PROCEEDINGS

OF THE

YORKSHIRE GEOLOGICAL AND POLYTECHNIC SOCIETY.

New Series, Vol. VIII., Part I., pp. 1 to 155.

With Five Plates.

Edited by JAMES W. DAVIS, F.S.A., F.L.S., F.G.S.

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LEEDS:

PRINTED BY A. MEGSON AND SONS, BAINES' BUILDINGS, BANK STREET.

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VOL. VIII.] [PART I.

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BIOGRAPHICAL NOTICES OF EMINENT YORKSHIRE GEOLOGISTS.

I. "JOHN PHILLIPS." BY THE EDITOR.

MY personal knowledge of Professor John Phillips dates no further back than the meeting of the British Association at Bradford, in 1873, only one year before his death. My recollection is very fresh of his kind and genial face, his winning and encouraging smile, the ever-ready and wise words with which he brightened and enlivened the most perplexing questions, and the deep knowledge and great experience which lay below and prompted all his observations. This comparatively slight personal knowledge, however, has served to give life and vigour, an actuality which otherwise might have been impossible, to the study of the works of the veteran geologist. Within the short period of the life of John Phillips, the history of geology as a science has had its birth, has been nurtured and grown, and before his death, its interesting ramifications had encircled the whole crust of the earth. The germs of truth gathered and elucidated by Professor Phillips and his uncle, William Smith, have served as the basis on which the whole superstructure of geological science has been erected.

Before the advent of the present century, a correct knowledge of the composition of the crust of the earth had no existence. The whole aggregation of the rocks was generally imputed to the action of the deluge as defined by the Mosaic description, and the occasional discovery of the embedded fossil remains of some plant or animal was considered due to a freak of nature, an accidental representation of some living form. Such were the theories of Tertullian and Pliny in the early part of the christian era, who, accepting the results of the labours of Aristotle and his school, considered that all fossil remains were due to a plastic virtue latent in the earth, or that the slime of rivers or the mud of the earth had power to originate the animals whose forms became entombed in the rocks. It is true, that even before the time of Aristotle, there were at rare intervals philosophers, as for instance, Zenophanes (500 B.C.), and Herodotus (450 B.C.), who attributed the presence of fossil fish and shells in the quarries far away from the sea, to the fact that the rocks containing them must at some previous time have formed the bed of the sea, and that the fish and molluscs died and were entombed in the soft mud. Such theories were, however, generally ridiculed. After the time of Pliny (*b.* 23 A.D.), who learnt much from the researches of the early Greeks, intervened some fourteen or fifteen centuries of almost universal darkness, during which time all knowledge suffered from the general dearth of intellect in Europe; science, art and literature being alike retrogressive and no development appearing to have been possible. During the 15th, 16th and 17th centuries, greater interest was taken in the collection of fossils, and several interesting books were written, largely illustrated with plates of specimens. This newly awakened interest was liveliest in Italy, but in this country Dr. Martin Lister contributed several articles to the Philosophical Transactions printed in the volumes for 1674 and succeeding years. He described certain stones figured like plants which he considered to be plants petrified. He also figured fossil and recent shells side by side, so that the close resemblance between the two at once became apparent, and supported his theory, that the fossils were once living animals. Altogether his work conduced much to produce a true knowledge of fossil remains. A belief gradually grew in the minds of intelligent people that the fossils represented animals which had lived at some former period, but the erroneous conviction now entertained was, that they were all carried and left in the position where they were found, by the Noachian deluge. Quite to the beginning of the nineteenth century, and even much later, the belief existed in the Mosaic account of the creation of the world in six literal days, and that the whole earth was subjected to an universal deluge by which every living thing was destroyed, except Noah and those with him in the ark. Entertaining these opinions, it is not very remarkable that all fossil remains should be identified with the flood, and that all the literature relating to geological subjects published about this time should be saturated with this belief. One or two instances of the prevalence of these opinions may be interesting:—Buffon, a natural historian of much merit, published his "Theory of the Earth" in 1749. In this work he discussed many important geological questions, touching the action of natural causes in wearing down the land, and the gradual interchange of position between sea and land. Soon after the appearance of his work he received a polite intimation from the Faculty of Theology, in Paris, that there were several propositions in his book which were reprehensible and contrary to the creed of the Church; he was invited to present himself and recant. Not feeling in any way bound to suffer as a martyr to science he drew up the following declaration, which he was required to publish. "I declare that I had no intention to contradict the text of Scripture; that I believe most firmly all therein related about the creation, both as to order of time and matter of fact; and I abandon everything in my book respecting the formation of the earth, and, generally, all which may be contrary to the narration of Moses."

In 1731, Professor Scheuchzer, a Swiss naturalist, discovered some bones which he described as those of a child destroyed by the deluge. He also found two vertebræ, which he attributed to another individual of gigantic size of the same race. The belief being thereby strengthened in the huge size as well as long life of our progenitors—both probably equally incorrect. Engravings of both these were subsequently given in the "Copper Bible." Cuvier afterwards examined these interesting relics and pronounced the skeleton of the supposed child to be the remains of a gigantic salamander, and the two vertebræ to be those of an ichthyosaurus!

During the latter part of the eighteenth century and early in the present one, William Smith, uncle of John Phillips, made a series of distinct and remarkable discoveries, which served in a few years to revolutionize and place on a truly scientific basis the whole theory of geological knowledge.

William Smith was a land surveyor and engineer, and whilst engaged in his professional labours he had repeated opportunities of studying the surface of the land in various parts of the country. Having become well acquainted with the series of oolitic rocks in the neighbourhood of Bath, his native place, he discovered that each separate stratum of rock or clay had its peculiar system of fossils, many of which were quite characteristic of the bed in which they were found and did not extend to those above or below. After fully maturing his conception of this fact, business called him to Yorkshire, and here he had opportunities of observing that the same fossil shells, etc., which characterized the strata near Bath also occurred in similar beds of limestone or sandstone in this county, and are equally certain in their distribution. Repeated visits to various parts of the country convinced Smith that his generalizations applied to all parts; and resulted, after many years of hard and patient labour, in a geological map of the strata of England and Wales, which was followed by more detailed maps of many of the counties. He also tabulated the whole series of strata occurring in England and Wales with the characteristic fossils of each section of the rocks. William Smith did immense service to the science by clearly demonstrating:—I. That the strata wherever present always occupy the same relative position. II. That the strata have been deposited at successive periods beneath water; and that the fossils found in them were the remains of organisms that lived in those waters, and were afterwards imbedded in the sand or mud and became fossil. III. That particular species of organic remains are limited to particular strata.

It is difficult at this day to realize the great importance of these discoveries. Before "Strata Smith," as he came to be familiarly known, had discovered by his painstaking and self-abnegating researches, that there was order and regularity in the arrangement of the strata composing the earth's surface, every phenomenon, whether with respect to the rocks or their fossil contents, was attributed to the action of the deluge. Scientific men of that day, as now, differed in matters of detail, but as regards the primary proposition, there were few instances where minds of strong calibre resisted the superstitious influence of the age, and made as in the instance of Buffon, even a few steps towards the great truth realized by William Smith. Practical miners and quarrymen certainly saw that there was an alternation of strata in the rocks through which they pierced, but that they were persistent over large areas, or that the strata were arranged in a regular consecutive order, were circumstances of which they had no conception. The work of Smith demonstrated all this, and laid a true basis for a correct knowledge of the principles which underlie all geological facts. He traced the extension of the oolites and lias from the Midland Counties into Yorkshire. The older rocks of the Welsh Mountains were found to be similar to those of Westmoreland and Scotland. The relations of the various coal fields, of the old red of Scotland and of Devonshire, and all the intermediate beds, were mapped and defined. In the short space of one man's life he mapped the whole of England, and published twenty-six county maps beside: forming a striking contrast to the amount of work done by the Geological Survey of the present day. The manufacturing and mining districts of the

West Riding have been surveyed for several years and still there are only about one half the sheets of the map of this important area issued at the present moment.

The vast work of Smith was readily appreciated by his brethren of the hammer. In 1807 the Geological Society of London was formed and took a position, which it maintains still, of the foremost organization in the world for the cultivation, recognition and dissemination of geological knowledge. Amongst the founders and early members of the Society were, Buckland, who investigated the Kirkdale Caves, in Yorkshire; Adam Sedgwick, who was born at Dent, and a thorough Yorkshireman; Vernon Harcourt—Charles Lyell, Phillips, Murchison, and many others whose names are revered as the pioneers in the science, though they have passed away. These *savans*, heartily recognizing the truth of the discoveries of Smith, advanced them, not only in this country but quickly bore them over the continent of Europe and to Asia and America. Everywhere the same evidence was afforded that the rocks composing the whole surface of the earth are the result of ever-acting causes, that the ordinary and common denuding agencies of rain, frost, and ice, gradually but incessantly grind down the surface of the earth, the disintegrated material being borne by rivers to the sea, there again to be deposited and in time raise up new lands. Such were the forces found to be now at work, and to be those on which a reasonable basis could be laid to explain long past accumulations of stratified rocks.

Fortunately, an account of Professor Phillips' early life written by his own hand, has been preserved in the "Athenæum" newspaper for May 2nd, 1874. From it we learn that he was born on Christmas Day, 1800, at Marden, in Wiltshire. His father, the youngest son of a Welsh family settled for many generations on their own property at Blaen-y-ddol, in Carmarthenshire, was trained for the Church in which some of his relatives had place; but this plan was not carried out. "He came to England, was appointed an officer of Excise, and married the sister of dear old

William Smith, of Churchill, in Oxfordshire. His father died when Phillips was seven years old, his mother soon after; and from that time he was under the charge of his uncle, a civil engineer in full practise, known as "Strata Smith."

At ten years of age, John Phillips was at a school at Holt-Spa, in Wiltshire, where a small microscope was given to him, and he speaks of the delight with which all natural objects were scrutinized by its magnifiers; he appears also to have been fond of athletic exercises, for he says, "When you see me now (χαλεπῶς βαδιζων) tired with the ascent of Geo Fell and the rough path of the Zmutt Glacier, you will hardly credit me as the winner of many a race, and the first in many a desperate leap. My work at this school was incessant for five years. I took the greatest delight in latin, french and mathematics, and had the usual lessons in drawing. We were required to write a good deal of latin, especially our Sunday theme; of such, I wrote many for my idle associates. I worked through Mole's algebra and Simson's Euclid, the first two books completely, and selections from the others. The French master was a charming old Abbé, a refugee, whose patience and good nature and perseverance were quite above praise. We spoke and wrote french in abundance. Of greek I learned merely the rudiments, to be expanded in after life. I did not work at german until some years later; italian I merely looked at."

On leaving school, Phillips accepted a twelve months invitation to the home of his ever-honoured friend, the Rev. Benjamin Richardson, of Farleigh Castle, "One of the best naturalists in the West of England, a man of excellent education, and a certain generosity of mind, very rare and very precious. Educated in Christ Church, he retained much of the indefinable air of a gentleman of old Oxford; but mixed with this, there was a singular attachment to rural life and farming operations. Looking back through the vista of half a century, among the ranks of many kind and accomplished friends, I find no such man; and to my daily and hourly intercourse with him, to his talk on plants, shells and fossils, to his curiously rich old library, and sympathy with all good knowledge I may justly attribute whatever may be thought to have been my own success in following pursuits which he opened to my mind."

From the rectory of Farleigh, John Phillips returned to his uncle Smith, whose house overlooked the Thames from Buckingham Street. William Smith at this time was in the exercise of a lucrative and honourable profession; he had for many years been at work on his great "Map of the Strata of England and Wales," which was published in 1815. "His home was full of maps, sections, models and collections of fossils; and his hourly talk was of the laws of stratification, the succession of organic life, the practical value of geology; its importance in agriculture, engineering and commerce; its connection with physical geography, the occupations of different people, and the distribution of different races. In this happy dream of the future expansion of geology, his actual professional work was forgotten, until at length he had thrown into the gulf of the strata all his little patrimony and all his little gains, and he gave up his London residence, and wandered at his own sweet will among those rocks which had been so fatal to his prosperity, though so favourable to his renown." In all the pursuits and cares of his uncle, John Phillips had his share; they were never separated in act or thought, and so his mind came to be moulded on that of his uncle.

In 1824, they accepted an invitation to give a course of lectures on geology at York, and from that time Phillips was constantly engaged in Yorkshire to give lectures and arrange museums, and many valuable friendships were created in its several towns; thus "the great county, in which thirty thoughtful years were afterwards passed, became known to me as probably to no others. The generous Yorkshire people gave no stinted remuneration for my efforts to be useful; and I employed freely all the funds which came to my hands in acquiring new and strengthening old knowledge, so as to be able to offer instruction in almost any department of nature, but especially in zoology and geology." At York he became associated with Mr. W. V. Harcourt, the first president of the Yorkshire Philosophical Society, and they along with Brewster, Forbes, Johnson, Murchison and Daubeny, were the principal means of organizing the British Association for the Advancement of Science. Professor Phillips concludes his short autobiography with the following sentence.—" Educated in no college, I have professed geology in three Universities, and in each have found this branch of science firmly supported by scholars, philosophers and divines."

We have considered, however briefly, the state of knowledge of the earth's crust anterior to the commencement of the present century. The exploded belief in the all-powerful energy and widely ranging results of the deluge gave place to an earnest endeavour by all scientists to collect and chronicle the fossil contents of the various strata. Cuvier did immense service in the tertiary beds of the Paris basin amongst the higher forms of animal life, and was worthily followed by his pupil Louis Agassiz, whose knowledge of recent and fossil fishes led him to perceive a succession in the forms deposited in the earliest rocks and ranging up to the present time, which bears some correspondence to the developmental stages of modern fishes. Professor Agassiz in this country found a fellow-worker amongst the fossil fishes, in Sir Philip Egerton, whose ichthyological contributions to scientific literature have been both important and extensive. Sowerby, Owen, Morris, Forbes and many others were collecting and describing fossils from the British rocks. John Phillips was not idle, in addition to his many other published works about this period, and all his lecturing and arranging museums, he published (1829—1836) his " Illustrations of the Geology of Yorkshire," in two quarto volumes, which beside the stratigraphical descriptions of the northern and eastern divisions of the county, contained descriptions and figures of hundreds of species of fossils, ranging over the whole series of the animal kingdom comprised in the strata between the silurian rocks of Howgill Fells and the secondary and tertiary series on the south eastern coast. In connection with the Geological Survey, he also produced in 1843, his work on the "Palæozoic Fossils of Cornwall, Devonshire and West Somerset," which contained an equal or larger amount of original matter in connection with fossil remains. The result of all this activity in every part of the world was very great; more than 30,000 species of fossils were named, described, and in many cases figured. The fossils were found to be far larger in number than the living forms, and many of them were ascertained to be without any living representative; others, found almost in the earliest rocks have existed through the untold ages since their first appearance and are still represented in the seas of the present day.

The varied picture presented to a careful and enquiring mind by the consideration of this subject is one of profound and awe-inspiring interest. It opens up a large field for speculation; and its bearing on the past history of the globe and its inhabitants is of the utmost importance.

Geology, as a science, is pre-eminently one of facts, and unless its truths are treasured and adhered to, speculations and generalizations, which of necessity must be interwoven with those facts, may prove not only misleading, but injurious. So long, however, as the imagination is chained down to a basis of truth, and a solid foundation of indubitable and thoroughly well digested knowledge serves to leaven the edifice, the superstructure of inference and deduction may be both correct, pleasing and highly instructive. Without the use of the imagination to fill in the pictures presented by a study of the fossils found in the rocks, of ages and periods long past, whose similitudes can never recur, geological as well as other science, would only prove barren and abortive. For example:—the fossil remains of some fish, or shell, or plant are found imbedded in the shales of the coal measures; the whole of the original matter composing the bones of the fish or the tissues of the plant have been removed, and in their place is a wonderfully well-preserved *fac-simile*, in all probability composed of the same material as the surrounding masses of shale. The structure which characterized the objects when living is retained with exquisite perfection, and the highest powers of the microscope only serve to expose the infinite exactness of this mineral reproduction. These are the facts: the inferences to be drawn from them are many. They call into operation a wonderful play of the highest powers of the human mind. All kinds of collateral sciences are brought to bear in the elucidation of the problems suggested by these facts. Zoology, by comparison with existing forms, enables us to ascertain, with more or less correctness, the nature and habits of the fossil fish, the shape and character of its teeth, its covering of dermal armature and the presence or absence of external means of offence, thus affording data on which may be based assumptions as to the character of its food and the necessity or otherwise for protection against powerful foes. The changes undergone by the fossil since it first sank to the mud at the bottom of the water, call in the aid of chemistry and mineralogy. Possibly the structure of the fish may give valuable insight into its habitat when living, as to whether it was a denizen of salt, estuarine, or fresh water, and thus, much knowledge may be gained as to the physical geography of the land and sea, and the method of aggregation of the strata deposited during that period of the world's history. A similar course of reasoning may also be applied to the fossil shell or plant.

The great accumulation of geological and palæontological facts, led a few years later on, to a number of theoretical generalizations which exercised the greatest scientific minds of this or probably any previous age. The stratagraphical knowledge accumulated by William Smith and his followers not only laid the foundation for geological science in this country, but the influence of their labours spread over a great part of the civilized world, the methods of research and the nomenclature used by British geologists having been adopted in every other country as a foundation whereon to base local and minor designations. Philosophers speedily collated their knowledge and proceeded to adapt it to already existing theories, or new ones were originated to account rationally for the phenomena of nature during the long past ages. Professor Phillips wrote in 1837,* "From a mass of crude speculations fitted to inaccurate observations, it (*i.e.* geology) has gradually grown up to a system of sound, though limited inferences, connected by some very probable generalizations, and supported by independent mathematical reasoning. The *laws of phenomena* are unfolded to a considerable extent, and in the opinion of eminent men of science, the time is at hand for effectual researches into the *laws of causation.* Not that the labours of observation should, for an instant, be suspended; *they* are the most important of all the means of advancing geology; on the contrary, they ought to be continually excited by new impulses, and turned into more profitable directions by the first, however rude, indications of theory. The state of geology is so prosperous, that its numerous cultivators may well agree to divide their forces so as to accomplish combined movements; to advance on the one hand, the mass of generalized phenomena, and on the other, to multiply the points of contact between dynamical, chemical and vital laws and the results of geological inquiry."

It would be impossible within the limits of this paper to trace the various theories which have finally resulted in the great work of Darwin on the Development of Species by Natural Selection. It is a little more than twenty-one years since the "Origin of Species" was issued from the press, and in that short period the work has created a complete revolution in all modern scientific thought. It is not to be supposed that the origin of this great discovery rested solely with Darwin: many minds had been working at the problem. It was the natural outcome of all the accumulated thought for years previously, and solved the problem which was the great stumbling-block to all advance. The belief in "special creations" had long been undermined by well established facts, and many naturalists

* Treatise on Geology, by John Phillips, F.R.S., &c., 1837.

were convinced that development or evolution was the true explanation of the origin of all the multitude of species which do now, and have in times past, peopled the earth; but to Darwin was reserved the grand discovery of natural selection and descent with modification. The many and important results of these researches may be briefly stated as follows. That all life is the result of development from pre-existing forms, and adaptation to the circumstances under which it exists; and, as Mr. Spencer has aptly termed it, "the survival of the fittest." A most important result of the theory is the present widely extended belief in the antiquity of man. The limited period of 6,000 years is now proved to be totally inadequate. The remains of man have been repeatedly found in association with extinct animals, both in Yorkshire and in all parts of the world. In the gravels of the Somme Valley, the Kjokkenmodding of Denmark and Sweden and the Lake dwellings of Switzerland, the worked and carved tools of the old inhabitants have been found. It is possible, nay probable, that man was in existence prior to the last so-called glacial epoch and descends even to the tertiary strata; if this be so, the age of man on the earth will of necessity be carried back much further than the few thousands of years assigned to him.

During the year following the publication of Darwin's "Origin of Species," Professor Phillips wrote his book, entitled "Life on the Earth, its origin and succession," in which he attempted to show the fallacy of Darwin's investigations. His arguments were derived principally from want of distinct evidence of the actual transmission of some peculiarity in the fossil forms. The several animals or plants existing fossilized in the rocks certainly exhibited great advances in structure and organization over those found in strata of greater antiquity, but the connecting links had not been discovered, and Professor Phillips, like most other people, was much inclined to consider all the several forms as independent creations. After reviewing in detail the difficulties attendant on the development of a higher form from a lower, Professor Phillips continues,* "If it is not possible in the existing ocean, among the innumerable and variable radiated, amorphozoan and foraminiferous animals, to construct one chain of easily graduated life, from the fertile cell to the prolific ovarium and digestive stomach, it must be quite vain to look for such evidence in the fossil state. In the face of the assumption requisite to imagine such a chain, we cannot venture to adopt it as a probable hypothesis, and thus the idea of one general oceanic germ of life, whether we like it or not, must be abandoned. Reasoning of the same kind will convince us that to derive by any probable steps any one great division of the animal kingdom from another, involves too much hazardous assumption to be adopted by a prudent inquirer."

From this extract it is clear that to the mind of Professor Phillips, in 1860, the difficulties in connection with the acceptance of Darwin's theory of evolution quite outweighed the simplicity and beauty of the conception, and he felt bound to reject it. But in the short space of a dozen years, the labours of many naturalists, in most cases equally unbelieving, had produced such a mass of confirmatory evidence, that the theory is now generally accepted by the scientific workers of every country.

The researches of Professor Huxley have demonstrated the close relationship between birds and reptiles. American palæontologists have discovered a series of fossil remains of animals which exhibit, in a no less clear than marvellous manner, the history of the ancestry of the horse from an animal little larger than a dog; this little animal, in some respects very different in structure to the horse, is found to have been slowly changed, step by step, through the successive stages of later geological time, until the noble quadruped, so useful, nay, indispensable to man, has been the result. The feline animals have also been shown to have had distant relations, during the tertiary period in the carniverous animals, *e.g.* Dinictis, Machœrodus and others, whose remains are found buried in those deposits. Much has been learnt respecting the ancestry of living fishes and of

* Life on the Earth, p. 211. 1860.

many of the, so-called, lower forms of life. Space will not permit that these instances should be more than alluded to at present. But they serve to illustrate one of the brightest characteristics of a mind trained to scientific methods, and pre-eminently such an one was that of John Phillips. A year or two after the publication of his friend Darwin's work, he had, after mature reflection opposed the whole theory; but in 1873, at the meeting of the British Association at Bradford, the ever-increasing mass of evidence in favour of natural selection and development had produced their natural result, and we find the Professor in his presidential address to the geological section discoursing as follows*:—" But concurrently with the apparent perpetuity of similar forms and ways of life another general idea comes into notice. No two plants are more than alike; no two men have more than a family resemblance; the offspring is not in all respects an exact copy of the parent. A general reference to some earlier type accompanied by special diversity in every case ('descent with modification') is recognised in the case of every living being.

" Similitude, not identity, is the effect of natural agencies in the continuation of life forms, the small differences from identity being due to limited physical conditions, in harmony with the general law that organic structures are adapted to the exigencies of being. Moreover, the structures are adaptable to new conditions; if the conditions change, the structures change also, but not suddenly; the plant or animal may survive in presence of slowly altered circumstances, but must perish under critical inversions. These adaptations, so necessary to the preservation of a race; are they restricted within narrow limits? or is it possible that in the course of long-enduring time, step by step and grain by grain, one form of life can be changed, amd has been changed to another, and adapted to fulfil quite different functions? Is it thus that innumerable forms of plants and animals have been 'developed' in the course of ages upon ages from a few original types?

* Brit. Assoc. Report, 1873. Trans. of the Sections, pp. 73, 74.

"This question of development might be safely left to the prudent researches of physiology and anatomy, were it not the case that palæontology furnishes a vast range of evidence on the real succession in time of organic structures, which on the whole indicate more and more variety and adaptation, and in certain aspects a growing advance in the energies of life. Thus at first only invertebrate animals appear in the catalogues of the inhabitants of the sea; then fishes are added, and reptiles and the higher vertebrata succeed; man comes at last to contemplate and in some degree to govern the whole.

"The various hypothetical threads by which many good naturalists hoped to unite the countless facts of biological change into a harmonious system have culminated in Darwinism, which takes for its basis the facts already stated, and proposes to explain the analogies of organic structures by reference to a common origin, and their differences to small, mostly congenital, modifications which are integrated in particular directions by external physical conditions, involving a 'struggle for existence.' Geology is interested in the question of development, and in the particular exposition of it by the great naturalist whose name it bears, because it alone possesses the history of the development *in time*, and it is to inconceivably long periods of time, and to the accumulated effect of small but almost infinitely numerous changes in certain directions, that the full effect of the transformations is attributed.

"For us therefore, at present it is to collect with fidelity the evidence which our researches must certainly yield, to trace the relation of forms to time generally, and physical conditions locally, to determine the life periods of species, genera and families in different regions, to consider the cases of temporary interruption and occasional recurrence of races, and how far by uniting the results obtained in different regions the alleged 'imperfection of the geological record' can be remedied."

I have, perhaps, dwelt longer on the important question of Darwinism than the nature of my subject will warrant, but it is one of such vital importance to the success of all future work in the natural history of living or fossil animals and plants, that I trust I shall be excused; and the experience of Professor Phillips may serve a very useful purpose if it teaches us the lesson of patience and forbearance in passing judgment on what may, in the first instance, be thought extraordinary or even ridiculous theories, but which may eventually be proved to be founded on just and right principles, the result of life-long thought and experiment.

In 1828, John Phillips was elected a Fellow of the Geological Society, and six years later, when 34 years of age, he was chosen as the Professor of Geology at King's College, London, and also a Fellow of the Royal Society. Ten years later again, in 1844, he became the Professor of Geology at Trinity College, Dublin. During this period he was working at several branches of science in addition to geology. He made very valuable observations in meteorology, a science at that time little understood or appreciated. Astronomy also received some attention, and several papers on the planet Mars and other subjects are printed in the Proceedings of the Royal Society. As already stated, Phillips played an important part in organizing and managing the British Association; for many years he was the secretary, and the first twenty-seven volumes of its proceedings were produced under his editorship. In 1859 and '60, he was president of the Geological Society, and in 1865 of the British Association. Meanwhile he had taken the place of Dr. Buckland as Professor of Geology at Oxford, a position which he held during the remainder of his life.

Professor Phillips was an indefatigable worker. He never tired in his efforts to spread abroad that love of nature which so thoroughly imbued his own existence. By example and teaching, whether orally or with the pen, his single aim was the advancement of those branches of knowledge which had proved so ennobling to his own existence. Never married, he was wedded to his science, and in all his labours, whether as an original investigator, an organizer of the means for encouragement and assistance of his fellow-workers, or more important than either, as an inculcator of a true knowledge and love of scientific method in the youthful minds of those entrusted to his care at the college or elsewhere,—he was always earnest and sincere.

No one would endorse more heartily than Phillips the noble words of a recent speaker, with which I will conclude this sketch, with the substitution of one word; they are as follows:—"The benefit to the student of *science* flows from the improvement of his own mind; from the exercise and expansion of his power to perceive and to reflect; from the formation of habits of attention and application; from a bias given to character in favour of cultivating intelligence for its own sake, as well as for the sake of the direct advantages it brings. The advantages lie in the far future, and do not administer to the feverish excitement which are of necessity in the various degrees incidental to the pursuits of the modern commercial world. The habits of mind formed by *Scientific pursuits* are founded on sobriety and tranquility; they help to settle the spirits of a man, fixing them upon the centre of gravity; they tend to self-command, self-government, and that genuine self-respect which has nothing in it of self-worship. It is one thing to plough and sow with the expectation of the harvest in due season when the year shall have come round; it is another to ransack the ground in a gold-field with the heated hope and craving for vast returns to-morrow or to-day. All honour then to *Science*, because, while it prepares young men in the most useful manner for the practical purposes of life, it embodies a protest against the excessive dominion of craving appetites, and supplies a powerful agency for neutralizing the specific dangers of this age."

ON THE WHITE CHALK OF YORKSHIRE. BY REV. E. MAULE COLE, M.A., F.G.S.

THE following notes are supplementary to the papers already published on the Red Chalk (1878), and on the origin and formation of the Wold Dales (1879.)

The white chalk of Yorkshire differs considerably from the chalk of Kent and Sussex. In the first place, it is much harder, and in places almost crystalline. Then, the flint-bearing beds are the lowest in the Yorkshire series, whereas they are the highest in the southern; the upper beds in Yorkshire, forming the inner edge of the Wolds, have not a trace of flint. The flints too are different; in the north they are light-coloured and can be shattered by a blow into a thousand pieces, whilst in the south they are black, tough, hard, and compact.

Numerous flint weapons, knives, arrow-heads, spear-heads, scrapers, &c., have been picked up on the surface of the Wolds, or extracted from the numerous tumuli, but they are almost invariably of foreign flint picked up probably on the sea shore, washed out of the Boulder Clay, the flint of Yorkshire not being adapted for the manufacture of flint weapons.

A Frenchman, Mons. Barrois has attempted to divide the Chalk beds into a series of zones, containing characteristic fossils, but enough attention has not yet been paid to the subject, in Yorkshire at least, to prove or disprove the truth of his theory.

It is certain, however, that very large *ammonites* are only found in the lower beds, and *marsupites* only in the highest, whilst on one horizon *inocerami* are very plentiful, and on another scarcely any fossils are found at all. So far this favors his views.

The chalk itself is very variable. Sometimes it is quite slaty, and splits up into thin layers; sometimes it occurs in massive beds without a trace of parting. Wherever a parting occurs there is almost always found a thin deposit of fuller's earth, which seems to have been the primary cause of the non-coherence of the layers above and below; sometimes as many as twenty of these partings will occur in one or two inches of chalk, dividing it into as many thin plates. On the other hand, layers of fuller's earth from one to three inches thick are occasionally found, and also beds of chalk one or two feet thick, without any parting at all.

Where masses of chalk have been rolled about on the sea shore and rounded, remarkable wavy lines like the sutures of a skull, may be traced on the surface. These are due to extremely fine layers of fuller's earth. We call it "fuller's earth" for lack of a better word, but it seems to have been a fine sediment of mud, deposited over the ocean floor as the chalk was accumulating, representing a certain amount of denudation carried on by the waves, much the same as the lagoons of coral atolls in the Pacific receive muddy deposits from the disintegration of the reefs.

If this idea is correct, it follows that chalk was not deposited in a deep sea, as once supposed, but in comparatively shallow waters, where coral reefs existed in all directions, with no neighbouring land, and no rivers bringing down sand and muddy impurities to stain the pure whiteness of the chalk.

This peculiar rock is doubtless composed largely of the calcareous skeletons of foraminifera which swarmed in the warm waters, which then covered Central Europe, much the same as they now contribute to the formation of the grey ooze of the Atlantic, but the formation of chalk was probably greatly accelerated by the disintegration of coral reefs, which, in the form of minute calcareous sediment, would assist in the accumulation of the beds known as Chalk.

The chalk area extends, with occasional breaks from Ireland to the Crimea, and from Sweden to the Pyrenees. It is absurd to suppose that this area ever formed a *deep* sea. Continents grow like everything else, and materials from the land, brought down by rivers and carried out to sea, are invariably deposited within about 150 miles of the shore line. Europe had certainly attained a continental form long before the deposition of the chalk, and there is no reason to suppose that a *deep* sea, such as the Atlantic, occupied its area in cretaceous times. It is more probable that a slight depression allowed the waters of the Atlantic to pour over its central portion, the constant flow, eastwards, of a stream similar to the present Gulf Stream, supplying an enormous quantity of foraminifera, which, by their decay, aided by the disintegration of coral reefs, caused the accumulation of calcareous sediment known as chalk.

It may be added that the fossils found in chalk, are indicative of animal life, existing not in deep, but shallow water.

The beds of chalk which constitute the Wolds dip in various directions, owing probably to irregularities of pressure or compression in the process of elevation, but the general dip of the whole semicircular mass is in the direction of a central point somewhere about Hornsea, consequently the beds on the N. ridge running from Acklam to Speeton dip southwards, whilst the beds on the W. ridge from Acklam to Hessle dip eastwards. The base of the chalk is met with all round the N. and W. edges at varying elevations, marked by the line of springs, (*vide* Red Chalk, 1878).

As a rule the higher the hills, the thinner the chalk. But the very fact of the chalk being thin, at most 200 feet on high elevations, shows that we are in the lower flint-bearing beds all round the N. and W. area, whilst we only reach the upper beds without flints on the inner and lower circle of ground, seawards.

A line drawn from the S. landing at Flambro' Head through Burton Agnes, Kilham, Cottam Warren to Life Hill, Sledmere, on the one hand, and from thence south through Wetwang, Tibthorpe, and Leckonfield, to the Westwood pits at Beverley, will separate the two areas of flint-bearing and nonflint-bearing chalk; that to the N. and W. containing flints, that to the S. and E. apparently without. A reference to the numerous chalk pits all over the country, will confirm this statement, but it is also proved by the presence or absence of flints on the surface of the ploughed fields. Chalk readily decays under atmospheric denudation, but not so flints. Hence, wherever the subsoil contains flints, they rapidly accumulate on the surface, and sometimes have to be picked off by hand.

We have spoken of flints as if they were all alike, but this is not the case, there are "flints and flints" according to the French proverb, in fact the different kinds of flints are so persistent over different areas, that they are useful in classifying and identifying zones of chalk, even without the help of fossils. For instance, in the lower beds, just above the Grey Chalk, the flints are *nodular.* This term however does not adequately describe the peculiar shape, so we must coin a word "finger-like" meaning thereby that the flints are rounded, tapering, resembling in appearance a thumb or fingers; another feature to be noticed is that unlike other flints, these are mostly found in a vertical or upright position. Good examples may be met with in the railway cutting immediately facing Burdale station.

In the slaty beds of chalk, which succeed next in order, the flints, as might perhaps be expected, appear in thin horizontal slices here and there.

Next above these are found *tabular* flints, *i.e.* solid compact beds of flint, of variable thickness, extending over a large area. On the sea coast, at the N. side of Flambro' Head, these tabular beds present level, but pitted surfaces, many yards in diameter, which have resisted the denudation of the waves, whilst the chalk which once covered them has long since been removed. In the interior, a fine example, 9 inches thick, has been exposed in a quarry on the top of the hill, between Fimber Station and Sledmere, by the roadside.

In the higher beds of the flint-bearing chalk, occur large angular masses of flint, partaking partly of the tabular, partly of the nodular form, of great thickness, but not wholly composed of flint; that is to say, streaks and patches of chalk are imbedded in the flint. Examples may be seen in several quarries in a straight line between Wetwang, North Dalton, and Middleton. This horizon is styled by Mr. Blake (Proceedings, Geol. Association, Jan. 1878) the "Zone of *immature* flints". He considers, it seems, that the process of the development of flint was arrested by the elevation of the chalk, and removal of pressure. It may be so, but the whole question of the formation of flint in chalk is still *sub judice*.

Above these last lies the flintless chalk, but curious to say, though there are no flints, the chalk, on analysis, yields nearly twice as much silica as the chalk which has flint. The silica seems to be dispersed throughout the mass, instead of being aggregated in tabular or nodular patches.

Now what is the origin of all these various forms of flint, including the huge "paramoudra" or "potstones" which are met with in the cliff at Flambro' and Speeton, 3 to 4 feet in height, and 1 to 2 feet in diameter?

One thing is clear, that, in a large majority of cases, they represent a mass of silica, which, by attraction or affinity, has been absorbed from the sea water which contains a quantity of silica in solution, round a nucleus of some decaying animal or vegetable.

Siliceous sponges, whose nutrition is contained wholly in the seawater, which passes through their pores, naturally form a basis for the accumulation of flint, and accordingly we find many flints bearing the exact shape of cup-shaped zoophytes, such as *spongites* and *ventriculites*. But in addition we not unfrequently find such a form as an Echinus, or "Sea Egg" completely transformed into flint, the external rays being as clearly delineated on the surface, as in the living specimens. Here, the decaying animal was evidently replaced atom by atom by silica.

The foregoing observations, meagre as they are, do not account for the large masses of *tabular* flint, though they may help to explain the origin of *nodular* flints. What can we say more? only this, that just as *calcareous* foraminifera are contributing by their decay to form the ooze of the Atlantic, as, in times gone by, they mainly formed the Chalk, so another class of life, the *siliceous* diatoms are busily engaged, at great depths, in secreting flint. Hence these may possibly form beds of flint.

But it cannot be denied that this is an unsatisfactory explanation, for beds of tabular flint occur in the middle of the chalk, deposited, as presumed above, at no great depth. Bearing, however, the fact in mind, that flint may be formed during the decay of vegetable matter, may it not be that *tabular* flints mark areas of greater or less extent, where masses of dead seaweed were accumulated?

The only argument to be urged against this hypothesis is, that dead seaweed is mostly washed up on a shore line. But what, if these areas were shore lines, or, in other words, surfaces of coral reefs? and what know we how much may settle at moderate depths out at sea? our contention throughout being that chalk was not formed in a deep, but in a shallow sea.

A word more must be added on *banded* flints; banded flints are not infrequent in the chalk. They resemble agates in showing concentric rings of silica of different alternate colours, and clearly point to a nucleus of attraction, round which layers of flint accumulated, much the same as stalactites are formed by successive coatings of liberated carbonate of lime.

At the recent meeting of the British Association at York, (1881) bottles containing silica in gelatinous forms, into which certain solutions of metallic salts had been introduced, were exhibited, showing in a beautiful manner how, in course of time, agates and banded flints *might* be produced, but the difficulty presented itself at once, that silica in a gelatinous form is not known to exist in nature, and that, for the formations in question, we must seek not for an artificial, but for a natural process of development.

In conclusion, we wish to draw attention to certain remarkable needle-shaped structures, which occur all over the chalk area of Yorkshire, but not apparently in the South of England, and which are to be met with immediately below and above the thin layers of fuller's earth, alluded to above, as interfering with the coherence of the chalk. They have been called "slickensides" by men of repute, not intimately acquainted however, with the phenomena—but they are *not* slickensides; and a thorough examination will prove convincingly that some other explanation must be sought. Either they mark an incipient form of crystalization, or they are the remaining traces of some low form of animal life of the coral type, which was arrested in its growth by the muddy deposits of fuller's earth, and began its work again as soon as the water was once more clear.

This is a question which deserves further attention in describing the Chalk of Yorkshire.

GLACIAL SECTIONS NEAR BRIDLINGTON. BY G. W. LAMPLUGH.

PART II. CLIFF SECTION EXTENDING 900 YARDS SOUTH OF THE HARBOUR.

In pursuance of my plan of describing sections in this neighbourhood which are likely to be closed to the geologist, it is desirable that some account should be given of the cliff-section which lies immediately to the south of the Harbour at Bridlington Quay, as this is already partly hidden. I have therefore drawn to scale a section of the cliff for a distance of 900 yards from the South Pier, as is shown in the accompanying plate, and this I now supplement, as before, with a description and notes of some deductions I have drawn whilst at work on the section.

Over the extent covered by my section and for about 500 yards beyond it, a private individual, the owner of the land abutting on the cliff, has obtained foreshore rights from the Board of Trade, with the avowed intention of reclaiming and defending his property by the erection of a long line of sea-defences. As a first instalment of this work, a concrete wall was commenced four years ago near the South Pier, and carried across the beach for a distance of 750 feet; but having been based on a soft laminated clay, (No. 4 of section), its foundations have slipped upwards and outwards in places; and it is now in a very unsatisfactory condition. I suppose it is owing to this cause that the work has been suspended.

The waste of the cliff along this section has always been very rapid, but since the wall was built, the sea has encroached still faster on the cliff beyond; so that while the recession of the beach-line between 1852, when the Ordnance Survey was carried out, and 1872, in twenty years, was 220 feet, the recession since then, that is, in ten years, has been 150 feet. The actual loss in thirty years on this small estate with an exposed frontage to the shore of 1,200 yards, has been about 26 acres. The sea is swiftly bringing about a final settlement of the land question in Holderness.

That part of the accompanying section which is now hidden by the new wall is from a sketch I made of the cliff in 1877, just before the building commenced; the exposed part I have more carefully planned this autumn.

On comparing this section with the one I published last year of the cliff to the north of the town, great differences will be observed in the beds above the Purple Clay. These I shall not now attempt to explain, but as I have got a full series of sections and notes from the deep drainage works which have just been carried out in the town, and as these extend from one side of the town to the other, I expect to be able to correlate the beds; and hope next year to give my results, and thus in effect to render the sections continuous.

The cliff line runs N.E. and S.W., and as will be seen, is lowest at the northern end, being here only 28 feet above Ordnance datum. In going south there is a rather sudden rise to a height of nearly fifty feet, but the cliff begins to sink again at D in Fig. 2, where the chalky gravel puts in, and has again lost five feet of its height at the southern end of the section. Beyond this the cliff sinks regularly and very gradually for about a mile, till it disappears below the blown sands of the beach near Auburn. Northward of the section there is a slight rise, and the marls which occupy the hollow thin out. Except in this hollow, the ground sinks from the cliff edge inland.

The following beds are seen in this section :—

1. Banded fresh-water marl containing shells, plant remains, etc.
2. Small gravel, chiefly of chalk, with streaks of sand.
*2*a*. Finely laminated and ripple-marked sand and clay.
*2*b*. Disturbed glacial gravel, with sand and clay seams.
3, 3*a* and 3*b*. Dark purple boulder-clay, (THE PURPLE BOULDER CLAY), including in its midst a band of bedded boulder clay (3*c*), which admits seams of sand at B, B, B.
4. Finely laminated chocolate-coloured clay, scarcely seen in the cliff but well shown on the beach.
5. Dark greenish-blue boulder-clay (THE BASEMENT CLAY), containing many shells and shell-fragments. It nowhere rises above high-water mark in this section.

The Freshwater Marls. (No. 1). These marls are only seen at the northern end of the section, and are very similar to those on the other side of the town which I described last year,† and I believe the two join, as they seem to reach from both sides into the hollow behind the town. Their greatest thickness in this section is 7 feet. They show an irregular and intermittent seam of peat in their midst, containing remains of beetles, seeds and plants. Where thickest, their lower layers consist of gritty clay, and apparently have a tendency to pass into

* I have numbered these beds somewhat arbitrarily to make the figures below agree with those in my last year's section. I do not imply there is any connection between 2 and 2*a*.

† Proc. York. Geol. and Polyt. Soc., 1881, p. 383.

the underlying sand and gravel; shells are absent from this part of the bed, but there are many plant remains.

Dr. Nathorst found leaves of the arctic birch *(Betula nana)* in these marls; he records his discovery as under.*

"Die Suszwasserablagerung en nehmen kleine Becken in Geschiebelehm. * * * Ich in einer solchen Bildung uumittelbar am südlichen Ende der Stadt mehrere Blätter von *Betula nana L.* fand."†

He also doubts not that rich additions might be made from the deeper layers of these beds, and regrets he had not time to search further.‡

The Chalky Gravel. (2). A chalky gravel is seen directly under the fresh-water marls in Fig. 1, but is absent from the remainder of that section. What I believe to be the same gravel, however, reappears a little further south, where the cliff sinks slightly, and is much better developed. I have therefore extended my section in Fig. 2, so as to embrace its recommencement; but it is still better seen yet further south, and can be traced for above a mile, till the cliff has sunk so low as to be hidden by blown sand.

It consists of fine gravel, chiefly of chalk, with seams of sand, often showing cross-bedding. The chalk pebbles are mostly flat and sub-angular. I have examined it carefully and up to the present have found no organic remains, but think my drainage sections will show that it is of fresh-water origin. It generally rests on a highly denuded surface of the underlying sand and warp series, which is cut into deep hollows (best seen beyond the limits of my section), and it seems to be altogether unconformable to those beds. The gravel has, however, been said to dovetail §

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* Ueber nèue Funde von fossilen Glacialplanzen. Englers botanischer Jahrbuch, 1881.

† "The fresh-water deposits occupy small hollows in boulder clay, * * * I found in one such bed immediately at the south end of the town, several leaves of *Betula nana, L.*"

‡ I hope sometime to be able to follow Dr. Nathorst's suggestion and my own inclination, and to make a close examination of these marls.

§ J. R. Dakyns, Proc. York. Geol. and Pol. Soc., 1879, p. 126.

into the sand below, and certainly in more than one place there is that appearance, but in all the cases I have examined except one, I found this appearance to be deceptive, being due to seams of sand in the cross-bedded gravel coming in contact with the underlying sand. The exception is at D in Fig. 2. where the gravel thins out; and here as the gravel is much weathered and confused, matters are not so clear.

I can give no certain information as to the manner in which the chalky gravel under the marls in the northern part of my section dies out southward, as my section of 1877 is unfortunately by no means clear on this point; at that time I confined my attention almost wholly to the boulder-clay, especially the 'Basement,' and have grouped the beds above the Purple Clay as 'clay, sand and gravel;' but from what I can gather from my notes, and from the now much obscured section, it seems to overlap the edges of the denuded sand and warp which forms the slope at C; the upper part of the sand and warp, however, contains much gravel here, and is also cross bedded. One hundred yards north of the north end of Fig. 1 a drain, which has just been cut, showed, at the surface, two feet of chalky gravel, resting directly on Purple Boulder clay. The marls had thinned out.

The Sand and Clay Series. (2a). This series, called by Prof. Phillips* 'the Warp beds,' is the chief component of the section. The upper part consists of fine yellow sand with clay partings, generally passing downward gradually into almost pure clay, in varying reddish-brown and greenish stripes; but in a few places there is a sharp line between the sand and clay. The whole series is finely laminated, and full of beautiful ripple-marking; cross-bedding is also of frequent occurrence, and in three or four places the sandy beds are crumpled and twisted in a curious manner along certain lines. This crumpling has been ascribed†

* Geology of Yorkshire, 3rd edition, p. 82.

† J. R. Dakins, Proc. Yorks. Geol. and Polyt. Soc., 1879 p. 126.

in some cases, to incipient concretionary action. In the sand near C, Fig. 1, hardened root-like tubes of cemented sand, crossing the bedding, where at one time brought out by weathering; and these I looked upon as being caused by the percolation of water which had passed through the chalky gravel above, and so became charged with lime. It may be that concretionary action may be set up by the same agent, though in a few cases the crumplings look very like contortions. I give an enlarged section of a case which seems to be concretionary (3).

The surfaces of the clayey layers often exhibit pittings and other markings, which deserve closer study than I have yet been able to bestow.*

The division between this series and the underlying gravel is generally abrupt, but in one or two places where the gravel is thick and sandy there is a clear passage between them.

Here and there streaks and pockets of gravel appear amongst the sand and clay, and in one or two places (as at E, but chiefly to the south of my section), the beds become charged with gravel from top to bottom. Three years ago a large travelled block was to be seen† imbedded in the lower part of this division, a few hundred yards south of Fig. 2, but this is the only recorded case of the kind. I have found no organic remains either in the sand or clay.

The Lower Gravel (2b). This is a rough drift gravel, chiefly composed of pebbles and boulders washed out of the boulder-clay; but in some places it also contains in its upper part many chalk pebbles. An occasional shell-crumb may be found in it,—no more than might have been derived from the boulder-clay

* At first I was disposed to regard all these markings as rain pittings, but onone surface I examined, the pittings were arranged in definite groups of four, so that unless in the rainy days which followed the break-up of the ice, such things as symmetrical showers occasionally fell the markings must be due to some other cause.

† Recorded by J. R. Dakyns, *supra cit.*

with the other pebbles. I have already mentioned that it sometimes passes upwards into the beds above; where this takes place it is generally thick, and sandy throughout. Downwards, its junction with the boulder clay is most irregular and peculiar. The general section and enlarged sections 1 and 2 will illustrate this better than a verbal description, and I would also refer to the account I gave last year* of very similar appearances to the north of the town.

The Purple Boulder-Clay (3). This boulder-clay answers closely to my description of the same bed in the above-cited paper, being a dark brownish-purple clay, containing a great variety of boulders, and a few shell-fragments. The chief point of interest in this section lies in the existence of a well-stratified portion, *(3c)*, which occurs along one horizon, and thus forms a band running thread-like throughout the section.

This stratified band varies in thickness from a few inches to three feet; it does not differ much from the rest of the clay except in being bedded, but is rather more earthy, (which causes it to weather faster), and also contains a sprinkling of small chalk pebbles, and these are rare in the clay below it, and not plentiful above. It contains scratched blocks like the rest of the boulder clay, but flat pebbles are nearly always laid horizontally. The bedding is sometimes very distinct and almost fine enough to be called lamination; at others it is almost, or quite lost, though the state of the cliff has something to do with this, as it is after the washing of a heavy sea that the bedding is best brought out. There are often reddish, whitish, or greenish streaks at its base, which seem to be the remains of crushed masses of soft rocks.

Its junction with the boulder-clay below is sharply defined, but upwards it is sometimes vague. As will be seen from the section, it rests on, and follows the inequalities of, an extremely uneven surface, rising and sinking in the cliff continually, varying

* Proc. York. Geol. and Polyt Soc., 1881, p. 384.

from about 20 feet above the beach to beach-line, and evidently lapping round and over lumpy and projecting bosses of the lower part of the clay,—passing over them sometimes at a high angle;—so that the line traced by this band in the cliff, if called a '*horizon*' is decidedly hilly in aspect.

At the points marked B in the sections, the band passes into, or admits, seams of fine clean sand, which appear to have been sheltered under the lea of a boss of the clay-bed, as they are usually sharply cut into, and cut off, by the overlying clay. I have not yet been able to ascertain whether the direction of the leaside is *always* the same, but in two cases the sand rested on the western slope of a knoll.

Owing to the same reason as with the gravels—the deficiencies of my early section—I have not been able to trace the course of the band in the now hidden part of the section, though its continuance is indicated by the sand-seam in the midst of the clay, and I also find reference in my notes to the 'two foot seam.'

The boulder clay above the band has suffered severe and irregular erosion, being in some places 10 or 12 feet thick,—in others nearly or quite, cut through, as at F in Fig. 1. The erosion is generally deep where the peculiarly disturbed junction with the gravel (2*b*), is well developed.

Beyond the limits of my section northward, the Purple Boulder-clay, following the upward slope of the Basement Clay, comes to the surface; southward, though holding, on the whole, a slightly higher level, it rises and falls irregularly as in the section.

The Laminated Clay (4). The laminated clay on which the Purple Clay rests does not in this section, nor indeed elsewhere, rise above the level of the highest tides, and is best developed on the beach a little distance from the cliff. Its course thereon is shown by the dotted lines below the beach line in Fig. 1; these lines form a rough ground plan of the beach between tide marks.

The clay is chocolate-coloured, and very fine and tough. It is beautifully laminated, and in places ripple-marked, and contains no pebbles nor other foreign admixture, save in its lowest layers. It rests on an eroded surface of the 'Basement Clay,' which has been worn into deep hollows. Upwards, it is cut off abruptly by the Purple Clay wherever it rises much above beach level, ending thus a little beyond the limits of my section on both sides.

About 350 yards beyond the southern termination of Fig. 2, just before the laminated clay is cut out as described, it passes upward into sand with clay partings, which are in one place seven feet thick. This is only seen for a short distance; the base of the purple clay above is forced down irregularly over it, and shows slickensides. A similar sand-bed remains above the laminated clay for a short distance, on the other side of the town, and I have no doubt that sand has once been continuous at this horizon, and has nearly all been swept off during the deposition of the Purple Clay.

The laminated clay completely fills the deep and wide hollow in the Basement Clay on the beach, near the northern end of Fig. 1, so that it has here a thickness of about 16 feet: elsewhere it rarely exceeds four or five feet. The foundations of the sea-wall were placed in this hollow, with the recorded results.

There is a thin seam of chalky gravel between the laminated clay and the underlying boulder clay in the bottom of the hollow, and this, whenever tapped, yields copious supplies of very pure water, which wells out at high tide but ceases to flow at ebb. A row of piles driven down into the Basement Clay in front of the wall (with the hope of staying its further advance) forms in this way a line of fine ebbing and flowing springs; and an iron tube, which has been let down behind the wall, discharges a strong and continuous jet at high tide. The well-known ebbing and flowing spring in the harbour is probably supplied from the same source.

I was for some time at a loss to account for the discharge of such a strong volume of water of fine quality from an apparently isolated and insignificant seam of gravel; but I am now of opinion that the water is derived from the chalk, either by the inland continuation and unconformable overlap of the gravel, for which the cliffs north of the town yield confirmatory evidence, or by the direct upward rise of the water through some gap or pervious place in the basement clay.

Water is shed copiously between tide marks along the range of chalk cliffs on both sides of Flambro' Head.

The Basement Clay (5). Of this boulder-clay I have given a full description in the *Geological Magazine* for December, 1881, p. 535, and need therefore give no further account of it here. I may mention, however, that I am at present trying to make a full collection of the older rocks which occur as boulders in such immense variety in this clay, with the hope that it may be possible to determine the source of many of them; and I shall be glad to send specimens for examination to anyone who thinks he can identify any local igneous rock known to him which may occur amongst them.

It will be observed that gravels containing a large proportion of chalk occur at three horizons in this section:—1st, above the sand and clay series (No. 2 of section):—2nd, above the Purple Clay (2*b*):—3rd, below the laminated clay. To these may be added the stratified boulder clay band (3*c*), which if washed would yield a similar gravel.

I think this a point worth attention, as these gravels indicate the constant recurrence of an exposed chalk surface in the neighbourhood during the deposition of the boulder-clays;—a condition to be borne in mind when considering the origin of the clays. The chalk wold extends in a curved sweep about a mile to the north and west of the sections. On the promontory of Flambro' Head there are some gravels containing much chalk and others with none, and much might be learnt from a study of their mutual relations.

I regard the whole of the beds above the Purple Clay as of fresh-water origin, but shall be better able to submit my reasons after I have described the drainage sections.

I suggested last year that the intrusions and contortions between the Purple Boulder clay and gravel might result from the movement of ice in fresh-water. I have been confirmed in this view by finding similar disturbances amongst undoubtedly fresh-water beds in some sections shown in the banks of Watermill Beck, a small stream which empties itself across the beach about three miles to the south of Bridlington Quay. The great thickness of undisturbed clay and sand overlying the seat of disturbances in Figs. 1 and 2, shows conclusively that it is not a recent surface movement that has affected the beds. At the same time I may note that after much rain, water is shed pretty freely from the gravel above the boulder-clay, and also that the lower layers of the overlying warp are sometimes slightly drawn downwards into the crushed gravels.

The stratified band in the Purple Clay is another point which must not be forgotten by the glacial theorist. At first glance the stratification might be supposed to occur at random throughout the mass of the clay, owing to the constant change in the height and position of the band in a cliff-face always in some degree masked by landslips (which come and go over every point of the section at a surprising rate), but when once noticed, there is no difficulty in tracing it as long as the boulder-clay is visible.

The material of which it is composed differs so slightly from the clay above and below, that it has almost certainly been derived from the same source; yet there can be no doubt that this material has been sorted and deposited in water, for sometimes streaks of sand make their appearance along every bedding plane. It cannot therefore be directly the product of land ice; neither is its position, nor composition, such as I should expect from a sub-glacial river; nor from icebergs. It looks to me as if deposited in open water, of no great depth, with no ice excepting light floes.

The question arises with regard to the hummocky nature of the clay on which the stratified band rests, whether this is due to erosion, or disturbance, or to unequal deposition? Appearances generally favour the latter, though there are signs of erosion also.

I expect eventually to show that the band is on the same horizon as the the thick sands and gravels which separate the Purple Clay on the north side of the town, and I also believe that its southward continuation may be found in a similar band which may be traced almost continuously throughout the Holderness sections; though before I can speak of this with certainty, it will be necessary to see that there is not more than one horizon for stratification in the Purple Clay.

If finally proved to have so wide an extension, the stratified band will become of value as a dividing line in the clays, though there seems to be a growing tendency amongst glacialists since the breakdown of the evidence for a series of recurrent interglacial periods to avoid new lines, just as naturalists now avoid new species, and to 'lump' the deposits as much as possible. Yet I think that apart altogether from the theoretical aspect, lines such as these, in a confused and refractory mass like our boulder-clays, all deserve careful study, even though they be of no more intrinsic value than the bedding planes in a mass of limestone. To me, it does not seem necessary to 'lump' the whole of the sections because some present intricacies and difficulties; and although the local variations which exist in the sections obscure and confuse them, and render a very close and careful study indispensable in many cases,—the oftener I examine them the more satisfied am I that wide-reaching divisions other than those already made, exist both north and south of Flambro'.

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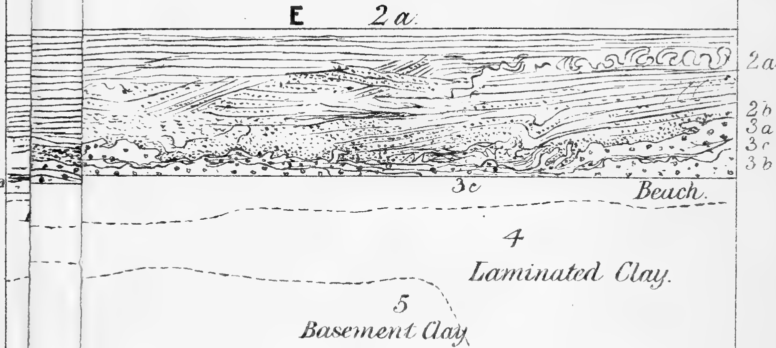
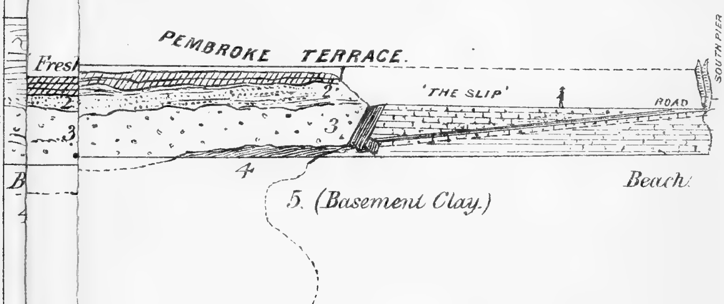
Sept.—Oct. 1882.

North East.



N. E.



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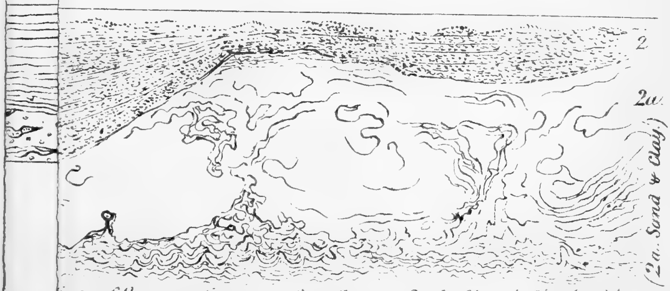
tion at Cliff top, 500 yds. S.W. of Fig 2 showing
e in bedding of Sand—supposed to be concretionary.



ions of the concretions are soft yellow sand; the lines indicate thin
ay which stand out through weathering.
the ripple marking is drawn upward as it nears the centre of disturbance.

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GLACIAL SECTIONS NEAR BRIDLINGTON. PART II.

Length of Section 740 yards
Height from 25 to 45 feet

Fig. 1. Cliff Section south of Bridlington Quay Harbour.

Sept. – Oct. 1882.

Scale 60 feet to an inch

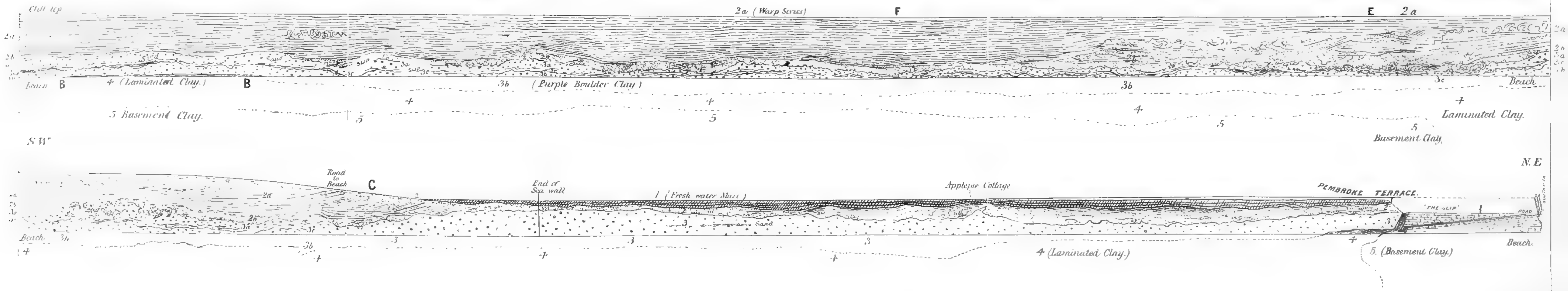
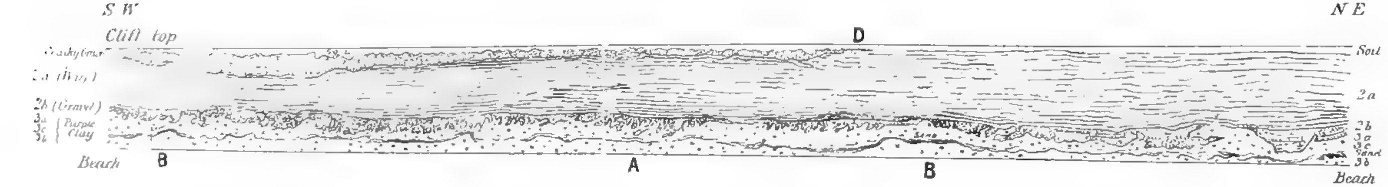


Fig. 2. Southward continuation of Fig. 1. Same Scale.

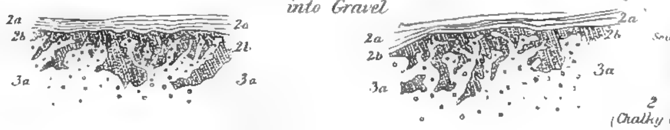
Length 170 yds
Height from 40 to 45 feet



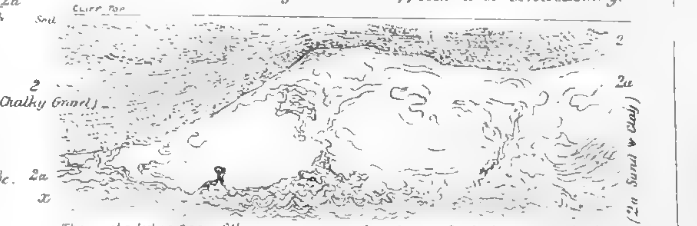
Enlarged Sections

Scale 10 feet to an inch in 1 & 2 _ 6 feet to an inch in 3.

1 & 2. Sections near A in Fig. 2., showing intrusion of Purple Boulder Clay into Gravel



3. Section at Cliff top, 500 yds. S.W. of Fig 2 showing disturbance in bedding of Sand supposed to be concretionary.



The unshaded portions of the concretions are soft yellow sand; the lines indicate thin leaves of Sandy Clay which stand out through weathering. Along the line x–x the ripple marking is drawn upward as it nears the centre of disturbance.

Explanation.

Top soil
1. Fresh water Marl
2. Chalky Gravel.
2a Sand & Clay _ 'Warp' Series
2b Drift Gravel.

3, 3a, 3b Purple Boulder Clay, containing a stratified portion 3c.
4. Laminated Clay
5. Basement Boulder Clay

The capitals indicate points referred to in the text.

NOTES ON THE OCCURRENCE OF FOSSIL FISH REMAINS IN THE CARBONIFEROUS LIMESTONE SERIES OF YORKSHIRE.

BY JAMES W. DAVIS, F.G.S.

THE fish remains of the Mountain Limestone of Yorkshire are not numerous, neither are they found in a great number of localities. If the great area of the western and northern portions of the county be taken into consideration, which are more or less occupied by the Mountain Limestone, extending from Clitheroe and Slaidburn, Thornton, Skipton, to Greenhow Hill in the south, to the limits of the county westwards and northwards, and that in all these localities, and very many others, the rock is exposed and excavated for commercial and agricultural purposes, in quarries of enormous extent, there can remain but one conclusion, that whilst these rocks are replete with fossil mollusca, corals and encrinites there appears to have been a most remarkable absence of fishes in the seas of that period. The non-discovery may be attributed to a want of interest in this branch of palæontology, on the part of collectors, who may perhaps have been more deeply interested in the collection of the beautiful and perfectly preserved specimens of fossil brachiopods, corals and others which abound in many localities, largely quarried, whilst the less known and infinitely rarer remains of fishes have been neglected. Notwithstanding this disadvantage there seems to be little doubt that the absolute sterility of most localities must be attributed to the absence of fossil remains rather that than the need of collectors, and we are driven to the conclusion that, only in few localities and on special horizons have fishes been preserved in a fossil state. The reason for this peculiar arrangement opens a wide field for most interestting speculation. It would appear improbable that during the deposition of the strata containing fish-remains there was an abundant ichthyic fauna in the carboniferous seas, extending only over a comparitively limited area, and existing only for a sufficient period to accumulate, in most cases, a very thin stratum of limestone in which the fossils are preserved, and that during the longer intervals when the intervening thickness of limestone was deposited, there was an almost total absence of fishes in the sea. It has already been observed that the limestone is generally a homogeneous substance of a more or less crystalline structure, but the exploration of the present beds of some of the deep seas where chalk or limestone is in process of deposition has proved that side by side with the foraminifera which secrete calcareous substances, there are others which have a more or less siliceous skeleton and that the latter constitutes a portion of the substance forming the sea bottom. One of the peculiarities in connection with the great aggregation of fish-remains in the Red Beds of Wensleydale is, that the beds are extremely cherty, masses of nodular chert extend in horizontal layers in close proximity with the fish-beds. The method by which the nodules and beds of chert have been separated is not understood; it is possible that the presence of submarine thermal springs, due to volcanic action, may have something to do with the aggregation of the silica to form the cherty or flinty masses. If such be the case, it might be equally probable that the ebullition of water, charged with perhaps poisonous ingredients, would result in the destruction of large numbers of fishes, and in this way the fish-beds may have originated. Except on some hypothesis such as this, it is difficult to conceive a good reason for the occurrence of immense numbers of fish-remains on definite horizons of small thickness, and their almost total absence throughout great thicknesses of intermediate limestone.

Notwithstanding the extreme localization of the beds containing fish-remains there is no reason to complain of the numbers of either specimens or species in localities where they do occur and have been carefully collected, but as will be observed further on, the characteristics of the Yorkshire Limestone fishes are peculiar. In many respects they are distinguished from those, either of the limestone of other localities of the British Islands, or of the coal measures which succeeded them.

Amongst the more frequent examples of ichthyodorulites found in the Mountain Limestone of Bristol, in which locality numerous specimens have been discovered, are the spines and teeth of large predacious fishes allied to the sharks now living. Some of the fish-spines are of immense size. An example in the collection of Earl Ducie at Tortworth Court, which is imperfect at the base, was probably, three feet in length. The fish to which it belonged, judging by comparison with living forms, must have been nearly forty feet in length. Many other genera and species of fishes which were possessed of large fin-defences occur in the limestone on the banks of the Avon.

The limestone at Armagh, in Ireland, contains a large number of teeth, which from their peculiar angular margins and flat surfaces, have evidently occupied the mouth of the fish with a flat pavement-like arrangement. This form of dentition is admirably adapted for preying on animals enclosed by hard shells like the mollusca. Perhaps the most characteristic teeth of the Yorkshire Limestones are those of Petalorhynchus and Pristodus, the dentition of the latter resembles that of the peculiar fish Diodon, now living in the seas under the warm rays of the tropical sun. In Diodon, each jaw is occupied by a single tooth which extends over the palate as well as envelopes the outer margins of the jaws.

Besides the fishes mentioned, which appear to be localized and peculiar to certain districts, there are many others which are common to all of them. Groups represented by the twisted teeth of Cochliodus, the pavement-like teeth of Psammodus, and the sharp-pointed, shark-like teeth of Cladodus, are found in greater or less abundance in all the localities where fossil fishes have been discovered.

The larger proportion of the fish-remains of the Carboniferous Limestone appear to be restricted to the formation; they are not found in the earlier strata of the Old Red Sandstone or the still older Silurians. The fishes found in the Old Red are comprised in the externally armour-plated fishes of which Coccosteus may be taken as the type, and the thick, enamel-scaled fishes represented by Cheirolepis, Acanthodes and Osteolepis, all of which are ganoids. In the Mountain Limestone, Ganoid fishes are almost entirely absent, being represented only by a few plates of Cœlacanthus from Armagh; unless it shall be found that the various-shaped pustulate plates of Oracanthus represent the external armour of a fish allied to Coccosteus.

The great Elasmobranch fishes, armed with dorsal fin-spines of great power, for either offence or defence, became of great importance during the limestone era, they are represented in earlier formations only by the small spines of Onchus in the Silurians. In later formations some of the Limestone Elasmobranchs are represented by descendants in the genus Ctenacanthus; others may also possess characters more or less common to the genera of both formations In the shales of the coal measures, ganoid fishes of very large size such as Rhizodus and Megalichthys become of frequent occurrence, the rare Cœlacanthus of the limestone, in the Cannel coal becomes an extremely abundant genus, and several placoid fishes possessing characteristics quite different from those of the Mountain Limestone becomes tolerably abundant. The Acanthodians, which were common in the Old Red Sandstone strata, but absent from the limestone, again put in an appearance in the coal measures. The great majority of the limestone fishes, however, are not found in the coal measures, the great group of Copodonts and Psammodonts, the Cochliodonts and the last remnant of the Coccostean group, if Oracanthus be such, have all disappeared prior to the deposition of the coal measures.

It must not of necessity be supposed that the changes indicated above were of univeral significance, it is far more probable that they were due to circumstances more or less localized in extent. The Carboniferous Limestone is a deep water formation, and the fish-remains contained in its strata were doubtless those of the fishes which inhabited those deep waters, but the Old Red Sandstone formations were accumulated in much shallower water, probably in many cases formed the shore during the deposition of the Limestone in the deep waters beyond, the fishes found fossil in those beds, may naturally be expected to differ in character from those of the deep water. The Coal measures again are the result of deposits of sand and mud brought from the land by streams either to an estuary of the sea or inland lakes, in either case, the piscine fauna may be expected to exhibit peculiarities totally different to those of the fauna of the Limestone.

It is proposed after giving the list of fishes found in the Yorkshire Limestone series which immediately follows, to consider the relationship they appear to possess with other fossil forms, and their zoological position with regard to allied fishes now existing, and to draw such inferences therefrom as may seem desirable.

Cladacanthus paradoxus, Agass.	Leyburn.
Physonemus arcuatus, Agass.	„
Cladodus mirabilis, Agass.	„
„ striatus, Agass.	„ Settle
„ basalis, Agass.	„
„ Hornei, Davis.	„
„ mucronatus, Davis.	„
Pristicladodus dentatus, McCoy.	„
„ Goughi, McCoy.	Kettlewell.
Glyphanodus tenuis, Davis.	Leyburn.
Orodus ramosus, Agass	„
„ Reedi, Davis.	Richmond.
Lophodus reticulatus, Davis.	Wensleydale.
Diclitodus scitulus, Davis.	„
Cochliodus contortus, Agass.	Leyburn.
Deltodus aliformis, Agass.	„
Deltoptychius acutus, Agass.	„
Psephodus magnus, Agass.	Settle.
Pœcilodus Jonesii, Agass.	Leyburn.
„ sp., nov.	„
Pleurodus Woodi, Davis.	Leyburn, Richmond.
Psammodus rugosus, Agass.	„ Settle.

Dimyleus Woodi, Agass.	Leyburn.		
Petalodus accuminatus, Agass.	„	Settle,	Richmond.
Polyrhizodus, sp.?	„		
Petalopsodus tripartitis, Davis. ...	„		
Ctenopetalus serratus, Agass.	„		Richmond.
Petalorhynchus psittacinus, Agass. ...	„		
Pristodus falcatus, Agass.	„		
Megalichthys, sp. ?	„		

The whole of the fish remains enumerated above are comprised in the sub-class, *Palæichthytes* as defined by Dr. Gunther. The sub-class includes two orders, the Chondropterygii and the Ganoidei. The latter is equivalent to Prof. Huxley's Ganoidei and Dipnoi, whilst the former comprises the Elasmobranchii of Prof. Huxley's classification and includes the sharks, rays, and chimeras. The order Chondropterygii is divided into two sub-orders: Plagiostomata, comprising the sharks and rays, and the Holocephala, the chimeras. The Elasmobranch fishes of the Mountain Limestone are all included in the Sub-order Plagiostomata. The remains of these fishes which have been preserved are always in a disintegrated condition and consist of detached teeth or spines. A slight consideration of the anatomy of an existing shark will at once explain the reasons why this is so. The framework of a shark is cartilaginous; the mandibles, skull, supports for the fins, &c. are each unossified, though well developed; and the vertebræ are also in many cases cartilaginous though various modifications occur. In some there is a slight ring of bone imbedded in the cartilage, in others the whole of the vertebra is ossified. The vertebræ of the plagiostomous fishes whose remains are found in the Carboniferous Limestone appear to have been entirely cartilaginous, for hitherto no trace has been found of their preservation. The only parts of the fish which have been preserved are the teeth, the spines which occupied positions in front of the dorsal or pectoral fins, and occasionally patches of the dermal covering like shagreen. The organs on which, since the researches of Johannes Müller, modern classification has been based—the heart, the spiral intestine and the optic nerves, have entirely disappeared, and it is only by comparison of the parts preserved fossil with similar ones in existing fishes that we are enabled to affirm that as in the recent fish, the teeth, &c. bear functional relationship with the soft parts of the fish, so in the fossil state similar teeth must have borne a corresponding relationship with the parts of the fish which have disappeared. That the remains which are preserved should be mixed up in almost inextricable confusion is not remarkable when it is remembered that after the cartilaginous portions of the fish, which connect its several hard parts, have become decayed, the latter, each separated from the other, are liable to be washed hither and thither by every tide or current, and to become widely separated and intermixed with remains of other fishes so that it is an occurrence of extreme varity to find even the teeth of a fish in so happy juxtaposition that they can be identified as pertaining to the same individual.

In attempting to trace the affinities and relationships of fossil fishes to recent forms the divergence between them is in some cases apparently slight, whilst in others, characters are developed which, unless they be regarded as connecting links between an older fauna and the present one, are inexplicable. So far as there is any evidence at present known, the Lower Silurian and all preceeding formations are devoid of fish remains; from which it may be inferred, that the advent of fishes took place during the deposition of the Upper Silurian Strata. During the succeeding Devonian and Old Red Sandstone age, immense numbers of fishes swam in the seas. In size they were little inferior and in structure they were scarcely less highly organized than the fishes inhabiting the waters at the present day. Notwithstanding this, they present many peculiarities which have long since disappeared and been replaced in following ages by others, again to flourish for a while and in their turn disappear. The fishes of the earlier formation whilst perfectly organized present a much simpler fauna than in succeeding ones, and whilst the number of individuals may have been as large as during any succeeding age, the diversity of form, which for convenience of reference we designate by the terms genera and species, has greatly increased; and at the present time the repeated divergence of the original forms through succeeding ages has produced an almost endless variety, infinitely greater than at any previous portion of the history of the world. It is more than probable that this great variety of forms has been produced by repeated slight differentiations from the parent stock, which, rendering the offspring better capable of adaptation to an altered environment, or presenting some feature more readily transmitted has gradually modified the species until all trace of relationship with its first parents is lost. It is for this reason, amongst others, that the study of fossil forms is essential to a thorough knowledge of existing fishes; the characters found in different families of the latter, now quite distinct, were originally combined or blended in the earlier fishes, so that the fossil fishes form links in an almost endless chain, which renders their study of intense interest to the modern biologist. The imperfections in this developmental chain are great; but every new addition to the knowledge of fossil ichthyology, derived from new or well preserved specimens, serves to throw additional light on the subject and to render a complete elucidation of the relationships of living species more possible.

Until a comparatively modern epoch the group of fishes with a bony skeleton, the Teleostei, which form by far the largest portion of existing fishes, is not represented in a fossil state, their first appearance being during the deposition of the chalk. The Plagiostomata or sharks have been represented from the earliest times to the present. Traces of this group are first observed in the Upper Silurian rocks of Ludlow, and they have continued to exist in greater or less profusion through every succeeding geological epoch. In the Carboniferous series of rocks the number of species already discovered is very large, and comprises a considerable variety of plagiostomous fishes which have since disappeared. Prof. Agassiz considered that a large proportion of the Carboniferous fishes bore a greater resemblance to the Cestracion, or Port Jackson Shark, than to any other existing genus; the latter is represented by one or two existing species only, and appears from its comparatively small numbers and localized extent to be almost on the point of extinction. An important characteristic of the sharks of the older geological ages lies in their possessing, to a much larger extent than at present, large fin-spines, in many instances highly ornamented.

The Ganoidei, which comprises an enormous assemblage and great variety of fishes in the ancient geological periods, is now reduced to a comparatively small number of species inhabiting the rivers of America and Africa, and the sturgeons which are marine. The typical ganoid, represented by the Garpike (Lepidosteus) of the American rivers, or the fossil Megalichthys, is covered with a coat of rhomboidal, thick, bony scales, with an enamelled surface. There are however, many exceptions to this character, and the living Amia of the American lakes, covered with thin imbricated scales, is devoid of enamel, they are of small size, very similar to some of the bony fishes.

The groups of fossil fishes found in the Yorkshire Limestone Series included in the sub-order *Plagiostomata* are the following.

Hybodontidæ,	represented	by	Cladodus, Pristicladodus and Glyphanodus.
Orodontidæ	,,	,,	Orodus, Lophodus and Diclitodus.
Cochliodontidæ	,,	,,	Cochliodus, Deltodus, Psephodus, Deltoptychius and Pœcilodus, (perhaps Pleurodus.)
Petalodontidæ	,,	,,	Petalodus, Polyrhizodus, Petalopsodus, Ctenopetalus, and Petalorhynchus.
Psammodontidæ	,,	,,	Psammodus.
Copodontidæ	,,	,,	Dimyleus.
Ichthyodorulites	,,	,,	Cladacanthus and Physonemus.

Besides these, the teeth of the genus Pristodus, which cannot be included with any of the above groups, but whose affinities seem to lie in the direction of the Plagistomata, is very abundant in the upper bed of the series and is peculiar to this district.

In other localities the group *Hybodontidæ* is represented by several genera of spines which bear a greater or less resemblance to the Hybodus of the Lias. Amongst the most formidable of these are the spines of Ctenacanthus and associated with them the teeth called Cladodus. It has been thought probable, from the spines of Ctenacanthus and the teeth of Cladodus occuring together with considerable frequency, that they may have been co-existent in the same fishes. It is well known that the spines of Hybodus of the Lias were associated with teeth to which Cladodus bear some resemblance. The latter differ from Hybodus in the cusps produced from the surface of the crown being longer and sharply pointed; in other respects they are similar. A peculiar circumstance in connection with this group in the Yorkshire Limestone is that, whilst the teeth of Cladodus are represented by five or six species, some of which, like C. strait-us, are very common; there has hitherto been no specimens of Ctenacanthus discovered. The teeth occur in the thick-bedded limestone of Settle and Giggleswick, examples from the quarries in the neighbourhood may be seen in the Museum of the Grammar School of the latter place; they also frequently occur in some of the thin limestones in Wensleydale, comprised in the Yoredale series of Prof. Phillips, and in the limestone quarries in the neighbourhood of Richmond, but in none of these localities have the spines of Ctenacanthus been discovered. Considering the large numbers of teeth of Cladodus which have been found, and the absence, hitherto, of any evidence of spines, even approaching in character to Ctenacanthus, negative evidence of considerable weight is afforded that the two genera were not so closely related as has been suggested, or at any rate, that the teeth of Cladodus may have belonged to a predaceous fish unprotected by fin-rays, in the Carboniferous area in this district.

The genius Pristicladodus is in many respects similar to

Cladodus, it is a thicker and stronger tooth with only one lateral cusp on each side the large central one. The name was given originally by Prof. M. Coy to teeth from the Limestone of Derbyshire. Glyphanodus is a very peculiar species, the teeth are excessively thin and compressed, the crown consisting of a single median cone with a chisel-like edge, sharp and smooth. The base descends co-extensively with the crown and resembles that of the Petalodonts more than Cladodus which usually extends in a more or less horizontal direction backwards; the crown of the tooth is however, much more closely related to Cladodus than the Petalodonts, possessing characters which would associate it with both genera it may perhaps be looked upon as a connecting link between the two. It has been found only in Yorkshire.

The teeth comprised in the group *Orodontidæ* have a very wide distribution both in the British Islands, on the continent of Europe, and in America. Those found in Yorkshire comprising two species of Orodus are small and comparatively rare; there is also one species of Lophodus and a new genus Diclitodus. The latter has only been found in Yorkshire, it differs from the genus Orodus in possessing two equal cones raised from the crown; in other respects it bears a considerable likeness to the Orodonts and has been placed provisionally amongst them.

The Orodonts in the Limestones of Bristol and Armagh are very much larger in size than the Yorkshire ones but it is rarely that two or more teeth are found in juxtaposition though two or three instances have occurred in which three or four teeth have been connected together in such a manner as to leave no doubt that they still retained a natural position. Though examples are rare in this country of specimens which exhibit the arrangement of the teeth on the jaws, American palæontologists have discovered at Osage, County Kansas in America, an extremely well preserved series of teeth which illustrate the whole dental arrangement. The teeth are from the coal measures and are described in "Palœontology of Illinois" Vol. VI. p. 311, by

Messrs. St. John and Worthen. Though very closely related to Orodus the authors consider that minor differences are sufficiently distinctive to form the new genus Agassizodus for the accommodation of the specimens. About four hundred and fifty to five hundred teeth comprised the whole of the left ramus of the lower jaw and a portion of the right one. In their description of this remarkable specimen the authors state that "the articular extremities of the jaw are not preserved, though fragments of the substance of the cartilage are scattered through the rock mass upon which the teeth are imbedded. These cartilages were doubtless comparatively thin, the outer and inner folds giving way to the pressure which flattened the rami, as shewn in the present condition. The teeth are disposed in serial rows having a convoluted inrollment from the inner to the outer border, and gradually increasing in size from the posterior extremity to the row of large median teeth, anterior to which the rows as regularly diminish in size towards the symphysis," the posterior portion of the jaw has six to nine rows of teeth similar in form to, but of smaller size than the teeth of the median portion. The middle portion of the ramus is occupied by a row of proportionately very large teeth which differ from the posterior teeth in having the crown produced into a strong, obtusely conical excentric prominence which culminates at a point more or less posterior of the middle of the tooth, whilst the posterior teeth are devoid of any defined median keel. The anterior portions of the teeth are very similar to those situated posteriorly of the median row. There are eight to nine rows, and contrary to the posterior ones they gradually diminish in size anteriorly as they approach the symphysis of the jaw. In the extreme anterior rows the teeth assume considerable diversity of form, and there are a number of minute, nearly circular teeth which exhibit in the form of the crown, and its sculpturing a strong likeness to Petrodus. "Generally considered, the teeth present the closest affinities with *Orodus* Ag., a group prevalent in the Lower Carboniferous formation." But the present group of teeth is distinguished by the prevailing prominence of the buttressed condition of the anterior coronal borders, and the relative uniformity or evenness of the posterior face, besides the relatively fewer rows of acuminate teeth, as inferred from this feature being so prevalent in all collections of Orodi, while the linear forms are least commonly met with. The authors also state that in addition to the teeth and pieces of cartilaginous matter which appear to have formed the supports of the jaws, there were a number of exceedingly small bodies "irregularly circular in outline, with a depressed convex coronal portion, which rises into an eccentric acumination or transverse ridge along one side, and delicately sculptured with irregular carina radiating from the apex towards the marginal borders." Below they are concave. No two specimens appear to be exactly alike, though they have a general resemblance, especially in the dark horny luster of the enameled crown, by which they are readily distinguished from the teeth with which they are associated. It seems not improbable that these minute bodies constituted part of the dermal covering or shagreen of the fish.

The description of the fossil Agassizodus from the Kansas coal measures bears a close resemblance to the description given by Prof. Owen of the dentition of the modern Cestracion, and as the subject forms one of the few rare instances in which one of the earlier plagiostomous fossil fishes can be reliably compared with an existing form, I venture to give Prof. Owen's description as follows, "The teeth at the anterior part of the jaws are the smallest; they present a transverse, sub-compressed, conical figure, with the apex produced into a sharp point; these points are worn away from the used teeth at the anterior and outer parts of the jaw, but are strongly marked in those which still lie below the margin. There are six subvertical rows of these small cuspidate teeth on each side of the jaw, together with a median row close to the symphyseal line; and from twelve to fourteen teeth to a row. Behind the cuspidate teeth, the five consecutive rows of teeth progressively increase in all their dimensions, but principally in their antero-posterior extent; the sharp point is converted into a longitudinal ridge, traversing a convex crushing surface, and the ridge itself disappears in the largest teeth. As the teeth increase in size, they diminish in number in each row; the series of the largest teeth includes from six to seven in the upper and from seven to eight in the lower jaw Behind this row, the teeth, although preserving their form as crushing instruments, progressively diminish in size; while at the same time the number comprised in each row decreases. From the oblique and apparently spiral disposition of the rows of teeth, their symmetrical arrangement on the opposite sides of the jaw, and their graduated diversity of form, they constitute the most elegant tesselated covering of the jaws which is to be met with in the whole class of fishes" (Odontography, page 51). A comparison of the two forms shews how small is the difference between them, both in the characters of the teeth and in the form of arrangement. The arrangement of the fossil is almost exactly similar to the appearance which would be presented by the teeth of Cestracion if they were spread out and compressed. The most striking difference between them lies in the more obtuse arrangement of the anterior portion of the jaw of Agassizodus. It may be naturally inferred that Agassizodus and the Orodonts generally, like the living Cestracion, fed on Molluscs and other animals which were protected by, or encased in hard shelly coverings, the arrangement of the flat crushing teeth admirably adapting them to break or crush the hard substances in order to extract the animal. The size of the fossil Orodonts may be inferred from a comparison with the existing species. The Cestracion found off the the shores of Australia is two to three feet in length and the jaws from three to five inches, the jaws of Orodus ramosus were probably three feet in length, and this would give the length of the fish at about thirty feet, a truly formidable creature.

The modern Cestracian is possessed of two defensive spines, one before each dorsal fin, but there is no evidence to shew whether the fossil Orodonts had such spines; the discoveries of further examples may serve at some future time to shew whether they had or not: so far as the evidence of the specimens found in Yorkshire goes, it would seem to indicate that they were not so defended.

Several species of the genus Lophodus have been found in the upper beds of limestone in Wensleydale. The genus was originated by M. Rowanowsky, in 1864 ("Bull. de la Soc. Imperial des Naturalists de Moscow," p. 160), and embraces the teeth of fishes which are closely allied with Orodus but present several features which had hitherto been considered to be characteristic of Helodus. Lophodus comprises teeth in which the crown of the tooth is more or less conical in outline with a corresponding concavity of the base, whilst in the teeth of Helodus there is no such concavity, and the crown, somewhat expanded laterally over the base, rises up from all sides to the apex. The base of the crown in Lophodus is contracted on each side and curved inwards to the root.

The Cochliodontidæ are well represented in the Yorkshire limestones, so far as number of genera goes, but the number of specimens found have not been very great. The genera comprise species in Cochliodus, Deltodus, Deltoptychius, Psephodus and Pœcilodus; they differ very considerably from each in many minor peculiarities, but they agree in others of greater importance. The distinguishing characteristic of the group is, that the teeth "grow or increase in size, not as in most fishes by the old and worn teeth being replaced from behind or below, but by continuous or repeated additions to the inner or posterior margin of the surface of the tooth, so that the same tooth is always increasing in size with the growth of the fish, and assumes an inrolled or convoluted form. An analogue of this pecular growth is seen in that of the testaceous covering of the mollusca, which though it assumes a wonderful variety of forms, increases in size by the addition of repeated layers to the open margin of the shell."* The genera Cochliodus, Deltodus and Deltoptychius exhibit a distinctly inrolled appearance in a transverse section, whilst Psephodus and Pœcilodus are flatter and increase in size by the radial expansion of the triturating surface. Hitherto, the complete dentition of any member of the group has not been found, but specimens of several of the genera shew that there were three teeth on each jaw; those in front which approached and joined at the symphysis of the jaw were the smallest, and the second and third pairs increased in size backwards. Those situated most posteriorly are expanded so as to form a wide, more or less convex surface, admirably adapted for crushing and triturating vegetable substances for food, which in all probability formed the principal part of their sustenance. The teeth were attached and partially imbedded in a strong cartilaginous jaw, which possibly extend inwards as to form a palate to which other teeth may have been attached. That teeth similar to those hitherto named Helodus may have occupied the central portion of the palate, is rendered probable by the discovery in some of the American strata of specimens of Cochliodus and Helodus in close apparent relationship, though the specimens found in this country have not indicated such a combination.

As already stated, the teeth of Cochliodus have a distinctly inrolled or helicine configuration whilst those of Psephodus are much flatter and very slightly curved. The latter vary greatly in size, as well as to a smaller extent, in form. The teeth of Cochliodus have been found not only connected together but the teeth of the two rami of the jaws united by their cartilaginous supports; the teeth of the Psephodus, however, have not been discovered so united, but their arrangement has been proved to be similar to those of Cochliodus by the peculiarly concave under surface. If one of the largest teeth be examined it will be found that the widest posterior edge is rounded, whilst the opposite edge

* Proc. Roy. Soc. Dublin, New Ser. Vol. I., p. 415.

of the tooth is more or less straight and rectangular, corresponding with this arrangement of the crown, the under surface, which was attached to the jaw, is seen to be concave, the concavity forming a channel or grove, widest at the rounded posterior extremity of the tooth, and diminishing in diameter as it approaches the straight edge. Median teeth may be selected which exhibit a similiar decrease from the back towards the front of the tooth in the channelled inferior surface whilst both margins are more or less straight. The widest end is equal in diameter to the narrowest of the previous tooth, and it diminishes forwards and is connected with a third and still smaller tooth which occupies the space between the median and the sympysis of the two rami composing the jaw. The inferior channel on the third tooth diminishes still more in diameter, and near the symphysis is almost attenuated to a point. In each tooth there is the characteristic convolution. One or two specimens have been discovered with long, narrow teeth attached in front of the teeth on each side the symphysis more or less resembling those called Helodus; it appears probable that these were attached in front of the anterior pair of teeth, which are small and narrow, in order to seize and secure their prey with greater facility; it is also possible that there may have been other smaller teeth distributed over the median portion of the palate.

The teeth of the other genera, Deltodus, Deltoptychius and Pœcilodus appear to have been arranged with modifications to suit their several peculiarities in form, in approximately close relationship with those already described. For the most part they had three teeth increasing in size backwards, as indicated by the channelled surface attached to the cartilaginous jaw, but it is probable that the teeth of the upper jaw of Deltodus and Deltoptychius existed singly, in this respect approaching the arrangement in the jaws of Ceratodus. The teeth in both jaws of Pœcilodus may have been single.

The Cochliodonts have been regarded by Prof. Owen and others as based on the type of the modern Cestracion or Port Jackson shark, differing from it, however, in possessing few and large teeth in place of a greater number of small ones. Prof Agassiz in the third volume of his Poisson's Fossiles, p. 113, regards Cochliodus as nearly related to Ceratodus; and considers that the relationship proves that Ceratodus is a plagiostomous shark, both being closely related to the genus Cestracion. Since Prof. Agassiz penned his description, an existing representative of the Ceratodus has been discovered in the mud-fish of Australia, whose dentition is in every respect similar to the fossils described by Prof. Agassiz. The relationship of the living fish is proved to be with the Ganoids, and it is not improbable that the Cochliodonts of the Limestone Formations may eventually be found to be much more closely related to the Ceratodus than to the Cestracionts. The dentition of Orodus and the American genus Agassizodus have been shewn to be very closely related to the living Cestracion; they were co-existent with the Cochliodonts, and it is extremely improbable that they were closely related; in arrangement and adaptation for feeding they are quite different from each other, the Cochliodonts for vegetable feeding and the Cestracionts to prey on Mollusca, &c.

The teeth of the Pleurodus Ag. occur in the Limestone in Wensleydale with considerable frequence. They are small, and in all probability are a different species to those found in the coal measures. Though this genus possessed a cartilaginous skeleton, its remains have been discovered in the shales of the coal measures at Newsham in Northumberland, and in those of the West Riding of Yorkshire, so well preserved that the form of the fish could be ascertained. It was four inches to a foot in length, having a deeply rounded and flat body with a spine in front of the dorsal fin immediately behind the occiput about one third the length of the body, one half the length of the spine was probably buried in the integuments of the fish. In the Newsham specimen the position of the spine and the form of the fish are clearly indicated by the expanse of chagrin or dermal tubercles which has remained quietly in position; at the anterior extremity ten or twelve teeth indicate the position of the head. Supposing the number of teeth to have been twelve, there would be three to each ramus of the jaw, which is the same number as in the Cochliodonts. The teeth of Pleurodus are not unlike those of Pœcilodus in form, and surface configuration, and it is within the range of possibility that there may be some relationship between the members of the Cochliodont group and Pleurodus, though it may be advisable to withhold a detailed expression of opinion until more extended observations shall have been made.

The representative of the Psammodontidæ occurring in Yorkshire are not numerous, and are small compared with those of Bristol and Armagh. They possess the usual characteristics of the group, and formed a flat pavement-like arrangement in the mouth admirably adapted for crushing the hard coatings of testaceous animals. Prof. de Koninck in his description of the Fossil Fauna of Carboniferous Limestone of Belgium, has suggested that the teeth were arranged so as to cover the whole of the palatal surface of the mouth; the square massive teeth being joined at their edges, and having on each side and in front smaller teeth, in some cases somewhat triangular in outline, to fill up the rounded conformation of the jaws.

Associated with the Psammodonts are smaller teeth, similar to them in being flat on the surface, but dissimilar in other respects. They were named by Prof. Agassiz, but not described, as Dimyleus Woodi, from specimens contributed by the late Mr. Wood of Richmond in Yorkshire, to the Enniskillen collection. At Armagh many other genera of fish-teeth have been found, which closely approximate with those of Dimyleus found in Wensleydale. A careful study of the whole group shows that they are distinct from the Psammodont family. They have therefore been grouped together as a distinct family, Copodus being regarded as the typical genus, they are termed the Copodontidæ.

Perhaps the most remarkable group of fish-remains found in the Yorkshire Limestone is comprised in the Petalodontidæ. The group was instituted by Messrs. Newberry and Worthen (Geology and Palæontology of Illinois, vol. ii, p. 31), and embraces several genera of fishes known only by their teeth, and so far as at present discovered, confined to the Carboniferous series of rocks. The genera which occur in this county are Petalodus, Agass; Petalopsodus, Davis; Polyrhizodus, McCoy; Ctenopetalus, Agass; and Petalorhynchus, Agass.

The genus Petalodus is represented by the well-known species Hastingsiæ and acuminatus. The latter is fairly abundant and frequently of large size, but otherwise the genus does not offer any features of peculiar interest. Polyrhizodus is represented by only one small and very rare species. This genus frequently occurs in the Limestone of Ireland, and appears to be of sufficiently diversified and well defined character to necessitate the formation of at least six species. The teeth are in many respects similar to those of Petalodus. The strong, well-developed crown with a sharp cutting-edge is equally characteristic of the two genera; the principal difference consists in the formation of the basal portion which was inserted in the jaw of the fish; in Petalodus the base is composed of a single massive root, whilst in Polyrhizodus, as implied in the name, the root is divided into a number of radicals or rootlets, varying in number from four or five, to sixteen or twenty. This character of the root of Polyrhizodus is very peculiar, and does not occur in any other group of fishes, either recent or fossil. The teeth of most of the Plagiostomous fishes are simply attached to the jaw by their under surface in a somewhat loose manner, and as might be supposed, not being firmly implanted in the jaw, but only *on* it, they are easily displaced. To compensate for this liability to loss, the fishes are provided with several rows or series of teeth, which until required, are arranged on the inner side of the jaw, their sharp edges pointing towards the palate. On the displacement or breakage of the teeth in active use, they are replaced by others from the reserve; this character obtains in all the Squali or sharks properly so called. In other groups with a flat and crushing dental arrangement, the old teeth are replaced by new ones which grow underneath them, or like the Cochliodonts, the old portion becomes inrolled on the jaw and a new surface is produced by additions to its lateral edges as already explained. The Petalodonts were very differently attached to the jaw; a strong and deeply-imbedded attachment to the jaw gave them a solidity more analogous to some of the Teleosteans, as for example, Sargus, or the higher vertebrates, than to the sharks, and in this respect the genus Polyrhizodus is more distinguished than its fellows by having the roots divided, and by that means being still more firmly attached to the jaw.

The genera Ctenopetalus, Ag., and Petalopsodus, Davis, are distinguished, the first by its serrated or crenated cutting surface, and the latter by having the coronal edge divided into three distinct and almost equal parts, each rising to a finely pointed apex. The root is not divided. The remaining representative of the group, the Petalorhynchus, Agassiz, is much the most abundant and has been found in large numbers. It is also very fortunate that several specimens have been discovered which throw considerable light on the general dentition of the genus. It is now known that the teeth were arranged in a semicircle conforming to the shape of the jaw in which their long roots were deeply implanted. The root in the older teeth is frequently four times the depth of the height of the crown. The crown has the usual Petalodont character, except that its central portion is produced and pointed, and is slightly bent inwards so as to resemble the pointed beak of a parrot. One central tooth was implanted on the symphysis of the two rami of the jaw, and on each side there extended three others, making a total of seven to each jaw. Specimens have also been found shewing how the teeth are replaced by successive larger growths, as the mouths of the fishes has increased in size. From these it appears that originally there was a single row of small teeth extending along the surface of each jaw, that, as these become worn and the fish increased in size, they were replaced by a set of larger teeth from the inside of the mouth, somewhat similarly to the increase in the sharks, except that the earlier row of teeth instead of becoming detached, adhered to the second or new row, and becoming firmly cemented to them served to strengthen and support them. In this way successive additions were repeatedly made, each additional row by its increase in lateral extent as well as in length being proportionate to the increased growth of the jaw. Specimens have been found with five such rows, all firmly cemented and adhering to each other.

The peculiar constitution of the jaw and teeth of Petalorhynchus with the median teeth over the symphysis of the jaw is aberrant from the usual type of the Selachians, and it has to this extent some affinity with the Rays. Messrs. Hancock and Atthey have pointed out the relationship of Climaxodus, McCoy, and Janassa, Münster, in a paper in the "Natural History transactions of Northumberland and Durham, vol. iii., pt. II., p. 330." The arrangement of the teeth of those fishes is very similiar to that of Petalorhynchus, they extend, however considerably more in a horizontal direction, over the palate of the mouth, and in addition to the sharp cutting-edge of the extremity of the tooth, the crown was developed so as to form crushing or triturating surfaces. The authors after a minute description of the specimens arrive at the conclusion that Janassa, Münster, approaches somewhat in character to Myliobates of the newer formations, which have a broad tooth occupying the median portion of the mouth with three rows of smaller teeth on each side extending from the extremity of the jaws inwards over the palate. Should this relationship be established and confirmed by the discovery of intermediate species, an interesting evolutional series may be traced from the Petalodonts of the Lower Carboniferous Limestone, through Chinaxodus of the upper beds of that series, the Janassa of the Permians, to the Myliobates of the newer formations to the members of that genus which still exist in the seas of the present time.

Before leaving the consideration of the relations of the Petalodont family to other groups of fossil or living fishes, it may be worth while to note the somewhat peculiar resemblance possessed by some members of the genus *Sargus*, at present existing in the warmer sub-tropical seas. Taking as an example *Sargus Rondeletti*, Cuv. and Val., the teeth present an extremely interesting arrangement. Along the anterior extremity of each ramus of the jaw there are four teeth, deeply rooted or implanted in the strong bony framework of the jaw; the portion of the teeth forming the root, and extending some distance beyond the surface of the jaw, is broad antero-posteriorly and somewhat contracted laterally; nearer the apex, however, the tooth becomes laterally expanded, spreading out into a spatulate concavo-convex crown, terminating in a thin straight cutting edge, with highly polished enamel surface and very sharp. The largest teeth are on each side the symphysis of the two rami, and occupy the central portion of the jaw, those on each side decreasing in size backwards, the posterior teeth being less than half the length or breadth of those in front but still preserving the same characters. The resemblance to the Petalodonts is probably merely an accidental one. They differ in the arrangement of the median teeth which are separated by the simphysis of the jaw, and do not extend across it as the Petalodonts do. Sargus lives in the waters on the coast of Madagascar, and its spatulate teeth are admirably adapted for seizing molluscs like the limpet which adhere strongly to the rock or other substance on which they exist. The resemblance may at least indicate a parallel in the food of the two genera.

Pristodus falcatus, Agassiz, occurs frequently in the upper beds of the limestone series of Yorkshire. A single tooth appears to have enveloped the whole of the upper or lower jaw to which it was attached, and extended along the palate and floor of the mouth inwards, so that the two teeth fit each other. The external edge envelopes the jaws, that of the upper jaw being extended downwards so as to considerably overlap the lower one. The extended edge forms a cutting surface which is toothed like a saw with the largest denticles in front and gradually diminishing in size backwards. The tooth of the lower jaw is devoid of denticles; it is raised in the centre of the external edge in the form of a single point, which fits a corresponding hollow inside the margin of the upper tooth. The pair of teeth present a resemblance to the beaks of a parrot, in the manner in which they fit to each other.

Amongst the fishes of the primary or secondary rocks there is no other genus known which approaches in form and character to Pristodus. Amongst living fishes the Diodonts offer a somewhat close resemblance to it. Diodon is an inhabitant of tropical seas; the fishes are sometimes called "sea hedgehogs," they are covered with a thick skin without scales, over which are distributed a large number of spines. They have the power of inflating the body, and assuming a globular form their spines become extended, like those of a hedgehog. Their jaws consist of a single undivided plate, and are admirably adapted for breaking off branches of corals, from which they principally obtain their food. Fossil remains of Diodon have been found in the tertiary limestones of Monte Bolca. The Pristodus of the Carboniferous Limestone agrees with the recent Gymnodont Diodon in its dentition, but there in all probability the resemblance ended. The recent fish has a bony skeleton and is covered with bony spines, the fossil was apparently cartilaginous, and no spines have been found which at all resemble those of Diodon. It is very likely that the similarity of the dentition may indicate a similarity of diet, the remains of coral are abundant in the limestone.

In addition to the genera of fossil fish-remains already mentioned and which have been previously described, there are others which have not received the same attention, but these in all probability may be included in one or other groups, already indicated. The peculiar spines, Cladacanthus and Physonemus, occur sparingly in the Limestone of Wensleydale. The relationship of these peculiar ichthyodoralites is little understood.

In conclusion—it may be drawn from previous observations, that the fishes occurring most frequently in the thick-bedded lower limestone of other parts of the British Islands are absent or only represented by dwarfed specimens. The great spines of Ctenacanthus and Oracanthus are not present. The great teeth of Orodus, most of the genera of the Cochliodonts, the large palates of Psammodus, and the teeth of the Petalodonts, have in each case become dwarfed and comparatively insignificant. They present the appearance of groups which have previously reached the climax of their existence and were gradually succumbing to a more or less unfavourable environment—with the advent of the coal measures they have almost entirely disappeared.

ON THE LEAD VEINS IN THE NEIGHBOURHOOD OF SKIPTON.

BY J. RAY EDDY, F.G.S.

Before directing attention especially to the subject of my paper, it is due to the Members to explain that it was first proposed that the Lead Veins in the Grit-beds of Craven should be considered, but ultimately the veins described by the present title were preferred. This change practically leaves me a somewhat barren subject, because the Cononley Lead Mine has been entirely abandoned for several years in the eastern part, and almost so in the western, and it is the only place near Skipton, where the regular working of a vein has been carried on.

A paper on the larger and much more interesting Mining field in Wharfedale may prove welcome on some future occasion when you may be inclined to extend your excursions to that district.

The main vein is part of a large "fault," the throw of which has never been truly ascertained by the miner, partly because the sides have been rarely seen, and further on account of the disturbed state of the strata where the walls of the vein have been proved. It is the most southern of all the lead producing districts of our county, removed some ten miles from the nearest mine, properly so called, and fourteen miles from those producing lead ore in the Grit-stone beds. These veins also proved the rare, perhaps the only exception in the investigations made by Mr. C. Moore, of Bath, which seems to establish the "existence of organic remains in the earthy matrix of mineral veins in the carboniferous rocks." Again, the main vein is the only one amongst the grit producing mines of Craven which has yielded lead ore in quantities commercially valuable, whilst traversing highly disturbed strata, and with accompanying masses of shale in the vein itself: the veins in the other mines requiring the beds to be comparatively regular to prove productive, and then as a rule becoming small and poor on the approach of the shale either as a "cheek" of the vein, or thrown in as a leader, or accompaniment of the vein.

The Cononley mines were worked very many years ago, certainly before the introduction of gunpowder into this district, but only to a shallow depth, except in one place. The workers were stopped in their progress by the combined drawbacks of too much water and too little lead ore. In one place however, on the crown of the hill, eastward, and near to Mason's shaft, they got down to the depth of our Upper Adit Level, or 24 fathoms from the surface at that point. Here the vein was poor.

Some time subsequent to 1830, Messrs. Hall, of Newcastle, began the deep adit level crosscut from a point in Nethergill, to the west of the village of Cononley, about 525 feet above the level of the sea, with the view of intersecting and draining the main vein at that depth. After driving through several faults and much disturbed ground for a distance of 90 fathoms, these gentlemen gave up the trial and the crosscut was continued on behalf of His Grace the late Duke of Devonshire. The vein was met with after a total drivage of 205 fathoms.

I will briefly state the principal levels and shafts in the mine before speaking of the nature of the vein itself. The deep adit driven east nearly to, and west to the ends of the mine: the middle level, 10 fathoms higher, originally driven from a rise eastwards and extended to near the east end, and westward beyond Taylor's shaft; the upper adit, 10 fathoms higher still, extending from the surface eastward the whole distance; and Briggs level, a superficial adit, begun at the surface east of the engine shaft and continued to the east end of the mine. Below the deep adit, the 15 fathom level was driven some distance east and west to a distance beyond Taylor's shaft, the 25 a short distance east and west of Engine shaft crosscut, and the 45 fathom level which extended but little from this crosscut. There is also an old adit crosscut driven from the south-west side of the hill in the Glusburn ground, with two small shafts upon it, but this does not communicate with the mine proper. The principal shafts are Taylor's, at the end of the main crosscut sunk to the deep adit level, eastward from this the engine shaft to the 45 fathom level below the deep adit; and Garforth's and Mason's shafts both sunk to the deep adit only. In this part of the mine an "inclined plane," or shaft, was extended from the surface to the deep adit eastward. Westward of the main crosscut are Remfry's shaft to the deep adit, and Good Hope shaft, which has of late years been sunk to a level about 10 fathoms below the deep adit.

At this, the western part of the mine, exists the only chance I know of at present for any further development of the Cononley Main Vein.

The principal crosscuts which have practically proved the worthlessness of the side veins north and south of the main fault vein are, eastwards, the old Glusburn adit crosscut, Brigg's crosscut, the middle level north and south, and the upper adit south; in the centre of the works the upper adit north, middle level south, deep adit north, and the 15, 25, and 45 fathoms crosscut south. In the west end, the deep adit south, and one north (not shown on plan).

Besides these works there have been drivages at the upper adit, middle level, and deep adit in the south vein which returned some ore under very different conditions to those observed in the main vein; and also an adit level driven and a shaft sunk into the Gib Hill, on a vein which never produced any ore; through this level and shaft—at a later date—the smoke from the smelting mill was conveyed for the purpose of facilitating a further condensation of the fumes.

The main vein has a general direction of 32° W. of N. Mag. varying from 45° W. of N. in the ore-bearing part of the lode to 27° W. of N. in the poor ends of the mine. The "underlie" or "hade" south-west in the latter is 20° from the vertical, and in the former about 10°. In depth, this vein should receive the south vein, which with a hade of 6° from the vertical to the north-east might have been expected to be a valuable feeder of the old vein, but both failing in depth this junction downwards has not been experienced.

Between the deep and the upper adits, the main vein varied in width from a mere joint to 5 or 6 feet; and in the bearing-length above the latter it increased in some parts to 20 feet wide or more, yielding ore in one place close to the surface clay.

Below the adit the good part of the vein produced lead ore to a depth of 8 fathoms, and a little to the 15 fathoms level under the adit, but practically the vein failed at the depth of 15 fathoms, or a total depth from the surface at the engine shaft of 50 fathoms.

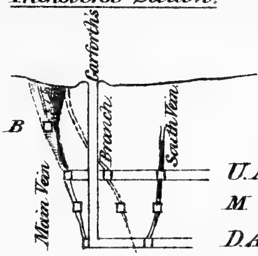
As will be seen from the plan the main vein was regularly productive for a comparatively short length of ground, the whole of the lode driven on east and west proving unremunerative, though not entirely barren.

In the productive channel of ground bounded by the main and south veins were several strings or smaller vein-branches, which leaving the old vein on its south side, robbed it, but not having strength to carry on to the south vein failed to enrich that lode east of the crosscut south of Garforth's shaft.*

* N.B.—On account of small scale of plan these strings and several other works are omitted.

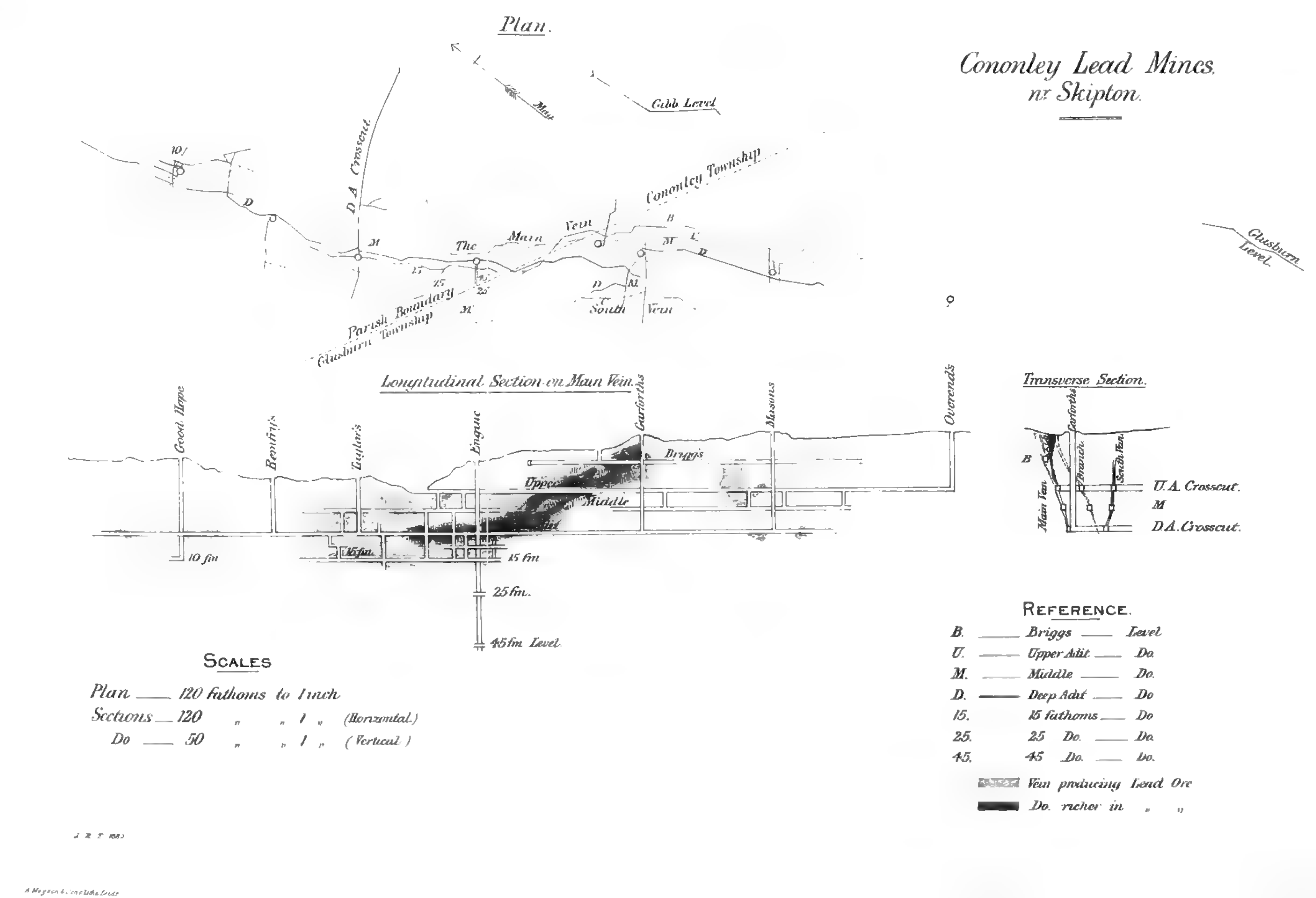
Cononley Lead Mines,
nr. Skipton.

Transverse Section.



Reference.

B.	——	Briggs ——	Level
U.	——	Upper Adit ——	Do.
M.	——	Middle ——	Do.
D.	——	Deep Adit ——	Do.
15.		15 fathoms ——	Do.
25.		25 Do. ——	Do.
45.		45 Do. ——	Do.
	▬	Vein producing Lead Ore.	
	▬	Do. richer in " "	



Cononley Lead Mines, nr. Skipton.
Plan.
Gibb Level
D A Crosscut
Cononley Township
The Main Vein
South Vein
Parish Boundary
Glusburn Township
Glusburn Level
Longitudinal Section on Main Vein.
Good Hope
Bentley's
Taylor's
Engine
Garforths
Masons
Overends
Briggs
Upper
Middle
10 fm
15 fm
25 fm.
45 fm Level.
Transverse Section.
Main Vein
Branch
South Vein
U. A. Crosscut.
M
D.A. Crosscut.
Scales
Plan — 120 fathoms to 1 inch
Sections — 120 „ „ 1 „ (Horizontal.)
Do — 50 „ „ 1 „ (Vertical)
Reference.
B. — Briggs — Level
U. — Upper Adit — Do
M. — Middle — Do.
D. — Deep Adit — Do
15. 15 fathoms — Do
25. 25 Do. — Do.
45. 45 Do. — Do.
Vein producing Lead Ore
Do. richer in „ „

The main vein above the upper adit widened out, and for a very short length on the north-west and near to Garforth's shaft was worked open to the surface.

The matrix of the vein being principally sulphate of barytes (heavy spar), and the substance of the wide part of the vein being intersected by "slants" or clay joints, the "stopping," or removing of this ground entailed considerable danger to the miners. In one part of the ground over the top level the vein-stuff was practically stratified, the matrix coming away in beds of one to three feet in thickness.

Besides the sulphate a lesser quantity of carbonate of barytes or "witherite" has been obtained. These with ochreous-marl, some calcite and much black clay have been the principal contents of this lode.

It is probably due to the large deposit of sulphate of barytes in the upper portion of this vein, that the water percolating through the mass of vein-stuff is so charged with sulphuric acid as to dissolve the good iron out of the tram rails, leaving the cinder in thin parallel plates as a tribute to the ability of the iron-master to manipulate other than good iron.

It is apparent that the main portion of the deposit of ore in this vein crops to the surface in the east-central part of the ground near Garforth's shaft, and dipping to the north-west is probably cut off by the "fault" known to range westwards, with the north side down.

The remainder of the deposit has been denuded and removed from the eastern and more elevated part of the ground, and I see no good reason for expecting that at any future time lead ore will be discovered in quantity further to the south-east.

The ore yielded by this vein was almost entirely the sulphide of lead, (or galena,) principally disseminated amongst the matrix of the vein throughout the width of the lode, and not often in solid masses. Being mixed with heavy barytes and some iron pyrites, the separation of the ore from the impurities was difficult, and its physical nature when prepared for the furnace made it most refractory in the smelting, very much more so than is usual in ores raised from mines in the same class of rocks.

The south vein—contrary to the characteristics of the main—had very little "throw," and regular cheeks or sides. It showed a north-east "underlie" of about 6°, and in the bearing part of the lode was of a width varying from a few inches to a foot. Its bearing is about 40° W. of N. Mag., bearing towards the main vein going westwards.

The junction, however, has not been seen in this direction, probably on account of the intervention of the "fault" before alluded to. This "fault" has not been recognised in the mine, for it is difficult and often impossible to see in the size of a level anything further than what appears a "backing" in the rock, whenever the "fault" is a mere joint.

The ore in the south vein was of a different nature to that from the main lode, being generally found loose in the vein, with little matrix, and that generally of friable carbonate of lime, with loose, dry, earthy mineral. In quality this ore was superior to that from the main vein, but unfortunately it fell far short in quantity.

The ore bearing zone was limited to a distance of about 18 fathoms, extending from the deep to a little higher than the upper adit, while in length the productive ground was still less than in the main vein.

In driving the middle level near Mason's shaft, the lowest part of the earliest works were met with, and in Brigg's level, east of Garforth's; a long length of old workings and a short crosscut were opened into. Here our predecessor had cut his ground with picks only, and every shift or day's-work could be accurately told by observation of the side of the level. Only in one place was a bore hole to be seen, and this was probably of a later date. The vein was filled with solid sulphate of barytes, but so hard that the modern miner had difficulty in even boring the ground. Probably the barytes had become somewhat harder by exposure to the air.

In the west end of the mine approaching Carleton Moor a trial has been in progress to trace the vein through the lower members of the Kinder-Scout grit into the limestone shales of the Carleton anticlinal. This has been a difficult matter, owing to the cross veins and the weakness of the right running veins. (Further trials in the western ground have shown considerable disturbance of the strata from the intersection of several "fault veins" in close conjunction, but though the mine has been closed I think the appearance of the vein just east of the disturbance justifies the hope that it would prove a productive one if it were explored west of the intersections, and in the settled beds which are known to exist there).

The total quantity of ore produced from the two veins is about 15,000 tons. The upper part of the old vein produced some carbonate of lead but not in quantity.

The only other places near, where any ore has been produced from the Kinder-Scout grit is at Cowling, about 1½ miles west of Cononley, where a trial was made and about 3½ tons of ore raised.

Trials were also made in the grit on Bradley Moor, and on Carleton Moor, but without success.

In the limestone of the district there are north and south veins running across theaxis of the Carleton Park-head and also of the Skipton Haw-Bank Quarries. From the former place, about 15 tons have been obtained, and from the latter, about 13 tons. These veins are very uncertain but carry ore of good quality in self lumps in the clay of the lode.

ON THE DISCOVERY OF FLINT IMPLEMENTS ON THE HILLS BETWEEN TODMORDEN AND MARSDEN. BY ROBERT LAW AND JAMES HORSFALL.

INCITED by the discoveries of Mr. J. W. Davis, Mr. John Aitken and others, a series of investigations were commenced by the writers in the Spring of 1879, to ascertain the distribution and mode of occurrence of Neolithic flints. The work has been carried on more or less successfully for three years. The places visited are the highest summits and most prominent hills in those parts of the Penine Range which lie within a radius of about twelve miles of Rochdale. The first locality visited was Dean Clough, a small upland stream about a mile north-east of Junction-in-Saddleworth, where one hundred and fifty flints were found; these consisted of chippings, flakes, one or two small cores and a beautifully worked barbed arrow tip. The flints were exposed on several small patches of dark stoney loam, the superincumbent peat, probably from ten to fourteen inches in thickness, having been removed by fire. Subsequent visits to this locality have resulted in the discovery of other flints, one of the most interesting being, an elegantly fashioned and most delicately chipped leaf-shaped arrow head, the point of which was long, sharp, and tapering (pl. III, fig. 2). It was found on the left bank of a small stream, about half a mile to the north of Dean Clough. This arrow head, when first seen, was sticking out from beneath peat about seven feet thick.

A little to the north of this stream a patch of bare ground was met with, about half an acre in extent, which after a careful search, yielded about 20 flint chippings and flakes, one of the latter had the appearance of having been ground to a sharp edge.

Flints appear to be so abundantly scattered on this elevated moorland, that in nearly every case where an opportunity was offered for an examination of the subsoil, one or more could be found. The most striking example was met with on March Hill, a conical eminence overlooking the Vale of Marsden.

This hill is completely isolated from the surrounding moors, and although of comparatively small dimensious more than two thousand flints were found on a few small patches of bare ground, on its southern side. The flints varied in size from chippings not larger than a pin's head to flakes two inches long. Several small flint cores and one leaf-shaped arrow tip with a broken point were also picked up. Indeed the number of small chips and flakes was so great, as to lead to the conclusion, that flint implements were manufactured there during "pre-historic times." It may be worthy of note, that while flints occurred in great abundance on the south side of the hill; the side facing the north, although there was much bare ground, only yielded ten pieces.

After every flint that could be seen on this hill had been picked up in the summer of 1880, we found on revisiting the place the following year, that another crop, as it were, had sprung up, for the bare ground on the south side of the hill was again strewn with flints. This occurrence might, at first, have thrown a little doubt on their antiquity, had we not removed a thin layer of soil, and found flints at a still lower level, and in this way convinced ourselves that they must have been laid bare by the denuding action of atmospheric agencies. Several small pieces of red ruddle (peroxide of iron) were found, which may have been used by the ancient men by whom the flints were worked.

After carefully examining the naturally bared surface, we dug at several places and exposed the following section:—

1. Peat, from ten to sixteen inches thick.
2. Dark Peaty-clay, from two to six inches thick.
3. Dark-grey Sand, with angular pieces of sandstone, all local, six inches thick. Flints occurred abunantly in this layer.
4. Red Ochreous sand, about twelve inches thick, resting on Yoredale shale.

It will be seen by the above section, that the true position of the flints was the dark-grey sand, No. 3, in which they occurred at all levels; it yielded from twelve to a hundred and twenty flints per square yard. Although the other layers were examined with equal care, not a particle of flint was found.

At this place a quartzite pebble was dug up, about two and a half inches in length, and an inch in breadth, which showed at each end distinct signs of having been used as a hammerstone. It was found in the grey-sand, beneath the thickest part of undisturbed peat.

Another quartzite pebble has lately been found on the moor, about half a mile south-west of March Hill, by Dr. March, of Rochdale, it is two and five-eights of an inch in length, and one and a half an inch in width, is thin and oval in form and has been bored through the centre, the operation having commenced from both sides of the pebble. It would appear from the position in which this bored pebble was found, that it was at one time under peat about three feet in thickness. (Pl. III, fig. 1).

About two miles east of March Hill, the most striking and prominent feature in the neighbourhood is Pule Hill. On its southern extremity, which is the most elevated part, about a dozen flint flakes were discovered; one of the most remarkable is about two inches in length and three eights of an inch in breadth; it is beautifully fashioned and may have been used as a knife. Near the foot of the hill a small patch of subsoil was examined and yielded upwards of two hundred fragments of flint and chert. They consisted of flakes, chips and cores; one of the former showed signs of having been delicately chipped along one side, in order to form a serrated cutting edge. It is two and a quarter inches in length, and one inch in its broadest part. (Pl. III, fig. 2).

At this place chert was more abundant than flint. Still further eastwards a few flints were obtained from Butter Hill and Waster Knab, they were all flakes, and only one showed distinct traces of secondary chipping.

While examining this part of the Penine Range, a sharp look-out was also kept for stones foreign to the district, which might indicate the presence of glacial *debris*, but not a fragment was met with.

Attention was next directed to an elevated and prominent ridge of moorland which lies about four miles west of Rochdale, and thence trends north-west to the neighbourhood of Burnley. On several points of this ridge flints have been discovered, the most interesting discovery however, was made on Middle Hill, near Whitworth. The opportunities for investigation on this hill were most favourable, owing to a considerable portion of its peaty covering having been burnt off some ten or eleven years ago. Since that time atmospheric agents have lowered the loamy subsoil at least an inch, as is proved by little earth-pillars capped with stones, seen here and there on its western flank. On the southern portion of the hill flint chippings, flakes, small cores and worked fragments, were so abundantly scattered over the bare ground that no less than three hundred and fifty have been gathered.

This contrasts strongly with the northern portion of the hill which, after a diligent search only yielded five flints. Many of the flints found at this place showed the bulb of concussion, others by secondary chippings have been fashioned into implements and weapons; of the former about twelve may be mentioned which have been worked into a circular form by chipping round the edges. They vary in size from half an inch to one and a half inch. Of the latter class, a perfect arrow head of the barbed type, delicately chipped on both faces, and a well formed javelin's head or knife have been found. The last named is about two and a half inches in length and three quarters in breadth, and has every appearance of having been much used.

About three per cent of the flints found on this hill appear to show the action of fire, their surfaces being traversed by small cracks bisecting each other at different angles. This leads to the inference that originally the flints were at different levels and are not all exactly of one age. Thus while those on the surface soil would be heated when it was burnt off, others buried in the underlying clay would be protected from such heat. At one or two places on the hill flints were seen sticking out of the loamy clay, while in other cases they were found capping little earth-pillars, thus indicating the position they occupied before the ground was bared.

The original covering of this hill consisted of a dry sandy loam, about eight or ten inches thick, which supported the growth of *bent*, a peculiar grass, rich in silica. This is proved by the occurrence at several points on the bare ground of small patches of soil which escaped the action of the fire referred to above. It will thus be seen, that the conditions for the formation of vegetable matter have been so unfavourable at this place, owing to the dryness of the ground, as to make it probable that the flints found there, though under so thin a soil, are quite as ancient as those occurring at much greater depths, in localities more favourable for the growth of peat. To the south, south-west and north of this hill, other prominent hills are located on which many fragments of flint have been found, among these, Knowl Hill and Bull Hill may be mentioned as being the most important on account of their having yielded implements undoubtedly worked by human hands.

A rather rude form of arrowhead with broken point, a flint core and a few chips have been found at Knowl Hill, while from Bull Hill we have obtained an arrow head with one of its barbs broken, one or two delicately worked bits of flint, and a few chips and flakes. On Bull Hill the flints appear to have been covered at one time with peat, varying from one to six feet in thickness.

From a ridge of high ground known as Midgley Moor about two miles north of Mytholmroyd, several flints have been obtained, among which a small leaf-shaped arrow head, a circular thumb-flint and two worked flakes, may be mentioned. The subsoil on which they were found, in almost every instance, has been laid bare by fires occurring from time to time.

In conclusion, it may not be out of place to call attention to one or two points in relation to the flints we have already discovered.

Firstly, the well-formed barbed arrow-heads and other well-worked flints were so associated with those showing little or no design, such as chips and flakes, to leave no doubt whatever on our minds that they all had a common origin and must have been fabricated by pre-historic man.

Secondly, in all cases the flint flakes and cores were of comparatively small size, which may be accounted for, on the supposition that this material was a scarce commodity among the ancient tribes who inhabited these hilly districts. This will seem all the more probable if we take into consideration the only two possible sources from which the flints could have been derived, viz., the Glacial Drift and far off Chalk districts.

Thirdly, so far as our investigations have yet gone, we have failed to detect any trace of polished stone celts, and in only two doubtful instances have ground or polished flints been observed. Had these ancient Britons been in the habit of using polished stone hatchets, it is not unreasonable to suppose that some fragments of them would have been left behind, especially at places where implements appear to have been made.

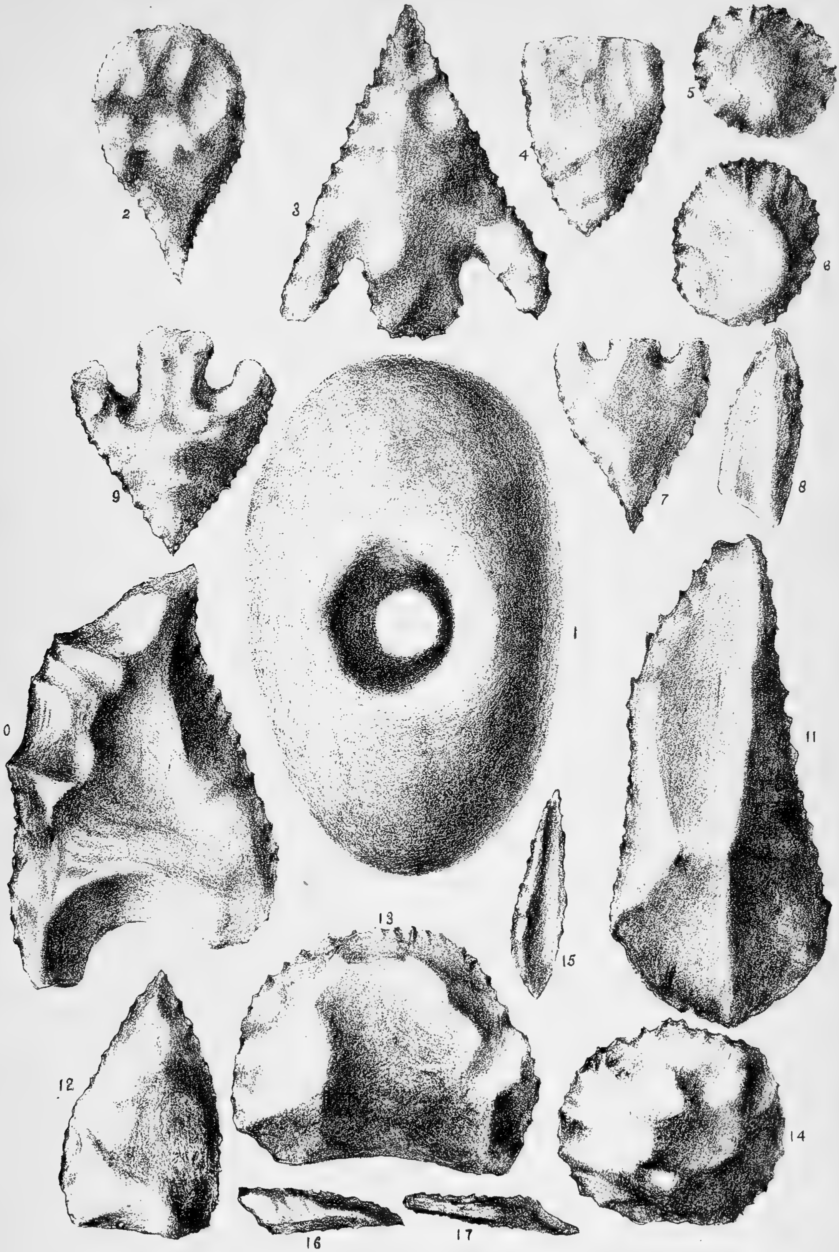
Lastly, two hills have been pointed out on which flints occurred more abundantly on the southern than the northern slopes, and this is true of almost all the elevated places where we have yet been able to detect flints. This may be explained by supposing the ancient men selected the more sunny and warmer side of a hill for carrying on the work of fashioning their tools and weapons.

The following table shows the approximate number of worked and unworked flints, and the places where they have been found.

PLACES WHERE FOUND.	NO. FOUND.	NO. WORKED.	NO. UNWORKED.
Dean Clough, Saddleworth	300	8	292
Moor, North of Dean Clough	20	2	18
March Hill, near Marsden	2300	30	2270
Moor, South of March Hill, near Marsden ...	30	1	29
Pule Hill, near Marsden	12	1	11
Foot of Pule Hill, near Marsden	200	2	198
Butter Hill, near Marsden	10	1	9
Waster Knab, near Marsden	6	1	5

PLACES WHERE FOUND.	NO. FOUND.	NO. WORKED.	NO. UN-WORKED.
Haugh Hey, near New Hey	4	0	4
Robin Hood's Bed, near Blackstonedge	10	1	9
Monshead Hill, near Ripponden	6	0	6
Studley Pike, near Todmorden	2	0	2
Basin Stone, Walsden, near Todmorden	2	2	0
Ramsden Clough, Walsden, near Todmorden ...	1	1	0
Foot of Ramsden Hill, Walsden, near Todmorden	1	1	0
Trough Edge, Walsden, near Todmorden ...	10	0	10
Hey Head, near Todmorden	1	0	1
Hades Hill, near Wardle	2	0	2
Middle Hill, near Whitworth	350	15	335
Brown Wardle Hill, near Whitworth	5	1	4
Rush Hill, Healey, Rochdale	3	1	2
Knowl Hill, near Rochdale	40	3	37
Bull Hill, near Ramsbottom	8	2	6
Whittle Pike, near Ramsbottom	1	0	1
Todmorden Moor	1	1	0
Wadsworth Cock Hill, near Hebden Bridge ...	9	3	6
Midgley Crow Hill, near Hebden Bridge ...	8	1	7
Cant Clough, near Burnley...	1	1	0
Cold Edge, near Sowerby Bridge	8	0	8
Rooley Moor, near Facit	3	0	3
Brock-holes, Walsden	4	1	3
Crow Knowl Hill, near Shaw	4	0	4
Turnshaw Hill, near Rochdale	50	0	50
Hunger Hill, near Rochdale	12	3	9
TOTAL	3824	83	3741

We are indebted to Mr. John Evans, F.R.S. for kindly examining a number of our flint implements. He concurs with our opinion that they are pre-historic, but whether they belong to the Neolithic or Bronze age there is not yet sufficient evidence to determine. He makes a special allusion to some very small but delicately chipped flints, many of which have been found on March Hill, and informs us they are the smallest flint implements that, to his knowledge, have ever been found in this country; we are moreover told that a similar type of implements has lately been found in Egypt, Mr. Evans believes they may have been used as "carving tools." (Pl. III, figs. 15, 16, 17).



STONE AND FLINT IMPLEMENTS FOUND ON MOORS, NEAR TODMORDEN.

A. Megson & Sons, Leeds.

YORKSHIRE FOSSIL MOLLUSCA. BY WILLIAM CASH.

THE organisms which in past ages inhabited salt or fresh water, are as one might expect, those which are preserved in the greatest numbers and in the best condition in the sedimentary rocks. The factors which appear to have favoured the preservation of marine and fluviatile animals as fossils, in quantity and variety, are:—

1. The hardness of the protective coverings or tests.
2. Their facility for undergoing mineralisation.
3. The quantitative development of genera, species, and individuals.
4. The variety of surrounding conditions, as to depth, horizontal distribution, &c., &c.
5. The early appearance on the earth, and continued persistence of forms during each successive geological epoch.

No sub-kingdom seems to have fulfilled these conditions better than the Mollusca, the hardness of their shells fitted them to resist a considerable amount of abrasion, and to defy the action of many tendencies to decay; their chemical composition (chiefly carbonate of lime) lent itself readily to changes in mineralisation; they abounded in the seas and lakes of the various geological periods, both in genera, in species, and in individuals, they flourished under the most varied climatal conditions, and were found at all depths; they appeared early on the theatre of the life history of the globe, and have held their own as a class to the present time. No wonder that they afford to the Geologist precious and most useful data for a philosophical interpretation of the world's early history.

Fossil Mollusca are well represented in the county of York, perhaps no equal area of land can be found to surpass Yorkshire in the variety and interest of its Geological strata, extending from the Silurian rocks in the north west of the county, through the Carboniferous area, and the wide vales of the Permian and Trias to the wonderful development of Jurassic and Cretaceous rocks on the east coat, with patches here and there of Post Tertiary beds,—and Fossil shells are to be found in most of these formations, in many instances in immense profusion; their value is greatly enhanced to the field geologist when they are found to be characteristic of particular strata and beds, this is found often to be the case, and this most notably in the so-called Ammonite Zones in the Lias, where the presence of one single Ammonite may be sufficient to indicate the exact stratigraphical position of a Geological stratum.

The following genera of fossil shells have been recorded for the county of York in Tate and Blake's Yorkshire Lias; Phillip's Geology of the Yorkshire Coast; Phillip's Geology of the Mountain Limestone District; Davis and Lee's West Yorkshire; the volumes of the Quarterly Journal of the Geological Society, &c.

No doubt some of these genera will be found on a careful study of specimens to be merely synonyms, others as the Ammonites, the Goniatites, some of the Lamellibranchs will require to be split up, at least into sub-genera.

GENERA OF YORKSHIRE FOSSIL CEPHALOPODA.

Teuthopsis	Jurassic
Beloteuthis	,,
Geoteuthis	,,
Belemnites	,,
Belemnitella	,,
Ammonites	
Amaltheus	Jurassic and Cretaceous.
Lytoceras	
Phylloceras	
Harpoceras	
Stephanoceras	
Œgoceras	
Arietites	
Cosmoceras, &c.	
Scaphites	Cretaceous
Hamites	,,

Ancyloceras	Cretaceous.
Crioceras	,,
Helicoceras	,,
Orthoceras	Silurian, Carboniferous
Actinoceras	Carboniferous
Cyrtoceras	Silurian
Phragmoceras	Carboniferous
Nautilus	Carboniferous, Permian, Jurassic and Cretaceous
Lituites	Silurian
Trochoceras	Silurian
Goniatites	Carboniferous
Poterioceras	,,

YORKSHIRE FOSSIL GASTEROPODA (GENERA).

Bellerophon	Silurian, Carboniferous
Porcellia	Carboniferous
Murex	Jurassic
Trophon	Pleistocene
Fusus	Pleistocene
Pleurotoma	Pleistocene
Buccinum	Carboniferous, (?) Pleistocene
Purpura	Pleistocene
Purpuroidea	Jurassic
Columbella	Pleistocene
Natica	Carboniferous, Permian, Jurassic, and Pleistocene
Scalaria	Pleistocene
Nerinea	Jurassic
Avellana	Cretaceous
Actæonina	Jurassic
Cylindrites	Jurassic
Chemnitzia	Permian. Jurassic
Loxonema ...	Carboniferous
Macrocheilus	,,
Eulima	Jurassic
Solarium	Cretaceous
Discohelix	Jurassic
Phanerotinus ...	Carboniferous
Cirrus	,, Jurassic (?)
Euomphalus	,, ,,
Platyschisma	Carboniferous
Pleurotomaria	,, Jurassic, Cretaceous
Murchisonia	Silurian, Carboniferous

Straparollus	...	...	Permian
Trochotoma	...	...	Jurassic
Alaria	...	...	,,
Admete	...	...	Pleistocene
Rostellaria	...	...	Cretaceous
Hydrobia	...	...	Jurassic
Trichotropis	...	...	Pleistocene
Cerithium	...	...	Carboniferous, Jurassic, Cretaceous
Melania (?)	..	...	Carboniferous
Littorina	...	...	Jurassic, Pleistocene
Amberleya	...	...	Jurassic
Rissoa	...	..	Permian, Jurassic
Bithynia	...	...	Pleistocene
Valvata	...	...	,,
Holopella	...	...	Silurian
Turritella	...	...	Carboniferous, Permian, Jurassic, Cretaceous, Pleistocene
Nerita...	...	...	Jurassic
Neritopsis	...	...	,,
Pileopsis	.	...	Carboniferous
Acroculia	...	...	,,
Capulus (?)		.	,,
Phasianella	...	...	Jurassic
Pitonellus	...	...	,,
Turbo ...	...	...	Silurian, Carboniferous, Permian, and Jurassic
Cryptæna	...	...	Jurassic
Eucyclus	...	...	,,
Monodonta	...	...	,,
Delphinula	...	...	Cretaceous
Trochus	...	...	Carboniferous, Jurassic, Cretaceous and Pleistocene
Emarginula	...	.	Cretaceous
Lepeta	...	...	Pleistocene
Puncturella (= Cemoria) ...			,,
Patella	...	...	Carboniferous, Jurassic
Dentalium	...	...	,, Permian, Jurassic, Cretaceous, Pleistocene
Chiton	...	..	Permian
Metoptoma	...	...	Carboniferous
Actæon	..	...	Jurassic
Bulla (?)	...	...	,,
Planorbis	...	...	Pleistocene

Limnea	...	...	Pleistocene
Succinea	...	..	,,
Limax	...	...	,,
Bulimus	...	...	,,
Zonites (= Helicella)		...	,,
Helix ...	...	...	,,
Cochlicopa (= Zua)		...	,,
Clausilia	...	...	,,
Achatina	...	...	,,
Pupa ...	...	...	,,
Vertigo	..	..	,,
Carychium	...	...	,,
Acme ...	...	...	,,

GENERA OF YORKSHIRE FOSSIL LAMELLIBRANCHIATA.

Pholas...	...	...	Jurassic, Cretaceous, Pleistocene
Teredo	...	...	Cretaceous
Gastrochœna	...	..	Jurassic
Saxicava	...	...	,, Pleistocene
Solemya	...	...	Jurassic
Mya ...	..	...	Cretaceous, Pleistocene
Corbula	...	...	Carboniferous, Jurassic, Cretaceous, Pleistocene
Anatina	...	...	Jurassic
Pleuromya	...	...	,,
Arcomya	...	...	,,
Ceromya	...	...	,,
Thracia	...	...	,, Cretaceous, Pleistocene
Pholadomya	...	...	,, ,,
Cardiomorpha	...	...	Carboniferous, Permian
Goniomya	...	...	Jurassic
Myacites	...	...	Carboniferous, Jurassic
Homomya	...	...	Jurassic
Panopœa	...	...	,, Cretaceous
Gresslya	...	...	Jurassic
Mactra	...	...	Jurassic (?) Pleistocene
Lutraria	...	...	Carboniferous (?) Jurassic
Sanguinolaria	...	...	Jurassic
Sanguinolites (?)		...	Carboniferous
Tellina	...	...	Jurassic, Pleistocene
Donax	...	...	Pleistocene
Scrobicularia	...	...	,,
Venus	...	...	Jurassic, Pleistocene
Cytherea	...	...	Jurassic

Thetis	Cretaceous
Isodonta	Jurassic
Pullastra	Carboniferous (?) Jurassic
Cypricardia	" "
Cyprina	Jurassic, Pleistocene
Sphœrium(= Cyclas) ...	Pleistocene
Pisidium ...	"
Cardium	Jurassic, Pleistocene
Cardiola	Silurian
Isocardia	Jurassic, Cretaceous
Edmondia	Carboniferous
Tancredia	Jurassic
Unicardium	"
Conocardium	Carboniferous
Protocardium	Jurassic
Artemis	(?) Carboniferous
Lucina	Carboniferous, Jurassic, Cretaceous
Cryptodon	Cretaceous
Corbis	Jurassic, Cretaceous
Opis	Jurassic
Cardinia	Carboniferous, Jurassic
Cardita	Jurassic
Unio	Pleistocene
Anadonta	"
Astarte	Jurassic, Cretaceous, Pleistocene
Montacuta	Pleistocene
Anthracosia	Carboniferous
Mytilus	Carboniferous, Permian, Jurassic, Pleistocene
Modiola	Carboniferous, Jurassic, Pleistocene
Myoconcha	Permian, Jurassic
Hippopodium	Jurassic
Lithodomus	do.
Perna	do. Cretaceous
Avicula	Carboniferous, Jurassic, Cretaceons
Aviculopecten	Carboniferous, Jurassic
Gervillia	Carboniferous, Permian, Cretaceous
Bakewellia	Permian
Inoceramus	Carboniferous, Jurassic, Cretaceous

Corbicella	Jurassic
Crenatula	,,
Pinna	Carboniferous, Jurassic, Cretaceous
Axinus (= Schizodus) ...	Permian
Trichites	Jurassic
Trigonia	Jurassic, Cretaceous
Posidonomya	Carboniferous, Jurassic
Pteroperna	Jurassic
Pterinea	Silurian, Carboniferous
Cassianella	Jurassic
Monotis	,, Permian
Myalina	Permian
Arca	Carboniferous, Jurassic
Macrodon	Permian, Jurassic
Cucullœa	Carboniferous, Jurassic, Cretaceous
Isoarca	Jurassic
Pectunculus	Pleistocene
Nucula	Carboniferous, Jurassic, Cretaceous, Pleistocene
Leda	Carboniferous, Permian, Jurassic, Pleistocene
Leptodomus	Carboniferous
Orthonota	Silurian
Pecten	Carboniferous (?) Jurassic, Cretaceous
Hinnites	Jurassic
Lima	,, Cretaceous
Limea	Jurassic
Spondylus	Cretaceous
Ctenodonta	Carboniferous
Anomia	Jurassic, Pleistocene
Plicatula	Jurassic, Cretaceous
Ostrea	,, ,,
Gryphæa	Jurassic
Sowerbya	,,
Quenstedtia	,,
Placunopsis	Cretaceous
Exogyra	,,
Dianchora	,,

The range of these Fossils in time in Yorkshire is shown by the tables following:—

SILURIAN.

CEPHALOPODA.—Orthoceras, Cyrtoceras, Lituites, Trochoceras.

GASTROPODA.—Bellerophon, Murchisonia, Holopella, Turbo.

LAMELLIBRANCHIATA.—Cardiola, Pterinea, Orthoneta.

CARBONIFEROUS.

CEPHALOPODA.—Orthoceras, Actinoceras, Phragmoceras, Nautilus, Goniatites, Poterioceras.

GASTROPODA.—Bellerophon, Porcellia, Buccinum (?), Natica Loxonema, Macrocheilus, Phanerotinus, Cirrus, Euomphalus, Platyschisma, Pleurotomaria, Murchisonia, Cerithium, Melania (?), Turritella, Pileopsis, Acroculia, Capulus (?), Turbo, Trochus, Patella, Dentalium, Metoptoma.

LAMELLIBRANCHIATA.—Corbula, Cardiomorpha, Myacites, Lutraria (?), Sanguinolites, Pullastra (?), Cypricardia, Edmondia, Conocardium, Artemis (?), Lucina, Cardinia, Anthracosia, Mytilus, Modiola, Avicula, Aviculopecten, Gervillia, Inoceramus, Pinna, Posidonomya, Pterinea, Arca (?), Cucullœa, Nucula, Leda, Leptodomus, Pecten, Ctenodonta.

PERMIAN.

CEPHALOPODA.—Nautilus.

GASTROPODA.—Natica, Chemnitzia, Straparollus, Rissoa, Turritella, Turbo, Dentalium, Chiton.

LAMELLIBRANCHIATA.—Cardiomorpha, Mytilus, Myoconcha, Gervillia, Bakewellia, Axinus, (= Schizodus), Monotis, Myalina, Macrodon, Leda.

JURASSIC.

CEPHALOPODA.—Teuthopsis, Beloteuthis, Geoteuthis, Belemnites (Ammonites = Amaltheus, Lytoceras, Phylloceras, Harpoceras, Stephanoceras, Agoceras, Arietites, &c.), Nautilus.

GASTROPODA.—Murex, Purpuroidea, Natica, Nerinea, Actæonina, Cylindrites, Chemnitzia, Eulima, Discohelix, Cirrus (?), Euomphalus, Pleurotomaria, Trochotoma, Alaria, Hydrobia, Cerithium, Littorina, Amberleya, Rissoa, Turritella, Nerita, Neritopsis, Phasianella, Pitonellus, Turbo, Cryptœna, Eucyclus, Monodonta, Trochus, Patella, Dentalium, Actœon, Bulla.

Lamellibranchiata.—Pholas, Gastrochœna, Saxicava, Solemya, Corbula, Anatina, Pleuromya, Arcomya, Ceromya, Thracia, Pholadomya, Goniomya, Myacites, Homomya, Panopæa, Gresslya, Mactra (?), Lutraria (?), Sanguinolaria, Tellina, Venus, Cytherea, Isodonta, Pullastra (?), Cypricardia, Cyprina, Cardium, Isocardia, Tancredia, Unicardium, Protocardium, Lucina, Corbis, Opis, Cardinia, Cardita, Astarte, Mytilus, Modiola, Myoconcha, Hippopodium, Lithodomus, Perna, Avicula, Aviculopecten, Inoceramus, Corbicella, Crenatula, Pinna, Trichites, Trigonia, Posidonomya, Pteroperna, Cassianella, Monotis. Arca, Macrodon, Cucullœa, Isoarca, Nucula, Leda, Pecten, Hinnites, Lima, Limea, Anomia, Plicatula, Gryphæa, Sowerbya, Quenstedtia.

CRETACEOUS.

Cephalopoda.—Ammonites, (Cosmoceras, &c.) Belemnites, Belemnitella, Scaphites, Hamites, Ancyloceras, Crioceras, Helicoceras, Nautilus.

Gastropoda.—Avellana, Solarium, Pleurotomaria, Rostellaria, Cerithium, Turritella, Delphinula, Trochus, Emarginula, Dentalium.

Lamellibranchiata.—Pholas, Teredo, Mya, Corbula, Thracia, Pholadomya, Panopœa, Thetis, Isocardia, Lucina, Cryptodon, Corbis, Astarte, Perna, Avicula, Gervillia, Inoceramus, Pinna, Trigonia, Cucullœa, Nucula, Pecten, Lima, Spondylus, Plicatula, Ostrea, Placunopsis, Exogyra, Dianchora.

PLEISTOCENE.

Gastropoda.—Trophon, Fusus, Pleurotoma, Buccinum, Purpura, Columbella, Natica, Scalaria, Admete (= Cancellaria), Trichotropis, Littorina, Bithynia, Valvata, Turritella, Cemoria, Trochus, Lepeta, Puncturella, Dentalium, Planorbis, Limnea, Succinea, Limax, Bulimus, Zonites (=Helicella), Helix, Cochlicopa (=Zua), Clausilia, Achatina, Pupa, Vertigo, Carychium, Acme.

LAMELLIBRANCHIATA,—Pholas, Saxicava, Mya, Corbula, Thracia, Mactra, Tellina, Donax, Scrobicularia, Venus, Cyprina, Sphœrium, (=Cyclas), Cyrena, Pisidium, Cardita, Cardium, Unio, Anadonta, Astarte, Montacuta, Mytilus, Modiola, Pectunculus, Nucula, Leda, Anomia.

From the foregoing lists we may form an idea of the comparative richness of the different formations of Yorkshire in fossil mollusca. It is my intention to present to the readers of the Yorkshire Geological and Polytechnic Society, from time to time, sketches of this molluscan fauna, and to take up the subject mainly in its Palæontological aspects. The first group proposed to be dealt with is the Cephalopoda, but before proceeding to any description of species we present the modern classification of the group as proposed by Dr. Paul Fischer in the Journal de Conchyliologie 3e Série, Tome xxii. No. 1. Paris, 1882, where he says, "For a long time the Class of the Cephalopoda has been subdivided into two orders. 1st. The Dibranchiata or Acétabulifera. 2nd. The Tetrabranchiata or Tentaculifera. I think it is now necessary to adopt a third order, that of the Ammonea in which the characteristics are mixed, approaching to the Dibranchiata by the initial sac of the shell in which is found a siphonal cœcum whose extremity does not touch the walls of the sac, but differing from the Dibranchiata by the animal having been always protected by an external shell to which it adheres by the aid of an adductor muscle; and by the absence of an ink-bag. On the other hand, if the Ammonea resemble the Tetrabranchiata by their external shell, and the absence of an ink-bag, they are easily distinguished from them by their initial shell without scar, and by the existence of one or two solid pieces (Aptychus) found in the chamber of habitation. The order Ammonea ought therefore to be intercalated betwixt the

Dibranchiata and the Tetrabranchiata.

The order Dibranchiata comprehends two sub-orders. Octopoda and Decapoda. I think it possible to divide the Octopoda into Monocotylea and Polycotylea according as the arms bear a single row or several rows of suckers (2 in Octopus, 3 in Tritaxeopus). The Decapoda form 3 large groups founded on the structure of the dorsal internal pen, which is Cartilaginous with the Chondrophora, Calcareous but without a chambered rostrum or guard in the Sépiophora (Ex. Sepia) and terminated by, or built up of, a series of air chambers, traversed by the siphon in the Phragmophora (Belemnites, Spirula). The Chondrophora, which are the most numerous, may be re-divided after D'orbigny into Oigopsidæ (Ommatostrephes) and Miopsidæ (Loligo).

The order Ammonea is divided into Rétrosiphonata and Prosiphonata, as the neck of the siphon is bent in a backward or in a forward direction. The Rétrosiphonata have for the type the Goniatites; the Prosiphonata includes all the shells called hitherto Ammonites. When these are unfurnished with an Aptychus, or possess only a horny Aptychus, they form the section Anaptychidea ; when their Aptychus is made up of two calcareous pieces, free or soldered together, they belong to the section Aptychida. Finally, the Anaptychida have been re-arranged by the shape of their first initial saddle into Latisellata and Angustisellata.

The order of the Tetrabranchiata is divided into Prosiphonata and Retrosiphonata after the direction of the siphonal neck. The Retrosiphonata comprehends two families, the Nautilidæ with chambers perpendicular to the axis of the shell, and the Ascoceratidæ in which the chambers are very oblique, becoming even sub-parallel to the axis.

Dr. Fischer's classification may be tabulated in the manner following :—

CLASS.—CEPHALOPODA.

I. ORDER.—DIBRANCHIATA.

A. sub-order.—*Octopoda.*
- a. Monocotylea. (Cirroteuthidæ, Eledonidæ).
- b. Polycotylea (Octopidæ, Tremoctopodidæ, Argonautidæ).

B. sub-order.—*eDcapoda.*
- a. Chondrophora.
  - § 1. *Oigopsidæ* (Cranchiidæ, Chiroteuthidiæ, Thysanoteuthidæ, Onychoteuthidæ, Ommatostrephidæ).
  - § 2. *Miopsidæ.* (Sepiolidæ, Sepiadaridæ, Idiosepidæ, Loliginidæ).
- b. Sepiophora. (Sepiidæ).
- c. Phragmophora. (Belosepiidæ, Belopteridæ, Belemnitidæ, Spirulidæ).

II. ORDER.—AMMONEA.

A. sub-order.—*Retrosiphonata* (Goniatidæ).

B. sub-order.—*Prosiphonata.*
- a. Anaptychidea.
  - § 1. *Latisellata.* (Arcestidæ, Tropitidæ, Ceratitidæ, Clydonitidæ).
  - § 2. *Angustisellata.* (Pinacoceratidæ, Amaltheidæ, Ammonitidæ, Lytoceratidœ).
- b. Aptychidea. (Harpoceratidæ, Stephanoceratidæ).

III. ORDER.—TETRABRANCHIATA.

A. sub-order.—*Prosiphonata.* (Nothoceratidæ).

B. sub-order.—*Retrosiphonata.* (Nautilidæ Ascoceratidæ).

ON THE RECENT EXTENSION OF MINING OPERATIONS UNDER THE PERMIAN FORMATIONS. BY THOS. WM. TEW, ESQ., J.P.

I HAVE pleasure in again welcoming the Society to the historical old town of Pontefract. You met here on Thursday, the 4th November, 1869, under the presidency of Lord Houghton, and thirteen years have not dimmed the recollections of that visit, to those who were then present, or relegated to oblivion the discussions which took place with regard to the geological wealth surrounding this ancient Borough, and the division of Osgoldcross, of which it considers itself the chief centre of importance. We, as residents in the town and district, hope that the speculations then hinted at have been developing cautiously, but surely, towards commercial success and realization; and we trust that the members of this Society may find that during this interval of time, industry, energy and capital have been brought to bear in the development of our underground wealth; and that they may appreciate the progress which has been accomplished by this practical application of geological science since they last honoured Pontefract with a visit.

First allow me to thank the Honorary Secretary of this Society and yourselves, for the compliment you have conferred upon me, in requesting me to act as your Local President on this occasion. I ask your considerate forbearance and co-operation in undertaking the duties of this Chair. At the same time, I desire to assure you of my earnest wishes to promote the interests of this valuable Institution, with which it has been my privilege to be associated for upwards of twenty years.

After the exhaustive addresses of your past Presidents, the devoted attention to special subjects of the scientific members of this Institution, and the published papers in its transactions, it is difficult for an amateur Geologist, like myself, to discourse on a special subject; but with your permission, I will venture to make some remarks upon the geological aspects of Mining in this division of West Yorkshire.

When the Yorkshire Geological Society was first formed, in 1836, the coal measures of Osgoldcross were hardly known. A little surface coal called "Crow Coal," or "Wheatwood Coal," about Glass Houghton, was scratched up by "Diggers of Cole," as John Dee, in 1570, described this new art of getting coal. And of the rest of Yorkshire, even to those engaged in mining works, the coal measures were only guessed at, pretty much as rare old Leland mentions them in 1535:—"Though here be plenti of wood, "yet the people burne much yearth cole by cawse hit is plentifull, "and sold good chepe." Deep mining was not yet possible.

Whatever Leland's "Yearth Cole" was, or the substance used in 1535, and subsequently as 'fuel," as Newcastle coal used to be called, no one but he who lived into the 19th century, and who can now estimate the full consequence of the agency of coal in the extension of the Railway, Steam Vessels, and Steam-transport systems could grasp the mighty fact, that the "Mineralized Vegetable matter," which Chemists tell us is composed of "carbon, "hydrogen and nitrogen," could give such impetus to the energy and industry of the people of England, and an enlightened policy in favour of commerce and manufactures. By this "Much Yearth Cole, by cawse hit is plentifull, and sold good chepe," has the commercial prosperity of the West Riding been built up.

The output in 1868, the return quoted when the Society was here in 1869, was over 103 millions of tons of coal; it is stated for the year 1880 to be over 140 millions of tons; whilst our Steam Navy, which in 1860 used half a million tons, in 1880 needed more than two and a half millions of tons—twice as much as all the other Steam Merchant Navies of the world combined.

This is the silver age of discoveries, and the golden age of Mechanics; and the unmatched progress of this country has been due to the natural energy of the race of Englishmen, and the narrowness of the bounds within which its increasing families are enclosed, and to the cheapness and abundance of the coal.

According to Mr. Lupton, coal is workable at a depth of 5,000 or 10,000 feet; but the temperature of the earth at a depth of 980 yards will be equal to blood heat, and if the miners have to penetrate another 500 yards "Mineral substances will be too hot "for the naked skin to touch with impunity." Under such conditions science and mechanics will, I have no doubt, render the conditions of human labour at these depths quite possible; and although it would appear that our new coal fields lie at great depths below the surface of the ground, I feel sure that whenever circumstances require it, coal will be raised from greater depths than 5,000 or 10,000 feet, whilst new beds will be discovered as yet undreamed of. Therefore, in my humble opinion, many of the conclusions of the Royal Commission were founded on insufficient data.

We must, I think, throw off, further away than ever, the question of the exhaustion of the British Coal fields, and the prospect of national ruin.

But if Leland could live again, and realise the dimensions of the industry his "Yearth Cole" has achieved from his day to 1882, he might feel inclined to write a new Itinery with reference to coal.

On the 25th Feb., 1869, the Haigh Moor Bed of the Merefield Colliery, at Glass Houghton, was struck at 347 yards from the surface of the ground, and the coal was found to be 4 feet 7 inches in thickness, with one dirt parting of three inches in the middle of the seam. This Colliery is now in working order, and is capable of turning out upwards of 1,000 tons of coal in 24 hours.

At a depth of 280 yards from the surface, salt water, much salter than that of the sea, is found; specific gravity 1·082 compared with fresh water: temperature 60 degrees of Fahrenheit's thermometer: four fluid ounces on evaporation leave a residue weighing 150 grains in slightly differing proportions to the other, as follows:—

Chloride of Calcium.
,, ,, Sodium
,, ,, Magnesium.
,, ,, Potassium.

Bromides a trace; Nitrates (from decomposed vegetable matter), Sulphates not a trace.

Again, at a depth of 347 yards from the surface, another basin of salt water is found—specific gravity 1·101: four fluid ounces on evaporation leaving solid ingredients weighing 170 grains, as under:

Cloride of Calcium.
,, ,, Sodium.
,, ,, Magnesium.
,, ,, Potassium.

Bromides not a trace; Nitrates (from decomposed vegetable matter) Sulphates not a trace.

These Pontefract samples of water contain a large amount of Chloride of Magnesium but no Magnesic Sulphates. The salt water is found in stronger saltness at the bottom of the "Prince of Wales" Colliery; again, deep down in the Wakefield rock; and Mr. George Roberts, of Lofthouse, informs me, on the 5th October, 1882, at 352 yards from the surface, this reservoir of salt water has begun to ooze through the roof of a Colliery there, increasing in quantity, and becoming troublesome and expensive to to deal with.

In the analysis of the brine at the Ryhope Colliery, 556 yards below the bottom of the sea and 800 yards from high water mark, in March, 1871, the constituents were:—

	Grains per Gallon.
Chloride of Sodium	6936·39
,, ,, Potassium	39·55
,, ,, Lithium	a trace
,, ,, Ammonium	1960·00
Carried Forward	8935·94

	Grains per Gallon.
Brought Forward	8935·94
" " Calcium	8·96
" " Magnesium	368·90
Iodide of "	0·08
Bromide of "	43·39
Carbonate of Iron	2·90
Total solids per gallon	9360·17
Specific Gravity	1·1

This analysis of the Ryhope Brine is furnished by Mr. T. W. Embleton, of Methley.

These waters are stronger than the salt waters pumped up at Droitwich, and contain ingredients different to those of ordinary sea water.

When you last assembled in this Town Hall, Mr. John Rhodes, the thrice elected Mayor of Pontefract, had not reached the coal at his "Prince of Wales" Colliery, but on the 1st of August, 1872, the Haigh Moor Bed was reached, at a depth of 477 yards, or thereabouts, from the surface; the coal, with two dirt partings, is 5 feet 6 inches in thickness.

This excellent coal possesses many valuable properties. Its illuminating power, by the method frequently adopted by Gas Engineers, is 14·5 ; density 0·528 (air = 1). Percentage of olefiant gas and similar substances 6·50. The number of cubic feet of gas per ton of coal 8,612.

The machinery at the "Prince of Wales" Colliery is capable of raising to the pit bank some 500 to 600 tons of coal every day. The colliery is ventilated by the most approved fan, 40 feet in diameter, the fanners being 10 feet in width and making some 35 revolutions per minute.

In addition to the coal which the enterprise of the Mayor is bringing to the surface, there are at about 30 feet below the ground, valuable beds of clay from 12 to 15 feet in thickness, which when chemically and microscopically examined revealed abundant evidence of organic matter, and of the extinct Flora of the Carboniferous rocks, whose decayed fragments mixed with sediment, (and together forming seat earth or "clay") are now manufactured into bricks and terra cotta designs.

These magnificent kilns can turn out 100,000 bricks per week. The clay contains in 100 parts :—

Moisture	4·30
Organic Matter and combined Water	7·71
Silicia	53·61
Protoxide of Iron	0·72
Peroxide of Iron	3·68
Lime	2·02
Magnesia	1·34
Alumina	25·96
Alkalies, other substances and loss...	0·66
	100·00

In the sample sent, one or two small rounded nodules were found, which on analysis consisted chiefly of Carbonate of Iron.

The Aketon Hall and Featherstone Manor Collieries belonging to Mr. Geo. Bradley, situated by the side of the Lancashire and Yorkshire Railway are worked; the "Stanley Main" bed of coal, 6 feet in thickness, at a depth of 240 yards, and the "Shale Seam," 3 feet thick, at a distance of 220 yards from the surface; the fuel is of superior quality from each mine.

Additional works for *winning* the celebrated "Barnsley Bed," which has been *proved* at a distance of 300 yards from the surface, are now nearly completed. This bed, Mr. Bradley says, is found to be 12 feet in thickness. and its existence at Featherstone, is, I hope conclusive testimony that it will be found to the South and South-East of Pontefract.

In the strata intervening between the surface and the Stanley Main Coal at these Collieries, salt water is found at a depth of about 200 yards. indicating that the salt rock exists somewhere in Yorkshire, but where has not been proved.* The recent discoveries near Newcastle-on-Tyne may, probably at no distant day, lead

* The salt has just been found at Middlesbro'.

to finding the salt rock on this coast, and if so, its importance cannot be over-rated.

Mr. Bradley, whom we have to thank for the development of coal at Aketon Hall, thinks it may interest this Society to know that ironstone ore has been found at Digby, in Lincolnshire, adjoining the Great Northern and Great Eastern Railways, and within 20 miles of the coast where it was supposed to exist. This ironstone being almost equi-distant (about 20 miles) from the sea and the Nottinghamshire coal field, will doubtless become a source of immense advantage to the towns and districts of the East Coast and of West Yorkshire.

On the 27th August, 1870, a little to the West of Pontefract. Messrs Ellison and Broadbent opened a new shaft at Syndale, and called it by the name of the "Whitwell Main Colliery."

The shaft, commenced on the 2nd February, 1869, was completed to the coal on the 19th August, at a depth of 228½ yards, and in rapidity of sinking, has scarcely a parallel. The beds of coal passed through, are the Shale Coal, 3 feet thick, and the Stanley Main coal, 7 feet thick.

On the 1st Dec., 1870, Messrs. Henry Briggs, Son & Co. (Limited) of Normanton, raised from their new pit to the surface, and screened and made ready for sale 1,006 tons of coal. The seam from which this tonnage was raised is the Stanley Main, to which three shafts are sunk. One shaft is used for pumping purposes, the other as an upcast, and the third is utilized as a downcast shaft and for coal drawing. This shaft is 12 feet in diameter, filled up with a pair of 18-inch cylinders, made by Messrs. Davy and Brothers of Sheffield. The cages are single decked, and carry two tubs of 10-cwt. each. This seam of coal is worked upon the long-wall system with banks of 30 yards in length, and single shifts.

The shaft used as the upcast shaft is 8-feet in diameter, and supplies to the workings 70,000 to 80,000 cubic feet of air per minute.

On the 20th April, 1873, the Hon. Robert Ashburton Milnes turned the first sod of a new coal shaft on the Frystone Estate of Lord Houghton, which is now, I believe, the nearest pit to the port of Hull, and the German Ocean. The Frystone Coal Co. pierced the Barnsley Bed, some 180 yards from the surface on 17th August, 1874. On the 5th May, 1875, they struck the Haigh Moor bed at 269 yards, and expect shortly to reach, at a depth of 451 yards, the Silkstone seam, at the same depth as the Wheldale Colliery, one mile off, and worked by the same Proprietors.

It is a very rich gas coal. The analysis of it (at Wheldale) gives,—

Cubic feet of gas obtained per ton	9,200
Tar, Ammoniacal liquor, etc., per ton of coal (avoird) ...	476lbs.
Carbonic Acid, Sulphuretted hydrogen	28lbs.
Coke, per ton of coals	1,480lbs.

The gas obtained has an illuminating power approximating to 17 candles, so far as could be ascertained by experiment on a small scale.

The specific gravity of the gas as compared with air calculated at a barometric pressure of 30 inches, and a temperature of 60° Fahrenheit is 0.51. The gas contains 5.6 per cent. of olefiant gas. It also contains the other usual constituents of coal gas upon which its lighting and heat-giving properties depend. The gas contains only traces of carbonic acid and no sulphuretted hydrogen.

This coal from the Silkstone bed is comparatively free from pyrites. It does not soil the fingers, and in appearance and physical properties possesses the characters of cannel coal. Its specific gravity as compared with water is 1·2811.

When carefully heated to bright redness, in a closed vessel, it gives 60.84 per cent. of coke, and after burning it leaves 3.02 per cent. of ash.

This new coal field consists of some 4,000 acres, and it is situated on the line of the North Eastern Railway on one side, and the river Aire in close proximity on the other side near Castleford, and about 2½ miles from Pontefract.

The Warren House or Barnsley bed of coal has been worked by this company for a distance of 2 miles in an easterly direction under the Magnesian Limestone, and is found there rising to the East at about an inclination of 1 in 77. The thickness of the Silkstone coal at Wheldale is 5 feet, and the coal is good and bright in appearance.

The shafts are each 15 feet diameter, which equals an area of $176\frac{3}{4}$ feet square each. In each shaft there are 70 yards of stone tubbing to tub off the water: the ventilation is created by a furnace which produces 130,000 cubic feet of air per minute; the horse power of the furnace being 28 H.P.

The number of coal seams which have been found to be workable on the estates of Lord Houghton and Temple, under those Royalties will, before being exhausted, supply a weekly quantity of coal of 10,000 tons for a period of nearly 200 years.

The Winding Engines, Plant, etc., now laid down, are capable of drawing 1,000 tons per day when required.

If from the Romans we received the idea of facilities of transport and communications throughout Ancient Britain, (for the Romans were the constructors of roads and highways) so from the Railway Companies we have received the most perfect scientific applications for rapidity of locomotion; and this district is benefited by this development of transport enterprise.

The Swinton and Knottingley Branch of the Midland and North Eastern Railway was opened for traffic on July 1st, 1879; the first sod of the Hull and Barnsley Railway was dug by Lieut-Col. Smith, the Chairman of the Railway Co., on Saturday, the 15th Jan. 1881; and the works on the line, generally, commenced about 1st Feb., 1881. The line, at present in course of construction, is about 50 miles long, and it is to be ready for inspection by the Board of Trade towards the end of 1884. The contractors, Messrs. Lucas and Aird (to whose representative we are indebted for an inspection at Upton of the Railway cuttings to-day) have brought mechanical contrivances to work, such as Steam Hydraulic

Navvy's, and Steam Grabbers, at the Dock, and elsewhere, which have enabled the contractors to construct this railway with a rapidity of growth, "like Jonah's gourd." This railway extension runs across the upper portion, so to speak, of the South Yorkshire coalfield, as the district is sometimes described, and for the present will stop at Halifax.

These two railways, North and South, and East and West mean a complete metamorphosis of Osgoldcross, not less remarkable than that which took place when the famous Roman Sixth Legion, about A.D. 117 marched from Danum to Legeolium—from Doncaster to Castleford, and nearly parallel with the Railway route by Ackworth to Doncaster. These two railways open out the new Yorkshire and Pontefract coal field of the future, of which deep shafts at South Kirkby, so energetically worked by Mr. John Shaw are the newest indications. What Merefield, Prince of Wales, Wheldale and Frystone, and the Manor Collieries of Mr. Bradley, at Featherstone, are to the Northern and Western sides of Pontefract, divided as it is by the sandstone ridge, on which the Town and Castle stand, so are these South Kirkby shafts, evidences of an extensive, valuable, and inexhaustible coal field to the south of the Borough.

The South Kirkby Colliery has two shafts, both 15 feet diameter—one as the upcast shaft, and the other as the downcast, and both are sunk to a depth of 640 yards.

The first bed of coal worthy of mention is the Shafton, found at a depth of 184 yards below the surface of the ground.

Section.	Feet.	Inches.
Coal	0	4
Dirt	0	1
Coal	1	0
Dirt	0	3
Coal	3	3

or a total thickness of 4 feet 7 inches of coal.

The bottom coal of this bed is of moderate quality for engine and brick making purposes; but as it burns to a white ash, it is not generally appreciated for domestic purposes; the two top beds of this Shafton coal, 1 foot 4 inches thick, are of inferior quality.

The next bed of coal worthy of mention before the Barnsley bed is reached, is the Kents Thin, or Bottom, or Best coal of the Stanley Main seam. It is 3 feet 2 inches thick, and of good quality for domestic use; but the other beds of coal, forming the Stanley Main Coal in the Normanton district (viz: the Lime Coal and Black Bands), are separated at this Colliery by many yards of parting or measures.

The famous Barnsley bed of coal is reached at South Kirkby at a depth of 634 yards, as per section:—

	Feet.	Inches.
Top Soft Coal	3	10
Dirt Parting	0	7
Hard Coal	2	9
Bottom Soft Coal	2	5
Total	9 feet, 7 inches.	

The following are the results of a careful analysis of the Barnsley Soft Coal, obtained from the South Kirkby Colliery, for gas making:—

Cubic feet of gas obtained per ton of coal ...	8,960 cubic feet.
Tar, Ammonical Liquor, &c.	408 lbs. (avoirds)
Carbonic Acid ... ... Sulphuretted-hydrogen	18·1 „ „
Coke and Ash	1,495 „ „

The gas obtained has an illuminating power approximating to 15 candles so far as can be determined from the quantity of coal operated upon.

The specific gravity of the gas as compared with air at 30 inches Bar. and 60° Fahrt. is 0·45.

The gas contains 4·8 per cent. of olefiant gas, or of substances of the same composition as olefiant gas.

As prepared and purified in the test apparatus by Mr. Thomas Fairley, F.R.S.E., of Leeds.—24th October.

An analysis of the Barnsley Hard Coal for gas, gives the following results:—

Cubic Feet of Gas obtained per ton of coal ...	10,400
Tar, Ammoniacal Liquor, &c.	41·25 lbs. (avoird)
Carbonic Acid ... ... } Sulphuretted hydrogen ... ... }	13
Coke and Ash	1504

The gas obtained has an illuminating power of 14·75 candles, so far as can be determined by the quantity of coal operated upon.

The specific gravity of the gas is ·41 (air=1).

The gas contains 4·5 per cent of olefiant gas, or of substances of similar composition. It was free from carbonic acid and sulphuretted hydrogen.

The coal is much harder than the other samples. Its specific gravity is 1·283. When heated in a closed vessel it gives 61·46 per cent. of coke, and when burnt leaves 4·28 per cent. of ash.

The sulphur separated from the gas from these coals in the test apparatus is, from the Fryston coal, 2·9 lbs. per ton; from the South Kirkby Colliery Soft Coal, 0.75 lbs.; and from the Hard Coal, 0·6 lbs. per ton.

This coal bed, 9 feet 7 inches in thickness, is extraordinary as compared with the generality of the coal of the Barnsley bed, and is equal in quality to other specimens of coal in the Barnsley coal field.

The upcast shaft is already sunk to this deep coal bed. and the downcast or drawing shaft is sunk to a depth of 400 yards; while it is expected to reach the coal about April, 1883.

Both shafts are cased with cast-iron tubbing, of which about 1,500 tons have been used to a depth of 126 yards.

The drawing engines are a pair of 42 inch cylinders, and 6 feet stroke; the nominal horse-power being 400 for the pair; and 10 boilers, each 30 feet by 7 feet.

At the drawing shaft, peculiar and novel modes both of winding and loading coal are to be used, whereby it is expected that the quantity of coals drawn up will be greatly augmented. For the purpose of ventilation at the upcast or air shaft, a Tchiele

Fan of 13 feet diameter is in course of construction to be driven by a pair of engines of 26 inch cylinders with a nominal power of 70 horses each. The capacity of the fan will be equal to about 250,000 cubic feet of air per minute.

This immense undertaking will involve an outlay of about £130,000. At Wheldale, the Barnsley bed is 202¾ yards below the ground surface; at Merefield Colliery, 254 yards; at South Kirkby, 634 yards; and at Denaby Main, near Conisbro', this splendid bed is successfully worked at a depth of 449½ yards.

Lastly, let me mention the probable extension of the Yorkshire coal field beneath the Magnesian Limestone and the New Red Sandstone, on the north side of the river Aire, and on the line of the Hull and Barnsley Railway, near Snaith, by Lord Beaumont of Carleton Towers.

A bore hole has been put down under the direction of Mr. Greaves, about 11 miles eastward of the Fryston Colliery, and two miles from Snaith, at West Bank, to a depth of 400 yards with the following results, viz:—

Earth, warp, and clay	15 yards.
New Red Sandstone	180 "
Upper Permian Marls ... ... / Red Marls with beds of Gypsum	23 "
Upper Permian Limestone ... ... / Limestone with some bands of Gypsum ...	28 "
Middle Permian Marls ... ... / Red Marl with thin bands of Limestone and Gypsum	41 "
Lower Permian Limestone...	68 "
Coal Measures, Sandstone, Blue Shale, Black Shale, Coal, 1 foot 6 inches, Spavin and Blue Shale	45 "
	Total, 400 yards.

Unfortunately, the boring stops short without reaching the Barnsley bed, which is believed to be a little lower down, because the contract for boring was only for this depth of 400 yards.

Mr. Greaves allows me to show a specimen of the Gypsum, which, if brought to the surface as a marketable commodity is valued at 1s. 6d. per ton, the inside core of the bore-hole being four inches in diameter.

The sub-division of the Permian Rocks occurs in the order in which they have been observed to crop up to the surface—they have each their usual character.

"There can be no doubt," says Mr. Greaves, "that the beds penetrated beneath the Permian Rocks are coal measures, and there are strong indications for believing that they belong to that part of the coal measures which contain workable seams of coal." The general character of the measures, the few fossils brought up in the cores, the clean and lustrous character of the thin seam of coal which has been passed through, all point to this conclusion; and that in the future the best portion of the Yorkshire coal field will be found between Barnsley and Snaith.

We shall hope that Lord Beaumont's restoration to health will enable him to continue this spirited investigation for coal, near Snaith, and that Mr. Greaves, the able and scientific pioneer of these sinking operations, may, at no very future date, be able to announce a discovery, that Lower Osgoldcross of 58,000, and Lower or one half of Barkstonash of 34,000 acres may be added as new coal fields to others in the County of York.

The Aire and Calder Navigation was opened in 1787; and the Knottingley and Goole Canal in 1826. The tonnage now reaching Goole, arriving and departing by this Canal in 1880, was above 392,000 tons. The return for the port of Hull and Dock Company, from January 1st to 31st October of the current year, dues was equivalent to 2,100,358 tons; and increase over 1881 of 214,388 tons; whilst up to the 31st October, 1882, the export of coal had increased by 68,000 tons.

THE PHOTOGRAPH FOR 1882.

THORNWICK BAY, FLAMBOROUGH. BY G. W. LAMPLUGH.

THE Photograph for this year is an excellent view of THORNWICK BAY, a little inlet on the northern side of Flamborough Head. The spectator is standing under the shadow of the cliffs on the west side of the "Bay," and looks due east across to the opposite headland.

The height of this headland is 150 feet. As will be seen, it is thoroughly riddled with caves and gullies, there being no less than seven caverns within the limits seen in the photograph,—and two long deep gullies which were probably once arched caves like the others. They are generally excavated along master-joints.

It is low-tide, and the beach in the foreground is strewn with rough blocks of chalk from the cliffs, with a thin scattering of darker transported masses from the boulder-clay; all covered with a plenteous growth of sea-weed, except near high-water mark. The weed is chiefly, but by no means wholly, the common Bladder-wrack *(Fucus vesiculosus)*.

The headland shows hard flinty chalk, capped with glacial drift of considerable thickness.

The Chalk contains much flint in irregular nodular layers; fossils are of rare occurrence,—here and there a large Inoceramus *(I. Cuvieri ?)*, an Echinoderm crushed beyond recognition, or a small Terebratula. The chalk dips gently south. The darker tint of the rock at the base of the cliff, within reach of the waves, is due to weathering and organic growth, and marks the limit of high tide.

The Drift is, as usual, complicated and variable, but the following section may be made out :—

At the top, 1.—Red boulder-clay (about 10 feet).

2.—Drift Gravel, very intermittent.

3.—Thick greenish or greyish boulder-clay, full of small pebbles but with a few large stones: often showing indistinct bedding, and appearing to pass into the gravel above and below it: fragments of marine shells plentiful in places.

4.—Drift gravel and sand; not seen on the headland, but well developed in the cliff near the middle of the bay.

5.—Fine angular chalky gravel or "wash" (possibly pre-glacial).

6.—Hard flinty chalk.

Though the beds above the chalk vary considerably both in thickness and composition, this section may be taken as a type of the geological structure of Flamborough Head.

I suppose the shape of The Head,—a blunted triangle, almost a cone, with its apex pointing due east, is known to all who will look on this picture. The cliff-line which forms its southern boundary, commencing near Bridlington and running east and east-north-east for five miles before the eastermost point is reached, pursues throughout a tolerably even course. But as soon as the projection is rounded and the coast faces north, a great and sudden change takes place, and the cliffs are indented and broken to such a degree, that from the Light-houses (which stand on the extremity) to the scene of the photograph, and for a little way beyond,—a distance in all of nearly three miles—the shore presents one long series of grand coast pictures, and we pass, step by step (where the tide allows), through caves and arches; into bays, and gullies, and nooks of ever-varying outline, with crannies and recesses innumerable; whilst here and there a massive rock-pillar stands sentinel-like apart. Add to this a clear and rollicking sea, dotted with many sail—one or two large steamers passing, no doubt, almost within hail—and occasional glimpses of the bold headlands of the coast-line stretching northward to Whitby—and you have, I think, as glorious a view as any on our Yorkshire coast.

Where the cliff is thus broken, its height nowhere exceeds 150 feet, but as we follow its course westward, it resumes its regularity, and rises somewhat swiftly to 250 feet, and then more slowly, till at Speeton, about five miles from Thornwick Bay, where the coast-line swerves northward and thus marks out the headland, the total height of the cliff is 444 feet.

The sudden change in the character of the coast at the eastermost point is not difficult to explain, and is due to more causes than one.

In the first place, the force of the sea is far greater on the exposed north than on the sheltered south side of the headland, and a violent tide-course also strikes it and is deflected eastward.

Then the upper flintless chalk,* which forms the cliffs between Bridlington and Flamborough, is soft and shattered, and yields readily to the waves all along the line; but at the headland, flints put in an appearance, and the chalk becomes extremely hard and unyielding, and withstands the attack of the sea so well, that differences of resisting power have time to produce great results, and all the weak points, along joints, or where the beds are crumpled or shattered, are carved out.

There is still another cause. It will be noticed in the photograph that the old chalk surface below the drifts slopes inland, so that while the chalk is 90 or 100 feet thick on the headland, it is not more than 8 or 10 feet in the recess, part of this decrease, however, being due to the rise of the beach. This is really the northern slope of a valley which, in pre-glacial times, has run almost parallel with, and at no great distance from, the present cliff-line. This valley, which has been filled with drift and nearly obliterated during the Glacial Period, follows the northern coast-line of The Head to its extremity, and there runs out, being cut across where the cliff swerves south-west for Bridlington. Lateral feeders seem to have run into it from the north-east; indicating a wide extension of land in that direction.

This old valley causes some of the finest features of the coast,

* This upper chalk contains a fair number of fossils, chiefly sponges.

for when the sea tunnels back into its weathered slopes, they yield readily, and in two cases the waves have actually burst through into the drifts which fill the hollow, and as these have been of course readily scooped out, circular chasms—pot-holes in fact—have been formed in both cases, some little distance from the cliff. One of these is small enough to act as a "blow-hole" in rough weather, the sea choking up the vent till the imprisoned air bursts out with much noise, driving upward a cloud of spray.

There are a few lateral crevices, connected with caves, that "blow" in the same way. Goethe must have seen something like this :—

> "*Und die langen Felsennasen*
> *Wie sie schnarchen, wie sie blasen!*"*—(*Walpurgisnacht*).

After all, I cannot tell which is the finer picture—the fantastic ruggedness of this part of the coast, or the simple grandeur of the precipice beyond, where the great grey cliffs hang in a straight unbroken wall above the waves that lap and lash far below.

There, in the spring and early summer, countless swarms of sea-birds take up their abode—guillemot, razorbill, puffin and kittiwake—and pass continually in and out, like bees to a hive.

Not always is this little bay so bright and pleasant as you see it here, for—

> "Sometimes the sea takes a passionate tone
> And roars and raves in an angry mood."

Even while I write such a mood has come upon it, and this is what has taken place on the very spot :—

The schooner *Cheval de Troie*, of Guernsey, Captain Marriette, with a crew of six, bound for Shields from Dover, in ballast, was caught in the gale and snowstorm of December 6th, off Flamborough Head and driven unobserved on these rocks.† Her crew

* "The giant-snouted crags, ho! ho!
How they snort, and how they blow!"—*Shelley's Translation.*

† From the wreckage brought ashore she seems to have first struck close to where the boat is seen in the left foreground of the photograph, and afterward to have shifted a little further west.

having lost all reckoning and not being able to see a cables-length ahead, had already taken to the rigging when the vessel struck; and one, Nicholas Williams, who was above the others, was flung oft into the sea by the shock. He lost consciousness, but was no doubt carried directly ashore. When he gained his feet and looked towards the ship, he saw that her masts had gone over the side, and her hull also immediately broke up, and disappeared. Of the rest of the crew he saw nothing. He was much bruised and exhausted, but made his way up the cliff and reached a farm house not far inland, carrying the first and only news of the disaster.

A little later in the day, the large collier steamer, *Black Diamond*, went ashore three miles further south. Her crew of sixteen were saved by the coast guards by means of the rocket-lines.

Such is an oft repeated chapter in the history of these pleasant cliffs.

ON SOME SECTIONS EXPOSED DURING THE FORMATION OF THE LINE OF RAILWAY BETWEEN UPTON AND KIRK SMEATON. BY JAMES W. DAVIS, F.G.S.

THE new line of railway at present in course of construction between Hull and Barnsley has exposed many sections of considerable geological interest. Amongst the most interesting is an exposure in the cuttings and tunnel near Kirk Smeaton, showing the junction of the coal measures with the superimposed magnesian limestone. The number of sections exhibiting the same arrangement are not very numerous. An instance occurs at Conisborough Castle where an outlier of sandstone forms a hill which is covered with Permian Limestone on which the castle is built. At Bramham Park, Knaresborough, and some other places, similar sections occur. In some sections the limestone rests on sandstone, and in others, on members of the coal measure series, but at the places last named the limestone lies above millstone grit rocks. It frequently happens that the sandstone or shale beneath the limestone is stained a reddish or purple colour, and the rocks so stained were considered from this circumstance to have been new red sandstone, the equivalents of the German *rothe–todte–liegende.* In the volume of "Proceedings" of this Society issued for 1877, I contributed a paper on "The unconformability of the Permian Limestone to the RedRocks below them," in which a somewhat detailed account is given of the occurrences, of such sections and circumstances attending their occurrence, along the line of the Permian escarpment, reaching in an almost north and south direction across the length of the county. In the present paper I propose to give a description of the sections exposed during the formation of the railway cutting, with a sufficiently detailed account of the immediately surrounding district, to make them intelligible.

The coal measures in the immediate vicinity consist of the upper measures exposed in the West Riding, and include a series of sandstones and shales, with beds of coal not at present worked in the district, though they are at short distances where railway accomodation has been accessible. The surface is characterized by gentle undulations, caused by the alternation of sandstones and shales dipping in the main eastwards with a north and south outcrop towards the west. The sandstones are not generally sufficiently thick and prominent to form escarpments such as characterise those of the lower measures westwards, but having resisted denuding agencies to a greater extent than the shales, remain to form the higher ground, whilst the hollows indicate the localities where the shale comes to the surface. The uppermost bed of sandstone exposed is the Houghton Common or Pontefract rock. It is the sandstone on which the Castle at Pontefract is built, and it extends round three sides of the hill, a fault running from Tanshelf roughly in a line with Causeway Lane to the south-west, throwing it out in that direction. South of Pontefract there are a series of sandstones occupying the surface around Ackworth, which are described in the Memoirs of the Geological Survey as the "Ackworth Rocks." Near the village they have been cut through by the River Went, exposing the shales beneath. A tributary of the Went running between East Hardwick and Went Hill also exposes the shales in a similar manner, the Ackworth Rock capping the slight elevation of East Hardwick on the west, and on the east immediately underlying the Permian Limestone escarpment forming the western boundary of Went Hill to Wentbridge and for some distance south of the deep channel formed by the river. This sandstone on the Geological Survey Map, 87 N.E., is indicated as a "Lower Red Sandstone and Marl," and considered a member of the Permian and Magnesian Limestone series. Later researches, as already stated, have proved that this is not the case, but that it is a sandstone of the coal measure epoch which has been stained by the superincumbent limestone a reddish or purplish colour. South of the Went, the whole of the district round Badsworth and South Kirkby is composed of shales with occasionally thin beds of raggy sandstone. Westwards of Hemsworth a sandstone occupies the surface extending to Brierley, called the "Brierley Rock;" and south-eastwards forming a semicircular patch, is an expansion of the Houghton Common or Pontefract rock, reaching to Clayton-in-the-Clay. Near Cudworth the line of railway cuts through some of Chevet Rocks, which along with the Oaks Rock are considerably developed towards Barnsley.

After the deposition of the coal measures a long interval elapsed before the Permian Limestone formation was deposited. The coal measures which had been evenly and uniformly accumulated above the millstone grit rocks over the surfaces now known as Lancashire and Yorkshire became subject to great displacement by subterranean agencies; the hills dividing the two counties were forced into existence, and during the process the whole country, east and west of the great central line of elevation was broken by innumerable faults, extending in every direction. These are especially frequent in the higher beds of the series where the measures are less persistent and more rapidly divided by alternating beds of shale, sandstone and coal. These strata being thinner were necessarily more easily influenced by the distributing force, and being further removed from the line of elevation and near the centre of the trough-like synclinal, had not only the pressure from the west to resist, but also that of the comparatively little influenced tract to the eastwards, which caused them to be broken into innumerable cube-like masses, whose relative lateral positions were much changed and faulted.

Subsequent denudation removed great masses of the much broken strata and planed it down to more or less even surfaces before the deposition of the Permian Limestones. This is amply proved by the position which these limestones occupy with regard to the underlying beds. The millstone grits, after extending in a north and south direction from Derbyshire to the neighbourhood of Halifax, make a great curve eastwards, and the whole of the district west of the Permian Escarpment, north of Leeds to the boundary of the county is composed of these rocks. The several sandstones and shales included in the divisions known as the "Rough Rock," immediately below the coal measures, the third grits, at Plumpton and Spofforth, and the equivalents of the Kinder Scout Grits the lowest beds, occuring in the neighbourhood of Ripon and northwards, successively disappear beneath the limestone escarpment with a southerly dip and a strike east and west; the opposite direction to that of the superimposed limestone. South of the neighbourhood of Leeds the successive beds of the coal measures dip under the limestone, always unconformably, the sequence of the strata from the lower coal measures north of Leeds, to the uppermost beds the Red Rocks at Rotherham, being successively obscured.

In the West Riding the Permian rocks consist of the following beds :—

Upper Marls with Gypsum and Sandstone.
Upper Limestone.
Middle Marls with Gypsum.
Small Grained Dolomite.
Lower Limestone.
Quicksand.

These rocks extend with varying modifications in a long narrow strip, rarely more than four or five miles in breadth from east to west, from Nottinghamshire through Yorkshire into Durham in a N.N.W. and S.S.E. direction. They usually present an escarpment to the westward, overlooking the undulating surface of the coal measures. The limestones dip towards the east beneath the New Red or Bunter Sandstone. The junction of of the two series is rarely visible, being covered by a considerable thickness of drift, the latter in great part composed of the denuded Permian Limestone. The Lower Limestone occupies the surface of the ground from Upton to the River Went beyond Kirk Smeaton, a distance of nearly four miles. The Quicksands which are in some localities, as at Garforth, of considerable thickness, occur sparingly. On the east bank of the River Went the Middle Marls occur on the slope of the hill surmounted by the Upper Magnesian Limestone, the latter being about one mile in breadth. The junction of the two may be seen in the cutting about 100 yards east of the river.

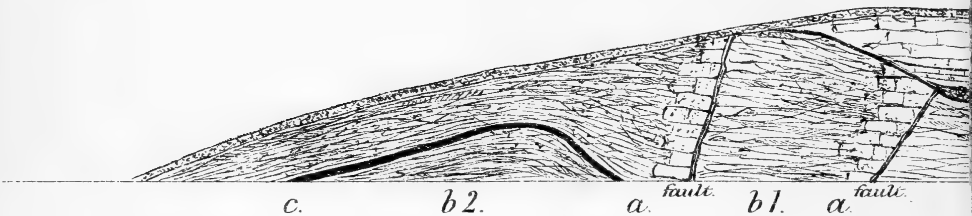
The junction of the Coal Measures and the Permian Limestone is exposed in the railway cutting near Upton Old Hall. The former consists of shales with beds of soft raggy sandstone which dip rapidly towards the S.W. They are a red or purplish colour. The Permian Limestone rests unconformably on the shales and extends almost horizontally towards the east.

The diagram (Pl. IV., Fig. 1) represents the section exhibiting the position of the two series of rocks. The Coal Measures are highly inclined and also considerably displaced, and broken by faults. The section is taken from the north side of the cutting; the greatest depth exposed is about 20 feet, and at that point a fault in the Coal Measures throws a raggy sandstone, *a*, against the shales, *b*, the latter nearly horizontal, the sandstone much broken and contorted. West of the sandstone a second mass of shales, *b* i, occur, and these are again thrown into juxtaposition with the sandstone, *a* i, by a second fault. The remaining portion of the cutting is in shales, forming an anticlinal, interstratified with them, there is a bed of coal, *c*, six inches in thickness. The Magnesian Limestone beds overlie those of the Coal Measures, extending a short distance to the west of the principal fault. At the base of the limestone is a bed of quicksand, *d*, about six feet in thickness, but thinning out towards the fault where it is only two feet thick. It is much current-bedded; and appears in all respects similar to the beds of quicksand at Garforth and other places. The lower six feet of the limestone is thin-bedded and somewhat slaty, above this it possesses the usual character of the lower limestone, being thick-bedded and massive, with numerous cavities lined with crystals of carbonate of lime.

Eastwards from the Upton section all the exposures are in the lower limestone until the tunnel is reached. The latter for a considerable distance from either end is quarried from the same limestone, but towards the centre of the tunnel coal measure shales are again met with. Beyond the tunnel the lower limestone dips rapidly eastwards, and above it a considerable thickness of the middle marls is exposed in the cuttings. Near the Pack Saddle Plantation, where an accomodation bridge crosses the cutting, the lower part is formed in the lower limestone, above which is about eight or ten feet of Red or Purple Marl. Between the two, in hollows on the surface of the limestone are small lenticular masses of unctuous yellow clay. (Pl. IV., Fig. 2).

Eastwards from the River Went, near Little Smeaton, the middle marls in turn disappear beneath the Upper Limestone. The junction of the two may be seen in the cutting about a 100 yards beyond the river, dipping rapidly eastwards. The marls are composed of a yellow sandy clay, with about four inches of

Fig. 1. Section at Upton in a Cutting



Coal Measures.

a. Sandstone.
b. b 1. b 2. Shales.
c. Coal.

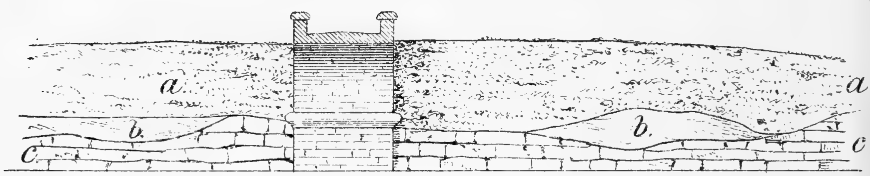
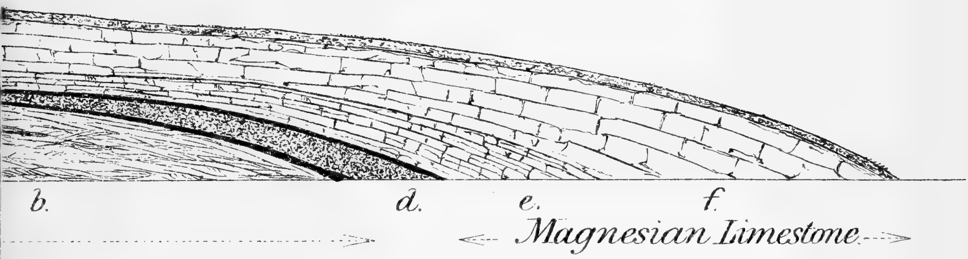


Fig 2. Section of Limestone and Middle Marls.

a. Red Marl.
b. Yellow Clay.
c. Lower Limestone.

n the Hull and Barnsley Railway.



d. Quicksand.
e. f. Limestones.

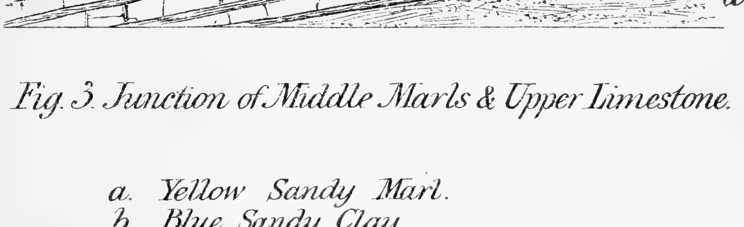
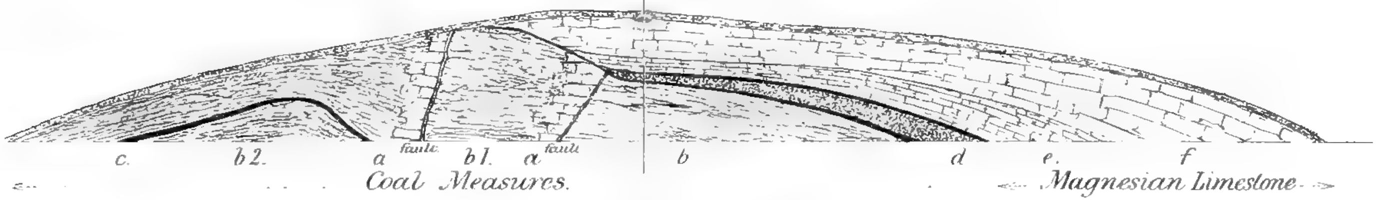


Fig. 3. Junction of Middle Marls & Upper Limestone.

a. Yellow Sandy Marl.
b. Blue Sandy Clay.
c. Thin Bedded Limestone with Marl Partings.

A. Megson & Sons Litho Leeds.

Fig 1 Section at Upton in a Cutting on the Hull and Barnsley Railway.



a. Sandstone.
b b1 b2. Shales.
c Coal.
d. Quicksand.
e f. Limestones

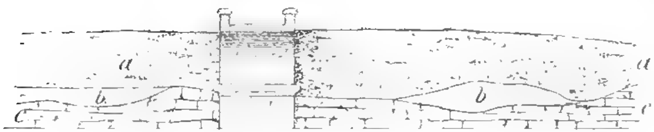


Fig 2. Section of Limestone and Middle Marls.

a Red Marl.
b. Yellow Clay
c. Lower Limestone

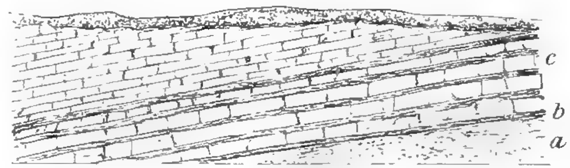


Fig. 3. Junction of Middle Marls & Upper Limestone.

a. Yellow Sandy Marl.
b. Blue Sandy Clay
c. Thin Bedded Limestone with Marl Partings.

a blue sandy clay. The limestone is thin-bedded with thin partings of clay or marl. (Pl. IV., Fig. 3).

NOTES ON THE EXCURSION TO THE WEST-RIDING OF YORKSHIRE: TOGETHER WITH PRELIMINARY REMARKS BY W. H. HUDLESTON, F.G.S., PRES. OF THE GEOLOGIST'S ASSOCIATION, LONDON.

The West Riding of Yorkshire exceeds in extent either Devonshire or Lincolnshire, yet in spite of its size the Carboniferous Rocks alone form a very large percentage of its area—a circumstance no doubt contributing largely to its wealth and importance. Thus, when people hear of the West-Riding, visions of smoke and steam, of factories, collieries, forges, and all the concomitants of a black country present themselves to the imagination. Yet the district visited on this occasion has none of these things, being purely agricultuaal or pastoral, mostly the latter; not densely inhabited, and constituting an agreeable tract of hill country which becomes mountainous towards the west. It forms part of a large block of older Carboniferous Rocks, which a series of east and west folds has brought to the surface between the Coal Fields of Durham and South Yorkshire, and is included within the wapontakes (hundreds) of CLARO and STAINCROSS, the latter being nearly coincident with the archdeaconry of *Craven.*

Claro commences where the first roots of the Penine chain spring out of the Vale of York. Hydrographically it comprises the whole of the basin of the Nidd, together with small portions of the Ure on the north, and of the Wharfe on the south. Harrogate, with nearly 10,000 inhabitants, is the largest town, but Knaresborough must be regarded as its historic capital. Excepting strips of Trias and Permian on the east, almost the whole of Claro is on Millstone Grit, in parts covered by Drift. The surface ranges from 100 feet to 2,200 feet above sea level, and contains a considerable proportion of indifferent land, some of which, however, forms the best grouse ground in the county. There are wide upland plateaux with valleys of moderate slope: the hills never attain to the dignity of a peak, the most salient features being crags of gritstone, such as Almias Cliff (Kinder Grit), Brimham Rocks (Third Grit), and the rocking stones on Roggan Moor so celebrated in the annals of shooting. The Millstone Grits of this district contain waters of remarkable purity, and the valley of the Washburn is now the storehouse for Leeds, just as Loch Katrine is for Glasgow.

On reaching the valley of the Wharfe at Bolton a different style of country begins to appear, though Bolton may be regarded as partaking of the Millstone Grit scenery of Claro, and of the Carboniferous Limestone scenery of Craven; where the hills are usually tabular, but with a peaked termination in places. The weathering of the Carboniferous Limestone produced long scaurs or cliffs, such as those at Malham, Gordale, and Kilnsea. The climate being wet and the soil calcareous, Craven is given over almost wholly to grass—some of the very best and most feeding pasturage in England. Skipton is the principal town, and has always been regarded as its capital.*

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* It used to be said that a squirrel could go from Knaresborough Castle to Skipton Castle without once touching the ground. Those were the days when Knaresborough Forest used to be covered with "*silva minuta*," most of which has long since disappeared.

Knaresborough was about as far south as the marauding Scots ever got in their numerous forays into the North of England. During the dis-organization which succeeded the battle of Bannockburn their army ravaged the country up to the very gates of York, (A.D. 1319). The people of Ripon paid black-mail and were let off. The men of Knaresborough, a royal burgh, stood the risk of battle, and were defeated. Part of the inhabitants took to the church tower, where the Scots tried to burn them alive; the marks of the fire are said to be still visible. The Scots returned home by way of Skipton, which was also

We obtain our knowledge of the geology of the country round Harrogate chiefly from Mr. Fox Strangway's "Memoir," whilst the excellent work of Davis and Lees treats of the West Riding as a whole.

The PERMIAN rocks in the eastern part of Claro, though mostly unfossiliferous, are not without interest. The *Lower Marl* has a very slight development; but 5 feet of red and grey marls, belonging to this section, are to be seen in St. Helen's Quarry, south-east of Knaresborough. These are the marls to which allusion will presently be made in connection with the subject of rock staining.

The most important member of the series is the *Magnesian Limestone.* Only a few fossils have been found in this district, and those chiefly from the lower beds, though traces of *Axinus* may be seen in beds which are highly dolomitzed. At Knaresborough the yellow earthy variety is most frequent. It lends itself to the formation of caves, and, owing to its peculiarly friable structure, imparts a character to the gorges through which nearly all the

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harried and burnt. The route between the two towns was so desolated that forest tenants were partly excused their rent to the King under the plea of impoverishment.

The more modern history of Knaresborough commences with the grant by Edward III. to John of Gaunt (A.D. 1371,) since which time the town and district may be said to have followed the fortunes of the duchy of Lancaster. About the same period Skipton was granted to Robert, Earl of Clifford, the ancestor of that ruthless partizan of the House of Lancaster, who slew the boy Earl of Rutland at the Battle of Wakefield.

We cannot doubt that, during the wars of the Roses, the district between Knaresborough and Skipton must have been strongly Lancastrian; and thus it came to pass that, when Henry VI. and Queen Margaret lay at York in the spring of 1461, an order was issued, in the name of the King, to summon all "liege men of the forest and demesne of Knaresburgh" to join the Lancastrian army. This was a few days before that fatal Palm Sunday which witnessed the complete triumph of the Yorkists at Towton on the banks of the Cock,

When the rivers ran all gory,
  And in hillocks lay the dead;
And seven and thirty thousand
  Fell from the white and red.

A battle wherein more Englishmen died than any other that has yet been fought.

rivers of the West Riding have to pass on their way into the Vale of York. Most of these earthy varieties contain probably about 25 per cent. of carbonate of magnesia; they are quite useless as building stones, but make excellent mortar. This porous, spongy sort of rock passes into yellow crystalline dolomite, frequently showing coloured bands; the more ferruginous varieties being studded with radiations of a metallic oxide, which is probably magnetite.* No purer form of dolomite than this would seem to occur in the Knaresborough district. But a few miles further south the crystalline dolomites of Huddleston Quarry are famous; there occurs also in Towton Field a form of Magnesian Limestone which is concretionary in small ovoids, almost resembling an oolite.

The *Middle Marl* succeeds the Magnesian Limestone, and in some cases must overlap it. This sub-division consists of red marls, and soft red sandstone, with some gypsum. Above it some small remains of the *Upper Limestone* are visable in a cutting to the west of Knaresborough.

The association of gypseous marls with beds of magnesian limestone is worthy of attention as having an important bearing on the origin of magnesian limestones, regarding which there are so many rival theories. Is the double carbonate a contemporaneous product, or the result of subsequent dolomitisation? Some are disposed to regard the formation of magnesian limestone as the

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Sir William Plumpton, the commander of the Knaresborough contingent, was taken prisoner, and his son slain along with many others of less degree, so that days of mourning fell upon the manor and forest.

The bloody Lord of Skipton, Shakespeare notwithstanding, had fallen in a preliminary skirmish, but his youthful son, afterwards known as the Shepherd Earl, found refuge under the care of Sir Launcelot Threlkeld in the wilds of Saddleback, whence he emerged to resume his rank and estates on the final triumph of the House of Lancaster.

The part played by the royal castles of Knaresborough and Skipton, during the Parliamentary wars, is too well known to require further mention.

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* These markings, on examination are seen not to be dendritic; still they may contain some oxide of mangnanese.

result of precipitation in an inland sea, or at any rate of deposits due to streams charged with carbonate of lime and sulphate of magnesia; when, as Sterry Hunt has endeavoured to show, dolomite and gypsum would be the products. Prof. Green thinks that the palæontological facts noted in the Magnesian Limestone of Yorkshire favour this view, and he gives a history of the sequence of events, beginning with sandy deposits (the quicksands at the base of the Permian in South Yorkshire), which pass into sandy dolomites, and thence into pure dolomite. The fossils occur mostly in the lower beds, and as the waters became more highly charged with saline matters, so life became scanty and dwarfed. He also looked to volcanic action as a source of supply for magnesian salts; but Mr. Lucas pointed out that the requisite materials might have been derived from the Yoredale Rocks and Millstone Grit of the neighbourhood, which were in all probability already above water. These questions have an additional interest as bearing on the probable position of the old shore line of the Permian sea in these parts, and on the date of the Pennine upheaval.

THE MILLSTONE GRIT Series is classified by Davis under the head of shore deposits with marine intercalations. The name serves to show the misleading character of a petrological title, as the group is full of shales, often containing ironstone, the smelting of which in former years has much to do with the disappearance of wood from Knaresborough Forest.

In the neighbourhood of Harrogate and Knaresborough the upper divisions of the Millstone Grit, including the "*Rough Rock*," are wanting, the highest beds now found belonging to the "*Third Grits.*" This circumstance is of course the result of pre-Permian denudation, which has not only removed the Coal Measures, but a considerable portion of the Millstone Grit likewise. Consequently, in this district, the Permians repose unconformably upon certain quartzo-felspathic grits, which are often of a red or purple colour. These are largely developed throughout many parts of the drainage area of the river Nidd, appearing in moderate elevations at Plompton, but rising to a height of nearly 1,000 feet above sea level in Brimham Rocks.

It is these Plompton Grits which the older geologists were disposed to regard as the equivalent of the "Rothliegende," apparently from a general impression that the base of the Permian should be *red*, in order to correspond with the beds in Germany. The Red Rock of Rotherham, now known to be a member of the Upper Coal Measures, was for a long time classed with the "Rothliegende," in deference probably to the opinions of Phillips and Sedgwick. It is hardly necessary to repeat that, throughout Yorkshire, the unconformity of the true Permian to all members of the Carboniferous is one of the most marked features in the stratigraphy of the country. This was recognized by Phillips, and yet he persisted in regarding the Plompton Grits as "Rothliegende." Mr. Binney seems to have been the first to suspect, from the character of the few fossil plants occasionally found in these beds, that they were not of Permian age, whilst later on, Mr. Clifton Ward and the Government Surveyors succeeded in establishing their true stratigraphical position as members of the Millstone Grit.

The coloration of these beds has also been the subject of much controversy. The causes which have produced rock-staining in the underlying beds, at the junction of the Permian and Carboniferous of these parts, may not be all of the same nature. Mr. Ward thought that the prevalence of a red colour in the underlying rock might be due to some action exerted by the Magnesian Limestone on the percolations; and this notion has attained a certain degree of acceptance, though it is difficult on chemical grounds to see exactly what the nature of such action can be. Moreover, it is quite an open question whether there really is any increase of red colour in the grits which lie beneath the Magnesian Limestone; indeed, that there is any such increase is denied by Mr. Lucas, who, as before mentioned, was inclined to attribute some of the red colouring to a lower marl now removed. In many parts of the Nidd valley the stratum of grit in actual conjunction with the Magnesian Limestone is often less highly coloured than the bed below. There can be very little doubt that much of the red colour of the Plompton Grits is due to the quantity of red felspar which they contain, so that possibly the principal causes were pre-existent within the rock itself.

The fossiliferous horizon known as the Cayton Gill beds, (*c* of the diagram, Fig. 1), is seen on both sides of the Harrogate anticlinal. *Productus semireticulatus* is the most abundant fossil; *Streptorhynchus crenistria* is fairly plentiful, as also a very pretty *Fenestella;* the joints of Encrinites are very abundant.

Kinder-Grits.—The base of the Millstone Grits consists of three thick grit beds associated with still thicker shales. Some of these grits have been extensively used for building stone at Harrogate, but they are very porous. Though usally pretty free from strong colours, these beds are occasionally very purple, though exposure soon removes the tint. The outliers of the Millstone Grit Series in Craven mostly belong to this section.

YOREDALE ROCKS.—This is a group established by Phillips for a variable series of beds between the Carboniferous or Scar Limestone of Craven, and the Millstone Grit. It is well devoloped in Craven and throughout the west, consisting of shales, limestones, and peculiar grits, often calciferous. In the bed of Hodder, Yoredale Shales, with their limestones and layers of ironstone, give rise to springs containing sulphuretted hydrogen. In Bolland Forest these shales are dark and full of molluscan and fish remains. Near Skipton the Yoredale Rocks consist of calcareous shales and limestones with many fossils, the beds sometimes being of a ferruginous and bituminous character; sulphur springs occur there in a position somewhat analogous to those at Harrogate. The altitude of the Yoredale Rocks at the latter place may be gathered from the diagram, Pl. IV, Fig. 1. Very little is known about the shales of this group, but the Harrogate roadstone (*a* of the diagram) is a remarkable rock; below this are other shales and another peculiar grit.

The Yoredale Grits at Harrogate are so peculiar that, being in some way connected also with the phenomena of the sulphur springs, a brief description may be useful, before proceeding to consider the subject of the waters themselves. A large hand specimen from the Beckwithshaw quarry shows three different phases. Firstly, a fine-grained quartzo-felspathic grit without lime; secondly, a calciferous encrinital grit, where the lime has mostly been removed, but where the structure of the crinoidal stem is better brought out in consequence; thirdly a more calcareous portion. A hand specimen from the bottom of the sulphur well on Harlow Carr is a very fine-grained quartzo-felspathic grit with much white mica, and coaly matter in bands and blotches. In the Low Harrogate quarry (Cold Bath Road), the crinoidal character is very prevalent, and where the soluble matter has been removed, it becomes a spongy, silicious, encrinital grit. The decomposition of this rock produces a good soil, but we may well believe that the surface beds have already parted with some of their constituents, and the iron-stained nature of the joint faces points in the same direction; it is in the stuff formed in these cracks that the little double-pyramid quartz crystals, known as Harrogate diamonds, have been deposited.

The Harrogate waters,* both sulphur and iron, occur in connection with a triangular patch of Yoredale rocks, of which a cross section is seen in Pl. IV., Fig. 1. This patch is bounded towards the N.W. by the main fault, and extends for about three miles S.W. of Harrogate. There are about 80 springs in all. The strongest waters rise in the little valley of Low Harrogate between the Bog Field, 375 feet, and the Montpelier Spa, 335 feet. This is the nucleus of the sulphur waters; the strong iron waters are near, but usually occupy an outer area. It is evident that an iron water

* For further details consult "The Harrogate Waters," by George Oliver, M.D.—H. K. Lewis, London.

and a sulphur water are incompatable, yet they wait closely on each other, and must in some way be connected. One of the great puzzles is to understand how they are kept apart in the ducts which convey them to the surface. The very high angle of the beds, and the peculiar jointing of the encrinital grit probably have something to do with it.

The composition of the Harrogate waters has often been studied from a therapeutical point of view, but it has also its geological aspect, and recent observations have brought out some features of considerable importance in this direction. Henceforth there will be less difficulty in understanding the vein deposits of the Carboniferous Series, as here we have an opportunity of testing the vital fluids of the rocks, as it were, in the act of circulation. An inspection of the accompanying table may serve to illustrate this.

The five waters, whose analysis is there given, are representative of the chief varieties. Technically the *Sulphur waters* are divided into strong saline, mild saline, and pure, the latter term being merely relative. It may also be noted that No. 3, selected as a type of the "pure sulphur," is situated at some distance from the triangular patch of Yoredale Rocks previously mentioned, and very near the junction of the Millstone Grit Shales with the Middle Permian Marls. At the same time it is not improbable that this spring may represent an overflow (from a spring) at Bilton, which is more in the direction of a slight prolongation of the anticlinal axis. In consequence of the absence in this water of the chlorides of the alkaline earths, there is a fair amount of alkaline carbonates, and the same is the case with the spring at Harlow Carr on the other side of Low Harrogate. In fact the further away from Low Harrogate the less amount of chloride occurs in the sulphur springs.

The Old Sulphur Well yields a pretty uniform supply, amount- to about 12 gallons per hour, though in the very dry year, 1868, there was some mention made of a threatened deficiency. The temperature is evidently pretty nearly that of the air, so that no appreciable amount of extraneous heat can be detected. Indeed, it may be said that all the waters of Harrogate are "cold," and, with one exception (the Alum Well), they have all a markedly alkaline reaction. Roughly calculating the Old Sulphur Well would yield seven tons of chlorides per annum, including 100 lbs. of Barium Chloride,* and 37 lbs. of Magnesium Bromide, with some Iodide. It would also produce 240 lbs. of Sodium Hydrosulphide (NaHS.)

The origin or source of these abundant impregnations has naturally been a matter of considerable difficulty. The most probable explanation is that the springs, though not superficial, are far from being deep-seated, and that the water supply comes mostly from the Harlow Hill district, which attains 600 feet elevation, and attracts a rainfall that cannot well average less than 35 inches annually. That the supply is not superficial may be inferred from the fact that the drainage from the Bog Field had no effect on the delivery of the waters, and thus the notion, held by Phillips, as to the bog origin of the sulphur waters would seem to be untenable. The large quantity of chlorides look very much as if a portion of the water of the sea or of an estuary† had been evaporated and the salts incorporated with the Yoredale Rocks during their formation. There is abundant evidence, both in this neighbourhood and elsewhere, of the quantity of organic matter,

* Barium Chloride was not noticed by Hoffmann, in 1854; and that chemist only found traces of Bromides and Iodides. Improvements in methods of analysis may account for the difference.

† The total Solids of the Mediterranean compared with those of the Baltic, present the following per centage differences. (Bischof, Vol. 1.)

	Mediterranean.	Baltic.
Solids	3·77	1·77
Haloids	$89\frac{1}{2}$	$94\frac{1}{2}$
Sulphates	$10\frac{2}{5}$	5
Carbonates	$\frac{3}{5}$	$\frac{1}{2}$
	$4·77\frac{1}{2}$	2·77

HARROGATE WATERS.—ANALYSES.

No. 1.—Old Sulphur Well (Strong saline Sulphur). Thorpe, 1875.

	Grains in gall.		Grains in gall.
Sodium chloride	893·7	Total haloids...	105·5
KCl. 9·6, LiCl. 0·7, NH_4 Cl 1·0, $CaCl_2$ 43·5, $BaCl_2$ 6·6, $MgCl_2$48	109·4		
Magnesium Iodide	0·1		
,, Bromide	2·3		
Calcium carbonate	29·8	Total earthy carbonates	35·8
Magnesium carbonate	6·0		
Alcaline carbonates			nil.
Sulphates			nil.
Barium sulphate			0·5
Silica			3·7
Total solids			874·6

Gases.—Principally carbonic acid, in moderate amount with oxygen and nitrogen.

No.5.—St. John's Well (Pure Chalybeate). Hofmann, 1854.

	Grains in gall.		Grains in gall.
Sodium chloride	1·5	Total haloids	1·5
Iodides	traces.		
Calcium carbonate	2·3	Total carbonates Ca. Mg. Fe	5·9
Magnesium carbonate	3·0		
Ferrous carbonate	0·6		
Sodium carbonate...	1·3	Total alkaline carbonates	2·3
Potassium carbonate	1·0		
Calcium sulphate ..			0·3
Silica			tr.
Organic matter			tr.
Total solids			10·0

Gases.—Principally carbonic acid, with some nitrogen, and traces of carburetted hydrogen and of oxygen.

HARROGATE WATERS.—ANALYSES.

No. 1.—OLD SULPHUR WELL (Strong saline SULPHUR). Thorpe, 1875.

	GRAINS IN GALL.		GRAINS IN GALL.
Sodium chloride	893·7	Total haloids...	105·5
KCl. 9·6, LiCl. 0·7, NH_4 Cl 1·0, $CaCl_2$ 43·5, $BaCl_2$ 6·6, $MgCl_2$48	109·4		
Magnesium Iodide	0·1		
„ Bromide	2·3		
Calcium carbonate	29·8	Total earthy carbonates	35·8
Magnesium carbonate	6·0		
Alcaline carbonates			nil.
Sulphates			nil.
Silica			0·7
SODIUM HYDROSULPHATE (NaHS)			5·2
Fe, SP_2O_5, Al_2O_3 and organic matter			traces.
Total solids			1407·2

GASES.

NOTE.—The amount of free H_2S found by Thorpe dissolved in water is given at an amount = 3·7 grains per gallon. In his paper in the "Journal of the Chemical Society" no other gases are mentioned. Hoffman in 1854 found carbonic acid 22 cubic inches, carburetted hydrogen 6 cubic inches, nitrogen 3 cubic inches. He also states that the bubbles rising from these waters spontaneously consist mainly of carburetted hydrogen and nitrogen.

Temperature.—In 1872 this was found to range between 46°F and 52°F.

No 2.—"MAGNESIA" WELL (Mild saline SULPHUR). Muspratt, 1867. Hospital Mild Sulphur.

	GRAINS IN GALL.		GRAINS IN GALL.
Sodium chloride	215·	Total haloids...	245·9
KCl. 27·9, $BaCl_2$ 1·2, Mg Cl_2 1·8	30·9		
Iodides, &c.	traces		
Calcium Carbonate	18·3	Total earthy carbonates	31 3
Magnesium Carbonate	13·0		
Alcaline carbonates			nil
Sulphates			nil.
Silica			1·6
SODIUM HYDROSULPHIDE (Na HS)			1·6
Si. Fe. Mn.			traces.
Total solids			280·4

GASES.

NOTE.—There seems to have been no separate estimation of the gaseous and alkaline sulphides. A moderate amount of carbonic acid was found together with some carburetted hydrogen, nitrogen, and a little oxygen.

No. 3.—STARBECK SPA WATER (PURE SULPHUR). Fairley, 1879.

	GRAINS IN GALL.		GRAINS IN GALL.
Sodium chloride	116·4	Total haloids	116·4
LiCl, $BaCl_2$	traces.		
Calcium carbonate	10·0	Total earthy carbonates	13·5
Magnesium carbonate	3·5		
*Sodium carbonate	14·5	Total alkaline carbonates	15·1
*Potassium carbonate	0·6		
Calcium sulphate			1·9
Silica			3·2
SODIUM HYDROSULPHIDE (Na HS)			1·4
Total solids			151 5

* According to Hoffman's analysis in 1854 the proportion of Na_2CO_3 to K_2CO_3 is nearly reversed. *Gases* not estimated.

No.4—"KISSENGEN" WATER (Strong saline CHALYBEATE). Attfield, 1879.

	GRAINS IN GALL.		GRAINS IN GALL.
Sodium chloride	674·5	Total haloids...	850 7
KCl 21·5, LiCl tr, NH_4 Cl 0·4, $CaCl_2$ 87, $SrCl_2$ 0·8, $MgCl_2$ 65·5	178·8		
Iodides, &c.	traces.		
Calcium carbonate	9·0	Total carbonates of Ca. Mg. Fe	20·7
Barium carbonate	2·1		
FERROUS carbonate	9·6		
Alkaline carbonates			nil.
Barium sulphate			0 5
Silica			3·7
Total solids			874·6

Gases.—Principally carbonic acid, in moderate amount with oxygen and nitrogen.

No.5.—ST. JOHN'S WELL (Pure CHALYBEATE). Hofmann, 1854.

	GRAINS IN GALL.		GRAINS IN GALL.
Sodium chloride	1·5	Total haloids	1·5
Iodides	traces.		
Calcium carbonate	2·3	Total carbonates Ca. Mg. Fe	5·9
Magnesium carbonate	3·0		
FERROUS carbonate	0·6		
Sodium carbonate	1·3	Total alkaline carbonates	2·3
Potassium carbonate	1·0		
Calcium sulphate			0·3
Silica			tr.
Organic matter			tr.
Total solids			10·0

Gases.—Principally carbonic acid, with some nitrogen, and traces of carburetted hydrogen and of oxygen.

chiefly of vegetable origin, locked up in the Yoredale Rocks. Hence it is not unreasonable to believe that the putrefactive distillation of such organic matter, acting very slowly and through long periods of time, effects more or less the complete deoxidization of the sulphates, and that to this we owe the quantity of sulphide present in the Harrogate waters. The considerable quantity of carburetted hydrogen and of nitrogen found by Hoffmann favour this view, which is much strengthened by the almost complete absence of oxygen, showing that the nitrogen present is due to organic decomposition. At the same time the very slight traces of phosphoric acid would show that this mainly arises from vegetable matter.

EXCURSION ON THE 17TH JULY, AND FIVE FOLLOWING DAYS.

Directors:—W. H. HUDLESTON, F.G.S., ETC., *President of the Geologists' Association, London;* AND JAMES W. DAVIS, F.G.S., ETC., *Honorary Secretary of the Yorkshire Geological and Polytechnic Society.*

The London contingent arrived at Harrogate on Monday afternoon, and having secured quarters at the Prospect Hotel, re-assembled with the other members of the party at the Old Sulphur Well. Here they tested the quality of the water for which the place is celebrated, and availed themselves of the permission which was given to them to descend underneath the floor of the building to inspect the springs which supply the pump-room above. The President of the Geological Association, London, who on this occasion was the director, offered a few remarks on the chemical composition of the water and of several other sulphur waters of Harrogate. He was enabled to illustrate his observations by means of a number of specimen tubes containing the saline contents of one gallon of each of the various waters to be found in the town, and by this method the different volumes were at once perceived. These very interesting tubes had been prepared from evaporations conducted by Mr. Davis, chemist, of Harrogate. They are the property of theHarrogate Improvement Commissioners, who kindly lent them for the occasion. Mr. W. H. Wyles (the Clerk to the Commissioners), and Mr. W. W. Harry (the engineer) afforded the party every facility in the examination of the specimens. Whilst the company were thus engaged, Dr Oliver, who is well known as the author of a valuable work on "Harrogate Waters," appeared at the wells and supplemented the President's observations. Dr. Oliver dwelt more especially upon the geological conditions under which the water finds it way to the surface in connection with the very remarkable anticlinal which is known to exist at Low Harrogate. The singular stratigraphy of Harrogate arrested the attention of geologists a long time ago. Mr. Wm. Smith, the father of English geology, was the first to appreciate the peculiarity, but although he recognized that there was an anticlinal or upthrust of lower rocks, extending from Harlow Hill to Lower Harrogate, he appears to have thought that within that anticlinal there was a synclinal basin towards which the springs gravitated. Later on, his nephew, the late Professor Phillips, who for forty years had given great consideration to the peculiarities of the geology of Harrogate, drew the attention of the Geological Society of London to the very remarkable features of the district, the difficulties in regard to which had been to some extent cleared up during the making of the new railway across the stray. The subject of the anticlinal was treated generally in a diagram in the paper brought before the Geological Society by Professor Phillips, and the relation of the millstone grit beds to the north and south of the Yoredale rocks beneath was made very clear. At the same time Professor Phillips seems to have had a notion that there was a sort of synclinal towards the apex of the anticlinal, and his section at this part of the diagram is somewhat obscure and difficult to comprehend.

When the party left the Old Sulphur Wells they proceeded to verify the stratigraphical facts in connection with the anticlinal, and for this purpose walked to the well-known road-stone quarry in the Cold Bath Road. This stone is one of the hard beds of the Yoredale rocks, and is a calciferous grit very largely charged with the remains of encrinites. In the Cold Bath Road quarries these rocks may be seen dipping at a considerable angle in a south easterly direction. In the bed of the stream, just at the back of the old sulphur well, the same rock is observed to dip in a direction somewhat to the north of east, and a little further up the hill, underneath Cornwall house, this same bed dips at a very high angle indeed, nearly due north. These facts are taken to indicate that there exists an anticlinal dome, which is here seen to be dying out to the eastward, and the north side of the anticlinal is very much steeper than the south—in fact, the anticlinal itself is fractured a little on the north-west side of what may be presumed to be its principal axis by a great fault which causes the road-stone to be brought into juxtaposition with the lower beds of the millstone grit. There are geologists at Harrogate who consider that the axis of this swelling or anticlinal is to be found beneath the Stray rather than at the sulphur springs, and this view receives some substantiation from the appearances which were noted when the railway was made across the Stray. The probable explanation is, that the Harrogate road-stone and its accompanying shales are bent into more than one series of curves, and that one of these curves very nearly reaches the surface in the railway cutting. A northerly dip of the beds near the Low Harrogate Church is further evidence of the probability of this view. The party having satisfied themselves as to the reality of the anticlinal axis, were conducted to the Bog Springs, where there are something like 34 different sources of sulphur and iron waters. Dr. Oliver here indicated the peculiarities of the position and nature of the several waters, and deduced from his observations the fact that as a rule the sulphur springs occupy an inner position, and that the iron springs are without, on either side of the main axis or upheaval. The nature of the several wells was pointed out, and attention was especially drawn to the very abnormal water known as the "Alum Well." It may be mentioned that one of the characteristics of the sulphur waters at Harrogate is the absence, more or less complete, of sulphates. This peculiarity enables many of the Harrogate waters to act as carriers of salts of barium and strontium, which would otherwise be insoluble. In the "Alum Well," however, a large quantity of sulphates exist. The probability is that this is due to the shallow origin of the spring, whose waters become oxidised, and this may account for the very considerable quantity of sulphates and the acid reaction so exceptional to the waters of this neighbourhood. Having spent some time at the springs, the company walked to Birk Crag, where they had an opportunity of looking from that very picturesque ridge of millstone grit over the wild and dreary scenery of Haverah Park, which consists entirely of the grits and shales of the millstone grit group. These rocks are noted for the purity of their waters. Oak Beck, which flows through Haverah Park, has been utilised for the purpose of supplying the town of Harrogate with pure water, just as the Washburn River has been adapted for supplying Leeds. The remainder of the evening was spent by the party in walking round by Harlow Carr and the back of Harlow Hill to Harrogate. They afterwards met at the Prospect Hotel and were very kindly welcomed to Harrogate by M. Richard Carter, F.G.S., of Spring Bank, Harrogate, who, with Mr. Harry and other gentlemen, had done much to facilitate the success of the excursion.

On Tuesday, the party left Harrogate for Knaresborough by an early train, and after a brief inspection of the old castle at the latter place, descended to the foot of the cliff on which what is left of the ancient pile stands. Here the unconformable junction of the magnesian limestone upon the millstone grit was pointed out by the president of the association and verified by the members. From this point they crossed the river for the purpose of visiting the Dropping Well, which is too well known to need description. Mr. Hudleston took occasion to explain the nature of the waters which flow over the rock. The stream supplying these waters springs out of the adjacent cliff, and represents the drainage of a hollow originating in the high ground towards Belmont. The ground is chiefly made up of the Middle Permian Marls, and it is to the salts in these marls that we must trace the impregnation of the Dropping Well Waters.

The following is an old analysis of the waters of the stream:—

	Grains to the gallon.
Carbonate of soda	6
Carbonate of lime	23
Sulphate of lime	132
Sulphate of Magnesia	11
Total	172

The deposit upon the sponges and other substances which are placed at the well, consist almost wholly of carbonate of lime, the amount of sulphate of lime deposited being very small indeed, notwithstanding the very large quantity found in the water. Mr. Simpson, the lessee of Long Walk and the "Mother Shipton Inn," recently possessed himself of some magnificent specimens of sponges, which, from their porous nature, show the action of the deposit remarkably well. Some time was spent by the party in examining the caves in the valley of the Nidd, and in listening to the stories of St. Robert and of Eugene Aram, after which they crossed the river at Grimbald Bridge and finally took leave of the magnesian limestone where the romantic Grimbald Crag is terminated by a small fault on its western side. Plumpton Rocks, a mile and a half distant, were next visited. These rocks are interesting to geologists as having been regarded in former days as forming a portion of the Permian series, equivalent to the German "Rothliegende." The researches of the Government surveyors in recent years have shown that these rocks are really nothing more than the highest beds in this district of the millstone grit series, which are unconformably overlaid, as already noted in the Nidd Valley by the Permian Rocks. The extraordinary action of the weather upon these rocks afforded matter for endless speculation. In this respect the Plumpton Rocks, which are the same bed of grit which forms the Brimham Rocks at a higher level, are possibly more singular and grotesque in their weathering, than even the Brimham Rocks themselves. The party now divided, some returning to Harrogate in carriages, the others walking along the road. In the afternoon they were joined by Mr. J. W. Davis, and about a dozen of the most euthusiastic members of the party including that gentleman and the president, drove to inspect the new quarry of Harrogate road-stone at Beckwithshaw. A small spring of sulphur water has recently been discovered near there by Dr. Oliver. In the evening, Mr. Hudleston congratulated the members on the arrival of Mr. Davis, and placed the direction of the excursions for the remainder of the week in his hands.

Wednesday was an important day for the excursionists, as they had to transfer themselves in conveyances from the base of operations at Harrogate to Skipton, *via* Knaresborough Forest and Bolton. The early part of the journey was sufficiently dreary, the scenery of this portion of Knaresborough Forest being somewhat tame and uninteristing. A number of fossils were discovered amongst the stone heaps on the roadside near the Little Wonder Inn, these coming from the well-known quarries in the millstone grit series, near Hampsthwaite. The excessive rarity of fossils in the millstone grit makes their occurrence in this bed of considerable interest. They appear to differ but slightly from species known to exist in the carboniferous limestone. Having safely passed the "dangerous corner" the director and his followers descended into the valley of the Washburn, where the extraordinary size of the artificial lakes provided for the Leeds water supply struck everyone with astonishment. The Pass of Kexgill, the next object of interest on the route, presents evidence of the anticlinical axis in the way in which the grit rocks dip on either side. Having reached the summit of this pass, the party drove rapidly down the descent to Bolton Bridge, and at about half-past twelve arrived at the Devonshire Arms, where a substantial lunch, for which the excursionists were well prepared, was served.

About four hours were devoted to Bolton Abbey and the Strid, where many of the gentlemen from the south for the first time saw one of the most beautiful and interesting spots in Yorkshire; indeed, so fascinated were they with the charms of this delightful valley, that it was rather late when the journey was resumed. It may be stated that the Strid is cut through what is known as the Kinderscout grit, being the lowest grit of the millstone series. Opposite Bolton Abbey there is a very fine section in the Yoredale shales, showing both faults and contortions. This is on the north side of the anticlinical. The stratigraphical phenomena between Bolton and Skipton are of the most marvellous kind. The long system of disturbances extending from the neighbourhood of Clitheroe to Harrogate, here assumes a most striking phase, and the quarries exhibit some extraordinary sections in consequence. The first quarries visited are known as the Hambleton Rock Quarries, where the Skipton rock, supposed to be mountain limestone, has been forced into a vertical position, and is variously contorted. Continuing the drive towards Skipton, the party made a diversion in the direction of Draughton Quarry, an excavation in the Yordale rocks, where some remarkable phenomena of rock curvature may be seen to great advantage. Some of the choicest of these have been photographed by the Yorkshire Society, and form beautiful pictures, apart from their supreme geological interest. The excursionists had some difficulty in finding their carriages again. Skipton was not reached until a late hour in the evening, and it was some time before the party were settled in their various quarters, but, thanks to the admirable arrangements made by the Honorary Secretary, everything was finally put to rights.

By an early train on Thursday morning the members of the Societies travelled from Skipton to Bell Busk, and most of them walked from thence to Malham, a distance of nearly five miles. The hillocky character of the ground, due to the glacial deposits was noticed. Malham Cove is situated on the line of the south Craven fault. (See diagram.) The director having arrived at the foot of that remarkable cliff, just where the river Aire springs from the base of the precipice, drew attention to the geological characteristics of the scene, more especially in connection with the underground course of the water which disappears a little to the south of Malham Tarn. The party retraced their steps in the direction of the village of Malham, and then walked to Gordale Scar, some of the gentlemen visiting Janet's Cave on the way. The gorge at Gordale is an excavation in what is known as the Scar Limestone, which is the lowest member of the carboniferous series in this district. The visitors were scarcely prepared for such an impressive scene, and nearly all agreed that it is one of the most remarkable spots, not only in Yorkshire, but in England, and that probably no part of the carboniferous limestone, not even excepting the celebrated Cheddar Cliffs, can compete with Gordale in wonder and magnificence. The stream which flows through this extraordinary gorge, by its numerous waterfalls, adds largely to the interest of the scene. There can be very little doubt that this excavation is almost entirely the result of water action, aided to a certain extent by rock-jointing in the first instance. The scramble up the gorge is a somewhat difficult undertaking, but was safely accomplished, and the whole of the party finally stood on the limestone pavement of the moors above. From thence a rather rough walk led them to within a short distance of Malham Tarn, which is said to be situated on Silurian rocks and boulder clay. At the place where the water sinks, to reappear, as already stated, at the foot of Malham Cove, the director read the following interesting communication from Mr. Walter Morrison with reference to the underground course of the water, which disappears at this point.

"MALHAM TARN, BELLBUSK, JULY, 10TH, 1882.

"DEAR SIR,

"Very unfortunately I have to leave home on Wednesday, July 19th, for a Board Meeting in London on the Thursday, and a Meeting of a Company of which I am a director, on the Friday.

It will thus be impossible for me to join you; but I assure you in all honesty, that I regret it very much; as an amateur geologist learns a great deal from accompanying experts in the field.

"The following notes may be of interest when you come into this parish, and may be new to you. Two years ago the Bradford Philosophical Institute came here to ascertain what becomes of the water of Malham Tarn after it disappears at the water-sinks south of the Tarn, The plan adopted was as follows: on the previous day I opened the sluice at the foot of the Tarn, and so lowered the water a foot below its normal level. Thus the beck running out of the Tarn became very low, almost dry, when we closed the sluice again, only allowing a mere trickle of water to run along the beck to keep the beck trout alive. On the next day we all compared watches, and then parties were placed to watch at the spring under Malham Cove and at Aire Head, the very strong spring which you will find marked on the one inch Ordnance Map, some 300 yards north-east of the farm house, called Kirkby Top, which is 800 yards south of Malham. Marks were placed in the water at each place. At 1 p.m. exactly, I let the tarn water out by the sluice, and it ran in a muddy stream, and with a rush down the beck to the water-sinks. The water-sinks were reached in 20 minutes; and in 65 minutes from then the water began to rise at Aire Head; in 5 minutes more the Aire Head was boiling up with a very turbid stream. The water at Malham Cove began to rise at 110 minutes from the time when the released tarn water reached the water-sinks, but did not rise much, nor was it turbid, so I infer that both Aire Head and Cove Springs are connected with the water sinks, but that a lower channel of a certain capacity communicates with Aire Head and another passage branching from it with the cove spring, which latter receives the tarn water when the Aire Head passage has become filled. The cove water in normal times probably comes from a water-sink in a pasture called Streets, south-west of the Tarn, but we have not been able to prove this.

"In walking from Malham the best foot road is by Well Head Lathe; it is shorter and prettier. By the carriage road observe at Carlton the conspicuous white farm house; this is on the site of the house of General Lambert. The church is interesting, observe the Saxon or Norman Font, the niches for saints in the pillars, said to be a characteristic of churches built by the Tempest family; also the Lambert Monuments.

"On Malham Moor the Silurian Rock crops out at the point where the road to Kilnsey crosses the beck above Gordale; in the line of springs between Waterhouses Caponer: in the bed of the beck in Streets Pasture; in the Grip by the side of the road near Caponer; on Black Hill, Catrigg Pasture, Neals Ing, and then at Horton.

"Two stones in the Tarn near to, and north of the great Close Plantation, are a conglomerate of fragments of slate mixed and cemented with lime. They just show above water. Bye the bye, will your party want my boats? I have three. Will any of them care to fish? If so write to me and I will tell my keepers.

"Believe me, yours very faithfully,

"W. MORRISON."

"JAMES W. DAVIS.

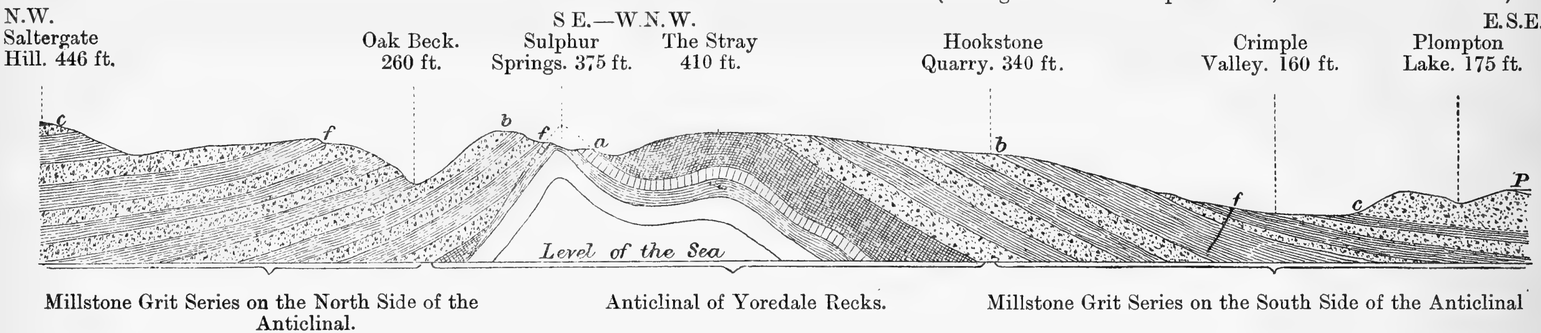
The opinion was expressed that the water at once falls into the north branch of the Craven fault, which crosses the moors about this spot. The kindness of Mr. Morrison in offering the party the use of boats and other facilities was duly acknowledged, and the Honorary Secretary was requested to convey the thanks of the Societies to that gentleman. Here the party divided. A number of them returned towards Malham, and thence to Bell Busk, and the other portion, under the guidance of Mr. Davis, took the road across the moors for the Victoria Cave and Settle. Owing to the inequalities of the ground, the latter party became sub-divided, though both sections arrived at the Victoria Cave about the same time. Some interesting observations relative to the position of the great north fault were made by some of the gentlemen present. The party finally descended into Settle by a very precipitous route. After a hurried visit to the museum at Giggleswick, where many of the objects found in the Victoria Cave are arranged, including the largest specimen of the grizzly bear which was ever found, the excursionists got to Settle Station just in time to catch the train for Skipton.

The weather, which had hitherto favoured the geologists in a most remarkable manner, changed for the first time during the week on Friday morning, when in a heavy shower the party proceeded from Skipton to Clapham. On arriving at the latter place, the clouds broke, and it was comparatively fine for a few hours. This enabled your secretary to take his trusty followers through the grounds belonging to Mr. Farrer, where the effects of one of the great faults are very well shown in the gorge of the stream. A section of the party then visited the well-known Clapham Caves, whilst a smaller number proceeded up Trou Gill to Gaping Ghyll Hole. It is very well-known that the waters which are collected on the southern flanks of Ingleborough and which flow as an ordinary beck down to this point, suddenly disappear in the yawning limestone just as one might imagine a river turned into a pit shaft. The waters are doubtless those which re-appear close to the Clapham Cave. At some time or other the course of this stream was on the surface, and the lines of the old valley are still to be seen, though the stream no longer excavates that portion of the valley between Gaping Ghyll Hole and the place of its final emergence into daylight near the Clapham Caves. It may be as well here to draw attention to the readiness with which water sinks in these limestone districts, —a circumstance due partly to the jointing of the rocks themselves and partly to their solubility in carbonated waters. Both branches of the party ultimately returned to Clapham, where they re-assembled at lunch, which was liberally provided by the landlord of the New Inn. Before leaving the table, Mr. Hudleston, the President of the Geologists' Association, took the opportunity of tendering the thanks of the Association to Mr. Davis for the admirable manner in which he had conducted the excursions. He spoke of that gentleman's extensive knowledge of the geological features of the district, and referred to the trouble which he had taken in making the arrangements which had given so much satisfaction to the visitors.—Mr. Davis made a suitable reply, in the course of which he expressed his gratification at having made the acquaintance of so many gentlemen, and hoped the present was only the first of a series of similar excursions. The rain was now coming down in torrents, and under these depressing circumstances very few of the members or their friends showed any anxiety to carry out the programme to its final completion. Only ten were found bold enough to enter upon the undertaking, amongst these being the Cicerone and the President. These gentlemen, well armed with umbrellas and waterproofs, walked, in a pouring rain which did not cease for a moment during the excursion, first of all to Norber, a distance of over a mile, where they saw the magnificent display of ice-borne boulders of Silurian rocks resting on mountain limestone. By Wharfe the small party walked round Moughton Fells to Foredale. At Combe Quarries they saw from below an almost classical section where the mountain limestone lies unconformably on the upturned and folded edges of the sulurian slates and grits. A hurried walk took them to Horton-in-Ribblesdale, where they had the good fortune to catch the 6.43 train to Skipton.

The contemplated excursion to Raygill Quarries on Saturday was abandoned, partly in consequence of the threatening nature of the weather, and partly because many of the members were anxious to return to their homes in good time.

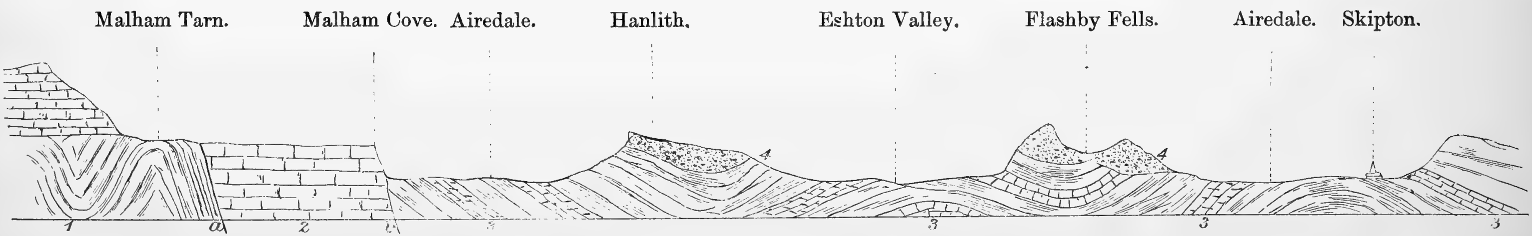
The excursions gave great satisfaction to the visitors, and were the means of introducing many persons for the first time to a district remarkable alike for its geological features and its fine scenery. There were few opportunities for obtaining fossils, but

DIAGRAMMATIC SECTION THROUGH THE HARROGATE ANTICLINAL. (Saltergate Hill to Plompton Rocks, a little under six miles.)



Explanation of Signs.—a. Harrogate roadstone. On the north side of the anticlinal this is forced against the principal fault *(f)*. *b.* The Uppermost Kinder Grit. *c.* Approximate position of the fossiliferous band (CaytonGill Beds) in the Millstoue Grit on either side of the anticlinal. *P.* Permian Beds (Magnesian Limestone.)

DIAGRAMMATIC SECTIGN FROM MALHAM TO SKIPTON- Distauce 12 miles.



Explanation of Sign.—1. SILURIAN GRITS. 2. MOUNTAIN LIMESTONE. 3. YOREDALE SERIES. 4. MILLSTONE GRIT. *a.* North branch of Craven Fault; *b.* South Branch.

some of the younger and more active members of the party applied their hammers at various points with considerable success.

NOTES WITH REFERENCE TO THE SECTIONS.

The section through the Harrogate anticlinal may be regarded as approximately correct so far as the surface is concerned. The folding of the Yoredale Rocks beneath the Stray is, to a certain extent, hypothetical. When the railway was made across the Stray the beds were observed to be so much disturbed that it was thought by some that the principal axis of elevation was at this point, rather than at the Sulphur Springs.

The Millstone Grit series consist very largely of Shale. It must not be supposed that the relative thickness of the Grits and Shales is accurately delinated in the diagram. Even the Plompton Grits, which form the highest section of the Third Grits in this district, are by no means free from associated Shales.

The section from Malham to Skipton is designed to give an approximate idea of the position and contorted character of the rocks in the vicinity of the Craven fault, and for many miles southward. The surface of the valleys is for the most part thickly covered with glacial clays, sand and boulders; but where exposures of the rock are met with they always exhibit a more or less contorted section. At Malham Tarn the Mountain Limestone extends in more or less horizontal beds on the upturned edges of the Silurian rocks. The grit rocks which occupy the higher ground at Hanlith and Flasby Fells are in the form of synclinals, whilst the summit of the anticlinals occupy the lower parts of the valleys. At Skipton, a Limestone is quarried, which is supposed to be equivalent to the Mountain Limestone at Malham, but this is by no means certain.

SECRETARY'S REPORT.

During the year concluded by the present meeting the Society has held meetings at Dewsbury and Pontefract for the purpose of listening to communications from its members.

On May 24th, a General Meeting was held at the Mechanics' Institution at Dewsbury. Mr. F. W. Reuss, president of the Institution, occupied the chair.

During the summer, arrangements were made for a joint Excursion of the members of the Geologists' Association of London and those of this Society. The combined Associations met at Harrogate on Monday, July 17th, and the geological features of the district were examined under the guidance of Mr. W. H. Hudleston, President of the Geologists' Association, and an account was given of the wells by Dr. Oliver, of Harrogate. On the following day the members visited Knaresborough and Plumpton. On the 19th (Wednesday), the party, now, and for the remaining portion of the excursion, under the guidance of the Honorary Secretary of this Society, left Harrogate and drove to Skipton, spending some pleasant hours at Bolton Abbey and its beautiful environment.

On Thursday, Malham and Gordale were visited, and one portion of the party walked across the moors to the Victoria Cave; and to Settle and Giggleswick. The Museum of the Giggleswick Grammar School was inspected. On the 21st (Friday), the members of the joint Societies proceeded to Clapham. The Caves, Trougill, and Gaping Ghyll Hole were visited. Hitherto the weather had been fine, but the remaining and concluding portion of the excursion was gone through in an extremely heavy downpour of rain. Most of the party however, notwithstanding the rain, visited Norber, with its immense assemblage of ice-born blocks, thence walked round the spur of Moughton Fell, inspected the quarries of slate, with superimposed limestone, and thence walked to Horton-in-Ribblesdale, and returned by train to Skipton. The Saturday's excursion to Lothersdale and Raygill was abandoned.

A detailed description of the excursion is printed in another portion of this volume.

The present meeting, at Pontefract, is the third during the year. The thanks of the Society are due to the Directors of the Dewsbury Mechanic's Institution and to the Corporation of Pontefract for the use of the rooms in which the meetings have been held, and to Mr. Reuss, and Mr. P. F. Lee, the local Secretary at Dewsbury, and to Mr. T. W. Tew, our present chairman, for the kind exertions they have made in the interests of the Society.

The number of members is 203, of whom 22 have compounded for their annual subscriptions and become life members, and the remaining 181 are ordinary members.

The Society has lost one of its most esteemed vice-presidents by the assassination of Lord Frederick Cavendish—a vote expressing the sorrow and condolence of the members was passed at the General Meeting at Dewsbury, and forwarded to Lady F. Cavendish and the Duke of Devonshire. An acknowledgement with thanks for our sympathy was received from Lord Ed. Cavendish in the name of the Duke of Devonshire.

The following is a list of the Local Secretaries and the places which they represent:—

Barnsley	Thos. Lister.
Bradford	Thos. Tate, F.G.S.
Bridlington	G. W. Lamplugh, F.G.S.
Brighouse	T. W. Helliwell.
Driffield	Rev. E. M. Cole, M.A., F.G.S., &c.
Halifax...	W. Cash, F.G.S.
Huddersfield	Peace Sykes
Hull	G. J. Wilson, M.A., &c.
Leeds	J. E. Bedford

Mexbro'	Rowland Gasgoine, F.G.S.
Middlesbrough	Dr. W. Y. Veitch.
Selby	J. T. Atkinson, F.G.S
Sowerby Bridge	J. Marshall,
Thirsk...	W. Gregson.
Wensleydale	Wm. Horne.
York	Rev. Thos. Adams, M.A., F.G.S

Proceedings, forwarded from their respective Societies, in exchange for those of our Society, have been received and may be consulted by applying to the Hon. Secretary or at the Museum of the Literary and Philosophical Society at Halifax. The following is an enumeration of them :—

List of Societies whose Proceedings are forwarded to the Yorkshire Geological and Polytechnic Society.

Yorkshire Archæological and Topographical Society.
Warwickshire Natural History and Archæological Society.
Royal Society of Tasmania.
Royal Dublin Society.
Royal Historical and Archæological Association of Ireland.
Geologists' Association.
Manchester Geological Association.
Literary and Philosophical Society, Liverpool.
Royal Institution of Cornwall.
Royal Geological Society of Ireland.
United States Geological Survey of the Territories.
Boston Society of Natural History.
Hull Literary and Philosophical Society.
Connecticut Academy of Arts and Sciences.
Academy of Science, St. Louis.
Historical Society of Lancashire and Cheshire.
Geological Society of London.
Royal University of Norway.
Sociètè-Geologique du Nord.
Oversigt ovet det Kongelige Dranske Videnskabernes Selskabs, Kjopenhavn.
Museum of Comparative Zoology, Cambridge. U.S.A.
Watford Natural History Society and Hertfordshire Field Club.

Copies of the Proceedings of the Society for the following years may be had on application to the Honorary Secretary Chevinedge, Halifax, price 2s. 6d. each :—1840, 1841, 1842, 1843, 1484-5, 1845-6, 1847, 1848, 1851, 1853, 1854-5, 1858-9, 1860, 1862, 1864-5, 1865-6, 1867, 1868, 1869, 1870, 1871, 1875, 1876, 1877, 1878, 1879, 1880, 1881.

During the past year the committee appointed by the Society to superintend the exploration of the Raygill Fissure in Lothersdale have found it advantageous to suspend operations for sometime longer. Mr Spencer, the proprietor of the quarries has very kindly removed a large mass of material which obstructed the entrance to the horizontal portion of the fissure which has now been reached. By this means the operations of your committee will be rendered very much easier and less expensive. It is hoped that early in next year operations will be recommenced.

The Society is again indebted to Mr. W. H, Dalton of H.M. Geological Survey for his assistance in the preparation of the Bibliographical lists and expresses the thanks due for his kindness.

Statement of Receipts and Expenditure of the West Riding Geological and Polytechnic Society.

FROM NOVEMBER 1ST, 1881 TO OCTOBER 30TH, 1882.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Balance ...	10	0	0	By Cash paid into the Bank	97	2	7
,, Beckett & Co.	91	16	3	,, Edmund Wormald	29	16	3
,, Subscriptions	97	2	7	,, A. Megson	50	19	0
				,, Expenses	11	1	0
				,, Balance in hand	10	0	0
	£198	18	10		£198	18	10

THE TREASURER IN ACCOUNT WITH BECKETT & CO.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Balance at Bank	32	4	7	By Cash from Bank	91	16	3
,, Cash paid to Bank	97	2	7	,, Balance in Bank	38	11	9
,, Interest ...	1	0	10				
	£130	8	0		£130	8	0

THE TREASURER IN ACCOUNT WITH BECKETT & CO.—CAPITAL ACCOUNT.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Balance at Bank	121	0	0				
,, Cash paid to Bank (Life Subscriptions)	25	4	0				
,, Interest ..	2	14	0	By Balance in Bank	148	18	0

THE TREASURER IN ACCOUNT WITH BECKETT & CO.—RAYGILL QUARRY EXPLORATION FUND.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Balance at Bank	9	4	0				
,, Cash paid to Bank (British Assoctn. Grant)	20	0	0	By Balance in Bank	29	4	0

Examined and found correct, GEO. PATCHETT.

MINUTES OF MEETINGS.

Meeting of the Council at the Museum, Leeds, November 21st, 1881.

Present, Mr. Richard Carter, C.E., in the Chair, Professors Green and Miall, Messrs. Atkinson, Bedford and Ray Eddy, and Honorary Secretary.

The minutes of the last meeting were read and confirmed.

The Honorary Secretary reported that Mr. Denny having declined the office of Assistant Secretary, it had been offered to Mr. Wilson, who had not yet given an answer.

Proposed by Mr. Atkinson, seconded by Mr. Eddy and carried, "That Messrs. Miall, Green, Sladen and Davis be a Revision Committee, and that all papers be submitted to, and approved by, the Committee before publication."

Proposed by Mr. Bedford, seconded by Mr. Eddy, and carried, "That the following accounts be paid:—

E. Wormald ...	...	£4	1*s*.	0*d*.
W. Hunt ...	...	0	10	0
		£4	11	0

Proposed by Mr. Eddy, seconded by Mr. Miall, and carried, "That a special Council meeting be called to consider and revise the rules."

Meeting of the Council at the Museum, Leeds, May 17th, 1882.

Present, Mr. W. Gregson in the chair, Messrs. Atkinson, Bedford, Lee and Honorary Secretary.

The minutes of last meeting were read and confirmed.

Moved by Mr. Atkinson, seconded by Mr. Bedford, and carried, "That the next meeting of the Society be held at Dewsbury, on May 24th, 1882, and that Mr. Councillor Reuss preside, and papers be read by Rev. E. Maule Cole, M.A., and James W. Davis, F.S.A.

Moved by Mr. Bedford, seconded by Mr. Lee, and carried, "That the following accounts be paid :—

	£	s.	d.
Edmund Wormald	£25	15s.	3d.
Angelo Megson	52	0	6
Petty Cash	10	0	0
	£87	15	9

Moved by Mr. Atkinson, seconded by Mr. W. Lee, and carried, "That a meeting be held in East Yorkshire, and that arrangements be left with Mr. Cole and the Honorary Secretary.

General meeting at the Mechanics' Institution, Dewsbury, on May 24th, 1882.

M. Councillor Reuss presided.

The minutes of the last general meeting at Bradford were read and confirmed.

A resolution was proposed by the Chairman, seconded by Mr. Marriott, J.P., and supported by the Honorary Secretary, as follows, and it was decided to forward the same to Lady Frederick Cavendish and the Duke of Devonshire. "That the Yorkshire Geological and Polytechnic Society desires to express to Lady F. Cavendish, the Duke of Devonshire and the family, their detestation of the crime which has deprived the Society of one of its Vice-presidents, who was esteemed, respected and beloved by all its members; Lord Frederick C. Cavendish was always anxious to support any cause which had for its object advanced education, or the promotion of original scientific research, and worthily adhered to the glorious example set by so many of his ancestors. For this reason this Society regards with the greatest regret and sorrow his untimely end, but are cheered by the thought that his good works will serve as a model for the guidance and encouragement of posterity."

The resolutions were duly acknowledged by Lord Edward Cavendish on behalf of the Duke of Devonshire.

The Chairman delivered an address.

Proposed by Mr. James W. Davis, seconded by Mr. P. F. Lee, and carried, "That the following gentlemen be elected members of the Society :—Charles Combe Arnold, Moorland House, Halifax; William Smith, F.S.A.S., Osborne House, Morley; H. G. Brierley, Clara Street, Huddersfield; F. W. Reuss, Dewsbury; C. H. Marriott, J.P., Manor Lawn Dewsbury."

Proposed by Mr. Cheetham, seconded by Mr. Bedford, and carried, "That the next meeting shall be held in Craven, to meet the members of the Geologists' Association from London, instead of East Yorkshire."

Papers were read by the Rev. E. Maule Cole, M.A., "On the White Chalk of Yorkshire."

James W. Davis, "On the Fossil Fish Remains of the Carboniferous Limestone of Yorkshire."

Proposed by Mr. Gray, seconded by Mr. Day, and carried, "That the thanks of this meeting be given to the Chairman and authors of papers."

After the termination of the proceedings, Mr. Reuss entertained the members at the Wellington Hotel.

Meeting of the Council at the Museum, Leeds, August 9th, 1882.

Present, Mr. J. Ray Eddy in the chair, Messrs. Reynolds, Bedford, Cheetham, Tate and Honorary Secretary.

The minutes of the last meeting were read and confirmed.

Proposed by Mr. Cheetham, seconded by Mr. Reynolds, and carried, "That the following accounts be paid :—

A. Megson	£0	19*s*.	4*d*.
H. Wolff	0	11	0
	£1	10	4

Proposed by Mr. Tate, seconded by Mr. Bedford, and carried, "That the photographs be obtained from the Autotype Company, on the terms mentioned by the Honorary Secretary."

Proposed by Mr. Cheetham, seconded by Mr. Tate, and carried, "That the photograph for 1883 shall be some object in the East Riding." A section in the Hull and Barnsley railway being suggested.

A joint excursion of the members of the Geologists' Association of London, and the Yorkshire Geological and Polytechnic Society, commenced on Monday, July 17th, and extended over the five following days, when the following localities were visited:—July 17th, Harrogate and district,—18th, Knaresborough, Plumpton, and Brimham,—19th, Harrogate to Skipton,—20th, Malham and Gordale,—21st, Clapham, Norber, and Moughton,—22nd, Raygill.

Meeting of the Council at the Museum, Leeds, October 25th, 1882.

Present, Thos. W. Embleton in the chair, Messrs. R. Carter, T. Lister, and Honorary Secretary.

The minutes of the last meeting were read and confimed.

Proposed by Mr. Carter, seconded by Mr. Lister, "That the following amounts be paid:—

A. Megson	£1	18*s.*	0*d.*
Whitley and Booth	0	13	0
Petty Cash	10	0	0
	£12	11	0

The Honorary Secretary reported that a photograph had been taken at Thornwick Bay, Flamborough Head, and sent to the Autotype Company, with an order to print 250 copies.

Proposed by Mr. Lister, seconded by Mr. Carter, and carried, "That the annual meeting of the members be held at Hemsworth or Pontefract, on November 8th, or 15th, 1882, and that papers be read by Messrs. Lamplugh, Cash, Law and Davis."

Annual general meeting of the members, at Pontefract, on Wednesday, November 15th, 1882.

The members met at the Town Hall, and were conveyed in carriages to Upton Old Hall, where Mr. Tew provided lunch. The new cutting on the Hull and Barnsley railway, close by, was then visited. The Permian Limestone is exposed in a fine section, resting unconformably on the coal measures. Mr. Davis explained the section and its bearings in a brief address. The party then drove back to

Pontefract. At four o'clock the members and friends met at the Town Hall, for the transaction of business.

The chair was occupied by Thomas W. Tew, Esq., J.P.

The minutes of the last general meeting were read and confirmed.

The Honorary Secretary read the annual report and balance sheet from the Treasurer.

Proposed by the Chairman, seconded by Mr. J. Rhodes (Mayor of Pontefract), and carried, "That the report and balance sheet be adopted."

Proposed by the Honorary Secretary, seconded by Mr. G. Scarborough, and carried, "That the following gentlemen be elected members of the Society:—J. H. Phillips, (Scarborough Philosophical Society); John Haigh, Dewsbury; Rev. W. C. Lukis, M.A., Wath Rectory, Ripon; John Rhodes, Mayor of Pontefract; John Shaw, Darrington Hall, Pontefract; George Buckley, Jun., Waterhouse Street, Halifax."

Moved by Mr. James Booth, seconded by Mr. A. Lupton, and carried, "That the Marquis of Ripon be re-elected president for the ensuing year."

Moved by Mr. W. Cash, seconded by Mr. W. Berry, and carried, "That the following noblemen and gentlemen be elected Vice-presidents for the ensuing year:—Earl Fitzwilliam; Duke of Leeds; Earl of Effingham; Earl of Dartmouth; Earl of Wharncliffe; Viscount Galway; Lord Houghton; Vicount Halifax; H. C. Sorby, Esq., L.L.D., F.R.S., &c.; T. W. Tew, Esq,, J.P.; Walter Morrison, Esq., J.P.; W. S. Stanhope, Esq., J.P."

Moved by Mr. R. Carter, seconded by Mr. Eddy, and carried, "That John Brigg, Esq., J.P., F.G.S., be re-elected Treasurer."

Moved by Mr. W. Cash, seconded by Mr. Embleton, and carried, "That James W. Davis, F.S.A., F.G.S., be re-elected Honorary Secretary."

Moved by Mr. J. T. Atkinson, seconded by Mr. W. Rowley, and carried, "That the following gentlemen form the Council of the Society for one year:—Wm. Alexander, M.D., J.P.; R. Carter, C.E., F.G.S.; W. Cheetham; J, Ray Eddy, F.G.S.; T. W. Embleton, C.E.; E. Filliter, C.E., F.G.S.; Prof. A. H. Green, M.A., &c.; Prof. L. C. Miall, F.G.S.; R. Reynolds, F.C.S.; W. Rowley, F.G.S.; W. Percy Sladen, F.G.S., &c.; W. Sykes Ward, F.C.S."

The Chairman (T. W. Tew, Esq.) gave an address on the "Recent development of the Coal Field in the neighbourhood of Pontefract."

The following papers were read:—

1.—"On the Cliff Section South of Bridlington Quay Harbour." By G. W. Lamplugh, Esq.

2.—"On the Distribution of Flint Implements and Flakes beneath the Peat on the Permian Chain, near Todmorden." By R. Law, Esq.

3.—"Notes on Yorkshire Fossil Mollusca." By W. Cash, Esq., F.G.S., &c.

4.—"On the Section showing the junction of the Coal Measures and Permian Limestone, near Kirk Smeaton." By James W. Davis, Esq.

Moved by the Mayor (John Rhodes, Esq.), seconded by the Vicar (Rev. J. J. Christie, M.A.), and carried, "That the thanks of the meeting be given to Mr. T. W. Tew, for presiding, and to the authors of papers."

At the conclusion of the meeting, the Chairman entertained about sixty of the members and friends at dinner, at the Red Lion Hotel, After the usual loyal toasts, the Chairman proposed "Success to the Society," and coupled with the toast the name of the Honorary Secretary, who replied. Mr. R. Carter proposed "The health of the Chairman," who replied, and the proceedings terminated.

Summary of Geological Literature relating to Yorkshire, published during 1882, with Addenda for 1881.

Compiled by James W. Davis.

1881—ADDENDA.

Crosskey, Rev., H. W. Note on some additions to the Fauna of the Post-Tertiary Beds at Bridlington, Yorkshire. *Proc. Birmingham Phil. Soc.*, vol. ii., pt. 2, p. 373.

Fairley, T. The Blowing Wells near Northallerton. *Chem. News*, vol. xliv., p. 242.

Flight, W. Report of an Examination of the Meteorites of . . . . . . Middlesbrough, in Yorkshire. *Proc. Roy. Soc.* vol. xxxiii., p. 343.

Kidstone, R. On the Structure of Lepidodendron Selaginoides (Sternberg) from the Coal Measures, Halifax, Yorkshire. *Proc. R. Phys. Soc., Edin.*, p. 97.

Thorpe, Prof. T. E. Contributions to the History of the Mineral Waters of Yorkshire. *Journ. Chem. Soc.*, p. 497.

1882.

Cameron, A. G. Subsidences over the Permian Boundary, between Hartlepool and Ripon. *Proc. York. Geol. and Polyt. Soc.*, vol. vii., pt. iv., p. 342.

——— On the Subsidences above the Permian Limestone between Hartlepool and Ripon. *Rep. Brit. Assoc.* for 1881. p. 617.

Cash, W. On the Halifax Hard Seam. *Ibid*, p. 626.

Clark, J. E. Glacial Sections at York, and their Relation to the later Deposits. *Proc. York, Geol. and Polyt. Soc.*, vol. vii., pt. iv. p. 421, pl. xxiii.; abstract in *Rep. Brit, Assoc.* for 1881, p. 614.

Dakyns, J. R. On Flots. *Proc. York. Geol. Soc.*, vol. vii., pt. iv., p. 381.

Davis, J. W. On the Exploration of a Fissure in the Mountain Limestone at Raygill. *Rep. Brit. Assoc.* for 1881, p. 645.

——— On the Zoological Position of the Genus *Petalorhynchus*, Ag., a Fossil Fish from the Mountain Limestone. *Ibid*, p. 646.

——— On *Diodontopsodus*, Davis, a new Genus of Fossil Fishes from the Mountain Limestone at Richmond, in Yorkshire. *Ibid*, p. 646.

——— Summary of Geological Literature relating to Yorkshire, published during 1881, with Addenda for 1880. *Proc. York. Geol. and Polyt. Soc.*, vol. vii., pt. iv., p. 453.

Fairley, T. On the Blowing Wells near Northallerton. *Ibid*, vol. vii,, pt. iv. p. 409, pl. xxii.; abstract in *Rep. Brit. Assoc.* for 1881, pp. 544, 601.

Harrison, W. J. Geology of the Counties of England and Wales. 8vo. *London.*

HICK, T. and W. CASH. On a Fossil Stem from the Halifax Coal Measures. *Rep. Brit. Assoc.* for 1881, p. 679.

——— A Contribution to the Flora of the Lower Coal Measures of the Parish of Halifax, pt. iii. *Proc. York. Geol. and Polyt. Soc.*, vol. vii., pt. iv., p. 400, pl. xxi., and abstract in *Rep. Brit. Assoc.* for 1881, p. 679.

HUDLESTON, W. H. Contributions to the Palæontology of the Yorkshire Oolites. *Geol. Mag.*, dec. ii., vol. vii., pp. 145, 193, 241, pls. v., vi.

LAMPLUGH, G. W. On the Bridlington Glacial Shell Beds. *Rep. Brit. Assoc.* for 1881, p. 616.

——— Glacial Sections near Bridlington. *Proc. York. Geol. and Polyt. Soc.*, vol. vii., pt. iv., p. 383. pl. xix.

——— The Bridlington Crag. *Geol. Mag.* dec. ii., vol. ix, p. 383.

MARR, J. E. On Some Sections in the Lower Palæozoic Rocks of the Craven District. *Proc. York. Geol. and Polyt. Soc.*, vol vii., pt. iv., p. 397, pl. xx., and abstract in *Rep. Brit. Assoc.* for 1881, p. 650.

MORTIMER, J, R. On the Sections of the Drift obtained from the New Drainage Works, at Driffield. *Proc. York. Geol. and Polyt. Soc.*, vol. vii., pt. iv., p. 373, pl. xviii., and abstract *Rep. Brit. Assoc.* for 1881, p. 617.

POULTON, E. B. A Preliminary Account of the Working of Dowkerbottom Cave, in Craven, during August and September, 1881. *Proc. York. Geol. and Polyt. Soc.*, vol. vii.. pt. iv., p. 351, pl. xvii., and abstract *Rep. Brit. Assoc.* for 1881, p. 622.

SPENCER, J. Researches in Fossil Botany. *Rep. Brit. Assoc.* for 1881, p. 627.

——— Notes on Astromyelon and its Root. *Ibid*, p. 628.

——— Astromyelon and its Affinities. *Proc. York. Geol. and Polyt. Soc.*, vol. vii., pt. iv., p. 439.

VINE, G. R. Notes on the Carboniferous Polyzoa of North Yorkshire. *Ibid*, vol. vii., pt. iv., p. 329, pl. xvi.

WOOD, S. V. The Newer Pliocene Period in England. *Quart. Journ. Geol. Soc.*, vol. xxxviii, p. 667, pl. xxvi,

——— The Bridlington Crag. *Geol. Mag.*, dec. ii., vol. vii., p. 192.

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SHARP, C. FORBES, Driffield.

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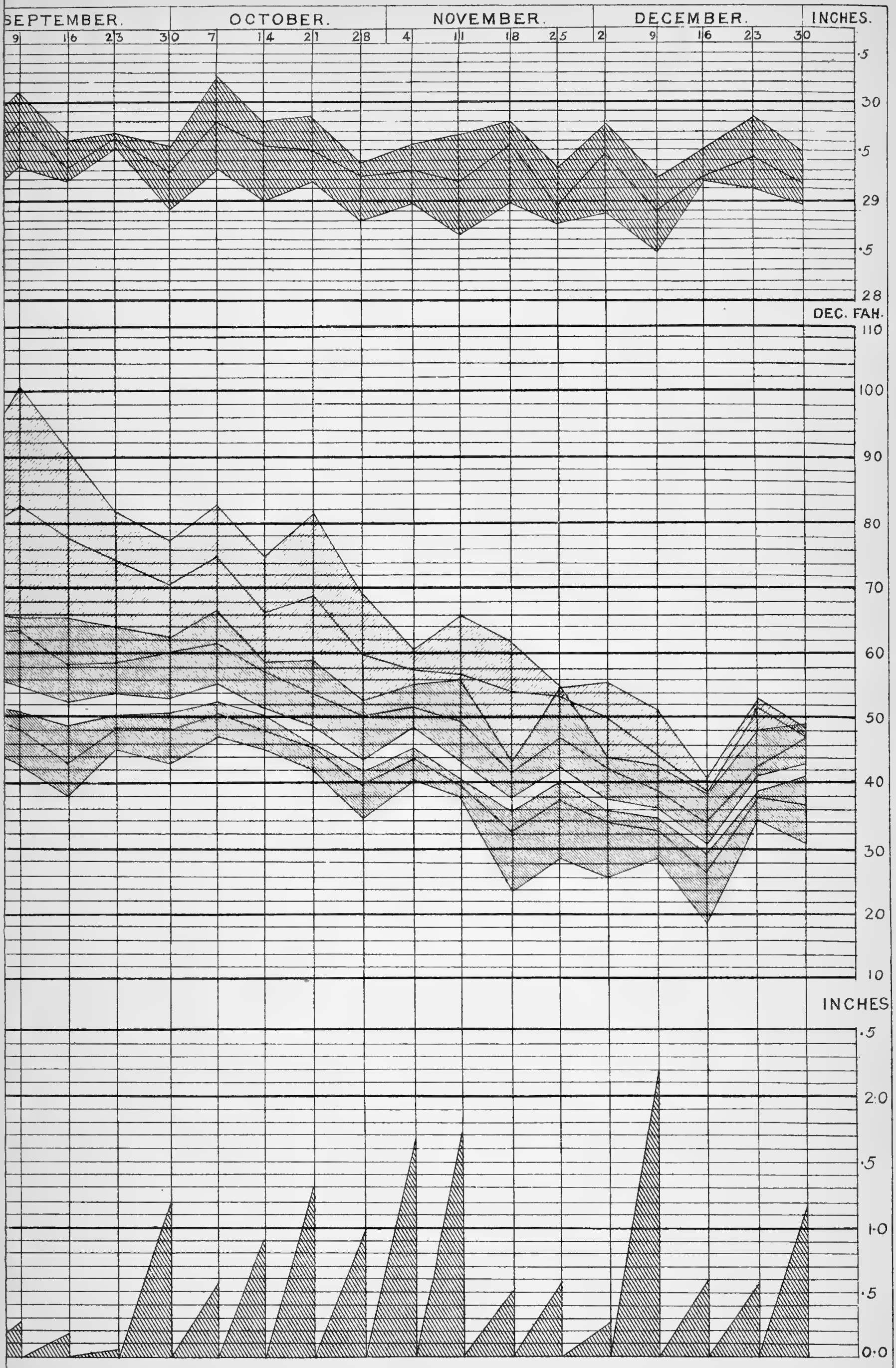
*** It is requested that Members changing their residence will communicate with the Secretary.

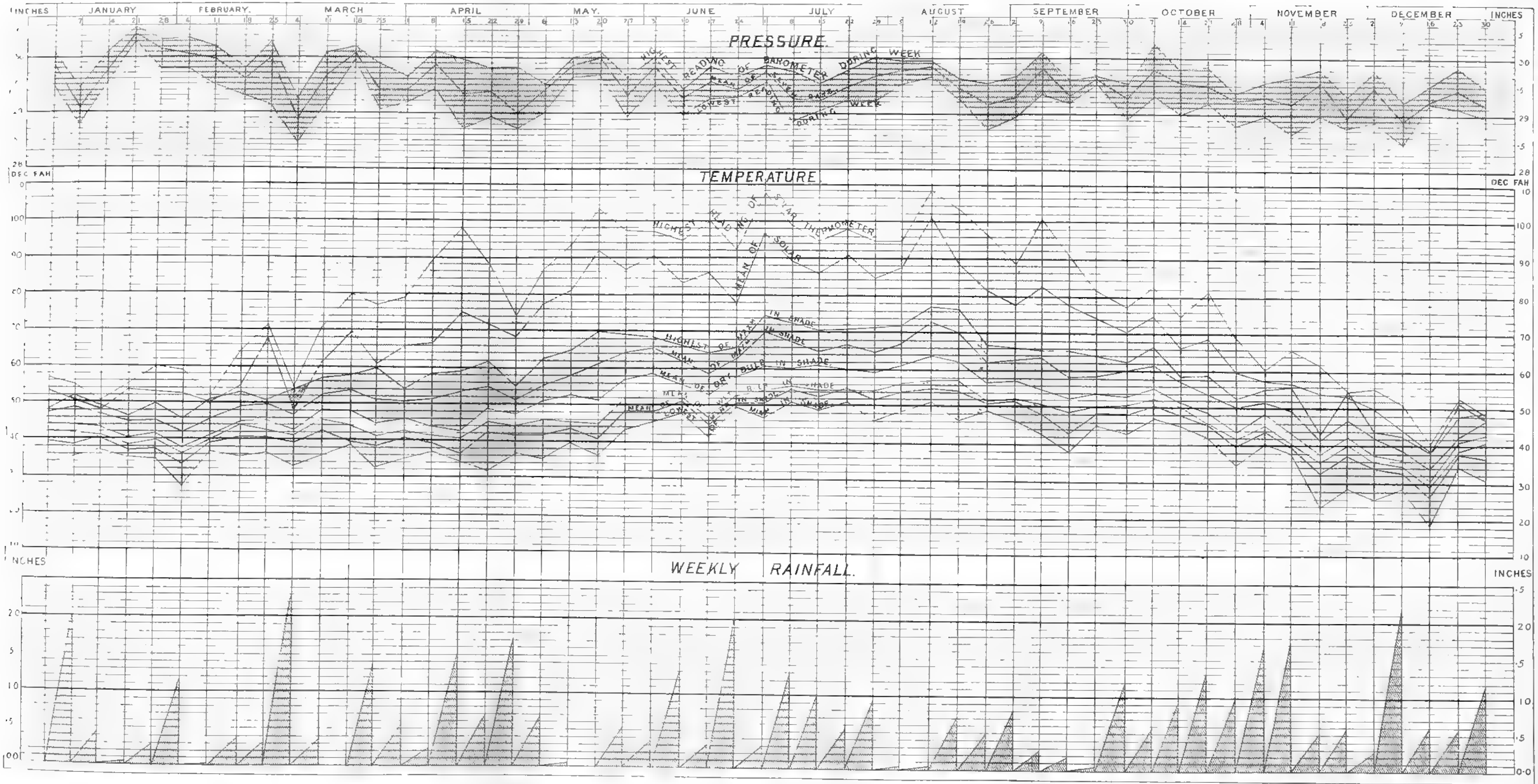
ANCE, BRADFORD,
C.E., F.M.S., F.G.S.



"Meteorology of Bradford for 1882."

Weekly Pressure, Temperature, & Rainfall, Recorded at the Exchange, Bradford,

by John McLandsborough, F.R.A.S., F.M.S., F.G.S. and Alfred Eley Preston, Assoc. M. Inst. C.E., F.M.S., F.G.S.



S. C. Bailey Surveyors Lithographer ... Road, Bradford.

D FOI

nge, Bradford,

on, Asso. M. I

Height above m

Mean of 14 years.	Mean Weight of a Cubic Foot of Air.	Highest Reading of Maximum Thermometer in Rays of Sun
—100	Grs.	Deg
86	552	60·5
86	548	71·2
83	541	80·0
78	539	98·2
74	537	103·4
72	530	101.4
70	525	107·2
74	526	108·0
78	531	100·6
83	535	82·6
83	540	66·2
85	545	53·2
79	537	86·0
79	539	91·2

TY, AND RAINFA

HUMIDITY.

Saturation = 100.)

	Lowest.	
.	Degree of Humidity during Year.	Date.
	0—100	
8	42	Sep. 2
29	40	July 1
7	43	Nov.
22	45	Sep. 2
11	41	Mar. 2
6	42	May 1
23	43	July
4	46	May
29	35	May 2
13	53	Aug.
7	51	Dec. 1
15	50	May 3
14	38	May 3
5	36	May 1
	43	

METEOROLOGY OF BRADFORD FOR 1882.

Computed from daily observations made at the Exchange, Bradford,

By John McLandsborough, F.R.A.S., F.M.S., F.G.S., and Alfred Eley Preston, Asso. M. Inst. C.E., F.M.S., F.G.S.

Latitude, 53 deg. 47 min. 38 sec. N.; longitude, 1 deg. 45 min. 4 sec. W. Height above mean sea level, 366 ft.

Pressure of Atmosphere in Month; Temperature of Air in Month

Months	Highest Reading of Barometer	Date	Lowest Reading of Barometer	Date	Range	Corrected for Capillarity and Temperature: Mean	Mean of 14 Years	Temp. Highest	Date	Lowest	Date	Range	Mean of all Highest	Mean of all Lowest	Mean Daily Range: Mean	Mean of 14 years	Mean of Dry Bulb
	Ins	On	Ins	On	Ins	Ins	Ins	Deg	On	Deg	On	Deg	Deg	Deg	Deg	Deg	Deg
January	30·511	19th	[illegible]	[illegible]	[illegible]	[illegible]	29·633	[illegible]	6th	33·0	29th	19·0	[illegible]	37·9	7·7	8·3	42·3
February	[illegible]	24th	[illegible]	[illegible]	[illegible]	[illegible]	29·412	54·0	20th	27·6	2nd	26·4	47·6	[illegible]	[illegible]	9·0	41·0
March	[illegible]	[illegible]	[illegible]	1st	[illegible]	[illegible]	[illegible]	59·[illegible]	[illegible]	32·7	22nd	27·1	51·1	[illegible]	11·5	11·3	45·2
April	[illegible]	[illegible]	[illegible]	11th	[illegible]	[illegible]	[illegible]	62·3	[illegible]	32·0	[illegible]	30·3	52·6	[illegible]	12·7	13·5	41·9
May	[illegible]	17th	[illegible]	24th	[illegible]	[illegible]	29·572	[illegible]	[illegible]	[illegible]	[illegible]	33·7	61·3	41·4	[illegible]	11·8	51·[illegible]
June	[illegible]	1st	[illegible]	[illegible]	1·41	[illegible]	[illegible]	74·4	30th	41·0	13th	33·4	[illegible]	[illegible]	11·1	15·1	54·8
July	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	29·517	[illegible]	1st	40·0	27th	27·8	[illegible]	[illegible]	13·2	[illegible]	[illegible]
August	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12th	[illegible]	[illegible]	31·1	[illegible]	[illegible]	[illegible]	14·4	[illegible]
September	[illegible]	7th	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2nd	[illegible]	15th	23·4	60·6	[illegible]	12·7	12·8	[illegible]
October	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	67	2nd	44·8	20th	32·4	55·0	45·7	[illegible]	10·8	49·0
November	[illegible]	14th	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6th	24·0	16th	[illegible]	46·4	37·7	[illegible]	9·2	41·8
December	[illegible]	[illegible]	[illegible]	4th	[illegible]	[illegible]	29·451	53·2	30th	18·8	11th	34·6	46·6	33·5	7·1	8·4	37·7
Means, totals	[illegible]		[illegible]		[illegible]	[illegible]	29·493	[illegible]		34·2		29·7	64·8	43·4	11·4	11·9	48·3
Means of 14 years	30·064		28·882		1·182	29·493	29·493	64·0		33·4		31·5	64·7	42·7	12·0	11·9	48·0

Adopted Mean Temperature; Vapour; Degree of Humidity (Complete Saturation = 100)

Months	Of Air: Mean	Mean of 14 years	Of Evaporation	Dew Point	Vapour: Elastic Force	In a Cubic Foot of Air: Mean	Short of Saturation	Humidity Highest	Date	Lowest	Date	Mean	Mean of 14 years	Mean Weight of a Cubic Foot of Air	Highest Reading of Maximum Thermometer in Rays of Sun	Date	Mean Reading of Maximum Thermometer in Rays of Sun	Highest Estimated Strength (Wind)
	Deg	Deg	Deg	Deg	Ins	Grs	Grs	0–100	On	0–100	On	0–100	0–100	Grs	Deg	On	Deg	0–12
January	41·9	38·7	39·9	[illegible]	[illegible]	2·6	0·5	[illegible]	29th	68	6th	86	86	[illegible]	[illegible]	25th	[illegible]	[illegible]
February	[illegible]	33·8	41·4	39·6	[illegible]	2·6	0·4	98	26th	64	10th	87	86	516	[illegible]	[illegible]	[illegible]	2·5
March	[illegible]	[illegible]	42·2	[illegible]	239	2·6	0·6	[illegible]	1st	55	[illegible]	[illegible]	83	541	100·0	17th	[illegible]	2·6
April	[illegible]	45·4	42·2	[illegible]	[illegible]	2·8	0·6	97	5th	44	21st	[illegible]	78	[illegible]	98·2	11th	[illegible]	[illegible]
May	[illegible]	49·4	46·4	41·3	[illegible]	2·5	1·3	[illegible]	1st	36	[illegible]	[illegible]	74	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
June	64·5	55·7	[illegible]	45·5	[illegible]	[illegible]	1·4	[illegible]	22nd	46	[illegible]	71	72	[illegible]	101·4	[illegible]	[illegible]	2·0
July	[illegible]	63·5	[illegible]	41·1	[illegible]	[illegible]	1·5	87	21st	45	17th	74	70	525	107·2	1st	[illegible]	2·5
August	[illegible]	[illegible]	53·4	[illegible]	[illegible]	3·9	1·0	[illegible]	15th	41	11th	[illegible]	74	[illegible]	[illegible]	9th	[illegible]	[illegible]
September	[illegible]	51·9	[illegible]	41·2	[illegible]	3·5	1·0	97	27th	41	[illegible]	78	78	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
October	[illegible]	48·2	47·6	46·0	[illegible]	3·5	0·5	97	13th	55	5th	[illegible]	[illegible]	[illegible]	[illegible]	6th	[illegible]	2·6
November	41·7	42·2	[illegible]	[illegible]	219	2·5	0·5	[illegible]	5th	69	[illegible]	[illegible]	[illegible]	[illegible]	66·2	10th	51·5	[illegible]
December	37·4	38·6	36·2	34·6	[illegible]	2·3	0·3	97	27th	44	11th	90	85	545	53·2	23rd	[illegible]	[illegible]
Means, totals	48·2	47·8	45·1	41·9	271	3·1	0·9	94		51		[illegible]	79	537	86·0		[illegible]	2·5
Means of 14 years	47·8	47·8	44·7	41·3	267	3·1	0·9	94		53		79	79	[illegible]	91·2		70·5	2·9

Wind; Rain

Months	Date	Mean Estimated Strength	N	NE	E	SE	S	SW	W	NW	Mean Amount of Cloud	Number of Days Rain fell	Amount Collected	Greatest Daily Fall	Date	Mean of Fourteen Years	Mean of Seven Years (surface of ground)	Mean of Seven Years with 1882 at Town Hall and Midland Station	Greater fall on surface at Town Hall & Mid. Stn.: Depth in Inches	Percentage of fall at Exchange
	On	0–12	No	No	No	No	No	No	No	No	0–10	No	Ins	Ins	On	Ins	Ins	Ins	Ins	Per cent
January	[illegible]	1·1	0	0	2	6	1	12	6	5	7·5	16	3·84	[illegible]	29th	2·44	2·209	2·474	0·265	11·2
February	[illegible]	1·2	0	0	0	2	4	10	8	6	7·7	11	2·21	0·82	26th	2·04	2·601	2·973	[illegible]	11·4
March	5th	1·4	0	1	0	1	0	21	5	3	6·4	18	2·08	[illegible]	25th	2·94	2·776	[illegible]	[illegible]	11·7
April	24th	1·0	0	[illegible]	5	[illegible]	1	5	4	[illegible]	7·0	20	4·41	[illegible]	29th	2·11	2·516	[illegible]	[illegible]	11·2
May	1st	0·8	0	5	[illegible]	3	3	6	2	4	4·9	11	0·92	0·31	25th	1·69	[illegible]	[illegible]	[illegible]	[illegible]
June	10th	0·9	0	2	0	7	0	3	8	5	6·0	23	3·92	1·45	22nd	2·61	2·657	[illegible]	[illegible]	10·6
July	[illegible]	0·9	1	1	0	3	0	23	0	3	6·6	25	4·12	0·62	25th	2·70	3·401	3·011	0·240	10·7
August	[illegible]	1·0	1	2	0	3	1	[illegible]	6	12	5·8	14	1·64	0·30	[illegible]	[illegible]	[illegible]	3·892	[illegible]	10·7
September	2nd	0·9	0	6	1	4	0	[illegible]	4	9	6·2	15	[illegible]	0·43	20th	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
October	[illegible]	1·0	0	3	0	8	0	6	6	6	7·1	27	4·08	[illegible]	19th	3·58	3·640	4·012	0·372	11·0
November	22nd	1·1	2	3	3	3	0	6	6	8	6·8	27	5·17	0·61	[illegible]	2·95	3·421	3·878	[illegible]	11·2
December	5th	[illegible]	1	6	0	1	0	11	2	10	8·6	25	4·51	1·61	6th	2·93	3·681	4·170	0·489	11·3
Means, totals		1·0	5	32	14	56	10	[illegible]	54	72	6·7	237	39·69	0·78		2·61	35·741	[illegible]	3·860	11·08
Means of 14 years		1·1	26	52	27	39	23	72	74	53	6·6	186	31·27	0·70		31·27				

Yearly Maximum and Minimum Atmospheric Pressure, Temperature, Humidity, and Rainfall, from 1869 to 1882, Inclusive.

Year	Pressure Highest: Reading of Barometer during Year	Date	Lowest: Reading of Barometer during Year	Date	Temp. in Shade Highest: Reading of Maximum Thermometer during Year	Date	Lowest: Reading of Minimum Thermometer during Year	Date	Date of Last Frost	Date of First Frost	In Sun's Rays Highest: Reading of Thermometer during Year	Date	Humidity Highest	Date	Lowest	Date	Rain: Total for Year	Mean of Years at Town Hall and Midland Railway Station	Greater fall on surface at Town Hall & Mid. Rly. Stn.: Depth in Inches	Percentage of fall at Exch'ge	Greatest Daily Fall during Year	Date	Snow: Date of Last Snow	Date of First Snow
	Ins		Ins		Deg		Deg				Deg		0–100		0–100		Ins	Ins	Ins	Per cent	Ins			
1869	[illegible]	Dec 6	29·500	Feb 1	[illegible]	Aug 30	[illegible]	Dec 28	Mar 27	Oct 29	127·7	Aug 30	99	Feb 8	42	Sep 24	[illegible]				0·670	Dec 18	April 3	Oct 9
1870	30·274	Jan 19	28·308	Jan 8	85·0	July 25	16·6	Dec 24	Mar 30	Nov 9	117·5	July 25	98	Jan 29	40	July 14	[illegible]				0·920	June 18	Mar 24	Nov 15
1871	30·182	Mar 28	28·308	Jan 16	84·0	Aug 12	[illegible]	Jan 1	April 11	Nov 13	126·7	July 17	98	July 7	43	Nov 2	[illegible]				0·955	June 16	Mar 15	Nov 16
1872	30·156	April 6	28·070	Jan 24	[illegible]	July 23	21·6	Mar 27	Mar 27	Nov 15	[illegible]	Aug 19	100	Mar 22	45	Sep 23	[illegible]				2·450	June 19	May 11	Nov 13
1873	[illegible]	Feb 18	28·022	Jan 20	[illegible]	July 23	[illegible]	Feb 24	Mar 11	Nov 6	124·5	July 23	100	Dec 11	41	Mar 26	[illegible]				1·200	Aug 4	April 25	Jan 3, '74
1874	30·476	Mar 6	28·276	Dec 11	[illegible]	July 20	15·0	Dec 31	Mar 12	Nov 11	[illegible]	July 20	100	Feb 6	42	May 10	[illegible]				0·740	Dec 7	May 9	Nov 26
1875	[illegible]	July 7	28·484	Nov 10	80·0	Aug 17	11·0	Jan. 1	Mar 22	Nov 26	122·0	July 5	100	Jan 23	43	July 6	[illegible]				[illegible]	Nov 15	Mar 12	Nov 9
1876	[illegible]	Jan 15	28·070	Dec 4	[illegible]	July 17	23·0	Jan 9	April 15	Nov 9	126·6	July 16	99	Oct 4	46	May 6	35·270	31·788	4·618	11·26	1·510	Oct 9	April 12	Nov 8
1877	[illegible]	Oct 6	28·300	Nov 29	80·0	June 19	20·0	Mar 1	May 4	Oct 18	111·4	June 19	100	Oct 29	35	May 23	[illegible]	[illegible]	4·449	11·19	1·420	July 16	May 19	Oct 15
1878	[illegible]	Mar 16	[illegible]	April 1	[illegible]	July 19	13·9	Dec 26	April 6	Nov 1	[illegible]	July 22	99	Jan 13	53	Aug 9	[illegible]	[illegible]	3·576	[illegible]	1·220	Aug 14	April 1	Nov 8
1879	[illegible]	Dec 13	28·600	Feb 10	74·4	July 30	13·2	Dec 7	May 1	Nov 14	111·2	Aug 13	100	Oct 7	51	Dec 12	35·017	[illegible]	[illegible]	[illegible]	1·070	June 8	May 7	Nov 20
1880	[illegible]	Jan 7	28·164	Nov 16	81·3	Sep 5	26·8	Jan 20	Feb 23	Oct 20	112·0	Aug 13	99	Dec 15	50	May 20	[illegible]	[illegible]	[illegible]	11·10	1·710	Oct 27	Mar 2	Oct 27
1881	[illegible]	May 10	28·250	Oct 14	83·3	July 6	12·0	Jan 25	April 21	Oct 13	116·5	June 1	98	Oct 14	38	May 31	35·434	39·312	4·458	11·26	1·425	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	118·0	Aug 9	99	Nov 5	36	May 18	39·693	43·103	3·420	10·86	1·608	Dec 6	Mar 21	Nov. 19
Means	30·328		28·309		83·1		16·9				119·9		99		43		31·268	39·601	3·860	11·08	1·359			

EXPLANATION.

The observations are made at nine a.m., and, with the exception of maximum and minimum thermometer readings, [illegible]

The highest and lowest barometric readings for each month, [illegible] are given [illegible] corrected for capillarity, temperature, and diurnal range. [illegible] and barometer reading 30 inches at sea level, [illegible]

[illegible] Glaisher's Hygrometrical Tables [illegible]

[illegible]

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. The mean yearly rainfall collected at the Exchange for the fourteen years ending with 1882 is 31·268 inches, and for the last seven years thereof 35·741 inches. As rain gauges on the summits of buildings are known to collect less rain than those placed on the surface of open ground adjacent thereto, in 1875 gauges were fixed on the surface of the open spaces near to the Town Hall and the Midland Railway Station, between which the Exchange gauge is about midway, and the ground about the same level. The mean yearly fall thus obtained on the surface for seven years ending with 1882 is 39·601 inches, being 3·860 inches, or 11·08 per cent., more than at the Exchange. There are cogent reasons for concluding that, not only are the differences in the rates of percentage due to the varying direction and force of wind producing different currents and eddies in the upper portions of the Exchange, but that the deficiency in the amount collected is attributable to the currents there prevailing preventing due precipitation, rather than to a generally supposed increase in the size of raindrops during their descent. By applying the mean percentage to the fourteen years' rainfall at the Exchange, the mean normal rainfall of central Bradford for such period is found to be 34·732 inches per annum.

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

The mean of fourteen years, where given, is for that period ending with 1882.