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PROCEEDINGS

OF THE

Yorkshire Geological Society

NEW SERIES, VOL. XIX.

1914—1922.

WITH FIFTY-FOUR PLATES.

EDITED BY

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

AND HERBERT E. WROOT.

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VOL. XIX.] [PART I.

PROCEEDINGS

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1914.

SOME REMARKS ON GEOLOGY IN RELATION TO THE EXACT SCIENCES, WITH AN EXCURSUS ON GEOLOGICAL TIME.

BY ALFRED HARKER, M.A,. F.R.S., F.G.S.,

PRESIDENT OF THE YORKSHIRE GEOLOGICAL SOCIETY.

(ADDRESS DELIVERED 21ST NOVEMBER, 1912).

Although the constitution of this Society enjoins us to confine our serious labours to a definite geographical field, it may still, I hope, be permissible upon occasion to vary the programme by discussing some general geological question or some particular aspect of the science. Assuming this liberty, I propose to offer a few remarks on the subject of geology in its relation to the exact sciences.

I take it as undisputed that, in the rough classification which serves the purpose of his catalogues, the book-seller is justified in ranking geology with the "descriptive," not with the "exact" sciences. We are nevertheless free to inquire to what extent the quantitative element may legitimately enter to strengthen geological methods and add precision to the results. Connected with this question is another, perhaps more elusive but certainly more fundamental: to what extent, and with what precautions, can the geologist admit deductive reasoning into his discussions?

My meaning will perhaps be clearer if I expand this latter question a little. The geometrician, once satisfied of the validity of a few simple axioms, can build up one theorem upon another by purely deductive reasoning, without any further appeal to experience. This is the extreme case ; but among the sciences dealing with the material world there are some in which mathematical precision and deductive reasoning find an important place. The mineralogical chemist, for example, has the law of molecular proportions, and (within limits) will reduce his analysis of a mineral to conform with this law ; in other words, he can use theory to correct observation. The law of rational indices affords like guidance to the crystallographer, and many other instances might be cited. There is, I think, no department of geology proper in which such a degree of certainty and exactitude has yet been attained. What the future may have in store I will not venture to predict ; but, so far as the immediate prospect is concerned, it seems that the only safe course for the geologist is that which makes continual appeal to observation, wherever such control is possible.

By many this will be regarded as a mere common-place, but it would be easy to give reasons for insisting on it. Five years ago a distinguished physicist undertook to combat what he termed "a curious obsession as to a matter of fact" on the part of geologists. While the text-books continue to repeat that the flow of a river is most rapid on the outer side of a bend, the fact is, he said, that it is most rapid on the inner side. This pronouncement, which can be confuted by any boy who has ever gone boating, was not made on the strength of any observations, but as the result of calculation applied to some ideal case. That was how the river *ought* to flow. It is true, there was also a reference to the behaviour of a wooden model, a subject to which I will return later. It is not my purpose to discuss the phenomena of the flow of rivers, and indeed the matter is less simple than appears at a glance ; but I have cited the incident for its bearing on the relations between geology and the exact sciences. On one point doubtless all geologists will agree ; that, when there is a conflict between deduction and observation, we must prefer the evidence of our eyes to the most cogent demonstration. Some will perhaps go farther, and, while welcoming help from any quarter, will hint that, in relation to such a study as physical geology, mathematics is a good servant but a bad master.

The truth is that such a problem as this is, from the point of view of analytical treatment, one of extreme complexity. It often involves a large number of factors. Some of these are taken into account, but others are left out, or are simplified in an arbitrary manner; and this is done with reference, not to the relative importance of these various factors, but to the exigencies of mathematical treatment. Indeed it is no reproach to the mathematician or the physicist to say that he is not always a good judge of what is essential in the statement of a complicated geological problem. This is a necessary consequence of that division of labour in the field of science which we call specialisation. We may recognize it with the less scruple, inasmuch as the same kind of criticism is applicable, *mutatis mutandis*, to ourselves; for there is no doubt that geological speculation is often vitiated by disregard of mathematical considerations, and those of no very recondite order.

It is often said that figures can be made to prove anything; and certain it is that a series of arithmetical operations does sometimes serve as introduction to very strange conclusions. The fault, of course, is not in the tool, but in the hand that uses it. In the larger issues of geology especially, where the gulf to be bridged between data and conclusions is so often a wide one, ingenuity of reasoning ought surely to be accompanied by a due sense of responsibility in the handling of figures. Calculation, in such applications, is by no means so simple an art as it may appear. In wrestling with problems of the kind indicated, and, I must add, in reading some very fascinating speculations by geologists of high standing, I have often wished that some obliging mathematician would put forth a small manual of applied arithmetic for the guidance of workers in the descriptive sciences. There are absolutely necessary precautions to be observed when calculation is based upon data always partial and at best roughly approximate, and these precautions are too often neglected. To be safe, we must have some conception of the probable error attaching to our observations, and we must note how the initial errors may be multiplied in the process of calculation. Especially there is the cumulation of error which must ensue when results obtained in this fashion are used as links in a chain of deduction. Here it is quite inadequate to say that the chain is no stronger than its weakest link; it is of necessity far weaker than its weakest link.

Without entering into these matters, some of which, as I have suggested, call for expert aid, I will take for illustration a single point, the frequent abuse of the average. Say that we wish to determine the amount of mud annually carried down by the Nile. Since there are variations, both seasonal and casual, we must take a sufficient number of observations, properly distributed in time, and an average, duly weighted, will then give us as good a result as the nature of the case admits. But now suppose that we wish to know the amount of sediment carried by all the rivers of the world. We have data for nine rivers, data which are likely to differ much in respect of probable error. Accepting them, however, as they stand, it appears that the water of the Rio Grande carries one part in 291 of sediment, that of the Uruguay River only one in 10,000, the other seven rivers giving intermediate values. The highest figure is thus 34 times as great as the lowest. Some geologists will simply take a mean of the nine figures and proceed contentedly to use this result in the most far-reaching conclusions. I do not believe that a mean of nine figures so discordant can afford any information of quantitative value. The average must be extended over a much wider area, before a result is obtained of which we can legitimately make use.

Where dynamical principles enter into the problem, the pitfalls which await the unwary are sometimes less evident. I will take as an illustration the case of models, such as have been constructed to elucidate the mechanism of folding and faulting. In no case, so far as I am aware, have geologists had regard to the conditions which are necessary in order that a model may correctly represent the working of the original. The various forces concerned must bear their proper ratios. Since the weight (for a given material) is reduced proportionally to the cube of the linear dimensions, the other forces must be reduced in the same ratio, and it is in fact impossible to make this adjustment as regards the internal forces which resist deformation and fracture. Moreover, the velocities of the moving parts should be reduced in proportion to the square root of the linear dimensions; and this makes it hopeless to think of imitating the slow processes of mountain-building. Models of this kind may afford useful *geometrical* illustrations, but can throw no light on *dynamical* problems. The same remark applies to models of glaciers, but here there is no need to go to artificial models to illustrate my point. Some geologists still argue from the behaviour of an Alpine valley-glacier to that of a continental ice-sheet, without perceiving how completely the different scale of magnitude must modify the mechanical conditions.

Experiment has undoubtedly afforded valuable help in the study of particular questions in the domain of physical geology, and this is to be recognized with gratitude. As regards the larger and more complex problems, however, imitative experiment labours under the same disadvantage as mathematical analysis. Any concrete problem can be treated only in an arbitrarily simplified form, and among the conditions which cannot be realised in the laboratory may be some which in nature are of vital importance. Especially will this be the case where the time element enters.

There is, however, another department of experimental geology in which we are justified in expecting results of very high value. I allude to the study of the conditions of formation and stability of different minerals, with the object of elucidating the mode of origin of igneous and other rocks. The artificial reproduction of many of the rock-forming minerals has engaged the attention of chemists, especially in France, during the last hundred years. Fouqué and Michel-Lévy succeeded even in imitating some of the simpler types of igneous rocks. These researches have furnished the petrologist with useful information, but it is information mostly of a very general kind. The laborious investigations now being carried out, more particularly in the Geophysical Laboratory of the Carnegie Institution at Washington, are of a different order, systematic and precise to the highest degree attainable. Their chief object is to apply to the cystallization of igneous rock-magmas the methods which have proved so fruitful in other branches of physical chemistry. This necessitates working over a far wider range of temperatures than is usual in laboratory operations, and must sometimes include high-pressure work also. It involves too, other practical difficulties, arising especially from the slowness with which equilibrium is established in many of the transformations investigated. Owing perhaps to these obstacles, and partly, it may be, to the scarcity of enlightened millionaires—for expense is here a weighty consideration—research on these lines has not yet been widely taken up. Meanwhile it is scarcely too much to say that Dr. Day and his colleagues at Washington are already laying the foundations of an exact science of Petrogenesis.

Concerning another American development of recent years, the quantitative classification of igneous rocks, I am constrained to speak in terms much less laudatory. We must all wish to see more of quantitative precision in this and other branches of geological science; but it must be a precision depending on principles to be educed from the subject-matter itself, not arbitrarily imposed from outside. With increasing knowledge, from the experimental side as well as the descriptive, it may some day become possible to construct a logical classification of igneous rocks, in which the numerical element will enter in the form of eutectic ratios or in some other way prescribed by Nature herself: but that is at present only an aspiration. Very different is the plan to which I have referred. Starting from a list of standard minerals, itself arbitrary and artificial, the authors have built up a classification depending on the relative proportions in which these minerals enter, or are assumed to enter, into the composition of the rocks. The dividing lines are not based upon the study and comparison of actual rocks, but merely on arithmetical symmetry, the system being, to all appearance, invented *a priori*. We are reminded of Macaulay's trenchant criticism of James Mill's Essay: "an elaborate treatise on Government, from which, but for two or three passing allusions, it would not appear that the author was aware that any governments actually existed among men." We find ourselves again among the pre-Baconian philosophers.

I have selected for notice these two Trans-Atlantic attempts to introduce quantitative considerations into Petrology, because they are instructive as exemplifying, in my opinion at least, how to do it and how not to do it. It would probably exhaust your patience, were I to prolong these rather rambling remarks by citing numerous other illustrations of the same general purport. I will therefore devote the rest of the time at my disposal to the consideration of a single problem, that of Geological Chronology.

Of all geological questions involving the numerical element, none has been more frequently canvassed than this, and none has excited more general interest. Since, moreover, it introduces several points germane to my subject, a brief glance at its history and present state will not be wasted. I suppose it has happened to most of us, when relating how in past times the mammoth roamed the plains of Holderness, or how coral-reefs once flourished where the Craven hills now stand, to be met by the inquiry: How long ago was that? The answer was perhaps to the effect that geology does not deal with the ordinary measures of time, but has its own system of chronology, not translatable into years and centuries. I must confess, however, to a sense of inadequacy in such a reply, and some sympathy with the lay-inquirer who is thus silenced but not satisfied. It seems a matter of reasonable regret that a science which deals with the history of past events should have no definite time-scale, by which those events could be ranged in a correct perspective.

No such reflection, it is safe to say, disturbed the minds of the early Uniformitarians, the founders of modern geology. Their reaction against the older catastrophic school led them constantly to lay great stress on the extreme slowness of geological processes, and they thus came to assume unlimited time for the past changes to which the stratified rocks bear witness. To Hutton there was "no vestige of a beginning, no prospect of an end": in other words he regarded geological time as infinite, and could no more contemplate reckoning it in centuries than numbering the sands on the shore. Later this position was reinforced from another quarter, as Darwin's doctrines gained acceptance; for these were held to push back to an immeasurably remote epoch the beginning of life on the globe. Geologists and biologists alike saw no reason for limiting their prodigal drafts on the bank of time.

From this comfortable attitude they were startled, as by a bombshell, just fifty years ago, when William Thomson, afterwards Lord Kelvin, published the first of his contributions from the mathematical side to this and cognate subjects. He pointed out that, apart from any changes on the surface of the globe, our planet as a whole must be undergoing a change of a secular, and so irrevocable, kind; viz., a continual loss of energy in the form of heat, as proved by the observed temperature-gradient. Since the store of energy cannot be inexhaustible, we must deduce both a beginning and an end of the existing geological *régime*; and Thomson endeavoured to set a limit to its past duration from a discussion of the rate of cooling of the globe. A parallel line of argument was based on the cooling of the sun.

Now as regards the validity of the general criticism there can be, of course, no doubt. Huxley's halting defence of what was then the orthodox position was easily broken down, and a wholesome check was given to the extravagance of the geologists. When we turn, however, from the destructive to the constructive part of Kelvin's argument, the case is different. The time to be allowed for the geological record was stated at first with considerable latitude, but was subsequently narrowed down, until, in 1899, Lord Kelvin concurred in Clarence King's conclusion that the globe was a molten mass about 24 million years ago. It is rather remarkable that so many geologists were found willing to submit to this narrow limitation. Doubtless they were impressed by the prestige of Lord Kelvin's authority, and perhaps some of them were influenced by a vague feeling that a result arrived at by strict mathematical reasoning is thereby entitled to credence. But, as has been so often pointed out, and so often for-gotten, what you get out of the mathematical mill depends upon what you put into it. The reasoning may be unimpeachable, but it merely proves that, if certain assumptions be granted, certain consequences will follow. It may be that Lord Kelvin himself, in the enthusiasm of enforcing his conclusions, did not always recall the foundations on which they rested, and it is to be suspected that many geologists read no more than the conclusions.

Kelvin's argument was based necessarily upon a number of assumptions. At the present time, in the light of fuller knowledge, it is sufficient to note one, which in 1862 seemed little open to question. Kelvin recognized that, while the earth is certainly losing heat, "it is possible that no cooling may result from this loss of heat, but only an exhaustion of potential energy, which in this case could scarcely be other than chemical affinity between substances forming part of the earth's mass." This, however, he dismissed as "extremely improbable," and proceeded on the assumption that heat is the only form of energy to be reckoned with. Since the discovery of radium we have learnt that the earth possesses a vast store of potential energy in a highly concentrated form then unsuspected. Strutt has calculated, from data of a very simple kind, that the observed temperature-gradient can be wholly accounted for by radio-activity, if the rocks to a depth of 45 miles contain as much radium as those at the surface. In other words, the heat generated by radio-active changes within this relatively thin crust will, on that supposition, be sufficent to compensate that lost at the surface. Clearly, therefore, the actual rate of cooling of the globe—if indeed it is cooling—must be far less than that adopted in Kelvin's calculation, and his estimate of the age of the earth must be enormously increased.

This is not all. A study of the various radio-active elements contained in minerals and rocks has shown that it is possible, in certain favourable cases, to calculate directly their age in years. Some estimates of this kind have been made, and the results are liberal enough to satisfy the most exacting claims of what may be called the reformed Uniformitarian creed.

With this turning of the tables one might suppose that the old controversy would come to an end. But the reversal of the situation is in fact more complete; for meanwhile there has arisen a formidable minority of geologists who contend, on geological grounds, for estimates of time no more elastic than Lord Kelvin's. The question is still, in great part, one between geologists and physicists, but it is now the geologists who offer us the stinted measure and the physicists the more liberal one.

It is not my purpose to discuss in detail the various geological arguments which have been advanced for limiting the age of the earth to a span of 80 or 100 millions of years. The method of procedure is broadly the same in all. A computation is made of the rate at which some fundamental geological process is going on; it may be the lowering of the land-surface by erosion, or its destruction by solution, or the deposition of sediment, or the addition of salt to the sea. Some estimate is then made of the total result of the process throughout geological time. Having the annual rate of increment and the total amount, simple division gives the measure of the time in years. The observational data employed in these calculations are of a very precarious kind, and it would not be difficult to point out instances of that levity in the handling of figures to which I have adverted. But the fundamental weakness of all such reasoning lies in the assumption that the present rate of any of these geological processes can be adopted as equivalent to its average rate throughout the whole time.

The existing configuration of the globe, and all the physical conditions that go with it, have been attained in consequence of a prolonged evolution. If we believe that, as the net result of all its vicissitudes, the land-area has on the whole been growing in extent, in complexity of distribution, in boldness of relief, we must believe also that differences of temperature, of humidity, of climate generally, between different parts of the globe have become progressively more accentuated, and that all geological activities have been quickened as the world has grown older. While there is difference of opinion concerning these *secular* changes, there can be no doubt as regards the great *cyclical* changes which have been repeated several times in the history of the earth: the cycle beginning in each case with an epoch of important crust-movements and including the train of consequences which follow upon this new step in the evolution of the earth. Such a cycle was initiated at an epoch not long remote by geological reckoning, and we are living in consequence in a time of more than ordinary geological activity, with the continental masses rising higher than their average level, and with large tracts of newly deposited strata exposed to the attack of destructive agents.

For these reasons I am of opinion that the present rate of erosion, and of its correlative sedimentation, is much higher than the average rate, and that any calculation based upon it must greatly under-estimate the duration of geological time. I do not ask you necessarily to concur in this conclusion, but at least to suspend judgment in the matter; for it will assuredly be a misfortune if geology, so lately freed from one bondage, should fall straightway into another no less galling. This at least is certain, that every one of the various geological processes which have been discussed in this connection, is controlled by conditions which cause its rate to be very variable. It is a clock which now hurries and now creeps, or stands still, and it can never be trusted as a time-keeper. Even for the most recent chapter of geological history we can make no approach to certainty on these lines. Attempts have been made, for example, to estimate the time since the final retreat of the ice in North America from the rate of recession of the falls of Niagara; but the evidence shows that this rate has varied widely even during the last half-century, and Gilbert, after a careful study of all the data, refrains from offering any opinion on this point.

Must we then abandon all hope of any practicable measure of time in geology? I do not draw this conclusion, but rather that we must search outside strictly geological phenomena for some physical process of which the rate is not affected by any disturbing conditions. There are, I think, only two classes of changes for which so much can be claimed—the transformations of the radio-active group of elements and the astronomical movements. It seems not improbable that in one or other of these two directions the solution of the problem may eventually be found.

The chemists have taught us that radium is derived from the spontaneous breaking up of uranium, the change taking place apparently in two stages and involving the liberation of three atoms of helium. But radium itself disintegrates spontaneously, giving the radium-emanation named niton and liberating another atom of helium. Niton in its turn undergoes disintegration, and so on through a succession of changes. The final product is lead, and in the gradual conversion of uranium to lead eight atoms of helium in all are set free. Of these various spontaneous changes some proceed with extreme slowness, others with comparative rapidity; but in each case there is a constant rate which, so far as experiment has tested it, is independent of temperature or pressure.

Professor Strutt has shown that this gradual liberation of helium can be made the basis of a method of estimating the absolute ages of minerals and rocks. For example, phosphates and some iron-ores are rich in radium, derived from uranium. They also contain helium, and the ratio of helium to uranium is found to be higher in the older deposits. Estimates of age calculated from these data give high figures, *e.g.*, the age of the hæmatite overlying the Carboniferous Limestone in Cumberland is given as 140 millions of years, and even that of the Eocene iron-ores of Antrim 30 millions. The results show some irregularities, and it is of course admitted that the method has its own difficulties. If, however, the chief source of error is, as appears probable, the loss of helium by leakage, the figures found will be under-estimates. Helium comes from the thorium series of derivatives as well as from the uranium series, and this is to be taken into account where thorium is found. Zircons from various igneous rocks have also been examined by Strutt, and found to give consistent results as regards the helium-ratio. Mr. Holmes has approached the question in a different way by considering the ratio of lead to uranium in various minerals rich in the latter element. The igneous rocks of the Christiania district, of Devonian age, are in this way calculated to be about 370 million years old. For the Archæan rocks of different countries the estimates range from 1,000 to 1,600 millions of years. Holmes' results are in general nearly twice as high as those of Strutt; but, if we bear in mind the error due to the escape of helium, which is proved to take place, a discrepancy to this extent is no more than should be expected at this early stage of the inquiry.

The other method which has been suggested for obtaining an absolute measure of geological time is of a more speculative kind, although the principle of it is sufficiently simple. It consists in detecting some clearly marked rhythm or cycle in the geological record, and correlating it with one of the known periodic movements of the earth. It was on these lines that Croll attempted to explain recurrent glacial epochs; but more to our present purpose is the theory which Blytt has based upon a study of the alternations observed in a succession of sedimentary strata. The most important astronomical cycle of long period is doubtless that which depends upon the precessional movement, by which the relation of summer and winter to perihelion and aphelion is gradually changed. This involves a change in the relative lengths of summer and winter, and must undoubtedly exercise a marked effect upon climatic conditions, though there is much difference of opinion concerning the exact nature of this effect. Changes of climate may in their turn cause differences in the nature of the sediments deposited successively at a given place, differences which will repeat themselves in a cycle corresponding with that of the precession. Probably the most noticeable effect will be a recurrence of limestones and chemical deposits alternating with detrital sediments.

If the matter were no more complex than this, it would be sufficient, where such alternations can be detected, to count them, as we count the rings of growth of a tree, and reckon 21,000 years for each sedimentary cycle, that being the period of the precession corrected for the movement of the perihelion. If the alternations can be distinguished only in some parts of the succession, some hypothesis must be devised to take account of the intervals. Gilbert has discussed in this way a succession of beds, 3,900 feet thick, forming part of the Cretaceous system in Colorado. Alternations of calcareous beds with shales come in four times, being separated by unbroken thicknesses of shale. Gilbert calculates for the part of Cretaceous time represented a duration of about 20 million years, with an uncertainty indicated by the number 2 as a "factor of safety."

We have to remember, however, that sedimentation is controlled by other conditions besides climate, and climate depends upon other causes besides the precession of the equinoxes; and, further, that most of these contributing causes cannot be described as periodic in any intelligible sense. There is, it is true, a second astronomical movement to which both Croll and Blytt have made appeal, viz., the variation in the eccentricity of the earth's orbit. This goes through a period of about 90,000 years; but there are considerable irregularities which repeat themselves in the course of 1,450,000 years, giving a larger cycle which embraces sixteen of the smaller cycles. The change of eccentricity must modify the effect of the precessional movement; but Blytt argues that it will also react on the ellipsoidal shape of the globe itself, and so give rise to a displacement of shore-lines. He claims to have traced this effect, as well as the climatic cycle, in such cases as the succession of the Tertiaries in the Paris basin and the Isle of Wight. His conclusion is that Tertiary time comprises two of the larger cycles, *i.e.*, about three million years.

It has usually been assumed that the year is too short a period to leave any recognizable mark on the geological record. This is probably true in general, but in certain favourable circumstances it may perhaps be possible to count annual layers of sediment. De Geer has recently attempted this in the case of certain finely laminated clays of late Glacial and post-Glacial age in Sweden. The material was brought down by sub-glacial streams at a time when the ice had retreated to the higher ground. Consequently the seasonal variations were strongly marked, and the accumulation of sediment was rapid enough to yield an appreciable thickness in each year. From such data De Geer has estimated that the recession of the last ice-sheet occupied a duration of about 5,000 years; and he further gives 7,000 years as the lapse of time since the recession of the ice.

As regards the longer astronomical cycles, it is clear that the argument involves a large element of hypothesis, and its application, as Blytt allows, is beset with practical difficulties. It possesses a special interest as lending a new significance to the details of stratigraphy, but as a means to the establishment of a geological chronology its value is at present only potential. The radium method of evaluating geological time seems to offer more immediate promise.

In conclusion, it is pleasant to note how these applications of chemistry, astronomy and meteorology, not merely to general principles of geology but to a definite geological problem, emphasize the fundamental unity of the sciences, and illustrate the powerful aid that may be rendered by one to another.

THE ANALYSIS OF ILKLEY SPA WATER.

BY BENJAMIN ARTHUR BURRELL, F.I.C.

Modern Ilkley occupies the site of the Brigantian stronghold of Llecan, which subsequently became the Roman station of Olicana.

"Ichley Fountaine," has been in repute for bathing for about two centuries, a small bath-house having been built in 1699* Hearne's edition of Leland's Itinerary contains a letter written by Dr. Richardson in 1709 stating, "Ilkley . . . chiefly famous for a cold well, which has done very remarkable cures in scrofulous cases by bathing, and in drinking of it."

In 1734 Dr. Short wrote, "Ichley Spaw springs out of the middle of a mountain, a Mile high. . . . The Water is very clear, brisk and sparkling, has no taste, colour nor smell different from the common Water, is of the same weight. Its Basin and Course are of no other Dye than that of a common Spring. . . . Five pints of this Liquor exhaled left seven Grains of sediment. . . . Therefore, though this Water is of the greatest Esteem and Repute of any in the North of England, in the King's Evil and other old Ulcers; yet it derives these Effects neither from its fixt nor volatile Parts, but wholly from the Coldness and Purity of the Element." †

Dr. Rutty in 1757 quotes from another treatise of Short's specifying the virtues of the "Ichley Water."‡

Dr. Adam Hunter's examination in 1819 gave :—

Temperature of water, 48° F.
Temperature in shade, 64° F.
Sp. Gr. at 55° F., 1·00015.

A wine gallon was found to contain :—

Muriate of Lime	6·50 grains.
Muriate of Magnesia ...	3·00 ,,
Total	9·50 ,,

* White's "Directory of the West Riding of Yorkshire," 1838. Vol. II., p. 511.
† "The Natural, Experimental, and Medicinal History of the Mineral Waters of Derbyshire, Lincolnshire, and Yorkshire," Thos. Short, M.D., of Sheffield. London, 1734. Page 307.
‡ "A Methodical Synopsis of Mineral Waters," John Rutty, M.D., London, 1757. Page 23.

Gaseous Contents :—

Carbonic Acid Gas... ...	12·60 cubic inches.	
Atmospheric Air	5·40	,,
	18·00	,,

Quantity 100 gallons per minute and situate nearly three-quarters of a mile from the village.*

T. Shaw, M.R.C.S., in 1830 stated :—"The water is, perhaps, for its purity, tenuity and coldness, the best qualified . . . of any water in this part of the country. It has been frequently analysed, but the decomposition always proved that it contains no medicinal quality . . . it is purity and softness only, which makes it more efficacious . . . than any other water known."†

There is a reference to the water in the "Spas of England."‡ The author having repeatedly measured the flow which he puts at 60 gallons a minute, the temperature being 47° F. and that of the atmosphere, 55° F. The analysis of Dr. Hunter is quoted.

William West in 1844 stated that he had not analysed it, but gives its composition in grains per gallon : §—

Chloride of Sodium ...	0·657
Sulphate of Soda	0·366
Sulphate of Lime	0·2
Carbonate of Lime ...	2·353
Carbonate of Magnesia ...	1·04
Silicate of Soda	1·066
Peroxide of Iron	0·060
Total	5·742

The following analysis is given in some of the local guides. The author is not stated :—

Sulphate of Sodium ...	2·939	grains per gallon.
Chloride of Calcium ...	0·572	,,
Carbonate of Calcium ...	2·185	,,

* "An Essay on Two Mineral Springs at Harrogate and on the Springs at Thorp Arch and Ilkley," Adam Hunter, M.D., Leeds, 1819.

† "The History of Wharfedale," by Thomas Shaw, M.R.C.S., Otley, 1830.

‡ "The Spas of England," Northern Spas, Vol. I., A. B. Granville, M.D., F.R.S., London, 1841.

§ "Brit. Assn. Notices," 1845, p. 107.

Silica	1·200 grains per gallon.
Chloride of Sodium ...	0·501 ,,
Solid Matter	10·796 ,,
Free Carbonic Acid ...	6·581 cubic inches per gallon.
Temperature, 43-45° F.	

For several years past the writer has taken samples of the water from the pipe used for filling the Roman Bath at the White Wells, the height of which is about 660 feet above sea level. The water issues from the middle or third grits of the Millstone Grit series. Variations in temperature are very slight, the following readings selected from those made on ten different occasions show the extreme variations :—

Temperature of Air (Shade).	Temperature of Water.
16·9° C.	8·8° C.
9·4° C.	7·7° C.

The water is clear and free from sediment. The general procedure was that recommended by Fresenius, and all numbers given are the mean of at least two, and generally of three or four determinations. For substances present in minute quantity the residues obtained by the evaporation of from 45 to 50 litres of the water were used. With such quantities neither bromine, iodine, barium nor strontium could be detected. International Atomic Weights, 1912, were used for the calculations.

The constituents are given in :—

	grams per litre.	grains per gallon.
SiO_2	0·0152	1·0641
SO_4	0·0176	1·2368
N_2O_5	0·0001	0·0093
Nitrous Acid	none	none
P_2O_5	trace	trace
Cl	0·0110	0·7700
Fe	0·00016	0·0112
Al	trace	trace
Ca	0·0169	1·1866
Mg	0·0090	0·6307
Na	0·0119	0·8331
K	0·00125	0·0876
Li	0·00019	0·0136
Free Ammonia	—	0·0011
Albuminoid Ammonia	—	0·0020
Oxygen absorbed in 4 hours @ 26·6° C.		0·0016

Taking into account the composition of the filtered boiled water, the acids and bases may be combined as follows the numbers being in grains per gallon :—

Ferric Oxide (Fe_2O_3)	0·0159 = Ferrous Carbonate 0·0232
Calcium Carbonate ($CaCO_3$) ...	0·8078
Calcium Nitrate ($Ca2NO_3$) ...	0·0140
Calcium Silicate ($CaOSiO_2$) ...	2·0535
Calcium Sulphate ($CaSO_4$) ...	0·5199
Magnesium Carbonate ($MgCO_3$)...	1·4235
Magnesium Sulphate ($MgSO_4$) ...	1·0900
Potassium Carbonate (K_2CO_3) ...	0·1548
Sodium Carbonate (Na_2CO_3) ...	0·8726
Sodium Chloride (NaCl)	1·1550
Lithium Chloride (LiCl)	0·0831
	8·1901

Total Solid Constituents dried at 173° C., 8·295.

TEMNOCHEILUS DERBIENSIS, SP. NOV.

BY WHEELTON HIND, M.D., B.S., F.R.C.S., F.G.S.

(READ NOV. 20TH, 1913).

c.f. *Nautilus latus* de Koninck 1878, Ann. Mus. d'hist. Nat. de la Belgique. Tom. II. ; Pt. I., p. 110, Pl. XXIV, Figs. 3, a, b, c.

The specimen on which this species is founded was obtained from a small quarry on the east of the lane leading from Thorpe to Tissington, Derbyshire. The horizon of the quarry is that of the Upper Dibunophyllum zone, and the fauna is rich in the characteristic brachiopods of the zone.

The specimen (Plate I) consists of three whorls and is entirely camerate and no indication of the body chamber is preserved. It has been impossible to completely expose the neanic and nephionic stages.

SPECIFIC CHARACTERS.—Shell of moderate size, involute, expanding gradually. Inner whorls well exposed. Umbilicus large and open, its outer margin angular and tuberculate, its sides only slightly convex. The greatest transverse thickness of each whorl is from outer margin to outer margin ; whorls at least 4. The peripheral margin of the whorl is broad and almost flat, near the margin it may be very slightly depressed before it is raised into the keel-like margin, which is tuberculate, the tubercles being separated from each other by about three cameræ, and having the extent of almost one camara.

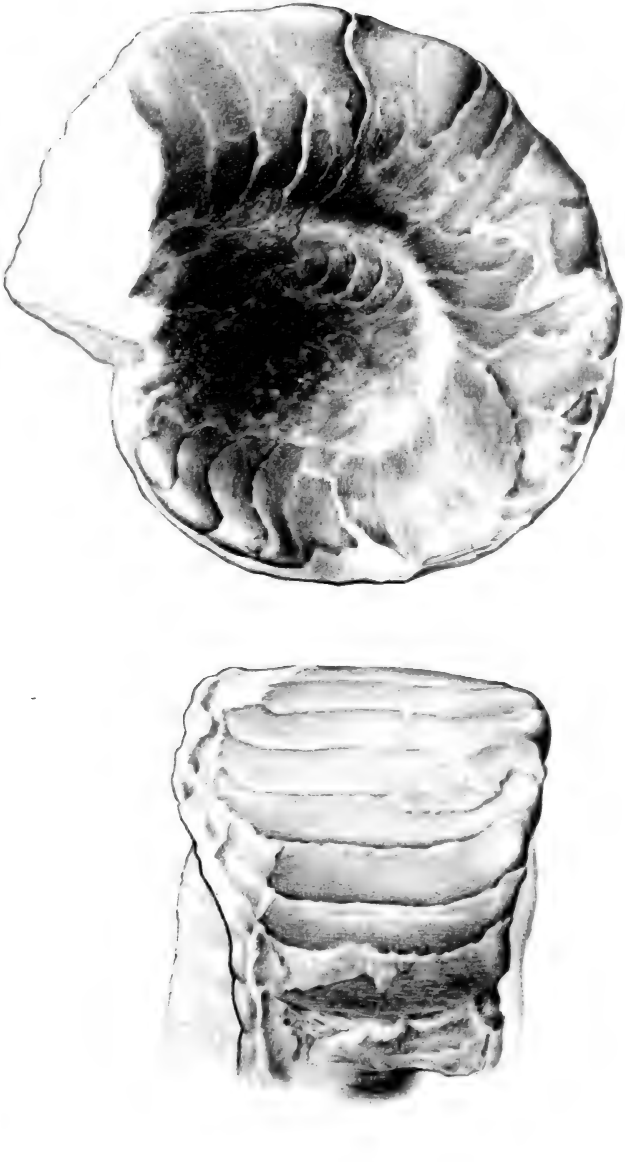
The cameræ are numerous, about 28 in the last remaining whorl of the specimen. The septa are concave on the sides and pointing forward at the peripheral margin, but on the periphery only slightly concave. The siphuncle is central.

Test, thin, ornamented by many close fine striæ.

MEASUREMENTS.—Greatest diameter, 78 mm. ; Periphery, 56 mm.

HORIZON AND LOCALITY.—Upper Dibunophyllum zone. Carboniferous Limestone quarry east of Tissington Hall, Derbyshire.

OBSERVATIONS.—The specimen under description is much too broad and the periphery much too flattened to be referred to *Temno-*



W. G. Browning del. Huth imp.

Temnocheilus derbiensis, *sp. nov.*

Proc. Yorks. Geol. Soc., Vol. XIX.

Plate I.

chielus coronatus which also has a much more convex umbilical slope and the peripheral margin less angular.

Judging from the figure of the Visean specimen of *Nautilus latus* figured by de Koninck (Op. supra cit.) I think it is identical with my specimen. *N. latus* was described and figured by Meek and Worthen and their type is from Illinois, N. America. Comparing their figure (Geol. Surv., Illinois, Vol. V, Pl. 30, Figs. 2, a, b), it is much less transverse and the whorl not so deep as in the Belgian specimen and I doubt whether the latter is correctly referred to Meek and Worthen's species. The American specimen is stated to consist of "half of one volution" and to be "unseptate."

THE MILLSTONE GRIT SEQUENCE BETWEEN MASHAM AND GREAT WHERNSIDE.

BY W. S. BISAT.

(READ SEPT. 20TH, 1913).

The district in which the rocks under discussion are situated is bounded on the N.W. by Coverdale, east by the Valley of the Ure, west by Wharfedale, S.E. by the watershed dividing the Burn and Laver valleys, and on the S.W. by an arbitrary line running due west from Ramsgill into Wharfedale.

The whole of the Millstone Grit sequence is not seen in this area, beds which have been referred to the top of the Third Grits being the highest that have escaped denudation.

It is of course well known that the succession consists of the usual alternations of grits, sandstones and shales, but owing to the variation horizontally and general similarity of the sandstone and grit bands, it does not appear possible or useful to attempt any division of the series based on the occurrence of grit or sandstone beds at varying horizons.

Marine fossils occur at two well-defined horizons, and it is proposed to make use of these two bands as a basis for the subdivision of the sequence.

Phillips in his "Geology of the Mountain Limestone District" (pp. 209-212) published in 1836, records five marine fossils from Colsterdale on the authority of Danby.

The Rev. J. S. Tute recorded from the neighbourhood of Ripon (Proc. Yorks. Geol. Socy., 1867 and 1886), a list of marine fossils from an horizon in the Third Grits which he termed the Cayton Gill Beds on account of their being well exposed in Cayton Gill, near Ripon. From the same neighbourhood Dr. Wheelton Hind has since recorded (*The Naturalist*, 1907, pp. 92, 93) a much fuller list, and the mapping of the Survey indicated that these beds continued as a fossiliferous horizon as far north as Masham.

The excavation of the trench for the core wall at Leighton Reservoir, near Masham, for the Leeds City Council, though unfortunately mainly passing through beds of a barren character, has provided an opportunity for making a fairly detailed examination of the sequence, the determination of the relative position of the two marine bands above alluded to, and the obtaining of satisfactory aunal lists therefrom.

Sandy shales.

Clay shales.

Limestone, 1 ft.

Clay shales, 1 ft. 6 in.

Grit floor.

Colsterdale Fossiliferous Band, as seen at Backstone Gill, Meugher Fell, Upper Nidderdale.

Using the two well established fossiliferous horizons to split up the series, we obtain the following groups of beds :—

Brimham Grit Group	350 ft.
Cayton Gill Beds	150 ft.
Barren Beds	250 ft.
Colsterdale Fossil Beds	10 ft.-80 ft.
Basement Shales	say 300 ft.-400 ft.
Basement or Bearing Grit... ...	0 ft.-200 ft.

The thicknesses given to the first three sections are of the series as developed at Clints, near Leighton Reservoir, Masham ; the thickness of the Colsterdale fossiliferous horizon (Plate II.) appears to vary to the indicated extent ; and the thickness of the basement shales is estimated from the Coverdale exposures.

These basement shales, which together with the basement or Bearing Grit form the lowest beds in the series, lie on a variable base, which is seen in Nidderdale and Coverdale ; and indications of erosion, which may be responsible for a good deal of the variation, are not lacking. The Bearing Grit, above alluded to, is seen very well in Howstean Beck and Blayshaw Gill near Lofthouse-in-Nidderdale, and appears to attain a maximum thickness along a north and south line under Great Whernside. The shales are usually fairly sandy, and contain some small sandstone bands, but are generally of a limp character. They are to some extent micaceous, and thin coals occur near the base. Occasional small obscure shells are met with, but I have not yet had the opportunity of examining the whole of the thickness, and a good deal of work remains to be done in the examination of these shales, and the underlying junction with the Yoredale limestones.

At the top of the above shales a sandstone or grit band occurs almost everywhere, with a coal seam in part of the area. This coal seam has been worked in Coverdale, Nidderdale and Colsterdale, has a thickness varying up to 1 ft. 6 in. or 2 ft., and is a useful guide to horizon. It is followed by shales containing a marine fauna. These fossiliferous shales may be traced from Colsterdale to Great Whernside and southwards from thence along the borders of Nidderdale and Wharfedale. Along this latter line the thickness of fossiliferous shale does not appear to be more than 10 ft., including a thin limestone band about a foot in thickness, which has been mapped and named by the Survey the " Tesselated Limestone " ; but the fossiliferous group thickens out to the north-east in Colsterdale, mainly owing to grit bands coming in. Here trial holes were sunk some years ago by the Leeds City Council for their water scheme, and the material tipped to spoil has yielded a fairly large fauna. The coal seam may be taken as forming the base of the fossiliferous group, but unfortunately there are no exposures showing the whole series, and failing this, it is not easy to assign any definite thickness to these beds, but lacking better evidence, about 80 ft. of beds may be taken as here belonging to the marine band, which thickness includes about 40 ft. of grit and ganister which seem to have fossiliferous layers.

Above these fossiliferous shales there is a thickness of about 250 ft. of sandstones, plates and shales, often very micaceous and apparently barren of any marine fauna. The sandstone bands are not of very great thickness, and very often merely seem to be long lenticular wedges. The thickest band seen is a well marked grit running down the east side of Birk Gill, where it forms the moor top. On reaching Healey Pasture quarry it has become finer grained and is not definitely traceable further south. Its thickness is 50 ft. to 60 ft., it occurs in the middle of the series, and is perhaps represented by rock bands seen at Leighton Reservoir and below Healey, but there appears to be no means of correlation. The shales form at Leighton about 60 per cent of the series, are fairly hard and sandy, and usually full of hard fine grained grey sandstone streaks, which may in a few feet horizontally change the shale into a sandstone. These sandstones contain large concretions of sandstones with a calcite matrix.

The above series of barren beds possesses on the whole strong features, and forms a cap in many places to the relatively softer beds below. Beds at this horizon form a capping to the Nidderdale hills in the neighbourhood of Great Whernside, but are best seen in the valley of the Burn, where characteristic exposures of alternating sandstone and sandy shale may be seen in most of the small gills and in the river Burn itself.

At the top of this series of barren beds there have been small exposures on the south side of the valley at Leighton Reservoir which show what appears to be a definite line of erosion of greater magnitude than the small signs of contemporaneous erosion that occasionally may be seen in these beds. Not only is the erosion line fairly well marked, but also the overlying sediments are of totally different character. The sandstones are thin and contain thick clay partings, and the shales are extremely argillaceous, a character which the shales in the whole of the 250 ft. intervening between this horizon and the underlying Colsterdale beds never assume, and only remotely approach in extreme cases. The channel formed by this erosion line appears to run north-east and south-west.

The shales above the erosion line have yielded *Lingula mytiloides*, and in the sandstone beds which follow a fauna especially rich in lamellibranchs is developed. This sandstone bed is the main shellbed of the Cayton Gill series, which may be taken as commencing at the erosion line. Unfortunately only the lowest and least fossiliferous part of this series was exposed at Leighton, but at Roundhill Reservoir, Arnagill Valley, High Ash Head Moor, and in the river Burn, near Shaw's Bridge, Swinton, more fossiliferous beds are exposed, and boulders may be seen strewing the line of outcrop. A dark, platy sandstone higher up in the series is seen at Arnagill Valley and High Ash Head Moor, and has yielded numerous brachiopods, but no lamellibranchs. A similar band on the bank of the Ure, near Hackfall, probably represents the same horizon. The boring at Roundhill noted on page 59 of Fox-Strangways' "Geology of the Country north and east of Harrogate," passed through the whole of this series, and indicated about 60 ft. of shales in the upper part, which unfortunately do not appear to be exposed anywhere in the district. There is some little difficulty in determining the exact thickness to assign to the Cayton Gill Beds as the top is nowhere seen owing to lack of exposures. The total thickness is here taken as 150 feet, which allows the shales immediately below the lower grit band of the Brimham Grit group to be included with the grits.

Beds of this age form the moor top to the east of Lofthouse, and stretch northwards round the bend of Nidderdale to Great Haw. In the region between Great Haw and the head of Grimes Gill a hard white ganisteroid sandstone appears low down in the Cayton Gill series, apparently underlying the main shell bed.

The base of the series at Leighton is mainly formed of clay shales, and this appears to be the case wherever exposures are available, similar shales being seen at Woo Gill, Nidderdale, and traces in Arnagill Valley and Ger Beck, Tranmire. These shales have only yielded *Lingula*, and that but sparingly. Shales a little higher are more fossiliferous.

The sandstone beds seen at Fountains, near Ripon, are much harder and more calcareous than those of this district.

It is not possible owing to lack of exposures to give much detail of the Brimham Grit group. There are two strong grit bands, one of which is quarried. The quarry baring shows overlying this grit band shales which are fairly argillaceous, and to some extent resemble the beds at the base of the Cayton Gill series, though they contain no fauna. There are one or two thin layers of coaly shale. They differ from the barren bed shales in the absence of the strong sandstone streaks which pervade the latter, and also their colour is much lighter.

Taking the whole series into consideration the fact emerges that the real clay shales are confined to one or other of the two bands which contain a fauna, and thus it would appear that the conditions which were favourable to abundant marine life usually led to the formation of shales of a clayey rather than a sandy type.

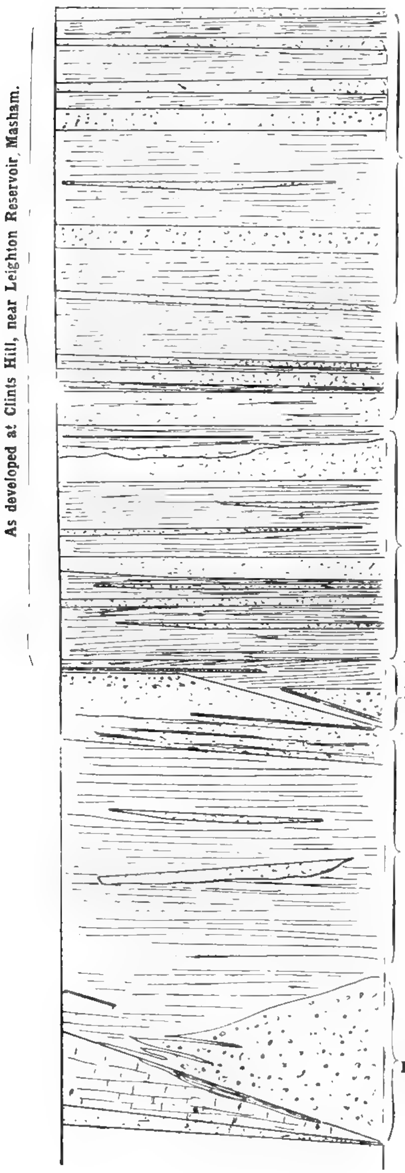
Dr. Hind states that the Colsterdale fauna has a Pendleside facies, and it appears to be a question for further investigation whether these lower beds are not really the northern equivalent of the Pendleside shales further south.

In conclusion, thanks are due to Dr. Wheelton Hind for the identification of the fauna, and to the officials of the Leeds, Harrogate, and Bradford Corporations for permission to visit tips and for information as to sections.

TABLE I.

Diagrammatic Section of the MILLSTONE GRIT sequence as seen between MASHAM and GREAT WHERNSIDE.

Vertical Scale 200 ft.—1 in.



BRIMHAM GRIT GROUP.
350 ft.

CAYTON GILL BEDS
With fauna.
150 ft.

Orthoceras morrisianum
Stroboceras bisulcatum
,, *sulcatum*
Allorisma tumid
,, *sulcata*
Aviculopecten clathratus
,, *dissimilis*
,, *occidentalis*
Ctenodonta lævirostris
Edmondia senilis (rudis)
,, *sulcata*
Grammatodon obtusum
Leiopteria laminosa
,, *thompsoni*
Myalina peralata
,, *verneuilli*
Derbya hindi
Productus carbonarius
,, *cora*
Nucula æqualis
,, *luciniformis*
Nuculana stilla
Pinna mutica
Posidoniella elongata
Protoschizodus axiniformis
,, *curtus*
Schizodus antiquus
,, *wheeleri*
Sanguinolites tricostatus
,, *modiolaris*
Spathella lata
Scaldia benedeniana
Sedgwickia transversa
Tellinomorpha transversa
Chonetes laguessiana
Schizophoria resupinata
Productus concinnus
,, *semireticulatus*
Etc.

Line of erosion.

BARREN BEDS.
250 ft.

Sandstone plates and shales. Shales (at Leighton) form about 60% of the series, are very strong and sandy, full of thin, grey, fine-grained sandstone streaks, thus making a hard, strong group. No coal seams, no clay shales, no fauna. Carbonaceous markings, occasional ripple marks, micaceous layers, calcite concretions. Sandstones not usually very coarse, except to north and west. Individual beds extremely variable.

COLSTERDALE MARINE BEDS
With fauna.
10 ft.-80 ft.

Glyphioceras diadema
,, *micronotum*
,, *phillipsi*
Orthoceras asiculare
,, *koninckianum*
Nomismoceras spirorbis
Allorisma sulcata
Aviculopecten occidentalis
,, *gentilis*
Ctenodonta lævirostris
Myalina peralata
Nucula gibbosa
,, *æqualis*
,, *luciniformis*
Nuculana attenuata
,, *stilla*
Posidoniella corrugata
,, *kirkmani*
,, *lævis*
Posidonomya membranacea
Prothyris elegans
Etc.

BASEMENT SHALES.
Say 300-400 ft.

Shales with a flagstone to grit top, and small sandstone bands at varying intervals. Shales generally limp and micaceous, with thin coals near the base in Nidderdale and Coverdale (Upper). Occasional obscure fossils.

BASEMENT or BEARING GRIT.
0-200 ft.

Rapidly develops on a north and south axis through Great Whernside, and appears to bend south easterly towards Lofthouse-in-Nidderdale, where grit is seen at the base of the series in Howstean Beck and Blayshaw Gill.

FIG. 1.

FAUNA OF THE COLSTERDALE MARINE BAND.

	Colsterdale.		Coverdale.	Upper Nidderdale.								
	Trial Holes near Gollinglith Foot.	Spruce Gill.	West Scrafton Colliery.	Woo Gill.	Foggyshaw Lodge Coal Level.	Trope Scar.	Lul Beck.	West Gill, off Blagshaw Gill.	Barkstone Gill, Meughe.	Stone Beck Head, Great Whernside.	Tops Gill, under Dead Man's Hill.	Stand Sike, under Dead Man's Hill.
Pisces.												
Acrolepis hopkinsi	×											
Cephalopoda												
Dimorphoceras gilbertsoni											?	
Glyphioceras diadema	?	×		?								×
,, *micronotum*	×											
,, *phillipsi*	×											
Orthoceras asciculare	×											
,, *koninckianum*	×											
Nomismoceras spirorbis											×	
Lamellibranchiata.												
Allorisma sulcata				×								
Limatulina occidentalis				×								
Aviculopecten gentilis	×											
Pterinopecten papyraceus				?								
Ctenodonta lævirostris				×								
Edmondia sp.	×											
Leiopteria sp.				×								
Myalina peralata	×	×		?								
Nucula gibbosa	×											
,, *æqualis*				×								
,, *luciniformis*	×											
Nuculana attenuata	×			?								
,, *stilla*	×			×								
Posidoniella corrugata	×					×		×	×	×		
,, *kirkmani*								×				
,, *lævis*	×	×		×				×	×	×		
Posidonomya membranacea	×											
Prothyris elegans	×											
Schizodus antiquus				×								
Brachiopoda.												
Lingula mytiloides	×		×	×	×		×					
,, *squamosa*	×			×								
Orbiculoidea nitida	×											
Orthotetes	×											
Productus aculeatus	×											
Schizophoria resupinata	×										×	
Seminula ambigua	×											
Gasteropoda.												
Bellerophon sp.	×											
Euphemus urei	×			?								
Macrocheilina brevispira	×											
Meloploma sp.	×											
Ptychomphalus interstriatus ? ..	×											
Straparollus sp.	×											

TABLE III

FAUNA OF THE CAYTON GILL BEDS.

	RIPON, PATELEY BRIDGE AND HARROGATE AREA.	MASHAM AREA.	
	[illegible]	Lower Bands in series.	Upper Band
[illegible]	[illegible]	[illegible]	[illegible]

PALÆONTOLOGICAL NOTES ON THE MILLSTONE GRIT BEDS BETWEEN MASHAM AND GREAT WHERNSIDE.

BY WHEELTON HIND, M.D., B.S., F.R.C.S., F.G.S.

(READ NOV. 20TH, 1913).

From time to time some Millstone Grit Fossils have been noted from the district round Harrogate and Pateley Bridge, the list given in the Memoir of the Geological Survey, "The Geology of the Country north and east of Harrogate," by Fox-Strangways, page 7, being the most recent and up-to-date.

I was fortunately able to make a fairly extensive collection from these localities at the time of the visit of the Yorkshire Geologists' Association to Pateley Bridge in 1906, and have been waiting since then for an opportunity to pursue the subject. Fortunately Mr. Bisat took up the question of fossil horizons in the Millstone Grits, and has kindly allowed me to examine all his material and now to co-laborate with him.

Several new species of lamellibranchs have occurred in the Cayton Gill Beds which I now propose to describe, but perhaps the most interesting fact is the facies of the fauna, which contains a large number of species common to it and the *Dibunophyllum* beds of the Carboniferous Limestone, and does not contain the *Goniatite* fauna and its associated lamellibranchs so frequently met with in the slate beds between the different members of the Millstone Grit, for example at Wadsworth, Eccup and Sabden.

Messrs. Barnes and Holroyd described a fossiliferous bed of Millstone Grit on Pule Hill (Trans. Manch. Geol. Soc., Pt. vii., Vol. xxv.), but the f[illegible] seems to be almost entirely different from the one under descrip[illegible] o brachiopoda were found there.

The [illegible]ence in the Cayton Gill Beds of so many species of fish, brachiopods, lamellibranchs and cephalopoda which were last seen in the *Dibunophyllum* zone opens up the whole question of stratigraphy. Do the grits of the Pateley Bridge area represent a horizon totally different from those further south ? Is the horizon of this fauna accurately known with regard to the occurrence of the same fauna elsewhere ? Why is not the real Millstone Grit fauna met with in the series except at Colsterdale, and there only in part ?

The Colsterdale fauna is almost totally different from that of the

Cayton Gill Beds, and may be said to have a Pendleside facies. If this bed is shown to be below the Cayton Gill Beds, then we at once have evidence of the fact that at the close of the *Dibunophyllum* period in the area in discussion, the fauna was not extinguished, but merely migrated and returned at a much later date when the conditions were favourable, but though favourable very different from those of the Carboniferous Limestone sea.

In connection with this band the occurrence of *Prothyris elegans* is interesting This shell occurs in the Millstone Grit of Scotland, and I have obtained it from Congleton Edge quarry just above the zone of *Glyphioceras spirale.* It is a North American species and is not uncommon in the Coal Measures of Nebraska.

GRAMMATODON REGULARIS sp. nov.

[Figs. 12-14 ; Plate IV.].

Parallelodon meridionalis Hind, 1897. Brit. Carb. Lamell., Pl. XIII., Fig. 9.

,, obtusum, 1902, Trans. N. Staff. F. C., Vol. XXXVI., Page 78.

SPECIFIC CHARACTERS.—Shell transverse, narrow and tumid, very inequilateral. The anterior border rounded. The lower border and hinge line almost parallel, the posterior border obliquely truncate from above downwards and backwards. The posterior superior angle obtuse. Umbones small, somewhat raised, nearer the anterior end. The valve is moderately tumid except on the dorsal slope where it is rapidly compressed and hollowed above an oblique rounded ridge passing from the umbo towards the posterior inferior angle. Escutcheon large and well marked.

INTERIOR.—The hinge plate and muscle scars normal.

EXTERIOR.—The surface is ornamented with fine lines of growth which become more pronounced and thicker on the posterior part of the valve. Fine decussating radiating lines are to be noted, which become much more apparent on the dorsal slope.

DIMENSIONS.—Fig. 14, Pl. IV. measures :—

Anteroposteriorly, 32 mm.
Dorsoventrally, 11 mm.
Transversely, 10 mm.

Localities.—The marine bed of Millstone Grit, Hazel Hill and Clint Quarries. The marine band associated with *Glyphioceras spirale* at Congleton Edge.

Observations.—I figured a specimen of this species showing the hinge-plate and both valves, Op. supra cit., referring it to *Parallelodon meridionalis* de Koninck, to which species it has a fairly close resemblance. The Belgian shell comes from the Tournasian beds and is less transverse, comparatively deeper and has its ornament and lines of growth more deeply incised and more irregular. *Grammatodon obtusus* is comparatively deeper in a dorsoventral direction and has a well-marked broad byssal sinus, which is practically absent in the species under discussion.

In lists of fossils from Congleton Edge I have referred to this species as *Parallelodon obtusum.*

Several specimens have been found at each locality.

SEDGWICKIA TRANSVERSA sp. nov.

[Figs. 18, 19, Pl. V.]

Specific Characters.—Shell transversely ovate, moderately gibbose, compressed and narrowed posteriorly, inequilateral, somewhat oblique.

The anterior end short, its margin broadly elliptical. The inferior border convex ; the posterior end obliquely truncate and almost straight, posterior superior angle obtuse. The hinge line is gently arcuate. The umbones are tumid, raised and incurved, placed at the junction of the anterior and middle thirds of the hinge plate. Passing backward from the umbo is a fairly well marked oblique ridge which marks off a very narrow dorsal slope from the rest of the valve. The curvature of the valve is regular but more convex from above downwards than antero-posteriorly.

Interior.—Anterior and posterior adductor scars large and well-marked ; the former close to the margin. Hinge edentulous.

Exterior.—The markings on the valve, as in all shells of the genus, consist of concentric lines of growth, strong, regular and well-marked on the anterior end, and becoming finer as they cross the shell and gradually obsolete, so that the posterior half of the valve seems smooth.

Dimensions.—Fig. 18, Pl. V., measures:—

Anteroposteriorly, 50 mm.
Dorsoventrally, 35 mm.
From side to side, 22 mm.

Locality.—Millstone Grit, Hazel Hill near Ripon and boulder near Masham.

Observations.—Two specimens of this species have been obtained. Each is a cast of the interior of both valves. The figured specimen was in a matrix which showed the characteristic external ornament of the genus.

Sedgwickia transversa is comparatively much less deep dorso-ventrally than *S. gigantia*, and more tumid.

It is not likely to be mistaken for any other species of the genus.

SANGUINOLITES MODIOLARIS, sp. nov.

[Fig. 23, Pl. V.]

Specific Characters.—Shell transverse, very inequilateral, modioliform. The anterior end is very short and narrowed, its margin rounded. The inferior border is straight, the posterior bluntly rounded and the hinge line straight, gently raised as it passes backwards. The umbones are placed very far forward, not terminal, narrowed and compressed, only slightly raised. Projecting backwards from the umbo is a well marked ridge which is separated from the rolled external margin of the escutcheon by a elongate concavity, which becomes slightly broader and shallower as it approaches the posterior superior angle. Below this ridge is the dorsal slope, which passes almost imperceptibly into the rest of the valve, but in some and more adult specimens there is a tendency to form an obscure oblique ridge from the umbo to the posterior inferior angle. The tumid portion of the valves is oblique from the umbo to the posterior inferior angle, in front of and below which the valve is gently compressed. The escutcheon is well developed. On the dorsal slope another obscure radiating line is sometimes seen.

Interior.—The large, marginal, deep, anterior muscle scar, with the ridge behind it, so typical of the genus, is well marked. Hinge plate apparently edentulous and normal.

EXTERIOR.—The surface is ornamented by fine concentric lines of growth.

DIMENSIONS.—Fig. 23, Pl. V., measures :—

Anteroposteriorly, 45 mm.
Dorsoventrally, 18 mm.
Elevation of valve, 8 mm.

LOCALITY.—The Millstone Grit of Hazel Hill and Clints quarry.

OBSERVATIONS.—A typical *Sanguinolites* somewhat resembling *S. tricostata*, but more transverse and not so markedly tricostate and there is no oblique ridge. The anterior end is very short indeed and almost entirely filled by the anterior adductor muscle scar.

PALÆOLIMA STRIATA, sp. nov.

[Fig. 9, Pl. IV.]

SPECIFIC CHARACTERS.—Shell small, oblique, subquadrate, compressed, broader dorsoventrally than anteroposteriorly, slightly inequivalve. The anterior border almost straight, the inferior, curved, the posterior almost straight, oblique, the hinge line straight, shorter than the inferior border. Umbones small, tumid, slightly raised and central, ears small, the posterior ear almost obsolete.

EXTERIOR.—The surface is ornamented by numerous fine, close radiating moniliform lines. The right valve almost smooth.

DIMENSIONS.—Pl. IV., Fig. 9 measures :—

Anteroposteriorly, 13 mm.
Dorsoventrally, 14 mm.

LOCALITY.—Millstone Grit, Clints quarry.

OBSERVATIONS.—The specimen consists of both valves which are exposed on the same slab, one of which has some fragments of the external surface preserved.

The species is at once distinguished from all others of the genus by its ornament and flattened shape.

One specimen shows the single adductor scar subcentral in position and indicates in the cast the ornament of the surface. The left valve seems somewhat more gibbose than the right.

LIMATULINA OCCIDENTALIS SHUMARD, sp. 1885.

[Figs. 5, 6, 7, Plate III.; Fig. 8, Plate IV.].

Pecten occidentalis Shumard, 1855, Missouri rep., page 207, Pl. c., Fig. 18.

,, cleavelandicus Swallow, 1858, Trans. St. Louis Acad. Sci., Vol. I., page 184.

,, cleavelandicus Meek & Hayden, 1864, Pal. Up. Mo., page 50, Pl. II., Fig. 10.

,, occidentalis Meek & Worthen, 1866, Geol. Rep., Illinois, Vol. II., page 331., Pl. XXVII., Figs. 4 and 5.

,, missouriensis (?) Geinitz, 1866, Carb. and Dyas in Neb., page 35, Tab. II., Fig. 18.

Aviculopecten occidentalis Meek and Hayden, U.S. Geol. Soc., Nebraska, page 191, Pl. IX., Fig. 10.

Specific Characters.—Shell unequivalve, the right valve almost flat, the left more gibbose, excluding the ears, subovate acute, not oblique. The anterior, inferior and posterior margins regularly rounded and moderately convex. Ears well marked and large, not extending quite as far forwards and backwards as the greatest transverse diameter of the valve. The anterior ear of the right valve is depressed and sharply marked off from the rest of the shell by an oblique groove, the posterior triangular, flattened and its posterior border falciform. The anterior ear of the left valve is triangular, well defined, and much depressed so that the shell from the umbo to the margin forms a marked angular ridge. The posterior ear more gradually compressed, and its posterior margin falciform. The umbo of the left valve is acute, erect, central.

Interior.—The hinge-plate is flattened and striated transversely.

Exterior.—The surface of the left valve is ornamented by numerous somewhat irregular radiating lines, some of which start from the umbo and others are intercalated between them as they pass across the surface so that it happens that in a group of four the outer lines are the strongest, the middle line a little less strong, and the intermediate lines still weaker. On the right valve the ribs are coarser and less numerous.

On the ears of the left valve the radiating costæ are crossed by concentric lines of growth which, as they cross them, make the ostæ imbricate.

Dimensions.—Pl. IV., Fig. 8, a left valve, measures :—
Anteroposteriorly, 40 mm.
Dorsoventrally, 38 mm.
Transversely, 10 mm.

Localities.—Millstone Grit, Hazel Hill, Clints Quarry.

Observations.—Some half-dozen good specimens have been obtained mostly in the form of casts, but an accurate idea of the surface marking can be obtained from squeezes of the external cast. One bivalve specimen is fortunately to hand, and this shows the typical characters of *Limatulina*. Meek, Op. supra cit., in describing the right valve of *A. occidentalis* states—" right valve nearly flat and having the general outline of the other excepting that its beak is scarcely distinct from the cardinal margin." I understand this to mean that the umbo of the left valve was raised over that of the right valve, and to indicate that the shell is a *Limatulina* and not *Aviculopecten*. The position of the opposing valves at the umbones is well shown in figures 7, 7a, Plate III.

L. occidentalis is a larger shell than *L. scotica*, comparatively broader and more gibbose. The ornament in *L. desquamata* and the radiating lines are not so regular.

L. alternata is much narrower and more convex.

TELLINOMORPHA TRANSVERSA sp. nov.

[Plate V., Fig. 24].

Specific Characters.—Shell transverse, tumid, superior and inferior borders sub-parallel, very inequilateral. The anterior end, short, depressed, narrowed, ellipsoidal. The inferior border almost straight, the posterior obliquely truncate, posterior inferior and superior angles well marked ; the hinge line almost straight. The umbones are small, elongate, tumid and placed at the junction of the anterior and middle thirds of the valve. Lunule and escutcheon well marked. The latter bounded externally by a rolled margin. The dorsal slope is hollow. The rest of the valve tumid. A well-marked oblique fold passes from the umbo to the posterior inferior angle.

INTERIOR.—The anterior adductor muscle scar is large and occupies the greater portion of the anterior part of the valve. Hinge-plate apparently edentulous.

EXTERIOR.—The shell is ornamented by somewhat irregular lines and striæ of growth.

DIMENSIONS.—Fig. 24, Pl. V., measures :—

Anteroposteriorly, 26 mm.
Dorsoventrally, 14 mm.
From side to side, 10 mm.

LOCALITY.—Millstone Grit, Hazel Hill.

OBSERVATIONS.—Two specimens of this species have occurred, both are bi-valved and casts of the interior. The general shape and the narrow elongate anterior end at once distinguish the shell from *T. cuneiformis*.

ALLORISMA TUMIDA, sp. nov.

[Plate VI., Figs. 26, 27].

SPECIFIC CHARACTERS.—Shell tumid, inequilateral, transverse. The anterior end blunt and rounded is very short. The superior and inferior borders sub-parallel, the posterior border bluntly sub-truncate. The umbones are blunt, incurved, not much raised and transverse. The dorsal slope is comparatively small, but compressed, lunule and escutcheon well developed.

INTERIOR.—Anterior adductor scar large. Hinge-plate not seen.

EXTERIOR.—The surface of the shell, especially in the anterior portion, is ornamented with a few broad concentric folds and sulci which become obsolete on the posterior part of the valve, the dorsal slope is smooth.

DIMENSIONS.—Pl. VI., Fig. 26, a small example measures :—

Anteroposteriorly, 19 mm.
Dorsoventrally, 16 mm.
From side to side, 11 mm.

LOCALITY.—Millstone Grit of Hazel Hill.

OBSERVATIONS.—Four examples of this species have been found but the material is poor and leaves much to be desired. It is not likely to be mistaken for any other species of the genus.

SPATHELLA LATA sp. nov.

[Plate VI., Figs. 32, 33].

SPECIFIC CHARACTERS.—Shell broadly ovate, inequilateral, moderately gibbose, with a compressed but narrowed dorsal slope. The anterior end is fairly prolonged, its margin rounded. The inferior border is gently convex; the posterior narrower than the anterior is apparently rounded, truncate in its upper portion. The superior border is arched in front, almost straight posterior to the umbo. The umbo is well marked, incurved, raised above the hinge and situated only a short distance in front of the centre of the upper border. Passing obliquely downwards and backwards from the point of the umbo is a strong ridge which soon becomes lost in the general convexity of the valve, which separates the rather narrow dorsal slope from the remainder of the valve. The escutcheon is long and narrow.

INTERIOR.—The anterior adductor muscle scar is rounded, not deep or marked off posteriorly by a ridge. The posterior oval, placed high up in the hollow of the dorsal slope. Mantle line entire.

Hinge plate thickened, concave from above downwards and apparently edentulous.

EXTERIOR.—Apparently almost smooth.

DIMENSIONS.—Fig. 32, Pl. VI., the cast of a left valve measures:—
Anteroposteriorly, 58 mm. (estimated).
Dorsoventrally, 30 mm.
Gibbosity of Valve, 10 mm.

LOCALITY.—Millstone Grit, Hazel Hill near Ripon.

OBSERVATIONS.—This is a largish shell, but almost featureless, both in external characters and the simplicity of the hinge-plate. Some half-dozen specimens have been obtained from the Hazel Hill locality, but it has not been found elsewhere in the Marine Band.

DESCRIPTION OF PLATES.

Plate III.

Fig. 1, Aviculopecten dissimilis (left valve). Clints quarry.
Fig. 2, ,, interstitialis (left valve). Roundhill Reservoir.
Fig. 3, ,, clathratus (left valve). Linden Gill, Leighton. (Daystones).
Fig. 3a, ,, interstitialis. Probably Fountains Quarry.
Fig. 4, ,, clathratus (left valve). River Burn, near Shaw's Bridge, Swinton.
Figs. 5, 6, Limatulina occidentalis (left valves). From a boulder, Leighton Road.
Figs. 7, 7a, 7b, ,, ,, (showing both valves). Same locality.

Plate IV.

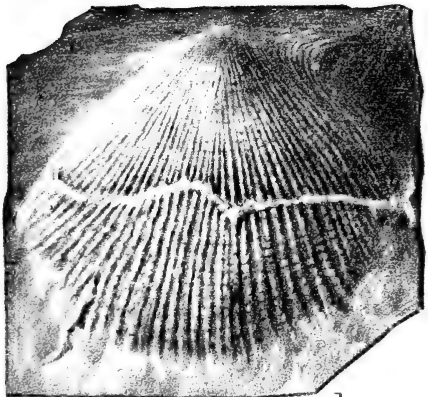
Fig. 8, Limatulina occidentalis (a left valve). Near Pott Hall, Leighton. (Daystones).
Fig. 9, Palæolima striata (both valves). Clints quarry.
Fig. 10, Myalina peralata (left valve). Near Linden Gill, Healey. (Daystones).
Fig. 11, Leiopteria thompsoni (left valve). Near Linden Gill, Healey. (Daystones).
Fig. 11a, ,, laminosa (right valve). Near Pott Hall, Leighton. ,,
Fig. 12, Grammatodon regularis (right valve showing posterior hinge teeth). Hazel Hill.
Fig. 13, ,, ,, (right valve, from a cast showing external surface). ,,
Fig. 14, ,, ,, (a bivalve example). Hazel Hill.
Fig. 15, Schizodus wheeleri (right valve). Near Pott Hall, Leighton. (Daystones).
Fig. 16, Protoschizodus axiniformis. From a boulder at Leighton Road diversion.

Plate V.

Fig. 17, Protoschizodus curtus (right valve). Hazel Hill.
Fig. 17a, ,, ,, Woo Gill, Nidderdale.
Fig. 17b, ,, ,, (right valve). Hazel Hill.
Fig. 18, Sedgwickia transversa (cast of both valves). From a boulder at Leighton reservoir.
Fig. 19, ,, ,, (cast of both valves). Hazel Hill.
Fig. 20, Edmondia m'coyi (right valve). Near Linden Gill, Healey. (Daystones).
Fig. 21, ,, ,, Hazel Hill.
Fig. 22, Scaldia benedeniana (right valve). From a boulder, Leighton Road.
Fig. 23, Sanguinolites modiolaris (a left valve). Near Linden Gill. (Daystones).
Fig. 23a, ,, ,, (a left valve). Hazel Hill.
Fig. 24, Tellinomorpha transversa (cast of both valves). Leighton Road diversion.

Plate VI.

Fig. 25, Tellinomorpha transversa (both valves). Nr. Linden Gill, Healey. (Daystones).
Fig. 26, Allorisma tumida (right valve). Near Pott Hall, Leighton. (Daystones).
Fig. 27, ,, sulcata (a bivalve example). Woo Gill, Nidderdale.
Fig. 28, Tellinomorpha transversa (external surface). Hazel Hill.
Fig. 29, Cypricardella parallela. Quarry near Pateley Bridge.
Fig. 30, Prothyris elegans. Trial hole near Gollinglith Foot, Colsterdale.
Figs. 31, 31a, Ephippioceras bilobatum. Hazel Hill.
Fig. 32, Spathella lata (a left valve). Near Pott Hall, Leighton. (Daystones).
Fig. 33, ,, ,, (a right valve). Hazel Hill.



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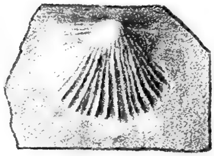

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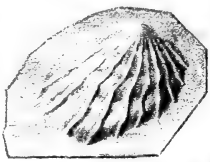

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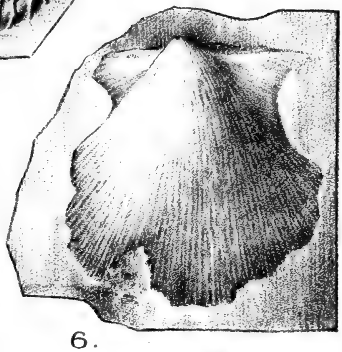

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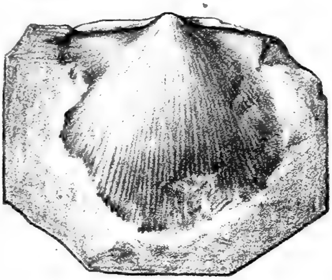

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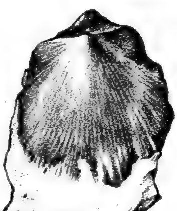

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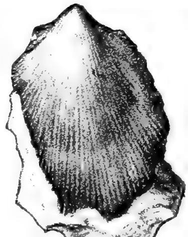
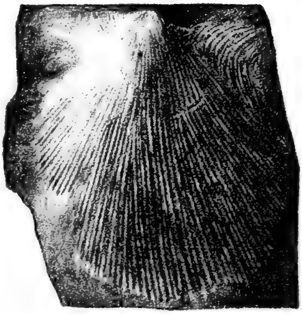


7b.

W. G. Browning del. et lith.

Huth imp.

Plate III.



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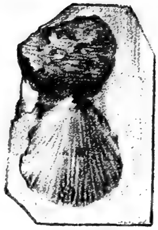

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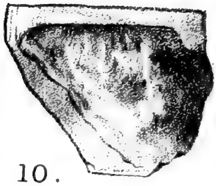

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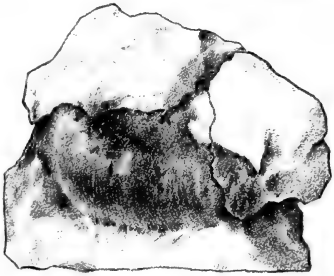
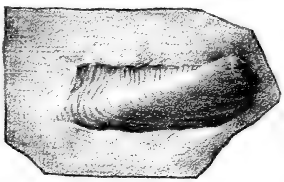


11a.

12.



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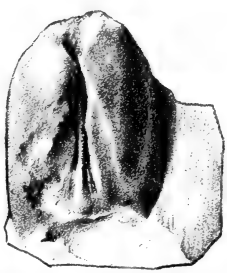

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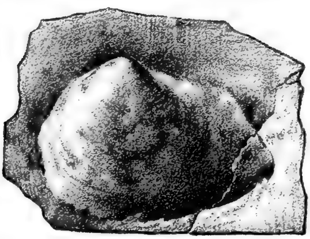
14a.



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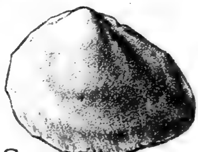
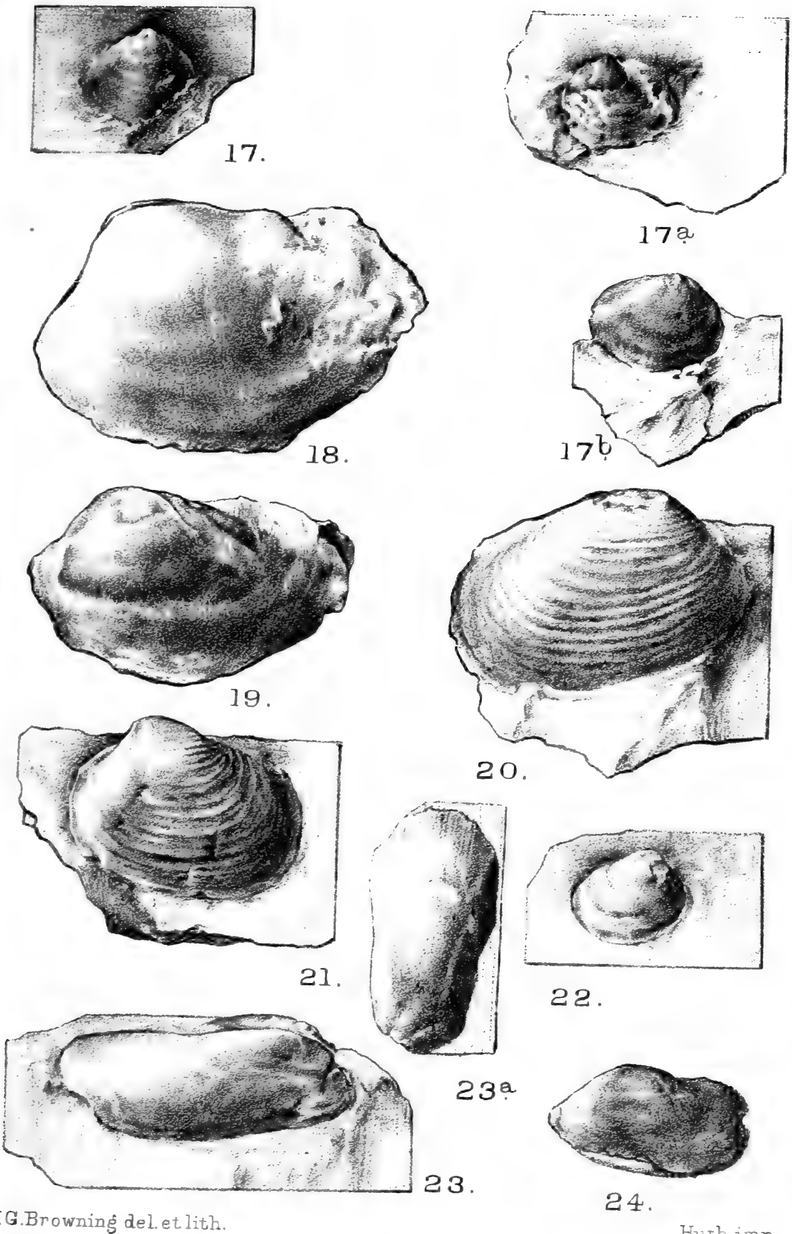


16.

W. G. Browning del. et lith. Huth imp.

Proc. Yorks. Geol. Soc., Vol. XIX.
Plate IV.

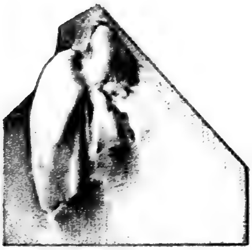


W. G. Browning del. et lith.

Huth imp.

Proc. Yorks. Geol. Soc., Vol. XIX.

Plate V.



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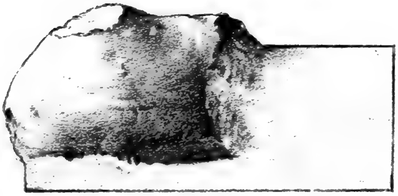

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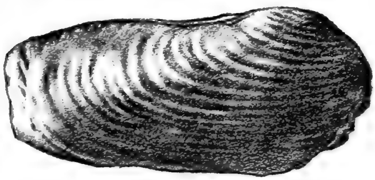

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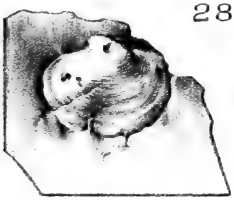

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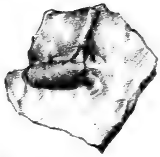

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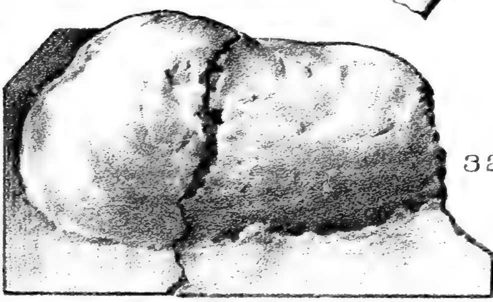

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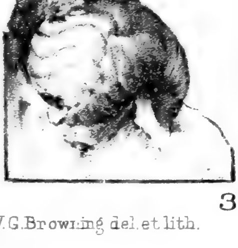
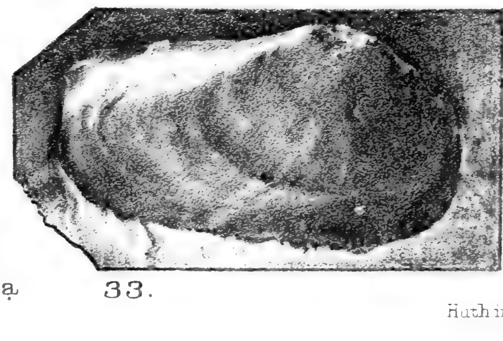


31a.



33.

W.G.Browning del. et lith. Huth imp

Proc. Yorks. Geol. Soc., Vol. XIX.

Plate VI.

ANNUAL REPORT FOR 1912.

The Society has enjoyed another successful year, an average number of members having attended the meetings and excursions. Part III. of Vol. XVII. of the Proceedings was published at the beginning of the year, but owing to a mistake on the part of the printers was cut smaller than the standard size. This would have caused a difficulty when binding the completed volume, so arrangements were made with the printers who undertook to reprint a number of copies. The members of the Society were informed of this and such as applied received copies cut to the normal size. Considerable progress has been made with the Bibliography of Yorkshire Geology. The special Editor, Mr. T. Sheppard, found—during the editing of the MSS. of the late Mr. Fox-Strangways—that many additions were necessary, so that ultimately the work will contain additional matter at least equal to that of the original MSS. This will cause delay in issuing the Bibliography, but will greatly enhance its value.

The Spring Meeting was held in Leeds on Thursday, March 7th, the morning excursion being well attended. The evening meeting was held in the Department of Geology at the University, and after the completion of the formal business Mr. A. Gilligan, F.G.S., introduced a discussion on "The Origin of the Millstone Grit," illustrating his remarks with lantern slides and rock specimens. The specimens included angular fragments of various types of rocks. A keen discussion followed, Prof. Kendall, Dr. Wilmore and Messrs. W. Simpson and Cosmo Johns taking part. The meeting then adjourned to the Geological Laboratory where specimens further illustrating the origin of the Millstone Grit were displayed. A suite of Antarctic rock specimens was exhibited, and a working model illustrating delta formation proved very interesting.

The Easter meeting was held in Appleby. Owing to the coal strike having impeded the train service, considerable difficulty was experienced by members in reaching the place of meeting, and under the circumstances the attendance, which included Mr. Alfred Harker, the President, was very encouraging. The field excursions were conducted by Prof. Kendall and covered the chief geological features of the district. The formal business meeting was held in the Tufton Arms Hotel on Saturday, April 6th, and resumed on Monday, April 8th, when Prof. Kendall introduced the question of the relationship of the Red Conglomerate of the district to the Carboniferous Limestone. This caused a most interesting discussion and though several present were of opinion that these beds should be considered as the base of the Carboniferous, the evidence brought forward by others who had worked at the Carboniferous rocks pointed rather to the existence in the district of beds of Tournaisian age, with a quartz pebble conglomerate, containing marine fossils at their base, and resting on red conglomerate lithologically similar to Upper Old Red Sandstone. This was followed by a criticism of the suggested inversion of the Keisley Limestone which gave rise to an unexpectedly vigorous discussion. Opinions were evenly divided, and the meeting terminated at a late hour with a cordial vote of thanks to Prof. Kendall.

The third excursion was to Robin Hood's Bay on Friday, June 21st and following days. Under the leadership of Prof. Kendall the coast sections down to the Peak Fault were examined, and the last day was devoted to the inland drift topography. The meeting was held in the Victoria Hotel on Friday, June 21st when a discussion on some of the local geological problems took place.

A fourth excursion for the study of the geology of Masham was made on Friday, September 20th and following days, under the leadership of Mr. W. S. Bisat. The general meeting was held in the Unicorn Hotel, Ripon, Mr. J. W. Sutcliffe occupying the chair, when Mr. Bisat read a paper on the "Faunal Sequence of the Millstone Grit Series of Masham." Maps, sections and specimens illustrating the paper were exhibited, and an interesting discussion followed.

At the Annual Meeting held in the Grosvenor Hotel, Hull, on Thursday, November 20th, Mr. Alfred Harker, F.R.S., was re-elected President and afterwards delivered an address on "Geology in Relation to the Exact Sciences."

It was decided that the excursions for 1913 should be held at :—

BUXTON (Easter).
MARKET WEIGHTON (Whitsuntide).
STOKESLEY (August).

Owing to the absence of the Hon. Secretary abroad, the Hon. Treasurer Mr. J. E. Wilson acted as Secretary of the Annual Meeting.

C. J.

ANNUAL REPORT FOR 1913.

Though there was an average attendance of members at the various meetings and excursions of the Society, the number of new members elected during recent years is less than should be the case. This is to be regretted since some members, whose researches and contributions to the work of the Society have played such an important part in its progress, are finding it increasingly difficult to attend its meetings. The decrease in membership, though not serious, is sufficiently evident to warrant attention being called to the fact. The increase in the facilities for geographical study and the remarkable development of coal-mining in the County encourage the hope that a larger increase of membership may be looked for in the future. The publication of the Bibliography of Yorkshire Geology has been delayed partly owing to the illness of its editor, Mr. T. Sheppard, and partly for the reasons given in the 1912 Report.

The opening meeting was held in Leeds, as usual, on Thursday, March 6th, the morning excursion being well attended. The evening meeting was held in the Geographical Department at the University. Mr. W. Cash, who was voted to the chair, referred to his long connection with the Society and his keen interest in the subjects that were to be discussed that evening. Mr. J. J. Burton, F.G.S., communicated a report on the present status of palæobotanical research in N.E. Yorkshire, and laid specimens on the table from the recently discovered plant-beds in inland localities in rocks of Jurassic age. Prof. Kendall and the Hon. Secretary referred to the importance of the new discoveries and to the fortunate circumstance that a geologist with the local knowledge and influence of Mr. Burton was the secretary of the Committee that is carrying on the researches. Professor Kendall introduced the question of the "Origin of coal," and reviewed the various theories that had been put forward. An animated discussion followed in which Messrs, Fennell, Hawkesworth, Gilligan, the Hon. Secretary and others took part.

The Easter excursion to Buxton, owing to the inclement weather and Easter falling very early, attracted a smaller number than usual. Some successful excursions were made and the chief geological features of this interesting district were visited. The evening meeting was held in the George Hotel, Buxton, on Saturday, March 22nd, Dr. Bowman taking the chair. After the formal business had been completed Mr. R. G. Carruthers of the Geological Society of Scotland described the occurrence of what are called "Burnt Oil Shales," in the oil shale region of Scotland.

The Whitsuntide meeting was held at Market Weighton, the excursions being under the leadership of Prof. Kendall and Mr. J. W. Stather. The general meeting was held in the Londesborough Hotel, Market Weighton, on Saturday, May 10th. After the formal business a discussion on "The geological problems affecting the proposed Humber Tunnel" took place, in which Prof. Kendall, Messrs, Stather, McTurk, Williams and the Hon. Sec. took part. The discussion aroused considerable interest, the principal Yorkshire papers being represented.

The attendance at the Stokesley meeting was affected by the difficulty members experienced in securing accommodation. Under Mr. Burton's leadership a number of interesting excursions were made including one to the important Jurassic plant beds from which valuable material had been obtained. As the members were dispersed in several villages through the difficulty in securing accommodation, it was not convenient to hold a general meeting.

The Annual Meeting was held in the Grand Hotel, Huddersfield, on Thursday, November 20th, when it was announced that the excursions for 1914 would be held as follows :—

Craven District (Easter).
Sheffield (June).
Thirsk (September).

Mr. R. H. Tiddeman was unanimously elected President for 1914. The retiring Hon. Secretary, Mr. Cosmo Johns, was thanked for his services and Mr. A. Gilligan, B.Sc., F.G.S., the University, Leeds, was appointed in his place. Mr. Alfred Harker, the retiring President, delivered an address on "Some Features of Canadian Geology." Mr. Harker was warmly thanked for his services during two years as President and for his address. The following papers were read and discussed :—

"Joints and their Relation to Folding," by Prof. Kendall.
"The Millstone Grit Series of Masham," by W. Bisat, Esq.
"A New Carboniferous Nautiloid," by Dr. Wheelton Hind.
"The Analysis of Ilkley Spa Water," by B. A. Burrell, Esq., F.I.C.

Prof. W. G. Fearnsides, the newly appointed Sorby Professor of Geology at Sheffield University, was elected Local Secretary for Sheffield.

C. J.

THE YORKSHIRE GEOLOGICAL SOCIETY.

Statement of Receipts and Expenditure from October 31st, 1911, to October 31st, 1912.

Dr.

	Receipts.		£	s.	d.
1911. Oct. 31	To Balance from last year		42	6	6
1912.	,, Members' Annual Subscriptions		70	17	0
Oct. 31	,, Members' Arrears received		11	1	0
	,, Life Members' Subscriptions transferred from Capital Account		12	12	0
	,, Interest on Mortgage Bonds, Halifax Corporation		12	3	10
	,, Sale of Proceedings		0	5	0
	,, Bank Interest		0	10	11
			£149	16	3

Cr.

	Expenditure.		£	s.	d.
1912.	By Postages and Sundries, Treasurer		0	16	7
	,, Proceedings :—				
	Andre & Sleigh	22 15 0			
	Macmillan	0 7 0			
	Maull & Fox	0 10 6			
			23	12	6
	,, Circulars, Stationery etc.		13	2	4
	,, Cheque Book		0	2	6
Oct. 31	,, Balance in hand		112	2	4
			£149	16	3

CAPITAL ACCOUNT

		£	s.	d.
1912. Oct. 31	To Halifax Corporation Mortgage Bonds	370	0	0
	,, Two Life Members Subscriptions	12	12	0
	,, Books, Proceedings, Maps, etc. at the Leeds University, as per agreement dated 20th November, 1907, in the custody of the West Yorkshire Bank, Ltd. (formerly the Halifax Joint Stock Banking Co.)			
		£382	12	0

		£	s.	d.
1911. Oct. 31	By Halifax Corporation Mortgage Bonds	370	0	0
1912. Oct. 31	,, Transfer to Revenue Account	12	12	0
		£382	12	0

Leeds, November 19th, 1912.

Examined and found correct, F. W. BRANSON, *Hon. Auditor*

J. E. WILSON, *Hon. Treasurer*

THE YORKSHIRE GEOLOGICAL SOCIETY.

Statement of Receipts and Expenditure from October 31st, 1912, to October 31st, 1913.

Dr.

Date	Receipts.	£	s.	d.
1912. Oct. 31	To Balance in hand	112	2	4
1913. Oct. 31	,, Members' Annual Subscriptions	66	6	0
	,, Members' Arrears received	10	8	0
	,, Interest on Mortgage Bonds, Halifax Corporation	12	3	10
	,, Authors' Reprints	4	11	0
	,, Sales of Proceedings	1	0	3
	,, Bank Interest	2	4	4
		£208	15	9

Cr.

Date	Expenditure.	£	s.	d.	£	s.	d.
1913. Oct. 31	By Proceedings and Reprints, Jowett and Sowry				38	18	7
	Chorley & Pickersgill	13	4	5			
	Treasurer	1	8	0			
	Editor	0	15	3			
	Librarian	0	3	6			
					15	11	2
	,, Griffin & Co.				0	7	6
	,, Expenses of Meetings				0	18	0
	,, Balance in bank				153	0	6
					208	15	9

CAPITAL ACCOUNT.

Date		£	s.	d.
1913. Oct. 31	To Halifax Corporation Mortgage Bonds	370	0	0
	,, Books, Proceedings, Maps, etc., at the Leeds University, as per agreement dated 20th November, 1907, in the custody of the West Yorkshire Bank			
		370	0	0

Date		£	s.	d.
1912. Oct. 31	By Halifax Corporation Mortgage Bonds	370	0	0
		370	0	0

Leeds, November 17th, 1913.

Examined and found correct, F. W. BRANSON, *Hon. Auditor.*

J. E. WILSON, *Hon. Treasurer.*

Vol. XIX.] [Part II.

PROCEEDINGS

OF THE

YORKSHIRE GEOLOGICAL SOCIETY.

Edited by W. LOWER CARTER, M.A., F.G.S.

1916.

THE KNOLL REGION OF CLITHEROE, BOWLAND AND CRAVEN.

A NOTE BY (THE LATE) ARTHUR VAUGHAN, M.A., D.SC., F.G.S.

(Read June 24th, 1915).

Part of this region, to wit, Slaidburn in Bowland, was the venue of the Yorkshire Geological Society in Easter, 1915, and, by the kind invitation of the President and the courtesy of the Society, I was fortunate to participate in the visit. This excursion was directed by the President, Mr. R. H. Tiddeman, with the purpose of examining the Carboniferous Rocks which he had surveyed some forty years previously. The result went to confirm the impression that I had obtained, on former visits to other parts of the Knoll Region, that geologists were insufficiently acquainted with the information that had already been acquired, both with regard to the sequence and correlation of the rocks, and with regard to the important and broad conclusions which had been deduced from the mapping. I need, therefore, scarcely apologise for the publication of this brief summary which in so far as it concerns Mr. Tiddeman's work, has been mainly extracted from the Report of the International Geological Congress of 1888 (London), pp. 313-323*. I have also availed myself of the information contained in sheet 92 S.W. (Clitheroe) 1873, and in the Geological Survey Memoir which deals with the Burnley Coal Field, 1875.

Commencing with the SEQUENCE of Carboniferous Rocks in the Knoll Region, we may make our remarks under the three main heads :—

(1) The lithological sequence of Tiddeman.
(2) Its correlation with the *Avonian* Time-scale of Vaughan.
(3) The *Pendleside* of Hind and Howe.

(1) *The Lithological Sequence* (*R. H. T.*)

Millstone Grit	
Bowland Shales ...	... 300-1000 feet.
Pendleside Grit ...	... inconstant.
Pendleside Limestone	... 0-500 feet.
Shales-with-Limestone	... 2500 feet [maximum].
Clitheroe Limestone	... 3250 feet exposed (base not reached.)

N.B.—The Pendleside Limestone on Pendle Hill is a capping of cherty limestones, at the top of the Shales-with-Limestone, whose thickness is very variable.

In the S. Craven Area (Malham, Swinden etc.,) the Pendleside Limestone is represented by some 600 feet of white knoll-limestone.

The Clitheroe Limestone is composed of two distinct, but nearly equal, divisions :—

Upper : The White Knoll-Limestone of the Clitheroe Knolls (Warsaw, etc.)

Lower : The Black Limestone (with shales) of Chatburn.

Hence we see that Mr. Tiddeman recognised knolls at two distinct levels, separated by some 2000 feet of Shales-with-Limestone. (He did not definitely state that the knolls were unconformable to the

* Dr. J. E. Marr was joint leader of the International Excursion to W. Yorkshire with Mr. Tiddeman in 1888, but the portions of the report with which we are here directly concerned, are all signed R. H. T. (The leader's account is, of course, translated into French—apparently very faithfully).

Shales-with-Limestone, although he seems often to imply it; recent work points to a considerable interval between the highest of the Clitheroe knolls and the shales which succeed it).

(2) *Correlation with the Avonian Zones.*

BOWLAND SHALES.

Although these shales form a continuous and striking lithological feature throughout the knoll region, the basal beds are not of precisely the same age at all points of the region :—

On Pendle Hill, they contain *Glyphioceros bilingue* and are the true base of the Millstone Grit (and therefore *post* "Pendleside" of Hind and Howe).

In S. Craven (Thorpe, Cracoe, etc. near Grassington) the basal beds of the shales which wrap round the knolls contain *Posidonomya becheri* and *Glyphioceras reticulatum*, and are of 'P' age.

In Bowland itself—the area which must decide the meaning of the term—we unfortunately do not yet know the age of the base of the Bowland Shales.

PENDLESIDE GRIT.

The time value of this division can only be determined from the ages of the fossiliferous beds above and below; as shown below, the date will therefore, on Pendle Hill, be 'P' of Hind and Howe.

PENDLESIDE LIMESTONE.

(*The upper part of the Shales-with-Limestone*).

Recent views are in accord with Mr. Tiddeman's correlation of the top of the Shales-with-Limestone (i.e., the Pendleside Limestone) on Pendle Hill, with the knolls of S. Craven. The relation is that of *Cyathaxonia*-beds to knoll limestones and can be accurately compared with the same correlation in the Midland Province (e.g., The Tissington *Cyathaxonia*-Beds with the Thorpe Cloud Knoll). The very inadequate collecting that has as yet been done at this important level, suggests that it lies in the zone of *Glyphioceras* (*Sphenoceras*) *striatum* and, therefore, immediately under 'P.'

SHALES-WITH-LIMESTONE.

These beds are characterised throughout by *Glyphioceras* (*Sphenoceras*) *crenistria* and *Prolecanites compressus* and, especially in the upper portion, by *Cyathaxonia rushiana* and rare *Zaphrentes.*

On Pendleside, they contain abundant *Prolecanites* at the base and frequent *Cyathaxonia* and *Sphenoceras** in the Pendleside Limestone which caps the series at Phynis, close to the top of the limestone-massif of Slaidburn, a considerable collection was made by the members of the Yorkshire Geological Society during our recent visit, from the base of the Shales-with-Limestone. The result was to definitely fix the level as D 2-3 of Gower (S. W. Province), the facies being that of the Oystermouth "Black-Lias" Quarry, near Mumbles. Other localities (Croasdale etc.) near Slaidburn, confirmed this general conclusion, viz:—that the Shales-with-Limestone are upper D in age and under P.

CLITHEROE KNOLLS.

These were all included together by Mr. Tiddeman in the upper division of the Clitheroe Limestone; there are, however, two distinct lines of knolls at two distinct levels, viz.:—

A lower line (Pimlico to Downham) of Waulsortian (Mid-Avonian) age included within the zone of *Productus sublævis* and itself containing fossils of St. Doulagh (Dublin) facies and a higher line (Salt Hill, Warsaw, Twiston) of Viséan age. The level attained is variable in the several knolls (for example, low S in Salt Hill) but in my opinion, never reaches D2.

In Bowland, the Ashknott Knoll has yielded the most advanced Brachiopods, but, even here, forms common in D2 are infrequent. By kind permission of Mr. King Wilkinson, we collected from the large Dunnow Knoll, near Slaidburn; and, to the generosity of Miss Peel of Knowlmere, I am indebted for an exhaustive collection from the Knowlmere Quarries. The Brachiopods from both these localities contain very few characteristically D forms and suggest for them a level somewhere in S, near that of the Upper line of Clitheroe knolls.

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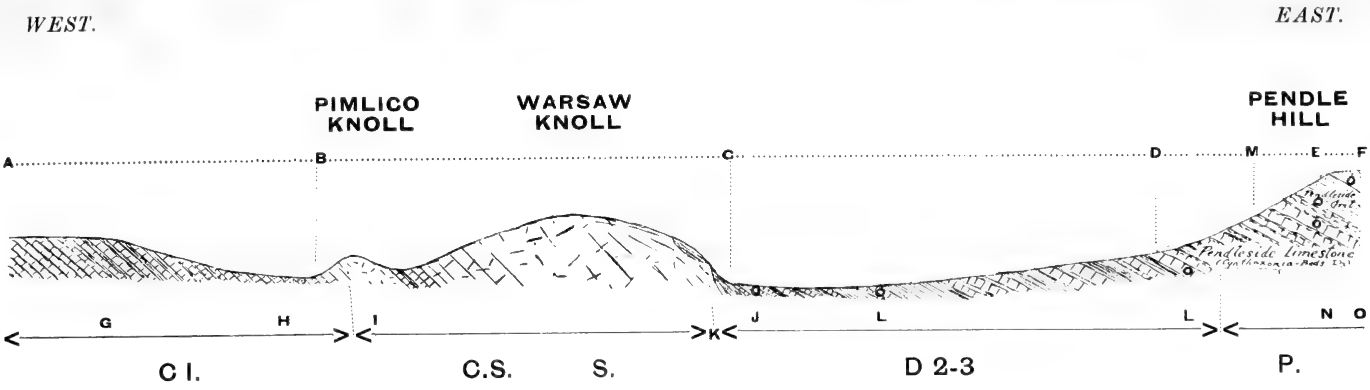
* *Sphenoceras* is a sub-division of *Glyphioceras*, and includes *Goniatites sphericus*, *G. crenistria*, and *G. striatus.*



SECTIONAL DIAGRAM OF PENDLESIDE AND CLITHEROE.

A—B = Chatburn Black Limestone.
B—C = Clitheroe Knolls.
C—D = Shales with Limestone.
D--E = "Pendleside" Series of Hind and Howe.
E—F = Bowland Shales.
G = *Caninia*-Beds.
H = *laminosa*—Dolomites.

I = *sublævis* Beds.
J = *Prolecanites compressus.*
K = Unconformable junction.
L—L = *Sphenoceras crenestria.*
M = *Beyrichoceras reticulatum.*
N = *Sphenoceras striatum.*
O = *Beyrichoceras bilingue.*

The CHATBURN BLACK LIMESTONES.

The Bold Venture Quarries are definitely of C 1 age by the admixture of small simple *Zaphrentes* with gigantoid *Caniniæ*. The black shales and limestones are capped by typical *laminosa*-Dolomites with large *Chonetes* cf. *comoides* and, finally, by the invasion of *Productus sublævis*.

Behind and below these quarries is a series of limestones, with thinner shale partings, which are very poorly fossiliferous; comparison with the N. W. Province, remembering the more southerly lie of the Chatburn beds, suggests that the whole series belongs to C 1, and, furthermore, that the base of the Carboniferous does not lie far below the lowest exposure.

The Sectional Diagram (Plate VII.) illustrates the general features of the sequence from west of Chatburn to the western flank of Pendle Hill; it is not an actual section, but merely elucidates the above description.

(3) *The "Pendleside Series" of Hind and Howe.*

In the original paper by Dr. Wheelton Hind and Mr. J. A. Howe (*Q.J.G.S.*, Vol. lvii (1901), p. 347 et seqq.) this series was defined as lying between the Millstone Grit and the "Limestone-Massif" on the side of Pendle Hill, and the name was chosen for the very reason that Mr. Tiddeman had already employed the terms Pendleside Limestone and Pendleside Grit, both of which were recognised as falling within the new "Pendleside Series."

Very few fossils were cited from Pendle itself beyond *Prolecanites compressus* near the base of the Shales-with-Limestone, and *Glyphioceras* (*Beyrichoceras*) *reticulatum* from the shales between the Pendleside Limestone and the Pendleside Grit.

As already stated, *Glyphioceras* (*Sphenoceras*) *striatum* has also been recorded from the top of the Pendleside Limestone.

The zoning of the "Pendleside Series" has been carried out elsewhere (Midlands, Ireland, etc.) and must now be re-correlated with the name-area.

In Brit. Assoc. Rept., York (1906), p. 311, the zonal sequence of the "Pendleside" is given by Dr. (now Col.) Wheelton Hind—

MILLSTONE GRIT (Zone of *G. bilingue*).

PENDLESIDE SERIES. (Emended Hind)	Zone of *G. spirale.* Zone of *G. reticulatum.* Zone [or maximum] of *Posidonomya becheri.* (This is, par excellence, the *Pendleside Shales*). Zone of *Prolecanites compressus.**

NOTES.

On Pendle Hill, the Bowland Shales are crowded with *G. bilingue*; this division therefore, belongs to the Millstone Grit and is above the "Pendleside" of Hind.

The zone of *Prolecanites compressus* was erroneously taken to include the whole of the Shales-with-Limestone together with much of the capping of Pendleside Limestone. These beds are mainly of D2-3 age and correspond to the *Cyathaxonia* phase, which so frequently replaces laterally the top of the Limestone-Massif†. They underlie the typical *Pendleside Shales.*

Hence the "Pendleside Series" of Hind is approximately included between the base of the Pendleside Limestone and the top of the Pendleside Grit and the employment of the term "Pendleside Series" seems to be completely justified.

We can now fully appreciate the two vital teachings of the knoll regions which Mr. Tiddeman so lucidly expounded and so unswervingly maintained :—

First Theory: The constitution and origin of the *Knolls.*

Second Theory: The early working of the *Craven Faults,* deduced from the wide phasal differences on the two sides of the Fault-belt.

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* The index fossil is characteristic of the top of the Limestone-Massif near Cork, from which locality the type specimens were derived.

† As already pointed out, the Clitheroe Knolls are not of the age implied by "top of the Limestone-Massif" but are considerably older; the term would aptly apply to the knolls of S. Craven.

FIRST THEORY—The *KNOLLS*.

The characters of knolls are now well understood by their study in many formations and in many localities; especially is this the case for the Carboniferous (Waulsortian) knolls in the Dinant Area of Belgium, where examples are perfectly dissected by the gorge of the Meuse.

At the time, however, at which Mr. Tiddeman was working, such knolls as those of Clitheroe were practically unknown to English geologists, and their proximity to the great Craven Faults suggested a common tectonic cause. Mr. Tiddeman maintained however, that the knolls were nothing more than discrete heaps on the sea floor which rose above the surrounding sediments (if any) to near the water surface in the form of reefs—" knoll-reefs "*

It will be sufficient to point out here the fundamental characters of knolls which Mr. Tiddeman succeeded in unravelling.

(i) The brecciated and calcite-veined nature of the rock.

(ii) The persistance of the ' dip of the country ' through a dissected knoll as seen in the Clitheroe quarries—however much it may be obscured by the nature of the knoll material.

(iii) The final roofing-over of a knoll by a dome-like layer of beds caused by the return of continuous deposition over the whole floor. Owing to this phenomenon, the outer layer of a knoll usually exhibits that qua-qua-versal dip upon which Mr. Tiddeman insisted and which is so well brought-out by the detailed mapping.

In the case of the Clitheroe knolls, the qua-qua-versal dip of the outermost beds is well shown at the eastern end of Warsaw. [Examples of this phenomenon are splendidly exhibited in the Belgian knolls near Waulsort, where they are cut through by the Meuse].

(iv) The deep-water character of the phase; this he deduces from the abnormal thickness of the deposits (see below).

We now know that the knoll phase always lies outside—that is,

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* Although the Congress Report, cited above, speaks twice of *Coral* Reefs, this is an error of translation; Mr. Tiddeman held that a knoll was a mere *accumulation* and not a *récif construit*.

on the seaward side of—the standard* and shallow-water deposits (dolomite, oolite, etc.)

There is in fact only one fundamental character of Knoll deposits which Mr. Tiddeman failed to record, viz. :—

The Knoll phase is marked by a definite assemblage of long-lived forms, by which it can at once be detected; indeed, so insistent is the faunal evidence of conditions that, without careful work, the evidence of age and province can easily be overlooked. It is sufficient to set side by side a random collection of Brachiopods from the Pimlico, Salt-Hill and Cracoe Knolls—i.e. from knoll deposits of three distinct ages, C1, S and D2—to appreciate the existence of a "knoll facies." The demonstration of such a facies disproves the possible dependence of knoll structure upon subsequent crust movement as has been suggested.

Second Theory.—The distinctness of the deposits North and South of the Fault-belt and the deduction that deposition and faulting were synchronous.

The two fundamental facts upon which Mr. Tiddeman bases this statement are :—

(i) The much greater thickness of deposit, during any selected interval, on the South side of the Faults (i.e., in the Knoll Region) than on the North side (i.e. in the Yoredale Region.)

(ii) The absence of the knoll facies to the North of the Craven Faults.

In proof of (i.), Mr. Tiddeman sets out the following correlation :—

North of Fault-belt.	*South of Fault-belt.*
(Yoredale Region of Ingleboro').	(Knoll Region of Clitheroe).

* i.e., encrinital limestones and shales with Brachiopods—in this connection, see E. E. L. Dixon in 'Gower' paper, *Q.J.G.S.*, vol. 67 (1911), pp. 332 *et seqq.*, from which I have freely borrowed.

MILLSTONE GRIT.

Yoredales, 400′-900′.	*Bowland Shales*.
	Shales-with-Limestone (including *Pendleside Limestone* at top). 2500′-3000′
Carboniferous Limestone (up to top of Great Scar), 400′-800′.	*Clitheroe Limestone* including *Clitheroe Knolls*, *Black Chatburn Limestone* 3250′

Base of CARBONIFEROUS LIMESTONE.

He points to the enormous difference:—some 800 feet in the North deposited at the same time as 6000 feet to the South (taking only the Carb. Limestone). Certain modifications are, however, necessary in order to obtain a correct comparison, and it will be more convincing if we take maxima North of the Faults and minima on the South.

(a) It is not at all probable that the Yoredales are entirely above the Pendleside Limestone; hence, to obtain a maximum, we assume that the top of the Yoredales corresponds to the top of the Pendleside Limestone.

(b) The base of the Carboniferous Limestone of Ingleborough is of C-S age and therefore above not only the Black Limestone, but also above the lower line of Clitheroe knolls (Pimlico-Downham); hence, the only part of the Clitheroe Limestone we can take account of in this comparison is the upper line of knolls (Salt-Hill, Warsaw, etc.)—say 1500 feet.

(c) The estimated thickness of the Shales-with-Limestone may be reduced to 2000 feet as a minimum.

On the other hand, there is undoubtedly an unconformity between the Knolls and the Shales-with-Limestone which would considerably increase the estimate—this we entirely omit.

Hence:— Minimum thickness S. of Faults 3500 feet.
Maximum thickness N. of Faults 1700 feet.

(The period being the same in both cases, viz. the Viséan or Upper Avonian). The conclusion that there is a great and sudden change of thickness at the fault-belt remains therefore quite as obvious as was originally pointed out by Mr. Tiddeman. Furthermore, it is difficult to conceive how this progressive increase of depth-difference on the two sides of the fault-belt could have been brought about, except by the depression of the Southern Region relatively faster than that of the North; in other words, by the initiation and working of the Craven faults already in Lower Carboniferous-time.)

CONCLUSION.

Although the large Knoll Region of Clitheroe, Bowland and Craven has yet many secrets to yield up, it is to Mr. Tiddeman that we owe the firm foundation of our knowledge.

With the help of Prof. E. J. Garwood's valuable description of the N. W. Province, we shall find it easy to extend the correlation in that direction.

To recent work we owe the fact that the broad datum-lines of the time scale are now firmly established. There is however, all the detailed palæontology yet to do, and, for this purpose, collecting must be thorough and unsparing. It is therefore to local workers that we look for further progress and in particular to Dr. A. Wilmore, of Colne, who has already commenced a detailed zonal survey of the whole region West and North of Pendle.

For my knowledge of the district, I am largely indebted to Dr. Wilmore's ready assistance on the occasions of my short visits; but above all to the demonstration and explanation of Mr. R. H. Tiddeman, my long-time friend and ever kind instructor, to whose inspiration this brief note owes whatsoever it posseses of use or merit.

[We much regret to record that before this paper was printed, the talented author died prematurely. His loss is a great one to geology in general, and to Yorkshire geology in particular].—Ed.

ON PTEROMYA CROWCOMBEIA MOORE AND SOME SPECIES OF PLEUROMYA AND VOLSELLA FROM THE RHÆTIC AND LOWER LIAS.

BY L. RICHARDSON, F.R.S.E. AND J. W. TUTCHER.

[Plates VIII. and IX.]

For a number of years past we have been engaged in studying the Rhætic and basal Lower-Lias deposits of Gloucestershire and Somerset. In the course of our investigations we have collected many specimens of *Pleuromya* and *Volsella*. Of these some could be readily identified with already-described and figured forms, but of the others, some appeared to be undescribed and others to be known by names that obviously required investigation.

The present paper is the result of our examination of the specimens we have collected.

THE GENUS PTEROMYA MOORE.

This genus was created by Charles Moore for the reception of such inequivalve Myadæ as his species *crowcombeia*.* It does not appear to have been generally accepted, but as he created the genus, and as the feature upon which he mainly founded it, namely, the inequality of the valves, is very distinctive, we are of opinion that it ought to be used.

PTEROMYA CROWCOMBEIA MOORE.

Plate VIII., figs. 1*a*, *b*, and 2.

1861. *Quart. Journ. Geol. Soc.*, Vol. XVII., p. 506, plate xv., figs. 22 and 23.

Remarks.—Moore's type came from the Flinty Bed of Beer Crowcombe, which is equivalent to the *Pleurophorus*-Bed of Blue Anchor.† Typical specimens, however, have only been found in abundance—and in great abundance—in bed 21 at Blue Anchor.‡

Moore, in his description, refers to the posterior ridge and area on the *left* valve, but when describing the *right* valve—whilst commenting

* *Quart. Journ. Geol. Soc.*, Vol. XVII. (1861), p. 505.
† *Quart. Journ. Geol. Soc.*, Vol. LXVII. (1911), p. 17.
‡ *Id.*, p. 17.

on the absence of these features—makes no mention of the curiously "thickened" margin and recurved posterior portions of the valve (see plate VIII., fig. 2). On the *left* valve the ribbing ends abruptly at the ridge (fig. 1*b*), but on the *right* valve it is continuous to the "thickened" margin. The test is extremely thin. On young forms the ribbing is very pronounced and regular, and the presence or absence of the thin test does not affect these features on the cast. On the other hand, on older specimens the ribbing on the later-added portion of the shell is much less pronounced.

PLEUROMYA TATEI nom. nov.

Plate VIII., figs. 3*a*, *b*, and *c*.

1871. *Myacites musculoides*, Geol. Surv., Phillips, *Geology of Oxford*, p. 107, plate vii., fig. 36.

1876. Tate and Blake, *The Yorkshire Lias*, p. 406, plate xiii., fig. 10.

REMARKS.—The form to which Tate applied the specific name of *crowcombeia* is common in and characteristic of the *Pleuromya*-Beds (the lower portion of the *Ostrea*-Beds auctt.) of the Lower Lias over a wide area, indeed from Yorkshire to the Dorset coast.

In Moore's *Pteromya crowcombeia* the valves are dissimilar : in *Pleuromya tatei* they are similar. The ornamentation of *both* valves of the latter species is similar to that of the *left* valve only of the former. In addition to this difference the Lower-Lias shell is very much larger. As in the case of the left valve of the Rhætic shell, the ribbing on both valves of the Lower-Lias shell terminates at the posterior ridge, beyond which is a narrow smooth area.

Associated with the above-described typical form of *Pleuromya tatei* are specimens (var. *altior* nov.) differing therefrom in having more central umbones, a stronger posteriorly reflected margin and a less defined ridge (plate VIII., fig. 4). In spite of these differences we do not consider it desirable to separate this form specifically from the above.

In the Langport Beds or White Lias proper, the *Pleuromya* that is commonest resembles in shape *Pleuromya tatei* var. *altior*. A considerable number of specimens has been examined, but in no case has any indication of ribs been observed. This may be due to the condition of preservation, but we consider it desirable to draw attention to the fact, and tentatively distinguish it as a variety—var. *langportensis.*

Tate refers to a specimen from the White Lias of Somerset in the Bath Museum, " named *Pteromya crowcombeia* by the author of the species else," he continues, " I should not have assigned our [Yorkshire] specimen to it."* Tate's doubts were quite justified, for whereas the valves of *Pteromya crowcombeia* from the *Pteria-contorta*-Beds are dissimilar, those of the shells from the White Lias are similar, as is the case with the species from the *Pleuromya*-Beds.

The specimen from Yorkshire figured by Tate is a small example of *Pleuromya tatei.* Associated with it, he states, are larger forms, which he suggests may be adult specimens. He draws attention to their close resemblance to *Ceromya infra-liassica* Peters, but our specimens do not agree with Peters' figure.† Possibly Tate's forms are our variety *altior.*

VOLSELLA‡ HILLANA (J. SOWERBY).

Plate IX., fig. 1.

1818. *Mineral Conchology*, Vol. III., p. 19. plate 212, fig. 2.

REMARKS.—Sowerby's type came from " Pickeridge Hill, near Roundsford Park, Taunton." We figure a particularly fine specimen from the *Pleuromya*-Beds of the same locality.

As will be seen on reference to the figures of *Volsella lævis* (J. Sowerby) (*Min. Conch.*, plate 212, fig. 2), and of this species (plate IX., fig. 5 of this paper), the latter is usually twice as large as an average-sized specimen of the former, and the anterior margin is practically straight.

Volsella hillana (J. Sowerby) is very closely related to, and probably the same as, *V. glabrata* (Dunker). §

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* *The Yorkshire Lias,* p. 406.

† Von Karl F. Peters *Uber den Lias von Fünfkirchen* (1863), tab. 1, figs. 1-3.

‡ =*Modiola.*

§ " Ueber die in dem Lias Halberstadt vorkommenden Versteinerungen," *Palæontographica,* t. I., p. 39, tab. 1, fig. 17.

VOLSELLA HILLANOIDES (CHAPUIS AND DEWALQUE).

Plate IX., figs. 8*a* and *b*.

1855. Chapuis and Dewalque, *Description des Fossiles des Terrains Secondaires de la Province de Luxembourg*, p. 185, plate xxv., fig. 3.

REMARKS.—This is the characteristic *Volsella* of the lower *Angulata*-Beds (Hemera *marmoreæ*) of England. Chapuis and Dewalque's type came from about the same horizon at Muno.

We agree with Tate* in regarding *Volsella psilonoti* (Quenstedt)† as a synonym of *Volsella hillanoides* (Chap. and Dew.)

VOLSELLA LÆVIS (J. SOWERBY).

Plate IX., fig. 5.

1812. *Mineral Conchology*, Vol. I., p. 30, plate 8.

REMARKS.—Sowerby's type was "gathered in the ruins of Caerphilly Castle," near Cardiff, probably from Lower-Lias limestone belonging to the *Pleuromya*-Beds.

Mature specimens of this species are readily distinguished from *Volsella minima* (J. Sowerby) (see plate IX., figs. 2 and 3, of this paper), by their more mytiliform aspect.

All our specimens were obtained from the *Pleuromya*-Beds, and are particularly abundant in the neighbourhood of Bristol.

VOLSELLA LANGPORTENSIS sp. nov.

Plate IX., figs 7 and 11*a* and *b*.

Type-description.—Shell rather more than twice as long as high ; inferior margin slightly arcuate ; hinge-line straight and about half the length of the shell ; margin from the end of the hinge-line to the posterior end slightly convex, then sharply curved to the inferior border ; keel well marked, dividing the valves into two almost equal portions ; anterior lobes prominent.

Var. *angustiformis*, var. nov. (fig. 12).—Differs in being a narrower shell with a shorter hinge-line, more anteriorly-directed umbo, smaller lobe, and less distinct keel.

Var. *erecta* nov. (figs. 9 and 10).—More cylindrical in form, straighter, with a very short hinge-line.

REMARKS.—In the Langport Beds or White Lias proper are a number of fair-sized *Volsellæ* which have been recorded frequently

* *The Yorkshire Lias* (1871), p. 377.

† *Der Jura* (1858), p. 48, tab. 4, fig. 13.

under the name of "*Modiola minima* Moore." Through the kindness of the Rev. H. H. Winwood, of Bath, we have been able to examine the specimen from the "Flinty Bed" of Beer Crowcombe figured by Moore as "*Modiola minima* Sowerby."* Under this name Moore also recorded the form from the Langport Beds, which we have named "*Volsella langportensis.*" The specimens from neither the "Flinty Bed" nor the Langport Beds, however, are *Volsella minima* (J. Sowerby).

The form that we have selected as the type of *Volsella langportensis* is that which is most individually numerous. Certain variations, however, occur, The commonest variety in the Langport Beds is a narrower shell—var. *angustiformis* (*vide supra*), a less common one is a straighter shell—var. *erecta* (*vide supra*).

VOLSELLA LIASINA (TERQUEM).

Plate IX., fig. 6.

1855. Terquem, *Palæont. Liasique Luxem.*, p. 312, plate xxi., fig. 9.

REMARKS.—We have collected several examples of this species from the lower portion of the *Angulata*-Beds (hemera *marmoreæ*) in the Bristol district.

VOLSELLA MINIMA (J. SOWERBY).

Plate IX., figs. 2 and 3.

1818. *Mineral Conchology*, Vol. III., p. 19, plate 210, figs. 5-7.

REMARKS.—This name has been somewhat indiscriminately applied. Sowerby has figured three specimens, two extremely small (plate 210, figs. 6 and 7), and one larger (fig. 5), which represents about the average size of the mature specimen. This last may be selected as the type. It was sent to Sowerby "from Taunton." It may have been obtained from the neighbourhood of West Hatch, where specimens identical with that figured by Sowerby (fig. 5) are very common in the basal portion of the *Pleuromya*-Beds.

We do not recollect having found typical specimens of *Volsella minima* (J. Sowerby) outside the *Pleuromya*-Beds.

Specimens have been procured wherever the *Pleuromya*-Beds are exposed.

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* *Quart. Journ. Geol. Soc.*, Vol. XVII. (1861), p. 505, pl. xv., figs. 26 and 27.

VOLSELLA WICKESI sp. nov.

Plate IX., fig. 4.

Type description.—Shell cylindrical, umbonal portion obtuse, inflated, margin straight, keel not well defined.

REMARKS.—This form—which we name after Mr. W. H. Wickes, of Bristol, who was the first to publish an account of the Rhætic and Lower-Lias sections of Redland,* whence the type specimen of this species came—is readily distinguished from other *Volsellæ* from the *Pleuromya*-Beds by its obtuse inflated umbonal region, straight anterior margin and the indefiniteness of its keel. It is not common and appears to be confined to the *Pleuromya*-Beds.

EXPLANATION OF PLATES.

Plate VIII.

Figs. 1*a*, *b*, *c*, and 2.—**Pteromya crowcombeia** Moore. (See p. 51.)
1*a*=Left valve, nat. size ; 1*b* enlarged (× 2) ; 2 right valves (× 2.)
Horizon.—**Pteria-contorta** or Lilstock Beds. Rhætic.
Locality.—Blue Anchor, near Watchet, Somerset.
Collection.—L. Richardson.

Figs. 3*a*, *b*, and *c*.—**Pleuromya tatei** nom. nov. (Nat. size.) (See p. 52.)
3*a*=right valve ; 3*b* umbonal view of the same valve ; 3*c*=left valve.
Horizon.—**Pleuromya**-Beds. Lower Lias.
Locality.—(3*a* and *b*) West Hatch, near Taunton, Somerset ; (3*c*) Aust Cliff, near Bristol.
Collection.—J. W. Tutcher.

Fig. 4.—**Pleuromya tatei** nom. nov. var. **altior** nov. (Nat. size.) (See p. 52.)
Horizon.—**Pleuromya**-Beds. Lower Lias.
Locality.—Filton, near Bristol.
Collection.—J. W. Tutcher.

Fig. 5.—**Pleuromya tatei** nom. nov. var. **langportensis** nov. (Nat. size.) (See p. 53.)
Horizon.—Langport Beds.
Locality.—Radstock Grove, Radstock, Somerset.
Collection.—J. W. Tutcher.

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* *Proc. Bristol Nat. Soc.*, Vol. IX., pt. 2 (1899), pp. 99-103.

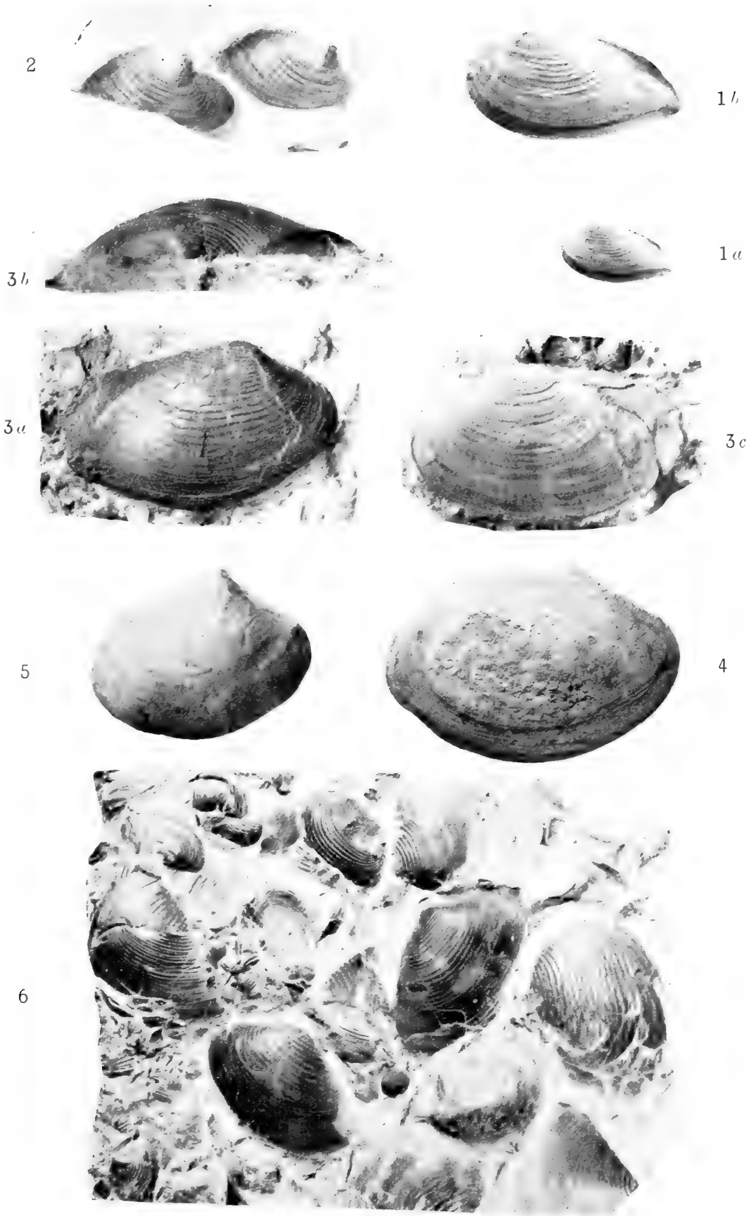

Photo by] [*J. W. Tutcher.*

Pteromya crowcombeia Moore, and Lower Lias Pleuromyæ.

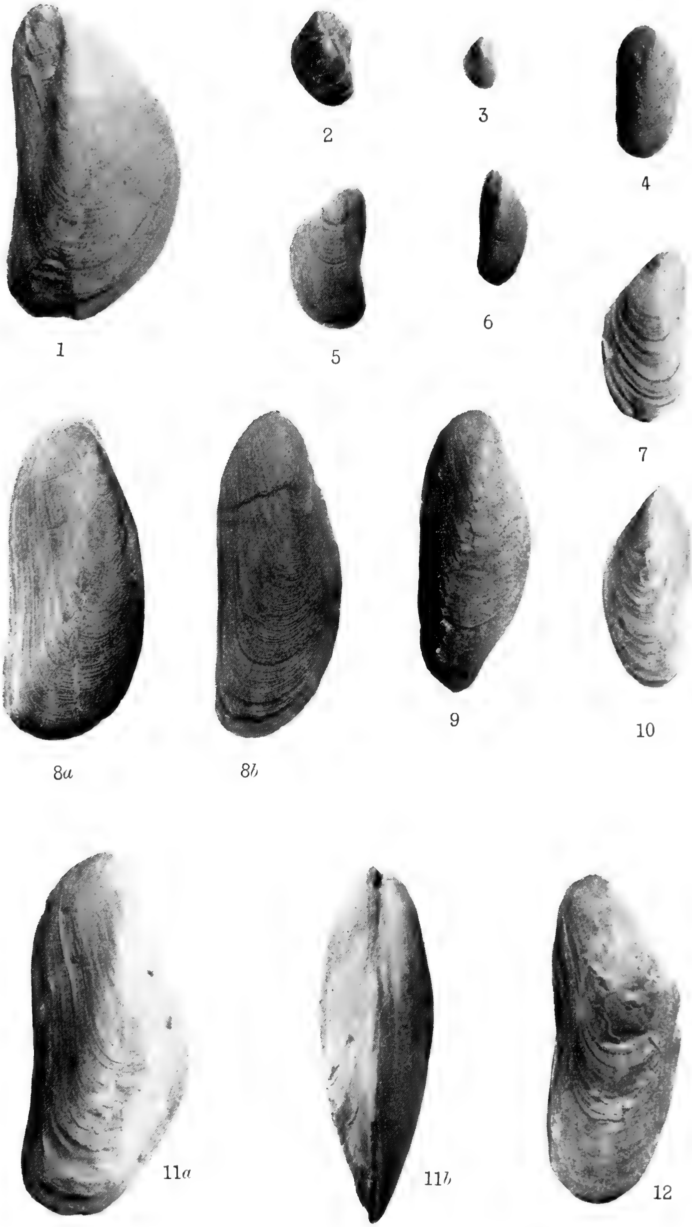

Photo by] [*J. W. Tutcher.*

Rhætic and Lower Lias Volsellæ.

Fig. 6.—Piece of **Pleuromya**-Bed limestone with **Pleuromya tatei** to show the abundance in which specimens occur at this horizon. (Three-quarters nat. size.)

Locality.—West Hatch, near Taunton, Somerset.

Collection.—J. W. Tutcher.

Plate IX.

Fig. 1.—**Volsella hillana** (J. Sowerby). (See p. 53.)

Horizon.—**Pleuromya**-Beds. Lower Lias.

Locality.—Pickeridge Hill, near Taunton.

Collection.—L. Richardson.

Figs. 2 and 3.—**Volsella minima** (J. Sowerby). (See p. 55.)

Horizon.—**Pleuromya**-Beds. Lower Lias.

Locality.—(2, mature specimen) Aust Cliff, near Bristol ; (3, immature specimen) West Hatch, near Taunton.

Collection.—J. W. Tutcher.

Fig. 4.—**Volsella wickesi** sp. nov. (See p. 56.)

Horizon.—*Pleuromya*-Beds. Lower Lias.

Locality.—Redland ("New Clifton"), Bristol.

Collection.—J. W. Tutcher.

Fig. 5.—**Volsella lævis** (J. Sowerby). (See p. 54.)

Horizon.—**Pleuromya**-Beds. Lower Lias.

Locality.—Redland ("New Clifton"), Bristol.

Collection.—J. W. Tutcher.

Fig. 6.—**Volsella liasina** (Terquem). (See p. 55.)

Horizon.—**Angulata**-Beds (hemera **marmoreæ**). Lower Lias.

Locality.—Winford (Somerset), near Bristol.

Collection.—J. W. Tutcher.

Figs. 7, 11*a*, and *b*.—**Volsella langportensis** sp. nov. (Nat. size.) (See p. 54.)

Horizon.—Langport Beds.

Locality.—(11*a* and *b*) Norton Down, near Stratton-on-the-Foss, near Radstock, Somerset ; (7) young specimen—Clan Down, near Radstock.

Collection.—J. W. Tutcher.

Figs. 8*a* and *b*.—**Volsella hillanoides** (Chapuis and Dewalque). (Nat. size.) (See p. 54.)

Horizon.—**Angulata**-Beds (hemera **marmoreæ**). Lower Lias.

Locality.—Hobbs Wall, Farmborough (Somerset), near Bristol.

Collection.—J. W. Tutcher.

Figs. 9 and 10. —**Volsella langportensis** sp. nov., var. **erecta** nov. (Nat. size.) (See p. 54.)

Horizon.—Langport Beds.

Locality.—(9) Pinhay Bay, near Lyme Regis, Dorset ; (10) Redland ("New Clifton"), Bristol.

Collection.—(9) L. Richardson ; (10) J. W. Tutcher.

Fig. 12.—**Volsella langportensis** sp. nov., var. **angustiformis** nov. (Nat. size.) (See p. 54.)

Horizon.—Langport Beds.

Locality.—Railway-cutting, Charlton Mackrell. Somerset.

Collection.—L. Richardson.

[All the figures in Plate IX. are natural size.]

BIBLIOGRAPHY OF YORKSHIRE GEOLOGY, 1915.

By T. SHEPPARD, M.Sc., F.G.S.

Now that the Bibliography of Yorkshire from 1534 to 1914 has been published, as Volume XVIII. of our *Proceedings*, it seems desirable that a Yorkshire list should appear annually in our *Proceedings*, in order that the Bibliography may be kept up-to-date. These lists formerly appeared in *The Naturalist*, but in future it is proposed only to print in that journal particulars of the items referring to the geology of the northern counties, with the exception of Yorkshire.

At the same time it is proposed to include particulars of any items that may have been omitted from the list in Volume XVIII. If, therefore, any of our readers notice any items which ought to have been included, perhaps they will kindly advise me.

1914.

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ANNUAL REPORT FOR 1914.

It has been felt for some considerable time that the enthusiasm which had in past years been so noticeable in the good work done by the Society has been waning. The records of meetings held during those periods when the investigation of the underground waters of North West Yorkshire, the glacial phenomena of the area, and the the earlier work upon problems connected with the Carboniferous Formation stand out in vivid contrast with those of later times. It is of course true that the outbreak of the present hostilities has affected our Society in common with all others of a like nature throughout the country. But this cause has only been operative during the last few unhappy months, and in no way explains the falling off during the last few years. It cannot be expected that any great improvement will be shown during the continuance of the war, but as soon as time and events are favourably conjoined it is hoped that our members will again continue their attack upon the problems to be found in plenty in our county.

Part 1, Vol. XIX., of the Proceedings was published at the beginning of the year, while the Bibliography of Yorkshire Geology, commenced by the late C. Fox-Strangways, is being brought up-to-date by Mr. Sheppard, and we may expect its early publication.

At the Council Meeting held in Leeds on March 19th, a communication was read from the President, R. H. Tiddeman, Esq., M.A., F.G.S., suggesting that the time was now ripe for a Conference to be held at which the Glacial Geology of the North of England could be reviewed, and our present knowledge brought to a focus. The Council expressed their entire agreement with this timely suggestion, and it was decided to place the matter in the hands of a committee consisting of Professor Kendall, Messrs. Sheppard and Stather, together with the Hon. Sec. and Hon. Treas. to make arrangements for such a conference in the early Autumn, but this had to be abandoned for the present. It will, however, be taken up when the times permit.

The General Spring Meeting was held in the evening of the same day in the Geological Dept. of the University of Leeds, and when the formal business had been disposed of the following papers were read:— "Blow Wells of the East Riding," by Prof. Kendall, and "The Glaciation of Rossendale," by Dr. A. Jowett. A discussion followed each paper, Messrs. Stather, Fennell, Burton and Gilligan taking part.

An excursion to the Sedburgh District was held on May 8th-12th under the leadership of Prof. Kendall and Mr. W. Robinson, F.G.S. The weather was not altogether favourable, but the members were not deterred, and spent a most profitable time in examining the many interesting features, paying particular attention to the Dent Fault in Taithes Gill, the Ordovician and Silurian Rocks of Helm Gill, and Helm Knott, with the associated igneous rocks.

One day was spent in examining the section in Pinskey Gill and then walking over the moors and down Spen Gill.

The second meeting was held at Hathersage on July 2nd-6th, under the leadership of Prof. Fearnsides. A most interesting programme had been arranged including the Derwent Valley Waterworks, where opportunities were afforded of examining folding in weak strata at the bottom of the valleys, whose sides are seriously affected by landslips. During other excursions, the palæontologist and petrologist found ample work, the former in the Carboniferous Limestone and Shale at the quarry between Pindale and Meadow House and other points, and the latter in the many fine exposures of Millstone Grit of the district and the volcanic rocks associated with the limestone. An evening meeting was held in the George Hotel, Hathersage, on Saturday, July 4th, the chair being taken by Mr. Cosmo Johns, when a discussion was opened by the Chairman on "Some Geological Problems of the Sheffield District," dealing especially with the climatic conditions of the area during Carboniferous and Permian times, and difficulties in correlating the glacial deposits of the district with the typical sections on the Yorkshire coast. A vote of thanks to the Chairman and Professor Fearnsides for leading the excursion brought the meeting to a close.

The Annual General Meeting was held in the Philosophical Hall, Leeds, on Wednesday, Nov. 18th, under the Presidency of R. H. Tiddeman, Esq., M.A., F.G.S., when the various officers were elected as recommended by the council and submitted to all members on separate leaflet at the time of the meeting.

Mr. M. Odling, M.A., B.Sc., F.G.S., then read a paper on "Some Unconformities in the Upper Jurassics," in which he mentioned observations which he had made in the South of England and the

Boulonnais. The subject is still receiving attention, and Mr. Odling hopes to publish a paper upon the subject in the near future.

Professor Kendall then introduced the subject of the proposed "Investigation of the Rivers of Yorkshire," pointing out the aims and importance of the work.

A good discussion followed in which the following members took part :—the President, J. E. Bedford, Esq. (Lord Mayor of Leeds), Dr. Forsyth, Messrs. Burton, Bingley, Thornber, Charlesworth, Bisat, Appleyard, Gill, Beaumont, and the Hon. Secretary.

The general feeling of the meeting was that the work would be one of great importance and of such a character that it would give scope to all members of the Society, and it was unanimously agreed that the scheme should be taken up by the Society.

On the motion of Mr. Odling, seconded by Dr. Forsyth, the following were elected as an organizing committee :—Professor Kendall, Messrs. Charlesworth, Hawkesworth and the Hon. Secretary.

The Committee has held one meeting and it was decided to initiate the work by an investigation of the Washburn Valley, but that the time was not opportune to proceed with the work in earnest.

ANNUAL REPORT FOR 1915.

The Society has passed successfully through a very trying year. Loyal help has been given by such of our members as were so circumstanced that they could spare a little time from the arduous labours which have devolved upon so many. The proposed investigation of the Yorkshire rivers is of necessity still held over, but the accumulation of material relating to the work has gone on, so that there need be no delay as soon as a favourable opportunity presents itself.

It had been hoped that the Bibliography would have been published this year, but the great additions which have been found necessary have increased the labour of compilation accordingly, and it has now reached dimensions which were not anticipated when the Society asked Mr. Sheppard to take the matter in hand. These additions will enhance its value greatly and we are assured that we may look for its early issue.

The Spring Meeting was held in Leeds on Wednesday, March 17th. In the morning Professor Kendall took the members up the Meanwood valley for an examination of sections in the Ganister Beds and to study the interesting topography of the valley due to the alternation of grits and shales.

In the evening the General Meeting was held in the Philosophical Hall, the President being in the chair.

A very interesting exhibit of maps, memoirs, etc., by William Smith, was on view, contributed by Professor Kendall and Mr. Sheppard. The latter gave the members a delightful talk upon the work done in Yorkshire by William Smith, and the members learned many new facts concerning the labours of that great geologist in Yorkshire which had been unearthed by Mr. Sheppard.

This paper will be published in extenso in the next part of the Proceedings.

Many of the members present expressed their appreciation of the researches made by Mr. Sheppard into the early records of the "Father of English Geology."

Mr. Albert Gilligan proposed the following resolution :—

That the Subscription to the Yorkshire Geological Society shall be 10s. 6d. per annum.

In speaking to the resolution he remarked that the present subscription of 13s. was larger than most societies of a like nature and that he was of the opinion that a reduction of the subscription to the amount stated would be likely to result in an increased membership.

The resolution was seconded by Mr. A. Charlesworth and after a long discussion it was agreed that the matter should not be proceeded with at the present time, but should come up for consideration when times were more settled.

The Easter Meeting was held at Slaidburn, near Clitheroe, and though only a small number of members attended, those who braved the elements were well rewarded. The President, Mr. R. H. Tiddeman, who had been responsible for the geological survey of the area, acted as leader, while the presence of the late Dr. A. Vaughan in the classic knoll reef country acted as a stimulus to diligent collecting among the limestones.

The Millstone Grit and Glacial phenomena of Bowland Knotts claimed some attention : the view from Knotteranum over to the Penines, with Clapham in the valley at the foot of Ingleboro', was adjudged one of the finest in Yorkshire.

Croasdale Beck and Phynis Beck afforded magnificent sections in the Yoredales, but the rain, while the party were in the Croasdale valley, proved too much for their enthusiasm and made them seek shelter in a friendly farmhouse.

At the Council Meeting held in the Philosophical Hall, Leeds, on Thursday, June 24th, it was resolved that day excursions within easy distance of Leeds should be substituted for the long week-end excursions which it had been customary for the Society to hold. The following times and places, with Leaders, were decided upon :—

July 10th.	CRACOE	Leader,	Professor Kendall.
,, 24th.	FEWSTON	,,	J. E. Bedford, Esq., F.G.S.
Sept. 8th.	KNOSTROP (LEEDS SEWAGE WORKS)	,,	,,
,, 25th.	CONISBRO'	,,	Albert Gilligan.

It is not thought necessary to give a detailed account of all these excursions; suffice it to say that the splendid attendance and interest shown in these meetings has completely justified the policy of the Council, and it is not too much to say that nothing better could have been done to quicken the life of the Society at this period.

A general meeting was held in the evening of Thursday, June 24th, in the Geological Dept. of the University of Leeds, the President being in the chair, when the following papers were read :—

"The Knoll Region of Clitheroe, Bowland and Craven," by Dr. A. Vaughan, M.A., F.G.S., and

"The Mineral Constituents of the Permian Sandstones and Breccias of the North of England," by Mr. H. C. Versey, M.Sc.

In the absence of Dr. Vaughan the former paper was read by the Secretary.

An interesting discussion followed each paper, in which the following took part :—The President, Prof. Kendall, Mr. Odling and the Secretary.

Members will be interested to learn that the unique collection of lantern slides and negatives made by our esteemed member, Mr. Godfrey Bingley, has been generously given by him to the University of Leeds, and is at present housed in the Geological Dept. of that University. They number upwards of 10,000 of each, slides and negatives, and form a complete record of the field excursions of the Society for the last quarter of a century. There is no need to enlarge upon the value and utility of such a collection, while their extreme beauty is known to a very wide field of geologists, and this Society counts among its happiest memories the exhibition of lantern slides made at one of its annual meetings for many years, by Mr. Bingley.

THE YORKSHIRE GEOLOGICAL SOCIETY.

Statement of Receipts and Expenditure from November 1st, 1913, to October 31st, 1914.

Dr.	Receipts.	£	s.	d.
1913. Nov. 1	To Balance in hand	153	0	6
1914. Oct. 31	,, Members' Annual Subscriptions	66	19	0
	,, Members' Arrears received ..	5	17	0
	,, Interest on Mortgage Bonds, Halifax Corporation ..	12	3	5
	,, Bank Interest	3	6	8
		£241	6	7

1914.	Expenditure.				Cr. £	s.	d.
Oct. 31	By Stationery and Postages ..				7	13	10
	,, Drawing Plates				15	0	0
	,, Expenses of Meetings :—						
	Huddersfield ..	0	10	6			
	Sedbergh ..	0	8	6			
					0	19	0
	,, Balance in hand				217	13	9
					£241	6	7

CAPITAL ACCOUNT.

1914.		£	s.	d.
Nov. 1	To Halifax Corporation Mortgage Bonds	370	0	0
	,, Books, Proceedings, Maps, etc. at the Leeds University (as per agreement dated 20th November, 1907, in the custody of the West Yorkshire Bank, Ltd.)			
		£370	0	0

1913.		£	s.	d.
Nov. 1	By Halifax Corporation Mortgage Bonds, £350 at $3\frac{1}{2}$% ..	370	0	0
		£370	0	0

Leeds, November 17th, 1914.

Examined and found correct, F. W. BRANSON, *Hon. Auditor*

J. E. WILSON, *Hon. Treasurer*

THE YORKSHIRE GEOLOGICAL SOCIETY.

Statement of Receipts and Expenditure from November 1st, 1914, to October 31st, 1915.

Dr.

Date	Receipts.	£	s.	d.
1914. Nov. 1	To Balance in hand	217	13	9
1915. Oct. 31	,, Members' Annual Subscriptions	66	6	0
	,, Members' Arrears received ..	5	17	0
	,, Life Member's Subscription, transferred from Capital Account	6	6	0
	,, Interest on Mortgage Bonds, Halifax Corporation ..	11	9	6
	,, Sales of Proceedings	2	4	0
	,, Bank Interest	4	12	2
		£314	8	5

Cr.

Date	Expenditure.				£	s.	d.
1915. Oct. 31	By Printing Proceedings				22	7	0
	,, do. Plates				8	5	0
	,, Clerical Work for "Rivers" Committee				2	0	0
	,, Stationery, Printing & Postage:—						
	Chorley & Pickersgill	15	3	1			
	Treasurer ..	0	10	6			
	Librarian ..	1	8	6			
	Secretary ..	2	15	6			
					19	17	7
	,, Expenses of Meetings				7	2	4
	,, Balance in hand				254	16	6
					314	8	5

CAPITAL ACCOUNT.

Date		£	s.	d.
1915. Nov. 1	To Halifax Corporation Mortgage Bonds, $3\frac{1}{2}\%$	370	0	0
	,, Life Member's Subscription ..	6	6	0
	,, Books, Proceedings, Maps, etc., at the Leeds University (as per agreement dated 20th November, 1907, in the custody of the West Yorkshire Bank)			
		376	6	0

Date		£	s.	d.
1914. Nov. 1	By Halifax Corporation Mortgage Bonds	370	0	0
	,, Transfer to Revenue Account..	6	6	0
		376	6	0

Leeds, November 25th, 1915.

Examined and found correct, F. W. BRANSON, *Hon. Auditor.*

J. E. WILSON, *Hon. Treasurer.*

WILLIAM SMITH: HIS MAPS AND MEMOIRS.

By T. SHEPPARD, M.Sc., F.G.S.

CONTENTS.

LIST OF ILLUSTRATIONS.

INTRODUCTION.

There are many memoirs dealing with William Smith; the earliest by his nephew, John Phillips, being published in 1844. More recently Dr. Henry Woodward, the late Prof. J. W. Judd, and others, have referred to his life and his maps. Smith's work has, naturally, had a considerable effect on the progress of Yorkshire geology, especially as his nephew and pupil, Phillips, received from him his early inspiration and training.

William Smith was born at Churchill in Oxfordshire in 1769, and died at Northampton, while on his way to the British Association meeting at Birmingham in 1839, when he had reached his three score years and ten.

Of the value of his pioneer work in identifying strata by means of their contained fossils, and in geological mapping, the scientific world well knows. At present it is proposed to refer more particularly to his maps and memoirs, and especially with regard to those referring to Yorkshire.

Smith spent some of his later years in our county. He lectured at York, Hull, Sheffield, Leeds and Scarborough. It was on our coast at Scarborough in 1826, that he first made the acquaintance of Roderick Murchison. In 1828 he was appointed Resident Land Steward to Sir John V. B. Johnstone, Bart., of Hackness, and he there made a map of the Hackness estate. From a plan in my possession it is also apparent that in 1819 Smith was engaged in connection with a "Proposed Aire and Dunn Canal to drain the contiguous Lands," etc.

In 1815 Smith purchased a property near Bath for the working of freestone, but it so happened that he, the one person then able to judge of the quantity and quality of stone, was deceived, and he lost heavily. His geological collection was sold to the British Museum in 1816, and two years later they acquired a further collection from him.* He received £700 in all from the Museum authorities.

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* Judd states (*Geol. Mag.*, 1898, p. 99.):—"It originally consisted of 2,657 specimens, belonging to 693 species, collected at 263 different localities; and such portions of it as can be identified have been brought together and arranged according to William Smith's original plan in the British Museum (Natural History) at South Kensington, by the pious care of Dr. Henry Woodward."

He must have made much money by his engineering skill, but it all seems to have been spent in connection with the publication of his maps. "In 1819 he gave up his house in London, and sold off all his furniture, collections and books, and for the next seven years he became a wanderer in the north of England, rarely visiting London save on professional engagements."* This doubtless accounts for the incomplete state of some of his publications, referred to later. Probably the first lecture Smith gave in Yorkshire, was delivered to the Philosophical and Literary Society at Leeds in 1821. I am indebted to Mr. H. E. Wroot for the following reference to it, which he has obtained from an old file of *The Leeds Mercury*:—

> "A lecture out of the ordinary course was delivered last Saturday evening, [Nov. 17th. 1821], at the Hall of our Philosophical and Literary Society, by Mr. WILLIAM SMITH, a geologist of distinguished merit and reputation. Mr. Smith, being present on the preceding evening, when a subject which in some degree connected itself with geology was discussed, generously offered to address the Society the following day, and to illustrate the subject by his own geological map. He gave therefore, on Saturday, a full and interesting description of the varied stratification of Yorkshire, occasionally extending his view to the principal strata of the whole Kingdom. Mr. SMITH made also some useful suggestions on the arrangement of the geological specimens in the Society's Museum. The lecture, which displayed surprising stores of knowledge, and great clearness as well as vigour of mind in the lecturer, gave universal satisfaction; and the society evidently felt much gratified by the interest Mr. SMITH showed in its welfare. We trust the example set by this gentleman will be followed by other eminent scientific men who may pass through the town.†

The lecture which attracted William Smith was a discussion by Mr. Luccock on the place in nature of the Hippocampus, the "sea horse." It is interesting to notice the vigour and enthusiam of the Leeds Philosophical Society in those days. It was able to hold meetings twice a week—Wednesdays and Fridays—with occasional

* Woodward, *Proc. Bath. Nat. Hist. and Ant. F. Club*, 1902, Vol. X., pt. 1, p. 7.

† *Leeds Mercury*, Nov. 24, 1821.

"specials" as in the case of Smith's lecture. And it appears to have had good audiences. It was not perhaps without need that the Society took a dose of elementary geology from Smith, for at the presidential address, a fortnight later, Mr. John Marshall, the President of the Society, "read a paper, which he had promised, developing a new theory of Geology. We can merely state" (says the bewildered reporter) "that the great principle of the theory is—the change of the axis of the earth's rotation, which, occasioning in the long succession of ages an alternate rise and subsidence of the ocean in different parts of the globe has mainly contributed to form the varied stratification of the earth's surface. Mr. Marshall approved, but not altogether, the Huttonian (*sic*) theory of the igneous origin of the earth's crust." (The reporter is apparently a little confused here between Hutton and Werner). "The numerous facts discovered by geologists as recorded in history, by which Mr. Marshall supported his theory, we are quite unable to allude to."

In the First Report of the Literary and Philosophical Society of Kingston-upon-Hull (1824-5, page 9) we learn: "Mr. Smith, the well-known laborious author of the geological maps of England, Yorkshire, etc., and his nephew, Mr. J. Phillips, being in this county in November, the council eagerly embraced the opportunity of engaging those gentlemen to deliver a course of nine lectures on the interesting study of geology, for the sum of £50, which were given at the Assembly Rooms, in the month of December, and illustrated by numerous drawings and specimens, in which the Society's Museum was again found to be exceedingly useful; and it must be satisfactory to the members to learn that it was pronounced by those competent judges to contain a highly valuable collection of specimens. The cost to the Society of these lectures was only £12 9s., and they were accompanied by an accession to the list of members, fully counter-balancing that sum, so as, in point of fact, to have been enjoyed by the Society gratis."

Later in the same Report* we find that: "Mr. Smith having been induced by the Yorkshire Philosophical Society to resume his examination of the strata of Yorkshire, the result has been a further development of the intricate geological arrangement of the eastern part of the county, and the identification of several distinct beds in the oolitic series, not

* pp. 10-11.

before discriminated, with those which are known in the southern course of the strata. Mr. S. is engaged in introducing these new observations into his geological map of Yorkshire, which he exhibited during his lectures ; and he also entertains an intention of publishing the documents on which the colouring of that map is founded—the valuable fruits of many years of laborious investigation. It must afford great satisfaction to the Society that they have in any degree been instrumental in encouraging the researches of so able a geologist."

A further reference to a visit to Hull by Smith occurs in the Society's report for the Session ending May, 1839, page 9 :—

" A recent visit to the town from Dr. Smith, enabled the father of English Geology, as he is justly styled, an opportunity of examining our collection of specimens illustrative of his favourite science, some of these he declared to be entirely new to him, while many others, upon his authority, were pronounced to be of great value and variety. He congratulated the Society on possessing the opportunity of resorting to so valuable a collection of well arranged fossils, as affording compensation, to a considerable extent, for the deficiency of our neighbourhood in geological interest."

This must have been Smith's last visit to Hull, for he died a few months later.

Smith and Phillips gave a similar set of lectures to that delivered at Hull to the Yorkshire Philosophical Society, and they are referred to in the report of the York Society in almost identically the same words as those quoted from the Hull report ! Later they were delivered at Sheffield and Scarborough. Fortunately a copy of this remarkable syllabus is preserved,* and as it is one of the earliest of its kind, and has a particular interest to Yorkshire geologists, it may be quoted here :—

SYLLABUS OF LECTURES ON GEOLOGY,

BY WILLIAM SMITH, MINERAL SURVEYOR.

LECTURE I.

" INTRODUCTORY.—Geology a Science of great extent and universal interest ; not a science of hard names, but beautifully

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* Phillips's Memoirs of William Smith, 1844, pp. 107-109.

according facts.—The great facilities for acquiring it afforded in our own country.—Inducements to the study of Geology.—A view of its application to the purposes of human convenience.—Explanation of first principles of the Science, as developed in the original investigation around Bath.—Enumeration and description of the Strata, illustrated by sections and maps; and the distinction explained between the alluvial and stratified matter.

LECTURE II.

" Connection of British Strata with those of adjacent countries.

" Exterior Form of Land, as influenced by the terminations of the Strata in the Sea.—Bays, Estuaries, Capes, Cliffs, Low Shores, mutability of the Coast.

" Interior of the Island.—Principal ranges of high and low ground, contours of Hills, and characteristic forms of Mountains and Valleys, illustrated by drawings.

LECTURE III.

" Principles of Natural Drainage.—1. Summits of Drainage; 2. Theory of Springs; 3. Courses of Streams, illustrated by reference to particular streams; 4. Characters of the Streams and Valleys in the respective Strata.—Lakes.—Interior Marshes.

" Sites of Population.—Origin of Towns, Villages, Castles, Abbeys, Seats, and Parks, as influenced by advantages arising from properties of the Strata.—Picturesque Scenery.—Varieties of Soil and their agricultural appropriations.

" Localities of Plants and Free Animals in the sea and on the land.

LECTURE IV.

" Strata identified by their imbedded Organised Fossils, and other remarkable bodies.—Use and application of the organised Fossils, in distinguishing one Stratum from another, exemplified by specimens and drawings, and reference to localities.—State of the preservation of Fossils, their relative antiquity, and resemblance to recent Shells, Corallines, etc.

LECTURE V.

"VARIATIONS FROM THE GENERAL REGULARITY OF STRATA.—Isolated Masses, attentuation and discontinuity of Strata; remarkable elevations and depressions; unconformity of course and declination, and apparent dislocations of Strata.—Dykes and Mineral Veins. Illustrated by sections and drawings.

LECTURE VI.

"GEOLOGY OF YORKSHIRE.—Exemplifications of the great principles of the Science, around the coast and through the interior of the county.—Enumeration and description of the Yorkshire Strata, with their included organised Fossils and other peculiarities.—Instances of elevations and depressions, and other conformities of the Strata, illustrated by Maps, Sections, and Drawings.

LECTURE VII.

"ON THE PRACTICAL ADVANTAGES OF GEOLOGY, and its beneficial application to Agriculture, Mining, Coalworking, and Commerce in Yorkshire.—Valuable products of Yorkshire: Building Stone, Paving Stone, Slates, Marbles, Bricks, Pottery, Casting Sand, Grindstones, etc.—Sites of population and Manufacture.—Discovery and working of Coal and Minerals.

LECTURE VIII.

"Review of the subject, with reflections on the FORMATION OF THE STRATA.—Proved to have been deposited from water liable to occasional agitation.—Change of climate considered.—Consolidation of Strata.— Effects of the Deluge in detaching fragments from the rocks, rounding them by attrition in water, and scattering them over other Strata at great distances.—Bones of land animals found in this gravel, and in Limestone Caves.—Account of the Caves of Kirkdale, of Oreston, etc.—Antediluvian inhabitants of the earth.—Conclusion."

Of these lectures Phillips says*: "A certain abstractedness of mind, generated by long and solitary meditation, a habit of following out his own thoughts into new trains of research, even while engaged in

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* loc. cit., p. 109.

explaining the simplest facts, continually broke the symmetry of Mr. Smith's lectures. Slight matters, things curious in themselves, but not clearly or commonly associated with the general purpose of the lecture, swelled into excrescences, and stopped the growth of parts which were more important in themselves, or necessary to connect the observations into an intelligible and satisfactory system. But there was a charm thrown over these discoveries by the novelty and appropriateness of the diagrams and modellings which exemplified the arrangement of the rocks, the total absence of all technical trifling from the explanations, and the simplicity and earnestness of the man."

This "side-tracking" alluded to by Phillips is obvious in Smith's books, particularly the first one.

One of the original copies of the "Table of Strata," by Smith, a complete set of the cross-country sections which he published, as well as a fine series of characteristic fossils,* left by Smith and Phillips at the close of these lectures, are among the most cherished possessions in the Hull Museum to-day.

The great work Smith did in our county, and the great effect the geology of Yorkshire had on some of his conclusions, is little known. Most that is recorded occurs in Phillips's Memoir, which is now an exceedingly scarce book.† This includes a few facts which are worthy of being preserved in our Proceedings.

In 1794, while engaged in the construction of a canal in the south of England, William Smith, "their engineer," was sent with two members of the Canal Company on a 900 miles' tour, in order to examine other navigations. During this trip he took notes of the country he passed through, and the following was written with regard to our county‡ :—

> "We found the small steam engines much better applied to raising coal in Yorkshire than in Somersetshire, where not more than one (I believe), badly constructed, was then in use.

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* These are referred to on p. 21 of the Third Report of the Hull Society, as follows :—"Mr. W. Smith, Mr. J. Phillips: Fossils, illustrative of the Stratification on the Coast of Yorkshire."

† My copy is inscribed to "Henry Davies Esq., with the best wishes of John Phillips, 13th Aug., 1856."

‡ loc. cit., pp. 12-13.

"Flat ropes were in use, and at Hisley Wood or White-lane Colliery, on Earl Fitzwilliam's estate, I stood on one end of a cross-bar to which corves were suspended, and Mr. Perkins on the other, and we were very smoothly let down a little more than mid-depth of the pit to see Mr. Cur's, so-called, sliding-rods ; when,

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MEMOIRS

OF

WILLIAM SMITH, LL.D.,

AUTHOR OF THE

MAP OF THE STRATA OF ENGLAND AND WALES

BY

HIS NEPHEW AND PUPIL,

JOHN PHILLIPS, F.R.S., F.G.S.,

PROFESSOR OF GEOLOGY AND MINERALOGY IN THE UNIVERSITY OF DUBLIN,
AUTHOR OF "ILLUSTRATIONS OF THE GEOLOGY OF YORKSHIRE"

Quæ fecimus, ipsi ..... ea nostra

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1844.

Reduced fac-simile of the title-page of Phillips's Memoirs.

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on being stationary and directed to look up, we saw the ascending corves over our head without knowing that they had passed us at the mid-depth enlargement of the pit.

"On reversing the motion of the engine we were soon again on the surface, and simply and easily as this seemed to be effected by grooves down from top to bottom of the pit, for opposite ends of the cross bars to move in with an enlarged place mid-way for their passing, my learned friend could not understand the mechanism, though I was occupied nearly the whole of a long stage in explaining it to him.

"The rocks of the Yorkshire coalfield, everywhere so well developed, opened to my mind new views of the facility of obtaining on the surface clear notions of the coal-measure stratification; and at Banktop, near Barnsley, I found some of the rocks of this series strongly developed.

"Leeds being near the extent of the coalfield, we found that further north there were no canals, but determined on seeing York Minster; and thus, in crossing Tadcaster Moor, I had a clear view of the magnesian limestone, which is a rock unknown in the south.

"From the top of York Minster I could see that the Wolds contained chalk by their contour.*

"We here had time enough to indulge ourselves with a good dinner and a pine-apple at the Black Swan, and resolved upon a run up to Newcastle to see the celebrated collieries there; and, after the first stage from York, I recognised in the Hambleton Hills the features of the Cotswold Hills viewed from the vale of Gloucester; saw near Thirsk the red marl in the road, and found that along Leaming-lane we were travelling upon red sandstone. The yellow limestone appeared again at Pierce Bridge, and at Ferry Hill they were working coal under it.

"Here it presented a well defined escarpment boundary to the Durham coalfield, as it did to that of Yorkshire; but these northern coal-measures were observed to be much more obscured by a thick cover of loose and mixed matter."

At Heaton Colliery, near Newcastle:—

"The mode of dividing their shafts and mother-gates by

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* Of this Phillips says:—"This was in fact the only authority he could rely upon for drawing, in 1800, the continuations of the Chalk of Wiltshire and the Oolite of Somersetshire through the eastern parts of Yorkshire, but he drew them with a considerable approximation to accuracy."

See under Martin Lister, 1683, below, where the Chalk Wolds are distinctly referred to. Of course Smith may not have known of Lister's paper.—T.S.

brattices of wood-work seemed inconvenient and unphilosophical and we, rather dissatisfied, hastened back through Ripon and Harrogate, where the M.D. took a nauseous draught of sulphur water as we sat in the chaise. We had crossed the yellow limestone between Ripon and Ripley."

Twenty-six years afterwards Smith again frequented Yorkshire. Phillips records* that :—

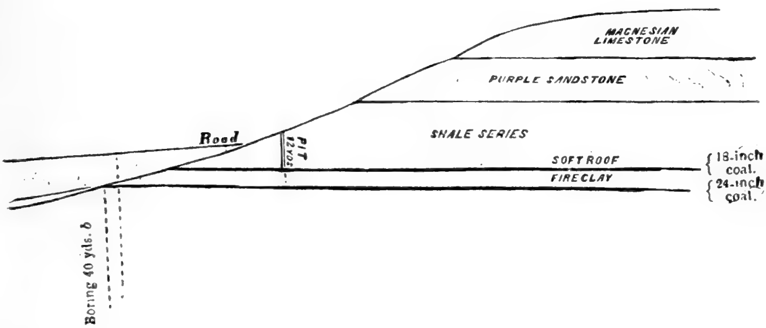
"Early in 1820 Mr. Smith was employed in Leicestershire, but the greater part of the year was passed in Yorkshire, about Ferrybridge, Whitby and Scarborough. While staying at the romantic and delightful town just named (in hopes to soothe the mental aberration of his wife, which became very manifest in this year), he imbibed for it a partiality which augmented with further knowledge. Mr. Dunn, one of the most affectionate and highly esteemed of his friends, remembers that even at this period it was in contemplation to found a museum at Scarborough, and that Mr. Smith attended a private meeting of a few inhabitants for the purpose, but the project was not urged into effect till after some years had elapsed, when the same individuals undertook the task of establishing the Scarborough Philosophical Society with better omens and stronger assurances of support.

"Early in 1821 the writer walked through the eastern parts of Yorkshire and rejoined Mr. Smith at Doncaster, and from this point accompanied him in a walking excursion through the coal district of the West Riding, passing by Bamborough, Houghton, Cudworth, Shafton, Wakefield, Ardsley, Horbury, Thornhill (the Rectory of the Rev. John Michell, the celebrated Woodwardian professor), Flockton, Bretton, Haigh Bridge, Silkstone, Stainborough Inn, Wentworth Castle, Tankersley Park, Wentworth Park, Rawmarsh and Conisborough. In this excursion particular attention was given to determine the true general order of the coal beds, ironstone courses, and characteristic rocks, and the result is seen in a comprehensive section on the Yorkshire map, to which nothing similar had ever been attempted in this country, perhaps in Europe. From the notes and sketches made on this journey, the first page is taken to show the kind of information which it was

* loc. cit., pp. 94-96.

proposed to gather, besides the lines of outcrop of the strata marked on the map.

' " 4th April, 1821.—Walked westward by Barlby and Warmsworth to Sprotborough Ferry, and thence by Cadeby over the verge of the magnesian limestone there. Cadeby is so very ill supplied with water, that those who hold tbe pump handle must frequently wait some time till the niggard stream furnishes its scanty supply. There is, however, a pool in the place, and some springs appear above the edge of the hill which, as at Micklebring, is kept by the purple sandstone. Several yew trees mark its course. Before we arrive at the mill on the Dearn, some clay



ground and dark shades in the soil indicate the outcrop of the uppermost workable vein of coal. Melton Hall, to the right on the edge of the limestone, is very conspicuous. We now ascend a bold bank, and at the junction of the Barmborough and Melton road, wind round a sudden swell of limestone and sandstone, whose outcropping beds form around the face a series of natural entrenchments clothed with wood. Beyond this hill the ridge recedes from our road and leaves a broad vacancy, wherein we descry a coal pit. To our left is Barmborough Grange, standing on detached sandstone.

" The boring marked (*b*), now prosecuting with the hope of piercing the two coals found at Goldthorpe and Thurnscoe. The upper, at Goldthorpe, 70 yeards deep, thin and not desirable; the lower 105 yeards deep, 5 feet thick. Solid sinkings, soft floor, but immediately beneath hard sinkings repeated." '

"To assist Mr. Smith's researches the author made a variety of other journeys from Doncaster, as to Roche Abbey, Gringley-on-the-Hill, and Gainsborough. At length the materials for completing the geological map of Yorkshire were deemed sufficient, and this remarkable work was published in the summer of 1821, in four sheets."

Still later it is recorded by Phillips that:—

"Some professional engagements at Scarborough and in other parts of Yorkshire occasionally drew Mr. Smith's attention, and he was especially interested in arranging a plan for a better supply of water to Scarborough. The deficiency of water in the summer season, when Scarborough is full of visitors, was extreme; the structure of the promontory on which the town and castle stand is such as to yield only a very inconsiderable quantity of water on the spot; and the distant springs, which, by reason of their higher level, might be available for the supply of the town, are in general beyond the control of the corporation.

"One small spring on Falsgrave Moor was at the disposal of the engineer, and it was in the economising of this scanty rill that Mr. Smith exercised his ingenuity. He applied this ingenuity at each end of the water-course. In the hill he excavated a subterranean reservoir, which might preserve from surface waste the water at its origin, and in the town he constructed a large closed reservoir, to meet the irregular demand of a varying population. These plans were successful, the little spring became a great blessing; the town is benefited; but it has grown in size, and now requires a further effort to obtain further supplies from another source."

OTHER MAPS OF SOILS, ETC.

Of course it is not contended that Smith was the first to map soils and rocks, as the following notes will show.

GEORGE OWEN, 1595.

The old historians and topographers, as is well known, often made reference to facts of geological interest. Perhaps one of the earliest of these was George Owen of Henllys, in Pembrokeshire.* He refers to geological features in the following words, and, on comparing them with a geological map, it will be seen that Owen's observations were very reliable, though made over three centuries ago :—

In a chapter on " natural helpes, which is in the countrey to better the lande [' lyme' being the ' chiefest '] " he writes : " First you shall understand, that the lymestone is a vayne of stones running his course, for the most part right east and west, although sometimes the same is found to approach to the north and south. Of this lymestone there is found of ancient, two veynes, the one small and of no great account, and not of breadth above a butt† length, or stones cast ; and therefore whosoever seeketh southward or northward over the bredth misseth it."

The course of this " veyne " is then traced for a considerable distance ; and a third " veyne of lymestone " is referred to. We then read that " For the veyne of coales which is found between these two vaynes of lymestone, as a benefit of Nature, without which the profit of the lymestone were neare lost ; betweene the sayd two vaynes from the beginning to the ending, there is a vayne (if not several vaynes) of coles, that followeth those of the lymestone. This vayne of coal in some partes joineth close to the first lymestone vayne, as in Pembrokeshire, and Carmarthenshire ; and in some partes it is found close by the other vayne of lymestone, as in Glamorgan, Monmouth, and Somersetshire. Therefore whether I shall say that there are two vaynes of coles to be found betweene these two vaynes of lymestone, or to imagine that the cole should wreathe or turne itself, in some places to one, in other places to the other ; or to think that all the land betweene these two vaynes should be stored with coles, I leave to the judgement of the skilfull miners, or to those which with deep knowledge have entered into these hidden secrettes."

* A History of Pembrokeshire, from a manuscript by George Owen, Esq., of Henllys, Lord of Kemes, &c.,—now first published by his great-grandson, Richard Fenton, Esq., *Cambridge Register* for 1796, Vol. I., p. 52, London, 1799. *See also Phil. Mag.*, Dec. 1832., p. 443.

† *i.e.*, archery butts = the length of the flight of an arrow = 100 yards.—T.S.

MARTIN LISTER, 1683.

In Volume II. of the Yorkshire Archæological and Topographical Journal, 1873, is a "Memoir of Martin Lister, M.D., F.R.S., 1638-1712," by Robert Davies, F.S.A. Referring to Dr. Lister's contributions to the Philosophical Transactions, and printed by the Royal Society, Mr. Davies states: "The earliest of the communications, which he read to the Society in person, was probably that delivered at a meeting held on the 12th of March, 1683-4. This paper is extremely curious, and gave an impetus to the study of geology. It is entitled, 'An Ingenious proposal for a new sort of Maps of Countrys, together with Tables of Sands and Clays, such chiefly as are found in the north of England.' The author commences: 'We shall be better able to judge of *the make of the earth,* and of many phenomena belonging thereto, when we have well and duly examined it, as far as human art can possibly reach, beginning from *the outside downwards.* As for the most inward and central parts thereof, I think we shall never be able to confute Gilbert's opinion, who will, not without reason, have it altogether iron.

"And for this purpose it were adviseable that *a soile or mineral map,* as I may call it, were devised. The same map of England may, for want of a better at present serve the turn. It might be distinguished into *countries,* with the rivers and some of the noted towns put in. The *soile* might either be coloured, or otherwise distinguished by variety of lines or etchings; but the great care must be, very exactly to note on the map, where such and such soiles are bounded. As for example, in Yorkshire, 1. *The Woolds*: chaulk, flint and pyrites, etc. 2. *Blackmoor*: moores, sandstone, etc. 3. *Holderness*: boggy, turf, clay, sand, etc. 4. *Western Mountains*: moores, sandstone, coal, ironstone, lead-ore, sand, clay, etc. *Nottinghamshire*: mostly gravel pebbles, clay, sand-stone, hall-playster or gypsum, etc. Now, if it were noted how far these [soils] extended, and the limits of each soil appeared upon a map, *something more might be comprehended from the whole and from every part than I can possibly foresee,* which would make such a labour well worth the pains. For, I am of opinion, *such upper soils, if natural, infallibly produce such under minerals, and for the most part, in such order.* But I leave this to the industry of future times."

The annexed extract of a letter from Mr. Aston to Dr. Plot, at

Oxford, gives some further account of Dr. Lister's ideas. It is dated London, March 13th, 1683-4. "I received from Dr. Lister two schemes of the sands and clays found in England, made by himself about twenty years since. He mentioned besides the great advantage of a map of the earths peculiar to some places and countries; he considers the sand and clays as two of the coats of the earth; the sand, probably, the uppermost coat (for some reasons he gives), whence it comes to be washed to the body of rivers and the seashore. By this opinion, I perceive, may be given an account of sand-beds, too often attributed to the sea."*

Dr. Lister's scheme for a map of England, distinguishing the soils and their boundaries by colours, has certainly the merit of priority. Sir Charles Lyell acknowledges that Lister was the first who was aware of the continuity over large districts of the principal groups of strata in the British series, and who proposed the construction of regular geological maps. The scheme, however, was never carried out in his time.†

Dr. Lister retained his love of geological studies to a late period of his life. In 1696, writing to his friend Thoresby, he says: "I desire to know if John Bolland of Halifax be alive. If so, I desire you will inquire of him where he had the blue or black slate-stone he sent me to York, in every leaf of which, were it cleft into never so thin sheets, there were very fair impressions only, and not the substance, of pectenites or scollop-like shells; I imagine in some coal-pit about Halifax. If it can be found, I would have a good piece of it sent up to me by the carrier. I will most willingly and thankfully pay for it." ‡

JOHN STRACHEY, 1719.

In 1719 John Strachey contributed a paper on the Somersetshire Coal District to the *Philosophical Transactions*§ which was re-published

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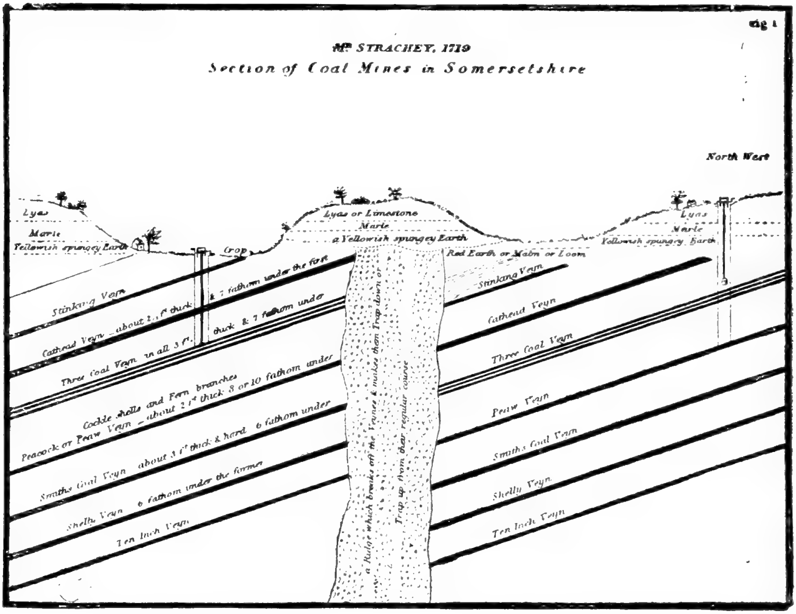
* Ashmolean MSS., No. 1813.

† The various soil maps appearing in the County Agricultural Surveys published by the Board of Agriculture, at the end of the eighteenth century and at the beginning of the nineteenth, carry out Lister's suggestion.

‡ Thoresby's Correspondence, Vol. I., p. 259. No doubt it refers to shale with *Aviculopecten*.

§ Vol. XXX., p. 968; another on the same subject followed in 1725, loc. cit., Vol. XXXI., p. 395.

in a pamphlet in 1729 (4to, 16 pp.), entitled, "Observations on the Different Strata of Earth and Minerals, more particularly such as are found in the Coal Mines of Great Britain." This is accompanied by a section of some coal-seams about ten miles south-west of Bath, which, on account of its early date, is reproduced herewith.* It will be noticed that this section, printed nearly two centuries ago, clearly defines the



Strachey's Section of Coal, etc., near Bath. 1719.

order and composition of the beds, their inclined position, their interruption by *ridges* (i.e., faults); and the occurrence above the coal-seams of freestone (Oolite), lias and red marl, lying horizontally upon and unconformably with the older beds. In his second paper the author states he had "never heard any coal was found to the west or south of Mendip-hills; so Cotswold to the N.E., and the chalk hills of Marlbury Downs and Salisbury Plain, seem to set bounds to the coal country."

The author concludes his paper with some weird and wonderful

* It is taken from the reprint, being slightly different from that published in the *Phil. Trans.* *See also Phil. Mag.*, Jan., 1833, Plate 2.

theories to the effect that "the foregoing or perhaps of ten thousand other minerals, all originally, while in a soft or fluid state, tending towards the centre; it must mechanically, and almost necessarily follow, by the continual revolution of the crude mass from west to east, like . . . . rolling up the leaves of a paper book . . . . must in some place or other, appear to the day, in which case there needs no specific gravitation to cause the lightest to be uppermost, etc., for every one in its turn, in some place of the globe or other will appear near the surface." This part of his paper, which is illustrated by a plan of the beds of the earth (which resembles the plan of a spiral staircase), does not interest us, except that on his sketch he gives the following order for the beds:—

Chalk.
Freestone [Oolites].
Limestone } [Lias].
Marl }
Yellow Earth } [Trias and Permians].
Red Earth }
Coal Cliffs } [Carboniferous].
Coal }
Lead, Copper, etc.

JOHN WOODWARD, 1723.

John Woodward, in his *Natural History of the Earth*, 1723, pp. 4-6, expressed views somewhat similar to those of Smith. He says: "I made strict enquiry wherever I came, and laid out for intelligence of all places where the entrails of the earth were laid open, either by nature (if I may so say) or by art and human industry. And wheresoever I had notice of any considerable natural spelunca or grotto, any sinking of wells, or digging for earths, etc., or the like, I forthwith had recourse thereunto. The result was, that in time I was abundantly assured that the circumstances of these things in remote countries were much the same as those of ours here."

NICOLAS DESMAREST.

Still before Smith's time were the views of Desmarest, as expressed in the *Encyclopedie Methodique*,* of which the following is a translation:

* *Geographie Physique*, tom I., pp. 416-417. (LXIV Livraison).

"That these bodies were not thrown haphazard nor in the state of confusion as before his time had been commonly believed—in place of this confusion a constant order is to be recognised in the arrangement of the shells, *certain individuals of which keep apart* and are not mixed with others which also have their tribes separate; that certain individuals are met constantly together, *whilst others are never found in the same beds, in the same layers*; that these collections of fossil shells, at the surface of certain parts of our continent, were in the same state of arrangement and distribution, as in the basin of the sea, where certain testaceous animals live together occupying the same habitat, and there form those species of societies or families, just as do certain plants which grow always in association on the surface of the earth."

CHRISTOPHER PACKE, 1743.

Dr. Packe "invented and delineated" "A New Philosophico-chorographical Chart of East Kent," in which the valleys and other physical features were shown, with the chalk districts, stone hills, clay hills, etc. There is, however, no reference to stratification. Dr. Packe was proud of his work. It was "no dream or devise, the offspring of a sportive or enthusiastical imagination, conceived and produced for want of something else to do, at my leisure in my study, but it is a *real* scheme, taken upon the spot with patience and diligence, by frequent or rather continued observations, in the course of my journeys of business through almost every the minutest parcel of the country; digested at home with much consideration, and composed with as much accuracy, as the observer was capable of."

JOHN MICHEL, 1760.

An anonymous writer* in *The Edinburgh Review* for 1818 points out that the most important observations on the subject of stratification that had hitherto appeared were made by the Rev. John Michel, in a paper on "The Course and Phenomena of Earthquakes," published in the *Philosophical Transactions* of 1760.† In this contribution the author not only states the general appearance of the strata, their

* This article was described by Phillips as "the most able, just, and discriminating survey of the progress of English Geology ever penned," and he implies that it was written by Dr. Fitton.

† Vol. LI., Part II., p. 566., Sect. 37 to 49.

identity of character, continuity and uniform thickness in length and breadth for many miles, the great inclination of the beds in mountainous countries, and their approach to the horizontal position in flat ones; but he clearly explains the arrangement of the strata in England. He states: "Let a number of leaves of paper, of several different sorts or colours, be pasted upon one another; then bending them up together into a ridge in the middle, conceive them to be reduced again to a level surface, by a plane so passing through them as to cut off all the part that has been raised; let the middle now be again raised a little, and this will be a good general representation of most, if not all large tracts of mountainous countries, together with the parts adjacent, throughout the whole world. From this formation of the earth it will follow *that we ought to meet with the same kinds of earths, stones and minerals, appearing at the surface, in long narrow slips, and lying parallel to the greatest rise of any long ridge of mountains*; and so in fact we find them. . . . . In Great Britain we have another instance to the same purpose, where the direction of the ridge varies about a point from N. by E. to S. by W. of which I could give many undoubted proofs. . ." As an example of the large extent of strata in level areas he says: "the chalky and flinty countries of England and France, which (excepting the interruption of the Channel and the clays, sands, etc., of a few counties), compose a tract of about 300 miles each way," and he adds that "the highest rise of the ridge, and the inclination of the strata, have very considerable irregularities," and this often makes it difficult to trace the appearances I have been relating, which, *without a general knowledge of the fossil bodies of a large tract of country, it is hardly possible to do.*"

JOHN WHITEHURST, 1778.

In 1778* Whitehurst published an "Inquiry into the Original State and Formation of the Earth," which contained information on "organised fossils," and he includes a chapter on "The Structure of Derbyshire and other parts of England." He states: "The arrangement of the strata being such that they invariably follow each other as it were in alphabetical order, or as a series of numbers. *I do not mean to insinuate that the strata are alike in all the different regions of the earth with respect to thickness or quality, for experience shows the*

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* 2nd ed., 1786.

contrary; but that in each particular part, how much soever they may differ, yet they follow each other in a regular succession. And again*: "It is my intention to have deposited specimens of each stratum, with its productions, in the British Museum, arranged in the same order above each other as they are in the earth; being persuaded that such a plan would convey a more perfect idea of subterraneous geography, and of the various bodies enclosed in the earth, than words or lines can possibly express." This project was subsequently carried out by Smith!

JOHN SMEATON, 1788.

In the *Philosophical Magazine* for 1810 (Vol. XXXVI., pp. 102-3) is a paper with the following somewhat remarkable title:—

"Information that a further Publication of the late Mr. Smeaton's Engineery Designs and Papers is in hand. Copy of a list of the principal British Strata by the late Rev. John Michel (of whose posthumos Papers on Geological subjects further information is requested)—with some experiments of Mr. Smeaton's on Limestones, and Queries respecting Mr. Tofield, communicated by Mr. John Farey to Mr. Tilloch."

This contains a list of strata, with details of their thickness, circa 1788, which is of interest for comparison with Smith's list dictated to Mr. Richardson in 1799. The following is an extract:—

"As my eldest son was a few days employed in examining the miscellaneous bundles of papers, which belonged to the late ingenious Mr. John Smeaton, the civil engineer, now in Sir Joseph Banks's possession, with a view to further publication by Messrs. Longman, Hurst, Rees & Co. of his Drawings and Reports on civil engineery, which so long and impatiently have been expected by those interested in this branch of the useful arts, he found a small scrap of paper (only four inches by three) in the handwriting of Mr. Smeaton, part of the cover of a letter, as appears by part of a seal and the London post-mark of November 21st, 1788, on the back of it, which, having obtained Sir Joseph's permission, I think of sufficient importance, in a geological point of view, to request the favour of you to lay before your readers."

"It relates to the order and thicknesses of the *strata* in England, as

* 2nd ed., pp. 178 and 180.

appears by Mr. Smeaton's title or endorsement on it, viz., "Mr. Michel's account of the south of England Strata," which is as follows, viz.:—

	Yards.	
Chalk	120	
Golt	50	
		Sand.
Sand of Bedfordshire	10 or 20	
Northampton lime and Portland limes lying in several strata	100	
Lyas strata	70 or 100	
Sand, of Newark	about 30	
Red Clay, of Tuxford and several	100	
Sherewood Forest Pebbles and Gravel ...	50	unequal
Very fine and white sand		uncertain
Roch Abbey and Brotherton limes	100	
Coal Strata of Yorkshire		,,

"The Mr. Michel alluded to, was, it appears, the late Rev. John Michel, Rector of Thornhill, near Wakefield, Yorkshire, who was an intimate friend of Mr. Smeaton, the late Mr. Cavendish, etc., etc., and whose name must be very familiar to most of your readers, from his many valuable papers in the Transactions of the Royal Society of London, of which he was a member."

"This account of the strata, imperfect as it is, appears to me important as showing that Mr. Michel was acquainted with the principal features of the south of England strata, at an earlier period than any thing was published on the subject, especially if we suppose, as is most reasonable, that this communication was made verbally by Mr. Michel to his friend Mr. Smeaton, very soon after November, 1788, who took it down on the cover of a recent letter as being the only piece of paper then at hand; for Mr. Smeaton's decease in September, 1792, shows that it must have been prior to that time."

SMEATON, 1791.

Dr. Fitton states that: "The most direct instance that we have met with, of the actual tracing the course of any of the strata of England, before the commencement of Mr. Smith's investigations, occurs in the celebrated work of Smeaton on the Eddystone Lighthouse, and it affords an excellent proof of the practical benefit to be derived from geological enquiries. Mr. Smeaton was in want of lime which possessed the property of forming a good cement for works exposed to the sea; and finding the lime afforded by the lias limestone at Aberthaw, on the coast of Glamorganshire, to answer his purpose, he was led to seek for stone of the same qualities in other places. This he found, in the first instance at Watchet, on the Somersetshire coast, 'where all agreed that they were the very same stratum of lias limestone, that were found on each side the Channel, though at the distance of twenty miles.' He went accordingly to Watchet, and examined the situation of the beds there, which he has very well described; and he subsequently traced the progress of the lias, through Monmouthshire and the intermediate counties, as far north as Newark in Nottinghamshire, a course which corresponds precisely with the results of more recent investigation. He mentions likewise, that Mr. Cavendish and Dr. Blagden had assured him of its existence at Lyme on the cast of Dorsetshire, which is the more remarkable, as a considerable mass of other strata intervenes upon the surface between that place and those which Mr. Smeaton had examined himself. It is not, however, improbable that Smeaton's inquiries upon this subject may have been connected with some previous communication with Mr. Michel; since he appears to have received from that gentleman, the list of the strata to which we have already referred, before the publication of his own work on the lighthouse."*

AGRICULTURAL SURVEYS, 1794.

In 1794 and the following few years, the Board of Agriculture published a series of County Surveys. Several of them contained maps indicating the nature of the surface soils by colours. In the Devonshire map "dunstone" and "limestone" occur in the list of soils, and on two of the others coal tracts are shown. There are no suggestions of stratigraphical structure, however, though there are a few sections of coal pits, etc.†

* Dr. Fitton points out that Smeaton's book, though dated 1791, is stated in the Introduction to have been printed in 1786. I can find no such information in my copy, though no doubt the fact that mine is the second edition, and dated 1793, accounts for the difference.—T.S.

† Details of the dates of publication of these various County Surveys occur in Sir Ernest Clarke's account of "The Board of Agriculture, 1793-1822," in *Journ. Roy. Agric. Soc.* 3rd Series. Vol. 9, 1898, pp. 1-41.

Through the kindness of Lord Selborne, I have recently had an opportunity of seeing the collection of these County Surveys in the Library at the Board of Agriculture and Fisheries, Whitehall Place. The soil maps are remarkably well done in many cases, and there is no doubt they were of guidance to Smith in his work. There are references to Dunstone, Freestone, Red Marl, Brash, etc., which words Smith subsequently used. In some cases, the colouring is remarkably like that adopted by Smith. We know that for several years he regularly attended the meetings of various agricultural societies.

JAMIESON, 1811.

In the *Memoirs of the Wernerian Society*, Vol. I., pp. 149-161, 1811, Prof. Jamieson in an article "On Colouring Geognostical Maps," stated that "the structure of geological maps, upon the plan of representing by colours the succession of the strata or formations, was also devised by Werner; so that it would seem, upon the whole, that a system coincident with the principles of Mr. Smith, so far as they extend, had been delivered in the publications and lectures of Werner before the period when the latter began his investigation of the neighbourhood of Bath." Werner's printed publications being few, however, it is difficult to trace the precise extent of his work.

The writer in *The Edinburgh Review* * stated that "Since the date of Lister's project for 'a soil, or mineral map,' there have been published, we believe, some attempts at a geological map of England, but we have not been so fortunate as to see them; and of the numerous continental maps, those of the older German writers, of Guettard in France, and the recent publications of the Wernerian school, are the only ones that have fallen within our examination. The maps which *Buache* published between 1745 and 1761, are described as relating more properly to physical geography than to geology; and they proceed upon a visionary hypothesis, about a certain framework or skeleton of the earth, which the author imagines to consist in chains of mountains, traversing the islands as well as continents throughout the face of the globe. The object of Guettard, in his improved collection of 1775, was merely to mark upon ordinary maps, in the characters employed by chemists, the several mineral substances found at each place; a plan obviously very defective and radically different from that which

* loc. cit., p. 321.

expresses the order of the strata, by colours. The maps referred to by the late M. Desmarest, as annexed to the *Encyclopedie Methodique,* have not yet appeared. But that author insists upon the great instruction to be derived from combining vertical sections with horizontal maps, and the benefit arising in general from even the attempt to reduce to maps, the results of geological investigation."

JAMES PARKINSON, 1811.

In the first volume of the quarto *Transactions of the Geological Society* of London, 1811, p. 325, is a paper on "Observations on some of the Strata in the Neighbourhood of London," by James Parkinson. He states that the method of identifying fossils with particular strata was "long since recommended by W. Smith, who first noticed that *certain fossils are peculiar to and are only found lodged in, particular strata*; and who first ascertained the constancy in *the order of superposition*, and *the continuity of strata of this island.*" He adds that "these observations have also lately occurred to Messrs. Cuvier and Brongniart whilst examining into the nature of the strata in the neighbourhood of Paris." The following is a translation of Parkinson's quotation:—

"This constancy in the order of superposition of the thinnest of layers and along an extent of 12 myriametres (75 miles) is, in our opinion, one of the most remarkable facts that we have established in the course of our researches. From them, for the arts and for geology, should result consequences the more interesting the more certain they are.

"The method that we have adopted for recognising in the middle of such a large number of calcareous beds, a bed already observed in a place a long distance away, is taken from the nature of the fossils discovered in each stratum; these fossils are always in a general way the same in corresponding strata, and present differences of species sufficiently distinguishable from one system of strata to another system. It is a method of examination which has not up to the present deceived us."

SMITH'S GEOLOGICAL WORK.

I propose now to deal with the geological work Smith accomplished.

SMITH, 1799.

" A Map of Five Miles round the City of Bath, on a scale of one inch and a half to a mile, from an Actual Survey, including all the new roads, with Alterations and Improvements to the present time, 1799. Printed for and sold by A. Taylor and W. Nayler, Booksellers, Bath." *

The map is circular, and fifteen inches in diameter. It bears the following inscription in Smith's handwriting :—

" Presented to the Geological Society, February 18th, 1831. Wm. Smith, Coloured Geologically in 1799."

" Though no lines are drawn, Smith's well-known method of colouring the base of a formation with a deep tint, and shading this upwards towards the outcrop of the next overlying stratum, enables us to see how carefully he had mapped all the geological lines around Bath. There are only three colours employed on the map and no index ; but it is evident that the yellow tint represents the Bath Oolite, the base of the freestones being very accurately mapped so that even the smallest outlines can be made out agreeing most closely with the map of the Geological Survey ; a blue tint is drawn at the base of the Lias, and a red one at the base of the Trias, the inliers of Carboniferous being left blank."

This " may be justly regarded as the oldest geological map in existence."† It is hung in the library of the Geological Society, Burlington House.

SMITH. 1800.

In 1800 Smith coloured a geological map connecting the structure of the north of England with the structure of the South-western districts, and delineating the whole oolitic series through England, in some places very correctly, and in all with a general approach to accuracy. This

* This excellent map, though with the date in one place altered to 1800, but with 1799 in another, appears in a fine work, " The Historic and Local New Bath Guide," 12mo, 160 pp., and there can be no doubt Smith obtained it from this source, and added the colours.— T.S.

† J. W. Judd.—Wm. Smith's MS. Maps, *Geol. Mag.*, 1897, pp. 439-447.

map, in 1831, was in the possession of John Phillips, the Curator of the York Museum.* It appears to be lost now.

SMITH, 1801.

"General Map of the Strata found in England and Wales, by Wm. Smith, Surveyor, 1801."

The geological features are coloured on a copy of Cary's index to the Map of England, which measures 11 inches by 9 inches. On the side of the map is written, "Wm. Smith, Midford, near Bath," and on the bottom, "Presented to the Geological Society by Wm. Smith, February 21, 1831," all the inscriptions being in Smith's own writing.

"The colours adopted . . . appear to have been very similar to those used in Smith's later engraved maps. There is nothing in the way of an index of colours attached to this first geological map of England and Wales, but, by reference to the author's later publications, it is not difficult to determine what the several bands of colour are intended to indicate. The formation of which the outcrops are represented range from the chalk to the Old Red Sandstone, the colours employed being eight in number, though a number of other signs, indicating collieries, mines, and slate quarries, adds much to the valuable information supplied by this remarkable map. The strata represented are, in descending order, as follows:—

1. Chalk (*green*).
2. "Sand of Portland Rock" with which is confounded (as in later maps) the Carstone of Norfolk (*purple*).
3. Oxford Clay ("Clunch Clay" of Smith) (*grey*).
4. Oolite. The Outcrop represented is that of the Great Oolite of the Bath area, and of the Inferior Oolite both south and north of that area (*yellow*).
5. Lias (*dull blue*).
6. Trias and Permian ("Red Marl" of Smith) (*light red*).
7. Carboniferous Limestone, with which is confounded the Magnesian Limestone (*bright blue*).

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* *See* Prof. Sedgwick's Address, *Proc. Geol. Soc.*, Vol. I., 1834, p. 273.

8. Old Red Sandstone (*reddish brown*)." *

This map, the first sketch towards Smith's great map of 1815, is hung in the library of the Geological Society.

SMITH, MS. 1801.

Among the papers left behind by Smith was one dated 1801, which was probably the work Smith had in mind when issuing his first prospectus in 1800. It is entitled : "*Plan* of the Work : To be divided into Two Parts." The *First* of which should treat of the structure of the earth, or general disposition of the most remarkable known strata, collected from the best authorities, and arranged according to the order discovered in England, and the *Second* should enter into the particulars of each stratum, with the fossils and minerals that have hitherto been discovered, with their connection and dependence one upon another. Though it is impossible for the labours of an individual ever to acomplish a thousandth part of what is proposed by this section ; yet when a system is established which has Nature for its prototype, every one will be enabled to contribute his mite, and carry it on from time to time, till after ages may get a tolerable description of the habitable world.

"*Many* sections of the strata, in different directions, will be necessary to show their various inclinations. In the general section, each principal stratum should be numbered with progressive numbers, beginning at the eastern strata of the kingdom ; or, till that can be accurately ascertained, at some stratum that forms a grand feature therein. As for instance, the chalk which I would call No. 1 ; and those lesser strata which are contained within it, or generally attached to it, or form any subdivisions therein, I would call 1a, 1b, 1c., &c. If any thin stratum should be omitted, or a new one discovered, it may be brought into those numbers, by making it 1aa, &c.

"After the general section of a country or district, should follow a large section of each stratum, with its concomitant small strata ; with drawings and descriptions of such peculiarities as the principal stratum, or those connected with it, are found to contain ; whether the exuviae of marine animals, vegetable impressions, or fossil wood, coal, and metal of every description.

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* J. W. Judd., *Geol. Mag.*, 1897, pp. 446-7.

"The same numbers which refer to the section, may refer to an explanation of the chemical properties of each substance, so far as discovered. This may be placed at the end of a book, or make a separate volume where those properties may be more minutely examined than can consistently be done in the body of the work, which is intended to form a true representation of the order of *Nature*, with no more digressions from the main subject than are absolutely necessary to make it intelligible. Plates should be bound up at the end of each volume, in a peculiar manner; these, as well as the strata, to make them more striking, should be coloured.

"The Second Section of the work may be divided into chapters, each stratum making a chapter or division, to which its name in conspicuous characters should stand as a title. The names of particular substances described in this division should also appear conspicuous and striking as well as the places they are found at, or near to; and a more particular *section* will accompany each part of the work, with a map divided into squares, or published in parts, which may be united together, and form a complete map and general section on a large scale. [Query, Map of each Stratum ?].

"The chemical part, which refers to the other by the numbers, may be arranged under the heads Iron, Coal, Limestone, &c. By this means those veins which lie very distant from each other, will admit of an easier comparison. This should form a summary of the more useful minerals."*

Fortunately we are able to show precisely what claims Smith had to priority in the way of geological mapping. When the first Wollaston Medal was awarded to him in 1831 he presented to the Society "some documents referred to in the president's address." These were:—

(1) A Table of the Order of Strata, and their imbedded Organic Remains, in the vicinity of Bath; examined and proved prior to 1799.

(2) A map of the country five miles round Bath, on the scale of one and a half inches to the mile. "Coloured geologically in 1799, by William Smith."

(3) The first draft of a geological map of England and Wales, entitled "General Map of Strata found in England and Wales, by William Smith, surveyor, 1801."

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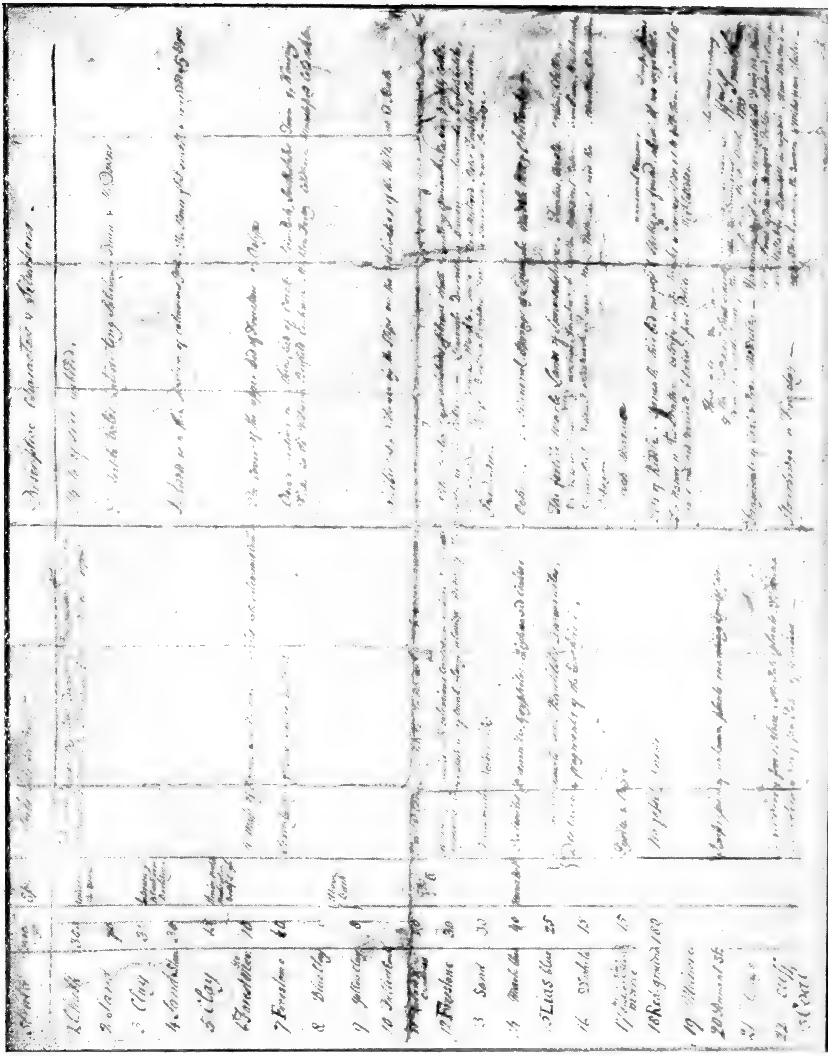
* *See Phil. Mag.*, Jan., 1833, pp. 48-9.



The original Table of Strata near Bath, dictated by W. Smith, and written by the Rev. Joseph Townsend, in 1799.

These documents, already referred to, were carefully preserved by the Society, though they are now considerably faded, and the old varnish on them does not add lustre ! A few years ago they were carefully copied and critically examined by Professor J. W. Judd,* copies being placed in the Science Museum at South Kensington ; the library of the

Plan of Bath, upon which Smith's first Geological Map is based. Reduced from "The Historic and Local New Bath Guide." 1799.

Geological Society ; the Natural History Museum, South Kensington ; and the British Museum Library at Bloomsbury. By the help of Mr. C. Davies Sherborn and Mr. Parsons, I am able to give reproductions of the photographs in the Natural History Museum, South Kensington, as these show the details more clearly than would photographs of the

* William Smith's Manuscript Maps, *Geol. Mag.*, 1897, pp. 439-447.

originals in the Geological Society's possession (Plates X.-XII.). I also give a reproduction (reduced) of the circular map in *The New Bath Guide* which was the basis of No. 2.

The first in the list is described by Phillips* :—

"One day, after dining together in the house of the Rev. Joseph Townsend (29 Pulteney Street, Bath) it was proposed by one of this triumvirate (Smith, Richardson and Townsend) that a tabular view of the main features of the subject, as it had been expounded by Mr. Smith, and verified and enriched by their joint labours, should be drawn up in writing. Richardson held the pen and wrote down from Smith's dictation, the different strata according to their order of succession in descending order, commencing with the Chalk, and numbered in continuous series, down to the Coal, below which the strata were not sufficiently determined. To this description of the strata was added, in the proper places, a list of the most remarkable fossils which had been gathered in the several layers of rock. The names of these fossils were principally supplied by Mr. Richardson, and are such as were then, and for a long time afterwards, familiarly employed in many collections near Bath. Of the document thus jointly arranged, each person present took a copy, under no stipulation as to the use which should be made of it, and accordingly it was extensively distributed, and remained for a long period the type and authority for the descriptions and order of superposition of the strata near Bath."

The table referred to, bears the following inscription in the handwriting of Smith :—"This Table of Strata, dictated by myself, is in the handwriting of the Rev. Ben$^{n.}$ Richardson, and was first reduced to writing at the house of the Rev. Joseph Townsend, Pulteney St., Bath, 1799. William Smith."

This important table of strata is reproduced in Phillips's "Memoirs" (p. 30) and many of the names there given are still in general use.

The headings are "Strata; Thickness; Springs; Fossils; Petrifactions, etc., etc.; Descriptive Characters and Situations. The Strata given are (1) Chalk, (2) Sand, (3) Clay, (4) Sand and Stone, (5) Clay, (6) Forest Marble, (7) Freestone, (8) Blue Clay, (9) Yellow Clay,

* Memoirs, p. 29.

Smith's Geological Map of the District near Bath. 1799.

The first Geological Map of England and Wales. By W. Smith. 1801.

(10) Fuller's Earth, (11) Bastard ditto and Sundries, (12) Freestone, (13) Sand, (14) Marl Blue, (15) Lias Blue, (16) ditto White, (17) Marl Stone, Indigo and Black Marl, (18) Red-ground, (19) Mill Stone, (20) Pennant Street, (21) Grays, (22) Cliff, (23) Coal.

The fossils of No. 11 are: "Striated cardia, mytilites, anomiæ, pundibs and duck-muscles" (*sic*), and of 12: "Top covering anomiæ with calcareous cement, strombites, ammonites, nautilites, cochliæ hippocephaloides, fibrous shell resembling amianth, cardia, prickly cockle, mytilites, lower stratum of coral, large scollop, nidus of the muscle with its cables."

With regard to the second document in the series, as Prof. Judd points out, it is "even more interesting, as it may justly be regarded as the oldest *geological* map in existence, if we distinguish geological from agricultural or soil maps. . . . How far William Smith was in advance of his contemporaries, is shown by a comparison of this map of William Smith, showing carefully indicated lines of outcrop, with the excellent map of the Environs of Paris by Cuvier and Brongniart (1809) in which colour is spread over the areas occupied by the several formations, without any clear and definite indications of the actual limits of the outcrops. The colours used by Smith in this map were the same as those employed by him in the later maps of 1801 and 1815, and thus we have in it the first indication of a scheme of colour now very generally adopted by geologists."

The third document is a copy of Cary's Index to the Map of England coloured geologically. It has the manuscript title, "General Map of Strata found in England and Wales by William Smith, Surveyor, 1801."* (See under Smith, 1801). This map was the basis of his later map of 1815. "Certain omissions and errors are noteworthy as affording the clearest evidence that the map was actually constructed at the date written upon it (1801), and that it had no additions made to it at a later date. The absence of any colouring for the Tertiary Strata of East Anglia and the London and Hampshire Basins, for the Wealden area, and for the Jurassic district of the Eastern Moorlands of Yorkshire, are especially striking in this connection."

* It now bears the signature and date :—"W. Smith: Feb. 21st, 1831," this having been put on at the time the document was handed to the Society.

SMITH'S PROSPECTUS, 1801.

In 1801 a 4-page 8vo prospectus was issued by W. Smith, dated at "Midford, near Bath, June 1st, 1801." It was entitled :—

> "PROSPECTUS OF A WORK, / ENTITLED / ACCURATE DELINEATIONS / AND / DESCRIPTIONS / OF THE / NATURAL ORDER / OF THE VARIOUS / STRATA / THAT ARE FOUND IN DIFFERENT PARTS OF / ENGLAND AND WALES: / WITH PRACTICAL OBSERVATIONS / THEREON. / BY WILLIAM SMITH, / LAND-SURVEYOR AND DRAINER, / AND MEMBER OF THE BATH AGRICULTURAL SOCIETY," etc.

It was evidently intended to be fairly comprehensive, as we learn that "the Philosopher may derive an inexhaustible fund of valuable information. The miner may learn more readily, as well as more certainly, to trace the course of his ore; and, while his ideas are extended a curiosity will naturally be excited, that may pave the way to new and unthought-of discoveries. The various artists employed in building, from the humble Mortar-maker to the enlightened Architect, must all be interested in a method of discovering sand, clay, stone, slate, and other materials, and of selecting with certainty such as are best. Fullers, Founders, Glass-makers, etc., will learn where to send for earths and sands of the qualities best suited to their respective purposes; and sources of supply will, probably, be opened in places of which they now entertain no idea. Chemists, Colour-men, Vitriol, Alum, and Salt-makers, will learn how to trace the materials they have occasion for; and will be enabled frequently to obtain, at once, the different advantages of more convenient situations, smaller expense, and an improved quality. The Canal Engineer will be enabled to choose his stratum, find the most appropriate materials, avoid slippery ground, or remedy the evil. The Building Contractor may also form his estimates with more certainty to himself, and more satisfaction to his employer, by the experience he has had, and the observations that he will be lead to make on similar works in a like stratum. Brick-makers, Potters, and others, are also interested in a knowledge of the correct Theory of those materials which furnish their sole employment. Indeed, there are but few of the most necessary occupations of life, that may not derive from this Work some useful hint or improvement."

Further, "The discovery of this regularity in the process of Nature, led the author to a complete knowledge of all springs, and the Drainage

An original befor Title

PROSPECTUS OF A WORK,

ENTITLED,

ACCURATE DELINEATIONS

AND

DESCRIPTIONS

OF THE

NATURAL ORDER

OF THE VARIOUS

STRATA

THAT ARE FOUND IN DIFFERENT PARTS OF

ENGLAND AND WALES:

WITH

PRACTICAL OBSERVATIONS

THEREON.

Presented to the Geological Society Feby. 18th 1831 by Wm. Smith

BY WILLIAM SMITH,

LAND-SURVEYOR AND DRAINER,
AND MEMBER OF THE BATH AGRICULTURAL SOCIETY.

"All Nature is but Art unknown to thee;
All Chance, Direction which thou canst not see;
All Discord, Harmony not understood;
All partial Evil, universal Good." POPE.

IT cannot be necessary to use many words in pointing out, to persons of judgment and discrimination, the uses to which discoveries of the nature above alluded to, may be applied; for what can be of greater importance in human science, than a Complete Theory of the Soil, which man is under a divine injunction to cultivate and replenish, that he may derive from that labour his daily subsistence? As on this particular province, therefore, depends the acquisition, not only of his own conveniencies and comforts, but those of every other creature that has been subjected to his will, too

Printed by B. M'Millan, Bow-street, Covent-garden.

Fac-simile, very slightly reduced, of the first page of Smith's Prospectus of 1801, with Smith's handwriting. The words "befor Title" are in pencil; possibly in another hand.

of Wet Lands, which he is now practising in different parts of the kingdom, in the fullest confidence of being able to effect a complete cure on the most difficult subject of experiment."

On page four are the following "CONDITIONS." "The Work will be comprized in One Volume, 4to. Price, to subscribers, Two Guineas; to be paid on the delivery of the Work, which will be published in November next.

"The subject of discussion will be arranged under the separate heads of Sand, Chalk, Free-Stone, Coal, &c., &c., in the same succession as they are found in the earth.

"A correct map of the strata will be given; describing the general course and width of each Stratum on the surface; accompanied by a General Section, shewing their proportion, dip and direction; and referring to the Map by corresponding numbers and proper explanations.

"The Maps and Sections, to make them more striking and just representations of Nature, will be all given in the proper colours."

The Prospectus in the Geological Society's possession bears the following inscription in Smith's own handwriting: "An Original. Presented to the Geological Society, February 18th, 1831, by Wm. Smith."

The proposed work was not issued, principally through the failure of the publisher, Debrett. Part of it was incorporated in the "Stratigraphical System of Organised Fossils, 1817," on the title page of the Geological Society's copy of which the Prospectus, the only one I have been able to find, is pasted.

MAP OF SOMERSETSHIRE, 1805.

In this year Smith had completed a large and detailed Map of Somersetshire, and it was publicly exhibited and described at meetings of the Agricultural Society, etc. It was also shown in a form not quite so advanced, at a meeting of the Agricultural Society at Bath in 1799. Unfortunately this map is lost.

"TREATISE ON IRRIGATION," 1806.

On the title page of Smith's "Strata Identified by Organised Fossils" (1816) reference is made to his book "A Treatise on Irrigation." This work at first I had great difficulty in tracing. I was told that there was not a copy in the Library of the Geological Society in London ; but later one was found, the Title, as mis-quoted by Phillips, apparently being misleading. Phillips, in his Memoir of William Smith, makes only a very brief reference to it (p. 49) and adds, " It has long been out of print." That was in 1844, and I feel sure that even Phillips never saw a copy, especially as the title given by him is nothing like that given on the work itself. As Phillips was born in 1800, he would only be a boy of six when the book was published.

However, after repeated advertising in the second-hand book-trade journals, and searching in innumerable channels, I was at last successful in securing a copy. It is 8vo in size, bound in boards. On the back is a label, " Smith on Water Meadows, &c. " ; and on the front, " Smith / on / Water Meadows, / Draining, / Peat Bogs, / and other Improvements." The title page, however, reads :—

> " OBSERVATIONS / ON THE / UTILITY, FORM AND MANAGEMENT / OF / WATER MEADOWS, / AND THE DRAINING AND IRRIGATING / OF / PEAT BOGS, / WITH / AN ACCOUNT OF PRISLEY BOG, / AND OTHER / EXTRAORDINARY IMPROVEMENTS, / CONDUCTED FOR / HIS GRACE THE DUKE OF BEDFORD, / THOMAS WILLIAM COKE, ESQ., M.P./ AND OTHERS ; / BY WILLIAM SMITH, / ENGINEER AND MINERALOGIST. / NORWICH : PRINTED FOR JOHN HARDING, 66, ST. JAMES'S STREET, / LONDON, / 1806."

On the back of the title page, at the bottom, is the imprint :— " Printed by Bacon, Cockney Lane, Norwich."

The " Contents " reads :—" Dedication, Preface, Introduction, The Origin and Antiquity of Water Meads, Their Advantages, Their Formation, Their Management, Low Meads and Marshes, The Prisley Bog, Various Water Meads, Lexham Water Meads, Ancient Water Meads, Conclusion." The Volume has v.+121 pages, and two plates ; No. 2 (frontispiece) " Plan of a Water Meadow made out of that part of a Bog on Prisley Farm which was attempted to be drained in 1795, completed by Wm. Smith 1803 " ; and Plate I., " Plan of a Water-Meadow, made out of a Bog at Prisley Farm, belonging to His Grace the Duke of Bedford, by Wm. Smith, 1803. Containing 9 acres."*

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* The method of shading, as shown on these plans, is very similar to that in some of the old County Agricultural Surveys already referred to.

In this book William Smith frequently gets away from his subject, and his lengthy sentences take some following. Perhaps I may quote three, taken from his Preface :—" The want of the knowledge of lines and levels, in the generality of our farmers, may enable

OBSERVATIONS

ON THE

UTILITY, FORM AND MANAGEMENT

OF

WATER MEADOWS,

AND THE

DRAINING AND IRRIGATING

OF

PEAT BOGS,

WITH

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AND OTHER

Extraordinary Improvements,

CONDUCTED FOR

HIS GRACE THE DUKE OF BEDFORD

THOMAS WILLIAM COKE, ESQ. M. P.

AND OTHERS;

BY WILLIAM SMITH,

ENGINEER AND MINERALOGIST.

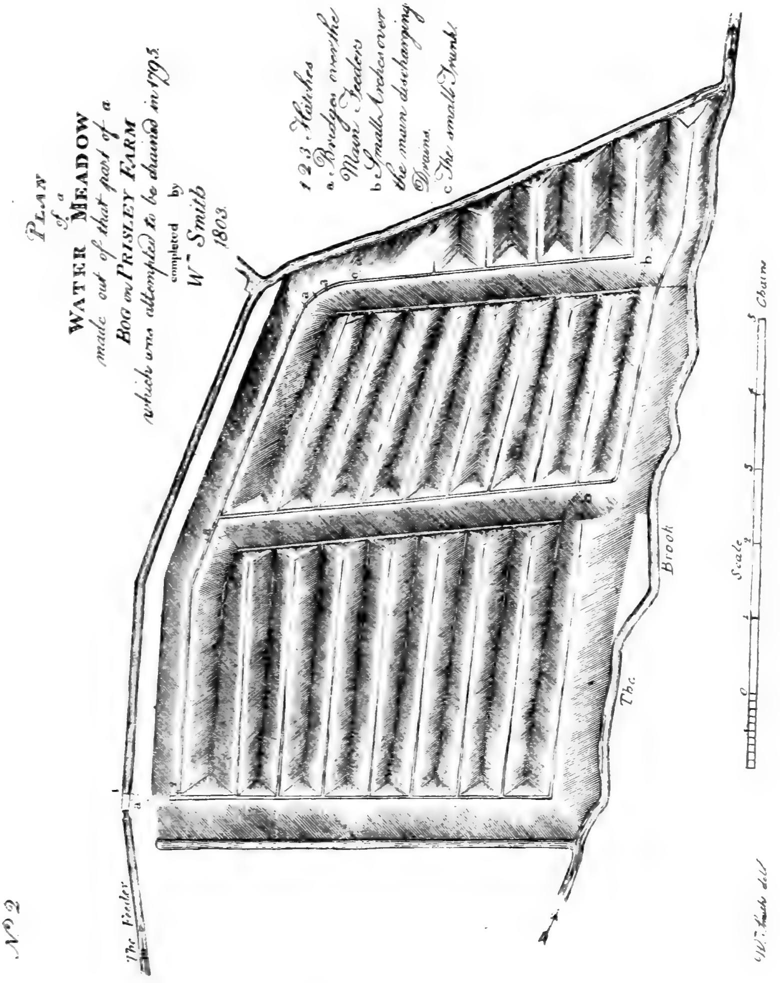
NORWICH: PRINTED FOR JOHN HARDING, 66, ST. JAMES'S-STREET

LONDON.

1806.

Fac-simile of Title of Smith's "Treatise on Irrigation," reduced.

us to account for the neglect of the important aid they afford ; and there can be no doubt but it would be much better for society, and much more condusive to improvements in agriculture, if farmers' sons were well instructed in practical geometry and the use of mathematical instruments, with the principles of machines intimately connected



Fac-simile of plate in Smith's "Treatise on Irrigation," reduced.

with their profession, instead of spending their time in learning latin, or pursuing other studies, for the attainment of which, not one out of a hundred has any occasion. This misapplication of time in early youth, is of much more consequence to society, than one half of the world is either aware of or inclined to believe. Youth is the time for collecting the useful information which lays the foundation of that knowledge, which is so highly beneficial to ourselves and society—for any man who employs his thoughts, may have an opportunity of making many serviceable observations, and suggesting hints for the purposes of improvement, without being educated as an author."

"This," he tells us, "has been my own case"! He was also fond of "poetry," good sprinklings of which occur among the pages. I will quote one sample:—

"Where barren moss or thistles only grow;
Where bogs their brown and useless herbage shew;
Where burning suns and dusty blowing sands
With poverty o'erspread surrounding lands;—
In meads where stagnant waters starve the soil,
There prove thy art, and there direct thy toil.
Tho' nature on thy infant efforts frown,
Rich plenty shall maturer labours crown!
If art and science point the prudent way,
Where flocks and herds their annual tribute pay."

These lines almost suggest that Smith "made them up as he went along."

The evidence of "*Strata*"-Smith being the author of this book appears at different places. On p. 54, after stating that he had to take up all the drains made on Prisley Bog by his predecessor, he adds:—"Hence it appears necessary for the designer of plans of irrigation to be fully master of the art of draining, which cannot be well understood but by a knowledge of the strata." And again (pp. 20-21): "Having been much accustomed to make particular remarks on the appearance of the country, in the course of numerous and extensive journies for the purpose of business and collecting information on the strata, it may not be amiss to point out some of the places which appear to be equally calculated for improvement by irrigation."

From a list of "Books on Agriculture, Farming, &c., Printed for

J. Harding, 36 St. James's Street, London." it seems that Smith's Treatise was sold for 8s.*

I recently saw a second copy of this scarce work for sale in Quaritch's Catalogue, and obtained it. The title page of this is different from that of the first. Except with regard to very slight differences in the spacing, due to the re-making up of the form of type, it is the same as the title page of the volume already described, as far as the words, "Engineer and Mineralogist." From this point the second copy reads: "Norwich: printed by R. M. Bacon, Cockey Lane; and sold / by Longman, Hurst, Rees and Orme, Paternoster Row, / London; and all other booksellers. / 1806."†

This difference on the title page does not necessarily imply that there were two editions, or even two impressions. It probably merely means that each London bookseller wanted his own name on the title page.

NAILSEA COLLIERIES, 1811.

In 1811 was published, in connection with the Bristol and Taunton Canal, the "Reports of Mr. William Smith and Mr. Martin, on The Strata of the Collieries at and near Nailsea" (8 pp., f'cap, with plan and sections).‡ Smith's report occupies pages 2 and 3, and he is of opinion that there is a sufficient supply of workable coal to justify the construction of a canal to the collieries. It is written from "15 Buckingham Street, York Buildings, London," and is headed "Bristol, July 1, 1811."

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* Smith's book is the fourth on the list, and it is worthy of note that the first three are of distinctly Yorkshire interest, viz :—

AN Essay on the means of improving POOR SOILS, where lime and manure cannot be had. By DR. JOHN ALDERSON, Hull. A new Edition improved, 8vo., 2s.

A Short Account of the DISEASES OF CORN, by SIR JOSEPH BANKS, BART.: a new Edition, with a letter from T. A. KNIGHT, ESQ., on the causes of Blight, and on a method of raising later crops of Garden Pease. 8vo. with a Plate, 2s. 6d.

Observations on the GRUB, and on the means of preventing the Ravages of Insects: by WILLIAM STICKNEY, of Hedon. 8vo, Second Edition, 1s. 6d.

† In this case there is no printer's imprint on the back of the title page. The copy in the London Geological Society's Library is similar to this one.

‡ A copy is preserved in the Library of the Geological Society.

SMITH'S MAP OF ENGLAND AND WALES, 1815.

Smith's great work, of course, was his wonderful large map of England and Wales, projected in 1801, but not finally published until fourteen years later. This delay certainly resulted in there being much more detail upon it. No fewer than 20 different colours are used in the map, in addition to which three uncoloured spaces occur in the legend.

The map measures 6 feet by 8½ feet and the scale is five statute miles to an inch. It includes England, Wales, and that part of Scotland occurring below a line drawn from the Forth of Tay westward. The inscription reads :—

> "A / DELINEATION / OF THE / STRATA / OF / ENGLAND AND WALES, / WITH PART OF / SCOTLAND ; / EXHIBITING / THE COLLIERIES AND MINES, / THE MARSHES AND FEN LANDS ORIGINALLY OVERFLOWED BY THE SEA, / AND THE / VARIETIES OF SOIL / ACCORDING TO THE VARIATIONS IN THE SUBSTRATA, / ILLUSTRATED BY THE MOST DESCRIPTIVE NAMES / BY W. SMITH. / TO THE RIGHT HONBLE. SIR JOSEPH BANKS, BART., P.R.S. / THIS MAP IS BY PERMISSION MOST RESPECTFULLY DEDICATED / BY HIS MUCH OBLIGED SERVANT, / W. SMITH, AUGST. 1, 1815."

The imprint reads : "Published by J. Cary, 181 Strand, London ; August 1st, 1815."

Opposite the Humber Mouth, on the area occupied by the North Sea, is a "Sketch of the Succession of Strata and their relative Altitudes." * And my copy contains the signature in ink, "Wm. Smith—a, 32" in Smith's own handwriting !

Measurements in feet of the greatest heights are given. The mountainous tract, with Snowdon, Scafell, Skiddaw, etc., is coloured and shown as "*Killas and Slate,*" with patches of "*Granite.*" Next in the "VALE OF WYE" the "*Red and Dunstone,*" and "*Limestone.*" Still coming south-east, are the "*Coalmeasures,*" the highest joint of which is shown as Crossfell ; there is another bed of "*Limestone,*" and then, in the "VALE OF SEVERN," "*Red Marl,*" "*Lias*" and "*Blue Marl.*" Next is a band, coloured red, not lettered, but evidently

* An outline of this is given on Plate XVI., Fig. 3

intended for the "*Under Oolyte.*" The "*Freestone*" follows. The greatest heights are "1,134 [feet] near Cheltenham" and "883 Stow on the Wold." The "VALE OF ISIS" is next, with "*Forest Marble,*" "*Cornbrash,*" "*Clay,*" "*Sand,*" "*Limestone,*" and "*Sand*"; then "*Chalk,*" and, in the "VALE OF THAMES" "*Brickearth*" and "*London Clay.*"

The Strata all dip to the South-east, the dip being at a less angle as the low ground is reached. The formation of the valleys and escarpments is clearly shown.

In the space to the west of the Bristol Channel is the following "EXPLANATION":—

*	*London Clay of Harrow, Highgate and Shooters Hills.*
	Clay and Brickearth, with some Sand and Gravel.
	Sand and Light Loam.
	Chalk.
	Green Sand, parallel to the Chalk.
	Blue Marl, or Oaktree Soil.
	Purbeck Stone, Kentish Rag, and Limestone of the Vale of Pickering.
	Iron Sand or Carstone.
	Clunch Clay or Shale, Vales of North Wilts. and Bedford.
	Cornbrash Limestone.
	Forest Marble and Clay.
	Great Oolyte or Bath Freestone.
	Under Oolyte.
	Blue Marl Pastures of the Midland Counties.
	Blue and White Lias Limestones.

* These tablets are coloured on the original to match the colours on the Map and Section.

Red Marl, Millstone and Breciated (sic) *Limestone.*

Magnesian Limestone.

Coalmeasures—Penant paving Grindstones and Millstones.

✦ ✦ ✦ ✦ *The Coal.*

RESTING ON SANDSTONE.

Derbyshire Limestone.

Red and Dunstone, Brecon and the South Eastern Part of Scotland.

Various Alternations of Hardstone, Limestone and Slate.

Killas and Slate of Cornwall, Devon, Wales, Westmoreland and Scotland.

Granit (sic) *Sienite and Gneiss.*

...... *Canals marked by strong lines thus.*

...... *Tunnels.*

...... *Rail Roads.*

...... *Other Roads.*

✦ ✦ ✦ ✦ ...... *Collieries.*

...... *Lead Mines.*

...... *Copper Mines.*

...... *Tin Mines.*

O O O O O { *Salt and.* *Alum Works.* }

The Figures shew the Altitude in Feet above the Level of the Sea.

Salt Works in the Redland of Cheshire,—Shirlywish near. Stafford and Droitwich near Worcester.

Alum Works,—North York Moors."

Professor Judd* admirably summarises the main defects of this map:—"The representation of the Tertiaries was very inadequate, no indication of the Crags being given, the Isle of Wight Tertiaries, the Bagshot Beds of Southern England, and the Boulder-clays of East Anglia being all confounded together, and the relation of these to the London Clay being left obscure. The Wealden Area was altogether unsatisfactorily treated, the argillaceous strata being coloured as "Oaktree Clay" and the arenaceous as ironsand (Lower Greensand, etc.). Lastly, the Jurassic estuarine strata of North Yorkshire were confounded with the "carstone and ironstone" of the South-East of England. On the other hand, it is interesting to note that Smith had already learned at this early date the existence of strata lying between the Old Red Sandstone and the slaty rocks of Wales and Cumberland. These have a tablet assigned to them in his legend with the description, "various alternations of hardstone, limestone and slate," though the information he possessed was not sufficient to enable him to extend proper colours for them to the map. This is probably the earliest notice of the strata afterwards made so famous by the researches of Murchison and his coadjutors."

The copy described above is evidently one of those "Mounted on canvas, fitted in a case for Travelling," which was sold at £7 0s. 0d.

Recently I have been fortunate enough to obtain another copy of this map, which gives us some additional information. It is in a wonderfully clean state, the colours being quite fresh. With it is a copy of the Memoir, in the original binding; and a copy of the original prospectus of the map, which I had not previously seen. This last is a small quarto four-page sheet, on the front of which is:—

* loc. cit., p. 101.

This Day is published, by JOHN CARY, *No.* 181, *Strand ;*

(Dedicated, by Permission, to the Right Honourable SIR JOSEPH BANKS, Bart., President of the Royal Society, and Sanctioned by the BOARD OF AGRICULTURE, the ROYAL INSTITUTION, and the SOCIETY OF ARTS, MANUFACTURES, AND COMMERCE ;)

A MAP

OF THE

STRATA

OF

ENGLAND AND WALES,

WITH PART OF

SCOTLAND;

EXHIBITING THE

COLLIERIES, MINES, AND CANALS,

THE

MARSHES AND FEN-LANDS ORIGINALLY OVERFLOWED BY THE SEA,

AND THE

Varieties of Soil,

According to the VARIATIONS in the SUBSTRATA :

Illustrated by the most descriptive Names of Places and of Local Districts ;

SHOWING, ALSO,

THE RIVERS, SITES OF PARKS, AND PRINCIPAL SEATS OF THE NOBILITY AND GENTRY,

THE OPPOSITE COAST OF FRANCE,

And the LINES of STRATA neatly coloured.

BY WILLIAM SMITH, MINERAL SURVEYOR.

MR. J. CARY takes the liberty of informing the Patrons and Subscribers to the Map of the Strata of England and Wales, by Mr. Smith, Mineral Surveyor, that the Copies are now ready for delivery. On the other side is annexed the Price of the Maps in Sheets, and in the various ways of Mounting; and Mr. C. entreats that the Subscribers, on ordering their Copies, will have the goodness to inform him in what way they would prefer to have them sent.

London, 181, *Strand.*

And on the back is :—

"The Map is engraved on a Scale of Five Miles to an Inch, and consists of Fifteen large Sheets. Size, when mounted, 8 ft. 9 ins. by 6 ft. 2 ins.

Price, in Sheets, with the Memoir	£5	5	0
Mounted on Canvass and Rollers	7	0	0
Ditto, ditto, and varnished	8	0	0
Ditto, fitted in a Case for Travelling ...	7	0	0
Ditto, on Spring Rollers	10	0	0
Ditto, ditto, varnished	12	0	0"

This prospectus gives, for the first time, information as to the different forms in which the map was published. Although the prospectus begins "This day," it is not dated, not even the year being given, but presumably it should bear the same date as the map, viz., August 1, 1815.

My second copy is evidently one of those described as "Price, in Sheets, with the Memoir, £5 5s. 0d. It is in fifteen sheets, each measuring 23½ ins. by 20 ins." The "Sketch of the Relative Succession of Strata and their Relative Altitudes," as in the previous map, bears the autograph signature of Wm. Smith; in this case, however, with "No. 78" added. Mr. C. Davies Sherborn informs me that the copy in the Natural History Museum, South Kensington, is signed, and with "*a* 61," and a further example just obtained from Messrs. Wesley & Sons, is numbered 96, so that it would seem that Smith autographed a number of his maps, but not all; as a nearly complete copy of the map in the London Geological Society's library (which map is intact so far as this Section is concerned), contains neither signature nor number. A map recently for sale by Messrs. Wheldon is neither signed nor numbered. Another map, recently purchased by the National Museum of Wales, is signed, and numbered *b*. 72.

The fifteen sheets in this second map (*i.e.* No. 78), are carefully mounted on guards, and bound up in a contemporary half-leather cover. But it contains a map or an extra sheet, which I had not seen before.* This is headed "General Map" and is a reduced facsimile of the large map, without the geological colours. It covers precisely the same area as the large map, and is divided into fifteen rectangles,

* I have since obtained a second copy of this "General Map."

numbered i.-xv. in Roman numerals, to correspond with the numerals on the sheets of the large map. It measures $14\frac{1}{2}$ by $19\frac{1}{2}$ inches, though it is printed on paper to correspond in size with the other fifteen sheets.

Some idea of the amount of work connected with these maps may be gathered from the following extract from Smith's diary:—*

"May 14, 1815.—Began at nine in the morning with an artist to colour for me the *first* printed copy of the 'Map of the Strata' on canvas.

"May 22, 1815.—Finished colouring the *first* 'Map of the Strata' on canvas.

"May 23, 1815.—Attended a meeting of the Board of Agriculture with the *first* finished copy on canvas of my 'Map of the Strata.'"†

This was the map for which the Society of Arts awarded Smith the premium of £50.

1815.

Smith's second book appeared nine years after his "Treatise on Irrigation," the same year in which his large coloured Geological map was issued. The volume is entitled: "A Memoir / to the / Map and Delineation / of the / Strata / of / England and Wales, / with part of / Scotland. / By / William Smith, / Engineer and Mineral Surveyor. / London: / Printed for John Cary No. 181, Strand. / 1815.

The dedication reads: "To the Right Honourable Sir Joseph Banks, Bart., President of the Royal Society, and the most general promoter of science; this work, by his particular encouragement advanced to its present state of perfection, [i]s most gratefully and respectfully Dedicated, by his obliged humble servant, William Smith. London, August 1, 1815." Then follows a list of about 400 subscribers to the work.

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* *Phillips's Memoirs*, p. 77.

† That Smith was familiar with the value of plants in geological mapping is shown from the following extract from a letter to the Rev. B. Richardson, dated Feb. 11th, 1813:—"As the season for a revival of the locality of indigenous plants is just approaching, I hope you will not forget to make a complete list of them on each stratum. This, with your able assistance, would form a most interesting chapter, and would serve to draw the attention of many to the subject of strata who probably might otherwise never think of it."—*Memoirs*, p. 75.

A

MEMOIR

TO THE

MAP AND DELINEATION

OF THE

STRATA

OF

ENGLAND AND WALES,

WITH PART OF

SCOTLAND.

BY

WILLIAM SMITH,

ENGINEER AND MINERAL SURVEYOR.

LONDON:

PRINTED FOR JOHN CARY, NO. 181, STRAND.

1815.

Reduced copy of the title-page of Smith's "Memoir to the Map, etc.

The volume, which consists of 51 quarto pages and two folding tables, is divided into four sections, viz., "Introduction," "Explanation of the Subject of Strata, and of the Colours by which they are represented on the Map," "General Account of the Soil and Substrata in the Respective Counties," and "Characteristic Distinctions of Soil and Surface in the Courses of the respective Strata, described in the Order in which their edges successively terminate."

Ostensibly the volume, as the title indicates, is a companion to the map, respecting which Smith says*: "After twenty-four years of intense application to such an abstruse subject as the discovery and delineation of the British Strata, the reader may readily conceive the great satisfaction I feel in bringing it to its present state of perfection. The chances were thought much against my ever completing it on a map, of the greater part of our island, large enough to show the general course and width of each stratum of the soil and minerals, with a section of their proportions, dip, and direction, in the colours most proper to make them striking and just representations of nature; and which is the first general mineralogical survey of the island."

The following extract, taken from pp. 2-3, is probably the first published statement in his own words of the great discovery which he made in reference to different strata having typical fossils, in whatever district found; an axiom which forms the foundation of the science of geology:—

> "The immense sums of money imprudently expended in searching for coal and other minerals, out of the regular course of the strata which constantly attend such productions; and in forming canals, where no bulky materials were afterwards found to be carried upon them; prove the necessity of better general information on this extensive subject. And I presume to think, that the accurate surveys and examinations of the strata, as well near the surface of the earth as in its interior, to the greatest depths to which art has hitherto penetrated, by the sinking of wells, mines, and other excavations, to which I have devoted the whole period of my life, have enabled me to prove that there is a great degree of regularity in the position and thickness of all these strata; and although considerable dislocations are found in

* In the Introduction.

No. I.

Order of the STRATA *and their embedded* ORGANIC REMAINS, *in the vicinity of* BATH; *examined and proved prior to* 1799.

Strata.	Thickness	Springs.	Fossils, Petrifactions, &c., &c.	Descriptive Characters and Situations.
1. Chalk	300	Intermitting on the Downs	Echinites, Pyrites, Mytilites, Dentalia, funnel-shaped Corals, and Madrepores, Nautilites, Strombites, Cochliæ, Ostreæ, Serpulæ	Strata of Silex, imbedded.
2. Sand	70	...	...	The fertile vales intersecting Salisbury Plain and the Downs.
3. Clay	30	Between the Black Dog and Berkley Hinton, Norton Woolverton, Bradford Leigh.		
4. Sand and Stone	30		...	Imbedded is a thin stratum of calcareous Grit. The stones flat, smooth and rounded at the edges.
5. Clay	15			
6. Forest Marble	10	...	A mass of Anomiæ and high-waved Cockles, with calcareous Cement	The cover of the upper bed of Freestone, or Oolyte.
7. Freestone	60	...	Scarcely any Fossils besides the Coral	Oolyte, resting on a thin bed of Coral.—Prior Park, Southstoke, Twinny, Winsley, Farley Castle, Westwood, Berfield, Conkwell, Monkton Farley, Coldhorn, Marshfield Coldashton.
8. Blue Clay	6	Above Bath.		
9. Yellow Clay	8			
10. Fuller's Earth	6	...	...	Visible at a distance by the slips on the declivities of the hills round Bath.
11. Bastard ditto, and Sundries	80	...	Striated Cardia, Mytilites, Anomiæ, Pundibs, and Duck-muscles.	
12. Freestone	30	...	Top-covering Anomiæ with calcareous Cement, Strombites, Ammonites Nautilites, Cochliæ Hippocephaloides, fibrous Shell resembling Amianth, Cardia prickly Cockle Mytilites, lower Stratum of Coral, large Scollop, Nidus of the Muscle with its Cables	Lincombe, Devonshire Buildings, Englishcombe, Englishbatch, Wilmerton, Dunkerton, Coombay, Monkton Combe, Wellow, Mitford, Stoke, Freshford, Claverton, Bathford, Batheaston, and Hampton, Charlcombe, Swanswick, Tadwick, Langridge.
13. Sand	30	...	Ammonites, Belemnites	Sand Burs
14. Marl Blue	40	Round Bath	Pectenites, Belemnites, Gryphites, high-waved Cockles	Ochre Balls.—Mineral springs of Lincombe, Middle Hill, Cheltenham
15. Lias Blue	25	...	Same as the Marl with Nautilites, Ammonites, Dentalia, and Fragments of the Enchrinni	The fertile Marl lands of Somersetshire. Twerton, Newton, Preston, Clutton, Stanton Prior Timsbury, Paulton Marksbury, Farmborough, Corston, Hunstreet, Burnet, Keynsham, Whitchurch, Salford Kelston Weston, Pucklechurch Queencharlton, Norton-malreward Knowle, Charlton, Kilmersdon, Babington.
16. Ditto White	15			
17. Marl Stone Indigo and Black Marl	15	...	Pyrites and Ochre	A rich manure.
18. Red-ground	180	...	No Fossil known	Pits of Ruddle. Beneath this bed no fossil, shells, or animal remains are found: above it no vegetable impressions. The waters of this stratum petrify in the trunks in which they are conveyed, so as to fill them, in about fifteen years, with red Watricle, which takes a fine polish.—Highlittleton.
19. Milstone				
20. Pennant Stone	...	...	Impressions of unknown Plants resembling Equisetum.	
21. Grays	...	...	...	Fragments of Coal and Iron Nodules.—Hanham, Brislington Mangotsfield, Downend Winterbourn Forest of Dean, Pensford Publow, Chelwood, Cumptondando, Hallowtrow near Stratford on Avon, Stonebench on the Severn, four miles from Gloucester.
22. Cliff	...	...	Impressions of Ferns Olive, stellate Plants, Threnax-parviflora or Dwarf Fan Palm of Jamaica	Stourbridge or Fire-clay.
23. Coal				

To face page 127.

collieries and mines, and some vacancies in the superficial courses of them, yet that the general order is preserved; and that each stratum is also possessed of properties peculiar to itself, has the same exterior characters and chemical qualities, and the same extraneous or organised fossils throughout its course. I have, with immense labour and expense, collected specimens of each stratum, and of the peculiar extraneous fossils, organic remains, and vegetable impressions, and compared them with others from very distant parts of the island, with reference to the exact habitation of each, and have arranged them in the same order as they lay in the earth; which arrangement must readily convince every scientific or discerning person, that the earth is formed as well as governed, like the other works of its great Creator, according to regular and immutable laws, which are discoverable by human industry and observation, and which form a legitimate and most important object of science. The discoveries and improvements, both in mining and agriculture, which are now confined to a few parts of the kingdom, may be fully extended to many more, and in some degree to all, by a better knowledge of geology; and a faithful general view of the soil and substrata of our island (in which no beds are omitted that can well be described in such a map) will be found a work of great convenience, in considering the various applications which are made to the legislature for canals, roads, and railways alone."

The first table in the volume, facing page 8, is entitled "Order of the Strata and their imbedded Organic Remains, in the Vicinity of Bath; examined and proved prior to 1799." Its remarkable state of completeness is due to the exceptional opportunities Smith had for examining that area. Details of 23 different beds are given, commencing with "chalk," and ending with "Coal." The particulars are classified under the heads of "Strata; Thickness; Springs; Fossils; Petrifactions, &c., &c.; Descriptive Characters and Situations." (See adjoining table No. 1).

The "Fossils," etc., in Chalk are given as "Echinites, Pyrites, Mytilites, Dentalia, Funnel-shaped Corals, and Madrepores, Nautilites, Strombites, Cochliæ, Ostreæ, Serpulæ."

And in the Coal, "Impressions of Ferns, Olive, Stellate Plants, Threnax-parviflora, or Dwarf Fan Palm of Jamaica."

One wonders what Smith would think if he could see the lists of fossils from those beds to-day !

Of this Bath list Smith says :—

> " The annexed Table No. 1, is a copy of the first MS. attempt at any regular account of my discoveries in the strata, a copy of which being shown to me by the late W. Reynolds of Colebrookdale, about twelve years since, and being assured by him and others of its multiplication and general distribution, even to the East and West Indies, I am induced to publish it in the original form."

Facing page 10 of this work is an " Explanation of Colours on the Map of STRATA, taken in succession from East to West, as the Strata occur." This may be taken as the first Table of British Strata ever published. The beds are divided into " London Clay, Clay or Brick Earth, Sand or Light Loam, Chalk, Green Sand, Purbeck Stone, Iron Sand and Carstone, Dark Blue Slate, Cornbrash, Forest Marble Rock, Great Oolyte, Under Oolyte, Blue Marl, Blue Lias Limestone, White Lias, Red Marl and Gypsum, Magnesian Limestone, Coal Districts.... Generally a Sandstone beneath, Derbyshire Limestone, Red and Dunstone, Various, Killas or Slate, Granite, Sienite, and Gneiss." Many of these terms are still in use to-day. In addition to the rocks mentiontioned, their equivalents are given, for instance, " Purbeck Stone, Kentish Rag, and Limestone of the Vale of Pickering." Chalk, we notice, is divided into " Upper Part, soft, contains Flints," and " Under Part, hard, none."

From the White Lias (which is " now used for printing from MS. written on stone ") upwards, is a note " Part on which Lime is rarely used as manure " ; while the rocks below are marked " Part on which Lime is generally used." In a further column are particulars of the economic value of the different beds, thus opposite " Coal districts " we find " Grind-stones, Mill-stones, Paving-stone, Iron-stone, and Fire-clay from Coal Districts." The " Oolytes " are bracketed with " The finest building stone in the island for Gothic and other architecture which requires nice workmanship." Opposite Upper Chalk occurs " Flints, the best road materials," which may have been correct in Smith's days !

In the section " General Account of Soil and Substrata in the respective countries " the description " will generally be given in the

No. II.

Explanation of Colours *on the* Map *of* STRATA, *taken in Succession from East to West, as the Strata occur.*

Nos. which refer to the preceding List of Strata.				
		London Clay, forming Highgate, Harrow, Shooters, and other detached hills	Part on which Lime is rarely used as a Manure.	Septarium, from which Parker's Roman Cement is made. No building Stone in all this extensive district, but abundance of materials which make the best bricks and tiles in the island.
		Clay or Brick-earth, with interspersions of Sand and Gravel		
		Sand, or light Loam, upon a sandy or absorbent Substratum..............................		These strata contain the Potter's Clay, and Sands used for different purposes.
1		Chalk { Upper Part, soft, contains Flints ..... Under Part, hard, none		Flints the best road materials. Good Lime for water cements.
2		Green Sand, parallel to edge of Chalk		Firestone, and other soft Stone, some times used for building.
3		Blue Marl, so kindly for the growth of oak as to be called in some places the oak-tree soil.		
		Purbeck Stone, Kentish Rag, and Limestone of the Vale of Pickering.		
		Iron Sand and Carstone, which, in Surrey and Bedfordshire, contains Fuller's-earth, and, in some places, Yellow Ochre and Glass Sand..		Some Lime used on these Sands in Sussex and Yorkshire.
		Dark Blue Shale produces a strong clay soil, chiefly in pasture, in North Wilts and Vale of Bedford.		
		Cornbrash, a thin Rock of Limestone, chiefly arable		Makes tolerable roads.
5, 6		Forest Marble Rock, thin beds, used for rough Paving and Slate.		
7		Great Oolyte, Rock, which produces the Bath Freestone		The finest building stone in the island for Gothic and other architecture which requires nice workmanship.
12, 13		Under Oolyte, of the vicinity of Bath and the midland counties		
14		Blue Marl, under the best pastures of the midland counties.		
15, 16		Blue Lias Limestone, makes excellent Lime for water cements.		
		White Lias, now used for printing from MS. written on the stone.		
18, 19		Red Marl and Gypsum, soft Sandstone and Salt Rocks, and Springs.	Part on which Lime is generally used.	
		Magnesian Limestone.... ————soft Sandstone		Small quantities of Copper and Lead.
20 to 23		Coal districts and the Rocks and Clays which accompany the coal		Grind-stones Mill-stones, Paving-stone, Iron-stone, and Fire-clay from the Coal districts.
		———— Generally a Sandstone beneath.		
		Derbyshire Limestone		Lead, Copper, and Lapis Calaminaris—Marble.
		Red and Dun-stone, of the southern and northern parts, with interspersions of Limestone, marked blue........................... Various.		Some good building Stone.
		Killas, or Slate, and other strata, of the mountains on the western side of the island with interspersions of Limestone, marked blue...		The Limestone polished for Marble. Tin, Copper, Lead, and other minerals
		Granite, Sienite, and Gneiss		The finest building Stone in the island for bridges and other heavy work.
		Alluvial deposits in low marshy grounds around the coast are shaded as original inlets of the sea.		

From Smith's "Memoir to the Map," 1815.

To face page 128.

order of their appearance on the surface, from east to west." On pp. 33-35 is the account of the geology of our own county, which, being one of the earliest of such descriptions, and from the pen of the master, we may be allowed to quote :—

YORKSHIRE.

"Yorkshire is a county of immense extent, which, in its eastern part, comprises all the strata of the southern and eastern counties ; its interior, those of the Midland counties ; its western, those of Durham, Northumberland, and the part of South Wales which contains the coal. Though the hills of the east moors and wolds are high, their altitudes are comparatively low to those of the coal-measures in the west and north-western parts of the county.

"Except the moors and wolds before mentioned, nearly all the rest of this vast county has one general declination towards the east, from the tops of Whernside and Ingleborough to the mouth of the Humber. On the shores of this great estuary, and of the river Trent, and others connected with the Humber, are large districts of alluvial and low marshy land, evidently formed by a sediment of the sea. The strip included between a district of this sort, and the easternmost part of the coast, called Holderness, is of the Strata incumbent on chalk, and much the same kind of soil as the east part of Norfolk. The wolds, on chalk, are as dry, arid, and open as Salisbury Plain. The clay and limestone of the Vale of Pickering form a much better soil than that which succeeds it to the north and north-west. These dreary and most extensive surfaces of brown, rusty-looking ling, upon a substratum of soft sandstone, are worse than any other district. The blue clay, or surface of alum shale, which succeeds it in the deep vales of the North York moors, and at the foot of them, is not good, and, in some parts of the vale of York, seems covered with alluvial sand, which has not improved the surface.

"A redder and much better soil runs through the middle of the county, parallel to the magnesian limestone, along the west side of the vale of York into Cleveland, and forms some of the best land in Yorkshire. The dry surface of the yellow or magnesian limestone is parallel to the red. Its course through the eastern half of the county is along the great north road, and in the northern parallel, and very near to it. West of this vast surface of coal-measures, generally producing a poor soil, and more or less productive in coal, rises gradually to the tops of the highest hills. Eminences on its eastern side, with those of the wolds and Hambleton hills, seem to form the extreme limits of an immense vale, the central part of which is the vale of York. The coal-measures form the largest portion of any of the Yorkshire strata. Its northern and western parts in Craven and Richmond are beautifully interspersed with a rich surface on a substratum of limestone. These are the two principal districts of this kind of land which so much relieve the general dreariness of surface, occasioned by the bleak high and wet moors of the coal measures ; but which vast surface is also further broken and relieved by various interspersions of the dry and rich soil of limestone, in Swaledale, Yoredale and others."

This volume was printed by "S. Goswell, Printer, Little Queen Street, London."

STRATA IDENTIFIED BY ORGANISED FOSSILS. 1816.

In the following year was published a large 4to volume, entitled :—

"STRATA / IDENTIFIED BY / ORGANIZED FOSSILS, / CONTAINING / PRINTS ON COLOURED PAPER / OF THE MOST / CHARACTERISTIC SPECIMENS / IN EACH / STRATUM. / BY WILLIAM SMITH, / MINERAL SURVEYOR, / AUTHOR OF "MAP OF THE STRATA OF ENGLAND AND WALES," AND "A TREATISE ON IRRIGATION." / LONDON : / PRINTED BY W. ARDING, 21, OLD BOSWELL COURT, CAREY STREET ; / AND SOLD BY THE AUTHOR, 15, BUCKINGHAM STREET, STRAND ; J. SOWERBY, 2, MEAD PLACE, / LAMBETH ; SHERWOOD, NEELY, AND JONES, AND LONGMAN, HURST, / REES, ORME, AND BROWN, PATERNOSTER ROW ; / AND BY ALL BOOKSELLERS. / JUNE 1, 1816."

Phillips states* that "the first part" of this work was issued in 1817, but as two parts were issued in 1816, it is apparent Phillips had made a slip. Of this publication Phillips tells us :—

"In this year (1817) also was issued the first number of another work, entitled "Strata Identified by Organized Fossils," consisting of numerous figures of fossils engraved by Sowerby and printed on paper to correspond in some degree with the natural hue of the strata. This remarkable work reached its fourth number (only seven were proposed). The publication of it was undertaken by Mr. Sowerby,

* loc. cit., p. 79.

STRATA

IDENTIFIED BY

ORGANIZED FOSSILS,

CONTAINING

Prints on Colored Paper

OF THE MOST

CHARACTERISTIC SPECIMENS

IN EACH

STRATUM.

BY WILLIAM SMITH,

MINERAL SURVEYOR,

AUTHOR OF "MAP OF THE STRATA OF ENGLAND AND WALES," AND "A TREATISE ON IRRIGATION."

London:

Printed by W. Arding, 21, Old Boswell Court, Carey Street;

And sold by the AUTHOR, 15, Buckingham Street, Strand; J. SOWERBY, 2, Mead Place, Lambeth; SHERWOOD, NEELY, and JONES, and LONGMAN, HURST, REES, ORME, and BROWN, Paternoster Row; And by all Booksellers.

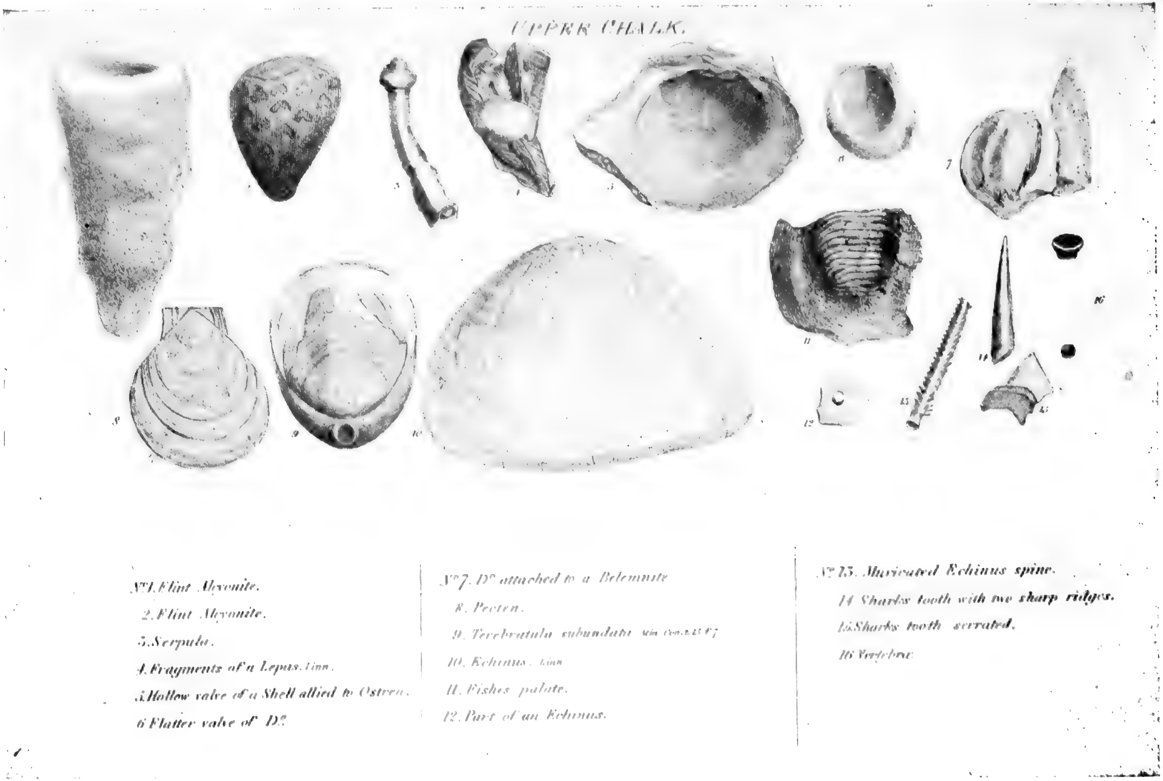
JUNE 1. 1816.

Fac-simile of Title; (reduced).

in consequence of an arrangement by which William Lowndes, Esq., of the Tax-office, a very strenuous and judicious friend of Mr. Smith, advanced £50 to pay for the cost of the first number. The expense of this work left to the author very little chance of profit. Mr. Sowerby estimated the cost of each number at £50; the gross sale price, supposing the whole (250 copies) to be sold, would yield £93 15s., from which the expenses of publication, bookseller's charges, &c., were to be deducted."

Following the title are two pages of INTRODUCTION, in which we are informed that "The Method of knowing the Substrata from each other by their various substances imbedded, will consequently shew the difference in their soils. All this is attainable by rules the most correct, and easily learnt, and also the simplest and most extensive that can well be devised; for by the help of organised Fossils alone, a science is established with characters on which all must agree, as to the extent of the strata in which they are imbedded, those characters are universal; and a knowledge of them opens the most extensive sources of information, without the necessity of deep reading, or the previous acquirement of difficult arts. . . . . Fossil Shells had long been known to the curious, collected with care, and preserved in their cabinets, along with other rarities of nature, without any apparent use. That to which I have applied them is new, and my attention was first drawn to them, by a previous discovery of regularity in the direction and dip of the various Strata in the hills around Bath." He also points out that the fossils prove "two distinct operations of water," viz., those occurring in their original matrix in the strata, and the "alluvial fossils," or derived fossils, found in gravels.

In the next two pages (1 and 2), "Strata with organized fossils," is a summary of the country's rocks and their localities. "The northernmost of the three principal portions, North and South of the Humber, is small, long, and narrow, lying low, and as yet little known for organized Fossils, except large bones washed out of the crumbly cliffs of Holderness, which correspond with those washed out of similar cliffs on the coast of East Norfolk, Suffolk, Essex, East Kent, and South Hants." Pages 3-4 are devoted to "London Clay," with particulars of soil, subsoil, excavations, etc., origin of the same, area of outcrop, Lists of Fossils, etc. Similar information is given in reference to Crag (pp. 5-6); Upper Chalk (pp. 7-8); Lower or Hard Chalk, frequently



Fac-simile of Table [4] of Upper Chalk Fossils (reduced).

called Grey Chalk (pp. 9-10); Class of Strata beneath the Chalk (p. 11); Green or Chlorite Sand (p. 12); Micaceous Brick Earth (p. 13); [page 14 blank]; Portland Stone (pp. 15-16); Oak Tree Clay (pp. 17-18); Coral Rag and Pisolite (pp. 19-20); " Clunch Clay and Shale (pp. 21-22); Kelloways Stone (pp. 23-24); Cornbrash (pp. 25-26); Forest Marble (pp. 27-28); Clay over the Upper Oolite (p. 29); Upper Oolite, or Calcareous Freestone (pp. 29-30); Fuller's Earth Rock (pp. 31-32). The series ends here, somewhat abruptly.

The plates are very beautifully drawn and coloured, apparently by Sowerby, though no reference to this fact appears to occur in the book. They are printed on tinted papers, carefully selected to match the colour of the respective rocks. Where it has not been possible to match the colour exactly, white paper has been tinted the required colour, before the drawings have been made. There are nineteen in all (unnumbered), as under :—

(1) Tooth of Mastodon.
(2) London Clay Fossils.*
(3) Craig (*sic*).
(4) Upper Chalk.†
(5) Lower Chalk.
(6) Green Sand.
(7) Ditto.
(8) Brick Earth.
(9) Portland Stone.
(10) Oak-Tree Clay.
(11) Coral Rag and Pisolite.
(12) Ditto.
(13) Clunch Clay and Shale.
(14) Kelloways Stone.
(15) Cornbrash.
(16) Forest Marble.
(17) Clay over the Upper Oolite.
(18) Upper Oolite.
(19) Fuller's Earth Rock.

The copy in the library of the London Geological Society is identical

* This plate has the words " Brit. Min., 246," evidently a reference to Sowerby's book.

† Reproduced on Plate XII.

with my own, with the exception that in the former the plates are engraved with the numbers, viz. :—

Mastodon Tooth is Tab. 1.
London Clay is Tab. 2.
Craig is T. 2 [error].
Upper Chalk is Tab. 3 [error].

In the London copy the covers are fortunately preserved, and each one is dated. Part I. besides title and 2 pages of Introduction, contains 8 pages and the above-mentioned four plates.

Part II. issued on October 1st, 1816 ; pp. 9-16, and 5 plates.

Part III. [date torn off, but from the advertisement on Part IV., was evidently September 1, 1817] ; pp. 17-24 and 5 plates.

Part IV., is merely dated "1819," and contains pp. 25-32 and 5 plates.

On Part IV. it is stated that the work is "To be comprised in Seven numbers, 7s. 6d. each" ; but apparently no more were issued. Probably the delay in the publication (it took three years to publish four parts) was partly responsible.

SMITH'S STRATIGRAPHICAL SYSTEM, 1817.

In 1817 was published a 4to volume entitled :—

"STRATIGRAPHICAL SYSTEM / OF / ORGANIZED FOSSILS / WITH / REFERENCE TO THE SPECIMENS / OF / THE ORIGINAL GEOLOGICAL COLLECTION / IN THE / BRITISH MUSEUM : / EXPLAINING / THEIR STATE OF PRESERVATION / AND / THEIR USE IN IDENTIFYING / THE / BRITISH STRATA. / BY / WILLAIM SMITH, / CIVIL ENGINEER AND MINERAL SURVEYOR ; / *Author of a "Treatise on Irrigation,"* a "*Map and Delineation of the Strata of England and Wales," with a / Memoir, "Strata identified by Organized Fossils," "Geological Section" and "Table."* / LONDON : / PRINTED FOR E. WILLIAMS, BOOKSELLER TO THE PRINCE REGENT, AND TO THE DUKE AND DUCHESS OF YORK, / NO. 11, STRAND, NEAR CHARING CROSS ; AND SOLD BY ALL OTHER BOOKSELLERS IN THE KINGDOM. / 1817."

Below is written on the Geological Society's copy : "Purchased with part of fund for procuring cabinets, Books and Maps." My copy has scribbled across it, "M. H. Humphreys, Surgeon, Thame, Oxon."

On the back of the title is the imprint "Cox and Baylis, Printers, Great Queen Street, / Lincoln's Inn Fields."

STRATIGRAPHICAL SYSTEM

OF

ORGANIZED FOSSILS,

WITH

REFERENCE TO THE SPECIMENS

OF

THE ORIGINAL GEOLOGICAL COLLECTION

IN THE

BRITISH MUSEUM:

EXPLAINING

THEIR STATE OF PRESERVATION

AND

THEIR USE IN IDENTIFYING

THE

BRITISH STRATA.

BY

WILLIAM SMITH,

CIVIL ENGINEER AND MINERAL SURVEYOR;

Author of a "Treatise on Irrigation," a "Map and Delineation of the Strata of England and Wales," with a Memoir, "Strata identified by organized Fossils," "Geological Section" and "Table."

LONDON:

Printed for E. WILLIAMS, Bookseller to the PRINCE REGENT, and to the DUKE and DUCHESS OF YORK, No. 11, Strand, near Charing Cross; and sold by all other Booksellers in the Kingdom.

1817.

Fac-simile of Title-page (reduced).

Then follows "Part I. Contents," with particulars of the contents up to page 113. Below is "Indexes to Genera and Species and to their

Localities will be given in the succeeding part of the work; and the characters of the Genera will be explained. *Part II. which completes the Work, will be speedily published.*" This Part II. however, never appeared.

From the "Introduction" we learn that "This novel and interesting description of near seven hundred species of Fossil Shells, Zoophites, and other organized Fossils, found in England and Wales, and collected in identification of the Strata, refers particularly to the specimens of a geological collection deposited in the British Museum. On the specimens, Roman capitals mark the genus,—the figures 1, 2, 3, &c, refer to the species—and the small letters, *a, b, c,* &c., to the localities or sites in the Strata."

"This copious reference to the stratum which contains the Fossils, to the particular site therein whence obtained, and to the individual specimens in the collection, which is intended to be publicly exhibited in the British Museum, seemed to render figures of them unnecessary; especially as reference is constantly made to another work of the Author's now publishing by Mr. Sowerby, which consists chiefly of engravings; and as further reference is also made to the numerous figures of Sowerby's *Mineral Conchology.*"

The "other work" referred to is "Strata identified by Organized Fossils," just described.

Smith goes on to tell us, in his characteristic way, that "The virtuoso will therefore now enter upon the study and selection of Organised Fossils with the twofold advantage of amusement and utility. The various component parts of the soil, and all the subterraneous productions of his estate become interesting objects of research; the contents of quarries, pits, wells, and other excavations, hitherto thought unworthy of notice, will be scrupulously examined." And later:—

"This particular branch of geology has already proved that a large portion of the earth once teemed with animation, and that the animals and plants thus finely preserved in the solid parts of the earth's interior, are so materially different from those now in existence, that they may be considered as a new creation, or rather as an undiscovered part of an old creation. They are chiefly submarine, and as they vary generally from the present inhabitants of the sea, so at separate periods of the earth's formation they vary as much from each other; insomuch that each layer of these fossil organised bodies must be considered as a

GEOLOGICAL TABLE OF BRITISH ORGANIZED FOSSILS,

WHICH IDENTIFY THE COURSES AND CONTINUITY OF THE STRATA *IN THEIR ORDER OF SUPERPOSITION*;

AS ORIGINALLY DISCOVERED BY W. SMITH, *Civil Engineer*; WITH REFERENCE TO HIS

GEOLOGICAL MAP OF ENGLAND AND WALES.

Organized Fossils which Identify the respective Strata.		Names of Strata on the Shelves of the Geological Collection.	Colours on the Map of Strata.	Names in the Memoir and the Peculiarities of the Strata.			Products of the Strata
Volutæ, Rostellariæ Fusus, Cerithia Nautili Teredo, Crabs Teeth and Bones	*Plains.*	*London Clay*		London Clay *forming Highgate, Harrow, Shooters and other detached Hills*			*Septarium from which Parker's Roman Cement is made.*
Murices, Turbo, Pectunculus, Cardia Venus Ostreæ		*Sand* *Crag*		Clay or Brickearth *with Interspersions of Sand and Gravel*			*No Building Stone in all this extensive District but Abundance of Materials which make the Best Bricks and Tiles in the Island.*
		Sand		Sand and Light Loam *upon a Sandy or absorbent Substratum*			*Potters Clay, Glass Grinders Sand, and Loam and Sands used for various purposes.*
Flint Alcyonia, Ostreæ, Echini .... Plagiostoma	*Chalk Hills.*	*Chalk Upper*		Chalk *Upper part soft contains flints*			*Flints the best Road Materials.*
Terebratulæ Teeth, Palates .... Plagiostoma		*Chalk Lower*		*Lower part hard contains none*			*Good Lime for Water Cements.*
Funnelform Alcyonia Venus, Chama Pectines, Terebratulæ Echini		*Green Sand*		Green Sand *parallel to the Chalk*			*Firestone and other soft Stone sometimes used for building.*
Belemnites, Ammonites	*Clay Vales.*	*Brickearth*		Blue Marl	*Numerous Trials for Coal.*	*Part on which Lime is rarely used as a Manure*	
Turritella, Ammonites, Trigoniæ, Pecten, Wood		*Sand* *Portland Rock* *Sand*		Purbeck Stone, Kentish Rag *and* Limestone *of the* Vales *of* Pickering *and* Aylesbury			*The first Quarry and Building Stone downward in the Series Kimmeridge Coal.*
Trochus, Nautilus, Ammonites in Masses · Ostreæ (in a bed) Bones		*Oaktree Clay*		Iron Sand and Carstone *which in Surry and Bedfordshire contain Fuller's Earth and in some places Ochre and Glass Sand*			*Fuller's Earth, Ochre and Glass Sand Some Lime used on these Sands in Sussex and Yorkshire.*
Various Madreporæ, Melaniæ, Ostreæ, Echini, and Spines		*Coral Rag and Pisolite*					
Belemnites, Ammonites, Ostreæ		*Sand* *Clunch Clay and Shale*		Dark blue Shale *producing a strong Clay soil chiefly in Pasture in North Wilts and Vale of Bedford*			
Ammonites, Ostreæ		*Kelloways Stone*					
Modiola, Cardia, Ostreæ, Avicula, Terebratulæ	*Stonebrash Hills.*	*Cornbrash*		Cornbrash *A thin Rock of Limestone chiefly arable lying in Clay*			*Makes Tolerable Roads.*
		Sand and Sandstone					
Pectines, Teeth and Bones, Wood		*Forest Marble*		Forest Marble Rock *thin Beds used for rough Paving and Slating*			*Coarse Marble, rough Paving and Slate*
Pear Encrinus Terebratulæ Ostreæ		*Clay over the Upper Oolite*		Great Oolite Rock *which produces the Bath Freestone*			
Madreporæ		*Upper Oolite*					*The finest Building Stone in the Island for Gothic and other Architecture which requires nice workmanship.*
Modiolæ, Cardia		*Fuller's Earth and Rock*					
Madreporæ, Trochi, Nautilus, Ammonites, Pecten		*Under Oolite*		Under Oolite *of the Vicinity of Bath and the Midland Counties*			
Ammonites, Belemnites as in the under Oolite		*Sand*					
Numerous Ammonites		*Marlstone*					
Belemnites, Ammonites in mass	*Marl Vales.*	*Blue Marl*		Blue Marl *under the best pastures of the Midland Counties*	*Greatest extent of good land*		
Pentacrini, Numerous Ammonites, Plagiostoma, Ostreæ, Bones		*Lias*		Blue Lias White Lias			*Excellent Lime for Water Cements. Now used for printing from MS. written on the Stone.*
		Red Marl		Red Marl and Gypsum *soft Sandstones and Salt Rocks and Springs*			
Madreporæ, Encrini in Masses, Producti	*Coal Tract.*	*Redland Limestone*		Magnesian Limestone Soft Sandstone		*Part on which Lime is generally used.*	*Small quantities of Copper and Lead and Calamine.*
Numerous Vegetables, Ferns lying over the Coal		*Coal Measures*		Coal Districts *and the Rocks and Clays which accompany the Coal generally a Sandstone beneath*	*Mines and Mineral Districts.*		*Grindstones Millstones, Pavingstone, Ironstone and Fireclay from the Coal Districts.*
Madreporæ. Encrini in Masses, Producti, Trilobites		*Mountain Limestone*		Derbyshire Limestone *or Metalliferous Limestone*			*Lead, Copper Calamine, Marble*
	Mountainous.	*Red Rhab and Dunstone*	● ● ● ● ●	Red and Dunstone *of the Southern and Northern Parts with Interspersions of Limestone marked blue*			*Some good Building Stone*
		Killas	● ● ● ● ●	*Various* Killas or Slate *and other Strata of the Mountains on the West Side of the Island with Interspersions of Limestone marked blue*			*The Limestone Polished for Marble. Tin, Copper, Lead and other Minerals.*
		Granite, Sienite and Gneiss		Granite Sienite and Gneiss			*The most durable building stone in the Island for Bridges and other heavy works.*

To face pag 137.

separate creation; or how could the earth be formed *stratum super stratum*, and each abundantly stored with a different race of animals and plants. Surely these innumerable and finely organized fossils are not the sports of nature placed there to excite the attention of the idly curious, but they must, like the other works of the great Creator, have their use."

"The chief object of this work being to show the utility of organized Fossils in identifying the Strata, nothing further will be attempted in the systematic arrangement than is necessary to make the subject intelligible; and the numerous useful and interesting deductions thence resulting will more appropriately follow than precede the regular description of them in the order of strata. *The Term* 'Organized Fossils' *is generally applied to all fossil matter that has a relation to the form of any organized body, either animal or vegetable.* These substances are also called '*Fossils,*' '*Petrifactions,*' and '*Organic Remains.*'

The Introduction occupies pages iii.-xi.

Then follows a coloured "GEOLOGICAL TABLE OF BRITISH ORGANIZED FOSSILS, / WHICH IDENTIFY THE COURSES AND CONTINUITY OF THE STRATA IN THEIR ORDER OF SUPERPOSITION; / AS ORIGINALLY DISCOVERED BY W. SMITH, CIVIL ENGINEER; WITH REFERENCE TO HIS / GEOLOGICAL MAP OF ENGLAND AND WALES."

The Table is divided into five columns, viz: "Organized Fossils which Identify the respective Strata," "Names of Strata on the Shelves of the Geological Collection," "Colours on the Map of Strata," "Names in the Memoir and the Peculiarities of the Strata," and "Products of the Strata." (Copy attached).

Generally speaking the Table is similar to that in "A Memoir to the Map and Delineation of the Strata of England and Wales," 1815, already described; but is more elaborate.

A note at the bottom of the Table states:—"*From the re-examination of the Author's numerous Specimens in the arrangement of his Geological Collection in the British Museum and his subsequent observations, this list of the Strata has been improved and his future exertions will be in proportion to the encouragement which he receives from the Public.*

This apparently was not much.

Below this, but outside the border, is "A Geological Map of England and Wales on 15 Sheets, dedicated by permission to Sr. Josh. Banks, P.R.S., by W. Smith, also by the same author, 'Strata identified by organised fossils.' Sold by John Cary, 181 Strand, London."

Page 1 begins :—

"LONDON CLAY
TESTACEA
UNIVALVIA
VOLUTA.

Voluta spinosa. *Sowerby's Mineral Conchology. Fig.* 5 *and* 6, *London Clay Plate, Strata identified, &c.* A cast of the inside of the shell; oblong, with a short spire and not many volutions, a few longitudinal undulations on the upper part of each.

Bognor."

Other univalves are dealt with ; then follows BIVALVIA. EQUIVALVED BIVALVES, etc., "London Clay" occupying four pages. Similar information follows relating to the Crag, Chalk, Green Sand, Brick-Earth, Portland Rock, Oaktree Clay, Coral Rag and Pisolite, Clunch Clay and Shale, Kelloways Stone, Cornbrash, Forest Marble, Clay over the Upper Oolite, Upper Oolite, Fuller's Earth Rock, Under Oolite, Sand and Sandstone and Marlstone. These occupy to page 118.

Then follows a "Stratigraphical Table of Echini," and there are "Observations on Echini," occupying other three unnumbered pages.

This "Table of Echini" is an extraordinary production. It is divided into headings, as under :—

ANOCYSTI.		PLEUROCYSTI.		CATOCYSTI.	
Cidaris	Clypeus	SPATANGUS.		Conulus	Galea
		Rays in Furrows.	Rays not in Furrows.		

There are elaborate "Descriptions and Names," and the "Strata containing Echini" are Chalk, Green Sand, Coral Rag and Pisolite, Cornbrash, Clay over the Upper Oolite, Upper Oolite, Fuller's Earth and Rock, and Under Oolite.

The descriptions of the various species of Echini are somewhat quaint ; we quote two :—

"Oval, very pointed at one end, rounded at the other ; rays biporous one third of the height downwards from the apex, distinct on the base ; ridge sharp ; apex excentric towards the broad end."

"Oval, pointed at one end, high; rays biporous two-thirds of the height downwards from the apex; arcæ flattened."

Of these tables Phillips records that they were "the first of the kind ever published."*

Comparison of Smith's Tables of Strata.

The following shows the differences in the tables of strata drawn up by Smith between 1799 and 1816. It is taken from Phillips's "Memoirs," page 146:—

Table drawn up in 1799.	Table, accompanying the Map drawn up in 1812.	Improved Table drawn up in 1815 and 1816, after the first copies of the Map had been issued.
	London Clay	1. London Clay.
	Clay or Brick-earth	2. Sand.
		3. Crag.
	Sand or Light Loam	4. Sand.
1. Chalk	Chalk	5. Chalk { Upper. Lower.
2. Sand	Green Sand	6. Green Sand.
	Blue Marl	7. Brick-earth.
	Purbeck Stone, Kentish Rag, and Limestone of the vales of Pickering and Aylesbury Iron Sand and Carstone	8. Sand. 9. Portland Rock. 10. Sand. 11. Oaktree Clay. 12. Coral Rag and Pisolite. 13. Sand.
3. Clay	Dark blue Shale	14. Clunch Clay and Shale.
		15. Kelloway's Stone.
	Cornbrash	16. Cornbrash.
4. Sand and Stone	....	17. Sand and Sandstone.
5. Clay	....	....
6. Forest Marble	Forest Marble Rock	18. Forest Marble.
		19. Clay over Upper Oolite.
7. Freestone	Great Oolite Rock	20. Upper Oolite.
8. Blue Clay 9. Yellow Clay 10. Fuller's Earth 11. Bastard ditto and Sundries	....	21. Fuller's Earth and Rock.
12. Freestone	Under Oolite	22. Under Oolite.
13. Sand	....	23. Sand.
		24. Marlstone.
14. Marl Blue	Blue Marl	25. Blue Marl.
15. Blue Lias	Blue Lias	26. Blue Lias.
16. White Lias	White Lias	27. White Lias.
17. Marlstone, Indigo and Black Marls	....	....
18. Red Ground	Red Marl and Gypsum	28. Red Marl
19. Millstone	Magnesian Limestone	29. Redland Limestone.
	Soft Sandstone	
20. Pennant Street 21. Grays 22. Cliff 23. Coal	Coal Districts	30. Coal Measures.
	Derbyshire Limestone	31. Mountain Limestone.
	Red and Dunstone	32. Red Rhab and Dunstone.
	Killas, or Slate	33. Killas.
	Granite, Sienite and Gneiss.	34. Granite, Sienite and Gneiss.

* Memoirs, p. 79.

GEOLOGICAL SECTIONS. 1817-1819.

Between 1817 and 1819 a series of geological sections was issued, prepared by Smith, and published by John Cary. Of these a complete set is framed in the Geological Gallery at the Hull Museum; I have a set, and the London Geological Society also has a set. It was principally the cost of the publication of these which necessitated Smith selling his London property, and leaving for Yorkshire, after which he published but little.

The first is a "Geological Table of British Organized Fossils." It measures 16¾ inches by 14½ inches (engraved surface) and is very similar to that published in his "Stratigraphical System of Organized Fossils," 1817,* see page 134—in fact most of it is apparently from the same plate. The chart published independently of the volume, however, has much additional information upon it, inasmuch as each of the beds is numbered (1 to 34) and a key is given showing exactly which beds occur in each county. This occurs below the bottom border of the chart, and takes the place of the advertisement of his large map, etc., which appears in the earlier issue. On the later chart the wording is:—"The figures of Reference to the Colours and Names show what Strata are found in each County—thus to find the Strata and Products of Norfolk look to the corresponding figures above, 1, 2, 3, 4, 5, 7, 8, 10, & 11." In this way particulars of the beds, etc., occurring in forty counties are given, and also similar information for "North Wales" and "South Wales." At the bottom is the imprint: "Sold by John Cary, 181 Strand, London."

The following is the list, and it clearly shows the extent of Smith's knowledge of the different strata represented in each county:—

Bedfordshire, 2, 4, 5, 7, 8, 10, 14, 16.
Berks., 2, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14.
Buckingham, 2, 4, 5, 7, 9, 10, 11, 13, 14, 16, 18.
Cambridge, 2, 4, 5, 6, 7, 8.
Cheshire, 28, 30.
Cornwall, 33, 34.

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* Prof. Judd places the date of this Section as 1815, the same year as the large Map. The copy in the Geological Society's Library, at any rate, and that in the Hull Museum, must be later than that appearing in the Volumes for 1817, as it they contain additional figures, etc., on the plate. These could not have been erased in the 1817 Volume.

Cumberland, 28, 30, 31, 32, 33, 34.
Derby, 28, 29, 30, 31.
Dorset, 1, 2, 4, 19, 21, 22, 23, 24, 25.
Devon, 5, 6, 26, 28, 31, 32, 33, 34.
Durham, 28, 29, 30, 31.
Essex, 1, 2, 4, 5.
Gloucester, 14 to 18, 20 to 29, 30, 31, 32.
Hants., 1, 2, 3, 4, 5, 6, 7, 8.
Hereford, 28, 29, 30, 31, 32.
Hertford, 1, 2, 4, 5, 7.
Huntingdon, 11, 14, 16.
Kent, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11.
Lancashire, 28, 30, 31, 33.
Leicester, 22 to 26, 28, 29, 30, 33, 34
Lincoln, 2, 4, 5, 7, 8, 10, 11, 14, 16, 18, 20 to 26, 28.
Middlesex. 1, 2, 4, 5.
Monmouth, 30, 31, 32.
Norfolk, 1, 2, 3, 4, 5, 7, 8, 10, 11.
Northampton, 14, 16, 17, 18, 20, 21, 22, 23, 24, 25.
Northumberland, 29, 30, 31, 32.
Nottingham, 25, 26, 28, 29, 30.
Oxford, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14, 16 to 25.
Rutland, 18, 19, 20, 22, 23, 25.
Salop, 28, 29, 30, 31, 32, 33.
Somerset, 5, 6, 7, 11, 12, 14 to 33.
Stafford, 28, 29, 30, 31.
Suffolk, 2, 3, 4, 5.
Surry (sic) , 1, 2, 4, 5, 6, 7, 8, 10, 11.
Sussex, 1, 2, 4, 5, 6, 7, 8, 9, 10, 11.
Warwick, 22, 23, 25, 26, 27, 28, 30.
Westmoreland, 30, 31, 32, 33, 34.
Wilts., 4 to 25 inclusive.
Worcester, 22 to 30.
Yorks., 4, 5, 7, 9, 10, 11, 14, 25, 26, 28, 29, 30, 31.
North Wales, 28, 30, 31, 32, 33, 34.
South Wales, 26, 28, 29, 30, 31, 32, 33, 34.

The next Section, issued in 1817, which we will call No. 2, is one of the most remarkable of Smith's publications. Of it Judd points out

"This very important work illustrates in a remarkable manner the clearness of Smith's views regarding both the underground structure of the country and the relation of the forms of the surface produced by denudation to that structure." It measures 53¼ inches by 12 inches, which is larger than the five following sections. It is headed "Geological Section from London to Snowdon, / showing the Varieties of the Strata, and the correct altitudes of the Hills. / By William Smith, Civil Engineer / 1817. / Coloured to correspond with his / Geological Map of England and Wales. / The numbers refer to the geological table by the same author.* / Various heights of hills, etc., are given by means of a 'scale of feet.'" On each side of the section these range from "Snowdon 3571" down to sea level. On the left margin of the chart is written :—

"*THIS SECTION shows correctly the relative altitudes and general Features of the Country along the Road through the Places marked on it forming an Epitome of BRITISH GEOLOGY, naturally and distinctly divided into seven Classes, four principal Ranges of High Ground and three of low*

"*The hills thus appear to be chiefly composed of rocky and hard Strata & the Vallies of lax and soft*

"*The Elevations above the Level of the Sea are obtained from the Trigonometrical Survey*

"*Several distant Eminences are shewn in the respective Ranges of Hills*

"*The Contour is unavoidably distorted from the Necessity of representing the Distances and Altitudes by different Scales*

"*Some Strata in the Series which are obscure upon this Road are very distinct upon others*

"*Further elucidation of the Strata discovered and traced by W. Smith are given in his other Works*

"*Geological Map of England Wales*—15 *Sheets accompanied with a descriptive Memoir* £5 5*s*. 0*d*.

"*Strata identified by organized Fossils in* 7 *numbers* 7*s*. 6*d*. *each*

"*Stratigraphical System of Organized Fossils*

"*Geological Table &c., &c.*"

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* From this it is apparent that the 'Geological Table of British Organised Fossils' just described, was published first.

The Section passes through Worcester and Oxford. The beds are named as well as numbered, and in some instances are continued into the hills in the distance. Over the Welsh mountains is the word "*MOUNTAINS*"; after the *Severn Valley* is "*COAL TRACT*," then the *MARL VALES* (*Vale of Severn*); the "*STONEBRASH HILLS*," *CLAY VALES* (*Vale of Isis, Vale of Aylesbury*), "*CHALK HILLS*," and "*PLAINS*" (*Vale of Thames*).

Under the Mountainous area is written "*MINERAL DISTINCTIONS. Mines and Minerals are all within this Part of the Series, chiefly in the Limestone beneath the Coal and in the Central Part of the Killas—Iron-works in the Coal Tract.* Under "Coal Measures":—"*More than* 20 *Veins of Coal are discovered and worked in different Parts of the Coal Tract.*" Under "Red Marl and Sandstone":—"*Gypsum, Salt Rock and Brine Springs.*" Under "Blue Marl":—"*The hot Waters of Bath rise to the Surface through this Stratum. Cheltenham and other Mineral Springs in its Course.*" Beneath the Section between Oxford and London:—The light and dry soils of the Chalk and Stonebrash Hills are chiefly appropriated to Sheep and Corn Farms and the heavy Soils of the Plains, Clay Vales, and Marl Vales, to Dairies and Grazing."

Below the border is the imprint:—"LONDON: PUBLISHED BY J. CARY, MAPSELLER, No. 181, STRAND, JULY 15TH, 1817."*

The next Chart (No. 3), was issued in 1819, and measures 36 inches by 10¾ inches. It contains two sections, viz., "GEOLOGICAL VIEW AND SECTION OF NORFOLK" and "GEOLOGICAL VIEW AND SECTION THROUGH SUFFOLK TO ELY."

The first begins at Lynn on the west, and cuts through E. Dereham, Norwich and Loddon to Yarmouth, and the positions of the river beds are shown. Beneath Lynn is written "*CLAY VALES. MARSHLAND.*" Beneath W. Lexham "*CHALK HILLS.* Flock District," and towards the east end of the Section "*PLAINS. Interspersed with Marshes.*"

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* This particular section is reproduced to illustrate an article by Dr. Fitton, "Notes on the History of English Geology," in *The Philosophical Magazine* for January 1833. The accompanying figure (Plate XIV., fig. 1) is taken from that reproduction.

Beginning at the west is a series of seven explanatory paragraphs,* as under :—

" *Lynn stands upon a Shaking Marsh A very deep well sunk in clay* "

" *Excellent Glass Sand in the Heaths near Lynn.*"

" *The Ploughed Land between Swaffham and Castle Acre strewed with Flints—North of Lexham the Ground sinks into Holes—Near it strong Springs issue from the Chalk, with which and other Water the Author several years since successfully converted the adjoining Bogs into excellent water Meadows.*" †

" *Heavy Soil with a retentive alluvial Clay Subsoil covers the interior heights of Norfolk like the Woodlands of Suffolk.*"

" *Bricks made West of Norwich, Chalk under and around the City is dug in great quantity, and at Whitlingham* 4 *Miles down the River where it sinks beneath the Marshes In the Gravel are the Bones of large Animals.*"

" *Gravel on the top of Portland Hill—The Clay below about the end of last Century induced a search for Coal.*"

" *Altogether a District of* 60,000 *Acres of very improveable Low Marshes from which the most alarming inroads of the Sea were prevented by the Authors repair of the Sea breaches North of Yarmouth in* 1805 90 *Parishes were laid under contribution to these repairs by an Act of Parliament in* 1610. *See their width in* 1792 *on Faden's Map of Norfolk.*"

The lower section, " Through Suffolk to Ely," begins at Ely on the west, and cuts through Bury, Stowmarket and Woodbridge to Baudsey. On the left are " *CLAY VALES* " (*Isle of Ely,* and *The Fens*); then " *CHALK HILLS* " (*Suffolk Sands Northward*); the *Vale of the Orwell*; beneath Woodbridge are *PLAINS*; and near the coast " *Sutton Walks, Suffolk East Sand.*"

There are also seven descriptive paragraphs to this section, viz., (beginning at the left) :—

" *The Stratified part of the Isle of Ely which rises above the*

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* These various descriptions are of considerable value, and as they have not previously been published, (except on the charts, which are very scarce), are now quoted.

† This refers to Smith's work described in his Volume of 1806.

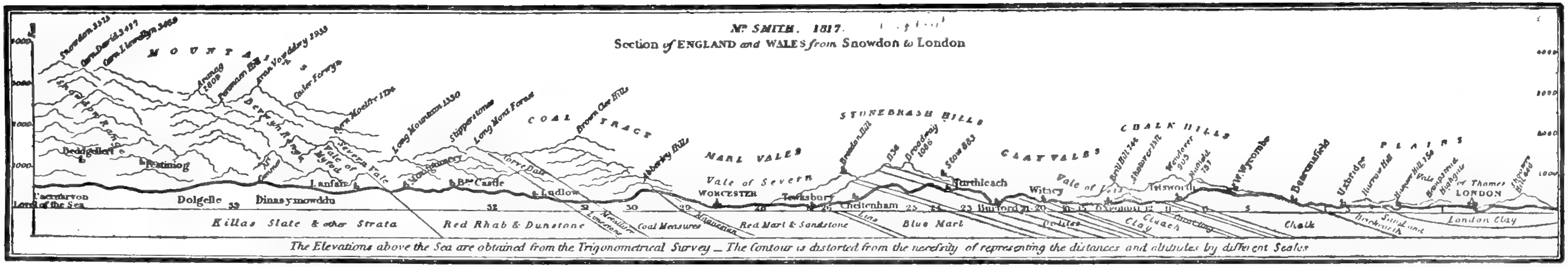

Fig. 1. Smith's Geological Section from London to Snowdon. 1817. (Taken from the reproduction in *The Philosophical Magazine*, Jan. 1833).

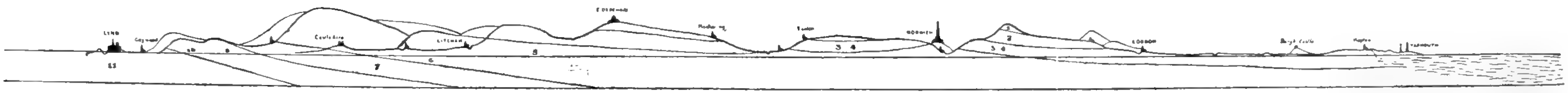

Fig. 2. Geological View and Section of Norfolk. 1819.

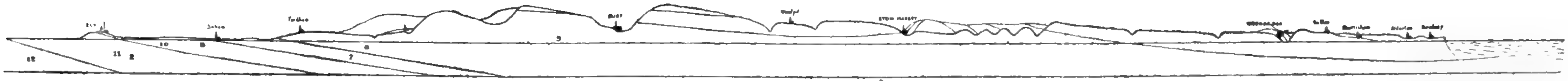

Fig. 3. Geological View and Section through Suffolk to Ely. 1819.

common Level of the Fens shows some of the Sand of Swindon and Shotover Hill, and beneath in the western rise of the Strata the Oaktree Clay with Flat Oyster Shells."

" The Golt Brickearth at the edge of the Fens between this Section and Cambridge contains in its upper part the same Fossils as in other more elevated situations."

" Ickworth on the Summit of the heavy Lands about three Miles South of the Section has an extensive view of the surrounding Country. The vast district of Blowing Sands which extend into Norfolk, appears to have been drifted from the Stratum of Sand over the Chalk."

" Woodland Clay Soil with retentive alluvial Subsoil like high Suffolk and therewith connected."

" The Chalk which is unveiled in the Ipswich River from Stowmarket to Claydon is but narrow It gives name to the village of Creting."

" Alluvial matter on the Heights between the respective Vallies has obscured the outcrop of the Crag which is very distinctly traced to Playford situate on one of the branches of the Woodbridge River. At Ipswich, Sand, Crag, Brickearth, &c., occur in regular order."

" Very loose or Blowing Sands common to the Surface where Crag most abounds, much of the sand appears to be alluvial."

Below the section appears the imprint:—" LONDON: PUBLISHED BY JOHN CARY, NO. 181, STRAND, MAY 1ST, 1819."

These are reproduced on Plate XIV., see figs. 2 and 3.

Neither the sections just described nor any of the following bear Smith's name nor, directly, any of his advertisements.

The next (No. 4), measures 36¾ inches by 11 inches. It is a "SECTION OF THE STRATA THROUGH HAMPSHIRE AND WILTSHIRE TO BATH. ON THE ROAD FROM BATH TO SALISBURY." It begins on the north-west near Bath, and cuts through Warminster and Salisbury to Southampton. Beginning at the north-west the headings are: "STONEBRASH HILLS" ("COTSWOLDS NORTHWARD"); "CHALK HILLS" ("THE EDGE OF SALISBURY PLAIN"); "PLAINS" ("THE NEW FOREST") and "SOUTHAMPTON WATER."

Descriptions are given in six columns, as below (beginning at the left):—

"*Hot and other Mineral Waters burst from the Strata at the foot of these steep Hills—Numerous Springs issue from these frequent alternations of Strata Coal is worked dipping N. or N.W. at Newton Pits only* 2 *Miles W. of Bath In the late experiment for Coal at Batheaston on the other side of Bath the Strata usually penetrated for Coal in these parts were found in regular succession, but the immense quantity of Water which burst in through a boringhole in the Red Earth alarmed the Conservators of the Bath Hot Springs as to their safety two of which failed about the same time, one party being tired of the vast expense attending such Water and the other having employed me to restore the Springs the experiment succeeded and restored tranquility in the minds of many.*"

"*Part of Selwood and other extensive Forests and Woodlands on these Clays.*"

"*Black Dog Hill the summit of drainage between the English and Bristol Channels.*"

"*The unconformableness of the Coral Rag and Pisolite* (12. 13) *is noticed in Wm. Smith's other Works.*"

"*The first Turnpike Road from Bath to Salisbury was made over the Downs—The present Road through the Willy Bourn, parallel to the hilly margin of the Downs, was called 'Undercliff.'*"

"*The Scarcity of Water and other reasons for the paucity of habitations on the Hills accounts for the numerous Sites of Population in the Vallies—The great Flocks of Sheep are kept upon these Downs and supplied with early Spring feed from water-meadows in the Vallies.*"

"*The Declination from Beacon Hill station towards Old Sarum, was too great for the accurate admeasurement of a Base Line.*"

"*Gun Flints formerly manufactured at Salisbury.*"

"*The Spire of Salisbury Cathedral is* 410 *feet high.*"

"*From these Hills of moderate altitude the vast extent of the New Forest slopes gradually to the Shores of the Sea and the Southampton Water— The Clay parts are covered with Oaks and the Sandy and the Gravelly like Bagshot Heath with Furze and Ling.*"

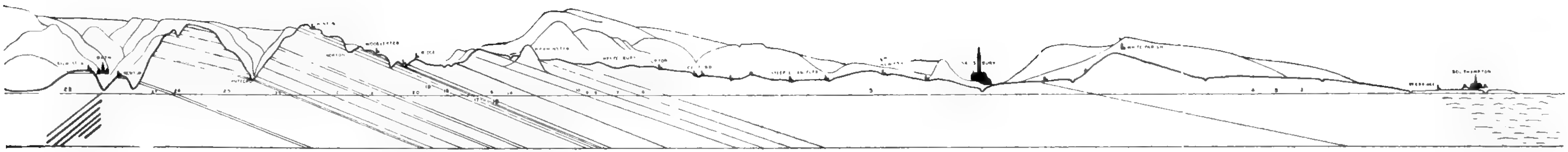

Fig. 1. Section of Strata through Hampshire and Wiltshire to Bath, on the road from Bath to Salisbury. 1819.

Fig. 2. Geological View and Section in Essex and Hertfordshire. 1819.

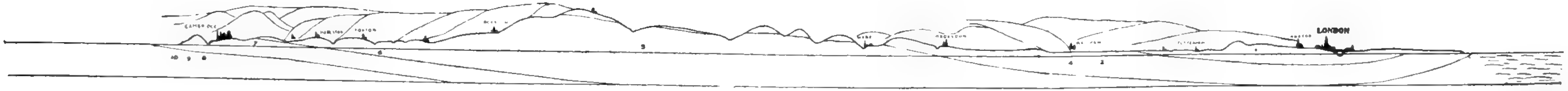

Fig. 3. Geological View and Section of the Country between London and Cambridge. 1819.

"*In* 1790 *an experiment for Coal in these Strata near the Shoe Alehouse at Platford on the borders of the New Forest.*"

This Section bears the imprint : "LONDON : PUBLISHED BY JOHN CARY, NO. 181, STRAND, MAY 1ST, 1819." (Reproduced on Plate XV., fig. 1).

The next Chart (No. 5), $36\frac{3}{4}$ inches by $10\frac{3}{4}$ inches, contains two sections, viz., "GEOLOGICAL VIEW AND SECTIONS IN ESSEX AND HERTFORDSHIRE," and "GEOLOGICAL VIEW AND SECTION OF THE COUNTRY BETWEEN LONDON AND CAMBRIDGE." (Plate XV., fig. 2).

The former begins at Wimpole on the North-West, and cuts through Royston, Bishop Stortford and Chelmsford to Shoebury on the South-East. Near Royston are "CHALK HILLS"; near Chelmsford, "PLAINS AND INSULAR HILLS" ("THE RODINGS") and, near Shoebury, "HUNDREDS."

There are eight sets of descriptions, viz., (beginning at the left) :—

"*Golt Brickearth occurs uniformly (and also beneath the alluvium) in this and other Valleys around Cambridge.*"

"*Part only of the thickness of the Chalk is ascertained by the deep wells at Royston.*"

"*Alluvial Gravel and Blue Clay with rounded fragments of Chalk frequently cover these heights and emarginate the plastic Clay Brickearth and Sand which regularly surmount the Chalk Stratum.*"

"*In the Valley of the River Stort a Branch of the Lea, Chalk is unveiled North of Hockerill, which reappears over the Summit on the Newmarket Road against Quendon.*"

"*The Rodings of Essex, Clay is connected thence North-eastward with the Clay Summit of Suffolk and Norfolk.*"

"*Alluvial Gravel in the Valley of the Chelmer River.*"

"*Hills of Clay, surmounting in the Series of Strata, the more regularly sloping Plains of Clay, Sand, etc.*"

"*Hundreds of Essex, chiefly low and Marshy, but Clay on the rising ground.*"

"*Very deep Wells sunk in these Clays show their correspondence with the opposite Coast of Kent.*"

The lower section, "between London and Cambridge," begins at Cambridge on the North, cuts through Royston, Ware, Hoddendon and Waltham, to London. The main headings are: *The Fens*: "CHALK HILLS" (*Royston Downs*") and "PLAINS AND INSULAR HILLS" ("*Vale of the River Lea—distant Hills of Epping Forest.*")

As in other sections, the positions of the river beds are indicated.

The description of the lower section occupies seven paragraphs; beginning at the left (north):—

> "*On the Castle Hill and in the City* [*Cambridge*] *three Wells have been recently sunk through the Golt* 140 *feet deep, which overflowed.*"

> "*Copious Springs of clear Water flow from the foot of the Chalk Hills.*"

> "*Water at a great depth on these dry Chalk Hills—Wells more than a hundred feet deep at Royston.*"

> "*In a dry Valley between High Cross and Collier's End, a most regular division between the Chalk and its incumbent Strata of Sand, with Brickearth above; and in Collier's End fine Blocks of Plumpuddingstone—Some of the Alluvial chalkspotted* Clay on these Hills.*"

> "*A copious Spring issuing from the Chalk Hill in Ware flows in the New River to London— The Pebbly Sandstone appears in the Hill between Ware and Wadesmill as in other parts of the Sand and gravel over Chalk.*"

> "*From Stamford Hill to Hoddesdon parallel to the Vale of the Lea the Level and dry Soil which is common to the Sandy and Pebbly Strata which form the Plains.*"

> "*The same Clay under London proved by deep Wells as in the opposite high ground of Epping Forest, and the same as in Highgate and Hampstead Hills; On the opposite side of the Thames it rises to Shooters Hill, Dulwich and Norwood Hills.*"

This Section bears the imprint:—"LONDON: PUBLISHED BY JOHN CARY, NO. 18, STRAND, MAY 1ST, 1819." It is reproduced on Plate XV., fig. 3.

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* "Chalkspotted Clay" is not at all a bad name for what is now known as the "Chalky Boulder Clay."

The next Chart (No. 6) is a "VERTICAL SECTION OF STRATA IN SURRY DIPPING NORTHWARD. SECTION OF STRATA IN SUSSEX DIPPING SOUTHWARD." It measures $36\frac{3}{4}$ inches by $10\frac{3}{4}$ inches. It begins near London on the north and cuts through Croydon, Godstone, East Grinstead, Lewes, Brighton and on to Cuckmere Harbour. The main headings are—commencing at London, "PLAINS AND INSULAR HILLS"; "SURRY CHALK HILLS" ("*This ridge extends through Kent to the Sea at Dover and Westward by the Hogsback to Hampshire*); "CLAY VALE" ("*Weald of Kent and Surrey*"); "*Forest Ridge extends to Sea at Hastings Ashdown Forest*"; "CLAY VALE" ("*Weald of Sussex*"); "SUSSEX CHALK HILLS" ("or *South Downs, Terminating in Beachy Head.*").

In this case there are ten sets of descriptive paragraphs. They are, beginning at the left (north):—

"*The little Water found in these Hills generally of a bad quality—In deep Wells sunk through the Clay Water rises from the Chalk.*"

"*Shooters Hill higher than Norwood and other Clay Hills South of London shows at its base the Chalk at Greenwich, Sand and Loam at Woolwich—Higher in the Clay lie Organized Fossils similar to those in the Clay on Newhaven Castle Hill—In deep Wells at Brixton Causway and Streatham the same species are found. On the Plain of Blackheath which is Sand and Gravel & the base of the more elevated Clay in the Hill, Wells are sunk into the Chalk, which shows the absurdity of the common opinion that Blackheath contains Coal.*"

"*Fossil Oyster Shells at Addington Hills and Sudbury.*

"*Fossil Echini occur in these Hills as in other similar parts of the Chalk.*"

"*The Golt Brickearth is identified by a small transparent belemnite.*"

"*On Copthorn Common near Newchapel is the Summit Level of the proposed Weald of Kent and Mesterham and Portsmouth Canals* 166 *feet above the Tunbridge Navigation.*"

"*Crowborough the central and highest part— A few Miles West along the Forest Ridge is the fine Turners Hill Stone a better part of these soft Sandstones.*"

"*At Bexhill the extremity of the Forest Ridge against the Sea was the late very expensive and useless search for Coal.*"

"*The ancient Ironworks were chiefly on opposite sides of the 'Forest Ridge' where Marl occurs with Ironstone and thin beds of Limestone.*"

"*About Sheffield Park and at Fletching Mill Pipe Clay and bitumenized Wood.*

At Newick Park bitumenized Wood induced a search for coal."

"*The Clay of Chailey Sth Common makes excellent Bricks.*"

"*Halmsey Malm Pits contain Fossils peculiar to the lower part of the Chalk.*

"*Excellent Wheat Land.*"

"*Much Chalk goes from these Hills by the Ouse Navigation to the interior of Sussex and is there used on the Land either in a crude state or burned into Lime by wood fires for that purpose.*

The Sussex Clunch or Grey Chalk like that of the Surrey Hills makes an excellent Lime for building in Water."

"*Newhaven Castle Hill, contains in its insular Cap of London Clay the species of organized Fossils which are found at Woolwich and in France.*

The Tide flows by Newhaven through an opening in the Chalk Hills up the River Ouse to Lewes."

The chart bears the imprint:—"LONDON: PUBLISHED BY JOHN CARY, NO. 181, STRAND, MAY 1ST, 1819." It is reproduced on Plate XVI., fig. 1.

The next chart (No. 7) measures $37\frac{1}{2}$ inches by $10\frac{3}{4}$ inches and is entitled: "GEOLOGICAL VIEW AND SECTION THROUGH DORSETSHIRE AND SOMERSETSHIRE TO TAUNTON ON THE ROAD THROUGH YEOVIL TO WIMBORNE MINSTER, &C." It begins at Taunton on the North-west, and cuts through Yeovil, Sherborn, Blanford, Wimborne Minster and Christchurch to the sea cliff at Hordle on the South-East.* The heights of the main hills are indicated. The main headings are, begining at the north-west (left): "MARL VALES" ("*Vale of Taunton Ilmoor and Westmoor*"); STONEBRASH HILLS; CLAY VALES, ("*Vale*

* Engraved "North East" in the diagram, in error.

of Blackmoor"), "CHALK HILLS" ("*Northward is Salisbury Plain and Cranbourn Chase*"), and, on the *South*-East, "PLAINS," ("*Northward is the New Forest, Southward Wareham and Pool Heaths.*")

There are eight sets of explanatory matter, viz. :—

"*Northward is the vast District of KINGS SEDGEMOOR and other low Marshes lately much improved by Draining. At Thorn Falcon a whitish Sandstone in the Red Marl.*"

"*Rich grazing District where the finest Devonshire Cattle are fed*

"*The Lias rises in the distant hills over the Yeo or Ivel River at Kingsdon and High Ham and sinks again in the Polden Hills to form the Trough of the Brue River.*"

"*The Dry Stony Soils of these Hills chiefly Sheep and Corn Farms as on the Cotiswold Hills.*

"*The Marlstone Rock near Yeovil rising Northward with the surface of Stone Farm has one Bed hard enough to be worked as Marble, called Yeovil Marble in which are fine sections of Ammonites and other Fossils which identify the Stratum, see Fig.* 4. *Strata identified & Descriptions of them page* 115, 116, *Stratig. System.*"

"*No.* 18* *Produces at Long-burton a few Miles Southward along its course fine specimens of the Marble wrought into Slabs and Chimney Pieces. In Whichwood Forest* (*Oxon.*) *called the Forest Marble.*

"*Sherborn Park on the edge of these Clays.*"

"*Dairy Farms on the Clays.*

"*A few miles North of this Section a fine soft calcareous Freestone is dug from No.* 12.†

Alfred's Tower on the Sand conspicuous from the Vale of Blackmoor.

"*This part of the Clay Series has not been free from its Trials for Coal.*"

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* No. 18 = Forest Marble.

† No. 12 = Coral Rag and Pisolite Sand.

"No. 9 This Stratum here obscured and imperfect produces in the Vale of Wardour a few Miles Northward the fine Stone of which Salisbury Cathedral was built."*

"Extensive Sheep Pastures on the Downs—Water Meadows in the Valleys.

"The River Stour which rises at Stourton near Alfred's Tower runs parallel to the track of this Section from Stalbridge to Wimborn Minster." .

"Pipe Clay or Plastic Clay worked extensively on the opposite side of Pool Harbour in the Isle of Purbeck, where these Strata dip in an opposite direction and form the Southern side of the great Trough.

"It occurs at Cary near Wareham, and has been sought for by various Trials on Pool Heath, &c., &c., some are said to have been experiments for Coal."

The imprint is: "LONDON: PUBLISHED BY JOHN CARY, No. 181 STRAND, MAY 1ST, 1819." It is reproduced on Plate XVI., fig. 2.

Later Mr. Cary published two sections† similar in size to those described, viz.:—GEOLOGICAL VIEW OF THE MINING DISTRICT OF CORNWALL CORRESPONDING WITH THE MAP FROM CHASEWATER TO CAMBORNE SHEWING THE ELEVATIONS OF THE HILLS AND THE DEPTHS TO WHICH THE MINES ARE EXTENDED, BY R. THOMAS. FALMOUTH, 1819." The imprint of this, however, reads: "LONDON: PUBLISHED BY JOHN CARY, No. 86, ST. JAMES'S STREET, JULY 1ST, 1824."

The other Chart is described as "GEOLOGICAL SECTIONS IN ILLUSTRATION OF THE MAP OF THE MINING DISTRICT OF CORNWALL, BY RD. THOMAS, FALMOUTH, 1819." In this case however, the imprint, which for the first time is within the border, reads: "LONDON; PUBLISHED BY JOHN CARY, No. 181 Strand, July 1st, 1819."‡

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* No. 9 = Portland Stone and Sand.

† These two are bound up with Smith's Section in the copy in the Library of the London Geological Society, and in my copy.

‡ There may be some reason for this imprint, which is five years earlier than that of R. Thomas's other diagram, being within the border. It looks as though the original imprint, outside the border, had been cut off.

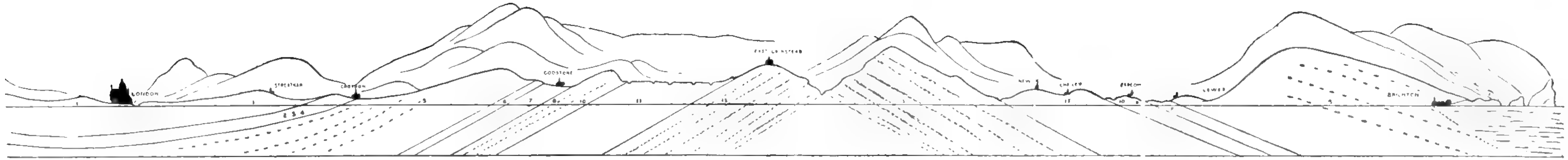

Fig. 1. Vertical Section of Strata in Surry [sic], dipping Northward. Section of Strata in Sussex, dipping Southward. 1819.

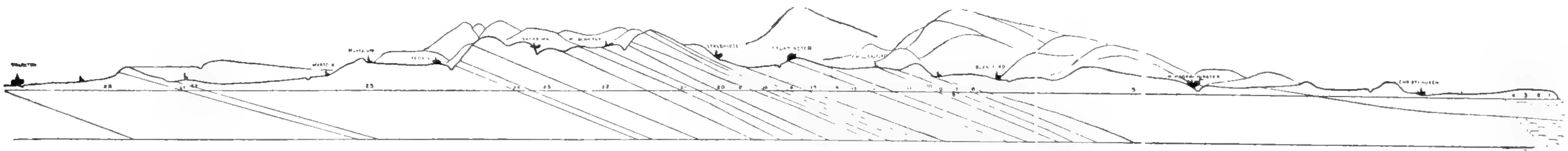

Fig. 2. Geological View and Section through Dorsetshire and Somersetshire to Taunton, on the road through Yeovil to Wimborn Minster, &c. 1819.

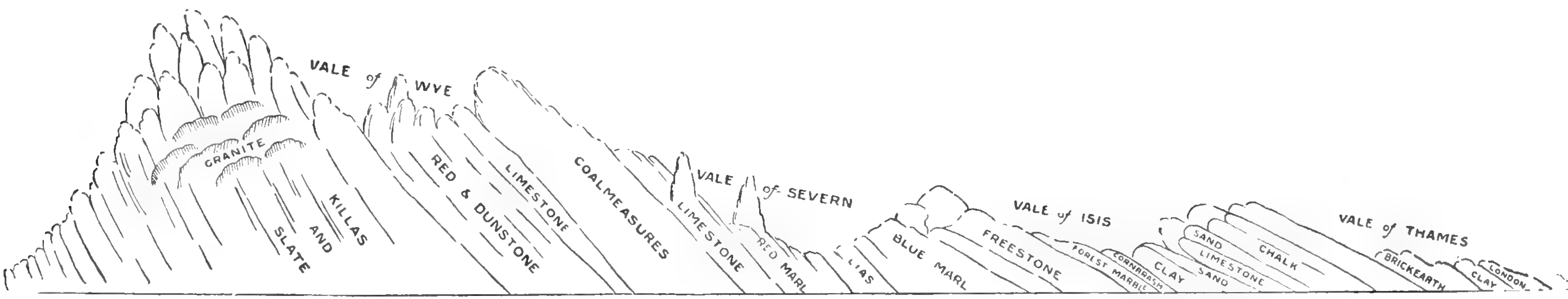

Fig. 3. Sketch of the Succession of Strata and their relative altitudes, very slightly reduced; from Smiths large Geological Map of 1815.

SMITH. 1817.

Distribution of Ammonites.

At the Annual General Meeting of the Geological Society, held on February 17th, 1860, John Phillips gives particulars of an "unpublished Table of the Distribution of Ammonites," which was drawn up by his own hand in 1817. It forms one of a series of such attempts of which an example has been printed, viz., the Table of *Echini*, in the "Stratigraphical System of Organised Fossils (1817)." This table is reproduced on a folding plate facing page xli. of the "Anniversary Address of the President" in *Quart. Journ. Geol. Soc.*, Vol. XVI., 1860. It is headed "Table of the Distribution of Ammonites, drawn up by John Phillips, under the direction of William Smith, in 1817." A footnote informs us that "The Table was drawn up previous to the publication, in 1817, of the 'Stratigraphical System of Organized Fossils," which contains a few more names of Ammonites—some proposed by Smith, as *A. calix*, which is now called *A. Blagdeni*."

AIRE AND DUNN CANAL. 1819.

Phillips tells us* that "From the eastern coast he [Smith] was called into Yorkshire to consider of a plan for a new canal between the River Aire and Knottingley and the River Don at Doncaster, with a branch down the River Went. On this matter he was employed at frequent intervals till 1819, when the Bill was brought into Parliament, and defeated by the strenuous opposition of the Aire and Calder Navigation Company." Phillips does not mention that a plan was prepared in connection with this scheme. Among a collection of Yorkshire maps, which I purchased a little while ago, is a lithographed copy of a map of south Yorkshire, which does not appear to have been seen by any of Smith's later biographers. The lithograph was reproduced in *The Naturalist* for 1912, page 282, and we are able to give the illustration herewith. It is described as "Proposed Aire and Dunn Canal to drain the contiguous lands and to shorten and connect the present navigation. William Smith, 1819." In the bottom right-hand corner is a note to the effect that the map was "drawn on stone by J. Phillips." This map was apparently issued with the prospectus of the proposed Company, as it is foolscap size, folded in four, and has on the back of one of the folds: "Aire and Dun (*sic*) Junction Canal and Extensive Drainage in Yorks. Printed by E. William's, 11 Strand."

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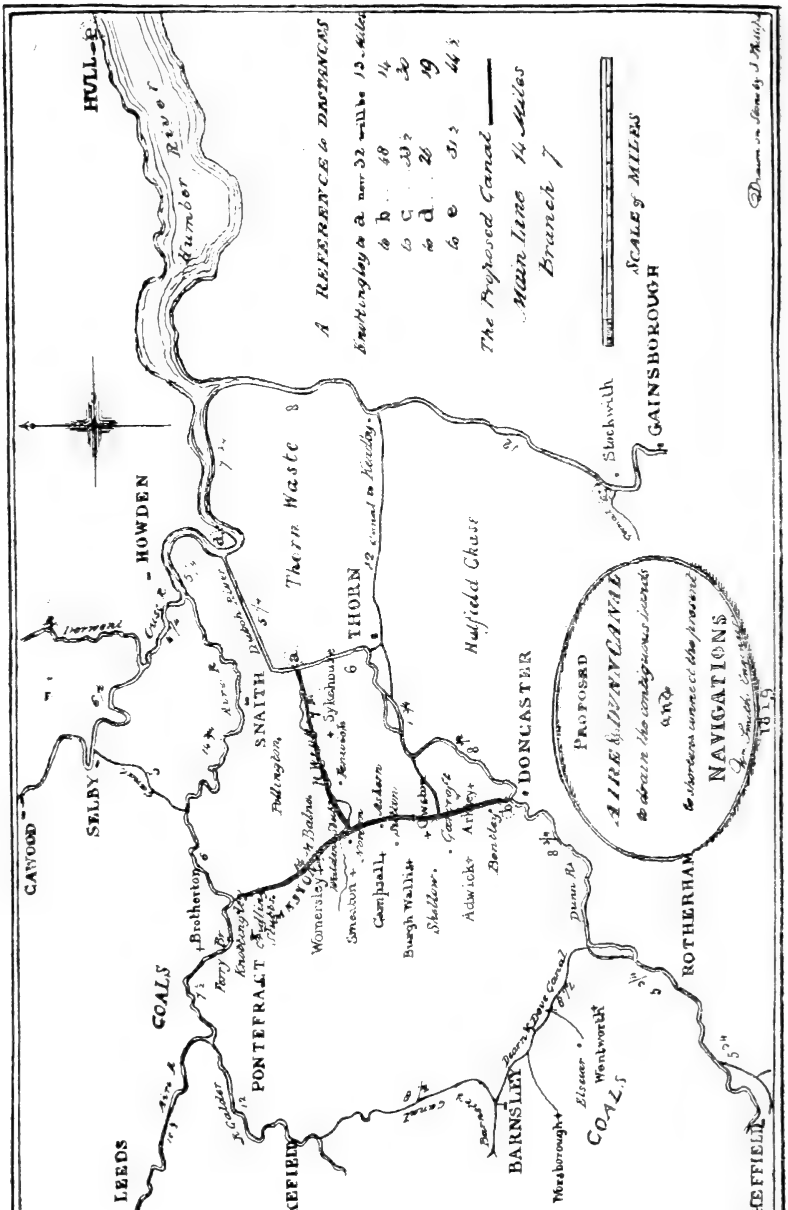
* Memoirs, p. 88.


PROPOSED
AIRE & DUN CANAL
to drain the contiguous lands
and
to shorten & connect the present
NAVIGATIONS
1819
A REFERENCE to DISTANCES
The Proposed Canal
Main Line 14 Miles
Branch 7
SCALE of MILES
HULL
Humber River
HOWDEN
CAWOOD
SELBY
SNAITH
THORN
Thorn Waste
Hatfield Chase
DONCASTER
Stockwith
GAINSBOROUGH
ROTHERHAM
SHEFFIELD
BARNSLEY
WAKEFIELD
LEEDS
PONTEFRACT
COALS
COALS

SMITH'S GEOLOGICAL ATLAS.

On January 1st, 1819, appeared the first part of a new work by Smith, entitled a "New Geological Atlas of England and Wales."* It contained maps of Norfolk, Kent, Wiltshire and Sussex. Part II., dated September 1st, 1819, contained the maps of Gloucester, Berkshire, Surrey and Suffolk. Part III. was published on February 1st, 1820, and contained maps of Oxford, Bucks., Bedford and Essex. Part IV., appeared in 1821, and contained a map of Yorkshire in four sheets. In the same year Part V. was printed, but was not published until 1822. It contained maps of Nottingham, Leicester, Huntingdon and Rutland. In 1824 Part VI. was published, with maps of Cumberland, Durham, Northumberland, Westmoreland. This Atlas, another of Smith's incomplete works, then ceased publication, although Phillips records that "other parts to complete this work were left in a state of forwardness."

All the county maps published contain much more information than was shown on Smith's large map of 1815, and indicate that during the intervening years he had done much to increase his knowledge.

The maps are based on Cary's county maps, and are headed, "By W. Smith, Mineral Surveyor." Each map measures 21½ inches by 19¼ inches; the scale varies slightly, but averages 3 miles to an inch. The usual footnote is added to the effect that "The numbers attached to the deposits of each stratum refer to the Geological Tables of British Organic Fossils which may be had of the Publisher, price 1s. 6d." Occasionally there are references to the sale of "accompanying sections at 5s. each."

SMITH'S MAP OF YORKSHIRE.

Of the Yorkshire map, in which we are principally interested, Prof. Judd truly says†: "This is one of the finest of Smith's works.

* "Between the appearance of the great general map in 1815 and the year 1821, [? 1824] Mr. Smith published no less than twenty geological maps of English counties, often remarkable for their accuracy; and he has not desisted from preparing others, amidst difficulties and privations such as few men devoted to science ever endured," *loc. cit.*, p. 218. Woodward, *loc. cit.*, says 21, "with (i.e. including) a four-sheet map of Yorkshire."

† *Geological Mag.*, 1898, p. 103.

It is full of admirably worked out details. In the West Riding, the outcrops of the chief of the grit beds are represented on the map with their relations to the coal-seams, and a fine vertical section of them is given; and in the north-east of the county, Smith clearly defines the estuarine strata of the Lower Oolites as follows: 'Sand Rock and Grit Freestone of the Moors, lying over the Alum Shale' (Upper Lias), 'and, in Scarborough Castle Hill,' under the Oolite or Calcareous Freestone. A thin coal in the cliffs is worked on the moors at Danby and other places.' In this work we see the fruits of Smith's residence at Scarborough, which commenced in the year 1820."

My copy of this map was formerly the property of Henry Holt, whose name is printed on the map case. It is in four separate sheets, each measuring 18¾ inches by 22¼ inches. They are so arranged that they can be pasted together as one map.

On the top left-hand sheet are the words "GEOLOGICAL MAP OF," and on the top right-hand sheet "YORKSHIRE. BY W. SMITH, MINERAL SURVEYOR."

In the former, the country west of Stokesley, Hawnby, Coxwold, Easingwold and Moor Monckton, and north of Plumpton, Rilston and Long Preston, is included. The "Whinstone Dyke," which is shown on the adjoining map as commencing near the Peak Alum Works, is here traced through Stainton to Coatham Stob, north-west of Yarm. Outside the county boundary tablets of colour are shown as an index to the colours on the map. These are:—

28. BROWN-RED SAND ROCK.

31. MOUNTAIN OR METALLIFEROUS LIMESTONE *beneath the Coal Measures alternating with Gritstone and Shale called Plate, the breaks in which contain the rich Veins of Lead and Calamine, extensively worked in the Mining Districts of Swaledale, Wensley Dale, &c.*

Millstone Grit. A thin bed of Coal over the Millstone Grit, worked at Tanhill, Leyburn, Wilton Fell, etc.

BLUE RAG, *uppermost of the series of Slate Rocks in Westmoreland.*

30 m. SHALE, *thin Coal and Ironstone.*

n. FLAGSTONES, *Penhill and Summersides with other Rock, a Coal beneath.*

The North-east Section adjoins that just described, and includes the country north of North Frodingham, Bainton, Fangfoss and York. An index to the colours representing the strata is given, commencing at the top, with

28. RED MARL *with Gypsum.*

14. CLUNCH CLAY *and* ALUM SHALE, *which is worked for Alum, by Guisborough and Stokesley to the N.W. extremity of the Hambledon Hills.*

13. SAND ROCK *and* GRIT FREESTONE, *of the Moors, lying over the Alum Shale, and in Scarborough Castle Hill under the Oolite or Calcareous Freestone—A thin Coal in the Cliffs, is worked on the Moors at Danby and other places.*

12. CORAL RAG *and its* OOLITE (*or Pisolite*) *the upper part of Scarborough Castle Rock, containing the Corals which are found in its range through Wilts—Figured and described in* STRATA IDENTIFIED BY ORGANIZED FOSSILS.

11. OAKTREE CLAY, *in its course have been many unsuccessful Trials for Coal.*

10. SAND OF THE PORTLAND ROCK.

5. CHALK *excavated for Lime into large Caverns.*

2. 4. BRICKEARTH *and* SAND, *in low Cliffs over the Chalk.*

On the Holderness Cliffs we find: "*Here stood Auburn, which was washed away by the Sea.*" "*Hartburn, washed away.*" "*Hyde, washed away.*"

The South-east Section of the map bears, in a large Circle: "A / NEW MAP / OF / YORKSHIRE, / DIVIDED INTO ITS / RIDINGS / AND / SUBDIVIDED INTO WAPONTAKES, / EXHIBITING / ITS ROADS, RIVERS, PARKS, &C. / BY JOHN CARY, ENGRAVER. /" Some imbecile* has carefully erased the date from this copy of the map, but it should be 1821.†

* Possibly the dealer from whom I purchased it, in order that the map might not be so much "out of date."

† *See* Phillip's Memoirs, p. 149.

The scale is shown, viz., 12 miles to $4\frac{1}{2}$ inches. In the "EXPLANATION" are shown Borough and County Boundaries, Chief Places of County Election, Polling Places, Boroughs returning Two Members, Boroughs returning One Member.

The Index to colours is shown on this section, those given, coming from north to south and west, being:—

2. 4. BRICKEARTH, SAND & CLAY, *in Cliffs which are washed away by the Sea.*

3. THE CRAG SHELLS, *and Sand occur in little Sand Hills in the Interior of Holderness.*

5. CHALK, dug in great quantity at Hessle.

12. CORAL RAG OOLITE OR PISOLITE.

13. SAND, *beneath*

28. RED MARL *with Gypsum.*

28. (*Beneath Red Marl*) A brown-red Sand and Sand Rock containing Pebbles.

29.	REDLAND LIMESTONE *over the* COAL MEASURES.	*A hard blueish white thin bedded Stone, which at Womersley, Knottingley, and Brotherton, makes the Lime, celebrated for Agricultural purposes.* *Red and Blue Clay, and Gypsum. A soft yellowish calcareous Freestone or Magnesian Limestone.*

This section bears the imprint: "LONDON: PUBLISHED BY J. CARY, ENGRAVER AND MAP-SELLER, No. 86, St. James's Str."

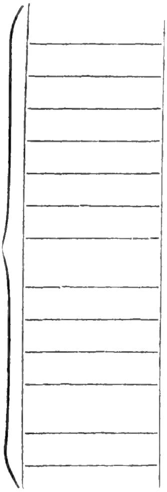
The South-West Section is of especial value. There is a sample of the colour (near Clitheroe) to show "MOUNTAIN OR METALLIFEROUS LIMESTONE BENEATH THE COAL MEASURES." And in the left-hand corner is an admirable Table of the Strata of our County as surveyed by Smith. It is as follows (the colours of course being omitted):—

A TABLE OF THE
STRATA OF YORKSHIRE
IN SUCCESSION, DIPPING EASTWARD.

	Colours of Strata.	Nos. in the Geological Table.		Districts where the Strata Occur.
		2 3 4	Clay or Brickearth. Crag, Shells *in Sand* Sand *and light Loam.*	*Holderness.*
		5	Chalk	*Wolds.*
		10	Sand of the Portland Rock.	
		11	Oaktree Clay	*Vale of Pickering.*
		12	Coral Rag and Pisolite or Oolite.	
		13	Sand *with Rocks of Calcareous Grit and Sandstone. (containing a thin Coal and some Limestone) rising N.W. to Hambleton Hill and Roseberry Topping*	*Nth. Riding East Moors*
		14	Clunch Clay and Shale. *Alum Shale*	*Cleveland, York Vale and the Levels.*
		26	Lias at *Topcliff*	
		28	Red Marl and Gypsum	
			Sand and Sand Rock	
Redland Limestone.			Knottingley Limestone	*On the North Road.*
		29	Red Clay and Gypsum	
			Yellow or Magnesian Limestone	
Coal Measures.		a	Pontefract Rock	*Coal District.*
		b		
		c	Ackworth Rock — *The Upper Part of the Coal series contains thin beds of swift burning Coal, which leaves White Ashes*	
		d		
		e	Chevet Rock	
		f 30		
		g	Red Rock	
		h	*The Midway Part thick beds of hard Coal, good for furnaces*	
		i	Bradgate Rock	
		k		
		l	Wortley Rock — *The Lower Part excellent bituminous Coal as at Silkstone, Flockton, etc, accompanied with Cannal Coal and Ironstone*	
		m		
		n	Flagstone — *On the extremity of the Coal-field, a thin Coal extends N.W. to some of the Moors*	*High Western Moors.*
			Clay	
			Moorstone or Millstone Grit	
		31	Mountain or Metalliferous Limestone	*Craven, and Dales of the Mining Districts.*
			Blue Rag or Slate Rock	
	— O O		Whinstone or Basalt.	

The colours marked b, d, f, h, k, m, *represent Clays, Shales, and beds of Coal, alternating with the Grit Rocks. To facilitate the reference to the Coal Measures, letters are added upon the Map, corresponding with those in the above Table.*

To enable him to give further details respecting the Coal Measures that Section is repeated, as under :—



Coal Measures.

a	Pontefract Rock	*but little used in building.*
b		
c	Ackworth Rock	*a soft Grit Freestone and Grindstones, Kirby Mexborough and Denaby*
d		
e	Chevet Rock ...	*a thin Rock of little use.*
f		
g	Red Rock	*a course Grit Rock, in some places loose Sand. Large blocks at Wolley-edge Newmillar-dam, etc.*
h		
i	Bradgate Rock .	*a fine grained Grit Freestone and Grindstones, some blue cutting Stone.*
k	*Course of the Shell Ironstone.*	
l	Wortley Rock ..	*a Grit Stone in thin beds, used in building.*
m		
n	F agstone	*Grit Rock, with argillaceous partings, some more micaceous, cleaving into flags and roofing Slate.*

Below the border is the familiar announcement :—

" NOTE.—The numbers attached to the description of each Stratum refer to the Geological Table of British Organised Fossils, which may be had of the Publisher, Price 1s. 6d."

The plates used for these county maps were apparently subsequently obtained from Cary by Messrs. Crutchley, and that firm's sixpenny county maps for many years contained the lines and legends of Smith's maps.

1819.

" A Reduction of Smith's large Geological Map of England and Wales, exhibiting a general View of the Stratification of the Country; intended as an Elementary Map for those commencing the study of Geology."*

The above is given among the list of Publications by Smith, on pages 148-9 of Phillips's "Memoirs." It is also referred to by Judd.

* *See* Phillips's Memoirs, p. 148.

I have not be able to trace a copy dated 1819, and fancy Phillips must have made a mistake of a year in the date, especially as he makes no mention of the map of 1820, referred to below.

SMITH'S MAP OF 1820.

A map in my possession not definitely referred to by Judd in his account of Smith's published maps, is entitled : " A NEW / GEOLOGICAL MAP / OF / ENGLAND AND WALES, / WITH THE INLAND NAVIGATIONS ; / EXHIBITING / THE DISTRICTS OF COAL / AND OTHER SITES OF MINERAL TONNAGE / BY W. SMITH, ENGINEER, / 1820. / London : Published by J. Cary, 86 St. James's Str., Mar. 18, 1820."

The map measures 24 inches by $29\frac{3}{4}$ inches, the scale being 15 miles to the inch. The colours are more clearly indicated than in the large map, and the dividing lines between one stratum and another are much clearer.

The following " EXPLANATION OF THE COLOURS," in two columns, is given at the bottom of the map, and contains additional information to that supplied on Smith's large map of five years earlier, upon which, of course, this one is based* :—

a LONDON CLAY, *forming detached hills in the Environs of London* ... ...

b BRICK EARTH AND CLAY, *interspersed with Sand and Gravel—The lighter shade of brown shews the sandy districts which form extensive heaths* ... ...

c CHALK, *the upper beds of which are soft and contain flinty Nodules The under beds with few Flints—sometimes used as a Building Stone At the foot of the Chalk is the Green Sand in which is found the Fire-Stone. Golt Brickearth beneath* ... ...

d SAND OF THE PORTLAND ROCK, *locally containing a Limestone, the first Quarry Stone, in the Series of English Strata, varying much in Quality, as at Portland, Purbeck, Chilmark, Swindon, Shotover, the Vicinity of Aylesbury, and Maidstone in Kent* ... ...

* The colours are given in the tablets at the end of the description of each bed.

e OAKTREE CLAY, *a tenacious Woodland Soil a bituminous part in the Isle of Purbeck used for fuel...* ... ...

f SAND AND STONE, *extensively overlayed in Yorks., Oxfords., Berks., Wilts., and Dorset, by the Coral Rag and its calcareous Freestone...* ... ...

g CLUNCH CLAY AND SHALE, *along its course have been several unsuccessful Trials for Coal,—on the northern part are extensive Allum Works* ... ...

h UPPER OOLITE, *or Bath Freestone Rock, overlayed by Cornbrash, Sand, and Forest Marble, coloured* ...

i UNDER OOLITE *separated from the upper by Fuller's Earth and its Rock. It is a coarse calcareous Freestone*

k BLUE MARL AND LIAS LIMESTONE, *the very thick superincumbent Marl is represented by the lighter Blue—The White Lias is used for Lithography* ... ...

l RED MARL *containing beds of soft red Sandstone and occasionally of blue Clay—The Salt Works of Cheshire are in this stratum In the environs of Bath, Coal is worked beneath the Red Marl* ... ...

m REDLAND LIMESTONE, *overlaying the Coal measures, much celebrated in Yorkshire for extensive Lime-works* ...

n COAL DISTRICTS *with the Rocks and Clays accompanying the coal comprising the great Iron-works* ... ...

o MOUNTAIN LIMESTONE, *alternating with beds of Shale, Chert and Gritstone and containing numerous Veins of Lead and Copper* ... ...

p TRAP ROCKS ... ...

q RED RHAB AND DUNSTONE, with *interspersions of Limestone* ... ...

r KILLAS OR SLATE, *and other Mountain Strata, abounding with Minerals* ... ...

s *Granite, Sienite* (sic), *etc.* ... ...

In the space occupied by the North Sea are two Tables, viz., " A LIST OF THE CANALS & NAVIGABLE RIVERS SHEWING THE PRINCIPAL ARTICLES OF MINERAL TONNAGE," and " RAILWAYS." The former contains a list of 100 Canals and 97 Rivers; the latter of 20 Railways. The "Articles of Tonnage" are principally coal, Iron and Ironstone, but include Granite, Lime, Limestone, Flagstone, Stone, Slate, Lead, China Stone, Sea Sand, Flints, Firestone, Fuller's Earth, Ore, Gravel, Culm, Mountsorrel Stone, Flags, Paving stone, "Defence Sea Beach," Pottery, Gypsum, Fire Clay, Potter's Clay, Sea Sand, Copper Ore, Salt, Salt Rock, Freestone, Gun Flints, Reach, Oysters, Millstones, Shell Sand, Cannel, Manganese, Chalk, Roadstone, Pipe Clay, Loam, Ochre, Marble, Powder, Grindstones.

Prof. Judd* records that in 1820 "Cary, who published all Smith's maps, issued a 'New Geological Map of England and Wales, reduced from Smith's large Map, for those commencing the Study of Geology.'" This title was puzzling, and I had not been able to trace a map which bore it. My copy had the title at the head of these notes. Another copy of the map, however, which I have recently obtained, explains the matter, and indicates where the title quoted by Phillips ("Memoirs," p. 149) was obtained, though so far I have not confirmed Phillips's date.

This second map is in every way identical with the first, except that the colours are more distinct. But it is in the original case,† upon the outside of which is a printed label:—

"A / NEW / GEOLOGICAL MAP / OF / ENGLAND AND WALES, / REDUCED FROM SMITH'S LARGE MAP; / EXHIBITING / A GENERAL VIEW / OF THE / STRATIFICATION OF THE COUNTRY; / INTENDED AS / AN ELEMENTARY MAP / FOR / THOSE COMMENCING THE STUDY OF / GEOLOGY. / = / LONDON: / PUBLISHED BY JOHN CARY, / NO. 86, ST. JAMES'S STREET, NEAR THE PALACE." Added in ink, (evidently a considerable time ago), is "Pd. 10s." Of this Phillips tells us‡ that the "Price, in sheet, neatly coloured and shaded, 14s.; Mounted in Case for Travelling, or on rollers, 18s."

It would thus seem that the "Geological Map" with the "Inland Navigations," etc., and the "map for those commencing the study of Geology" are one and the same.

A second edition of this map is said to have been published by John Cary in 1827, but so far I have not been able to trace one. §

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* loc. cit., p. 102.

† The first named map is also in its original case, but it bears no label.

‡ i.e. under the wrong date, 1819. § See next page.

SMITH'S MAP OF 1824.

Beyond a casual reference to the fact that a second edition of Smith's small map of England and Wales had been published, I had no evidence that a further edition had been issued. Through the good offices of Mr. R. H. Barker, however, I have been able to record one. It seems that in August, 1916, Mr. Sydney P. Turnbull, J.P., found a roll containing two uncoloured maps of England and Wales, one of which he has kindly given to me. It is obviously from the same plate as Smith's map of 1820, but the date on the oval title has been altered to 1824, and the date of the imprint beneath has been similarly dealt with, though the day of the month, viz., March 18th, remains. The title of this 'second edition' therefore reads :—

"A New / Geological Map / of / England and Wales, / with the Inland Navigations ; / Exhibiting / The Districts of Coal / and other sites of Mineral Tonnage / by W. Smith, Engineer, / 1824. / London : Published by J. Cary, 86 St. James's Street, Mar. 18, 1824."

The map is of the same measurement and scale as that of 1820. These two recently discovered copies are not coloured, though the tablets appear at the bottom for the colours to be inserted. Whether they were ever issued in the coloured state or not, with this date, I cannot say.

This uncoloured impression indicates that the more prominent features of the Coal-fields, etc., are shown by dark markings on the plate itself, so that the darker patches on the colouring of the earlier maps are made without the application of a darker layer of colour. They also act as useful guiding lines for the artist.

On the outer edge of this map, which is uppermost when rolled up, is written, apparently by Smith himself, "2 Geological maps of England and Wales / by / W. Smith, &c. / (Uncol.)" ; and in the corner is "Map of England."

ON COAL. BY W. SMITH.

1830.

In his notes on "Politics, Statistics, &c." (see Appendix E,) Smith informs us that at the request of the Editor of *The Whitby Repository,* he had sent some observations on Coal to that Magazine. On account of the scarcity of old-time journals of this type, and the method then adopted of publishing scientific matter, I have had difficulty in tracing these notes.* From the date given by Smith it is apparent that his paper appeared in the first series of *The Whitby Repository,* which I now possess. There is an imperfect copy in the Bradford Public Library, and this Mr. Butler Wood has also kindly allowed me to consult. In the number for December, 1830, Vol. 6. pp. 370-372, is a note to "Mr. Editor, Sir," from "An Original Subscriber," apparently the Editor himself! This note is headed

"Bed of Coal at Robin Hood's Bay."

The writer informs us that "several† months ago" he was "amusing himself" by looking into Phillips's Illustrations of the Geology of Yorkshire, and he was especially struck with the extraordinary dislocation of the strata near the Peak and Robin Hood's Bay. Judging by the dip of the strata, the position and range of the succeeding strata (red marl and magnesian limestone) in approaching the Durham Coal field, he was led to think that, near Robin Hood's Bay, "where the lowest lias bed was at the greatest elevation above the level of the sea," was the point where coal might be tried for with the greatest prospect of success.

The writer stated that "Being in some degree acquainted with a gentleman, who is looked upon as one of the first geologists in the kingdom, and who I knew was well informed as to the geology of this district in particular, I wrote to him . . . . I was favoured with an elaborate and luminous answer, from which I have much pleasure in making some extracts."

Smith is not mentioned, but "one of the first geologists in the kingdom," the characteristic "elaborate and luminous answer," the

* There were two series of *The Whitby Repository.* The first series was issued in 1825-1833, and the second between 1866 and 1868. See "Yorkshire's Contribution to Science," by T. Sheppard, 1916, p. 87.

† Phillips's book was only issued in 1829, the year previously.

answer itself (see below), the record it contains as to the writer's statement that "nearly forty years since, I lived amongst coal pits, commonly sunken through the lias and the red marl,"* and the independent statement made by Smith that he had agreed to a request to supply some notes on Coal to *The Whitby Repository,* all point to the notes being by Smith. The following are the extracts quoted from Smith's 'elaborate and luminous communication':—

> "I perceive, by your letter, that your views of the probability of finding coal are not, like those of too many others, founded on the hope of finding it in shale or lias clay; but the question where to prick upon that intermediate range of the coal seams which may connect the coal-fields of Yorkshire and Durham, involves a great deal of deep geological consideration. My thoughts have often been turned to that important object; which, in a well chosen spot, is worthy of a national experiment. We know that all the beds of coal and their accompaniments, in the West Riding, sink under the Magnesian limestone in the vicinity of Abberford, much in the same manner as they rise from beneath the same kind of limestone at Ferry-Hill, in Durham; but the limestone being, in both cases, an uncomformable covering, we have no clue from the Upper strata to the range of the coal seams between those two very distant parts. From the east and west range in the northernmost coals in Yorkshire, and a similar range in the southernmost coals in Durham, and from intermediate borings which I am acquainted with, I am satisfied that the coals do not range under an uncomformable cover, through the low ground, in a straight line between those two places; and if they range in a curving line under the high land of the eastern moors, it is there impossible to get down to them. It seems unlikely, from various circumstances I can enumerate, both in Yorkshire and Durham, that a line curving eastward less than a semicircle, will never unite the coal-fields in question; and, as the greater part of this line passes under enormously thick piles of strata, mostly in very high ground, the only chances there are of finding coal at any great distance from those two coal-fields, are on the sea shore; and the best of all these, as I have long thought, is in Robin Hood's Bay. The magnesian limestone, if it could be

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* i.e. in Somersetshire.

found would not be worth getting by a pit in the Bay ; and if coals can be found it would be well if the red marl could be sunken through without it, which I have reason to expect, or at least that it may be thin. It is a rock that varies much in thickness, and in the southern parts becomes extinct. The red marl, which is an uncomformable cover to coal, of least extent in those parts, is sunken through, at all the pits, from 10 to 30 fathoms in thickness ; this, like the limestone, varies much in thickness, and there are circumstances attending it which lead me to think it may not be very thick in some parts of the North Riding.

Nearly forty years since, I lived amongst coal-pits, commonly sunken through the lias and the red marl, and some of them through superincumbent beds as high in the series as the inferior oolite. We know that the alum shale or lias clay, and some of the other strata in these eastern moorlands, are of extraordinary thickness ; but there is no reason to believe that the red marl, and especially the beds below it, which have no relation to those above, are thereabout thicker than usual."

GEOLOGICAL MAP OF HACKNESS, 1832.

Phillips informs us* that " Among the many eminent persons who at different periods of Mr. Smith's life, took a lively interest in his welfare, it is the pleasing duty of his biographer to mark with grateful distinction one whose friendly regard he gained about this period, and retained during the remainder of his life, Sir John V. B. Johnstone, Bart. of Hackness. On succeeding to his estates, this enlightened gentleman was desirous of converting to practical effect on his farms, some of the geological and botanical truths which he knew to have been established in the museum and the laboratory ; he found in Mr. Smith the union of practical and theoretical knowledge which was necessary for his object, and a desire to exemplify that knowledge in agricultural improvements, which exactly coincided with his own wishes. From 1828 to 1834, Mr. Smith acted as his land-steward, resided at Hackness, occupied himself in the usual concerns of a large landed estate, and then passed (in the judgment of the writer) six of the calmest and happiest years of his declining life. The worthy proprietor of Hackness had hoped that the retirement which seemed so well suited to Mr. Smith's age and taste,

* Memoirs of William Smith, p. 113.

would have been memorable for the production of the results of a life of scientific toil, and spared neither friendly entreaty, nor pecuniary aid, nor personal exertion, to bring this favourite design to effect. Mr. Smith meditated and wrote, but did not arrange his papers, and except a beautiful geological map of the Hackness estate, executed in great detail and with extreme exactitude, nothing of importance came from his hands to the public. He was now advanced to the age of sixty years."

As the Report of the British Association shows that this geological map was exhibited at the inaugural meeting at York in 1831, it seems probable that the Hackness map was drawn in 1829 or 1830.

In the hope of tracing this, the last piece of mapping executed by Smith, and relating to one of the most interesting parts of our county, I recently communicated with the Hon. Francis Johnstone. He informs me that he had the estate papers looked through but was unable to find Smith's map, or any of his papers. He had also asked Lord Derwent, who remembeied the map, but it was feared it was destroyed, as all the family papers were burnt when the Hall was destroyed. Thus this fire, in addition to destroying many valuable family documents, robbed geological science of a great treasure.

In Fox-Strangways' "Jurassic Rocks of Yorkshire," Vol. I., (Appendix), occurs a note to the effect that the Hackness Map was "lithographed by Day, London."

In a list of the "Scientific communications received at the Society's Meetings" published in the Yorkshire Philosophical Society's Report for 1831, I find "Memoir on the stratification of the Hackness Hills, accompanied by a Geological Map of the district, by William Smith Esq." And among the "Donations to the Library," on page 35 of the same report is "Wm. Smith Esq. Geological Map of the Hackness Hills."

This led me to enquire at the York Museum, but I regret to learn that, though the Society possesses many of Smith's published maps and memoirs, these two important items cannot be traced.

I next turned to the Reports of the Scarborough Philosophical Society, as, while staying at Hackness in his later years, Smith's home was within a few miles of Scarborough, and his employer, Sir J. V. B. Johnstone, was at that time the President of the Scarborough Philosophical Society. It is fair to assume therefore that Smith might have taken some part in the Society's proceedings.

My earliest copy of the report of the Scarborough Society is the fifth, in 1834, and I see from page 25 that Mr. W. Smith presented to the Society "Lectures on the Science of Agriculture, by Sir J. Sinclair, Bart ; Hints on Vegetation, by the same author ; List of Members of the British Association for the advancement of Science ; and View of the Castle Hill, Edinburgh," This is doubtless *the* W. Smith, judging by the nature of the gifts, and bearing in mind the other circumstances mentioned.

I therefore wrote to Dr. J. Irving, who some time ago assisted me in my quest for a set of the Scarborough Society's reports. He, with the librarian, Mr. Cross, has kindly made a search. He states that in the Society's first report, it is recorded that the arrival of Smith in the district in 1820 "gave a new feature to the study of geology, and an impulse to the student, which may be considered to have laid the basis of the Scarborough Museum."

It was also Smith's suggestion that the Museum assumed the circular shape as being most suitable for the display of fossils arranged on sloping shelves according to stratigraphical order. This fact is referred to by Prof. Buckland in his Presidential address to the Geological Society in 1840. In referring to the recent death of Wm. Smith, he states* "In 1817† he planned the beautiful Museum of Scarborough, in which he employed his original and instructive method of representing by sloping shelves passing one beneath the other, the inclined position of the strata ; each shelf bearing the fossils that are respectively characteristic of the stratum it is intended to represent."

Originally the museum was circular in plan, as may be judged from the sketch given in the Society's earlier reports ; the side wings were added in 1861.

Seeing that Smith had a hand in the designing of the Scarborough Museum, I thought that it was more than possible the section of the strata of the coast, which was painted round the building on the

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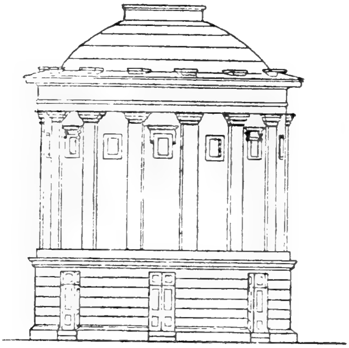
* *Proc. Geol. Soc.*, Vol. III., p. 251.

† Prof. Buckland must have been a little premature here. The Scarborough Society was not founded until 1827, Smith went to Hackness in 1828, and the Museum was built in 1829.

inside, was his work. It may, however, be the work of Phillips. The beds, as I well remember, were shown in inverse order, as though viewed from the land. There appears to be no reference to the matter in the reports, so that the point may not be cleared up. Unfortunately, about ten years ago, the work was obliterated, though Dr. Irving informs me it was, by painting and stencil, exactly reproduced by reversal, so that the sections are now shown as seen from the sea. Some of the colours



Scarbro' Museum
1828

View of the Scarborough Museum as originally built; from the Scarborough Philosophical Society's early reports.

were made more distinct; the colours in the reproduction were copied from the previous chart, but they are not the colours that Smith would have used, such as we see on all his maps and sections.

In answer to my enquiry in reference to the Hackness map, Dr. Irving states, "We could find but one map, probably the one to which you refer, and it, I understand, came into the Society's possession during the past month or two. It is somewhat dirty, more or less tattered at the edges, and slighty torn."

It seems that this map was originally in the possession of John Williamson, (father of Prof. W. C. Williamson) who was curator of the Scarborough Museum in Smith's time. He lodged with the grandmother of Mr. Brogden, a member of the present Scarborough Society. At his death, most of his goods were sold, but the map and a few old books were left in the possession of the lady, who had recently handed them to her grandson, who, in turn, gave them to the Scarborough Museum.*

In the Third Report of the Scarborough Society, for 1832, it is recorded that a Geological Map of the Hackness Hills given to the Museum was " beautifully coloured by W. Smith." Dr. Irving, on making further search, states " This map, mounted on rollers, I find is still extant, but by exposure to light, has faded almost to vanishing point. Some years ago, it must have been rolled up and thrown aside."

There is an interesting note in the Society's Fourth report, viz :— " Mr. W. Smith has been kind enough to colour for the Society Knox's Excellent Map of the Vicinity of Scarborough† ; he has also presented a minute geological map of the Hackness Hills. His pupil, Mr. Turnbull, has received orders from Sir John Johnstone to colour Greenwood's Map of Yorkshire under the eye of this great British Geologist." Not one of these maps, however, is so far forthcoming.

The Scarborough Philosophical Society has kindly given us the map which has recently come into their possession, and thus we are able to give a detailed description. It is 23 ins. by 36 ins. (without margins) lithographed, and, unfortunately, uncoloured. It is entitled,

" STRATIFICATION IN HACKNESS HILLS / BY W. SMITH. / 1832/ W. DAY, LITH$^{G.}$ TO THE KING / 17 GATE ST., LINCOLNS INN FIELDS. /

There is a " Scale of Furlongs (12 *Chains to one Inch*) "

At the bottom left-hand corner is the key to the strata, which is far more elaborate and detailed than anything previously accomplished by Smith, and clearly shows that he was familiar with every part of the ground shown on the map. It is headed :—

" VERTICAL SECTION OF THE STRATA " and shows

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* The Scarborough Philosophical Society has since presented this map to the Hull Municipal Museum.

† This is the one issued in 1820, and before that reproduced in the scarce " Descriptions Geological, Topographical and Antiquarian, in East Yorkshire, between the Humber and the Tees, with a Trigonometrically surveyed map, extending twenty-five miles from Scarborough, &c." By Robert Knox, 1855. Royal 8vo, 210 pp.

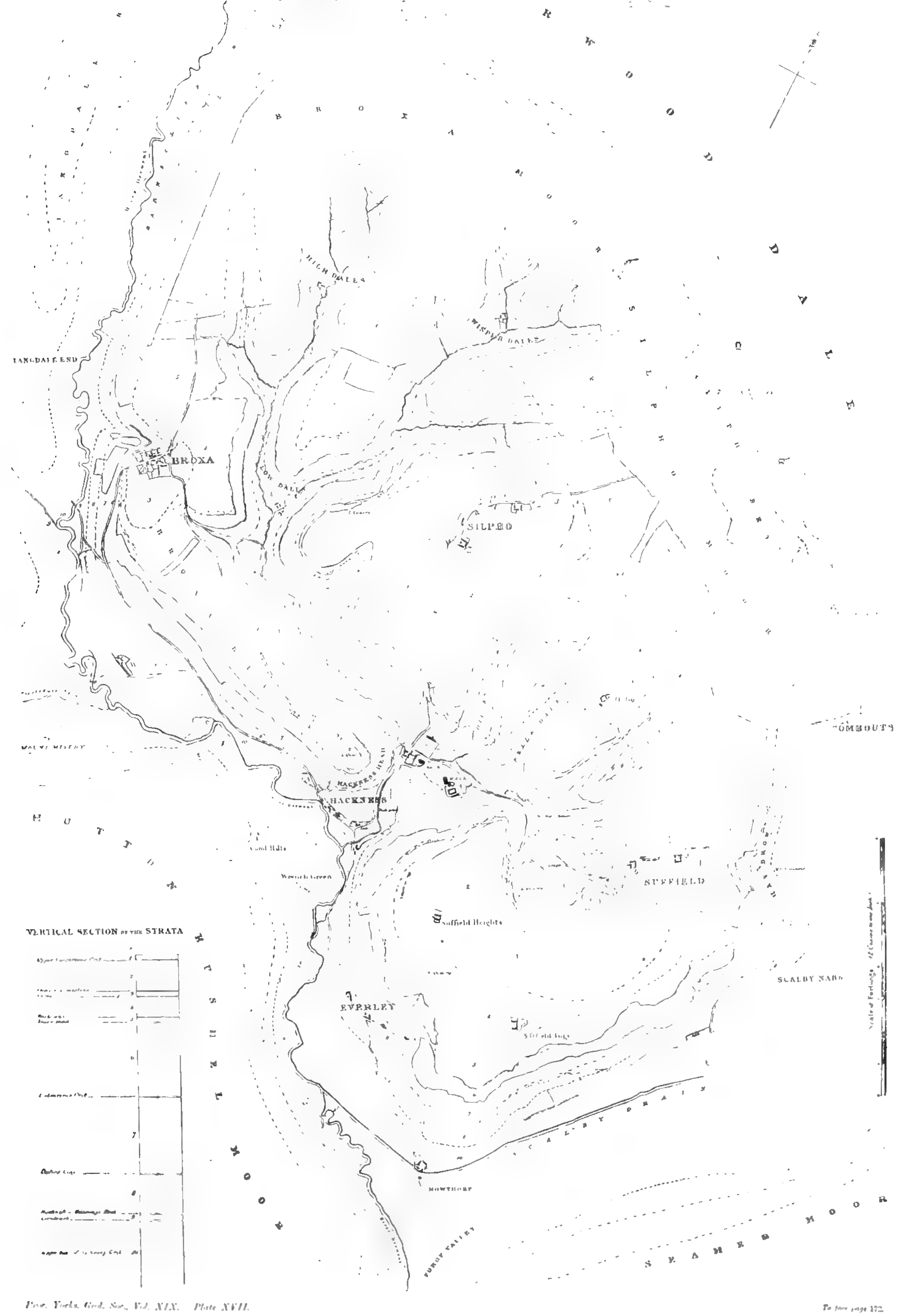
	No.
Upper Calcareous Grit	1
Oolitic Limestone	2
Coral	3
Wallstone	4
Yellow Sand	5
Calcareous Grit	6
Oxford Clay	7
Hackness or Kelloways Rock	8
Cornbrash	9
Upper Beds of the Coaly Grit	10

STRATIFICATION IN HACKNESS HILLS

BY

W^m SMITH.

1832



The village of Silpho is in the centre of the map ; in the top right hand corner (north) is Harwood Dale ; Lang dale Rig is in the top left-hand corner ; and the map includes High Dales, Wisper Dales, Low Dales, Barnscliffe Woods, Broxa and Broxa Moor, Silpho and Silpho Moor, Mount Misery, Hackness, Suffield, and Combouts. Towards the bottom of the map are Everley, Scalby Nabs, Scalby Drain, and Mowthorpe, and finally Forge Valley. The River Derwent is shown at the left. Throughout, the various beds are numbered, so that the colouring of the map would not be a difficult matter.

I give a reproduction of this valuable document, taken from the uncoloured lithograph. (Plate XVII).

To show the accuracy of Smith's work, I give on Plate XIX, a reduced reproduction of our copy of Smith's Hackness map, which we have coloured from the faded copy in the possession of the Scarborough Society ; and on the adjoining Plate (XVIII,), a reproduction of the Geological Survey Map, 1″, as surveyed by the late C. Fox-Strangways in 1878.

Two other copies of the Hackness map, uncoloured, have since been traced at Scarborough, which have been kindly given to me by Mr. Sydney P. Turnbull, J.P.

In his " Jurassic Rocks of Yorkshire " Vol. 1. 1892, p. 513, Fox-Strangways states that the " old drawing," the original of the lithograph by Day of the Hackness Map, " is still in the possession of the Turnbull family." It was shown at the " Special loan collection of scientific apparatus " at South Kensington in 1877, and was described in the Catalogue (3rd. ed. p. 823) as William Smith's original Geological Map of Hackness Hill, Yorkshire, being one of the earliest geological maps ever constructed on a large scale . . . . The maps . . . of the outlying mass of the Middle Oolite at Hackness, exhibit in a striking manner the great knowledge of the author, and the able manner in which he traced and mapped their geological structure, and pointed out its bearing on the agriculture of the District. The Geological Survey Map of the same area [hung by its side in the collection] . . . . shows that William Smith was well acquainted with the general details of this unique and somewhat obscure group of rocks.

The late C. Fox-Strangways prepared* the following

* loc. cit. page 514.

TABLE of STRATA near HACKNESS showing the DIVISIONS made by WILLIAM SMITH and those of the GEOLOGICAL SURVEY.

Mr. Smith's Classification.		Classification adopted by the Geological Survey.
	Upper Calcareous Grit.	Upper Calcareous Grit.
Coralline Oolite	Limestone.	Upper Limestone and Coral Rag.
		Middle Calcareous Grit.
		Lower Limestone with Coral Bed at base.
	Spongite Coral Bed.	
	Grey or Wallstone.	Passage Beds or Greystone.
Calcareous Grit	Reddish yellow sand.	Lower Calcareous Grit. (The different bands noticed, but not classed as divisions.)
	Cherty bed of stone.	
	Freestone.	
	Oxford Clay.	Oxford Clay.
	Hackness Rock.	Kellaways Rock.
	Clay.	Cornbrash with clays above.
	Cornbrash.	
	Coaly Grit.	Estuarine Series.

Portion of the 6-inch Geological Map of Hackness, as surveyed by C. Fox-Strangways in 1878, reproduced with the sanction of the Controller of H.M. Stationery Office.

Reduced illustration of Smith's Map of Hackness. 1832. Coloured.

SYNOPSIS OF GEOLOGICAL PHENOMENA.

SOURCES OF EVIDENCE.	DEDUCTIONS.	RESULTS.	REMARKS.
Fishes in abundance	indicate that	Water prevailed.	
Petrified shells are so filled	as to evince minute solution	1. Polarity of atoms.	
Cyrstals blunted prior to union in masses	show aqueous action..........	2. Crystallization of particles.	
Shells in rocks not crushed, ...	therefore rocks hardened quickly	3. Aggregation, induration, and cementation of mineralized masses in the *Stratification.*	
—— by hardening of matter	were fixed.		
—— none in open joints and veins, ...	therefore joints and veins opened subsequently to their fixation, ...		
Mineral veins obviously were cavities—are filled with spar and ore—spar, the principal filling. This therefore, traced through cavities of all sorts, in all the rocks, from chalk to mountain limestone, including cavities in fossil shells, and those caused thereby in blocks of stone, into which no gross matter could enter	shows that all these, and thus by analogy, that	*Mineral Veins* were filled by segregation.	Where the mineral veins are cavernous, there, and there only, all the fine crystalline cabinet specimens of minerals occur.
The trade winds and sea currents	are existing effects of the earth's centrifugal force.	General Action	
Which force at the complation of the earth	arrived at its maximum effect.		
By the spheroidal figure of the earth	water as well as land is 13 miles higher under the equator than at the poles.		
Evidently such force was deflected by primitive rocks, and further as the matter formed, locally—the elevating force remaining greatest at greatest depths of water	therefore the force which caused that general elevation under certain circumstances was adequate to the casual elevation of land, 3 or 4 miles higher than the ordinary level.	This uplaying fluid action was therefore the origin of HILLS which with passes thro' the liquid matter of all strata being successively kept open was the origin of VALLEYS.	

By the remains of land animals mixed up with water-worn stones	We ascertain that the	Earth was dry and inhabited.
By the bouldered stones every where scattered over the earth's surface, ...	There has been water in action.	THE DELUGE.
By the fossil shells in those boulders, identified with those in the stratified rocks, ...	We ascertain the way of action	
By the height to which the boulders and sea-shells have been raised, ...	We get the force of action and height of the water.	

ILLUSTRATIVE EFFECTS OF THE DELUGE.

By alum-shale, organised fossils, those of coal, and mountain limestone, and boulders from all the rocks northward, in abundance, ...	The effects of a great current from the N. are obvious on the Yorkshire coast.	The first rush of water was by sea from the North.
By the same, ...	with the like effects, ...	Down the vale of York, from N.
By the absence of alum-shale fossils in the vale of Pickering, ...	Filey cliff was not surmounted, which gives the height of	First rush of water about 200 feet.
By bays being filled up, and low places inland, as at	Staiths, Whitby, Scalby, Scabro', and all Holderness, ...	by westward uplaying.
By whinstone, porphyry, conglomerates, jasper, etc., etc.	on Suffield heights, etc.	From the N.
By Shapfell granite, mountain limestone, etc.	Cleveland hills, Lestingham,† Suffield hill, etc., to coast of Holderness, ...	From the N.W.
By sea shells on the Lancashire coast.		
By seas shells under 20 feet of gravel, ...	1000 feet high in Snowden mountains, ...	
By rounded chalk and flints, ...	on side of ditto, from north of Ireland	With wonderful uplaying, from N.W.
By flints from the chalk hills, ...	Vale of Taunton and below Bristol, on the hills near Bath, Cricklade common, ...	Currents from S. and S.E.
By bouldered chalk and flints, far in	Northamptonshire, Rutland and Huntingdon	
By flints, ...	Ashby de la Zouch, and vale of Trent, ...	
By lias fossils in gravel, of	Needwood Forest, ...	From E. to W.
By the instances cited by Mr. Phillips of slate boulders on the side of Ingleborough.	Moughton Fell, (see papers on Craven rocks,) 500 feet above the slate, ...	Current deflected, with wonderful uplaying force.

By the absence of Cornish and Devonshire granite and schist boulders, and of Welsh schist and primitive boulders in the interior,	there seems to have been no general currents from W. and S.W.

* In the original document this read "and ore," but these two words are crossed out and "are" inserted in ink.

† = Lastingham.

W SMITH

Oxford, June 22, 1833.

To face page 175.

1832.

Apparently the last separate publication Smith issued was a single folio sheet, entitled a "Synopsis of Geological Phenomena," which was printed at Oxford in 1832 at the second meeting of the British Association. It measures 14 ins. by 21 ins. No mention whatever appears to be made of this "Synopsis" in the detailed report of the Oxford meeting. Fortunately, one of these is preserved in the Geological Society's Library, and a copy of it, in smaller type, is given herewith.

1837.

The first volume of *The Magazine of Natural History* new series, 1837 (usually known as *Charlesworth's Magazine*), contains two contributions by Smith. They are both short, but important. The first occurs on pages 386-7, and is entitled *Practical Distinctions in Minerals*, and is signed William Smith, LL.D., Scarborough, May, 10, 1827.* It reads :—

"PRACTICAL DISTINCTIONS IN MINERALS.

"On March 31st, 1836, I discovered that the finest particles of mica and quartz in stone may be readily distinguished without the aid of glasses ; and, conceiving that this simple method of knowing the difference in some of our most common minerals may be serviceable to geologists, I beg the insertion of it in your most useful magazine.

"With this view, therefore, without attempting any philosophical explanation of the phenomenon, I merely relate the circumstances of its practical application : first observing, with pleasure, that the eye, which gives us the power of knowing so much, and of knowing one thing from another so distinctly, without our being able to explain how we make the distinctions, is happily receiving from Sir David Brewster, and other philosophers eminent in optical science, that attention it is entitled to.

"My sight has been particularly good, having been able to distinguish objects very clearly, near and at a great distance ; and now, in my 69th year, I can distinguish a small speck of mica, in a brown-red sandstone, at the distance of 4 yards ; and, *in the full bright light of the sun* the brilliant reflections from facets of much smaller crystals of quartz. I was led to this experiment by finding amongst our Scarborough gravel,

* A misprint for 1837 ; Smith did not get his honorary degree till 1835.

a brown red sandstone pebble the crystal of which brilliantly reflected the full light of the sun. Viewing it in the house, on a table before my window, with my spectacles on, and the addition of a small pocket lens, the glistening specks appeared too small for me to decide whether they consisted of quartz or mica ; but, as I had lately selected from the same gravel specimens of mica slate, and mica sandstones of all degrees of fineness, it occured to me that small specks of mica were always visible without the sun's full bright light. I found them so ; and, by collating the sandstone with the finest grained micaceous specimen, both on one piece of paper shifted alternately into the bright and shady light of the sun, we have a clear and ready distinction, between the finest grains of mica and quartz, without the aid of glasses, and that even at a distance of 4 yards.

"In my practical observations on the different kinds of land, I had long observed, by the glistening in foot-paths, how we may readily distinguish the finest sand in soil ; and, at Harrogate, I have often amused myself, on the nicely sanded footpaths about the Swan Hotel, by fixing my eye upon any detached crystal (of mill-stone grit) which brilliantly reflected the light of the sun, and not without speculating on the application of such brilliant reflections to some useful purpose ; but, in geology, the brilliancy of those facets of quartz crystals in our coarsest sandstone seems to render doubtful the 'theory of sandstones being derivative rocks.'—

"William Smith, LL.D., Scarborough, May 10th, 1827."

The next is entitled Coal-finding, and occurs on pages 645-647.* It is signed "William Smith, Scarborough. Sep. 29th, 1837," and is as under :—

"COAL FINDING."

"In the mysterious business of coal-finding, we are warranted in making any reasonable experiments which may lead to a recovery of the range of the whole series of coal-measures, and in drawing inferences for our guidance in the choice of places of trial, from the most remote phenomena which seems to favour our purpose ; for the seemingly abrupt terminations of some of our coal-fields are certainly the most difficult problems in geology. Here, the practical man, with a vast field

* The page number of this in the "Contents" of the Volume is wrongly given as 464.

of experience by the side of him, is at a loss how to proceed. What, therefore, has he to do but to seek out all the analogous cases, and, even if not strictly analogous, to learn, if he can, by the known the way to the unknown.

"Now there are certain *partial interruptions* to the regular courses of the coal-beds in the great northern run of the coal-measures which extends through Derbyshire and Yorkshire, which may help to elucidate the mysteries at the two extremities of that long coal district, and to satisfy us whether they really are terminations, or only great and unusual deflections in the ranges of those strata, deeply hidden and unexplored, and which, better known (perhaps only by experiment), may enable us to judge of the probability of uniting or extending our coal-fields.

"For solving these important questions on our coal-fields, some few years since noticed by Mr. Coneybeare in a very general way (not altogether correct), I think much may be deduced, both from the observations of the geological phenomena, and from experience.

"Some are not certainly extricable in the direction of their ranges, while others appear to be so; and, therefore, there is a probability of some of them being united.

"Some of the coal-fields, particularly in the middle of the island, seem not yet wrought to any well defined limits of the coal series; and, consequently, in such cases there is good ground for expecting an extension; and especially as geology, by its settled order of superposition in the rocks, does away old erroneous notions of cut-offs, &c., by the red rock, and by the interposition of faults or dikes.

"From the numerous instances of now well-ascertained undulations across the general ranges of the strata, by which their planes are formed into coverns, and intermediately, in the reverse of these forms, so that the strata of coal may rise on one side up to an unconformable covering, cut off by the red marl or red rock, there may be good reason to expect the coal-measures to go down again on the other side of the so-called anticlinal line at no great distance; and especially where it can be ascertained that such lateral rise of strata has not brought up the deepest part of the coal series; but, where the mill-stone grit or mountain limestone appears, there, with certain exceptions, the case may be decisive.

"That there are such opposite lateral rises and dips in the strata, where the coal-measures are deeply unconformably covered by the red marl, is well known in the extensively wrought colleries of Somersetshire (where I commenced my studies of geology) ; the planes of the coal are subject to hollows and ridges, though the extent of these irregularities may not yet be known.

"We see that the strata, in part, or in the whole series of strata in their superficial exposures, form such natural hollows and ridges to a great extent, chiefly across the bearings of their ranges ; and, therefore, we *have a right to expect such forms in them even where they are deeply covered.*

"The broad and very long coalfield of South Wales terminates north and south with opposite rises in the strata.

"The coal in Durham rises, in its southward boundary, nearer to the surface ; so that good coal is found at no great depth beneath its uncomformable cover of magnesian limestone.

The northernmost coal of Yorkshire rises northward beneath a cover of the same limestone, and ranges E. and W. : forming, with its south western boundary, a westerly pointed figure, widening and deepening south-eastward.

"The question of an east or north-easterly continuation of the coal-measures can only be entertained at the easterly end of the east and west range, before mentioned ; but we must previously turn to other places, to see, by analogy, how far any subterraneous deflection in the range of the coal-measures may be thereabout expected.

"Along the westerly edge of the coal-measures, both in Yorkshire and Derbyshire, there are well known irregularities occasioned by elevations and depressions across the general range of the series, causing sinuosities in the marginal edges of the coal-fields. The lands eastward, over the ridges, contract, and those westward, in the hollows, expand the width of the coal-measures ; so that the first rise in the north side of the Dun causes a vacant space between Sheffield and Chapletown ; and the second rise south of Sheffield, and in Derbyshire, causes a vacant space in the productive coal-measures between the high part of Sheffield Park and Coal Aston ; and in the hollow between these two ridges the coal is thrown back under Sheffield. But there is a greater westward receding in the Dronfield trough, one side of which rising to the north causes a long east and west range through Coal Aston.

"We have therefore, north and south of the Dun, two east and west ranging lines of the coal-measures (similar to, but much shorter than, that on the north side of the Yorkshire coalfield), from which two east and west ranging lines the coal is known, in both cases, to return and resume its regular course.

" That in Derbyshire, from Eckington to Stubly, is several miles in extent ; but it is not from the magnitude, but from the similarity, of these irregularities that we may infer the probability of the coal-measures in class of the most northerly works in Yorkshire, continuing easterly, or resuming a north or north-easterly range, though it may be at a great distance beneath their unconformably covering strata.—

" William Smith, Scarborough, Sept. 29th, 1837."

On the last page of this volume is an interesting editorial note to the affect that " A very highly finished and admirable likeness of Dr. William Smith, author of *Strata identified by their Fossils*, and now in his 69th year, has been executed on steel, by Ackerman of the Strand." This is no doubt the well known portrait appearing in Phillips' " Memoirs " and elsewhere, the original painting of which occupies the place of honour above the President's chair in the meeting room of the London Geological Society.*

1838-9.

One of the last pieces of work accomplished by Smith was in connection with the selection of stone for the Houses of Parliament. By the direction of the Government, Mr. Barry, Mr. (later Sir) de la Beche and W. Smith were desired to visit the various quarries for suitable stone, and also to examine well known cathedrals, etc. Eventually, the stone selected was the " firm, yellow, granular magnesian limestone of Bolsover Moor, Derbyshire." Phillips tells us that " This was an investigation to which Dr. Smith † willingly gave all the earnest attention which it merited, and his previous knowledge of nearly all the building stones and quarries in the kingdom was found highly beneficial to the Commission. Five days after the signing of the report (in London) he attained his

* Other portraits of Smith apparently existed, for an account of which *see* Phillips's Memoirs, pp. 125-126.

† The honorary degree of LL.D. was conferred upon him by the Provost of Trinity College, during the Dublin meeting of the British Association.

seventieth year, in excellent health and spirits, which appeared to promise years of thought, if not activity. Exept a few days employed in re-examining with Mr. Barry the quarries near Worksop, which had been selected by the Commission, he remained principally in the vicinity of Scarborough (' walking over farms at Silpho and Broxa, and other parts of the Hackness estate ') till July."

Smith's work on this Commission appears in a detailed " Report to the Commissioners of Her Majesty's Woods, Forests, Land Revenues, Works and Buildings," dated 16th March, 1839. It is accompanied by elaborate tables with details of the stone, etc. The report however, is signed jointly and no part of it is shown as by Smith alone. Details are also given in the second part of a paper on " Lithology, or observations on Stone used for building, by C. H. Smith. Read at the Ordinary General Meetings of the Royal Institute of British Architects, held on Monday, the 29th of April, and on Monday the 3rd of June, 1844. Treating chiefly of the Magnesian Limestone of Yorkshire, Derbyshire and Nottinghamshire, with reference to the selection of stone for building the exterior of the New Houses of Parliament." * 4to. 36 pp. map and section.

SMITH MSS.

Another interesting series of papers has recently been brought to light by the enquiries of our friends of the Scarborough Philosophical and Archæological Society. As already pointed out, Mr. R. Turnbull was a pupil of Smith's at Hackness, and received many of his maps and papers. These passed into the hands of his daughters, from whom Mr. S. P. Turnbull, M.A., J.P., grandson of Mr. Smith's pupil, obtained them. These papers have since been given to the Scarborough Society for its Museum, and I am indebted to the Society for the loan of them.

They consist of

(*a*) Biographical Notice of William Smith, LL.D., by John Phillips. *Mag. Nat. Hist.*, 1839, p. 213, *et sec.*

(*b*) Geology of England. Mr. Smith's Claims.

(*c*) MS. (4pp. 8vo) apparently in Smith's Handwriting, on " Freestone " (2 pp.) and " Building Stone." (2 pp.)

* This contains the statement (p. 11) that "The Churches at Hull, Beverley and Tadcaster are mostly built with magnesian limestone from Bramham Moor, and are in such a condition as to convey to the beholder a very unfavourable impression of the durability of that material."

(*d*) A Table headed " Elective Attractions by Solution," and
(*e*) A collection of MSS., entitled " Dr. Smith's papers."

They mostly have upon them the words " A and E. Turnbull," these being the daughters of R. Turnbull.

The first of these is a reprint of Prof. Phillips's obituary notice of Smith, to which we have already referred to in detail.

The second (*b*) is a valuable document, which I have not previously seen mentioned or described. It consists of 14 octavo pages, written in small but legible handwriting, and is lithographed. It appears to be in Smith's handwriting throughout. On the front, in large writing, is " Geology of England. Mr. Wm. Smith's Claims," and on the last page, " Wm. Smith, Civil Engineer, 15 Buckingham St., York Buildings, London, June 1818. (See p. 182).

It was evidently published during the controversy which ensued with regard to priority, when Greenough published his large map for the London Geological Society. It contains the sentence " Thus. while all who could pick up the information thus profusely scattered—thought themselves at liberty to publish it, I have been left to pursue, unrewarded and alone, the drudgery of mere substantial utility, and my numerous papers, from want of means, are suffered to remain from year to year unpublished."

The document is quoted *in extenso* in appendix A.

The next document (*c*) is in a rather cramped hand, and presumably was written when Smith was well on in years, and during his work and connection with the Royal Commission with regard to the stone required for building the Houses of Parliament. It is no doubt a memorandum in connection with his work which was finally published after Smith died. It is reproduced in appendix B.

The next (*d*) is a somewhat remarkable document. It is headed " Elective Attractions by Solution," and, in Smith's writing "Arranged by—P. and S.—" Adjoining this, in lead pencil, is " Phillips, afterwards Prof. of Geology at Oxford, and W. Smith,—Father of English Geology. R. Turnbull* Dec. 23. 1875. This paper must be about 45 years old." [*i.e.* c. 1830].

The top of the diagram, (which measures $13\frac{3}{4}$ ins. by $7\frac{3}{4}$ins.) is

* The latter part of Mr. Turnbull's signature is not quite distinct.

14

As the Public can only judge partially of these labours, by the small proportion of my Documents yet before them others who may be engaged in fol-lowing out & correcting what they suppose to be imperfect might spare much of that trouble if they knew the extent and accuracy of my yet unpublished papers.

Wm Smith
Civil Engineer

15 Buckingham Street
York Buildings
London

June 1818

divided into headings, beginning with (1) Caloric, (2) Oxygen, (2a) Hydrogen, (3) Sulphur, (4) Saline Sulphurets, (5) Silax, (6) Alumina, (7) Barytes, and so on up to (64) Fixed oil.

Beneath each heading is a row of small squares containing numbers or words, and most of the squares, and headings, are coloured. Below, the table is written in Smith's fine handwriting :—" Oxygen and acids *yellow*, Metals *blue* and their oxydes *green*, Alkalies and earths *red*, Neutral salts *orange*." And, in the bottom right-hand corner, "Remark. It appears that eight of the acids have the same effect upon the earths and alkalies (with the exception of Fluoric acid upon Silex) and the same on water and Alcohol. W. S."

These initials " W. S." are of the utmost importance. They are obviously the initials of Smith himself, though usually his signature is written in a large hand. It also shows that the MSS. referred to in the next item (*e*) are in Smith's own handwriting. The whole of the table above referred to is in Smith's writing.

On the fly-leaf of the document, a similar table is ruled out, but, with the exception of the heading, " Elective Attractions by Fusion," nothing further was done.

On the back, in R. Turnbull's handwriting, are the words " By Dr. Smith," which confirms the supposition in reference to the writing, Turnbull himself having by no means a neat hand.

The last document acquired by the Scarborough Society is of the greatest possible value and importance. The cover, a piece of white note-paper, is in the handwriting of John Phillips* and is as follows :—

" *Dr. Smith's Papers.*

1.

Smith's Stratification of Hackness Hills.

2.

Smith on Farming. Its ill success.

3.

Newspaper Extracts respecting Dr. Smith.

4.

Smith on Farm Buildings.

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* I have a number of Phillips's letters and MSS. and there is no question about this writing.

5.

Smith on Farming.

6.

Smith on Statistics &c."—

On the top right-hand corner of this cover is the figure 8.

On the back cover is written "This MS. contains 22 leaves and the cover 45 pages in all and belongs to A. and E. Turnbull."

On the inside of the cover, (numbered 9), is written, by Phillips, "Copy of Mr. Smith's Memoir of the Stratification of Hackness Hills," 1829. The whole of this page is in Phillips's writing, and extends to the words "Danby Dale above Thornton extends its ramifications." The next page (10) is in Smith's writing, which is unusually small and neat. Apparently Phillips had written out the first page to replace the first page of Smith's notes, which was doubtless damaged or discoloured. At the bottom of page 10 is "V. 15."

This memoir on Hackness is apparently that read to the Yorkshire Philosophical Society, when Mr. Smith presented a copy of his Hackness map to that Institution. It is printed *in extenso* in appendix C.

Page 11 is only partially filled. It is headed "Geography. Rules for pronunciation." It contains sixteen lines, such as "*eaux* as *o*, in Bordeaux, &c."

Pp. 12 and 13 are missing, but fortunately were apparently of no great importance.

P. 14 begins "are among the most fatal snares. Alas! there is too much truth in the severe observation, 'How few young professors are there, that will not forsake their Christian friends and their Redeemer, for an ungodly wife or husband,'" and there are other sentences quoted from "Persuasives to early Piety, by G. Pike. 1821."

Below this is "The penetential prayer of Archbp. Cranmer, a few moments before his Martyrdom," which is quoted.

P. 15. On this is evidently a continuation of the Hackness Memoir. Below the first word "Geology]" is "10," on which page occurred the "V. 15." This page is reproduced herewith, actual size (page 185).

15

Geology.] *Fine natural sections of all these strata
10 in their corresponding order of superposition may be seen on Scarbro Castle hill & the cliffs between Filey & the latter place.

That Geology is a Science of unlimited extent & utility cannot be doubted but while Geologists choose to be mannerists rather than correct immitators of nature some of its purposes remain unanswered. The application of this science to its most practical uses is nearly as herculean as its establishment.

Its uses in Agriculture are of the utmost importance to the country and therefore cannot be brought forward at a more convenient time than the present which calls for every stimulus to the skill and industry of the owners & occupiers of the soil. That a knowledge of Geology is the only infallible guide to determine correctly the value of Land was said 30 years since by that eminent land valuer, Davis of Wiltshire when the principles of the science were explained to him. To know what plants are best suited to the soil a knowledge of the varieties of soil is necessary which can only be obtained by an acquaintance with their subsoils & the upper strata upon which they rest & from which they are respectively formed.

Local circumstances and casual coverings of diluvial matter may make many shades of difference in the colour of a soil but with these allowances there certainly is no other method of obtaining such a general and practical knowledge of soils as by an acquaintance with the strata ~~the~~ which form them & upon which they rest. There may be considerable variety and great difference in the nature of a soil where no adventitious mixture occurs and this arises only from a difference in the nature of the beds composing the thick stratum from which the soil is formed. These great varieties of soil varying according to the kind of stone upon which it reposes is well known to practical Farmers on the Hackness hills, and to most other occupiers of the same kind of land ~~from~~ Steane to Hambleton. They all know there is a thin, dry, stoney soil over the Limestone, a deeper and more tenacious soil over the Wallstone nearer the moors a range of free working yellowish sand land and poor, blackish, or grey sand upon the Moors

This memoir is continued on pp. 16, 17, 18, 19, 20, 21, 22, and 23, and three lines are written on the bottom of the next page, which has been all cut away except for these few concluding words of the Memoir. It ends up with the date "October 2nd, 1830."

In order to preserve it, this small fragment containing the last three lines of the Hackness Memoir has been pasted on a sheet from the same note book, which apparently contained some of Smith's botanical notes. These are headings to paragraphs "On Sap," "Fall of the Leaf," "Size of the Vegetable Organs," "Inclination of Plants towards the light," etc. The notes themselves, however, are in shorthand—most clearly and beautifully written, and from the perfect outlines they must have taken longer to write than if in longhand; though of course the signs do not occupy so much space.

The next page (25, unnumbered) is headed "Agriculture. An investigation of circumstances relating to the present ill-success of farming. By W. Smith." This article, which occupies 5½ pages, is in shorthand, with the exception of the headings:—"land tax," "In the matter between the farmer and the labourer" (?), and "Sources of employment."

The paper referred to occupies pp. 25-30 (unnumbered, as are the remainder.)

Page 31 is headed "Vegetable Phisiology" (sic.) It is mostly in shorthand, but among the headings to the paragraph are "Causes of the beautiful meadows and lawns peculiar to England," "Manner of preparing a soil on a hard rock," etc. Page 32, contains the concluding part of an extract from the *Journal of the Royal Institution* in reference to extracting teeth!

P. 33 [2] is headed "Extract from the York Courant and Original Advertiser, Tuesday, March 6, 1832. *Mr. William Smith.* We last week stated that at the Annual Meeting of the Geological Society on the 17th ult., it was announced that Government, on the application of Lord Morpeth, had granted a pension of £100 per annum, to Mr. Will. Smith, late of Scarbro, but now in this city, a reward for his long and valuable services to geology. This instance of patronage reflects great credit on Government." Then follows an extract from Townsend's "Character of Moses established," which we have already quoted.

Next is a quotation from the Rev. R. Warner's *Literary Recollec-*

tions, which also occupies the whole of page 34 [3] and the top of p. 35. [4]. It refers to Smith's patriotism in refusing a very tempting offer to go to Russia to search for coal for the Russian Emperor.

Pp. 35, 36 and 37 [4, 5, and 6], are occupied by "Considerations which determine the conveniences of a small farm house and offices."

p. 38 is blank.

p. 39 gives a curious insight into one aspect of Smith's life, judging by the nature of the books he read. It is headed "Books read in leisure hours," and is as follows :—

Doddridge's Rise and Progress of Religion in the Soul.
Butler's Analogy.
Locke on the Human Understanding.
Conversations on Chemistry.
Togwood's Dissent from the Church of England.
Murray's Lectures on Revelations.
Faber's Prophecies.
Jone's [*sic*]. Church History.
Bate's Harmony of the Divine Attributes.
Wesley's Sermons.

page 40 is blank.

page 41 is headed :—

"Agriculture. Paper by Mr. Smith. Feb. 7, 1831." It occupies pp. 41, 42, 43, 44 and 45 (see appendix *d*).

Page 46 is blank.

Page 47 is headed "Politics, Statistics etc." (see appendix *e*). The paper occupies pp. 47, 48, 49, 50, 51, 52, 53 and 54.

Page 55 is blank, except for the heading Religion, Theology, etc.

SMITH MS., 1827.

The Misses Turnbull have kindly permitted me to make the following copy of a document in their possession. The original letter was from W. Smith to Sir John Johnstone, who was anxious to help Smith in his work. It throws interesting light on several Scarborough matters, including the Reservoir referred to on page 188. The map of Yorkshire mentioned is evidently that being prepared in 1826, but unfortunately the memoir on the Geology of Yorkshire never appeared. Two years later, in 1829, was published the first edition of "The Geology of Yorkshire," by his nephew, John Phillips.

"Scarborough,
16 Feby., 1827.

Dear Sir John,

Your brother having kindly favoured me with a call and your address, I beg leave to trouble you with some account of my proceedings during your absence. Ever since you left I have been almost daily employed by the commissioners for improving the town of Scarborough which suddenly became a truly improving place. The church is rising fast and a grand Spaw walk is forming at a great height along the frightful slope of the Spaw cliff and the gaping chasm between it and the cliff close against the sea is already united by the immense platform required for constructing an Iron Bridge of 5 arches 70 feet high. This grand project—suddenly started by subscribers from York, commenced in November and is rapidly proceeding. In addition to this stupendous bridge, there is already constructed what some have called "a magnificent Reservoir" and in addition to this public work lighting the town with gas is seriously contemplated, my share in these great works though least seen is considered with great satisfaction, not the least useful. The Reservoir situate in the high part of the town, is I expect, the largest covered receptacle for water in England. It consists of a brick built cylinder sunk near 20 feet beneath the solid ground, 40 feet in diameter covered with a brick dome 40 feet span and 20 feet high, the whole of which immense arch consisting of 250 tons of brick work turned without centreing or any woodwork to support the bricks, was closed the 20th. of January and we are now fast proceeding with the appendages requisite for filling it and a better distribution of water in the town. Nearly the whole of this building containing 120,000 bricks is underground or covered with a puddle and strong bank of earth giving it altogether the appearance of an immense Tumulus.

It will contain 4,000 Hogsheads of water, but the other Reservoir (wholly unseen) made at my suggestion in the hills at a trifling expense to pen up in the rocks 5,000 Hogsheads of water is by far the most curious and perhaps the most useful practical hint hitherto deduced from Geology. It has so far exceeded our expectation of pinning up at the calculated height of four feet the above quantity that it has risen 12 feet and thence reasonably expected to produce in the next Summer fifteen thousand Hogsheads of water—So far, I think I was never in my life more usefully employed but the intricate calculations required in practical Hydraulics and the many complicated considerations thereof together with the superintendance of the works has retarded the progress of my intended publications on Yorkshire Geology—only the one sheet Geological map of the vicinity of Scarborough is complete. The six sheet (Cary's) new map of Yorkshire (as I shall now be more at liberty to complete the colouring) may shortly be published and notwithstanding my other engagements I have made considerable progress with my papers so that I think that the six sheet maps may be published for 3 guineas and the Geology of the County to accompany it for 2 guineas. I hope shortly to give you a better account of this work—and remain—most respectfully,

Your greatly obliged servant,

Wm. Smith."

SCARBOROUGH WATER SUPPLY, 1827.

It is not often that Smith contributed to any of the magazines, but an account of his work in connection with the Scarborough Water Supply appears in the *Philosophical Magazine*, New Series, Vol. I., No. 6, June, 1827, p. 415. The paper was "Read to the Yorkshire Philosophical Society on March 6th, 1827, and communicated by the Rev. W. V. Vernon, Pres. Y. P. S." The paper is entitled "On retaining Water in the Rocks for Summer Use,"* and is by William Smith, M.Y.P.S. [Member of the Yorkshire Philosophical Society].

The paper begins with the usual Smithian philosophy on general lines, as to the desirability of conserving water. He then states: "In the month of May last a small quantity was found to issue from a bore hole made several years since for draining the land. On cutting an open channel up to this, the discharge increased and at the depth of nine or ten feet amounted to twenty-four hogsheads per hour. This

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* When it was read to the Yorkshire Philosophical Society the title was "On the Construction of a Reservoir near Scarborough, on Geological Principles," by William Smith, Civil Engineer, Hon. Mem. Y.P.S. It is given in a list of Memoirs and Communications made to the Society, on page 45 of the Report for 1827, published 1828.

encouraged them to proceed; the channel under my direction was deepened four feet, when the discharge became for some time fifty or sixty hogsheads per hour.

"Suspecting from an intermediate and subsequent diminution that we had drawn off a confined stock of water, and that the regular run of the spring at the end of a dry summer might not be found sufficient, I suggested the propriety of damming up the produce of this spring for summer use, as the previous supply was more than sufficient for the town in winter.

"The circumstances were favourable for the purpose, as there was no other known issue of water from the rock in that hill, which is about a mile long, narrow on the top, and insulated in all the upper part of its stratification. The same rock is not opened or known anywhere else on these hill sides, but in a deep valley which separates the insular hill from the main and higher hill of Falsgrave Moor. In the upper end of that valley a spring was opened several years since in the same kind of rock, and was brought with a declivity of thirty or forty feet round the south end of the insulated hill, near to and high enough to run into the opening made to the new spring. This was sufficient to prove the general rise of the rock westerly in the base of the insular hill, and beneath an isthmus connected with the main ridge of Falsgrave Moor and Seamer Beacon. The rock in which the spring was found is a yellowish fine grained crumbly sandstone, in thick beds, with open irony joints, the same as in the cliff south of Scarborough Spa. From the quantity of carbonaceous matter in it, it is here called 'coaly grit.' This sandstone, with its overlying and alternating clays, is analogous in position to the clay and sand and sandstone between the cornbrash and great oolite rocks. At the depth of ten feet the rock was found covered with a regular clay about four feet thick; on this a mark of coal, and a thin bed of hard stone full of imperfect vegetable impressions; and up to the surface a very tenacious *slidden* clay. The rock was found, by boring through it, to be ten feet thick, lying on clay. The channel excavated up to the spring about thirty or forty yards long and fifteen feet deep, at the upper end was entirely in a very tenacious clay partly diluvial, with a few rounded stones in it deeply covered by slidden clay. Within four feet of the edge of the rock lay gravel (deeply covered also with slidden clay), consisting of large and small boulders of whinstone, granite, mountain-limestone, etc., which gravel, between the clay and the face of the rock tapered downward ' to nothing ' in the bottom of the excavation.

" About two yards within the edge of the rock (which was nearly as upright as the edge of a wall) a basin six feet in diameter and four feet deep was excavated, to receive the water flowing from the joints of the rock. Cast-iron pipes branching from the main line of pipes were laid up to this basin, to receive the regular flow of the spring, which before the end of summer was reduced to less than six hogshead per hour. The clay channel, in the bottom of which the pipes were laid, was refilled with clay and puddled, so that no water could pass from the rock but through the pipes. The end of the last pipe was closed, and a vertical aperture made for receiving the run of the spring. No further contrivance was required for stopping the water and damming it up in the rock, than an open vertical pipe, ground to fit tight into the aperture in the horizontal pipe, and this to a height of four feet was done by pieces of pipe, each a foot in length, tight-fitting one into another for the convenience of wholly or partially damming or drawing off the stored water as occasion might require ; the water being allowed to run in at the top of the pipe.

" After the rainy days in the beginning of November last, these short pieces of pipe were put in one after another, and found to dam up the water in the joints of the rock to the height of four feet, which from the quantity wasted last summer during the progress of the works was calculated to contain 5,000 hogsheads. The vertical pipe being since closed at the top (and lately also the main iron pipe), the whole of the water from those parts becomes forced in to the cavities of the rock, and now stands 14 feet deep at the spring, or ten feet higher than we calculated upon penning it ; so that the subterraneous reservoir may contain 12,000 or 15,000 hogsheads of water. This will be ascertained in the summer as it is drawn down from time to time into the new arched reservoir in the town. This reservoir, formed of a brick cylinder 18 feet deep, sunk in the ground, and covered by a dome 40 feet span and 20 feet high, surrounded by a strong bank of earth, is calculated to contain 4,000 hogsheads."

The paper is dated, " Scarborough, Feb. 5, 1827."

NOTICES OF SMITH'S WORK.

In addition to the remarks made by Phillips in his "Memoirs of William Smith," referred to at the commencement of this paper, other references to Smith's work have been made.

CONYBEARE AND PHILLIPS, 1822.

In the Introduction to "Outlines of the Geology of England and Wales," 1822 (pp. xlv-xlvii), W. D. Conybeare and W. Phillips give an excellent tribute to the worth of Smith, which, being contemporary with Smith, seems likely to be the more reliable. They say :—

"In 1790 Mr. William Smith (a name which can never, in tracing the history of English Geology, be mentioned without the respect due to a great original discoverer) appears to have commenced his researches in the neighbourhood of Bath, having in that year drawn up a tabular view of the strata exhibited in that district, which in fact contained the rudiments of his subsequent discoveries. Ten years afterwards he circulated proposals for publishing a treatise on the Geology of England to be accompanied by a coloured map and sections, and in the interval had freely communicated the information he possessed in many quarters, till in fact it became by oral diffusion the common property of a large body of English Geologists, and thus contributed to the progress of the science in many quarters where the author was little known. In this same interval, between 1790 and 1800, several volumes of reports were published by the Board of Agriculture, many of them containing much local geological information ; and to this Board must undoubtedly be ascribed the honour of having produced the earliest geological maps of any part of England, for its first series of reports published in 1794 contains very adequate geological maps of the North Riding of Yorkshire, of Derbyshire, and of Nottinghamshire, and a less perfect one of Devonshire ; that of Kent, published in 1796, has a regular geological map of that county (which, indeed after the treatise of Packe in the beginning of the century it was easy to construct). Between this date and 1813, the same Board has also given useful maps of Sussex, Surrey, Berks, Bedford, Gloucester, Wilts, Lincoln, Durham, and Cheshire, besides publishing the second report of Derbyshire dedicated exclusively to its mineralogy by Mr. Farey. Maton's tour through the western counties published in 1796, has also a regular though of course imperfect geological map of the west of England.

"These are certainly the earliest published geological maps of any part of this island ; but it is probable that Mr. Smith had already commenced the manuscript of his own, which after many delays at length made its appearance in 1815, and was succeeded by various county maps on a larger scale, sections, etc.

"D'Aubisson has liberally said of this great performance of an unassisted individual :—

"'That which the most distinguished mineralogists have accomplished in a small part of Germany in half a century, one man alone (Mr. William Smith, mining engineer) has taken in hand and executed for the whole of England; and his work, as beautiful in its results as it is amazing in its extent, has led to the conclusion that England is divided regularly into strata, that the order of their superposition is never inverted, and that they are exactly similar fossils which are found in all parts of the same stratum even at long distances away.

"'In paying to the work of Mr. Smith the tribute of admiration which is due to it, I may be permitted to hope that further observations may confirm its correctness, and already, on several points, the work of the English mineralogists has confirmed it.'" *

"Nor is this praise in any respect too high; to say indeed that the first Geological map of any country is likely to be free from material imperfections, is to maintain a position which everyone acquainted with the ordinary progress of science must feel to be untenable. This is an object only to be gained by a series of gradual approximations, and it is by no means a small tribute of commendation to say that Mr. Smith has commenced that series with a performance, in which the trifling errors of detail which it may exhibit, bear no proportion in importance to the great general views which it correctly lays down. If we cast a rapid glance over this and his other publications, beginning with his representations of the more recent strata, and descending the geological series, we shall at once see what he has achieved, and added to our previous information, and what he has left for others. The tertiary beds above the chalk he has represented only generally, their more accurate division having been reserved for the researches of Mr. Webster, &c.; the chalk formation he has laid down with great precision, but its limits had, as we have seen, been before generally stated by many authorities: hence through the series of sands and oolites, down to the

* This quotation, in the original, is given on the back of the title-page of Phillips's "Memoirs of William Smith."

new red sandstone or red ground, the whole field is, with few and immaterial exceptions, entirely his own. Before his researches it would have been known only under the vague designation of a district of secondary shell limestones and sandstones, and to him we owe the attempt, in most instances successfully made, to ascertain by precise determinations the various and important members of this series, and to trace them from one extremity of the island to the other. In this enterprise (sufficiently arduous to try the powers and establish the reputation of any individual entering upon the ground hitherto untrodden) he may, perhaps, in some instances have suffered a few omissions to escape without detection, and more rarely have identified too hastily beds in distant parts of the country really belonging to different formations; but still the great mass of his divisions remain unquestioned and unquestionable, and has been adopted, though with an occasional change of nomenclature, and have a few requisite corrections, by all the geologists who have followed his steps, as well as in the present work. The carboniferous districts are also on the whole represented with a near approach to correctness, but are far inferior in this point to those occupied by the series last mentioned, and here there was also extant a greater quantity of previous materials; the districts of the old red sandstone, and those occupied by the transition and primitive rocks, are very inadequately represented.

"Subsequently to the publication of Mr. Smith's map, in 1819 another on nearly the same scale was published by Mr. Greenough; the execution of this is more minute and delicate, and the details more exactly laboured; the general configuration of the surface of the country, its hills and vallies, are represented with far more precision than had previously been attempted in any general map of the island—points which did not enter into the construction of Mr. Smith's map; and many of the imperfections of the former are removed."

W. C. WILLIAMSON, 1896.

In "Reminiscences of a Yorkshire Naturalist," by the late W. C. Williamson (1896) one or two interesting references to Smith occur. Williamson says: "In 1824 my father* became personally acquainted with the great Father of Geology, William Smith, and with his subse-

* John Williamson, the first Curator of the Scarborough Museum.

quently distinguished nephew, the late Professor John Phillips. In 1826 Dr. Smith and his eccentric wife established themselves in our house, where they dwelt for a considerable time. . . . . One of the grandest figures that ever frequented Eastern Yorkshire was William Smith. . . . . My boyish reminiscences of the old engineer, as he sketched a triangle on the flags of our yard, and taught me how to measure it, is very vivid. The drab knee-breeches and grey worsted stockings, the deep waistcoat, with its pockets well furnished with snuff, of which ample quantities continually disappeared within the finely chiselled nostril, and the dark coat with its rounded outline and somewhat quakerish cut, are all clearly present in my memory. Spending the greater portion of his morning in writing, towards noon he would slowly wend his way to the museum, where he always found in my father a friend with whom to gossip about the rocks of the Cotswolds, the clays of Kimmeridge, or the drainage of the Eastern Fens. He would expound in a Coleridgean fashion his ideas of their relation to the strata of Yorkshire and of the other parts of England. His walking pace never varied, it was slow and dignified; he was usually followed a few yards in the rear by his rose-cheeked partner in life. We have a thousand times contemplated the fine old man, who, amid his favourite haunts, thus laid the foundations of geological science."

1826.

From the Report of the Council of the Yorkshire Philosophical Society for 1826,* we learn that "The Yorkshire collection has also been enriched by an extensive suite of fossils (presented by Mr. Dunn and Mr. Bean) containing some new crustaceous kinds, from the grey shale near the base of Scarborough Cliff, which Mr. Smith has identified with the Oxford Clay. . . . . *But the most valuable geological present which the society has received, is a map of the north-eastern part of Yorkshire, in which Mr. Smith has laid down with accuracy his recent discoveries.* He has, at the same time, announced his expectation of completing, in a short time, his description of the whole county, on the excellent sheets lately published by Mr. Cary; and proposes to accompany his map with a work comprising a detail of the numerous observations on which the colouring is founded. The council cannot forbear from expressing a strong hope, that this work

* York, 1827, p. 15.

will be patronized by liberal subscriptions, and afford the author some remuneration for a long life of successful, but ill rewarded labour in the service of science."

The map presented to the Society would presumably be the north-east section of his map of Yorkshire issued four years previously, and the 'map shortly to be issued on the maps by Mr. Cary,' was presumably a new edition of this. I cannot find, however, that a new edition was published; certainly the proposed "accompanying work" never appeared.

JOHN PHILLIPS, 1829.

In 1829 appeared the first edition of John Phillips's well-known "Illustrations of the Geology of Yorkshire." This was dedicated

"To
William Smith, Esq.,
who has spent his life
in establishing the
Philosophical Principles of Geology,
and in applying them, when established,
to practical use,
This Work
is respectfully dedicated,
By his Affectionate Nephew,
and grateful Pupil,
John Phillips.

In his "Introduction" to this work Phillips makes the position in regard to Smith's investigation very clear. He says:—

"The first person in England who studied, and who taught others to study, the structure of the earth upon the strict principles of the inductive philosophy, was Mr. Smith. Having provided himself with methods of identifying the strata by an attentive examination of all the circumstances which distinguish the one from the other, and especially by a comparative survey of their organic contents, he extended his observations to districts far distant from that in which they were originally commenced, and fixed at length on a substantial basis, the important doctrine of general formations. It was in 1794, that Mr. Smith first saw the wolds and moorland hills in the eastern part of Yorkshire ; and guided by the knowledge which he had even then acquired, of the correspondence of contour between different portions of the same strata, he decided at once, on a distant view, that the wolds were composed of chalk, and that the moorlands belonged to the oolitic series of rocks. This opinion was fully expressed in his manuscript Map of the Strata of England, for the publication of which proposals were issued in 1800.

"The coast was afterwards further examined by him in 1813 ; in 1817, I had the advantage of accompanying him to Whitby and Scarborough, and was much occupied there with him also in 1820. In his Geological Map of Yorkshire published in 1821, the lines of chalk, Kimmeridge Clay, and coralline oolite, are traced with considerable accuracy, but the lower beds are erroneously named, owing to the anomalous character of the strata, which in this district represent the oolites of Bath. The error, however, was quickly discovered by Mr. Smith, and corrected in several copies of the map which I coloured for his friends. In the same year he shewed me some fossils collected by him near Scarborough, which I immediately recognised as belonging to the Kelloways rock ; but so cautious is this experienced geologist in the application of his own rules, that he scrupled to rely on such evidence of indentity between two points so distant as the localities in Wilts., and in Yorkshire ; and it was not until 1824, that he satisfied himself by a re-examination of the cliffs at Scarborough, with a particular view to their relations with other rocks, of the distinct existence there, both of this and of most of the other members of the series which lies between the coralline oolite and the the lias."

FITTON, 1833

In an admirable series of "Notes on the History of English Geology," Dr. William Henry Fitton, F.R.S, in *The Philosophical Magazine* (1832-3) reviews the claims of various geologists in regard to discoveries in stratigraphical geology. Much of his paper is admittedly on similar lines to the notes which appeared from his pen, though not signed, in *The Edinburgh Review* for 1818.

The Section of the paper appearing in *The Philosophical Magazine* for February 1833 is almost entirely devoted to Smith's work. He had previously carefully, even generously, considered the claims of other workers. He concludes :—

"This sketch of the progress of geology in England has now been brought down to the period of Mr. Smith's publications; beyond which it was not the intention of the writer to extend it. In the course of these remarks, conflicting claims may possibly have been weighed with too much exactness, against observations not in the first instance derived from study, but suggested by sagacity, or almost spontaneously arising from the facts as they came into view. It may, therefore be right to repeat, that nothing has been stated here with any intention to question the consciousness of originality, in those inquirers whose observations we have shown to have been anticipated. No better conclusion for this paper can be adopted, than a passage from the eloquent and effecting address delivered from the chair of the Geological Society, in conferring upon Mr. Smith the first mark of public gratitude which it was in the power of that body to bestow. Mr. Sedgwick, while exercising upon that occasion, what he justly calls the 'high privilege' of rewarding distinguished merit, has thus adverted to the labours of preceding inquirers:—'The works of these authors were, however, entirely unknown to Mr. Smith during his early life, and every step of his progress was made without any assistance from them. But I will go further, and affirm, that had they all been known to him, they would take nothing from the substantial merit of his discoveries. Fortunately placed in a country where all our great secondary groups are brought near together, he became acquainted in early life with many of their complex relations: he saw particular species of fossils in particular groups of strata, and in no others; and giving generalization to phænomena, which men of less original minds would have regarded as merely local, he proved, so early as 1791, the continuity of certain groups of strata, by their organic remains alone, where the mineral type was wanting. He made large collections of fossils; and the moment an opportunity presented itself, he arranged them all stratigraphically. Having once succeeded in identifying groups of strata by means of their fossils, he saw the whole importance of the inference,—gave it its utmost extension, seized upon it as the master-principle of our science;—by the help of it disentangled the structure of a considerable part of England,—and never rested from his labours till the public was fairly in possession of his principles. If these be not the advances of an original mind, I do not know where we are to find them: and I affirm with confidence, after the facts already stated, that the Council of the Geological Society were justified in the terms of their reward; and that Mr. William Smith was the first in this country to discover and to teach the identification of strata, and to determine their succession, by means of their imbedded fossils.' "

This article is illustrated by a large folding plate on which are represented (a) " Mr. Stracey, 1719. Section of Coal Mines in Somersetshire," (b) " Mr. Stracey, 1715, Structure of the Globe;" (c) " Mr. Mitchell, 1760, Internal Structure of the Earth," and (d) " Mr. Smith, 1817. Section of England and Wales from Snowdon to London."

This last, I believe, is the only time any of Smith's sections have been reproduced. It had been redrawn and reduced for the purpose, but the detail is so clear that I am reproducing it in preference to a new tracing such as are made for other of Smith's sections. (See pl. XIV. Fig. 1.

BRITISH ASSOCIATION, OXFORD, 1832.

The following is an extract from the Report of the second meeting of the British Association at Oxford in 1832, (p. 99.):—

> " At the conclusion of the minutes of the Geological Section, the President requested the meeting to allow the Wollaston Medal, which had been awarded by the Geological Society to Mr. William Smith, to be delivered to him in the presence of the members of the Association. The President of the Geological Society, Mr. Murchison, having in consequence presented the medal to him, in the name of that Institution, as a testimony of respect to the acknowledged 'Father of English Geology,' Mr. Smith expressed his gratitude for the high honour which had been conferred upon him in the Assembly of the British Association, and in the public theatre of so distinguished a University, an honour, he said, which was the more grateful to his feelings, from the circumstance of Oxfordshire being his native county. He little thought in his youth that so proud a moment as the present would ever arrive; and he trusted that his example and success would stimulate others to follow in the same course. In devoting himself to his geological pursuits, and opening a new page of knowledge, he had had the satisfaction of procuring the good will of many kind and indulgent friends; he hoped that he had served his country, and in so doing, he had endeavoured to serve his God."

BRITISH ASSOCIATION, CAMBRIDGE, 1833.

Smith was also present at the British Association at Cambridge in 1833. In that year was published a quarto volume of "Lithographed Signatures of the members of the British Association for the Advancement of Science, who met at Cambridge, June M.DCCC.XXXIII," on page 26 of which, in a good "copper-plate" hand, and more legible than any other signature in the volume, is that of

453 Wm. Smith Geologist Hackness Scarboro

1839.

We learn from the *Magazine of Natural History* (Vol. III., N.S., 1839, pp. 217) that "In 1808 the president and other members of the Geological Society visited Mr. Smith, and saw his collection of fossils. In 1811 appeared the first volume of the 'Geological Transactions' in which Mr. Smith's discoveries regarding organic remains are noticed; in 1813 the Rev. Joseph Townsend published the first volume of his curious work, 'The Character of Moses vindicated.'"

In his introductory remarks Mr. Townsend pays the following tribute to Smith (pp. iv-v.) :—

"The person by whom he* was first led to trace and clearly to ascertain the succession of strata in our Island, is Wm. Smith. The discoveries of this skilful Engineer have been of vast importance to geology, and will be of infinite value to his nation. To a strong understanding, a retentive memory, indefatigable ardour, and more than common sagacity, this extraordinary man unites a perfect contempt for money, when compared with science. Had he kept his discoveries to himself, he might have accumulated wealth: but with unparalleled disinterestedness of mind, he scorned concealment, and made known his discoveries to every one who wished for information."

"It is now eleven years since he conducted the author in his examination of the strata, which are laid bare in the immediate vicinity of Bath. Subsequent excursions in the stratified and calcareous portion of our island have confirmed the information derived from this examination."

* i.e. Townsend.

Phillips* informs us that "At this period of his life Mr. Smith was utterly unacquainted with books treating of the natural history of the earth; he had no other teacher than that acquired 'habit of observation' which he has justly recommended to his followers. It is difficult in these days to conceive of such insulated and independent research, as that into which the young philosopher entered; rumours at least of the progress of science now circulate through the Cotteswold Hills; and it would be impossible for the most reserved student to be wholly uninfluenced by them. That Mr. Smith was so uninfluenced is a fact attested by the very nomenclature which he created and established in Geology. The 'cornbrash,' the 'forest marble,' the 'lias,' etc., form a system of names almost barbarous to ears polite, but so firmly rooted in English Geology, as to constitute a most durable monument of the sagacity and originality of their author."

"William Smith, Author of the Geological Map of England" was on the Sub-Committee of Geology and Geography appointed at the first meeting of the British Association at York in 1831.† The other members were W. Buckland, W. D. Conybeare, Sir Philip G. Egerton, J. D. Forbes, G. B. Greenough, W. Hutton, R. I. Murchison, J. Phillips, A. Sedgwick, H. Witham and J. Yates. At this meeting William Smith exhibited his "Geological Map of the district round Hackness."‡ Smith was also on the same Committee at the Oxford meeting in 1832. §

In the first Report issued by the British Association, which contained reports of both the York and Oxford meetings, the Rev. W. D. Conybeare gives a "Report on the Progress, Actual State, and Ulterior Prospects of Geological Science." In this he says (pp. 370-371), "The English School has distinguished itself by the ardent and successful zeal with which it has developed the whole of the secondary formations; in these the zoological features of the organic remains associated in the several strata, afford characters far more interesting in themselves and important in the conclusions to which they lead, than the mineral contents of the primitive series. This school generally recognises the masterly observations of Smith, first made public in 1799, as those which have principally contributed to its establishment; although the

* *Mag. Nat. Hist.*, Vol. III., p. 215.
† *See* 1st Report Brit. Assoc., p. 47.
‡ loc. cit., p. 91.
§ *See* Rep. Brit. Assoc., p. 114.

regular distribution of organic remains had before been recognised in Italy by Steno, and in France by Rouelle; and although Werner in his lectures, and Saussure . . . appear to have indicated generally that the laws of this distribution bore a relation to the geological age of the formations containing them, yet a degree of vagueness hung over the whole subject, which precluded any extensive or useful application of this great principle, until the acute observations of Smith first brought it prominently forward in all the precision of exact detail as applied to a vast succession of formations, including the most important portion of the geological series; and as from his situation in life we must consider the discoveries of Smith as the extraordinary results of native and untaught sagacity of intellect, they must on this account be held to challenge a still warmer tribute of approbation, and may be regarded as strictly original in him, even where faint traces of anticipation may be found in Continental writings little likely to have fallen beneath his observation." Later, Conybeare adds*: "The publication in 1815 of Smith's general geological map of England, succeeded by his more detailed separate county maps, illustrated by the work of the same author on 'The English Strata identified by Organic Remains,' and by the contemporaneous production of Sowerby on Mineral Conchology, filled up the whole great outline of English Geology, and left to those who followed little more than the task of condensing and concentrating what was already ascertained, and enlarging and rendering more precise the detail."

It is interesting to thus get a contemporary estimate of the value of Smith's work, on the authority of Conybeare, particularly when it is remembered that in all probability Smith was present and heard the address delivered.

BUCKLAND, 1840.

In his Anniversary Address to the Geological Society† in February, 1840, Prof. Buckland gave a lengthy account of the work of William Smith, who had recently died. He stated that "the establishment of the types in secondary geology from the chalk to the new red sandstone, is due to England; and the discovery of the leading natural divisions of that important portion of them which constitutes the oolite formations, was almost exclusively the work of Mr. William Smith."

* loc. cit., p. 373.

† *Proc. Geol. Soc.*, Vol. III., 1840, p. 249, *et sec.*

Buckland gives us the information that "among his unpublished papers were found unfinished *and in part printed*, an introductory work on geology, and preparations for a volume on Economic Geology, both illustrating the originality of his views."

MITCHELL, 1869.

W. Stephen Mitchell contributed some notes on "The Centenary of William Smith's Birth" to the *Geological Magazine* for 1869, pp. 356-9. He dealt with the question of the actual dates of some of Smith's discoveries, made from an examination of the papers of the Coal Canal Company, Bath. The author concluded "The connection of William Smith with Bath during the development of his geological ideas, is thus summarised:—The examination of the district between High Littleton and Bath first led him to suppose a regularity in the succession of *all* the strata; the planning of the Somersetshire Coal Canal near Bath, was the cause of the tour through England which enabled him to confirm his supposition: the difficulty in distinguishing 'the Oolitic rocks on and near the end of the canal towards Bath led him to the discovery of a mode of *identifying* the strata by the organized fossils respectively embedded therein.'

"The *first* collection of fossils stratigraphically arranged was made by him at Cottage Crescent, Bath.

"The *first* table of the order of strata was drawn up by him at Pulteney Street, Bath.

"The *first* geological map known is his map of the district of Bath.

"The *first* geological map of England was coloured by him while living near Bath.

"The *first* announcement of the publication of a geological map of England, was his 'prospectus' dated from Midford, Bath.

The *first* introduction of his discovery to public notice, was through the friends he made in Bath."

This paper contains a note that in 1869, "the Committee have agreed to place a tablet on the walls of the [Royal] Institution in Bath to commemorate Smith's connection with that city."*

* This was not carried out, but instead, a tablet was placed on the Mill where Smith lived; as will be seen later.

MITCHELL. 1873.

In the *Geological Magazine* for January, 1873, p. 31, "A book about William Smith and the Somersetshire Coal Canal, with an account of the Origin of Stratigraphical Geology of England. By W. Stephen Mitchell LL.B., F.L.S., F.G.S.," was announced for publication by subscription at one guinea.

The book "is designed to bring together into one record all the information that can be obtained of the geological work of the "Father of English Geology." Unfortunately, the work never appeared.

"Notes and Queries on the Classification and Nomenclature of the English Strata. By W. S. M." [W. Stephen Mitchell], appeared in the *Geological Magazine*, 1873, pp. 113-115 and 355-356. They refer to the nomenclature on Smith's Map. Probably these notes were prepared for the "Book about William Smith" which was not published.

1877.

In the *Geological Magazine* for 1877, page 378, G. S. Boulger pointed out that Mr. Edward Stanford had recently purchased the sixteen copper plates for W. Smith's original atlas, and he suggested that they should be purchased for the Geological Society. Apparently the suggestion was not agreed to.*

Through the kindness of Mr. Meredith T. Whittaker of Scarborough, I have seen a copy of the First Report of the Scarborough Philosophical Society, bound up with which are reports of the opening ceremonies in connection with the Scarborough and York Museums; the former in 1829 and the latter in 1830. On both occasions Wm. Smith was present, and spoke; the report of one of his speeches giving us the exact date of the completion of the first draft of his Hackness Map.

On the fourth page of the Scarborough Philosophical Society's Report is the following copy of the

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* Prof. Boulger informs me that there was no response to his appeal, and that the plates were melted down. It seems difficult to believe that in 1877 there was not sufficient interest in Smith's work to enable English geologists to pay for the price of the copper in order to preserve these historical plates.

INSCRIPTION ON A BRASS PLATE
Attached to the
Foundation Stone of the Museum.

This Building, Erected for a Museum,
By Subscription of the Members of the
SCARBOROUGH PHILOSOPHICAL SOCIETY.
was begun April 9, 1828.
The Principal Projectors were,
Sir John V. B. Johnstone, Bart., President ;
Thomas Duesbery, Esq.,
who presented the collection of the late Thos. Hinderwell, Esq.;
Robert Tindall, Jun. Esq., Chairman of the
Building Committee ;
John Dunn, Esq., Secretary ;
William Smith, Esq., Geologist ;
Mr. Bean and Mr. Williamson, Naturalists.

This bears Smïth's name and lends colour to the remark in the report that Smith suggested the circular shape of the Scarborough Museum.

The first pamphlet is 12mo., 16 pp. and is entitled " Proceedings at the Public Dinner, on the opening of the Scarborough Museum, on Monday, Aug. 31, 1829 [Extract from the *Yorkshire Gazette*]. The following appears on pp. 14-15 :—

" Sir George Cayley said, he would propose the health of an individual who was not only really and *bona fide* the discoverer and the father of Geology, but who had brought the Science before them, and made it demonstrably apparent ; and whose observations and discoveries had not only been extremely useful in this country, but on the continent—Mr. Smith, the Father of Geology,—three times three.

" Mr. Smith, in returning thanks, expressed the pleasure it gave him to be in any measure useful ; he only wished to live for this purpose, and he was sorry that he could do no more for the science at present. He had much more information in store ; and he had this day produced a map of the stratification of the Hackness Hills. His maps and papers were so numerous, that he had neither time nor means to bring them before the public.

"Sir J. Johnstone begged for one moment to interrupt Mr. S., and to state, that if he could do anything for him he would, in easing him of the burden of any part of his maps, &c., if he would prepare them and bring them out,—[Mr. Smith, we understand, is at present land steward to Sir John].

"Mr. Smith resumed. He had more MS. than he could carry already in store; and it would want more time and means than he possessed, to send it to the press. But if assistance was given to him, he should use his endeavours. He was beginning to lose the use of his faculties, his hearing being nearly gone, and therefore he wished to lose no time; and nothing he was sure would give him more pleasure, than to promote the objects of science.

"Sir John Johnstone again rose and said that nothing would give him greater pleasure, than an opportunity of rendering Mr. Smith assistance, both by pecuniary means and leisure time; and he hoped soon to see his MSS. in a proper form to bring before the public. He had had a conversation with Mr. Phillips (nephew to Mr. S.), who had said that he would lend him all the assistance in his power, as he considered himself greatly indebted to Mr. Smith, for the instructions he had given him in his youth.

"Mr. Smith expressed his thanks for the kind offer, and said he should prepare them and bring them forward."

The second pamphlet "extracted from the *Yorkshire Gazette* of February 6th," 1830, [36 pp.] is entitled "Proceedings of the Annual Meeting of the Yorkshire Philosophical Society, and opening of the new museum, February 2. 1830." This includes an account of "The Dinner." From the account of this (p. 31) we find that the Chairman gave the health of Mr. Smith, the Father of English Geology.

"Mr. Smith returned thanks; and said, he could truly say with Mr. Atkinson, that nothing gave him greater pleasure than the promotion of science, and particularly in assisting this Society; for he had been very handsomely received in this county, where he had now been resident many years. He had always endeavoured not to be behind in the *March of Intellect*; and had early habituated himself to habits of observation, reflection, and of combination; and this was the only way to

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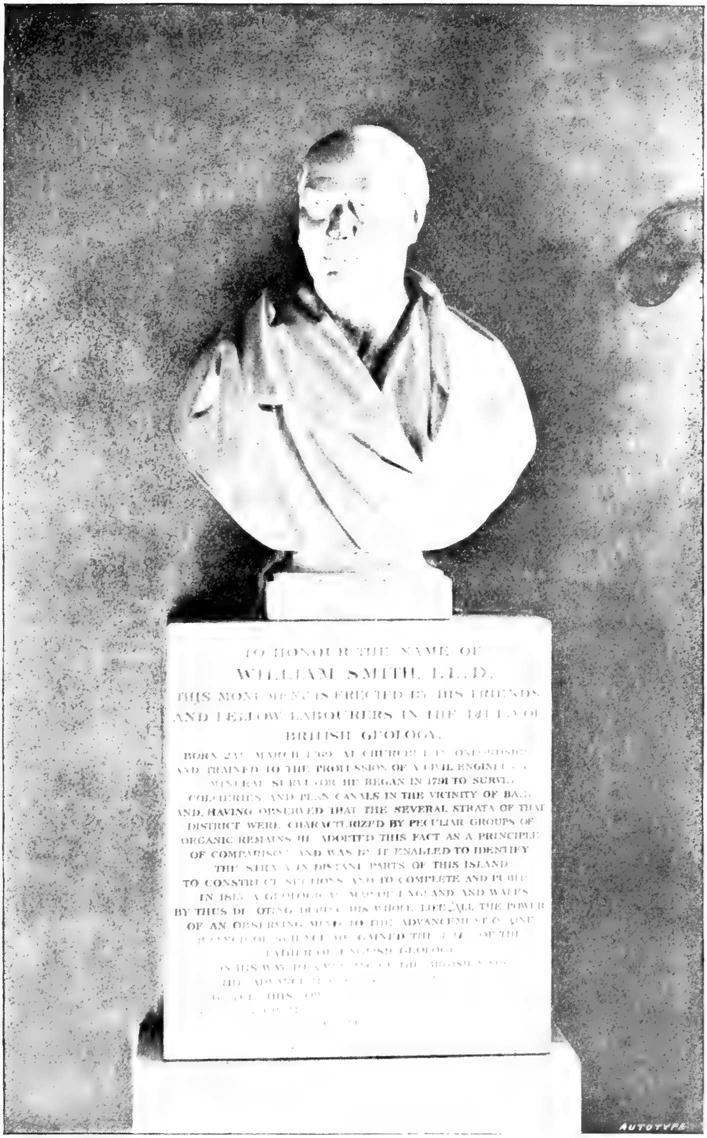
* Apparently the only tangible result of this was that the Hackness Map, completed on Aug. 31st, 1829, was lithographed by W. Day, (in outline only), in 1832.



Smith's Monument in St. Peter's Church, Northampton.

The Bust of W. Smith in St. Peter's Church, Northampton.

acquire useful knowledge. He gave, at some length,* an account of the progress of his discoveries; the origin of which he dated about forty years ago, when he was employed in superintending canals and coal mines, and in surveying land, in the west of England; and concluded by returning thanks for the honour the company had done him."

MEMORIALS, ETC.

A bust surmounts a tablet to Smith's memory "within the fine old Norman Church † at Northampton, where he lies buried a few feet from the west tower. The bust is placed within the church, against the west wall of the nave, south of the grand Norman arch over the entrance to the tower."‡ It stands on a marble pedestal inscribed:

"To honour the name of William Smith, LL.D. This monument is erected by Friends and Fellow-labourers in the same field of British Geology. Born 23rd. March, 1769, at Churchill in Oxfordshire, and trained to the Profession of a Civil Engineer and Mineral Surveyor. He began, in 1791, to survey collieries and plan canals in the vicinity of Bath, and having observed that several strata of that district were characterised by peculiar groups of organic remains he adopted this fact as a principle of comparison, and was by it enabled to identify the strata in distant parts of this island, to construct sections, and to complete and publish in 1815 a Geological Map of England and Wales. By thus devoting, during his whole life, all the power of an observing mind to the advancement of one branch of Science, he gained the title of the "Father of English Geology." While on his way to a meeting of the British Association for the Advancement of Science at Birmingham, he died in this town, at the house of his friend George Baker, the historian of Northamptonshire, 28th of August, 1839."

A photograph of this bust is given by Dr. Woodward in his paper quoted, and through his kindness we are able to reproduce the block (pl. XXI.). A copy of the bust is with the Smith collection in the British Museum (Natural History); another is with the Geological Society, London, another is at Scarborough in the possession of the Misses Turnbull, grand-daughters of Smith's apprentice at Hackness.

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* This '*at some length*' was evidently one of Smith's weaknesses.

† St. Peter's. Phillips states All Saints', but that is an error.

‡ Woodward, *Proc. Bath. Nat. Hist.* and *Antiq. Field Club.* Vol. X., Part I., 1902, p. 12 (of reprint).

With regard to this bust at Northampton, Dr. Henry Woodward, both in the *Geological Magazine* and in the Bath Society's Transactions, states it is by Chantrey. The Vicar of St. Peter's doubted this. Dr. Woodward informs me that he cannot now remember where he obtained the information. The *original* marble bust of Smith was in the possession of his nephew, the Professor of Geology at Oxford. I therefore wrote to Professor W. J. Sollas, who informs me that the bust is still at Oxford, and that it bears the name of "M. Noble" at the back. Noble lived at Hackness for some years. There is a plaster replica of the Oxford bust in the possession of the Misses Turnbull, Scarborough. Mr. Barker informs me that on the back of it is incised "W. Smith, LL.D, M. Noble, 1848."

I am indebted to Mr. R. H. Barker for the following note in reference to this sculptor:—

> Matthew Noble, the eminent sculptor, was a native of Hackness, near Scarborough, where his family, for at least three generations, were employed as Stone Masons on the estate of the late Sir J. V. B. Johnstone Bart, M. P. He was born in the year 1816, and early in life, he assisted his Father in work on the Estate.
>
> As a young man, he was proficient in modelling in clay, and this attracted the friendly notice of Sir John Johnstone, who at his own cost, sent him to London, where he received tuition in the Sculptor's art, which became his life's profession. He became eminent, and many of his works survive. He was many times employed by the Royal Family, and among his many works are the effigy of Archbishop Harcourt in York Minster; the Bust of Barrow, in the Chapel of Trinity College, Cambridge; Statues of the late Lord Derby and other prominent statesmen; and the Monument to the memory of Dame Margaret, the Mother of Sir John Johnstone, in Hackness Church, is the only local product of his chisel.
>
> He died 23rd June, 1876, in London, having shortly before his death suffered the shock of a son's death in a railway accident. A surviving son lives at Brighton, and near relatives of his still reside at Ayton, near Scarborough, where they continue the business of stone masons. In life, he was of a very modest and endearing character, and was much beloved by his many friends,

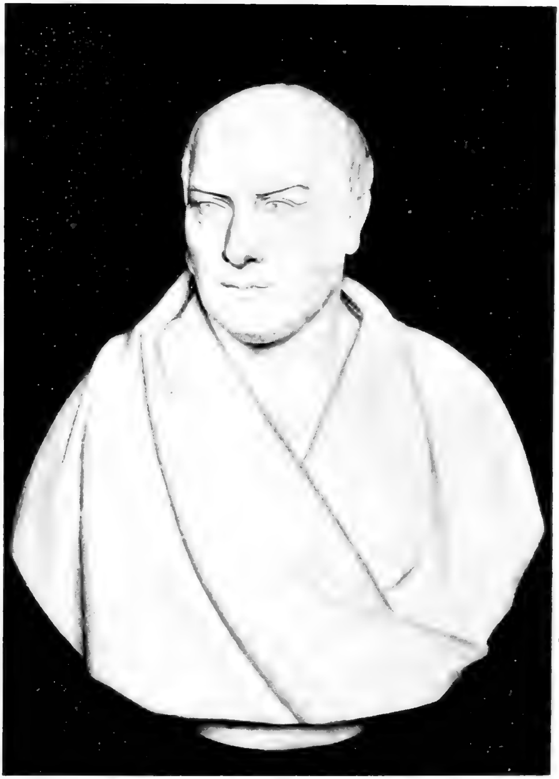

Photo by] [*J. Irving.*

Copy of Bust of W. Smith in St. Peter's Church, Northampton ; now at Scarborough.

Photo by] [*J. Irving.*

Bust of W. Smith, taken from life by J. B. Baker, Scarborough; now in the Scarborough Museum.

some of whom survive in Scarborough and its neighbourhood to the present day.

The bust at Northampton is evidently a replica. The Rev. R. M. Sergeantson informs me that it is not signed, but "is undoubtedly rough white unpolished marble."

In addition to this, I find there is a somewhat crude, but probably much more life-like bust, in the Scarborough Museum. It is of plaster, and on the back is incised the following:

J B Baker
fecit
Scarbro' 1873.

In Baker's "History of Scarborough" (Longmans 1882) the Author gives copious notes on Smith, and adds

"There is a bust of him in the Museum, at Hackness Hall, and in the York Philosophical Society, taken from life by his personal friend, the author of this volume."

The bust in the Scarborough Museum was given by Baker to the Institution, and in the Society's Report for 1873, the following sentence occurs:—

"The Committee take this opportunity of expressing their thanks to various members and friends for donations to the Museum during the past year. Amongst these may be mentioned a bust of William Smith, the Father of Geology, presented by Mr. J. B. Baker, by whom it was executed."*

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* Dr. J. Irving has kindly sent me a photograph of Mr. Baker's original letter in reference to the matter. It reads:—

"4 Belle Vue Square,
Scarborough,
October 28th, 1873.

To the Chairman and Council of the
Scarborough Philosophical society,

Gentlemen,

Allow me to present you with the bust of my old and valued friend the late Dr. W. Smith, the father of English Geology. It was taken years ago by myself from the living subject and I believe the only bust extant of the Doctor. The original mould is destroyed.

I am, Genl
Yrs & etc. [sic],
Joseph B. Baker."

Joseph Brogden Baker was originally a chemist on the Cliff at Scarborough, and then resided in a house in Bar Street, which had a garden extending to the Cliff. His wife was a member of the well known Rowntree family, and living members of that family well remember both Baker and his wife, whom they frequently visited at Throxenby, where he lived later in life, and there carried on the business of a Farmer. He was a big, burly man, well known in Scarborough, and was in the habit of giving gratuitous lectures on various subjects at the Mechanics' Institution and other places. He was regarded as an eccentric man.

Probably the G. Baker,* the "Historian of Northamptonshire," at whose house Smith died, was a relative of the J. B. Baker, the author of the "History of Scarborough."

In the *Geological Magazine* for February, 1892, we learn that "a monument has just been erected by the Earl of Ducie, F. R. S., F. G. S., to the memory of William Smith, at Churchill, Oxfordshire, where he was born; a village already famous as the birthplace of Warren Hastings. The monument is formed of huge Oolitic ragstones of the district, similar to the Rollright stones. The name 'Oolite' was given by William Smith to the rocks of the formation of which the higher grounds in the locality are a part. It is a monolith standing on a double base. The lower base is 10½ feet square, and 3¼ feet high, the upper one is 6¼ feet square, and 2½ feet high. The monolith stands 9 feet high above the upper base, and is about 3 feet square. A marble slab is inserted in the side facing the road from Chipping Norton, and bears this inscription:—'In Memory of William Smith, "The Father of British Geology"; born at Churchill, March 23rd., 1769; Died at Northampton, August 28, 1839. Erected by the Earl of Ducie, 1891."'

A reproduction of a photograph of the monument is given in the *Geological Magazine*, 1892, p. 96. Through the kindness of Dr. Henry Woodward, the block is reproduced herewith (pl. XXIV.):

During the meeting of the British Association at Bath in 1888, a committee of the Bath Natural History and Antiquarian Field Club was appointed, with the Rev. H. H. Winwood as Secretary, for the purpose of tableting the house where William Smith resided longest. "After every possible enquiry was made, the uncertainty as regards any house

* He died a bachelor.

Monument to W. Smith, erected at Churchill, Oxfordshire, by the Earl of Ducie.

From a photograph by Lord Moreton.

Photo by] [*Dr. Norman.*
The Mill at Midford near Bath, showing Memorial to Smith
in the wall to the right of the Porch.

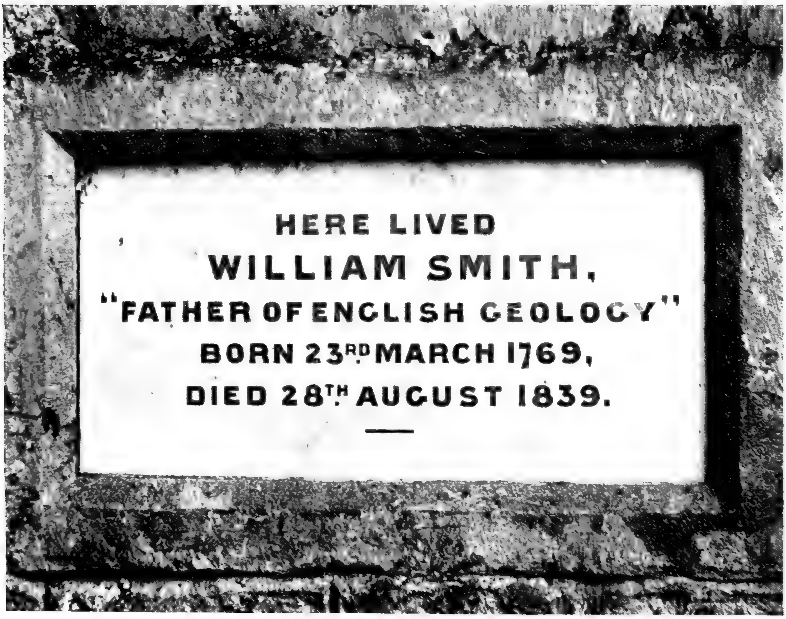

Photo by] [*Dr. Norman.*
Memorial to Smith at Midford near Bath.

in Bath was so great that the committee decided to recommend that the memorial should be placed on the house adjoining the Tucking mill at Midford, where there was no doubt he had lived for several years. Accordingly, in the following year, 1889, the committee, having obtained the sanction of the proprietor, had the memorial of this distinguished geologist inserted in the wall, where it may be seen on the bank of a portion of his own canal."*

The tablet reads :—

" Here lived
William Smith,
'Father of English Geology.'
Born 23rd. March, 1769.
Died 28th. August, 1839."

An illustration of the slab, and of the mill in which it is placed, from photographs by Mr. G. J. Grey, are given with the Rev. H. H. Winwood's paper.

This is doubtless the memorial which, judging from a notice in the press, it was originally proposed to place in the Royal Institution, Bath. I understand, however, that no such memorial is in that Institution.

According to his own statement (Memoirs, p. 125), three portraits of Smith were painted ; the best, completed at a single sitting by M. Fourau, was presented by his grand nephew, W. Smith of Cheltenham, to the Geological Society, which also possesses a cast of the bust in St. Peter's Church, Northampton.† Other portraits are by Solomon Williams and John Jackson (1778—1831) ‡

The portrait in the London Geological Society's rooms is the same as that reproduced in Phillips's " Memoirs " and elsewhere. A small reproduction of it is given on p. 212, with the permission of the Editors of *The Naturalist*. It appeared in that journal for November, 1907, p. 378.

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* Rev. H. H. Winwood. Proceedings of the Bath and District Branch : Somersetshire Archæological and Natural History Society for 1908, p. 197.

† This is the one reproduced in Phillip's " Memoirs of William Smith " : by H. Woodward in the *Proc. Bath. Nat. Hist. and Antiq. Field Club* (1902) in "The History of the Geological Society," etc.

‡ Dictionary of National Biography ; Vol. LIII., p. 151. I have not seen these two portraits.

Through the kindness of the Misses Turnbull of Scarborough, we are able to reproduce a photograph of an oil-painting of Hackness Vicarage, which is the house in which Smith lived while he was in the employ of the Johnstone family. The photograph (pl. XXVI.) shows the house as it was when Smith resided there; the wing on the left of the picture was used as his office. The corresponding wing on the right of the building was added at a later date when the house was used as a vicarage. It was here that Mr. Turnbull worked while he was apprenticed to Wm.

Smith. The picture shows the characteristic scenery of the Hackness district, well explained on Smith's map of Hackness. The house was so damaged by the floods of 1857 that it had to be taken down, and a new building now occupies the site.

My best thanks are due to the Geological Society of London, and their official Mr. C. P. Chatwin, for the facilities they have given in allowing me to examine and describe their maps, etc.; to the Rev. R. M. Serjeantson, the author of the "History of St. Peter's Church, Northampton," for the loan of the block, Plate XX.; to Dr. Henry Woodward for the loan of blocks on Plates XXI. and XXIV.; to the Editors of *The Naturalist* for the loan of the blocks on pp. 154 and

Photo by] *A. E. Reynolds, Scarborough.*

The following note occurs on the original photograph: Hackness Vicarage, damaged in the flood of 1857, and taken down soon afterwards. Dr. Smith lived here in 1828, where R. Turnbull joined him and began Civil Engineering.

212; to Mr. C. D. Sherborn of the Natural History Museum, London, for help with regard to the photographs reproduced on Plates X., XI. and XII.; to Dr. J. Irving, Mr. R. H. Barker and other Scarborough friends for the valuable help they have given in searching for information in the Scarborough district; to the Misses Turnbull of Scarborough for the photograph reproduced on Plate XXVI, and maps; to the Scarborough Philosophical Society for allowing me to copy the manuscripts now in their possession, reproduced in the appendices A, B, C, D and E, as well as for permitting me to retain for the Hull Museum one of the maps of Hackness, by Smith; to the Editors of *Nature* and *The Geological Magazine* for enabling me to obtain information relating to scarce maps and publications through the medium of their columns; to the Controller of H.M. Stationery Office for permission to reproduce the map on Plate XVIII.; to other friends at Whitby, Scarborough, Hackness, Bradford, York, Cheltenham, Gloucester, Oxford, Bath, London and Northampton, who have taken so much trouble to answer my numerous enquiries; and to the Editor of *The Publishers' Circular*, through whose columns I have been able to trace many maps and memoirs prepared by Wm. Smith.

APPENDIX A.*

On the title-page is:

GEOLOGY OF ENGLAND: MR. WM. SMITH'S CLAIMS

Page 2 reads:—

GEOLOGY OF ENGLAND.

JUST PUBLISHED.

Information acquired in 30 years Practice in directing the works of Draining, Canals, Collieries, &c., by William Smith Engineer.

	£	S.	D.
A Map & Delineation of the STRATA in 15 Sheets, with the Memoir—(Cary, 181. Strand)...	5	5	0
Geological Table of Organized Fossils (at Do.) ...	0	1	6
A picturesque Elevation and Section of the Hills, Mountains and Strata† (at Do.)	0	7	0
Three Numbers of "Strata Identified," 5 coloured Plates in each, No. 4 in the press, each No. ...	0	7	6
Published for Mr. Smith by Sowerby, 2 Mead Pl., Lambeth.			
"Stratigraphical System of Organized Fossils," Part 1. Part 2 will be speedily published (E. Williams, 11 Strand), each Part	0	15	0

Mr. Smith's other Publications are in Progress.

* In these pages the original spelling, etc., is adhered to.

† This will refer to the large "Geological Section from London to Snowdon," which Smith published in 1817; all his other sections were issued in 1819, the year after this "Claim."—T.S.

Mr. Smith's Map and other Works before the Public being well received, and very favourably noticed in the Edinburgh Review, and a "Statement of His Claims" being published by his Friends, he may now with propriety explain the subject himself.

Mr. William Smith's Claims to the Discovery and Establishment of Principles which have perfected the System of English Geology.

My Claim to the Original Discovery of "constancy in the Order of superposition," and "continuity in the courses of British Strata," with the peculiar mode of identifying them by organized Fossils imbedded, can be supported by many to whom these early observations were communicated: particularly by the Revd. Benjamin Richardson, who in the presence of the late Revd. Joseph Townsend, drew up my first "Tabular Account of British Strata," printed in my Geological "Memoir," Table 1, p. 8. Copies of this Paper were taken by the two Gentlemen present, and another was given to Mr. James, Land Agent.

Reference may also be made to Sir Joseph Banks, The Duke of Bedford, and Mr. Coke, at whose Sheepshearings, and Agricultural and Philosophical Meetings, my original Maps of the Strata were exhibited and explained, from 1799 to 1804; and many original Letters and Papers can be produced.

The Revd. Benjamin Richardson, Revd. Joseph Townsend, Chas. Joseph Harford, Esqr., of Bristol, and The Revd. Richd. Warner, were the first of the Scientific Gentlemen in the West who became acquainted with the subject, and immediately adapted my new arrangement of Organized Fossils, in the Order of the Strata which contain them.

In 1799, the information began to spread in Wiltshire, through Mr. Wm. Cunnington, and others, to whom I had explained it, and in the latter part of this year and the beginning of 1800, through Dr. James Anderson, who proposed to insert Papers on the subject in his work called "Recreations on Agriculture."

In 1801, Proposals were issued for publishing a Quarto Vol. on the subject, and a small Map was lodged with Mr. Debret.

In 1802, the late Duke of Bedford had so far satisfied himself of the general accuracy and usefulness of my Discoveries, as to request me, but a few weeks before his Death, to send him specimens of all the

Strata and their contents, to be fitted up in their natural Order in a Room at Woburn.

In 1802, The Discovery, and the confirmation thereof by numerous Organized Fossils, and other Specimens, was fully explained at Bath, to the late Mr. Wm. Reynolds, of Coalbrook Dale who showed a Copy of my original account drawn up in 1799, which, he said "was not secret, but to his knowledge had been widely circulated." Dr. Beddoes, and several other Scientific Gentlemen were of the Party.

In the latter part of the same year the subject was explained by Maps & Sections to Mr. Crawshay, who requested me to wait on the Marquis of Bute, to whom the Maps and Papers were fully explained; and again in July 1804, to a large party of Mr. Crawshay's Friends in London.

In May, 1804, this subject was recommended to the attention of the Board of Agriculture by a Letter from His Grace the Duke of Bedford, very fully explained at the Woburn and Holkham Sheep-shearings; and in July following, His Grace the Duke of Bedford came from Longleat to Bath, to see my Geological Collection, then arranged in the Order of Strata, in small Boxes on the Floor. Dr. Randolph was present at this explanation.

In the autumn of 1804, the Collection was removed to London, and fitted up in the Order of Strata. All this was previous to the establishment of the Geological Society in 1807. Early in 1808, Mr. Greenough and Sir James Hall called in Buckingham Street, and saw the Collection, and on the 8th of March, repeated their visit.

While I was thus spreading the information, and in all parts of the country which I travelled over, practically exhibiting its utility in the various works which I executed, my Brother was spreading it by his works in the West, Mr. Farey in the North, and in all parts by his various Publications, and the Rev^{d}. J. Townsend by his works, and, personally, to most of the learned & distinguished visitors of Bath.

Dr. Kidd and others who have since distinguished themselves by Pulications on the subject, saw the Original Collection in my house; and by repeated reference to other Collections, similarly arranged ever since my first public disclosure in 1799, any Gentleman, Foreigners or Natives, had unlimited opportunities of acquiring the most particular knowledge of the subject: and, thus through the great exertions of my truly good friend the Rev^{d}. Benjamin Richardson, and the indefatigable Zeal and industry of the Rev^{d}. Mr. Buckland, the Science, and probably some of the newly arranged Collection, was transferred from Farley to Oxford.

By this industrious diffusion of the Science, my highly esteemed Friend & others thought they were greatly serving me, and the Country, " which expects every man to do his Duty," and that a suitable reward for the Discovery and establishment of English Geology, would not be long withheld.

So rapidly and extensively has the Science spread in the West that Ladies in Wiltshire, and parts adjacent, where specimens of identification are numerous and obtained with facility, have distinguished themselves by these acquirements.

The Geological Society, formed in 1807 of Members whose minds had been purposely, or imperceptibly, stored with this knowledge, could not fail to make the rapid progress for which they are distinguished. And in the first Vol. of their Transactions, Mr. Parkinson, in his Paper on Fossil Remains contained in the Strata near London, observes, that "this mode of conducting our enquiries was long since recommended by Mr. Wm. Smith, who first noticed that '*certain Fossils are peculiar to and are only found lodged in particular Strata, and who first ascertained the constancy in the order of superposition, and the continuity of the Strata of this Island.*' "

These numerous Public Exhibitions and Explanations of Maps, Sections, and Specimens of all the Organized Fossils which identify the Strata ; and Presents thereof with their Localities written on them, could not fail to increase and extend the most useful knowledge on the subject ; so that Boys of 14 have acquired the Rudiments of the Science, without a word of instruction from me. So industriously and successfully has the Science of British Geology been taught that Hundreds have become practically acquainted with it, without even Books or " Hard Names." These are proofs of the simplicity and usefulness of the Science of Geology over any other Science yet established.

The gratification of curiosity, and the satisfactory results of investigation, have alike engaged the young and the old in these pursuits. The acquirement of this useful knowledge in the country is thus rendered very familiar, and every Cabinet of Curiosities becomes tributary to the general stock of knowledge.

This information was, immediately on its development, converted to use by

Mr. Davis in his Valuation;

Mr. Farey in the numerous investigations which his avocations require;

Mr. B. Bevan, in his situation of Engineer;

Mr. Townsend in the compilation of his Book;

Mr. Parkinson, made it an important Article in his 2nd and 3rd vol.,

Mr. Phillips also;

The Encyclopædia Brittanica (through Mr. Farey) has numerous articles derived from the same source;

The Philosophical and other Magazines;

Philosophical Transactions;

Sowerby's Mineral Conchology, might not otherwise have been published or with much less interest than it now has, and it may be questioned whether

The Geological Society would have been so early established without the above-named general diffusion of knowledge on the subject.

The Art of Mapmaking is improved by it; Mr. Cary and Mr. Arrowsmith, in their new Maps having evidently attended to the courses of the Strata in their shading of the Hills.

Thus, while all who could pick up the information thus profusely scattered thought themselves at liberty to publish it, I have been left to pursue, unrewarded and alone, the drudgery of more substantial utility, and my numerous Papers, from want of means, are suffered to remain, from year to year unpublished.

My Claims derived from established Discoveries, which result from 30 years of observation on British Geology, consist:

In having so long back "developed the structure of the Earth, in the neighbourhood of Bath, and unravelled the perplexity which the Beds in that neighbourhood exhibit, and made known the Facts & Inferences which they suggested." "This enumeration of the West of England Strata was circulated very extensively in MS; and by the exhibitions of Maps also, and Sections of the Stratification in other parts it became a Key to the structure of the remaining part of the Island."

The Elements of the Discoveries thus made public "have had a very important though unobserved effect upon the labours of all succeeding enquirers, who have been, perhaps unconsciously, but not the less really, indebted to the Author, for very essential assistance in their progress." Their rapid diffusion of this System amongst the individuals who make up the Nation, and profit by the development of Principles which extend and improve the "principal sources of wealth, & greatness in England," does sufficiently establish my Claim to national remuneration.

In thence deducing a particular distinction between the Alluvial and Stratified parts of the Earth's Surface.

In establishing the *order of supposition* of the principal Strata of England & Wales.

In proving their *common declination.*

In identifying the respective Strata by Specimens of Organized Fossils collected from remote parts of each, and depositing them with their Localities in the British Museum as Vouchers thereof.

In drawing Vertical Sections of the Strata, showing how the respective Masses form separate ranges of Hills, and how the great Features of the Island may be thus readily distinguished, by the contours of the Strata and other superficial indications of their courses.

In proving the continuity of these courses of Strata, by accurate delineations of their surfaces and Lines of Escarpment, on Maps of the largest Scale, and publishing the same on a large Map of England & Wales, with other illustrative works.

In having introduced the New Art of Mineral Surveying.

In having discovered and put in practice very extensively a New Art of Draining and improving Land founded on a knowledge of the Strata and of the Springs they produce and also a new mode of supplying Canals with Water, derived from the same Principle; and,

In thence deducing a correct Theory of Springs or an accurate knowledge of the receptacles and Currents of Water in the Earth; which accords with the practice of Mining and Draining, and is thus rendered extremely useful in obtaining water for Canals Brew-houses &c., requiring a large supply; which in some cases may be obtained without Machinery.

As the Public can only judge partially of these labours by the small proportion of my Documents yet before them others who may be engaged in "following out & correcting" what they suppose to be imperfect, might spare much of that trouble if they knew the extent and accuracy of my yet unpublished Papers.

WM. SMITH
Civil Engineer

15 Buckingham Street
York Buildings
London

June 1818

APPENDIX B.

[By Wm. Smith.]

FREESTONE.

The Hackness Stone is a fine-grained silicious Freestone chiefly of a mellow brownish yellow colour, or what is commonly called a good stone colour. Rubbed and finely jointed this stone presents a smooth surface and a most agreeable appearance in passages, halls, etc., and externally in fronts of Houses Churches and other public buildings is unequalled in colour and beauty of ornamental work.

Hackness Hall built of this stone thirty years since * is a proof of its good qualities. The stone being naturally dry and unabsorbent of moisture neither suffers by damp from the earth or by exposure to sun rain or frost nor does it moulder in sheltered places under cornices, like many other of the soft freestones.

It is not essentially necessary that this stone should be placed in its bed—stones for columns 12 or 15 feet or more in length may be raised from beds 2 to 5 feet in thickness.

When raised from the quarry this stone is soft but hardens by exposure, works free and tough with any kind of tools receives and preserves the finest arriss of any stone in use may be turned and carved into the finest kind of ornamental work required, which by specimens thereof in Hackness Hall appear likely ever to retain their form and sharpness.

BUILDING STONE.

A hard compact silicious stone even in texture and free from extraneous matter, of little but uniform colour, brownish white—neither splits scales or moulders by the longest exposure—capable of being wrought with a pick, point, or chisel, rubs down to a good surface for steps and other purposes; and though hard this stone requires but little working from the great facility of cleaving it either in or across the bed.

Four or five feet of the upper part of the rock is sufficiently

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* Hackness Hall was built in 1805, so that the date of this note would be 1835 or so, a little before Smith died. His last work was in connection with the Commission re Building Stone for the new Houses of Parliament.—T.S.

lameller to cleave for Flags which require but little dressing—may be firmly jointed and are very strong and durable, and placed edgewise for Curbstones are not liable to split. The blocks may be easily cleft for area or cellar steps sills or Linterns and may be placed endways for pillars or large Columns. The Stone may be raised from the quarry, from beds 2 feet and upwards in thickness or any portable length and width and from its firmness this stone will suffer less damage from carriage than any in the London market. For Bridges Docks Wharf Walls and all kind of heavy works on the Thames, & for Piers and Harbours this stone is particularly well calculated as by the longest exposure to air and salt water it suffers no change.

This stone is excellent for sound and strong Troughs or Cisterns.

APPENDIX C.

"Memoir of the Stratification of the Hackness Hills, 1829."

[By Wm. Smith.]

The principal object of the annexed map is a delineation of the GEOLOGICAL structure of some of the most irregular ground in England, namely, that around Hackness Hall. The valleys of this District, with their intermediate ridges of hills, both in form and Geological construction, may be considered *unique.* The valleys which unite about Rivaulx Abbey have the nearest resemblance, and the various branching valleys north of Lockton, which comprise the hole of Hurcomb, are also singularly formed ; but the intermediate hills are not composed of the same number of strata. Numerous other valleys in the long range of the TABULAR HILLS from Scarborough to Hambelton have no resemblance in form, although their Geological construction, generally speaking, is the same. Troutdale and Deepdale branch up into the moors in singular form, and Dalby Dale above Thornton, extends its ramifications by Stones-dale almost to the edge of Cross-cliff, so that the district between Newton-dale and Harwood-dale, which is part of the Tabular hills, and bounded by the same kind of high contour, has the most singular valleys deeply curved into the planes of the Stratification. On Knox's excellent map of the vicinity of Scarborough those forms are well depicted and may be readily compared. The form of Hackness valleys comprised within the high land of Suffield, Silpho, and Broxa, which is Geologically insular, may be compared to the branchings of a stag's horn. And no one can understand the intricate forms in the surface of this ground without traversing the hills as well as the valleys ; for on riding along the high side of the elevated plane of Silpho and Broxa moors, even the ends of the valleys are not discernible. Such is the ground of which we have to show the Geological construction composed of insulated parts of some of the most regular strata in the British Series.

The highest edge of Silpho and Broxa moors like that of all the rest of the Tabular hills from thence to Hambleton, is composed of Calcareous Grit, but this is not the highest stratum in the series, as the Coralline limestone reposing thereon forms the points of most of the hills around Hackness Hall and at Silpho the lower beds of that stratum which Mr. Phillips calls the Upper Calcareous Grit, reposes on the

Limestone. The lowest stratum in this insular part of the stratification (wh. might be called "Hackness Island") is the *Cornbrash,* and below this the alternations of sandstone & shale called the *Coaly Grit* may be traced around the Island between Silpho brow and Harwood-dale, and down the Derwent, and in the line of Scalby drain to the cliffs at Scarborough, & is thus shown to be the base of the Island, and in connection with the high cliffs North of Scarborough & the strata which form the surface of the Moorland district.

The series of beds in the stratification traceable by their edges around or in the Island therefore consist

1. Upper Calcareous Grit.
2. Coralline Oolite.
3. Calcareous Grit.
4. Oxford Clay.
5. Kelloways or Hackness Rocks.
6. Clay Beneath.
7. Cornbrash Rock.

Geology.—Fine natural sections of all these strata in their corresponding order of superposition may be seen in the Scarborough Castle hill and the cliffs between Filey and the latter place.

That Geology is a science of unlimited extent and utility cannot be doubted, but while Geologists choose to be mannerists rather than correct immitators of nature, some of its purposes remain unanswered. The application of this science to its most practical uses is nearly as herculean as its establishment.

Its uses in Agriculture are of the utmost importance to the country and therefore cannot be brought forward at a more convenient time than the present which calls for every stimulus to the skill and industry of the owners and occupiers of the soil. That a knowledge of Geology is the only infallible guide to determine correctly the value of land was said thirty years since by that eminent land valuer, Davies of Wiltshire, when the principles of the science were explained to him. To know what plants are best suited to the soil a knowledge of the varieties of soil is necessary, which can only be obtained by an acquaintance with their subsoils and the beds of strata upon which they rest, and from which they are respectively formed.

Local circumstances and casual coverings of diluvial matter may make many shades of difference in the colour of a soil, but with these allowances there certainly is no other method of obtaining such a general and practical knowledge of soils as by an acquaintance with the strata which form them, and upon which they rest. There may be considerable variety and great difference in the nature of a soil where no adventitous mixture occurs, and this arises solely from a difference in the nature of the beds composing the thick stratum from which the soil is formed. These great varieties of soil varying according to the kind of stone upon which it reposes is well-known to practical farmers on the Hackness hills, and to most other occupiers of the same kind of land thence to Hambleton. They all know there is a thin, dry, stony soil over the limestone, a deeper and more tenacious soil over the wallstone nearer the moors, a range of free working yellowish sand land and poor, blackish, or grey sand upon the Moors.

The two last kinds are both of them upon the plane of the Calcareous Grit rock. The two other kinds, which commonly enclose a much better soil between them, are upon the stratum of Coralline Oolite so that we have five very different kinds of land upon two strata which shows the necessity of examining the rocks in detail instead of grouping them into formations, at least it is absolutely necessary to do so in Agricultural Geology—and especially where it is to be, as in this case, locally applied to the distinctions in the rocks and soils of an estate or farm. The following is detailed view of the strata very distinguishable in the Hackness Hills.

One Formation according to Phillips.	Upper Calcareous Grit	
	Coralline Oolite	Limestone.
		Spongite Coral Bed.
		Grey or Wallstone.
	Calcareous Grit	Reddish Yellow Sand, corresponding with the indurated sand exposed north side of Scarboro' Castle hill.
		Cherty bed of Stone which forms the planes of the moors and the high and well-defined edge of the Tabular hills.
		Freestone beds below this.

Oxford Clay.
Hackness Rock.
Clay Beneath.
Cornbrash.

By laws established in Geology and the help of organised fossils, the rocks in these hills are identified with the contemporaneous portions of their ranges through this Island to the extent of several hundreds of miles, and as well on the Continent. They are verified by the localities thereof enumerated in Phillips's Geology of Yorkshire, and further by the specimens exhibited in the Scarborough, Yorkshire, and numerous other museums, and by these means Philosophers are satisfied with the extent and accuracy of the Science, and Naturalists thus know where to collect specimens of each rock, from cliffs, quarries, and other broken ground, but those comprehensive views of the subject which enable us to trace ranges of the respective strata from field to field and from hill to hill and assign to each their proper limits and so to construct Geological Maps on a large scale, must be sought in the visible changes which the different kinds of strata make on the earth's surface. Such for instance, as the principal ranges of hills and valleys, the contours of hills, swells or knolls on the sides of hills, the flatness or steepness of roads, the ranges of springs which some of the strata produce, the springs and streams, the wetness or dryness of land, and the different kinds of soil turned up by the plough, &c.

In generallising these and numerous other circumstances essential to the science, we are assisted by the works of art, both ancient and modern. In the earliest stages of population the dryest range of soil became a way-worn track, the shoal caused by a rock in the river a ford, and the best spring an abode. By the old method of trial and error, men found out the richest land, and by numbers assembling for a share thereof those parts became the most populous. In modern times the same original dry track became a road, the rocky ford the best place for a bridge, or a mill, and the finest spring near to dry and good land the best place for a town or village.

Thus before trade and commerce had much interfered with man's original Agricultural employment, the greatest breadth of dry, good, land supported a city, and the next in degree a market town, and so on in gradation to the cottage. The best piece of good land in a village is commonly near the church, and that of a farm, near the house. Supply and demand afford and water made the union of water with dry good land everywhere essential to the site of population, and although this as at Stow-on-the-Wold and some other places seems to have been disregarded, yet a fine spring is at no great distance below and we find it the same at Suffield, Silpho and Broxa situated on the Hackness hills, but Suffield, originally the largest place of the three, had a supply for most of the year from a pond and shallow springs from the diluvium which also increased the depth of the soil on these rocky hills.

The fine trees and hedges here and at Silpho so much higher than the naked but less exposed hills over the Derwent seem unaccountable until Geology unravels the mystery by finding that the better soil of these heights is derived from limestone. On principles common to the sites of population it appears that the three villages are each of them situated on the best soil of all the high land. The two farm houses on Suffield heights, and Tholso farm house also stand in the range of this best land which by investigation appears to be derived from an earthy parting in the limestone rock running through these places which though but thin fortunately occupies a good breadth of surface.

Next to these superficial distinctions which render this greatly elevated plain strikingly different from any other portion of the Tabular hills, we may notice a character which it has in common with the whole range, viz., its well edged elevated contour, and the occurrence of Nab ends therein which also are common to the outline of all the singular District, before noticed, between Harwood Dale and Newton Dale. They are well defined in Troutsdale, at Saltergate conspicuous at a great distance. Some may be seen in crossing the Vale of Pickering to Malton, and the singular features of more westerly points of these hills may be recognised from the walls of York.

So extensively useful in Geology is the knowledge of contours that the great book of Nature is thereby laid open to us plain enough to read as we run.

The detailed particulars of each stratum in Hackness hills as they range through the fields can only be interesting to the owner and occupiers of the land. Suffice it therefore to say that the stratum composed of whitish light blue and blackish beds of clay above the coaly Grit rock, which forms the sliding cliffs of White Nab, South of Scarborough; is in Barnscliff and other places around Hackness Island similarly characterised by slips, and wet strong land, everywhere grows oaks of the best quality but is commonly over saturated with water issuing from the rocks above. There are no sites of population on this stratum nor scarcely a building unless it fortunately happens to be covered with gravel.

The CORNBRASH is a thin hard limestone rock recognised only in four places around Hackness Island, at one of which in the bed of the Derwent at Langdale bridge it became a ford. It lies near the bottom of the Hackness rock and nowhere appears to diverge from it. It also forms a ford in a moorland beck about a mile and a half west of Lastingham which village like most other sites of habitation at the foot of the Tabular Hills is upon top of the Hackness rock.

Hackness Hall and the village of Everley are upon that stratum called the Kelloways or HACKNESS ROCK, but the modern cottages at Hackness and Mowthorpe Farm are injudiciously placed below it. The bye road from Everley to Scalby Nabs follows its track to those farm houses which stand upon it.

It crosses the new road up Hey hill at the first steep place, ranges the hill sides to Mr. Williams's house and below Comboats diverges from the higher ranges of rocks southward round a secondary prominence and returns to and follows the road by the three Underbrow farms, and follows that bye road to William Pashby's house, which stands upon it. At this place a well 30 feet deep is sunk through the rock. Two other little farm houses on the north side of the Tabular hills stand on Nabs or projections of this rock some of which more remarkable points are the site of Barnscliff Cottage. This seems to be the greatest elevation of the rock from whence we look down on that great wood and the Derwent rolling below at the foot of Langdale rig which is formed of corresponding rocks terminated by the singularly conical hill of Oxford clay called the "Sugar Loaf." Through Barnscliff the Hackness rock, traceable by its dry soil and casual protuberancy comes to the junction of roads from Broxa and Langdale End where it slopes down with the lane to the verge of the river which in ancient times was a further inducement to ford the river upon the solid floor of the Cornbrash rock. From hence the dry soil over the Hackness rock becomes the road to Hackness. This rock skirts the cow pasture in the bank at the back of the cottages and the Inn to the rise in the road which from the redness thereof has been called "red brow" and thence through the wood by the road to the great quarry. It branches up the bottom of the valley to the great spring at the water house and forms so much of the brows on each side of the road to the Hall as lies below the Springs. In the same manner it is traceable up Longfield valley in the beck and under the dry soil and steep banks on each side thereof to Low-dale, High-dale and Whisperdale farmhouses. The dry soil over this rock on many accounts afforded the earliest inhabitants the most desirable sites of habitation but most so about the church where it is deeply covered with gravel. It is everywhere near to water issuing from springs above or below the rock. Up the interior valleys the Springs which are numerous flow only from the top of the rock, but about the village numerous springs issue from the bottom of the rock and some from the top of it and in the same manner by the issuing of springs more or less copiously may the bottom and top of this stratum be traced in and around the Island. Sites on this rock were also desirable for being above the floods, and alluvial soil between it and the river and from their contiguity to the better land of the stratum of Oxford clay lying in the slope above while the steeper parts of the hill sides covered with wood, afforded fuel, and shelter and timber for constructing their houses, for it appears by the oak ribs of several old buildings yet standing that they were long so constructed. The use of the valuable stone of this stratum in the construction of mansions & churches and of Museums to shelter Philosophers and their gleanings from nature, was left for these enlightened times.

The OXFORD CLAY lying over this rock has a parallel range all round the Island and up the sides of all the interior branching valleys forming good pastures, and where the ground is not too steep it forms some of the best wheat land. And in the low sides of the woods, where the debris of the rocks above is not too thick for the tap roots of oak to penetrate, it grows large and good timber. The upper part of this clay becomes harder and more sandy and finally so like the soft stone of the next incumbent stratum as to have no well defined boundary between them.

This soft under part of the CALCAREOUS GRIT as well as the freestone over it which occurs in this rock, is always in the steep hill sides which are mostly covered with woods and modern plantations. A hard cherty bed containing fossil shells chiefly Ammonites, Terebratulae and Pectens, forms the well edged contour of the hills and much of the poor surface of the Moors which all slope inwardly towards a central depression, somewhere about Hackness Hall. On the poorest parts of the moors we discover among the short ling, weather bleached cylindrical stones an inch or more in diameter which may have been fragments of large Alcyonites. Beneath the soil lies a subsoil called "a pan" which by its retaining water in some parts of the moors might seem to contain clay hardened by the oxyde of iron. The Rev. Wm. Vernon, in a late chemical anlysis of some of these soils detected clay and decomposed Basalt probably diluvial as in the black sand in and about the plantations, pebbles of jasper, porpbory, and other hard rocks have been found. The black sand which only skirts the better cultivated land certainly cannot be considered as the soil of any bed in the stratification but may have been washed off the moors, for

The YELLOW SAND, corresponding with that exposed in the N.W. side of the Scarborough Castle hill and with the same kind of sand at Newton, the Rabit Warren at Lackton, and the potato land at Sawdon, completes the varieties comprised within the mass called Calcareous Grit.

It is the pile of beds already enumerated which composes the general range of TABULAR HILLS as those superadded on the lower portions of the plane of Calcareous Grit Range parallel to the Vale of Pickering to Hambleton and are nowhere of great width except about Lockton. It is remarkable that all the following superadded beds composing the pile called CORALLINE OOLITE seem gradually to thicken as they decline towards the low ground, so that their terminating edges are cunated or wedge-shaped, and therefore make no irregularities in the general slope of the hills toward the south or south-east. They preserve the same character in a curved line round the inner and lower portion of the plain of the Hackness hills, and on their dipping side in the many digitated ends of the elevated plane presented to the Hall valley they end with the abruptness common to escarpments.

The first and lowest distinction in the beds of rock composing the thick stratum of Coralline Oolite is the WALL-STONE or Grey stone, which in shallow quarries commonly rises in flat thin pieces for fence walls. Some are good roadstone. This rock reposing on the Yellow Sand is covered with a deepish soil, stiff and tenacious with few stones in it, and those generally flat and thin. It grows good crops of oats and seems kindly for grass. The soil of this rock between Suffield and Silpho, where it is most distinguishable on the cultivated lands seldom occupies more than one field in breadth, it seems, however, to occupy a considerable portion of the cultivated ridge between Broxa and Hackness Head.

The CORAL BED is a more earthy bed, reposing on the Grey stone only about six feet thick, containing lumps of coral and small spongites, &c., which distinguish it from the coral over the limestone and which has been noticed before for forming the best land about the three villages, and that on the best farms is covered with a soil so superior to the one preceding that a pasture south of Broxa the difference in the herbage over the two rocks is easily distinguished. It forms only a small insular portion of soil under and just around the village of Broxa. It occurs north and east of Silpho, mostly north and west of Tholso Farm, where it produces the fine piece of land called the great pasture. South-eastward it is narrowed between the ravines and moors but widens again north of Suffield. It is considerably obscured about the village by a diluvial covering, but in its greatest and most regular breadth occupying many long narrow fields it was anciently distinguished by the name of "Suffield Ings" and about the northernmost of the two farms in Suffield heights it forms two large and good old pastures and the soil over this bed, which is only a parting between the wallstone and limestone of the stratum called coralline oolite, wherever it is in tillage grows the best wheat. It is remarkable that most of the pools on these hills for supplying stock with water are in the range of this stratum though we cannot suspect the makers of them of knowing anything about Geology.

The limestone occurs in several places which we shall next describe it forms lower ground than the preceding stratum and is about twenty feet or more in thickness but which, like the thinner divisions of the great rock, makes no perceptible difference in the gradually sloping surface of the hills except in its having a thinner soil thickly strewed with fragments of Limestone. The LIMESTONE forms properly saintfoin land, but from its contiguity to the woods and the thinness of the soil in some of its banks, much of it has long lain in sheep walks; burnet abounds in its herbage which however, forms a great contrast with that of the soil before described. The Limestone occurs in several places, but nowhere of the full thickness of the rock except on the hill south of Silpho, as on no other parts of the limestone can the Melanæ Striatus, Heddingtonensis, and the coral on the top of the rock be found.

This coral lies just beneath the soil about a quarter of a mile in length, but is soon covered with some of the UPPER CALCAREOUS GRIT, wh. on the higher part of three or four fields producing a fine loamy soil, like that on the same rock on the border of the low ground in the Vale of Pickering, and which is there called "Red Land" and which by good judges is considered to be the best arable land in the Vale. This is the highest stratum on Hackness hills, and from the pile of rocks which support it being of their full thickness it forms the highest interior land, but which is much below the marginal contour formed by the Calcareous Grit beneath the Coralline Oolite.

Thus by a superficial survey of the characteristic development of each stratum, I have made out the ranges and width of a considerable pile of strata which have also been locally and extensively identified by their organised fossils, to which as they are arranged in the Scarborough Museum and to the account published by Phillips and others I must refer, and I may add that by the characteristic distinctions herein employed and others peculiar to the terminating edges of the different strata, many Geological maps of the largest scale be made of Districts, Parishes, Estates, or Farms, which by readily exhibiting the varieties of soil, and inducing a better knowledge thereof, would be very interesting and instructive to the owners and occupiers and generally beneficial to the agricultural interest. October 2nd, 1830.

APPENDIX D.

AGRICULTURE.

Paper by Mr. Smith. Feb. 1831.

Grass cannot be prudently stored either for Summer or Autumn use: for the Farmer who does not eat his grass in Summer as fast as it grows, loses much of what the land would produce; and he that leaves it late on the ground for Autumn use, in what is called "fogg," wastes much thereof, and makes his grass-land course. Therefore, he that would farm grass-land to the greatest advantage, must either keep it through the Winter, or lay in as much stock as will eat down all the SUMMER grass on his pastures, as fast as it grows; and also as much cattle as will well eat down in the Autumn all the after-grass on the land that he mows. This is the only way to keep grass-land fine, and in good condition, and free from moss, weeds, and bad grasses; but many may think this would be going too *near the wind*, and that their stock would be liable to suffer from shortness of grass in dry seasons. It may be so where the Farmer has none but grass-land, but this ought not to be the case upon any Farmer, for on no account, whatever, should the provision for these casualties be sought for in grass-land. The casualties of a dry Summer, and of occasional wants of keep, should be provided for in that part of the Farm which is cultivated, where such crops as Tares, Rye, &c., can be gotten up high enough to cover the ground before dry weather commences, and thus insure their growth. It is well known that winter Tares & Rye, sown early enough, can be cut and served out to Stock to the greatest advantage in the dryest Summer; and at all times they make the best of all provisions for the latter part of Spring, or the beginning of Summer, when Farmers are in more danger of injuring their grass-land by hard and too early stocking, than at any other time of the year. These and every other kind of early crop, which can be cut green, or in case of excess, for that purpose may be cut for Hay, or ripened for seed, should be grown in sufficient quantity upon every Farm. In this way the casualties of a dry Summer, & the wants of the latter part of Spring, may be certainly and profitably provided after Swedish Turnips, Carrots, and other roots are consumed. These two kinds of food for Stock, namely, the late roots, and early green crops, should ever be objects of the highest importance to a Farmer who endeavours to keep as much Stock as possible; for Farmers in general admit that they could keep more in other parts of the year, than in the two months preceeding Old-May-Day. This period limits the quantity of Stock kept upon every Farm, and also the value of that Stock; for the Farmers profits thereon will be more or less, according to the plentiful or scanty provision for Stock in these two months. Therefore, it is evident that the overflowing food of Summer, cannot be consumed to the greatest advantage, without artificially making ample provision for this naturally the greatest ebb-tide of food in all the year.

With regard to AUTUMN, many North-country Farmers may ask, why should we do without fogg? I answer, for many reasons. First, because such grass should have been turned into milk, or fat, or for the support of young Stock, while it was sweet and good eatage. Second, by letting such long grass remain on the ground, a second bite of grass of better quality is lost. Thirdly, on account of the injury done to the Crop in the next Summer, be it either for pasture or Hay; and besides its being at any rate a slovenly, and wasteful practise, and an ill-judged method of shortening Winter. But how are they to do without it? A south country, or Norfolk Farmer, would say, "As *we* do by taking care to have plenty of turnips for Autumn, Winter, and Spring." But many will say, their land will not grow turnips; but in many cases it may be questioned whether the defect be in management or the soil. Strong land is commonly thought to be unfit for turnips, yet farmers grow them on the strong land of Suffolk, and Essex, and in Scotland, cabbages, carrots, &c., form part of the winter stock of food. At any rate fogg ought not to be resorted to upon dry and turnip soils; for by beginning in time with cabbages, turnips, and other roots, to succeed each other according to their different kinds through Autumn, Winter, and Spring, this unfertile time of the year, in which while one farmer makes nothing, the other renders most profitable. By beginning soon after Michaelmas to pull the best of his turnips for Bullocks, he turns out a good number of them for the Butcher between Lady-Day and May-Day, when Beef generally fetches the best price, and by folding off the smaller turnips, he improves the land on which they grow, makes up his forward Sheep for the Butcher about Xmas, others later as they are wanted, Winters his store sheep well, his Ewes also to, and during the lambing season, and from his Bullocks, stale-fed upon Turnips, turns out a great quantity of the best kind of manure for growing another good crop of turnips, or any kind of grain. His Cows, by occasionally getting turnips, &c., with their hay, are kept in good condition, and longer and fuller of milk nearly to the time of Calving. Thus while the barely-keep-alive Farmer, who has nothing but the produce of his barn to depend on, and is obliged to thrash out and sell at any price, and also to provide straw for his starving Stock, the Winter-providing Farmer takes his corn to market to better advantage, and gets in, from fat stock sold about Xmas, or in the Spring, two of his principal returns toward Rent and turns out plenty of stock in a wealthy condition to fatten or fill the Pail, from a full bite on his pastures. As one evil is sure to follow another, so is one benefit linked to another; for this reason, Cows and Ewes having been wintered well, the casualties of parturition and disease are reduced, and their progeny fatten and come to perfection sooner. Thus also, from his own increasing and improving Stock, he can retain and select as much as is required for the seasonably coming grass. And thus also, from a farm in arable and grass, or what is called a convertible soil, tilled for the purpose of growing crops to support the greatest possible quantity of Stock, he will never be in want of Manure, and will consequently grow good crops of corn upon what he tills, and from this, his Pork and Bacon, Beef, Mutton, Veal, Wool and the Dairy will have always something coming in to pay current expenses, and will never be at a loss to make up his rent.

In this view of the routine upon a Farm, it may be seen how much of the Farmer's good or ill success depends upon his good or ill provision for winter. That to shorten winter as much as possible, and that at both ends of it, should be the Farmer's first object; for if a man is improvident in that respect, it is evident he cannot succeed in farming. The long cessation of profitable growth in our pastures, must be artificially supplied by preserving and extending the growth of our Summer through Autumn, Winter and Spring to the full commencement of the next Summer's crop of grass. It is evident too, that this must be done by roots, and other succulent vegetables in a living or well preserved state; for hay and straw, or, too commonly, straw alone for stock to subsist upon is like dry bread alone to a labourer. How can a poor skin-and-bone Cow, subsisting solely upon Straw, or dry Hay and water, be expected to give a sufficient quantity of rich and good milk? Her milk must fail much sooner than that of a cow daily supplied with succulent plants along with her hay. She will be in bad condition at calving, and ill-conditioned to fatten her calf. An overgreat dependence upon Hay is also bad for the Farmer in a many other respects, especially upon that grown upon poor or even middling land, as the grasses upon such land are bad, and the crop light and late, as well from late Spring feeding as from the poverty of the soil; it is often badly made, and in these parts rarely if ever well stacked. From the scanty produce per acre the Farmer is obliged to shut up too large a proportion of the Farm for mowing, and that of course from the best of his old grass-land, which is too often by the needy farmer frequently mowed without a due return of manure, and thus it becomes mossy, and further impoverished. The scythe and the rake having to go over many more acres for the requisite quantity, a bad crop of hay is always made at more expense than a good one; and from the too many acres shut up for Hay, the pastures are contracted, so that stock sufficient is not kept upon a farm, even in Summer. The necessitous and the nigardly Farmer, both of whom endeavour to get more from the land than it can produce without help deceive themselves egregiously in this bad management of grass-land, which is but too common in the northern Counties. Not only the old grass land, but the "seeds," as they are called, which alternate with their tillage, are generally ill managed. These lie not only two years, but pieces called "seeds" may be found upon many farms which have lain five, six, or more years in an unprofitable state, arising from various causes. The first is from an over desire to plough more land than can be properly managed by the strength, manure and capital on the Farm. Secondly from a want of care or skill as to the kind of seeds best suited to the soil, or from niggardliness, both as to quantity and cost, the seed is collected from hay of old grass land (chiefly *Holcus lanatus*), and this is extensively propagated, the worst of all greatly called in the South by the name of "Yorkshire White Grass," the hay of which is known to be bad, and also the eatage. From land so laid down, or even with better seeds so scantily sown as to see the seed-fields whitened with Daisies, what profit can be expected? It may however be expected, that some who have held their farms at a low or moderate rent, are disinclined to make their pastures look well, that they may have an excuse for breaking them up again, and giving them, what they call, "another round," that is another series of improverishing crops, commencing with a crop of Oats on one ploughing. Where the Occupier has land enough to let one half the Farm lie in an unprofitable state, while he crops the other half, this may do, but not long for it is evidently done with a loss to himself, his landlord, and to the community. A better system of cropping some of this unprofitable grass-land with Turnips, or other Roots, and green crops, scarcely needs any further detail of the advantages thus resulting, it being evident that less land would be required for Hay, more would be depastured, the same stock would be kept better or more might be kept upon the Farm; there would be more employment for labourers, the consumer would be better supplied and the Farmer's profits would be greatly increased.*

* In 1831 was published 'Observations on an Improved System of Agriculture,' by William Smith, London, R. Hunter, 72 St. Paul's Churchyard, 8vo, 39 pp., price 2s. A perusal shows that it is not by Smith the geologist, however, and it is dated from The Prae, St. Albans.

APPENDIX E.

POLITICS, STATISTICS, &c.

[By Wm. Smith.]

That the wealth of a nation depends upon the good employment of its inhabitants, cannot be doubted; and if that wealth and employment be equally diffused, its benefits must be general; but if, from any internal natural advantages of the country, wealth, and employment becomes locally and prodigiously increased, and that at the expense of the most valuable article in the country, and if the persons so employed derive their food and the articles they are employed upon from a foreign soil, and if foreign ships be allowed to benefit by the commerce between such privileged locations of trade and the foreign market, then the truth of that maxim and its general benefits may be doubted,—And further too, if it can be shown that those acquiring wealth from local advantages in this country applied to a foreign trade, have also superseded the ancient employment of others at home, who have no such natural advantages. That all men have a right to benefit by the natural advantages they possess, must be allowed; it being the principle that all men have acted upon from the earliest locations of population and trade. Most of our ancient cities and boroughs sprung up into consequence from their respective natural advantages in supporting a numerous population, chiefly employed in manufacture and trade, and many of them (whose occupation is gone) were incorporated and enfranchised to encourage and improve those manufactures. It is also well-known that many of the earliest improvements in arts and manufacture, were made by foreigners invited here and incorporated for that purpose, and in one of the Charters of the town of Kidwelly, it is said, that no Welchman shall be of the corporation. This was ever a poor place but many others, originally wealthy and populous, are annually becoming poor, from causes wh. are now powerfully operating against them. It has been said of Salisbury, that no new house has been built therein within a century but upon the site of an old one. This, as well as Exeter, Chichester, Colchester, Ipswich, Norwich and many others, were, in the former state of things, good situations for manufacture and trade, but it being my present object to notice only those locations of Trade wh. depend upon our Minerals, I shall merely add that Chichester was enriched by the great IRON-TRADE of Sussex, about 100 years since transferred to South Wales. This transfer of wealth, and employment, to the mountains of Wales, where it has been wonderfully extended and improved, arose out of the local advantages of coal, accompanied with iron-stone, in the greatest abundance. From these advantages Iron being cheapened to the lowest degree, the benefits of the transfer are extended all over the Island, and from the raw material being our own, and from the abundant employment the trade affords, no evil whatever can arise from the greatest possible extension of our Iron-trade in Foreign Markets. The transfer of the ALUM TRADE, brought into the country by Sir Thos. Challoner, in the reign of Eliz., and from wh. Whitby and its vicinity derived great wealth and employment, has also been made for the convenience of coal. As new arts arise new articles are required, and thus, to encourage the manufacture of IRON WIRE for cards, and in the Woollen manufacture, Germans, in the reign of Eliz., were brought over, and encouraged by a patent to make Iron wire, for that purpose, first at Tintelm in Monmouthshire, and about the same time, two Germans of the name of Wm. Humphrey, & Ch. Sh . . tes,* had the royal privilege of searching the Island for CALAMINE AND COPPER, for making Latten. All the Minerals then belonged to the Crown. The employment afforded by extracting minerals from the mountains in Wales, was prodigious, and the wealth, thence acquired by Sir Hugh Middleton, was all vested in labour to make the new river from Ware to London. It was also from the wealth of those mines that Sir Carberry P......... contested the royal right to minerals, which by an act of Parliament in the reign of Wm. the III., became vested in the owners of the soil. Great wealth and employment arose out of the Copper mines in the Island of Anglesea, for many years. And, I have been told, at the Alshee copper mines on the shores of Bantry Bay, in the south of Ireland, which originated in my suggestions, £5,000 a year was soon paid in labour, and that, in one year, they sent to Swansea 800 tons of copper ore, of the finest quality. These are some of the great advantages of attending to our Minerals as sources of good Employment for the Inhabitants, and consequently of wealth. These benefits from the metallic ores are, however, but local, and in some instances precarious and transferable. The advantages to be derived from the

* As in MS.

metallic ores, are also known now to be confined to certain ranges of strata in the interior, and on the western side of our Island and in those parts confined to certain narrow ranges called veins; but the courser kinds of minerals, such as all kinds of STONE, SAND, CLAY, &c., wh. are stratified, and applied to many useful purposes are, on account of their now well known regularity and continuity, good sources of employment and profit. No place can be better stored with the articles than the greater part of this Island. They in former times, seem however to have been little attended to, as in the time of Sir Robt. Walpole and probably much latei, the streets of the Metropolis were paved with Bremen stone. Purbeck stone was much in use since I can remember, which gave way to the finer flags from Yorks., first introduced by Sir Wm. Stains, and the great employment this kind of stone affords, and the profits thereon, between the quarries and their place in the pavement of London and numerous other great Towns, is become a settled national benefit, and to which many new and extended uses of freestone, slate, flints, &c., have largely contributed. All the best kinds of POTTERY called Delft-ware, was formerly imported from Holland, the clay for which, to the disgrace of the country, was taken from our shores, but which, to the immortal memory of Wedgewood, has become a permanent source of employment to many thousands of men, women and children, in the populous but new district of Etruria. This manufacture *to my knowledge* is capable of great extension, and which, like the Iron Trade, from the raw materials being our own, is one of the best that the country can encourage for the employment of labour and capital, and that even to any extent for exportation. FLAGS AND GRINDSTONES are the accompaniments of coal, and therefore from their quantity, quality and accessibility, Britain, to the advancement of labour and commerce, might supply all the world with these articles. FLINTS are most extensively used in potteries, which, like the pipe clay, are the chief minerals of value in the south-eastern part of the Island, but to calcine the flints and the ware, these articles go to the coal districts.

We now come to the most valuable mineral in the Island, the COAL, wh. seems to be drawing a variety of employments into its own vortex, and with the whirling rapidity of its appendant machinery, is employed not only to make but to convey the made and unmade, with the velocity of the wind, to and from all parts of the world. Now, if we look to a Geological Map for the sites of Coal, we find three of our principal coal districts mainly occupied for this purpose. With commerce so extensive that the sun, it is said, never sets upon the British flag, our fields and rivers traversed by Steam Engines, and every part of the Ocean spotted with them, we may ask, what is to be the supply of coal, and what may be the price of it to those who derive no benefit from such foreign intercourse? The Iron trade, not of 100 years standing, has been said to consume as much coal as all the house-fires of that kind in the Island. The S. Wales, Staffordshire, the Derby, and Yorks., and the Scotch Coalfield, are the chief sites of the Iron trade, and the various and much increased uses of coal, begin to clash so much with each other, as may shortly expel the Iron-trade from some of these. The furnaces in Derby and Yorkshire districts, make but little Iron compared to their abundant supplies of Iron-stone, and that chiefly from the advanced price of coal. Staffordshire, also, with a very thick coal, but very limited in extent, has great demands for its coal in Birmingham, and other great Towns, and the country thence to the Metropolis. The Shropshire coal by the Severn and Canals, and the Scotch by the great towns of Edinburgh, Leith, Paisley and Glasgow, and the manufactories; so that, in all of these, it may be expected, coal will, at no very distant period, become too dear for making iron.

It is already well ascertained where Iron can be made to the greatest advantage so that it is in vain to look for new establishments of that trade in any other or any of the lesser coalfields. There is plenty of Ironstone in that small coalfield about Mesham and Ashby-de-la-Zouch and in the Cumberland coalfield where Iron has been made. It was also made in Northumberland and in most of the coal districts Ironstone might be found but for the reasons before stated Iron cannot be made in these coal districts which have an extensive country supply, that of great Towns, extensive other Manufactories, and the Metropolis.

Coal may be considered a kind of common property on which many have encroached so much as to render it almost necessary to allot each claimant their proper share or at least to put a tax upon so much of this our national property which is devoted to the purpose of manufacturing transmarine products for a foreign market.

Fortunately the iron trade nor any of the extensive manufactories were ever established in the Coal District of Durham which supplies the Metropolis and the only one it has to look to for a supply. The workings commenced in Northumberland on Newcastle moor not many centuries back and not until the Civil Wars when Shippers from the Tyne refused to send coal to London had there been much shipped from the (Wear yet ?) from Northumberland in a line across Durham about twelve miles long and two or three miles wide, all the five best seams of coal for the London Market are wrought out or left underground in waste, and pillars and lent for what is gotten from the old works would there now be much Coal shipped from Northumberland, for in the small corner of that County occupied by coal it may be questioned whether there is sound coal enough left for a new colliery.

The five best seams in Durham are well known to range under high hills of Limestone toward the sea, but a volume might be written on this subject were it investigated as it deserves. Now according to a recent report of an eminent coal-miner there is no prospect of finding coal under the limestone of those hills, but at any rate according to the general state of information amongst those concerned in working coal, the practicability of finding and working coal is not expected to extend beyond the range of the Magnesian Limestone. In the more southern and western districts when this rock never occurs as a cover to coal, the occurrence of Red rock, is by the same rule, considered to limit the extent of the Collieries but the mistification which has so long obscured all we can collect on this naturally difficult but highly important subject should be cleared away. All sides of the Dean Forest and Welch and Scotch coalfields are well defined as are some others of less extent and importance. The prospect of finding and following the coal on the deep side of the main range of the series is, however, on many acc^{ts}. of the most importance to the Metropolis, and much of the midland and southern parts of England. We have already shown what opinion prevails along the main range as far as the Magn. Limestone extends, wh. is to the N. side of the Vale of Trent.

South of the Trent and in defiance of the distortion-making rocks of Charwood Forest and Mount Sorrell where that commonly superficial and endwise barrier to Coal, the Red rock, closes with Granite Schist so that all the intermediate stratification becomes delitescent, few practical colliers would think of trying for coal and especially when the should-be range thereof presents only a broad surface of Lias and Lias clay.

More southward but less overloaded by the incumbent strata, distorted positions and red rocks are the repeated obstacles to extension, and this red rock with the red marl over it is considered impenetrably to limit the deep side of the coal, and indeed almost all knowledge of it to the vicinity of Sodbury wherefrom the Lias is superadded (& with its high clay hills capped with Oolite much of the way), is known to be the cover of the Coal-series quite to the extent of the main range in Gloucestershire and Somersetshire. No wonder that under such variable circumstances generally strange and almost unknown to practical men in their respective Districts there should be such a variety of opinions.

These, I conceive, are some of the most knotty points which experimental Geology has to unravel, but the chief object of this essay being to show things as they are I shall set down a list of the respective coal districts with the occupancy of each.

[This part of the subject is not yet commenced].

Having thus briefly stated how the coalfields of Britain are occupied and the local and imperative demands upon each, I may now be allowed to draw the reader's attention more particularly to a Geological view of the subject.

The various beds of coal so well known at the respective works may be said to range through the interior of England parallel to the general ranges of their overlying strata rather N.E. & S.W. of a Meridianal line. They range across Scotland from E. to W. and through South Wales in nearly the same direction but much less in extent, on the shore of N. Wales. On the eastern border of Wales, Shropshire and Herefordshire, some detached portions occur which, with the longer and more valuable detachments thereof on the west side of the Summit of Drainage at Coolbrook-dale and in Lancashire and Cumberland and several thousand acres in the forest of Dean, lying between the Severn and Wye comprise a general view of those situations where coal has been long and extensively wrought. The latter and all in the west side of England's summit of Drainage as well as the great coalfield in South Wales and a few others may be considered as detached portions of the main range before described. Some of these as the South Wales & Dean Forest we are sure can have no connexion between them or with any other beds of coal northward of Staffordshire can any of the coal on the western side have any connexion with that on the eastern side of the summit of Drainage. Some on the eastern side also, at about Newcastle under Lime are probably detached or lie too far from the main range of coal which accompanies the superimposed series of English strata to be considered therewith, and it may be observed in the main range there are many and some very wide vacancies. It is more than probable that the boundaries of some of the detached coalfields may in particular places be enlarged, as I, nearly thirty years since, found two beds of coal and established a Colliery for the Earl of ——— on that border of the Lancashire Coalfield which is nearest to Liverpool; but it is the probability of filling up the vacancies in the main range of our Coal to which at present I wish to draw the attention of y^{e} Public.

Thus beginning with the northernmost it is impossible for the Coalfields of Scotland and Northumberland to be united, as they both range to seaward in the same range the southernmost workings of Coal in Durham are confidently expected to terminate. The recommencement of Coal workings in the centre of Yorkshire is, however, so far inland as to lead to an expectation that some of the coal ranging under an unconformable cover and probably in a very circuitous course may be found and wrought, and on which I some time since gave an opinion to a gentleman at Whitby who published an extract therefrom in the Whitby Miscellany. Now the Coals of Yorkshire, Derbyshire and Nottinghamshire are so well connected as to be considered as one District which on account of its length and regular course has been called "*The Great Northern Run.*" Now the Southern.

ADDENDUM.

In Thompson's "Collections for a Topographical and Historical Account of Boston," 1820, pages 292-300, is given copy of a letter from John Farey, dated February 24th, 1808, addressed to Sir Joseph Banks, which contains an interesting reference to Smith, as under :—

> "That the boring at Boston, or rather the sinking which I should recommend, if persevered in would reach this limestone, and supply a most plentiful spring of excellent water, I cannot have the least doubt ; and I am happy in being able to refer to a case in Buckinghamshire, which though so distant, is exactly in point. Early in the spring of 1802, when my friend Mr. Bevan, the engineer and myself, were receiving practical instructions from Mr. William Smith relative to his discoveries on the stratification, in a tour undertaken for that purpose, we accidentally met with the Reverend Mr. Le Mesurer, Rector of Newton-Longville near Fenny-Stratford, who related his having undertook to sink a well, at his parsonage house, within a mile or two of which, no good and plentiful springs of water were known, but finding clay only at the depth of more than 100 feet, was about to abandon the design ; Mr. Smith, on looking into his map of the strata, pointed out to us, that Newton-Longville stood upon some part of the clunch clay strata, and that the Bedford limestone appeared in the Ouse river below Buckingham, distant about eight miles in a north-west direction, and he assured Mr. L. that if he would but persevere, to which no serious obstacles would present themselves, because all his sinkings would be in dry clay, he would certainly reach this lime stone, and have plenty of good water, rising very near to the surface ; Mr. L. accordingly did persevere in sinking and bricking his well, and at 235 feet beneath the surface (the first 80 feet of which were in alluvial clay with chalk and flints, etc., similar exactly to what I have uniformly found on your estate at Revesby, and in the bottoms of many of your fen drains) the upper lime stone rock, (8 feet thick) was reached and found to be so closely enveloped in strong blue clay, as to produce not more than 9 feet of water in the well in the course of a night ; from hence, an augur hole was bored in blue clay, for some distance, to the second limestone

rock, which produced a plentifully jet of water, which filled and has ever since maintained the water, I believe almost up to the surface of the ground, but I have unfortunately mislaid my memorandums of the two last measurements."

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1877.—Catalogue of the Special Loan Collection of Scientific Apparatus at South Kensington. 3rd edition, 1877, p. 823 [refers to Smith's map of Hackness].

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Photograph by] [*Godfrey Bingley, Leeds.*

View of the cutting for sidings at Water Haigh Pit. The water just covers the eroded surface of the Coal Measures—here dipping deeply east. The section on the right shows sand overlain by gravels and sands. The plain beyond is of laminated clay. The picture gives an impression of the 50 ft. "river terrace."

ALLUVIAL DEPOSITS AT WOODLESFORD AND ROTHWELL HAIGH, NEAR LEEDS.

BY ALBERT GILLIGAN, M.SC. (Leeds), B.SC. (Wales), F.G.S.

(Read in abstract on November 16th, 1911)

Woodlesford is situated about six miles south-east of Leeds, and is built chiefly upon the south side of the River Aire on a slope of Coal Measure shale with the Thornhill Rock forming the high ground. Immediately to the south-east of the town, the valley of the Aire opens out considerably, and, stretching as far as Methley Grange—a distance of three miles—and occupying all the low ground at the junction of the Aire and Calder is found the alluvial deposit. The area covered by the alluvium is about two and a half to three square miles. It is marked upon the 1-inch Geological Map as chiefly Second River Terrace gravel, with two patches near the Aire and one near the Calder of First River Terrace. On the northern bank of the River Aire at this part, only the First River Terrace is marked, and that only as a thin fringe not more than half a mile and generally less than a quarter of a mile wide. On the south side of the Calder the Second River Terrace is again found, but only in small detached patches.

Messrs. Henry Briggs, Son and Co., wishing to work the Silkstone and Beeston Seams in the northerly portion of their area, decided to sink new shafts somewhere between Spencer Pit at Newmarket (a little south of Rothwell) and Woodlesford. There were several projects, but a consideration of railway and canal facilities, trade with Leeds and with shipping centres, such as Hull and Goole, pointed to a site near Woodlesford as being the most desirable. The next business was to examine thoroughly the country around Woodlesford from a mining engineer's point of view in order to settle on a definite site for the new colliery. This involved a consideration of the country with regard to the following points :—

(*a*) Topography and surface contours. This is necessary because the expected coal must be got cheaply both on to the main line of railway and the canal.

(*b*) Space for the laying out of extensive sidings for full and empty trucks, and for the surface buildings and equipment.

(*c*) Drainage of all surface waters and of the water which may possibly be met with underground.

(*d*) Ease or difficulty of sinking the shafts due to water, faults, and subsidence caused by old workings, etc.

After due consideration of these points a site between the railway and the canal, exactly across the railway from the site finally selected, was more closely examined. This gives ready access to both railway and canal, but it was found unsuitable as not affording space for siding accommodation, and it would further have necessitated the formation of very high railway embankments to deal with the coal by gravitation, and to effect a railway connexion with the main line. On the south west side of the railway, however, is a flat tract of ground bounded on the river side by the 50 ft. contour, and marked as Second River Terrace gravel on the geological maps. This stands about 20 feet above the ground first selected on the other side of the river, which is the First River Terrace. A section taken across the valley at right angles to the railway is like a shallow saucer with the canal and river at the lowest point. The embankment which carries the Midland Railway passes down the centre, and to approach this height at ground level it is necessary to work from the Second River Terrace.

The next question was whether much difficulty would be experienced in sinking the shafts for the colliery through the alluvium. Obviously at any point low down near the axis of the valley there would be much water in the alluvium to contend with, and there was justifiable hope that at any point away from the axis the alluvium would be thinner as a consequence of the slope of the old valley before it was infilled. This slope would determine the direction of flow of the ground-water, whereas the direction of flow of the surface-waters is, of course, determined by the present outline of the surface. Away from the axis, therefore, the alluvium tends to be less water-logged than nearer the centre.

Next, with regard to subsidences caused by old underground workings. The workings in the Haigh Moor seam—at a depth here of noly 67 yards—extend from Spencer Colliery almost to the Midland

Railway, and run parallel with the railway at a distance of 150 yards. It was, therefore, possible to draw a line east of which no further subsidence might be expected. This question of subsidence due to coal workings was of great importance, because of the desirability of having good foundations for the surface equipment, especially head-gears, winding engines and boiler chimney. The next point was so to fix the site in this stable area that the curves to the main line and canal would be suitable for the traffic, and so that the minimum amount of embanking and excavating would be necessary to lay down empty, screen, and full sidings. This led to a line parallel with the Midland Railway being fixed. West of this line no surface buildings were permitted, and no embankments higher than the present Midland Railway embankment.

The consideration of all these questions fixed the line for the shafts and for the sidings along which the gravitation from north-west to south-east was decided on. In this way an embankment became necessary on the north-west end of the site, and a large excavation at the south-east end. It was in the making of this excavation, and in excavating the soft ground on the north-west to build up the embankment, that the extensive sections in the alluvium were exposed. These points in connection with the choice of the site have been rather fully dealt with as affording an excellent illustration of the importance of Geology to the mining engineer in all his undertakings, even before a sod had been turned.

The work was carried out under the direction of Mr. Isaac Hodges, F.G.S., and most of the information contained in the above description was obtained from Prof. E. L. Hummel, who was at that time engaged on this work. The first step was to put down a borehole to strike a road in the Haigh Moor seam from Spencer Colliery. The object was to test the accuracy of the plan of the workings, to prove the strata down to this depth and to gain some knowledge of the quantity of water which would be met with in the sinking. The borehole passed through alluvium, and then filled with water, but boring was continued until the underground road was pierced, when the water poured down into it and the hole was then plugged up. Digging operations on the shaft site soon revealed the nature of the material making up the alluvium in much surer fashion than the borehole had done. At No. 2 shaft, the section record was :—

	ft.	*in.*
Surface soil	1	0
Brown laminated clay	3	8
Sand and loam	7	0
Blue laminated clay	4	6
Sand (sharp)	3	10
Sand (dark)	0	4
Sand (running)	11	10
Marl, clay and boulders	1	0
	[illegible]	2

The Sand at the bottom, called "running sand," carried vast quantities of water, and gave great trouble in the sinking operations.

A typical section was that which was exposed in excavating the alluvium to build No. 3 Engine House :—

	ft.	*in.*
Surface soil	1	2
Brown laminated clay	5	0
Sand and loam	3	2
Strong, slaty brown laminated clay	5	10
Gravel	1	8
Sand	3	8
Black sand with manganese dioxide	2	8
Total depth of foundations	23	2

The following was the succession of the beds in the excavations made to the north-west of the shafts to obtain material for the embankments :

	ft.	*in.*
Surface soil and poor clay with pebbles	3	0
Brown finely laminated clay	2	0
Gravel with large pebbles	0	6
Fine yellow sand (current bedded)	2	0
Gravel (coarse)	1	6
Fine clayey sand	1	0
Banded sand	2	6
	12	6

The height of the solid rock at the north-west end of the excavation, where no alluvium is found, is 71 above O.D., and at the engine house, 44 ft. above O.D., which gives a fall of 27 ft. in about a quarter of a mile. The upper laminated clay can be traced from end to end of the site, but the lower laminated clay commences a little north-west of where the shafts are situated, and is found right to the south-east end of the excavations. The presumption is that it continues still further to the south-east.

PETROLOGY OF THE DEPOSITS.

Gravels.

The pebbles of Coal Measure sandstone and grit were very variable in size, the largest being about $6 \times 3 \times 2$ ins. of Coal Measure sandstone. Ironstone nodules of a flattened type—evidently from the Coal Measures—occur in great numbers, while fragments of chert, often cuboidal in form, were by no means rare. The pebbles were somewhat irregularly laid, but there was a general tendency for them to lie with their long axes north-west and south-east, parallel to the present course of the River Aire. The gravel, when treated with dilute hydrochloric acid, showed a brisk effervescence, and this was found to be due to small fragments of limestone and calcite in the finer material intermixed with the gravel. Small pieces of grit and Coal Measure sandstone effervesced slightly, and seemed to be more or less impregnated with calcite. The heavy minerals and general mineral composition of the finer material was found to be identical with the sands associated with these deposits, and do not call for a separate description.

Sands.

The thickness of the beds was very variable, as the sections show, and the current bedding very pronounced, the general direction indicating deposition by water flowing south-east.

A microscopical examination of the sands shows the size of the grains to be very variable, the pieces of grit and sandstone being the largest. These were distributed irregularly through the sands. The fragments and minerals present (neglecting the heavy minerals to be named later) included sandstone, ganister, grit, chert, coal (occasionally forming bands), limestone, ironstone, quartz, felspar and mica. This is just such an assemblage as would be yielded by the rocks occurring in the basin of the River Aire. The quartz showed the development of new crystal faces just as it so frequently does in the Millstone Grit: the felspar was quite fresh and was extremely abundant in some layers. Some of the bands of sand were coloured black in consequence of the presence of manganese dioxide, while other bands were deeply stained by the oxides of iron.

In a brief account *of these deposits given in 1911 to the Leeds Geological Association, it was stated by the authors that very few garnets and zircons were found in these sands. The sands had then only been examined in bulk under the microscope, and no separation of heavy minerals had been carried out. This has since been effected by means of a Sollas bottle and Sonstadt's solution, with the results given below, the minerals being named in the order of their abundance. Sand from different horizons and various parts of the excavation have been examined—including the sand mixed with the gravels—and no perceptible differences have been made evident, except that there was a greater abundance of garnets in the sands from the gravel beds:—

(1) Garnet, in abundance in some of the beds.
(2) Zircon, very abundant in all separations.
(3) Leucoxene, often with ilmenite in the interior and anatase or rutile as secondary outgrowths.
(4) Tourmaline, chiefly brown, but blue and purple also occur.
(5) Monazite, several grains in each separation.
(6) Barytes, a few grains in the gravels.

There was often a quantity of clay-ironstone present. Xenotime is possibly also to be added to the list, as many grains were found resembling zircon except in the fact that they were pink in colour or clouded.

These minerals are in all respects similar to those found in the Millstone Grit and Coal Measure sandstone and shales, and will be fully described in my paper upon the Millstone Grit of Yorkshire.

Clays.

As shown in the section exposed at the engine house, two beds of clay occur, separated by a varying thickness of sand and gravel. Whilst

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* "Alluvial Deposits at Woodlesford," by A. Gilligan, B.Sc., and E. L. Hummel, B.Sc. *Trans. Leeds Geological Assoc.*, pt. xvi., p. 24.

the base of the top bed of clay maintained a constant horizon the top of the lower bed of clay, which was exposed at the end of the excavation, was undulating and, of course, the sand and gravel separating the beds increased in thickness where the lower bed of clay was thinner. This would point to contemporaneous erosion of the lower clay by a stream which shifted its course.

The most striking character of the clays was the fine lamination which they showed when the spades of the workmen made a clean

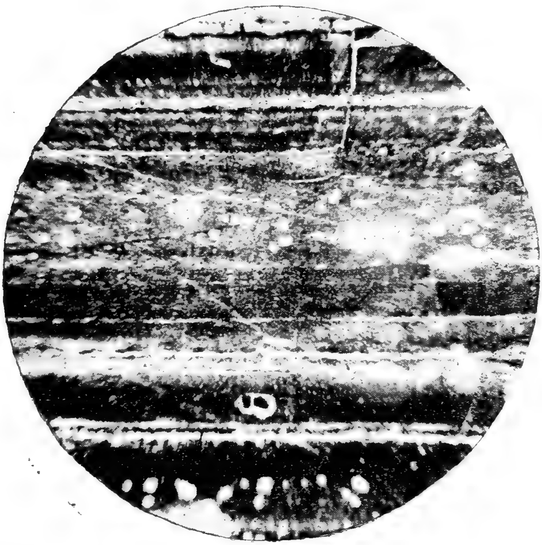

Photo: A. Gilligan] [*X 15.*

Photomicrograph of the
UPPER LAMINATED CLAY OF WOODLESFORD.

vertical cut. The alternating layers were light brown and dark brown in colour. The number of laminæ varied from 90 to 130 to the inch so far as they can be counted with a binocular mineralogical microscope, but observations upon dried specimens of the clay show that many of the laminæ which had been counted as one split up into two, so that the number given above would have to be increased. The dark brown laminæ appear to be very fine grained with a few grains of quartz and mica. The mica is variable in quantity, being most abundant when the brown lamina is thickest. The quartz grains are exceedingly small and angular. The light brown laminæ are much more open in texture and usually somewhat coarser than the dark laminæ. One milky looking grain looked very like a piece of calcite with rhombohedral outline, and when a drop of hydrochloric acid was placed upon it a brisk effervescence took place, showing that the diagnosis had been correct. Following this up by testing other grains, it was found that calcite was present in some quantity in all the light brown layers. If a piece of the laminated clay be taken and a smooth face prepared perpendicular to the laminations, and then a brush dipped in hydrochloric acid be drawn across the laminations each light brown lamina effervesces briskly while each dark lamina is unacted upon. Further reference to this fact will be made in the Appendix, where other laminated clays are also described.

It was also found that each bed of clay had its laminations completely destroyed by penetrating rootlets in certain layers, and in many cases a cast of the hole caused by a rootlet which had decayed had been made in calcite. Some of these were separated and examined, and found to be hollow in each case while the branching of the minute rootlets had been perfectly preserved. When dissolved in dilute hydrochloric acid, only a slight deposit remained showing them to be almost pure calcite, with only a very slight admixture of clayey material. This destruction of the laminæ by penetrating rootlets is interesting in the light it throws upon the absence of bedding shown by true under-clays of the Coal Measures. An excellent demonstation of the fact that the rootlets had actually destroyed the laminæ was afforded at Rothwell Haigh. The washings from sand had been allowed to settle in a pool, where they formed a laminated clay. Upon the dried surface of clay, clumps of grass were found growing, and on digging these up it was seen that the clay penetrated by the fibrous rootlets of the grass was without laminations, though laminations were distinct where there had been no growth of vegetation.

Scattered through the laminated clay, especially in the top bed at Woodlesford were concretions of practically pure carbonate of lime of very irregular shape, reminding one of the "race" in the Thames Valley brick earths. A careful search was made in the clays for traces of organisms and concretions, but beyond the rootlets mentioned above nothing was found.

Looking at the 1-inch Geological Map it is seen that Oulton Beck meanders across this deposit of alluvium from west-north-west to east-south-east, and it occurred to me that this beck may have in some measure contributed the material which is now found here. The deposits are undoubtedly of deltaic origin, laid down in a lake or pool, and are not such as are ordinarily formed by rivers in such a part of their course. The lacustrine conditions may have been due to the blocking of the mouth of the Humber by the North Sea ice at one stage of the last Glacial period. This ice held up a great lake in the central valley of Yorkshire. As Professor Kendall* points out, the presence of finely laminated muds is indicative of lacustrine conditions, and such clays were present in the great system of lakes which he proved to have formerly existed during the Glacial period on the northern flanks of the Cleveland Hills and in the Vale of Pickering, which latter in Glacial times was a lake receiving practically all the drainage of the Cleveland area. In the Vale of York itself, these laminated muds or clays also cover a very large area, and are found to have exactly the same characters as these at Woodlesford.

How are we to interpret the presence of the two clays with the intervening sands and gravels ? The phenomena must mean either that the level of the lake was lowered after the formation of the first clay and that in consequence the rivers could sweep out their coarser material further than previously ; or, that there was an increase in the carrying power of the water caused by uplift of the source or an increased volume of water. The irregular surface of the lower clay points to the former explanation, and to the river or stream having meandered over its surface after its formation.

As stated above, Oulton Beck suggests itself as a likely vehicle for the conveyance of some of the material in this delta, and support is given to this view by the fact that it is seen to cut through or rather pass between two very large patches of sand and gravel capped by laminated clay and boulder clay. These occur at a height of 175 to 250 ft., capping the high ground which forms the spur between the

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* P. F. Kendall, *Proc. Yorks. Geol. Soc.* Vol. XV. pt. 1, pp. 38-39.

Rivers Aire and Calder. The material at Woodlesford would represent the redistribution of these high level gravels by Oulton Beck. There is evidence also of a diversion of Oulton Beck, which flows south-east at first, and approaches within a mile of the Calder, which it probably formerly entered. But instead of doing so, it now turns due north at Lofthouse Gate, turns east again at Rothwell, and flows between the gravel patches, where it occupies a valley quite disproportionate to the present stream. This diversion could well have been caused by the ice which Mr. Lower Carter* believed to have dammed up the Calder and formed its valley into a lake. In fact, this seems to be the most reasonable suggestion.

Deposits at Rothwell Haigh and Oulton.

These were described in 1905 by Mr. E. Hawkesworth in the *Proceedings of the Yorkshire Geological Society* (Vol. XV. p. 456), to which reference may be made for the general phenomena and for accounts of the types of pebbles which occur. One remark, however, with regard to these seems necessary, viz., that a careful search has yielded no igneous rock, and in many visits to the similar gravels at Newlay, I have been unsuccessful in finding even the smallest fragment of igneous rock. This is the more remarkable since in the *Memoir of the Yorkshire Coalfield*, 1878 (p. 779), "trap and flesh-coloured granite" are recorded in the Glacial deposits at Whinmoor, north east of Leeds. I have also carefully searched the new exposures made on the south-east side of the Rothwell Haigh deposits—where a very coarse gravel is found—but without success as far as igneous rocks are concerned. Particular attention has been given to the Rothwell Haigh patch of gravel, and many points of interest have presented themselves which will amplify the description and record given by Mr. Hawkesworth. The boulder-clay which was mentioned in the paper on "The Glaciation of the Bradford Area" by Messrs. Jowett and Muff, (*Proc. Yorks. Geol. Soc.*, Vol. XV. p. 193), as having been found at Rothwell Haigh in making drains, is to be seen at the top of the section near the John o'Gaunt Inn, and though every glacialist would at once recognise it as boulder clay, it is satisfactory to note that scratched boulders have been found in it, both by Prof. Kendall and myself.

* W. L. Carter, *Proc. Yorks. Geol. Soc.*, Vol. XV., 1905, p. 434.

These are usually of Carboniferous limestone or fine grained sandstone. Below the boulder clay is found a bed of finely laminated clay, and this calls for further description. The bed is best seen on the south side of the gravel pit. Indeed, it is hardly seen properly on the north side as the laminations have been almost completely destroyed, for it is not there capped by boulder clay. It is redder in colour than that found at Woodlesford, and contains fewer laminæ, but it is in such a crumpled condition—no doubt as a consequence of its being over-ridden by the ice which deposited the boulder clay—that it is difficult to count the laminæ. Towards the bottom the clay is much bluer, as is usually, of course, the case, as a consequence of the oxidation of the upper part. At the eastern end of the section the boulder clay cuts out the laminated clay and rests directly upon the sand. As recorded previously,* blocks of Magnesian Limestone are found embedded in this laminated clay. The largest seen in situ—which yielded *Axinus* and *Turbo*—was about 1 ft. × 10 in. × 7 in., but the largest seen in the pit and evidently derived from the clay, as some was found adhering to it, was 2 ft. 4 in. × 1 ft. 4 in. × 1 ft. 2 in., and was a hard crystalline mass with well-marked bedding. A peculiarity is observable in the distribution of these Magnesian limestone masses and pebbles. They are fairly common in the lower part of the laminated clay, but most common about the middle just at the junction of the blue lower and brown upper clay. No Magnesian limestone has so far been found in the boulder clay, nor in the sands and gravels below the laminated clay, unless some of the chert pebbles have been derived from such a source. In the *Memoir on the Yorkshire Coalfield* (p. 779), chalk is recorded among the pebbles occurring in the drift at Whinmoor, and some of the masses found at Rothwell Haigh are as white as the chalk, but a microscopical and chemical examination of one such piece proved it to be a magnesian limestone containing practically no iron or manganese. The mistake could also be forgiven anyone who imagined some of the chert pebbles to be flints derived from the chalk, but I am of opinion after comparing them with chert from the Magnesian limestone that that is their source.

Irregular concretions of carbonate of lime occur as in the laminated clays of Woodlesford, and the action of hydrochloric acid on the different laminæ is the same. Some of this clay was tested for heavy minerals,

* *Trans. Leeds Geol. Assoc.*, pt. XVI., p. 31.

and also to see whether the carbonate of lime was present as original fragments of limestone or calcite, or as a secondary mineral. The heavy minerals yielded were the following:—zircon, garnet, leucoxene, rutile and tourmaline, named in the order of their abundance. One or two very small grains may be monazite, but of this I am not sure. When the heavy liquid with which the separation was effected was reduced to sp. gr. 2·7, it was found that a large number of the grains which came down were of rhombohedral form with the boundaries very sharply defined, and also showing zonary banding. In addition, masses showing a radial structure and giving a faint black cross were fairly numerous as well as a few groups of sharp pointed crystals which on closer examination with a high power objective, were seen to be scalenohedra of calcite. Here, then, is the explanation of the cause of the effervescence, and a further test showed that the calcite had been deposited in the more porous layers which gave the effervescence in the tests before described.

Below the laminated clay is sand about 15 ft. thick. It shows current bedding with a prevalent direction from north-west to south-east. The sand is noticeably coarser in the bottom part than near the top.

Petrology of the Sands.

The description already given for the sands at Woodlesford is applicable to these except that the manganiferous patches are absent, or nearly so, and there is a greater abundance of coaly layers. The material making up these sandy beds are just such as would be yielded by the rocks occurring in the valleys of the Rivers Aire and Calder, and of these the Millstone Grit has been by far the most important contributor. When the sands are treated with hydrochloric acid there is a slight effervescence.

Percentages of various grades:—

Weight of sand taken			=465·0	grams.
Stopped by	10	mesh	= 11·2	,,
	30	,,	= 50·3	,,
	60	,,	=223·8	,,
	90	,,	=127·6	,,
Through	90	,,	= 51·5	,,
			464·4	

The slight discrepancy is due to the material sticking in the meshes and adhering to the sides of the sieve.

The material which was greater than one-tenth inch consisted of pebbles of sandstone, clay ironstone, ganister, chert and grit, named in the order of their abundance. Separations of the heavy minerals with liquid of sp. gr. 2·8 yielded the following in order of relative abundance :—zircon, abundant in all separations, leucoxene, garnet, rutile, tourmaline, monazite, and anatase.

These are of exactly the same type as those found in the Millstone Grit and Coal Measures. Whilst the list is not a long one, the actual amount of heavy minerals is rather large. As in the separations made from the Millstone Grit and Coal Measures almost the whole of the heavy minerals are found in the material which has passed through the 90 mesh, and is less than ·01 inch as actually measured with the micrometer. The exceptions to this in some of the separations were the garnets and lencoxene which were found in notable quantities in material of grade which passed the 60 mesh but did not pass the 90 mesh.

Origin of the Deposits.

In the description given of these deposits in the *Memoir of the Yorkshire Coalfield* (pp. 783 and 784), they are spoken of as river gravels of considerable antiquity, formed when the stream was flowing at the level on which they now lie. But, as pointed out by Mr. Hawkesworth in the paper already cited, the problem cannot be so easily dismissed. In the *Memoir*, no mention is made of the laminated clay, which I first observed in 1909, and the first record of boulder clay at Rothwell Haigh was made by Messrs. Jowett and Muff in 1904. Mr. W. Lower Carter, in his paper on the Glaciation of the Don and Dearne Valleys, mentions these deposits at Rothwell Haigh and Oulton, and in supporting his idea of the existence of a glacier-like in Calderdale, writes* :—

> The northern edge of this lake (*i.e.*, Lake Calderdale) would creep up to and over the watershed of the Calder and Aire at Lofthouse and Rothwell, would discharge its waters over the gap at Tingley into the Churwell valley and lapping round Middleton, would be bounded northward by the Airedale Glacier. This lake

* *Proc. Yorks. Geol. Soc.*, Vol. XV., Pt. III., p. 435.

would serve to explain the Rothwell and Oulton Gravels which cap the watershed between the Aire and Calder from the 175 ft. to the 250 ft. contour. I regard these detrital deposits, often well bedded and associated with fine tenacious clays, as part of the lateral moraine of the Airedale Glacier rearranged in the lake which washed the side of the glacier.

Now, whilst I am disposed to agree with the statement that a lake existed here—as is indeed evidenced by the presence of the laminated clay—a little more explanation is needful than that given in the latter part of the quotation. Mere rearrangement of the material will not suffice to give us the succession found at Rothwell Haigh, where we have coarse gravel at the base, succeeded by sands becoming finer towards the top, and these surmounted by laminated clay and capped by boulder clay.

This series of beds represents a succession of conditions in this area such as might result from a glacier gradually approaching and creeping up the spur between the Aire and the Calder.

There were two glaciers which have to be considered in this area: (1) the ice coming down Airedale; (2) the Vale of York ice.

Messrs. Jowett and Muff assumed that the Rothwell gravels were, in fact, the morainic product of the Airedale glacier, but there is certain evidence on this point which was not in their hands. Among the erratics of the boulder clay, I have mentioned Carboniferous limestone. Professor Kendall has pointed out that some of this limestone is of a type only to be matched by Carboniferous limestone to be found in situ about Richmond, and therefore beside the track of the Vale of York ice. Secondly, I have found in the gravel-pit pebbles which certainly have a wind-polished and pitted surface, and which seem to have belonged to the Trias of the Vale of York. I have not actually found these in situ in the boulder clay, but I can conceive no other explanation of their presence than that they were washed out of the clay. Thirdly, in the laminated clay are found boulders of Magnesian limestone. There is no Magnesian limestone on the route of the Airedale glacier. But the escarpment of the Magnesian limestone tract lies a few miles to the east of Rothwell. We may imagine these boulders then to have been rafted by bergs of ice from the advancing glacier and thrown down here.

These facts convince me that the glacier in question was the Vale of York ice. Now, if this ice-front reached the spur between the Aire and Calder it must have obstructed whatever drainage of water accompanied the glacier in Airedale. At the earliest stage these Airedale waters would throw down their coarsest detritus as soon as they entered Lake Humber—which they would do just at this spot at Rothwell. But as the ice-front became higher and higher on the Aire-Calder spur, the Aire waters would be obstructed and the lower part of the Aire valley formed into a lake. The coarser detritus would be thrown down by the waters immediately they reached this lake, and, though it cannot be demonstrated with certainty, it may very well be that the deposit at Newlay, which is of exactly the same type as that at Rothwell, but at a height of about 200-250 ft., belongs to this stage. But as the confluence of the Aire waters with the Airedale lake advanced farther and farther away up the valley, the sediments reaching Rothwell would become finer and finer, until at length the ice-front itself covered the spot and brought the boulder clay.

Relative Age of the Deposits at Rothwell Haigh and Woodlesford.

After what has been said above it need hardly be stated that a great interval of time must be represented between the period when the Rothwell gravels and clays were formed and that at which those at Woodlesford were deposited. The first was an early phase and the latter a somewhat late phase of the Glacial period. Indeed there is every evidence that as the glaciers retreated up the Pennine Valleys the great rush of melt waters would scour off the material laid down in deltas and as moraines upon the slopes of the valleys and spurs of the hills to redistribute it in the low ground, and especially to carry the fine material forward into Lake Humber, where it now forms the warp of the Vale of York.

Examination of Various Laminated Clays.

With a view to throwing a little more light upon these widely spread clays I have examined a number from various parts of Yorkshire and Lancashire and, by the kindness of Prof. Leverett, from North America also.

I find that they are all of the same general character, being composed of light and dark layers. The light layers invariably yield an effervescence when treated with hydrochloric acid. They vary greatly in the number of laminæ to the inch, this being a function of their fineness.

Clays from various localities were taken and, after being dried at 100 deg. C. and finely powdered, were treated with cold dilute hydrochloric acid, when the following results were obtained :—

	Percentage Insol. in HCl.
Woodlesford	89·5
Rothwell Haigh	87·6
Victoria Cave	86·5
Danby (Cleveland)	83·4
Robin Hood's Bay	82·2
Brickfield, south east of York ..	72·0

A sample of lacustrine clay of glacial origin from Wisconsin, kindly forwarded to me by Prof. Leverett, gave 69·24 % insoluble in dilute hydrochloric acid.

The presence of irregular masses of carbonate of lime, and also of rhombohedral crystals of calcite has already been mentioned. So that it would seem that calcium carbonate (if all the soluble portion be reckoned as such) is an important constituent of all these clays. It is probable that the waters of the lakes contained a large percentage of calcium carbonate in solution—for it need hardly be pointed out that limestone forms much of the area from which the ice came, and also that calcium carbonate is more soluble in cold water than in warm. It is probable also that much of this calcium carbonate in the clays was originally secreted from the lake waters by algæ, of which no traces remain.

The finding of the laminated clay in the washpools at Rothwell Haigh and Newlay suggested the experiment of washing the sands from these deposits in the laboratory and allowing the fine material to settle. It was found that the resulting fine material gave a deposit consisting of a lower lighter and an upper darker layer, for every separate wash. Working with boulder clay from Rothwell Haigh it was found that it yielded all the material of the sands and gravels as well as the laminated clay. The heavy minerals were also the same though monazite was not found in such abundance as in the sands.

Evidently then, the Vale of York ice, which I have shown probably contributed the boulder clay, must have incorporated a large amount of material from the Millstone Grit, and the lesser quantity of monazite is quite in agreement with the fact that the Rough Rock was not so important a contributor to the burden borne along by this Vale of York ice, for the Rough Rock does not occur to the north, and it is the bed from which the greatest quantity of monazite has been obtained in my work upon the heavy minerals of the Millstone Grit.

Here, then, is a direct connection between the three types of deposit which may be helpful in elucidating some of the problems of the distribution of such deposits over such an area as the Vale of York. For instance, if quantitative work along such lines were carried out for a number of boulder clays and morainic material, and the thickness and area of the laminated clay over the Vale of York ascertained, it seems to me it would be possible to obtain the volume of the original material which must have been redistributed in order to yield it. A microscopical examination of the upper laminated clay of Woodlesford shows that it consists very largely of rock flour, being, in fact, a very finely divided quartz mud, and it would thus seem to be due to the grinding of fresh rock in Glacial times rather than to the old soils, residual earths and clayey material resulting from subaerial decay of the rock in pre-Glacial times. In the lower laminated clay at Woodlesford there is not so much rock flour and more clayey material, and doubtless differences of this kind would be found in whatever clays were examined, resulting from a sorting of the finer clay particles from the rock flour the further the area of deposition may be from the source of supply.

CORRELATION AND FACIES OF THE UPPER AND MIDDLE OOLITES IN ENGLAND AND NORTH-WEST FRANCE.

BY M. ODLING, M.A., B.SC. (OXON.), F.G.S.

(Read November 18th, 1914.)

The Jurassic, probably better than any other System, emphasizes the fact of a gradual transition of one series into another by means of passage beds, represented locally by unconformities,* and in spite of numerous local facies, the general sequence may be readily followed.

The beds dealt with in this paper comprise a well-marked group of clays, sandstones and limestones, the "Tripartite Series" of Phillips,† commencing with the Cornbrash at the base and terminating with the Purbeck Beds at the top.

These beds have been very fully dealt with, not only in the Memoirs of the Geological Survey, but also in numerous individual papers by Messrs. Blake, Hudleston and, more recently, Morley Davies.‡

In spite, however, of the attention that these beds have most deservedly received, there appears to be no readily accessible paper in which their general correlation can be found§. At Prof. Kendall's suggestion, therefore, I am venturing to attempt to supply this want.

Perhaps the most remarkable feature of the whole series is the inclusion at various horizons of arenaceous and calcareous facies in what is as a general rule an argillaceous series of beds. As has been pointed out by Blake, Hudleston and others, these beds are to be regarded as purely accidental, and the fauna is in every case transitional, the apparent sharp palæontological breaks being due to environment rather than to an actual change in a fauna by the extinction of a previous one. We thus find, as we should expect, repetitions of fauna, which render exact correlation extremely difficult. More especially is

* A recent school of geologists would probably prefer the term "non-sequences," since the unconformity is only recognizable by the absence of beds, not by a marked change in dip.

† *Geology of Oxford*, p. 392.

‡ *See* Bibliography at the end.

§ A correlation of the English and Weymouth sequence is given by Pellat, *Proc. Geol. Assoc.*, Vol. IV., p. 20.

this noticeable in the Supra-Corallian beds in the Weymouth districts where the alternation of Corallian and Kimeridgean faunas is well marked. Before the beds were examined by Dr. Hans Salfeld* in reference to Ammonite zones, the Abbotsbury Iron Ore, for instance, was always considered as the highest bed of the Corallian ; it is now seen, however, that this bed occurs high up in the Kimeridge Clay, and that the Corallian facies of its fauna is due to local conditions.

In this country the term "Corallian" is of such stratigraphical importance that its abolition would be most undesirable, yet when dealing with an area of Continental magnitude its abolition has much to recommend it. Similarly, as Dr. Strahan remarks,† the terms "Oxfordian," "Kimeridgian" and "Portlandian," associated as they are with definite districts, convey to us a very definite meaning, but they have been adopted in quite a distinct sense on the Continent. For this reason the terms "Upper" and "Middle Oolites," though inappropriate to argillaceous deposits, would be far more desirable.

The zones generally recognised in this country may be seen in Plate XXVIII. and are for the most part generally recognizable over the country ; the zones, suggested by Dr. Salfeld,‡ which are based entirely on Ammonites, are of considerable palæontological interest, but the unfamiliarity to British geologists of a number of the zonal indices and the adoption of a number of new genera and species render it very difficult to correlate his zones with those more generally known. A zonal table based on other groups—as has been done by the late Dr. Vaughan in the Avonian—placed at the side would have considerably increased the value of Dr. Salfeld's paper.

Shortly before his death, Blake commenced a monograph on the Fauna of the Cornbrash,§ with a view to shewing that it was more intimately linked with the beds above than with the beds below ; unfortunately, owing to his untimely death, the part dealing with the Pelecypods, on which most of his conclusions were based, was never published.

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* *Quart. Journ. Geol. Soc.*, Vol. LXIX., p. 423 *et seq.*

† *Quart. Journ. Geol. Soc.*, Vol. LXIX., p. 432.

‡ *Ibid.*, p. 423 *et seq.* *See also* fig. 2.

§ Palæontol. Soc. Monograph, *Fauna of the Cornbrash.*

From my own field observations, extending over several years, at numerous points along the outcrop from Weymouth to Peterborough, I cannot help feeling that his views are fully upheld on purely stratigraphical considerations, and that the Cornbrash represents a period of great transgression, more often than not resting unconformably on the beds below. The classification is thus more readily brought into line with that of Continental geologists, who group the Cornbrash with the Kellaways under the general term of Callovien.

Starting therefore with the Cornbrash as a datum line, it is the object of this paper to point out the sequence in various districts and their correlation, paying special attention to passage beds.

In the neighbourhood of Weymouth there occurs in a comparatively small area a most complete sequence from the base of the Cornbrash into the Cretaceous. Here, also, the sequence is rendered very complete by the inclusion of numerous passage beds, so that this becomes a most suitable sequence with which to compare the beds in other areas.

On the shores of "The Fleet," near Langton Herring, the Cornbrash rests on beds usually classed as Forest Marble, but which may, to a large extent at all events, include the Middle Fullonian—true Great Oolite being apparently absent.

Succeeding the Cornbrash is a small thickness of sandy clay, the Kellaways Beds, which are best exposed at low water at Furzey Cliff (the "Ham Cliff" of old writers), just east of Weymouth. These form a complete transition from the Cornbrash into the purely argillaceous Oxford Clay above.

Between the Oxford Clay and the Calcareous Grits there occurs a series of passage beds with an admixture of Corallian and Oxfordian forms. These passage beds, consisting of the Nothe Grits, with the Nothe Clay above, are best seen just west of Nothe Point, the promontory constituting the western side of Weymouth Harbour ; they also occur at the base of Bencliff, east of Furzey Cliff, but are here almost entirely hidden by the talus from the overlying Calcareous Grits, the Bencliff Grits. Ignoring the faulting, which is as a rule only slight, the south-easterly dip continually brings in newer beds, so that between Furzey Cliff and White Nab an almost complete sequence of Middle and Upper Oolites may be studied.

Above the Bencliff Grits, and passing up from them, occurs the Upper Corallian, consisting of the Osmington Oolite and *Trigonia* Beds. Further inland a true Coral Rag facies—*i.e.*, a facies replete with numerous corals such as *Isastrœa*, *Thamnastrœa* and *Thecosmilia* occurs, but this facies does not appear to exist in the coastal sections, except in the Supra Corallian of Ringstead Bay as stated below.

Succeeding the *Trigonia* Beds there occurs a series of remarkable passage beds from the Corallian into the Kimeridge Clay, consisting of sandstones and sandy limestones alternating with clays, the hard beds having a Corallian fauna, whilst the intervening clays are full of specimens of *Ostrea deltoidea*, a typical Lower Kimeridge form. These passage beds are best seen in the cliff section near Sandsfoot Castle, west of Weymouth, but the uppermost two beds only occur in Ringstead Bay, east of Weymouth, and the highest Corallian facies, the Abbotsbury Iron Ore in the neighbourhood of Abbotsbury is well up in the Kimeridge Clay as mentioned above. The struggle for existence of the two facies (Corallian and Kimeridgian) is so remarkable that it seems desirable to record the complete sequence here. It is to be noticed that although *Ostrea deltoidea* occurs in the arenaceous beds, it is almost the only fossil in the clays, especially in the base where the lowest specimens are attached to the sandstones. To this series Hudleston has aptly given the name of Supra-Corallian, which includes the Kimeridge Grit of Damon.

SECTION OF SUPRA-CORALLIAN IN THE WEYMOUTH DISTRICT (EXCLUDING THE ABBOTSBURY IRON ORE).

Supra-Corallian.	Upper Coral Rag.	6.—Gritty Limestone (Kimeridge Grit of Damon), with *Thamnastrœa, Thecosmilia, Stylina, Exogyra nana, Ctenostreon proboscideum, Cidaris florigemma*, etc.
	Sandsfoot Grit.	5.—Blue Clay with *Ostrea deltoidea*.
		4.—Ferruginous sands with *Ostrea deltoidea* and *Ctenostreon proboscideum*.
	Sandsfoot Clay.	3.—Blue Clay with *Ostrea deltoidea*.
		2.—Ferruginous sandstone with *Ostrea deltoidea, Pecten vagans, Pecten episcopalis*.
		1.—Blue Clay with *Ostrea deltoidea* and *Astarte sp.*
Corallian		*Trigonia* Beds.

The Kimeridge Clay, which succeeds, calls for no special note. The village of Kimeridge, from which it takes its name, being in the immediate neighbourhood, the sections are the type sections. The general succession will be most readily seen by reference to Plate XXIX., which shows the correlation between the Weymouth and Boulonnais districts.

At the top of the Kimeridge Clay, and insensibly passing up from it, come the Portland Sands, capped by Portland Stone, forming the Lower and Upper Portlandian of the district. The separation, though purely lithological and probably not occurring at a constant horizon, is valuable for mapping purposes. Above come the Purbeck Beds, a series of land, freshwater and estuarine beds, which seem to link the Jurassic with the Cretaceous. All these last beds are best studied in the Isle of Portland, with the exception of the Portland Sands, which are more accessible at Ringstead Bay.

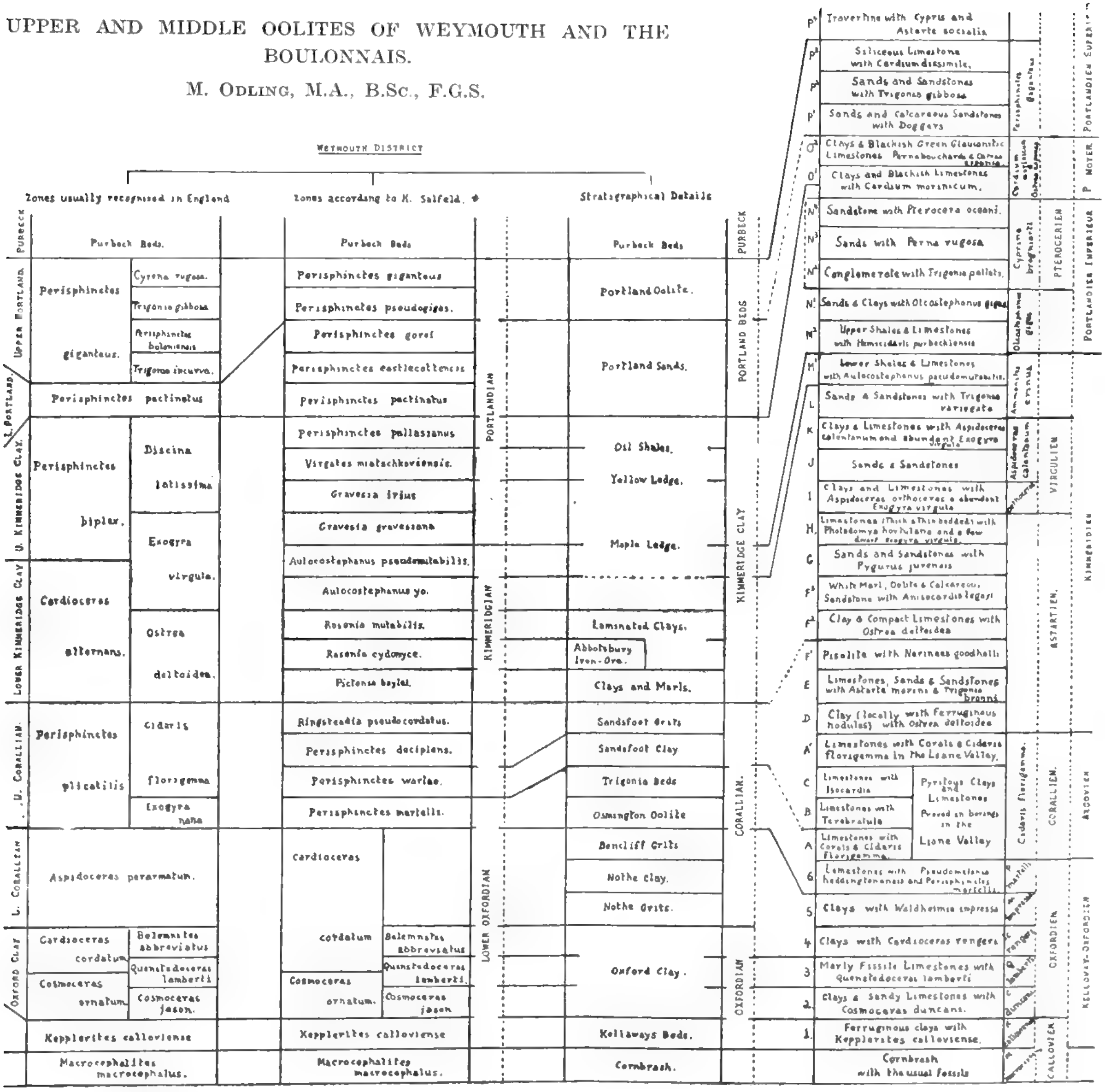
Turning now to the Oxford district—with which is included not only the immediate vicinity of Oxford, but also some of the more easterly outcrops—we find many marked differences. The thicknesses of the beds have all enormously decreased.

Starting with the Cornbrash, we find that a lower horizon has come in, marked by an abundance of *Terebratula intermedia*. Of the Kellaways Beds there appears to be no definite representation, unless certain somewhat sandy beds at the base of the Oxford Clay in part represent them. The junction of the Calcareous Grits with the Oxford Clay is nowhere accessible, but the information afforded by well-borings, etc., gives no suggestion of alterations of clay and sandstones representing the Nothe Grits and Nothe Clays of the Weymouth district.

The Corallian in the neighbourhood of Oxford is usually divided into an Upper, or Coral Rag, and a Lower or Calcareous Grits. This classification, though useful for mapping purposes, is unfortunate since the base of the Upper Corallian is thus often included in the Calcareous Grits. The junction between the Upper and Lower Corallian is represented by a band characterized by a mixture of Lower and Upper Corallian forms, and containing numerous pebbles, chiefly of chert, quartz and jaspedeous cherts. Passing eastwards from the neighbourhood of Oxford the Corallian, with a total thickness of about 100 feet,

UPPER AND MIDDLE OOLITES OF WEYMOUTH AND THE BOULONNAIS.

M. ODLING, M.A., B.Sc., F.G.S.



✦ For restrictions of specific names see Q.J.G.S. Vol. 69 Pages 423-424.

undergoes remarkable changes. In the region round Studley and Arngrove we find a local facies of Lower Corallian in the form of a "chert" largely composed of the spicules of a sponge (*Rhaxella*) which is also common in the Lower Calcareous Grits of Yorkshire. This facies has been named the *Rhaxella* Chert or Arngrove Stone by Dr. A. Morley Davies,* and appears to occur at the base of the Calcareous Grits in this region only.†

The Upper Corallian is for the most part represented by "Coral Rag," usually resting on sandy beds with a pebble bed below, but on tracing it to the east of Oxford, we find rapid changes. At Stowood, Headington and Shotover, and to the west of this line, typical coral reef material exists, but to the east it is not seen in any of the quarries. Near Woodperry, Stanton St. John and Wheatley, the rock consists of detrital calcareous material with few perfect fossils; at Lye Hill a few beds of clay appear, and east of this the calcareous facies rapidly gives place to an argillaceous facies, the Ampthill Clay.

The only exposure at present showing the junction of the Kimeridge Clay with the underlying Corallian occurs on Shotover; here, in contrast to the Weymouth district, there is a sharp break between the two, the clay resting on an eroded water-worn surface of the limestone, all the Supra-Corallian of Weymouth being absent.

The junction of the Kimeridge with the Portland is usually hidden by slips, but wherever the uppermost beds are exposed, the Kimeridge Clay becomes somewhat arenaceous, showing a transition into the Portland sands above. This is especially the case in the Culham brickyard, where the *mammilatus* beds of the Gault rest directly on the Kimeridge Clay; these uppermost beds of the Kimeridge Clay may, however, be of Hartwell Clay age.

In this district, the Portland series is largely arenaceous, but locally the upper beds are sufficiently cemented with calcareous material to form a "roach," the *Trigonia* "roach" bed of Portland, for instance, being readily recognizable at Wheatley.

Locally there occurs a well marked pebble bed of lydites and phosphatized bones separating the Upper Portland from the Lower

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* *Quart. Journ. Geol. Soc.*, Vol. LXIII., 1907, pp. 37, 38.

† The Lower Calcareous Grits of Filey Brig also contain an abundance of spicules of *Rhaxella*.

Portland.* Blake remarks that this does not occur at a constant horizon, but H. B. Woodward† considers that the evidence of Blake's lists of fossils does not uphold this conclusion, and considers that such a marked lithological break extending over a large area is most likely to occur at a constant horizon. The beds of this age have been described in some detail by Dr. A. Morley Davies, who also appears to agree with Woodward.‡

On tracing this series eastwards it is found that the Lower Portland becomes more argillaceous, finally passing into the Hartwell Clay in the neighbourhood of Aylesbury, while to the south-west it is represented by the Swindon Clay. This, the Hartwell and Swindon Clay, appears to include some of the upper beds of the Kimeridge Clay as well as the Lower Portland, and constitutes a facies of its own. A similar condition is found in the Boulonnais.

In the neighbourhood of Wheatley and Brill sandy and marly beds have been described by Fitton§ as being of Purbeck age, and this identification has been verified by Morley Davies. The Purbeck on Shotover, however, does not appear to have been rediscovered.||

In the neighbourhood of Upware, near Cambridge, the occurrence of Upper Corallian in the form of a true Coral Rag is remarkable, occurring as it does as an apparently isolated patch. Below comes the Ampthill Clay with Elsworth Rock at the base, resting on Oxford Clay.

In Lincolnshire we find the Kimeridge Clay well developed at Market Rasen, while the Portland and Purbeck may in part be represented by the Spilsby Sandstone, which is considered to be equivalent to the *Belemnites lateralis* Beds of Speeton.**

Of the Yorkshire or North Country district, the valuable memoir by Fox Strangways†† renders certain facts quite clear. First, the

* Dr. Salfeld places the Lydite pebble bed of Swindon in the middle of the Lower Portland, as recognized in England, zone of *P. eastlecottensis*. *Quart. Journ. Geolog. Soc.*, Vol. LXIX., p. 424.

† Geolog. Survey Memoir, *Jurassic Rocks of Britain*, Vol. V.

‡ *Proc. Geol. Assoc.*, Vol. XVI., p. 25.

§ *Observation on Strata between the Chalk and the Oxford Oolites.*

|| *Proc. Geol. Assoc.*, Vol. XVI., p. 38 *et seq.*

** Lamplugh, *Quart. Journ. Geol. Soc.*, Vol. XLV., pp. 575-615.

†† Geol. Survey Memoir, *Jurassic Rocks of Great Britain*, Vol. I.

Cornbrash passes into the Kellaways, and often its exact junction cannot be defined ; thus further showing the affinity of the Cornbrash to the Middle rather than to the Lower Oolites. Secondly, the Kellaways often becomes locally of great importance, sometimes entirely replacing the Oxford Clay. Of this fact more will be said later. Thirdly, we find a bed of Oolite, the Hambleton Oolite, capped by calcareous grits separating the Lower Calcareous Grits from the Upper Corallian. Fourthly, Supra-Corallian beds occur, represented by the Upper Calcareous Grits. Fifthly, no Portland or higher Jurassic beds are definitely recognizable, except possibly at Speeton.

Taking these beds *seriatim*, we begin with the Cornbrash, which, in Yorkshire, probably represents only the uppermost beds of the southern counties.* That it is homologous to the south country Cornbrash is fairly clear, but it was probably deposited in an area cut off from the main mass by some land barrier. Petrologically and palæontologically the two types differ considerably, and a geologist from the South of England might well be excused in not at first sight recognizing the Yorkshire beds as Cornbrash. The succeeding beds, the Kellaways into which the Cornbrash merges, are of very special interest. The lower beds—for instance, those exposed round South Cave—are evidently true Kellaways, characterized by the abundance of specimens of *Kepplerites calloviense*, but the greater part of the Kellaways to the North of the Vale of Pickering—*i.e.*, round Roulston Scar—appear to be of a different age. Not only does it represent an arenaceous facies of the Oxford Clay, but it may in part locally represent Lower Corallian, and even the base of the Upper Corallian, since among other fossils Fox-Strangways mentions *Perisphinctes plicatilis*, the zone-fossil of the Upper Corallian.

The diagram (p. 280) indicates the general relationship of these interesting beds.†

To this replacement of Oxford Clay by Kellaways Beds is due the success of an artesian borehole sunk at Oswaldkirk, near Gilling, on the suggestion of Prof. Kendall. Here the thickness of Oxford Clay

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* Buckman, S. S., *Proc. Yorks. Geol. Soc.*, Vol. XVII., p. 191.

† Reference should also be made to *Jurassic Rocks of Britain*, Part I., Plate 5.

<table>
<tr><th></th><th colspan="2">WILTSHIRE</th><th colspan="2">YORKSHIRE</th></tr>
<tr><td>Upper Corallian</td><td colspan="2">Perisphinctes plicatilis</td><td colspan="2">Perisphinctes plicatilis</td></tr>
<tr><td>Lower Corallian</td><td colspan="2">Aspidoceras perarmatum</td><td colspan="2">Aspidoceras perarmatum</td></tr>
<tr><td rowspan="3">Oxford Clay</td><td>Cardioceras cordatum.</td><td>Belemnites abbreviatus</td><td rowspan="3">Oxford Clay Facies</td><td rowspan="3">Pseudo-Kellaways Facies</td></tr>
<tr><td rowspan="2">Cosmoceras ornatum</td><td>Quenstedoceras lamberti</td></tr>
<tr><td>Cosmoceras jason</td></tr>
<tr><td>Kellaways Beds</td><td colspan="2">Kepplerites calloviense</td><td colspan="2">Kepplerites calloviense</td></tr>
<tr><td>Cornbrash</td><td colspan="2">Macrocephalites macrocephalus</td><td colspan="2">Macrocephalites macrocephalus</td></tr>
</table>

GENERAL CORRELATION OF THE NORTH AND SOUTH COUNTRY MIDDLE OOLITES.

between the Corallian and the Kellaways is greater than anywhere else recorded in Yorkshire. This, however, is partly due to the high dip towards the fault near to which the borehole lies.

We thus see that in Yorkshire we have two distinct types under one name. The Lower or true Kellaways is comparable with that of the South, and, together with the Cornbrash, is approximately equivalent to the Callovien of Continental geologists. The Upper, to which the term " Pseudo-Kellaways " may be given, is of more recent date and is only an arenaceous and ferruginous facies of Oxford Clay and sometimes of even higher beds.

The Corallian calls for little special notice, the inclusion of an additional bed of calcareous grit and oolite (the Middle Calcareous Grits and Hambleton Oolite) above the Lower Calcareous Grits, appears to be peculiar to Yorkshire, whilst the Corallian Oolite may be represented in the South by minor bands of marl and thin oolitic limestones.

Of the Kimeridge Clay little is known. Forming as it does the floor of the Vale of Pickering, which is bounded to the north and south by fault scarps, it is almost entirely concealed by beds of glacial origin.

In the neighbourhood of Speeton there occurs a remarkable series of argillaceous beds, the Speeton Clay, showing a complete transition from the Jurassic into the Gault. The interest specially centres in the zone of *Belemnites lateralis*, below which lies undoubted Kimeridge Clay and above which is undoubted Neocomian. This zone contains a mixed fauna, some of the forms being certainly Neocomian, while others are claimed as being of Portland and Purbeck age. By some, these latter are claimed to be derived, but Lamplugh and Pavlow* appear to consider them to belong strictly to the beds in which they are found. Whichever view is adopted, there appears to be no doubt that beds of Portlandian age were deposited either in this district or very near to it ; personally I should be inclined to consider them as an extreme form of passage beds.

In Scotland, the only comparatively complete sequence is to be found on the east coast, in Sutherlandshire. The most noteworthy points are the apparent absence of Upper Corallian and the admixture of Upper and Lower Kimeridge forms together with cycads, etc.

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* *Quart. Journ. Geol. Soc.*, Vol. XLV., pp. 590 & 609 *et seq.*

On crossing the Channel to Boulogne, a very complete series of rocks from the Cornbrash into the Wealden may be examined in the coastal sections. Here the facies is for the most part argillaceous, except in the Corallian facies which is purely local. The limestones appear to be always argillaceous. Sandstones occur intercalated with the argillaceous deposits, and are for the most part neither constant over any large area nor restricted to definite horizons, as is the case with the Calcareous Grits and Portland Sands of this country.

The most noticeable stratigraphical break in the series occurs about the centre of the Portlandien Inferieur with the *Trigonia pellati* Conglomerate, which is certainly below the uppermost beds of our English Kimeridge Clay.*

The lower beds of the Astartien, with possibly the upper part of the Argovien, may be roughly paralleled with the British Supra-Corallian, to which series they bear certain affinities. The conditions, however, under which they were deposited were apparently more Kimeridgean.

The limestones composed almost entirely of *Exogyra virgula* form the most noticeable feature in the whole series. It is significant that this fossil flashes into prominence (in the zones of *Ammonites orthoceras* and *A. calentanum*) and then suddenly dies out, as in this country. The *Pterocera oceani* fauna appears to be unrepresented in Britain.

The true Portland Series include a Hartwell Clay facies, and an Upper Portland facies somewhat resembling that in the Oxford District capped by similar Purbeck Beds.

The resemblance between the two districts is further accentuated by the capping of ferruginous sands of Wealden age of a similar type to the Shotover Iron Sands. The complete sequence will be found by reference to Plate XXIX.

Summary.

The whole of the Middle and Upper Oolites form one natural group normally without any sharp break between the various members.

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* *T. pellati* is often recorded from the Portland of this country; if this is identical with French species we have a further case of the same fossil occurring at different horizons in different areas.

Where such a break occurs, the higher beds rest either on a pebble bed or on an eroded surface of the underlying bed. The purely local faunas such as that of the Astartien, Pterocerien and Hartwell Clay are due entirely to local conditions, and are no more than the fossil equivalents of the local faunas that may be found to-day on the sea-floor.

When free-swimming animals, such as Ammonites, are taken as zonal indices instead of the more sedentary types such as oysters and echinoderms, it is seen that the general stratigraphical terms such as Coral Rag, Calcareous Grit, Kellaways Beds, etc., are of no more than local value, and that the occurrence of a similar lithological and palæontological group in two districts need not by any means mean contemporaneity in deposition, but is due to purely local conditions.

At the same time, correlation by Ammonites must not be carried to an extreme. The absence of a particular Ammonite need not necessarily mean the non-deposition or contemporaneous erosion of beds of this particular age, but merely that this form was not so rapidly distributed. The fact that absolute repetition of Ammonites does not appear to occur, whereas their more sedentary associates frequently are repeated at different horizons, is suggestive and tends to place more faith in their value for purposes of correlation.

When considering the Jurassic Series over large areas the fact of there being in reality only two great breaks in the Series—the Bathonian Transgression and the Callovien Transgression—is forced upon one, and the desirability of a regrouping of the series without reference to such terms as Portlandian, Kimeridgean, etc., names that can only be associated with local areas, becomes obvious.

Should this be adopted, we should then have the following general groups :—

Upper Jurassic	All below the Wealden down to and including the Cornbrash.
Middle Jurassic	All below the Cornbrash down to and including the zone of *Parkinsonia parkinsoni*.
Lower Jurassic	All below the zone of *Parkinsonia parkinsoni* down to and including the Rhætic.

Appendix I.

ON AN ARTESIAN WELL AT OSWALDKIRK.

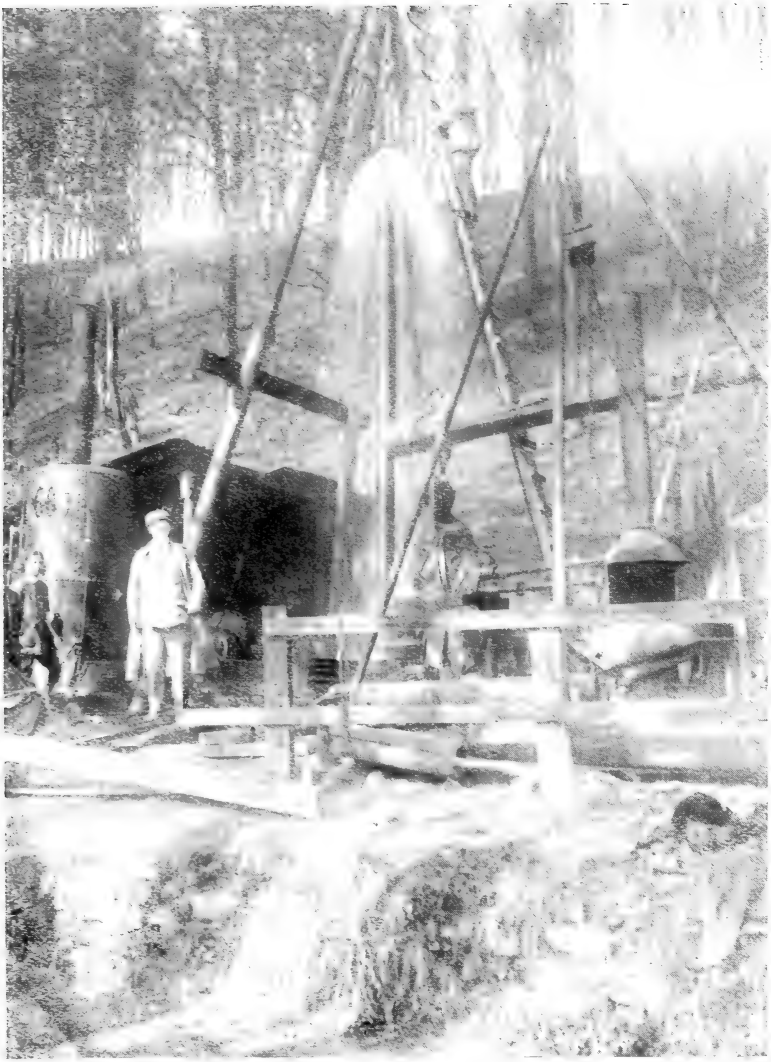
BY PERCY FRY KENDALL, M.SC., F.G.S.

A boring was put down under my direction near the village of Oswaldkirk, in 1912-13, in the expectation that the " Kellaways Rock " would be found beneath a cover of Oxford Clay and that, as its outcrop near Wass and Kilburn is at high level, water would be obtained under an artesian pressure.

The site chosen was on the north side of the high road from Ampleforth to Oswaldkirk, at the foot of a lofty escarpment of Corallian rocks, and within a few yards of the northern fault of the Coxwold-Gilling trough. The ground falls somewhat steeply from the site to the little Syke Beck, which gives good exposures of Kimmeridge Clay. At Oswaldkirk Hall there is a well 35 ft. deep which, by the description given in the Geol. Survey Memoirs, may be in Kimmeridge Clay ; another at the opposite end of the village is 50 ft. deep.

The section (Plate XXXI.), drawn roughly to scale, shows the succession of strata encountered. Down to a depth of 178 feet a good deal of water was met with at intervals, but all ran away into the numerous fissures—some a foot wide—that were found to exist in the rocks. The base of the Corallian was at 180 feet, and until the boring had reached 178 feet, water had to be provided for the lubrication of the boring tool. It is a very remarkable circumstance that all this water, as well as that yielded by the strata pierced, ran away at 178 feet, for the level of the ground, which is about 330 O.D.at the well-head, does not descend to an equivalent level (330—178=152 ft.) for a considerable distance.

When the Oxford Clay was pierced at 308 ft., water rose with considerable violence, and overflowed near the ground-level at the rate of about 200,000 gallons *per diem*. The pressure was estimated to be sufficient to raise the column of water 92 feet above the ground level. Several months elapsed before the requisite valves and other machinery could be fixed in position to bring the water under control, and some apprehension was felt that the hydrostatic pressure would " run its head off," but I pointed out that not only does the " Kellaways Rock " provide an enormous reservoir that it would take many years to de-

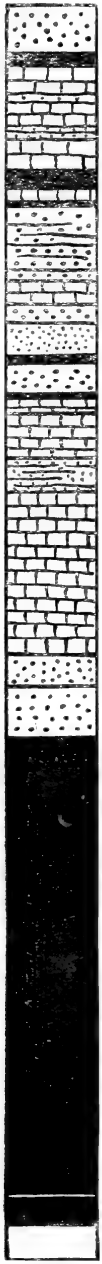


Photo] [Albert Gilligan.

Artesian Well at Oswaldkirk.

OSWALDKIRK BORING.

Professor Kendall's interpretation of samples.



1	Soil and Sandstone	
2	Clay	
3	Limestone and Sandstone ...	
4	Limestone	
5	Clay	
6	Limestone	
7	Yellow Clay	...51
8	Sandstone and bands of clay	
9	Sandstone	
10	Limestone	
11	Sandstone	
12	Calc. Sandstone	...80
13	Clay	
14	Sandstone	
15	Clay	
16	Limestone	
17	Ool. Limestone	
18	Clay and Sandstone ...	...120
19	Ool. Limestone	
20	Sandstone	.. 160
21	Water head	...180 178
22	Oxford Clay	
		...300
		308 (9-1-13)
		316

plete, apart from the renewal of the supply by the absorption of rainfall, but, at Roulston, a large area of "Kellaways" is in contact with the very porous Corallian, which would consequently act as a catchment for maintenance of the supply.

The Oxford Clay brought up from the borehole yielded to Mr. Odling's scrutiny fossils of Oxfordian type.

APPENDIX II.

NOTE ON THE STRATIGRAPHY OF ROULSTON SCAR.

BY M. ODLING, M.A., B.SC., F.G.S.

A short visit to Roulston Scar in December, 1917, yielded the following information :—

(1) Towards the northern end of the Scar the break between the Calcareous Grits and the underlying Kellaways is sharply defined; the Corallian consisting of a fine-grained non-ferruginous grit contrasting with the ochre-coloured Kellaways. Towards the southern end, however, this junction is not so readily seen, the lower beds of the Calcareous Grits being largely ferruginous.

(2) The top of the Kellaways appears to be everywhere marked by a bed consisting largely of rolled fragments of Belemnites together with smaller nodules; the nature of this deposit forcibly calling to mind the two beds of rolled fossils and phosphatic nodules in the Gault and pointing to pene-contemporaneous erosion.

(3) The general section below the Calcareous Grits is approximately as follows :—

Ferruginous sandstone, shrly in parts, crowded with water-worn fragments of Belemnites, apparently belonging to the following species: *B. abbreviatus* and *B. oweni*, 4 to 6 inches; ferruginous sandstone, unfossiliferous, about 1 foot; ferruginous sandstone, fossils abundant but very badly preserved, *Trigonia* allied to *T. clavellata*, *Pecten inaequicostatus* and *P. demissus*, *Hinnites* sp. together with a few fragments of belemnites and unrecognisable fossils, about 10 inches.

[From apparently the same bed at the southern end of the Scar two species of ammonites were obtained; these were sent to Mr. S. S. Buckman, who wrote—

"Roughly speaking your Amm. show a *Macrocephalites* indicating top of the Cornbrash (*macrocephalus* zone, base of the Callovian) and something of *Zuendstedoceras* style, indicating Callovian, I should expect not later than *ornatum* zone—which is called Kellaways rock in Yorkshire."]

Ferruginous sandstone with many *Gryphaeas,* including *G. bilobata* and forms resembling *G. dilatata*, about 1 foot.

The fossil evidence therefore is very unsatisfactory, although according to the Geological Survey, there is about 40 feet of Kellaways below this, in one bed of rock two ammonites are found less than three feet apart, on point ng to the top of the Cornbrash or base of the Kellswaya, the other to about the lower part of the middle Oxford Clay of the south of England; below this come *Gryphaeas* shewing affinities both to the Oxford Clay and also to the Kellaways, and at the top *Pectens* of species which occur in the Kellaways, below the Oxford Clay at Scarborough.

Of the ammonites mentioned by Fox-Strangways from the Kellaways marking higher beds in the Oxford Clay, and even in the Corallian, not traces could be found. Much careful collecting, therefore, remains to be done before the true relations of the series exhibited at Roulston Scar to the section provde at Oswaldkirk can be made out.

The topmost bed of the Kellaways contaniing rolled Belemnites may have been deposited contemporaneously with the clay of Oswaldkirk, Roulston Scar being at this period an area of non-deposition, or even of contemporaneous erosion, the only forms representing this period capable of withstanding the scouring without being entirely comminuted being the Belemnites. Against this, however, must be taken the fact that the Kellaways does not exhibit the characteristics of a shallow water deposit, false bedding, for instance, being apparently absent.

APPENDIX III.

THE PRINCIPAL WORKS DEALING WITH THE UPPER AND MIDDLE OOLITES.

BARROIS, C., Geological Sketch of the Boulonnais. *Proc. Geol. Assoc.*, Vol. VI., pp. 20-25.

BARROIS, C., Report of Geological Expedition to the Boulonnais. *Proc. Geol. Assoc.*, Vol. VI., pp. 39-42.

BAYZAND, C. J., *See* SOLLAS, W. J.

BLAKE, J. F., Kimmeridge Clay of England. *Quart. Journ. Geol. Soc.*, Vol. XXXI., pp. 196-232.

BLAKE, J. F., Portland Beds of England. *Quart. Journ. Geol. Soc.*, Vol. XXXVI., pp. 189-235.

BLAKE, J. F., and HUDLESTON, W. H., Corallian of England. *Quart. Journ. Geol. Soc.*, Vol. XXXIII., pp. 260-402.

BUCKMAN, S.S., Appendix to Dr. SALFELD's Paper. *Quart. Journ. Geol. Soc.*, Vol. LXIX., pp. 423-427.

BUCKMAN, S. S., "Kelloway Rock" of Scarborough. *Quart. Journ. Geol. Soc.*, Vol. LXIX., pp. 152-168.

DAMON, R., Geology of Weymouth.

DAVIES, A. M., Contributions to the Geology of the Thames Valley. *Proc. Geol. Assoc.*, Vol. XVI., pp. 15-56.

DAVIES, A. M., Kimmeridge Clay and Corallian Rocks of Brill. *Quart. Journ. Geol. Soc.*, Vol. LXIII., pp. 29-48.

FITTON, W. H., Observations on Strata between the Chalk and the Oxford Oolite. Reprint, with additions, of various papers in the *Quart. Journ. Geol. Soc.*

HUDLESTON, W. H., *See* BLAKE, J. F.

LAMPLUGH, Sub-division of the Speeton Clay. *Quart. Journ. Geol. Soc.*, Vol. XLV., pp. 575-616.

ODLING, M., Notes on the Corallian and Kimmeridge Clay of Weymouth compared with that of Oxford and Boulogne. *Report Ashmolean Natural History Society*, 1909, pp. 26-31.

PELLAT, EDM., Excursion à Samer. *Bull. Soc. Géol. de France*, Série 3, Tome 8, pp. 579-583.

PELLAT, EDM., Excurison au Mont Lambert et à Ecaux. *Bull. Soc. Géol. de France*, Série 3, Tome 8, pp. 634-638.

PELLAT, EDM., Terrain Jurassique Moyen et Superieur du Bas-Boulonnais. *Bull. Soc. Géol. de France*, Série 3, Tome 8, pp. 647-699.

PHILLIPS, J., Geology of Oxford and the Valley of the Thames.

ROBERTS, T., On the Upper Jurassic Clays of Lincolnshire. *Quart. Journ. Geol. Soc.*, Vol. XLV., pp. 545-560.

SALFELD, HANS., Certain Upper Jurassic Strata of England. *Quart. Journ. Geol. Soc.*, Vol. LXIX., pp. 423-427.

SOLLAS, W. J., and BAYZAND, C. J., Expedition to Shotover Hill. *Proc. Geol. Assoc.*, Vol XXVI., pp. 315-318.

STRANGWAYS, C. FOX., Jurassic Rocks of Britain (Vol. I.—Yorkshire). Memoir Geol. Survey.

WOODWARD, H. B., Jurassic Rocks of Britain (Vol. V.—Middle and Upper Oolites). Memoir Geol. Survey.

WOODWARD, H. B., Geology of Weymouth. Memoir Geol. Survey.

See also Geological Survey Memoirs descriptive of 1-in. maps on which rocks of this age occur.

Also Note Explicative de la Carte Géologique de France (No. 3—Boulogne).

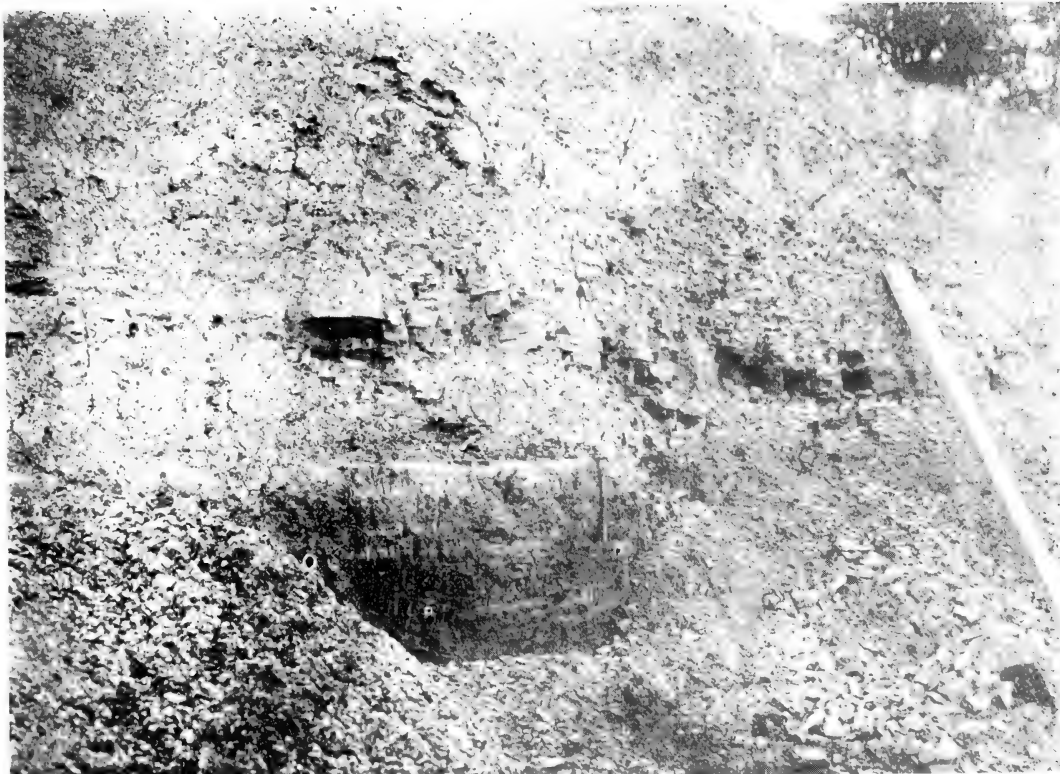


Photo by] [*M. Odling.*

The **Lower Permian**, showing the conglomeratic bed at the base and the thin bedded marls and limestones above. The base of the conglomerate, about 2 ft., is obscured.

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THE LOWER PERMIAN AT ASHFIELD BRICK AND TILE WORKS, CONISBOROUGH.

BY ALBERT GILLIGAN, M.Sc. (Leeds), B.Sc. (Wales), F.G.S.

(Read November 25th, 1915.)

This section has long been under observation by Yorkshire geologists, but no detailed record has hitherto been given of the Lower Permian beds as exposed here within the last few years. The chief interest has been centred upon the Upper Coal Measures upon which the Permian rests, beds which have yielded a rich harvest of fossil-plants. The top-most bed of the Coal Measures is a fine-grained micaceous sandstone deeply stained with hematite. The surface of this sandstone is undulating, and in the hollows are found deposits of Permian age, consisting of conglomeratic material. The largest pebbles in this conglomerate are in general not more than an inch in diameter, but during a visit to the section in September, 1915, some large boulders up to eighteen inches in diameter, were found, which had been taken out of the conglomerate by the workmen. These boulders consisted of sandstone, identical with the underlying Coal Measure sandstone, and a dense siliceous sandstone also possibly a Coal Measure type.

Intercalated with this conglomerate are beds of fine sand, which sand is in all respects, except colour, like the sand which occurs in similar stratigraphical positions along the edge of the Permian escarpment from North-east Durham to Yorkshire. As the section shows, this lowest bed is in its thickest part about 5 ft. 6 ins., but in a distance of 15 ft., it has thinned away to 15 ins. of fine sand with very few pebbles. Resting upon this bed and traceable right through the quarry is a bed of chocolate-coloured marl, the junction with the conglomerate being quite sharp. From this bed I obtained, some years ago, casts of *Schizodus* and these appear to be the only fossils present in the beds below the massive Magnesian limestone. The chocolate marl is succeeded by other thin bedded grey and brown marls, with some of which (as in beds E and H in section) are intercalated bands of buff-coloured limestones.

It will be noted from the chemical analyses given in the appendix that the intercalated limestones are highly dolomitised, while the insoluble residue in all the marls is very high, the kaolin reaching

38·58 per cent. in bed J, which is immediately below the massive Magnesian limestone.

These beds correspond, of course, in position with the Marl Slates of Durham, but have not yielded the fish fauna of those beds.

Petrology of the Conglomerate and Associated Sands.

Among the pebbles the following have been noted :—sandstone, quartz, clay ironstone, hematite, chert and pink felspar. The material is not at all well compacted, but layers occur sufficiently indurated to yield sections for the microscope, and several have been made and examined with the following results.

The grains of hard material are all exceedingly well rounded, while the softer materials are somewhat flattened. The dominant constituent is quartz, the grains of which are chiefly of the complex type. Some of them show an extreme degree of mylonitisation, while others have "crenulate" and "mortar structure" well developed. Many grains of sandstone are present which are evidently from the under-lying rock. Chert-grains are numerous, but show no traces of organisms. Limonite and hematite are also common.

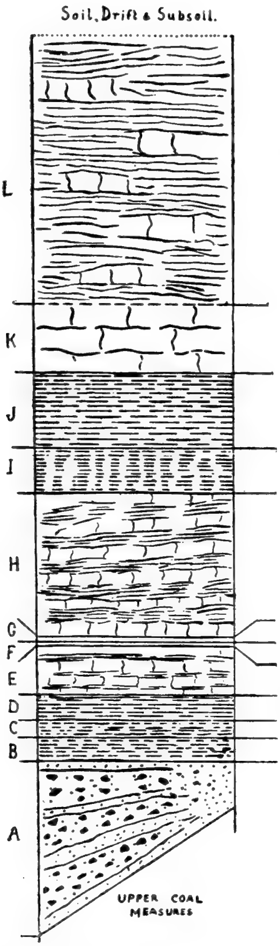
Felspar, other than microcline, is rather rare in the fresh condition, while muscovite is present in somewhat large flakes. A few pieces of micro-pegmatite have been noted, having in two cases lath-shaped felspars associated with and penetrating the grain. The matrix is chiefly calcite.

Heavy Minerals in the Sands.

These were separated by means of a Sollas bottle and Theulet's Solution :—

Cubic.—Garnet, Magnetite, Fluorspar.
Tetragonal.—Zircon, Rutile, Anatase, Xenotime.
Rhombohedral.—Ilmenite, Hematite, Limonite, Tourmaline, Apatite.
Orthorhombic.—Staurolite.
Monoclinic.—Biotite, Chlorite, Epidote, Monazite.
Triclinic.—None.

SECTION OF LOWER PERMIAN EXPOSED IN THE ASHFIELD BRICK WORKS, CONISBOROUGH, Sept. 29th, 1915.



8 ft. Well bedded marl with blocks of limestone. Probably a solution phenomenon.

2 ft. Massive cavernous Lower Magnesian Limestone and *Bakewellia antiqua*.

2 ft. 3 in. Red and grey marl.

1 ft. 4 in. Stiff marl (fairly well bedded).

4 ft. 3 ins. Thin bedded limestones with red and grey marls.

2 ins. Grey marl.

2 ins. Red marl (fine bedded).

1 ft. 5 ins. Buff limestones with thin bands of marl intercalated.

8½ ins. Brown marl.

7 ins. Dark grey marl.

8 in. Chocolate red marl. (Passing up, grey at junction with bed below.

5 ft. 6 in. Breccia with fairly persistent beds of sands about 2½ ins. thick; beds of fine sand at the top with only small pebbles; base obscured. the whole replaced by 15 ins. of sand with few pebbles to the west.

Proc. Yorks. Geol. Soc., Vol. XIX., Plate XXXIII.

To face page 290.

In decreasing order of abundance these minerals would appear thus :—hematite, limonite, ilmenite, garnet, magnetite, zircon, tourmaline, rutile, staurolite. Only a few grains have been noted of the following :—fluorspar, xenotime, apatite, epidote and chlorite, while only one undoubted grain of monazite has been seen.

The heavy residue also contains a number of rounded grains with aggregate polarisation tints of the high orders. They possibly represent some altered mineral, and consist now chiefly of micaceous material, but they are never found in association with any other mineral so that their origin is obscure.

It is interesting to note that Mr. R. C. Burton found that the dominant heavy minerals of the Yellow Sands at the base of the Permian of Durham were :—garnet, zircon, rutile and tourmaline, while the sands also contained felspar and mica.*

Garnet.—This is a very abundant mineral, the grains being usually rounded or irregular with no crystal outline. In colour they vary from a deep red, through pink to colourless. Frequently they contain inclusions. The dodecahedral cleavage is well developed upon the surface of some of the grains, giving a zigzag appearance.

Magnetite.—A large number of rounded grains of this mineral are present, the crystal form of the octahedra being rarely seen.

Fluorspar.—A few isotropic grains showing the octahedral cleavage characteristic of this mineral occur, and its low refraction compared with garnet is very noticeable.

Zircon.—Excluding the iron ores, the greater part of the heavy residue consists of garnet and zircon. A fairly high percentage show a sharp crystal outline consisting of prism and simple pyramid. Others are rounded at the termination, due possibly to having had originally a number of pyramid faces developed. Zonal structure is common, especially in the short and stout prismatic forms. Inclusions also are numerous, usually arranged parallel to crystal faces. As is usual in the case of zircons occurring in detrital deposits the birefringence is very high.

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* Note by Dr. Woolacott to his paper on *The Geology of N.E. Durham and S.E. Northumberland.—Proc. Geol. Assoc.* Vol. XXIV. pt. 2, p. 93.

Rutile.—Present in relatively small quantity, compared with garnet and zircon. Usually it occurs as prismatic needles, pyramidal faces being extremely rare, while rounded grains are common. The colour varies from deep yellow to brownish red. No case of twinning has been noted.

Anatase.—Separate grains do not occur, but it is often associated with ilmenite and leucoxene.

Xenotime.—The clouded and purple crystals similar in other respects to zircon have been referred to this mineral.

Ilmenite.—This is a common constituent. Very frequently it is enveloped in the white alteration product leucoxene with outgrowths of anatase. It is more abundant than magnetite.

Hematite.—Rounded grains of bright red colour by reflected light occur plentifully.

Limonite.—This mineral is equally as abundant as hematite.

Tourmaline.—The grains of this mineral are usually rounded, though a few stumpy crystals consisting of prisms terminated by simple rhombohedra occur. The colour is most frequently brown, having in one case a blue border. Only one grain of distinctly blue tourmaline has been seen. The pleochroism of the brown variety is usually intense. Inclusions are somewhat rare.

Apatite.—A few crystals of this mineral have been noted.

Staurolite.—This mineral is of frequent occurrence. Usually it is quite fresh. The characteristic form is that bounded by cleavage faces, and presenting a "toothed" appearance. The colour varies from amber yellow to brown and the pheochroism is distinct.

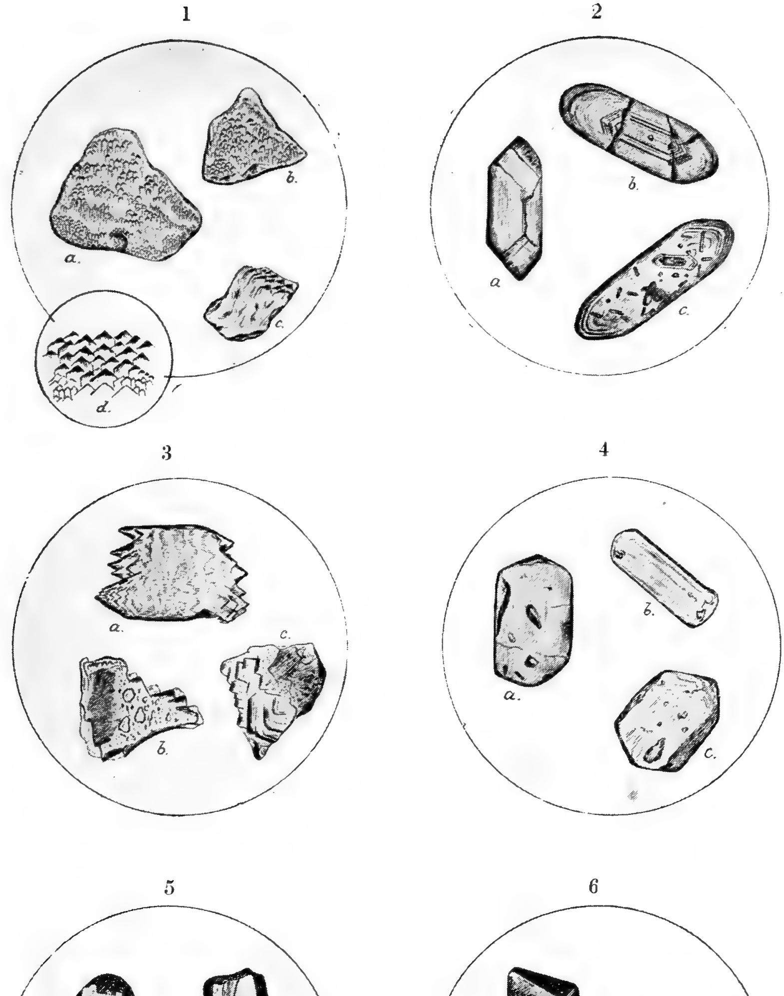
Biotite.—Both the brown and green (chromium) varieties occur, though the latter is not abundant.

Chlorite and *Epidote.*—These occur as rounded grains, very similar in colour, but the high birefringence of the latter and the low birefringence of the former enable them to be separately identified. Both are somewhat rare.

Monazite.—Of this mineral, only one undoubted grain has been

Description of Plate XXXIV.

1.	*a*	Garnet	× 90
	b	,, ...	× 95
	c	,, ...	× 100
	d	Enlargement of part of surface of *a*.	
2.	*a*	Zircon	× 140
	b	,, (showing zoning)	× 115
	c	,, (showing zoning and inclusions) ..	× 125
3.	*a*	Staurolite	× 75
	b	,, ...	× 130
	c	,, ...	× 85
4.	*a*	Tourmaline	× 135
	b	,, ...	× 65
	c	,, ...	× 90
5.	*a*	Rutile	× 110
	b	,, ...	× 75
	c	,, ...	× 80
6	*a*	Magnetite	× 140
	b	,, ...	× 75
	c	,, ...	× 140



Proc. Yorks. Geol. Soc. Vol. XIX., Plate XXXIV.

Between pages 292 *and* 293.

noted. It shows the rounded form and amber yellow colour with patches of alteration products. When tested spectroscopically it yields the characteristic spectrum.

Source of the Material.

The writer must refrain from making any wide generalisation upon this subject, at this time, postponing such until the larger work which he has carried out in collaboration with Mr. H. C. Vessey, M.Sc., on the Permian Sands and Conglomerates of the North of England is ready for publication. It will be sufficient here to point out that, with the exception of the staurolite, all the other pebbles and minerals herein described have been found to occur in the Carboniferous Rocks of the Pennine area. The staurolite is interesting as being fairly common, and as having the same "toothed" or "frayed" outline which has been figured and described by Dr. H. H. Thomas as occurring in the New Red Sandstone of the West of England,* and by Mr. T. O. Bosworth from the Carboniferous Sandstones of Scotland.*

I am much indebted to Mr. J. A. Butterfield, M.Sc., for the careful drawings of the heavy minerals which he has made to illustrate this part of the work.

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* *Petrography of the New Red Sandstone* (Dr. H. H. Thomas). *Quart. Journ. Geol. Soc.*, Vol. LXV., Pl. XII., fig. 4c.

* *Heavy Minerals in the Sandstones of the Scottish Carboniferous Rocks*. *Proc. Geol. Assoc.*, Vol. XXIV., Pt. 2.

Specimen	B	C	D	E	F	G	H[1]	H[2]	H[3]	I	J	K
Loss on Ignition . . .	1·89	4·13	2·99	1·22	3·39	3·71	1·09	2·21	3·01	2·81	6·03	1·62
Residue Insoluble in $HCl + SiO_2$	79·65	77·49	77·82	21·55	82·32	66·60	13·62	28·93	68·61	82·22	48·59	6·17
Al_2O_3, etc.	5·25	4·29	3·45	2·70	5·32	3·42	3·03	6·05	3·97	4·93	15·23	1·01
Fe_2O_3, etc.	4·17	2·85	6·33	2·92	6·49	5·10	4·68	3·95	9·02	7·96	4·82	1·91
$CaCO_3MgCO_3$ . . .	0·24	5·20	4·76	64·63	1·05	0·22	64·94	49·95	9·86	0·04	13·39	87·72
$CaCO_3$	8·65	5·06	4·42	6·02	1·40	20·79	12·30	8·57	4·86	1·37	11·71	1·37
Loss due to Sulphates, etc	0·15	0·92	0·23	0·86	0·23	0·16	0·34	0·24	0·67	0·67	0·23	0·30
Total . . .	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00
Percentage of $CaCO_3$.	98·76	76·70	81·26	58·13	80·41	99·52	61·51	60·85	69·43	98·29	75·61	55·09
,, $MgCO_3$.	1·24	23·30	18·74	41·87	19·59	0·48	38·49	39·15	30·57	1·71	24·39	44·91

CHEMICAL CONSTITUTION OF PERMIAN ROCKS OF CONISBOROUGH.

Specimen	B	C	D	E	F	G	H^1	H^2	H^3	I	J	K
Insoluble Residue & Loss on Ignition	73·49	75·03	75·53	18·63	77·64	65·07	10·06	21·87	65·54	77·57	31·27	6·15
Kaolin	13·30	10·88	8·73	6·84	13·39	8·66	7·08	15·32	10·05	12·39	38·58	2·67
Total . .	86·79	85·91	84·26	25·47	91·03	73·73	17·74	27·19	75·59	89·96	69·85	8·80
Percentage of Kaolin in total Insoluble Residue	15	13	10	27	15	12	56	41	13	14	55	30

TABLE TO SHOW RELATIONS OF THE INSOLUBLE RESIDUE TO THE ALUMINA WHEN THE LATTER IS CALCULATED AS KAOLIN.

Appendix.

Chemical Composition of the Beds.

BY M. ODLING, M.A., B.SC. (OXON.), F.G.S.

About 40 grams from each bed were crushed up and well mixed so that a fair sample might be obtained. In the case of the marls shewing banding of grey and red the specimen crushed was somewhat larger and contained both, so that an average sample could thus be obtained.

Since it had been found in the case of Permian marls recently examined from other districts that the insoluble residue left after dissolving in hydrochloric acid consisted largely of gypsum, it is remarkable to find that these marls are practically free from sulphates. In the cases of specimens yielding a high percentage of insoluble residue a portion was fused up and tested for sulphates, but in most cases the amount found was not considered sufficient to justify the expenditure of time necessary for a complete examination; in the cases in which this was done it has been neglected in the tables, as when estimated as $CaSO_4$ $2H_2O$ it never amounted to over 0·3 per cent. of the rock.

In the first table (p. 294) the "Loss on Ignition" would appear to be chiefly due to the water from hydrated silicates; the "Insoluble Residue" contains also all the silica, the Fe_2O_3," etc., would contain small traces of MnO_2 and other oxides of this group, whilst the Al_2O_3, etc., might contain traces of TiO_2. The calcium and magnesium have been calculated as carbonates and entered as dolomite and calcite as being the most probable state in which they occur.

In the last two columns is shewn the relative percentage of calcium to magnesium carbonate, which in a pure dolomite should be $CaCO_3$, 54·27 per cent.; $MgCO_3$, 45·73 per cent.

Assuming that all the alumina existed in the form of kaolin and deducting the necessary amount of silica and water to satisfy this alumina from the "Insoluble Residue" and "Loss on Ignition" respectively, we get the results shewn on table 2 (p. 295), which also shews the approximate percentage of kaolin to silica and undecomposed silicates.

I cannot conclude without expressing my obligation to the Laboratory Assistant, R. Simpson, for the conscientious way in which he has carried out my instructions. But for his help, time could not have been found for this investigation.

MARTIN SIMPSON AND HIS GEOLOGICAL MEMOIRS.

BY T. SHEPPARD, M.SC., F.G.S.

(Read December 12th, 1917.)

In part 1 of *Yorkshire Type Ammonites*, by Mr. S. S. Buckman, issued in 1909, occurs the following :—" The works of Martin Simpson are very little known outside his native county, and are almost unprocurable. His 'Monograph of Lias Ammonites' (London, 1843), is extremely rare ; and his 'Fossils of the Yorkshire Lias' (London, 1855) is very scarce. Yet these modest works are more important than those of the other authors so far as Ammonites are concerned : they contain careful and discriminative studies of many species, and their worth has not yet received due recognition. Without full illustration of Simpson's types it is almost impossible to obtain due knowledge of Lias Ammonites, and certainly dangerous to describe or name species as new."

As the present writer possesses copies of the books mentioned, as well as several others, and as Simpson's work certainly has not been recognised in the way it should, it seems desirable, while the opportunity occurs, to record what is known. He is urged to do so, as through the kind help of Mr. J. T. Sewell, J.P., and Mr. J. Woodhouse Parkinson, of the Whitby Museum, photographs of Simpson are available, as well as much useful information bearing upon his work in the Whitby area.

As will be seen from the pedigree kindly prepared by Mr. Sewell, Martin was the eldest son of John and Jane Simpson ; he was born in 1800* and died in 1892, and thus, like many another Yorkshire naturalist, far outlived his three score years and ten.

Simpson was born at Whitby, he served his apprenticeship to a cabinet maker there, and afterwards entered as a student at Edinburgh University. In 1836, he became second master at the Wakefield Grammar School, and frequently lectured on Geology in that neighbourhood.†

The Rev. Gideon Smales, in his book on " Whitby Authors and their Publications " (1867, p. 168) writes, " Mr. Martin Simpson, the Curator of our Whitby Museum, studied in the University of Edinburgh, and

* " C.D.S." in the *Geological Magazine,* 1893, (p. 144) says on November 20th, 1798, but this is apparently an error, as Mr. Parkinson has kindly examined the Parish Registers for me, and finds the date to be November 20th, 1800.

† *loc. cit.*

Your very obt.
humble Servt.
M. Simpson.

Whitby Museum
March 30th 1854

To face page 298.

for many years was well known as a public lecturer on science. He has been engaged at different times in the arrangement of public museums and in various other scientific pursuits, and whilst he cultivates, like every true philosopher, an acquaintance with, and comprehensive views of, the great fields of research, his position and connexion with the rich fossiliferous district of Whitby has specially brought out his efforts in the science of geology."

In *The Whitby Repository* (new series) for June 1, 1867 (pp. 465-474), is "A Lecture on the Passions: given at the Wakefield Literary and Philosophical Institution, 1830"; this is his first literary effort that the writer has been able to trace.

His first book, which in many respects was his most important, was his work on the Lias Ammonites, published in 1843 (12mo, 60 pp.), the title* of which the following is a copy.

A MONOGRAPH

OF THE

AMMONITES

OF THE

YORKSHIRE LIAS;

CONTAINING THE SPECIFIC CHARACTERS, AND POPULAR NOTICES, OF MORE THAN 100 SPECIES; WITH REFERENCES TO THE PARTICULAR BEDS AND LOCALITIES WHERE EACH IS TO BE FOUND; INCLUDING, ALSO, THE TWO SPECIES OF NAUTILUS.

DESCRIBED FROM NATURE,

BY M. SIMPSON,

Curator to the Geological and Polytechnic Society of the West Riding of Yorkshire, and late Keeper of the Whitby Museum, Lecturer on Geology, &c.

LONDON:

SIMPKIN, MARSHALL, AND CO., AND ALL BOOKSELLERS.

1843.

* The wording on the cover is identical, though the words "A Monograph" are decorated, and there is an ornamental border.

The preface to this work, dated "Whitby, Feb., 1843," is not without interest, and shows that in those early days attention was paid to the law of priority in nomenclature. Notwithstanding what Simpson says as regards illustrations, it is a great pity that the suggested plates were not prepared, as much subsequent confusion would have been avoided. He writes :—

"Nearly the whole of this work was written two or three years ago, while I was arranging the Whitby Museum, and had favourable opportunities for observation; and its appearance has been delayed wholly from the want of some convenient means of publication. To those, therefore, who have aided me by their subscriptions, I feel the more grateful. It would have given me pleasure to have obliged my friends by the addition of plates, but the general forms of the genus have already been well illustrated in that way by others; and the best figures can do but little in representing specific characters.

"Some of the names, perhaps, may appear objectionable. But where I did not observe a name inharmonious, or conveying a wrong character, I thought it better to let it pass, than to invent a new one. In all cases, to the best of my knowledge, as a matter of justice, I have adopted the names of previous authors, and I have also paid the same respect to the excellent manuscript names of my friend Mr. Bean. It may appear surprising that so many species of ammonites should occur in one group of strata, and in one small district, but so far from having over-rated the number, I believe that when these fossils shall be more generally studied, and fresh localities shall have been carefully examined, the number of species will be still further increased."

As specimens of his descriptions, below are given his accounts of two well-known species, *A. heterophyllus* and *A. elegans* :—

[page 7] I. Without a dorsal keel or furrow.

a. No spines.

1. A. HETEROPHYLLUS, *Sow. Syn. N. Whitbiensis, Y. and B.*

Rather depressed; inner volutions concealed, outer whorl $\frac{6}{10}$ the diameter; umbilicus small; striæ numerous, annular, diverging; aperture ovate: diameter 1 to 16 inches.

This ammonite may be readily distinguished from all the others of this group, except the next, by the inner whorls being entirely concealed.

It is found in every bed of the upper Lias, but those specimens which are obtained from the upper part of this division, are the largest. The striated shell is thin, and when removed, the varied angular, and rounded forms of the septa are displayed ; which gives to the cast a beautiful foliated appearance. On the outer whorl of some large specimens, may be observed straight, obtuse, radii, which become obsolete before reaching the back ; but in the smaller specimens these are scarcely discernible.

[page 31] II. With a keel on the back.

a. Outer whorl broad.

54. A. ELEGANS, *Sow.*

Much depressed ; volutions 4 or 5, inner ones $\frac{6}{10}$ concealed, outer whorl rather more than $\frac{1}{3}$ the diameter, inner edge sloping or concave ; radii twice bent, faint ; keel sharp, prominent, entire ; aperture triangular · diameter 3 inches.

This elegant shell is rather abundant in the jet rock and hard shale of the upper lias ; the shell is thin, and both it and the cast are smooth and shining. About $\frac{1}{3}$ of an inch from the inner edge of the whorl, is a concentric line, in some specimens distinct, in others obsolete. The inner edge of the whorls of this group being deeply indented by the succeeding whorls, the apertures have more or less the shape of arrow heads."

After his descriptions of 108 species, he gives a short note on "Malformations." The index is arranged under the heads of :—

NAUTILUS.			
AMMONITES.	I.—Without a dorsal keel or furrow.	*a.*	*No spines.*
		b.	*Armed.*
,,	II.—Carinated.	*a.*	*Outer whorl broad.*
		b.	*Outer whorl narrower.*
,,	III.—Keel between two furrows.	*a.*	*Furrows slight.*
		b.	*Furrows distinct.*
,,	IV.—With a dorsal furrow only.		

There is a list of forty-two subscribers, among them being W. Bean, J. Buckman, the Rev. W. Buckland, J. Leckenby, John Morris, John Phillips, the Rev. A. Sedgwick, H. E. Strickland and the Rev. G. Young.

In 1855 appeared Simpson's book entitled :—

" The Fossils / of the / Yorkshire Lias ; / Described from Nature / with a short outline of the / Geology of the Yorkshire Coast / illustrated with sections ; / and intended as / A Guide to Strangers /

By M. Simpson / lecturer on natural science, and curator of Museums.

"London : / Whittaker & Co., Ava Maria Lane. / Whitby : Silvester Reed. / 1885."

It contains as frontispiece a "General [vertical] section of the East Yorkshire Strata," from the Drift to the Red Marl ; and "Sections of Strata on the Yorkshire Coast," from Filey to Whitby, both of which are used again in the author's "Guide to the Geology of the Yorkshire Coast." It is in two sections. The first twelve pages describe "The Geology of the Yorkshire Coast" ; the remainder is devoted to the "Fossils of the Yorkshire Lias."*

The Preface, dated "Whitby, March, 1855," reads :—

"Being engaged, a number of years ago, in arranging the Whitby Museum, and finding the fossils of the Yorkshire Lias but very imperfectly described, I made it a practice to note down in a book the characters of every species that came under my notice ; and this I have continued to do, as opportunity afforded, until the present time. As this greatly facilitated my labours in the Museum, I also found it to be a most improving exercise in promoting habits of minute and accurate observation. Twelve years ago, I published descriptions of more than one hundred species of Ammonites ; and these being favourably received by many intelligent and learned persons, I now venture to publish such descriptions of our Lias Fossils in general as, I trust, will facilitate the studies and pursuits of those who feel interested in the subject. In order to render the work more useful to those intelligent strangers who frequently visit this part of Yorkshire, I have given a short description of the Strata exhibited on the cliffs from Bridlington to the Tees."

In this work the following curious reference is made (p. 3) to Filey Brig :—"Before geological investigations were much attended to in these parts, it was supposed that this celebrated reef was formed by some Typhœus, or by some other supernatural being of a worse name, with the intention of continuing it to Denmark and Norway, so that the witches, who, braving the perils of the deep, had been accustomed to come over to this country in egg shells, might arrive by dry land ; but fortunately this evil-disposed personage lost his hammer before his wishes were realized, so his labours ceased."

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* In the Catalogue of Books, etc., in the British Museum (Natural History), Vol. IV. (p. 1929), it is recorded that "The author's original drawings of some of the Belemnites described in this work are in the Library of the Geological Department."

This first edition contains an illustration (p. 16) of "Plesiosaurus," which does not occur in the later editions, and the second edition of "The Fossils of the Yorkshire Lias," 1880, contains (p. 25) a restoration of a belemnite which does not occur in the first edition.

A second edition of this work, evidently considerably enlarged, as it contains xxiv.+256 pages, appeared in 1884. The following is a copy of the title :—

"The Fossils / of the / Yorkshire Lias ; / Described from Nature / with a carefully measured section of the / strata, and the fossils peculiar to each. / By / Martin Simpson / Lecturer on Natural Science, and Curator of / the Whitby Museum ; Author of a Guide / to the Geology of Yorkshire. / Second Edition.

"Whitby : / Printed by Forth & Sons, Flowergate, / Sold at the Museum. / London : / John Wheldon, Natural History Bookseller, / 58, Great Queen Street, Lincoln's Inn Fields. / 1884."

This work was "Price 5s. to Subscribers only," judging from an advertisement on the cover of the second edition of his "Guide to Whitby and the Vicinity," 1887.

In his Preface to this second edition, Simpson states "The Fossils of the Yorkshire Lias, and especially the Ammonites, had been objects of superstition and poetick fiction from mediæval times, but respecting their true nature no one ventured to express an opinion."

He states that the "honour of first introducing the study of the rocks and organick remains of eastern Yorkshire into Whitby and the region round about, is due to the Rev. George Young, M.A., of Edinburgh. In 1818, he published his History of Whitby . . . . . in which he gave a very luminous and correct exposition of the rocks and organick remains of the district." Simpson then gives the following paragraph, which it is interesting to read in these times :—

'The Publication of this work immediately produced a general revolution in publick opinion respecting the fossil remains of the district, and excited great zeal for further discovery. There was, indeed, at this time, in Whitby, a strong desire after intellectual pursuits, not only amongst the learned, but amongst many whose circumstances in life were unfavourable to such pursuits. The cessation of a long and exhausting war, the energies aroused by that war, and the want of employment before the return of commercial prosperity, all had a tendency to intellectual pursuits, and, no doubt, contributed greatly to the establishment of Philosophical Institutions and Museums, which the great wealth and the national prosperity of the present era scarcely sustain."

Reference is made to Young & Bird's "Geological Survey of the Yorkshire Coast" (1822), to the work of Bean and Williamson, John Phillips's "Illustrations of the Geology of Yorkshire" (1st edition, 1829), and the formation of the museums at Scarborough and Whitby. He states that he was lecturer to the Whitby Society, and curator of its Museum in 1837, that he published his "Ammonites of the Yorkshire Lias" in 1843, and, in 1855, his descriptions of "all the then known fossils of the Yorkshire Lias, together with an outline of the Geology of the Yorkshire Coast."*

As a fine piece of early zonal collecting, we may quote the following†:

"Being convinced by observation that few species of the Lias fossils had existed during the deposition of any great thickness of strata, but, on the contrary, were often confined to thin seams, I measured carefully, with a two feet rule, all the beds and seams of Lias, both to the south and north of Whitby, and at the same time collected the fossils from each stratum. This section I published in 1868, in the fourth edition of my 'Guide to the Geology of the Yorkshire Coast.' This section I now reprint (pp. ix.—xxiii.), with slight alterations, and to which the fossils in the catalogue are referred."

He then refers to Tate & Blake's work on "The Yorkshire Lias." "As they [Tate & Blake] expressed their intention to recognise and do justice to my previous researches and publications, I willingly laid open to them what I had been accumulating towards the further illustrations of our Lias. Their work was published in 1876; . . . and the scrupulous fidelity and honour with which they have treated my labours gives me the highest gratification."‡

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* Apparently this is considered to be the first edition of his "Guide to the Geology of the Yorkshire Coast," the second edition of which was issued in 1856.

† p. vi.

‡ The references to Simpson's work, by Tate and Blake, are (in the Preface), "We think we ought especially to acknowledge the kindness of Mr. Simpson, the Curator of Whitby Museum, who has permitted us to examine his types, though we have often thereby come to a different opinion as to their interpretation"; and (on p. 9), "1865-8, Mr. Simpson published, in a small handbook called 'A Guide to the Geology of the Yorkshire Coast,' 'A Section of the Yorkshire Lias,' as seen between Whitby and The Peak. Its chief value is its localizing the various fossils before-named by the author. It consists of a

Simpson also gratefully acknowledges the honour done to him by the Council of the London Geological Society in awarding him a portion of the Murchison Donation Fund [*i.e.* in 1884].

After the Preface follows the account of " A section of the Yorkshire Lias." The Fossils are then described in the following order :—

Teleosaurus ..	2	species	Trigonia	3	species
Plesiosaurus ..	9	,,	†Mytilus	23	,,
Ichthyosaurus	6	,,	Isocardia ..	8	,,
Placoideis ..	5	,,	Cardinia	12	,,
Lepidoides ..	8	,,	Cardium	9	,,
Sauroides ..	11	,,	Tellina	14	,,
Sepia	5	,,	Venus	5	,,
Belemnites ..	84*	,,	Corbula	4	,,
Nautilus ..	6	,,	Myacites ..	32	,,
Ammonites ..	200	,,	Mya	7	,,
Trochus ..	26	,,	Pholadomya ..	17	,,
Turbo	45	,,	Lingula	2	,,
Nerita	5	,,	Terebratula ..	16	,,
Tornatella ..	6	,,	Spirifer	7	,,
Buccinum ..	1	,,	Orbicula	2	,,
Cerithium ..	9	,,	Serpula	8	,,
Ostrea	17	,,	Dentalium ..	6	,,
Pecten ..	25	,,	Astacus	4	,,

description of every bed of the Lias, with their respective thicknesses, and the included fossils. In some parts it fairly represents the truth, but in others it is not possible to follow it at all on the spot, and, as portions of the series appear to be omitted, gives no true idea of the total thickness."[3] Also (on p. 270), " In 1843, Simpson published 'A Monograph of the Ammonites of the Yorkshire Lias,' without any figures—in this he enumerated 108 species, of which 50 were supposed to be new. Many of his names, however, both original and adopted, were afterwards superseded in 1855 by his 'Fossils of the Yorkshire Lias,' in which 191 names were applied, which included all those that had before been used. Three of these are applied to non-liassic shells by mistake, but I cannot agree with the author in considering all the remainder as sufficiently distinct from each other to deserve a specific name, while some are in my [*i.e.* J. F. Blake's] opinion the young of others, and some are described from insufficient material. After all such deductions we find the total number raised to 89, of which 64 go under other names than Simpson's, and 5 are adopted on his authority alone as I have not seen them."[3] Blake names some of the Liassic fossils after Simpson. In Tate and Blake's list of important works on the Lias (pp. 5-11), no reference whatever is made to Simpson's book on the Ammonites.

* Also 3 species from beds between the Lias and the Oolite : Bleawyke, Peak.

† Misprinted *Mylilus,* on p. 193.

Lima ..	.. 15	species	Asterias ..	.. 8	species
Anomia	.. 4	,,	Pentacrinus	.. 4	,,
Spondylus	.. 4	,,	Echinus ..	.. 3	,,
Perna ..	.. 10	,,	Corals ..	.. 5	,,
Avicula	.. 13	,,		—	
Pinna	.. 3	,,	Total	.. 745	,,
Arca ..	.. 27	,,		—	

Simpson also points out that Mr. Blake has described seventeen species of Entomostraca ; a wing-case of a beetle, and two neuropterous wings ; and there are brief notes on " Vegetables " [2 sp. named], " Minerals " and " Jet." There is a good index in which all the species are enumerated.

It does not follow, of course, that all the species described by Simpson hold good to-day ; Mr. S. S. Buckman, in his " Yorkshire Type Ammonites " has changed many, and specialists in other directions would not accept all the names enumerated ; but the fact remains that Simpson's list is a remarkable piece of work, the more welcome to the average field geologist because of the descriptions of the species given. Simpson stated : " On whatever subject I write, I have constantly before me persons of ordinary education, and for their benefit I sink, as much as possible, anything which might appear technical or learned."

The next work of Simpson's is his " Guide to the Geology of the Yorkshire Coast," and of this what is described as the " second edition " (1856) is really the first, as what he apparently considers his first edition was a portion of his first edition of " The Fossils of the Yorkshire Lias," already described. The following appears on the title-page of the first independent issue of his Guide :—

" A Guide / to the / Geology / of / The Yorkshire Coast ; / illustrated with sections / By Martin Simpson, / Lecturer on Natural Science, and Curator / of Museums. / Second Edition.

" Whitby : / Silvester Reed, Old Market Place, / 1856."

It contains 28 pages,* the title and cover (of green paper) are

* On the last page is the announcement :—" Recently published by the same author / ' The Fossils of the Yorkshire Lias ' ; / Described from Nature / with a short outline of the Geology of / The Yorkshire Coast. / Illustrated with sections / Price 2s. 6d."

identical. Before the title are "General Section of the East Yorkshire Strata" (with thicknesses) and [six] "Sections of Strata on the Yorkshire Coast," between Filey and Whitby.

In 1859 was issued the "Third edition,"—in reality the Second—with similar title to the preceding, in a red cover, with slightly wider pages, and with "Price Sixpence" added. It is enlarged to 32 pages there are additional notes on Drift, Ironstone and Alum ; and the price of "The Fossils of the Yorkshire Lias : recently published," is now given as 1s. 6d. There are two plates of sections as in the preceding.

In 1868 was published the "Fourth edition"—in reality the Third (64 pp.), in stiff buff covers ; the wording of the title is similar to that of the previous editions, except for the words "Fourth Edition" and the date "1868," but on the cover the Imprint is given as "London / Whittaker & Co., / Ave Maria Lane / Whitby : Silvester Reed /1868 / Price 1s. 6d.

Two plates of sections are now added, making four in all.

A further "fourth edition" (64 pp.) was also issued, the title and contents of which are similar to the preceding, but the cover is different, as the words "Lecturer on Natural Science and Curator of Museums" occupy one line instead of two, and the imprint now reads :—

"London : Whittaker & Co., Ave Maria Lane. Whitby : S. Reed, 2 John's Street, West Cliff."

and occupies four lines instead of three : there is no date and no price marked, and the back cover contains an advertisement of S. Reed's Public Library, whereas the previous one is blank. Possibly part of the impression was kept in sheets, and the cover added as the earlier impressions were sold.

There was evidently a difference in the dates of the publication of these two "fourth" editions, as the first contains an oval label in black, on the inside cover, which reads :—"Wm. Dalton, Successor to J. Shuttleburgh Fossil and Shell Dealer, 38, Cliff Street, Whitby. Ammonite and Pentacrinite Brooches, Pins and Studs. Fossils, Shells, and Corals in great variety, Shells" ; whereas the second named issue contains an oblong red stamp, from which it appears that Dalton is now at "The Old Curiosity Shop" at 14 & 15 Cliff Street, and in addition to his brooches, etc., he now deals in "Jet, Sea-weeds, Antique China, Japanese goods, &c." The four plates are also given in different order in the later edition. Thus, this second "fourth" edition really is the fourth.

Both these "fourth" editions contain the usual advertisement on the last page, in reference to "The Fossils of the Yorkshire Lias," etc., but we are now informed that "A new edition is in preparation." This, as already shown, appeared in 1884.

In Part II. of G. Markham Tweddell's "History of Cleveland"* (1855) is "The Fossils of the Yorkshire Lias," which is a short description of the Lias, and concludes with "A Systematic Catalogue of the Fossils of Our Lias" (pp. 50-54), by M. Simpson. It follows an article by John Phillips. It is a reprint of this (4 pp., Whitby, no date, *see* Bibliography) that is in the collection at the British Museum (Natural History). There is one in the Whitby Museum, and I have another. The list is in three columns, and was printed by "Silvester Reed, Printer, Old Market Place, Whitby." It bears the following :—"*Just published*, price 2/6. A Descriptive Catalogue of the above Fossils, with a short outline of the Geology of the Yorkshire Coast ;" this work being issued in 1855.

The next separate publication by Simpson appears to be his—

"Geology of the Whitby District / Report / of / A Lecture / delivered before the / Whitby Literary and Philosophical / Society. / By Mr. Martin Simpson. / Re printed from the "Yorkshire Gazette," / with additions, etc.

"Whitby : / Printed by S. Reed, Old Market Place, and West Cliff."

This was a 12mo pamphlet of 12 pages, in small type. It is given in "The Bibliography of Yorkshire Geology"† as [n.d. ?1840]. I had

* This was issued in parts, four only of which were published. On p. 50 of Simpson's paper, the publisher adds, "For full notice of Mr. Martin Simpson's literary and scientific labours, see the chapters on Whitby in the present History, and the Second Series of 'Bards and Authors of Cleveland and South Durham," but apparently neither publication appeared.

† *Proc. Yorks. Geol. Soc.*, Vol. XVIII., 1915, p. 59.

not then seen a copy, and the information was given on the strength of one seen by the late C. Fox-Strangways, possibly in the British Museum. My copy, which was recently given to me by Mr. J. W. Stather, shows that it must have been published after the summer of 1860, as it contains a statement (p. 10) that during the summer of that year Mr. Simpson had spent much time between Whitby and Peak, in examining the fossils of each particular stratum. From the reports of the Whitby Literary and Philosophical Society, it is clear that the lecture was delivered there in 1861, which is probably the date of the pamphlet.†

In 1862 was published "A Guide to Whitby and the Neighbourhood, by Martin Simpson, author of "A Guide to the Geology of the Yorkshire Coast," etc. 18mo, pp. 24, Whitby: Corall & Lockey, *Times* Office, Baxtergate, 1862, 6d." I have not seen a copy of this work, but the information is given on page 168 of Smales's "Whitby Authors and their Publications," 1867. A second edition of the Guide appeared in 1887.

In 1867 Simpson contributed "A Synopsis of the Contents of the Whitby Museum" to the *Whitby Repository*, New Series, which occupied eight pages. This was reprinted as an 8 pp. pamphlet for distribution to visitors to the Museum, and, in June 1881, it was reprinted with additions, the second impression having a plan of the cases, etc., on the first page. This method of issuing a brief summary of the contents of the Museum has been followed since Simpson's death, two or three different editions having been printed.

His next publication is a remarkable book, which was issued after he was eighty years of age, though the subject had occupied his attention for a very long time. Simpson always considered that this work would be better known than any of his geological publications. The title page reads :—

"A / History of England / from / The Revolution of 1688 ; /

† There is a copy in the Whitby Museum which apparently is the original. It slightly differs from the above in the paging, though there are 12 pages. The Whitby Museum copy is "Reprinted from the *Yorkshire Gazette* of February 28th, 1861," and states that the lecture was delivered on "Monday, February 4th, 1861." This is clearly the first edition, the pamphlet just described being the second.

being / A Continuation of Hume's History of England, / By / Martin Simpson, / Lecturer in Natural Science; Author of 'A Guide to the Geology / of the Yorkshire Coast;' 'Lias Fossils;' 'Guide to / Whitby;' etc., etc. / and Curator of the Whitby Museum. / Vol. I. / The History of the Reign of / William the Third; / Being a History of England from the Glorious Revolution of / 1688 to the death of William in 1702; comprising the / interregnum, the reign of William and Mary, and / of William III., with remarks on the principal / events and public characters of that / memorable period.

"Tweddell & Sons, / Stokesley. / 1881."

It is bound in yellow cloth, on the back of which is "History of England, William III., Simpson," in gold. The book is octavo, and contains viii.+260 pages, and was printed by Forth & Son, Printers, Flowergate, Whitby. No subsequent volume appears to have been published, though an advertisement on the back of the second edition of his "Guide to Whitby and the Vicinity: (1887)" says it is "To be continued to the end of the great French War."*

In 1887 was published the second edition of Simpson's "Guide to Whitby," on the green cover of which is the following colloquy:—

"STRANGER: Sir, we have just arrived by steamer, and have only a short time to remain; can you tell us where we can have the best view of the town?

"GUIDE: If you direct your course towards the old Parish Church, perched on the edge of the East Cliff, and ascend 199 stone steps, you will have the Town and Harbour spread before you. By going a few yards further you can see much of the ruins of the Abbey."

There are 47 pages (12mo), and no title page. Besides dealing with the Abbey, St. Mary's Church, the Town and Harbour and the sur-

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* An advertising slip, sent to me by Mr. T. W. Parkinson, gives the price of this book as 5s. There is also the following announcement:— "Will be published, price 6s. 6d. / The History of the Reign of Queen Anne, / By the same Author, / As soon as a sufficient number of copies are subscribed for to clear / the Expenses of Publication. / Subscribers' names will be gladly received by THE AUTHOR at the Museum, Whitby, or by TWEDDELL & SON, Publishers, Stokesley, from whom alone copies can be obtained."

rounding villages, there are notes on alum, and a chapter devoted to natural history. This last is under the heads of vertebrata, mollusca, articulated animals, the radiated animals, botany and minerals. There is also an account of the antiquities. On the back of the cover are advertised, " By the same author :" the " Guide to the Geology of the Yorkshire Coast " (1/6), " The Fossils of the Yorkshire Lias " (5/-), and " A History of England—William III.—To be continued to the end of the great French War." This promise of completion was made when Simpson was eighty-seven years of age.

The Reports of the Whitby Literary and Philosophical Society —a complete set of which I possess by the kindness of the late Thomas Newbitt—contain some useful information relating to Simpson. The first reference appears in the Thirteenth Report, published in 1835, where it states (p. 8), " A short course of Lectures on Astronomy and Optics was delivered last month [September] in the Library Rooms, to a respectable audience, by Mr. Martin Simpson (a native of Whitby)."

In the Fourteenth Report (1836), the name, " Mr. Martin Simpson, Wakefield," appears in the list of honorary members. In 1837 (p. 7), we read, " The Council, in order to expedite the improved classification of the Fossils, and other contents of the Museum, and to promote the general interests of the Society, have engaged Mr. Simpson, as Keeper of the Museum and Lecturer to the Institution," and his name continues to appear as the Curator, sometimes with a colleague, till the 70th Report in 1892, so that it appears that he acted for 55 years as a curator.

In the Sixteenth Report we find that " new shelves are fitted, upon which are arranged fossils of the Yorkshire Coast in their stratigraphical order " ; some duplicates were sold to Prof. Sedgwick for the Cambridge Museum, for £13. The minerals were also re-arranged and labelled. The " list of additions " to the Museum contains particulars of several specimens by the Curator, such records appearing fairly regularly during the next half century.

In the following year it seemed necessary to dispense with the Curator's services, on account of lack of funds, but a footnote adds " Since the above was written Mr. Simpson has been engaged another year." The balance sheet for 1839 contained the item " to Mr.

Simpson's salary, £20." By 1841, he relinquished his duties on account of the state of the Society's finances. In 1842, he gave about 1,800 fossils, "greatly above the value of Ten Guineas," which entitled Simpson to rank as a Life Governor of the Society. In 1842, he was appointed as curator of the Museum of the West Riding Geological and Polytechnic Society. Letters printed by Mr. J. W. Davis in his History of the Society (*Proceedings* Vol. X., pp. 161-168) show that Simpson entered with energy into the task of arranging the collections in the Society's possession, but the engagement only lasted a year, as the Council decided no longer to maintain a museum at Wakefield. An arrangement was entered into with the Leeds Philosophical and Literary Society that rooms should be set aside in the Philosophical Society's hall for the reception of the fossils, and that they should be kept there as a separate collection, reclaimable at pleasure on notice by the Geological Society. During his curatorship at Wakefield, however, Simpson arranged with the Whitby Society an exchange of specimens, by which the Yorkshire Society's collections received some 200 Jurassic fossils, and the Whitby Society apparently gained Carboniferous plants and fishes. Evidently Simpson returned from Wakefield to Whitby in the summer of 1843. In 1847, according to the Whitby report, he was thanked "for his assiduous and valuable labours in arranging and marking our [*i.e.* Whitby] collection of recent shells . . . . . Mr. Simpson is proceeding to bestow the same patient and persevering attention on the arrangement of our other specimens," so that apparently he was practically the Curator, though unpaid. In 1848, the Society hoped to publish a "Synopsis of its Museum." Subsequent reports still record thanks to Simpson, who, besides possessing the "talents, time and taste for the task, has also the disposition to exert them in the cause of science." By 1856, the council "regretted the state of the Society's funds did not admit of an adequate renumeration being awarded him," but a payment of £10 to him is shown in the balance sheet, and a similar payment appears fairly regularly each year until his death.

For several years he compiled the Meteorological Records, which were published in the Report. He was a frequent lecturer to the Society, on a variety of subjects, among which may be mentioned "Taste," "Natural History," "Geology," "Ammonites and Belemnites," "The Geology of the Neighbourhood" (published in 1861, already referred to), "The Sun," "The Early British Constitution," "Dr. Young's Education," etc.

The last official reference to him in the Society's Reports appears in 1893, when his death is briefly recorded as occurring in the previous December [31st], at the age of 93. It states he "has been so greatly identified with the Museum, that for many years it seemed almost to engross his whole care, with results gratifying to his own philosophical tastes, and not less to the advantage of the Members of the Society, and to the community in which he was so long a familiar figure."

From "A Brief account of the Foundation and Earlier Years" of the Society, published by the Rev. J. B. Brodrick, in 1894, we learn that "under Mr. Simpson's direction, the fossils were arranged in stratigraphical order, and a section of the strata of the coast was painted on the frieze above the cases, the arrangement being, as the Council I think justly say, a monument of the skill and taste, the patience and perseverance of Mr. Simpson."

Mr. J. T. Sewell tells me he remembers Simpson well ; he was a short man with a very big umbrella that was always carried when rain might be expected. It was Simpson's intention to have left all his effects and property to the Whitby Museum, but the intention was not given due legal effect, and he died intestate—to the loss of the Museum.

Dr. W. J. Veitch recently sent me two letters written by Simpson, which are well worth quoting, especially as one gives particulars of the prices paid for old-time Yorkshire Geological collections :—

WHITBY MUSEUM,
September 15*th*, 1884.

DEAR SIR,

Thanks for your friendly communication. You have got a difficult business in hand, and I fear we cannot help you. All our duplicate fossils went to the Continent many years ago, in exchange for minerals and fossils. In preparing a second edition of my catalogue of the Yorkshire Lias Fossils I collected a great number of Belemnites from all the strata, which I have described, and intend to dispose of the duplicates sometime. The 2nd edition of my book was published in June last, price to Subscribers, 5s. ; at the Booksellers, 6s. 6d. I enclose you a few slips, and shall be obliged for any patronage you might obtain for the book. I have got a very respectable list of subscribers, but it will require many more to meet the cost of publication. The publication has been long delayed, but in February last, the London Geological Society did me the honour to award me nearly £30, "in recognition of my lifelong researches in the Palæontology of the Jurassic Rocks of Yorkshire." Under this high patronage I ventured on publication, though I cannot expect the work to obtain ready sale. My Geological Guide to the Yorkshire Coast is well received by the visitors.

Wishing you success in your arduous undertaking,

I am, Dear Sir,

Yours truly,

To W. J. VEITCH, ESQ. MARTIN SIMPSON.

WHITBY MUSEUM,

October 15th, 1884.

DEAR SIR,

Thanks for the remittance. I sent off the book this morning by parcel post. There are good Lias Fossils in Chapman's shop, but I believe they are costly. I think you may collect some at Redcar, Coatham, etc., where Prof. Tate made great discoveries, and in the Junction Mine close at hand. You will have to be patient. It has taken us 62 years to collect what we have and have absorbed several private collections. All the private collections are gone: Bean's to the British Museum, £500; Leckenby's to Cambridge University, £800; Wood's (Richmond), £800, to York. Some time ago I went over to Scarborough in pursuit of Oolite Fossils for our Collection, but I got none. No one was collecting.

You will have many tastes to please, but scientific arrangement must be adhered to.

Dear Sir, Yours truly,

MARTIN SIMPSON.

To DR. VEITCH.

LIST OF PAPERS, ETC., BY M. SIMPSON.

1843.—A Monograph of the Ammonites of the Yorkshire Lias. 60 pp.

1844.—Observations on the Discovery of Coprolites in the Stanley Shale and Flockton Coal, or Fish Coal. *Proc. Yorks. Geol. Soc.*, Vol. II., pp. 171-181.

1855.—The Fossils of the Yorkshire Lias, described from Nature, with a short outline of the Yorkshire Coast. 149 pp.

1855.—A Systematic Catalogue of the Fossils of the Yorkshire Lias, drawn up by M. Simpson. Whitby, 8vo, 4 pp. [reprinted from G. M. Tweddell's "History of Cleveland."

1856.—Guide to the Geology of the Yorkshire Coast, Second [First] edition. 28 pp.

1859.—A Guide to the Geology of the Yorkshire Coast, Third [Second] edition. 32 pp.

1861.—Geology of the Whitby District 12 pp. [two editions, one dated 1861—the other, not dated, being later].

1862.—A Guide to Whitby and the Neighbourhood. 18mo, 24 pp., 6d. [second edition in 1887].

1865.—The Drift of the East of England. *Geol. and Nat. Hist. Repository,* Vol. I., p. 57.

1865.—The Plant Strata of Gristhorpe-Bay, near Scarborough, *loc. cit.*, pp. 71-72.
1866.—Inferior Oolite, Lias, Belemnites, etc., of the Yorkshire Coast. *loc. cit.* pp. 215-216.
1867.—A lecture on the Passions, given at the Wakefield Literary and Philosophical Institution, 1830: *Whitby Repository*, N.S., June 1, 1867, pp. 465-474. This was reprinted, with slight corrections, to occupy 8 pp., 8vo.
1867.—Synopsis of the Contents of the Whitby Museum, *loc. cit.*, August, pp. 78, 79, 70, 71, 72, 73, 74, 75 [reprinted as a pamphlet of 8 pages; Second edition in 1881].
1867.—The Water Shrew (*Sorex fodiens*). *Whitby Repository*, N.S., Vol. I., March 1, pp. 326-327.
1867.—On the Geology and Scenery of Craven, in Yorkshire. In a letter to the Rev. George Young, M.A., by Mr. M. Simpson. October, 1836, *loc. cit.*, pp. 428-431.
1868.—Meteorological Observations at Whitby [with notes on Thunder and Lightning Phenomena], *loc. cit.*, N.S., Vol. II., pp. 316-317.
1868.—The Viper and other Snakes, *loc. cit.*, April, pp. 389-391.
1868.—Observations on collecting Specimens in Natural History, *loc. cit.*, May, pp. 433-39.
1868.—A Guide to the Geology of the Yorkshire Coast. Fourth [third] edition, 64 pp.
1868.—A Guide to the Geology of the Yorkshire Coast [another and later impression]. Fourth edition, 64 pp.
1881.—A History of England from the Revolution of 1688. Vol. I., The History of the Reign of William the Third. 260 pp.
1881.—Synopsis of the Contents of the Whitby Museum. 8 pp. [First edition in 1867].
1884.—The Fossils of the Yorkshire Lias, 2nd edition, pp. xxiv.+256.
1887.—A Guide to Whitby and the Vicinity. Second edition, 47 pp.
1891.—Whitby Museum [summary of contents], 8vo, 4 pp. [This was subsequently reprinted, with slight alterations, by T. Newbitt.]

MARTIN SIMPSON, OF WHITBY.

Thos. Spenchlah = Elizabeth Gofton, b. June 4, 1738 (the same day as George III.)

m. June 29, 1765.

A Simpson Particulars unknown.

B Martin = Elizabeth Webster [1749-1790] | John = Jane Spence ← Jane, m. Dec. 31, 1799, d. 1816. | Probably had other children who all took the name of "Spence."

C Leonard—twice married, lived in London.

D Elizabeth = Thos. Lund. Martha John Andrew

E Martin, b. Nov. 20, 1800. d. Dec. 31, 1892. | Jane, b. 1802. d. 1802. | John, b. 1803. d. 1832 at sea. | Elizabeth, b. 1805. d. 1832. | Jane, b. 1807. | Susan, b. 1809. d. 1863. = Wm. Chadwick, of Wakefield. d. 1832.

F John Simpson Miss Chadwick. both living 1917.

A—"Capt." Simpson, carried troops to Scotland in 1765.
B—John, Captain of the "Adventurer," carried convicts to Van Dieman's Land, three voyages. Owner of "Albatross."
C—Leonard, lived in London, also a sailor.
D—Lund, still living. Andrew, known to J.T.S. as Martin Simpson's cousin.
E—Martin Simpson, Curator of Whitby Museum. Buried in Sneaton Churchyard.
F—John S. Chadwick, heir-at-law.

J. T. SEWELL,
Jan. 25, 1918.

In Memoriam.

HENRY CULPIN.

(1861—1912.)

THE loss of an amateur worker in Science is always a heavy one in a band that is diminishing in numbers, or is becoming merged in a crowd of professionals and semi-professionals. Culpin's death was an especially severe blow, as it was wholly unexpected, and he died with his chief scientific work in an unfinished state.

Henry Culpin was born on January 25th, 1861, at Walton, near Peterborough, receiving his early education at the neighbouring village school of Werrington, and subsequently at a private school in Peterborough. At the age of fifteen he entered the services of the Great Northern Railway at Peterborough as clerk, and subsequently became their Chief Locomotive Accountant at Doncaster.

In the summer of 1912, Culpin appeared to be in the pride of health and strength. On the 23rd December, death from heart failure came suddenly to him, without giving any definite premonitory signs. He left a widow and three children, of whom the eldest son died fighting in France shortly after completing a brilliant university career at Oxford. Culpin was a Freemason attached to St. George's Lodge, Doncaster. He was elected a member of the Yorkshire Geological Society in 1904. The best of Culpin's life was given to his employers, but he found time to gather a good knowledge of English literature and foreign languages which helped him as a debater in literary and political meetings in Doncaster.

His bent towards Geology appeared late in life, and his interest seems to have been excited by a course of University Extension Lectures on the Ice Age which he attended at Doncaster ; but this constituted the sole help, and all his scientific knowledge and practice was self-acquired. At Doncaster, he quickly attained a grasp of the outstanding problems relating to the geology of the district, and in excursions farther afield his views were always illuminating and his energy untiring.

It is chiefly, however, in connexion with the Yorkshire Coal Measures that his name will be associated and his work highly valued. On this subject he had accumulated a vast amount of material, obtained by a systematic examination of every exploration for coal between Retford and Selby. Fossils new to science and many additional zones were discovered, so that our knowledge of the fauna and flora of the Yorkshire Coal Measures was considerably extended. By means of this patiently collected knowledge he foretold the results of coal explorations, much to the astonishment of the mining engineers, who frequently appealed to him for help, and who always received a generous response.

Only a fraction of his work was published, but enough to show that with a longer lease of life and less exacting official work, he would have produced a philcsophical account of the history of the Coal Measures of his district. His contributed papers were fledglings, but they possessed strong wings.

W. Gibson.

July 13th, 1918.

[A list of his published papers appeared in *The Naturalist* for **1913.**]

WILLIAM CASH (1843—1914).

In Memoriam.

WILLIAM CASH.

(1843—1914.)

WILLIAM CASH was born in Leeds in April 1843. He migrated to Halifax as a boy and entered the service of the Halifax and Huddersfield Union Bank, becoming eventually a manager. He took much interest in public life, and in 1889 was Chairman of the Halifax School Board at the time that his friend, J. W. Davis, was Mayor of the town, so that the rising Halifax was pretty fully penetrated with modern ideas of the proper position of science in the community. About 1893, Mr. Cash severed his connection with the bank and established himself in business as an accountant. When he retired from that profession, in somewhat straitened circumstances, shortly before his death, a Civil List pension was conferred upon and grants were made to him by the Murdoch Trustees, which were supplemented by an income from the scientific work upon which he was engaged. He died at 26 Mayfield Terrace South, Halifax, on December 16th, 1914.

William Cash rendered inestimable service to the Halifax Scientific Society, of which he was one of the founders, and twice its president; and he was also president of the Halifax Geological Field Club. He was elected as a Fellow of the Geological Society of London in 1876, and became a member of the Yorkshire Geological Society in the same year, and later was elected by the Council as a life member. To the Society he gave many hours of work, acting at one time as treasurer, and as joint editor with the Rev. W. Lower Carter of the Society's publications from 1893, when he succeeded his friend, Mr. Davis, till 1905.

The place he filled in the scientific world of Yorkshire can perhaps be best conveyed if I sound a rather intimate and personal note.

Little more than a year after my arrival in the North of England, I attended the meeting of the British Association at Manchester in August, 1887—a most notable gathering alike in the record attendance of members, in the number and eminence of the foreign guests, and in the importance of the papers that were communicated and discussed. Yorkshire was represented, among others, by a little circle including J. W. Davis, Thomas Hick, C. P. Hobkirk and William Cash; and the many hours that I spent in their society impressed me very deeply with the importance of the amateur work in science in Yorkshire and the generous spirit of comradeship that animated them all. They were naturalists of the best type, each a specialist in some one branch, but none restricted to a single subject ; men of wide interests and extensive reading. Among them all William Cash seemed to me, without disparagement of the others, to possess the widest outlook, and when I reflect upon the nearly thirty years during which our intimacy lasted, and note how his interests were maintained and even enlarged, I feel that Cash was as deeply imbued with the true spirit of a naturalist as any man I have met.

It is difficult to say what were his primary interests—perhaps the study of the Carboniferous rocks and Coal Measure plants, a field of work in which he had distinguished himself by discovery of new types and by careful description of his finds ; but it is evident from the variety of his publications that he was by no means restricted to Palæobotany and that Invertebrate Zoology had a large place in his activities, while either singly or in collaboration with Hick, who became assistant to Williamson in the Botanical Department of the Owens College, he wrote upon the structure and affinities of new types of Carboniferous plants, for the most part represented by sections by James Spencer, another notable Halifax worthy. Of these sections he accumulated a magnificent collection. With characteristic generosity he placed his treasures freely at the disposal of other experts when he thought that they could make better use of them than he could himself. In this way many of Cash's most important specimens came to be described by Professor W. C. Williamson, and some went to the great Continental palæobotanists with whom Cash corresponded. It is gratifying to know that the Cash Collection of Fossil Plants, almost in its entirety, is lodged in the Manchester Museum, along with a great deal of Williamson's material.

In the course of his scientific work he found the need for a knowledge of foreign languages, and he became an adept in French, and acquired a good working knowledge of German, both of which he used to my advantage in the last year of his life. His proficiency in these languages enabled him to maintain a correspondence with several eminent palæobotanists, particularly Professor Zeiller and the Graf zu Solms-Laubach.

At our first meeting I was as much attracted by the charm of Cash's personality as by his scientific sympathies. I was a young man just beginning to make my way in the world, and the help I derived from his encouragement is not easy to appraise. He sent me presents of books, many of which have been tools in constant use ever since. He lent me others, and in a multitude of ways assisted me—and it is a very gratifying recollection that during the last year of his life and down to the very day of his death, he found his principal occupation in work upon certain features of coal-seams in which we were jointly engaged.

Cash's amiable and sympathetic nature was for ever seeking some new object upon which to bestow its favours, and great numbers of young naturalists, some of whom have since attained distinction, owed their start in science, and not a few even their advancement in life, to his generosity and helpfulness. One of the most notable of these, I believe, was Walter Percy Sladen. Cash helped him very greatly and was his chief inspiration, and had Sladen lived it would assuredly have made a great difference to Cash's later years.

He devoted a great deal of his time to popular lecturing. He took great care in the preparation of his matter, and many new recruits were added to the numerous army of Yorkshire naturalists by his stimulating teaching; nor was he satisfied with the mere germination of the seed. He watched over the later growth, and guarded it against the chills that might arrest or prevent its full development.

PERCY F. KENDALL.

[A list of William Cash's papers and monographs appeared in *The Naturalist* for January, 1915. The Council are indebted to the Editors and Publishers of *The Naturalist* for the use of the accompanying portrait].

In Memoriam.

BENJAMIN HOLGATE, F.G.S.

(1838—1915).

TO present-day geologists Benjamin Holgate was little more than a name, but he was well known, personally and through his work, to those of twenty or thirty years ago. Born in 1838, he passed away in 1915, after a strenuous life, a great part of which was devoted to the service of his fellow-men. Born in humble circumstances, and commencing work at an early age, by dint of perseverance and good character, he eventually attained a very responsible position with what was one of the largest engineering firms in Leeds. He was a fine specimen of a "self-educated" man. Whilst still young, he began to take interest in the study of Nature, with a particular leaning towards Geology, which became more marked in the course of time, until he came to be recognised as a good amateur geologist, with a special knowledge of the Carboniferous rocks and their fossils, especially the plants.

He had an intimate and commendable acquaintance with the geology of Leeds and its neighbourhood, and he was ever glad to have the opportunity of imparting his store of information to others, either by reading papers at meetings of local scientific societies, or by conducting excursions. A geological excursion under his guidance always attracted a large party, and his genial manner, homely descriptions and fund of anecdote drew many of those who came into contact with him on these occasions to take interest in our science, even if they could not be termed geologists.

The diffusion of knowledge was one of his great aims in life; his anxiety was for others to participate in the intense pleasure and benefit he derived from the study of Nature. A request for a paper or lecture to a Young Men's, Working Men's, Mutual Improvement, or similar society, usually met with ready acceptance. Amongst such he did a most useful work. The connection of the writer with Geology dates back to the early "eighties," after hearing two lectures by Mr. Holgate before such a society.

Mr. Holgate joined our Society in 1875, and its *Proceedings* contain three contributions by him :—"The Minerals of the Yorkshire Coal-

BENJAMIN HOLGATE, F.G.S. (1838—1915).

field as Applied to the Modern Manufacture of Iron, (1877) " ; " Some Physical Properties of Coal, (1890) " ; and " The Mode of Deposition and Properties of the Carboniferous Strata of Leeds and its immediate Suburbs (1892)." He also contributed papers to *The Naturalist* and *The Transactions of the Leeds Naturalists' Club and Scientific Association.* He was one of the original members of the Leeds Geological Association, and for many years one of its most active workers. Its *Transactions* contain abstracts of many of his papers, the most important one being a detailed description and measurement of the Coal Measures of Leeds, made from sections in clay-pits which are now obliterated. He became a Fellow of the Geological Society of London in 1877, and contributed two papers on local geological matters at the meeting of the British Association in Leeds, in 1890. The Leeds Co-operative Field Club was founded by him, and under his guidance for many years a good work was done, which still continues.

His activities were not confined to Geology. Societies in connection with his profession as engineer had the advantage of his wide learning and long experience, and he was an active worker in the Church of England.

E. HAWKESWORTH.

[The Council are indebted to the Editors and Publishers of *The Naturalist* for the use of the accompanying portrait].

In Memoriam.

WILLIAM SIMPSON, F.G.S.

(1859—1915.)

THE death of William Simpson, of Catteral Hall, Settle, was a serious loss to the Society of which he was so active a member, as well as to his numerous personal and geological friends.

Born on December 18th, 1859, Mr. Simpson was son of the late Thomas Simpson, of Halifax, and was for many years associated with the firm of Simpson & Sons, Ltd., cabinet makers, of Halifax and Blackburn, a business which had been established in the early days of the nineteenth century by his grandfather, John Simpson, a native of Rudston, near Bridlington.

Beside acting as managing director of this business, Mr. Simpson was a director of the Calder and Hebble Navigation Company, and of Messrs. J. W. & C. Ward, Ltd., textile manufacturers.

Until middle life he lived in Halifax, and in his youth came under the influence of the local group of naturalists who have left so strong a mark in Yorkshire scientific history. For many years he took a prominent part in the affairs of the Halifax Scientific Society, which body he served as president, and to which he gave several lectures, his special interest being the local geology of the Millstone Grit. He was a member of the Yorkshire Naturalists' Union, and served for some years on the committee for observing and recording glacial boulders. He studied glaciology in Switzerland and Norway, and in some of his addresses turned the knowledge thus acquired to good account in the interpretation of the glacial geology of Yorkshire.

He was elected a member of the Yorkshire Geological Society in 1892, and as a Fellow of the Geological Society of London a few months later. Having served the Yorkshire Society for some years as local secretary for the Halifax District, and as auditor, he was in 1906 elected as hon. treasurer, which office he held till 1911. His services in these capacities were invaluable to the Society, and were recognised, on his retirement, by his election as a vice-president. He gave his time ungrudgingly, not only to financial affairs, but to the work of the Society generally.

WILLIAM SIMPSON, F.G.S. (1859—1915).

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As a field geologist his activities were very noticeable, and his many contributions to the literature of geology indicate a wide range of research. Another phase of his work was displayed in the classic investigation of the Underground Waters of North-west Yorkshire (*Proc. Yorks. Geol. Soc.*, Vol. XIV.), to which he gave aid in many ways. His presence on the excursions and field investigations of the Society was an incentive of the best kind, as his knowledge was wide and his deductions sound.

After coming to reside at Catteral Hall, Giggleswick, Mr. Gimpson took a part in local affairs, and acted as a governor of the Giggleswick Grammar School. He died on March 20th, 1915.

F. W. Branson.

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In Memoriam

JOHN WESLEY JUDD, C.B., L.L.D., F.R.S,, F.G.S.

(1840-1916.)

THE death, in fulness of years, of Professor J. W. Judd, which took place on March 3rd, 1916, leaves a memory of a wide range of observational work, very great powers of exposition, and a kindly spirit constantly made manifest in the encouragement and advancement of younger men. The biography and bibliography issued in his lifetime in the *Geological Magazine* (1905, p. 385) renders a detailed account of his career unnecessary. The present notice is a tribute to his contributions to our knowledge of the stratigraphy of Yorkshire and of neighbouring districts, and an expression of the loss felt throughout the British Isles by those privileged to receive his advice or to work with him in the laboratory and the field.

After a varied apprenticeship in science as a schoolmaster and an analyst in Sheffield steel works, the result of a railway accident forced Judd towards an occupation that kept him in the open air. His first geological paper appeared in the *Quarterly Journal of the Geological Society of London* in 1867, " On the Strata which form the base of the Lincolnshire Wolds," in which he was able to show that marine representatives of the Neocomian beds of the Continent occur in England. In two vertical sections, he compared the strata at Louth in Lincolnshire with those of Speeton Cliff. In the same year he was invited to revise the Jurassic strata in Northamptonshire, Lincolnshire and Rutlandshire for the Geological Survey. A memorable paper on " The Speeton Clay " appeared in 1868 (*Quarterly Journal of the Geological Society*, vol. XXIV., p. 218),followed in 1870 by one on " The Neocomian strata of Yorkshire and Lincolnshire, with notes of their relation to beds of the same age throughout Northern Europe " (*Ibid.*, vol. XXVI., p. 326). A description of " The anomalous growth of certain fossil oysters " (*Geological Magazine*, 1871, p. 355) has an interest for geologists in Yorkshire, one of the most remarkable specimens, a *Placunopsis* bearing the impression of *Goniomya*, having been obtained from the Cornbrash beds of Scarborough.

Judd's memoir on " The Geology of Rutland, and parts of Lincoln, etc.," in explanation of Sheet 64 of the Geological Survey map, a work pleasantly illustrated by Frank Rutley, did not appear until 1875.

Meanwhile, he had joined the Education Department under Matthew Arnold as an Inspector of Schools; but Jurassic rocks again attracted him, and the friendship of Lyell and Scrope enabled him to undertake considerable researches in the west of Scotland and on the Continent. His papers on "The Secondary Rocks of Scotland" (*Quarterly Journal Geological Society*, vol. XXIX., p. 97: vol. XXX., p. 220, and vol. XXXIV., p. 660) published between 1873 and 1878, not only proved the existence of Cretaceous strata in the Mull district, but gave renewed interest to MacCulloch's work among the igneous rocks of the Inner Hebrides. Though, like MacCulloch, he failed to realise the evidence that the granitic series of this area is intrusive in the central gabbros, the actual succession of these rocks is of small importance compared with his exposition of their Cainozoic age and his recognition of the sites of huge volcanoes comparable in extent to Etna. Crystalline igneous rocks were at that time regarded by Continental authors as of necessity older than the Eocene period—an obsession that infected France from Germany, and spread, under the influence of Rosenbusch's pupils, even to the United States. Judd's persistent advocacy of the application of Lyellian principles to the study of volcanoes saved British petrology from the literary confusion induced by these academic aberrations. His services to science in this respect may be compared with those rendered by Hutton, Playfair and von Buch in the eighteenth century when they broke the tyranny of the Wernerian domination.

Judd's appointment, in 1876, to the Professorship of Geology in the Royal School of Mines marks the beginning of a new epoch in the teaching of the subject. For the first time in the history of the institution, students were given access to collections of specimens which they were encouraged to handle for themselves. The work of Sorby, whom Judd had met in Sheffield, bore fruit in organised courses in which the microscope played an important part. Those who, like the present writer, attended the lectures at Jermyn Street in 1876, and who found that Judd's descriptions of natural processes were also lessons in the "humanities," were led to take every opportunity of viewing earth-features in the field. After a trial course with a limited number of students in 1877, regular laboratory instruction in geology was organised in the new buildings at South Kensington in the autumn of 1878, and the example thus set was followed by Cambridge, and subsequently by all the Universities in our islands.

The fact that for a long period geology was placed on the curriculum of every associate student in the Normal College of Science, as well as in the Royal School of Mines, brought some sixty men under Judd's influence in every year. The Geological Surveys and universities of the English-speaking world in consequence bear testimony to much that was gained from his personality, in addition to the discipline acquired from following his ordered modes of work.

In 1888, Judd contributed to the *Proceedings of the Yorkshire Geological Society* (vol. IX., p. 474) a paper on "The Relation between the Central Societies and the Local Ones"—an important subject that has been again raised by one of his pupils, Sir Thomas Holland, in an address in recent years.

After his retirement from the duties of Professor and Dean at the Royal College of Science at South Kensington in 1905, Judd remained in constant touch with the progress of science and with his numerous geological friends. Increasing deafness prevented him from attending meetings during his later years, but he published a very characteristic work, "The Coming of Evolution," in 1909, as the first of the Cambridge Manuals of Science and Literature. In this he recorded, as a contemporary and a fellow-worker, one of the greatest episodes in scientific progress. The pupil of Lyell and Darwin, the colleague of Huxley, and the organiser of systematic instruction in the subject that he loved, has left no finer testament than this volume, written in the ripeness of his later years.

GRENVILLE A. J. COLE.

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—— [See P. G. H. Boswell].

ON THE SUPPOSED RAISED BEACH AT SALTBURN.

By G. W. Lamplugh, F.R.S.

(Read November 26th, 1919.)

The supposed presence of a Raised Beach of Post-Glacial age at Saltburn, at 35 feet above high-water mark, has afforded one of the minor problems in the geology of the Yorkshire Coast. The 'beach' was first described by Dr. W. Y. Veitch in the *Proceedings* of our Society for 1883 (N.S. Vol. VIII., pp. 221-6), and was referred to shortly afterwards by Mr. G. Barrow in his memoir, "The Geology of North Cleveland" (*Mem. Geol. Surv.*, 1888, p. 71). Dr. Veitch describes the 'beach' as "a band of alluvial sand containing shells and fragments of shells," of which six kinds are mentioned, all common on the present shore (*Purpura, Littorina, Trochus, Lachesis minima* and *Cypraea europaea*); and states that it was exposed in the steep drift-slope below Saltburn in operations by the Saltburn Improvement Company, the deposit "extending 70 or 80 yards from the bridge up Saltburn Beck, where it abruptly comes to an end." He also found shells at about the same level "south" [east] of the beck, on the seaward slope of Cat Nab, and considered that they indicated a continuation of the beach. Mr. Barrow gives practically the same particulars, and endorses the view that the deposit represents a Raised Beach, though he notices the abnormal circumstance that a beach of this kind should be preserved in a perishing cliff of soft Glacial beds and should be absent from the neighbouring rocky headland of Huntcliff, composed of much more durable Liassic strata.

The main reason why this 'beach' has always been questionable is that a Post-Glacial submergence of the amount implied would have inundated wide tracts of the adjacent lowland south of the Tees; and, unless the submergence were confined in a perplexing way to one small area only, the sea farther south would have entered upon the land at several places and would have extended over a large part of Holderness. But nowhere else in the coast-sections of Yorkshire has any indication of Post-Glacial submergence been found*; on the other hand, there

*In our *Proceedings* for 1883, in juxtaposition with Dr. Veitch's paper, there is a short note (p. 220) by the Rev. J. S. Tute on "Some Indications of a Raised Beach at Redcar," recording the occurrence of *Rissoa ulva*, with broken mussel and cockle shells, in sandy clay in foundations of houses at Warrenby, where the surface is stated to be about 14 feet above high-water mark. On a flat shore like that west is everywhere, both on the coast and in the interior, strong evidence that all the low ground south of the Tees (except the new land at sea level due to the accretion of warp, etc.) has been under subaerial conditions continuously from the close of the great glaciation to the present day.

With this difficulty in mind, I sought to examine the deposit some years ago when investigating the drift-sections of the coast. But the exposures seen by Dr. Veitch had been covered up, and I could make out nothing except that there was a terrace-like feature, covered with sandy soil, in the cliff of boulder-clay on the western side of the beck, where the ravine is truncated by the shore-line. From its sheltered and recessed position, however, it seemed unlikely that the terrace could have been cut by the sea.

On revisiting Saltburn in the early summer of the year 1917, I found that excavations had been made right across the terrace, and also along the sloping cliff on the opposite side of the beck, behind Old Saltburn, where Dr. Veitch found the shells that he regarded as a further indication of the 'beach.' These excavations afforded a most advantageous opportunity for examining the deposit, and this, by permission of the military authorities, I was able to do.

The excavations north and west of the 'hair-pin' bend in the road down from the Zetland Hotel to the beach and bridge were made along the north-western part of the terrace, and were continued beyond its termination in the boulder-clay slope of the outer cliff. They were about 5 ft. deep, and were for the most part entirely in sand, but touched boulder-clay at the bottom at one place, and also showed the sand ending off against a sloping bank of boulder-clay where the terrace-like feature disappeared. There were no beach-pebbles in the sand, even where it was seen to rest on boulder-clay; but in one place it contained a thin streak of small bits of shale. A few weathered marine shells, mostly *Littorina*, were scattered among the sand, and in the upper part it contained small land shells (*Helix* and *Pupa*?). A piece of rotten wood, 3 or 4 inches long, was also noticed.

The excavations south and east of the same road, both within and to the south of the 'hair-pin' bend, revealed the structure of the remainder of the terrace, up to its southward termination in the

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of Redcar, some of the lighter marine waste is always pushed above high water mark by storm-waves, and onshore winds, and its occurrence at this low level is no proof of submergence.

slope of the ravine of Skelton Beck, just within the boundary of the pleasure-grounds. On the flat part of the terrace the continuation of the sand was seen, up to a depth of 6 ft., again with a few shells, including two species of *Littorina* (some being of large size), *Natica*, *Trochus*, *Cardium* (fragmentary), and the small land shells as before. Just under the fence of the gardens some large slabby stones, up to 8 inches in diameter, occurred half-way down in the sand, along with some smaller stones reddened by fire, the whole being suggestive of an old hearth-place. In another spot a lenticle of subangular gravelly wash, up to 9 inches thick, set in between the sand and the underlying red boulder-clay. It contained no shells and was not like a beach-gravel, but resembled river-wash.

Where the terrace narrowed toward its southern termination, the sand became mixed and streaked with red loam, evidently the result of rain-wash from the neighbouring slope of boulder-clay. A more clayey rain-wash covered the slope a little farther southward, where there was no sand, and this clay-wash (which might readily be mistaken for boulder-clay in place), itself contained some large periwinkle shells, like those in the sand.

At the opposite or eastern side of the valley, the sections ran continuously along the steep slopes of the weathered cliff of drift behind Old Saltburn, at about the same level as on the western side. They were all in red boulder-clay, with here and there a patch of silt or of clayey gravel, evidently recent slope-wash, but in three or four places they crossed superficial pockets of shells of *Littorina* and *Patella*. These shell-pockets were a foot or two wide and two or three inches deep, and in one place included some bits of bone. They were clearly artificial 'kitchen-midden' heaps, and probably of no great antiquity. Heaps of limpet shells of this kind are commonly left in such situations in the recesses of the coast by fishermen in baiting their lines; but I am not aware that the periwinkle is used in this way for bait. The shells noticed by Dr. Veitch on this slope are explained by the presence of these pockets, which have certainly nothing to do with a raised beach.

As regards the terrace with its sandy deposit west of the beck, I am satisfied, after seeing the sections, that this also is not a raised beach, although the feature at first sight suggests such origin. The sand has all the characteristics of a blown sand. In structure, texture and general aspect, it resembles the blown sand of adjacent slopes.

The coast from Saltburn to Redcar is exposed to all winds between north-west and north-east, and at low tide these winds cross broad tracts of bare sand before reaching the cliff, with the result that sand is driven up far above high-water mark on the lower slopes of any crumbling bank of drift that fronts the shore. Even where the cliff rises well over the 100 ft. contour, north-west of the Hazel Grove ravine, its sloping portions are veneered quite to the top with blown sand.

The presence of sporadic marine shells in the sand of the terrace is no proof that it is an old beach. The smaller shells—*Lachesis* and *Cypraea*—are of kinds readily blown by the wind, while the heavier shells are such as may have been distributed by sea-birds and by man, whose agency is clearly indicated by the burnt stones mentioned above. Anyone who has scrambled about on the steep grassy slopes that front the sea in many of the little bays of the Yorkshire coast will remember how common it is to find accidentally transported shells and shell-fragments upon them, and, in consequence, how careful one has to be, in searching for shells in the drift deposits, to distinguish between these and the true drift-shells. The fact that some shells similar to those in the supposed beach-sand are present also in the clayey rain-wash of the slope, as I have mentioned in describing the sections, is further evidence for the accidental distribution of the shells; and the 'shell-pockets' on the Old Saltburn slope were seen to be, beyond doubt, artificial.

The terrace-feature which has perhaps afforded hitherto the most generally-accepted presumptive evidence for the supposed beach remains to be dealt with; and I think that it can be very simply and satisfactorily explained. It is almost certainly an old erosion-terrace of Skelton Beck, before the ravine was cut down to its present level and when its mouth lay to the seaward of its present position. Below the point, over half a mile inland, where the beck leaves a narrow rock-gorge, a wide trough has been carved entirely in the Glacial drifts; and all along this trough (now the picturesque Pleasure Grounds of Saltburn) there are remnants of old erosion-flats, here and there at various levels, marking stages of the down-cutting. Close to its present mouth the valley expands, owing to the confluence of two small streams on the eastern side, which have cut the deep gullies in drift known respectively as Saltburn Gill and Little Dale. As is usual under such conditions, the terracing of the main valley has been accentuated around the confluence; and the small embayment on the western side, which carries the supposed raised beach, occurs just where the main stream is likely to have been driven against the western slope by the agency of its eastern tributaries. If it be recognized, as I think it must, that the platform has had its origin as a river-terrace, all difficulties as to its position disappear; and there is seen to be a corresponding feature at about the same level on the opposite side of the valley, on the spur between the main beck and its chief tributary. The fluviatile aspect of the patch of gravelly wash seen beneath the sand in the recent cuttings on the terrace lends further support to my opinion that the platform has not been cut by the sea, but by the beck.

At the time that the terrace was formed it would, of course, be well within the valley, which must then have extended some distance farther northward than now before reaching the sea. The drift-cliffs up to the setting in of the solid Liassic rocks east of Old Saltburn show every indication of steadily wasting land, and the encroachment of the sea must have been in progress here until it was checked by the artificial defence-works. The persistence of the terrace-feature on this wasting coast, on the supposition that it was an ancient beach, was always difficult to account for, but if considered as a feature belonging to the valley, there is no difficulty.

Other supporting arguments against the 'beach' origin might be brought forward, but it seems unnecessary to labour the discussion further. I think that we need no longer take this awkward and anomalous 'Raised Beach' into our reckoning in dealing with the Post-Glacial history of the Yorkshire coast-lands.

In conclusion I may mention that the examples of former stream-diversion on a small scale, which cause the irregularity of the ridges between the confluent streams and the cliff-front, are probably due to the readjustment of the drainage-gradients between the main stream and its tributaries, consequent upon the shortening of the principal valley by the encroachment of the sea. The features afford an instructive physiographical study in miniature.

ON THE FOSSIL FLORA OF THE SOUTHERN PORTION OF THE YORKSHIRE COALFIELD.

Part II.—North Derbyshire.

By the late E. A. Newell Arber, M.A., Sc.D., F.G.S., Trinity College Cambridge: University Demonstrator in Palæobotany.*

(*Read November 26th*, 1919).

In a previous paper, published by this Society some ten years ago,† I described the fossil flora of the Middle and Lower Coal Measures in the extreme south of the Yorkshire Coalfield in Nottinghamshire and Derbyshire. In the present paper an account is given of the Middle Coal Measure flora of a region in Derbyshire further to the North, but lying to the South of Chesterfield. This district appears to be a comparatively poor collecting ground for fossil plants, with the exception of two pits at Temple Normanton—Bond's Main and Grassmoor Collieries—which in recent years have become well known on account of the excellence of their fossil floras. It is with the plants collected at these localities that the present paper is concerned.

Two lists of species occurring at Bond's Main have been already published by Horwood‡ and by Dr. Moysey,§ and the former has also added a short list from Grassmoor Colliery. Further collections from both these localities, which are now in the Sedgwick Museum, Cambridge, were formed some years ago, partly by the Author and partly by Mr. I. Rogers. They include a number of species not hitherto recorded, as well as examples of many of the plants instanced by Horwood or Moysey or both observers.

The horizon‖ of the plants in question is the roof of the Silkstone seam or between the Deep Hard and the Silkstone coals. The Silkstone

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* [Owing to the author's death before this paper was revised, the responsibility for any errors which it may contain rests with me. I have to acknowledge a grant from the Royal Society in aid of the preparation of this and other memoirs left by my husband in various stages of completion.—Agnes Arber.]

† Arber (1910).

‡ Horwood (1912).

§ Moysey (1913).

‖ [A later note by Dr. Arber indicates that he regarded the horizon as representing the dividing line between the Middle and Lower Coal Measures.—A. A.]

seam occupies a considerably lower position in the Middle Coal Measures than the Top Hard and Barnsley Thick Coal from which were derived the greater number of previous determinations from this field, both in Yorkshire itself and from the southern extremity in Nottinghamshire and Derbyshire.

The following is a list of the new records :—

NAME.	Bond's Main Pits.	Grassmoor Pits.
EQUISETALES.		
Calamites ramosus Art.	X.	...
Calamophloios verticillatus (L. & H.)	X.	...
FILICALES AND PTERIDOSPERMEÆ.		
Sphenopteris Potieri Zeill.	X.	...
S. Laurenti Andrä	X.	X.
S. (Zeilleria) avoldensis Stur	X.	...
S. (Zeilleria) delicatula Sternb.	...	X.
LYCOPODIALES.		
Lepidodendron lycopodioides Sternb.	...	X.
Sigillaria principis Weiss	X.	...
S. elongata Brongn.	X.	...
S. discophora Kidst.	...	X.
Lepidophloios laricinus Sternb.	...	X.
CORDAITALES.		
Cordaites principalis (Germar)	...	X.

The following is a complete list of the species now known from Bond's Main and Grassmoor Collieries, and may be regarded as an example of the flora of the lower part of the Middle Coal Measures of the Yorkshire field.

NAME.	Authority. (*)	Bond's Main Pits.	Grassmoor Pits.
EQUISETALES.			
Calamites ramosus Art.	A.	X.	...
C. undulatus Sternb.	A.M.H.	X.	...
Calamophloios verticillatus (L. & H.) ...	A.	X.	...
Annularia radiata (Brongn.)	A.M.H.	X.	...
Calamocladus charaeformis (Sternb.) ...	A.M.	X.	...
Pinnularia columnaris (Art.)	M.	X.	...

* "A" indicates that this plant is recorded by the Author "H" by Mr. Horwood; "M" by Dr. Moysey.

NAME.	Authority. (*)	Bond's Main Pits.	Grassmoor Pits.
SPHENOPHYLLALES.			
Sphenophyllum cuneifolium (Sternb.) ...	A.M.	X.	...
S. cuneifolium var. *saxifragae folium* (Stb.)	A.	X.	...
FILICALES AND PTERIDOSPERMEÆ.			
Sphenopteris Potieri Zeill.	A.	X.	...
S. furcata Brongn.	A.M.	X.	...
S. Laurenti Andrä	A.	X.	X.
S. flexuosissima (Stur)	M.	X.	...
S. (*Corynepteris*) *Sternbergi* (Ett.) ...	A.M.	X.	...
S. (*Zeilleria*) *avoldensis* Stur.	A.	X.	...
S. (*Zeilleria*) *delicatula* Sternb. ...	A.	?	?
Neuropteris heterophylla Brongn. ...	A.M.H.	X.	X.
N. tenuifolia (Schloth.)	H.	X.	...
N. obliqua Brongn.	A.M.H.	X.	X.
N. obliqua forma *impar* (Weiss) ...	M.	X.	...
Alethopteris valida Boul.	A.H.	...	X.
Mariopteris muricata (Schl.)	A.M.	X.	X.
Pecopteris Miltoni (Art.)	A.M.H.	X.	X.
P. (*Dactylotheca*) *plumosa* (Art.) ...	A.M.H.	X.	...
Rhacophyllum crispum var. *lineare* (Gtb.)	A.M.H.	X.	...
LYCOPODIALES.			
Lepidodendron obovatum Sternb. ...	A.H.	X.	X.
L. aculeatum Sternb.	M.	X.	...
L. lycopodioides Sternb.	A.	X.	X.
L. ophiurus Brongn.	M.H.	X.	...
L. simile Kidst.	M.	X.	...
Lepidophloios laricinus Sternb.	A.M.	X.	X.
Bothrodendron minutifolium (Boul.) ...	M.H.	X.	X.
Sigillaria principis Weiss.	A.	X.	...
S. scutellata Brongn.	A.H.	X.	...
S. elegans (? Sternb.)	A.M.	X.	X.
S. elongata Brongn.	A.	X.	...
S. mamillaris Brongn.	A.H.	X.	X.
S. tessellata (Steinh.)	M.	X.	...
S. discophora Kidst.	A.	...	X.
S. tenuis Achepohl	H.	...	X.
S. ovata Sauveur	M.	X.	...
Lepidophyllum majus Brongn. ...	M.H.	X.	X.
L. lanceolatum L. & H.	H.	...	X.
Sigillariostrobus rhombibracteatus (Kidst.)	H.	X.	...
CORDAITALES.			
Cordaites principalis (Germar)	A.	X.	...
Artisia transversa (Artis)	A.H.	...	X.
Cordaianthus pitcairniae (L. & H.) ...	A.H.	X.	X.

* "A" indicates that this plant is recorded by the Author: "H" by Mr. Horwood; "M" by Dr. Moysey.

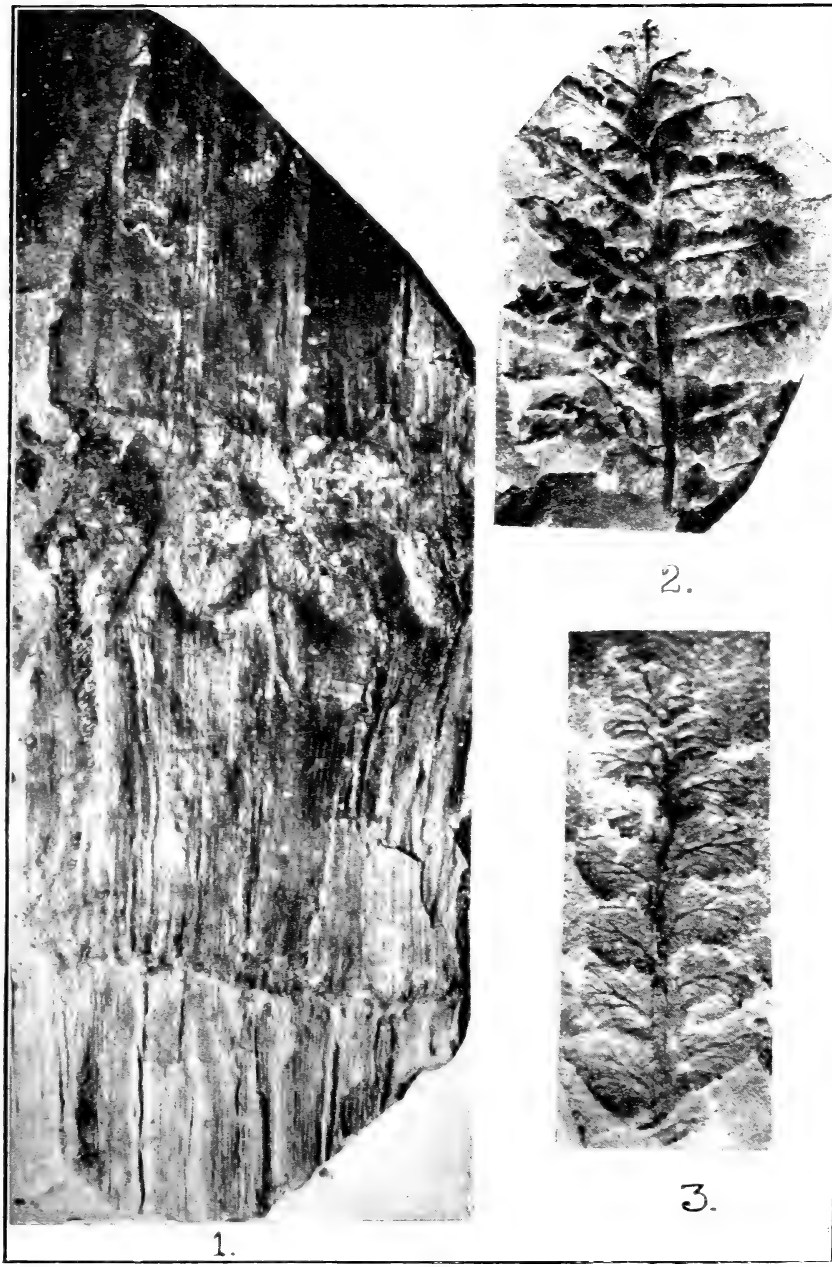

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Photo by] [W. Tams

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A representative collection of the species in the above list, recorded under the authority of the Author, is preserved in the Sedgwick Museum, Cambridge, Nos. 2741 to 2814 in the Carboniferous Plant Collection.

NOTES ON THE FIGURED SPECIMENS.

I append figures of some of the more interesting specimens recorded above, with some remarks upon them.

Calamophloios verticillatus (?) L. and H.

Plate XXXIX., Fig. 1 ($\frac{3}{4}$ nat. size.)

External surface of stem.

1893. *Calamitina verticillata*, Kidston, *Trans. Roy. Soc. Edinb.*, Vol XXXVII., p. 311, pl. IV., fig. 18.

1911. *Calamites verticillatus* (pars), Jongmans, *Anleit Bestim. Karbonpfl. West-Europas.*, Vol. I., p. 61, fig. 67.

Pith-casts.

1835. *Calamites verticillatus*, Lindley and Hutton, *Foss. Flora*, Vol. II., pl. 139.

1886-88. *Calamophyllites verticillatus*, Zeiller, *Flore Foss. Bass. Houill. Valenciennes*, p. 360, pl. 57, fig. 2.

1910. *Calamites varians*, Renier, *Doc. Étude Pal. Ter. Houill.*, pl. 45.

1911. *Calamites verticillatus* (pars), Jongmans, *Anleit. Bestim. Karbonpfl. West-Europas*, Vol. I., pp. 61, 62, fig. 68.

I have recently instituted (*) the genus *Calamophloios* for the reception of specimens showing the external surface of Calamite stems as opposed to pith-casts. The specimen figured on pl. XXXIX., fig. 1, reduced in size, is an example of a rare Calamite stem showing the external surface. Several pith-casts, probably belonging to the same species, have been figured by Zeiller and Renier, and probably by Lindley and Hutton. The type of the authors last mentioned is, however, lost, but from the somewhat rough drawing which they give of it, one may conclude that the specimen was more probably a pith-cast than the external surface of a Calamite stem.

These stems belong to the *Calamitina* section of the genus, characterised by the periodic occurrence of branch scars. In this species

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* Arber (1916), p. 140. See also Arber, E. A. N. and Lawfield, F. W., On the External Morphology of the Stems of *Calamites*, *Journal of the Linnean Society*, Bot. Vol. XLIV, 1920, pp. 507-530, pl. 23-25.

the scars are very large and closely set, and the internodes are of unequal length. In the present specimen four large branch scars are seen above (*) a node. The internodes have well-marked longitudinal primary ridges, distant about 2 cm. from each other, and between these occur numerous faint and very slight secondary ridges, anastomosing with one another, and forming an elongate network. In this latter respect we have an interesting approach to the genus *Dictyocalamites* Arber (†), in which the surface reticulations are more prominent. The scar-bearing internode is about 9 cm. in length. The leaf-scars on the nodes are not clearly seen.

It is possible that the specimen which I have previously figured from Nottinghamshire (‡) may be allied to that under discussion here.

Sphenopteris Potieri Zeill.

Plate XXXIX., Figs. 2 and 3.

1886-88. *Sphenopteris Potieri*, Zeiller, *Flore Foss. Bass. Houill. Valenciennes*, p. 88, pl. 14, fig. 1.

The frond figured on pl. XXXIX., fig. 2, natural size, appears to me to be identical with Zeiller's *S. Potieri*, a very rare plant, apparently hitherto unknown from Britain, and one of which only one specimen seems to have been previously recorded. This species is characterised by the very prominent longitudinal ridges on the rachises of all orders, by the broad lobes of the pinnules with undulating but not toothed margins, and the strong "tuning fork" lateral nervation. The latter is seen in part of a pinnule enlarged three times on plate XXXIX., fig. 3.

Sphenopteris Laurenti Andrä.

Plate XL., Fig. 2.

1865. *Sphenopteris Laurentii*, Andrä, *Vorweltliche Pflanzen*, p. 39, pl. 13, figs. 1-3.

1865. *Sphenopteris stipulata*, Andrä, *ibid.*, p. 40, pl. 13, fig. 4.

1868. *Sphenopteris stipulata*, (von Gutbier), Roehl, *Palaeontogr.*, Vol. XVIII., p. 58, pl. 16, fig. 6A.

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* Fig. 1, Pl. XXXIX is reversed, so that the branch scars appear to lie *below* the node. A.A.

† Arber (1912), p. 97. See also Arber and Lawfield, *l.c.*

‡ Arber (1910). *Proc. Yorks. Geol. Soc.*, Vol. XVII., p. 144, pl. XIII., figs. 1 and 2.

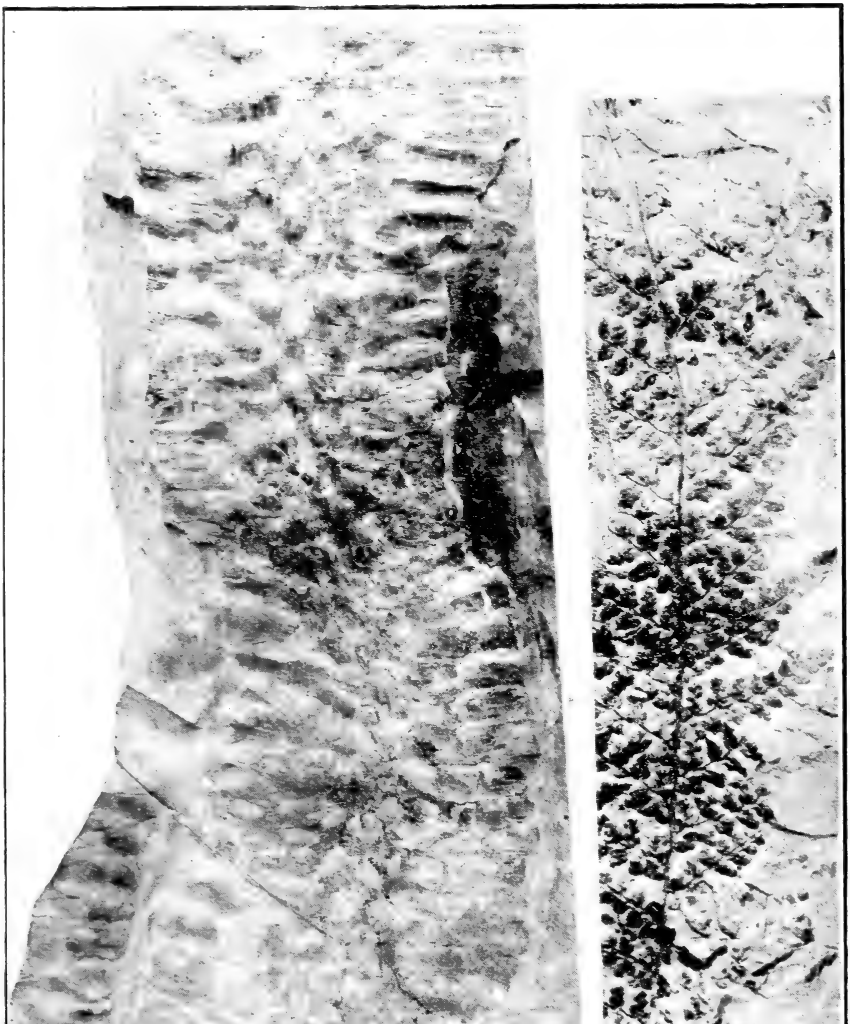

Photo by] W. Tams

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1885. *Hapalopteris Laurentii*, Stur, *Abhandl. K. K. Geol. Reichs. Wien*, Vol. XI., p. 36, pl. 44, figs. 5-6.

1886-88. *Sphenopteris Laurenti*, Zeiller, *Flore Foss. Bass. Houill. Valenciennes*, p. 85, pl. 6, fig. 3; pl. 9, fig. 4.

1899. *Sphenopteris* (*Renaultia*) *Laurenti*, Zeiller, *Mém. Soc. Géol. France* (Pal. Mém.), VIII., 21, p. 16, pl. 1, fig. 16.

1909. *Sphenopteris Laurenti*, Behrend in Potonié, *Abbild. und Beschr. Foss. Pflanz.*, Lief. VI., No. 105.

1910. *Sphenopteris Laurenti*, Renier, Doc. *Étude Pal. Terr. Houill.* pl. 65.

1912. *Sphenopteris Laurenti*, Vernon, *Quart. Journ. Geol. Soc.*, Vol. 68, p. 620, pl. 57, fig. 2; pl. 59, fig. 7.

1913. *Sphenopteris* (? *Renaultia*) *Laurenti*, Gothan, *Abhandl. k. Preuss. Geol. Landesanst.*, N. F. Heft 75, p. 134, pl. 17, fig. 3.

This species, which is not very abundant in Britain, is one of the most easily recognised members of the genus. The pinnules are small, distant from one another, the lobes being relatively broad, the margins usually undulating, or slightly crenate, and the lateral nerves very distant from one another, with a few very wide dichotomies.

Neuropteris obliqua Brongn.

Plate XLI, Figs. 1, 2, 3.

1832. *Pecopteris obliqua*, Brongniart, *Hist. Végét. Foss.*, p. 320, pl. 96, fig. 1-4.

1837 ? *Neuropteris heterophylla*, Lindley and Hutton, *Foss. Flora*, Vol. III., p. 90, pl. 183.

1882. *Odontopteris binervosa*, Achepohl, *Niederrh.-Westfäl. Steinkohlengebirge, Essen und Leipzig*, Lief. 7, p. 118, pl. 36, fig. 5.

1886-88 ? *Neuropteris obliqua*, Zeiller, *Flore Foss. Bass. Houill. Valenciennes*, p. 284, pl. 48, figs. 1, 2 (? fig. 3), figs. 4-7.

1886-88. *Neuropteris acuminata*, Zeiller, *ibid.*, p. 255, pl. 41, fig. 4.

1893. *Neurodontopteris impar*, Potonié, *Jahrb. k. Preuss Geol. Landesanst.* für 1892, p. 1, pl. 1, figs. 1, 2, 4.

1906. *Neurodontopteris obliqua*, Gothan in Potonié, *Abbild. und Beschr. Foss. Pflanzen.*, Lief IV., No. 68, text figs. 2 (B), 4, 5; pl. 1B.

1907. ?*Mixoneura obliqua*, Zalessky, *Bull. Com. Géol. St.-Pétersbourg*, No. 134. Vol. XXVI., p. 404, pl. 15, figs. 11, 12 and 16.

1907. *Mixoneura obliqua*, Zalessky, *ibid.*, No. 135, Vol. 26, p. 479, pl. 19, figs. 1-10.

1911. *Neuropteris impar*, Kidston, *Mém. Mus. R. Hist. Nat. Belgique*. Vol. IV., p. 83, pl. VIII., figs. 1, 2, 3 and 3A.

1913. ? *Neuropteris obliqua*, Gothan, *Abhandl. k. Preuss Geol. Landesanst.*, N. F. Heft 75, p. 207, ?pl. 50, fig. 5.

Neuropteris obliqua is a plant of very variable habit, wide variations occurring in the size, shape and insertion of the pinnules in different parts of the same frond. The pinnæ of this species occurring at Bond's Main are the small-pinnuled forms, which in my experience are very rare in Britain. The minor pinnules of this plant were first figured by Brongniart, and there can be no doubt that the examples illustrated here on plate XLI., figs. 1, 2 and 3, are identical with the continental specimens described by Brongniart, and by others more recently.

In these pinnæ the higher pinnules are oblong, attached by their whole base, decurrent, and the nervation arises directly from the rachis, there being no true median nerve.

In these characters these pinnules agree remarkably with members of the genus *Odontopteris*. But the pinnules situated lower on the rachis tend to become Neuropteroid, being more oval in form, contracted at the base to a point of attachment and not decurrent. These pinnules also possess a more distinct median nerve. The larger or major pinnules of the same plant, which, however, have not been found at Bond's Main, are also more Neuropteroid than Odontopteroid, hence the species is retained in the genus *Neuropteris*.

The specimen figured in Plate XLI., fig. 2, shows a pinna composed of small pinnules, part of which is seen enlarged on fig. 3 of the same plate. An enlarged view of the nervation of another specimen is shown on fig. 1.

There is also a more common British plant which I believe has often been mistaken for *N. obliqua*, but which I think is a distinct type. I have figured examples of this from Kent* and from Cumberland,† and I regard the frond to which Kidston and Jongmans ‡ have attributed a large seed as another specimen of the same plant, which I propose shortly to redescribe under a new specific name.

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* Arber (1909), p. 26, pl. I., fig. 3.

† Arber (1903), p. 4, pl. I., fig. 2.

‡ Kidston and Jongmans (1912), p. 25, pl. (unnumbered), fig. 3.

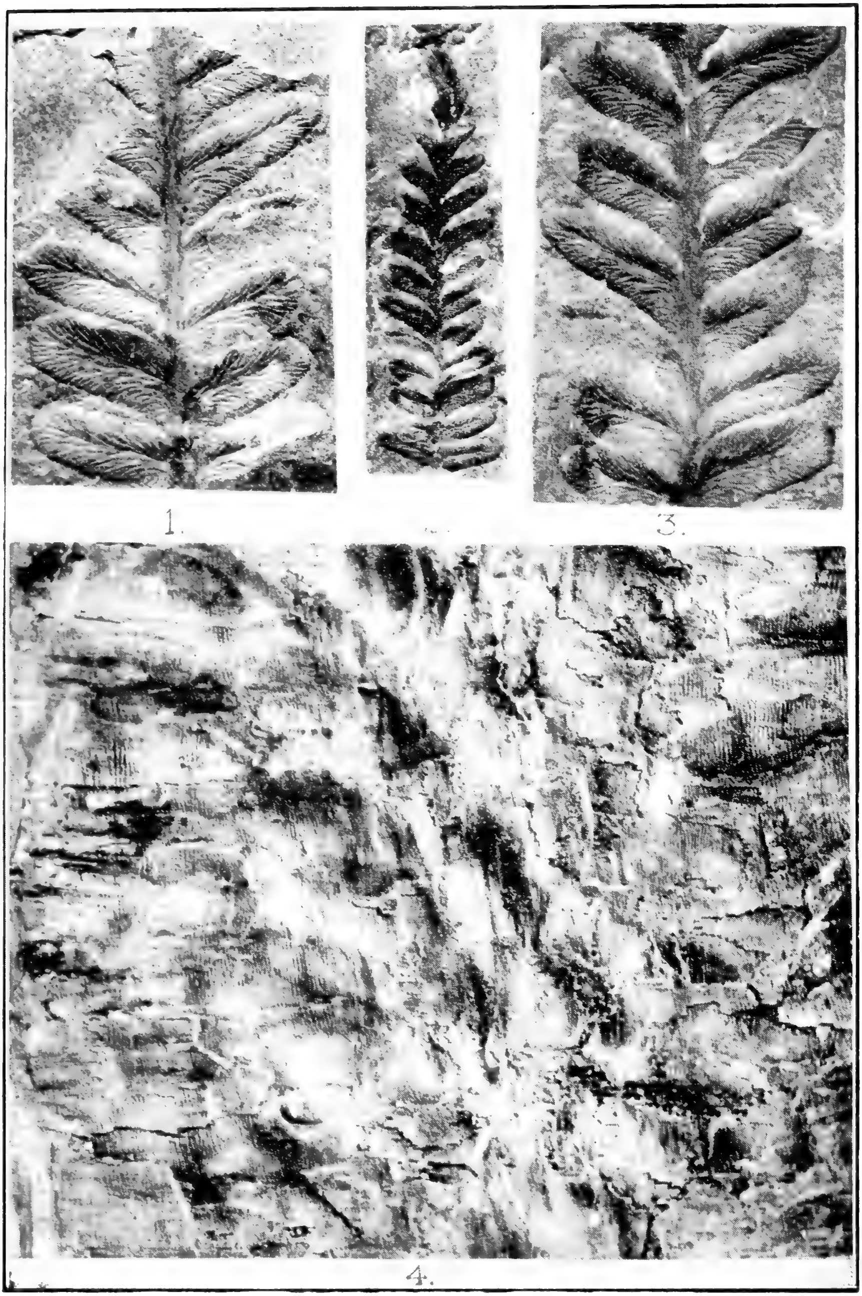

Photo by W. Tams

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Stigmaria ficoides Sternb.

Plate XL., Fig. 1, and Plate XLI., Fig. 4.

1902. *Stigmaria ficoides,* Kidston, *Proc. Yorks. Geol. and Polyt. Soc.,* Vol. XIV., pt. III., p. 357, pl. 52, fig. 3.

1911. *Stigmaria ficoides,* Kidston, *Mém. Mus. R. Hist. Nat. Belgique,* Vol. IV., p. 212 (contains a full synonymy).

The specimen figured on Plate XL., fig. 1, and enlarged on Plate XLI., fig. 4, represents a very rare state of preservation of this very common fossil plant, of which casts of the external surface are the most abundant of plant remains in the Coal Measures. The specimen consists of a longitudinal impression of the woody cylinder seen in tangential section.

The transversely oblong areas, seen especially at the sides of the specimen, are the woody bundles frequently anastomosing with one another, and in many cases broken off short, since the plane of the impression does not coincide with the planes of the bundles. In the enlarged figure (plate XLI., fig. 4), these oblong areas are seen to possess a delicate but distinct and close ribbing. These ribs are, of course, the impressions of the tracheids themselves.

Kidston (see above) has figured a similar specimen from Lanarkshire, which, however, has split along a radial plane, and shows a cast of the pith cavity. In the present case the pith cast lies behind the impression of the woody bundles figured here.

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EXPLANATION OF THE PLATES.

(All the figures are from specimens from above the Silkstone Coal Bond's Main Colliery, Temple Normanton, Derby, now in the Carboniferous Plant Collection, Sedgwick Museum, Cambridge; the numbers following the specific names are the numbers allotted to them in that Collection. All the figures are from photographs by Mr. W. Tams, Cambridge).

Plate XXXIX.

Fig. 1.—*Calamophloios verticillatus* (L. & H.), No. 2741, × $\frac{3}{4}$. [This figure is upside down].

Fig. 2.—*Sphenopteris Potieri* (?) Zeill., No. 2766, natural size.

Fig. 3.—*Sphenopteris Potieri* (?) Zeill., No. 2770, ×3.

Plate XL.

Fig. 1.—*Stigmaria ficoides* Sternb., No. 2745, natural size. See also Pl. XLI., Fig. 4.

Fig. 2.—*Sphenopteris Laurenti* Andrä, No. 2779, natural size.

Plate XLI.

Fig. 1.—*Neuropteris obliqua* Brongn., No. 2798, ×2½.

Fig. 2.—*Neuropteris obliqua* Brongn., No. 2793, natural size.

Fig. 3.—*Neuropteris obliqua* Brongn., No. 2793, × 2½.

Fig. 4.—*Stigmaria ficoides* Sternb., No. 2745, ×3. See also Pl. XL., Fig. 1.

ON SOME CARBONIFEROUS AMMONOIDS NEW TO ENGLISH ROCKS.

By the late Lt.-Col. W. HIND, T.D., M.D., F.R.C.S., F.G.S.

(Read November 26th, 1919).

The quarry at Kniveton, Derbyshire, north of Standlow farm, has yielded a fauna characteristic of Vaughan's *Caninia* horizon and certain goniatites new to England occur there. Two of them have been described from a similar horizon in Ireland. It is important to publish these facts and to figure the English specimens in order to establish a Goniatite zone in Upper C beds, which is lower than any previously known in the Carboniferous series. Three species of Ammonoids, which are unknown at other levels, characterise the horizon—*Pericyclus fasciculatus* M'coy, *Glyphioceras inconstans* de Koninck, *G. corpulentum* Foord.

GLYPHIOCERAS INCONSTANS, de Koninck, 1880.

Glyphioceras inconstans de Koninck, 1880; *Ann. Mus. Roy. d'Hist. Nat. de Belgique, Faune de Calcaire Carb. de la Belgique*, Tom. V., 2me Pt., p. 120, Pl. XVIII, figs. 4, 5, 6, 7, 8, 9.

SPECIFIC CHARACTERS.—Shell discoidal, compressed, involute, attaining a diameter of 70 mm. in well-grown examples. Greatest thickness at the umbilical edge. Inclusion not complete. Whorl sub-elliptical. Body chamber occupying almost the whole of the last whorl. Whorls several. Periphery regularly arched in the young, becoming flattened in the larger specimens. Umbilicus small and deep, its margin rounded and simple. Cameræ are deep—about 8 to the whorl. Shell apparently thin, ornamented by almost obsolete transverse lines of growth, arched sinuously on the periphery, so that they are slightly concave forward and form a very shallow sinus there. The suture line: the peripheral lobe is deep and broad, with parallel borders, and is markedly trifid; the peripheral saddles are broad and rounded; the lateral lobe V-shaped, and the lateral saddle obtusely rounded.

DIMENSIONS.—The specimen figured by Foord in Plate XLIIa., which is a medium-sized individual, measures in diameter 50 mm., and transversely 15 mm.

LOCALITY.—Carboniferous Limestone; Kniveton (Derbyshire), Clitheroe (Lancs.), Rathkeale and St. Doulaghs (Ireland).

OBSERVATIONS.—In full-grown examples, as de Koninck points out, this species resembles very closely *G. truncatum* Phill., but the latter has a much wider umbilicus. The sides of the periphery of *G. inconstans* are much more sub-quadrate, and the broad trifid median lobe of the suture is altogether different from that of *G. truncatum*. De Koninck also lays stress on the presence in young examples of *G. inconstans* of 3 or 4 radiating grooves which he evidently thinks do not occur in *G. truncatum*. These folds are not well understood, and as far as I am aware are not of specific value, but they certainly are present in some of the British specimens from Kniveton. A single large specimen labelled "Clitheroe" from the collection of the late James Spencer, of Halifax, now in my possession, I consider belongs to this species.

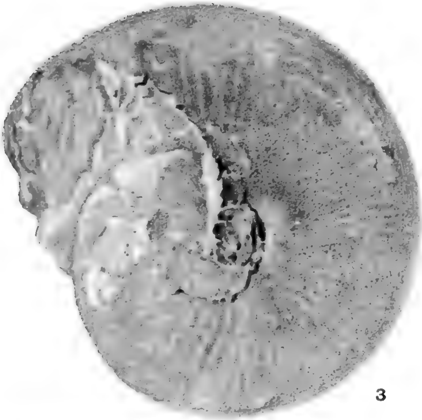
I would call attention to the suture line of *G. crassum* as figured by Foord, (*Carb. Ceph. Ireland*, Pl. XLII, fig. 10c); which is very similar indeed to that of *G. inconstans*. His species is from a Lower Limestone locality. In England *G. truncatum* is quite common in the *G. crenistria* zone, but Foord has recorded this species from Lower Limestone localities in Ireland. The actual horizon from which Phillips obtained his type specimen is obscure, as he only mentions Bolland, which is the name of a district where all horizons of the Lower Carboniferous beds occur. I have, however, collected specimens of *G. truncatum* only from the higher beds of the series at Black Hall and Cold Coates, near Chipping, and from D_2 beds at Castleton and Chrome Hill and Elbolton; and in Belgium from the upper beds of Visé. At Kniveton *G. inconstans* occurs with *Pericyclus fasciculatus*, and it is important to note that both species occur at Pauquys in Belgium—a much lower horizon than the Viséan.

GLYPHIOCERAS OBESUM Foord.

Glyphioceras (*Muensteroceras*) *obesum* Foord 1903; *Carb. Ceph. Ireland*, p. 196, Pl. XLIII, figs. 3 a-c.

SPECIFIC CHARACTERS.—Shell, large sub-globose, somewhat compressed, involute, more so in old age. Greatest thickness at umbilical margin. Height of outer whorl about one-third the diameter, broadly

Proc. Yorks. Geol. Soc., Vol. XIX., Plate XLII.
(To face page 360.)



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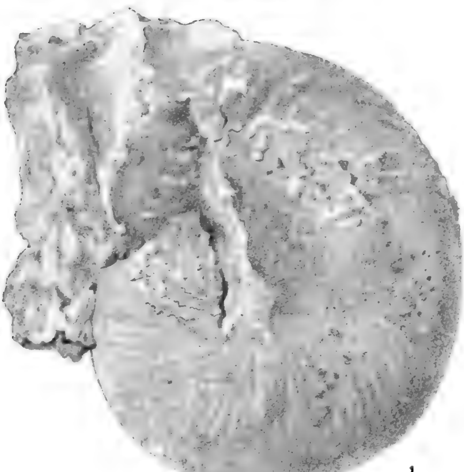

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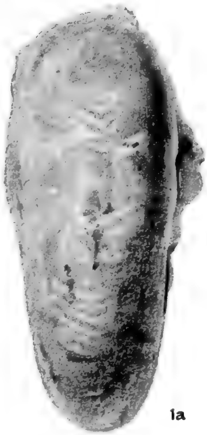

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elliptical in section. Umbilicus open, measuring about one-seventh the diameter of the shell. Whorl indented to about a half its depth by preceding. Periphery regularly convex. The sides very gently convex. Body chamber occupies a complete whorl. Chambers about 18 to the whorl. Suture line as in Foord (Pl. XLIII, 3b); external saddles high, and broadly rounded. Test thin and smooth.

Dimensions.—Transverse diameter 115 mm.; thickness of shell, ·65 mm.

Localities.—*Cyathaxonia* beds at Bradbourne (Derbyshire); Elbolton (Yorkshire).

Observations.—This species attains a larger size than any other British species of *Glyphioceras*. The suture shows an affinity to *G. sphaericum* Phill., but the shape of the shell is much more compressed and less globose in comparison with its diameter. The suture line at once separates this species from *G. crenistria* Phill. and *G. striatum* Sow. *G. obesum* Foord., has been obtained from Little Island (Co. Cork), from beds which I take from the fauna to be very high up in the Carboniferous Limestone series. *Prolecanites compressus* has been obtained there, which indicates the base of the Pendleside Limestone.

GLYPHIOCERAS CORPULENTUM Crick.

Glyphioceras corpulentum Crick., 1899; *Ann. Mag. Nat. Hist.*, Sec. 7, Vol. III., p. 447, Fig. 12. *G. corpulentum* Foord, 1903; *Carb. Ceph. Ireland*, p. 176, Pl. XLVII, figs. 1 a.b.; Pl. XLVIII, Figs. 1 a.c.

Locality.—Kniveton (Derbyshire), Zone C.

Observations.—It is unnecessary to repeat the full and detailed descriptions given both by Crick and Foord. It is important to note in the Kniveton Limestone the occurrence of this species, the types of which came from St. Doulaghs. I consider both these quarries to be on the same horizon. *Cœlonautilus pinguis* is present at both localities.

GLYPHIOCERAS COMPLICATUM de Koninck.

Ammonites complicatus de Koninck, 1842; *Descr. Anim. foss.*, p. 507, Pl. L, fig. 8.

Goniatites complicatus Bronn, 1848; *Gesch. d. Natur*, Vol. III., p. 541. *G. complicatus* de Koninck, 1882; *Ann. Mus. Roy. d'Hist. Nat. de Belgique*, Vol. V., *Fauna Calc. Carb.*, Pt. II., p. 105, Pl. L, figs. 4-4c. *G. complicatum* Hyatt, 1884; *Proc. Boston Soc. Nat. Hist.*, Vol. XXII., p. 329. *G. complicatum* Foord and Crick, 1897; *Cat. Foss. Ceph. Brit. Mus.*, Pt. III., p. 208, fig. 99.

LOCALITIES.—Castleton and Bradbourne (Derbyshire).

OBSERVATIONS.—It is unnecessary to re-describe this species as Foord and Crick have already done so (*op. supra cit.*), but no British specimen has been figured. The suture line is very distinctive, and the cameræ are very shallow and numerous. The species is not at all common. I noted its occurrence at the above localities in my paper on "The Distribution of the British Carboniferous Goniatites." *Geol. Mag.*, Dec., VI., Vol. V., p. 443, 1918.

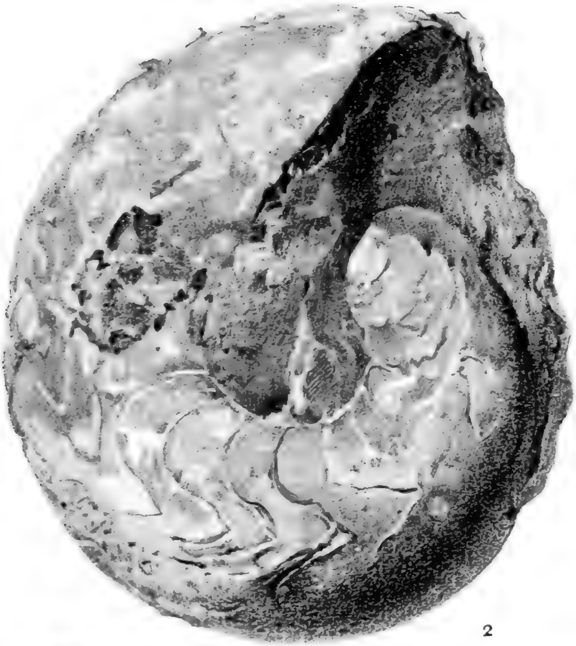
The angularity of the peripheral lobe shows an affinity to *G. crenistria*. The specimen described by Foord and Crick was obtained from Visé (Belgium).

EXPLANATION OF THE PLATES.

Plate.

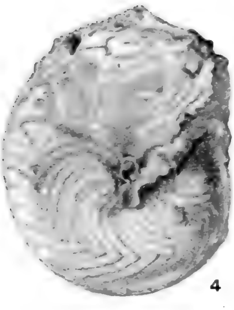
Fig. 1. —*Glyphioceras inconstans* de Koninck.
Fig. 1a —*Glyphioceras inconstans*, in profile.
Fig. 1b.—*Glyphioceras inconstans*, suture line.
Fig. 2. —*Glyphioceras obesum* Foord.
Fig. 2a.—*Glyphioceras obesum*, suture line.
Fig. 3. —*Glyphioceras corpulentum* Crick.
Fig. 3a.—*Glyphioceras corpulentum*, in profile.
Fig. 4. —*Glyphioceras complicatum* de Konink.
Fig. 4a.—*Glyphioceras complicatum*, in profile.
Fig. 4b.—*Glyphioceras complicatum*, suture line.

All illustrations natural size, except 4b, which is slightly enlarged.



2

2a



4

4b

4a

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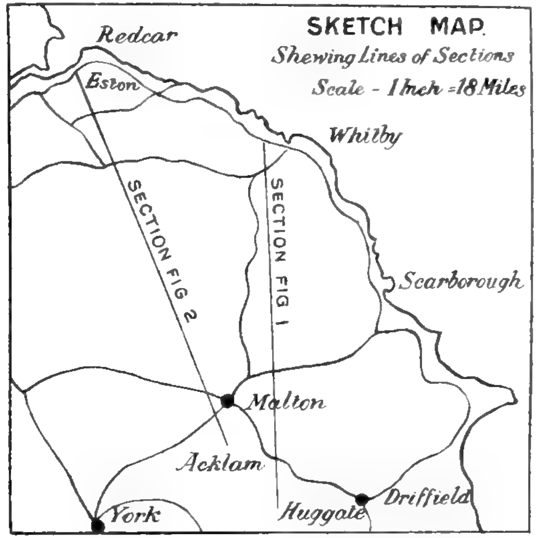


FIG 1. RELATIVE POSITION OF SEDIMENTARY PLANES IN THE YORKSHIRE JURASSIC ROCKS BETWEEN HUGGATE AND SANDSEND AS MEASURED FROM A HORIZONTAL RHAETIC BASE

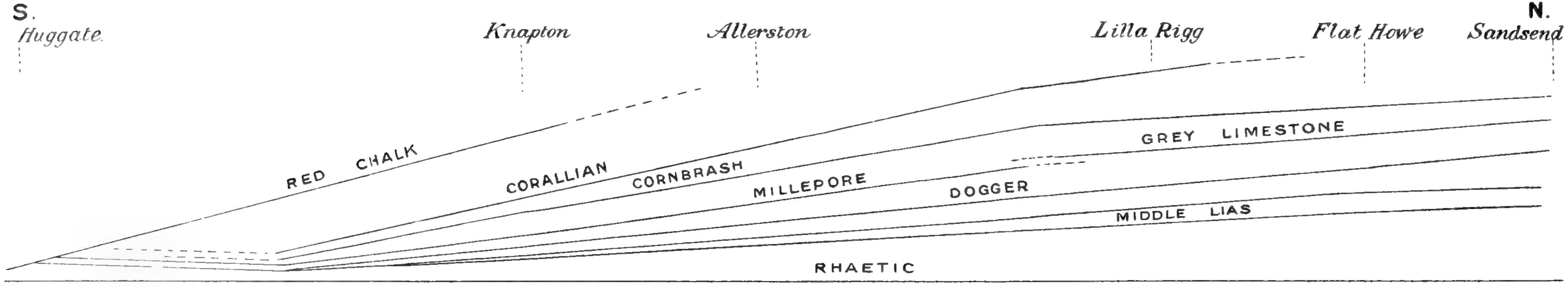
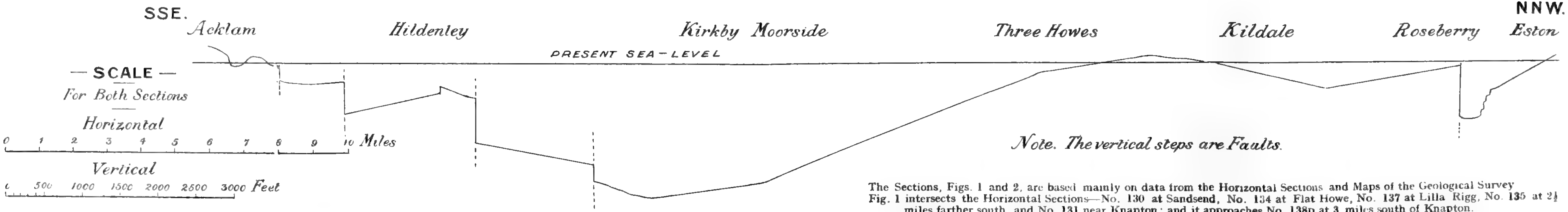


FIG 2. ESTIMATED PRESENT POSITION OF THE RHAETIC BETWEEN ACKLAM BROW AND ESTON.



The Sections, Figs. 1 and 2, are based mainly on data from the Horizontal Sections and Maps of the Geological Survey

Fig. 1 intersects the Horizontal Sections—No. 130 at Sandsend, No. 134 at Flat Howe, No. 137 at Lilla Rigg, No. 135 at 2½ miles farther south, and No. 131 near Knapton; and it approaches No. 138D at 3 miles south of Knapton.

Fig. 2 runs near and parallel to No. 132 from Eston to Kildale; and it intersects No 134 at Three Howes, No 137 at Kirkby Moorside, No 138C near Hildenley, and No. 139 at Acklam

ON DIFFERENTIAL EARTH-MOVEMENT IN NORTH-EAST YORKSHIRE DURING THE JURASSIC PERIOD.

By G. W. Lamplugh, F.R.S.

Presidential Address.

(Read at York, November 16th, 1921.)

In dealing with the structure of the Weald three years ago, in a Presidential Address to the Geological Society of London, I referred briefly to the wedge-like arrangement of the Jurassic rocks of Yorkshire, and mentioned that these deposits, like those of the south-country Weald, yielded evidence that they similarly were accumulated in a slowly sinking trough.* On the present occasion I propose to enter into some of the particulars relating to this matter, and to apply to the Yorkshire Oolites the method adopted for the Wealden rocks.†

There is nothing novel in the method. It was applied by Mr. Cosmo Johns to the Coal Measures of Yorkshire in a suggestive paper published by our Society in 1906;‡ but, so far as I am aware, it has not previously been tested in respect to the Yorkshire Jurassic sequence. It is simple in essence, and may be stated as follows:—

> When a particular bed in a stratified sequence bears evidence of having been deposited at the same depth, and at about the same time, over a wide area, it marks a plane originally parallel to the sea-level of its period—*i.e.*, a plane of horizontality.
>
> When several beds of this kind occur at intervals in the sequence and are not parallel to each other, we must infer that there has been relative change in the local plane of horizontality during the accumulation of the sequence, and we are enabled to determine the direction and amount of the change.

Glacial and Post-Glacial marine beaches have long been recognized as affording data of this kind; and the beaches of older periods would be equally useful if we could be sure of their synchronism throughout their extent, which is often doubtful. Estuarine or brack-water

---

* *Quart. Journ. Geol. Soc.*, Vol. LXXV. (for 1919), pp. lxxxvii-ix.

† "On the Mesozoic Rocks in some of the Coal Explorations in Kent," by G. W. Lamplugh and F. L. Kitchin. *Mem. Geol. Surv.*, 1911, pp. 88-94.

‡ "On Differential Earth Movements during Carboniferous Times, etc." *Proc. Yorks. Geol. Soc.* for 1905. N.S., Vol. XV., pt. iii., pp. 372-9.

bands, whether intercalated in a marine or in a fresh-water series, are perhaps the surest indications of ancient planes of horizontality, since they must have been accumulated at or close to the sea-level of the period and are frequently continuous over wide areas. Coral-reefs and similar zoögenetic beds composed of organisms that thrive within narrow limits of depth are likewise serviceable; and we can find also other extensive marine deposits, particularly among those of the calcareous sandstone type, which possess faunal and lithological characters indicative of an even sea floor.

On the other hand, some limestones and most shales or clays, unless carrying an estuarine fauna, are not safe indications of level, as they may have been deposited at variable depths on a sloping or irregular floor.

When the change of relative level within a given district has been considerable in the interval between the deposition of two originally horizontal beds, a definite unconformity may have been developed by the erosion of the uptilted portion of the lower band before the higher band was accumulated. More commonly, the displacement has not been sufficiently great to produce this result, and the inequality has been levelled up by the precipitation of thicker sediments over the depressed area; so that the strata between the bands form a blunt wedge, of which the thick end indicates the area of greatest depression.

When several index-beds of horizontality can be detected in an unbroken sequence of deposits, the intervening wedges of strata will show whether the movement was constant in direction, and will give its vertical measure between any two of the planes.

Index-Planes in the Yorkshire Jurassic sequence.

There are several planes within the Yorkshire Jurassic sequence for which, with certainty, we may postulate former horizontality, and others which we may place in the same category with fair confidence. They are fortunately so distributed as to give us an insight into events through almost the whole of the period; and their evidence points consistently to the predominance of downward movement in one quarter from beginning to end, in spite of some minor local oscillations. This differential movement was superimposed upon the wider general movements affecting the area in common with other regions during the period.

Starting at the bottom, we have in the Rhætic beds a typical example of horizontal sedimentation. From their faunal and lithological characters, we recognize that these beds were deposited in a shallow sea which invaded a broad inland basin already levelled up with the sediments of a salt-lake constituting the Keuper Marl. Though sparingly exposed, these Rhætic beds are believed to extend unbrokenly beneath the Lias from the Tees to the Humber. Therefore they afford a most convenient basal plane from which to reckon Jurassic earth-movement.

The Gryphæa-beds of the Lower Lias and the Pecten-beds of the Middle Lias carry evidence of original uniformity of depth over a wide area, and afford information as to the progress of the movement during Liassic times.

The Dogger at the base of the North Yorkshire Oolites usually marks a break in the sedimentary sequence; but in the coast-sections at Blea Wyke the transition from Lias to Oolites is gradual, through passage-beds which indicate progressive shallowing of the Liassic sea. The irregularities produced at the close of the Liassic period by tilting and perhaps locally by faulting appear to have been levelled up by the Dogger; so that, although its base is uneven, its top may be accepted with fair confidence as originally a horizontal plane, on which the lowest beds of the Estuarine Oolites were accumulated. The relation of this plane to that of the Rhætic affords us a useful measure of the net displacement during Liassic times.

The relatively thin Marine Bands intercalated with the masses of estuarine or fresh-water sediments which form the major portion of the Lower Oolites of North Yorkshire have long been recognised as having been deposited in shallow water during wide-spread incursions of the sea on a subsiding tract. They are three in number—the Ellerbeck Bed, with its southern equivalent, the Hydraulic Limestone; the Millepore Bed; and the Scarborough or Grey Limestone; and though their value is somewhat impaired by the fact that they are not continuous over the entire area, they furnish us with three trustworthy and complementary datum-planes fulfilling all the required conditions. For generalizing purposes, it will be most convenient to take the Grey Limestone in the northern part of the area and the Millepore Bed in the southern part as representative of the three, since all three yield practically the same evidence. Some points of minor consequence, with which I do not propose to deal, may, however, be deduced from the relations of the three planes to each other in passing across the district.

At the top of the Lower Oolites, I think that we may take the base of the Cornbrash with fair confidence as having been originally horizontal. The position and persistency of the Cornbrash at the top of the Estuarine series leave no doubt that it represents a wide encroachment of the sea over the estuarine or fluviatile flats; and its relation to the overlying sandy Kellaways Rock points to the persistence of shallow and uniform conditions on the sea-floor of the period.

In the Middle Oolites, the Oxford Clay affords little or no indication of relative levels, but the Corallian series unmistakably denotes shallow-water conditions. Perhaps the best criterion in this series is the horizon of the coral-reefs—the Upper Corallian limestone and Coral Rag—which must have been everywhere close to the sea-level of the period; and although the reefs may not have been strictly contemporaneous throughout the district, the earth-movements within the narrow time-limits of the reef-formation were too small to be appreciable in the present discussion.*

The remainder of the Jurassic sequence in Yorkshire is represented by clays—the Kimmeridge Clay and the doubtful Portlandian of Speeton—which were deposited in seas of some depth and probably on a shelving floor, so that they contain no plane on which we can depend. They are, however, shaved off southward into a wedge, in common with all the Oolites, by the great unconformity of the Upper Cretaceous rocks.

The conglomeratic Red Chalk under the Western Wolds, which passes unconformably across well-nigh the whole of the Jurassic sequence in approaching the crest of the pre-Upper Cretaceous anticline near Market Weighton, was probably at first nearly, if not quite, horizontal; but although so thin, the accumulation of this band appears to have covered a long period of time, and may not have been exactly contemporaneous in all parts of the district. We cannot tell what thickness of the Kimmeridge Clay was deposited over the site of the anticline, where it is now absent; but from the indications obtainable where the formation sets in again on the southern side of

* For purposes of calculation of thickness it is convenient to include the Upper Calcareous Grit with the other Corallian rocks, as I have done in the summary, p. 393; but the plane shown in the diagram (Fig. 1) is drawn at the top of the limestones.

the anticline towards the Humber, we may be fairly certain that it was never anything like so thick on the crest as in the Vale of Pickering. In any case, the Upper Cretaceous unconformity itself proves that the northern area was still further depressed relatively to the south during the closing stages of the Jurassic, and probably also during a large part of Lower Cretaceous times, while the Speeton Clays were being deposited. We may therefore, I think, use the Red Chalk as a datum-plane to round off our investigation; but its value is impaired by the fact that it now remains in the southern part of the district only, and cannot safely be assumed to have maintained the same attitude in its former northward prolongation.

For the purpose of analysing the inter-Jurassic movements, it will suffice to consider the following six planes, as the others enumerated are less conveniently spaced, besides merely repeating the evidence.

6. Red Chalk.
5. Corallian Limestones.
4. Cornbrash.
3. (*a*) Millepore Bed (southern area); (*b*) Grey Limestone (northern area).
2. Dogger.
1. Rhætic.

Relative Position of the Planes.

We fortunately possess full data respecting the position of the planes in the admirable series of Geological Survey maps, sections, and memoirs embodying the work of the late C. Fox-Strangways and his colleagues; and the exceptionally close contouring (25 feet intervals) of the 6-inch Ordnance maps, the basis of the geological work for this district, affords unusual facility for calculating the levels from the position of the outcrops. The published "Horizontal Sections" of the Geological Survey in particular show the relations of most of the planes, on a true scale, in various directions across the district. But on these long sections, drawn to the same scale vertically as horizontally, it is impossible to bring out distinctly the salient points of the structure as a whole, not only because of the scale, but also because the dominant characters are frequently obscured by local accidents of undulation and faulting. To render the matter explicit, a diagrammatic treatment of the facts is requisite, with the elimination of local circumstance and a considerable exaggeration of the vertical scale. This has been done to some extent, and piecemeal, by Fox-Strangways, in a series of plates in his General Memoir on the Jurassic Rocks of Yorkshire;* also on more general lines by Professor P. F. Kendall in his Report on the Concealed Coalfield,† in which he illustrates the Jurassic wedges and shows their disposition in respect to the Market Weighton anticline.

My further treatment of the subject will be based almost entirely on the Survey records to which I have referred. In the diagram, Fig. 1 (Pl. XLIV.), I have plotted the thickness of the strata between the several planes, with a vertical exaggeration of 26, on a north-south line of about 36 miles running from the coast at Sandsend, west of Whitby, to the neighbourhood of Huggate, near Pocklington. The line selected is that of Longitude West 0° 40′, but any parallel line for several miles eastward or westward would yield nearly the same section.

Most of the Jurassic sediments attain their maximum thickness shortly before reaching the northern end of this section and dwindle slightly towards its termination, as is shown by the flattening of the curves. If the section had been drawn farther westward, to start from the coast near the mouth of the Tees, it would have added 6 or 8 miles to the length shown, and the additional portion would have presented a more decided northward contraction from the maximum thickness.

In the diagram, I have plotted the lowest plane—that of the Rhætic — as a level-course, and have adjusted the higher planes to the positions they would occupy if the Rhætic still lay horizontally under the whole area. Owing to the much greater thickness of the superjacent strata in the north, where the succeeding planes up to the Corallian are spaced out in a column of about 2300 feet, as against less than 300 feet in the south, this arrangement gives to all the higher planes a southward inclination, steadily increasing in amount in upward order. But we know that each plane in turn was originally horizontal;

* "The Jurassic Rocks of Britain, Vol. I., Yorkshire." *Mem. Geol. Surv.*, 1892.

† "Royal Commission on Coal Supplies," Appendix III., Final Report, 1905, pt. ix.: "Sub-report on the Concealed Portion of the Coalfield of Yorkshire, Derbyshire and Nottinghamshire," pp. 19-24, 28, and Plate VII., Fig. 4.

and when in this position, any plane buried below it must have had an opposite or northerly inclination.

The varying conditions can indeed be roughly exemplified by the diagram, if it be pivotted at a point near the southward end of the section where most of the planes if prolonged would intersect. Thus pivotted, it can be rotated to bring any desired line to horizontality, and will then show the relative positions of the others. If one of the middle planes, say that of the Grey Limestone or of the Millepore Bed, be placed horizontally, the dip of the beds above and below it will be in opposite directions, although there is no pronounced break or unconformity in the stratification. The reversal of dip thus revealed depends entirely upon the relatively greater thickness of the strata, both above and below the plane, at the northern end of the section. In the diagram the discordance of dip is, of course, greatly intensified by the exaggeration of the vertical scale; it is really slight, and to be reckoned in feet per mile rather than in angular degrees; in fact the cumulative effect of the whole wedge from bottom to top would yield a dip of barely 1°. None the less, its consequences as a factor in the stratigraphy of the region are important.

Rendered in terms of feet per mile, the following are the average southward dips of the Jurassic planes in the northern 30 miles of the section, reckoned from a horizontal Rhætic base:—

Corallian—about 63 feet per mile (=1 in 84).
Cornbrash—about 50 feet per mile (=1 in 105).
Grey Limestone and Millepore—about 43 feet per mile (= 1 in 123).
Dogger—about 36 feet per mile (=1 in 146).

Interpreting the course of events from the relations of these planes, we perceive that between the Rhætic period and that of the Dogger the subsidence in the north had been over 1000 feet greater than that in the south, and continued in about the same proportion throughout the period of the Lower and Middle Oolites, so that by Corallian times the northerly subsidence had reached about 2100 feet more than in the south, with a further increase of uncertain amount during the Kimmeridgian period.

These figures do not, however, give the full measure of the depression, as they leave out of account the vertical contraction which must have occurred in the column of sediments during their consolidation.

The hard dry shales of the Lias and Oolites in their present state must represent a much greater thickness of the original clay-sediment, and even the sandstones must have shrunk, though to less degree, in parting with the water of sedimentation. The shrinkage began, no doubt, almost as soon as the beds were deposited; it may indeed have aided in producing the effect of slow subsidence in the basin when the deeper crust-movement was temporarily in abeyance. But the process must be gradual and continuous, and is probably still to some slight extent operative. Its measure as between one period and another cannot be computed; but I should think that we might safely make an average addition of 10 per cent. to the present measurements on this account.

The subsidence reached its maximum in an oval tract truncated by the present coast between Scarborough and Whitby. It diminished gradually westward and northward, but in these directions the recession of the outcrops has greatly reduced the evidence as to the original limits of the depressed tract.

General Deductions.

The probability that high land bordered the Jurassic basin at no great distance on the north and west has long been recognised,* and is fully discussed by Fox-Strangways in his General Memoir on the Yorkshire Jurassic Rocks.† The westerly thinning of the sediments is well displayed in three "Horizontal Sections" of the Geological Survey, which run east-and-west, to wit, Nos. 134, 136 and 137, particularly in the last; it is also brought out clearly in some of the "Comparative Sections" in the above-mentioned Memoir (Plates III., IV. and V.). Near the western escarpment in the Hambleton Hills the Lias is shown to be at least 700 feet thinner than in the eastern coast-sections, and the Lower Oolites 200-300 feet thinner. In the Middle Oolites, so far as they can be compared, there is less difference; but the sequence in the Hambleton country is incomplete.

The eastward prolongation of the trough or basin lies beneath the North Sea and cannot be followed; but its longer axis appears to have trended approximately W.S.W. to E.N.E.

Judging from the position and characters of the Speeton Clay and

* *e.g.* A. J. Jukes-Browne, "The Building of the British Isles," 2nd ed. Lond., 1892, pp. 222-237 and pl. viii.

† *Mem. Geol. Surv. supra cit.* Chap. XVI., pp. 383-407.

of the patches of Lower Cretaceous Sands beneath the Chalk of the Western Wolds, it is probable that the relative depression of the basin was continued, and perhaps accelerated, during Lower Cretaceous times, and did not cease until after the whole region was invaded and sunk beneath the wide waters of the Chalk sea.

The later history of the area must rest for the most part on surmise, as it embraces a period of long-continued uplift and erosion, during which the original bounds of the strata have been everywhere greatly reduced, and the evidence of the process constantly blotted out as the surface was lowered. The complete removal of the cover of Chalk from the northern tract debars us from any certain knowledge of the state of that region at the close of Upper Cretaceous times; but the known thinning of the Lower Chalk northerly and westerly in the Wold country,* along with some hypothetical considerations which may be left unstated for the present, suggest that the deepening of the northern basin had ceased then, and was giving place to a relative uprise. Some traces of this counter-movement are perhaps still to be found in the low anticline which strikes inland westward from Robin Hood's Bay through the deepest part of the old depression.

In many features, the structure recalls that of the Weald of Kent, where the present anticline is superimposed upon an underground syncline; but with this difference, that in Yorkshire the whole basin has been tilted up, so that all the once-horizontal planes within it are now inclined, whereas in the Weald the final result of the movements is that one of the medial planes is now once again horizontal, or nearly so, over a considerable tract.†

If at the beginning of Tertiary times the column of Chalk above the Oolites of the present Moorland country was as thick as that now existing in Holderness and the Wold country (supposed to be 1400-1500 feet ‡), the total thickness of strata above the Rhætic would be about 4000 feet in the north and about 1750 feet in the south. But the present position of the rocks shows that the Tertiary uplift has been

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* W. Hill, "On the Lower Beds of the Upper Cretaceous Series in Lincolnshire and Yorkshire." *Quart. Journ. Geol. Soc.*, Vol. XLIV. (1888), pp. 320-366.

† See "The Structure of the Weald and Analogous Tracts." *Pres. Address Geol. Soc.*, 1919, *supra cit.*, Plate of Sections.

‡ *See* "On a Boring at Kilnsea, Holderness," in *Summary of Progress of Geol. Surv. for* 1918, p. 63 and *The Naturalist*, February, 1920, p. 64.

greatest in the Yorkshire area where the Secondary strata were thickest; and it is the same in the Weald and in the South Midlands of England. We may call in the weight of the sediments to explain the progressive deepening of the basin, but the idea fails us, here as elsewhere, when we come to deal with the whole history of the area. If, under certain conditions, extra weight be operative in the production of such basins, its operation is clearly not cumulative, and can be overpowered and obliterated by other factors, whatever these may be.* In applying this "theory of isostasy" (as it is sometimes called), there is obviously a danger of confusing cause and effect. Sediments would tend to accumulate within a basin lying in their path, whatever its origin; and they would continue to gather there so long as it continued to deepen. How are we to distinguish between a case in which the position of the sediments is due to the presence of the basin, and one in which the position of the basin is due to the presence of the sediments?

Reverting to the diagram Fig. 1, it is obvious that when the Upper Cretaceous plane was horizontal, all the underlying Jurassics in the line of section must have had a northerly dip, if we may rule out the uncertain factor of concealed pre-Cretaceous faulting. Therefore the present general southerly dip of the Lias and Oolites between the valley of the Esk and the Vale of Pickering, if measured from the horizontal, does not give the full value of the relative northern uplift, but requires to be supplemented by the amount of the previous opposite dip. The northern upheaval appears to have pivotted on nearly the same hinge-line as the preceding subsidence, and regained in this quarter more than was lost. But it has not wholly obliterated the original basin. The bold westerly bulge of the Jurassic outcrops between the Tees and the Humber is to some extent indicative of the position of the deeper part of the basin; and this is still more clearly displayed if we plot the present profile of the Rhætic plane along a line drawn south-south-eastward from the mouth of the Tees to the western corner of the Chalk escarpment, as I have done in Fig. 2 (Pl. XLIV.). This plane has, of course, been affected by every movement

* Some of these difficulties in the theory of isostasy have been recently discussed from the physicists' standpoint by Dr. H. Jeffreys, in a speculative paper "On Certain Geological Effects of the Cooling of the Earth," *Proc. Roy. Soc.* Series A, Vol. 100, No. A703 (1921), pp. 122-149.

since Rhætic times, and its present position shows the net result of all the movements. Its synclinal attitude, now interrupted toward the north by the superimposed anticline of the northern moorlands and by the Guisbrough trough, is the residue of the deeper syncline before the Tertiary uplift. It will be noticed that the deepest part of the depression still coincides nearly with the tract in which the Oolitic sediments attained their maximum thickness.*

Summary and Conclusion.

To sum up the course of the events which we have traced with the help of the planes, we may recognise :—

1. A horizontal floor throughout the north-eastern part of Yorkshire during the deposition of the Rhætic beds.
2. A subsidence during the period of the Lias, with a tilting of the floor downward to the north, so that at the close of the period it was over 1,000 feet lower in the north-east than in the south-west.
3. A continuance of the same unequal subsidence during the period of the Lower Oolites, bringing the extreme difference of level up to 1600 feet.
4. Toward the close of the period of the Middle Oolites the difference had increased to about 2100 feet.
5. A further increase of the depression during the period of the Upper Oolites and until Upper Cretaceous times, but the amount not now directly ascertainable; the maximum depth of the depression, however, was probably not less than 2500 feet.
6. A reversal of the process during the Tertiary epoch, with a relatively greater uplift of the country in the north than in the south, obscuring and partly obliterating the original arrangement.

* Incidentally, the plotting of the Malton group of faults north of Acklam, from the data on the Geological Survey maps and sections, brings out the circumstance frequently to be observed in much-faulted districts, that the *average* inclination of the dominant folding-structures is hardly altered at all by the step-faults, the local effect of the faults being counteracted by a reduction, or reversal, of the dip in the blocks of strata between the faults. There is probably some complementary faulting on the northern slope of the hollow, where none is shown; the presence of Kimmeridge Clay at the surface above this slope is unfavourable for the detection of faults.

The inference to be drawn from these considerations is that there was a persistent south-eastward land-border to the Jurassic basin somewhere in the region now covered by the Chalk, and that in this region the concealed Jurassic strata are likely to continue to decrease in thickness as they recede beneath the Chalk, just as they are known to do in Kent and the Eastern Midlands. Deep borings in South-eastern England have proved that the wedge of pre-Cretaceous Secondary rocks thins out entirely before reaching the East Coast between Northern Kent and Norfolk, so that Palæozoic formations are found in this quarter immediately beneath the Cretaceous strata, and at much less depth than in the area beyond the Chalk escarpment. How far northward this condition may extend we do not know as yet, but it is hardly likely to swing north-westward far enough to catch the south-eastern corner of Yorkshire. Nevertheless, it is not probable that the thickness of the Jurassic rocks would be formidable in an exploratory boring anywhere between the South Holderness coast and the western edge of the Wolds. Unfortunately the same cannot be postulated for the New Red rocks (Trias and Permian). These are usually absent in the South-east of England, but are likely to be very thick under the Wolds and Holderness, judging from the results of the Market Weighton and other borings in the low ground bordering the upper reaches of the Humber.* In fact these results appear to denote that the Market Weighton anticline may itself mark an uplift over the deepest part of an infilled Triassic basin, comparable to the uplift of the Yorkshire Jurassic basin and of that of the southern Weald. But we need a bold and persevering plunge with the boring-rods east of the Wolds before we can complete the Mesozoic history of the county; and the plunge should be worth making for the practical knowledge it would give us, even though it should yield no results of immediate commercial value. If there be a man of means to do this for us, he may at least count upon our thanks, should no other reward be forthcoming.

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* W. Gibson, "On a Deep Boring near Market Weighton." *Summary of Progress of the Geological Survey for* 1917, pp. 42-45: also "The Concealed Coalfield of Yorkshire and Nottinghamshire." *Mem. Geol. Surv.*, 1913 (Selby, Barlow, Carlton, Thorne and other borings).

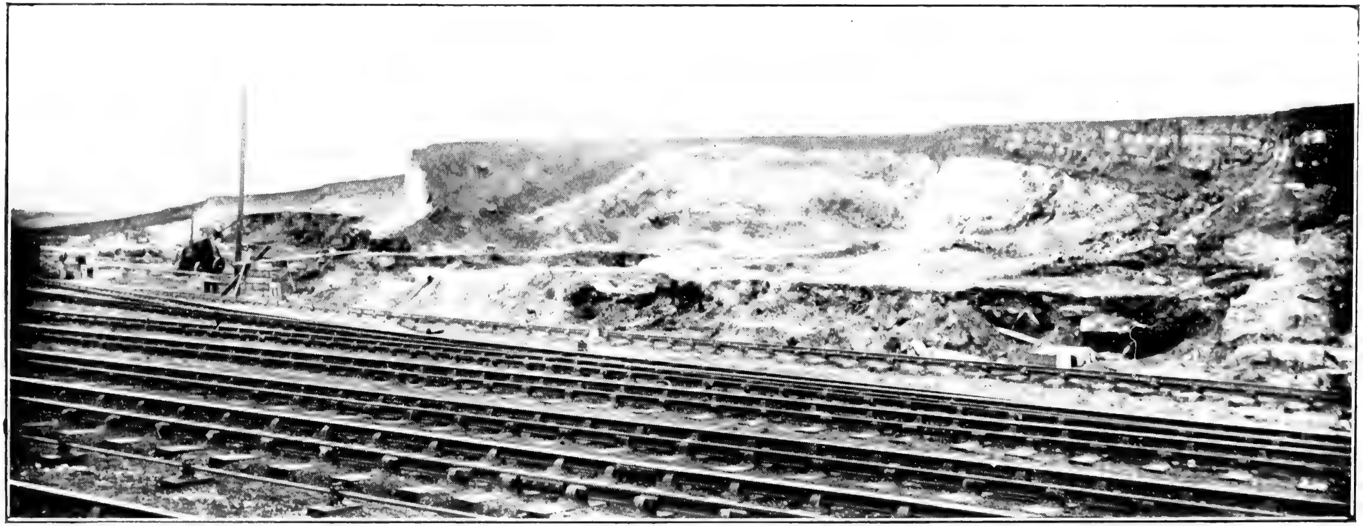

Photo by] SOUTH CAVE SECTION: GENERAL VIEW. [*J. T. Dyson, Hull.*

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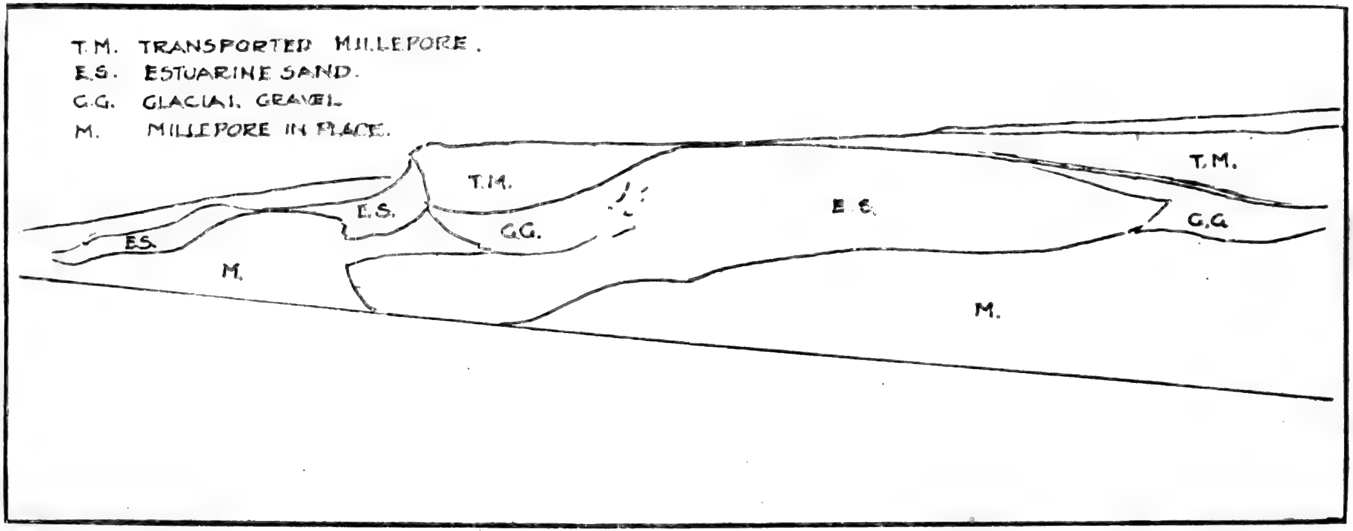

T.M. TRANSPORTED MILLEPORE.
E.S. ESTUARINE SAND.
G.G. GLACIAL GRAVEL
M. MILLEPORE IN PLACE.
T.M.
E.S.
G.G.
M.
T.M.
E.S.
G.G.
E.S.
M.

ON A PECULIAR DISPLACEMENT IN THE MILLEPORE OOLITE NEAR SOUTH CAVE.

By J. W. Stather, F.G.S.

A section in the Millepore Oolite on the Hull and Barnsley Railway, close to South Cave Station, and on the south side of the line, was described in 1883 by Keeping and Middlemiss* as follows :—

"The cutting now entered is twelve feet in the highest part and 792 feet long. The rock is uniform in character—being a characteristic well-bedded Oolite, quite like the Millepore Oolite of the Howardian Hills. Oolite grains form the mass of the rock."

The beds of this cutting have been recently excavated on an extensive scale by The Grey Stone Company, Ltd., and the quarrying back of the limestone has revealed some unexpected features.

The most important of these is the occurrence of an irregular band of flinty and chalky rubble-drift, beneath a mass of displaced Millepore limestone, partly shattered, but in some places maintaining its original bedding, so that except for the evidence of the section it might have been regarded as *in situ*.

The Millepore Oolite and Estuarine Sands.

In working back into the hill, the section rapidly increased in height, and the sands of the Estuarine Oolite and Kellaways Rock,† normally overlying the Millepore in this district, set in at the top, and in some parts of the section rapidly attained as much as 14 feet in thickness. The sands appeared to be disturbed, and were unevenly distributed, in some places occupying hollows in the underlying Millepore, apparently due to displacement of some kind. The Millepore Limestone itself shewed unmistakable signs of disturbances, for, though the main lines of bedding are well maintained, they are almost throughout the section bent and shattered, shewing open joints, cracks and large cavities. It seems likely that this condition is due to irregular slipping of the Millepore beds down the hillside into Drewton Valley, and this explanation becomes all the more probable when we remember that the Millepore Limestone is here underlain by wet and slippery

* *Geol. Mag.*, dec. II., Vol. X., p. 216.

† Fox-Strangways, *Jurassic Rocks of Britain*—Yorkshire, Vol. I., pp. 260 and 290.

Lias shales, and that the thin Lower Estuarine Clays and sands which usually underlie the Millepore* appear to be absent at this point. The Lias shales were well seen in a large trial hole, twelve feet below the floor of the quarry, and the following fossils were collected from them :—*Protocardia truncata* (J. de C. Sow.), *Pholodomya* cf. *ambigua* J. Sow., *Pleuromya costata ?* Y. and B., *Ceromya ?*

The displacements in the lower part of the section appear to be quite independent of the curious complications in the higher part associated with the rubble drift, and are probably of earlier date.

The Rubble-Drift.

The lowest drift-deposit is an irregular band, ranging up to 6 ft. in thickness, and consists of fragments of flint and chalk up to several inches in diameter, along with occasional pieces of Red Chalk and some larger fragments of Millepore Limestone, set in a matrix of gritty chalk-wash like that seen underneath the drifts in some of the deeper hollows of the Chalk on Flamborough Head. The band first made its appearance when the quarry had been cut back a few feet from the original face, and it is not continuous at present through the whole of the section.

A few stones foreign to the district have been found in this material. Prof. P. F. Kendall, M.Sc., has kindly examined five of these, and remarks as follows :—

No. 1.—Quartz porphyry, origin unknown.

No. 2.—Crushed and sheared granite, origin unknown; not English, but may be British.

No. 3.—A fine grained felsite with tourmaline.

No. 4.—Decomposed porphyrite of the Cheviot type.

No. 5.—Red Sandstone; might have come from Millstone Grit or Old Red.

The Clay Band.

Usually at the top of this chalky rubble-drift there are a few inches of dark blue or blackish clayey material of problematic origin. On washing this clay, it is found to contain fragments of a small *Pentacrinus*, which suggests that the material has been derived from

* *Ibid.*, p. 204.

the Lias occurring below the Millepore rock. Some minute tubular cavities in the clay are suggestive of rootlets of vegetation such as might indicate an old land surface, but no carbonaceous matter has been found, or any other proof of land conditions. The clay band is in some places crumpled and contorted.

This clay-seam beneath the displaced sheet of limestone has apparently formed the gliding plane on which the limestone has slid.

The Displaced Millepore Limestone.

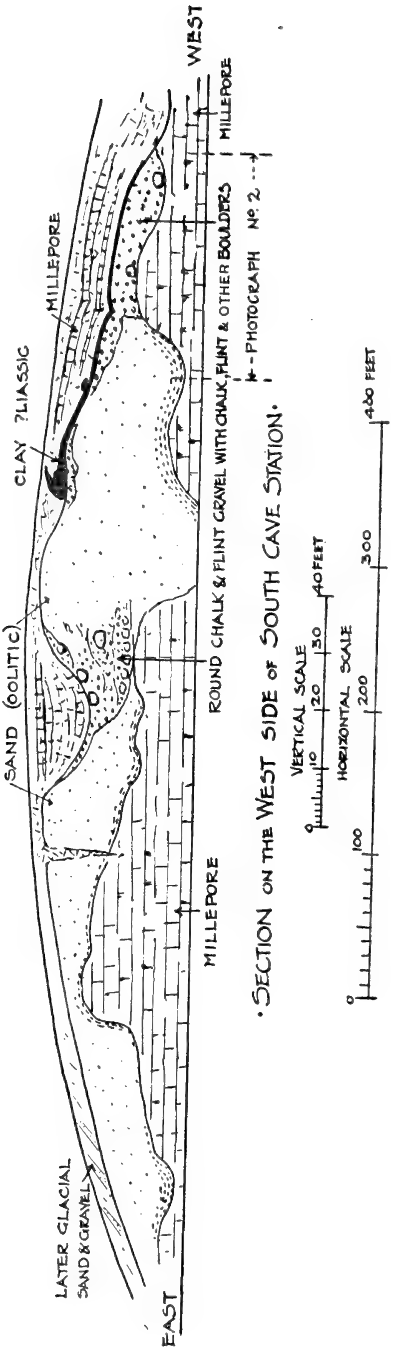
Immediately above the clay band, there was in October, 1920, a displaced sheet of Millepore Oolite—sometimes shattered, sometimes in long tabular bedded masses—extending to the top of the section as seen at present. In thickness this displaced Oolite varied from 3 feet to 12 feet, and was seen for a length of 300 feet.

The presence of the Millepore limestone in this situation, not only above the chalky rubble, but also above the Estuarine Sand, can only be explained by supposing the limestone has been carried over the newer deposits by some transporting agency, presumably Glacial. There is no place in the immediate neighbourhood from which the Millepore Oolite could have slipped by gravity into its present position.

During the past two years the face of the quarry has been carried back at least ten yards, and the sections exposed have been constantly under observation. As might be expected, the Millepore beds at the base and the Sands above them, owing to their disturbed and shaken condition, have shown constant change in detail as the section was cut back, but they have maintained their relative positions. The rubble-drift also has shown much variation in thickness and arrangement. On the other hand, the narrow band of clay above the drift has shewn little alteration, and has persisted uniformly underneath the displaced slabs of Millepore. The displaced limestone itself has gained in thickness and regularity as the excavation has been carried deeper into the hill.

It would be premature to attempt at present a complete explanation of this puzzling section, as the full extent of the displacement has not yet been disclosed. It is, however, now evident that the complications include two distinct factors :—

(1) The confusion due to the irregular downward movement of the Millepore beds, caused by slips or creep over the shaly Lias, brought



·SECTION ON THE WEST SIDE OF SOUTH CAVE STATION·

Photo by] SOUTH CAVE SECTION: NEAR VIEW. (II.) [*J. T. Dyson, Hull.*

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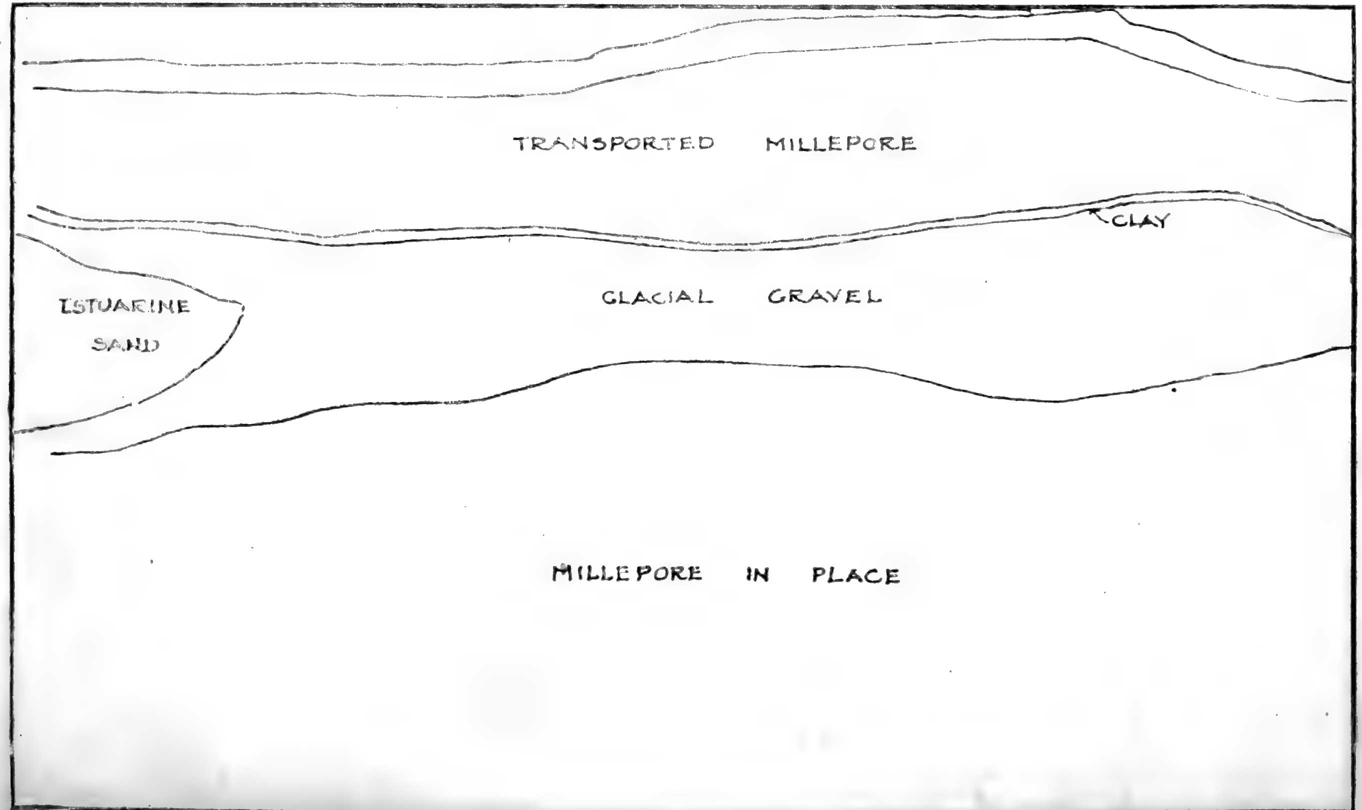
TRANSPORTED MILLEPORE
CLAY
GLACIAL GRAVEL
ISTUARINE
SAND
MILLEPORE IN PLACE

about by the action of springs and the erosion of the valley of the Drewton Beck. There is likewise the possibility of the rocks being affected still earlier by a small strike fault.

(2) A later displacement of the sheet of Millepore Oolite above the Glacial rubble at the top of the section, which must apparently be attributed to some kind of Glacial action.

As to the mode of this Glacial action, no conclusion can at present be reached. The absence of boulder clay and the predominance of local detritus in the gravelly drift tell against the supposition that the transport is the result of the direct impact of the great Eastern Ice-sheet. It has, however, long been postulated that when the estuary of the Humber was blocked by this ice-sheet—of which the boulder clay at North Ferriby is believed to mark the moraine—the low ground west of the Yorkshire Wolds must have been occupied by a lake, to which the name "Lake Humber" has been applied.* There are several features in the South Cave section which suggest that the shore of this old lake may at one time have been situated in this quarter. If so, the displacement of the limestone may have been due to the winter freezing of the shallow waters and the shifting of portions of the rock-floor when the ice broke up, and was driven inshore in the summer.

It is to be noted that the curious mass of rubble-drift at Sancton,† which has some features in common with the South Cave drifts—notably the presence of a clay-streak—occurs nearly at the same level—about 170 feet above sea-level. Also that the mammaliferous Glacial gravel at Mill Hill, Elloughton, described by Lamplugh and Sheppard, occurs at about 115 feet above sea-level.

Since the above paper was read to the Society, Prof. Kendall has kindly sent me the following valuable notes relating to the lacustrine deposits of the Vale of York :—

"The alluvial plain of the Lower Ouse, Aire and Trent, extending from the Escrick moraine down to the latitude of Bantry, and from the Magnesian Limestone outcrop in the West to the Jurassic escarpment of the East Riding of Yorkshire and North Lincolnshire, is mainly constituted of warp clays, long recognised as of lacustrine origin. They attain a thickness of 200 feet at Barnby Dun.

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* Carvill Lewis, Extra Morainic Lakes, *Geol. Mag.*, dec. III., Vol. IV., pp. 515 to 517. Kendall, Glacier Lakes in the Cleveland Hills, *Quart. Journ. Geol. Soc.*, Vol. LVIII. p. 567.

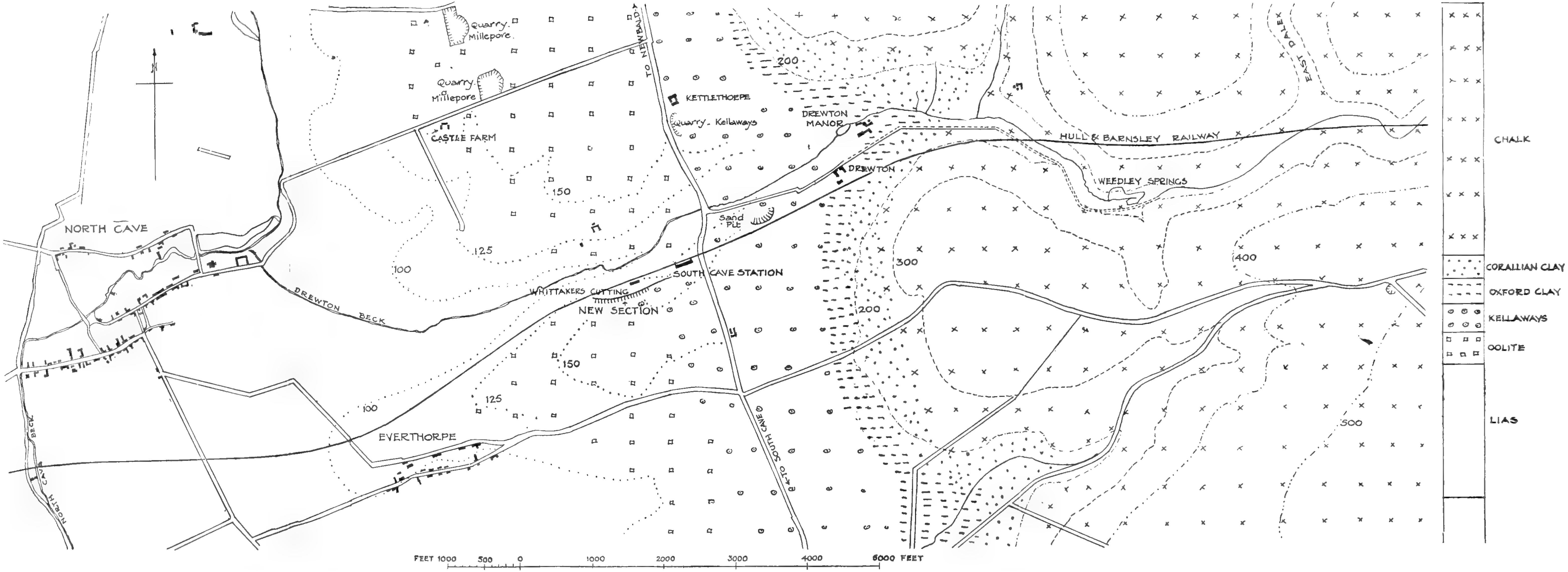
† *Trans. Hull. Geol. Soc.*, 1894, Vol. II., p. 10.

"A very significant section is exposed at Harworth, about 8 miles S.E. of Doncaster. About 20 feet of clay is exposed in a brickyard. When seen in 1896, the clay appeared to be devoid of lamination or bedding, but sections now visible show both features well. On some faces the stratification is thrown in great rolls and minor contortions, often enclosing masses of stratified sand. These eyes of sand vary in size from an inch in diameter up to several feet. The stratification may be at any angle to the horizontal, and in the larger bodies is, besides, being abruptly cut off at the ends. The smaller inclusions may be crowded together like the pebbles in a gravel, and all, whether large or small, have, it is suggested, been moved in a frozen condition.

"The interpretation offered is that the deposit was laid down in a lake subject to severe freezing and drifting of floating ice, which contorted the deposits when it grounded.

"There are many pebbles and boulders, chiefly of local rocks, but a peculiar significance attaches to the frequent occurrence of glaciated blocks of hard Chalk of the type found in the Wolds of Yorkshire and Lincolnshire, accompanied by large tabular grey flints of the same provenance. One specimen was found of fossiliferous oolitic limestone of a very distinctive type, recognised by Mr. M. Odling as exactly resembling a rock he has observed on the Hambledon Hills. The altitude at which this deposit occurs is about 100 feet above sea-level."

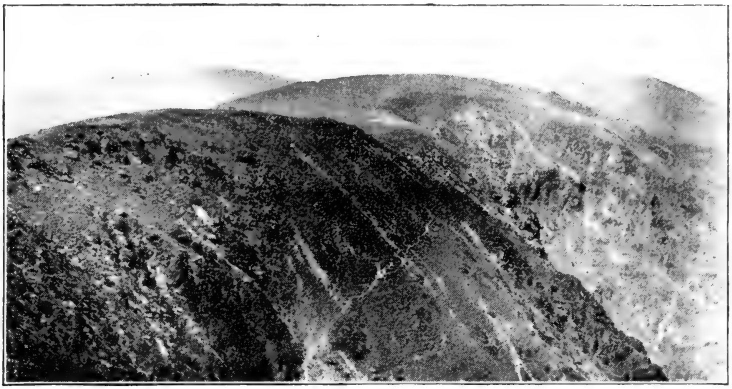
In conclusion, I should like to thank Prof. P. F. Kendall, M.Sc., and Mr. G. W. Lamplugh, F.R.S., for many helpful suggestions during the preparation of these notes; and also to mention how much I am indebted to Mr. W. H. Crofts for obtaining detailed measurements of the section from time to time, and supplying the illustration on page 398 and the map. Thanks are also due to Mr. J. T. Dyson for the photographs, and also to Mr. Thos. Sheppard, M.Sc., for help in the field and in many other ways.



Drawn by W. H. Crofts.

MAP OF THE NORTH AND SOUTH CAVE DISTRICT.

To face page 400.



THE ROUNDED SUMMITS OF THE CONISTON OLD MAN RANGE.

VIEW DOWN RED DELL, SHEWING STEP INTO LOWER VALLEY.

To face page 401.

SOME OBSERVATIONS ON THE GLACIAL GEOLOGY OF FURNESS.

By George Grace, B.Sc., A.R.C.Sc., and Frederick Howard Smith, B.Sc.

(Read on March 29th, 1922.)

For the purposes of this paper Furness may be taken as that portion of the Lake District which is bounded on the west by the River Duddon, on the north by the Little Langdale, and on the east by Windermere and the River Leven. Within this area the solid geology, so far as it affects the glacial geology, is very simple. If a line be drawn from Duddon Bridge in a north-easterly direction through Coniston and forward, it will cut off a north-westerly portion composed of Ordovician volcanic rocks of the Borrowdale series, and leave a south-eastern area chiefly made of Silurian slates and grits. Although there are minor variations in the dip and strike of these rocks, they may be regarded as having a general strike parallel to the dividing line mentioned, and a dip towards the south-east.

The volcanic area consists of a mountainous massif, culminating in the Coniston Old Man (2633 ft.), and running to the south-west until it is cut off by the Duddon estuary. The south-east area is divided naturally into a hilly portion in the north, reaching in several places to 1000 feet, and a much flatter area, south of Ulverston, generally known as Low Furness, much of which is below the 50 feet contour.

Very little attention appears to have been given to the glacial geology of Furness for many years. Clifton Ward* published details of the glaciation of the southern Lake District in 1875, but stopped at the northern boundary of Furness, and no one appears to have continued his work. We have failed to find any systematic description of the glaciers of High Furness, although their general courses seem to have been common knowledge, and are referred to by many writers, notably by Prof. Marr in his " Geology of the Lake District." Most of the details we give in the following paper appear to be quite new.

The drifts of Low Furness and, to a certain extent, of High Furness, were dealt with by Mackintosh,† who gives a full and accurate account

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* *Quart. Journ. Geol. Soc.*, Vol. XXXI. (1875), pp. 152-165.

† *Quart. Journ. Geol. Soc.*, Vol. XXV. (1869), pp. 407-431; Vol. XXIX. (1873), pp. 351-359; and Vol. XXX. (1874), pp. 174-179.

of them in several papers, but his conclusions are invalidated by his failure to distinguish between the insular drift and that from the Irish Sea. He seems to have regarded granite as the criterion of Upper Boulder Clay; consequently his Lower Boulder Clay and Middle Series are mostly insular drift. The same confusion occurs in J. D. Kendall's* paper in 1880.

B. Smith,† in his paper on the Glaciation of the Black Combe District, deals with some of the phenomena produced by the ice at the head of the Duddon estuary, and his observations seem to fit consistently with those recorded below. In the latter part of his paper he suggests "that the water accumulating in the Duddon estuary must have escaped somewhere to the south along the coastline of Furness." This has turned out to be an accurate forecast of what we have found.

The Pre-Glacial Condition of Furness.

It is generally admitted that at the beginning of the Glacial Period the Lake District had been above sea level for a considerable period, and that the agents of normal denudation had been at work for a sufficient time to reduce it to what Prof. Davis has termed an area of "Subdued Relief." The present condition of High Furness is very far from this type of topography, and must be regarded as, largely, the product of the abnormal erosion of the Glacial Period. The Ordovician area abounds in angular rocky scenery—the well-known vertical crags and canal-like valleys—which are the antithesis of Prof. Davis's flowing curves, while the Silurian area contains several large basin-like depressions not hitherto described, which it is difficult to regard as the result of normal erosion.

These are: The Coniston Basin, The Lowick Basin, The Broughton Beck Basin, The Duddon Estuary and its continuation northwards to Woodland. Of these the Coniston Basin is the most important, and we propose, therefore, to discuss its origin in detail. (See map of High Furness, Plate XLIX.).

It is composed of two separate valleys, which have originated quite independently. These valleys are a considerable distance apart at their southern ends, but merge into one another in the north. The more westerly is the straight valley running from Woodland to Torver

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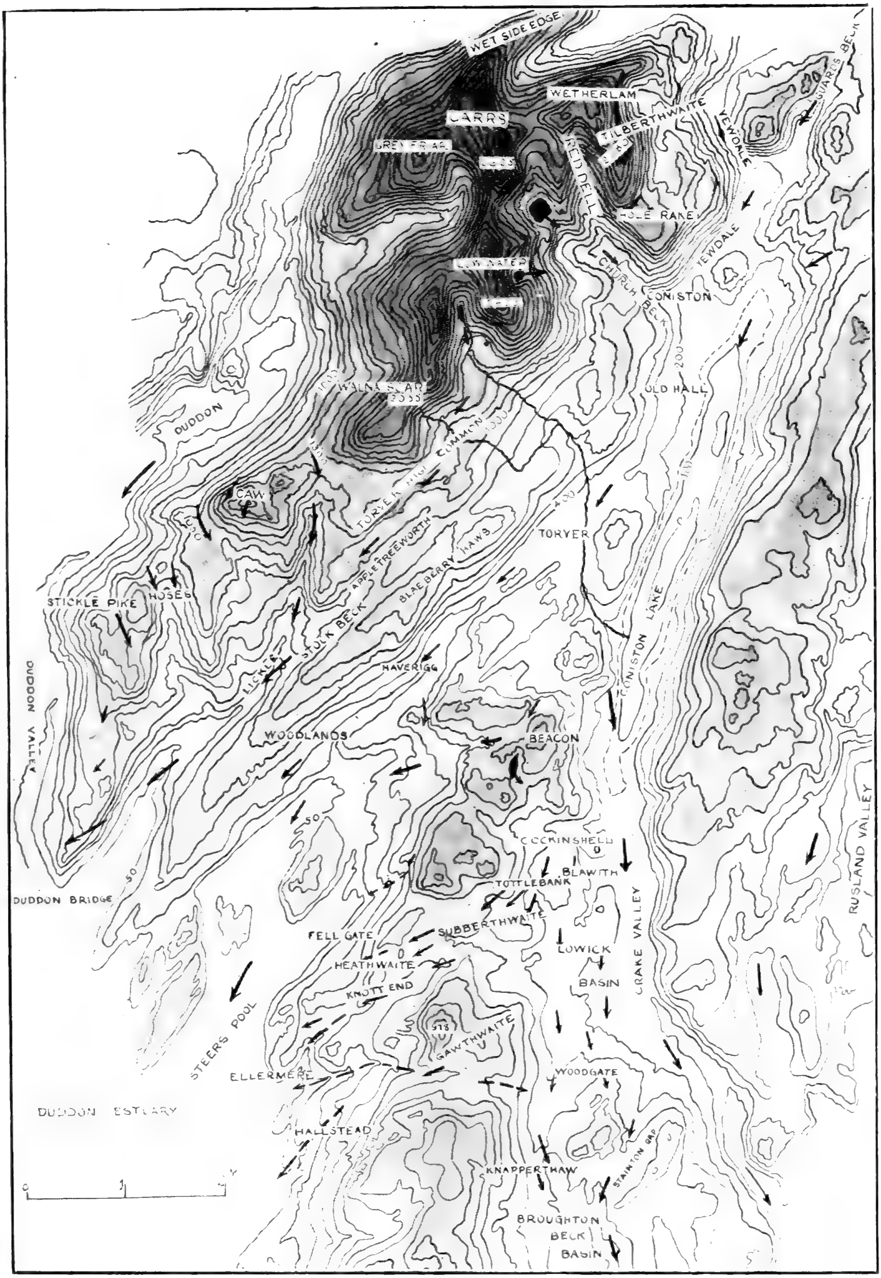
* *Quart. Journ. Geol. Soc.*, Vol. XXXVII. (1880), p. 29.

† *Quart. Journ. Geol. Soc.*, Vol. LXVIII. (1912), p. 402-448.



Map of High Furness.

To face page 402.

and continuing, more or less clearly, almost to Coniston Old Hall. This originated as a strike valley, and owes its canal-like aspect to its coincidence with the line of bedding and cleavage of the slates. It is not easy to decide how far it had reached northwards before the interference of glacial conditions. The gap through which Torver Beck empties into the lake seems too old to have originated during Glacial times, and, if so, indicates that a stream crossing the valley at this point was not diverted down the strike valley, and that, therefore, the latter had not reached so far. The most probable condition was that, from a col near Haverigg Holme, one stream ran south-west towards Woodland, and another flowed north-east into Torver Beck, and that north-east of the Beck there was no trace of a depression between the Fells and the present lake valley.

The eastern valley, where Coniston Lake now stands, cannot be explained so simply. It coincides at the head with a well-marked fault, but this disappears about half way down the lake, so that it does not account for the valley. Also, the present valley cuts across the grain of the rocks, so that it is not structural. It probably originated so long ago that the circumstances which began it have disappeared and cannot be reconstructed. If our reconstruction of the Torver Valley be correct, this eastern valley must have carried the drainage from both Yewdale and the Church Beck Valley, and received the Torver Beck as a tributary near its present confluence. Its straight course, however, suggests that its present form is more due to glacial action than to normal erosion. The slopes on its eastern side are lacking in any suggestion of spurs, such as might have been expected if it had been a normal river valley only slightly modified by glacial action. Also the fact that the side valleys which run into it, viz., the Church Beck Valley, both the branches of Yewdale and the Torver Beck Valley, are all, at some part of their courses, hanging valleys, suggests that the Pre-Glacial level of the stream into which they ran was much higher than now.

The profile of the Church Beck has two distinct steps. A smooth curve continuing the highest reaches of the stream seems to point to the old level of the main valley as being between the 300 and 400 feet contours. This estimate is confirmed by the profile of Upper Yewdale, which falls from 500 feet to 300 feet in less than a mile, and by the Guards Beck, which has a similar profile. If this is anywhere near the truth, as the lowest part of Coniston Water is 42 feet below O.D., the rock erosion during Glacial times must have been as much as 350 to 450 feet.

Originally the Ash Gill Beck and the Torver Beck passed through separate gaps near Torver Park, but they must have united somewhere near Torver, as there is only one gap leading into the lake. Now, the Torver Beck has captured the lesser stream on the moor, and left its lower course as a dry gap. The bed of the combined streams as it comes down into the present Torver valley is a succession of cascades. Its course across the valley bottom is not in line with its previous course, and suggests that it is making for the gap once used by the Ash Gill Beck. Through this it cascades again into the lake, confirming the suggestion that the valley at Torver originated during Glacial times, and that the present level of the lake is much lower than the pre-Glacial level of the stream into which the Beck ran.

The conclusion we draw from these facts, and the details of the Yewdale valley—which have been previously described by Prof. Marr, and are, therefore, omitted here—is that the present Coniston Basin can be regarded as almost entirely the product of glacial erosion, and that, in pre-Glacial times, the slopes from the mountains on the west flowed in smooth curves, considerably higher than the present surface, down to a shallow valley above the site of the present lake.

The Sub-Glacial Surface.

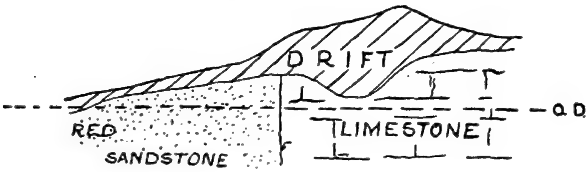
If all Glacial and Post-Glacial deposits were removed from Furness a surprisingly large portion of the Sub-Glacial surface would be below present sea level. Large areas in the Lickle Valley and Steers Pool Valley on the west, and in the Rusland and Windermere Valleys on the east, have been eroded below O.D., and, in the centre, Coniston Water goes 42 feet below O.D., and, if lake deposits were removed, would probably be deeper. Much of the Crake Valley, too, and a large area around Ulverston, and another area east of Barrow, shew no sign of solid rock above sea level. Very little information can be obtained regarding the Sub-Glacial surface beneath these deposits. In the Duddon Estuary, the thickest Drift of which we have obtained records reaches to 150 feet below sea level. A boring in the valley south of Furness Abbey is recorded as passing through Drift to a depth of about 400 feet below O.D.* The rest of the borings in the same

* Memoirs of Geol. Survey: *Geol. of Furness*, 91 N.W.

valley do not shew drift below 220 feet, and this smaller value corresponds much better with borings in other places. It is possible, therefore, that the 400 feet record is a mistake, and due to the local name for both Yoredale Shales and Boulder Clay being " Pinel."

On Walney Island a boring at Biggar proved Drift to — 150 feet, and another at North Scale to—130 feet. The boring for salt at South Walney only reached 89 feet below O.D. before coming to Keuper Marls. So that, on the whole, the evidence points to the greatest depth of the Sub-Glacial surface being somewhere in the region of —200 feet.

Mr. Lawn, the manager of the Park Mines, has kindly supplied



SECTION AT YARLSIDE.

the accompanying section giving the data obtained by him concerning the Sub-Glacial surface in the Yarlside district, east of Furness Abbey.

THE PERIOD OF MAXIMUM GLACIATION.

The usual evidence of glaciation reaches to just above the 2000 feet contour. Higher than this there is an entire absence of smooth faces, scratched rocks, boulders, etc. The most probable explanation of this is that during the later stages of the Glacial period this area would be exposed to severe frost action, and any traces of previous glaciation would be removed. This seems more reasonable than that it was never subject to the action of moving ice. The highest signs of glaciation all shew that during the maximum period the direction of ice movement ignored the present valleys, and suggest a flow from the north and north-west, much of it, apparently, from the higher mountains around Scafell. A col at 2080 feet glaciated from the north-east crosses the southern spur of Wetherlam. This is the highest col over which we have evidence of moving ice. Further down the slope towards Hole Rake are many beautifully glaciated surfaces, all indicating movement from the same direction. There is also strong evidence of a flow of ice from the Upper Duddon Valley across the Fells, the details of which are shewn on the map. These will be dealt with in greater detail later.

Caw, which rises to 1735 feet, is glaciated to the summit, from a direction almost due north, whereas Stickle Pike, which is only 1230 feet high, has an area on the top which is entirely free from glacial evidence, although abundant traces of ice action are all around.

It is interesting to note that other workers have found similar vertical limitations to the evidence of glaciation in many parts of the Lake District. C. Ward, when describing the glaciation of the Northern Lake District* shews that :—(*a*) the greatest height of signs of glaciation at the head of the Derwent Valley is a little over 2000 feet (p. 424), and in W. Langstrath about 2000 feet; (*b*) on the west of Helvellyn this height is about 2500 feet (p. 425-6); (*c*) in Ennerdale, 2000 feet, and on the ridge between Deepdale and Grisedale, 2000 feet; (*d*) the Syenite boulders on the top of Starting Dodd rise to 2084 feet; but that all over the area occupied by rocks of the volcanic series perched blocks are numerous up to considerably more than 2000 feet (p. 428), although he never found any striations on the highest summits (p. 441).

Dr. Marr and Professor Fearnsides† found an "unglaciated area" on the top of Howgill Fells at about 1500 feet.

On the hill south of Walna Scar, marked 2035, and northwards to the hill 2625, the surface is smooth, grass-covered, and almost meadow-like, and this smooth surface extends well down the western slopes. The western col between Carrs and Grey Friar is smooth, and so is the western face of Wet Side Edge. The eastern side of the whole massif is a series of rocky precipices in striking contrast to these western slopes. Even the top of Wetherlam, which is east of the main ridge, is a tangled mass of gigantic boulders. This assymmetric aspect of the summit is well shewn in the accompanying photograph. Prof. Kendall has suggested to us that it is similar, on a large scale, to the "crag-and-tail" found in the courses of valley glaciers, and that it may be the result of glaciation from the north-west during the maximum period. A good description of the magnificent series of combes on the eastern face of the mountains is given in Prof. Marr's "Geology of the Lake District."

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* *Quart. Journ. Geol. Soc.*, Vol. XXIX. (1872).
† *Quart. Journ. Geol. Soc.*, Vol. LXV. (1909), Plate XXX.

In the Silurian area of Furness the highest summits do not reach much above 1000 feet, so that any evidence found there probably does not belong to the maximum period.

The Period of Valley Glaciers.

The period of valley glaciers, which succeeded that of maximum glaciation, is that part of the Glacial Period which has left most abundant data for examination. For some time after the maximum period the surface level of the ice was high enough to admit of cross-streams from one valley to another, and we have evidence of many of these high level streams. But eventually the ice would be confined entirely to the valleys, and the direction of motion would coincide with the present valley bottoms. The chief valley glaciers in Furness were the Duddon, the Lickle, the Coniston, the Rusland and the Windermere. The glaciation of some of these valleys has been described previously, and we propose to confine our paper to details which appear to be new. On account of the necessity for compression we are compelled to make our observations somewhat disconnected.

The details of the glaciation of the Duddon Valley have recently been described by B. Smith.* It is noteworthy that the floor of this valley is rock all the way to Duddon Bridge, so that probably the glacier which occupied its lower part was comparatively small.

The Lickle Valley Glacier drew its supplies from several sources. A considerable stream of ice came from Torver High Common by way of the Appletreeworth Valley, including, during part of the time, a glacier nearly a mile wide which can be traced from above Coniston along the depression between Bleaberry Haws and Walna Scar Fell, and also one from the Goat's Water Combe. The present valley in which the Appletreeworth Beck runs is continued northwards as a dry valley to Ash Gill, and has apparently conveyed a considerable stream of water along the margin of the ice from the mouth of the Goat's Water Combe into the Lickle Valley. A glacier quite as large came over the Dunnerdale Fells at 1300 feet and down the Upper Lickle Valley, which is a U-shaped glaciated valley with a V notch in its base, down which the present river flows. A third stream came over the Fells to the south of Caw, but a fourth down the valley in which Hoses stands seems to have found the Lickle Valley so full of

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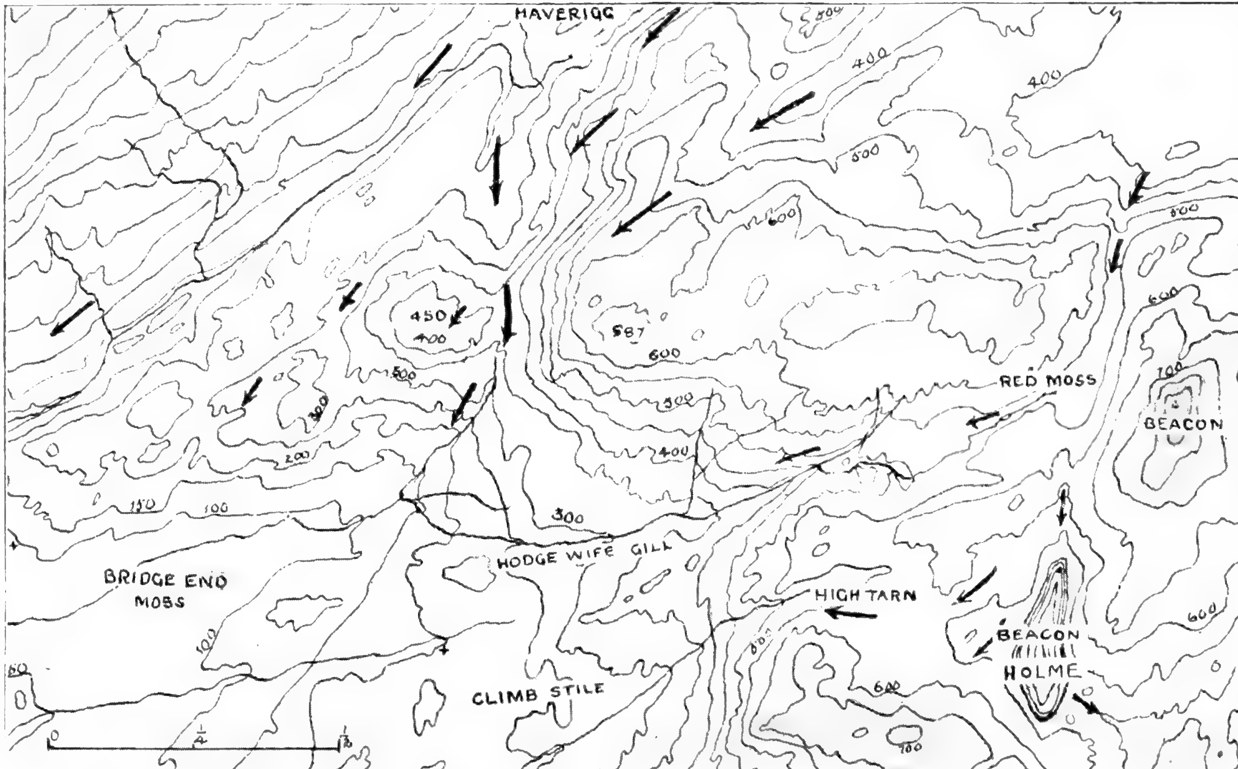
* *Quart. Journ. Geol. Soc.*, Vol. LXVIII. (1912), p. 408.

ice that it was diverted to the south-west and kept along the fell side until it reached the part of the fell which falls from over 1000 feet to 700 feet, when it turned almost westwards, and passed back into the Duddon Valley, or rather, across its mouth. The interpretation of the evidence near the mouth of the Duddon is difficult, and the stream of ice westwards may belong to a later phase.

The glacier associated with the Coniston Basin was the largest in Furness. Its ramifications may be seen on the map. The whole of the Fells at the head of the basin are glaciated from the north, the evidence extending westwards up the slopes of Wetherlam to over 2000 feet and eastwards beyond the limits of our area. A number of deeply cut channels converge towards the Coniston Basin, and near High Cross are several large erratics of Ordovician Ash. The amphitheatre at the head of the lake is deeply scored by valleys, and at the bottom of the slope, near the north-east corner of the lake, is an area covered with drift-like hummocks. Besides this complicated series of minor valleys, the chief feeders into the basin during the definite valley stage would be the Church Beck Valley and Yewdale.

There are many features in the Church Beck Valley which must be regarded as due to the abnormal erosion of the Glacial Period. The general appearance of its head is that of a large and somewhat irregular amphitheatre into which three hanging valleys open. The most westerly of these is the highest, and also the least. It is a well developed combe, which holds Low Water at a level of 1786 feet, and is drained by a stream which falls from 1700 feet precipitously to below 1200 feet, so that the combe hangs almost 600 feet above the valley. The middle valley holds Levers Water (1350 feet), and is longer, and shews signs of glaciation. It is probable that the wide portion near the tarn with its vertical rocky sides is due entirely to ice action. Here again there is a rapid fall from the level of the upper valley to that of the main valley, and the stream descends in a series of cascades The Red Dell, on the other hand, gives less evidence of glacial action being V-shaped, except near its mouth where there are large areas of rounded and polished rock, and the valley becomes more U-shaped. This also hangs in relation to the main valley. The stretch of valley from the Copper Mines to the bridge is strikingly level, and traces of the same floor may be found further down, but at the bridge the stream plunges to the bottom of a V-shaped valley which has been cut into the floor of a wider one.



Map of Overflows from Coniston Basin near Beacon.

To face page 409.

Here the details have been obliterated by road making, but the simplest explanation of the gorge seems to be that it has been cut by water during the later Glacial and Post-Glacial times since the deepening of the Coniston Basin. A similar, but smaller, gorge is to be seen at the mouth of the Red Dell, where the beck is now engaged in cutting the lip of the gorge back into the higher valley.

Low Yewdale is an excellent instance of a U-shaped valley with very steep sides and a flat floor. Two valleys open into its head, viz., Guards Beck and Upper Yewdale. When viewed from its northern end the Guards Beck is seen to occupy a narrow valley cut in the floor of a much wider one, which shews every sign of severe glaciation. Immediately before its entry into Low Yewdale the mouth of the lower valley is narrowed by an area of rough ground considerably higher than the valley floor. To the north of this is a triangular shaped flat with every appearance of having once been the site of a lake, of which the rounded gravel which occurs at its upper end may be part of the old beach. The whole appearance suggests that the valley was glaciated to the level of the rough ground, and afterwards cut down by water to its present level, when the streams were adjusting their levels to the deepened Coniston Basin. Upper Yewdale is at right angles to Low Yewdale, and is a wide U-shaped valley with afloor falling rapidly into the deeply excavated Low Yewdale. That the glacier which came down it was of considerable size is indicated by the striking width of Low Yewdale opposite its mouth.

The outlets from the Coniston Basin are three, viz., (1) The Woodland-Torver valley ; (2) a small dry valley over Beacon Tarn ; and (3) the Crake Valley.

A considerable glacier passed through the Torver-Woodland valley into the Steers Pool Basin, leaving large accumulations of drift. At Town End, where the Steers Pool crosses the road, a conical hill cut by the railway is made entirely of drift Further north is a larger one also of drift, and along the base of the hill on the western side are other morainic mounds. In the valley bottom near Haverigg Holme are a number of curious dry channels cut in solid rock, which have no relation to the present drainage of the valley, and are probably the result of the erosive action of the copious streams which flowed down this valley when the glaciers were melting.

A smaller channel at about the 500 feet contour near Beacon (See Map of Overflows from Coniston, near Beacon, Plate L.)

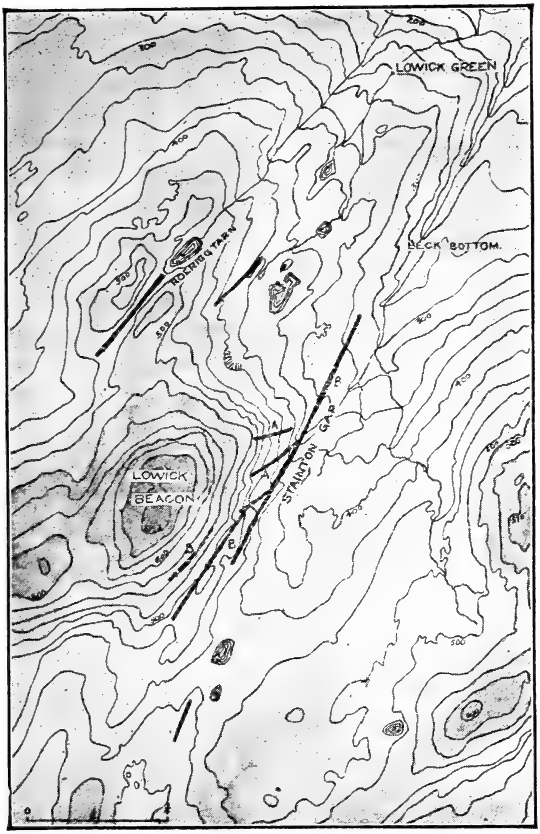
can only have been in use during the early part of the valley period. Later, the area between Beacon and Torver must have been more or less stagnant. The present surface of Torver Low Common is strikingly uneven, abounding in depressions with mounds of solid rock between. These depressions in some cases may be rock basins, but they are too much obscured by morainic material for this to be determined with certainty. In many respects this area closely resembles Lowick Common, which also has a barrier to the south, and we suggest that, in both cases, the unusual features were produced by standing ice forming an area of comparative stagnation, with the more active streams passing on either side. The Beacon outlet passes over Red Moss and forwards over the site of Beacon Tarn where it has left numerous glaciated surfaces. Then one stream of ice turned eastward and joined the main Crake Valley glacier at Cockenshell, and another turned westward over High Tarn Moss to Climb Stile, where there is a considerable accumulation of moraine. The valley down Hodge Wife Gill shews no signs of glaciation below the fall, and is distinctly water- cut. It undoubtedly carried a large stream of water at some time, and a delta still shews where this entered the Duddon Lake at 100 feet.

The Crake Valley was the most important outlet for the Coniston Glacier, and below Blawith must have carried a glacier quite two miles wide. We have traced four branches of this main glacier, two at Subberthwaite and Gawthwaite into the Duddon Estuary, and two at Wood Gate and Stainton Gap into the Broughton Beck Basin. We propose to describe these in detail.

The valley down which the Subberthwaite branch passed is an impressive U-shaped trench almost a mile wide. The highest point in its floor is just over 400 feet, and its southern side rises very steeply to over 800 feet. Its northern side is not quite so high. Numbers of large erratics are strewn along its floor. At its western end there is clear evidence of a delta where it enters the Duddon Lake near Gill Wood. A smaller branch turned eastwards above Heathwaite and left a delta near Fell Gate.

The valley of the Gawthwaite branch is not so easy to understand. Its general course is east and west at about 45 deg. to the direction of the ice stream. Its eastern portion shews no signs of glaciation, but the western half is strongly glaciated. It opens westwards into two valleys at Grisebeck and Hallstead, both of which contain deltaic deposits. It was probably abandoned when the ice was unable to override the 700 feet contour.

A large glacier passed up the rising ground at Woodgate to the western side of Lowick Beacon, oversteepening the cleft at Knapper-



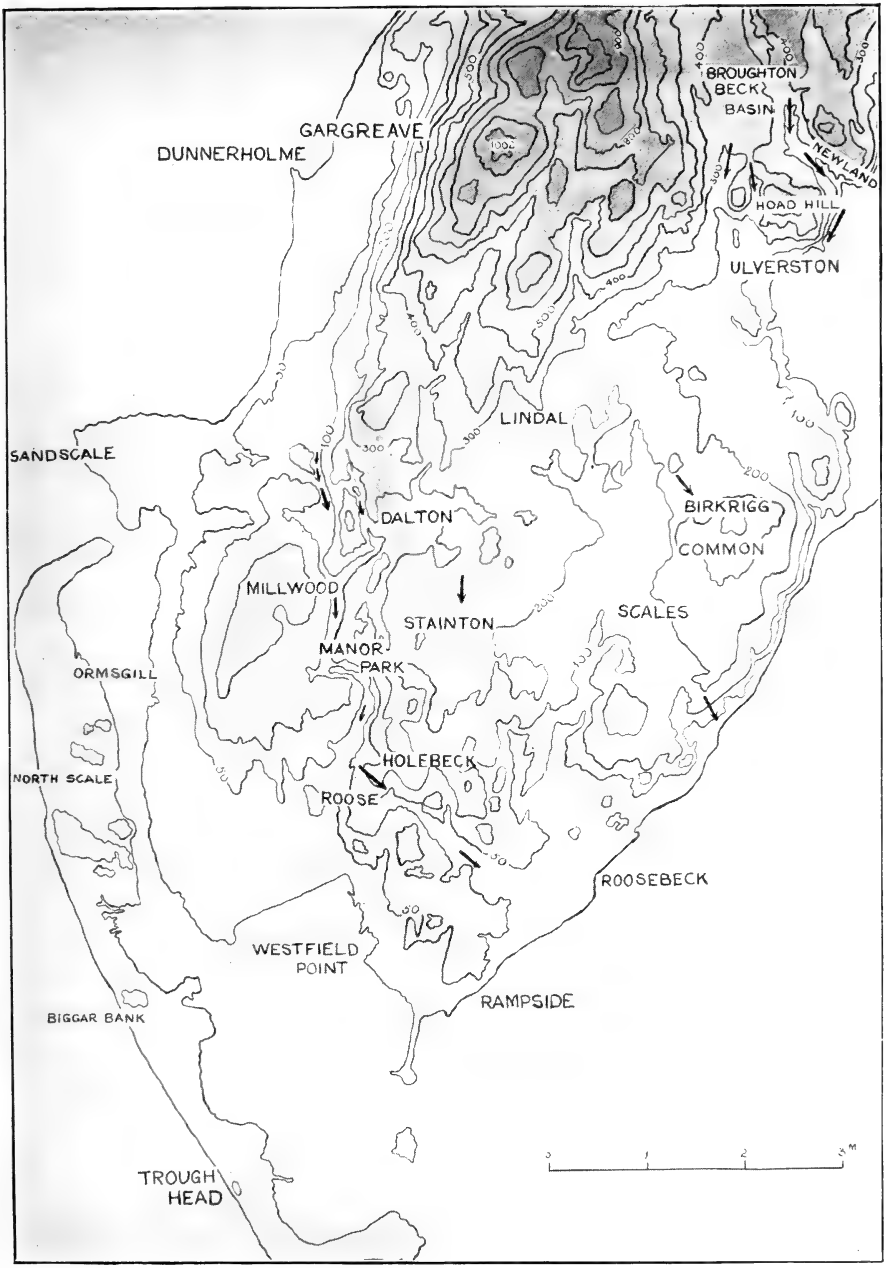
MAP OF STAINTON GAP.

thaw, and leaving a gravelly deposit at the junction of the roads and joining the Stainton Gap Branch in the Broughton Beck Basin.

Although the Stainton Gap Branch (see Map above) was a much smaller branch than the last it is much more interesting. It is probable that it ceased to carry a through current of ice fairly early, and became the bed of a large stream of water which flowed northwards into the Crake Valley. On its north side, near Lowick Green, extensive deposits of semi-stratified gravel with patches of unstratified drift have been exposed for road mending, and must have come down from the Gap. In the Gap itself is a system of straight channels cut in rock, which seem to be analogous to those described by Prof. Kendall in Cleveland, and by Mr. B. Smith around Black Combe, and to be due to the erosive action of water along the margin of the ice. The details of these are shewn in Fig. 5, and they point strongly to the direction of flow being northwards. At Beck Bottom is a sandpit which at our first visit in 1911 shewed a predominence of stratified gravel, but in 1916 this had been removed, and more unstratified drift appeared. On the common to the north of Lowick Beacon is an irregular surface which, as previously noted, clearly resembles that at Torver Low Common. It is cut into channels, north-east by south-west, and parallel to the strike of the rock. Only one of these, that containing Roerigg Tarn, is carried through the hill; the others shallow out as they reach the steep hill side. A number of round-headed combes facing northwards are a marked feature of this hill side, and the general appearance suggests a copious drainage towards the north-east. So long as the ice was able to pass over Stainton Gap (425 feet), very little stagnant ice would accumulate. Once it failed to attain this level the whole area would become stagnant, and only drainage to the north-east would be possible. It is significant that the combes occur along the 425 feet contour and below.

The last two branches of the Coniston Glacier appear to have joined together in the wide, shallow depression we call the Broughton Beck Basin, and passed southwards until the glacier joined the main body of ice near Ulverston. When it was unable to surmount the barrier north of Ulverston the ice—and later the water from it—were discharged through three openings as shewn on the map of Low Furness, Plate LI. Of these, the most important is that near Newland, which has been severely glaciated, but has subsequently been the bed of a large stream of water, and is in the form of a wide U-shaped valley with a water-worn V-shaped notch cut in its floor, the latter notch being at least 18 feet deeper than the glaciated surface. The south-east slopes of Hoad Hill are very much over-steepened by the westward pressure of the ice in the estuary.

The Rusland valley is a wide, flat-bottomed valley which only



MAP OF LOW FURNESS.

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reaches the 50 feet contour at Rusland village. It has been eroded to a considerable depth, and then silted up again to sea level. It was probably the site of a lake, either during the Glacial Period or since A thick deposit of peat covers much of its floor, the components of which show that a wide peat-water swamp followed the silting up, and in turn gave place to a "moss." A rock barrier south of Rusland Beaches almost cuts this swamp into two basins. A number of morainic mounds near Rusland, and much undisturbed drift in several places suggest that the level of the lake can never have been much above present sea level. We have been unable to find any volcanic rocks among the boulders and drift of this valley, a fact which indicates that the ice filling it came from the north-east rather than the north-west. It is possible that quite early in the valley stage the ice ceased to flow over Hawkshead Moor, and that the Hawkshead area became either stagnant or continued down the Cunsey Beck Valley. Abundant suggestions of rounding may be found among the rocky prominences in the Rusland Valley, but slate rocks do not preserve this as well as the volcanic series. Smoothed rocks suggesting movement from east-north-east occur in Haverthwaite schoolyard, and others indicating motion from north-east near Causeway End.

Only the southern part of Lake Windermere belongs to our area. The northern half and the valleys converging on the head of the lake are in Westmoreland. The Windermere Valley belongs to the radial scheme of drainage previously referred to, and in Pre-Glacial times continued southwards by Cartmel. The Backbarrow valley, now draining the lake, was probably commenced in Pre-Glacial times by tributaries of the Crake and Windermere, flowing in opposite directions with a col sufficiently defined to govern the route of the ice overflow. It is still possible to distinguish the glaciated U-shaped valley below Newby Bridge, where the present river has cut a trough about 6 ft. deep in the glaciated floor. A second ice-stream came over the Finsthwaite Valley, and joined the first above Backbarrow. The gradient of the River Leven seems to confirm the above theory of its origin. In the first two miles of its course until it reaches the bend above Backbarrow it only falls 28 feet from the lake-level to the 100 feet contour. In the next two miles it drops from 100 feet to practically sea-level. The final part of its course is across an alluvial flat with very little slope. Probably the Pre-Glacial tributary originated above Backbarrow, and had a branch up the Finsthwaite Valley, if, indeed, the latter be not its real head.

THE DRIFTS OF LOW FURNESS.

In northern Furness drift plays only a subsidiary part in the topography, but Low Furness is distinctly an area of deposition, and is largely covered by Glacial deposits. These deposits have been described by Mackintosh, Bolton* and J. D. Kendal. We, therefore, confine ourselves to observations not in those papers.

The Drifts of Furness are easily divided into two types—

(1) The Irish Sea Drift, which covers the southern end of the peninsula and contains granites and other rocks from Eskdale and further up the coast.

(2) The Local Drift, which is found in the remaining parts of the district and contains only rocks of local origin.

The line of division between these is necessarily somewhat indefinite and not easy to place on a map. We have, therefore, marked it by a shaded area which approximately separates the granite-bearing drift from that of purely local origin. We have repeatedly failed to find granite, other than that taken there for farming purposes, in the district around Lindal, but it should be noted that J. D. Kendall records having found it there.†

The Local Drift consists of a series of heterogenous deposits mostly of very limited extent, which varies from place to place so much that it is impossible to co-relate the different exposures. We do not think there is any justification for making a Middle Series of Sands and Gravels as is sometimes suggested. The motion of the ice over the whole of Low Furness appears to have been almost due south, and we were unable to find any signs of cross-channels on the moors which divide Low Furness into two areas. The western slopes which border the Duddon Estuary are thickly covered with drift which, in the stream gullies, shews sections sometimes 15 feet thick. It is distinctly clayey in places, but most of it is sand and gravel. The streams down the hillside are mostly Post-Glacial and occupy gullies in the drift, and one or two of them have valleys cut into solid rock, and may occupy the beds of Pre-Glacial streams. The low ground at the bottom of the slope is composed entirely of drift, which in some cases forms drumlins rising to the 100 feet contour. On the eastern side the combined glaciers formed by the junction of the Broughton Beck glacier with the ice from

* *Quart. Journ. Geol. Soc.*, Vol. XVIII. (1862).

* *Quart. Journ. Geol. Soc.*, Vol. XXXVII. (1880), p. 29.

the Greenodd Estuary was pressed in a south-westerly direction over the low-lying land around Ulverston and Lindal, and continued southwards with a tendency towards the east as it approached the Irish Sea ice. This is shown by scratches on the underlying limestone recently exposed near Baycliff and in the quarries at Stainton, and also by the contents of the drift along the eastern shore.

The Irish Sea Drift is quite different in character. It can be fairly clearly divided into three series, viz., two distinct beds of true boulder clay, very similar in character and contents, divided by a variable middle series of sands and gravels, etc.

The Lower Boulder Clay forms the foundation of the whole of South Furness below the line indicated. Its upper surface rises towards the south, so that though it does not appear at Sandscale, there are good exposures near Rampside, Westfield Point, Roosebeck and on the west coast of Walney south of Trough Head. It is a typical boulder clay with numerous erratics, some of which are three or four feet cube. Several similar large boulders of Eskdale Granite, Carboniferous Limestone, Borrowdale Ash, etc., were brought up during the dredging operations in Walney Channel in 1912.

The middle series of sands and gravels are of very varied nature, and we think that some of them are lenticular deposits in hollows in the upper surface of the clay, and they may not be all of the same age. At Rampside they form a cliff of almost pure sand 40 feet high. At Westfield Point they are much thinner, and consist of gravels and sands with sandy loam beds. At Biggar Bank they are less than three feet thick, and in one place, about a mile south of the tram terminus, they include a definite bed of peat, with fragments of wood. This was mentioned in J. D. Kendall's paper. Samples have been examined by Miss Chandler and contain—

Batrachium aquatilis Linn.	*Myriophyllum* sp.
Menyanthes trifoliata.	*Potamogeton* spp.
Viola palustris Linn.	*Carex* spp.
Hippium vulgaris Linn.	*Chara.*

This is essentially a temperate assemblage of plants, and raises the possibility of the deposit being of Post-Glacial age, and its apparent position in the Middle Series being due to Post-Glacial movements of the Upper Boulder Clay. On the other hand, a boring in North Walney at North Scale gives 9 feet of peat resting on Lower Clay, and below 15 feet of Upper Clay. This seems difficult to explain except on the assumption that the peat is an Intra-Glacial deposit.

The exposures along the west coast of Walney shew an almost continuous line of sands and gravels from Biggar Bank to Trough Head, where it passes out at the top of the drift. It is of very variable thickness, but seldom reaches more than three feet.

The Upper Boulder Clay is a typical boulder clay, red and compact. Good exposures are seen at Ormsgill and at the north end of the west coast of Walney. It also appears north of Trough Head and at the north end of Westfield Point, and can sometimes be seen at the base of the sand dunes at Sandscale.

The Duddon Lake.

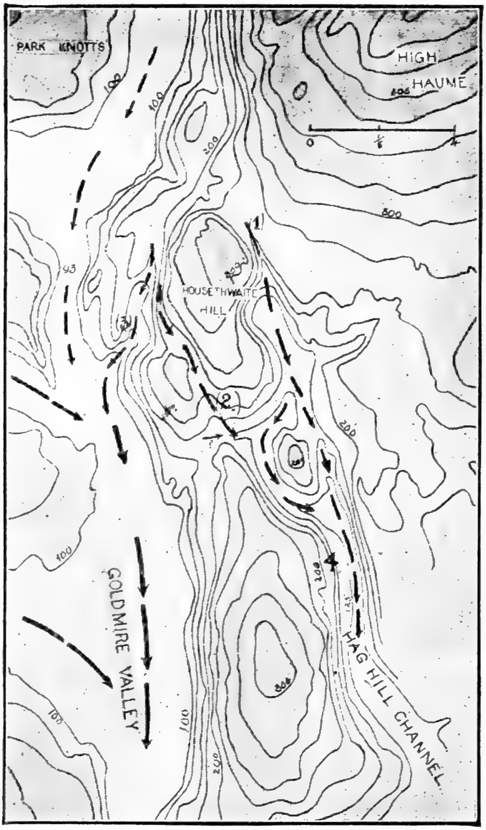
Towards the end of the valley period the ice in the Duddon Estuary appears to have commenced shrinking on its eastern margin. The first consequence of this was a marginal channel at about 250 feet, which cut a notch between Housethwaite Hill and High Haume very similar to those described by Prof. Kendall under the name of "Severed Spurs."* This Stage was followed by a gradually widening lake, the surface of which at first stood just above 200 feet, but sank lower and lower, as openings across Furness became available, until the water was not far from the present level. Pauses in this sinking took place at 200 feet and 100 feet, and we have collected evidence of this in the form of (1) Beaches ; (2) Deltas ; (3) Overflows, at both levels.

(*a*) *The Marginal Channel at* 250 *feet.*

We have found no traces in the shape of gravels or beaches at 250 feet. The evidence for a stream of water at this height consists of the deeply cut notch mentioned above. This is a V-shaped valley cutting across the outcrop of the Coniston Limestone and leading from the open hillside on the north to a wide amphitheatre with a floor below 175 feet, and in direct communication with the Hagg Gill Channel. The further course of this channel (No. 4) belongs as much to the 200 feet stage (No. 2) as to the 250 feet, but may be conveniently followed here. From Hagg Gill Wood to Dalton is a wide, deep valley with steep sides and a floor about 120 feet which has

* *Quart. Journ. Geol. Soc.*, Vol. LVIII. (1902), p. 482.

no relation to the present drainage. This opens, near Dalton Church, into the Dalton Valley—a wide, well cut valley below the 100 feet contour, joining the Goldmire Valley near Mill Wood, and continuing southwards with a bend at Furness Abbey until it reaches Roose.



OVERFLOW CHANNELS FROM LAKE DUDDON.

Below here its present mouth must have been barred by the Irish Sea Ice for the glacial channel turns eastwards down a wide valley, now dry, and enters Morecambe Bay near Roosebeck. Extensive deposits of water worn gravel are found at about the 100 feet level at Manor Park, and on the convex side of the curve at Holebeck. In both cases the gravel includes rocks from the Irish Sea Drift as well as from the Local Drift.

(*b*) *The* 200 *feet Lake.*

A number of fragmentary terraces, composed of well worn gravel, occur along the eastern side of the Estuary about the 200 feet contour. The best of these can be seen at Gargreave and Bank End. Stronger evidence of the permanence of the lake at this height is furnished by a number of deltaic deposits, where streams from branches of the Crake glacier entered the lake. These are :—(1) In the valley where Hallstead Farm now stands, about half a mile south of Grisebeck. This appears to have been formed by drainage from one of the outlets of the Gawthwaite cross valley. (2) In the valley above Grisebeck where the other outlet from the Gawthwaite valley discharged. (3) In the Ellermire valley where the Subberthwaite cross valley drained into the lake. (4) A little north of Hill where a small branch from the Subberthwaite valley drained into the lake at the most northern point at which we have found any evidence of the 200 feet phase.

These deltas are more or less fan-shaped. They are conspicuously stony at the tops, most of the stones being almost uniform in size, with their largest dimensions between 3 inches and 6 inches. Some of them are rounded but the majority are angular. Further down the delta the slope of the surface increases, and the stones become fewer and eventually give place to a fine alluvium quite free from stones. These deltas are most easily discernable in winter, when the soil is bare.

The first overflow of the 200 feet lake was by a channel (No. 2) on the west of Housethwaite Hill leading into the Long Bank Wood side of the Hagg Gill Channel. The further course would then be the same as No. 1. Later shrinkage of the Irish Sea Ice opened a channel (No. 3) a little to the west of No. 2, which leads at 180 feet into the Goldmire Valley. It is doubtful whether this marks more than an intermediate stage between the 200 feet and the 100 feet phases.

The area occupied by the 200 feet lake was probably quite small and confined to the eastern side of the estuary. There is no evidence of it on the western side, and a moraine near Fell Gate suggests that the 200 feet lake did not reach further north than Hill.

(*c*) *The* 100 *feet Lake.*

The area of the 100 feet lake must have been much greater. It is almost certain that it included a large area in the Steers Pool Valley, but in the absence of definite evidence it is not easy to decide whether any of the Lickle Valley was clear of ice. The Duddon Valley was most probably still filled with its glacier, extending along the western side of the estuary. This would account for the entire absence of evidence on that side.

Numerous remains of sandbanks and what appear to be terraces are to be found at 100 feet all the way from Askham to Woodland Church, but the growth of vegetation and Post-Glacial alterations have made some of them very difficult to recognise. A large delta occurs in the Woodland valley bottom, near Bridge End, which does not reach above the 100 feet contour, and a delta-like deposit near Woodland Church seems to belong to this stage. A well marked channel with thick, current bedded sandy deposits runs from Askham southwards to Park Farm.

The overflow for the 100 feet lake was a well-marked channel on the eastern side of Park Knotts leading directly into the Goldmire Valley and by Mill Wood. This is a much larger channel than those previously described, and was probably in use for a longer period. The railway cutting near Park Mine has considerably modified the shape of the valley there, but the original height of the col (93 feet) confirms our estimate of the level of the water.

(*d*) *The Final Stage of the Lake.*

The last stage of the lake to be represented by present deposits would be reached when the Irish Sea Ice retreated as far as Walney, and the existing channel between that island and the mainland may have been the last drainage channel of the Duddon before the sea was entirely open. Walney Island contains no rocks older than drift down to a level of 80 feet below O.D., and, consequently, is entirely of Glacial and Post-Glacial origin.

The only published reference to these glacial lakes in the Duddon Estuary appears to be by Mr. B. Smith in his paper on the Glaciation of Black Combe.*

In conclusion, we beg to acknowledge the assistance and advice of Mr. Bernard Smith and Dr. Gilligan, whilst we have been preparing this paper, and also the help, on several points, of Prof. P. F. Kendall, whose papers on Glacial Geology have been a continual inspiration during the twelve years we have been working at the geology of Furness.

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* *Quart. Journ. Geol. Soc.*, Vol. LXVIII. (1912), p. 420.

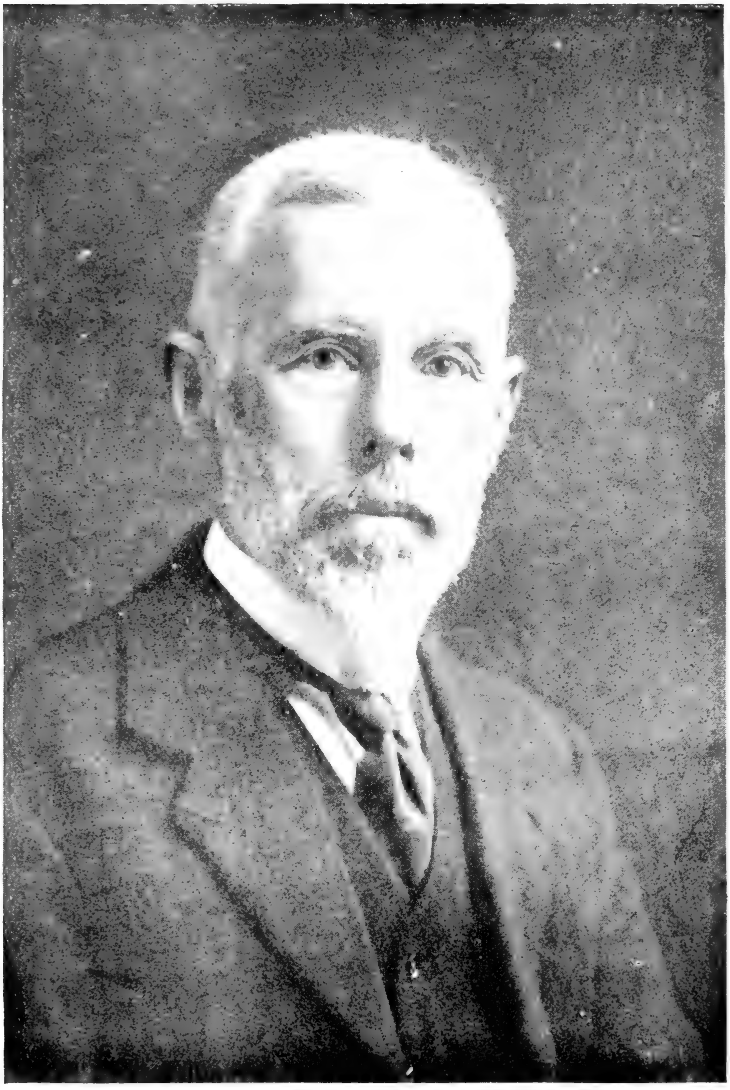
In Memoriam.

Clement Reid, F.R.S., F.L.S., F.G.S.,
1853—1919.

Yorkshire geologists are deeply indebted to the late Clement Reid for his careful and calm consideration of the Geology of part of their county. He joined the Geological Survey in 1874, and had experience in many parts of the country, including the moorlands of North Yorkshire, before proceeding to Holderness. As long ago as 1885, he produced his classical Memoir on the "Geology of Holderness," in which his extensive knowledge in many directions was demonstrated, and that work has proved the basis of all subsequent investigations in the area. Not only did Clement Reid make a careful geological survey of this interesting district and interpret many of the then complex geological problems, but he brought much historical information—from documents, old charts, maps and plans—to bear upon the illustration of the changes due to Coast Erosion and the accumulation of new land. His knowledge of Conchology and Botany enabled him to elucidate the puzzles which presented themselves in the various lacustrine beds in the district, and the geological information he gleaned as a result of study of the plant-remains, especially the seeds, obtained from the Holderness beds, led him, in later years, to specialize in this particular line of research, so that he came to be looked upon as the greatest authority on the subject, a position justified by his books on "Submerged Forests," and "The Origin of the British Flora." In much of this work he was assisted by his wife, formerly Miss E. M. Wynne Edwards, B.Sc., and it is pleasant to think that Mrs. Reid is still carrying on valuable investigations on the same lines as had been set out by her husband.

Clement Reid was the author of a number of other memoirs issued by the Geological Survey, though his first, which dealt with Cromer (1882) and that on Holderness, are among his best. The list following, which has been kindly copied by the Librarian from the catalogue of his works in the Library of the Geological Society of London, may not be complete, but it can be taken as representative.

Clement Reid was of a quiet and unassuming nature, a conscientious worker, but rarely entered into discussion or dispute; consequently he did not come before the geological world quite so prominently as



Clement Reid, F.R.S., F.L.S., F.G.S.

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many others whose work in originality and importance cannot be compared with his.—T.S.

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The Rev. W. Lower Carter, M.A., F.G.S.

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In Memoriam.

The Rev. W. Lower Carter, M.A., F.G.S.

1855—1918.

On June 22nd, 1918, was laid to rest, at Bushey, in Hertfordshire, the body of the Rev. William Lower Carter, M.A., F.G.S., who had for twenty years been a prominent member and official of the Yorkshire Geological Society, and it is but fitting that a brief notice of his career and of his devoted services should be put on its records.

Mr. Carter was born on August 9th, 1855, at Stafford, and was educated at Derby School. Later he was a student at Springhill College, Birmingham; and then, having gained an exhibition at Emmanuel College, he proceeded to Cambridge. After a course of four years' study in Natural Science, he passed the Tripos with first class honours, specialising in Geology. For a time, he studied at the University of Halle, Germany, and then he returned to Springhill College in order to complete his theological training. He was successively minister of the Congregational Churches at Bilston, in Staffordshire, at Hopton in Mirfield, and at Oxton in Birkenhead. In all of these charges he was a faithful pastor, revered by his people.

In 1884, Mr. Carter was elected F.G.S. of the Geological Society, London. In 1892 he became a Member of the Yorkshire Geological and Polytechnic Society, and in 1893 he was elected Hon. Secretary. From 1894 till 1904 Mr. Carter was associated with the late Mr. William Cash as Joint Editors of the *Proceedings*—which position he continued to hold—for a time in conjunction with Dr. Dwerryhouse—till 1909.

His own original researches were not very numerous, but include two important papers on "The Evolution of the Don River System," and on "The Glaciation of the Don and Dearne Valleys," which he contributed to the fifteenth volume of the *Proceedings of the Yorkshire Geological Society*. But his reports as Secretary of the field work of the Society are very full and often contain summaries of papers and records of observations that have never been published in any other form. No one writing on topics connected with the Geology of Yorkshire can afford to neglect them, and the Classified Index to 64 years of our *Proceedings* is a piece of work of more use in promoting the progress of Geology than many papers. The abstract of Professor Kendall's paper on "The Glacial Lakes of Cleveland," which appeared in the *Proceedings* for 1903, was entirely his work, and he contributed to the reports of several explorations carried out by the Society. He was engaged with Professor Kendall in a study of the Glaciation of East Lincolnshire, but this investigation was interrupted by his removal to Birkenhead, and later, during his work in London, he studied the glaciation and evolution of the river system of the course of the Wye in Hereford- shire, and the adjacent area.

For several years he was closely associated with the geological work of the British Association for the Advancement of Science. He acted as Secretary of Section C, and he was secretary of a Committee appointed by the British Association, at the instance of Professor Kendall, to draw up a list of characteristic fossils. Unfortunately his death and the dispersal of his papers rendered all the work done in that respect nugatory.

On March 1st, 1907, the appreciation of the members of the Yorkshire Geological Society for Mr. Carter's services to science, and especially in the observation and study of the geological problems of Yorkshire, was shewn by the presentation to him of a mahogany writing table, a petrological microscope (with a series of 111 rock sections), and a set of furs was also presented to Mrs. Carter.

In 1908, he was appointed Lecturer in Geology to the East London College, and later he delivered courses of lectures at other Colleges and Institutes in London. His indefatigable attention and skill made him not only the teacher, but the personal friend of his students. On June 7th, 1918, when lecturing at Queen's College, Harley Street, London, he had an apoplectic seizure, from the effects of which he never rallied. In a manner he died at his post !

As Secretary and Editor of the Yorkshire Geological Society, Mr. Carter not only upheld the high position of the Society as a meeting-ground for earnest workers and students in practical and theoretical science ; but by his tactful organisation and untiring zeal he made the *Proceedings* such a publication that valuable contributions of original work were readily made in it by men of eminence in Science. It has been well said that to them and to Mr. Carter is due the Yorkshire Geological Society's " proud pre-eminence among the County Geological Societies of the country." Whether at the meetings, or in the field, Mr. Carter was ever a brotherly man, a kindly friend, and an uplifter in thought and deed to his fellow members.—G. B. and D. F.

JOHN HENRY HOWARTH, F.G.S.

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In Memoriam.

John Henry Howarth, F.G.S.

(1853—1918.)

By the death of John Henry Howarth on March 8th, 1918, Yorkshire Geology lost one of its steadfast supporters and most earnest amateur workers. Born at Kirkby Malham in 1853, Howarth exhibited in his stalwart frame and strong lineaments characteristics of a type not uncommon in the Craven district. Brought up among the bold scars and ravines of that district and educated at Giggleswick Grammar School, it is not surprising that his attention was early directed to the subject of Geology, but a decisive influence seems to have been the fact that in his youth and early manhood he became acquainted with two men of notable personality who were engaged in mapping the district for the Geological Survey. These were J. R. Dakyns and R. H. Tiddeman. These were the great days of Yorkshire Geology. In the year that Howarth reached the age of 19 years, Tiddeman's epoch-making paper on "The Evidence for an Ice-sheet in North Lancashire and adjacent parts of Yorkshire" was published, and at the same period Tiddeman was spending his vacations in the exploration of the Victoria Cave. The Geological Survey was massing its forces here or hereabouts, and some of its ablest men were engaged in the mapping. McKenny Hughes was at work round about Ingleborough; Goodchild's great Glacial paper followed so closely upon Tiddeman's that it seems probable that his results were independently reached through embodying the same principles; De Rance was at work in Lancashire; Green and Aveling and Clifton Ward in the country north and south of Leeds. A little later, Fox-Strangways, fresh from his successful work in North-east Yorkshire, came into the Limestone country to assist in the mapping of the fells at the head of Wensleydale. What wonder, then, that the interest of a young man of Howarth's mental qualities was aroused.

A strong and enduring friendship sprang up between him and Tiddeman that lasted through their lives. A community of literary tastes was a further bond, and we have heard from Howarth humorous descriptions of their joint essays in the dramatic art. Some of their productions in the way of light and rather topical comedy were performed at Skipton, and one little play of the kind, in which, in addition to both these friends, the late J. J. Wilkinson, of Skipton, had also a finger, is among the rarities of local typography.

Howarth's interests in Geology were wide, and his judgments always useful, but it was chiefly as the careful and discriminating observer and recorder of ice-borne boulders that his chief service to Yorkshire Geology was rendered.

A Yorkshire Boulder Committee was set up in November, 1886, to remove the reproach from the county that in fourteen years only seven reports on erratics had been sent to the British Association Committee. Year by year, under successive secretaries, the Committee continued its labours, until, in 1896, on the death of its very active and competent Secretary, Thomas Tate, Howarth was induced to add to the labours of his busy life the duties of Secretary. His sound knowledge of petrological methods enabled him to sort out and appraise at their proper value reports that came in from local workers who had not this special qualification. This is made very manifest when the Boulder Committee's reports for the years after Howarth's assumption of the secretariate are compared with those of early years. Not only is there a great increase in volume, but along with greater reticence in the attribution of some erratics a firmer touch is manifest in regard to others. Thus in pre-Howarth days all dark-grained rocks were "Whin Sill"; on the other hand, thanks largely to Howarth's support, the Yorkshire Geological Society, which he had joined in 1890, made long excursions to places likely to have contributed to the tale of far-travelled rocks, and we find accordingly records of rocks from the Lake District, the Vale of Eden, the Cheviots and Melrose (where Howarth presided over the Meeting) stated with a decision not previously justified. In 1903, Howarth inscribed upon a large scale map of the Cleveland area symbols to indicate the distribution of the principal types of erratics according to their respective sources. Accompanying this we had six pages of "Notes" by Howarth—actually a very clear and valuable summary of the knowledge of boulder distribution throughout Yorkshire.

Adopting as a youth the profession of banking, John Henry Howarth started as a junior clerk with the Yorkshire Banking Company, and was in the service of the bank for thirty years. In 1899 he was appointed as general manager of the Halifax Joint Stock Bank, afterwards the West Yorkshire Bank, in which institute he ultimately became Chairman and Director, as well as general manager, and established a high reputation in banking circles. His experience of administration was of great advantage to the Yorkshire Geological Society, in which organisation he was for many years a member of the Council; from 1902 to 1906, Hon. Treasurer; and in 1907 Hon. Secretary. A man of very wide social instincts and sense of duty, he took an active part in the public life of Halifax, where the last nineteen years of his life were spent, and of which town he was a magistrate. By the members of the Yorkshire Geological Society these manifold activities were regarded perhaps a little jealously, as they led to his more seldom appearance in the field, where, however, he was always a delightful companion, and we have memories of notable debates after the day's walking was finished in which he bore an energetic share, and which his sound logical acumen, and his genial humour made veritable Noctes Ambrosianæ.

P. F. K. and H. E. W.

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THE YORKSHIRE GEOLOGICAL SOCIETY.

CAPITAL ACCOUNT, Nov., 1920.

Date		£	s.	d.	Date		£	s.	d.
1920—					1920—				
Nov. 24—	To Halifax Corporation Mortgage Bonds	370	0	0	Nov. 24—	By Halifax Corporation	370	0	0

Books, Proceedings, Maps, etc., at the Leeds University as per agreement dated 28th November, 1907, in the custody of Lloyd's Bank, Ltd., Halifax.

J. W. Sutcliffe,
Hon. Treasurer.

TREASURER'S ACCOUNT, Nov. 24th, 1920.

Receipts.

Date		£	s.	d.	£	s.	d.
1919—							
Nov. 16—	To Balance from Mr. J. E. Wilson ...				58	16	3
1920—							
Nov. 24—	To 94 Members' Subscriptions				61	2	0
	,, Halifax Corporation Stock—						
	Interest, April 6th, 1920	6	1	4			
	Interest Oct. 4th, 1920	6	1	4			
					12	2	8
	,, Lloyd's Bank, Ltd.—Interest on Current a/c				2	18	0
					£134	18	11

Audited and found correct, December 1st, 1920.
(Signed) F. W. Branson.

Expenditure.

Date		£	s.	d.	£	s.	d.
1919—							
Dec. 4—	By Room for Annual Meeting				1	3	6
	,, Lantern				0	18	6
1920—							
Mar. 30—	,, Envelopes	0	17	0			
	,, Circulars	3	0	0			
Feb. 4—	,, Circulars	1	2	0			
Apl. 13—	,, Circulars, *re* Yorkshire Rivers	5	4	10			
July 31—	,, Circulars	1	10	9			
	Total Printing and Stationery				11	14	7
	,, Hon. Sec., Postages ...	2	5	0			
	,, Hon. Treasurer, Postages	0	3	10			
					2	8	10
	,, Cheque Book				0	2	0
	,, Two Sheets of Drawings				3	0	0
Nov. 16—	,, Lantern, etc.				0	10	0
	,, Grant to Hon. Secretary for Clerical assistance for the year				15	0	0
,, 17—	,, Balance, as per Lloyd's Bank, Ltd., Halifax				100	1	6
					£134	18	11

J. W. Sutcliffe,
Hon. Treasurer.

THE YORKSHIRE GEOLOGICAL SOCIETY.

CAPITAL ACCOUNT, Nov., 1921.

	£	s.	d.
1921—			
To Halifax Corporation Mortage Bonds	370	0	0

Books, Proceedings, Maps, etc., at the Leeds University as per Agreement dated 20th November, 1907, in the custody of Lloyd's Bank, Ltd., Halifax.

	£	s.	d.
1921—			
Nov. 16—By Halifax Corporation Mortgage Bonds	370	0	0

J. W. Sutcliffe,
Hon. Treasurer.

REVENUE ACCOUNT, Nov. 16th, 1921.

Receipts.

	£ s. d.	£ s. d.
1920—		
Nov. 24—To Balance brought forward		100 1 6
1921—		
Nov. 16— ,, 77 Subscriptions, 13/-		50 1 0
,, 1 Subscription		0 17 6
,, Income Tax refunded		5 3 10
,, Interest on Halifax Corporation Stock—		
April 3	6 1 4	
October 3	6 1 4	
		12 2 8
,, Lloyd's Bank, Ltd.—		
Interest, Dec. 31, 1920	1 12 10	
Interest, June 30, 1921	1 18 6	
		3 11 4
		£171 17 10

Examined and found correct,
F. W. Branson,
November 18th, 1921.

Expenditure.

	£ s. d.	£ s. d.
1920—		
Dec. 28—By Stationery		0 13 8
1921—		
Jan. 10— ,, Collotype Prints		17 0 0
,, 31— ,, Circulars		1 14 8
Oct. ,, Circulars		1 19 6
,, 19— ,, Postages—Secretary ...	3 0 0	
,, Postages—Treasurer ...	0 8 0	
		3 8 0
,, Advert. of Annual Meeting		0 11 3
,, Balance as per Pass Book	149 9 6	
Less cheques not presented	2 18 9	
		146 10 9
		£171 17 10

J. W. Sutcliffe,
Hon. Treasurer.

LIST OF MEMBERS, 1922.

HONORARY MEMBERS.

1898 Whitaker, William, B.A., F.R.S., F.G.S., Wellesley Court, Wellesley Road, Croydon.

1907 Woodward, Arthur Smith, LL.D., F.R.S., F.L.S., British Museum (Natural History), S. Kensington, London, S.W.

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* Life Members who have compounded for the annual subscriptions.

Elected.

1883*Abbott, R. T. G., F.S.I., Whitley House, Malton.

1899 Appleyard, J. H. R., B.Sc., 5 Willow Lane East, Huddersfield.

1908 Archer, J. Fletcher, B.A., M.I.Mech.E., 48 High Street, Doncaster.

1900 Ashley, Theodore, 1 Fieldhouse Terrace, Durham City.

1900*Ashworth, John Hoyle, The Bungalow, 151 St. Andrew's Road South, St. Anne's-on-Sea.

1919 Baker, S.E., M.A., Winder House, Sedbergh. (Local Secretary.)

1919 Barker, Wilfred R., 64 Grove Street, Barnsley.

1922 Barr, C. H., M.B.E., B.Sc., Technical School, Normanton.

1879*Bartholomew, C. W., Blakesley Hall, near Towcester.

1912*Barrow, George, Geological Survey, Museum of Practical Geology, Jermyn Street, London, S.W.

1914 Beard, G., 2 Brookville, Hipperholme, Halifax.

1912 Beaumont, A. G., Wakefield Waterworks, Rishworth.

1878 Bedford, J.E., F.G.S., Arncliffe, Shire Oak Road, Headingley, Leeds. (Member of Council.)

1895 Bingley, Godfrey, Thorniehurst, Shaw Lane, Headingley, Leeds. (Member of Council.)

1909 Bisat, W. S., 1 Selwyn Avenue, North Ferriby, near Hull. (Member of Council.)

1907 Booth, Peter, Holmwood, Richmond Road, Wakefield.

1876*Bowman, F. H., D.Sc., F.R.S.E., F.I.S., 181 Stamford Street, Brooks Bar, Manchester.

1896 Bradley, F. L., Ingleside, Malvern Wells.

1894 Branson, F. W., F.I.C., F.C.S., 14 Commercial Street, Leeds. (Member of Council.)

1909 Broadbent, Fredk. J., Croft House, Knowle, Mirfield.

1907 Brown, T. E., Green Hill, Salterforth, Colne, Lancs.

1921 Brown, Tom L., 55 West Road, Loftus.

1882*Buckley, George, Tower Chambers, Halifax.

1904 Burton, Jos., J., F.G.S., Rosecroft, Nunthorpe, R.S.O. (Member of Council.)

1905 Carpenter, F. G., Claremont, Bradford Road, Wakefield.

1900 Carr, Professor J. W., M.A., F.L.S., F.G.S., University College, Nottingham.

1909 Carruthers, R. G., B.Sc., F.G.S., Geological Survey of Scotland, 33 George Square, Edinburgh.

1891*Chambers, J. C., Edgerton Road, West Park, Leeds.

1913 Charlesworth, A., M.Sc., 37 Sandringham Street, Hull. (Member of Council.)

1875*Charlesworth, J. B., J.P., Hurts Hall, Saxmundham.

1906 Cheetham, C. A., Wheatfield, Old Farnley, Leeds.

1892*Childe, Hy. Slade, F.G.S., Mining Engineer, Wakefield.

1877*Clark, J. E., B.A., B.Sc., Aysgarth, Riddlestown Road, Purley, Surrey.

1919 Comber, Norman M., B.Sc., A.R.C.S., The University, Leeds.

1916 Clegg, Colin, F.G.S., Engineer's Office, Bolsterstone, Sheffield.

1915 Clegg, T. D., Ebor House, Middleton, Leeds.

1889 Crewe, Marquess of, Crewe Hall, Crewe.

1894*Crowther, Henry, F.R.M.S., Philosophical Hall, Leeds. (Local Secretary.)

1894*Davis, James Percy A., Old Bunting, Nqqueleni, *via* Umtata, Pondoland West, South Africa.

1886*Dobinson, Launcelot, 157 St. Andrew's Road, S., St. Annes-on-Sea.

1908 Durnford, H. St. John, M.Inst.C.E., 2 Sepulchre Gate, Doncaster.

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1921 Elliss, W. J., 92 Burngreave Road, Pitsmoor, Sheffield.

1894 EMBLETON, HENRY C., Central Bank Chambers, Leeds.

1913 EVANS, JOHN, F.I.C., F.C.S., Public Analyst's Laboratory, Sheffield.

1913 FEARNSIDES, Professor W. G., M.A., F.G.S., The University, Sheffield. (Local Secretary.)

1887*FENNELL, CHAS. W., F.G.S., 82 Westgate, Wakefield. (Local Secretary.)

1913 FISHER, GREEVZ, 78 Chapel Allerton Terrace, Leeds.

1902 FITZWILLIAM, Earl, Wentworth Woodhouse, near Rotherham.

1893 FORSYTH, DAVID, D.Sc., LL.D., M.A., 101 Caledonian Road, Leeds. (Past President.)

1919 FOWLER, the REV. J., M.A., F.G.S., Nidd Vicarage, Harrogate.

1894 FOX, C. E., F.S.I., 7 Rawson Street, Halifax.

1909 GILL, EDWIN, Ivy Dene, Mirfield.

1907 GILLIGAN, Professor ALBERT, D.Sc., F.G.S., The University, Leeds. (Hon. Librarian and Member of Council.)

1881 GLEADOW, F., Brookbank House, Malton.

1920 GRACE, GEO., B.Sc., 23 Alexandra Crescent, Ilkley.

1905 GREEN, Hugo, 19 Bank Street, Wakeffeld.

1843 HALIFAX, VISCOUNT, Hickleton Hall, Doncaster. (Vice-President.)

1918 HANLEY, J. A., Ph.D., A.R.C.S., The University, Leeds.

1906*HARGREAVES, WALTER, Rothwell Haigh, Leeds.

1895 HARKER, ALFRED, M.A., F.R.S., F.G.S., St. John's College, Cambridge.

1909 HARTSHORN, J., Leyburn, R.S.O., Yorkshire.

1887 HASTINGS, GEOFFREY, 17 Welbury Drive, Bradford.

1920 HASTINGS, CUTHBERT, 29 Brook Street, Bradford.

1919 HASWELL, P., B.A., Giggleswick School, Settle. (Local Secretary.)

1896 HAWKESWORTH, EDWIN, Sunnyside, Crossgates, near Leeds. (Member of Council.)

1921 HAYDOCK, A., 5 West View, Settle.

1913 HENZELL, CHAS. G., M.Inst.C.E., Redcote, West Park, Leeds.

1910 HOBSON, BERNARD, M.Sc., F.G.S., Thornton, Hallamgate Road, Sheffield.

1917 HOGG, CEDRIC C., Birkwood, Redhill, Castleford.

1919 HOLMES, JOHN, 9 Campbell Street, Crosshills, near Keighley.

1881*HORNE, WM., F.G.S., Leyburn. (Local Secretary.)

1907 Hummel, Ernest, B.Sc., H.M.I., 130 Otley Road, Leeds.

1919 Humphrey-Williams, Miss Marjorie, B.Sc., The College, Harrogate.

1922 Ingle, T., Holme Road, Market Weighton.

1887*Jones, J. E., Solicitor, Halifax.

1897 Jowett, Albert, D.Sc., Oakleigh, Whitefield, nr. Manchester.

1892 Kendall, Percy F., M.Sc., F.G.S., Moor Allerton, Leeds. (Past President.)

1902 Kidston, Robert, LL.D., F.R.S., F.R.S.E., F.G.S., 12 Clarendon Place, Stirling.

1897*Kitson, R. H., LL.D., F.G.S., Elmet Hall, Leeds.

1877*Lamplugh, G. W., F.R.S., F.G.S., 13 Beaconsfield Road, St. Albans. (President).

1894 Law, Arthur W., Salterville, Halifax.

1906 Lofthouse, J. H., F.G.S., Lyell House, Dragon Parade, Harrogate.

1877*Lupton, Arnold, F.G.S., M.Inst.C.E., 7 Victoria Street, Westminster.

1894*Maufe, H. Brantwood, B.A., F.G.S., P.O. Box 366, Salisbury, Rhodesia.

1895 Muller, Harry, F.G.S., 12 West Park, Eltham, Kent.

1903 Naylor, E., Corner Garth, Leadhall Lane, Leeds Road, Harrogate.

1902*Nettleton, Stanley, Roundwood, Ossett.

1922 Newbold, W., M.A., Cromer Hall, Leeds.

1911 Odling, M., M.A., B.Sc., F.G.S., 240 Linthorpe Road, Middlesbro'.

1899*Ormerod, William, The Crossways, Leeds Road, Harrogate.

1875*Parke, G. H., F.G.S., F.L.S., Aysgarth, The Mall, Southgate, London, N.

1922 Parkinson, D., 61 West View, Clitheroe.

1892*Pawson, A. H., F.L.S., F.G.S., Howe Combe, Watlington, Oxon.

1919 Petch, Frank, M.C., B.Sc., 6 Trentham Street, Dewsbury Road, Leeds.

1916 Pickering, G. F., Woodcroft, Horsforth.

1905 Punch, J. W. R., Howe View, Castleton, Grosmont, S.O.

1859*Ramsden, Sir J. W., Bart., Byram Hall, near Pontefract.

1904 Rastall, R. H., M.A., F.G.S., Christ's College, Cambridge.

1920 Regnart, H., 33 Eskdale Terrace, Newcastle-on-Tyne.
1914 Roberts, W. H., M. Inst. M.E., Low Laithes Colliery, Wakefield.
1907 Roome, G. W., B.Sc., F.G.S., 214 Psalter Lane, Sheffield.
1903*Rowe, Arthur W., M.S., M.B., F.G.S., 1 Cecil Street, Margate.
1922 Rowe, J. Hambley, 88 Horton Grange Road, Bradford.
1902*Rowland, Lewis G., Thwaitefield, Goathland.
1896*Rowley, Walter, D.L., F.G.S., F.S.A., 20 Park Row, Leeds. (Vice President.)
1882 Scarborough Philosophical Society, The Museum, Scarborough.
1905 Sewell, J. T., Arran, Bagdale, Whitby.
1897*Sheppard, Thomas, M.Sc., F.G.S., F.R.G.S., F.S.A.(Scot.), The Museum, Hull. (Member of Council.)
1906 Sibson, Ernest O. D., 36 Elton Parade, Darlington.
1904*Simpson, J. T., J.P., Brackenholm, Rutland Road, Harrogate. (Local Secretary.)
1881*Stansfield, Alfred W., The Raikes, Skipton, Yorkshire.
1890 Stather, John W., F.G.S., Brookside, Newland Park, Hull. (Vice-President.)
1915 Stephenson, T. C., 28 Old Road, Crayford, Kent, S.E.
1885*Stockdale, T., Spring Lea, Leeds.
1902*Stringer, G. E., Jun., Clayton West, nr. Huddersfield.
1894 Sutcliffe, J. W., 14 Clifton Road, Halifax. (Hon. Treasurer.)
1897*Teal, Joseph, Banksfield House, Yeadon, near Leeds.
1894 Tetley, Ed. H., B.A., 18, Moorland Road, Leeds.
1880 Tetley, C. F., M.A., Spring Road, Headingley, Leeds.
1919 Thomas, the Rev. Harold, M.A., F.G.S., Dogley Lane, Feney Bridge, Huddersfield.
1886 Thompson, R., Dringcote, The Mount, York.
1902 Thompson, G. R., B.Sc., 10 Springfield Mount, Leeds.
1899*Turton, Robert B., Kildale Hall, Grosmont, Yorks, R.S.O.
1914 Versey, H. C., M.Sc., F.G.S., The University, Leeds.
1907 Wager, Morton E., B.Sc. (Lond.), Cragg Road, Mytholmroyd, Yorks.
1910 Walker, Joseph, Wooldale, Thongs Bridge, Huddersfield.
1884*Walmsley, A. T., M.Inst.C.E., F.S.I., F.K.C., Engineer to the Dover Harbour Board, Engineer's Office, Dover Harbour.

1894 Walton, F. Fielder, F.G.S., L.R.C.P., 19 Charlotte Street, Hull.

1898 Wellburn, Edgar D., L.R.C.P.E., F.G.S., Beech House, Sowerby Bridge. (Member of Council.)

1906 Wells, George John, 51 Millhouses Lane, Sheffield.

1921 Wilcockson, W. H., M.A., The University, Sheffield.

1909 Wills, Albert E., Madge Croft, Mirfield.

1905 Wilmore, Albert, D.Sc., F.G.S., Noyna, Belmont Road, Bushey, Herts.

1894 Wilson, J. E., F.G.S., Hatch Cottage, Kingsley Green, Haslemere, Surrey.

1906 Wilson, J. R. R., M.Inst.C.E., H.M.I.M., 4 Park Terrace, Newcastle-on-Tyne.

1909 Wilson, R. B., 20 Park Row, Leeds.

1909 Wilson, G. V., B.Sc., Geological Survey of Scotland, 33 George Square, Edinburgh.

1915 Winter, W. P., B.Sc., F.G.S., 20 Hurst Wood Road, Shipley.

1909 Wroot, H. E., 99 Spencer Place, Leeds. (Hon. Secretary.)

1921 Wyon, Dr. G. A., 5 Spring Road, Headingley, Leeds.

1921 Young, W. H., M.A., H.M.I., 4 Clifton Terrace, York.

*** It is requested that any Member changing his residence will communicate at once with the Hon. Secretary.

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1887 Hughes, Prof. T. McK., M.A., F.R.S., F.G.S., Ravensworth, Brooklands Avenue, Cambridge.

1887 Judd, Prof. Jno. W., C.B., LL.D., F.R.S., F.G.S., 30 Cumberland Road, Kew, Surrey.

1887 Woodward, Henry, LL.D., F.R.S., 13 Arundel Gardens, Notting Hill, London, W.

1907 Woodward, Arthur Smith, LL.D., F.R.S., F.L.S., British Museum (Natural History), S. Kensington, London, S.W.

1898 Whitaker, William, B.A., F.R.S., F.G.S., Freda, Campden Road, Croydon.

ORDINARY MEMBERS.

* Life Members who have compounded for the annual subscriptions.

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1909 Wroot, H. E., 45 Pollard Lane, Bradford

*** It is requested that any Member changing his residence will communicate at once with the Hon. Secretary.

PROCEEDINGS

OF THE

Yorkshire Geological Society.

55.06 (42.7

NEW SERIES, VOL. XIX., PART I., PAGES 1-40,
AND LIST OF MEMBERS.

With Six Plates.

Edited by W. LOWER CARTER, M.A., F.G.S.

1914.

CONTENTS.

Issued October 15th, 1914.

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OFFICERS AND COUNCIL FOR 1914

ELECTED AT THE ANNUAL MEETING AT HUDDERSFIELD,

November 20th, 1913.

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Yorkshire Geological Society.

OBJECTS.

This Society was founded in the year 1837 at a meeting of coal proprietors of the West Riding at Wakefield, and for nearly forty years its operations were confined to that Riding. The purposes for which it was formed were the investigation of the Yorkshire Coalfield and the gathering of such definite information about its seams of coal and ironstone as would be of use in the prosecution of mining operations. The scope of the Society was soon enlarged to include the Arts of Mining and Metallurgy and their dependent manufactures, and of the machinery and tools employed therein, and the name was correspondingly expanded to "Geological and Polytechnic." The subscription was originally half-a-guinea, but when Proceedings were published half-a-crown extra was added to meet the cost. In 1838 the work of establishing a Museum was commenced, and in 1839 the preparation of a section across the Pennine Chain was undertaken. Meetings were held regularly at which papers on geology, palæontology, mining, and kindred topics were read and discussed. In 1877 the rules were revised, and it was decided to extend the Society's operations from the West Riding to the whole county. In addition to the ordinary meetings of the Society, from time to time investigations were undertaken by the aid of funds specially raised. Among these were the investigation of the bone-bearing deposits of Raygill, the pre-historic mounds of Grassington, the source of the Aire at Malham, and the Underground Waters of Ingleborough. In the two latter the Society worked in conjunction with a Committee of the British Association. At the Annual Meeting in 1906 it was resolved to change the title to "The Yorkshire Geological Society."

MEMBERSHIP.

There is no entrance fee.

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PUBLICATIONS.

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PROCEEDINGS

OF THE

Yorkshire Geological Society.

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With Three Plates.

Edited by W. LOWER CARTER, M.A., F.G.S.

1916.

CONTENTS.

Issued November, 1916.

Yorkshire Geological Society.

OFFICERS AND COUNCIL FOR 1916

ELECTED AT THE ANNUAL MEETING AT LEEDS.

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Prof. PERCY F. KENDALL, M.Sc., F.G.S.
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A. CHARLESWORTH, M.Sc. (Leeds).

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PROCEEDINGS

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Yorkshire Geological Society.

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1917.

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Issued March, 1917.

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ELECTED AT THE ANNUAL MEETING AT LEEDS.

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With Twelve Plates.

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1918.

CONTENTS.

Issued November, 1918.

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1919-1920.

CONTENTS.

Issued December, 1920.

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1921-1922.

CONTENTS.

Issued December, 1922.

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