out of which the casual visitor may well consider it hopeless to bring forth order. But in that case let him turn from the task for satisfaction to the glorious view over sea and land which confronts him. Under favouring circumstances it is quite possible to trace out a definite succession of zones, each containing fossils proper to it and not found elsewhere, and thus were compiled the details of the full section given in my paper on the subject in *Q. J. G. S.*, XLV., pp. 575 to 618.

But if the members cannot see the sequence as there recorded, they should, by searching carefully over the clay-slopes, especially towards the shore-line under "Black Cliff Ridge" and to the westward of it (see map above), be able to collect at least a few of the characteristic fossils of some of the zones, *e.g.*—*Ammonites noricus* (= *Hoplites amblygonius*), *Bel. jaculum*, *Bel. lateralis*, etc., and to satisfy themselves of the fact of the limitation of certain fossils to definite zones. This fact is of the highest importance in the correlation of the beds with those of other countries, as has recently been shown by Prof. A. Pavlow of Moscow, who has been able by means of the material collected in this section to work out the relationship existing between the beds of the same age throughout Northern Europe, and to prove at Speeton itself a most interesting alternation of northern and southern faunas. *(Bulletin de la Société Impér. des Naturalistes de Moscou, Nos. 3 and 4. 1891.)*

I have found it convenient to divide the Speeton Clays broadly into three zones by means of the Belemnites (with some subdivisions based on the Ammonites) as under—

(B.) Zone of *Bel. brunsvicensis.*

(C.) Zone of *Bel. jaculum.*

(D.) Zone of *Bel. lateralis.*

Besides these, there are (A) Marls with *Bel. minimus* overlying the beds B, and forming an upward passage into the Red Chalk; while at the base of the series below D come, first, a thin band of Coprolite-nodules (E), and then the bituminous Kimeridge shales with *Bel. Owenii* (F).

This interesting Speeton Series is soon cut out by pre-glacial erosion, and disappears under the drifts. At the base of the glacial deposits on Middle Cliff Ridge (see map), an estuarine shell-bed of muddy sand deserves examination. It seems to be of about the same age as the Buried-Cliff-Beds of Sewerby. (See *Geol. Mag.*, dec. II, Vol. VIII., p. 2). Between Speeton and Filey the cliffs are entirely composed of glacial deposits, which include, just above high-water mark in the neighbourhood of Mile Haven, some transported masses of Lower Lias shale with the original bedding still preserved.

If the members ascend the escarpment at Speeton, they will notice a remarkable chain of mounds composed of sand and gravel, fringing the edge of the declivity. Speeton Windmill stands on one of these, and the Beacon on another, while others rest on the very summit of the sea-cliffs between Speeton and Buckton. These mounds belong to the glacial series; and though they are made up in the main of stratified material, their position is scarcely explicable under any theory of submergence. The only probable supposition seems to me to be that they have been deposited along the edge of the ice-sheet, chiefly by its surface drainage, when the North Sea in this latitude was choked with a glacier which was thick enough to overtop the escarpment, though not to over-ride it.

NOTE.—Permission to use the clichés of woodcuts from the Quarterly Journal, issued in illustration of these notes, was kindly granted by the Council of the Geological Society.

SOME NOTES ON THE YORKSHIRE COALFIELD AND ITS EASTWARDLY EXTENSION. BY PROF. ARNOLD LUPTON, F.G.S., M.I.C.E.

(Read November 7th, 1894.)

It is impossible to attempt more than an outline sketch of two or three salient features of the geology of the Yorkshire Coalfield, and any description must be something like a magazine story, "to be continued in our next." It may be completed sometime in the next century when the eastern boundary of the Coalfield has been explored. In this respect the Yorkshire Coalfield differs from some others in this country to which the boundaries are completely traced, for instance, the Irish Coalfields are fully exposed. The boundaries of the Scotch and Northumberland Coalfields are known, except that they dip under the sea. The same remark applies to the Durham Coalfield, except the southern corner, which is covered by newer formations. The great Coalfield of Glamorgan and Monmouthshire has its boundaries well-defined, and the same may be said of the small Coalfield of the Forest of Dean. The Coalfields, however, of Somersetshire, South Gloucestershire, Staffordshire, Warwickshire, Leicestershire, Cheshire, Denbighshire, Shropshire, South West Lancashire and Cumberland are each unexplored on one side at least, and the newly-discovered Coalfield at Dover has not yet been seen by the eye of man in any part. It is therefore evident that the next century will provide plenty of work for those who explore our Coalfields, but of all the storehouses of fuel there is none more likely to be vigorously explored than that great Coalfield which stretches from the latitude of Leeds, on the north, to the neighbourhood of Nottingham, on the south.

At a period before the geological maps of Yorkshire were published, the writer had occasion to make a geological examination of this Coalfield, and to prepare plans and sections for the use of the Royal Coal Commission, and in the year 1879 he contributed a paper to this Society on some of the features of this Coalfield. The writer has prepared a plan and sections to illustrate these notes.

Figure I. is a plan of the Coalfield showing the outcrops of three of the best known seams of Coal, also the Millstone Grit below. The outcrops of the Permian, New Red Sandstone, Lias and Oolite are also shown.

Figure II. is a longitudinal section from north to south of the Coalfield, along a line drawn through some of the collieries. The total length of the section is sixty-eight miles.

Transverse sections were also shown, one across the Coalfield from west to east in North Derbyshire, and another from west to east along a line of latitude about two miles south of Leeds.

These two transverse sections, one on the extreme north and the other on the extreme south of the Yorkshire Coalfield agree in showing a continuous dip from west to east, except the eastern end of the northern section, where a slight eastwardly rise has been noted. The question is, is this eastwardly rise merely a local variation or does it mark the beginning of the general eastwardly rise which will be continued till the coals crop out against the lower surface of the Permian formation. Everybody admits that the Coalfield ends somewhere before the coasts of Denmark are reached.

Those who are most sanguine think that the Coalfield extends under the whole of Lincolnshire. Others think the river Trent represents the eastern boundary of the Coalfield.

It may be interesting to consider for a few moments how far the evidence that now exists throws any light upon this problem.

There are three important boreholes. No. 1 is the deep boring for coal at Scarle. No. 2 is the boring near Carlton and Snaith, and No. 3 is the boring near Haxey, between Doncaster and Gainsborough. The Scarle boring reached a depth of 2,030 feet, and passed through 1,425 feet of New Red Sandstone ; the strata at the bottom of the borehole were never fully identified. The boring near Scarle, whatever it proved, has not yet led to any further developments, and the details have not been published. The boring near Haxey has reached a depth of nearly 1,100 yards, and it has been publicly stated that a seam of coal supposed to be the Barnsley bed has been found at that great depth.

Figure III. is a section drawn from the north-western corner of the Coalfield at Denholme, through Batley, Wakefield, Hemsworth, Doncaster and past Gainsborough.

The faults are not shown on the section, but the dip is averaged from the outcrop to the deepest point. The writer thinks it quite reasonable to omit the faults from this section because he has observed that in this Coalfield a seam of coal descends from the outcrop to the deepest place where it has been proved sometimes by a general dip and sometimes in steps. These steps are the faults, but for the purpose of a general section such as this it does not matter whether the dip is shown as proceeding along a slope or whether the detail of the steps or faults is shown.

One of the most interesting questions is that of the level of the upper surface of the Carboniferous formation where this formation is covered up by the Permian. In the section the present average inclination of the Carboniferous land surface is shown having a gentle dip from west to east. Another dotted line shows the possible inclination of the Carboniferous land surface before the Permian was deposited and the denudation of the Coalfield was completed down to its present level. If that inclination should continue there must be an enormous thickness of more recent formations. It is, however, possible and probable that the easterly dip of the ancient surface is less rapid, and it is possible that there may be a ridge of the Carboniferous formation under Gainsborough. That the inclination of the old land surface flattens appears to be now proved by the boring near Haxey.

The total thickness of the Yorkshire Coal Measures has not yet been definitely ascertained. It may be that east of the Permian outcrop the dip of the Coal Measures may in some places be steeper than the dip of the Permian, in which case there will be room for a greater thickness of Coal Measures above the Barnsley bed than has yet been proved. It is believed that the section line No. III. is taken along the deepest or one of the deepest troughs of the Coalfield.

At Deholme there is the greatest westerly extension ; along the northern outcrop of the Coalfield there is a southerly dip, for instance, at the now closed Newton Colliery, near the northern outcrop, the Warren House coal, which corresponds to the Barnsley bed, lies about 500 feet below the sea level, giving a dip of 1,300 feet in ten miles from north to south. Going further south, the coal rises from South Kirby to Denaby Main, where, on the corresponding line of longitude, this coal is only 1,200 feet in depth. It is, therefore, evident that South Kirby is very nearly in the centre of a trough from which the coal rises north and south and west. There will also be from South Kirby a gradual eastwardly dip.

The deepest shaft yet sunk to the Barnsley bed is that at Cadeby, about four and a-half miles south-west of Doncaster, where the coal is 750 yards deep. Judging from the rate of inclination down to the east, proved by the dip of the coal from the outcrop near Barnsley to Cadeby, it is probable that the depth under Doncaster will be about 1000 to the Barnsley bed, and it may be a little more and it may be a little less.

The total thickness of the Yorkshire Coalfield yet proved down to the Millstone Grit is about 4,700 feet, or in round figures 5,000 feet. There are altogether about fifty seams of coal, and the total thickness is over 100 feet.

At the present time coal seams are worked in Yorkshire varying in thickness from about 14 inches to 10 feet. A 14-inch coal can only be profitably worked under peculiar local conditions, and it is only in a few localities that 10 feet of coal are found workable in one seam. In Yorkshire any coal under 3 feet is classed as a thin seam.

The Coalfield is roughly divided into two districts by a line of longitude passing through Leeds. Westward of this line of longitude is the thin coal district and eastward is the thick coal district. In the thin coal district the coal is got in the proximity of the town and factory where it is used, though the working cost is pretty high, amounting to 7s. or 8s. a ton. In the district to the east the coal seams are 3 feet and upwards and the cost of working is greatly reduced, but the larger collieries have to send most of their coal some distance by railway or canal. Before this Coalfield is exhausted every seam of coal over 4 inches in thickness will be worked, and in many districts, where thick coals have been worked and exhausted, the old wastes will be worked over again for the sake of the slack, the pillars, and beds of inferior coal that have not been considered good enough for the market. When this time comes the average price of coal at the pit top will be perhaps 20s. a ton, and the smoke nuisance will be considerably abated.

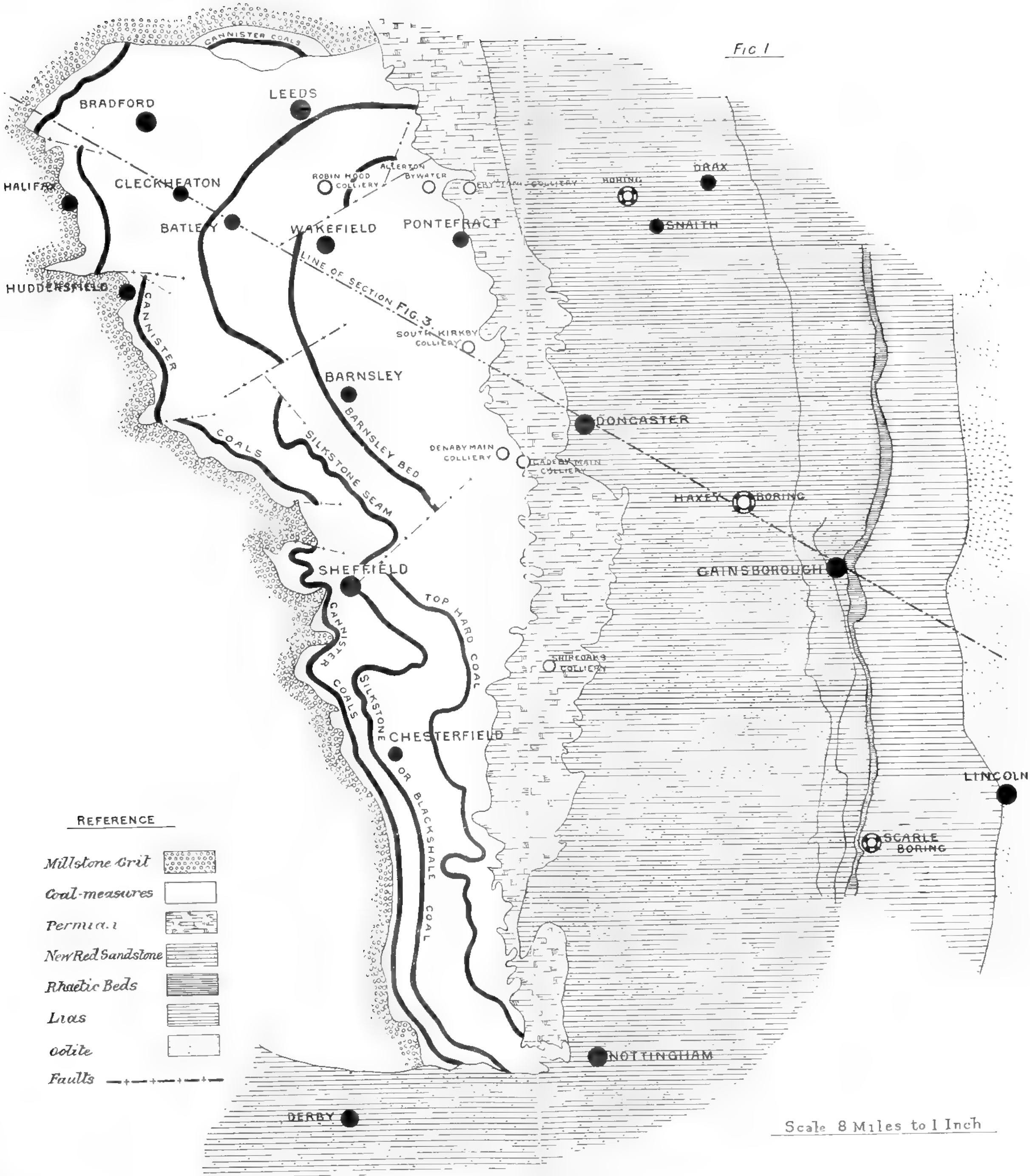


Fig. I
Cannister Coals
Bradford
Leeds
Halifax
Cleckheaton
Batley
Wakefield
Pontefract
Robin Hood Colliery
Allerton Bywater
Drax
Boring
Snaith
Huddersfield
Cannister
Line of Section Fig. 3
South Kirkby Colliery
Barnsley
Barnsley Bed
Silkstone Seam
Coals
Doncaster
Denaby Main Colliery
Haxey Boring
Sheffield
Gainsborough
Top Hard Coal
Cannister Coals
Silkstone or Blackshale Coal
Shireoaks Colliery
Chesterfield
Lincoln
Scarle Boring
Reference
Millstone Grit
Coal-measures
Permian
New Red Sandstone
Rhaetic Beds
Lias
Oolite
Faults
Nottingham
Derby
Scale 8 Miles to 1 Inch

TO ILLUSTRATE PROF. ARNOLD LUPTON'S PAPER ON "SOME NOTES ON THE YORKSHIRE COALFIELD AND ITS EASTWARDLY EXTENSION."

FIG. 2. SECTION

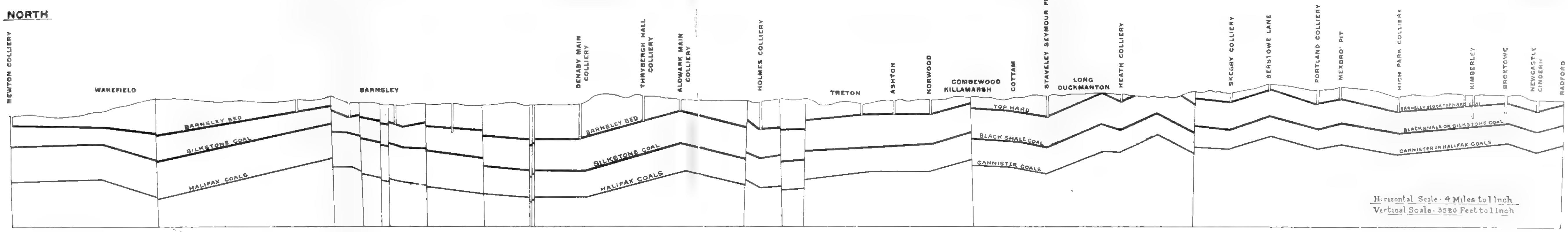
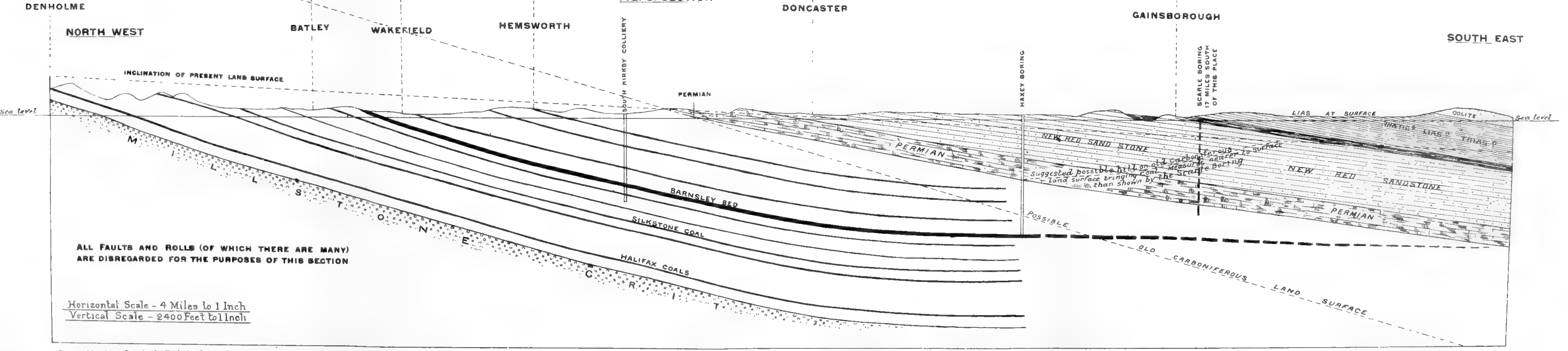


FIG. 3. SECTION



THE OCCURRENCE OF LIMESTONE CONGLOMERATES ON THE NORTH SIDE OF THE CRAVEN FAULTS. BY R. H. TIDDEMAN, M.A., F.G.S., OF H.M. GEOLOGICAL SURVEY.

(Read November 7th, 1894.)

(Communicated with the permission of the Director General of the Geological Surveys of the United Kingdom.)

In 1890, when the British Association met at Leeds, at the request of the Local Committee I drew up a description of the "Physical History of the Carboniferous Rocks of Upper Airedale," which appeared in the Local Handbook presented to the visitors. Through the instrumentality of your late Secretary, Mr. Jas. W. Davis, this paper was rescued from the limbo of so ephemeral a publication, and printed in the Proceedings of your Society (vol. xi. part iii).

Amongst other things it called attention to the great discrepancies in the Lower Carboniferous Rocks on either side of the Craven Faults, and showed that these different types, which were called the Bowland and Yoredale types, extended, the one from the plains in Lancashire bordering the Irish Sea to the Craven Faults, and the other from those faults away to the Scottish border. It was pointed out that these two distinct types showed no tendency to assimilate at the line of junction, but were if anything still more pronounced there.

The enormous thickness of the rocks on the Bowland, south, or downthrow side of the faults (as compared with the Northern or Yoredale type) was regarded as evidence that the faulting was going on concurrently with the growth of the deposits on that side.*

Further, an attempt was made to sketch out the geography of the Carboniferous seas in the North of England at that early period. A moderately full description was given of the "Knowl Reefs" of the country on the south side of the Craven Faults. These are great mounds of white limestone made up of organic remains, such as Brachiopods, Lamellibranchs, Gasteropods, Crinoids, and Corals.

* See also paper by the author, "On Concurrent Faulting and Deposit in Carboniferous Times in Craven, Yorkshire, with a note on Carboniferous Reefs. Tran. Brit. Assoc., Newcastle-upon-Tyne, 1889.

Evidence pointed to their having grown up as reefs on a slowly sinking bottom by the growth and death of the animals of whose remains they are formed. It was shown that they were formed in shallow seas, and that the tops of them were often awash in the turmoil of the waves. In short they formed islands or reefs. One of the points of evidence was the frequent occurrence on their sides or on the sea-bottoms surrounding them of angular fragments of the limestone, which had evidently been broken off from them in the surge of the sea, and had either accumulated on their sides at an angle of rest or had been consigned to the deeper water below, and subsequently covered up by the shale and mud of a later stage. These so-called breccias were generally made of angular fragments, but occasionally the pieces were well rolled into pebbles, and the deposit might be called a conglomerate.

In summing up the bearing of these and kindred facts on the geography of these Carboniferous Seas I wrote as follows :—" If we ascend to the top of the crags above Malham Cove we soon find ourselves upon the great plateau of the Mountain Limestone proper. This, though broken at the foot of Malham Tarn by the North Craven Fault which throws up the base and shows us how thin it is, and crossed by many minor faults, is one and the same as the great spread of Mountain Limestone which lies beneath all the Yorkshire Dales, and extends north beyond the Tyne Valley. We have crossed the Fault and in so doing have exchanged the Clitheroe or Bolland series for the Yoredale type, and if we could realize the state of affairs when these rocks were forming we should probably say that we had left a deep sea dotted with islands and come on to a wide and long and shallow reef." The sea with the islands was a generalization, the result of a very fair amount of evidence. The long reef was hardly more than a conviction based on probabilities. Some evidence I had seen, but hardly enough to form a satisfactory demonstration, and at first sight it seemed unlikely that any remains of the beach of that supposed reef, ranging along the flanks of the high hills which border on the Craven Faults, would be present, if it had ever existed.

It was, therefore, a pleasant surprise when I was working in the hills between Appletreewick and Greenhow Hill last Summer to come upon some evidence which, to some extent, supports the conviction at which I had arrived from a priori grounds.

Dibbles Gill, a pleasant little upland stream runs down from the Millstone Grit Fells above, and about Grimwith Reservoir it passes over the Yoredale beds, here somewhat degenerate in their type, and goes under the road from Grassington to Greenhow hill at Dibbles Bridge. Lower down it crosses the main Craven Fault, that branch which brings down the picturesque grit escarpment of Fancarl Crag against the Mountain Limestone. In its further course it runs in a rather deep ravine between Limestone hills, formerly much mined for lead, and enters the Wharfe between Burnsall and Appletreewick. It is with the upper part above the Craven Fault that we are now concerned. A good sized quarry below Dibbles Bridge shows a black limestone, containing beds of chert and abundant remains of *Producta gigantea*; corals also occur in it. These beds have much the look of the Hardraw Scar Limestone. They extend beneath the bridge with a northerly dip.

Nothing more is seen up-stream for about 300 yards. We then meet with a sandy-looking limestone forming the bed of the stream, and here and there are exposures which show pebbles of limestone in the matrix. Above this again is a black limestone with few fossils but containing corals. The beds are not well seen in the stream, but if we leave the stream and go up through the fields along the strike, between this point and the road across the moor to Grimswith Reservoir, we shall find old quarries in them, and the dry walls around bear ample evidence of the rock quarried in them, though the quarries themselves are now unfortunately grassed over. These walls are full of excellent specimens of limestone conglomerates. The pebbles range in size generally from a mustard seed to a broad bean, but bigger fragments are occasionally seen. The whole material looks very much like a concrete. The pebbles are light-blue grey and the material is of a yellowish colour and feels gritty.

Some other evidences of land or shallow water conditions were found in the tip from the mining level, which comes out at Kell Well, east of Grimwith Reservoir, and cuts through the same set of beds.

The present time is an important one for calling attention to those beds, because of the long water tunnel now in course of excavation under Greenhow Hill, for the Bradford Waterworks, in which there is every probability that these beds will be met with. The tunnel will at any rate make a clean cut through the Craven Fault, and results of much value may be anticipated if those who are in charge of the works should take an interest in the matter.

FIELD EXCURSION TO BROAD LANE JUNCTION, BRADFORD.

In connection with the General Meeting at Bradford, November 7th, 1894, a Field Excursion was taken to inspect a section exposed by a cutting on the Great Northern Railway, between the bridge opposite "The Trees Inn" and Broad Lane Junction. The party was under the direction of Mr. Walter Rowley, F.G.S., who described the various features of interest exhibited in the section.

When the section was first exposed some two or three years ago, the Coal seams and the Fault were clearly shown, but owing to the weathering of the shales and rain carrying down *debris* from the upper part of the cutting, there is some difficulty in examining the section at the present time.

Commencing at the bridge opposite "The Trees" a seam of Coal is seen, probably the *Crow Coal*; it is difficult to measure the thickness accurately, but it is given on the Geological Ordnance Map as 1′ 4½″.

A little further on the *Black Bed Seam* is exposed, and the overlying nodules of ironstone can be plainly picked out; after this shales and sandstones alternate until the *Better Bed Coal* is exposed; hereabouts a fault is shown on the Geological Ordnance, but the exact line of fault cannot be very clearly made out. Continuing past Broad Lane Junction the strata are much disturbed and contracted, ganister and sandstone being seen dipping in various directions.

Throughout the whole of the section the beds are highly inclined and much steeper than the usual dip of the district. In places the strata in the cutting are hidden by grass.

The party walked back to Laisterdyke Station, and returned to Bradford by train.

DESCRIPTION OF PHOTOGRAPH OF BOULDER CLAY CLIFFS, CARR NAZE, FILEY. BY REV. E. MAULE COLE, M.A., F.G.S.

I. General Description of the Locality.

Filey Bay is well-known to tourists and to most geologists. In point of scenery it is one of the most beautiful, if not the most beautiful, bay on the Yorkshire Coast. Its almost unrivalled sands extend for a distance of upwards of four miles, from Carr Naze on the north to the celebrated Speeton Clays on the south. Looking seawards, the eye rests with admiration, on the right, on the magnificent vertical wall of chalk forming the cliffs of Speeton and Buckton, four hundred feet in height, and extending, with diminishing altitude, to the North Landing at Flamborough Head; whilst on the left is seen the remarkable spur, running out to sea for half-a-mile, commonly known to visitors as Filey Brigg, which protects the bay from north-easterly gales. This spur is continued outwards as a submarine ridge for another mile, to a buoy with a bell attached, which does not appear to have been always successful in preventing shipwreck on the Brigg. Rather more than half of the western portion of the ridge of Oolitic rocks is covered with a thick deposit of Boulder Clay, rising to a height of nearly one hundred feet, forming the promontory known as Carr Naze. Originally, no doubt, the Boulder Clay extended much farther seawards and covered a larger portion of the ridge of rock, but the waves and the rain combined have reduced it to its present moderate dimensions. In historic times the Romans are credited with having used Filey Brigg as a landing place, but whether this was so, which is much to be doubted, or not, there is no doubt that the old Norsemen had an attraction for it, for their nomenclature has been distinctly preserved. The headland is called Carr Naze, which, under the name of Næs, our "Ness" or "Naze," is one of the most common place-names in Norway; whilst the word Brigg, commonly and properly spelt with two g's, has nothing to do with the Yorkshire dialectic "brig" for "bridge," but is the Norwegian "Bryggr" = "a quay, or landing-stage," as seen at Bergen at the present day.

II. Composition of the Section.

In the foreground is a marine platform of alternate beds of grits and limestones, which form the lower passage-beds between the Lower and Middle Calc. Grits of the Middle Oolites. Similar beds are continued at the base of the stratified portion of the section. In the centre is the Middle Calc. Grit six feet thick. These beds, as will be noticed, rise slightly towards the east, but the real dip is to the south-west. It must be remembered that the view before us is that of a promontory, and that we are looking at the south side; immediately to the north is the sea, at a distance of 150 yards, but with very different cliffs opposed to it. There the beds, which in the photograph have only an elevation of some eight to twelve feet above sea-level, rise up in cliffs thirty to forty feet above sea-level, so that the dip is considerable.

Immediately upon the stratified beds rests about a foot thick of rubbly-decayed Oolitic conglomerate, very similar to what may often be seen on the top of the Chalk. It marks the old land surface before the deposition of the Boulder Clay, and shows the denudation that was then going on by frost and snow. The main body of the cliff, which is nearly one hundred feet in height, is composed of Boulder Clay, and probably no finer section can be found in the kingdom, for the clay is to a great extent homogeneous, that is to say, there is an absence of pipes of sand, which, in so many instances of Boulder Clay cliffs, allow water to percolate the mass and destroy it piece-meal. Here the cliffs are remarkably firm and consistent, and the clay seldom gives way to mud. Numerous boulders will be observed sticking out from the face of the clay, one especially, to the left, composed of sandstone, which will soon be undermined and fall to the beach to join the many which have already found there a temporary rest.

III. Origin and Age of the Boulder Clay.

It is generally conceded by geologists that Boulder Clay is the product, not of icebergs or ice-floes, but, of land-ice, or glaciers. Into the arguments *pro* and *con* it is not necessary here to enter. As a matter of fact Boulder Clay, of great thickness, is found all along the Yorkshire Coast, from Redcar to Kilnsea on Spurn Point, filling up old bays of the sea, and land valleys debouching on the shore. The Geological Surface maps show its extension in Yorkshire so that there is no occasion to enter into detail. These maps bring out prominently, however, the facts that there were two sources of supply,—1, glaciers descending from the Pennine Range into the Vale of York; and 2, a great glacier impinging on the Yorkshire Coast, laden partly with Scandinavian boulders; also, that the Moorland Dales, south of the anticlinal from Burton Head to Robin Hood's Bay, as well as a large portion of the Wolds, were islands in a sea of ice. The glaciers swept round them on all sides, but not over them.

As regards Filey Bay the effect of the ice pressing on the land in its course southwards was to pile up masses of Boulder Clay and morainic sands and gravel, so as to completely block up the end of the Vale of Pickering, and to alter its drainage, *e.g.* the River Rye, which used to flow into the sea near Filey, now passes through a modern gorge at Malton to the Vale of York. So thick was the ice that moraines were deposited at Speeton, and further along on the very top of the chalk cliffs, containing numerous large boulders of whinstone from Upper Teesdale, granite from Shap, together with various other rocks, such as quartz, Mountain Limestone, Lias, mica schist, &c., and even porphyry from Christiania.

In attempting to ascertain the age of the Boulder Clay of Carr Naze several difficulties present themselves. In the first place the cause of the Ice Age itself is not a matter of general agreement, some geologists attributing it to astronomical changes, others to geographical. Again, there are distinct evidences of several Boulder Clays, lying one upon another, with different characteristics, especially in Holderness, such as the Basement Clay, with arctic shells, the Purple Clay, and the later Hessle Clay. Recent investigations (Geol. Soc., 1895), have re-established the theory that there were inter-glacial periods in the Ice Age, which facilitated the decay of the glaciers during years of comparatively warm temperature. But, to all appearance, the Boulder Clay cliff of the section is homogeneous throughout,* and, as it rests upon the original Oolitic rock, it must

* Unless a line of stratified sand about half-way up the cliff marks a possible division.

be the oldest deposit in this locality, to whichever section of clays it may eventually be assigned.

It is interesting to note, in this connection, the marvellous vicissitude of climate which, in long-passed ages, has occurred in the British Isles. On the one hand we find rocks due to the growth of corals, which can only exist in a temperature of some 68 degrees, and, on the other, a super-stratum of clay, the product of intense glaciation. Countless years, of course, intervened, but the fact remains.

IV. Present Denudation.

We come now to the present denudation. It exhibits in a remarkable way the effect of the rainfall in contradistinction to other agencies. No doubt frost has played its part, but only as a concomitant of the water which forced its way into the cracks. The cracks were mainly produced by the heat of the sun, acting on clay cliffs exposed to the south, so that various atmospheric influences have been at work. The sea has had little to do with it, except in removing the masses which from time to time fall on the shore. Such a mass may be seen on the left of the photograph ; it fell shortly before the picture was taken, but has now disappeared (April, 1895).

The chief effect of the rainfall on these particular cliffs has been to carve out the sharp ridges and arrètes which are so conspicuous a feature in the landscape. Here and there tiny earth-pillars are found, with a stone on the top, which has for a brief time arrested the washing away of the clay ; elsewhere, miniature ravines or corries show where gathering tiny streams have run together and caused a temporary waterfall. In the centre of the photograph, however, there is a ravine of an entirely different character. It resembles the ravines at Filey, and the gaps of Hunmanby and Speeton. It is a valley excavated by a perennial stream which rises from a spring on the top of the cliff some 150 yards back. There are several valleys of a similar character between Sarnwick and the North Landing at Flamborough Head. These springs, however, effect little in the way of denudation compared with the numerous sipings which trickle down the face of the clay cliffs in other sections. The damage they do is incalculable, no amount of drainage seems capable of retarding their destructive tendency. The whole cliff is slowly set in motion and glides down to the shore, to be washed away by the next high tide. Its top is in constant recession, and field after field is swallowed up. Two yards a year is a common, and, in some parts, four yards a year not an uncommon, rate of loss.

When this is borne in mind, it can easily be imagined what a vast alteration has taken place both in the extent and aspect of the coast-line since the deposition of the Boulder Clay. Filey Bay had then probably no existence at all, and the same might be said of Robin Hood's Bay, Runswick, Whitby and Bridlington Bays. But the sea was there before the clay, and the sea is merely regaining its own. In some places it has already done so. There are only a few inches of clay left sticking in the interstices of the rocks under the Spa at Whitby. The old shore-line of Lias cliffs has been completely exposed at the south end of Robin Hood's Bay, and similarly in other places; but Carr Naze, Filey Bay, and Holderness still remain, and will go in time. In the memory of persons now living vast changes have taken place in the aspect of Carr Naze, both on the north and on the south sides, and it is not too much to say that some of the next generation may live to see Carr Naze cut in two at the top, and perhaps an outlier formed between the path which, on the south, leads to the summit, and the extreme point.

As a record for future observers it may be stated here that the narrowest portion of the ridge at the top of the said pathway was 18 feet 6 inches in April, 1895. The widest portion of the Naze, nearer the point, was at the same time 137 feet 6 inches.. The narrowest part at the base of promontory near the Spa was 147 feet.

SECRETARY'S REPORT, 1893-94.

Since the issue of the last Secretarial Report the Society has passed through a period of special bereavement, more prominent members having been removed by death than, probably, during any similar period in the history of the Society. Obituary notices have already appeared of two of its most active supporters, the late Honorary Secretary, Mr. James W. Davis, F.S.A., F.G.S., and Mr. T. W. Embleton, and to these severe losses must be added the names of Messrs. William Cheetham, F.G.S., Thomas H. Gray, and the Rev. W. C. Lukis, well-known as an antiquarian. During the last months other old supporters of geological work in Yorkshire have passed away, including Mr. David Swallow, Manager of the Bradford Gasworks, at the advanced age of eighty-two, Mr. Charles Bartholomew, of Ealing, and Sir Chas. Lowther, Baronet. Notwithstanding these serious losses the present position of the Society is strong and its future hopeful. After preliminary conferences between members of the Council and other of the Association's workers, the Council met at the end of November, 1892, and unanimously resolved to invite the Honorary Secretary of the Leeds Geological Society, Rev. W. Lower Carter, M.A., F.G.S., to undertake the Secretarial work of this Association. This invitation was accepted, and Messrs. W. Lower Carter and William Cash were appointed joint-editors of the Proceedings. To aid them in their work a Consultative Editorial Committee was appointed, consisting of Dr. H. C. Sorby, F.R.S., Mr. P. F. Kendall, F.G.S., and Mr. H. M. Platnauer, F.G.S., to whom any questions that might arise in the publication of the Papers could be referred for decision.

Since the issue of the last Report several changes have been made in the list of Local Secretaries, and the following gentlemen have been recently appointed by the Council to assist the General Secretary in the local organisation of the Society: Messrs. J. W. Wilson (Bradford); William Simpson, F.G.S., (Halifax); J. W. Stather, F.G.S., (Hull); Jos. Field (Huddersfield); J. H. Howarth, F.G.S., (Leeds); J. J. Wilkinson (Skipton and Keighley), and Chas. W. Fennell, F.G.S., (Wakefield).

During the Spring of 1893 "The Proceedings," Vol. XII. part III., was published, and the membership there recorded is :—

Honorary Members	6
Life Members	45
Subscribing Members	139
Total	190

but enquiries evidently proved that the names of many gentlemen had been retained on the roll after they had ceased to have any active interest in the affairs of the Society. A careful revision of the roll has resulted in a considerable reduction in the numbers, but without, by any means, a corresponding loss of interest or support. During the period, June 1893 to December 1894, thirteen of the members have been removed by death, and thirty-two by resignation. During the same period eighteen new members have been admitted. The present roll of membership is as follows :—

Honorary Members	6
Life Members	48
Subscribing Members	109
Total	163

During the past eighteen months six Council Meetings have been held, and also four General Meetings, as below, the particulars of which are given in the records of the Minutes.

Jan. 16th, 1894, Prospect Hotel, Harrogate.
Chairman, Richard Carter, Esq., C.E., F.G.S.

April 11th, 1894, Firth College, Sheffield.
Chairman, Dr. H. C. Sorby, F.R.S., F.G.S., F.L.S.

June 8th, 1894, Alexandra Hotel, Bridlington Quay.
Chairman, Wilfrid H. Hudleston, Esq., F.R.S., F.G.S., F.L.S.

Nov. 7th, 1894, Grammar School, Bradford.
Chairman, The Mayor of Bradford (Jonas Whitley, Esq.)

The issue of the Proceedings, Vol. XII., part IV., was unfortunately delayed by several unforseen difficulties, and the Editors much regret that it should have been so late in reaching the members. They hope, however, in future to issue the papers read during the year as early as possible after each Annual Meeting. An enlarged Woodbury type reproduction of an excellent photograph of the late Mr. James W. Davis (by Mayall and Co., London), with autograph, was issued to the members in the place of the usual geological photograph, and gave great satisfaction to the numerous friends and admirers of our late Honorary Secretary. The practical side of geology has not been forgotten in the arrangement of the General Meetings. In connection with the Sheffield Meeting a visit was paid to the famed Ruskin Museum, in Meersbrook Park, where the unique collections of minerals, gems, and art treasures were exhibited and described by Mr. Charles Bradshaw, F.C.S., of the Weston Park Museum, in the unavoidable absence of Mr. William White, the Curator. In connection with the Bridlington Meeting a two-days' Field Excursion was arranged for the examination of the coast sections between Bridlington and Filey, which, notwithstanding the unfavourable weather of the second day, was much enjoyed.

Our Proceedings have, as usual, been forwarded to leading Scientific Societies in all parts of the world, and the following Societies have forwarded their publications in exchange :—

Royal Dublin Society
Royal Historical and Archæological Association of Ireland
Manchester Geological Society
Academy of Natural Sciences, Philadelphia, U.S.A.
Societé Imperiale des Naturalistes, Moscow
United States Survey of the Territories, Washington, D.C.
Geological Society of London
Royal Society of Edinburgh
American Philosophical Society, Philadelphia
Comité Geologique de la Russie, St. Petersburg
Sociedad Cientifica "Antonio Alzate," Mexico
Elisha Mitchell Scientific Society, University of North Carolina, U.S.A.
Smithsonian Institution, Washington, U.S.A.
Liverpool Geological Society
British Association
Manchester Literary and Philosophical Society
Meriden Scientific Association, U.S.A.
Musen Nacional de Rio de Janeiro
New York State Museum
La Bibliothéque de l' Academie Royale Suédoise des Sciences, Stockholm
Liverpool Geological Association
Geological Institution, Université Royale, Upsala
Leeds Geological Association

The best thanks of the Society are tendered to the above Societies for their kind contributions.

RECORDS OF MEETINGS.

General Meeting, Philosophical Hall, York, May 18th, 1892.

The chair was taken by Mr. Tempest Anderson, M.D., B.Sc.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen were elected members of the Society :—

William Simpson, Halifax.

W. Lower Carter, M.A., F.G.S., Leeds.

The Chairman delivered an address on "The Volcanoes of Iceland."

The following papers were communicated :—

"On the Excavation of Duggleby Howe," by J. R. Mortimer.

"On the Crania exhumed from Duggleby Howe," by J. G. Garson, M.D.

"Notes on some Drainage Sections in Flamborough," by G. W. Lamplugh, F.G.S.

"The Geology of the Country between Grassington and Wensleydale," by J. R. Dakyns, M.A.

"Fossil Polyzoa ; Further Additions to the Cretaceous Lists," by Geo. R. Vine.

The members dined together at the Clarence Hotel.

Council Meeting, Philosophical Hall, Leeds, 16th November, 1892.

The chair was taken by Mr. Richard Carter, F.G.S.

Present :—Messrs. R. Reynolds, W. Horne, J. T. Atkinson, W. Cheetham, W. L. Carter, T. Tate, G. H. Parke, W. Rowley, and J. W. Davis.

The minutes of the previous Council Meeting were read and confirmed.

Resolved that the Annual General Meeting be held in Leeds.

Resolved that the Society be recommended to undertake the exploration of certain pre-historic remains in Upper Wharfedale, and that subscriptions be raised for the purpose.

Resolved that the following gentlemen, with power to add to their number, be appointed a committee of investigation :—Prof. Boyd Dawkins, Messrs. Tiddeman, Davis, Eddy, Wilkinson, Hartley, Cheetham, W. Morrison, Cudworth, Mortimer, Carter, Tate, Horne, and E. E. Speight as Secretary.

Resolved that the Council tenders its congratulations and best wishes to the Honorary Secretary on his election, for the third time in succession, to the Mayoralty of Halifax, and hopes his year of office may be, like the others, a happy and prosperous one for the town and for himself.

Annual General Meeting, Queen's Hotel, Leeds, December 14th, 1892.

The chair was taken by Mr. R. Carter, F.G.S.

The minutes of the last General Meeting were read and confirmed.

The Honorary Secretary read the Report and the Treasurer's Balance Sheet, which were adopted.

The following new members were elected :—

Miss Hilda Carter Mitchell, L.L.A., Bolton Abbey.
Percy F. Kendall, F.G.S., Yorkshire College.
A. H. Pawson, Farnley.
Ernest E. Speight, Shipley,
Thos. Binns, Sawley Hall, Ripon.
Henry S. Childe, Wakefield.

Resolved that the Marquis of Ripon, K.G., be elected President.

Resolved that the Vice-Presidents be re-elected, with the addition of Mr. Wilfrid H. Hudleston, F.R.S., President of the Geological Society, to their number.

Resolved that Mr. William Cash, F.G.S., be re-elected Treasurer, and Mr. James W. Davis, F.G.S., F.S.A., Honorary Secretary.

Resolved that the Council consist of the following members :—

J. T. Atkinson, F.G.S.	Thos. H. Gray.
J. E. Bedford, F.G.S.	Arnold Lupton, F.G.S.
R. Carter, F.G.S.	Percy F. Kendall, F.G.S.

W. Cheetham, F.G.S. | G. H. Parke, F.G.S., F L.S.
J. Ray Eddy, F.G.S. | R. Reynolds, F.C.S.
T. W. Embleton. | W. Rowley, F.G.S.

An Address was given by the Chairman.

The following papers were communicated :—

J. G. Garson, M.D., "On the Crania and Human Remains exhumed from Duggleby Howe."

"Additional Notes on the Howe, Duggleby," by J. R. Mortimer.

"On the occurrence of the Tooth of a Mastodon in the Glacial Drift, near Ripon," by Rev. J. Stanley Tute.

"On some singular Nodules in the Magnesian Limestone," by Rev. J. Stanley Tute.

"Notes on the Polyzoa—Stomatopora and Probiscina groups—from the Cornbrash of Trapston, in Northamptonshire," by George R. Vine.

"Record of a remarkable Shooting Star, April 2nd, 1892," by Richard Reynolds, F.C.S.

Votes of thanks were accorded to the Chairman and the Writers of the Papers.

The members dined together at the Hotel.

General Meeting, Philosophical Hall, Leeds, March 29th, 1893.

The chair was taken by Mr. Percy F. Kendall, F.G.S.

The minutes of the previous meeting were read and confirmed.

David Forsyth, D.Sc., M.A., was elected a member of the Society.

The Chairman delivered an address on "The Glacial Deposits in the neighbourhood of York."

The following papers were communicated :—

"On Calamostachys," by Thomas Hick, B.A., B.Sc.

"A Sketch of the Geology of Nidderdale and the Washburn north of Blubberhouses," by J. R. Dakyns, M.A.

"On the Glacial Phenomena of Wharfedale, between Bolton Abbey and Kettlewell," by J. R. Dakyns, M.A.

A Model of the Parallel Roads of Glen Roy was exhibited by Mr. S. W. Cuttriss.

A vote of thanks was passed to the Chairman.

The members dined together at the Queen's Hotel.

Council Meeting, Philosophical Hall, Leeds, November 22nd, 1893.

The chair was taken by Mr. R. Carter, F.G.S.

Present :—Messrs. Cash, Bedford, Peach, Eddy, Atkinson, Kendall, and Stubbins.

Letters of regret for non-attendance were received from Messrs. Reynolds, Rowley, Gregson, Gray, and Lord Ripon.

Mr. Cash made a statement about the severe losses recently suffered by the Society.

Resolved that the Rev. W. Lower Carter, M.A., F.G.S., be elected Honorary Secretary of the Society.

Mr. Carter was then introduced to the meeting, and briefly responded, accepting the position.

Votes of condolence and regret were passed to the families of the late Mr. J. W. Davis, and Messrs. T. W. Embleton and W. Cheetham.

Resolved that Messrs. W. Lower Carter, M.A., F.G.S., and William Cash, F.G.S., be joint-editors of "The Proceedings."

Resolved that an Editorial Committee be appointed to assist the Editors, by advice and help, in the issuing of "The Proceedings;" and that the following gentlemen be the members of that Committee: Dr. H. C. Sorby, F.R.S., Messrs. P. F. Kendall, F.G.S., and H. M. Platnauer, F.G.S.

A letter was read from Mr. Thos. H. Gray resigning his seat on the Council, owing to ill-health. Two seats had also been vacated through the decease of Messrs. Embleton and Cheetham. The following gentlemen were elected to fill the vacancies until the next General Meeting, Messrs. A. E. Preston, F.G.S. (Bradford), John Stubbins, F.R.M.S., F.G.S. (Leeds), and J. H. Howarth, F.G.S. (Leeds).

Mr. William Simpson, F.G.S., was appointed Local Secretary for Halifax.

Council Meeting, Prospect Hotel, Harrogate, January 16th, 1894.

The chair was taken by Mr. R. Carter, F.G.S.

Present :—Rev. E. Maule Cole, Messrs. Cash, Atkinson, Bedford, Howarth, Stubbins, Simpson, Peach, Kendall, and Carter (Hon. Secretary).

The minutes of the previous Council Meeting were read and confirmed.

The Honorary Secretary read the replies to the votes of condolence passed to the families of the late J. W. Davis, T. W. Embleton, and W. Cheetham.

Resolved that a similar resolution be forwarded to the family of the late Mr. Thos. H. Gray.

The following gentlemen were elected Local Secretaries :—J. H. Howarth, F.G.S., Leeds, J. W. Stather, F.G.S., Hull.

A letter was read from Mr. G. H. Parke, resigning the Local Secretaryship for Wakefield.

The Secretary read his Report which was adopted.

The Treasurer presented the Balance Sheet, which showed a balance in hand, but he stated that there was a printer's account of £80 still unpaid, mostly on account of the printing of the History of the Society. It was resolved that this matter should be considered at the next Council Meeting.

Resolved that in the place of the usual Geological Photograph, a photo-print of the late Mr. James W. Davis, should be produced and sent to the members. A specimen of the style suggested, and the photograph chosen by Mrs. Davis, were exhibited and approved by the Council.

The Secretary presented the following accounts which were passed for payment :—

	£	s.	d.
Crowther (for Plates)	4	0	0
Taylor (Electros)	0	5	6
King (Carriage)	0	1	6
Carter (Stationery)	4	8	6
Petty Cash	2	8	3
	£11	3	9

Annual General Meeting, Prospect Hotel, Harrogate.

The chair was taken by Mr. Richard Carter, C.E., F.G.S.

Letters of regret for absence were read from Dr. Bowman, Messrs. Eddy, Tate, Reynolds, Lupton, Buckley, Gregson, Pawson, and Parke.

The Hon. Secretary read the Report which was adopted.

The Treasurer presented the Balance Sheet, which was approved.

On behalf of the Council the Honorary Secretary moved the following resolutions :—

(1) "It is with deep sorrow that the members of the Yorkshire Geological and Polytechnic Society record their sense of the almost irreparable loss which the Society has suffered in the premature death of its Honorary Secretary, Mr. James William Davis, F.G.S., F.L.S., F.S.A. Mr. Davis' acceptance of office in 1876 marked an important era in the Society's affairs, and his devotion to its interests was exhibited in unsparing work directed by great tact. The renewed vitality of the Society has been successfully maintained, and it is only justice to our lamented friend to attribute this result largely to his efforts. Power such as that of Mr. J. W. Davis, combining devotion to experimental science, with high executive ability and unbounded industry as applied to private and public business, is rarely met with, and it is to be hoped that his example will not only show how much is possible in this way, but will be a stimulus to others to give some of their time and strength to the promotion of geological science."

(2) "The members record their deep regret at the death of Mr. T. W. Embleton, of Methley, an old and valued member of the Council, at the venerable age of 84 years. Mr. Embleton's membership in the Society was of far longer standing than that of any other active member, and his opinions were always received as being entitled to the greatest consideration. The prominent position held by Mr. Embleton in connection with the Institute of Mining Engineers, and his work in the development of the Yorkshire coal-mining industry, made his name prominent amongst practical geologists, and his work will long be remembered."

(3) "The members desire to put on record their sense of the impor-

tant services that have been rendered to the Society by Mr. William Cheetham, F.G.S., and Mr. Thomas H. Gray, for many years members of its Council, and always interested and active in its work, and especially in the popularization of geological knowledge. The enthusiastic energy of Mr. Cheetham, especially, and his love for geology were so evident that his death has made a gap in our ranks which it will be hard to fill. Mr. Gray and Cheetham were life-long friends, and in death they were not long divided."

The following gentlemen were elected members of the Society :—

A. L. Peace, Thorne.
Edmund Herbert Tetley, B.A., Leeds.
Henry C. Embleton, Methley.
John Stubbins, F.G.S., F.R.M.S., Leeds.
Henry Crowther, F.R.M.S., Leeds.
Arthur W. Law, Halifax.

Resolved that Mr. J. Percy A. Davis be elected a Life Member of the Association in remembrance of his father's long and important work for the Society.

The following officers were then elected :—

President :—The Marquis of Ripon, K.G.

Vice-Presidents :

Earl Fitzwilliam.
Earl of Wharncliffe.
Lord Houghton.
Viscount Halifax.
Viscount Galway.
H. C. Sorby, LL.D., F.R.S.
Walter Morrison, J.P.
W. T. W. S. Stanhope, J.P.
Thos. W. Tew, J.P.
James Booth, J.P., F.G.S.
Dr. F. H. Bowman, F.R.S.E.
Richard Carter, F.G.S.
Prof. A. H. Green, F.R.S., F.G.S.
Wilfred H. Hudleston, F.R.S., P.G.S.

Treasurer : William Cash, F.G.S.

Hon. Secretary : W. Lower Carter, M.A., F.G.S.

Members of the Council :

J. T. Atkinson, F.G.S.
J. E. Bedford, F.G.S.
Richard Carter, C.E., F.G.S.
J. Ray Eddy, F.G.S.
George H. Parke, F.G.S.
R. Reynolds, F.C.S.
Walter Rowley, F.G.S.
C. Fox-Strangways, F.G.S.

Percy F. Kendall, F.G.S. Arthur E. Preston, F.G.S.
Prof. A. Lupton, F.G.S. John Stubbins, F.G.S., F.R.M.S.

Resolved that the best thanks of the meeting be given to the Officers and Council for their careful conduct of the affairs of the Society during the past year.

An Address was delivered by the Chairman.

The following papers were communicated :—

" On the Mineral Waters of Askern, in Yorkshire," by C. H. Bothamley, F.I.C., F.C.S.

" On the Effects of Faults on the Character of the Seashore," by Theo. T. Groom, B.Sc., F.G.S.

" Some Speculations regarding the Origin of the Chalk," by Percy F. Kendall, F.G.S.

" On the Geology of Calderdale," by James Spencer.

" The First Annual Report of the Committee for the Exploration of Upper Wharfedale," by Ernest E. Speight, B.A.

A series of photographs to illustrate the Progress of Marine Denudation round the Coast of Great Britain, was exhibited by Mr. Godfrey Bingley, and described by Mr. J. E. Bedford, F.G.S. The lantern was kindly lent by Sir Matthew Dodsworth, Bart.

A vote of thanks was passed to the Chairman.

At the close of the meeting the members and their friends were entertained to dinner at the Prospect Hotel by the Chairman.

After the usual loyal toasts, " The Yorkshire Geological and Polytechnic Society " was proposed by the Mayor of Harrogate, and was responded to by the Secretary and Treasurer. " The Local Scientific Societies " was proposed by the Rev. E. Maule Cole, and responded to by Mr. Millward, president of the Harrogate Field Club and Camera Society. The last toast was " The Mayor and Corporation of Harrogate," which was coupled with the names of the Mayor (Ald. Fortune) and the Town Clerk (Mr. W. H. Wyles).

Council Meeting, Philosophical Hall, Leeds, February 17th, 1894.

The chair was taken by Mr. R. Reynolds, F.C.S.

Present :—Messrs. Atkinson, Kendall, Tate, Speight, Horne, Howarth, Cash, and Carter (Hon. Secretary).

The minutes of the previous meeting were read and confirmed.

The Secretary read letters of regret for non-attendance from Messrs. R. Carter, Parke, Lupton, Gregson, Simpson, and Stather.

The Secretary read an acknowledgment of the vote of condolence sent to the family of the late Mr. Thos. H. Gray.

Mr. Ernest E. Speight, B.A., was appointed Local Secretary for Skipton and Keighley.

Mr. Charles W. Fennell, F.G.S., was appointed Local Secretary for Wakefield.

Arrangements were made for the holding of the next General Meeting at Sheffield.

Resolved that the Hon. Secretary be authorized to draw up a brief statement of the objects of the Society, to be printed with the form of proposition for membership, and to be distributed to the Local Secretaries.

Mr. Ernest E. Speight, B.A., read "The First Report of the Committee for the Exploration of Upper Wharfedale," and exhibited photographs in illustration of the same. It was resolved that the Report should be printed in the Proceedings, and that fifty reprints be sent to Mr. Speight.

Correspondence was read with Messrs. Mayall and Co., London, respecting the copyright of their photograph of the late Mr. Jas. W. Davis, and it was resolved that they should be requested to submit specimens of their styles of work ; and that Mr. Richard Reynolds and the Honorary Secretary should be a sub-committee to decide on the style.

Resolved that the Halifax Corporation Bond, lately standing in the name of Mr. J. W. Davis, be transferred to the names of William Cash, William Lower Carter, and James H. Howarth, and that a copy of this resolution be sent to the Halifax Corporation.

Resolved that fifty pounds be transferred from the Capital Account to the General Account, and be paid to Messrs. Whitley and Booth, Printers, Halifax.

Resolved that Messrs. Percy F. Kendall and Godfrey Bingley be elected members of the Wharfedale Exploration Committee.

Resolved that a Camera and Outfit be purchased by the Council at an expenditure not exceeding £10, Mr. Godfrey Bingley to be consulted as to the most efficient instrument.

Resolved that the Camera and Outfit be lent to the Wharfedale Exploration Committee during the pleasure of the Council.

Resolved that Mr. Richard Reynolds, F.C.S., be a Vice-President of the Society.

The Secretary reported that he had a Meisenbach block of the late Mr. J. W. Davis on loan from Mr. Frank Tate, of Liverpool.

It was resolved that prints of this block be taken and inserted with the obituary of Mr. Davis in the next issue of the Proceedings.

Council Meeting, Firth College, Sheffield, April 11th, 1894.

The chair was taken by Dr. Henry Clifton Sorby, F.R.S.

Present :—Messrs. Kendall, Fennell, Stather, and Carter (Hon. Secretary).

The minutes of the previous Council Meeting were read and confirmed.

Letters of regret for non-attendance were read from Lord Ripon, Messrs. Howarth, Rowley, Tate, Gregson, and Rev. E. M. Cole.

With respect to a letter from Mr. Speight asking for the immediate publication of the Upper Wharfedale Exploration Report, it was decided to publish at as early a date as possible, but that the Balance Sheet and List of Snbscribers be not published in the Proceedings.

Mr. Godfrey Bingley's recommendation as to the Camera was laid before the Council. It was resolved to purchase from Messrs. Pearson and Denham, Leeds, the Camera recommended by Mr. Bingley.

Resolved that the Annals of British Geology, by Rev. J. F. Blake, M.A., F.G.S., be purchased on behalf of the Society.

The Secretary reported that the Sub-Committee appointed to arrange for the issue of the portrait of the late Mr. J. W. Davis, had decided on a Woodbury type print mounted, with autograph.

A letter was read from the Treasurer stating that the Town Clerk of Halifax would transfer the Bond for £350 into the names of new Trustees, on the production of the minute authorizing the the investment of the amount by Mr. Davis.

Arrangements were made for the next General Meeting to be held at Bridlington Quay, and for a two-days' excursion to examine the coast sections between Bridlington and Filey, on June 8th and 9th.

Resolved that a brief account of the geology of the neighbourhood be sent out with the circular announcing the meeting.

General Meeting, Firth College, Sheffield, April 11th, 1894.

The chair was taken by Dr. H. C. Sorby, F.R.S.

The minutes of the previous General Meeting were read and confirmed.

The following members were elected :—

W. Clement Williams, F.R.I.B.A., Halifax.
C. Fox, do.
J. W. Sutcliffe do.
F. Fielder Walton, L.R.C.P., F.G.S., Hull.

The following papers were communicated :—

"On the Origin of the Chalk," by Percy F. Kendall, F.G.S.

"The Microscopic Structure of the Successive Zones of the Chalk," by A. J. Jukes-Browne, B.A., F.G.S.

An Address was delivered by the Chairman.

The discussion on "The Origin of the Chalk" was continued by Messrs. Walton and Carter, and Mr. Kendall replied.

Votes of thanks were passed to the Chairman for presiding, to the Writers of the Papers, and to the Governors of Firth College.

The members dined together at the Wharncliffe Restaurant, Dr. H. C. Sorby presiding.

During the morning the members visited the Ruskin Museum, and the unique collections of agates, jaspers, crystals, and works of art were exhibited and described by Mr. C. Bradshaw, F.C.S., in the unavoidable absence, through illness, of the Curator, Mr. William White.

General Meeting and Field Excursion, for the examination of the coast sections between Bridlington and Filey, June 8th, 1894.

The programme included an examination of the cliff sections, starting at Bridlington and continuing to Bempton.

June 9th. The field-work was resumed at Filey, and the party walked on the beach to Speeton, returning to Bridlington by train.

The Rev. E. Maule Cole, M.A., F.G.S., Messrs. Percy F. Kendall, F.G.S., and J. W. Stather, F.G.S., officiated as leaders.

The members dined together at the Alexandra Hotel, Bridlington Quay, on Friday evening, June 8th, Wilfred H. Hudleston, Esq., F.R.S., P.G.S., presiding.

General Meeting, Alexandra Hotel, Bridlington Quay, June 8th.

The chair was taken by Wilfred H. Hudleston, Esq., F.R.S., P.G.S.

The minutes of the previous General Meeting were read and confirmed.

Mr. John Stears, Hull, was elected a member.

A paper was read on "A new section in the Hessle Gravels," by F. Fielder Walton, L.R.C.P., F.G.S.

A discussion followed, introduced by the Chairman, in which Messrs. Kendall, Carter, Boynton, and Stather took part. Mr. Walton briefly responded.

Mr. Walton's paper was illustrated by a large plan and section showing the new pits in the neighbourhood of Hessle, and all the bones found in the deposit were exhibited, together with the samples of sand and gravel, and the boulder found in the overlying Boulder Clay.

An Address was given on "The Drifts of Flamborough Head," by Percy F. Kendall, F.G.S., illustrated by a map of glacial geology.

An Address was given on "The Cretaceous Beds between Bridlington and Filey," by the Rev. E. Maule Cole, M.A.

A collection of Arctic shells, obtained from the "Bridlington Crag," was exhibited and described by Mr. W. B. Headley.

A collection of articles found in the Ulrome Lake-Dwelling was exhibited by Mr. Thos. Boynton; also a fine series of sections and maps of the Grand Canon of Colerado.

Votes of thanks were passed to the chairman for presiding, and to those who had read papers and exhibited collections.

Council Meeting, Philosophical Hall, Leeds, September 11th, 1894.

The chair was taken by Mr. R. Carter, F.G.S.

Present :—Messrs. Kendall, Cash, Fennell, Reynolds, Howarth, Stubbins, and Carter (Hon. Secretary).

A letter was read from the Town Clerk of Halifax, *re* Debenture 2811, £350, Water Fund. He gave notice that this Loan would be repaid on March 1st, 1895, unless a reduction in the interest from 3¼ to 3 per cent. were agreed upon before September 30th. In case the loan was renewed at 3 per cent., an option was given of renewing at six months' notice, or for a period of three, or five, years.

Resolved that the Loan of £350 be renewed to the Halifax Corporation for a term of five years, from March 1st, 1895, at the rate of 3 per cent. interest per annum.

Resolved that the subscription to the "Annals of British Geology," by the Rev. J. F. Blake, be continued.

Resolved that the Secretary be empowered to sell the back numbers of the Proceedings, where sufficient are in stock, in odd volumes, at five shillings a part, but that a reduction may be made on a series of parts.

Resolved that the Secretary be empowered to purchase six Geological Maps of the Coast between Bridlington and Whitby.

Resolved that "The Yorkshire Oolites," by C. Fox-Strangways, and "The Yorkshire Lias," by Tate and Blake, be purchased for the Library of the Society.

The following accounts were passed for payment :—

	£	s.	d.
Mayall—Photo of Mr. Davis...	25	5	2
Griffin—Year Book of Science	0	7	6
Pearson—Camera	11	7	0
West—Plates for Proceedings	2	11	4
Typographic Co.—Clichés	0	9	3
Carter—Circulars and Stationery	3	15	0

The Secretary was instructed to correspond with Lord Ripon as to date and place for the Annual Meeting.

Council Meeting, Philosophical Hall, Leeds, October 12th, 1894.

The chair was taken by Mr. R. Carter, F.G.S.

Present :—Messrs. Reynolds, Cash, Parke, Tate, Stather, Fennell, Howarth, and Carter (Hon. Secretary).

Letters of regret for non-attendance were read from Messrs. Atkinson, Simpson, and Stubbins.

The minutes of the previous Council Meeting were read and confirmed.

The Secretary reported that Lord Ripon's engagements made it impossible for him to preside at the Annual Meeting.

The Secretary reported that he had been in communication with the Bradford members with respect to holding the meeting in that town.

The preliminary arrangements were approved.

A letter was received from Mr. C. Fox-Strangways resigning his seat on the Council on account of his removal to Leicester. His resignation was accepted with regret.

Mr. Thos. Tate, F.G.S., resigned his position of Local Secretary for Bradford. Mr. J. E. Wilson was nominated as his successor.

Resolved that the best thanks of the Council be given to Mr. Tate for his sixteen years' valuable services.

Resolved that Mr. Tate be nominated to fill the vacancy in the Council caused by the resignation of Mr. C. Fox-Strangways.

A letter was read from Mr. E. E. Speight, B.A., who had removed to Oxford, resigning his position as Local Secretary for the Skipton District, and also as Secretary of the Upper Wharfedale Exploration Committee.

Resolved that a meeting of the Exploration Committee be summoned in Leeds on October 17th.

Resolved that Mr. G. H. Parke, F.G.S., be added to the Wharfedale Exploration Committee.

Annual General Meeting, Grammar School, Bradford, November 7th, 1894.

The chair was taken by the Mayor of Bradford (Jonas Whitley, Esq).

The minutes of the previous General Meeting were read and confirmed.

Letters of regret for non-attendance were read from Messrs. De Rance, Gregson, R. Carter, Eddy, and Parke.

The Hon. Secretary read the Report, and the Treasurer presented the Financial Statement which were adopted.

The following members were elected :—

Herbert Muff, Bradford.	J. F. Ianson, Wakefield.
F. W. Branson, F.I.C., Leeds.	A. E. Norton, Halifax.
S. W. Meyer, York.	Arthur Thornton, M.A., Bradford.

The following officers were then elected : –

President : The Marquis of Ripon, K.G.

Vice-Presidents :

Earl Wharncliffe.	Thomas W. Tew, J.P.
Lord Houghton.	James Booth, J.P., F.G.S.
Viscount Halifax.	R. Carter, C.E., F.G.S.
Viscount Galway.	F. H. Bowman, D.Sc., F.R.S.E.
H. C. Sorby, LL.D., F.R.S.	Prof. A. H. Green, F.R.S.
Walter Morrison, J.P.	Wilfrid H. Hudleston, F.R.S., P.G.S.
W. T. W. S. Stanhope, J.P.	Richard Reynolds, F.C.S.

Treasurer : William Cash, F.G.S.

Hon. Secretary : W. Lower Carter, M.A., F.G.S.

Council :

J. T. Atkinson, F.G.S.	G. H. Parke, F.G.S., F.L.S.
J. E. Bedford, F.G.S.	A. E. Preston, F.G.S.
R. Carter, C.E., F.G.S.	Richard Reynolds, F.C.S.
J. Ray Eddy, F.G.S.	Walter Rowley, F.G.S.
Prof. A. Lupton, F.G.S.	John Stubbins, F.R.M.S., F.G.S.
P. F. Kendall, F.G.S.	Thomas Tate, F.G.S.

Local Secretaries :

Barnsley - - -	T. W. H. Mitchell.
Bradford - - -	J. E. Wilson.

Driffield - - -	Rev. E. Maule Cole, M.A., F.G.S.
Halifax - - -	William Simpson, F.G.S.
Harrogate - - -	Robert Peach.
Huddersfield - -	Joseph Field.
Hull - - -	J. W. Stather, F.G.S.
Leeds - - -	J. H. Howarth, F.G.S.
Skipton - - -	J. J. Wilkinson.
Thirsk - - -	W. Gregson.
Wakefield - - -	Chas. W. Fennell, F.G.S.
Wensleydale - -	Wm. Horne, F.G.S.

An Address was delivered by the Chairman.

The following papers were read :—

"Notes on the Strata and Deposition of the Millstone Grits," by William Simpson, F.G.S.

"On Limestone Conglomerates on the North side of the Craven Faults," by R. H. Tiddeman, M.A., F.G.S.

"On the New Cutting on the North-Eastern Railway, near Marsh Lane Station, Leeds," by Benj. Holgate, F.G.S.

"Some Notes on the Yorkshire Coalfield and its eastwardly extension," by Prof. Arnold Lupton, F.G.S.

Short criticisms of the papers were given by Messrs. Walter Rowley and P. F. Kendall.

A hearty vote of thanks was passed to the Mayor of Bradford for presiding.

The Mayor briefly responded.

Votes of thanks were also passed to the Readers of the Papers, and to Dr. Keeling for kindly allowing the use of the Grammar School for the meeting.

The members dined together at the Midland Hotel under the presidency of Mr. Richard Reynolds, in the unavoidable absence of His Worship the Mayor.

During the morning a party, under the guidance of Mr. Walter Rowley, F.G.S., examined some interesting sections in the Coal Measures on the Great Northern Railway, between Cutler Heights and Quarry Gap.

Statement of Receipts and Expenditure of th

1st January, 1894, t

Receipts.

INCOM

	£	s.
To Balance in hand, 31st December, 1893	25	9
,, Subscriptions	50	3
,, Transfer from Capital Account	60	0
,, Halifax Corporation—Interest	11	0
	£146	13

CAPITA

	£	s.
To Balance, 31st December, 1893	39	17
,, Life Members' Compositions	25	4
,, Interest	0	1
	£65	2
To Balance	5	2
,, Halifax Corporation Bond	350	0
Capital	£355	2

WHARFEDAL

	£	s.
To Balance, 31st December, 1893	23	4
,, Interest	0	1
,, W. Morrison, Esq., J.P.—Donation	10	0
	£33	6

1st October, 1894.

CCOUNT. **Expenditure.**

	£	s.	d.
'y Whitley and Booth—on account	50	0	0
, Do. to close old account ...	10	0	0
,, Postages, Expenses of Meetings, &c.	9	7	0
, Printing and Stationery	6	19	10
, Pearson and Denham—Photographic Camera ...	11	1	6
, Mayall and Co.—Cost of Mr. J. W. Davis' photograph	25	5	2
, Books bought	1	8	6
, West and Co.—Lithographs	2	10	0
, Electros	0	6	3
,, Balance in Treasurer's hands, 31st October, 1894 ...	29	15	3
	£146	13	6

CCOUNT.

	£	s.	d.
'y Transfers to General Account	60	0	0
,, Balance in Treasurer's hands, 31st October, 1894 ...	5	2	4
	£65	2	4

XPLORATION FUND.

	£	s.	d.
'y Rent of Cottage, Cost of Excavation, &c.... ...	21	3	8
,, Balance in Treasurer's hand, 31st October, 1894 ...	12	2	6
	£33	6	2

Audited and found correct,

GEO. PATCHETT.

HONORARY MEMBERS.

Elected.

1887 Bodington, Principal N., M.A., The Yorkshire College, Leeds.

1892 De Rance, Chas. E., C.E., F.R.M.S., 55, Stoke Road, Shelton, Stoke-on-Trent.

1887 Hughes, Prof. T. McK., F.R.S., F.G.S., Cambridge.

1887 Judd, Prof. Jno. W., F.R.S., F.G.S., Science Department, South Kensington, London.

1887 Williamson, Prof. W. C., F.R.S., Owen's College, Manchester.

1887 Woodward, Henry, Esq., LL.D., F.R.S., British Museum (Natural History), London, S.W.

LIST OF MEMBERS.

Life members who have compounded for their annual subscriptions are indicated by an asterisk (*)

1883*Abbot, R. T. G., Whitley House, Malton.

1875 Atkinson, J. T., F.G.S., Hayesthorpe, Holgate Hill, York.

1890*Ackroyd, W., F.I.C., Borough Analyst, Halifax.

1875 Balme, E. B. W., J.P., Cote Hall, Mirfield.

1879*Bartholomew, C. W., Blakesley Hall, near Towcaster.

1875 Bedford, James, Woodhouse Cliffe, Leeds.

1878 Bedford, J. E., F.G.S., Arncliffe, Shire Oak Road, Headingley, Leeds.

1892 Binns, Thomas, Sawley Hall, Ripon.

1875*Booth, James, J.P., F.G.S., Spring Hall, Halifax.

1885 Bould, Chas. H., Halifax Old Road, Huddersfield.

1876*Bowman, F. H., D.Sc., F.R.A.S., F.C.S., F.G.S., Ashleigh, Ashley Heath, Bowdon, Cheshire.

1875*Brigg, John, J.P., F.G.S., Keighley.

1881*Briggs, Arthur, J.P., Cragg Royd, Rawden, Leeds.

1894 Branson, F. W., F.I.C., Commercial Street, Leeds.

1857 Brooke, Ed., F.G.S., Fieldhouse Clay Works, Huddersfield.

1877 Brooke, Lieut.-Col. Thos., J.P., Armitage Bridge, Huddersfield.

1887 Brownridge, C., C.E., F.G.S., 26, North Road, Devonshire Park, Birkenhead.

1882*Buckley, George, jun., Waterhouse Street, Halifax.

Elected.

1848 Carter, R., C.E., F.G.S., Spring Bank, Harrogate.

1892*Carter, W. Lower, M.A., F.G.S., Hopton, Mirfield.

1875*Cash, W., F.G.S., 35, Commercial Street, Halifax.

1891*Chambers, J. C., 14, St. John's Terrace, Belle Vue Road, Leeds.

1875*Charlesworth, J. B., J.P., Stradsett Hall, Downham Market.

1892 Child, Hy. Slade, Mining Engineer, Wakefield.

1877*Clark, J. E., B.A., B.Sc., 20, Bootham, York.

1878 Cole, Rev. E. Maule, M.A., F.G.S., Wetwang Vicarage, near York.

1894 Crowther, Henry, F.R.M.S., The Museum, Leeds.

1879*Dakyns, J. R., M.A., of H.M. Geological Survey, 28, Jermyn Street, London, W.

1883 Dalton, Thos., Albion Street, Leeds.

1894*Davis, James Percy A., Chevinedge, Halifax.

1888 Dawson, Oswald, Caledonian House, Leeds.

1878*Denham, Charles, London.

1879 Dewhurst, J. B., Aireville, Skipton.

1891 Dodsworth, Sir Matthew, Bart., The Cedars, Harrogate.

1887*Duncan, Surr W., Horsforth Hall, Horsforth, near Leeds.

1879 Eddy, J. Ray, F.G.S., Carleton Grange, Skipton.

1894 Embleton, Henry C., Central Bank Chambers, Leeds.

1895 Farrah, John, F.R.Met.S., Crescent Road, Harrogate.

1887 Fennell, Chas. W., F.G.S., 17, Wood Street, Wakefield.

1885 Field Joseph, West Parade, Huddersfield.

1839 Fitzwilliam, Earl, K.G., Wentworth Woodhouse, near Rotherham.

1883*Fleming, Francis, Elm Grove, Halifax.

1893 Forsyth, David, D.Sc., M.A., 2, Lifton Place, Leeds.

1894 Fox, C., P.A.S.I., 22, George Street, Halifax.

1891*Furness, Christopher, M.P., Brantford, West Hartlepool.

1890 Garforth, W. E., C.E., F.G.S., Halesfield, Normanton.

1875 Gascoigne, Col. F. C. T., Parlington Park, Garforth, near Leeds.

1883*Gaukroger, W., J.P., Fernside, Halifax.

Elected.
1881 Gleadow, F., 84, Kensington Park Road, London, W.

1875 Greaves, J. O., Wakefield.

1875*Green, Prof. A. H., M.A., F.R.S., 137, Woodstock Road, Oxford.

1882 Gregson, W., Baldersby, S.O., Yorkshire.

1843 Halifax, Viscount, Hickleton Hall, Doncaster.

1878 Halliday, J., Burley Road, Leeds.

1895 Harker, Alfred, M.A., F.G.S., St. John's College, Cambridge.

1887 Hastings, Geoffrey, 13, Neal Street, Bradford.

1887 Hawell, Rev. Jno., Ingleby Greenhow, Northallerton.

1883 Hewitson, H. B., 11, Hanover Place, Leeds.

1875 Holgate, Benj., F.G.S., Cardigan Villa, Grove Lane, Headingley, Leeds.

1881 Horne, Wm., F.G.S., Leyburn.

1890 Howarth, J. H., F.G.S., The Crescent, Newton Park, Leeds.

1889 Houghton, Lord, Fryston Hall, near Pontefract.

1883*Hudleston, W. H., F.R.S., P.G.S., 8, Stanhope Gardens, South Kensington, S.W.

1894 Ianson, J. F., Cardigan House, Wakefield.

1887*Jones, J. E., Solicitor, Halifax.

1885 Jury, Samuel, Eleanor Street, Hillhouse, Huddersfield.

1888*Kerr, R. Moffatt, Solicitor, Halifax.

1892 Kendall, Percy F., F.G.S., 5, Woodland Terrace, Chapel-Allerton, Leeds.

1877*Lamplugh, G. W., of H.M. Geol. Survey, 28, Jermyn Street, London, W.

1875 Lancaster, Edward, Barnsley.

1894 Law, Arthur W., Greetland, Halifax.

1885 Learoyd, S., F.G.S., Sherwood House, Huddersfield.

1889 Lister, John, M.A., Shibden Hall, Halifax.

1877*Lupton, Arnold, F.G.S., M.Inst. C.E., 6, De Grey Road, Leeds.

1891*Masham, Rt. Hon. Lord, Swinton Castle, Bedale.

1853 McLandsborough, J., F.G.S., F.R.A.S., 5, Lindum Terrace, Manningham, Bradford.

Elected.
1894 Meyer, S. W., Glandebrye, Holgate Hill, York.
1892 Mitchell, Miss Hilda Carter, L.L.A., The Rectory, Bolton Abbey, Skipton.
1875 Mitchell, John, Swaith Hall, near Barnsley.
1875 Mitchell, Josh., F.G.S., Worsbro' Dale, Barnsley.
1883 Mitchell, T. Carter, F.S.A., Topcliff, Thirsk.
1889 Mitchell, T. W. H., Barnsley.
1879*Morrison, Walter, J.P., Malham Tarn, near Leeds.
1878 Mortimer, J. R., Driffield.
1891 Morton, J. H., Broad Street, Halifax.
1894 Muff, Herbert, Aston Mount, Heaton, Bradford.
1875*Myers, W. Beswick, 14, Victoria Street, Westminster, London S.W.

1875 Nelson, Henry, St. John's Cottage, Leeds.
1889*Nicholson, M., J.P., Middleton Hall, near Leeds.
1894 Norton, A. E., Park Place, Parkinson Lane, Halifax.

1875*Parke, G. H., F.G.S., F.L.S., St. John's Villas, Wakefield.
1883 Patchett, George, junior, Upper Shaw Hill, Halifax.
1892*Pawson, A. H., Lawns House, Farnley, Leeds.
1894 Peace, A. L., C.E., Thorne, Doncaster.
1883 Peach, Robert, James Street, Harrogate.
1885 Platnauer, H. M., F.G.S., The Museum, York.
1876 Pocklington, Henry, F.R.M.S., Park Row, Leeds.
1882 Preston, Alfred Eley, C.E., F.G.S., The Exchange, Bradford.
1891 Pearson, John T., The Hall, Melmerby, Thirsk.

1859*Ramsden, Sir J. W., Bart., M.P., Byram Hall, near Pontefract.
1864 Reynolds, Richard, F.C.S., Cliffe Lodge, Leeds.
1864*Rhodes, John, Snydale Hall, Pontefract.
1856*Ripon, The Marquis of, K.G., F.R.S., &c., Studley Royal, Ripon.
1888 Rowley, Brook, Weymouth Street, Halifax.
1869*Rowley, Walter, F.G.S., 20, Park Row, Leeds.
1875*Ryder, Charles, Westfield, Chapeltown, Leeds.

1882 Scarborough Philosophical Society (J. H. Phillips, Secretary).
1883 Scratcherd, T. H. C., Halifax.

Elected.

1869 SEAL, STEPHEN, F.G.S., Darfield Quarries, Barnsley.

1882 SHAW, JOHN, Darrington Hall, Pontefract.

1892*SIMPSON, W., F.G.S., The Gables, Halifax.

1885 SLATER, E., Ashville, Farsley, near Leeds.

1887 SLATER, M. B., West Grove, Malton.

1879 SLINGSBY, W. C., Carleton, near Skipton.

1876*SMITH, F., Huddersfield Road, Halifax.

1851 SORBY, H. C., D.C.L., F.R.S., F.G.S., Broomfield, Sheffield.

1892 SPEIGHT, ERNEST E., B.A., 61, Kingston Road, Oxford.

1875 STANHOPE, W. T. W. S., J.P., Cannon Hall, Barnsley.

1881*STANSFELD, A. W., Skipton-in-Craven, Yorkshire.

1890 STATHER, J. W., F.G.S., 16, Louis Street, Hull.

1894 STEARS, JOHN, Westholme, Hessle, Yorkshire.

1885*STOCKDALE, T., Spring Lea, Leeds.

1889 STOCKS, MICHAEL, junior, Shibden Head, Halifax.

1870 STOTT, W., Greetland, near Halifax.

1878 STRANGWAYS, C. FOX, F.G.S., Abbotsbury House, New Walk, Leicester.

1879*STRICKLAND, Sir CHARLES W., Bart., Hildenly, Malton.

1894 STUBBINS, JOHN, F.R.M.S., F.G.S., Ridge End, Wood Lane, Headingley, Leeds.

1894 SUTCLIFFE, J. W., 27, West View, Halifax.

1888 SYKES, Sir TATTON, Bart., Sledmere House, near York.

1875 TATE, THOMAS, F.G.S., 5, Eldon Mount, Leeds.

1887 TAYLOR, JOHN HENRY, Borough Surveyor, Barnsley.

1894 TETLEY, ED. H., B.A., Foxhills, Weetwood, Leeds.

1880 TETLEY, C. F., M.A., Spring Road, Headingley, Leeds.

1869*TEW THOMAS W., J.P., Carleton Villa, near Pontefract.

1889 TRAVIS, Rev. W. TRAVIS, M.A., Ripley, Yorkshire.

1889 THOMPSON, J. C., Selby.

1886 THOMPSON, R., Dringcote, The Mount, York.

1875*TIDDEMAN, R. H., M.A., F.G.S., of H.M. Geological Survey 28, Jermyn Street, London, W.

1894 THORNTON, ARTHUR, M.A., The Grammar School, Bradford.

1875 TURNER, R. BICKERTON, J.P., Oak Leigh, Buxton.

1875 TUTE, Rev. J. STANLEY, B.A., Markington Vicarage, Leeds.

Elected.

1884*Walmisley, A. T., C.E., F.S.I., F.K.C., 5, Westminster Chambers, Victoria Street, London.

1894 Walton, F. Fielder, F.G.S., L.R.C.P., 19, Charlotte Street, Hull.

1875*Ward, J. Whiteley, J.P., F.R.M.S., South Royd, Halifax.

1839*Wharncliffe, Earl of, Wortley Hall, Sheffield.

1840 Wheatley Charles, Sands House, Mirfield.

1890 White, J. Fletcher, F.G.S., 24, St. John's, Wakefield.

1881*Whiteley, Fredk., Clare Road, Halifax.

1889 Wilkinson, J. J., Burnside, Skipton.

1894 Williams, W. Clement, F.R.I.B.A., George Street, Halifax.

1890 Wilson, Edmund, Denison Hall, Leeds.

1894 Wilson, J. E., 5. Selborne Terrace, Bradford.

1878 Woodall, J. W., J.P., F.G.S., Old Bank, Scarborough.

1878 Woodhead Joseph, J.P., Longdenholme, Huddersfield.

*** It is requested that Members changing their residences will communicate with the Secretary.

METEOROLOGY OF BRADFORD FOR 1894.

Computed from daily observations made at the Exchange, Bradford, by John McLandsborough, M. Inst. C.E. retired., F.R.A.S., F.R.Met.Soc., F.G.S., and Alfred Eley Preston, M. Inst. C.E., F.R.Met.Soc., F.G.S.
Latitude, 53deg. 47min. 38sec. N.; longitude, 1deg. 45min. 4sec. W. Height above mean sea level, 366ft.

Pressure of Atmosphere in Month.

Months	Highest Reading of Barometer	Date	Highest during 26 Years	Mean of Highest of 26 Years	Lowest Reading of Barometer	Date	Lowest during 26 Years	Mean of Lowest of 26 Years	Range	Corrected for Capillarity and Temperature: Mean	Corrected: Mean of 26 Years
	Ins	On	Ins	Ins	Ins	On	Ins.	Ins	Ins.	Ins.	Ins.
January	30·240	3rd	30·544	30·176	28·914	31st	28·070	28·725	1·346	29·381	29·519
February	30·158	19th	30·412	30·106	28·90[illegible]	12th	28·3[illegible]0	28·810	1·256	29·529	29·519
March	30·184	23rd	30·476	30·134	28·[illegible]16	13th	28·17[illegible]	28·792	1·538	29·468	29·500
April	29·934	5th	30·50	30·064	28·96[illegible]	[illegible]	28·332	28·896	0·972	29·465	29·491
May	30·110	24th	30·482	30·062	29·168	2[illegible]th	28·661	29·048	0·922	29·541	29·544
June	30·14[illegible]	30th	30·500	30·035	29·320	2nd	28·840	29·171	0·820	29·583	29·536
July	30·052	1st	30·305	29·978	28·970	1[illegible]th	28·690	29·142	1·082	29·445	29·509
August	29·980	24th	30·232	29·970	29·036	15th	28·67[illegible]	29·058	0·974	29·473	29·497
September	30·176	30th	30·232	30·077	29·438	25th	28·452	29·017	0·738	29·784	29·527
October	30·202	1st	30·394	30·127	28·512	25th	28·250	28·729	1·690	29·502	29·447
November	30·194	30th	30·376	30·067	28·630	14th	28·060	28·669	1·664	29·497	29·457
December	30·302	27th	30·358	30·127	28·5[illegible]0	22nd	27·652	28·669	1·782	29·546	29·480
Means, or totals	30·144		30·376	30·077	28·920		28·346	28·894	1·244	29·520	29·505

Temperature of Air in Shade during Month.

Months	In Each Month: Highest	Date	Highest during 26 Years	Mean of Highest of 26 Years	Lowest	Date	Lowest during 26 Years	Mean of Lowest of 26 Years	Range	Daily Mean, In Each Month: Of all Highest	Mean of 26 Years	Of all Lowest	Mean of 26 Years	Range: Mean	Range: Mean of 26 Years	Of Dry Bulb: Mean	Of Dry Bulb: Mean of 26 Years
	Deg.	On	Deg	Deg.	Deg.	On	Deg.	Deg.	Deg.	Deg	Deg.	Deg.	Deg	Deg.	Deg.	Deg.	Deg.
January	52·0	12th	57·2	52·7	10·2	6th	6·7	22·5	41·8	42·3	42·8	34·0	34·2	8·3	8·6	37·9	39·0
February	54·0	8th	59·8	53·4	20·2	20th	16·8	25·9	33·8	45·2	44·2	35·0	35·3	10·2	8·9	39·5	39·5
March	62·0	31st	66·0	57·3	31·0	17th	17·4	25·9	[illegible]	51·4	46·6	37·3	35·4	13·1	11·2	43·3	40·6
April	67·2	12th	74·0	63·9	35·1	21st	25·0	31·3	32·1	55·2	52·7	42·0	39·4	13·2	13·3	47·3	44·7
May	65·0	26th	83·9	70·1	32·4	21st	28·6	35·0	32·6	54·9	58·3	42·2	41·0	12·7	14·3	47·7	49·8
June	77·0	30th	87·8	77·1	40·4	7th	38·0	41·9	36·6	62·3	64·9	50·3	50·1	12·0	14·8	55·7	55·9
July	80·8	1st	89·6	79·4	51·0	14th	42·0	46·8	29·8	63·0	67·9	54·7	55·8	14·3	14·1	59·8	59·8
August	68·6	1st	85·2	77·8	45·2	21st	38·6	45·2	23·4	63·1	66·8	52·8	53·2	10·3	13·6	57·3	58·8
September	65·0	2nd	81·3	70·7	39·2	28th	33·5	40·2	25·8	58·5	61·8	48·0	49·6	10·5	12·2	52·6	54·6
October	60·4	13th	69·9	62·9	30·8	23rd	26·7	32·3	29·6	52·5	53·7	43·5	43·3	9·0	10·4	47·9	48·1
November	60·2	2nd	61·5	56·5	36·9	30th	23·0	29·0	23·3	51·8	47·5	43·7	38·6	8·1	8·9	47·1	43·0
December	54·0	14th	57·8	53·1	28·0	31st	13·2	23·1	26·0	46·5	42·9	38·5	34·4	8·0	8·5	42·7	39·2
Means, or totals	63·9		72·8	64·6	33·4		26·0	33·3	30·5	54·3	54·2	43·5	42·6	10·8	11·6	48·2	47·8

Adopted Mean Temperature and Vapour.

Months	Of Air: Mean	Of Air: Mean of 26 Years	Of Evaporation: Mean	Of Evaporation: Mean of 26 Years	Dew Point: Mean	Dew Point: Mean of 26 Years	Elastic Force: Mean	Elastic Force: Mean of 26 Years	In a Cubic Foot of Air: Mean	Mean of 26 Years	Short of Saturation	Mean of 26 Years	Mean Weight of a Cubic Foot of Air	Mean of 26 Years
	Deg.	Deg	Deg.	Deg	Deg	Deg	Ins	Ins	Grs	Grs	Grs	Grs	Grs	Grs
January	37·9	38·6	35·8	36·9	33·0	34·6	·188	·202	2·2	2·3	0·5	0·4	547	549
February	39·6	39·4	38·0	37·7	35·9	35·4	·211	·208	2·4	2·4	0·4	0·4	548	548
March	43·1	40·2	40·1	37·8	36·5	34·7	·216	·203	2·5	2·3	0·7	0·6	543	547
April	47·2	44·7	44·1	41·3	40·6	37·4	·253	·225	2·9	2·6	0·8	0·8	538	542
May	47·3	49·6	43·4	45·4	39·0	41·2	·248	·250	2·7	3·0	1·5	1·1	540	537
June	55·1	55·8	51·1	51·3	47·3	46·9	·327	·323	3·7	3·6	1·2	1·4	532	531
July	59·8	59·6	55·2	54·1	51·1	49·8	·377	·360	4·2	4·0	1·6	1·7	524	526
August	56·8	58·5	52·8	53·9	49·2	50·1	·350	·363	4·0	4·1	1·2	1·4	528	526
September	52·3	54·7	49·2	51·3	46·0	47·9	·312	·335	3·5	3·8	0·9	1·0	538	531
October	47·4	47·8	45·3	45·4	43·0	42·6	·277	·274	3·2	3·1	0·6	0·7	539	537
November	42·2	42·7	44·4	40·5	41·3	37·7	·260	·227	3·0	2·6	0·7	0·5	539	543
December	42·6	38·9	40·3	36·9	37·5	34·4	·225	·200	2·6	2·3	0·6	0·5	545	548
Means, or totals	48·0	47·5	45·0	44·4	41·7	41·1	·269	·265	3·1	3·0	0·9	0·9	538	539

Vapour: Degree of Humidity (Complete Saturation = 100).

Months	Highest	Date	Highest during 26 Years	Mean of Highest of 26 Years	Lowest	Date	Lowest during 26 Years	Mean of Lowest of 26 Years	Mean	Mean of 26 Years
	0—100	On	0—100	0—100	0—100	On	0—100	0—100	0—100	0—100
January	100	8th	100	97	61	28th	34	65	83	86
February	97	22nd	100	97	62	13th	42	65	87	86
March	95	7th	99	96	42	30th	28	54	78	82
April	94	8th	100	95	61	11th	30	51	71	77
May	96	2[illegible]th	99	92	44	25th	30	44	74	73
June	94	5th	100	93	46	29th	32	47	75	72
July	86	25th	99	92	40	5th	35	48	73	70
August	93	17th	99	93	55	5th	41	51	76	71
September	94	19th	99	95	59	13th	38	54	80	78
October	96	31st	99	97	61	1st	49	61	86	83
November	97	17th	100	96	47	5th	43	63	81	83
December	93	17th	100	97	64	30th	44	63	83	84
Means, or totals	96		100	95	53		37	56	79	79

Bright Sunshine; Temp. of Air in Sun's Rays; Wind Direction.

Months	Bright Sunshine: Greatest Daily Duration	Date	Total of Month	Per cent of Possible Duration	Temp. in Sun's Rays: Highest	Date	Mean	Direction (Relative Proportion of at 9 a.m.): N.	NE.	E.	SE.	S.	SW.	W.	NW.
	hr min	On	hr min		Deg.	On	Deg.	No.	No.	No.	No.	No.	No.	No.	No.
January	4 0	24th	16 5	6	65·8	28th	59·5	5	0	2	6	3	10	3	2
February	6 15	20th	36 40	13	83·0	28th	64·5	1	1	3	3	2	10	6	2
March	7 40	25th	88 35	24	101·0	26th	81·2	4	0	3	4	3	5	8	4
April	8 45	22nd	68 25	16	103·6	12th	86·2	4	7	9	5	4	1	0	0
May	10 20	13th	105 35	21	104·4	13th	94·4	7	6	0	2	4	3	5	4
June	12 40	30th	84 50	17	105·0	28th	93·9	2	6	2	1	3	1	9	6
July	12 45	1st	139 5	27	105·2	9th	101·5	1	3	6	1	3	1	14	2
August	7 0	21st	82 45	18	104·6	9th	97·6	1	2	1	2	3	6	12	4
September	9 [illegible]	16th	76 13	20	105·0	2nd	88·1	10	10	3	0	0	0	3	4
October	5 35	16th	31 35	10	93·2	15th	75·0	6	6	9	4	3	1	1	2
November	4 [illegible]	17th	24 65	10	86·2	3rd	69·3	2	1	4	3	7	6	6	1
December	3 20	16th	16 45	7	73·0	14th	63·7	6	1	3	2	1	3	9	6
Means, or totals	7 37		771 28	17	94·2		81·2	49	42	45	33	36	47	76	37

Wind: Velocity and Pressure.

Months	At 9 a.m.: Mean	Highest	Date	During 24 hours: Mean	Mean of 8 years	Highest	Date	Highest of 8 years	Total Registered in Month	Mean of Monthly T't'l of 8 yrs	Highest Monthly T't'l of 8 yrs	Pressure: Mean of all Daily Highest	Mean of all Daily Hghst in 11 Years	Highest	Direction	Date	Mean of Highest of Month of 11 Years
	Miles p'r hr	Miles p'r hr	On	Miles per d	Miles per d	Miles per d.	On	Miles per d.	Miles.	Miles	Miles.	lb. per sq ft.	lb. per sq. ft	lb per sq ft		On	lb. per sq ft.
January	8·9	28·0	27th	198	160	473	28th	473	6135	4972	6724	2·47	2·69	5·5	W S W	22nd	10·52
February	8·2	19·6	6th	230	170	593	12th	593	6443	4805	6443	3·70	2·72	17·4	W S W	12th	10·49
March	6·2	20·6	6th	156	158	379	6th	569	4849	4897	5803	2·40	2·28	7·8	W S W	11th	9·18
April	5·5	9·6	12th	100	138	171	6th	359	29[illegible]0	4129	5569	0·50	1·94	1·2	S S W	25th	7·00
May	7·4	13·3	27th	125	143	242	4th	376	3879	4441	5349	0·97	2·07	3·9	W N W	5th	6·86
June	5·7	13·3	25th	108	129	201	24th	282	3232	3863	4764	0·67	1·53	1·8	W N W	12th	5·49
July	6·0	10·2	4th	129	136	265	13th	359	4002	4219	4771	0·57	1·67	0·9	W	4th	5·68
August	7·0	13·3	20th	134	132	306	15th	493	4165	4092	4603	0·59	1·72	1·8	W S W	15th	6·80
September	5·8	11·0	18th	104	133	190	7th	381	3131	3988	4873	0·45	1·86	1·8	N E	19th	5·94
October	5·3	13·6	25th	102	142	368	25th	390	3158	4407	5127	0·81	2·14	10·8	S W	26th	9·01
November	6·3	14·0	20th	145	151	296	14th	490	4348	4626	7853	0·67	2·28	5·8	S	14th	9·37
December	6·7	39·3	22nd	148	140	465	29th	465	4580	4344	5440	2·84	2·60	18·0	S S W	23rd	10·35
Means, or totals	6·6	17·2		140	144	329		435	50902	52683	5610	1·39	2·13	6·4			8·06

Cloud and Rain.

Months	Mean Amount of Cloud	Rain: Number of Days it fell	Greatest Daily Fall	Date	Amount Collected	Mean of 25 Years	Mean of Seven Years ending with 1882, 65½ft above surface of ground	Mean of 7 Yrs endg with 1882 at T'n Hall and Mid Rly Station on surface of ground	Gr'ter fall on surface at Town Hall & Mid Stn than at 65½ft above surface at Exch: Depth in Inches	Percentage of fall at Exch'ge
	0–10	No	Ins	On	Ins.	Ins	Ins	Ins.	Ins.	Per cent
January	7·8	26	0·37	30th	3·87	2·56	2·209	2·474	0·265	11·2
February	7·1	22	0·83	[illegible]	5·47	1·99	2·609	2·872	0·363	11·4
March	5·6	14	0·83	[illegible]	2·74	2·09	2·776	3·260	0·484	11·7
April	7·1	15	0·56	[illegible]	2·48	1·98	2·516	2·835	0·319	11·2
May	7·0	18	0·26	[illegible]	1·42	1·90	2·103	2·277	0·174	10·8
June	7·1	15	0·79	[illegible]	2·44	2·25	2·837	3·011	0·174	10·6
July	6·9	20	0·81	2[illegible]th	2·76	2·84	3·401	3·641	0·240	10·7
August	7·4	22	0·50	[illegible]rd	2·61	2·63	3·654	3·892	0·238	10·7
September	7·4	1	0·17	[illegible]th	5·64	2·47	2·894	3·229	0·335	11·2
October	7·9	17	1·11	2[illegible]th	4·61	3·66	3·640	4·012	0·372	11·0
November	7·0	18	0·68	14th	1·60	2·74	3·421	3·828	0·407	11·2
December	7·6	17	0·48	22nd	2·13	2·62	3·681	4·170	0·489	11·3
Means, or totals	7·2	214	0·59		32·78	29·63	35·741	39·601	3·860	11·08

METEOROLOGY OF BRADFORD FOR 1894.

SHEET 2.

YEARLY MAXIMUM AND MINIMUM ATMOSPHERIC PRESSURE, TEMPERATURE, HUMIDITY, BRIGHT SUNSHINE, WIND PRESSURE, AND RAINFALL.

Year.	Pressure. Highest. Reading of Barom. during Year.	Pressure. Highest. Date.	Pressure. Lowest. Reading of Barom. during Year.	Pressure. Lowest. Date.	Temperature. In Shade. Highest. R'ding of Maximum Thermom. during Yr.	Temperature. In Shade. Highest. Date.	Temperature. In Shade. Lowest. R'ding of Minimum Thermom. during Yr.	Temperature. In Shade. Lowest. Date	Temperature. Last and First Frost of Seasons. Date of Last Frost.	Temperature. Last and First Frost of Seasons. Date of First Frost.	Temperature. In Sun's Rays. Highest. Reading of Solar Thermom. during Yr.	Temperature. In Sun's Rays. Highest. Date.	Humidity (Complete Saturation = 100.) Highest. Degree of Humidity during Yr.	Humidity. Highest. Date.	Humidity. Lowest. Degree of Humidity during Yr.	Humidity. Lowest. Date.	Bright Sunshine. Greatest Daily Duration.	Bright Sunshine. Date.	Bright Sunshine. Total of Year.	Bright Sunshine. Per cent of Possible Duration.	Wind Pressure. Highest.	Wind Pressure. Date.	Rain. Total for Year	Rain. Mean Y'ly Rainfall at Town Hall and Mid Rly Stn. on surface of g'nd	Rain. Grtr. fall on srfce. at Tn H'll & Mid. Stn than at 65½ ft. ab've surf at Exc. Depth in Inches	Rain. Grtr. fall ... Percentage of fall at Exch'ge	Rain. Greatest Daily Fall during Yr.	Rain. Date	Snow. Last and First Snow of Seasons. Date of Last Snow.	Snow. Date of First Snow.
	Ins.		Ins		Deg.		Deg.				Deg		0–100		0–100		hr. min.		hr. min.		lb. per sq. ft.		Ins.	Ins	Ins.	Per cent	Ins.			
1869	30 290	Dec. 6	28 500	Feb. 1	85·2	Aug. 30	19·8	Dec. 28	Mar. 27	Oct. 20	127·7	Aug. 30	99	Feb. 8	42	Sep. 24	......	......	......	......	......	......	......	......	......	......	...	......	April 3	Oct. 19
1870	30 284	Jan. 19	28 308	Jan. 8	85·0	July 25	16·6	Dec. 23	Mar. 30	Nov. 9	127 5	July 25	98	Jan. 29	28	Mar. 8	......	......	......	......	......	......	24·120	......	......	......	0·820	June 18	Mar. 24	Nov 15
1871	30 152	Mar. 28	28 308	Jan. 16	84·0	Aug. 12	6·7	Jan. 1	April 11	Nov. 13	128·7	July 17	98	July 7	43	Nov. 2	......	......	......	......	......	......	21·640	......	......	......	0 985	June 16	Mar. 15	Nov. 16
1872	30 156	April 6	28 070	Jan. 24	86·4	July 23	24·8	Mar. 27	Mar. 27	Nov. 19	124·8	Aug. 19	100	Mar. 22	45	Sep. 23	......	......	......	......	......	......	42·060	......	......	......	2·490	June 19	May 11	Nov. 13
1873	30 338	Feb. 18	28 022	Jan. 20	88·8	July 23	19·2	Feb. 24	Mar. 14	Nov. 5	124·5	July 23	100	Dec. 11	41	Mar. 26	......	......	......	......	......	......	21·440	......	......	......	1·200	Aug. 4	April 25	Jan. 3, '74
1874	30·476	Mar. 6	28 276	Dec. 11	80·9	July 20	16·0	Dec. 31	Mar. 12	Nov. 11	125·8	July 20	100	Feb. 6	42	May 18	......	......	......	......	......	......	23 560	......	......	......	0·740	Dec. 7	May 9	Nov. 26
1875	30 305	July 7	28 484	Nov. 10	80·0	Aug. 17	13·0	Jan. 1	Mar. 22	Nov. 26	122·0	July 5	100	Jan. 23	43	July 6	......	......	......	......	......	......	30·280	......	......	......	1·700	Nov. 15	Mar 12	Nov. 9
1876	30 300	Jan. 15	28 070	Dec. 4	87·6	July 17	23·0	Jan. 9	April 15	Nov. 9	125·6	July 16	99	Oct. 4	46	May 5	......	......	......	......	......	......	35·270	39·788	4·518	11·28	1 810	Oct. 9	April 12	Nov. 8
1877	30·358	Oct. 6	28·300	Nov. 29	80·0	June 19	20·0	Mar. 1	May 4	Oct. 18	116·4	June 19	100	Oct. 29	35	May 23	......	......	......	......	......	......	40 650	45·499	4·849	11·19	1·420	July 16	May 19	Oct. 15
1878	30·320	Mar. 16	28 630	April 1	89·6	July 19	13·9	Dec. 26	April 6	Nov. 9	118·2	July 22	99	Jan. 13	53	Aug. 9	......	......	......	......	......	......	35·434	39·010	3 576	11·01	1·220	Aug. 14	April 1	Nov. 8
1879	30 352	Dec. 13	28 500	Feb. 10	74·4	July 30	13·2	Dec. 7	May 10	Nov. 14	101·2	Aug. 13	100	Oct. 7	51	Dec. 12	......	......	......	......	......	......	28 017	30·298	2 281	10 82	1·020	June 8	May 7	Nov 20
1880	30 332	Jan. 7	28·154	Nov. 16	81·3	Sep. 5	20·8	Jan. 20	Feb. 23	Oct. 20	112·0	Aug. 13	99	Dec. 15	50	May 30	......	......	......	......	......	......	35 690	39 616	3 926	11·10	1·710	Oct. 27	Mar. 2	Oct. 27
1881	30 382	May 10	28 250	Oct. 14	63·3	July 6	12·0	Jan. 26	April 21	Oct. 17	116·5	June 1	98	Oct. 14	38	May 31	......	......	......	......	......	......	35 434	39·892	4·458	11·26	1·435	Oct. 13	April 20	Oct. 29
1882	30 544	Jan. 18	28 452	Mar. 1	77·4	Aug. 12	18 6	Dec. 11	April 16	Nov. 12	108·0	Aug. 9	99	Nov. 5	36	May 18	......	......	......	......	......	......	39 683	43·103	3·420	10·86	1·608	Dec. 6	Mar 21	Nov. 19
1883	30 500	April 9	28 452	Sep. 2	76·2	July 3	19·8	Mar. 10	Mar. 29	Nov. 12	107·6	May 17	99	Dec. 26	30	April 9	......	......	......	......	......	......	34·396	......	......	......	1 338	Sep. 26	Mar. 24	Nov. 10
1884	30·364	Oct. 5	28 376	Jan. 27	84·4	Aug. 12	26·5	Nov. 30	April 24	Nov. 24	107 8	Aug 9	98	Jan. 23	30	May 22	......	......	......	......	24·00	Jan. 24	27·657	......	......	......	1 170	Jan. 23	Feb. 28	Nov. 23
1885	30 273	Mar 14	28 400	Jan. 11	82·2	July 27	22·1	Dec. 11	April 5	Nov. 16	113·6	July 27	100	Jan. 23	32	June 4	......	......	......	......	15 25	Dec. 4	25 699	......	......	......	1·208	Sep. 3	May 7	Dec 9
1886	30 355	Nov. 24	27 652	Dec. 8	79·5	July 3	17 4	Mar. 7	April 30	Dec. 2	108 8	July 5	99	Jan 12	32	May 4	11 45	July 6	851 48	19	18 00	Dec. 9	35·993	......	......	......	2·130	July 26	May 12	Nov. 6
1887	30 412	Feb. 8	28 328	Nov. 3	82·8	July 9	21·1	Jan. 17	April 17	Oct 12	107·6	July 9	100	April 21	35	July 9	12 40	July 3	1120 58	25	15 00	Feb. 4	18 665	......	......	......	0 810	Oct. 9	May 21	Oct. 14
1888	30 333	Jan. 10	28 410	Mar. 28	80 4	June 27	19 2	Feb. 14	April 8	Oct. 2	110·0	Sep. 15	99	Mar. 15	39	June 11	13 40	May 24	984 20	20	13·00	May 4	25 646	......	......	......	1 050	Nov. 3	April 8	Oct. 1
1889	30 358	Dec. 5	28·460	Mar. 20	77·5	Aug. 1	21·3	Mar. 4	Mar. 22	Nov. 27	115·2	June 23	99	April 22	39	June 26	12 15	July 8	827 45	18	12·00	Feb. 9	22·141	......	......	......	0 590	Mar. 9	Mar. 21	Nov. 25
1890	30·376	Feb. 23	28 315	Jan. 23	76·4	Sept. 10	18·4	Dec. 22	Mar. 10	Oct. 28	111·0	June 16	99	May 11	31	May 29	14 25	May 25	824 5	18½	14 00	Jan. 19	25 730	......	......	......	1 485	Jan. 22	April 13	Oct. 21
1891	30 394	Oct. 31	28 060	Nov. 11	79 9	Sept 12	12 0	Jan 19	May 18	Nov. 25	107 0	July 27	100	Feb. 20	37	July 17	11 45	May 12	805 35	18	13 50	Aug. 26	27 303		......		1 20	Dec 1	May 17	Nov 26
1892	30 256	Mar 30	28 638	Feb. 2	77 0	Aug. 24	18 8	Feb. 19	April 19	Oct. 25	107 5	July 23	99	Jan. 12	32	April 3	12 30	June 7	866 53	19	10·00	April 28	28 881				2 720	Oct 15	April 28	Oct. 24
1893	30·358	Dec 30	28 300	Feb. 26	65·0	Aug. 19	19·0	Jan 5	April 12	Oct 31	117·8	Aug. 19	98	Mar. 1	37	April 25	13 0	May 10	980 36	22	13 20	Nov. 19	22·667			......	1 180	May 18	Mar 17	Nov. 5
1894	30 302	Dec. 27	28 512	Oct. 25	80·8	July 1	10 2	Jan 6	Mar. 17	Oct 22	105·2	July 9	100	Jan 8	40	July 5	12 45	July 1	771 28	17	18 00	Dec. 23	32·782		....		1 114	Oct. 27	Mar 13	Dec 29
Means	30·341		28·316		81 8		17 8				115·3		99		39		12 45		881 30	20	16·09		29·634	39·601	3 860	11·08	1 368			

EXPLANATION.

The observations are made at nine a.m., and, with the exception of maximum and minimum thermometer readings, again at three p.m.

The highest and lowest barometric readings for each month, also the monthly range, are given as recorded; while the mean pressure is deduced from bi-daily observations corrected for index error, capillarity, temperature, and diurnal range. To correct for altitude or reduce to sea level (the air temperature being 48 degrees and barometer 30 inches at sea level), add ·401 inch to the heights given.

A remarkable instance of barometric depression occurred on the 8th December, 1886, when at 8 40 p.m. the mercury of the Exchange barometer had fallen to 27 466 inches only—the lowest reading on record here. The cyclone indicated by this depression was the cause of great loss of life and property, extending over an unusually large district.

All thermometric observations and deductions are given in degrees Fahrenheit.

The adopted mean temperature of air is deduced from the dry bulb and the maximum and minimum readings; the temperature of evaporation from the dry and wet bulb and the maximum and minimum readings. The dew point, elastic force of vapour, humidity, &c., are deduced from bi-daily readings of the dry and wet bulb hygrometer, by Glaisher's Hygrometrical Tables, sixth edition.

Bright sunshine is recorded in hours and minutes by glass sphere on cards, known as Campbell's recorder, fixed on Professor Stokes' zodiacal frame.

The solar thermometer has a black bulb enclosed in a vacuum.

The direction, velocity, and pressure of wind are recorded as indicated by anemometers fixed 10½ feet above the ridge of roof of Exchange. The velocity per hour at 9 a.m. is determined from anemometer readings made one minute and a half before and a like period after that hour, by multiplying the difference thereof by 20. The pressure is given in pounds avoirdupois per square foot.

The amount of cloud is estimated by a scale ranging from 0 to 10.

Rainfall includes melted snow and hail.

The rain gauge is fixed upon the top of central roof of the Exchange, at an elevation of 65½ feet above the surface of the ground and 395 feet above mean sea level. As rain gauges on the summit of buildings are generally found to collect less rain than when placed upon the surface of open ground adjacent thereto, steps were taken in 1875 to determine to what extent this was the case with the Exchange rain gauge, when two additional gauges were provided and fixed upon the surface of adjacent open spaces, one near to the Town Hall, the other near to the Midland Railway Station, between which the Exchange gauge is situate about midway, and the surface of ground about the same height. At both of these gauges, as well as at the Exchange gauge, daily observations were made from the commencement of 1876 to the end of 1882, a period of seven years, when the surface gauges were removed in consequence of the ground they occupied being no longer available for the purpose. The particulars of these gaugings are set forth in tables. The results show that the mean yearly rainfall on the surface of ground for the seven years ending with 1882 is 3 86 inches, or 11 08 per cent., greater than at the summit of the Exchange. The mean yearly rainfall recorded at the Exchange for the twenty-five years ending with 1894 is 29·634 inches. By adding 11·08 per cent. thereto the mean normal rainfall of central Bradford for such period is found to be 32 917 inches per annum. There are good grounds for concluding that the smaller amount of rainfall collected on the Exchange—and on buildings generally—than on the surface of ground is due to the varying direction and force of wind there producing different currents and eddies, which prevent due precipitation on the top or ridge of roof where the gauge is fixed. The rainfall of 1869 was collected by a gauge placed on the ridge of outer roof of Exchange, near to the north-west corner thereof. This position not being deemed quite satisfactory, the gauge was removed at the end of that year to the ridge of central roof—the place it has since occupied. To avoid risk of inaccurate results, the rainfall of 1869 is omitted from these returns.

The instruments with which the observations are made have been verified by comparison with the standards at Kew Observatory.

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