PROCEEDINGS

OF THE

GEOLOGICAL

AND

POLYTECHNIC SOCIETY

OF THE

WEST RIDING OF YORKSHIRE.

1839—42.

VOLUME I.

LEEDS:

PRINTED BY EDWARD BAINES AND SONS.

1849.

PREFACE.

THE GEOLOGICAL AND POLYTECHNIC SOCIETY of the West Riding of Yorkshire originated at a meeting of the coal proprietors of that district, held in Wakefield, on Friday, December 1st, 1837, Thos. Wilson, Esq., of Banks Hall, near Barnsley, in the Chair. The extent and importance of the Yorkshire coal field, comprising not less than 462 square miles, and the imperfect information possessed respecting its numerous beds of coal and ironstone, having been considered, and also that in the winning and working of the same a large amount of capital was embarked, and extensive machinery and a numerous population employed, it was suggested that great advantages would result from the institution of a Society for collecting and recording Geological and Mechanical Information, with the accuracy and minuteness necessary for the successful prosecution of mining. These objects, it was hoped, would be most effectually attained by the formation of a collection of maps, plans, sections, models, mining records, and every kind of information respecting the geological structure of the country; the construction ultimately of a complete geological map or model; the formation of a museum, as well of the various fossils and mineral products of the district, as of drawings and models of the machinery and tools employed in mining; the consideration of the various systems of ventilation in use; the holding of public meetings in the principal towns of the West Riding, for reading communications and discussing topics connected with these subjects; the publication of papers, reports, and transactions; and the corresponding and co-operating with the metropolitan and other similar societies. While these subjects would occupy the principal attention of the society, it was considered desirable (particularly as there was no other society embracing these objects) to extend its operation to whatever was connected with the staple manufactures of the West Riding; together with the bearings of geology and chemistry upon agriculture, and the application of mechanical inventions to the common arts of life.

This proposal having met with the unanimous approbation of the meeting, immediate steps were taken for organising the Society, of which forty gentlemen at once signified their wish to become members, and the Right Hon. Earl Fitzwilliam, F.R.S., accepted the office of President.

The preliminary business having occupied the first two or three sittings, Professor Johnston, of Durham, in May, 1838, delivered the first public lecture, "On the Economy of a Coal Field," which was published in a separate form.

The following papers were submitted at the subsequent Meetings, of which no permanent record is preserved except in the local journals of the period :—

"On the Dislocations in the Valley of the Don," by H. Hartop, Esq.

"Illustrations of the Geology of the Yorkshire Coal Field," by the Rev. W. Thorp.

"On the Inefficiency of the Compass for Mineral Surveying, and Suggestions for taking the Magnitude of Angles," by C. Morton, Esq.

"On the Mode of Ventilation adopted at Middleton Colliery," by T. W. Embleton, Esq.

"On the Non-identity of the Haigh Moor and Rothwell Haigh Seams," by Henry Briggs, Esq.

"A Comparison of the Yorkshire and Lancashire Coal Fields," by the Rev. W. Thorp.

"On the Miners' Safety Fuze," by T. W. Embleton, Esq.

"On an Improved Safety Lamp and Suggestions for Lighting Mines by means of the Fire Damp," by Mr. Fletcher.

"Remarks on the Section from the Bradgate Rock to the Forty Yards Coal at Middleton," by T. W. Embleton, Esq.

"On the Causes of Explosions in Boilers of Packet Engines, and Suggestions for their Improvement," by H. Hartop, Esq.

"On the Principle and Manufacture of the Patent Wire Ropes," by Mr. Lear.

"On the Geology of the Neighbourhood of Sheffield," by the Rev. W. Thorp.

"On the Utility of Geology as applied to Mining, Agriculture, and the Arts," by C. Morton, Esq.

The printed Proceedings of the Society, therefore, commence with the Meeting held at Leeds, December 6th, 1839.

Leeds, 17th April, 1849.

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1842.

LIST OF OFFICERS AND MEMBERS

OF THE

Geological and Polytechnic Society

OF THE

WEST-RIDING OF YORKSHIRE.

LIST OF OFFICERS AND MEMBERS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

OF THE

West-Riding of Yorkshire,

1st May, 1842.

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REPORT OF THE PROCEEDINGS

OF

THE QUARTERLY MEETING

OF THE

GEOLOGICAL AND POLYTECHNIC SOCIETY

OF THE WEST RIDING OF YORKSHIRE,

HELD IN

THE HALL OF THE LEEDS PHILOSOPHICAL AND LITERARY SOCIETY,

ON THURSDAY, DECEMBER 6, 1839.

THE REV. W. F. HOOK, D.D., VICAR OF LEEDS, IN THE CHAIR.

LEEDS:

PRINTED FOR THE SOCIETY, BY R. PERRING, COMMERCIAL-STREET.

1839.

GEOLOGICAL AND POLYTECHNIC SOCIETY

OF THE WEST RIDING OF YORKSHIRE.

The Quarterly Meeting was held on Thursday, December 6th, 1839, at Leeds, in the Hall of the Philosophical and Literary Society, and was numerously attended by both members and strangers.

The Morning Sitting commenced at eleven o'clock. Amongst the gentlemen present we observed—C. J. Brandling, Esq., Middleton Lodge; the Rev. Samuel Sharp, Vicar of Wakefield; Henry Leah, Esq., of Byerley; the Rev. Theo. Barnes, Castleford; Dr. Carr, Knostrop; the Rev. Thomas Furbank, Bramley; William Sharp, Esq., Bradford; Edward William Binney, Esq., (the Secretary) and J. E. Bowman, Esq., a deputation from the Manchester Geological Society; William Cooper, Esq., Mount Vernon; Dr. Wright, Wakefield, Thomas Wilson, Esq., the Banks, Barnsley; T. G. Clayton, Esq., Byerley; Rev. W. Thorp, Womersley; J. G. Marshall, Esq., Headingley; Henry Hartop, Esq., Hoyland; Henry Briggs, Esq., Overton; Edward Waud, Esq., Chester Court; T. W. Embleton, Esq., Middleton; Charles Morton, Esq., Darton; William Bull, Esq., Hostingley House, Rev. W. H. Teale; Andrew Faulds, Esq., Worsborough; R. D. Chantrell, Esq., George Shaw, Esq., John Lapage, Esq., Robert Arthington, Esq., Dr. Williamson, Dr. Hunter, J. P. Sanderson, Esq., Anthony Titley, Esq., W. Willock, Esq., E. J. Teale, Esq., G. W. Bischoff, Esq., Henry Teal, Esq., Thomas Hebden, Esq., Dr. Pyemont Smith, Mr. Bateson, Mr. Hare, Mr. Samuel Smith, Mr. Price, Mr. Thomas Butler, Mr. Wm. Hey, Mr. S. D. Martin, Rev. R. W. Hamilton, Mr. W. West, Mr. J. O. March, Mr. N. P. Simes, Mr. W. S. Ward, Mr. C. J. Smith, Mr. Benjamin Biram, Wentworth, &c. &c.

On the table were a number of specimens of recent fishes, and of fossil fishes, from the Philosophical Society's collection, and also of fossil fishes from the collection of Mr. Embleton to illustrate Mr. Teale's valuable paper.

There was also a specimen of Calamites Cannæformis, presented by Godfrey Wentworth, Esq., Woolley Park.

On the motion of James G. Marshall, Esq., seconded by the Rev. S. Sharp, the Rev. DR. HOOK, Vicar of Leeds, was invited to take the chair.

DR. HOOK'S OPENING SPEECH.

Dr. Hook complied with the call, took the chair, and opened the proceedings as follows :—Gentlemen, having been requested by your Committee to preside at the West-Riding Geological Society, I have done myself the honor of acceding to the request, though I must, without any affectation, repeat to you what I said to them, that I am conscious of my inability to discharge the duties of the office with credit to myself or with satisfaction to you, since my acquaintance with Geology is merely such as might be expected from any person acquainted with the literature of his country, and I speak in the presence of gentlemen who have sounded the depths and shoals of the science. But thus much I may be permitted to say, that it is a science sublime as well as interesting and important ; interesting it is to have the mind carried back to the revolutions of those distant eras when the seeds were sown, if I may so say, of those fields of coal of which we are reaping the harvest which ministers a supply to so many human wants, and to which we especially owe the prosperity of the district of which we are the inhabitants. Of its importance I need not speak to practical men ; it is at once admitted by the miner, the chemist, the agriculturist, the builder, the engineer. Sublime it is, for what can be more sublime to the dwellers upon earth than the archaiology of the globe ? Gentlemen, you are aware that scarcely half a century has elapsed since Geology began to be studied scientifically ; and, owing to the crude and conflicting theories of those geologists who ventured to theorize before they had collected facts or collated the observations of practical men, some prejudice for a time was excited against it : but that prejudice is passing away, and the object with Geologists seems now to be merely to collect phenomena, to classify and compare them. I believe that I have now the pleasure of addressing gentlemen who aspire to no higher honour than that of being collectors and collators of facts. Gentlemen, with those persons who fear lest the study of Geology should be detrimental to the cause of Religion, however excellent they may be, I profess to have no sympathy. My faith in the inspiration of Holy Scripture is such that I am certain the discoveries of science will only tend to the confirmation of its unassailable veracity. To the theories of many Geologists I may be opposed, and I may be so on scientific principles, because I find that in the year 1806 the French Institute counted not fewer than eighty theories, supposed to be hostile to Scripture history, of all which theories scarcely a vestige is now to be traced, scarcely a record has been preserved. To show, however, that there is nothing in the cosmogony of the Bible repugnant to the real discoveries of Geology, I would refer you to the commencement of Dr. Buckland's Bridgewater Treatise, and especially to Dr. Pusey's valuable note appended to it. The very learned Professor of Hebrew there states it as his opinion that the first two verses of Genesis contain merely a summary statement of what is related in detail in the rest of the chapter, and that the time of the creation is not defined. We are told only of what we are concerned to know, that all things were created by God. The rest may have been left indefinite, as so many other things have been, that there may be free scope for the exercise of those high endowments with which our Maker has blessed our species, namely, our reason and our imagination. But were the interpretation to which I have alluded merely the conjecture of Dr. Pusey or Dr. Buckland to meet an apparent difficulty, after the discoveries of Geology, I, for my part, should attach to it no importance whatever; nay, I should be among the foremost to contend against it. But I find it to have been a very general opinion among the Fathers or early writers of the Christian Church. The learned Professor of Hebrew refers to some of these writers. I may add that I find Justin Martyr in the second century, and Gregory Nazianzen in the fourth, expressing their belief that an indefinite period elapsed between the original creation, and that disposition of things of which we have the narrative in the Book of Genesis. Their judgment was, of course, on this point unprejudiced and independent, and therefore all must admit that, in such a case, their authority is great. We may, indeed, conclude, that if the discoveries of Geology are opposed to some modern interpretations of Scripture, they are not opposed to Scripture rightly interpreted. Opposed! I ought rather to say that the investigations of Geology are in perfect accordance with Scripture. For when Scripture tells us of the deluge, the Geologist is able to comment upon the fact by pointing to the valleys of denudation, and by calling attention to those pinnacles of granite which are found standing insulated and detached from the neighbouring mountains, to the boulder stones and other diluvial deposits, to the fossils of later date, to the surface of the earth moulded at a comparatively late period, all tending, as the celebrated French Geologist remarks, to shew that the last revolution that disturbed the surface of the Globe is not of very ancient date. Nay, Gentlemen, when we reflect on what has been; when we hear Geology speaking of the primeval revolutions in this globe, of the series of past disruptions, elevations, dislocations; when we hear it discoursing of central heat, we are better prepared to listen to the inspired penman when he tells us that, as the world which once was, being overflowed with water, perished, so the heavens and the earth which are now, are kept in store, reserved against fire; when he thus tells us that another revolution is approaching, not of water but of fire. After these observations, Gentlemen, I shall conclude my address with saying that I, for one, will bid you God speed. Geology can give no results hostile to revelation. A discrepancy will never be found between the words and the works of Almighty God. (Applause.)

Mr. Embleton then proposed a list of gentlemen for admission as new members.

Mr. Hartop seconded the nominations, and they were adopted.

Mr. Morton said it was probably not known to the chairman, much less to the auditory, that a deputation from the Manchester Geological Society had attended this meeting in the hope of promoting that union which it was desirable should at all times exist between the two Societies. This was the first step towards it; they had been at the trouble of coming over, and he trusted that in future the members of the Societies would interchange visits, and that gentlemen would be deputed from this meeting to visit the Manchester Society at its next meeting. A great ridge of hills divided the places of their meeting, but it was the interest and it would be the duty of each Society to investigate, not only the ridge itself, but the hills in its vicinity, and the strata on each side of it. He would beg leave to move

"That the gentlemen who compose the deputation from the Manchester Geological Society, E. W. Binney, Esq., the Secretary, and J. E. Bowman, Esq., be elected Honorary Members of this society."

Mr. Henry Briggs seconded the proposition, and it was unanimously agreed to.

MR. T. P. TEALE ON FOSSIL ICHTHYOLOGY.

Mr. T. P. Teale, F.L.S., then read his paper "On the Fossil Ichthyology of the Yorkshire Coal Field." He began by saying that the title of the West-Riding Geological and Polytechnic Society sufficiently explained its principal objects, namely, Theoretical Geology and Practical Mining. The former, the science which investigates the laws whereby were regulated the original deposition and the subsequent disturbances of the stratified rocks; the latter, the art which renders available to man the stores of mineral treasure provided by an all-wise and beneficent Creator for alleviating the wants and for ministering to the comforts of his creatures. These two departments, although often separately pursued, are nevertheless capable of being rendered mutually subservient to each other's advancement. Thus, whilst the daily labours of the miner are disclosing new facts upon which the geologist builds his theories, the generalizations of the geologist direct the proceedings of the miner, and save the enormous waste of time and capital which has so repeatedly attended mining efforts when unaided by the the light of geological science. Within the sphere of the Society's operations, there are few objects of greater practical importance than the identification of strata. It was formerly imagined that the valuable beds of coal worked at Middleton, Haigh Moor, and Lofthouse, in this neighbourhood, were identical; but it has now been demonstrated, by means of this Society, that the main-coal of Middleton is not identical with that of Haigh Moor and Lofthouse. But he understood that all are not yet agreed whether the Middleton beds occupy a position higher or lower in the series of strata than those of Haigh Moor and Lofthouse. It is, however, evident (he said) that if the Middleton beds are lower than the others, there must be, at Haigh Moor and Lofthouse, beneath the beds now worked, beds continuous with those of Middleton; and, on the other hand, if the Middleton beds are higher in the scale, there must be at Middleton, beneath the present works, beds continuous with those of Haigh Moor and Lofthouse. Hence it is evident that the non-identity of the Middleton and Haigh Moor beds of coal is a fact of no trifling importance as to our future prospects, when we consider the present lavish expenditure of fuel, and a fact of no little interest to the owners of the soil. The means of identifying stata are various, but they may principally be referred to two heads: 1st. the observation of the physical characters of the strata, namely, their colour, structure, hardness, and chemical and mineral composition; 2nd. the comparative examination of their organic contents. The physical characters are in many instances alone sufficient for the purposes of identification; but, on the other hand, it is known that the appearance of the same stratum frequently varies so greatly, even at distances not very remote, that portions from different localities bear but little resemblance to each other, and have been supposed to belong to different beds. Whole geological formations have been thus supposed to belong to different geological epochs, when the general appearance produced by the physical character of the rocks was solely relied upon, whereas such rocks, remotely separated, and of very different physical character, when investigated by the light derived from the examination of their organic contents, have been proved to be co-temporaneous deposits. On the smaller scale, even, individual beds are sometimes capable of being thus identified by their accompanying fossils, when their physical characters alone would fail to determine their relative position. A remarkable illustration of this fact occurs in our own district. At Moortown, three miles north of Leeds, is a bed of a black earthy looking substance, about four inches in thickness; and this is identical with the beds of coal, several feet in thickness, which are worked at Halifax, and supply the extensive manufacturing districts of Bradford and Halifax with the greater part of their fuel. But, how do we know the thin bed of black earth at Moortown to be the same bed as the coal at Halifax? Their appearance, or in other words, their physical characters, do not enable us thus to decide. It is from their being accompanied by a particular fossil, the Pecten Papyraceus, which is now known to be characteristic of this bed. The shale which forms the roof of the Halifax coal is crowded with this beautiful fossil, and by means of this shell, may be traced, overlying the black earth of Moortown, the impure coal of Kirkstall wood, and the progressively improving coal of Idle, Bradford, and Halifax. All fossils, however, are not of equal value for the purposes of identification. The Pecten Papyraceus is of great importance in this respect, for, although occurring extensively in the mountain limestone formation, it is only known to prevail in the Yorkshire coal measures in the single bed of shale which forms the roof of the Halifax coal. On the contrary, other fossils, as the Unio Acutus and Unio Constrictus, may have so wide a distribution as to be of but little diagnostic value. Before, then, we can determine the diagnostic value of any fossil species, genus, family, or class of the animal kingdom, a careful and extensive investigation is required as to the precise range of its distribution. Throughout the whole animal kingdom there is no class more calculated, by the examination of its fossil remains, to aid the geologist than fishes. This class, placed in the vertebrated division of the animal kingdom, in that division which includes even man himself, is thereby associated with the highest of organized beings, and thus requires in common with them certain conditions necessary for its existence ; but although thus highly placed in the scale of beings, it is at the same time by the peculiarity of its respiration, (fishes being water-breathing animals,) linked to the lowest grades of the animal kingdom, with which until the close of the carboniferous era it had been doomed solely to associate. I repeat, then, that the class of fishes, from its peculiar position in the zoological scale, from its consisting of vertebrated animals, but still water-breathing animals, is calculated as much, and probably more, than any other class to aid the inquiries of the geologist, to throw light upon the physical condition of this earth and its atmosphere during the time the carboniferous strata were deposited. And it cannot be regarded but as a subject of profound interest to ascertain what were the physical conditions of the surface of this planet which, at the period alluded to, allowed of the existence of vertebrated animals, but of such only as respired through the medium of water ; and again what physical changes had been effected at the termination of the carboniferous era, so as to allow of the existence of air-breathing reptiles which in the varied forms of saurians crowded the ocean during the deposition of the Lias and subsequent formations. I cannot resist the temptation of here briefly noticing the conjectures of M. Brongniart on this interesting subject. Conjectures indeed they only are, but where all is darkness, or light but dimly seen, conjecture may be the herald of discovery. Considering how prodigiously luxuriant must have been the vegetation in the carboniferous era, in order to have produced those enormous masses of vegetable matter which form the coal strata, and considering that this excessively luxuriant vegetation could not have been supported by a soil highly nutritious, from being strongly impregnated with carbon, like our own soil, from the wreck of pre-existing vegetation, M. Brongniart is led to inquire, from what source could these plants derive the carbon necessary for their enormous and rapid growth ? The only source that conjecture can supply is the atmosphere, and M. Brongniart supposes that, during the carboniferous era, and previous to that period, the atmosphere of this planet differed essentially from its present condition, in being, not, as now, only slightly charged with carbonic acid, but intensely impregnated with this gas ; and as we know that in our own atmosphere plants absorb carbonic acid and appropriate its carbon to their nutrition, so in these ancient periods of the globe the vegetation may have derived its support from this source, and to the great fertility of this source may not improbably be due the rich luxuriance of the carboniferous vegetation. And surely this conjecture gains no little force from the fact, that until after the termination of the carboniferous era no air-breathing vertebrated animal is known to have existed. For in such an atmosphere, so highly loaded with carbonic acid, no air-breathing vertebrated animal could have existed. But when this enormous quantity of carbonic acid had undergone fixation by the deposition of the mountain lime-stone rocks, and still further fixation, by the profuse vegetation which is entombed in the coal measures, the atmosphere thus purified may have been reduced to its present condition—to such a condition as to be compatible with the existence of animals which breathe air. Into this state the atmosphere appears to have been brought at the termination of the carboniferous era, and then, and not till then, does it appear that air-breathing vertebrated animals were created. Since, then, it has been shewn that the identification of strata is a subject of great importance to the well-being of man, and that the investigation of organic remains is a very essential means of identification, and that of all classes of animals the class of fishes appears best calculated to aid the labours of the geologist, more especially in reference to the coal formation, it is evident that the study of the fossil Ichthyology of the Yorkshire coal-field is appropriate to the business of this Society. And from these considerations I was induced, when invited by Professor Johnston, a short time ago, to prepare a paper for the present meeting, to select this subject, considering that a statement even of the little we know of the fossil fishes of the district, combined with some general observations on the class of fishes, and a brief exposition of the classification of M. Agassiz, might form a convenient starting point in the study of the fossil Ichthyology of the Yorkshire coal-field. Mr. Teale then proceeded to explain and illustrate by specimens from the Museum the Cuvierian classification of fishes, which, from its being based upon the osseous system, was shewn to be inapplicable to the purposes of *fossil* Ichthyology, on account of the perishable nature of the bones of fishes. Hence it became necessary for M. Agassiz, on entering upon the investigation of this extensive and difficult subject, to select some other part of their structure, less perishable than the bones, as a basis of classification. The dermal system, or skin, appeared to him the best adapted to the purpose, from the imperishable character of the scales, and from the scaly integument of fishes not only bearing a special reference to the watery medium they inhabit, and to the conditions under which they exist, but also from its being an index to their internal structure. From the form or structure of the scales, M. Agassiz arranges fishes under four orders, but since two only of these existed during the carboniferous era, the author limited his observations to the description and geological distribution of these two, namely, the Ganoid and the Placoid orders; the first being named from the splendour or shining character of the scales, and the latter from the scales consisting of plates of enamel more or less broad. Of the Ganoid order, Mr. T. described the characters, and exhibited specimens of four Genera which occur in the Yorkshire coal-field: Acanthodes, Platysomus, Megalicthys, and Holoptychus. After describing the Genus Megalicthys, the author related the following history of it. "The earliest known specimens of this fossil are some in the Leeds Museum, of which a description was sent upwards of fifteen years ago by the late Mr. Edward Sanderson George, to the Geological Society of London, at which time they were regarded as the remains of a Saurian reptile. In 1833, at the limestone quarries of Burdiehouse, near Edinburgh, were discovered in great abundance, teeth, scales, and bones of large size. These formed the subject of several papers to the Royal Society of Edinburgh, in the earlier of which they were described as the remains of reptiles. In 1834, at the meeting of the British Association in Edinburgh, these fossils, which by this time had excited great interest amongst naturalists, were shewn to M. Agassiz. This gentleman immediately doubted their reptilian character, and advanced the opinion that they belonged to fishes, to that family of fishes of the Ganoid order which he had denominated Sauroid, from their numerous affinities to Saurian reptiles, and which have as their living type, or representative, the Lepidosteus. But of the truth or fallacy of this opinion, no positive evidence could be adduced, for the scales and the teeth had never yet been found at Burdiehouse in connexion. A few days afterwards, M. Agassiz, in company with Professor Buckland, visited the Leeds Museum, and I well remember the delight, the extatic delight, evinced by the distinguished naturalist of Neufchatel when he first beheld the splendid heads of this animal in the Leeds Museum. Here, said he, we have the same scales and the same teeth as those of Burdiehouse, conjoined in the same individual. It is therefore no longer a conjecture that they might belong to the same animal. And in these self-same specimens, we have the hyoid and branchiostic apparatus of bones (a series of bones connected with the gills, an indubitable character of fishes); it is therefore no longer a conjecture that the Burdiehouse fossils were the remains of fishes and not of reptiles. Thus was dissipated, by the evidence afforded by the identical specimens now upon the table, the illusion founded upon the Burdiehouse fossils that Saurian reptiles existed in the carboniferous era. To this animal M. Agassiz assigned the name of Megalichthys." Mr. Teale next severally described and illustrated by drawings and specimens the following genera of the Placoid order in the Yorkshire Coal Field: Gyracanthus, Hybodus, Pleuracanthus, Ctenoptychius, Helodus, Ctenodus, and Diplodus. In conclusion, the author remarked, "I have now endeavoured, even at the risk of being tedious, to bring into one view the scattered fragments of our knowledge of the fossel Ichthyology of this district, and have attempted to assign to each element of this knowledge its proper position in the large Zoological group of fishes; it must, however, be evident, that we have as yet but entered upon the very threshold of the investigation. Much, very much remains to be accomplished before we have completed even the first stage of the inquiry, namely, the determination of all the genera and species of fishes which exist in the neighbouring strata, and the distinguishing characters of each. In this extensive work, a work of no little labour, the combined exertions of many are required. All members of this society, and the public in general, are able to co-operate in the work; if not in the investigation and determination of species, at least in providing materials for observation, by the collecting and contributing of specimens. And when, by combined exertion, this part of the science is so far advanced, that we can from a small fragment pronounce with certainty to what species it belonged, then may be pursued with advantage and effect the second and ulterior department of the fossil Ichthyology, namely, the determining of the precise range and circumstances of distribution peculiar to each individual species. Towards this latter branch of the inquiry, the mere amateur in Geology like myself, who has only cultivated the science, or rather the Zoological department of it, as an occasional relaxation from his ordinary pursuits, can do but little. For its accomplishment we must look to those gentlemen (many of whom I have now the honour of addressing) whose very profession is Geology; whose daily avocations lead them into the interior of the earth; and whose education, and habits of patient and accurate observation, eminently qualify them for the task. When the Fossil Ichthyology of the district in this its most extended sense, is thoroughly investigated, we may with confidence expect that many and valuable will be the practical applications of the information thus obtained; nor will the results be limited in their interest to this densely peopled district; Geological science in general will have received a precious boon; some light will have been thrown upon the history of that most interesting to man of all the geological epochs, the carboniferous era; and we may be allowed a clearer view of the wisdom, and the power, and the goodness of Him, who, long anticipating the wants of man, first made the iron and the coal, then sunk them safe and deep beneath the accumulating sediments of countless ages, and in his own appointed time, by his mighty agents the volcano and the earthquake, upheaved the riven rocks, and brought their treasures to the light of day."—(Loud applause.)

The CHAIRMAN eulogised this excellent Paper, and invited discussion, but none took place.

MR. HARTOP ON STEAM BOILERS AND HIGH CHIMNEYS.

Mr. HARTOP next made a communication "On the boilers of steam engines and the construction of engine chimneys." He said: On presenting myself before a meeting at Leeds, (where the steam-engine is so well understood,) to make observations on steam-engine boilers, I feel some apology to be due from me, but I trust that, however trifling the advantage pointed out may be, its application in so wide a field as is here presented will amply repay any attention given to it. I need not go further back than the introduction of the waggon boiler by the late Mr. Watt, which, from its excellent arrangement, was the standard boiler for so many years, during which time a very general opinion prevailed amongst practical men that, whenever the length of the boiler exceeded four times that of its grate (say 25 feet), such additional length was useless, as to the quantity of steam produced, although a considerable degree of heat always passed away up the chimney. The cause of this I conceive to be that the heated air in these flues passes *last*, and therefore when at its coolest, through the side flues, by which it is brought in contact with the water near the surface in the boiler, and therefore at that point where it was the hottest; in consequence of which the boiler, if made very long, might re-impart a portion of its heat to the air in the flues before it passed to the chimney. This point will, however, be better defined on our considering the boiler now in general use in Cornwall. Before doing so, I may, however, be excused, for making a few observations on a boiler, which, from its simplicity and strength, is at present becoming a very fashionable one, if I may be allowed the expression—I mean the cylindrical boiler with semi-spherical ends. This, there can be no doubt, is a boiler of great strength, and I believe it was introduced at a time when engines were in use with steam at 200lbs. or 300 lbs. pressure per square inch. This dangerous pressure, I am happy to inform the public, is in modern engines not required, the highest now in use being that for locomotive engines at about 60 lbs. per square inch; the boilers for which are so constructed as to render danger *to the public* very improbable. In the expensive engines of Cornwall, the steam used rarely exceeds 50lbs. per square inch, and in the high pressure engines of the best makers the steam in use is little more than 30lbs. per square inch, from which it will be seen that great strength in a boiler is not now so requisite as formerly, and particularly when it is considered that the same accidents will happen to the strongest as well as to the weakest boilers, from similar causes, and that when they happen to a strong one, the explosion is the more terrific in the direct proportion as the boiler is the stronger. We should therefore avoid the *cause* of these dreadful accidents rather than strengthen the boilers. Now, there is one very great disadvantage in the cylindrical boilers, viz., that the incrustation will all collect in that portion of the boiler which is nearest the fire, and being a non-conductor of heat, will expose that portion of the boiler which lies between the fire and such incrustation to be burnt away. The argument in favour of this boiler, derived from "the ease with which it may be repaired," is therefore more than done away with by its so often standing in need of that repair which in well constructed boilers will not be required for the first 12 or 14 years. The next and last boiler I shall at present occupy your time in considering, is that of the Cornish boiler. It consists of an outer cylindrical case, having an inner tube passing through its whole length, in one end of which the fire bars or grate is placed, by which arrangement the heated air and flame is made to pass nearest the surface of the water in the boiler, where both air and water are the hottest; the former then returns through the side flues, and, descending under the grate, passes under the boiler last, where both the heated air and water are at their coolest, so that in a boiler of sufficient length the whole heat given out by the fuel may, under this arrangement of the flues, be imparted to the water in the boiler, and it is consequently found in Cornwall that they may be used to advantage to the extent of *fifty feet in length.* I am induced to appear before you on this subject in consequence of my not having found these points hinted at either in the very excellent practical work on steam-engine boilers by Mr. Armstrong of Manchester, or elsewhere. I may here also mention the very great importance it is to the owners of steam-engines that the iron selected for these boilers should be of a proper quality for that purpose, for I have known many instances of the bottom of boilers being entirely worn out in 18 months, instead of lasting nearly *as many years*, the kind of boilers in both instances being in every respect the same, from which circumstance there can be no doubt that it is on the real stamina of the iron from which the boilers are made that their goodness or goodfornothingness depends. Connected with this subject is that of the chimney, which is very often carried to the height of 160 and 200 feet, and consequently made so small in the internal flue at the top as to cause the smoke to pass off with some difficulty. Having about 18 years ago built one 110 feet high with its internal flue wider at the top than at the bottom, it was found in practice to answer so well that on applying 14 puddling and other furnaces to it; the draft up to that point seemed rather to be improved with each additional furnace than impeded. I now find the practice becoming a general one in Scotland and Lancashire, which I attribute to my having mentioned the circumstance from time to time to my friends; and I do not hesitate to say that in good situations 80 feet will be found an ample height for the largest engines, and 100 feet in situations less favourable.

The CHAIRMAN having invited discussion—

Mr. J. G. MARSHALL said the meeting was much indebted to Mr. Hartop for his observations respecting steam boilers. One part of the subject which he had explained he thought exceedingly satisfactory; he alluded to his description of the superiority of the Cornish boiler, over those commonly used called the waggon boiler. He himself thought them much superior, and chiefly for the reasons that Mr. Hartop had stated—their greater adaptation to the application of heat. He had been so far convinced of that that he had caused to be erected boilers of that shape; but there was one point which Mr. Hartop had reckoned amongst the advantages of the Cornish boiler that he should be rather disposed to doubt, and that was its greater safety. The external shape of that boiler was undoubtedly stronger, but he thought that the internal surface, which had to resist the fire, was weaker, by reason of its form, than the ordinary boiler; and he believed that several steam-boat accidents had been attributed to the internal shape of the boiler. Its construction was such that if the internal tube in any degree got out of its correct shape it immediately collapsed. Several accidents had occurred to the Cornish boiler, and he thought it was most probably to be attributed to that source. He thought it would be desirable as a means of guarding against accidents, that the makers of those engines should state the force they would bear externally and internally; and it might also be of advantage if means were devised for "staying" them. With respect to what Mr. Hartop had said about the inutility of extending the length of the boiler, he should be disposed to differ from him, inasmuch as the parts which received the application of the fire were extended, as well as those that did not receive it. With respect to the performances of the Cornish boilers he also thought that there was still a great deal of doubt. The results of experiments upon different boilers varied materially, and he thought it very possible that they might have been incorrectly taken.

They were all high pressure engines, and some portion of the variance might have arisen from leakages, &c. He did not think that the saving in the Cornish engine was wholly to be attributed to the construction of the boiler. Upon the whole, he thought that the suggestion to adopt the Cornish boiler was a very valuable one, for it was equally adapted to high and low pressure engines, care being taken as to the relative strength of the internal and external surfaces. With respect to the chimneys, he thought it probable that the widening of the mouth would have the effect of increasing the draft, but nothing could decide that so well as experiments, and he hoped they would soon be made.

Mr. Hartop was exceedingly obliged to Mr. Marshall for the remarks which he had made. He quite agreed with him in his observation as to staying the boilers, and perhaps he should have gone further into detail on that subject had he not been wishful to avoid unnecessarily occupying the time of the meeting, especially after the great deal of information which had been recently laid before the public by Mr. Armstrong of Manchester, who had written a really practical book on the subject. There was, however, one part of the subject to which Mr. Marshall had referred that he would direct the attention of the meeting to for a few moments. Mr. Marshall had observed that accidents happened to cylinder-shaped boilers on board steam packets; that was, doubtless, true, and nothing could more conduce to the comfort of the travelling portion of the community than a successful endeavour to remedy an evil of that description. He had spent much time in considering the causes of the bursting of boilers on board steam packets, and a remedy for it, for that was the only place where any real risk was run. The fact had not occurred of any great injury having been done by the bursting of a boiler of a locomotive steam engine, which, next to that of a steam packet, was one with which the public were most likely to come in contact. Any little device that would save even one accident of this description would be well worthy of ten minutes' consideration. He was very confident that it was not any peculiarity in the shape of the boilers on board packets that had been the cause of their bursting; but he was inclined to think that it was frequently owing to irregularity in the supply of cold water. The depth of water in the boiler, over the fireplace, was sometimes not more than ten inches or a foot, and, therefore, if any interruption in the supply of water took place, the flue became red hot, which might occasion it to collapse, or a fresh supply of water might cause a blow up. As the depth of the water in the cylindrical boilers was so very small, it became the more important that the supply of water should be very regular, and as one means of obviating any danger on that score he recommended that two feed-pumps should be used instead of one. (Mr. Hartop referred to a diagram to explain the position of his proposed pumps.) In conclusion, Mr. H. observed that he believed eight out every ten accidents that occurred to steam-boat engines arose from the want of a regular supply of water; and he remarked that it was a lamentable fact that the real cause of an accident of that sort could never be got at by a Coroner's inquest. He had read reports of a great many inquiries of that sort, but the results were always unsatisfactory; indeed, when there were so many interested individuals necessarily examined, they ought not to look there for the truth. Practical men generally knew how these things happened, and on two or three occasions, many months after such an accident had gone by, it had been whispered to him how the facts really occurred.

The Rev. THEO. BARNES said that every improvement of the steam engine, whether in the boiler or the working part of it, was of utility, inasmuch as that it enabled man to get further into the bowels of the earth. They ought, therefore, to do justice to the gentleman who had introduced the improvement in the Cornish boilers which Mr. Hartop had described. For those improvements they were indebted to Mr. Hornblower. It was at first doubted that his invention would effect the saving that he predicted, and many were reluctant to try it, upon which he made proposals to put up the boilers at his own cost, and to take ten per cent. annually upon the increased profits, the quantity of work done being registered by a counter. When he returned at the end of a year, it was found that the profits had really been very great, for they had been enabled to work mines that they had previously abandoned; and as the mining proprietors did not like to pay him such large sums as the original agreement would entitle him to, a fresh arrangement was made by which they were at liberty to use his invention on payment of a definite sum. An idea had been thrown out that the supply of coal might possibly fail; that, however, was not very likely to happen, if they were to go on improving their steam engines; and he trusted that such an event was far distant, and that the prosperity of the town of Leeds would go on advancing satisfactorily.

Mr. SIMES said he was apprehensive that the 80 yards chimneys which Mr. Hartop recommended would not carry away the smoke from the houses of the inhabitants so well as the 120 yards chimneys.

Mr. Morton thought that the theorist would concur with the practical man in condemning the narrow-topped chimney, for it was well known that if the orifice through which any fluid passed was lessened, the friction was increased in a much greater ratio than the ratio of the diminution of the orifice. Thus, if the bore of a pipe was lessened to one-half, it did not follow that the opposition to the passage of the smoke, or water, or gas was only doubled ; it was in reality much more than doubled ; and as smoke became more rarified and increased in bulk the higher it ascended, the bore of a chimney ought to be much larger at the top than at the bottom. The principal object of his rising, however, was to make a suggestion as to the means of ascertaining what the engines in Yorkshire did as compared with those used in the Cornish mines ; for it was no disparagement to Mr. Hartop to say that in Yorkshire there was very great ignorance on the subject. In Yorkshire no man knew what his neighbours were doing with respect to the fixing of their steam boilers, the form of their boilers, or the work their boilers can do. Would it not, then, be of advantage if some system like that pursued in Cornwall were adopted here ? The statistics of the Cornish engines were generally very complete, though probably they might be at times incorrect. Still, the balance of correctness over error must be very large, and he would therefore suggest that returns should be made, by the coal-owners and others, of the form and construction of their boilers, the mode of their fixing, the number of horses' power of the engine, the quality and quantity of the coal consumed, the cost of working, the quantity of work done, and the amount per annum that it costs to keep the boiler or engine in repair, and the circumstances under which accidents occur. This might be done, very economically, by this Society sending out sheets to the proprietors of engines, to be filled up with the particulars required. They might or might not fill them up as they pleased, but great good would arise if they did so.

Mr. Wm. West said he had a strong impression that if ever such information was obtained, it would be obtained by societies like this, and not by individuals. He had made a great deal of individual inquiries on one branch of this subject, but hitherto without effect, for he either got answers so vague and contradictory that they could not be depended on, or no answer at all. His attention had been directed to ascertain the proportion of fuel consumed to the quantity of water evaporated from the boiler, and that information he had sought in vain. After all his inquiries he could find no light thrown upon the question. He had asked the engineers on the Leeds and Selby Railway how much water they consumed, and how much fuel they burnt, but he could get no information, and yet Mr. Hartop would probably allow that if this object could be accomplished it would come very near to the test of how much of the extra duty performed was produced by the consumption of fuel, how much depended upon the difference in the boilers, and how much upon the difference in the arrangement of the machinery. Mr. Hartop had stated that the Cornish engines would raise half as much more steam, and that they would do three times the duty; there was no reason to doubt that; and supposing it to be true, it was apparent that if an increase of one-half in the steam would treble the work done, much of it must be set down to improvements in the machinery after the steam leaves the boiler. If the society should take up the inquiry which had been suggested, he hoped that the particulars to which he had alluded would be included in the inquiry.

Mr. Hartop said that this point was one which had occupied the serious attention of the British Association for the Advancement of Science, and a sum of money had been voted for the purpose of making experiments on boilers in Cornwall and elsewhere. He would, however, beg to direct the attention of gentlemen to a very interesting paper published by the Society of Civil Engineers—a paper by Mr. Parker, on Steam Engine Boilers, which contained much valuable information on this important subject. He (Mr. Hartop) had assigned a great deal of the saving effected by the Cornish engine to the improvement of the boiler, but Mr. West was correct in supposing that a great deal was to be attributed to the improvements in the machinery. In Cornwall, a great saving was effected by surrounding the boilers and cylinders with non-conducting substances, which conserved the heat so much that it was no uncommon thing for a Cornish engine-house to be so cold as to require the use of a great-coat, whereas in Yorkshire and other places they were generally at a very considerable heat.

Mr. Embleton trusted that the meeting would see the importance of the question started by Mr. West, namely, how much water could be evaporated in a boiler of a given size, by a certain quantity of coal. This, he thought, was distinct from the improvements which had been effected in the Cornish engines, for though their power had been greatly increased by the better conservation and application of the steam when generated, it did not necessarily follow that a greater quantity of water had been evaporated by a given quantity of fuel in the Cornish boiler than in the waggon boiler under the same circumstances. He saw the importance of Mr. Morton's proposition, particularly with regard to the saving of fuel. At present nothing was known in Yorkshire as to the quantity of coal consumed by engines.

Mr. March said he did not think that the form of the circular boiler deserved the castigation which Mr. Hartop had bestowed upon it. He condemned it on account of the settling of the sediment in that portion of the boiler which was most exposed to the operation of heat, but the same happened to the waggon boiler in a nearly equal degree; and he thought that any disadvantage arising from that circumstance was counterbalanced by the facility with which the circular boilers could be repaired.

Mr. Hartop said that the effect of the settling of the sediment was very different in the waggon shaped boiler from what it was in the cylindrical boiler. In the former it did not remain at the top of the arch which was immediately over the fire, but it dropped down into the *laggons* at the sides; whereas in the cylindrical boiler the sediment fell and remained upon that part of it which was most in contact with the fire. He did not say this in recommendation of the waggon boiler, but to show the difference between those boilers and the Cornish boiler, which he was anxious to introduce, because it was the best that had been tried on a large scale.

Here the conversation terminated, and the meeting immediately afterwards adjourned.

EVENING SITTING—FROM SEVEN TO TEN O'CLOCK.

At the evening sitting, the Rev. Dr. Hook resumed the chair.

Mr. Embleton thought that the first business of this meeting should be to thank the society which had accommodated them with the use of that room for their morning and evening meetings, and for announcing to their members the intention to meet in that Hall. He moved—

"That the thanks of the society be given to the Philosophical and Literary Society of Leeds, for their kindness in offering the use of their Hall, and opening their Museum to the Society, and to the President and Secretaries for the great assistance which they afforded the Society in making arrangements for the meeting."

Mr. BRIGGS seconded the motion, and it was unanimously adopted.

Mr. HARTOP begged to propose that their indefatigable secretary, Mr. Wilson, and Mr. Embleton and Mr. Morton, be deputed to attend the next meeting of the Manchester Geological Society.

Mr. T. P. TEALE seconded the motion, and it was agreed to.

Mr. WILSON proposed the admission of an additional list of New Members which he read.

Mr. EMBLETON seconded the nominations, and the gentlemen were admitted.

Mr. MORTON moved that the next meeting of this Society be held at Bradford in March next. The migratory system had answered so well that it was desirable to keep moving, and as Bradford was the next best place that had not yet been visited, he begged leave to offer the motion which he had submitted.

Mr. WILSON seconded the motion, and it was agreed to.

MR. CHARLES MORTON ON THE SAFETY LAMP.

Mr. CHARLES MORTON placed on the table a variety of safety lamps, and proceeded to make some observations and experiments upon them. He called to the recollection of the members the attendance of Mr. Fletcher, of Bromsgrove, at one of the former meetings, when that gentleman produced and described a safety lamp constructed on an improved principle. Mr. Fletcher had since modified his lamp in accordance with the suggestions thrown out at that meeting, and the lamp which Mr. Morton exhibited had been sent to him by the inventor for trial in the coal-mines. The novelty of the apparatus consists in a door or damper at the top, which is held up by a string tied fast to the lower part of the lamp. If this string be cut or burnt, the damper drops down and extinguishes the light, in the same way as the shutting of the damper on the top of a furnace-chimney puts out the fire beneath. When therefore the lamp is introduced into an inflammable atmosphere, the combustion of the fire-damp inside burns the thread, and the damper dropping down destroys the flame. Mr. Morton thought the damper would give rise to so much trouble that the colliers would not use it. The string is not very readily adjusted, and it passes so near to the wick that a slight inclination of the lamp or waving of the flame burns the string, and the falling of the damper leaves the collier in darkness when he neither expects nor desires such a result; and to get rid of this annoyance he would prop up the damper and effectually prevent its falling even when it was desirable that it should do so, *i. e.* when it happened to be in a fiery part of the mine. In other respects this lamp is much like the one invented by Upton and Roberts. The air for feeding the flame enters through holes beneath, and is brought into immediate contact with the wick by means of a brass cup. The sides of the lamp are partly glass and partly brass, fitted together so as to prevent the admission of air. In Upton's lamp there is a wire gauze cylinder inside the glass, but in Mr. Fletcher's there is none. By this omission the light produced is much stronger, but the safety is materially lessened; for if the glass of Mr. F's lamp were accidentally broken, the naked flame would be exposed to the fire-damp, and an explosion would ensue. Mr. Morton stated that he had submitted this new lamp to a variety of experiments both in and out of the coal mines, and he considered it deserving of the attention of this society. He thought the invention was still capable of considerable improvement, and hoped that Mr. Fletcher (though a gentleman entirely unconnected with mining pursuits) would devote more of his time and talents to the perfection of an apparatus the ingenuity of which had already entitled him to the thanks of the public. Mr. Morton remarked that the necessity of attempting to improve the safety lamp would become more generally manifest if it were universally known that Davy's lamp is *not safe* under certain circumstances. When "the Davy" is introduced into an imflammable atmosphere, *at rest*, it may be said to be safe; but if the lamp be in motion, or if a current of fire-damp be directed upon it, there is great danger of explosion. By means of a gas jet on the lecture table, Mr Morton caused the flame of "the Davy" to pass from the inside to the outside of the wire guage cage; and he contended that, under similar circumstances, an explosion must inevitably ensue in a firey coal mine; and he had no doubt some of the dreadful catastrophes that have occurred in the pits were occasioned in this manner. Mr. Morton said that the over zealous admirers of Davy had attributed a quality of infallible safety to an instrument which its illustrious discoverer never ventured to claim for it. On the contrary, this distinguished philosopher, in a treatise which he published more than twenty years ago on the subject of the safety lamp, distinctly points out its *unsafety* when introduced into an inflammable atmosphere in rapid motion; and he warns his readers against using "the Davy" under such circumstances. Mr. Morton was of opinion that if the notion which generally prevails about the absolute and certain safety of "the Davy" were dispelled, it would have a tendency to produce greater care and caution among miners. Mr. Morton, in conclusion, directed attention to an apparatus contrived by Mr. W. S. Ward, of Leeds, which he thought might be used for giving light in fiery mines, or in operations with the diving bell. The apparatus consists of a small gasholder, containing a compressed mixture of coal gas and oxygen. To this is attached one of Hemming's safety tubes and a common jet, at the point of which is placed a ball of quick lime. The kindled flame of gas being directed upon the lime ball, a brilliant light is produced, and as the light is covered with a glass jar, the flame is rendered safe by being completely insulated or cut off from the external atmosphere.

The CHAIRMAN said that when they considered the danger to which our fellow creatures who work in mines are exposed from that noxious vapour, the fire damp, they must all see the importance of the subject to which Mr. Morton had called their attention. If all the other discoveries of Sir Humphrey Davy were forgotten, the invention of the safety lamp alone would be sufficient to hand down his name to posterity, as one of the greatest benefactors of the human race. The subject was one of vital importance, and it was one of the objects of this Society to suggest improvements in this or other inventions. He was glad to observe that his friend, Mr. Sykes Ward, had turned his attention to the subject, and he hoped they would live to see the day when great improvements would be effected.

Mr. W. SYKES WARD said that he should scarcely have placed under the notice of the meeting so rude an apparatus as that on the table, but from its intimate connection with the subject which Mr. Morton had just brought before them. He did not propose it as a substitute for the safety lamp, for the apparatus was quite imperfect, and too complex in its construction ; he had merely brought it to show the effect of a light produced without any communication with atmospheric air. He could not recommend it as a safety lamp, because it was too complex to be put into the hands of a miner ; it might, however, be a step in advance, and its production on this occasion might lead to further improvements. He did not claim any thing new in it, except the modification of a principle. The hydro-oxygen blow pipe had been long known, but that was liable to explosion, for want of a safe means of bringing the gas to operate upon the lime. One learned professor had proposed to pass the gas through oil, but that did not answer, and the plan which he (Mr. Ward) had hit upon was to drive small wires into a tube so as to make the apertures so small that gas at the ordinary pressure would not pass through. But though he did not think it would be of much utility to coal miners, he thought it might be used with the diving bell. The greatest desideratum in the diving bell was some light that would enable the divers to work in muddy water without regard to the tide. He believed that this gas (a mixture of oxygen and coal gas) would burn at any depth to which the divers could descend, and from the construction of the apparatus before them it would be seen that it would not consume the atmospheric air that was so necessary for the existence of the diver. He should be very happy if even in that respect it should be found of any utility.

Mr. Bull suggested that probably the explosion of the external gases might be prevented by applications similar to those used in the stuffing boxes of steam engines.

Mr. Hartop said he remembered that some twelve months ago Mr. Morton had called attention to that defect of the Davy lamp which he had to-day pointed out, that of firing the vapour on passing quickly through a current. He (Mr. Hartop) then suggested an alteration that he thought likely to effect the desired improvement, but Mr. Morton said it had been tried and failed. But one of the lamps on the table, he observed, was made something after the manner of the alteration he had suggested, and it appeared to obviate, to a considerable extent, the difficulty which his suggestion was intended to remove ; it also gave a greater light to the workmen employed. But he did not rely much upon any improvement of the safety lamp, for after the interesting discussion that they had some time ago with Mr. Fletcher, respecting his lamp, he had a piece of information from him which he had not forgotten, and probably never should, namely, that since the invention of the Davy Lamp a greater loss of life had occurred than was ever known before in mines. He would not yield to any man in anxiety to see the safety lamp improved, but he feared that any further improvement would require a degree of simplicity in construction which had not yet been arrived at. Seeing, therefore, that there was not much hope of improvement in the safety lamp, he would hope that coal-owners would give their best attention to the ventilation of their mines. He hoped that they would not sleep at their posts until an improvement of the safety-lamp was effected.

Mr. Morton said that he had not condemned the reflector, which was part of the suggestion of Mr. Hartop; but he read an extract from Sir Humphrey Davy's account of the safety-lamp to show that he had himself suggested a semicircular cylinder as an additional protection, but that he had not found it to answer.

Mr. Hartop and Mr. Morton explained, and the discussion terminated.

MR. EMBLETON ON THE STRATA IN THE NORTHERN YORKSHIRE COAL FIELD.

Mr. Embleton next read his paper, illustrated by sections "On the Order of Succession of the Coal Seams in the Northern Coal Field of Yorkshire." The subject of discussion on this paper was confined to a consideration of the order of the various seams found in the Township of Whitwood, Methley, Stanley, Wrenthorpe, Lofthouse, Rothwell, Ardsley, Middleton, and Beeston. Mr. Embleton commenced his paper by saying it would be of great importance to the society if the order of the seams of coal were determined in each district, and that it was the only sure foundation for comparison with distant parts of the coal field. He remarked that it was only by a careful collection of shaft sections that many important questions in local geology could be satisfactorily cleared up. As for instance, the thinning or thickening of certain seams in particular directions, the existence of seams at one colliery which were not found in an adjoining one, the origin of coal itself. They would also show when that variety of coal, called cannel coal, was chiefly found, and whether, as had been often stated, though, perhaps, without much foundation, it was only found in the vicinity of certain throws. The workable seams in the Townships before mentioned are the Stanley Shale Coal, the Stanley Main Coal, the Warrenhouse Coal, the Lofthouse or Haigh Moor Coal, the Fish Coal, the 40 Yards Coal, the Yard Coal or Little Coal, and the Main or Deep Coal of the Rothwell Haigh and Middleton Collieries, the Eleven Yards Coal, and the Beeston Coal Of these seams, the 40 Yards Coal, the Yard Coal, the Main Coal, and Beeston Coal supply Leeds with fuel, both for domestic and for manufacturing purposes. The necessity manufacturers had for rendering assistance to this society was very obvious. (Without the numerous sections exhibited we cannot give more than a minute outline of this interesting paper.) The Stanley seams, as occupying the highest position in the district, were first minutely described. These seams are worked at Hatfield Colliery, Auchthorpe Colliery, and the Victoria Colliery; the seams are usually 17 yards apart; the upper seam is 2ft. 6in. thick, the under one very variable, and composed of three or more beds separated by argillacious bands. The next section was at Whitwood, east of Stanley. The strata here were compared with those at Stanley, and the similarity fully established; but there was here another deeper bed. At Wrenthorpe the sinking of the shaft was commenced just at the outbreak of the Stanley Main Coal, and continued to a depth of 186 yards. This shaft passed through the Whitwood Lower Coal, and also the Haigh Moor Coal. By the Newmarket section, the Lofthouse coal was proved to be the same as the Haigh Moor; and that the lower seam at Whitwood, the middle seam at Wrenthorpe, and the Warrenhouse coal at Newmarket were also identical. The northern outbreak of the Lofthouse coal was traced from Rothwell to Ardsley, and the fact insisted on of the occurrence a few hundred yards beyound that outbreak, of a peculiar yellowish sand-stone rock, commonly called the *Quarry-stone*. This is called by Dr. Smith the Bradgate Rock, but Mr. Sharp has proved that the Bradgate Rock is much deeper. The Thornhill Lees or Middleton Rock was given as more distinctive. In two sections of strata below the Haigh Moor Coal, Mr. E. pointed out the situation of this rock, and thus fixed its position with regard to the old and inferior seams. He likewise compared their section with the Middleton section, and assigned the position of the Fish Coal and the 40 yards coal; the former seam being 80 yards below the Haigh Moor Coal. The roof of the Fish Coal consists of bituminous shale 6 inches in thickness, from which nearly the whole of the specimens described by Mr. Teale were obtained. A remarkable fact of the thinning away of Sandstone was mentioned. Two of the Middleton pits are 300 yards apart; in one, the Quarry stone or rock is 16 yards thick, in the other only 2; although the depth from the surface to the 1st seam is the same at both pits. Here followed a description of the yard coal at Middleton, the Main Coal, the 11 yards coal, and lastly the Beeston Coal. The section at Beeston was similar to that at Middleton. Other seams are known to exist below the Beeston seam, but Mr. Embleton deferred a consideration of them to a future opportunity The following is the order of the seams, with the probable distances between them :—

	About
From surface to Stanley Shale Coal	80 yards
Further to Stanley Main Coal	18
Further to Warrenhouse Coal	88
Further to Lofthouse or Haigh Moor Coal	92
Further to Fish Coal	80
Further to Forty Yards Coal	20
Further to Yard Coal	46
Further to Middleton Main Coal	32
Further to Eleven Yards Coal	12
Further to Beeston	84
Yards	552

REPORT ON GEOLOGICAL SECTIONS.

Mr. Morton then made a verbal report of the proceedings and suggestions of a Sub-Committee appointed to consider the best means of constructing a Geological Section on the eastern side of the Penine Chain, and to prepare a plan of operations in conjunction with the Manchester Geological Society, the members of which at their last annual meeting having resolved to continue the section forward to the westward across the Lancashire coal-field. Mr. Morton dwelt on the general and local importance of such sections. There were no accurate sections on a large scale across the island in this latitude, and he considered that the completion of even one section across Yorkshire and Lancashire would throw so much light upon the structure and stratification of the two coal-fields, and of the ridge of hills which divides them, that great benefit would be conferred on the geological public generally, and on the members of these two local societies in particular. Three different lines of section had been proposed, but it was desirable to concentrate all the energies of the Society upon one of them. Such a section should be carried in a north-easterly direction, this being the line of greatest dip of the strata; and its latitude should not be further north than Leeds, nor further south than Sheffield; otherwise it would be beyond the limits of the Yorkshire coal-field altogether. Perhaps the best line would be an intermediate one; that is, in the latitude of Barnsley, for the stratification of this coal-field is probably more fully developed between Penistone and Goole than in any other direction. The information which this section should contain ought to be local and in detail, not as geological sections too often are—composed of vague generalities and a mixture of half fact and half fiction. The surface of the country should be carefully levelled and laid down; towns, villages, roads, rivers, collieries, &c. should be noticed; vertical sections of pits, boreholes, quarries and cliffs should be delineated; the intersection of the bassets or outcrops of coal, ironstone, and other remarkable strata should be marked down, with their names and thickness; the crossing of "faults" or "throws" should be registered, and the extent of the dislocation up or down should be stated; the continuous position and dip of the different beds (where these can be correctly ascertained) should be drawn. The sources from whence the requisite information may be obtained are various and numerous; and the means of executing both this and other lines of section are in the Society's own hands. The distance from the Penine Chain at the Sheffield and Manchester Railway Tunnel to the Holderness Coast is about 70 miles, and if ten members of the Society would each undertake a portion of seven miles the whole length might be completed within a reasonable time. Each individual would have to level his own portion, either with the spirit-level or the theodolite, and to measure it with the chain or take his lengths from accurate township maps. Each would lay down on paper his observations and results, and their respective sheets, when joined together, would form the section required. Respecting the scales of these sections much may be said. Mr. De la Beche, recommends that the scales of lengths and depths should be equal; but this suggestion cannot always be beneficially acted upon; and it certainly cannot in the present instance. The summit of the ridge near Penistone, is probably about 1800 feet, or one-third of a mile above the sea. Consequently, if an uniform scale of three inches to a mile were adopted, the length of our section, when laid down on paper, would be 17½ feet, and its height only one inch. The most likely scale for lengths is three inches to a mile, and for depths one inch to 50 feet; which would make the length of the sheet 17½ feet, and its depth three feet. As before stated, three different lines of section have been proposed; which may be named the Leeds line, the Barnsley line, and the Sheffield line. The first to commence at the Leeds and Manchester Railway Tunnel, at Todmorden, and proceed by Halifax, Leeds, Aberford, and Pocklington, to Barmston, on the Holderness Coast. The second to commence at the Sheffield and Manchester Railway Tunnel, near Penistone, and proceed near Darton, north of Barnsley, Brierley, Swinefleet, near Goole, Cave Sands, and Cottingham, to Aldbrough, on the same Coast. The third to commence at the central axis of the Penine Chain, near Castleton, and proceed by Sheffield, Maltby, Tickhill, Bawtry, north of Gainsbro', Caistor, to the mouth of the Humber below Grimsby. The second or Barnsley line is preferable because it crosses the coal field in the direction in which its peculiar stratification and richness is most fully exhibited, and because the means of obtaining accurate geographical and geological information are more abundant, and more accessible to the members of this Society, than on either of the other lines. The Barnsley line would possess the advantage of having the millstone grit and flagstone strata beautifully illustrated by the great tunnel, sinkings, and cuttings on the railway near Penistone. The Wortley and Bradgate rocks, containing the valuable and important beds of coal known by the names of the Flockton, Park Gate, and Silkstone beds, with their associated strata of ironstone, would be clearly exhibited by the sinkings in Mr. Wilson's pits near Darton, which are the deepest in the county. The Woolley Edge rock, containing the thick Barnsley coal and other seams, would be not less distinctly illustrated by the borings and sinkings of the same gentleman near Staincross. Farther eastward the Chevet and Ackworth rocks would be delineated by borings already in the possession of members of the society ; and the magnesian limestone, by borings made near Womersley, under the immediate inspection of the Rev. W. Thorp. At Swinefleet, the section would pass the very deep borehole recently made by Egremont and Co., through the new red sandstone and its associated beds of gypsum; and across the Cave and Holderness districts, considerable geological information may be gained, by examining the country with the writings of Professor Phillips and Mr. Harcourt for guide books. Mr. Morton further stated, that the Barnsley line, if continued westward, would cross Lancashire in a more advantageous locality for investigating and illustrating that coal field than either of the other lines ; and he concluded his report by reading an extract from a letter written by Mr. Greenough, on the subject of these sections, wherein he recommends the adoption of the Barnsley line, but advises the Society to confine its attention solely to the coal measures, and deprecates the extension of this, or any other section, across the new red sandstone, oolite, and chalk districts of the East Riding.

Mr. Binney thought that the scale of the sections proposed in the report would not answer the purpose, especially on the Lancashire side of the ridge. To attempt to display the Lancashire coal field in a section of three inches to the mile, would be futile indeed. In the rich part of the coal field, about Ashton and Duckinfield, they would have 45 seams of coal within about a mile and a half. With regard to the particular line to be adopted, he thought it should be along the line of the Sheffield and Manchester Railway, as then they would have the plans drawn and the sections correctly taken. If the Northern (or Leeds) line mentioned in the report were chosen, it would go through the unprofitable part of the Lancashire coal field, and it would be 150 yards below the Sheffield coal about Ormskirk. It would not suit either the line or dip of Lancashire. In that county the dip was generally to the South-West, so that to follow the proposed North line they would take the range of the coal instead of the dip. The Southern (or Sheffield) line suggested would cut out the Lancashire coal field nearly altogether, and would extend into Flintshire, and into the Silurian or Slate system of Wales. The Middle (or Barnsley) line which had been pointed out, was not, perhaps, the best that could be chosen, but for the reasons he had stated it was preferable to either of the others. Perhaps the best plan would be to take a line from the central axis near Salter's Brook to Mottram, and then diverge into two lines, so as to embrace the whole of the great Lancashire coal field. On the Lancashire side there would not be more than fifty miles of coal field to traverse, which would give only five miles to each of ten persons, instead of seven, as on the Yorkshire side. With respect to the sections, he thought that they ought to represent the "cleet" of the coal amongst the other particulars. In the Lancashire coal field, some of the different beds were not to be identified by either fossils or any thing else, so that the cleets, which in Lancashire were very useful, might not avail in Yorkshire. The pecten, which Mr. Teale had stated was to be found only over one description of coal in Yorkshire, was distinctly found over three kinds in Lancashire. Therefore, neither salt water nor fresh water shells would serve them in Lancashire to the same extent as in Yorkshire, but still they might be useful.

Mr. Embleton thought that the meeting ought not to separate without coming to some understanding with the Manchester gentlemen as to the line of section to be adopted. If not now determined, it would be left till the March meeting, and then those gentlemen might not be present. For himself he should prefer the centre or Barnsley line before any other that had been mentioned.

Mr. Bull thought that a line a little more to the north than the Barnsley line would take in a greater breadth of coal ; in that case it would embrace the vale of Calder, where he knew there was a good deal of matter of interest to the geological inquirer. Mr. Bull also made some suggestions as to the scale upon which the sections should be drawn but we did not hear his observations distinctly. He concluded by saying that he should be glad to subscribe towards defraying the cost of the sections, and he recommended that at the end of every quarter of a mile marked on the sections, a permanent bench-mark should be put down in the ground, which could be referred to at any time hereafter.

Mr. S. D. Martin said he should be glad to undertake a portion of the section.

Mr. Hartop observed, with reference to the suggestion to go a little to the north of the centre or Barnsley Line, that he had his fears that that Barnsley line itself was rather too far north. The only thing that reconciled him to that line, as proposed by the Committee, was that it afforded facilities for getting valuable information on various matters which they could not come at if they were to go a little further to the southward. If they had to begin the whole thing *de novo*, it would seem very desirable to adopt a line rather more to the southward than that pointed out, as the coal field was more equal, but he was disposed to give up his opinion in favour of a more southerly line, for the reasons which he had stated as operating to the advantage of the centre line proposed. He did, however, think that they would act very wrong indeed if they were at this meeting to prescribe any line for the Lancashire Society to adopt The Lancashire gentlemen should be at liberty to select their own line, and that, without reference to what should be done on the Yorkshire side. They should select a line that would pass at right angles with their minerals. And if it did not deviate far from the straight line, he thought it might with great advantage deviate a little. He did not think it necessary that the two lines should meet in the centre of the Penine chain. There might be opportunities of uniting the two lines by particular observations, and if each could be so drawn as to give the gentlemen on each side of the ridge an opportunity of taking that direction which was best for their particular coal fields, it would be better than adopting one continuous line.

Mr. Morton moved—

"That the Council be empowered to proceed with the section from the eastern end of the tunnel of Sheffield and Manchester Railway at Dunford Bridge, across the Yorkshire Coal Field, in conjunction with the Manchester Geological Society, in such manner as they shall consider most likely to attain the desired objects."

Mr. Embleton seconded the motion, and it was agreed to.

The Vicar then vacated the chair, and it was taken by Mr. T. P. Teale.

On the motion of J. G. Marshall, seconded by Mr. Embleton, it was resolved by acclamation—

"That the thanks of the society be given to the Vicar of Leeds for the readiness with which he consented to take the chair, and for the great ability with which he has discharged the duties of it."

The Vicar briefly acknowledged the compliment, and the meeting broke up about ten o'clock.

The Ordinary took place at Scarborough's Hotel, Dr. Hook in the Chair. The proceedings were merely routine and complimentary.

The following forty-two gentlemen were elected members. Rev. Dr. Hook, F. W. Vernon Wentworth, Esq., of Wentworth Castle, George Stephenson, Esq., the celebrated engineer, Dr. Chadwick, Messrs G. W. Bischoff, George Beecroft, Thos. Butler, Ambrose Butler, John Cross, W. C. Copperthwaite, W. Croft, Josh. Dunning, E. Eddison, J. K. French, C. Fowler, W. Gott, W. Hey, Jun., Dr. Hunter, J. R. Hubbard, R. W. Hoblon, (York,) S. Hare, Josa. I. Ikin, Thos. Kell, (Bramham,) Jas. Longridge, J. W. Leather, R. Perring, Thos. B. Pease, C. J. Smith, N. P. Simes, W. Stead, W. Sharp, (Bradford,) J. W. Tottie, E. J. Teale, F. Titley, Anthony Titley, Geo. Turton, (Sheffield,) J. Willans, W. S. Ward, W. West, J. F. Wright (Sheffield), Rev. C. Wicksteed, — Walker.

[R. PERRING, PRINTER, LEEDS.]

PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

OF THE

WEST-RIDING OF YORKSHIRE.

THE NINTH QUARTERLY MEETING WAS HELD AT BRADFORD ON THE 11TH MARCH, 1840.—ON THE MOTION OF MR. SHARP, PRESIDENT OF THE PHILOSOPHICAL SOCIETY OF BRADFORD, SECONDED BY H. LEAH, ESQ., THE REV. DR. SCORESBY, THE VICAR, TOOK THE CHAIR.

THE REV. DR. SCORESBY rose amidst much applause, and opened the proceedings as follows:—Ladies and Gentlemen,—Science never appears to so much advantage as when it is connected with its useful and practical relations; and this is the position in which the society now assembled presents itself before us,—as a GEOLOGICAL AND POLYTECHNIC SOCIETY. Its objects are at once interesting and useful, because it contemplates the acquisition of knowledge relating to the phenomena and the construction of the globe which we inhabit; and, with regard to the practical bearings, the objects of the Society assume much importance, as these not only bring us into relation with the operations of mining, but make us acquainted with the nature and value of those various minerals which form so very rich a source of our national prosperity. (Hear, hear.) Hence, perhaps, no subject could be brought before the inhabitants of the West-Riding of Yorkshire,—one of the great mining districts of the country,—which, as a matter of science, assumes a position of such important consideration as this. The art of mining is manifestly of very ancient date; for we read in the very earliest parts of sacred history, of the existence of iron, copper, brass, silver, and gold, evidently in their metallic condition, and therefore there must have been at that time a knowledge of the process of extracting these substances from their ores. The structure of the earth, or the theory of its formation, is also, as a subject of speculative consideration, of very ancient date; indeed, many theories have been suggested, in various ages of the world, with the view of explaining the phenomena observable about the surface of the globe. And whilst some of these were extremely erroneous or absurd, others exhibit more or less of approximation to what is apparently the truth, and which modern science shows to to be something like the real theory of the globe. But the *science* of Geology is quite of modern date; for it was not until within a very few years of the present time that it could be regarded as a science. Previous to that, the knowledge of minerals or earthy substances was carried to a tolerable extent; but the inquiry as to the relation in which the various substances and strata stand with reference to the construction of the earth, is very recent. Hence the science of Geology, with respect to its age, may be regarded as a mere infant; and this will explain to us why, through the self-confidence incident to its age, it has been occasionally brought into disrepute—exposing it, shall I say, to ridicule on the one hand, or to the charge of being the agent of scepticism on the other hand. Geology, like children, has its child-like faults, from which, however, we may expect to see it relieved, as it advances in its measure of attainment, and when mature judgment and age shall have served to correct its too hasty speculations. At the same time, whilst conceit and incaution, or defect of perception, have put forth theories and speculations on the construction of the earth, which may have had the effect of exciting ridicule or giving occasion for scepticism, neither of these results can be justly charged against Geology, as properly belonging to it as a science. The more, in fact, the science is investigated, the more shall we find it rise above such unworthy results, and the more shall we be impressed with the wisdom and goodness of the Divine Being, which its researches must develope,—and the less prevalent will be those follies and prejudices which an imprudent theorizing on very imperfect knowledge of the subject has engendered. For nothing is more certain, than that the works of nature and the word of God must be essentially the same,—that is, when speaking of the same thing, they must declare identically the same truths. But there is one cause, not generally taken into consideration, why there is sometimes an *apparent* discrepancy between the *word* of Revelation and the *revelation* by the works of creation. We should remember, that although the works of God and the word of God, with regard to what they teach concerning the earth, must be essentially the same, yet they teach in different languages. The language of nature and the language of revelation are different. Now, it is the province of the Christian geologist to resolve the language spoken by the earth into our mother tongue; and it is the province of the scientific theologian to resolve the original language of the bible also into our mother tongue; and we may rest perfectly assured, that when this is fairly and effectively done, we shall find the revelation of God in the bible, and the works of God in creation, equally demonstrating His wisdom and goodness, and uniting the same testimony and bearing the same witness of their perfect accordance, inasmuch as both are written by the finger of God. With reference to the pursuit of this or any other science, there is one effect which, in my judgment, is of great importance, though, perhaps, we do not attach to it sufficient weight. One of the universal effects of scientific inquiry, well pursued, is, that just in proportion as it gives us positive knowledge, it gives us the knowledge of our ignorance. The further our investigations carry us into the depths of science, the more they discover to us the depths yet unfathomable. A knowledge of our ignorance is of no small importance in the practical relations of life; and it would save us a great deal of anxiety and much of expense, if we knew fairly and justly the limits of our knowledge, and the extent of our ignorance. (Hear, hear.) The manner in which our ignorance is developed to us in the progress of science, I might illustrate in this way. Let us take an example from the science of astronomy. Before the invention of the telescope, a person very much interested in the structure of the heavens, and looking at the star-lit sky, would be very much struck with the thousands of suns presented to his eye; and he would also be conscious of the fact, that out of these a very large number could only be very faintly and imperfectly discerned,—as the simplest twinkling of a distant star. The reflecting observer would then naturally suppose, that if he could get any instrument to bring him as it were nearer to the sky, or to give him a more distinct view of its wonders, he should obtain a very accurate knowledge of the contents of the starry heavens. Suppose, now, he obtained the aid of a telescope of ordinary power, and brought it to bear on the heavens,—the stars which before he had seen very imperfectly, would now become very distinct, and be resolved into something like form; but instead of becoming *perfectly* acquainted with the extent of creation, he would find that the very instrument which had given him a better view of his previous amount of knowledge, would reveal to him so much beyond, still as remote and indistinct as before, as to impress him with a deeper sense of his own ignorance, and to show how far he was yet distant from the attainment of his object. Let him then avail himself of the forty feet reflecting telescope of Herschel, and present it to the heavens. Now he would discover that a number of nebulous bodies, which before he had indistinctly seen, were resolved into vast clusters of stars, whilst other additional nebulæ had been brought into sight, leaving the vast unfathomed space of creation manifestly deeper than at first. For instead of these new and more powerful aids to vision bringing his investigations to a close, the further he goes the more he is convinced of the still greater extent of what remains yet unexplored and unknown! The effect, therefore, of all legitimate and sound science, profoundly investigated, is to produce in the well-ordered and intelligent mind that principle of humility, of which we find so many admirable examples among the most illustrious philosophers. Pride and conceit are the necessary fruits of ignorance, and of an imperfect acquaintance with things. The more we investigate the deep works of the Almighty Creator, which are all infinite, the more shall we be impressed with a sense of the impracticability of their ever being fully grasped by any finite understanding; and hence we shall be more cautious in putting forth crude speculations, and be brought into a condition of mind more humble and consistent with our Christian profession. And so, it may well be anticipated, will the science of Geology—against which many have been prejudiced by its numerous hasty, imperfect, and changeable theories,—be ultimately chastened by increased researches, till it assume more of the solid characteristics of the older sciences. To the extent, however, to which Geology has already advanced, its investigations may be shown to be practically very important. For, the mere determining of what may be certainly known of the structure of the earth, or the limits of knowledge as to what we may be ignorant of, becomes a valuable guide in a mining district. Every one acquainted with mining operations is aware of the fact, that many thousands of pounds have been expended in searching for coal, where, had the parties been intimate with the facts acquired by the science of Geology, they would have known for a certainty that it was impossible for coal to exist. It is evident, therefore, that a continued pursuit of this science must lead to still further discoveries of a very profitable kind; whilst there is nothing in its course, legitimately followed out, that ought to militate against, but the rather direct us to serious reflections with respect to, our eternal interests. In a mental point of view, this, in common with other sciences, tends to improve the powers of the mind, to elevate our tastes, and withdraw us from pursuits of a less dignified or less useful character, as well as to promote the good of society generally, and, in its ultimate practical results, the national prosperity. I cannot, therefore, do otherwise than wish this society all the success which its most sanguine friends can desire.

On the motion of Mr. Wilson, seconded by Mr. Embleton, the following gentlemen were elected members of the society:—Rev. Dr. Scoresby, Dr. Outhwaite, Messrs. John Rand, William Rand, J. G. Horsfall, Joshua Mann, Henry Harris, Alfred Harris, A. G. Robinson, Samuel Sharp, Henry Hagen, Joseph Smith, Joseph Bean, William Woodhead, Dr. W. Alexander, (Halifax), Messrs. William Wheatley, Charles Wheatley, Jun. (Hopton), Mr. J. Neill, (Wakefield), Mr. W. W. Wigglesworth, (Wortley).

The following Resolutions were also passed:—

Moved by Mr. Briggs,
Seconded by Mr. Hartop,

That the thanks of the Society be given to Mr. Sharp, the President, Mr. Darlington, the Secretary, and the Members of the Philosophical Society of Bradford, for their active exertions in making arrangements for the Meeting.

Moved by Mr. Wilson,
Seconded by Mr. John Hartop,

That the next Meeting be held at Sheffield, on Thursday, the 4th of June.

The Chairman said, he had now the pleasure to propose the commencement of the real business of the meeting, by calling upon the Rev. William Thorp to read his paper, on a subject which was in some measure discussed at the last meeting, in consequence of an invitation from the Manchester Geological Society to join them in executing a Section which should contain a list of the rocks and minerals from the river Mersey to the German Ocean,—each Society to undertake one half of the work.

ON THE PROPOSED LINE OF SECTION BETWEEN THE COAL FIELD OF YORKSHIRE AND THAT OF LANCASHIRE.

BY THE REV. WM. THORP, of Womersley.

Not being able to be present at the discussion at Leeds concerning the proposed section between this Coal Field and that of Lancashire, and as Mr. James Heywood informs me that a committee was appointed at the last meeting at Manchester to determine the best line, and also the proper scale upon which the section may be projected, I hope it may not be too late to offer a few observations upon the subject.

In the first place then, in order to form a correct section of the minerals and strata of a country, it is absolutely necessary that it be made at right angles to the range or "line of strike" of the different beds. But the "line of strike" is determined by the course in which the major axis, upon which any country is elevated, may run; and it is therefore necessary in the first place, that the direction of the axis be well ascertained round the margins of those Coal Fields, and accurately laid down on a map. Now, it is well known that the elevation of the Lancashire and Yorkshire Coal Fields is due to forces which have operated over a very extensive region, extending from the Tyne, in Northumberland, to the Peak of Derby; the effects of which forces are indicated by lines of dislocation and anticlinal axes, traversing those countries in various directions, as seen in the diagram: but these great axes seldom preserve the same course for many miles together: thus from Brampton, the great Penine fault comes to Brough in a S.E. direction, from Brough S.W. to Kirby Lonsdale, from which point the two Craven faults range S.E. From Kirby Lonsdale to Clitheroe the country has a system of anticlinal lines of convulsion of its own: these lines first run from N.E. to S.W., and elevate the Burnley Coal Field, Pendle Hill, &c., but in the Skipton valley they change their course to east and west, so as to cross the Wharf in a direction due east. From this last system of disturbances, the Derbyshire axis arises and proceeds from Burnley to the Peak of Derby, running in a general direction of N.N.E. and S.S.W., and throws off the Yorkshire Coal Field on its east, and the Lancashire on the west side of its axis. This N.N.E. and S.S.W. direction is, however, not constant, but it changes its course opposite Mottram, and again opposite Stockport. Now, the general character of the declinations along, not only the Derbyshire axis, but also the great fault from Northumberland to Kirby Lonsdale, is a long and moderate slope of the strata from it to the east, and a violent and short dip from it to the west; consequently, the Lancashire Coal Field being on the west, and nearer the centre of the axis, is not only more affected by it,—and hence the steep dips and numerous longitudinal faults,—but the direction of the dip of the strata in that Coal Field is also more affected by the minor changes in the direction of the Derbyshire axis; hence at Ashton, the strata dip due west at an angle of 45°, at Stockport S.W., at an angle of 75°; while the northern edge of the Lancashire Coal Field, being elevated by the Haslingden axis (which runs east and west, parallel, and probably related, to the Ribblesdale system) the strata from Bury and Bolton to Middleton dip south; so that in fact the level of any single coal bed, as the "black mine," would, if it could be traced the whole distance, describe a perfect semicircle. Owing, therefore, to these causes, and particularly to the influence of two great contiguous axes upon the strata, it becomes almost impossible to follow any single line of section directly across that Coal Field. And when Mr. Binney says " that perhaps the best plan would be to take a line from the central axis near Saltersbrooke to Mottram, and then diverge into two lines, so as to embrace the whole of the great Lancashire Coal Field, and from thence proceed 50 miles," it seems to me impossible to accomplish it. In the first place, the central axis does not cross the line of section near Saltersbrooke, but between Mottram and Stayley Bridge, and opposite Mottram the line of strike is north and south, and the measures dip due west at an angle of 45°; from this point, then, only one correct line of section can possibly be taken, and to take any other except in this one line must be incorrect. But there is a great objection to Mottram as a starting point, and that is, that from it the higher strata in the series, as those of Bradford, cannot be reached at all; for the levels of the Bradford Coal Field are parallel to those of Oldham, and ought to be approached by a line of section passing from the Millstone grit at Saddleworth through Oldham. In fact, the proposed section on the Lancashire side is under similar circumstances as if one were contemplated from the Millstone grit at Otley by Leeds to Wakefield, i. e. on the line of dip, and thence to proceed to Barnsley nearly on the level of the strata.* There is also another objection to any society expending much time in collecting data with regard to coal strata opposite Mottram, because two sections of it are already published. Hall's section of the Dukinfield country, which is in every person's hands, is very correct, as proved by Mr. Clay's section, which is nearly a copy of it; and moreover, Mr. Heywood is about to publish his section of the same district, in the Literary and Philoso-

* Barnsley and Wakefield stand upon the same rock.

phical Transactions of Manchester. It would, indeed, be very presumptuous in me to propose any line for the Manchester Society, and I perfectly agree with the observation of Mr. Hartop, that it would be wrong for us to prescribe any line for the Lancashire Society, but that they should select their own line, without reference to what should be done on our side, and that the two lines might be united by particular observations. Nevertheless, I must give it as an opinion, that the lines of section in that Coal Field which Elias Hall has published, are the very best which can be adopted. They are all at right angles with the minerals, and if it were possible for their Society to correct these sections, they would contain every thing which it is possible or requisite to know of that country. They would enable them to compare the changes which occur in their minerals in their passage from north to south, and to ascertain how far the law* *of developement or maximum thickness on the one direction, and a corresponding decrease on the opposite*, corresponds with that which seems to obtain in the Yorkshire Coal Field. And Hall's sections of the northern side, if corrected, would also be of immense value to us, and enable us to solve some of the difficulties connected with the strata on the north of the Calder between Halifax and Aberford; we should learn whether there is not a general decrease in the thickness of coal beds in their passage to the east, and thus obtain a knowledge of the true form of these strata, which would lead to such generalizations in the mode of the distribution of coal, as would be of great service to inductive geology.

With regard to the proposed line of section through part of our Coal Field, it may be said,—1st, that the whole country on this side of the Derbyshire axis at Mottram to Saltersbrooke, a distance of ten or twelve miles, is of the most uninteresting description (speaking geologically.) Four

* A law pointed out by me on a former occasion.

thick gritstones, with their intervening shales, cover the whole country; the limestone shale itself being exposed only for a short distance around Tintwistle. Mr. Morton says "that the Barnsley line would possess the advantage of having the millstone grit and flagstone strata beautifully illustrated by the great tunnel, and sinkings, and cuttings on the railway near Penistone;" but in fact only one of the two beds of millstone grit will be sunk through in the deep shaft at Saltersbrooke; the tunnel at this place commencing at the top of the lower grit. The whole of the millstone grit is therefore not exhibited. From the top of the railway shaft, which commences in the fourth grit, to the flagstone, is a thickness of strata of 200 yards, and I consider it of the greatest importance to have a correct section of it; because it so well corresponds with strata on the Lancashire side. But unfortunately the full thickness of not even the flagstone itself is shown, as the railway crosses it by a viaduct, on the south side of Thurlstone gap, and on the south of Ingbirchworth, where the line crosses, it is not worked, so that neither it nor any of the inferior beds are illustrated at all. Again, from the top of the flagstone to the Silkstone coal, the distance is 160 yards; but neither the Bowling ironstone (which I shall prove extends south of the line of the section) nor the Whin Moor coal, will be crossed where any thing is known of them at the point of intersection, so that in fact there will be not only a distance of five or six miles from the flagstone to Cawthorne village without a single coal or rock to be delineated, but also from the flagstone to the tunnel three or four miles in addition similarly circumstanced. Mr. Morton again speaks of the Wortley and Bradgate rocks containing the valuable and important beds of coal called the Flockton, Park Gate, and Silkstone, to be clearly exhibited by sinkings at Darton; but allow me to ask him where the Wortley rock is to be found north of Banks Hall, and where on the line of section? and as to the Bradgate rock being well exhibited, it is only four feet thick at Darton, while it is twenty-five yards at Sheffield. I also doubt whether it be well-judged to cross this Coal Field where the Silkstone coal is reduced in thickness to only two feet. If any rock in this coal district possesses its analogue in Lancashire, it is the red rock of Rotherham; but the red rock of Rotherham is not identical with the Staincross rock, as Mr. Morton and Smith's map would lead us to suppose; for the latter, in the Wentworth Section, is 100 yards below the former. And I am certain that there is scarcely any place in the country where there is a worse exhibition of the red rock of Rotherham than in a direction over Staincross heights. Mr. Morton then speaks of the Chevet rock being delineated; but permit me to say that the Chevet rock of Smith, north of Darfield, and on the line of section, is nothing more or less than the upper portion of his red rock, as every person knows who studies geology from the country itself, and not from maps: and that the Hooton Roberts rock—(which is above the Rotherham red rock, and preserves its character through the whole district, but is confounded with the Chevet rock by Smith in one part of his map, and not coloured at all by him in another, neither made mention of by Mr. Morton)—will be passed over in the line of section where nothing can be known or seen of it.

If asked, then, what line would you recommend, I reply, an east and west line through Rotherham, over the coal district on the south side of the Don, over the toadstone, near Tidswell, and the mountain limestone near Buxton. Over this line, the Coal Field of Yorkshire is well known, containing at least fourteen beds of worked coal, viz. the Dennaby, Herringthorp, four feet coal, yard bed (Park coal), High Hazle, thick coal, Swallow Wood, Park Gate or Manor, Walker's thin, Sheffield coal, the Halifax hard or Pecten, Halifax soft, The Hallam coal, which is the lime coal of Lancashire, and below this a coal between the two millstone grits: while on the other line there are only six beds worked, viz. Shafton, Mapplewell, thick coal, Flockton, Park Gate, and Silkstone, and some of these very imperfectly developed; the three beds which Mr. Morton describes as being valuable and important here are severally, the Flockton, 2.0.; the Lower Flockton, the best in Yorkshire, 6 inches to 10 inches, the Park Gate, 4 feet 9 inches, and the Silkstone, 2 feet. Surely the Lancashire gentlemen would exclaim upon an inspection of the completed section, that we must have made some mistake!—that while they had 50 worked beds, amounting to 150 feet of solid coal, we had only six diminutive, forsooth riding coals, amounting to 24 feet; they would say that their great coal field can certainly have no relationship with the Yorkshire, at least if it has, the Yorkshire is only the fag end of it!!

The rocks of our Coal Field on the Don line are also well developed, particularly that of Hooton Roberts, from which place it was carried to build Wentworth House, the red rock in Canklow Wood, and the Bradgate rock at Sheffield. The Millstone grits are as well exhibited, and particularly the lower one on Ladyborough, better than at Saltersbrooke. The Limestone shale has also its peculiar interest, abounding in marine fossil shells: a vertical section in Derbyshire compared with another through the same stratum in the north of Yorkshire, would of itself be a sufficient refutation of the opinion that coal grew upon the spot where it is now found. Volcanic rocks are found in most Coal Fields, those belonging to our own are not found north of Tidswell. The number of these beds, whether there are three, as maintained by Mr. Hall, or only one, as by Mr. Hopkins—their connection with and intersection by metalliferous veins,—the direction of the veins themselves,—their products, a comparison of them with those found in the north of Yorkshire,—the crystallized materials embedded with the ores,—the stratum in which each vein is most productive,—are all subjects worthy of consideration.

Again, the mountain limestone of Derbyshire is a part of the carboniferous series which certainly belongs to the Coal Field of Yorkshire; it does not basset out from under the Lancashire but the Yorkshire Field, and therefore in fact belongs to us. It possesses along with its extensive suite of fossils (of which 400 different species are contained in the lower scar limestone) the very highest geological interest. A collection of fossils from this region, compared with one from the magnesian limestone, both of which we have the finest opportunity of collecting, would at once show how many species are similar, and if any at all are identical. And the details of the Derbyshire limestone being embodied in the section, would make it of value not only to the two Societies, but to all who study the science. Again, there is a system of transverse and longitudinal valleys in the Yorkshire Coal Field to which none other in the British Isles are exactly analogous; a study of these valleys, with their relation to the Derbyshire axis, the passage of large bodies of water from the west, and the diluvium which they severally contain, would well repay the labour bestowed; for, if a true theory of the formation of these valleys could be made, it would afford a clue to the interpretation of the mode of action of the forces which elevated our continents. Those within the area of the Coal Field scarcely contain any diluvium, but those of Derbyshire abound with pebbles left above the highest flood-mark. The line of the proposed section follows one transverse valley of a tributary of the Dearne, crosses one slight escarpment, thence to the source of the Don, and keeps along the valley of Woodhead for a distance of 10 miles, entirely avoiding the numerous characteristic valleys of this coal field.

It must be recollected also, that there is another sister-portion of these two Coal Fields in Derbyshire. The Don section would at once apply and be a key to the stratification of that country. Surely we are as much connected with that Coal District as with the one of Lancashire. Can we gain no information from the study of that country, and will none of the members of either Society visit that District? Is there no Society at Chesterfield or Derby, with which we may correspond? At all events, in addition to having obtained truly valuable information, the executors of this line of section would return refreshed with health from a tour in the picturesque dales of Derbyshire, and laden with fluor spars and marine shells to store our cabinets; whereas they would return from the inhospitable regions of Saltersbrooke and Woodhead, where snow is frequently seen in July, half perished by cold and want of food, perplexed by the grit rocks they had seen, and I question whether any wiser for their journey.

The CHAIRMAN having invited discussion,

Mr. H. HARTOP rose and said,—The section on which they had heard so very interesting a paper from his friend Mr. Thorp, was, as they had heard from the Chairman, brought before the Society on a former occasion. At that time he thought it would have been better to take a line to the south of that suggested by Mr. Morton. He felt, however, some delicacy on this point, as he happened to live on the very line which he thought best, and as it might therefore be thought to be something like selfishness in him to recommend a line to which he would not have far to go. The line proposed by Mr. Thorp, would go through Rotherham southward of the valley of the Don, but it would here be attended with a difficulty which he would point out. (Mr. Hartop here drew a diagram to show that below Sheffield the strata took a turn nearly at right angles to their usual direction, and that below Rotherham, by a similar turn, they recovered their former direction.) Before, however, Mr. Thorp's line reached Rotherham, he would cross this great heave in the valley of the Don, which would be a very unfavourable circumstance, as the dip of the strata would be nearly at right angles with the line of section. The objection to Mr. Morton's line, Mr. Thorp had pointed out much more clearly than he could do. He was of opinion that the line he recommended was one from which they would obtain the best information respecting the coals and ironstones, and on that account, and not because he resided near to it, he thought it was the best for the Society to adopt. He admitted that it was a matter of opinion, and he should not have ventured to have offered one, if he had not been practically acquainted with the line he proposed.

Mr. T. W. Embleton said, he begged to detain the meeting with a few observations on the line of section which Mr Thorp had proposed, and he was induced to do so because he understood that Mr. Thorp at one time highly approved of the line of section which he had this morning so strongly condemned. He much regretted that Mr. Thorp had not before given the Society the benefit of the remarks which had just been read. When the proposal for completing a section across Yorkshire was first agitated, the object in view was, with the assistance of the section, to ascertain if there was any similarity between the coal field of Yorkshire and that of Lancashire, and as far as he (Mr. E.) had always understood, such was the object of a section now. *The section was not in particular to illustrate the Yorkshire coal field, but to be the means of comparison between the two coal fields.* To effect this the section across Yorkshire should commence at the same point as the section across Lancashire. The West-Riding Society did not pretend to dictate to the Lancashire gentlemen as to the line they intended to take, but he fully agreed with Mr. Thorp, that the line ought to be carried in the direction of the full dip of the strata, as this would allow more strata to be intersected than any other direction. The line proposed by Mr. Morton and himself had this recommendation; and besides the Lancashire Society had fixed upon the same starting point, the tunnel of the Sheffield and

Manchester Railway. Mr. Thorp's objection that, on the Barnsley line, some of the seams of coal and some of the rock formations were only slightly developed, stood for nothing, for no one line could be selected where every stratum was developed to its greatest extent. Of course other sections would be commenced, and which would with advantage be carried through those parts of the coal field where some coals attained their greatest thickness; but as before observed, this section was merely to assist in instituting a comparison between the two coal fields, and as such could not be made with advantage to the Society, unless the line proposed at the Leeds Meeting was adopted.

The Rev. W. Thorp's objection to Mr. Hartop's line, was chiefly that it would escape the volcanic rocks and the mountain limestone of Derbyshire. He had already pointed out the importance of these strata. With regard to Mr. Hartop's observations respecting the disturbances in the valley of the Don, he did not think the section would be much affected by them, but on the other hand, the line on the south side of the Don would throw some light on those disturbances, and particularly to the West of Sheffield. He regretted he had not mentioned the subject fully before, but he might say, he never approved of the line mentioned by Mr. Embleton, as the latter gentleman seemed to suppose he had done.

The Chairman would take the liberty to ask whether, in the several sections pointed out, there was any advantage in one over another, with respect to the facility with which the geological characteristics of the line might be ascertained?

Mr. Hartop begged to observe that at the former meeting at Leeds, he had entertained somewhat of an objection to any straight line being taken. Supposing the western end came up to the millstone grit, which was an exceedingly well defined portion of the strata, and the Lancashire Society were to bring their line up to the millstone grit, it would be no disadvantage if they did not terminate at the same point. The line he should recommend was neither north nor south, but that which would best develope the construction of the strata between the millstone grit of Yorkshire and that of Lancashire. He thought the line across Derbyshire would be a very interesting one, and he hoped it would at some future time be undertaken. But they appeared there as a West-Riding Geological Society, and whilst he should be exceedingly glad for theirs to join the Lancashire line, he did not think that they ought to go away from the best point, and go across Derbyshire in order to do so. In the line which he (Mr. Hartop) had pointed out, there would be one advantage, namely, the use of the Wentworth House section, which the geological world had had so many years before them, which, although not quite correct throughout, was still exceedingly accurate, considering the knowledge which existed at the time it was made. He thought he might say that that section had made more geologists in the West-Riding than any other yet produced. They had had the opportunity of examining the country where that section was originally formed, and since that period it had been corrected, and was now as good as could be obtained. This subject, he was aware, to a meeting like the present, was a very dry one, and therefore, he proposed they should have a meeting in the evening, in order to discuss the matter more fully.

Mr. Leah, being called upon by the chairman, said—The paper which I have very inadvertently engaged to bring before you, and for which I most sincerely solicit your kind indulgence, though originally designed for a very different company, has on the present occasion received the title of

AN ESSAY ON THE EFFECTS OF AQUEOUS VAPOUR IN THE ATMOSPHERE, AS APPLIED TO BLAST FURNACES, IN THE MANUFACTURE OF PIG IRON.*

BY HENRY LEAH, ESQ., OF BYERLEY HALL.

It is now upwards of five years since you formed yourselves into an Association, not merely to discuss topics relative to the regulation of your concerns as iron-masters, but also, to make a reciprocal communication of your several experience in the art of smelting and manufacturing iron, through all its different branches: that a more perfect knowledge thereof might be promoted, and the certain advantages resulting therefrom obtained.

To accomplish this desirable object, it was well proposed by your then president, (Mr. Dawson,) that essays should be written by each member in rotation; and questions proposed for discussion upon subjects relating to the art, at each quarterly meeting : and it was with much pleasure we witnessed your president follow up his proposals with an introductory dissertation, furnishing hints abundantly sufficient to ground essays upon, from that period to the present; and also with a copious, entertaining and instructive essay upon the effect of air and moisture upon Blast Furnaces: in which he evinces at least a disposition of inquiry highly commendable, and gives an example of industry and perseverance in observing, collecting, and arranging facts, well deserving the gratitude of every ironmaster.

From that author's well known abilities, opportunities, and other ample, and more than ordinary sources of information, any opinion he may adopt certainly assumes a very imposing authority; and it is therefore with much diffidence, that we venture to differ from him in our views of the effect of air and moisture upon blast furnaces.

* This Essay was originally intended for, and addressed—" To the Society of Iron Masters of the Counties of York and Derby;" and was delivered at their Quarterly Meeting held at Bradford, June, 1805.

He appears to have adopted, as the basis of his essay, Dr. Hamilton's theory of spontaneous evaporation. This affords him a supply of air, but investigates not the quality of that air: however, as it seems necessary that this air should contain a large portion of oxygen gas, to supply the daily consumption of that gas by various processes, he lays down an hypothesis, that "the atmosphere in its different "circumstances, acquires a different affinity for the oxygen "or hydrogen part of the water, and converts it into air as circumstances require." This hypothesis he thinks confirmed or rendered highly probable, from some eudiometrical experiments of Dr. Priestley: by the notion of Dr. Girtanner, that atmospheric air was composed of oxygen and hydrogen gases in very near the same proportion as water; and by additional experiments with the eudiometer, by M. Humboldt.

By the aid of those high authorities, he satisfactorily concludes that the atmosphere is a chemical composition or solution of gases; that it may be, and frequently is, composed of the gases oxygen and hydrogen; the proportional parts of which are subject to considerable variation in different seasons and temperatures; and hence, together with the spontaneous evaporation of water, he deduces the principal cause of its greater or less fitness for the purposes of combustion, particularly as applied to the production of iron from the blast furnace.

Having understood, five years after the publication of this essay, that he still maintained the same opinions, we took the subject into a more particular consideration; and after a minute examination of his hypothesis, and a copious comparison of its supports with more recent and correct authorities (at a length indeed so great, as quite to forbid its introduction on this occasion, *but which will, with much pleasure, be submitted to the inspection of any gentleman here,*) we felt bound to differ most essentially from these opinions of Mr. Dawson; particulars we must here wave, and only for the present, very briefly quote the conclusion or general result of such examination, viz., "That Mr. Dawson's hypothesis, in every point of view, is wholly inadmissible."

As a further attempt to lay down a theory more consistent with obvious facts, we then drew up a statement of our views on that subject; together with the sources of information on which they are grounded, which, with permission, we now beg to introduce, requesting as a favour, that any one who may have the misfortune to keep awake, during the very dry, tedious, and perhaps unintelligible detail, will kindly bear in mind that these views were advanced full 35 years ago. We are not aware, however, that much novelty has been discovered in this particular branch of research, and therefore proceed therewith without further remark or apology.*

"It is easier to find fault than to mend," says an old and true adage. To prove, however, that the preceding remarks originated not merely from a spirit of contradiction, we will now submit to your disquisition, a few hypothetical observations, different indeed from those alluded to, but upon the same subject—the effect of air and moisture upon Blast Furnaces. And after the example of the author, whom as far as facts will bear us company, we shall always be proud to follow, we will first attempt an inquiry into the constitution of the atmosphere; at least, so far as respects the mixture and proportions of its constituent gases; and the agency which aqueous vapour, or moisture possesses, in diminishing the fitness of the air for combustion, according as it abounds therein in weather of different temperatures.

The atmosphere, we contend, is not a chemical, but a mechanical mixture of gases; and Mr. Dalton's theory of the properties of that mixture, appears to us by much the most probable and satisfactory.

* The Essay originally consisted of two parts—in the first Mr. Dawson's theory was examined and controverted—in the second, which is now published, an attempt is made to establish a more correct theory.

The distinguishing principle of that theory is, "that "mixed gases neither attract nor repel each other; and that "though existing together, every gas is as a vacuum to every "other gas." This has been confirmed by Mr. Henry, who, after a very scrupulous examination of the theory, under impressions very unfavourable, expresses himself satisfied, that "It is far better adapted than any former one, for explaining "the relation of mixed gases to each other, and espe- "cially the connexion between gases and water."

As, however, it would be of no particular service to us, and as our limits will not allow us to give a view of the subject sufficiently comprehensive to be understood, we must refer you to Mr. Dalton's essays on the constitution of mixed aeriform fluids, &c.

We would only remark that as every gas is as a vacuum to every other gas, and as Mr. Henry proved to the Royal Society, that the relation of gases to water is altogether a mechanical one, the quantity of gas absorbed by water being always exactly as the pressure; it follows that the quantity of any of the atmospherical gases absorbed by water in contact with the atmosphere, will be proportional to the quantity or pressure of that particular gas; and hence the sea, and indeed water of every description, when exposed, may perform the part of an equalizer, or regulator, if not a renovator of the atmosphere; for should any of its constituent gases, by any means exceed its usual proportion, the pressure of that gas would be so much increased, and part would of course be absorbed by the water: at the same time, the pressure of the other gases collectively, must be as much diminished, and consequently those gases must receive a portion from the water to restore the equilibrium.

Hydrogen gas confined over water is as a vacuum to every other gas contained in that water, and the pressure by which those subaqueous gases are held, being removed, they quit the water, and assume their gaseous form in the vessel; at the same time part of the hydrogen, proportional to its pressure, becomes absorbed by the water; hence the volume of air in the vessel is not much altered, but its quality approaches that of the atmosphere. The same process takes place with oxygen, or any other gas or foul air : for water exposed to the pressure of the atmosphere, will contain a certain quantity of the gases composing that atmosphere, and will therefore restore or reduce any gas confined over an adequate quantity of it, to a certain degree of purity, varying with the nature of the gas so confined.

This principle, then, appears to be one of the chief means employed by nature to preserve the atmosphere of an uniform quality. Permit us further to observe, that wind seems to be another of those means. Oxygen gas, by the sun's influence upon vegetation, &c., may be produced in abundance at some particular period or place; this, however, is immediately dispersed by the wind, *whose velocity when scarcely perceptible, according to Dr. Hutton is about one mile per hour*, but which, at a medium velocity, may travel round the earth in a month's time ; it therefore must pass both large barren tracts of land, and an extensive portion of the sea; to either of which it will impart of its excess of oxygen gas. When it is considered that this dispersion is a daily process, and also that in countries where cultivation, and of course vegetation is in the greatest perfection, population, with its consequent respiration, combustion, and other destructive processes proportionally abounds; we think it scarcely possible to be seriously conjectured that any considerable variation can exist in the quality of the atmosphere; at least so far as the two gases of oxygen and nitrogen are concerned in its composition, which we now come to consider.

It is acknowledged that the atmosphere is composed principally of the two gases oxygen and nitrogen, which by different philosophers have been stated in various proportions, from 25 per cent. oxygen, *and* 75 *nitrogen*, to

28 per cent. oxygen, and 72 *nitrogen.* This difference no doubt arises, not so much from the air examined, as from the uncertain methods of trial made use of; but it seems very probable, from the more accurate experiments of Berthollot, Davy, &c., that the atmosphere is compounded of oxygen and nitrogen gases in some constant proportion between those of 21 *to* 79 *and* 22 *to* 78; or 21 to 22 per cent. oxygen.

It may be objected, that a mixture of these two gases in any of the above proportions, forms a compound of a specific gravity superior to that of the atmosphere, and a small addition of carbonic acid gas, generally found therein, will add to the objection; something therefore must exist in the atmosphere of a considerably less specific gravity than any of these mentioned gases.

M. de Luc long ago stated, that the evaporation of water was not effected by chemical solution, but by union with caloric; forming steam or vapour, which he found to exist in and augment the elasticity of the atmosphere. Mr. Dalton has lately verified these observations of de Luc; and by numerous experiments determined, not only the existence, but also the precise expansive force of vapour in the atmosphere, in all pressures and temperatures. From the force he gives to vapour at 55°, and the expansion it occasions in dry air, under the pressure of 30 inches of mercury, we find that aqueous vapour occupies a space equal to 1½ per cent. of the atmosphere at that temperature. This affords the bulk of vapour, but its specific gravity seems not to have been determined by any direct experiment. Mr. Watt "never found steam more than 1800 times rarer than water "at the temperature of 212°, and under the pressure of the "air." Taking the expansion therefore at 1800, the specific gravity will be .55; that of water being 1000: and this result very nearly corresponds with that of M. Schmidt, who by saturating dry air with moisture or vapour, calculated the weight of the vapour to be to that of perfectly dry air as 10 to 23.5. From these circumstances, without doubt, the something wanted to complete the compound of the atmosphere is aqueous vapour; and from the data they afford, we compute the proportions of a cubic foot of atmospheric air to be as follows, viz:—

		Mr. Murray.			
	Cubic inches.	Cubic inches.		Weight in Parts.	
Oxygen gas	366	363.	...	23.32	*
Nitrogen gas......	1334	1339.1	...	75.55	
Carbonic acid gas	2	1.4	...	.1	
Aqueous vapour ...	26	24.5	...	1.03	
	1728	1728.		100.	

And the specific gravity of this compound, we find to agree with that of atmospheric air, as determined by Mr. Kirwan in nearly the same temperature.

Having noticed the mixture and proportions of the gases constituting the atmosphere, at a medium temperature, let us now inquire into the cause of the very obvious difference in its effect on the Blast Furnace during the seasons of summer and winter. This variation follows so uniformly the heat or coolness of the weather, that we formerly were led to conclude it originated entirely from some different modification of the atmosphere, by the presence or absence of caloric: that either the oxygen gas being more dilatable by heat than the other gases, became in summer considerably rarer, and consequently less in its proportional quantity: or that the oxygen gas was subject to a partial spontaneous combustion, somewhat similar to that of phosphorus, at a lower heat than that of our summer's day; by which the purity of the atmosphere might be much diminished. These notions, however, upon a closer investigation, we found alto-

* These numbers of measure and weight were gathered from a Lecture by Mr. Murray, from fifteen to twenty years ago, and are inserted here merely for the sake of comparison.

gether untenable; for it is fully decided, both by M. Gay Lussac, Mr. Dalton, and others, that all the gases yet known, expand equally with equal degrees of heat; and also that their expansion is constantly proportional to their heat. We also found it proved, to our conviction at least, that the proportions of oxygen and nitrogen gas were nearly the same, both in summer and winter, in warm and cold climates.

These facts of course overthrew all our suppositions together, and the question again recurred to us, what can that substance or principle be, from which, by the operation of the heat, so essential a change is produced in the fitness of the atmosphere for combustion?

Carbonic acid gas we rejected, its proportion being both extremely small, and also subject to the same alteration by heat as the other gases. Nor could we connect, in any satisfactory way, the agency of electricity or galvanism, which is admitted to be of the first importance in some of nature's operations. It was therefore more from necessity, than any hope of success, that we turned our attention to the aqueous vapour existing in the atmosphere.*

Aqueous vapour, as we have endeavoured to show, does exist in the atmosphere to the amount of $1\frac{1}{2}$ per cent. in weight, or 26 cubic inches per foot in volume. This, it must be observed, is at the temperature of 55°, and not given as a constant proportional part; for the force of vapour, and consequently its expansion, is variable in different degrees of heat; nor does this variation follow any equable proportion to the accession of heat, as is the case with the other gases; but the degrees of expansion form a

* The agency of electricity on the atmosphere, we are convinced from numerous observations, at different times, is very powerfully operative on blast furnaces. But though those effects are quite obvious, they do not appear uniform; nor are we acquainted with any means whereby to ascertain the peculiar quality or state of electricity in the air, or its respective influence on the same, or on the processes of combustion.

kind of geometrical progression to the arithmetical increase of the degrees of temperature.

Thus 1728 inches, or a cubic foot of any of the gases, expand uniformly by 67° of heat (the difference from 13° to 80°, which we have made choice of, as being about the two extremes of temperature in summer and winter) into 1972 inches, or in the ratio of 100 to 114, while the expansion in aqueous vapour, generated from water of 13° and 80° temperature, is found to be 0.1 and 1.0, or in the ratio of 1 to 10. The expansion of vapour at 55° is found to be .45; here, then, we have data to calculate the quantity of moisture in the atmosphere, supposing the same to be saturated therewith, (though we know it seldom is completely) and taking it for granted that the quantity is always proportional to the expansive force.

For if the atmosphere at 55° temperature, when the expansive force is 0.45, contains 26 cubic inches of vapour per foot, it must, at the temperatures of 13° and 80°, or with expansive forces of 0.1 and 1.0, contain respectively 5.8 and 58 inches of vapour per cubic foot of air. From the conclusions of General Roy and Mr. Schmidt, a much larger proportion of moisture is held in the air at those temperatures; but they seem to have been led into considerable errors, by attempting to establish mean rates of expansion from different points of the thermometric scale. Admitting, therefore, the above results, which are calculated after the later and much more accurate experiments of Mr. Dalton, we have two very distinct effects of heat on the atmosphere,—the proportional expansion of the gases, and the progressional accumulation of aqueous vapour.

First, supposing the air to be perfectly dry, we find that a cubic foot of it in winter, at the temperature of 13° will contain about 370 inches of oxygen gas; but this gas, by the summer heat of 80°, will expand into 422 inches: hence it is evident that a foot of dry air in winter contains 1-7th more oxygen gas than the same volume in summer. As, however, the nitrogen gas, &c. from the same cause, must be diminished after the same rate, we cannot conceive that the consequence would be injurious to the blast furnace, provided the speed of the blowing engine was accelerated 1-7th, so that the same quantity of the gases might be thrown in as in the winter. On the contrary, we are apprehensive that a beneficial effect would be experienced, if the air, equally free from moisture, could be obtained at 80° temperature: for we presume, that oxygen gas unites not with a combustible body at a lower temperature than that which produces ignition in that body: the heat therefore requisite to add to the presented air, that its temperature may be raised to the point of ignition, must be abstracted from the burning body, and so much will the combustion thereof be impeded; consequently the hotter any air is, when equally free from moisture, and its proportion of oxygen the same, the greater effect will that air produce in a blast furnace.

We are aware that this proposition will be thought singular, and by practical ironmasters treated as chimerical; for we have frequently heard their partiality to a blast that is cool, especially in summer. With all due deference to their judgment, we must, notwithstanding, suppose their notion to originate in error, which we hereafter intend to notice; and in confirmation of our opinion we have the concurrence of Mr. Sadler, chemist to the Admiralty, who, perceiving a difference in the effects of the blowpipe, which he could attribute to nothing but the difference in temperature of the air employed, constructed an apparatus, whereby he gave an elevated temperature to the air just before its issuing from the nozzle; and by these means he found the heat excited "so great, as to fuse the purest specimens of native rock "crystal, and also those of lime. The other effects were "likewise proportionally greater." It is true, oxygen was the gas Mr. Sadler made use of, but we see no reason why the same, or proportional advantages should not be obtained by a similar application of atmospheric air, when so circumstanced as to prevent any further accession of vapour.

For it is secondly, to the effect of heat on the rapidly progressive accumulation of vapour in elevated temperatures, that we principally ascribe the deleterious effects of a summer's air to the product of the blast furnace, and other processes of combustion.

We have assumed the extreme points of temperature of summer and winter to be 13° and 80°, (though we have known the mercury several degrees both above and below those points,) and from the expansive power of vapour at those temperatures, taken its quantity in the air in summer to be 5.8 and 58 inches per cubic foot, and which at the specific gravity of .55, will give .001846, and .01846 oz. advoirdupoise, the weight of vapour in each cubic foot of air respectively.

Supposing then 2000 such feet of air to be thrown into a furnace per minute, and some furnaces have much more, the respective quantities of vapour thrown in therewith, in winter and summer, will be 3.7 and 37 oz. weight per minute. Dr. Crawford by experiments purposely and carefully made, has stated that to decompose 1 oz. of water requires as much heat as would raise its temperature 9485°; and Dr. Thompson states the specific caloric, or capacities of water and iron to be 1 and .1264, as 8 to 1 nearly, or the caloric requisite to raise the temperature of a given weight of water 1 degree, would raise the same weight of iron 8°, or 8 times the weight of iron to the same temperature.

In our case it is not water but vapour that is thrown into the furnace; and vapour in its formation from water, per Mr. Watt's experiments, we must notice, has already taken up 920° of caloric ; hence the decomposition of 1 oz. of vapour into its component gases of oxygen and hydrogen, will require a quantity of caloric sufficient to raise 1 oz. of water 9485°—

920=8565°; or as much as would elevate about three times that weight of iron to the point of fusion, taking the same at 20577° temperature.*

From which it appears, that to decompose the vapour introduced into the furnace in weather of 13° and 80°, and when the atmosphere is fully saturated with moisture at those temperatures, as much heat is requisite as would fuse in the first, 12.2 oz., and in the second case 122 oz. of iron per minute. This caloric, which we conceive lost to any useful purpose, we confess seems an immense quantity; but when it is considered that the air is very rarely if ever found to be perfectly saturated with vapour, that even this large quantity bears no very great proportion to the whole mass of caloric generated in the furnace; and that the heat sufficient, either in quantity or degree, for fusing iron, is considerably less than that necessary to produce iron from ironstone, as is abundantly evident from a comparison of the blast and produce of a blow-hole and blast furnace,—when these considerations are attended to, we think the effect of vapour, as stated, is by no means incredible.

Admitting then their reality, we have now some prospect of tracing to their source the mischievous effects of a summer's air in blast furnaces.

We do not indeed attribute these effects to the mere abstraction of heat we have just calculated; for though that certainly is an evil to some extent, yet it is of inferior mag-

* VARIABLE ESTIMATES OF THE DEGREE OF HEAT REQUIRED TO FUSE CAST IRON.—ALL FROM DR. THOMPSON, VIZ.:—

20577° Encyclopædia Britannica } In article "Chemistry."
17997° Ditto Ditto. }
3470° in a late work of Dr. Thompson.
All by Fahrenheit.

The last ought to be most correct; the first numbers appear too high, probably obtained by guess only; the last may possibly be below the truth, though ascertained by later and more correct means. The difference between the first and last being as much as 6 to 1, will make an enormous difference in our calculation, which we have not either time or inclination to ascertain at present.

nitude, and may be remedied in a great measure by an augmentation of blast. The grand destructive power, we are decidedly of opinion, resides in the oxygen and hydrogen gases, entering the furnace along with the air, in the form of vapour, but which are immediately decomposed, or separated, by coming in contact with the ignited combustibles in the furnace.

To render our ideas upon this intricate subject more intelligible, we must first take a short view of the phenomenon of combustion, the various matters used, the action of each, and the changes effected thereby in the reduction of iron by combustion, or in the blast furnace.

The subject, it must be confessed, is yet involved in much obscurity, and, sensible of our very imperfect acquaintance with what is known, it is with considerable diffidence we submit the following conjectures upon it. The materials necessary to make crude, or pig iron, are ironstone, which in this vicinity is iron, combined with oxygen and argillaceous earth, or alumina, limestone, or lime united to near an equal weight of carbonic acid gas, and coke, which is carbon mixed with sundry saline and earthy substances.

When these matters are intermixed in a furnace in proper proportions, the cokes lighted, and the blast introduced, consisting of the gases, &c. we have before enumerated, we imagine these phenomena take place. The free oxygen of the air unites with part of the carbon of the cokes, and forms carbonic acid gas, or carbonic oxide; this gas, or oxide, having a much inferior capacity for caloric, takes up somewhat less than one-third of the heat evolved from the oxygen; the redundant two-thirds serve to raise the temperature of the other materials to the point of fusion. It is then that the lime, (from which the carbonic acid gas is previously driven off by the heat,) combines with the clay of the ironstone, and perhaps some portion of the metallic oxide, (we suppose this, because it is said that the earths lime and alumina, either together or separate, are infusible in the heat of a furnace) and these together become a liquid scoria: while at the same instant, the oxygen of the ironstone, separating from the metal or iron part, combines with the other part of carbon of the cokes, and the metal thus set free, by its superior specific gravity, falls through the scoria into the bottom of the furnace. The nitrogen of the air seems capable of no action in combustion, but that of taking off caloric sufficient to raise its temperature to an equilibrium with its surrounding matters.

Carbon then unites with two portions of oxygen, that of the air, and that of the iron-stone: and when it is found in such abundance as to saturate both, and to spare, the surplus partly unites with the metal, and constitutes a grey, kishy, or carbonated iron; but when oxygen is most abundant, the metal is found inclining to whiteness, imperfect, and by a covering of its oxide or honey-comb when cast, is known to be oxygenated or forge iron, and this in a greater or less degree, as the principle of carbon is more or less deficient in the furnace.

It is worthy of remark, that when carbonated iron is made it leaves the furnace at a temperature below that of oxygenated iron; yet the fusion of the former is said to be more perfect than that of the latter.

This seeming paradox we thus explain—It is known that the capacity for heat, of all the gases and liquids is much greater than that of any of the metals or solids; hence so long as there is carbon sufficient in the furnace, to take up all the oxygen, the formation of carbonic acid gas, or oxide, prevents the furnace from exceeding a certain point of temperature; and the metal having lost all its inherent oxygen, (that combined with it as iron-stone or an oxide) by its union with carbon, is rendered very fluid and perfectly reduced. On the other hand, when the proportion of carbon is too small, the excess of the oxygen of the air becomes fixed in the metal, forms a new oxide of iron, and the heat developed thereby, being somewhat more in proportion to that given off by the formation of carbonic acid gas than 3 to 2, the temperature of the furnace is found considerably higher; while the metal, owing to the want of carbon, becoming again oxygenated, though very hot, runs stiff, soon dies, and exhibits a very imperfect reduction.*

Mr. Dawson having, by the united agency before noticed, made out a deficiency of oxygen in warm weather, says, "That the furnaces in this state always worked cool, and "that the metal had every appearance of an imperfect re- "gulus."

We must confess we have not yet seen an instance of a furnace working cool, and producing an imperfect regulus, except the same has been occasioned by a stoppage of some considerable time, or by a foul, mismanaged, or new, or cold hearth.

Mr. Dawson also states, that by the introduction of steam above the Twyere, the temperature of the furnace was effectually raised, "but the heat, which the steam "took from the lower part of the furnace, to be converted "into air, so cooled the furnace in that part, as in a great "measure to scaffold it over and prevent its working." We can easily conceive, that the metal by oxidation with the oxygen of the steam and air, almost before its separation from its earthy matrix, would be precipitated in a state partly fluid and partly solid, and which, from its inability to run out of the furnace, whatever might be its temperature, might therefore be termed cool. But to conceive that heat could, by any means, be taken or abstracted from

* While the carbon of the cokes unites with the free oxygen gas of the atmosphere, and also with the fixed oxygen in the iron stone, may not the oxygen of the vapour become fixed in the iron, and to a degree correspondent to the quantity of such vapour, oxygenate the iron, or destroy or neutralize a portion of additional carbon to prevent such oxidation ?

one part of a furnace, to raise to a degree considerably higher, or indeed higher in the least, the temperature of another part of the same furnace, is perfectly incompatible with every theory and definition of heat that we have hitherto met with. Leaving, however, these statements to reconsideration, we return to the subject of our inquiry—the effects of the oxygen and hydrogen gases in the furnace, set at liberty by the decomposition of vapour, the subsequent actions of which, though different, are, we imagine, both baneful to the production of iron.

To elucidate this, we must beg your attention to the well known experiment of passing steam or vapour through a tube heated to redness, and containing iron filings or wire. Here we find the component gases of the vapour separated, the oxygen combines with the iron, and therewith forms an oxide, and the hydrogen is liberated in the state of gas. There does not, however, appear to be any caloric generated or set free, for to continue this decomposition, it is absolutely necessary to furnish a constant strong external heat to the tube: now granting that the formation of hydrogen gas takes up a large quantity of caloric, yet the fixation of the oxygen ought to afford that quantity of caloric, and a surplus of nearly 1-4th; the comparative quantities of heat contained by oxygen and hydrogen, in proper proportions for composing water, being as 4 to 3.2 nearly. How happens it, then, that a continuation of external heat is requisite after decomposition has once begun? Again, iron is decomposed in water, and the same kind of oxide is formed as that produced from the preceding decomposition of vapour, and we have reason to suppose with no greater evolution of caloric; but on the contrary, it is very probable that oxidation would not take place were the water perfectly deprived of heat; for this oxidation is proportional to the heat of the water, though it is known that by heating water, the uncombined oxygen it contains is driven off in its gaseous state; the oxidation does not, therefore, seem dependent upon the quantity of oxygen in the water, but principally upon the caloric therein, which may enable the hydrogen to assume a gaseous form.

These and other similar facts, contrasted with the very different phenomena attending the action of free or atmospheric oxygen, led us to suspect some essential difference between the free oxygen of the air, and that combined in water or vapour: the first being absolutely requisite to combustion, and the latter appearing incapable of maintaining that process.

We could not, however, draw this conclusion, because it was opposed by some experiments in electricity and galvanism: for when water is subjected to the action of an electric or galvanic discharge, by means of golden or platina wires, its two constituent gases of oxygen and hydrogen are produced, and these identical gases, found capable of reduction again into water, by being fired together. Hence it appears that oxygen may be obtained from water, fit for the support of combustion. The difficulty stated as arising in this experiment is quite satisfactorily explained in the following.

During the embarrassment hereby occasioned, and after we had made the preceding remarks, we met with Dr. Pearson's Experiments in Electricity, where we find him asserting as the result of a great number of experiments:—" It is " demonstrable that the electric discharge and spark contain " fire, and very probably they are merely a state of fire, &c." " It is demonstrable, also, that the ponderable parts of " oxygen and hydrogen constitute water. There is strong " evidence that these gases consist of a peculiar species of " matter, which is ponderable, and of imponderable matter, " which is that which is separable from them in the state of fire " or flame." " It has been rendered at least very probable, " that when water or its constituent gases, oxygen and hydro- " gen, are rendered into the gas state, they absorb or unite " with a large quantity of caloric, or of both caloric and light."

Whence it appears that the production of the gases from water is effected by the agency of the caloric given off by the electric or galvanic discharges through that water, which caloric again discovers itself, in the explosion of the said gases, by which they become reduced to water again.

Such assertions, from such authority, we presume, warrant the conclusion that the free oxygen of the atmosphere possesses a large portion of caloric, which the oxygen of water or vapour does not possess; and that the power of oxygen to promote combustion entirely depends upon this possession of caloric; and of course that the effect of introducing water, steam, or vapour into a blast furnace, cannot in any respect be beneficial thereto, but certainly must be injurious; for the gases produced from the same, as we before stated, take up a large quantity of caloric from, but are incapable of any action favourable to, the produce of the furnace.*

This is also fully confirmed by Dr. Thompson's invaluable "Remarks on Combustion," in which he classes water among the products of combustion, and expressly says "No product of combustion is capable of supporting combustion," &c.

We now come, more particularly, to the action of each of these gases, formed by the decomposition of vapour, so far as they respect the production of iron from the furnace. The oxygen gas from vapour, though dispossessed of its caloric, seems to retain its other properties, or at least its affinities; for at a sufficient temperature it combines readily with both iron and carbon; forming with the first an oxide, difficult to reduce, and with the latter carbonic acid gas; results which, it is probable, are both pernicious to the produce of a furnace. The appearance of metal in summer, when vapour is abund-

* Many other experiments and facts might have been adduced in confirmation of the important distinction between the free oxygen in the atmosphere and the fixed oxygen of water, and the various metallic oxides, &c. &c. A full illustration, however, might extend too far for our present, and must be left to a future opportunity.

ant, induces us to suppose, that no proportion of carbon or cokes, however large, will prevent the iron from being, in some degree, oxygenated by the oxygen of that vapour; however, as we have not data whereon to form any precise estimate of its direct effects upon the metal, we will suppose this oxygen wholly to unite with the carbon of the cokes, for the sake of calculation, and because its affinity for that substance stands in the first rank.

The hydrogen gas of vapour has not, as far as we can find, any other action upon iron than that of taking off the excess of oxygen from it, when it possesses a larger portion than is necessary to form the black oxide; and as occasion for this action, we presume, cannot occur in a blast furnace, we take it for granted that the whole of the hydrogen also combines with carbon, and constitutes carbonated hydrogen gas.*

We then propose the following positions, which we have gathered from the best authorities, and which, for perspicuity, we have reduced to the same denomination, the oz. avoirdupois :—

1st. In summer time, at the temperature of 80°, it is possible for 2000 cubic feet of air to contain 37 oz. of vapour, but as the air is seldom or perhaps never completely saturated with vapour at that temperature, we will say 35 oz. of vapour for 2000 feet of air, or suppose that quantity thrown into a furnace per minute.

2nd. 100 oz. of this vapour is composed of 85 oz. of oxygen, and 15 oz. hydrogen.

* By throwing water upon the outside of a blast-bag, it will be seen that a small portion of air makes its escape through the same, however thick or dense the leather may be. This has often suggested the idea, that very probably the air so oozing out may be hydrogen, that gas being the lightest. A report in the Mechanic's Magazine, about a year ago, gives a series of experiments, proving that hydrogen is composed of ultimate atoms, smaller than those of any other gas, and that that gas will pass through, by pressure, a finer substance, and thereby be separated from any gas it may be mixed with.

3rd. Carbonic acid gas consists of 72 oz. of oxygen, and 28 oz. of carbon per 100 oz.

4th. Carbonated hydrogen gas is formed of (from 74 to 80, say) 77 oz. of carbon, and 23 oz. of hydrogen per 100 oz.

5th. Cokes proper for a furnace afford, we presume, from 70 to 80 per cent. of carbon, say 75 oz. of carbon from 100 oz. of cokes.

These proportions granted, leave us data to infer that 35 oz. of vapour, with the assistance of caloric from the furnace, will produce 29. 75 oz. of oxygen gas, and 5.25 oz. of hydrogen gas; and this 29.75 oz. of oxygen gas to form carbonic acid gas, will take up, consume, or destroy nearly 11.6 oz. of carbon, or 14.5 oz. of cokes. The 5.25 oz. of hydrogen gas, to form carbonated hydrogen gas, will also take up or destroy 17.6 oz. of carbon, or 22 oz. of cokes. Hence it appears the introduction of 35 oz. of vapour per minute will completely deprive the process of combustion going on in the furnace, of the aid of 36.5 oz. of cokes per minute, or 137 lb. per hour: a quantity which will equal a sixth, or a seventh part of the whole quantity of cokes used in a furnace, requiring a blast of 2000 cubic feet of air per minute. By pursuing a similar calculation, we shall find that the effects of vapour in winter will be about one-tenth of the preceding quantity, or 13.7 lb. per hour loss of cokes will be the result. The great difference, therefore, in the produce of a blast furnace, in the different seasons of summer and winter may, we presume, with sufficient reason, be attributed to the great difference in the destruction of carbon or cokes in the furnace, by the vapour admitted along with the air; that difference appearing to be no less than 124 lb. of cokes per hour. Whether a proportionate difference is, or is not, found in the produce of a blast furnace, we refer to the experience of every iron master present.

It remains for us to notice the effects of a water regulator upon the compressed air contained therein. From the experiments of several philosophers, it is rendered pretty certain, that the capacity of air for heat, follows some reciprocal ratio to its density; hence when the air by expansion becomes rarified, a thermometer within the receiver falls several degrees, and by the sudden cold thus produced, the vapour of the air is condensed and becomes visible: on the contrary, when air is compressed, its temperature is proportionably raised, and if water or moisture be present, it immediately converts as much of it into invisible vapour, as will again reduce its temperature to an equilibrium with the water or other surrounding bodies. This well-known fact gives a very clear and just idea of the process continually going on in the water regulator; every succeeding cylinder of air thrown into the chest, enters with a temperature elevated in proportion to the degree of pressure it sustains; but so much as comes in contact with the water in the chest, is immediately reduced to the standard temperature, its excess of heat uniting with water and producing vapour; and by continuation of this process the superincumbent strata of air become successively reduced. This, however, requires some time to effect, and hence it appears that the larger the waterhouse, or the nearer the surface of the water the eduction pipe is fixed, the more perfectly will the air be reduced in its temperature, or saturated with moisture.

We should be glad to know of any series of experiments being made to determine the relative capacities for heat, of confined air under different pressures; as then the additional quantity of vapour taken up thereby might be ascertained.

Lambert and Saussure's tables, of the proportions of vapour under different pressures, being calculated for the open air, are not, we think, directly applicable in this case.

That a quantity is taken up, and a considerable one too, is however sufficiently manifest, from Mr. Roebuck's observations, respecting the air vault at Devon Iron Works;

a vault, excavated out of a rock, and containing upwards of 13,000 cubic feet of air. He, with his companion, entering the vault, while the engine was silent "found "a dampness and mistiness in it, which disappeared after "the door was shut, and the engine recommenced working:" "and when he "gave the signal to stop the engine, as soon "as it ceased to work, and the condensation abated, and "before the door of the vault was unscrewed, the whole "vault in a few seconds was filled with a thick vapour, so "that they could hardly see the candles at four or five yards "distance."

This singular experiment contains much information, and corresponds exactly with the preceding statement. Mr. Roebuck does not indeed seem to be aware of the cause of this appearance and disappearance of vapour, as neither of his supposed causes are sufficient. The first is evidently inadequate; and if the second be admitted, if "the air in "a state of condensation be capable of holding a greater "quantity of water," (in a state of vapour) how happened it, that a gallon of water per day, was collected in the wind chest, where it is certain the air was equally condensed? The fact appears clearly to be, and Mr. Roebuck thus, though indirectly, acknowledges it: "The very small "quantities of water we at times discovered, proceeded from "nothing else but this vapour, in its passage to the furnace "along with the blast, being condensed into water by the "coolness of the eduction pipe and iron wind chest." But if its condensation depended upon cold, certainly its formation depended upon heat, not any heat proceeding from the furnace, but the heat given off by the compression of the air.

We may further observe, that for every portion of vapour thus condensed, the pipe and chest would receive the heat of that vapour, and consequently would soon become of a temperature equal to the compressed air; and of course, cease to condense or produce water at that pressure. In exact agreement thereto, Mr. Roebuck says, "This appear-"ance of water only showed itself occasionally, for it never "was observed, but either when the engine, after working "slowly, was made to work quicker, or after being stopped "for a few minutes, was set to work again."

If, then, from such trifling deviations in the pressure and consequent temperature, a gallon of water per day could be collected, we may fairly infer that the whole quantity taken up by the additional pressure of 2, 2½, or 3lb. per inch, and thrown into the furnace along with the air, must be very considerable indeed.

Admitting a mean of the results, obtained from the tables of Saussure and Lambert, the additional quantity of vapour will be about one-fifth of that the air contains, with the atmospheric pressure at all temperatures; or if we reckon the ratio of vapour to be simply as the pressures, or as 30 to 35, 1-6th will be the additional quantity taken up by compression, and consequently, following our preceding calculations, we may state the additional quantity of cokes lost, by making use of a water-house, at about 24 lb. weight per hour, on an average throughout the year, or about 100 tons per annum, in every such furnace.

This result, which we believe exceeds not the truth, gives a very evident superiority to a dry blast, and which we have no doubt, when properly regulated, is due thereto.

But our wish to be understood having led us out far beyond our intention, we must, at present suppress several circumstances which might be adduced in confirmation of this conclusion. We must also reserve some suggestions for extracting part of the vapour from air, by the use of quick lime, potash, sulphuric acid, &c., which we think might be found practicable in a dry blast or air vault; and if so, *well worth the attention of the iron master.*

We do not affirm this train of reasoning and computation to be altogether accurate; for though the data, in general, are furnished from much better authorities than we have any pretension to, yet from our deficiency both in time and talent, their application may too frequently be erroneous.

Under a belief, however, that the principle we have advanced has fact for a foundation, we submit the blemishes of the superstructure to your correction.

Its direct opposition to the favourite hypothesis of Mr. Dawson, induces us in particular to look up to him for a critical examination; and, as we doubt not his candour, neither do we doubt his conviction of the truth and importance of the principal fact, the destructive effect of moisture or vapour in a furnace.

In our mode of estimating that effect, we may very probably have fallen into numerous errors. If such are found of importance enough to induce some abler hand to expose them, no doubt the object you have in view will be thereby promoted, and we shall, with much pleasure, reform our speculations: truth being, we trust, our only object: after which, and much at your service, *we* are a very humble

Inquirer.

The Chairman inquired if any gentleman wished to make observations on this important subject?

Mr. Hartop said, it must be exceedingly gratifying to Mr. Leah to find that the main substance of his paper, written thirty-five years ago, had been verified by experience, as well as by experiment, and the improved condition of science. (Applause.) There was one point which he was exceedingly anxious to have taken into consideration, (of which all scientific men were aware) that it was not merely the vapour which they had heard of, that affected the value of the produce of a furnace, but in a still higher degree Electricity. They found that on the approach of thunder or lightning, the produce of the furnace was exceedingly deteriorated. He mentioned this fact, in order that some experiments might be made, or at least in the hope that some gentleman would favour the meeting with his opinions on the subject. It was found the production of furnaces might, from the causes he had mentioned, be injured to the extent of 15s. or £1 per ton. Practically, he had known this loss frequently, and, indeed, the fact was well known and admitted by every man interested in the iron trade. If, then, this deterioration occurred on the produce of one furnace, they might very easily see that, in this country, where considerably above one million tons per annum was made, a very serious injury might be sustained.

Dr. Alexander, of Halifax, said—He thought the question under discussion was one of considerable interest, from their being in the vicinity of many great iron works in active operation. With respect to the opinions which Mr. Leah had offered, he had certainly made out a priority of claim to the substitution of hot air for cold in blast furnaces. He (Dr. Alexander) had previously imagined that it had been a recent and modern improvement, but if he understood Mr. Leah correctly, that gentleman, thirty-five years ago, was perfectly satisfied that air, heated above the ordinary temperature, would materially aid the consumption of the fuel and the decomposition of the iron stone. It must be very flattering to Mr. Leah to find that his opinions were confirmed, and that the hot air blast was very generally introduced. He had an opportunity two or three days ago, of seeing over the Low Moor Iron Works, accompanied by Mr. Lamplugh Hird, and he found that the hot air blast was not introduced there. He was told it had been used for a while at Shelf, and the production was considerably increased, but it was subsequently abandoned under the conviction that it did not equal in quality what they had been accustomed to produce. With respect to aqueous vapour, he could easily believe that it would reduce the temperature: if, for example, they supposed that the atmosphere contained 20 parts of oxygen with 80 of nitrogen, the latter having no action whatever, as was supposed, in the converting process, would pass off without serving any useful purpose in the smelting of ore; but if it underwent decomposition, by its oxygen being so much reduced by the carbonizing of the coal, and the hydrogen became converted into flame, he did not see the proposition so clearly. Mr. Babbage, who had given his opinion on the subject, thought a process might be adopted so as to liquify the oxygen. As, however, he was speaking in the presence of several iron masters, and as he had great deference for their practical knowledge, he would not pursue the subject further.

Mr. Hartop said, with respect to the substitution of hot air for cold, of which his two friends seemed to approve, he wished to make one or two observations, because he was anxious that the question should be understood by the public at large. He was afraid that the introduction of hot air was erroneously termed an improvement in the iron trade, and, therefore, he was most anxious to concede any merit for the introduction of it. He was happy to say that few iron masters in Yorkshire had adopted what was termed this improvement, and hence when contracts were advertised for steam engines, but more particularly for steam packets and locomotive engines, they had the pride and gratification to see a clause introduced, that they should be made of Yorkshire iron. He believed there was only one work in Yorkshire which had adopted the hot air system. Now, there was one point which it was very important for the public to know. It had been stated that by the hot air blast double the quantity of iron might be made. He thought that perhaps on an average, one-half more might be made, but the quality of the article was deteriorated regularly in the market £1 per ton. He was contradicted in the British Association when he said he could purchase it at 15s. less. That went the round of all the periodicals of the day, not only in England, but in America, but he should not have thought it worth while to call the attention of the public to it, if it had not borne very much on what had been advanced by Mr. Leah and Dr. Alexander. Experiments had been made on this subject, and he could inform the public that castings generally made from iron produced by hot air, were £2 or £3 per ton worse than those made by cold air, and in many instances they were too dear to have them given. This was a subject of considerable importance to the public, particularly to the manufacturing portion of it, and, therefore, he had thought it his duty to state to them the grounds on which they stood in this respect.

Mr. Embleton would take the liberty of inquiring whether there was any reliance to be placed on more recent experiments made on the relative strength of cold and hot blast iron?—for he understood that the hot blast iron had been ascertained, by the experiments to which he alluded, to be of greater strength than *even* the cold blast iron of Byerley.

Mr. Leah inquired, who were the parties making the experiment referred to?

Mr. Hartop replied that it was Mr. Fairbairn of Manchester.

Mr. Leah observed that experiments had been reported upon iron made at different works in the kingdom, and amongst the rest those of Low Moor and Byerley. The raw materials at both those places were exactly the same. The Low Moor Company were getting on one side the fence, and Byerley on the other, and yet the iron produced by the former was stated to be very considerably different from the latter, which was a strong proof that there was no dependence to be placed on these experiments. The locality proves this a real mistake; though it must be admitted that the gentlemen of the north, of all ranks and degrees, combine every exertion of talent and ingenuity to establish the repute of hot blast iron, so abundantly made in Scotland. Their success, however, must be doubtful so long as dreadful explosions of steam boilers, and extensive breakages of machinery, traceable to the use of that iron, continue so frequently to spread destruction and alarm.

The Chairman wished to ask what was the difference involved in the question—was it the capacity of the iron to sustain weight, or its capability to take such fine impressions from the mould ?

Mr. Hartop replied, its capability to sustain weight. It was strong iron only that could be used for forge purposes with effect. In the experiments made by Mr. Fairbairn of Manchester, the strength of the Byerley iron was placed very far indeed below that of Low Moor,—a circumstance which went the full length of showing that experiments in such matters, on a small scale, even when made with the careful attention Mr. Fairbairn had given to them, were liable to two objections. In the first place, there was great difficulty in obtaining *a fair and proper quality of each iron* to be experimented upon, in order to bring out a correct comparison between the various kinds of iron; and in the second place, the experiments in question were altogether at variance with the results of all practical experience on a large scale; for it was a well known fact, that if there was any difference whatever between the irons of Low Moor and Byerley as to strength, it was rather in favour of the latter. There were many other circumstances tending to show the inferiority of iron made by hot blast, particularly the price in the market, which was the grand criterion of the value of any commodity. But he could adduce other facts in support of his position, and they need only go to Leeds, and inquire what had happened at Pottery-field, with which his friend Mr. Embleton would be acquainted. An engine of large power was put up there a short time ago, made at Bolton, in Lancashire, of hot blast iron. That engine broke, as well as the greater part of the castings in those works, and must have cost the proprietor many hundred pounds, as well as great hindrance in business, the losses on which account did not admit of very easy calculation. He had been informed that since its reparation not one casting remained unbroken, cast of iron made by hot air blast. It was well known that this engine was made of Scotch iron, which was principally made by the hot air process. A bar iron work was attempted to be established in Glasgow, and after many thousand pounds had been expended, the attempt failed altogether, and was at this moment entirely stopped. He had been informed that so many breakages took place in so short a time, that the workmen could not work for the same wages as at other works, and ultimately the quarrel became so great between them and their master, that the undertaking was abandoned, and he believed was never likely to be renewed. This was an experiment on a very large scale; and he could mention many others, if it were necessary to do so. It was experiments on a large scale to which they were to look, and on a question of so much public importance as this, he thought it was impossible to bestow too much attention upon it. He had been occupied for some time past in drawing out a statement of the advantages and disadvantages of what had been so erroneously called an improvement in the manufacture of iron, and he hoped on some future occasion, when more time could be devoted to the subject, to lay that statement before the society.

The Chairman said that Mr. Leah's paper indicated a great deal of profound research and an intimate acquaintance with the principles of chemical science: hence he, (the Chairman) had certainly not felt it to be a dry subject, but a very interesting and useful one. Before he sat down, he would say a few words in reference to the mention which had been made as to the effect of electricity on the quality of iron. The quantity of electricity put in action on the change of a solid or fluid substance into a permanently gaseous state, was enormous. The quantity of the electric or galvanic fluid which went into a given quantity of vapour, to convert it into a separate aëriform element being immênse, it was not unreasonable to suppose that the nature or quality of iron might have connection with the electrical state of the atmosphere, at the time of its being obtained from the ore. The electric conditions, in the case referred to by Mr. Leah, underwent a two-fold change. There was the electricity of decomposition, and the electricity of recomposition. For the aqueous vapour which might be supposed to operate unfavourably on the quality of the iron, because of its electric relations, might not only be decomposed and so converted into its elements of oxygen and hydrogen, but again in part, as to one of its elements, be received into a new combination, or into another form; and therefore, they must first ascertain the quantity evolved in the one change of state, and then the quantity absorbed in the other change of state, before they could determine whether there was any actual electrical change or not—or what the final electrical result might be? The question was one of considerable importance, especially in a neighbourhood like this, and he hoped that the investigation of it would not be lost sight of by this society. The Rev. Gentleman then called upon William West, Esq. to read his paper.

Mr. West then read a paper

ON THE PROPORTION OF SULPHUR IN COAL;

In which, after observing that, though chemists are aware of its existence, in none of the published analyses of coal is its presence adverted to, he described a mode of ascertaining the proportion, and pointed out some of the precautions needful for correctness, and stated the results of his experiments upon coal and cokes of various descriptions from Yorkshire, Durham, and Northumberland.

These show that sulphur is present in coal very pure in appearance, in larger proportion than is usually supposed; that it is very imperfectly got rid of in coking, and that it must in some specimens exist in other states than, as generally supposed, as sulphuret of iron. It is Mr. West's intention to repeat and extend his experiments before publishing the particulars.

Mr. Leah begged to ask Mr. West whether, in his selection of coals, he was particular in taking the top, bottom, or the middle of the strata?

Mr. West replied that with respect to the greater part of the coal he had no opportunity of making such a selection, but probably Mr. Leah, from an inspection of the specimens, which lay on the table, would be able to form some judgment. His great object was that the coal should contain no visible fragment of pyrites, however small, and so far as he could ensure it, the coal brought to him to be operated upon, should be an average of the strata from which it was taken.

Mr. Leah observed it was pretty well ascertained that in beds of coal there were portions which contained considerably more or less of sulphur than others. The top bed, for instance, would contain more than the middle and bottom bed. As far as his experience went, there was a considerable difference in the quality of different portions of the bed, but perhaps Mr. Hartop or Mr. Briggs could give the meeting more information on the subject.

Mr. Hartop said he might not have understood Mr. West correctly, but if he had, he thought he was not correct in estimating the quantity of sulphur in the coke, to ascertain that in coal. There was one fact which he thought of considerable importance, namely, that the discussion of such questions at meetings like these brought into contact men of great practical experience and of scientific attainments, whose joint endeavours might not only prove of great benefit to science but to the interests of the public generally.

With respect to the question more immediately under discussion, he might say that he had frequently observed two distinct descriptions of coal, or rather a combination of sulphur with coal, which he had perhaps very erroneously considered a chemical and mechanical combination between sulphur and coal, and that observation would bear on what Mr. West had said, in having thrown out such pieces of coal as he found to contain sulphur visible on the exterior. He could speak practically to the point, that the coal which was used for making iron, in that part of Yorkshire in which he resided, exhibited a large quantity of sulphur on the exterior, but in coking the coal, nearly the whole of it was expelled, and the coke made a very excellent iron. They had other coals which exhibited no appearance of sulphur or iron pyrites, but in reality did contain a very large portion of sulphur, which he had supposed to be chemically combined. But the coal in question, which exhibited no sulphur, had so much in it that no treatment could make it suitable for the making of iron. This supposition might or might not be correct,—he merely took the liberty of suggesting it, in order that it might be of some use to the society on this exceedingly interesting subject.

Mr. West remarked that the proportion he found in coke was 196 in 10,000, which would be equivalent to 98 in the coal. In two or three cases of coking, where he had the best opportunity of judging of the coal, the proportion would probably be one half.

The Chairman inquired of Mr. West whether he had thought of any chemical process by which the sulphur might be got rid of to a greater extent?

Mr. West said he had reflected on the subject, but instead of trying any further experiments, he thought a change of coal would be desirable.

Mr. Hartop observed that in practice (it might be chemically wrong) a large quantity of water was poured on the coke in order to allow the escape of an additional quantity of sulphur.

The Chairman supposed that a chemical combination took place between the water and the coke, but what effect it would have on the expulsion of sulphur, it would perhaps be premature in the present stage of the inquiry, to determine.

Dr. Alexander begged to call the attention of the meeting to a valuable mineral spring discovered in this neighbourhood. The water was in the hands of Mr. West for the purpose of making an analysis, the result of which would shortly be made public. In his (Dr. Alexander's) opinion, the spring was a very valuable chalybeate, and as it might lead to important discoveries with reference to iron pyrites or sulphate of iron, he thought it might fairly be said to have reference to the subject of Mr. West's paper.

Mr. Embleton begged to move a vote of thanks to the Rev. Mr. Thorp, Mr. Leah, and Mr. West, for their valuable communications. In doing so, he could only regret that Mr. Thorp had not made his observations sooner, as they were of an extremely valuable kind, and in the evening he hoped they would be taken into more deliberate consideration. With respect to Mr. Leah, he must be exceedingly gratified to find that he had anticipated several discoveries years ago. Mr. West had introduced a subject which was not alluded to in any work. The sulphur spoken of by Mr. West existed in the coal itself, not in the form of sulphuret of iron, but as a component part of coal.

Mr. H. Briggs seconded the motion, which was put from the chair and adopted amidst acclamation.

J. G. Horsfall, Esq. moved a vote of thanks to the Rev. Chairman for his kindness in taking the chair, and the ability he had displayed in presiding.

Mr. Hartop seconded the motion, which was carried amidst much applause.

The Vicar returned thanks. He said he considered it a privilege to be allowed to join the society, and he esteemed it an honour to be placed in the chair. With reference to geology his position was a very humble one, but in the rival science of philosophy, perhaps he might have some claim to be a member. He had not professed to go into much detail in any thing he had said, for it required a great amount of study to keep pace with the progress which science had made within the last few years. He could only say that he sincerely thanked them for the honour they had done to him, and he would do all in his power to further the interests of the society.

The assemblage then dispersed, and the meeting was adjourned to six o'clock in the evening.

THE ORDINARY.

The ordinary, which had been previously announced, took place at the Talbot Inn, at four o'clock, when about 40 gentlemen sat down. JOHN GARNETT HORSFALL, Esq. presided, and the Vice-chair was occupied by Dr. OUTHWAITE.

THE EVENING MEETING.

In the evening a number of gentlemen, who had taken an interest in the proposed section, assembled to discuss it. A good deal of practical information bearing on the subject was elicited; but the meeting was unable to come to a decision on a subject that involved so many points of detail, and the matter was referred to the Committee on the section for further consideration and report.

ERRATUM, page 18, line 2, instead of—

"The line he should recommend was neither north nor south, but that which "would best develope the construction of the strata between the millstone grit of "Yorkshire and that of Lancashire;"

Read—

The line he should recommend was neither that proposed by Mr. Morton nor that suggested by Mr. Thorp, but one that would best develope the construction of the strata between the magnesian limestone of Yorkshire and the millstone grit of Lancashire.

NOTE to page 8, line 2. For the Diagram referred to, see Illustrations of the Geology of Yorkshire, by Professor Phillips, part 2, plate 24, No. 14.

EDWARD BAINES AND SONS, PRINTERS, LEEDS.

PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

OF THE

WEST-RIDING OF YORKSHIRE,

AT THE TENTH QUARTERLY MEETING, HELD AT SHEFFIELD, ON THE 4TH JUNE, 1840.

On the motion of Dr. Knight, seconded by T. A. Ward, Esq., W. Bennet Martin, Esq., of Worsborough Hall, Vice-president of the Society, being called to the chair, rose and spoke as follows:—Gentlemen,—Circumstances of a domestic nature (which it is unnecessary for me more particularly to explain) have occurred, which might have justified me in absenting myself on this occasion; but as the arrangements for the meeting had been made, and the advertisements issued, containing my name as the chairman, I determined that the circumstances to which I have adverted should not prevent my attendance. There is another reason against my taking the chair, and that is my incapacity to discharge the duties of the situation in an adequate manner. I shall, however, do my best, and throw myself upon the indulgence of the meeting. The commercial prosperity of the country, depending as it does on its mineral resources, and on the quantity of coal and iron which we can bring to the surface of the earth, for the support of the manufacturing districts, it becomes of the highest importance that we should use every exertion to increase our power to supply the manufacturing interests with those minerals.

Nothing is so likely to accomplish this end as the endeavour to throw as much light as possible upon the subject. We ought not only to endeavour to discover other fields of coal, in addition to those which are already known, but we should improve as much as possible the methods of working those which we already possess. A great protection has doubtless been extended to miners by the important and valuable invention of Sir Humphry Davy—the Safety Lamp. It gives me great pleasure to observe that, at a recent meeting of this society, the improvement of that most valuable invention was made the subject of discussion. I am sorry to say, that on my own property, and in my own immediate neighbourhood, we have been heavy sufferers from explosions by fire-damp. On no occasion, however, have accidents occurred when the Davy lamp has been properly used; but they have arisen either from the miners working without the lamp, or from their using it in an improper manner. I have no doubt that any improvement of this most valuable instrument would be hailed by mineral proprietors with the greatest satisfaction. There is another subject which I have had much at heart ever since I have resided in this neighbourhood, and I cannot help expressing a hope that the Coal and Iron Masters of the West-Riding will unite together to institute a society for the maintenance of those who suffer by the terrible accidents to which I have alluded. I have already suggested to Earl Fitzwilliam the propriety, or rather the necessity, of establishing an accident fund. A society might be formed on the principle of the benefit society established by Mr. Nicholls, (who has been made one of the Poor Law Commissioners,) which has been of such important advantage in the midland parts of England. I hope that something will be done to set the matter in motion.

On the motion of Mr. Wilson, seconded by Mr. George Chambers, the following Noblemen and Gentlemen were elected members of the Society :—The Duke of Norfolk, the Lord Hawke, Messrs. William Cooper, James Ray, William Marsden, David Nesbitt, (Chapeltown,) Thomas Rayner Bourne, (Chesterfield,) William Hanson, (Derby,) Francis Parker, (Iccles,) and John Scholey, (Wakefield.)

The following resolutions were also passed :—

Moved by Mr. HARTOP,
Seconded by Mr. W. F. FAIRBANK,

That the Annual Meeting be held at Wakefield, on such day as the Council may appoint.

Moved by Mr. LUCAS,
Seconded by Mr. MORTON,

That Mr. Biram be requested to audit the accounts of the Treasurer, and that they be presented at the Annual Meeting.

Moved by Mr. LEAH,
Seconded by Mr. M. CHAMBERS,

That Messrs. Embleton, Morton, Briggs, Holt, Hartop, and Wilson, be a Committee to draw up Rules for the government of the Society, which shall be considered at the Annual Meeting.

Moved by Mr. HOLT,
Seconded by Mr. BRIGGS,

That Rev. W. Thorp, Mr. Hartop, and Mr. Lucas, be a deputation from this Society to attend the Meeting of the British Association for the Advancement of Science, at Glasgow.

Moved by Mr. HARTOP,
Seconded by Mr. BOULTBEE,

That the thanks of the Society be given to the Master Cutler for the use of the Hall.

Moved by Mr. MORTON,
Seconded by Rev. W. THORP,

That the thanks of the Society be given to the Literary and Philosophical Society of Sheffield, and their sub-committee, for their kind assistance in making the arrangements for the meeting.

The following communications were then made to the Society :—

ON THE DISTURBANCES IN THE DISTRICT OF THE VALLEY OF THE DON.

BY REV. WM. THORP, OF WOMERSLEY.

Upon the last visit of the Society to Sheffield, I had the pleasure of describing some of the geological features of the neighbouring district, and particularly those of the country between Rotherham and Sheffield. I have again taken the liberty of giving a brief mining notice of the disturbances of the same district, because they are not only of such enormous magnitude as to be of great interest to the geologist, but a knowledge of them is necessary to the successful mining operations of that neighbourhood.

Upon the former occasion, it was contended by one party that not only were the strata on the North side of the Don elevated above those of the South side, to the amount of 600 yards in vertical height; but that also there had been a horizontal lateral movement of the beds of the North side, in an eastward direction, to the length of five or six miles.*

* The proofs then adduced in support of a *lateral* movement were—1. That the various beds come from the North, up to the edge of the valley of the Don, but do not preserve their Northerly and Southerly direction across the valley, but are found several miles to the West ; *e. g.*, the Silkstone coal ranges to Dropping Well, near Kimberworth, and is not found at the same depth until we arrive six miles West, at Sheffield town. 2. A sudden variation in the direction of the water levels, from North and South to East and West, down the valley of the Don. 3. A fault, of exactly fifty yards, in the ironstone at Tankersley Park, running North and South; and another fault in the same ironstone, in Tinsley Park, (ten miles distant,) running in the same direction, and being of the same amount, were supposed to be one and the same fault, before the lateral traction

I hope, however, now to be able to prove—1. That there is no *vertical* elevation of the beds of the *whole* country, on the North side of the valley of the Don, or, that the previously described elevation is merely local ;—2. That the supposed *lateral* movement is due, in reality, to a depression or synclinal axis of the beds on the South side.

It is, indeed, true that there is a vertical elevation, in the beds of the North side, over those of the South, if you commence at Iccles Hall, and trace any of the deeper beds as far only as Keppel's Column ; but, in this case, part only of the disturbed country is described. These disturbances extend over a much greater tract of country than is generally supposed : for instance, in the Thick coal they commence on the borders of Derbyshire, and extend as far as Elsecar ; so that the whole country from Orgrave, near Beighton, and perhaps beyond it, to Elsecar, North of Wentworth House, is disturbed by variable and sudden inclinations of strata to the horizon, by one synclinal, and probably two anticlinal axes, and is more or less broken by faults of considerable magnitude ;—similarly, the disturbances commence in the Sheffield coal, North of Birley Moor, and terminate only at Chapel Town ; and in the Gannister, at Dore, three or four miles on the South side of Dronfield, and terminate only at Deep Car; but beyond the two points where each of these beds first becomes regular, or assumes its usual inclination to the West, there is indeed no material elevation of one side of the country above the other.

In order to prove this, it is only necessary to ascertain the difference in elevation above the sea, or between each

took place. The proofs in support of a *vertical* movement were, the abrupt rise of all the beds to the North, between Rotherham and Sheffield; accompanied with several faults, which elevate the beds to the North, both of which are seen in Mr. Chambers' Works, at the Holmes, and on the line of the Sheffield and Rotherham Railway. These are further explained in the sequel.

other, of any of the same beds, at the two points where the disturbances cease, on a North and South magnetic line. I shall, therefore, take one of the uppermost beds in the series, and one of the lowest—*i. e.*, the Thick coal at Orgrave, on the edge of Derbyshire, and the same bed at Elsecar; and the Gannister, or Pecten coal, at Dore Moor, in Derbyshire, and the same at Deep Car. Now the fall of level on the surface, from Elsecar to Swinton, is 67 feet, or $22\frac{1}{3}$ yards, and the fall from Orgreave, on the North Midland Railway, to Kilnhurst, is not more than forty yards, and probably less; so the difference in point of level can only amount to eighteen yards. Again, the Gannister or Pecten coal, at Dore Moor, from barometrical observations made by me, in 1838, is 48 yards above the river Sheaf, at Hunter's Lane Bar; and Deep Car, through which passes the Manchester and Sheffield Railway, with a gradient of five yards to the mile, being eight miles distant, will give forty yards of elevation above Sheffield; so that the difference of elevation between the same coal at Dore Moor and at Deep Car, will only amount to a few yards. Thus, there is no material difference, in level, of the Thick coal, which, in the scale of strata, is a higher bed; and, similarly, in the lowest worked bed, the Gannister. There is, therefore, no material elevation in the country on the North, above the same beds on the South side of the valley of the Don; the intervening disturbances, therefore, are merely local, and have no general effect upon the stratification of the whole country.

I now proceed to shew that the supposed lateral movement is due to a depression of the beds on the South side of the Don. The water levels* on each side of the disturbed dis-

* A water level is a line at right angles to the steepest inclination of the coal, and is correctly represented by the spouts which carry water in any street; if the roofs of the houses rise due West, the direction of the street will be North and South, and the line of spouting, or water level, will be the same. A change of direction, therefore, in the water level, merely indicates an azimuthal change of the inclination of the coal-bed.

trict run due North and South, by the compass; but, in the distracted country, the beds rise more to the South, and the levels change to 23° and 28° to the West of North; now, by this southerly rise, there is communicated to the disturbed beds a dip of one yard in 20 or 25, in the due North and South direction*; so that, from Beighton to the turn or axis where the beds rise North, by the change of level alone, any single bed will be 150 yards deeper (supposing the surface level.) This southerly rise is proved by the extensive water levels in the Sheffield coal, which, at Birley Moor, the most southerly point of the Sheffield Coal Company's workings, run due North and South, magnetic; but, upon coming further North, the levels change to 23° West of North; they are two miles in length, and, upon the colliery map, are semicircular. Again, the due North and South line from Orgreave runs over Brinsworth to Jordan Dam; Brinsworth is equi-distant from the two places, and stands upon the red rock of Rotherham. Now it is most certain that the Thick coal at this place has suffered an enormous depression, and that Brinsworth stands over the bottom of a synclinal trough; for the Thick coal is here 350 yards deep†, while at Orgrave pit it is 120 yards, the surface at Brinsworth being 18 yards higher. From Orgreave to Brinsworth, then, the Thick coal is depressed, either by dislocations or the variation of level, or by both, to the amount of 200 yards at least. From Jordan Dam, a place near the Sheffield and Rotherham Railway, the same bed is depressed in an oppo-

* These beds rise 1 yard in 7. At an angle of 15°, or half between the level and steepest inclination, 1 in 14; at an angle of 30°, 1 in 21, which last is nearly the direction of the Tinsley Park and High Hazles Levels. In fact, the rapid rise of strata, of 1 in 7, would of itself lead to the supposition that the whole beds were irregular.

† The four foot coal is 140 yards under the red rock of Rotherham, which is here 30 to 40 yards thick. The High Hazles Coal is 80 yards under the four-foot coal; and the thick coal 91 yards under the latter.

site direction, south towards Brinsworth, but to a greater amount, for the Thick coal appears on the railway rising at a very acute angle to the North. The exact amount of depression will be 350 yards, minus the difference of surface level between Brinsworth and Jordan Dam. A very fine natural section is next exhibited in the cutting of the North Midland Railway, under Treeton; the beds are rising rapidly to the South, from the red rock, opposite Catcliffe, to the High Hazles coal, at Swallow Nest; and in the last southward cutting, through the Red rock, there is a fault which, if the coal in the cutting is the four-foot bed, will not be less than 140 yards, producing an elevation to the South, or depression of red rock, which, from this point, ranges up to Brinsworth. Again, the same effects are exhibited, in the lower beds in the Gannister, East of Dore and Totley, which is rising rapidly to the South. At Ringinglaw Bar, the Hallam coal is seen similarly disposed; so that, a little to the North of the present pits, it is covered by the third gritstone, from which slates are there dug. The same depression is proved by a consideration of the position of the High Hazles coal; its basset is seen opposite Beighton, at the bottom of the hill ascending to Swallow Nest, a place 1½ mile South of Treeton; the place of basset being a quarter of a mile on the East side of the North Midland Railway; but the same bed is 260 yards deep, at Brinsworth, and is worked at some depth near High Hazles, a long way to the west of Swallow Nest. In like manner, the North Midland Railway, about half a mile South of Beighton, crosses over the basset edge of the Thick coal, and then rests upon inferior strata. The depression, therefore, of beds from the south, or the southern axis of the synclinal, is proved, 1st, by a section in the Sheffield coal; 2ndly, by one in the Thick coal; 3rdly, by that of the North Midland Railway, under Treeton; 4thly, by that of the Gannister or Pecten coal; 5thly, by that of the Hallam coal, at Ringinglow Bar ; 6thly, by a consideration of the position of the High Hazles coal, at Swallow Nest ; and 7thly, by the Thick coal South of Beighton, and the situation of this coal with regard to the railway, and the general workings of this bed.

The northern axis of the synclinal, or depression from the North, is well known ; it may be traced accurately in the workings of the Park Gate coal. Commencing at Keppel's column, this bed dips to the South, at an angle of 17° for 400 yards, to a throw of 125 yards ; it then dips at an angle of 28°, and afterwards at an angle of 32°, across the railway, down to the axis. But Keppel's column is also the centre of an anticlinal axis ; for this coal dips rapidly *to the North*, from this point, down to the Old Park Gate Pit, on Thorp Common, and is there 44 yards deep ; the bearing of this pit from the column is 24° West of North (magnetic.) Again, the Northern axis is well exhibited in the flagstone which appears at Shirecliffe Hall, above Pitsmoor ; but from hence the flagstone dips North to Wadsley Bridge, and here forms a shallow synclinal ; from which places it rises to Grenoside and Wharncliffe Lodge, and finally dips away rapidly to the level of the river Don, at Deep Car, forming one synclinal and two anticlinals. The Gannister from Crookes Moor dips to Hunter's Lane Bar, where it becomes 130 yards deep, under the flagstone ; but Crookes Moor is the centre of another anticlinal, for the Gannister is next seen at a much lower level, at Malin Bridge, and thence ranging up to Stannington ; from Malin Bridge, it rises rapidly North, through Wadsley, to Owen's Moor ; and then dips North to Deep Car, forming, in its course from Crookes, one synclinal and two anticlinal axes. The levels in the Thick coal indicate, in addition to the northerly rise, several variations in the inclination ; beginning, on the North, at Stubbing, to Upper Hough, they run 4° West of North ; South of Upper Hough, they run North 10° West, then change to 40° East of North; and the South level from the pit is 50° North of West; but from the termination of the Northern rise, at Stubbing, the lower red rock dips rapidly North, by the old whin-cover, towards West Melton. So that Stubbing forms the centre of another anticlinal, similar to that of Keppel's Column, Shirecliffe Hall, Wharncliffe Lodge, Crookes Moor, and Owen's Moor; the effects of which are to reduce all the various beds elevated by the Northern axis* of the synclinal of the Don, to their original level.

But this depression, or great synclinal trough, over Brinsworth, Tinsley Park, up to Bent's or Bench Green, produces a false appearance of a *lateral* movement; and first, from Derbyshire, in the Thick coal. On the North Midland Railway, about half a mile South-East of Beighton, the Thick coal is basseted out on the surface; but its western basset is prolonged as far as Handsworth, by Darnall, to Attercliffe, where it is 44 yards deep; and if the inclination of the strata over this tract had been less than 1 in 7, its basset would have extended West of Sheffield; and that this coal has not been kept below the surface by the rise of ground from Beighton, is plain, for there is no difference of level between Beighton and Attercliffe, as proved by the two railways; while the coal is on the surface, at the place before mentioned, near Beighton, while it is 44 yards deep three miles to the West, at Attercliffe. This prolongation of the coal to the West affords an appearance as if the coal had been drawn laterally backwards three miles from Attercliffe, down to the East of Beighton. 2ndly, half a mile West of Mosbro', in Derbyshire, is the outcrop of the Sheffield coal;

* The highest elevation of the beds, by this axis, as at Keppel's Column, Crookes Moor, Shirecliffe Hall, &c., is from 200 to 280 yards above the same beds, as elevated by the Southern axis of the synclinal, as at Orgrave, Dore Moor, &c. It would be of great use to the Society to ascertain how far these disturbances extend to the West. They seem to terminate to the East, near Rotherham, and are connected with some great faults which run North and South.

but this outcrop is continued by Gleadless, North of Heeley, to St. John's Church, in Sheffield; and the extension of this coal so much to the West produces a ficticious appearance, as if it had suffered lateral traction, to the amount of four miles, to Mosbro', near Eckington. The same appearances are exhibited in the Gannister or Pecten coal, from Beauchief Abbey to Bench Green.

In like manner, on the North side of the Don, the Thick coal is worked at Rawmarsh, and much at the same depth at Attercliffe, and appears here to have been drawn back four miles. Again, the Sheffield coal at Dropping-Well near Kimberworth, is worked much at the same depth as in Sheffield Park, and exhibits an appearance as if it had suffered lateral traction to the amount of six miles. But both the appearance of a lateral movement of the beds on the Derbyshire side, just mentioned, and also that on the North side of the Don, is merely owing to the depression or synclinal axis above described; and, as an effect of this depression, an extension of the disturbed beds to the West, beyond their general range, phenomena which are exhibited in every East and West fault, where the downcast beds are always prolonged in their outcrops to the West. There is, however, this to be observed, that the beds of the Northern axis of the synclinal of the Don are elevated more abruptly, and to a higher level, than those on the opposite side, (as observed in the note,) and, as a consequence, have suffered denudation to a greater amount; and their basset edges are driven back further than those on the Derbyshire side of the axis. There is, therefore, no *lateral* movement of beds on either side of the Don; neither is the country on the North side vertically elevated 600 yards above that on the South side, maintaining that elevation, as was stated at a previous meeting. In fine, the whole phenomena are well described by a writer in the Magazine of Natural History, and quoted in the Arcana of Sciences for 1838:—" Along the Westerly edge of the " coal measures, there are well-known irregularities, occa- " sioned 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 " ridge 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 Chapel Town; and the second rise, South of " Sheffield, and in Derbyshire, causes a vacant space in the " productive coal measures between the high part of Shef- " field Park and Coal Aston; and in the hollow between " these two ridges, the coal is thrown forward under Shef- " field. But there is a greater Westward receding (projec- " tion) in the Dronfield trough, one side of which, rising to " the North, causes a long East and West range through " Coal Aston."

Mr. Hartop said, Mr. Thorp had observed that he stated on a former occasion that the strata North of the Dun were elevated. What he contended was, that either those on the North had been elevated, or those on the South had been depressed; but he never gave a positive opinion, further than as to the fact that there was a difference in the level of the strata on the two sides of the valley, of nearly 700 yards. Geologists found much difficulty from the want of a sufficiently correct map, shewing the bearing of the minerals; and probably considerable discrepancies would be found between the map he produced and that of Mr. Thorp. He should confine himself to the facts he had ascertained from his own observations; and he thought, if the information of the different members could be collected on a map on a large scale, it would greatly increase the usefulness of the Society. He then proceeded to make some remarks on the Thick coal, which was worked at Beighton, at Handsworth, at Attercliffe Common, at Masbro', and at Earl Fitzwilliam's colliery at Rawmarsh ; pointing out the changes in the depth of the coal at these places, and in the direction of the water levels; that while the general direction of the water levels, both to the North and South of the valley of the Don, was from N.W. to S.E., yet, in the valley, for five miles, the direction of the water levels was at right angles to their general course, viz., from N.E. to S.W.

Mr. Hartop illustrated his remarks by a map of his own, constructed some years ago, for the purpose of laying down the water levels of the different collieries, and he thought it would be very useful if this were made a leading feature in geological maps, in mineral districts.

Mr. Morton said, the Society had several times been favoured with explanations of the geology of the Don valley. Indeed, it had become a sort of standing subject, but unfortunately there were not two explanations alike. The arguments advanced to-day by Mr. Thorp to prove the existence of a synclinal axis were certainly novel, and, he thought, philosophical, and in accordance with facts. Mr. Morton's own observations of the geological structure of the country between Leeds and Chesterfield, led him to coincide with Mr. Thorp's views. From Billingley to Leeds, the strata rise to the North and North-West, but from Rotherham to Chesterfield they rise to the Southward ; and the inference is, that the measures between Billingley and Rotherham lie in the bottom of a deep hollow or depression, which, in fact, is Mr. Thorp's synclinal axis. Mr. Hartop, on former occasions, had endeavoured to shew that a lateral movement of the strata had taken place towards the East ; but the evidence was not sufficiently strong to satisfy him (Mr. Morton) that such was the case. From the commencement of the Society's discussions on this subject, Mr. Morton had always considered that the geological phenomena of the Don valley could be explained by the supposed intervention of a large fault, which had considerably uplifted the measures on the North side of the river; and if this elevation were proved, all the other appearances could be shewn to have resulted from violent denuding causes, that had operated over a considerable surface of country Northward. But Mr. Thorp had adduced facts to-day which disproved the upraising of the strata on the North side *only*, and demonstrated that an elevation existed on *both* sides; for he stated that the difference of level between the Thick coal at Orgreaves, near Handsworth, and the same coal at Elsecar, was only 18 yards, although its depression under Attercliffe common was considerable. Supposing Mr. Thorp's barometrical measurements and other data to be correct, the conclusion to be drawn was, either that the strata in the valley of the Don had sunk down, or that the strata on the North and South sides of it had risen up several hundred feet, forming a synclinal axis in the vicinity of the river; and Mr. Morton considered this theory more rational, and more in accordance with facts, than any other theory that had hitherto been advanced. The appearances most difficult to explain are local; they are seen in the immediate vicinity of the river between Sheffield and Rotherham; and they are such as to render an intelligible description on paper almost impossible. Plans and sections give but a very unsatisfactory explanation of the great and sudden turn in the direction of the basset edges of the Coal measures in this district, and it is only by a model of the country, like Mr. Sopwith's model of the Forest of Dean, that its very curious and interesting geological features can be fully exhibited.

Mr. Hartop thought the slight difference in the level of the strata at those points proved nothing at all. He should not have been surprised had the difference been much less, when the length and the fall of the streams from each point were taken into account, both of which meet in the river Don at Conisbro'. As to there being a basin or trough, he thought there was no intimation of anything of the kind; for by reference to the map, it would at once be seen that the Thick coal, which it was now contended was on the same level at Handsworth and at Elsecar, would, if it had continued in its usual course from Handsworth, have been 700 yards deeper when on the line of "rise" opposite Elsecar; or if traced from Elsecar, would have been found so much higher than it is to the "deep" of Handsworth.

Mr. Thorp, in reply, then said, that he should not have brought this subject again before the Society, had he not thought that our reputation as geologists would be affected by the imperfect state in which we left our inquiries, at the former meeting at Sheffield, upon the disturbances of the Don. Upon that occasion, it was maintained that the whole country on the North side of the Don, from Sheffield to Rotherham, had not only been horizontally drawn back five miles, but also elevated vertically 700 yards. He thought that he had now proved that neither the one movement nor the other had taken place. Mr. Hartop (with whom before was Professor Johnston) seems now to abandon as untenable the *lateral* movement, for he has said nothing upon the subject, except that the water levels change their course at right angles down the line of the Don. But a change in the direction of a water level merely indicates a change in the "rise," or azimuthal inclination of the coal bed, a common occurrence in every coal field, and it is not the least evidence of any lateral movement. Besides, if there is a lateral movement at all, there are two lateral movements, one on each side of the river Don, drawing the Thick coal from Attercliffe, on the South side, back to Beighton; and on the North side, the same coal to Rawmarsh; but to suppose any such movements is perfectly absurd. Mr. Hartop, however, yet contends for the vertical elevation of one side of the Don over the other to the amount of 700 yards. And no doubt this is correct locally, or if a short North and South section be taken, (for instance, from Iccles Hall, or any place contiguous to the river, and prolonged as far only as Keppel's column,) but then part only of the disturbed district is passed over; and because he had studied, and yet recommends to be studied, only the small tract of country adjoining the river, and not rather to consider the general effect which these enormous disturbances have upon the disposition of the strata of the whole country, it hence arose that we all left the former discussion of the subject, under the erroneous impression that the whole country was elevated to the above amount, and maintained that elevation Northwards through Yorkshire, which has been proved perfectly incorrect in the paper, by an inquiry into the difference of elevation above the sea of the same coal at Elsecar, near Wentworth House, and at Orgreave, on the borders of Derbyshire. Mr. Hartop, however, yet thinks that "the slight difference in level proved nothing at all;" but it proved everything which he (Mr. Thorp) required, viz., that the vertical elevation of 700 yards is only local, and that there is no vertical elevation of the beds of the whole country on the North side of the Don above those of the South. But Mr. Hartop still says, that "as to there being a basin or trough, he thought that there was no intimation of anything of the kind." Now, that there is a South side of the basin, or rise of beds to the South, has been proved in my paper by—1st, a section in the Sheffield coal; 2nd, by one in the Thick coal; 3rd, by that of the North Midland Railway; 4th, by that of the Gannister and Pecten coal; 5th, by that of the Hallam coal; 6th, by a consideration of the position of the High Hazles coal, at Swallow Nest and at High Hazles; 7th, by that also of the Thick coal at Beighton and at Attercliffe, and its position with regard to the two railways. And that there is a North side of the basin, or rise of beds to the North, has been proved—1st, by a sight of the beds anywhere on the Sheffield and Rotherham Railway; 2nd, by a section in the Park Gate coal; 3rd, by one of the flagstone; 4th, by that of the Gannister and Pecten coal; 5th, by one of the Thick coal. If any single one of these sections be correct, it would be sufficient to prove that there exists a trough or basin; but I have produced seven sections shewing a rise to the South in seven different localities, and five shewing a rise to the North; and yet Mr. Hartop, without attempting to disprove the correctness of any one section, contents himself by asserting that he thinks there is no intimation of anything of the kind! Mr. Hartop is also in error when speaking of the Thick coal as at Handsworth and Elsecar. The North and South magnetic line from Elsecar reaches Orgreave by Lord Fitzwilliam's large map, and the coal at these two points is nearly at the same elevation above the sea, or any other fixed point; but the water levels of Handsworth, as now worked, range N. 25 W., and point to the Flagstone at Grenoside, as proved by Mr. W. Jeffcock and himself (Mr. T.,) and if prolonged, would ultimately go in that direction West of all coal beds in Yorkshire. And to suppose the Thick coal continued in its usual course from Handsworth, where it is irregular and disturbed, laying near the bottom of the trough, is as absurd as to suppose it continued from Keppel's column to Elsecar, where it once stood at the former place 300 yards above the present Park Gate coal, and should therefore be 300 yards higher at Elsecar than as at present existing. In fine, the whole phenomena of this system of disturbances had been so ably described by Mr. Morton, who is perfectly acquainted with the country (with one slight exception, which he should mention, viz., that there is no general rise entirely to Leeds, as proved by the Silkstone and Barnsley levels; and that Billingley is not in the bottom of the trough, for the coal there rises S. end 5½ inches per yard,) that he should say no more upon the subject.

THE REPORT OF THE COMMITTEE APPOINTED TO RECOMMEND A LINE OF SECTION ACROSS THE YORKSHIRE COAL FIELD.

BY MESSRS. MORTON AND HOLT.

The Committee appointed to make arrangements for the execution of a longitudinal Section of the Yorkshire coal strata, beg to present the following Report of their proceedings :—

It will be recollected that the original proposal for a section of this magnitude emanated from the Council of the Manchester Geological Society, who were anxious to compare the stratification of their own coal field with that of Yorkshire, by means of a continuous section across both.

This important suggestion was referred to the consideration of your Committee, and at the Society's meeting, held in December last, at Leeds, a line of section was defined which commenced at the Sheffield and Manchester Railway tunnel, near Penistone, and traversed the coal field in a North-Easterly direction towards Goole ; and in order that a strict comparison of the Yorkshire and Lancashire strata might be instituted, it was thought that the section to be undertaken by the Manchester Society should commence at the same point, and proceed Westward.

It afterwards appeared, however, that a line of section down the valley of the Etherow would not fully develope the Lancashire coal field ; and at the same time, it was considered that a North-Easterly line from Penistone would not exhibit the Yorkshire strata so completely as a line of section taken in another locality. It became a matter of considerable doubt, therefore, whether any continuous line of section could be adopted, proceeding Eastward and Westward from the Penine chain, which should at once be the means of comparing the geological structure of *both* coal fields, and of thoroughly developing the stratification of *each*.

The attention of the Committee and of the Society was next directed to a line of section pointed out by Mr. Thorp, in a communication read by him at the Society's last meeting, held in Bradford. This line commenced in the Peak of Derbyshire, and crossed the Yorkshire coal field southward of Sheffield and Rotherham; and although it seems to furnish much geological information, yet the Committee consider it too far removed from the sphere of the Society's operations to be adopted with advantage. Nevertheless, they feel assured that a work of so much interest will not remain unnoticed, but will, ere long, occupy the attention of geologists resident in the neighbourhood of Sheffield and Chesterfield.

Another route has subsequently been suggested by Mr. Holt, commencing near Halifax, and proceeding in a South-Eastern direction towards Doncaster, which, while it developes our own Coal measures to the fullest extent, does not altogether lose sight of the original object; for it is supposed that, if this line were continued Westward to the Penine chain, it would intersect certain strata on the *Eastern* side of that ridge, which are already proved to be identical with certain other strata on the *Western* side, and thus the Yorkshire section and the Lancashire section might be said to have a common point of departure, *geologically* speaking, though not *geographically*.

Under these impressions, the Committee have determined to recommend to the Society the adoption of the last-mentioned line; and they further consider it advisable to confine the attention of the Society exclusively to that part of the section which traverses the Coal measures, without regard to the Magnesian Limestone and Red Marl deposits, that lie farther to the East; in the hope that, by a concentration of the Society's energies to one portion only, we shall more speedily and more accurately carry out the fundamental object of the Society, namely, the thorough examination and elucidation of the Yorkshire Coal field.*

* As this line has been long premeditated by Mr. Holt, and as he has, in the

"The line of section proposed by me commences in Northowram, on the flagstone, wherein lie the Halifax hard and soft beds of Coal. It then crosses a district of table land, composed of flagstone, to the most western escarpment of the Wortley Rock, in which are deposited a bed of first-rate Furnace Coal, the 'Low Moor Better Bed,' and a Coal accompanied by an excellent black ironstone, the 'Low Moor Black Bed.' Passing South of Norwood Green, where coals are worked by Sir George Armytage's lessee and others, the line reaches Bailiff Bridge, where a great dislocation down to the West occurs, running parallel with the valley that extends from Brighouse to Low Moor. The bold cliff of Clifton is next mounted, and the line proceeds by Woolrow, and crosses the Leeds and Elland turnpike-road, about half-way between the village of Clifton and the Pack Horse.—The 'Low Moor Black Bed,' and 'Better Bed' underlie this township, and an accurate knowledge of them may be obtained from the colliery workings of Mr. Walker, and from borings which have recently been made, near the line of section. The levels in this part range a few degrees East of North.—Entering the township of Hartshead, the line traverses three-quarters of a mile of unexplored ground, in which the marked lines of springs, and other circumstances, indicate considerable dislocations, at right angles with each other.—The site of Hartshead Colliery is next crossed. Here the 'Blocking Coal' is worked, and a large dislocation runs almost due North and South. The levels first range nearly East, and afterwards nearly North. A short distance further, the escarpment of the 'Lime Coal' is met with; and next, the escarpment of the 'Cromwell Bed,' which I believe is identical with the 'Park Gate Coal.'—Proceeding to the division of the townships of

course of his professional engagements, collected a variety of information respecting it, he has, at the request of the Committee, prepared the following outline of it, which he illustrated by a plan and section.

Hartshead and Mirfield, and near the old Huddersfield and Leeds road, a considerable "throw" up to the South is found. The extent of this elevation is supposed to be not less than 100 yards, which opinion is corrroborated by the levels.—The line of Section then intersects another outcrop of the 'Blocking Coal,' which may be traced through the village of Mirfield, to the South side of the river Calder, where it has been worked by the Wheatleys and the Walkers.—In the township of Thornhill, the ground rises Southward from the river, and sufficient cover is obtained for the 'Lime Coal,' or 'Wheatley's three-quarters Coal,' and the 'Cromwell bed,' which have been worked for many years by Messrs. Wheatley. I have taken many lines of water levels here, but I have not been able to ascertain the average dip of the strata, owing to their distracted state.—From this high ground, the line of Section descends the dell in Mr. Ingham's estate, where the 'Cromwell bed' is worked; and, further on, it crosses the outcrop of the 'Flockton Coal;' then climbs the bold escarpment of 'Bradgate rock,' on which stands the village of Thornhill, and proceeds along a plain, about a quarter of a mile in length, to another escarpment, on the brink of which are Mr. Ingham's collieries, working the 'Flockton Thin Coal.'—A deeply denuded valley separates this cliff from the rising ground of Emroyd, under which Messrs. Briggs and Stansfeld are working a seam of coal that lies about 81 yards below the 'Flockton Thin Coal. The levels in Emroyd Colliery generally range nearly East and West.—Having attained the summit of the Emroyd ridge, at a point about half-way between Overton and Middlestown, the line of Section descends into the Coxley valley; passes through the steep wood on the opposite side, and goes over another hill, between Midgley and Netherton, into the Bullcliffe Wood valley.—It then traverses an elevated ground, in the township of Bretton, crossing the Denby Dale road, at Sun Wood, and proceeds towards Woolley. The district between Middlestown and Bretton is almost unexplored; the geological information respecting it is very scanty; and the outcrops of the coals, if any occur, are distant from the present line of Section.—Near the division of the townships of Bretton and Woolley, is a bed of Coal, worked by Mr. Twedale. The Coal is near the surface, and I think it is probably a part of the 'Barnsley Thick Bed.' The latter, however, has not yet been found, in its full thickness, farther North than Darton. Passing along the extensive and bold escarpment of Woolley Edge, the line of Section goes near the outcrops of the 'Beamshaw,' 'Winter,' and 'Woodmoor' coals, which have been worked in this locality by Messrs. Charlesworth, for a distance of three-quarters of a mile on the line of Section.—From the elevated summit of Woolley Edge, the line proceeds through the village of Woolley, along a gentle slope of unexplored ground; but there is little doubt that the strata here dip nearly conformably with the fall of the ground.—The Sheffield and Wakefield turnpike-road is crossed near Ridings Quarry, (which, I think, is a western outlier of the 'Chevet Rock formation.')—Notton Park is next passed through; and at the intersection of the line with the Staincross and Roystone road, two beds of Coal, supposed to be the 'Thick coal' of the 'Chevet Rock,' and the 'Woodmoor' bed, have been bored to.—Parts of the townships of Roystone and Carlton are then traversed, where there is no positive information concerning the coals; though I have little doubt that the 'Thick Coal' just mentioned, and the 'Woodmoor Coal,' are here, and at no great depth.—After crossing the Barnsley canal, the line of Section is carried through the township of Shafton; and here I am unable to lay before the Society further plans, except those derived from published maps, on a small scale; for I am informed that there is no township plan of Shafton. I recommended that the line should proceed in the same direction through the townships of Cudworth, Darfield, Billingley, and Bolton-upon-Dearne, to the Magnesian limestone ridge; but Mr. Thorp is of opinion that a better development of the strata may be had by curving the line, in Woolley, to the North-East, and passing through Notton, Roystone, Shafton, Brierley, Great Houghton, and Clayton-in-the-Clay, to the Magnesian limestone. There is, however, little geological interest between Notton and the limestone ridge, (so far as regards coal beds,) there being only two workable seams.

"In conclusion, I may observe, that I recommend this line to the attention of the Society, because I think it crosses over more bold hills, descends deeper vallies, and consequently intersects the outcrops of more Coal beds and strata than any other line I could suggest, in the middle part of the coal-field. It also crosses the country at those places where the minerals are known to be of the best quality, and where they are most worked, particularly in the valley of the Calder."

The Committee recommend that the section should embrace the various details mentioned in the Committee's Report, at Leeds; namely, that the surface of the country should be carefully levelled and laid down; that towns, villages, roads, rivers, canals, collieries, boreholes, and township boundaries, should be noticed; that vertical sections of pits and boreholes should be delineated; that the intersection of the "basset" or "outcrop" of coal, ironstone, and other strata, should be marked down; that the crossing of "faults," or "throws," should be registered, and the extent of the dislocation stated; and that the continuous position and dip of the different beds should be drawn as far as they can be correctly ascertained.

The Committee are further of opinion that, in order to make the proposed section as practically and generally useful as possible, it should be accompanied by a map or plan of the fields, &c., as before mentioned, for a distance of five or ten chains on each side of the line; which map should be made either from actual survey or from accurate township plans.

The Committee having maturely considered the scales at which the proposed section should be drawn, recommend—For the

Scale of lengths,...264 feet (or 4 chains) to 1 inch.

Scale of depths, ... 40 feet to 1 inch.

To facilitate the comparison of sinkings or borings, it is indispensable that shaft sections, and local vertical sections, should be drawn on an *uniform* scale. The Committee, therefore, hope that those members who may think proper to forward such sections to the Society's Museum, will on all occasions prepare them *on a scale of* 8 *feet to* 1 *inch*.

In a work so extensive as the intended section across the Yorkshire Coal Field, (comprising, as it does, about 25 miles of country, and from 3,000 to 4,000 feet of strata,) it is obvious that the combined talent and exertion of all the geologists in the Society will be required to accomplish it; and, although the Committee have not yet been favoured with many names of members willing and able to engage in the undertaking; yet they have the satisfaction to announce that the following gentlemen have volunteered their services to assist in the execution of various portions of the line:—In the townships of Northowram and Hipperholm, Mr. Martin has offered his aid; in Clifton and Hartshead, Mr. Holt; in Mirfield, Mr. Bull; in Thornhill and Shitlington, Mr. Briggs; in Bretton, Crigglestone, and Woolley, Mr. Morton and Mr. Embleton; in Notton, Roystone, and Shafton, Mr. Hall; in Brierley and Great Houghton, Mr. Hartop; and in Clayton and South Elmsall, (where the line enters the magnesian limestone,) Mr. Thorp.

The Committee, in conclusion, earnestly call the special attention of the Society to this object, and invite all those gentlemen who may be desirous of entering into it, to forward their names to the Secretary, without delay.

MR. SOPWITH'S ISOMETRICAL PROJECTION OF THE MINING DISTRICT OF ALSTON-MOOR

Was exhibited; and, being called upon by the Chairman, Mr. Sopwith gave the following explanation :—

He observed, that the general subject of plans and sections of mines and mineral districts was one of great importance to the community, and especially deserving the notice of Societies like the present. The preservation of such plans is requisite,in order to preserve a knowledge of what has been done in subterranean works; and, with this object in view, it is important that such representations should be as clear and explanatory as the circumstances will admit of. The usual drawings employed in connexion with mining, are what are well known by the name of Ground Plans and Sections; the one representing all horizontal objects, the other all vertical objects. Every object, therefore, which departs from a parallelism with these planes, must be, to a greater or less extent distorted; and this imperfection is common to all plans or drawings which are confined to the representation of one plane only. This description of plan and section, however, from its great simplicity and universal adoption, is that on which we must be chiefly dependent for perpetuating a knowledge of mining operations. Mr. S. stated that Government had established an office in connexion with the Museum of Economic Geology, for the purpose of preserving mining records. Draftsmen would then be employed to copy, on an uniform scale, all such plans and sections as may be deemed of sufficient interest to be thus preserved; and, by this means, he trusted that a body of information would be collected which would prove of the utmost value in carrying on the future operations of this and of all other mining districts. With respect to the want of accurate maps, Mr. S. trusted that some important data might be obtained from the Board of Ordnance, whose rough maps, or, at all events, the main features, he believed, were laid down on a scale sufficiently large to admit of the principal mineral features being sufficiently delineated. Mr. S. exhibited a number of small hand models, by which the nature of plans and sections were illustrated, and from which it appears how difficult it is to obtain a correct projection of the contour of objects, varying so much in curvature and inclination as the outcrops of strata usually do. He explained the mode of constructing such hand models, which, he believed, might prove of considerable use in extending a general knowledge of geological features; for there were many phenomena which could not be clearly comprehended by the mere use of planes only. He would instance the V form which strata present in valleys; the point of the V being in some places up the valley, and at other places down the valley. Now this was believed by many persons to indicate a different inclination of the strata; but by the two models which he exhibited, it was apparent that in both cases the inclination was the same, and that the V assumed these positions accordingly as the strata were more or less steep than the descent of the valley. The great perplexity frequently caused by slip dykes, and by axes of elevation, could thus be presented at once to the eye; and the simplicity of constructing such models, combined with their extensive utility, would doubtless lead to their being more generally used. The Isometrical Drawing which he had presented to the Society was a medium between the common ground plan and the model.—Mr. S. then stated, that to the late Professor Farish, of Cambridge, the merit of originating this beautiful method of projection was due. That gentleman had frequent occasion to construct rude drawings, to enable his workmen to put models of machinery together; and it was this that suggested to him the adoption of a method of drawing which, instead of only shewing one side of a cube, should present three sides at once to view; and this Mr. S. showed, by a diagram, was at once effected by inscribing a hexagon in a circle, and uniting the angles. By means of a protractor, constructed for the purpose, any angle might be at once projected on any one of the three sides of the cube thus presented to view; and, keeping in mind the cube, as the type and origin of this method of projection, it would easily be understood, that every plane surface parallel to any one of these three sides could be at once correctly delineated, by principles exactly similar to those on which the common ground plan and section are constructed.—Mr. Sopwith exhibited a diagram of faint blue lines, by which the process of Isometrical Projection is greatly facilitated; and also an instrument which he had contrived, by means of which the principal points of a common plan could be transferred to the respective positions required in isometrical drawing. Mr. S. then described the principal geological features of the Isometrical drawing, which was exhibited, and which represents an interesting portion of the mining district of Alston Moor. Several vertical sections are combined with a pictorial representation of the surface, on which the roads, fields, houses, trees, &c., are delineated.

Mr. Sopwith also exhibited a section of the Carboniferous or Mountain Limestone formation, from Hownes Gill to the summit of Crossfill Mountain, a distance of 28 miles. This section formed part of a larger one, across the island, from Whitehaven to Monkwearmouth, near Sunderland, which had been divided into four parts. The first comprised the Whitehaven Coal Field, and was to be executed by Mr. Williamson Peile. The second contained the Cambrian Rocks, and was undertaken by Professor Sedgwick. The third was the one now shown, representing the Carboniferous Limestone; and the fourth exhibited the Newcastle Coal Field, and would be executed by Mr. Buddle.

MR. SOPWITH'S MODEL OF THE FOREST OF DEAN.

Mr. SOPWITH said, he regretted that he could not exhibit the model on the table, so that it might be well seen by all present, but he would endeavour to explain it. It represented the Forest of Dean, in Gloucestershire, on a scale in which each five inches represented a mile. The surface was divided into square miles, to measure the extent, and shew the relative position of the places. The various colours represented the enclosures, the villages, towns, &c. The ends and middle were parted, to represent the sections of the strata. They shewed the old red sandstone, of which the thickness was considerable, and which was overlaid by the mountain limestone and coal beds, of which the commencement was here seen. To shew the structure of the forest from North to South, Mr. Sopwith exhibited the section of the centre of the model, where the beds of coal were represented by black lines. The outcrops of the various seams of coal were shewn on the surface, and the sections of them in the North and South position. In constructing drawings, two portions were made apparent; but from above the model, they might see the stratification on both sides. The surface of the model was made to come off, to shew the situation of the different seams of coal. The portion first taken off represented the part of the surface, with the rocks down to the first vein of coal. When this portion was removed, the upper seam of coal was disclosed. The first seam being taken off, disclosed another seam under it, which also was removed, and so on to the lowest bed of coal, where was shewn the outcropping and under strata, with the lines of the water levels. This exhibited a continuous bed, about six miles in one direction, and three or four miles in the other, forming a basin of coal. He would now say a few words on the mode of constructing the model. Plans were frequently inadequate to convey a correct idea of the state of the case, and that was particularly so in the Forest of Dean, owing to the steepness of the beds, and the position of the coal. The highest veins in geological position could not, in some places, be worked without pits, while the lowest coal, in other places, could be worked by levels. With a view of explaining these phenomena, this model was constructed for the Commissioners of Woods and Forests. It might at first appear to be a matter of mechanical difficulty to obtain the required shapes without carving. The method resorted to was a simple one, and he hoped would be adopted in other districts, where gentlemen possessing the necessary information might combine, and with little trouble, might produce a model like this. First, the information of such gentlemen must be collected from a great number of places in the district, of which it could with certainty be said, there are certain seams of coal at such a depth; and then, by combining such information, relating to different points, and reducing it to direct lines, the sections of the principal parts might thus be drawn on slabs of wood one-eighth of an inch thick. These were "half-lapped" together, to form a sort of network, or skeleton of the model. What was known having been marked on these, the parts must be filled up with judgment by those acquainted with the district. Having a certain number of facts, they must draw their inferences from them, so as to shew the bearings in a tangible form, where they had not been ascertained by workings. When these had been drawn on the blocks by a draftsman, the slabs must be taken to pieces, and sawn in portions, having been previously numbered, so that they might again be put in their proper positions. They might then be put together again by a workman, and the interstices filled up with pieces of solid wood. When any particular phenomenon occurred, such as variations or irregularities in the surface, or subordinate basins, or ridges, they could be introduced by means of small cross sections, in such a way, that the whole method was reduced to two simple operations. The strata having been delineated on the wood, it then became the province of a workman to put the material together, to form the wood in the proper shapes, and the whole must be afterwards painted, under the superintendence of a draftsman. Upon the surface objects were painted as on a map. The information given by a model like this was varied. It contained information from the pits in different places. The various steepness of the strata it was almost impossible to bear in mind; but when the various known points were reduced to shape in this manner, the rest of the work assumed a degree of probability which could not be attained without a model. This model was the first attempt of the kind, and, notwithstanding the difficulty of instructing the workmen, for the first time, the whole expense, including the case, was not more than £28 or £30. That cost was trifling, compared with the interest of the subjects represented; and he conceived that it was deserving of the attention of this Society, to attempt to form similar models of the districts, or portions of the districts, in which they reside. He was not aware of anything that could give greater interest to geological study than such models; and many gentlemen of experience had expressed the opinion, that the more frequent construction of such models would tend greatly to the increase of geological knowledge. Geology, at the present time, was a science of facts. They had now arrived at the extent of knowing their ignorance. When first Geology attracted attention, it was a science of theory. Theories were propounded in which the formation of the world was attempted to be explained: some saying that fire, and some that water, had been the principal agents employed by the

Creator. Many were the disputes on these subjects. But now a different feeling prevailed. It was now the universal impression that, by a patient accumulation of facts, by observing and recording what they saw, without endeavouring to account for how these things came to pass, by aiming to state things in the clearest manner, they could alone expect to arise to any considerable improvement in Geology. The construction of models of this kind would enable persons at once to understand the details of a district of which they viewed the representation. Interesting as were the papers they had listened to in the morning, no ordinary plans and sections could enable a person, without considerable time and attention, fully to comprehend them. But if a model had been exhibited, they would have been far better understood. Suppose that here and there an hiatus had occurred, yet if, with respect to a number of particular points, they had certain information, then such a model would be a very great means indeed of enabling persons, at one glance, to understand the general relations of the strata; and it was probable that persons who had travelled in the district, and observed the strata in different situations, might be able to make valuable suggestions, which might not occur to those whose time and attention had been chiefly occupied with the details of one particular district. Hence, he conceived that the construction of models of interesting geological districts was a subject so important, that he hoped it would engage the attention of all societies formed for the promotion of geological objects. He should be happy to answer any inquiries which gentlemen present might suggest, and to give all the information in his power on the subject, now or at any future time. In answer to a question, Mr. Sopwith stated that the surface of the model was formed on the scale of five inches to a mile; but the vertical scale was enlarged in the proportion of three to one, which gave a tolerably correct idea of the undulations of the country. If the height had been on the same scale as the surface, it would give the idea of a country flatter than was really the case. But, making the vertical scale three times more, gave a tolerably accurate idea of the proportions.

☞ *Mr. Biram's and Mr. Morton's papers are unavoidably deferred till the next Report.*

THE END.

PROCEEDINGS

OF THE

GEOLOGICAL AND POLYTECHNIC SOCIETY,

OF THE

WEST-RIDING OF YORKSHIRE,

AT THE ELEVENTH QUARTERLY MEETING, HELD AT WAKEFIELD ON THE 5TH OCT., 1840.

The Rev. THEOPHILUS BARNES having moved that the President, EARL FITZWILLIAM, do take the Chair, and the Rev. HENRY WATKINS having seconded the motion,

His LORDSHIP addressed the meeting as follows:— Gentlemen, when last we had the pleasure of meeting here, our Society had not assumed a very solid form; but from what I have observed and heard of the proceedings at other places since that time, I have derived much gratification, and feel now an assurance that we shall assume that position which will enable us to confer great and lasting benefit upon the country with which we are connected. I well remember that at that time a notion was entertained that this was a Society the sole object of which was to advance the knowledge and interests of those who were more particularly connected with Collieries. Upon the present occasion I believe we shall have a practical refutation of the idea that our views are confined to such limited objects; for I understand that in the course of our discussions this morning you will hear one paper, at least, read, which has a very different object in view, and which will tend rather to show the connection which Geology has with the Cultivation of the Earth itself. And I trust, too, if we are not led to do so on the present occasion, yet that in the course of time we may pursue our operations in other parts of the Riding which are unconnected with the coal field—I mean that part in which what is called the Mountain Limestone particularly prevails. I am not sure whether our excellent friend, Professor Sedgwick, is just now in the room, but every one will feel great gratification in learning that he is in the town, and I trust that, in addition to the general information which he will be able to give you, he will particularly advert to that part which forms much the largest portion of the Riding of which he is a most distinguished native and ornament. (Hear.) I shall not now trouble you with any further observations, but beg to apprise you that a paper will be read to you by Mr. Thorp, upon the Geology of this part of the Riding, and particularly as connected with its Agriculture.

On the motion of Mr. Wilson, seconded by Mr. Hartop, the following gentlemen were elected members of the Society:—

Rev. Dr. FENNELL, Wakefield.
GEORGE BANKS, Esq., St. Catharine's, Doncaster.
HENRY WALKER, Esq., Clifton.
JOSEPH SCOTT, Esq., Badsworth Hall.
E. B. BEAUMONT, Esq., Finningley Park.
Dr. SCHOLFIELD, Doncaster.
Mr. W. MOFFATT, Ditto.
— WILSON OVEREND, Sheffield.
— JOHN ATKINSON, Chesterfield.
— JOSEPH MACHELL, Kirkstall.
— EDWARD GREEN, Wakefield.
— HENRY MORTON, Ditto.
— BENJAMIN BRADSHAW, Upper Thong.
— THOMAS SHEPHERD, Huddersfield.

The SECRETARY then read

THE REPORT OF THE COUNCIL OF THE GEOLOGICAL AND POLYTECHNIC SOCIETY OF THE WEST RIDING OF YORKSHIRE, PRESENTED AT THE ANNUAL MEETING, ON THE 5TH OCTOBER, 1840.

The progress of the Society during the past year, and its present condition and prospects, may be considered satisfactory and encouraging. The number of Members has increased from 200 to 280, and consequently the Annual Income from £105 to £147.

The Accounts of the Treasurer up to 31st December last, have been examined by the Auditor, and show a Balance in favour of the Society of £159. 3s. 0½d., in addition to the sum of £88. 10s. which had been subscribed for the purchase of cases for the Museum. A similar statement, however, made up to the present time, when all demands against the Society have been discharged, would only leave a balance of £150. This sum will not appear large when the many important objects contemplated by the Society are considered, some of which are unavoidably postponed until the funds are permanently increased by a large accession of Members.

In the last Report, the establishment of the Bradford Philosophical Society, and the revival of the Geological Section of the Leeds Society, were alluded to, and a hope expressed that these circumstances would not be injurious to the cultivation of local Geology It is most satisfactory to the Council to believe that in that hope they will not be disappointed. In confirmation of this opinion they may appeal to the reception which the Society met with at those places, and at Sheffield, in all which towns the visits of the Society have tended to awaken an interest in the objects for which it was instituted.

The Rules of the Society, which were passed at the commencement, having been found unsuitable to its present condition, have been carefully revised, and will be submitted for the approval of the Members in the course of the present Meeting.

The extensive cuttings carried on by the Railway Companies have afforded opportunities of collecting and recording Geological information which have not been lost sight of. By the liberality of the Directors of the North Midland Railway, a large party of the Members were enabled to inspect the whole of that line; and by the kindness of Mr. Swanwick, the Report of the Committee, which will be presented to day, is illustrated by a beautiful section. The invitation also of the Manchester Society to execute a section across this coalfield, with a view to a comparison with that of Lancashire, has been the subject of much deliberation, and though it has not been deemed advisable that the sections, as was first proposed, should start from a common point, yet a line has been chosen which will exhibit a favourable view of the Yorkshire Coal Measures, and the work having been undertaken by different Members of the Society will shortly be commenced.

The Council have long been anxious to place in the hands of each Member a permanent record of the papers that are read, and the discussions that take place. This most desirable object is in part accomplished by the publication of Reports; but though, for the sake of economy, all explanatory drawings have been omitted, yet even in the present form the expense is greater than the funds of the Society are able to bear, and the Council are therefore reluctantly compelled to recommend that an annual charge for the Reports of 2s. 6d. should be made on each Member, in addition to the Subscription.

It will be unnecessary, in consequence of these reports, to give more than a very brief account of the papers that have been read. In the Geological department, Mr. Thorp has continued his valuable contributions to local Geology by a comparison of the

Yorkshire and Lancashire Coalfields, and by remarks on the disturbances in the Valley of the Don, which have contributed much to the solution of the difficulties that surrounded that subject. A comprehensive sketch of Fossil Ichthyology and of the Fossil Fishes of Yorkshire was presented by Mr. T. P. Teale. The Committee appointed to recommend a line of section has produced two reports, and the extensive section of the minerals on the Wentworth House Estate, and a part of the same section in the neighbourhood of Darton, have been described by Mr. Biram and Mr. Morton.

In the Polytechnic department, the value of the application of Chemistry to Geology was illustrated by Mr. West on the Proportion of Sulphur in Coals, and by Mr. Leah's paper on the Influence of Atmospheric Moisture on the Manufacture of Iron. In this department, too, Mr. Hartop has contributed Observations on the Form of Boilers, and Mr. Morton's Remarks on Mr. Fletcher's Safety Lamp, and on Mr. Sykes Ward's application of the Drummond Light forcibly exhibited the two great defects of that most valuable invention of Davy. The methods of recording and delineating geological and mining operations and information were fully explained by Mr. Sopwith, in his description of the Principles of Isometrical Projection, and by the exhibition of his admirable Model of the Forest of Dean.

It is much to be regretted that the number of those who contribute papers is so small. There must be in the ranks of the Society many who in the course of their daily experience are constantly meeting with important information, but who, it is believed, are deterred from coming forward by the supposition that only a long and elaborate paper is worthy the Society's attention; such an opinion cannot be too soon abandoned, nor can they be too often reminded that the communication of any *fact* connected with the objects of the Society, however simply and briefly related, is of great importance.

In the commencement of the Society's career, the Council, indulging the hope of being able to erect a suitable museum, had been enabled by the liberality of their Noble President to purchase a site; but finding themselves at present disappointed in their expectations, they have considered it advisable to accept an advantageous offer for its disposal. In the meantime they have not neglected an object so important, but have fitted up the temporary Museum with cases, and can now invite the members to inspect it. The Collection, notwithstanding the short time since the cases were completed, amounts to nearly 1000 specimens, and contains many very valuable Fossils. There is, however, ample room for a much larger collection, and the Council most earnestly solicit every member to exert himself to add to its stores: and they beg to remind them that a knowledge of Fossil Botany is not in this case necessary, since any fossil and every mineral product, if accompanied with a statement of the place and stratum in which it is found, will have a value in the Museum of a Society such as this.

In conclusion, the Council would express their conviction that the Society is steadily advancing in public estimation, and that it has only to persevere in the course it has hitherto pursued, to secure for it that support which will enable it to accomplish the objects for which it was established.

AN ABSTRACT
OF THE RECEIPTS AND EXPENSES OF THE SOCIETY,
FROM 2ND DEC. 1837 TO 31ST DEC. 1839.

Receipts	£.	s.	d.
Subscriptions from 132 Members for 1838....	69	6	0
Do. 131 Members for 1839	68	15	6
Do. for the Museum....	10	10	0
Do. for Cases for Do.....	9	10	6
	£158	1	6

Expenses	£.	s.	d.	£.	s.	d.
Printing and Stationery				19	9	0
Advertising........................				21	9	4
Hire of Rooms and Attendance				11	8	2
Two Public Lectures				14	10	0
Report and Printing of Professor Johnston's Lecture	28	9	2			
Received for the sale of Do.	26	13	0			
				1	16	2
Postages and Sundry small payments				9	11	3½
1840.				78	3	11½
Jan. 1. Balance in the Treasurer's hands	27	19	10½			
Do. in the Yorkshire District Bank..............	51	17	8			
				79	17	6½
				£158	1	6

1840.
an. 1. Assets of the Society.

	£.	s.	d.	£.	s.	d.
Balance in Cash	£79	17	6½			
Subscriptions due for 1838 for 34 Members	17	17	0			
,, 1839 117 ,, ...	61	8	6			
				159	3	0½

BENJAMIN BIRAM, AUDITOR.

The following Resolutions were then passed :—

Moved by Mr. PORTER,
Seconded by Mr. CHAMBERS,

That the Report of the Council be received and printed.

Moved by Mr. HARTOP,
Seconded by Mr. HOLT,

That the Accounts of the Treasurer, up to 31st of December last, showing a balance in favour of the Society of £159. 3s. 0½d. be passed.

Moved by Dr. Alexander,
Seconded by Rev. W. Thorp,

That the following Noblemen and Gentlemen be elected Officers for the ensuing year:—

PRESIDENT: Earl Fitzwilliam.

VICE-PRESIDENTS:

The Duke of Norfolk.
The Earl of Effingham.
The Earl of Scarborough.
The Earl of Dartmouth.
The Lord Wharncliffe.
The Lord Stourton.
The Viscount Milton.
The Viscount Howard.
Hon. W. S. Lascelles, M.P.
Hon. J. S. Wortley.
Rev. Theophilus Barnes.
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Godfrey Wentworth, Esq.
W. Bennet Martin, Esq.
C. J. Brandling, Esq.
J. G. Marshall, Esq.
Michael Ellison, Esq.
Rev. Samuel Sharp.

TRUSTEES:

The Earl Fitzwilliam.
Th Earl of Effingham.
The Lord Wharncliffe.
The Viscount Milton.
The Viscount Howard.
Hon. W. S. Lascelles.
Hon. J. S. Wortley.
T. W. Beaumont, Esq.
J. S. Stanhope, Esq.
W. B. Martin, Esq.
C. J. Brandling, Esq.
Godfrey Wentworth, Esq.

COUNCIL:

Mr. J. Charlesworth, Jun.
— Joseph Charlesworth, Jun.
— Henry Briggs.
— T. W. Embleton.
— Charles Morton.
— Henry Hartop.
Rev. William Thorp.
Mr. J. Brakenridge.
— J. M. Stansfeld.
— Henry Holt.
— Joshua Smithson.
— W. T. Hall.

SECRETARY AND TREASURER: Mr. Thomas Wilson.

CURATORS: Messrs. Embleton and Holt.

AUDITORS: Messrs. Biram and G. W. Chambers.

Moved by Mr. Morton,
Seconded by Mr. Briggs,

That the thanks of the Society be given to the Directors of the North Midland Railway, for permitting the Society to inspect the line, and for their liberality in placing a special train at their disposal.

Moved by Mr. Embleton,
Seconded by Mr. Brakenridge,

That the thanks of the Society be given to the Lords Commissioners of Woods and Forests, for permitting the Model of the Forest of Dean to be exhibited before the Society.

Moved by Mr. Holt,
Seconded by Mr. Lucas,

That the thanks of the Society be given to Earl Fitzwilliam, Rev. S. Sharp, Messrs. Briggs, Embleton, Hartop, and Wilson, for their donations of Fossils to the Museum.

Moved by Mr. Wilson,
Seconded by Mr. Hartop,

That James Heywood, Esq., Vice-President of the Manchester Geological Society, be elected an Honorary Member.

Moved by Mr. Embleton,
Seconded by Mr. Morton,

That the next Meeting be held at Doncaster, on Wednesday the 2nd December.

Moved by Mr. Wilson,
Seconded by Mr. Hartop,

That the following Rules be adopted :—

RULES OF THE GEOLOGICAL AND POLYTECHNIC SOCIETY OF THE WEST-RIDING OF YORKSHIRE,
PASSED 5TH OCTOBER, 1840.

1. The Title of the Society shall be the Geological and Polytechnic Society of the West-Riding of Yorkshire.

2. The Objects of the Society shall be 1st. the investigation of the Geology of the West-Riding, with the accuracy and minuteness necessary for the successful prosecution of Mining and Agriculture; 2nd., the improvement of the Arts of Mining and Metallurgy, and their dependent Manufactures, and of the Machinery and Tools employed therein; and 3rdly, the amelioration of the condition of the population connected therewith.

3. The Means by which it shall pursue these objects shall be the collection of Maps, Plans, Sections, Models, Mining Records, and every kind of information respecting the Geological structure and Mineral resources of the country—the construction of a complete Geological Map or Model with a Book of Reference—the formation of a Museum, as well of the various Fossils and Mineral products of the country, as of Drawings, and Models of the Machinery and Tools employed in Mining and Manufacturing—the holding of public meetings for discussing topics connected with these various objects—the publication of papers, reports, and transactions—the corresponding and co-operating with the metropolitan and other similar Societies for the advancement of their common objects.

4. Every *Candidate* for admission into the Society must be proposed by two members at a general meeting, and elected by a majority of the votes of members present.

Note.—Each member will have the privilege of admitting ladies and children at the Quarterly Meetings.

5. Notice of his having been elected shall be sent by the Secretary to each member, with a copy of the Laws and of the following Declaration, which he shall be requested to sign and return to the Secretary.

To the Council of the Geological and Polytechnic Society of the West-Riding of Yorkshire.

I do hereby declare that as a member of the above Society, I will conform to its laws, and endeavour to promote its objects.

Signed

Dated

6. Any member may *withdraw* from the society by giving notice in writing of his intention to the Secretary, and paying up his subscription to the end of the current year.

7. Any individual who resides out of the West-Riding of Yorkshire, and is distinguished for the pursuit of the objects contemplated by the Society, or who may render any services to the Society, may be elected an *honorary member* in the same form as an ordinary member.

8. The Annual Subscription shall be half a guinea, and 2s. 6d. for the Reports, which shall be payable in advance on the 1st January each year.

Note.—Members who are elected at the December meetings shall not be liable to subscriptions until the 1st January following.

9. If any member allow his subscription to be in *arrear* for more than one year, and after receiving notice from the Secretary, do not pay it within one month, the Council may erase his name from the list of subscribers.

10. No new Law shall be passed, nor any *law altered*, except at a General meeting, nor unless a notice in writing, signed by six members, have been given at the preceding Quarterly Meeting, and afterwards inserted in the circulars calling the meeting.

11. The Officers of the Society shall be a President, Vice-President, and Twelve Trustees, a Secretary, a Treasurer, and two Honorary Curators, and a Council of Twelve Members in addition to the Officers.

12. The officers shall be elected at the Annual Meetings; they shall be re-eligible, and shall continue in office till their successors are appointed.

13. ELECTION OF OFFICERS.—At the June Meeting lists shall be prepared, on which any Member may enter the names of any Member of the Society as a Candidate for any Office, and at the Annual Meeting the lists so prepared shall be marked by the Members present, and those whose names have the greatest number of marks shall be declared elected to their respective offices.

14. The *Museum* and *property* of the Society shall be vested in the TRUSTEES, and as soon as the number by death or resignation is reduced to three, a new trust deed shall be executed.

15. The COUNCIL, of whom three shall be a quorum, shall meet once a month; they shall have the entire control of the property and the management of the business and funds of the society. They may exchange or present duplicate specimens—offer Premiums for Essays or Inventions—present copies of the Transactions to individuals and societies—supply vacancies in the Offices until the Annual Meeting be held—and they shall present a Report to the Annual Meeting on the condition of the museum and property, and on the position and prospects of the Society.

16. The *President*, *Secretary*, or any *three of the Council*, may, at any time, call a *Council Meeting*, by notice through the Post-office seven days previous, stating the objects of the Meeting.

17. The TREASURER shall keep an account of all monies paid and received for the Society, produce his vouchers and accounts whenever required by the Council, and lay the accounts for the year ending on the 30th June, before the meeting of the Council in August, that they may be examined before being submitted to the Auditors.

18. All MONIES received for the Society shall be paid into such Bank as the Council shall appoint, and no sum exceeding £2 shall be paid without an order of the Council.

19. The Annual Abstract of the accounts shall be prepared so as to show the expenditure of the Society under the most important heads, viz. rent, salaries, purchase of collections, printing transactions, &c. &c. and it shall be presented at the Annual Meeting, and printed with the Report of the Council.

20. The Secretary shall take minutes of the proceedings of the general, special, and annual meetings, and of the meetings of the Council, and enter them regularly in the minute book; he shall conduct the correspondence of the Society under the superintendence of the Council, and shall prepare and bring before the Council every thing that relates to the business of the Society, and carry their directions into effect.

21. General Meetings of the Society shall be held on the first Wednesday in March, June, and December, in the principal Towns of the West Riding, for transacting the business of the Society, and for discussion. The members present at each meeting shall fix the place where the next meeting shall be held.

22. The Annual Meeting shall be held in Wakefield in the Autumn, at such time as the Council may appoint, when the Officers and two Auditors shall be elected, the Accounts and Reports received, and the general business of the Society transacted.

23. A Special General Meeting may at any time be called by the President, the Council, or by any Twelve Members in the same form as prescribed by Rule 16.

24. At all General Meetings the President shall take the Chair, or in his absence a *Chairman* shall be elected. All questions shall be decided by a majority of the votes of the Members present, the Chairman, if necessary, having the casting vote.

25. Those Members who intend reading Papers must give two months' notice of their intention to the Secretary, and send in their Papers for the inspection of the Council one month previous to the Meeting at which they are to be read.

26. The Society shall not be *dissolved* except at a Special General Meeting called for the purpose, (of which three months' notice shall be given to each Member by the Post,) and by a majority of three-fourths of the Members present, and in case of the dissolution of the Society, its Collections shall not be sold, but presented to some National, Local, or Permanent Institution.

The following Communications were then made to the Society :—

ON THE GEOLOGY OF THE WEST-RIDING OF YORKSHIRE, CONSIDERED GEOLOGICALLY—AND FIRST, OF THE NEW RED SANDSTONE DISTRICT. BY THE REV. WM. THORP, OF WOMERSLEY.

The intimate relation which subsists between Agriculture and Geology is evident to every scientific agriculturist ; indeed of such importance is it that a sub-committee have been appointed by the Yorkshire Agricultural Society to obtain *An Essay on the Agricultural Geology of some part of Yorkshire.* In a printed report they state that "the object of their "appointment was to show in how great a measure "soils, and therefore their vegetable products, are "modified by the strata on which they rest ; and thus "to prove to the agriculturist that to farm to advantage "it is necessary to be acquainted with the leading "geological features of the district in which he resides ; "that agriculture is already to a considerable extent "carried on upon geological principles, though without "the knowledge of the occupier of the farm." And, in order to carry their purpose into effect, they enumerate six points requiring notice, viz. :—"1. The geographical "limits of the formation. 2. Its general character, such "as height and form of hills, or ridges, depths of "beds, &c. 3. Its chemical composition. 4. The "plants which seem to thrive best upon it. 5. The "manures which have been found most applicable; "suggesting, if possible, others which, from their "chemical properties, seem likely to supply deficiencies "in the soil. 6. The insects and diseases which are "found most destructive to the crops, with the remedies "where known." They conclude the report by saying that they are naturally desirous of commencing an undertaking which they feel confident will eventually strengthen the foundations of agriculture, and therefore pave the way for an extension of its superstructure, and, lastly, "*That agriculture will never receive its full* "*development until its connexion with geology shall be* "*closely examined, and clearly defined.*"

This subject, then, being one of vast importance to the agriculturist, I do think it the duty of this society to afford to the Agricultural Society every assistance in their power towards carrying into effect their great and beneficial undertaking; and for this purpose these papers are written.

I hope, therefore, now to be able,

1. To describe the geographical limits not only of the Formation, but of each of the beds subordinate to it; to project these upon a map of the scale of 6 inches to the mile, and to produce vertical sections of the hills, depths of beds, &c.

2. To examine the chemical composition of soils upon the same strata, and to compare the infertile with the more productive.

3. To notice the state of agriculture as at present existing over the country described, and offer suggestions for its improvement where required.

The country which I now purpose to describe commences three miles South of Doncaster, and extends

Northwards to the river Aire and Calder, is about twenty miles in length and five or six broad, and situated upon the New Red Sandstone.* The Western boundary of the great plain of New Red Sandstone is accurately laid down by Smith in his county maps, and also parts of it through Yorkshire by Professor Sedgwick, in the third volume of the Geological Transactions, and over the district now described, it commences East of Wadworth, passes near Hexthorp, thence by Cusworth, Carcroft, Owston, Norton, Womersley, to Knottingley, the line of demarcation being easily visible throughout its whole course between it and the Upper Slaty Limestone. The Geology of this district is not so simple as at first might be anticipated owing to the occurrence, over various parts, of diluvium or beds of gravel, boulders, and sand, of considerable thickness, which are superincumbent to the true beds of the New Red Sandstone. The latter also does not here consist of Red Sand, but principally of thick argillaceous beds, with the intervention of thin sand beds: the whole of these, however, are disposed with great regularity.

The soils on the South side of Doncaster (the low Carrs East of Wadworth and at Bessecar excepted) are situated upon *Diluvium*, which lies in very irregular masses.

There is one range of gravel beds† extending from Doncaster race course to Rossington bridge, from two to three miles in breadth; these beds form a slight

* At the end of the paper will be found a vertical section of the beds of this district, which passes over the Estates of Mr. Childers, of Cantley, Sir W. B. Cooke, Wheatley, Mr. P. D. Cooke, Owston, Mr. Yarborough, Camps Mount, Lord Hawke, Womersley, and Sir Samuel Crompton at Whitley and Kellington.

† See the Section and Map.

escarpment to the West, and the great North road from Bawtry to Doncaster runs nearly on the edge of it, but they thin away to the East at Cantley, so that the lowest bed emerges from beneath, and forms the basis of a considerable tract of country between the former place and Armthorp.

The section at Cantley consists of:

1. Boulders, gravel, and sand, forty to fifty feet. 2. Yellow Clay and Boulders, twenty feet (probably.)

Another range of diluvium commences near Balby, one mile and a half West of Doncaster, and ranges in an East and West direction down by Wheatley to Sandal and Hatfield; the breadth of this mass is from two to three miles.

The section in Doncaster town is:

1. Sand and Gravel, three feet. 2. Sand, eighteen feet. 3. Gravel rough, part Boulders, fifteen feet. 4. Yellow Clay and Boulders, three feet. This arrangement of the upper beds is purely local, for the section varies even in the same quarry.

The lowest bed of Yellow Clay and Gravel in the Doncaster section has a very extensive range, and is found at Cantley under the upper gravel beds, and extends on the surface from that place, two miles to Armthorp, and three miles also in a North and South direction, being the basis of a tract of wet land. The eighteen feet Sand forms the excellent soil of Doncaster Field.

Of the origin of the beds I hope to speak this evening in another paper. The productiveness of these upper gravel beds very much depends upon the seasons. In hot and dry summers they suffer much from drought, which is a great drawback on the profits of their cultivation. For sheep husbandry they are well adapted, the treading being invaluable—under favourable circumstances the produce of Barley will be four quarters per acre, the quality good. Wheat is not cultivated without the addition of Rye, and six to eight loads per acre are grown. The cultivated grasses, if not too often repeated, are produced a tolerable crop: but the soil is too light for the permanent grasses. The rent averages from fourteen shillings to twenty shillings, but some separate fields are said to be worth forty shillings per acre: the latter are situated upon the next bed to be described as their subsoil, which makes them more retentive of moisture.

The Yellow Clay and Boulders requires a separate notice, on account of the extent of soil which it forms, and of the sudden transition from a dry to a wet soil, on the same formation, being a tract of moist land between Cantley and Armthorp. This bed certainly extends from Doncaster to Cantley, as I found it impossible to bore through it at the latter place. The boulders identify it with the diluvial beds. The soil is too wet for the cultivation of the permanent grasses; indeed, if it could be made to produce them, it would be invaluable to the occupiers of the light sandy diluvial beds; its tenacity, however, as I shall shew in its analysis, is not owing altogether to its texture.

Before entering upon the chemical analysis of these diluvial soils, it may be well to examine what information will be derived from the inquiry. The Agricultural Society require simply the chemical analysis of each formation; and if by this we were able to pronounce whether a soil is fertile or infertile, or in what earth it is deficient, the result would be of the greatest advantage to the practical farmer. But it does not appear to be known what combination of earths produces the highest degree of fertility. The four earths, silica, alumina, lime, and magnesia, a small proportion of the muriate of soda, sulphate of magnesia, muriate and sulphate of potash, nitrate and sulphate of lime, oxide of iron, the mild alkalies, potass, and soda, are all the ingredients which are found in soils, and their permanent productiveness must therefore depend upon a certain admixture and combination of several of these. Now if Von Thaër's classification of soils* be examined, it will be seen that they receive their value in proportion to the quantity of clay which they contain, and decrease in value as they possess *silica.* But if, on the other hand, we compare the soils of Sinclair, no estimate of their value can be deduced from the quantity of either silica or alumina: *e. g.* Sinclair's "best rich alluvial" soil contains 17 per cent. of alumina, Von Thaër's 74 per cent. of clay. Sinclair's "rich black clayey" contains only 5 per cent. of alumina, and Von Thaër's "2nd soil" 81 per cent. of clay. Sinclair's "tenacious clay" contains only 13.7 of alumina. Neither will the proportions of sand serve as a criterion of infertility, even in Thaër's own list, his soils, Nos. 5 and 6, containing more than Nos. 7, 8, 9, 10, and 11, all inferior to the former.

Again, the best loam in France analysed by Tillet would approach very near to Thaër's "rich barley land No. 6," except that it contains more lime than Thaër's. But the quantity of lime will not serve for a better test of fertility, as may be seen by the inspection of Thaër's list; indeed, it is well known that the Flemish soils scarcely contain any carbonate of lime. The Polder of Orderen, an alluvial soil, (which Polders are cropped many years in succession without the benefit of manures,) contains 81 per cent. alumina, 18 per cent. sand, but no lime. A soil in the Waes district

* See the Table of Soils at the end of the paper.

of East Flanders, which produces finer crops than any sand in Belgium with the least manure, contains only 13 per cent. alumina, 84 per cent. sand, and not a particle of lime.* There are, in fact, several circumstances which modify the productive powers of soils, whatever their chemical constitution may be: for instance, alumina will absorb by cohesive attraction 2½ times its weight of water; lime its own weight; and silica ¼ of its own weight; but although alumina has the greatest power of absorption, yet stiff clay soils do not take up so great a quantity of water as when mixed with a certain quantity of sand; for clays in dry weather become indurated on the surface, which prevents absorption. A mixture of lime also prevents the cohesion of clays, and allows the ingress of moisture; it is evident, therefore, that we cannot pronounce soils to be wet in proportion to the alumina which they contain. Again, if the soil be shallow, and the subsoil retentive of moisture, the soil itself, whether clayey or sandy, will be proportionably wet; and here again chemical analysis would fail us. The state of division in which the sand exists also materially influences the fertility; if the sand be in large quantity and coarse, the soil will be sure to be infertile, for when the sun comes upon it after rain, the particles cohere together like glass; if in a minute state of division, the soil will be comparatively fertile. Mr. Tower's direction to form the best loam for horticultural purposes is 83 parts sand, nearly impalpable, and 17 lime and clay, but, says he, if the sand be coarse, in hot weather after rain, the soil will set like mortar. In fine, Professor Lowe says upon this subject, "It has "been found that the fertility of soils is not dependent on "the prevalence of any one mineral in the soil, but on "a mixture or combination of several. But what the

* Farmers' Series: Flemish Husbandry. Page 10.

"precise proportion of these is, which is most favourable "to fertility, has not yet been determined." Strictly speaking, the soil itself merely affords a mechanical support for the plants which grow in it, and contains their food, but is not itself, except to a small extent ($\frac{1}{50}$ of the plant) their food, and therefore, *ceteris paribus*, those soils which hold the greatest quantity of this nutrition are the most fertile.

But in what state does this nutrition exist in the soil? Now the food of plants consists of decomposed animal and vegetable matters reduced by the process of putrefaction so far as to be soluble in water, but not to the ultimate elements of oxygen, hydrogen, carbon, and nitrogen, and not always to binary combinations; for the compounds of vegetable matter are ternary or quaternary, and the tendency by decomposition of these elements is to form binary compounds among themselves, and with other simple substances in the atmosphere around them. Sir H. Davy endeavoured to ascertain whether soluble vegetable substances passed in an unchanged state into the roots of plants by comparing the products of plants that had grown, some in common water, and some in a solution of sugar, and the results seemed to prove that soluble matters do pass unaltered into the roots of plants; but he also found "that solutions of sugar, mucilage, tannin principle, and jelly, require to be diluted with 200 times their weight of water. And that although mucilaginous, gelatinous, saccharine, oily, and extractive fluids, and solution of carbonic acid in water, are substances that in their unchanged states contain almost all the principles necessary for the life of plants, yet there are few cases in which they can be applied as manures in their pure forms, for vegetable manures in general contain a great excess of fibrous and insoluble matter which must undergo fermentation before they can become the food of plants." But the manures thus rendered soluble in water also unite chemically with certain portions of the soil, and thus become partially insoluble by water: indeed, if this was not the case, by continued rains in warm weather, fields lately manured would soon be exhausted of their nutrition, and no food would be left for the ensuing crop. The vegetable substance thus rendered insoluble was first examined by Klaproth, and called ulmic acid; by Berzelius it was called apotheme; and by Thaër humus. Malagutti's formula of the composition of ulmic acid is:

30 Atoms	of Carbon......	22.5	or per cent. 57.15
15	of Hydrogen	1.875...............	4.76
15	of Oxygen...	15.0	38.09
		39.375	100.00

Ulmic acid is alluded to by Sir H. Davy, though not by name, in these words:—"In most of the black and brown vegetable moulds, the earths seem to be in combination with a peculiar extractive matter afforded during the decomposition of vegetables. This is slowly taken up or extracted from the earths by water, and appears to constitute a prime cause of fertility in soils." It has been examined by Saussure and Braconnot,* and is said to have a great affinity for alumina; it also combines with lime, and forms an ulmate of lime; but a great desideratum is to know whether it combines with impalpable silica and the proportions of its combinations with the earths. (Caustic potass, and the alkaline

* Analysis of Mould by Saussure.

	Mould.	Oak Tree.
Carburetted Hydrogen Gas	124	116
Carbonic Acid	34	29
Water containing Pyrolegnate of Ammonia	53	80
Empyreumatic Oil	10	13
Charcoal	51	41½
Ashes	8	0½

Mould contains more charcoal, and also more ammonia, and therefore more azote than the Oak from which it was derived, 42.5 is the atomic weight of ulmic acid.

carbonates dissolve it, and acids throw it down from these solutions.) For if this were known, we could at once decide upon the inspection of an analysis whether a soil were permanently fertile or not. Nevertheless some information may be gained by a comparison of analyses, particularly if the foregoing considerations are kept in mind, as I hope to be able to shew.

The soil of a field near the house at Cantley, on the diluvium, and reckoned to be worth 40s. per acre, gives sand (two-thirds coarse) 86½ per cent.; of lime, clay, and other impalpable matter, only 13.5. Now, by comparing this with any of the soils in the table, for we cannot compare it with any superior to it on the same stratum, it will be at once seen that it contains more sand than any, except Sinclair's "Poor Silicious : and that it is defective in cohesion, is proved by the treading of sheep being so useful to increase its compactness; and Mr. Childers, of Cantley, has applied earthy matter from the bed of yellow clay and boulders to about twenty acres in his park, which he says is considerably improved. This soil is better than its analysis would indicate, owing to one-third of its sand being in a minutely divided state.

The soil formed by the bed of yellow clay and boulders has been stated to form a considerable tract of land running from Armthorp South towards Brampton. Now this soil, notwithstanding its wetness, contains 76 per cent. of fine sand. It is however much wetter than the analysis would seem to indicate, being too retentive of moisture to produce turnips, and dangerous for the pasture of sheep: which must, therefore, be attributed to the consolidated subsoil, and the fine sand increasing the capability of the 24 per cent. of clay and lime to absorb and retain moisture. It, however, plainly contains too much silica to be applied to the diluvial beds to improve their texture; there might, however, be found some portions of this bed *containing more alumina than others*, and of course better adapted to the improvement of those soils. Some fields, which were drained, were producing large crops of turnips, and I am told that it is very dry land when once that operation is performed. In fact, any soil with 76 per cent. of sand must be dry, if water is not retained by its subsoil.

The next stratum Northward composes the excellent lands of Arksey, Bentley, Almholme, Shaftholme, an alluvial deposit, I believe, of the river Don; at one time, I did think it to be the uppermost bed in the true New Red Sandstone series, but it is impossible to trace this soil under the diluvial beds on the South of Doncaster. The proof of its alluvial origin is corroborated by the fact that the greatest portion of it is now frequently covered by inundations from the River Don. It bassets out by thinning away suddenly to the North, in an East and West line, which extends from the Doncaster bar on the great North road, by Hall Ville Toll Bar, Shaftholme, towards Fenwick, and then follows the course of the river. This land produces excellent crops of all descriptions, as well as feeding pastures for cattle. This analysis* is from a field which

* Analysis of 400 Grains, by J. W. Wilson, Esq. of Whitby.

	Grains.	*Per cent.*
Water of absorption	50	12.4
Fine Sand	92	23
Carb. Lime	11¾	3
Carb. Magnesia	18¾	4.6
Vegetable matter destructible by heat	31	8
Silica	154	38.5
Alumina	25	6.2
Oxide of Iron	17¼	4.3
Loss	¼	0
(Ulmic Acid 7 per cent)	400	100

has borne for thirteen successive years, without any manure, (being only once limed) as much as eighteen loads of beans, eight quarters of barley, fifteen loads of wheat, and had this year upon it, though full of weeds, at least fifteen loads per acre of wheat. Perhaps the land of Bentley and Arksey is not inferior to any in Yorkshire. In a field near Shaftholme the soil is 3 feet 3 inches, resting on 7 feet clay; underneath is 5 feet 9 inches sand, with clay again underneath. The great fertility of this land probably depends on several causes. The depth of its soil is very great. It is also perfectly dry without draining; and has great power of absorption of moisture from the atmosphere, being 50 in 400 grains, which Sir Humphrey Davy calls "very absorbent." Its sand exists in minute division, being impalpable. But the proximate cause of fertility is its power to combine with a large proportion of ulmic acid. The soil even of the field which had been cropped thirteen years without the addition of any manure contains 8 per cent. At Stockbridge, the quantity of sand in a good field increases, being 36 per cent. The above analysis approaches nearest Sinclair's "rich alluvial," but is different from any of Thaër's. It would be useless to compare this soil with any of the same stratum, as it is impossible to improve its texture. The rent of this land only averages 27s. per acre.

The next inferior stratum, the bed of clay No. 1, emerges from beneath the Arksey soil, and has a very extensive range, forming the basis of the lands at Owston, Norton, Womersley, Fenwick, &c. stretching Eastwards towards Goole. This bed at Tilts is seven feet thick, forming there and at Owston a most inferior soil of nine inches, with a retentive subsoil. This clay, however, thins to the North, and at Owston Park Gate it is four feet thick. It is the same thickness on Askerne Common. At Moss and Fenwick it is six yards thick, evidently thickening to the East. At Lake Drain, in Womersley, it varies from two to three feet, and eventually bassets out at the North side of Womersley parish, in an East and West line, which runs down through Balne. After boring through this clay the water invariably rises above the bottom of the clay. At Shaftholme it rose three feet six inches; at Fenwick, six feet; at Telts, five feet. There are few, if any, springs rise through the clay. Its cohesive nature may be judged of by the fact that bricks and tiles are made of the soil and subsoil at Telts. The drainage is, of the Owston and Askerne pastures, into the Don, and of Fenwick, Womersley, Balne, &c. into the river Went. In places some fields stand higher than others, and they are always more fertile; even if a field stands one foot above the adjoining field, it will be found superior to it. Yet there is little variety in the quality of the soils on this stratum of clay; perhaps some of the best land is on Norton common, where the subjacent sand approaches the surface. The Fenwick land is perhaps superior to any upon it, but there is a tract of alluvial soil, which enhances its value, running parallel to, and formed by, the river Went. The rent of the Fenwick land is as high as 30s. per acre. The whole of the land on this stratum may be termed wheat soil, which crop it best produces, but even this grain of inferior quality and in small quantity; perhaps 15 bushels per acre would be an average of the whole district. Not an acre of feeding pasture is found upon it, those at Fenwick being an alluvial deposit from the Went. Hence this land is "over-cropped and under-stocked." The rent is from 8s. to 20s. per acre.

From a comparison of the chemical contents of these soils at various places, it is evident that the infertility of this large tract of wet land is not altogether owing to the adhesive properties of its soil. For although the Owston soils are very retentive, yet they do not contain near the clay in Von Thaër's first class of soils; and the analysis of the Womersley soils* very nearly corresponds with Thaër's 3rd soil, which he denominates 1st class of strong wheat soils. I shall speak upon the causes of this wetness, &c. when the agriculture of the country is described.

The Bed of Sand Soil— emerges from beneath the clay soils described, in a narrow East and West line of about a quarter of a mile in breadth: it runs through the Womersley farms of Wood Hall and Fulham, and down to the North road from Doncaster to Selby; it then veers to the South into Balne. Some lands situated upon it are adapted to the alternate husbandry, and produce good crops of turnips, but the depth of soil on the Southern edge of it becomes thin. The juncus glomeratus may be seen growing in sand. The Wood Hall Farm, at Womersley, formerly grew excellent perennial grass, and fed beasts. The worst field in Womersley, which is situated upon it, gives 215 grains out of 400 of sand. The proportion of sand in this soil† would make it equal to Thaër's No. 12, "good barley."

* Analysis of Womersley soil. Old Turf.
Water of absorption....60.

	Grains.	*Per cent.*
Calcareous sand	123	31
Clay	167	41
Carbonate of lime	50	12½
Magnesia		¼
Destructible by heat	63	15
	404	100

† Analysis, 400 grains
Sand ....215..........54 per cent.

The last New Red Sandstone Bed is clay fifteen yards. In a boring and sinking at Whitley there was no alternation of sand beds. This stratum contains a small portion of carbonate of lime. Tiles and bricks are made from soil and subsoil. The Goole and Knottingley Canal is cut in this stratum, and the most adhesive soil of the whole country is found upon it. The water found below it rose up twelve yards, so that no subterraneous draining by Elkington's plan can be adopted. Great quantities of teazles are grown upon this stratum, the rent being about 15s. per acre. It forms only a small tract of land on the North end of the map. I have no analysis of it.

A Tract of Diluvium commences near Ferrybridge, and ranges in an East and West direction, down by Pollington to Snaith; of the origin of which I shall not now speak. This range of gravel beds is not so thick as that near Doncaster, and lies more regularly. The general section is five or seven yards of boulders, five or six yards red and brown sand, with layers of broken coal, and at the bottom limestone boulders imbedded in yellow clay and sand. The two diluvial groups have a correspondence in the yellow clay and boulders. A great portion of this land is of very superior quality, being well adapted to the alternate system of husbandry, producing large crops of turnips and artificial grasses, and perhaps some of the best barley land in the West Riding is situated upon this red and brown sand No. 2.* It is excellent sheep land, superior to any portion of the magnesian limestone, being always dry in winter and after rain, and therefore not injuring, nor is it injured,

* This bed of sand is omitted in the small maps and section; it forms the soil of Beale and Birken.

by the presence of sheep. The lands on the upper beds of gravel are of inferior quality, but very variable; some very light soils at Whitley, on the boulders, contain 83 per cent. of coarse sand. Marl would no doubt be of great service to the whole of them. The rent averages 28s. per acre, but portions are held with some excellent grazing land adjoining the river Aire and Calder. The produce is on an average six quarters of barley, ten loads of maslin, wheat being rarely grown without rye.

The *alluvial soil* contiguous to the river Aire and Calder is very productive in the permanent grasses, and is kept therefore entirely for grazing purposes. Its extent, however, is very inconsiderable, forming only a narrow zone running parallel with the river. It is not superior to the Arksey and Bentley soils; and is also liable to sudden inundations from the river, one of which last year buried the whole adjoining country for ten days.

I have no analysis of this soil; but it is evident that its texture cannot be improved: 400 grains lost by drying 90 grains: it is therefore very absorbent. The soil also is at least four feet deep, and does not require draining.

I now describe the state of agriculture as at present existing over these different soils, and offer some suggestions for its improvement, and I hope these suggestions will be well canvassed and discussed by any agriculturists present. But before doing so, there is one question put by the Agricultural Society which requires notice. They wish to have a list of the manures which have been found most applicable to each formation, and others which, from their chemical composition, seem likely to supply put on clays and moist lands, but is serviceable on all; and it is also probable, from hence, that particular soils produce peculiar modifications in manures applied to them, either during the stage of their decomposition, or in their mode of chemical union with them, and for this reason there is an adaptation of particular soils to grow particular plants. For it is certain that plants which flourish in wet clayey soils do not choose this habitat on account of the clay, for they do not contain more alumina than those growing in other regions, neither is it on account of the moisture, for if that were the case all bog plants would be succulent and juicy, which is not the case. There are, evidently, then, various effects produced upon ulmic acid by the native soil of different plants.

It is also true that certain manures are adapted to particular crops, and ought to be applied accordingly. This Grisenthwaite proved ten years ago. The inquiry, therefore, of the Agricultural Society should have been *to obtain a list of manures applied to particular crops, and upon what soils?* The other question, viz., What manures will supply the deficiencies in each soil? is plainly impossible to be answered; for if chemistry is unable to ascertain of what earth a soil is deficient, and also the modifications which are effected upon ulmic acid by different soils, it seems very improbable that any effectual knowledge can be gained respecting the deficiencies of manures in soils, particularly without a consideration of the crop intended to be produced by its application.

Now, in order to explain the operation of different manures, I have introduced a table,* principally from Madden and Sir H. Davy, and it will appear from this

* See the Table, No. 2.

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common salt is ineffectual on poor land; nitrate of soda is suited to clay lands in wet seasons, and also to chalk, if applied in humid weather; rape dust is to be put on clays and moist lands, but is serviceable on all; and it is also probable, from hence, that particular soils produce peculiar modifications in manures applied to them, eitheir during the stage of their decomposition, or in their mode of chemical union with them, and for this reason there is an adaptation of particular soils to grow particular plants. For it is certain that plants which flourish in wet clayey soils do not choose this habitat on account of the clay, for they do not contain more alumina than those growing in other regions, neither is it on account of the moisture, for if that were the case all bog plants would be succulent and juicy, which is not the case. There are, evidently, then, various effects produced upon ulmic acid by the native soil of different plants.

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Throughout the farms in the country described there is the greatest waste of manures; there is not one tank to collect the liquids, and very few farm buildings are spouted to take away rain water. So that the manure in wet weather becomes macerated, and in dry, the liquid parts are either evaporated or sink into the earth. The floor of farm yards ought to be impervious to water. It has been well said that the Belgians are a century before us in the preparation and preservation of manures. The diluvial beds on both sides of the country have been described as sheep soils, and an experiment on the soiling of sheep under cover by Mr. Childers deserves notice. A shed is erected, which holds eighty, the interior is raised two feet from the ground by wood work, and the sheep thus sleep dry. Seventy sheep were fed on turnips, and allowed 1s. worth per week each of extra food, as beans, crushed barley, salt, and hay. The net profit in three months was from 15s. to 20s. each, besides fifty loads of excellent manure. It is supposed that, during this year, ten acres of turnips will feed 400 sheep on this plan. Soiling under cover is a novel experiment, but Sir John Sinclair, in his Husbandry of Scotland, states that 308 wethers produced 800 tons of the best manure, folded upon an English acre. In the Complete Grazier there is another account of 134 ewes and 30 lambs producing in six weeks 28 loads of manure, value £14. It is highly probable that if the above turnips had been steamed the profit would have been larger; indeed, it was well known, from the experiments of M. Biot on vegetable substances with the polarised ray of light, that the nutritious matter of some roots is nearly doubled. Schœffer, Carolini, and Swammerdam long since demonstrated that the farina or meal of grain consists of globules. Raspall and M. Biot are now enabled to state that each of these globules is furnished with a capsule containing the nutritive part—that these globules, whether of grain or of roots, are incapable of affording any nourishment, as animal food, until they are broken—and that a mechanical breaking or grinding is only partially efficient, and the only effectual method is by heat or panification. Vegetable substances turn the polarized ray of light to the right hand in proportion to the nutritive matter contained in them. The juice of carrots, when boiled, turned the ray at an angle double that of raw juice. Similar phenomena were observed in the juices of turnips. M. Biot has also determined the precise proportion of saccharine matter which the juices of the cerealia contain in different stages of their growth, and some information is hoped to be gained by his experiments respecting the food of plants.

The rotation of crops upon the whole diluvial beds, on both sides of the section, is the Norfolk or four years' course. 1, turnips; 2, barley; 3, clover; 4, maslin. But in this course the return of the same crops, and of fallow, is too frequent, and red clover is very often a failing crop. The following is a remark made upon this sort of land in the Quarterly Journal of Agriculture, Vol. ix.: "The rotation of four, viz. 1, turnip fallow; "2, barley; 3, grass; and 4, a white crop, is not "adapted to any *sand land*, even with an unlimited "command of manure, for that course keeps light land "too much under the plough, makes it too pulverulent, "and thereby endangers its texture with deafness. "Such land should always be pastured at least two "years, and better still for three, in order that it may be "consolidated into a firm condition by time, rain, and "the tread of animals." A dressing of clay, as tried by Mr. Childers, would improve the texture, where circumstances would admit of the application; on the Southern range of diluvium near the Aire much of this land lies contiguous to the clay of fifteen yards; and on the Northern range near Doncaster, some portion of the yellow clay and boulders would be suitable. But clay requires exposure to the atmosphere, and not too great a dose applied at once; 120 cubic yards will cover an acre one inch thick; and if the soil be six inches deep, there will be $14\frac{2}{7}$ per cent. of clay or marl added to the soil. All the clays on the New Red Sandstone are, in fact, marls.

With regard to the agriculture of the alluvial soils of Bentley, Arksey, &c. I have little to say. The rotation is this: 1, fallow (limed), except turnips; 2, barley or maslin; 3, clover or beans (manured); 4, wheat. Here each exhausting crop alternates with a restorative one; and half of the farm is under an exhausting, and half under a restorative system; but this course is defective, as mentioned before; that the same kind of crops return at too frequent intervals. The land also would bear a more exhausting rotation, and probably that pursued on rich clays would suit it, viz.: 1, summer fallow (manured); 2, wheat; 3, sown grasses, for hay or green forage; 4, oats; 5, beans; 6, barley or wheat. Here two-thirds of the farm is under exhausting, and one-third in summer fallow and restorative. It would be less severe if the grass were to remain two years in that state, and then three-sevenths would be restorative, and four-sevenths exhausting; and the course would fulfil, in an eminent degree, the condition that two crops of the same species should return at as distant intervals as possible. The pastures certainly are not growing the best grasses; at least the superior grasses are not sown in the proportion in which they ought to exist; for the land is sufficiently fertile to grow them. One-half, at an average, is the Holcus lanatus, which is a very inferior soft grass, disliked by horses, and not containing much nutrition. Alopecurus pratensis, Phleum nodosum, Lolium perenne, Festuca (pratensis), Poa trivialis, are seen very thinly scattered. The only way to obtain good grass seeds is to sow them in beds, reap them when their seed is ripe, and not, as is usual, obtain seeds from the hay-chamber, from grasses cut in the first week in July, when most of the superior grasses have not then ripened their seeds. Every large farmer should have a plot of land reserved for the purpose. Much difference of opinion exists regarding the variety of grasses which ought to be sown. Sinclair, in his Hortus Gramineus, gives a list of eighteen varieties, because he had found them in the best pastures examined by him; but Professor Low recommends only seven, saying that "it is the business "of the farmer to stock his pastures with the best "grasses which they are capable of producing; inferior "kinds will quickly tend to occupy the ground." The seven named by him are Alopecurus pratensis, Phleum pratense, Festuca pratensis, Poa trivialis, Dactylus glomeratus, Lolium perenne, and Lolium Italicum.

The most difficult part of the task is now the description of, and suggestions for, improvement of the lands subordinate to the true New Red Sandstone, *i. e.* of the two clay beds, which form the soils of Tilts, Owston, Akern, Womersley, &c. They may all be described as thin clay wet soils on retentive subsoils. The rent of the land averages from 8s. to 20s. The rotation of crops is the same as that pursued over the Diluvial district, viz.—fallow, wheat, seeds or beans, oats.* Barley is

* At Moss, frequently—fallow; wheat; beans; wheat; beans; oats. Five exhausting, and onerestorative, *crop*.

sometimes grown on the lighter varieties, but it is coarse in quality. The soil is too retentive for turnips, and when the course is fallow, wheat, beans, and oats, the land is occupied by three exhausting and only one restorative crop, so that it is cropped more severely than some of the superior qualities of land, which only increases its poverty. The want of turnips and natural feeding grass upon which to maintain stock, verifies the maxim, "no food no cattle, no cattle no dung, no dung no corn," concerning this land. Deep draining of twenty-two inches at least, thorough-draining by tiles, is little performed, (perhaps $\frac{1}{0}$ of the land is not drained at all,) and in no instance is it accompanied by deep ploughing. A writer in the Doncaster Farmer's Journal of 26th Sept., 1840, as a means of improving these poor clay lands, recommends a particular rotation of crops. Of them, he says that the quantity of turnip land is small, or none, and the scanty produce obtained from the lands affords a very limited supply of dung from the want of green crops, and the animal manures that accompany them. Lands, badly fed, cannot stand constant cropping, even with plants the most suitable; the soil must have rest, and since animal and putrescent manures cannot be obtained, it remains to produce vegetable matter in the soil itself. The four years' course exhausts thin soils; manure is applied once during the rotation, and scantily from want of material. He therefore recommends that seeds invariably be sown after wheat, and mown or pastured for two or three years. He gives a mixture of

½ bushel	Perennial Rye Grass.
½	Cocksfoot.
6lb.	Dogstail.
4	Catstail.
4	Meadow Fescue.
6	Red Clover.
4	White Clover.

Now there is no doubt that these lands would be improved under this management, provided the grass seeds would come to perfection; but, unfortunately they decline, and eventually are eradicated by the indigenous weeds of the soil. At Fenwick it takes twelve years to produce a tolerable swarth. The weeds are very numerous. Mr. Cooke, of Owston, has given me an incomplete catalogue of them, of which forty-six prevail in permanent pastures at Owston, and fourteen in their annual crops.

Weeds in permanent pastures at Owston:—

Achillea millefolium.
Agrimonia Eupatoria.
Ajuga reptans.
Alchemilla vulgaris.
Apargia hispida.
Caltha palustris.
Campanula rotundifolia.
Cardamine pratensis.
Carex palustris
C...... pennula
Centaurea nigra.
Chlora perfoliata.
Convolvulus sepium.
Epilobium hirsutum.
Erythræa centaurium.
Galeobdolon luteum.
Galium aparine.
Geranium Robertianum.
Glechoma hederacea.
Inula dysenterica.
Juncus, effusus, glomeratus, acutiflorus.
Lamium purpureum.
Linnum album.
Linum catharticum.
Lotus corniculatus.
Lychnis sylvatica.
Lysimachia nemorum.
——— vulgaris.
Myosotis palustris.
Orchis pyramidalis.
——— conopsea.
——— maculata.
Plantago major.
——— media.
——— lanceolata.
Primula veris.
Prunella vulgaris.
Ranunculus acris.
——— ficaria.
——— reptans.
——— bulbosa.
Reseda lutea.
Sanguisorbia officinalis.
Senecio Jacobæa.
Vicia cracca.

Weeds in annual pastures at Owston:—

Anagallis arvensis.
Bartsia odontiles.
Convolvulus arvensis.
Epilobium parviflorum.
Euphrasia officinalis.
Hypericum perforatum.
Alopecurus agrestis.
Lychnis dioica.
——— sylvatica.
Myosotis arvensis.
Ranunculus arvensis.
Rhinanthus crista-galli.
Sonchus arvensis.
Tussilago farfara.

Of the weeds in permanent pastures, the carex palustris and pennula form one-third of the grasses, and give that peculiar blue tint to the swarth. The alopecurus agrestis and sonchus arvense are exceedingly troublesome to the corn crops; the former by farmers is supposed to produce rot in sheep, and is called "spry"; it ripens the seed in June, and consecutive crops of it continue flowering all the summer.*

Now, it is evident from the analysis of the Womersley and Owston, and Whitley soils, that they do not owe their infertility to their texture, for, according to Thaër's classification, his best soil contains 80 per cent. of clay, while the stiffest of these do not contain 45 per cent. All this country lies very flat, there being only 15 feet of fall between Goole and Ferrybridge, although the means of draining into the Went and Don are much improved lately. It was before remarked, that if the subsoil is retentive, the soil, if shallow, whatever its quality may be, will likewise be wet, and if these lands had a much less tenacious soil, they would be wet from the want of draining. The first step, then is to get rid of surface water, which now is left to be evaporated by the atmosphere, for no other egress has it. The next step, after affording a passage for surface water, is to carry away the stagnant water from the roots of the plants, which can only be effected by deep subsoil

* There are also two or three varieties of moss very prevalent; but of the musci it may be said that they are not the cause but the effect of infertility, and never injure land. The grass turf always degenerates before they ever vegetate. The sporules in the first instance receive nourishment from the soil, but after a short time the roots of the moss plant die and it receives nutriment from the air alone. They, in fact, preserve the grass from cold in winter, and the heat of the sun in summer.

ploughing, by which the land is left in as light a state as if it had been dug or trenched. It is very singular that the subsoil plough, invented by Smith of Deanston, and which has effected such a change in wet lands in Scotland, has scarcely been even heard of by the farmers of this district, and yet this is the very land to which it is adapted. Before using the subsoil plough the land must be well drained to the depth of 22 inches at least; the width from drain to drain may vary from 4 to 7 yards, according to the nature of the subsoil. The subsoil plough follows the common plough after it has turned up each slice, and by the double ploughing the land is to be stirred to the depth of 16 inches, 6 inches being left between the sole of the plough and the top of the drain. Concerning this plough and thorough draining, I shall beg leave to quote two passages from Mr. Smith's pamphlet, published by Drummond of Sterling:—"Thorough draining is the "*foundation* of all good husbandry, and when combined "with *deep ploughing* ensures a general and uniform "fertility, assisted, no doubt, by those essentials, "thorough working and cleansing, ample manuring, "and a proper rotation of cropping. Being asked by "the Committee of the House of Commons—'Have you "used your subsoil plough without having the land first "drained?' he answered, 'I have, and it is the worst "thing possible to deep plough land without having it "first drained'; and it is upon that ground that in "England the shallow ploughing is so much resorted "to; the deeper stiff clay is ploughed the worse it is, "because there is thereby a greater reservoir formed to "hold water. So soon as wet lands are thoroughly "drained, deep ploughing may follow with the greatest "advantage, but not sooner." The following passage is taken from Mr. Shaw Lefevre's Letter to his constituents in North Hampshire—(he was Chairman of the Select Committee to investigate the causes of agricultural distress)—and is worthy of notice:—"The "most astonishing effects, however, appear to have been "produced by a new agricultural implement, the "invention of Mr. Smith, of Deanston, near Sterling, "called the subsoil plough. This machine is a necessary "accompaniment to draining; but when that is done "effectively, it seems calculated to render the most "sterile and unproductive soil fertile and profitable. "Mr. Smith's most ingenious invention, (which is "admirably described in his evidence, to which "I beg to refer you for a more complete explanation "of its principle), by breaking the subsoil without "bringing it to the surface, renders it pervious both "to air and water. The same chemical changes which "take place in a fallow, owing to its exposure to "the action of the wind and rain, are thus brought "to operation in the subsoil, whilst the upper is in "the ordinary course of cropping; and when, after a "few years, by a greater depth of ploughing, the sub- "soil is mixed with the upper, it is found to be so "completely changed in its nature as to be capable of "producing every description of corn. The advantages "of this system of husbandry are so apparent that no "farmer will be at a loss to appreciate the merit of the "invention. I believe it to be quite as important an "improvement in the management of clay lands, as "the introduction of the turnip system has been with "reference to light soils, and as the experiment has been "tried for twelve years, and with uniform success, I "cannot but anticipate its ultimate adoption in those "districts of England where, from the cold retentive "nature of the soil, the greatest extent of agricul-

"tural distress has hitherto prevailed, and where "draining is essential to preserve them in a state of "cultivation."

I can only add, in proof of the efficacy of draining and deep ploughing, the success attending it upon a farm now occupied, and scientifically conducted, by the Honourable Stanhope Hawke, situated on Clay No. 1. This land, four years ago, even with excessive manuring, could not be made to produce more than five loads of wheat per acre; this year it has upon it twelve loads. Some of it is now being subsoil ploughed by a plough of Mr. Gully's, who has obtained abundant crops by its use.

In the next paper I purpose describing the country from Bawtry, by Hatfield and Thorne to Goole*; to notice particularly the abuse of lime upon large portions of these wet soils, where it is converted into a hydrate before it can act on the vegetable matter as a solvent; to notice the breeds of cattle, for different breeds are adapted to particular geological situations as much as the plants upon which they feed; and if, by a judicious selection and crossing of animals, we obtain that breed which attains the greatest weight and earliest maturity, on the least quantity of food, the soil then secures the greatest profit with the least labour, and produces the maximum quantity of animal food of which it is capable; and hence Geology is not only connected

* Since the above was written, I find that the Society's next meeting will be held at Doncaster; I intend, therefore, to treat first of a district that will have more local interest—the Magnesian Limestone Tract from Worksop to Ferrybridge.

with soils and the rocks from which they are frequently produced, with the chemical component parts of them, with the plants which they produce, with the manures which feed these plants, but with cattle and sheep which again feed upon them, and which God has given for the use of man.

The Earl Fitzwilliam said he was sure they must all feel obliged to Mr. Thorp for the trouble he had taken in compiling the paper, and he trusted they would be able to enlist some antagonist of Mr. Thorp's views, who would put some questions to him upon the various opinions which he had advanced. When he said "antagonist," he did not mean to be understood as wishing that they should be refuted, but that they should be established upon a firmer basis than the mere *ipse dixit* of any individual; he should therefore be glad if any one would enter the lists.

The Rev. Theo. Barnes said he would enter the lists, but not as an antagonist. Mr. Thorp had mentioned Mr. Smith's subsoil plough; but he had not mentioned a machine which was getting into great use in the neighbourhood of Pontefract, and which was producing larger crops than could be produced on some lands without it. That machine was called "Crosskill's Crusher." There were some lands which were so open, as Mr. Thorp would say, especially in the neighbourhood of Doncaster, that they would derive great advantage from the use of this crusher. He had heard a farmer say that he could get two loads an acre more by using this instrument than he could without it. Sir George Wombwell had an estate in the North Riding on which he never thought of growing corn until he had become acquainted with the use of this crusher. The cost of the implement was about £10 for a heavy one, and £5 for a light one; and he thought the light one would generally be sufficient. There was a singular fact, to which Mr. Thorp had not adverted, which he would just mention. In Devonshire, where the Red Sand stone soil prevailed, the apples grown produced cyder possessing both a stronger body and a higher flavour than those which were not grown on such soils. He was sorry that Mr. Thorp had left out this encouragement to the cyder trade, and this encouragement to the landlord to grow apples.

Earl Fitzwilliam inquired whether the instrument described by Mr. Barnes pressed the soil, or it only pressed the furrows?

Mr. Barnes.—It only presses the furrows.

Earl Fitzwilliam said he thought it would be of very great use on all the limestone soils.

Mr. Charles Morton said it was a matter of gratification to himself and all who were friendly to the society, that Mr. Thorp should have undertaken to show the connection between Agriculture and Geology, because it interested a very large and very influential class who had hitherto withheld their support from the society. He did not recollect having seen at the meetings of this society many agriculturists before to-day. Its members had chiefly been connected with coal and iron mining. This was very much to be regretted, and he hailed the very able paper which Mr. Thorp had read that day as an inducement to those gentlemen to come amongst the members of the society, and he hoped they would soon join them. He thought they must have seen by the developement of Mr. Thorp's views, and his map and section, that Geology was intimately connected with Agriculture, and that if they studied it attentively it must be of great importance to them in an economical point of view. He was much interested by Mr. Thorp's statement of the different crops which grew upon different strata, clearly shewing some relation between the vegetation and the substratum of a district. He had read Sir Humphrey Davy's views on this subject in his valuable work on Agricultural Chemistry, and had also heard of the important results which Mr. Coke (now Earl of Leicester) had obtained by mixing lime and sand and clay in such proportions as to obtain a soil almost permanently fertile. But it seemed by Mr. Thorp's statement, that great improvements could yet be made, and he thought Mr. Thorp was fully competent to the investigation of the subject, because he was well acquainted with chemistry and geology, as well as with practical farming; and he hoped he would be able to throw much additional light upon agriculture. If by this combination of chemical and geological information, and its application to practical agriculture, they should succeed in obtaining the greatest possible fertility of the soil, the labours of this society, and of Mr. Thorp in particular, would not have been in vain. Before he sat down he would take the liberty of requesting the noble Chairman to call upon a distinguished geologist, who was in the room, to favour the society with his views on the subject.

Earl Fitzwilliam said he wished to ask Mr. Thorp a question on the subject of his paper. He had alluded to the artificial admixture of sand with clay soils and clay with sandy soils. He wished to know whether in his researches upon the subject, he had found that such an admixture had been made either by the occupiers or landowners in the district he had spoken of, and whether any observations had been made upon the effect produced by such an artificial admixture, as had been made in other parts of the country. His Lordship said that he did not know whether in the line which Mr. Thorp had pursued, he had visited what was called the fen country, below Hatfield Chace, but in a part of that country with which his Lordship was acquainted, there had been introduced within the last few years a practice of claying the soils which had greatly increased their fertility. The time was when the black soils produced no wheat, or if they did, it was exceedingly bad in quality; but when the black soil was clayed, where the subsoil happened to be clay, it was greatly improved. Within the last ten or fifteen years the practice of digging out the clay and throwing it upon the surface had been much adopted, and the consequence had been a great improvement of those soils, rendering them capable of bearing to a very considerable extent.

Sir Francis L. Wood said that Mr. Banks of Wothersome had done so to a considerable extent.

Mr. Walker Smith said he was acquainted with some gentlemen who had mixed clay with other soils to a considerable extent, but whether the advantage derived arose simply from the admixture or from the operation of the atmosphere was a point to be determined. If by such an admixture they could constitute a soil that would preserve an equality of temperature, and would not give out, during the night, the heat it had acquired during the day, he apprehended that some improvement might be effected.

Sir Francis L. Wood said he knew so little of geology that he was not prepared to enter into the general question, but he was perfectly convinced that an acquaintance with the science was necessary to a perfect knowledge of the art of farming; and that the farmer must know something of the nature of the subsoils before he could advantageously mix them for the production of corn or grass. There was an experiment tried lately near Hatfield of mixing sand with the peat or black earth, which had proved so successful that they could now get crops of Swedish or common turnips six times better than they could get them before.

Professor Sedgwick said, that having been so pointedly called on, he should say a few words, though the immediate subject of their discussion was one to which he was almost a stranger; he meant the nice examination of soils and their bearings upon agricultural produce. His pursuits of geology had been on a large scale, and he had studied its relations to great questions both of natural history and of general physics; but its application to the science of agriculture he had hardly ever touched upon. They were all greatly indebted to Mr. Thorp for the skill with which he had drawn up his paper, and for the instructive facts and observations he had laid before them.

With regard to the connexion between geology and agriculture, (the subject on which he was called on to speak,) he might just remark, that a knowledge of the great mineral masses that constitute the superficial portions of the earth was the first business of geology; and it was true that each successive deposit was derived from a new arrangement of the materials that preceded it. To this rule the vegetable soil, or, at least, the materials on which it rested, and which in fact entered into its composition, offered no exception; they were derived from the deposits which preceded them, and which might be considered as the raw material out of which they were formed; so far, there was an undoubted and immediate connexion between geology and agriculture. But there were often insuperable difficulties in proving this connexion from the phenomena of a limited district, for the drifted matter forming the subsoil, to which Mr. Thorp had given the name of *diluvium*, was often on so large a scale, and had been brought from so great a distance, that the materials of most importance to the agriculturist had scarcely any relation, in their structure or composition, to the rocks in his immediate neighbourhood.

This remark did not, however, apply to the soils in the vicinity of Doncaster, which, according to the facts plaeed before them, seemed to be derived from the pulverisation and comminution of the neighbouring strata of the country. But let any member of the Society examine the subsoils of the North or East Ridings of Yorkshire. Would he then be able to come to a similar conclusion? Unquestionably not. The transported matter under the vegetable soil had often come from a great distance. For example, in the South Eastern Cliffs of Yorkshire there were innumerable pebbles and large boulders which could not be assimilated to any known British rock; and there was good reason for supposing that at least some of them had been drifted by marine currents or floated by icebergs from the Scandinavian Chain. Some parts of the Southern cliffs of their native county contained also blocks of Shap granite, and other masses derived from the Cumbrian

Chain; and the same kind of boulders might be traced nearly along the whole of the lower valley of the Tees.

He did not offer these facts as new, but as proofs that the subsoil was often drifted in considerable parts, from a great distance, and that the connexion between agriculture and the primary objects of geology was less immediate than might be at first sight imagined. He did not make such statements with any view of discouraging their investigations; far from it. He only wished to caution them against the seduction of hasty generalizations, which often led to disappointment, and so tended to retard science.

The conclusions to which these general remarks seemed to point, might be illustrated by an appeal to facts of a more specific kind. Take, for example, the carboniferous limestone in its range through Derbyshire, Yorkshire, and Cumberland, to the confines of Scotland. In one place they had associated with it, and partly derived from it, a soil of extreme fertility and well irrigated; in another, a soil deficient in quantity and unproductive from want of water; in a third, (for example, in parts of Westmorland and Cumberland,) a sandy and barren soil had been drifted over the limestone from the neighbouring sandstone formation. The same rocks give support, therefore, to soils of most contrasted qualities.

It was not, therefore, true that the agriculturist could in the first instance derive much help from the study of a geological map. It was only by minute details and local investigations, (like those just read,) that he could learn the nature and value of his subsoil. But this knowledge once gained, he was then prepared to receive the contributions of geology, and to turn them to profit. For geology teaches the true principles of irrigation, and determines the distribution of all mineral treasures; and such knowledge must ever have an important bearing on the economical labours of the agriculturist.

Again, geology led to the study of great physical laws; and the contemplation of such laws had ever tended to promote the well being of man. They gave a dignity and consistency, and a bearing to the minutest investigations of nature; and had always been found, and often in a way little expected, to have a bearing on the utilities and conveniences of life.

In alluding to practical questions he must speak with great humility, and trusted that he might claim the indulgence of the gentlemen then assembled, who were incomparably better acquainted with such matters than himself. There were, however, some hints in the paper they had heard that morning, on which he trusted they would proceed to act, by the formation of experimental gardens on a great scale. In such gardens every variety of seed might have a fair trial in combination with every variety of soil. Every variety of manure might in turn also have its proper trial; and out of the combined results some practical conclusions might surely be arrived at. And when the first series of results had given them experimentally the quantity of produce under given conditions of cultivation, the experiments might again be followed out by ascertaining the successive rates of exhaustion by the repetition of the same crops, as well as the best succession of crops, to secure permanent fertility. These were noble experiments; and they were of a nature not to be expected from the practical farmer.

If made at all, at least if made properly, it could only be by the combined efforts and capital of a society of gentlemen deeply interested in agriculture, such as he had then the honour of addressing.

Before he sat down (lest a false impression should have been produced, by what he had first stated,) he hoped he might be permitted to allude to one or two instances which had lately fallen under his observation, and which proved how important it was to the agriculturist to have a knowledge of the structure of his country. In several parts of the Bedford level, and the fen lands to the north of it, very expensive sinkings had been undertaken, in the hope of procuring water, but they had all failed. Now any geologist, (though he might not have blamed the experiment,) would have anticipated the result. For the Oxford clay forms the substratum of all that flat region, and is of such enormous thickness that it has never yet been pierced through by any sinking, far removed from the beds which crop out from under its lower surface. On the contrary, the success of the Artesian wells of Essex, (of inestimable value to the farmer when the surface water fails, as it does in very dry seasons,) would have been anticipated by any geologist, before a single boring rod had pierced the London clay. Examples like these show that a knowledge of the stratification of his district may direct a farmer to the useful employment of his capital, or save him from the improvident waste of it.

If a knowledge of geology was of value in teaching the best methods of bringing water to the surface, it was also of obvious value in all great questions of draining. Top water might sometimes be carried off by drains conducting it to the outcrop of a pervious stratum. Thousands of acres of land were poisoned by stagnant water drained from the outcrop of beds of clay. Very often, in such cases, the evil might be cured by a single longitudinal drain cutting off the water at its source. Ignorant as he was of practical matters, he might dare to say that he never returned from a geological tour without having seen some flagrant instance of waste of capital from unscientific draining.

The grandest examples of draining were to be seen in the Bedford level, and the country to the north of it, from which he had lately returned. It was true that such works belonged to the civil engineer rather than the geologist. But all the geological maps (years before the information was turned to any good account) had taught the farmer that under his light fen lands was an inexhaustible supply of clay, which might be obtained at a small expense, and spread upon the surface. By this treatment, adopted only within a few years, thousands of acres of dry turf soil gained at once tenacity and fertility, and were loaded year by year with the richest crops of corn. As an example of this kind he quoted an estate near Downham, which not long since might have been purchased for £1,300, and was now let for £1,300 a year.

In conclusion, he begged to thank Mr. Thorp for his investigations, and hoped that he would go on with them; and he trusted that his recommendations would meet with effectual support from the members of the Society.

The Rev. W. Thorp said that his remarks upon what had fallen from gentlemen around should be very brief. As Mr. Barnes had departed he would not enter into the question as to the growth of apples; but Professor Sedgwick knew very well whether the Devonshire apples were grown upon the Old Red Sandstone or not.

Professor Sedgwick.—They were grown upon the New Red Sandstone; but in Herefordshire they are grown upon the Old Red Sandstone.

The Rev. W. Thorp said there was more matrix in the Old Red Sandstone than in the new. With respect to the mixture of soils, he might state that Mr. Childers had tried it to some extent upon 20 acres of his park. With regard to Hatfield Chace, and the peaty soil there, he had not yet examined it, and peaty soils required great consideration. He hoped to make a number of small bore-holes, to get to know of what the subsoils consisted, and those subjects would come into his next paper. With regard to the drift beds of Yorkshire, he should have to show in the evening that they were of very different origin.

Specimens of wire rope, with a variety of fossils, were exhibited, and

Specimens of the sinkings of a Colliery at Castleford, worked by Messrs. Stansfeld and Briggs.

The meeting then adjourned.

In the evening the Rev. W. Thorp read a continuation of his Illustrations of Yorkshire Geology, which will be published on a future occasion.

TABLE I.

CLASSIFICATION OF SOILS.

No.	THAER'S LIST.	Clay. Pr.cent.	Sand. Per cent.	Carbn. of Lime. Pr.cent.	Humus. Per cent.	Value.
1	First class of strong Wheat Soils.	74	10	4½	11½	100
2		81	6	4	8⅗	98
3		79	10	4	6½	96
4		40	22	36	4	90
5	Rich light land in natural Grass	14	49	10	27	?
6	Rich Barley	20	67	3	10	78
7	Good Wheat	58	36	2	4	77
8	Wheat Land	56	30	12	2	75
9	Ditto....................	60	38	Very minute quantity.	2	70
10	Ditto....................	48	50		2	65
11	Ditto....................	68	30		2	60
12	Good Barley	38	60		2	60
13	Ditto, second quality......	33	65		2	50
14	Ditto....................	28	70		2	40
15	Oatland	23½	75		1½	30
16	Ditto....................	18½	80		1	20

SINCLAIR'S LIST.	Alumina.			Vegetable Matter. Per cent.
Poor Silicious	2	84	0.5	1
Hungry Sand	1.5	89	1.5	1.5
Heath Soil	0.5	79	—	16
Rich Silicious	2	74.5	1	7.5
Sandy Loam	4	70	1	5
Rich black Clayey	5	41	5	10
Clayey Loam.....................	14.5	47	2	4
Tenacious Clay	13.7	39.7	6	2
Rich alluvial (best)	7.	46	6	8.5
Vegetable Mould	4.5	58	—	14
Fertile Peat	4	39	—	17
Mr. Tower's Loam		83 fine.		
Sir H. Davy's rich Soil, Drayton	29	32	32	11
Turnip Soil..................	11	15	63	5
Tillet's best Loam in France	16	66	37	
Loam at Chamart, used as basis of artificial Soils	33	64	1	0.5
				16
Rich Bog Earth (Meadow)........	—	62	0.8	2) fibres.
Polder of Orderon..........(Clay)	81	18	—	
Ditto of St. Catharine	52	21	19	iron 7½
Waes district of East Flanders	13	84		iron 3
Arksey, near Doncaster	6.2	61.5	3	7 humic acid.
Womersley......................	41	31	12	15 vegetable matter.
Cantley	—	86.5	—	
Ditto Yellow Clay and Boulders ..	—	76	—	
Owston	56?	34	10?	
Womersley worst land............	36½	54	10?	
Stockridge, near Arksey	—	35	—	

TABLE II.

A TABLE OF MANURES ACCORDING TO THEIR ACTION.

BY YIELDING NUTRITION TO THE PLANTS IN THE FORM OF CARBONIC ACID, OR AMMONIA.	BY YIELDING EARTHY AND SALINE MATTER.	BY ACTING UPON NUTRITIVE MATTER CONTAINED IN THE SOIL. BY FERMENTATION.	BY ACTING UPON NUTRITIVE MATTER CONTAINED IN THE SOIL. AS CHEMICAL SOLVENTS.	BY ACTING ON THE TEXTURE OF THE SOIL.	AS STIMULANTS ON THE ROOTS.
RAPE CAKE { Contains mucilage, albumen, a little oil, and woody fibre. To be used *fresh.*		Rape Cake excites great fermentation, and thus acts powerfully on the nutritive matter in the soil, and as it contains little itself it *exhausts.* (Madder.)			
MALT DUST contains saccharine matters. To be applied *fresh.*		☞ When a putrescible substance is mixed with inert vegetable matter (as fermenting dung with dry peat) putrefaction is produced in the whole mass.			
STEEPINGS OF FLAX AND HEMP { Contain soluble putrescent matter, vegetable extract, and matter analogous to albumen. Require no preparation.	All more or less.				
GREEN PLANTS { Contain saccharine and mucilagious matters and ligneous fibre. Applied when flowering.	GREEN PLANTS in the ashes of their ligneous fibre.				
STRAW { Soluble matter 8 grains in 400, and soluble salts, earthy phosphates, carbonates, &c. Less fermented to a fallow; more rotten to turnips.	THE ASHES OF WHEAT STRAW contains earthy phosphates 6 per cent., carbonates 1 per cent., silica 61·5 per cent., metalic oxide 1 per cent., soluble salt 22 per cent.	All vegetable manures slightly.	Lime and the alkalies decompose vegetable matter and ulmic acid, they are therefore *exhausters.*		This mode of action is only probable.
PEAT, WOODY FIBRE, TANNER'S SPENT BARK, { Contain no soluble matter, but are to be mixed with hot lime or fermenting farm-yard dung to decompose them.	Phosphate of lime in the straw of all the cerealia, and of peas, beans, and tares; is soluble in water containing an acid.				
FARM-YARD DUNG, { Of Sheep, 3 per cent. soluble matters, which are animal mucus and bitter extract; remainder woody fibre, more valuable from fed cattle than lean as 10 is to 16. If rotted to a dark unctuous mass, one half of the animal parts is lost.	DUNG OF CATTLE, nearly all which the food contained.				
DEAD ANIMALS { Contain gelatine, fibrine, mucus, fatty or oily matter, albumen, urea, uric acid, and different saline and earthy matters, and therefore yields nitrogen.					
FISH. { The skin is gelatine, and easily soluble in water; fat, oil, and fibrous matter. Ploughed in fresh and applied sparingly.	FISH.—Phospate and carbonate of lime. Cartilage according to their species.				
BLUBBER.—Carbon and nitrogen in it account for its effects. To be mixed with soil.					
EXCREMENT { Abounds in substances composed of carbon, hydrogen, azote, and oxygen. To be mixed with lime or marl.	All yield earthy and saline matters in some degree.				
URINES, { Of Cows, contain water 65, phosp. of lime, 3, muriates of potassa and ammonia 15, sulp. of potassa 6, carbonates of potassa and ammonia 4, urea 4. Of the Horse: carbon. lime 11, carbon. soda 9, benzoate of soda 24, muriate of potassa, 9, urea 7, water and mucilage 940. To be diluted with water, and suffered to ferment.	URINES.—Phosphate of lime, muriate of potassa and ammonia, sulphate of potassa, carbonate of potassa and ammonia, urea.	All more or less.			
HORN, { More powerful than bones; 500 grains of ox horn yield 488.5 grains of coagulated albumen, and 1 part phosphate of lime. Is rendered slowly soluble in water.	HORN.—1.5 in 500 grains of ox, phosphate of lime.				
HAIR, WOOLLEN RAGS, FEATHERS, { Analagous in composition to horn, and consist of albumen united to gelatine.					
BONES { Consist of gelatine, albumen, animal oils and fat, 38 per cent. The more divided the more powerful are their effects. The gelatine contains nitrogen.	BONES contain phosp. carbon, sulphate and fluate of lime, and carbonate of soda, 62 per cent.	Bones excite great fermentation, and thus decompose the nutritive matter in the soil; and, as they contain comparatively little soluble matter themselves, they *exhaust.* (Madder.)			
SOOT { Yields a brown extract to hot water; also empyreumatic oil and charcoal, in a state capable of being rendered soluble by the action of oxygen and water; and ammonaical salts are formed.					Soot turns the blade dark green.
	CHALK contains carbonate of lime.		Lime (hot) decomposes vegetable fibre, and also unites in the proportion of 28 grs. lime with 318·5 humic acid.	MARL.	
	GYPSUM found in clovers, sainfoin, and all grasses, and in turnips in small quantity. It fixes ammonia in the soil.			CHALK.	
	MARL.—Carbonate of lime.			LIME (mild)	
	*SALTPETRE is found in barley; is always formed in all soils when azotized substances are exposed in a mixture with lime and oil.			CLAY.	Saltpetre probably stimulates the roots.
	NITRATE OF SODA.—Its fertilizing effects due to the nitrogen principally.		Common Salt. With carbonate of lime salt forms carbonate of soda and muriate of lime, and the carbonate of soda acts as a solvent.		
	COMMON SALT, a direct constituent of many plants.				Dr. Priestley says he proved salt to be a stimulant.
	KELP AND SEA WEEDS contain carbonate of soda.		Carbonate of soda in kelp.		
	ASHES OF PLANTS.—All the saline ingredients of the plants from which they were derived, together with humic acid and carbonate of potassa.		Carbonate of potassa in ashes.		
	PEAT ASHES, some one-third to one-fourth gypsum.		Iron, when soluble, is prejudicial. In the decomposition of farm-yard dung, sulphuretted hydrogen is one of the products, and when oxide of iron comes in contact, water and sulphuret of iron by exposure to the air become converted into sulphate of iron (a soluble salt), but by carbonate of lime there results gypsum and oxide of iron, which is inoffensive.		
	SULPHATE OF IRON, decomposed by carbonate of lime into carbonate of iron, and forms gypsum.				

* Composed of

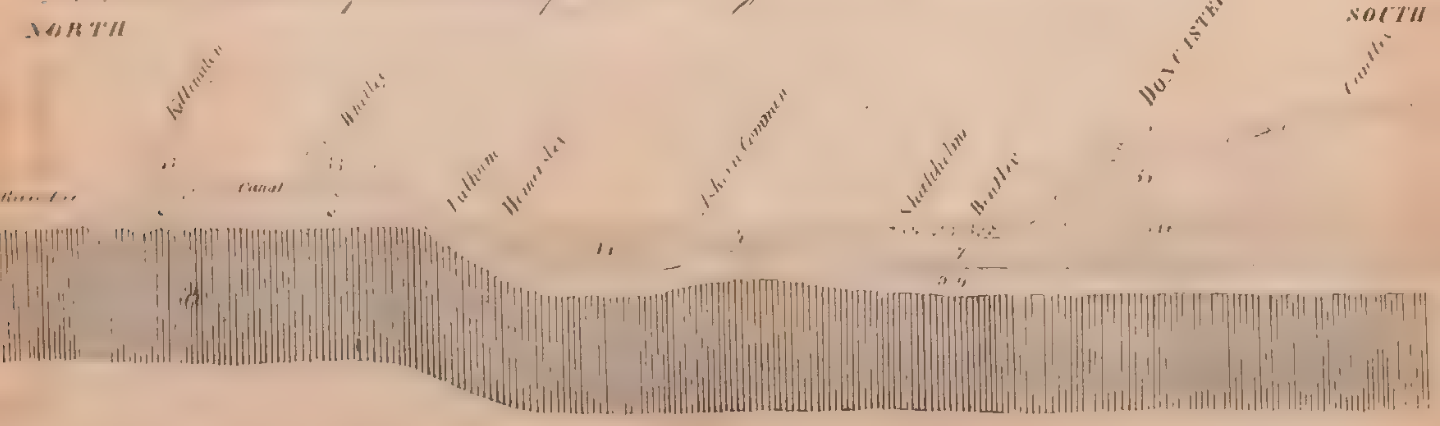
14 Nitrogen. 48 Oxygen. 40 Potassa. } Arranged { 14 Nitrogen. 40 Oxygen. } Nitric Acid. { 40 Potassa. 8 Oxygen. } Potassa.

The origin of nitric acid is from the nitrogen of the animal or vegetable matters combining with the oxygen of the air, or that contained in the organic matters themselves.

Plate I

Geological Map of the Soils from Bawtry to the River Aire.

[illegible] of the Soils from [illegible] to the River Aire



PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE TWELFTH QUARTERLY MEETING, HELD AT DONCASTER, ON THE 2ND DECEMBER, 1840.

Sir W. B. Cooke, Bart. having moved that E. B. Beaumont, Esq. do take the chair, and the motion having been seconded by W. B. Wrightson, Esq., M.P.,

The Chairman addressed the Meeting as follows:—

Ladies and Gentlemen,—When I was first requested to take the chair at this meeting, I hesitated to comply, inasmuch as in a district so large as that of Doncaster, and where there are so many men of highly intellectual and highly influential qualities, who are so much better acquainted with the subject than I can presume to be, I felt that I was the last man in the room on whom this duty should have devolved; but when it was expressed to me that I might do a service to the Society by taking the chair, I felt I had no alternative, and that the choice was no longer left to myself. I am here, therefore, to do my duty, and I trust to your indulgence in endeavouring to discharge it. I hope the interests of the society will not suffer on account of my humble abilities, and my limited acquaintance with the subject that is to be brought under discussion. This is the twelfth meeting which the Society has held, and as its objects are so well known to all of you, that I shall confine the few remarks which I have to make to what I consider the more immediate application of the science of Geology to this neighbourhood. At a late meeting of the Society held at Sheffield, Mr. Martin, the chairman, made some most appropriate remarks with reference to the application of Geology to the neighbourhood of that town, which owes not only its wealth, but its position in the commercial world, to the numerous veins of ironstone and coal with which it abounds; but in this neighbourhood, which is purely of an agricultural nature, I shall call your attention to remarks most applicable to it in that light. Without an acquaintance with the analysis of the soil, it is impossible that farming operations can be conducted to advantage. How often do we see the application of Geology entirely neglected in agricultural pursuits? How often do we see alkaline tillage heaped on lands that are already saturated with alkaline matter? It is the peculiar province of Geology to remedy these errors; and if it does not inform us of the exact description of tillage which would be most beneficial, it is at least calculated to prevent us from applying those which are obviously injurious. I do entreat my brother farmers to consider this, not as a mere theory, not as a drawing-room refinement of science, and recommending that which is impossible in practice, because I imagine it to be far otherwise, and I believe it to be in the power of every farmer to make himself acquainted with the nature of the soil. The chemical analysis necessary for this purpose is by no means difficult; the utmost refinement of such analysis is not called for in such an investigation. I do not mean to say that a farmer is to make the most abstruse sciences his study; but what I mean is, that by the commonest attention to what is obvious to every body, he may safely and advantageously apply the science of Geology to the soil in his own district. As there may be some among us who are neither landowners nor coalowners, nor interested in any way in the soil, and who may consider the science of Geology purely as a science, but whom it is equally my interest to enlist in our cause,—to them I would say, that as a science, it stands, perhaps, second to none. The elements it offers for philosophical inquiry are abundant. The objects to be achieved are of common interest to all; and although nothing is to be acquired without intellectual exertion, yet at the same time it is not necessary to call in the aid of the more abstruse sciences for their true development. The salutary truths which Geology offers even to the most common observer, are so intimately bound up with the moral of our existence here, that I can scarcely conceive the mind to which this study would not impart gratification of the highest and most refined description. Insinuations have been thrown out not only against science in general, but more particularly against this, our favourite science, namely, that it is at variance with revealed religion; or, in other words, that the facts which it teaches are at enmity with truth. This accusation is so exceedingly absurd, that I think it beneath me to attempt to refute it. One thing, however, I may say, that if there is one circumstance more than another which can lend a charm to the study of this science, it is that it proves, even to our finite understandings, that the infinite system of the universe harmonizes with its history as recorded in the Bible, and it proves to the very letter that we ought to be satisfied with the truth as it is there told us. Nay, we may go further than this. I say, taking the Mosaic account, about which some trifling doubters have cavilled, as not being consistent with their ideas of reason, modestly supposing that what they cannot comprehend must be incomprehensible, that according to the undulating and only correct theory of light, that account is directly in accordance with our views, and is consistent with what common reason might suppose it would be, and it would be obviously incorrect in us to adopt any other system than that which is there laid down. This is only a faint outline of the many advantages which the study of Geology affords; and upon its utility I need not dwell, for it is obvious in every step we take. I will not trespass upon your time by offering any further remarks of my own, but simply move that the business of the day be proceeded with.

The following gentlemen were then elected members of the Society:—

Sir W. B. Cooke, Bart. Wheatley.
J. W. Childers, Esq. M.P. Cantley.
P. D. Cooke, Esq., Owston.
George Cooke, Esq., Carr-House.
J. G. Elmsall, Esq., Woodlands.
H. M. Greaves, Esq., Hesley.
J. Fullerton, Esq. Thriberg Park.
C. Wilson Faber, Esq., North Deighton, Wetherby.
W. B. Wrightson, Esq. M.P., Cusworth.
Thomas Walker, Esq., Wilsick.
Wm. Aldam, Jun. Esq., Warmsworth.
G. C. Yarboroogh, Esq,. Campsmount.
J. S. Bower, Esq. M.D., Broxholm.
Edw. Kater, Esq., Mexborough.
Rev. Geo. Chandler, Treeton.
Rev. Wm. Monk, Owston.
Mr. Wm. Eddison, Huddersfield.
Mr. George Masser, Leeds.
Mr. John Maxfield, Wath.
Mr. William Thorp, Thorne.
Mr. Jas. Alexander, Doncaster.
Mr. Charles Baker, Do.
Mr. Edmund Baxter, Do.
Mr. Thomas Brooke, Do.
Mr. Charles Jackson, Do.
Mr. T. R. Mandall, Do.
Mr. J. E. Morey, Do.
Mr. Isaac Morley, Do.
Mr. Edw. Sheardown, Do.
Mr. Robert Storrs, Do.
Mr. G. C. Walker, Do.
Mr. W. C. Wimberley, Do.

The following Communications were then read to the Society:—

ON THE AGRICULTURE OF THE WEST RIDING OF YORKSHIRE CONSIDERED GEOLOGICALLY:

2ND. ON THE MAGNESIAN LIMESTONE DISTRICT.

It has been truly said, that "there is no profession which can be compared in importance with that of agriculture, for to it belongs the production of food for man and animals; on it depends the welfare and development of the whole human species; the riches of states, and all commerce." But a rational system of agriculture cannot be pursued without the application of scientific principles; for such a system must be based on an exact acquaintance with the means of growth and nourishment of plants, the comparative value of their produce as food, the action of different manures upon them, and the influence of soils in their development. It is then to physiological Botany, Chemistry, and Geology, to which both the theoretical agriculturist and the practical farmer are to look for aid to supply the practical principles on which the art depends. In the two former branches of science, little has been done since the time of the immortal author of Agricultural Chemistry, until very recently Professor Liebig, of Giessen, justly celebrated as the first organic chemist in Europe, has endeavoured to follow the path marked out by Sir Humphrey Davy, and we have now before us a series of facts of the highest interest, and such that, by their adoption, Dr. W. Gregory predicts a new era in agriculture is about to commence.

At our last meeting, I had the pleasure to describe the agriculture, in its chemical and geological relations to the soils of a portion of the new red sandstone series, extending over the country from Cantley, Doncaster, Arksey, Owston, Askern, Womersley, to the river Aire and Calder; and it is now purposed to extend the same observations to the magnesian limestone formation, commencing in the south of

Yorkshire, near Worksop, and terminating at the same point, the river Aire and Calder. I hope therefore,—

I. To examine the soils, in connection with their Geology, over each of the beds subordinate to the magnesian limestone, to produce vertical sections of their thickness, &c., and to project them upon a map of six inches to the mile.

II. To inquire what aid may be derived from physiological Botany and Chemistry in their cultivation.

III. To describe the state of agriculture as at present existing, and offer some suggestions for its improvement.

I. The magnesian limestone from near Worksop to the river Aire and Calder, consists of four independent beds, each varying in agricultural character. The section of the whole beds consists of, in the descending series—

	YARDS.
1. Upper, thin-bedded grey limestone	7 to 12
2. Red marl and gypsum...........	10 „ 30
3. Yellow magnesian limestone	50 „ 80
4. Lower red sandstone of Sedgwick or Pontefract Rock of Smith..............................	10 „ 25

1. *The Upper Slaty, or Grey Thin-bedded Limestone** first commences at Carlton, near Worksop, and from thence ranges north by Oldcoats, where it is now dug for agricultural purposes, from thence it passes to Tickhill and Wadworth, where it is cut asunder by a considerable fault, and then forms a narrow zone of productive land by Loversall, Balby, to Hexthorpe, near Doncaster; it afterwards passes over the River Don to Cusworth Park. Between Hexthorpe and this latter place it has been denuded to a considerable extent, and the fertile grass lands between these two places are of alluvial origin, and must on no account be classed among the limestone soils. From Cusworth, it extends to the east of Marr,

* See Map and Vertical Section.

by Adwick-le-Street, Robin Hood's Well, and as far east as Owston Park, thence by Campsall, Womersley, Criddling Stubbs, to Knottingley. The estates situated upon the upper thin-bedded limestone are Mr. ——, Carlton, Mr. Coleman, Wadworth, Mr. Cooke, Loversall, Mr. Banks, St. Catherine's, Mr. Wrightson, Cusworth, Captain Elmsall, Woodlands, Mr. Tasburgh, Burghwallis, Mr. Yarborough, Camps Mount, Lord Hawke, Womersley.

This bed, from the Aire and Calder to the River Don, maintains the same agricultural character, with great regularity. At Knottingley and at Criddling Park the inferior bed of red clay and gypsum is often seen on the surface, being brought into that position, not by the simple dislocation of the beds usually observed in the carboniferous series, (for there is no vertical displacement of the limestone strata on either side of the red clay bed,) but apparently as if the clay had been pushed up from below. This interruption in the continuity of the limestone, is not only a source of expense to the excavator of the stone, but produces for three miles to the south of Knottingley, a variable tract of wetter land. To the south of Womersley, however, there is little variation in fertility of soil, until Skellow and Adwick-le-Street, where it certainly is superior, but made so, I believe, by the more perfect management of the farmers, for the soil at Adwick is only fourteen inches thick, which is about its average thickness, and the increased fertility is therefore not to be attributed to greater depth of soil. There are, however, a few productive fields around Norton, one of which has produced seventeen loads of wheat per acre, and twelve to fourteen is the customary crop; the depth of the soil, however, in these fields is three feet. Again there is a fertile tract of grazing land, as pointed out to me by P. D. Cooke, Esq., running in an east and west line from Carcroft to near Skellow, yet this land is not strictly limestone soil, and is not formed by the degradation of that rock, but a thin layer of the new red sandstone runs immediately upon the back of the upper limestone, and is in fact drained by it. Oak trees flourish near Carcroft, which they seldom do on the real limestone soil. There is also on the east side of Norton, parallel with the river Went, a portion of new red sandstone, made very fertile by being drained by the limestone. The soils in both places are of considerable depth. On the south of the Don from Hexthorpe by Balby and Loversall, to Tickhill, this bed of limestone is covered, and its soil intermixed with diluvial debris which at once alters the texture and quality of the soil, and from this cause the lands at Hexthorpe, Balby, Loversall, and particularly at Tickhill, afford excellent grazing pastures, and the rents at the latter place reach as high as £2 to £2 10s. per acre. The average rent of the remainder may perhaps be stated at 23s. to 25s. per acre. The places at which lime is burnt for agricultural purposes are Knottingley, Criddling Stubbs, Spring Lodge, and Womersley, and for four miles to the south of Knottingley the stone is of superior quality; but in one mile and a half to the south of Womersley, magnesia enters into the composition of the stone, and it can then be used only for making mortar. The magnesian beds, which are true dolomites, are easily known without any analysis: they are granular and crystalline, and when examined with a lens, show a glimmering lustre, and do not exhibit the smooth conchoidal fracture. The crystals, if any cells can be found, generally exhibit the inverse rhomb, rarely the equiaxe; but where the magnesian disappears the crystals generally lose the rhombic form, and exhibit modifications of the dog-tooth form. Between Womersley and Tickhill, stone from this bed is not at present burnt for agricultural purposes; but near the latter place, though the bed is seventeen feet thick, and contains of this six feet six inches of true dolomite, it is yet used in the quantity of three chaldrons to the acre, more would probably cause sterility, but six chaldrons per acre may be safely used of Knottingley or Womersley lime.

2. *The Red Marl and Gypsum,** which is the next subjacent bed, occupies generally a position atthe base of the escarpment formed by it and the upper thin-bedded limestone; it however in some places extends considerably to the west, and then runs in a thin layer upon the inferior yellow limestone. All farmers of these limestone soils ought to be acquainted with the range and extent of this bed, not only because it contains a most valuable manure, gypsum, but as requiring a peculiar mode of draining and crops, differing from those grown on the limestone. The places at which it extends to the west of the escarpment formed by it and the upper bed of limestone, are Grove Hall, where it forms the soil of the park; again at Stapleton Park, where it extends full one mile to the west of its accompanying limestone; again in the valley of the Went a great surface is exposed; (but the excellent grass lands adjoining this river from Wentbridge to Fishlake are of alluvial origin;) again near Askern there is a great extent of red marl and gypsum exposed by an enormous fault traversing the country in a line from Barnsdale by Camps Mount and Campsall Lake, which elevates the limestone on Askerne Mount. From Campsall to Sandbeck Park there is no extension of this bed beyond the base of the declivity described, but at the latter place it ranges into each side of the Park, and particularly on the north side forms the soil of a considerable tract of wet land. The mode of cultivating this soil will be spoken of in the sequel. This bed finally terminates to the south near Letwell, where it becomes of great thickness and the upper thin-bedded limestone disappears also from the formation. An enormous fault between Loversall and Wadworth divides the whole bed, and hence

* See Map and Vertical Section.

there are two out-crops of the red marl at the latter place. The places through this line of country where gypsum has been excavated, are:—1. Half a mile west of Oldcoats, on the Firbeck road. 2. The mill dam, three quarters of a mile west of Tickhill. 3. Brick pits, west of Wadworth. 4. South-west end of Cusworth Park. 5. West side of Campsall and Clay flatts. 6. The west side of the village of Askern. 7. The south-east end of Norton. 8. On both sides of the Went below Little Smeaton. 9. In Womersley belt, half a mile south and west of the house. 10. Pits on the west side of Grove Hall. 11. In the cutting of the York and North Midland Railway, at Brotherton. 12. Plasterpit Hill, near Fairburne.

3. The geographical extent of the *Yellow Limestone* is well known and requires little notice. Its precipitous escarpment defines its western boundary, and the beds last described its eastern one. Its great western terrace extends from Glass Houghton, near the Aire and Calder, by Pontefract to Wentbridge, at both of which places the whole thickness of the bed has suffered deep denudations by the action of a large body of waters bearing with them pebbles from the carboniferous series. From the latter place it extends by Upton Beacon, Hooton Pagnell, Hickleton, and Melton Park to Cadeby. Down the course of the Don it has been denuded to a considerable extent, Conisbrough Castle, standing on an outlying mass of rock which remains as a monument of the disrupting forces which excavated the valley of the Don. The limestone from hence passes by Micklebring, Maltby, and is then carried as far east as near Sandbeck park, a little to the west of which the limestone is cut through, and the subjacent coal strata are to be approached at no great depth from the surface; and there is no doubt that the estates of Lord Scarborough here cover

some of the richest coal beds in the Derbyshire and Yorkshire coal field. The escarpment then ranges from Laughten-en-le-Morthen and Dinnington (where this lower bed is burnt for agricultural purposes) to Anstone, where the rock is now quarried for the new houses of Parliament. Upon the back of this stratum are the estates of Mr. Athorpe, of Dinnington, Mr. Gally Knight, of Firbeck, Earl of Scarborough, at Sandbeck, Mr. Walker, of Wilsick, Sir Joseph Copley, of Sprotbro', Mr. Fountayne Wilson, at Melton, Sir F. Wood, at Hickleton, the Thelluson estate at Brodsworth, Mr. Ward, of Hooton Pagnell, Mr. Barton, of Stapleton park, Mrs. Oliver, at Darrington, and Mr. Milnes, of Frystone.

The agricultural character of the soils over the whole of this district maintains very great regularity, and the variations in quality are due strictly to geological influences. Wherever a rapid dip of the rock to the east is found, there the depth of the soil is less, and the lands are inferior in quality. At Frystone, particularly to the west of the house around Sheep Walk-house & Glass Houghton, there is a rapid dip, and the soil is not more than three to six inches thick. At Stapleton park, and in other places around Broccodale and Darrington, the same effects are seen. Also upon the higher parts of Barnsdale. There are also other places on the south and north side of the Don, where the soils are found often averaging from three to six inches, as at Edlington, and near Melton, Sprotbro', &c. In fact, wherever there exist east and west valleys, which indicate the passage of floods of water over this stratum, the rock seems to have been completely laid bare, or what is probable, the harder undecomposable rock has been left exposed. Over the whole of this stratum the depth will be a correct diagnosis of the quality of the soil. Some lime burnt at Levett Agg is sold for agricultural purposes.

4. *The lower red Sandstone*, of Sedgwick, or the *Pontefract Rock*, of Smith, is the lowest bed, and the last to be described. It consists of a bed of sand, containing, in some places, and generally in the lower portion of it, beds of red and blue variegated marls. This stratum forms the basis of the yellow magnesian escarpment, in a manner similar to that in which the red marl and gypsum forms that of the upper thin bedded limestone. The Pontefract rock seldom extends to the west of the magnesian limestone terrace, but forms a tract of light unproductive land at its base. At Pontefract, around the old castle, and in the several entrances to the town, it forms a soil for the cultivation of licorice, for which it seems well adapted. At Upton Beacon the red marls are of great thickness, and there is an extensive prolongation of them to the west, as far nearly as Badsworth church; they here form the red soils of Rogerthorp, and some lands occupied by Mr. Scott. At Hickleton the garden of Sir F. Wood stands one half of it upon sand and the other on the marls, both subordinate to this bed. Around Melton park there are, however, some excellent pastures formed by the marls belonging to it: they commence in the gardens of Mr. F. Wilson, and in the park being drained, form a considerable extent of good grazing land. Down the valley of the Don, towards Sprotbro' ferry, and between Clifton, Hooton Roberts, and Conisbro', there is a large tract of country formed by the Pontefract rock. Similarly, between North and South Anstone, and between Laughton and Firbeck, the same rock is found as the subsoil. Throughout its whole course it may be described as a loose disintegrating bed of sand, never affording a stone for building purposes, and may always, on this account, be distinguished from the uppermost rock of the true coal measures, to which it is very similar in appearance. Its marls, if drained, produce excellent grazing lands, and in several places are burnt for tiles. They do not contain

anhydrous gypsum, but selenite is occasionally found imbedded in veins.

II. I now inquire what aid may be derived from physiological Botany and Chemistry, in the cultivation of these soils, and more particularly from a consideration of the recent opinions of Liebig.

In the former paper read by me, it was stated, that the quality of soils could not be determined by an inspection of their analysis, or, in other words, that it was not known what combination of the earths produced the highest degree of fertility. Professor Liebig, however, does give us a very simple criterion by which their quality may be determined, which, if it proves to be correct, will be of inestimable value to the practical farmer.

There must, in the first place, *be free access of the atmosphere, as well as of moisture to the soil.* Liebig says, "Land of the greatest fertility contains argillaceous earth and other disintegrated minerals, with chalk and sand in such a proportion as to give free access to air and moisture. A fertile soil in the next place must contain clay, or rather *alumina.*" There must be, says he, "something in aluminous earth which enables it to exercise an influence on the life of plants, and assist in their development. Pure sand and pure limestone, in which there are no other organic substanees except siliceous earth, carbonate or silicate of lime, form absolutely barren soils, but *argillaceous earths form always a part of fertile soils.* Now from whence come the argillaceous earths in arable land; what are their constituents, and what part do they play in favouring vegetation? They are produced in the soil by the disintegration of aluminous minerals by the action of the weather; and the influence which alumina exercises on the life of plants depends on its invariably containing *potash and soda.* Alumina exercises in another way, also, an indirect influence on vegetation, by its power of attracting and retaining water and ammonia; it is itself very rarely found in the ashes of plants, but silica is always present, having in most places entered the plants by means of alkalies. Potash is present in all clays; according to Fuchs it is contained in *marl;* it has been found in all the argillaceous earths in which it has been sought clay slate contains three per cent. of potash, and one Hessian acre of 20 inches in depth, will contain 200,000 lbs."

"The land in the vicinity of Vesuvius may be considered as a type of a fertile soil, and its fertility is greater or less according to the proportion of clay or sand which it contains. The soil, from disintegration of lava, cannot possibly, on account of its origin, contain the smallest trace of vegetable matter: yet, when the volcanic ashes have been sometime exposed to the air and moisture, a soil is gradually formed in which all kinds of plants grow with the greatest luxuriance. The fertility is owing to the alkalies which are contained in the lava, and which, by exposure, are rendered capable of being absorbed by plants. The first colonists of Virginia grew Wheat and tobacco for a century upon the same fields without the aid of manure, but now, whole districts are converted into unfruitful pasture land, which without manure produces neither wheat nor tobacco. From every acre of this land there were removed, in the space of 100 years, 1,200 lbs. of alkalies in leaves, grain, and straw; it became unfruitful, therefore, because it was deprived of every particle of alkali, which had been reduced to a soluble state, and because that which was rendered soluble again in the space of one year, was not sufficient to satisfy the demands of the plants. Almost all the cultivated land in Europe is in this condition; fallow is the term applied to land left at rest for further disintegration. It is the greatest possible mistake to suppose that the temporary diminution of fertility is owing to the loss of decaying vegetable matter or humus; it is the mere consequence of the exhaustion of the alkalies. Again, how does it happen that wheat does not flourish on a sandy soil, and that a calcareous soil is also unsuitable for its growth, unless it be mixed with a considerable quantity of clay? It is because these soils do not contain alkalies in sufficient quantity—the growth of wheat being arrested by this circumstance, even should all other substances be presented in abundance."

I now beg leave to present the analyses of nine specimens of the lower rock, four of which are sent me by Professor Daniell, who lately examined them for the Commissioners of Woods and Forests, in order to ascertain the most suitable stone for the new houses of Parliament. Bolsover is near Chesterfield, Roach Abbey, is near Tickhill, Barnsdale is near Robin Hood's Well, and Huddlestone is near Sherburne. Mr. J. W. Wilson, of Whitley, has also kindly analysed for me, four specimens of soils, two upon the upper and two upon the lower rock, and accurately examined them for potassa. They are of opposite qualities; that is two from the worst and two from the best land on each stratum.

YELLOW LIMESTONE.

	Bolsover.	Huddle-stone.	Roach Abbey.	Barnsdale Park Nook.
Silica	3.6	2.53	0.8	0.0
Carbonate of Lime	51.1	54.19	57.5	55.7
Carbonate of Magnesia	40.2	41.37	39.4	41.6
Iron and Alumina	1.8	0.30	0.7	0.4
Water and Loss	3.3	1 61	1.6	2.3

The following analyses are extracted from the Philosophical Transactions for 1799, and were made by Tennant :—

	Quantity of spar which the acid required to take up the Magnesia would have dissolved.	Quantity of Magnesia	Quantity of Lime.	Iron and Clay.	per Cent.
Warnsworth	12.75	5.61	7.34	0.25 × 5=1.25	
Thorp Arch	10.95	4.84	7. 8	0. 6	0.30
York Minster, prob. Stapleton	11. 0	4.84	8.26	0. 1	0.5
Worksop	11. 6	5.104	7.496	0. 6	0.30
Sherburn	11. 5	5.08	7.56	0.56	2.70

From a quarry south of Robin Hood's Well, by Holme.

THE UPPER ROCK.

Water.	Silica.	Carb. Magnesia.	Carb. Lime.	Alumina and Red Oxide of Iron.
1.0	1.25	60.25	29.75	7.75

UPPER BED.

NORTON BEST SOIL, &c.
Produced 17 *Loads of Wheat per Acre.*

	GRS.
Water of Retention ...	11,250
Loose Stones	11,250
Vegetable or Animal matters destructible by heat	5,500
Fine Sand	61,550
Lime.........................	1,875
Magnesia and Iron	5,750
Alumina	2,450
Potassa.....	0,250
Loss	0,125
Total	100,000

WOMERSLEY WORST SOIL, &c.
Produced 6 *Loads of Wheat per Acre.*

	GRS.
Water of Retention ...	15,000
Loose Stones	13,000
Vegetable or Animal matters destructible by heat	7,500
Fine Sand	49,275
Lime	4,250
Magnesia and Iron	7,750
Alumina	2,975
Potassa.........	0,125
Loss...............	0,125
Total	100,000

LOWER BED.

Pontefract Best Soil. *In Grass.—Rent £3 per Acre.*	GRS.	**Stapleton Soil.** *In Grass.—Rent 10s. per Acre.*	GRS.
Water of Absorption ...	23,500	Water of Retention ...	20,250
Loose Stones	13,125	Loose Stones	14,500
Vegetable or Animal matters destructible by heat	16,125	Vegetable or Animal matters destructible by heat	8,812
Fine Sand	4,538	Fine Sand	29,385
Lime	12,675	Lime.......	6,000
Magnesia and Iron	21,250	Magnesia and Iron	12,250
Alumina	5,912	Alumina	2,678
Potassa......................	0,250	Potassa.	0,125
Loss	2,750	Loss	6,000
Total	100,000	Total	100,000

It may be remarked in the first place concerning the rocks, that the quantity of clay or rather alumina in them is very small; three by Daniell and three from Tennant, do not contain one per cent. of that earth. The one from Sherburn, and that near Robin Hood's Well, by Holme, are probably the upper rock, and contain the one 2.70 and the other 7.75. Six of the soils therefore contain under one per cent. and two above that quantity of alumina, and to the want of this earth must be ascribed partly the small weight of crops which the limestone soils comparatively bear. For if we consider that the firmness and consistency of a soil is due to the presence of this earth, and is of considerable importance in regard to the fertility of land, and moreover that the power of condensing and absorbing carbonic and ammoniacal gas is also given to the soil by alumina, it is easy to perceive the reason why the limestone soils require the yearly application of manure to each crop, and particularly as they are always friable and are at all times freely aerated, which also hastens the decomposition of the manures applied to them.

Upon the inspection of the *analyses of the soils*, it will be seen that the criterion of Liebig, with regard to fertility, is verified, and that the quantity of *potassa* indicates their relative productiveness. The quantity being 0.250 in the two superior, and one-half of it in the inferior soils. The depth of the Norton and Womersley soils examined, can have little influence, because they are both above three feet deep, and therefore the depth is only a criterion within certain limits, that is to say, if the depth to the rock in one place be only five or six inches, and at another fifteen to twenty inches, it will be found that the latter soil, whatever may be its constitution, will be the more productive. It is however probable that the fertility of the land in the vicinity of Vesuvius is not wholly owing to the quantity of alumina, and therefore of alkali contained in it, as stated by Liebig, but principally to the genial temperature maintained by the heated lava, and also from the evolution of ammoniacal gas, as proved to be the case by Dr. Daubeny. The quantity of alkali in the soil of Virginia and in all newly cultivated lands, is not to be ascribed to the original quantity in the rock from which the soil originates, but from the accumulation, by the periodical decomposition of vegetable matter grown on the spot. In fact the same thing occurs in old swarth by the decay of the roots, &c. of the grass. It is also highly probable that the inability of the limestone soils to produce clover oftener than every eighth year is due to the exhaustion of alkali, and not to the want of gypsum, for there being so small a portion of alumina, and therefore of potash in the rock, little or no alkali is supplied by the soil itself, or by the manures applied; for it is on boned lands that this crop more particularly fails. It is probable that several causes affect the growth of clover; want of firmness or consolidation of the land is one; after teazles it never fails; again on headlands, which have been carted upon and trodden, it always grows—on the stiffer lands east of the limestone, when drained, if the clover-seed grows, it never sickens in the spring.

We may then, I think, infer, that the soils of the magnesian limestone are perfectly aerated, and are sufficiently pervious to air and moisture; that alumina or clay would not only give firmness and consistency to the limestone soils in summer, but would make the farm-yard manures go further, and hence produce a greater weight of crops, and also the permanent grasses; but on the other hand, clay or marl would, by producing a greater tenacity, make them less adapted to the depasturage of turnips by sheep, and which will be seen in the sequel to be one of the disadvantages attending their cultivation.

The next inquiry is concerning manure, or the food which the crops upon the limestone soils require for their nutrition; and upon this subject Liebig affords most valuable information. He says, "That hitherto the true theory of the nutritive process in vegetables is not known, and hence we have been deprived of the best guide to a rational practice of agriculture. Any great improvement in that most important of all arts is inconceivable without a deeper and more perfect acquaintance with the substances which nourish plants, and with the sources whence they are derived, and no other cause can be discovered to account for the fluctuating and uncertain state of our knowledge on this subject up to the present time, than that modern vegetable physiology has not kept pace with the rapid progress of chemistry."

Now the development and existence of all vegetables is dependent on the reception by them of certain substances, which are used for the nutrition of their frame. Any inquiry therefore into the cultivation of particular plants involves the study of those substances which serve them as nutriment, and the changes which those substances undergo in the process of assimilation.

The substances which constitute the principal mass of every vegetable are compounds of *carbon*, (or the inflammable part of charcoal,) and the elements of water *oxygen* and *hydrogen* in variable proportions. Woody fibre, starch, sugar, gum, wax, resins, oils, vegetable acids, are all compounds of carbon and oxygen and hydrogen.

Nitrogen or *azote* forms only a very small part of plants, but it is never entirely absent from any part of them. Even when it does not absolutely enter into the composition of a particular organ or part, it is always to be found in the fluids which pervade it.

I. Our first inquiry must then be from whence do plants derive their carbon and nitrogen? and secondly, concerning certain saline and inorganic bodies, which are equally necessary for their development.

1. *The Carbon.* An opinion among vegetable physiologists has hitherto prevailed that plants derive their nourishment and the greatest portion of their carbon from manures rendered soluble by putrefaction, and that they are absorbed, being dissolved in water, by the spongioles of the roots. But Liebig has, I think, proved otherwise, and that they obtain carbon from manure, not by a solution of its carbonaceous matter in water, but from carbonic acid exhaled during its decomposition, and absorbed in water. He also asserts that twice as much carbon is received from the air as from the soil, and that cultivated land receives as much carbon back in the form of excrementitious matter as it afforded to the plant. The opinion is not new that the carbonic acid of the air serves for the nutriment of plants, and that its carbon is assimilated. The elegant writer Mrs. Marcet, states in her Conversations on Vegetable Physiology, "The sap contains carbon in two states: first in that of carbonic acid, secondly, combined in animal and vegetable matter. In the first state the sun's rays decompose the acid, the carbon is deposited, and the oxygen which flies off purifies the atmosphere. But what do you suppose, says she, becomes of the carbon contained in the animal and vegetable matter which the sap holds in

solution? I suppose it is assimilated to the substance of the plant, together with the other nutritive ingredients which the sap holds in solution. No, that cannot be; for in order to render carbon fit to be assimilated, it appears to be necessary that it should previously be combined with oxygen, and afterwards separated from it." It is in this second mode of the reception of carbon that Liebig differs from De Candolle, whose opinions these of Mrs. Marcet's are; and he thinks that the quantity of carbon received from the air has not been duly appreciated by naturalists. Boussingault proved in 1838, that if full-grown plants, endowed with perfect organization, be transplanted into a soil deprived of every particle of organic matter, by subjecting it to a red heat, they do not only receive nitrogen, but also carbon, and although they had nothing but water and air for their whole food, nevertheless they flowered, and produced seed to perfect maturity; his experiments were upon clover, peas, and oats.

			CARBON.	HYDN.	OXGN.	AZT.
Peas sown ...	1,072	contg. grains of	0.515	0.069	0.443	0.055
Crop	4,441	Do.	2.375	0.284	1.680	0.110
	3.369	Gain on culture	1.860	0.215	1.237	0,055

In this experiment 1,072 grains of pea-seed gained 3,369 grains of organic matter in 99 days of vegetation during the hottest months of the year. The plants of clover were taken from a field which had been sown the previous year.

The clover was transplanted into sand previously calcined on the 28th May, and sheltered from dust floating in the air. It first languished, but soon afterwards showed remarkable vigour. On the 15th of July it flowered, and its colour was of a beautiful flesh red. On the 1st of August, it was taken up, and it was then obvious that the roots had not grown any.

	GRAINS.
The transplanted clover weighed	0.884
After 63 days' culture in sand	2.264
Gain........, ...	5.380

	CARB.	HYDR.	OXGY.	NITR.
Before culture the plants contained grains of ...	0.384	0.048	0.419	0.033
After culture	1.200	0.145	0.863	0.056
	0.816	0.097	0.444	0.023

Thus, in two months' vegetation, from the air alone and water, the clover may be said to have tripled its elementary matter, and the azote to have been nearly doubled.

On the 20th June were disposed several plants of oats in shelter from dust. The roots were plunged in distilled water. On the 10th August the plants bore perfect seeds.

	GRS.
Before experiment, the plants of oats weighed	1,560
The whole crop	3,118
Gain on culture	1,558

The plants contained before	CARB.	HYD.	OXY.	AZOTE.
experiment	0.827	0.106	0.568	0.059
After 41 days' vegetation ...	1.500	0.193	1.372	0.053
	0.673	0.087	0.804	0.006 loss.

Comptes Rendus, 19th November, 1839.

Boussingault also examined, by analysis, the comparative proportions of the elements yielded by each crop in a rotation, and the quantity of manure supplied to the crop. In a five years' rotation of—1st. potatoes or red beet dunged; 2nd, wheat; 3rd, clover; 4th, wheat; 5th, oats, the manure was applied to the first crop, and it was found the dung consumed on the hectare contained 2,793 kilogrammes of carbon; in the suite of crops produced by this dung, the carbon was raised to 8.383 kilogrammes; thus 5.400 of carbon was furnished by the carbonic acid of the air. In the same rotation, the azote primarily included in the dung weighed 157 kilogrammes. By culture, the weight attained 251, and the atmosphere had furnished 94 kilogrammes of azote.

In another rotation, the carbon of the crops surpassed the carbon of the dung by 7.600 kilogrammes, and the azote was increased to 163 kilogrammes.

If, therefore, the plants receive three times as much carbon from the air as they do from the soil, as is proved by these experiments, supposing them to have assimilated the whole carbon of the manure without any being lost, which is very improbable, and if the carbon derived from the soil must be combined with oxygen as carbonic acid, I think we may from these facts deduce several important results.

1. That manures are useful only during the process of their decay, or as long as they afford carbonic acid, and therefore are to be applied during an early period of their fermentation; and hence also that soils, and the manures contained in them, require to be aerated as well as watered.

2. That crops exhaust, not in proportion to the quantity of nutritive matter contained in the crops produced (for then we should tacitly acknowledge that all the organic matter of plants originates in the soil), but that those plants which receive the most elementary matter from the atmosphere, exhaust the least; and Liebig proves that plants receive from the atmosphere in proportion to the size of their leaves and green parts; and, therefore, the leguminosœ, the clover, potatoes, and turnips, &c., exhaust less than the cerealia.

3. That if plants receive so large a proportion of their carbon from the atmosphere, and in fact can receive the whole, as proved by the experiments in calcined sand, then it will follow that all manures which contain simply carbon, oxygen, and hydrogen, as simple straw, &c., whether fer-

mented or unfermented, are comparatively of little value to the growing plant.

II. The opinions of Liebig, concerning the origin and assimulation of *nitrogen*, are of great value in an agricultural point of view. He establishes the fact that this organic element is uniformly derived from *ammonia.* He has demonstrated the existence of ammonia in rain-water to the amount of one quarter of a grain to the pound, by original experiments. Nitrogen, which has hitherto been thought only to be contained in those plants which contain gluten, he has found in all plants examined. "Ammonia," says he, "exists in every part of plants, in the roots, in the stem, and in all blossoms. It yields nitrogen to the vegetable albumen, the principal constituent of plants. Nitrogen exists in corn, grass, and all plants without exception. We may furnish a plant with carbonic acid and all the material which it may require; we may supply it with humus or decaying vegetable fibre in the most abundant quantity, but it will not attain complete development unless nitrogen is afforded it—a herb will be formed, but no grain; sugar and starch may be produced, but no gluten." But the formation in plants of substances containing nitrogen, such as gluten, takes place in proportion to the quantity of this element which is conveyed to their roots in the state of ammonia derived from the putrefaction of animal matter.

Thus Pronst found	PER CENT.	
French Wheat to contain	12.5	gluten.
Bavarian, ditto..............	24.0	„
Winter, ditto	19.0	„
Summer, ditto	24.0	„
Sicilian, ditto	21.0	„
Barbary, ditto	19.0	„
Alsace, ditto..	17.3	„
Jardin des Plantes, ditto.........	26.7	„
Winter Wheat in ditto	3.33	„

Such differences must be owing to the different methods of cultivation.

It is the gluten of wheat which produces the fermentation of dough, and upon its presence depends the excellence of the flour derived from it. The following experiment of M. Tessier, from Grisenthwaite, will place this fact (i. e. the quantity of gluten produced in wheat in proportion to the ammonia afforded as manure) beyond question. He divided a piece of ground into nine plots, each containing two perches twenty-two feet square, French measure, and manured it with—

		GLUTEN.
	140 sheep and goats, folded two hours ...	5 oz. per lb.
3.	2 sacks of rotten horse dung	5 oz. per lb.
4.	2 ditto rotten cow dung	5 per lb.
2.	64 quarts urine	6 oz. per lb.
3.	36 quarts of bullocks' blood	5 per lb.
4.	2 sacks of vegetable refuse, reduced to mould..............................	5 per lb.
1.	3 bushels of pigeons' dung	5 per lb.
2.	3 bushels of dried night soil	4 oz. per lb.
	No manure.. (twice quantity of seed sown)	5 per lb.

That manured with urine produced the greatest quantity of gluten: that with dried night soil the least; but it is probable that the ammonia in this instance was evaporated in drying. That manured with pigeons' dung produced the greatest quantity of wheat. That of urine marked 2 the next in quantity; then night soil 2 the next in quantity. Then bullocks' blood and horse dung numbered 3; then cow dung, and vegetable refuse, numbered 4. The quantities are not stated, neither the quantity produced by the folding of sheep and goats.

The produce of plants then may vary according to the substances given them as food. A superabundance of carbon in the state of carbonic acid, conveyed into the plant, cannot be converted into gluten, albumen, wood, or any other component part of an organ, without the presence of nitrogen; e. g. the starch of potatoes increases when the soil contains much decaying vegetable matter, and they acquire a mealy consistence; but it decreases when the soil is manured with strong animal manure, although the number of cells increases, and they become soapy. Beet roots taken from a barren, sandy soil contain a maximum of sugar, and no ammoniacal salts. And the Teltona turnip loses its mealy property in a manured land, because then cells are formed in its substance. The exudations of mannite or gum in strong healthy plants is owing to a want of nitrogenous manures.

Now all plants cultivated by the agriculturist contain more or less of nitrogen, and the value of them as food is proportionate to the quantity of this substance which they may contain, i. e., the cerealia contain the greatest quantity, and are accordingly the most valuable of our cultivated crops; but this is not all, for *the greater the quantity of azotized substances which may be used as manures, the greater the quantity of produce;* and the chief art of agriculture depends *not only upon the collection and preservation of those manures which contain ammonia in the greatest quantity, but also on the just application of it to those cultivated plants which require it.* In order therefore to afford a clear view of those manures which contain the greatest quantity of ammonia, and also of those plants which require or contain the most nitrogen in their component parts, I have added a list of manures, each standing in the order in which they are most valuable.

The following is a list of manures, &c. :—

[See Table at the end.]

1. The urine of the horse contains 10 per cent. ammoniacal salts.
2. The urine of the cow contains 7 per cent. ammoniacal salts.
3. Of that of the sheep no analysis has been obtained.

Then follow the the solid excrements which are greatly inferior to the urines.

Concerning solid excrements—

The dung of the horse contains only 1 per cent. of nitrogen.

That of the cow 1 in 200,000 parts.

That of sheep unknown, but it ranks before that of cows.

One hundred parts of urine is as rich as 1300 parts of the dung of horse.

Ditto. ....human..................600 of the cow.

The following comparative value of manures was determined by Prof. Hembsladt, of Berlin, for the Saxon and Prussian authorities. The experiments were carried on for a considerable period. They were afterwards repeated with unvaried success by Prof. Schübler.

If the soil without any manure yields three times the quantity of the seed sown; then the same quantity of land will produce

THE QUANTITY OF SEED SOWN,	IF MANURED WITH
5 times	Old herbage, grass, leaves, &c.
7 times	Cow dung.
9 times	Pigeons' dung.
10 times	Horse dung.
12 times	Human urine.
12 times	Sheep dung.
14 times	Human manure.
14 times	Bullocks' blood.

"Liquid animal excretions," says Liebig, "if suffered to undergo the process of putrefaction, contain the greatest quantity of ammonia, and in that form of salts which has lost its volatility, and when presented in this condition, they are the most valuable of all manures, and not the smallest portion is lost to the plants. It is all dissolved by water, and imbibed by the roots." (For additional information respecting the preservation and application of urines, see a paper of Dr. Sprengel, in the Journal of the English Agricultural Society, vol. 1, p. 470.) They require to be diluted with an equal quantity of water, and not applied until the ammonia is converted into a carbonate, otherwise they "burn" the vegetation; generally six weeks in summer, and ten or twelve in winter is sufficient. They may, however, be greatly enriched, and the time of fermentation shortened, by adding powdered gypsum, green copperas, common salt, bone dust, potash, &c.

We may hence deduce three important practical remarks :—

1. That the dung of cattle is much inferior to the animal liquid excretions.

2. That the liquid manures should not be exposed to the atmosphere prior to their use, as the volatile ammonia quickly evaporates.

3. That the Cerealia, as Wheat, Barley, Oats, which contain the greatest quantity of nitrogen, should have applied to them the liquid animal manures.

III. *Phosphates and Neutral Salts.*

Carbonic acid, water and ammonia, are necessary for the existence of plants, because they contain the elements from which all their organs are formed; they are strictly the pabulum vitæ. But there are other substances obtained from the inorganic kingdom, which are necessary for particular parts of plants. Such inorganic constituents exist in small quantities in those parts of a plant in which the process of assimilation is most active, as in the mass of woody fibre, and the leaves contain more inorganic matter than the branches, and the branches more than the stem. The potatoe plant contains more potash before blossoming than after it. These substances are found in the ashes after incineration.

" Most plants, (says Liebig,) perhaps all of them, contain organic acids, all of which are in combination with bases such as potash, soda, lime, or magnesia. These bases evidently regulate the formation of the acids, for the diminution of the one is followed by a decrease of the other, e. g. the quantity of potash contained in the juice of grapes is less, when it is ripe than when unripe, and it is certain that these substances exercise an important influence on the development of seeds. Again, he says, that any one of the alkaline bases may be substituted for another, the action of all being the same; but this refers only to the carbonates found in the ashes. Alkaline bases, existing in the ashes of plants, must therefore be necessary to their growth, since if this were not the case, they would not be retained.

All grasses contain the acid silicate of potash. And in corn fields this salt does not vary much, because it is carried back in the putrefying straw. But this is not the case in a meadow, and hence we never find a luxuriant crop of grass on sandy and calcareous soils, which contain little potash, evidently because one of the constituents indispensable to the growth of grasses is wanting. Wheat grown in a rich soil of mouldered wood never comes to perfection, but droops prematurely. The cause is this: the strength of the stalk is due to *silicate of potash*, and the corn requires *phosphate of magnesia*, neither of which a soil rich in humus can afford.

Phosphate of Magnesia, in combination with ammonia, is an invariable constituent of the seeds of all kinds of grasses.

I have already spoken of potash, when treating of soils, which may be replaced in many cases by soda, magnesia, or lime; but there are other substances besides alkaline required to sustain the life of plants, and one is *phosphoric acid*, which has been found in the ashes of all plants hitherto examined, and always in combination with alkalies or alkaline earths: it is a constituent of all land capable of cultivation, and plants yield it to animals, to be used in the formation of their bones. Some plants, however, extract other matters from the soil besides *silica*, *potash*, and *phosphoric acid*, which are essential constituents of the plants ordinarily cultivated: these are *common salt*, *sulphate of potash*, *nitre*, *chloride of potassium*, and other matters as necessary constituents.

The leguminosœ, turnips, and potatoes, require only small quantities of potash.

The vicia faba contains no free alkali, and not one per cent. of phosphates; lucerne, only 0.83 per cent. of phosphates of lime.

10,000 parts of wheat straw contain			47.3	phosp. lime.
Ditto	ditto	grain	79,45	ditto.

I have subjoined a table of the constituents of the ashes of plants found in most of the cultivated plants.* In another column are the quantities of gluten or albumen, and therefore the proportional quantity of nitrogen. In the other table of the analysis of manures, it will be seen that the dung of animals contains principally neutral salts and phosphates, and, therefore, can afford only inorganic substances to plants. They contain very little nitrogen; that of the cow 1 in 200,000 parts, that of the horse one per cent. The ashes of trees contain various saline and earthy constituents, and are used in Flanders; the ashes of the beech 20 per cent. of phosphates.

Bones contain 55 per cent. of phosphates of lime and magnesia, and 8 lbs. of bones contain as much phosphate of lime as 1000 lbs. of hay or wheat straw, and 2 lbs. of bones as much as 1000 grains of wheat or oats.

Therefore 40 lbs. of bone dust, says Liebig, per acre, is sufficient to supply three crops of wheat, clover, potatoes, and turnips, with a sufficient quantity of phosphates.

The urinous liquids abound in phosphates and neutral salts.

Peat ashes contain silicate of potash and some phosphates, and might therefore replace the dung of the cow and horse, when they can be obtained.

III. I now proceed to describe the state of agriculture, as at present existing over these different soils, and to offer suggestions for their improvement.

The Magnesian Limestone soils are strictly calcareous,

* See Table II. at the end.

indeed the rocks from which they are derived do not contain on an average more than two per cent. of either alumina or silica; the remaining portion being magnesia and lime. They, however, possess some useful qualifications: the farmer is seldom prevented performing for a long continuance the operations of farming, and the land soon regains its usual dryness after rain; the labour required is also less than upon tenacious clays; the weeds are not very numerous, and may with little labour be eradicated. The following list given me by Sir Francis Wood, are the most prevalent, and therefore, on their account alone, fallowing is not so frequently required. The elevation of the highest portions of the formation do not much exceed 500 feet above the sea; 350 is the average; the climate is temperate, and the season of harvest earlier by seven or ten days, than on either the Western Coal series or the Eastern plain of the New Red Sandstone. The disadvantageous circumstances attending the cultivation of this land are the necessity of frequent manuring and the liability of the growing crops to suffer from extreme drought in summer. The quality of the upper bed is in some respects superior to that of the lower, and will produce of wheat eight to ten loads per acre, and of barley four and a half to six quarters; but some single fields near Norton, have produced as much as seventeen loads of wheat per acre. The lower bed is better adapted for the pasturage of sheep upon the turnips, but the soils upon both of the beds suffer materially if sheep are fed on late in the year, for the soils become kneaded or puddled into a stiff paste by the feet of these animals, and hence turnips cannot be fed off after January, without considerable risk of not being able to render the land sufficiently pulverulent for the ensuing crop of barley. Croskill's clod-crusher, which is formed by a number of loose iron dentated wheels, fixed upon a revolving axle, is a very useful implement for the reduction of land after turnips. It is an instrument of great power, and may be seen at Lord Hawke's farm. The grass lands on the north side of the river Don are certainly of an inferior description, (some of the parks excepted,) few being sufficiently fertile to fatten cattle. There is some excellent grass land extending from near Carlton to the east side of Pontefract, the rent of which amounts to £3 per acre, while, in half-a-mile to the east, it again becomes inferior. It is extremely difficult to account, not only for the distribution of particular grasses upon the limestone, but for the unequal fertility which prevails in different places. At Stapleton, in the plantations under the fir tribe of trees, the superior grasses grow with the greatest luxuriance, but immediately upon passing into the open country, there only exists the dwarf Cynosuros cristatus, Bromus pinnatus, B. sylvaticus, and one variety of Festuca, and not one hundred of these upon the square foot of turf. And in some of the parks, as Womersley, which is exceedingly well-manured, the grasses do not grow intermixed, but in separate clusters; these are, Festuca pratensis, the Poa and Phleum pratense, Bromus mollis, and B. pinnatus, which is peculiar to the limestone, Alopecurus pratensis, but no Dactylus glomeratus, except under the fir trees. I can only think, that as the needles of the fir contain 6 per cent. of potass, and this salt is a constituent of all grasses, the increased growth is produced by their decomposition. While few weeds are found in the arable land, those in the pasture land are exceedingly numerous Dr. Lankester has given me a list of 300. It is said that the best grazing lands in the north, between Staindrop and Darlington, are upon this formation, and the production of grass around Tickhill cannot be due to any other cause than the intermixture of foreign debris, containing alumina; it is hence very probable that some lands, particularly the thinner soils of Frystone, Stapleton, and Barnsdale, would be much benefited by the application of a portion of the red marl and gypsum bed. The addition of marl would not, however, give an increased facility to the depasturage of turnips by sheep, but a greater power of absorption of moisture, and hence less liability to be affected by drought in summer, and the production of greater quantity of wheat and permanent grasses. Marl would also afford alkalies. I know of no instance of its application, except at Stapleton park, by the late Mr. Hodgson: it, however, was applied, not to the thin limestone soils of that place, but upon the red marl and gypsum bed, in fact to the surface of the soil, to which it forms the sub-soil. The professed rotation of crops upon the whole of these soils is—1. Turnips, 2. Barley, 3. Seeds, and 4. Wheat, and at this season of the year, one-fourth of the whole arable land of the whole country (permanent grass excepted) ought, therefore, to be in turnips. But it is evident to any person passing over it, that this is not the case. There is no easy mode of ascertaining the exact quantity of turnips, but as a rude guess, I should say, that one-tenth or one-twelfth of the arable land is the utmost extent covered with that crop at the present time: so that one-sixth is in open fallow. There must, therefore, be a great waste of land over the country described; for this extent of fallow cannot be required to subdue weeds, which we see by Sir Francis Wood's list are few and easily exterminated. Is it that the excrementitious matter from former crops remains, and requires putrefaction? then caustic lime applied would effect this more speedily: or is it a want of the alkalies, which, locked up in undecomposed portions or fragments of the soil, want time for their liberation? then this object would be attained sooner by the addition (as manures) of those substances which contain in them alkalies, as wood-ashes, cow-dung, &c.: but some farmers say, the risk of the barley crop deters them from feeding off turnips from the ground; but surely the turnips may be pulled, and cattle of some description kept, as is done in innumerable instances. And the management of other farmers shows, that fallowing is not absolutely required every fourth year.

Speaking generally, the stall feeding of cattle is pursued to a very limited extent, so that little manure is made at home. Six beasts, consisting of milch cows and young calves, is the average quantity of cattle (sheep excepted) kept on 100 acres; these are kept in winter in the straw-fold. There is considerable doubt expressed by many farmers, respecting the efficacy of the manures derived from depasturage by sheep, and many are of opinion that the injury received by the land is greater than the benefit derived from the practice. Indeed, from the known volatility of ammoniacal salts, it is plain that the liquid manures and the nitrogenous portions of the solid ones are nearly all evaporated before the time they can be of service to the ensuing barley crop; hence, if one-tenth only of the whole land be in turnips, and this only imperfectly manured, and little manure be made at home by the stock which are kept in open yards, where the evaporation of ammonia is constantly in progress,—it will follow that the magnesian limestone farmers are very near wholly indebted to the foreign manures purchased for the production of their crops. Now this mode of obtaining manure to raise the whole crops is extravagant in the highest degree. Bones and rape dust are applied in variable quantities; that is, for 100 acres. There are three modes of manuring in use for turnips, three for the barley crop, and three for the wheat crop, and by taking an average expense of each of these, we shall be able to ascertain the sums paid for foreign manures. One farmer uses bones only, and applies 3 qrs. per acre at 24s., which amounts to £3 12s. per acre, and on one-fourth of 100 acres (supposing his farm entirely upon the four-course shift) would amount to £90. Another farmer uses five loads per acre of his own manure and only 12 bushels of bones, which amount to £1 16s. per acre, and on 25 acres it will be £45. Another practice of farmers is the use of both bones and rape dust, 2 qrs. of each, which amount to £4 16s. per acre, and £120 for the 25 acres. The average, however, of these three modes of cultivation is £85. Similarly the average for the barley crop £45. That of the wheat crop £55, or as below:—

FOR TURNIP CROP.	£.	s.	Acres.	£.
1. 3 qrs. of bones at 24s.	3	12	× 25=	90
2. 5 loads of manure, 12 bush. of bones	1	16		45
3. 2 qrs. Rape dust 24s. / 2 ditto bones ... 24s.	4	16		120
Average				85

FOR THE BARLEY CROP.	£.	s.	Acres.	£.
1. If the turnips are not eat off, 12 bushels of rape dust	1	16	× 25=	45
2. If the turnips are eat off, no manure, but more frequently 8 bushels of rape dust	1	4		30
3. If land in open fallow, 2 qrs. per acre	2	8		60
Average				45

FOR THE WHEAT CROP.	£.	s.	Acres.	£.
1. If seeds mown, 1½ to 2½ qrs. per acre, or say 2 qrs. rape dust	2	8	× 25=	60
2. If eat off, generally 1 qr. per acre	1	4		30
3. If mown (having open fallows, and no sheep,) 2½ qrs. per acre	3	0		75
Average				55

Or if a farmer of 100 acres who sows turnips, is prevented by the weather, or from the tenacity of the land, eating them off, and he mows his seeds,

	£.
Turnip crop will average	85
Barley crop	45
Wheat crop	60
Total	190

If, as is more usually the case, the turnips and seeds are eaten off,

	£.
Turnip crop	85
Barley crop	
Seeds, $1\frac{1}{2}$ qr. of rape dust, if even eaten off	45
Total..	120

If he has no sheep, and has open fallows, and mows his seeds,

Barley crop, 2 to $2\frac{1}{2}$ qrs.........................	60
Seeds mown	
Wheat crop, $2\frac{1}{2}$ qrs.........	75
Total	135

The greatest of the sums paid for manures on 100 acres, is £190, and the least £120, and the average will be £150 for every 100 acres, or 30s. per acre. So that over the whole area of 33 miles long, and $3\frac{1}{2}$ broad, there will be the enormous sum of £100,000 paid annually for these articles; that is supposing the whole area under the regular four-course system. It is also to be recollected that the bones and rape dust used by the farmer are (the greatest proportion of them) imported from foreign countries. In 1838 the official value of bones, as given me by Dr. Holland, was £255,967. In 1839, £224,342, and the quantity of rape dust is not less, so that nearly £500,000 is paid to foreigners for manure annually.

It may then be asked what suggestion can be made for remedying this extravagant mode of obtaining manures. I answer, first, in the collection of those manures which have been proved to be the most valuable, and the keeping of stock to produce them. And second, in the just application to the plants which require them.

The application of manures to particular crops, presupposes a knowledge of the constituent elements of both: this subject, which I shall only just notice, may be learnt from the tables: for example, if the plants to be raised abound in mucilaginous or saccharine matter, as potatoes, peas, turnips, carrots, clovers, then the manures which contain carbon, oxygen, hydrogen, as elements, as fermented straw, rape dust, &c. are to be used. If, as in wheat, barley, and oats, albumen and gluten abound, then the animal manures, as bones, urinous liquors, &c., in which nitrogen is contained, must be applied. The inorganic ingredients must also be studied; for example, potatoes and the grasses contain much potash; and cow dung, which contains a large proportion of that salt, must be used. The earthy ingredients of plants require particular attention; the phosphates and silicates of potash abound in the cerealia; these substances must be supplied from either cow or horse dung, or from bones. But there is a great waste in the application of bones as respects their earthy constituents; forty pounds of bones per acre is sufficient, says Liebig, to supply with phosphates, &c. three crops of wheat, clover, turnips, &c. if properly applied, by being first mixed with half their weight of sulphuric acid, diluted with four parts of water, to which 100 parts of water are afterwards to be added, to be sprinkled on the land before ploughing.

But the two former principles of keeping stock and collecting manures, have been acted upon by the Flemish farmer for centuries past, and they are now being adopted through some parts of France, through Switzerland, Germany, and parts of Italy. The Flemish farmer collects with the greatest assiduity all kinds of manures; for the collection of liquid he provides large tanks; by a judicious succession of crops he has every part of his land in a constant state of production; yet with a soil inferior to the limestone, and only to be compared to the poor light soils of Norfolk, and with a climate in which the frosts are longer and more severe than in England, the agriculture of Flanders maintains a population of ten souls on every sixteen acres, and exports one-third of the produce of the whole country annually, while England, with a population of only ten souls on every twenty acres, is obliged to import a considerable portion of food.

For a full account of Flemish husbandry, I must refer you to Loudon's Encyclopædia of Agriculture, to three numbers in the Farmers' series, entitled "Flemish Husbandry," and to a pamphlet written by Sir John Sinclair, entitled "Hints on the Agricultural state of the Netherlands." In the meantime I would mention, that every beast produces at the rate of ten to twelve tons of dung and twenty-six hogsheads of urine in the year. The following quantities are taken from the Farmers' series "On Manures," and from the Flemish Husbandry :—

URINE.

Urine, quantity produced, 12 lb. turnips produce 6 gallons of urine, besides the water which they drink, (p. 274.—F. S.)

Every beast produces 26 hogsheads of 54 gallons per year, (p. 22.) Flemish husbandry—or 4 gallons per day—5 tons weight per year.

5 cows produce 365 casks of 20 gallons each, (p. 79.) Liebig says one pound of urine will produce one pound of wheat, and therefore one cow's urine 64 loads of wheat per year ! !

SOLID AND FARM-YARD DUNG.

Each beast produces 20 to 12 tons per year, fed on distillery grain, of solid dung (page 22.)

A cow fed on 81 lb. of brewer's grains, 30 lb. of raw potatoes, and 15 lbs. of hay, produced 45 lb. of solid dung, no litter allowed. The same cow fed on 170 lb. of potatoes and 25 lb. of hay, amounted to 73 lb. of solid dung.—(Farmers' series, p. 255.)

When well littered and fully fed with turnips, 12 beasts yield a one-horse cart load of dung every 24 hours ; but 16 or 18 will scarcely produce that quantity if bedded on straw, with a small allowance of turnips.—(Do.)

Dr. Coventry, professor of agriculture, states, that 21 cwt. is the average amount of straw per acre from wheat, barley, or oats, and if properly managed, will produce 4 tons per acre of farm-yard manure.—(p. 253, Farmers' Series.)

45 oxen with 20 loads of stubble, (waggon loads,) while fatting, produced 600 tons of rotten dung.—(p. 255, Arthur Young.)

Consequently, if 33 beasts be kept to the 100 acres, there will be collected 350 tons of solid dung, and 858 hogsheads of 54 gallons each, (or 46,332 gallons) of urine. But with an allowance of straw and fully fed with turnips, 12 beasts will yield a one-horse cart load of manure every 24 hours, (p. 255, Farmers' Series,) and therefore 33 similarly circumstanced will yield 512 loads. Consequently, on 100 acres of land there would be, on the Flemish system, 700 to 900 loads of unfermented dung, and 858 hogsheads of 54 gallons each. There is also to be added the liquid drainings from the farm yard, which are always kept in a separate tank.

It is to be observed that the urines are collected in covered tanks, preserved so that no evaporation can take place, and they are kept several weeks before use; the urea is then converted into lactate and carbonate of ammonia. In Flanders there is always a separate covered tank for the yard drainings. For expenses of them, and the size, &c., see letter signed "Nimrod," in the Farmers' Magazine of last year, where he states that the cost of a large tank, and the usual pumps, carriages, &c., was £25.

And that one beast for every three acres, or 33 beasts for 100 acres, is the average quantity of stock kept in Flanders, and will keep that quantity of land in the highest state of fertility, there is sufficient proof from the quantity of manure produced as stated above, and from the practice adopted by the countries mentioned. But another consequence arises, from having great quantities of manures collected at home, and ready to be applied at the most suitable seasons, and that is, a more early maturity of the crops sown, a more lengthened rotation, and a greater produce. On their poorest sandy soils they have ten crops in succession. Turnips and carrots are with them seldom made a principal crop, but are sown after the barley or rye have been reaped, the barley being sown in autumn. These turnips, says the writer in the Farmers' Series on Flemish Husbandry, are not such as are sown in England under the name of stubble turnips, and give but a poor produce during the winter and early in spring. They are already a good size in September and October. In fact their growth is rapid beyond belief by the use of liquid manures. The beasts are all stall fed, by which there is not only a great saving in the quantity of food, as every farmer knows there is by soiling, but in this manner only could the manures from stock be properly collected. Forty pounds of turnips, twenty of potatoes, and twenty of carrots are given as the *brassin* to each beast daily, and fourteen acres of turnips, fourteen of potatoes, and seven of carrots, will therefore keep 33 beasts for six months. Fourteen acres of clover, mown twice, will keep the same quantity five months, and the other month they are kept with tares or barley cut green.

I have no calculation with respect to the quantity of manure, &c., produced by sheep, on the adoption of the plan of Mr. Childers, of Cantley, but in order to carry into effect the Flemish plan, it would be necessary that the sheep have a flagged court yard and tanks attached, and the whole court washed with water once a day. Mr. Childers's plan, if properly conducted, would not only yield a great quantity of manure of both kinds, but a greater quantity of flesh upon the least quantity of food is thus produced. All animals feed better on a variety of food, and are kept more healthy. Majendie proved that dogs die when kept on jelley for a long time. The rabbit, if kept on cabbage without any other food, becomes affected with the rot, entozoa breed in its liver. Entozoa, however, are not the sole cause of rot in sheep; for they are frequently present in the liver of healthy sheep, as I have verified myself in innumerable instances.

The rotation in Belgium for the richer kinds of light soils, and probably similar in texture to our limestone is this :

1 Flax and carrots.
2 Barley and turnips.
3 Rye and carrots.
4 Potatoes.
5 Wheat.
6 Rye or barley & turnips.
7 Flax and carrots.
8 Oats.
9 Clover.

To compare the quantity of produce raised by this rotation with the quantity raised on our own soils, suppose each of these 11 acre-fields equal to 99 acres in the whole. Of carrots, turnips, carrots, potatoes, turnips, and carrots, there will be 66 acres grown in the year instead of 25 acres of turnips in the 100 acres of limestone soils, and instead of 50 acres white crops, there will be, of barley, rye, wheat, barley, oats, of each 11 acres, making 55 acres, and in addition 22 acres of flax, equal at least to 77 acres of corn. The gain on the Flemish system will be 31 acres of green and root crops, and 27 acres of corn on the same quantity of land.

The two following rotations show the quantity of manure used, and it is evident that most of it is raised on the farm; first, at Alost, on a stiff loam :—

1. Potatoes, 20 tons of dung per acre.
2. Wheat, 3½ ditto, and 50 barrels of urine of 36 galls. each.
3. Flax, 12 ditto, and 50 ditto, with 5 cwt. of rape-cake,
4. Clover, 20 bushels of wood ashes.
5. Rye, 8 tons of dung, 50 barrels ditto.
6. Oats, with 50 barrels of urine.
9. Buck wheat, no manure.

In these 100 acres there requires 473 tons of dung, and 1300 hogsheads of urine.

On the western side of Woomen and Ypres there are two modes of rotation: one a nine years' course, in which wheat is but once introduced, and the other a ten years' course, in which they grow it a second time, but manure is never omitted, except for buck wheat, and occasionally for rye :

this seems to be the general system. The following is the course with only once wheat :—

1. Potatoes or carrots (4 ploughings) 12 tons per English acre English acre of farm-yard dung.
2. Flax (2 ploughings) 105 bushels of ashes, and 48 hogsheads of urine.
3. Wheat (2 ploughings) $10\frac{1}{2}$ tons of farm-yard dung.
4. Rye and turnips (2 ploughings) $10\frac{1}{2}$ tons of farm-yard dung.
5. Oats with clover (2 ploughings) $10\frac{1}{2}$ tons of farm-yard dung.
6. Clover top dressed, 104 bushels Dutch ashes.
7. Rye (1 ploughing) and 52 hogsheads of urine and night soil.
8. Oats (2 ploughings) 52 hogsheads do.
9. Buck wheat (4 ploughings) and without manure.

In 100 acres, there will be used of farm-yard manure 393 tons, and 1672 hogsheads of urine, so that some of the latter must be purchased, or more stock than usual is kept.

The following calculations of produce and expenses are taken from a report made to the French Government, in 1812, by M. de Lichtervelde, on Spade Husbandry, and the quantity of produce is not said to be extraordinary, being the same as is produced on a farm cultivated with the plough. The calculation is of 100 acres, and the following produce being sent to market, calculated at English prices :—

210	Load of wheat at 25s.	£272	10
78	Quarters of Rye at 40s.	157	0
210	Bushels of buck wheat at 4s.	42	0
87	Quarters of oats, at 24s...	104	8
7	Acres of flax, at £10	70	0
560	Bushels of rapeseed at 6s.	158	0
56	Cwt. butter from 30 cows, at £5	280	0
14	Fat hogs, at £5	70	0
7	Heifers and 14 calves sold annually	84	0
		1226	18
	The expenses upon the farm, calculating labour at the rate paid in the dearest parts of England, amounted to	616	0
	Leaving for profit, rent, interest of capital..	£610	18

The rotation was as follows, which is compared with the Limestone rotation:—

Acres.		White Crop. Bushels.	Root and Green Crop. Tons.
11	Oats	440	
11	Clover		22
11	Rape and Potatoes		77
	7 tons each...		77
11	Wheat.......... ...	264	
11	Rye and Turnips..	352	110
11	Barley and Carrots	440	164
11	Buck Wheat		44
11	Wheat	264	
11	Rye and Turnips..	352	110
99		2112	605
		1500	300
	Difference	612	305

Manure expended, but collected on the farm, 46,200 gallons of urine, and 364 loads of dung.

LIMESTONE ROTATION.

Acres.		White Crop. Bushels.	Root and Green Crop. Tons.
25	Turnips..		250
25	Barley ...	800	
25	Clover ...		50
25	Wheat ...	600	
100		1500	300

Manures expended and bought from foreign countries:—

	£.
Bones	90
Rape Dust	45
Ditto	60
	195

Consequently in the Flemish system there is an increased produce of 612 bushels of grain, and 305 tons of roots and green crops on the 100 acres, or about one-third more of grain, and twice as much of green crops and root, than on the limestone.

The manure expended was 364 loads and 2310 casks of 20 gallons, or 46,200 gallons; all of which is produced by 33 head of cattle.

To enumerate the advantages of the Flemish system, which, if adopted upon the magnesian limestone, would be—

1. A saving of 30s. per acre now expended on foreign manures.

2. An increased production of nearly 50 per cent. of grain, or 100 per cent. of root and green crop per acre, and a progressive state of improvement of the soil.

3. A saving of one-half of the quantity of seed sown: the Flemish sow just one-half the quantity that we do, (see

Farmers' Series); the higher the state of cultivation the less seed required.

4. An exemption from the smut and other diseases of wheat, and the loss of turnips from the fly.

The growth of fungi in wheat crops is almost unknown in Belgium, and by irrigation from the tank, the turnip is quickly out of danger from the attacks of the turnip fly.

5. An earlier harvest.

6. Not only greater crops of all kinds, and therefore economy on a given portion of land, but an increased weight of flesh from a given quantity of food, as is known to be produced wherever the soiling system is adopted.

It is very true that with the limited supply of manure at the command of the Limestone farmer, turnips, carrots, and potatoes, after rape, could not be produced as second crops, and it can only be effected by the application of liquid manures, to force them in the earlier period of their growth. But under the Flemish system these manures, which are now lost, would be saved. And no reason can be adduced why these crops should not be raised after white crops on the limestone, as in Belgium. It would not be necessary to follow the same rotations of crops which are grown in that country; for instance, flax, which requires a large supply of manure, is only worth £10 per acre. Neither is it probable that the red carrot would grow on the Limestone soils sown broad cast; but the white carrots are used by the Belgians, and are now beginning to be cultivated in England, and have shorter tap root; and there is an instance of the red being grown at Knottingley in drill, and producing of the value of £75 per acre. There would be immense saving of land by the growth only of turnips, or rape and potatoes as a second crop, or spurrey, which is very nutritious, and gives a rich flavour to butter (Lowe), might be produced after any of the Cerealia, as easily as is done by them, provided there could be obtained a supply of manure on the before-mentioned plan. Turnips have been grown as a second crop by Mr. Addeman, of Almholme, near Doncaster, after stubble oats, averaging 14 tons per acre; by Mr. Dickenson, of Partridge Hill, near Finningley; and Mr. East, of Bawtry, of eight or nine tons per acre; and are constantly grown around Carlton on the Trent after white crops, which is a sufficient proof that our climate can effect this object. Indeed there is no more difference between the climates of our southern counties and those of Belgium, than between the north and south parts of England. According to Humboldt, there is only one degree of difference upon the *whole year*, and not quite one degree in the autumn, between London and Brussels, the season most upon which the ripening of the second crops depend.

The temperatures of London, Brussels, and Amsterdam, as ascertained by Baron Humboldt, are as follows, and will give an approximation of the difference of climates.

	Coldest Month.	Warmest Month.	Mean temperature of the year.
London	37.76	64.40	50.36
Brussels	35.60	67.28	51.80
Amsterdam	35.42	66.92	51.62

MEAN TEMPERATURE OF WINTER, SPRING, SUMMER & AUTUMN.

	Winter.	Spring.	Summer.	Autumn.
London	39.56	48.56	63.14	50.18
Brussels.........	36.68	53.24	66.20	51.08
Amsterdam	36.86	51.62	65.84	51.62

Concerning the two remaining beds, the red marl and gyysum, and the Pontefract rock of Smith, little need be said. The upper red marl and gypsum has been described as a zone of wet land at the base of the escarpment of the upper limestone bed; every square inch of which requires deep draining and subsoil ploughing. Subsoil ploughing was suggested as an improvement of the lands of Owstone, Askerne, and Womersley, in the paper read by me at Wakefield, and I fear that this operation is not duly appreciated, and wish, therefore, to add the following quotation, taken from the History of the State of Improvement in Scotland, since the end of the 17th century. After speaking of the establishment of the Highland Society, and the introduction into Scotland of the turnip husbandry, the author says, "There yet remains another epoch in the history of Scotch "agriculture to be spoken of—the thorough or Deanstone "mode of draining. This so great benefit, not for Scotland "only, but for the whole kingdom, is yet in its infancy. "Already the fame of the utility of it is spreading all over "the island, and we have no doubt, in a short time, there "will not be found a spot (where improvements are carried "on,) that has not been made anew by means of this simple, "yet powerful and efficient system of draining. Now no "man holding land ought to be ignorant of the thorough or "Deanstone drain. It is perfectly wonderful to behold the "mighty change this thorough drain system is making in "different parts of the country where it is in operation; "wet land is made dry, poor weeping clays are converted "into turnip soil, and even what would formerly have been "accounted dry is advanced in quality. Whole parishes in "the vicinity of Stirling are transformed from unsightly "marshes into beautiful and rich wheat fields, and where "the plough could scarcely be driven for mud and water, we "see heavy crops per acre."

There is one word to be said concerning the use of gypsum, which abounds in the bed of red marl; the places where it has been dug have been mentioned. The chemical properties of gypsum, as a manure, are not well understood; its operation is to fix the ammonia which exists in the air, and in the richer manures in the soil. The gypsum is decomposed by the carbonate of ammonia, and the result is sulphate of ammonia and carbonate of lime. The sulphate of ammonia is not so volatile as the carbonate, and yields nitrogen gradually to the growing plants. The effects of gypsum, however, are not immediately visible, but are slow and permanent. A small quantity, if strewed in the stables of horses, not only destroys the effluvia, but a valuable manure is thus formed. This salt really abounds in the stratum described, and can be had at so cheap a rate, that it must be worthy of trial. Lord Leicester presented Mr. Grisenthwaite with a piece of plate, for his exertions in introducing it. Liebig states, that if a field be strewed with gypsum, and then with putrefied urine, or the draining of dunghills, all the carbonate of ammonia will be converted into the sulphate, which will remain in the soil. By judicious draining of this stratum a considerable quantity of water may be cut off from passing to the lowest portion of the clay by Elkington's plan: the water falls on the limestone, and breaks out at the bottom of it: a deep drain cut parallel, or in a north and south line, generally would intercept it.

The *Lower Red Sandstone*, or *Pontefract Rock*, wherever it contains marl, requires the same mode of farming, its marls require deep draining and subsoil ploughing; the sand beds upon it are infertile, and would be greatly improved by the admixture of marl. This rock contains no gypsum.

So much, then, for the existing state of farming on the Magnesian Limestone. In fine, the great secret in agriculture is to follow the indications of Providence. He has, however, ordained a great circle of transmutations. Vegetables collect food from inorganic bodies, while animals derive sustenance from vegetables, the decay of both affords a fresh supply of nutrition to vegetables. The atmosphere is a vehicle for the supply of one substance, the earth of another, and one remaining constituent has been left to be adduced by man. In some countries man does follow the suggestions of the laws of nature. But in England, which has risen to a pinnacle unattained by any nation in the world in the arts and in commerce, agriculture languishes! And why do we hear of agricultural distress in the midst of continual demand for agricultural produce? Why is she obliged to import not only a large proportion of corn, but an enormous quantity of manures to raise her own corn? The reason is obvious. Those employed in the agricolation of Great Britain undervalue those substances which constitute the chief food of the vegetable kingdom, and therefore the agriculture of England is inferior to that of Belgium, China, and several other portions of the Continent of Europe.

At the conclusion of the paper, Mr. Thorp was loudly cheered.

The Chairman said he should be very glad if any gentleman would comment on the paper which had just been read. It was only by discussion that truth could be elicited, and if there was any difference of opinion, he was quite sure Mr. Thorp would feel pleasure in hearing it expressed.

J. W. Childers, Esq. M.P. was afraid he could not enlighten the meeting much on the subject, and his main object in rising was to express his thanks to Mr. Thorp for his exceedingly able and most useful paper. It was a paper which he should have very great pleasure in seeing printed. As a member of two societies, the Royal Agricultural Society of England, and the Yorkshire Agricultural Society, he believed both would be exceedingly gratified and interested with the information that had been communicated. Owing to a combination of unfortunate circumstances, neither of those societies had yet been able to offer such productions to the public. An arrangement had been made last year with a distinguished geologist, Professor Phillips, to go over the same district as that described by Mr. Thorp, and to report upon it; but his being employed by the government in the county of Cornwall, had interfered with that plan. He must confess he had attended the meeting with some prejudices on his mind against the Society. He came there with the idea that it had originated in a particular part of the country, and was formed by a body of gentlemen engaged in mining operations, for their exclusive benefit, and that nobody but themselves were interested in it. That prejudice, however, formed as many prejudices were, from imperfect knowledge, or from being at a distance from the spot, had been completely dispelled. He had been considerably gratified with the paper read by Mr. Thorp, and he now felt that this Society would fill up a gap which he had long wished to see filled up, but which he had found no inconsiderable difficulty in accomplishing. It had often been thought difficult to unite agriculture and science together, but he was of opinion that this Society was extremely well calculated to effect that most desirable object. Notwithstanding the cordial support which had been given in various towns to the Geological Society, it could not be said that the attendance on this occasion was that which it ought to have been. It had occurred to him whether it would not be possible, especially considering the intimate connection between this Society and the Yorkshire Agricultural Society, to meet together at the same time, and to devote one part of the day to discussion, and the other to the show of cattle. It appeared to him, that by adopting this plan, they would ensure a large accession of members, and would render the objects of the Society more fully understood by those who were more particularly interested. What the Yorkshire Agricultural Society had at heart exactly corresponded with the subjects on which Mr. Thorp had treated; and therefore, he thought they might, with great propriety, cooperate together. He observed that this Society was termed a West-Riding one, but if the Council would consent to alter the title " Yorkshire," there would be no difficulty in meeting the other Society at Hull next year. He hoped that by union of purpose, they would effect most important improvements in the art of cultivation. He quite agreed in the observations of Mr. Thorp as to the importance of sub-soil ploughing, and although it had not been tried successfully in this country, there could be no doubt, from what had been experienced in Scotland, that it was of immense advantage. He also quite agreed with Mr. Thorp in the opinion he had expressed, as to the importance of gypsum as a manure; yet although there appeared to be beds of it in the neighbourhood, few experiments had yet been made upon it. In foreign countries it was esteemed of very great value, and was used with considerable advantage, and if he might express an opinion, he thought that his brother farmers should try it, and see if they could not employ it with the same success as elsewhere.

W. B. Wrightson, Esq. M.P., was not aware that gypsum had been used for agricultural purposes in this country, though he had often heard the experiment suggested.

E. B. Denison, Esq., observed that it was commonly used in Derbyshire.

Sir W. B. Cooke, Bart., said he had often heard Mr. Wrightson's father say that he had tried many experiments with gypsum, and all he could say was that the land was no worse for it.

J. W. Coulman, Esq., inquired of Mr. Thorp at what depth he found the gypsum to exist?

Mr. Thorp replied that in many instances it was immediately close to the surface.

Mr. Coulman would take the liberty of putting another question. Mr. Thorp had recommended straw-yard manure. Would he recommend it to be applied in a fresh state, or in a state of decomposition? Next, with regard to the preservation of liquid manure in tanks, a plan recommended by

Mr. Thorp. There appeared to him to be some difficulty about the matter. How could he prevent the admission of water, because, if there happened to be a considerable down-fall, the strength of the preserved liquid would, in a great measure, be destroyed?

The Chairman thought the admission of water might be easily prevented, by having the tank covered in.

Mr. Coulman had heard practical persons assert that the application of straw-yard manure in an early state was much more beneficial both as regarded grass land and potatoes. A person of the name of Baker, residing at Nassau Cottage, near Leeds, who had written extensively on agricultural subjects, stated that, from experience, he had found this to be the fact.

The Chairman had no doubt whatever that Mr. Baker's observation would apply to potatoe crops, but with respect to grass he was not quite sure.

P. D. Cooke, Esq. fully concurred with his friend Mr. Childers in his expressions of gratitude to Mr. Thorp, for his very able paper. He was not aware whether it would be in accordance with the rules of the Society that he should move a distinct vote for the printing of the paper, but if it was, he should have great pleasure in doing so.

The Secretary observed that it was the practice of the Society to print the Papers read at its meetings.

Mr. Denison said he thought so highly of the paper, that if it was printed he should take 20 copies for distribution. He thought one of the most effectual means of promoting the objects of the Society was by each member taking a certain number of copies, and distributing them among the farmers in his own neighbourhood.

The Chairman, thought the suggestion an extremely valuable one, and he hoped it would be acted upon.

The following Resolutions were also passed :—

1. That the thanks of the Society be given to the Mayor, for the use of the Mansion-house.

2. That the next Meeting be held at Halifax, on Wednesday, the 3d of March.

3. That the thanks of the Society be given to the Rev. W. Thorp, for his valuable paper.

At the Evening Meeting Mr. EMBLETON brought up the

REPORT ON GEOLOGY OF THE NORTH MIDLAND RAILWAY, PREPARED BY MESSRS. EMBLETON, HOLT, & MORTON.

In preparing this report for presentation to the Society, the Sub-committee of the Council have had considerable difficulty; and they regret that it is not so complete as they could have wished. Two reasons may be assigned for this. First,—that many of the cuttings being covered with soil prior to the Society's excursion on the 23rd June last, some of the more minute geological features could not be examined with any degree of accuracy. And second,—that the Railway passes through certain districts of which, geologically speaking, scarcely anything was previously known. Mr. Swanwick, the talented engineer, with a degree of liberality that does him honour, has considerably lightened the first-mentioned difficulty by presenting to the Society a large and splendid section of the whole line, on which the various strata passed through in the cuttings and tunnels are beautifully delineated and coloured. The Committee have naturally taken Mr. Swanwick's section as the groundwork of the present Report; and they embrace this opportunity of recording the obligations of the Society to that gentleman for his valuable donation.

The Railway Station at Leeds, adjoining Hunslet-Lane, is calculated to be 40 or 50 yards above the "Black Bed" of Low Moor. It frequently has been bored to in this neighbourhood for the purpose of finding water. In the first cutting south of the Leeds station several beds of shale and sandstone appear; and one bed of the latter, which comes to the surface near Jack-lane, affords stones and flags of very fair quality. Where the cutting enters Hunslet-moor, the "Beeston Coal" bassets out, and is of the usual thickness, namely, from five to six feet. This coal lies seventy or eighty yards above the Low Moor "Black Bed," which is here termed the "Royd's Coal." The "Beeston Coal" has been worked under the north part of Hunslet Moor, and in cutting this portion of the Railway, several old pits were discovered near the bridge opposite to Mr. Bower's glass works.

The strata in this locality dip moderately towards the south-east. A short distance nearer the village of Hunslet the cutting is crossed by a Fault, running nearly East and West, which throws down the measures forty-five yards to the South, so that at the Silk Mill, near the road to Middleton, the "Beeston Coal" is seventy yards deep.

In the Woodhouse Hill Cutting the "Middleton Main Coal" is seen near the Jeffrey Lane Bridge; and its appearance here is caused by a downcast Throw to the South-east of thirty-five yards. A little further on there is another Throw down of about forty yards in the same direction, which depresses the "Middleton Main Coal;" and a thick bed of sandstone now occupies the principal part of the Cutting, which is fifteen or sixteen yards above the "Middleton Yard Coal."

Near the southern end of this excavation a third Fault occurs, which elevates the strata about thirty yards. Two of these Faults have been met with in Middleton Colliery, and may be seen in the road near Belle Isle, where the Middleton Rock is thrown to the surface, forming a ridge of considerable length, which extends to within half a mile of Woodhouse Hill. The identity of this rock with the Middleton rock has been proved by boring through it in both places to the same beds of coal. Proceeding along Rothwell Haigh, the strata dip to the south-east, and the "Middleton Forty-yard Coal", (or "Crow Coal," as it is here termed,) is just below the surface of the ground. On the hill side adjoining the stone quarry, two thin seams of Coal crop out from beneath the sandstone. These coal seams are probably the Middleton Upper Beds; and the sandstone is certainly the Middleton Rock; for it can be distinctly traced from one locality to the other.

In the Woodlesford Cutting the same Coal seams lie beneath the same Sandstone until they are cut off by a downcast Throw of unknown extent, which occurs near the bridge; and from this point to the Wakefield and Aberford road the sides of the excavation are entirely sandstone. A long embankment then carries the Railway past the Methley Colliery. The coal worked here is about sixty yards deep, and is supposed to be the "Warren House Coal," which is nearly two hundred yards above the "Middleton Beds."

It is much to be regretted that no accurate section of the strata sunk through in this colliery can be obtained, and consequently no very satisfactory comparison can be instituted between them and the "Warren-house" and "Lofthouse" measures at Newmarket. But if, as it is supposed, the "Methley Coal" be identical with the "Warren-house," it follows that a Throw down of considerable magnitude intervenes between Swillington Brewery and Methley Colliery, which will account for the non-appearance of the out-crop of the "Lofthouse Coal" in this neighbourhood.

In prosecuting the geological examination of a district, it is obvious how much the work may be facilitated by references to shaft sinkings and borings: and the Sub-committee would here venture to recommend that persons connected with, or interested in mining operations, should accurately register the nature and thickness of the strata sunk or bored through in their respective works.

In the Methley Cutting, near to the York Junction, a bed of Coal, covered with shale and rock, appears, which probably corresponds with one of the Coal seams in the Whitwood borings. In this Cutting there is also a Throw down to the south, but its extent has not yet been ascertained.

The Railway here crosses the river Calder, and soon afterwards enters the excavation near Normanton, which is one of considerable interest, because of the dislocations cut through, and the alternation of Bind and Sandstone beds here exhibited. Sudden and unaccountable changes from Sandstone to Bind, and vice versa, are often observed in sinkings near to each other; but in this Cutting the passage from one to the other is distinctly seen. In the first part of the excavation the strata *rise* rapidly to the South, until we reach the road leading from Normanton to Newland, where a Fault occurs, which reverses their position, causing them to *dip* to the South. In the Northern portion of the Cutting beds of Bind predominate; but these gradually disappear and are replaced by blue Sandstone in the southern portion. Farther on, two dislocations are seen near to each other: the first is a Throw *down* to the South, and the second a Throw *up*.

At the entrance of the Oakenshaw cutting, near Goosehill, three beds of Coal present themselves, rising rapidly to the Southward. They are supposed to be the same as the Sharleston beds. Farther South, strata of hard white Sandstone emerge from beneath the last-mentioned coal seams. These Sandstones (which have afforded most excellent building materials for the bridges, station houses, and other erections, connected with the railway,) continue along the sides of the Cutting to within half a mile of the Wakefield and Pontefract turnpike road, when they are broken off by a Fault that re-introduces the Sharleston Coal seams dipping fast to the Southward. Consequently, the ridge between Goose-hill and Oakenshaw through which this excavation passes, appears to be an anti-clinal axis.

Crossing the stupendous viaduct over the Barnsley Canal, the railway enters the Chevet Sandstone near Walton, and continues in the same formation through the Chevet tunnel.

The deep Cutting at Notton High Bridge presents some singular and interesting features. Several Faults occur which cause the dip of the strata to vary considerably. Their general rise, however, is towards the South. A bed of Coal three feet thick is here passed through, which is supposed to be the "Shafton coal." The teeth and scales of fishes have been found in the shaly roof of this Coal, and the Chevet sandstone lies almost immediately beneath it. The Whin Cover Cutting, the Cutting at Cudworth station, and the Cutting to the Southward thereof, are in the Chevet Sandstone; the beds of which for the most part dip to the south-east. Near the 50th milestone at Little Houghton, the "Billingley Coal"—which corresponds with the "Shafton Coal," is found about four feet thick. At this point the measures dip southward; but at Billingley colliery they rise in that direction.

The railway then enters the Darfield tunnel which passes through a hill of Chevet Sandstone. The same rock is worked in Cat-hill quarry, near Darfield station, and affords excellent building stone.

The report on the Geology of the remaining portion of this important line of railway is unavoidably postponed, in order that the committee may have an opportunity of examining more minutely the interesting excavations in the neighbourhood of Swinton, Rawmarsh, and Masborough.

TABLE OF MANURING SUBSTANCES IN THE FOLLOWING ARTICLES:

Names.	Carbonic Acid.	Nitrogen.	Phosphates.	Neutral Salts.
Urines. ——— Human.	......	5.1 per ct. Ammoniacal Salts.	of Magnesia. — Soda. — Lime.	Sulphate of Potash. ——— of Soda.
——— of Cow.	......	10 per ct. Ammoniacal. ——— Salts (Brande). 1.6 per ct. (Sprengel.)	of Lime (3 per cent.)	Sulph. of Potasse, 6 per ct. Muriate of Potasse, 7 pr. ct.
——— of Horse.	......	0.7 per cent Urea.	......	Carb. Lime, 1.1 per cent. ——— Soda, 0.9 per cent. Muriate of Potassa, 0.9 pr. ct. Benzoate of Soda, 2.4 pr. ct.
Dungs. ——— Ordure.	......	$1\frac{1}{2}$ to 5 per cent.	of Lime. } 10 per cent. of Magnesia } of Soda.	Carb. Soda, .08 Sulp. Do. ——— Potash.
——— of Sheep.	......	18.0 per cent. of substances containing Nitrogen.	Carb. and phosp. of Lime 2.0 per cent.	Carb. Sulp. and Muri.; Soda 1.6; Silica 6.0 per cent.
——— of Horse.	......	1 per cent. Nitrogen.	of Magnesia, 14 per cent.	Carb. of Lime. Mur. Soda. Silicate Potash. Sulp. Do. Carb. Do.
——— of Cow.	......	1 in 200,000 parts. 1 p. ct. of albumen (Sprengel)	of Lime, 9 to 28 per cent.	Muriate of Soda. Silicate of Lime.
Ashes of Beech.	......	......	Phosphates, 20 per cent.	......
Bones.	......	5 per cent. Nitrogen.	of Lime, 55.35 per cent. of Magnesia, 2 per cent.	Carb. Lime, 11 per cent. Soda } 1 per cent. Muri. of do. }
Wheat Straw.	......	......	Phosphates, 6 per cent.	Silicate of Potash.

Note—1 lb. of Urine will produce 1 lb. of Wheat. (*Liebig.*)——100 lbs of Sal Ammoniac contains 26 pts. Nitrogen = the quantity of Nitrogen in 1200 lbs. of Wheat, in 1480 lbs. of Barley, and 2755 of Hay.

Horse dung loses $9\frac{1}{2}$ per cent. of the best manuring matter in two months by exposure, consisting of ammonia, carbonic acid, carburetted hydrogen, and carbonic oxide. That of horned cattle, 5 per cent. in forty days, (Sprengel.) The annual value of the manures of the United Kingdom has been estimated at twenty millions sterling. The loss by evaporation and the waste by drainings through and out of farm yards, is not less than one-third! W. T.

Names.	Ashes in 1000 Parts.			Saline and Earthy Constituents of the Ashes.						Nutritive Matters per Cent.		
	Ashes from 1000 parts Green.	From Do. Dry.	Water from 1000 parts Green.	Soluble Salts of Potash and Soda.	Earthy Phosphates	Earthy Carbonates.	Silica.	Metallic Oxides.	Loss.	Mucilage or Starch.	Sugar.	Gluten or Albumen.
				pr. ct.	pr. ct.	pr. ct.	pr. ct.	pr. ct.				
PEAS, plants of (in flower)...	......	95	......	49.8	17.25	6.	2.3	1.	24.65	50.1	2.2	3.5
Plants of ripe peas...........	......	81	......	34.25	22.	14.	11.	2.5	17.25	......	......	......
VETCHES, before flowering...	16	150	895	55.5	14.5	3.5	1.5	0.5	24.50	......	......	......
Do. in flower, June 23d ...	20	122	876	55.5	13.5	4.12	1.5	0.5	24.38	......	......	......
Do. ripe (seeds separated)...	......	115	......	42.	5.75	36.	1.75	1.	12.9	......	......	......
Seeds of do.	......	33	......	69.28	27.92	......	......	0.5	2.3	......	......	......
Do. in flower raised in distilled water	......	39	......	60.1	30.	......	......	0.5	9.4	......	......	......
WHEAT, in flower	......	......	......	43.25	12.75	0.25	32.	0.5	12.25	......	......	......
Do. seeds ripe........	......	......	......	11.	15.	0.25	54.	1.	18.75	......	......	......
Do. a month before flowering	......	79	......	60.	11.5	0.25	12.5	0.25	15.5	......	......	......
Do. in flower, June 14th ...	16	54	699	41.	10.75	0.25	26.	0.5	21.5	......	......	......
Do. seeds ripe...................	......	33	......	10.	11.75	0.25	51.	0.75	23.	72.5 to 75.	......	23.9 to 24.
Straw of Wheat	......	43	......	22.5	6 2	1.	61.5	1.	7.8	......	......	......
Seeds of do.	......	13	......	47.16	44.5	......	0.5	0.25	7.6	......	......	......
Bran	......	52	......	4.16	46.5	......	0.5	0.25	8.6	......	......	......
Chaff of Barley	......	42	......	20.	7.75	12.5	57.	0.5	2.25	......	......	......
Seeds of do.	.....	18	......	29.	32.5	......	35.5	0.25	2.8	79.0	7.0	6.0
Do.	......	......	......	22.	22.	......	21.	0.12	29.88	......	......	......
OATS	......	31	......	1.	24.	......	60.	0.25	14.75	64.1	1.5	8.7
RYE...	......	......	......	......	......	......	......	......	......	64.5	3.8	10.9
BEANS...........................	......	......	......	......	......	......	......	......	......	42.6	......	10.3
TURNIPS	......	......	......	......	......	......	......	......	......	0.7	3.4	0.1
SWEDES	......	......	......	......	......	......	......	......	......	0.9	5.1	0.2
POTATOES	......	......	......	......	......	......	......	......	......	15. to 20.	1.5 to 2.	3. to 4.
RED BEET........................	......	......	......	......	......	......	......	......	......	1.4	12.1	1.3
CARROTS..........................	......	......	......	......	......	......	......	......	......	0.3	9.5	......

DAVY'S AGRIG. CHEM. p. 138 and 139.

In 2 pounds, or 15560 grains, Schröeder found the following number of grains weight ..

	Wheat.	*Rye.*	*Barley.*	*Oats.*	*Rye Straw.*
Silica	13.2	15.6	66.7	144.2	152.
Carbonate of Lime	12.6	13.4	24.8	33.75	46.2
Carbonate of Magnesia	13.4	14.2	25.3	33.9	28.2
Alumina (Clay)	0.6	1.4	4.2	4.5	3.2
Oxide of Manganese	5.0	3.2	6.7	6.95	6.8
Oxide of Iron	2.5	0.9	3.8	4.5	2.4

(Schrœder,) Gehlens Journal, Vol. III. p. 525.

PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE THIRTEENTH QUARTERLY MEETING, HELD AT HALIFAX,

ON THE 3RD MARCH, 1841.

The Rev. SAMUEL SHARP, having been called to the Chair, said,—

Ladies and Gentlemen,—I regret exceedingly that the Council have not been able to find a better President than myself, because I do think that a man who stands in the responsible situation in which you have now done me the honour to place me, ought to know something of the subject on which he is to speak. It does so happen that I know scarcely any thing of Geology. All I know is, that it is a most entertaining subject, and one well deserving the attention of every person who has leisure to devote to it; but it is a subject which must require considerable time, and that time I have not had it in my power to devote. No person, I think, can take the least notice of the surface of the earth, without observing that at some period, and by some means or other, great and extraordinary changes have taken place. The object of the study of Geology, if I know what it is, appears to me to be to ascertain, as well as the limited faculties of the human mind will admit, when these changes took place, and what was the great and prevailing cause that effected them. There has been a prejudice against this study in the minds of some persons, extremely well disposed, but perhaps, of rather timid dispositions, who have thought that the study of Geology might lead, or, at all events, have a tendency to lead to scepticism and infidelity. Now, I do not think there is any subject, a slight knowledge of which would have so great a tendency towards these evils as Geology; but I have not the slightest doubt but that a close attention to the science will satisfy the mind of the most timid that there is no danger to be apprehended from the pursuit of it. A partial attention to the subject has shaken, and may hereafter shake, the timid mind, but a thorough investigation and examination of the subject will, I have no doubt, reconcile every one to the study, and prove that no injury is likely to accrue to religion. It is partly on this account that I have taken some share in the formation of the "West-Riding Geological and Polytechnic Society." Having had the pleasure and satisfaction of being present at Cambridge, at a Meeting of the British Association, when I heard a most eloquent address from Professor Phillips, in which he stated that he thought it was better to have a bad theory than no theory at all, I confess the brilliant eloquence of that wonderful man, of that learned and philosophic mind, led me away, and induced me to think that he was right in that opinion. But, however presumptuous it may appear in an humble individual like myself to express an opinion contrary to that of so eminent a philosopher, I do venture to say that I think he is wrong. I think the progress hitherto made in the science of Geology—I mean the collection of facts,—is not sufficient to enable any man, however clever or ingenious, to form such a theory as would not be attended with insuperable objection. I would earnestly recommend to all the students in Geology, the collection of facts rather than to form theories, and one great object of this Society is to do that, and to ascertain whether the theories which have been advanced are corroborated or contradicted by those facts.

My attention has been drawn to two objects presented by Mr. Briggs. He has furnished us with specimens of all the strata from the surface to the very bottom of a shaft: he has given us a list of all the fossils found in each stratum, and every thing connected with it. I wish that every person connected with collieries in the whole of the West-Riding would do what Mr. Briggs has done. The Society would be extremely happy to receive such communications, and would value them highly.

The following gentlemen were elected Members of the Society :—

The Ven. Archdeacon Musgrave, Halifax.
Christopher Dawson, Jun. Esq. Do.
John Rhodes Ralph, Esq., Do.
Rev. W. Turner, Do.
Joseph Stocks, Esq., Upper Shibden Hall.
Edward Akroyd, Esq., Bank Field.
H. Akroyd, Esq. Woodside.
R. Mellin, Esq., Wakefield.
H. Clarkson, Esq. Do.
R. K. Lumb, Esq., Halifax.
Rev. F. Russell, Do.
Dr. Inglis, Halifax.
Wm. Briggs, Esq. Do.
John Dawson, Esq. Do.
Abraham Jubb, Esq. Do.
E. N. Alexander, Esq., F. S. A. Do.
Wm. Haigh, Esq., Shay, Halifax.
Thos. Varley, Esq., Edgerton House, Huddersfield.
Henry Macaulay, Esq., Huddersfield.
Wm. Wallen, Esq. Do.
Rev. Michael Trappes, Do.
J. Nowell, Esq., Farnley Wood, Do.
Thomas W. Rawson, Esq., Bradford.

The following Resolutions were passed :—

" That the next meeting be held in Leeds, on the 2nd of June."

" That the thanks of the Society be given to the Philosophical Society of Halifax, for the use of their hall, and for their kindness in making arrangements for the meeting."

The following Papers were then read :—

ON THE MINERAL SPRINGS OF THE PARISH OF HALIFAX, GEOLOGICALLY CONSIDERED, BY W. ALEXANDER, ESQ., M. D., HALIFAX.

One great design of the Geological department of the West-Riding Society, in its migratory visitations, is, I believe, the acquisition of *local* information of a *practical* kind. Its object is, patiently to explore and accurately examine the *present* existing arrangements of mineral masses, and the phenomena to which they give rise, so as to collect facts, and convert the results to useful economical purposes, rather than enter upon speculations of a vague and uncertain character, as to the *past* operations of nature.

It will be thus, that the difficulties met with will be overcome,—that Geological problems will be solved and wisely interpreted,—that the Gordian knot will ultimately be unravelled, and this branch of natural science, by universal consent, placed in the elevated position to which it is entitled.

In accordance with this plan, I have endeavoured to restrict myself to a *plain statement* of what appears to be the *stratification* of this parish, and the relation which the springs bear to it; and in extenuation of the very imperfect manner in which my subject is treated, I must observe, that it was undertaken at the suggestion of the Honorary Secretary as being new to the Society; and with respect to the Geology of this district, I must plead the general absence of information either in any published works or private accessible source to which reference might have been made for assistance in confirmation of my own views.

The very detached manner, variable thickness, and transition into a gritstone of finer grained texture, which the Millstone Grit presents in different localities, being sometimes wanting, and again appearing at distant points, are very embarrassing, and render exact results difficult of attainment. The frequently jointed and fractured appearance it assumes, together with its occasional oblique lamination, serves to increase the difficulty in deciding the question of identity as to this triple series, when remotely situated, and perplexes any determination as to the dip or inclination of strata.

A part of the parish to the East, I apprehend constitutes a variation of the upper group of the millstone grit and shale series; I conceive also, that this town rests on the middle term, with an outcrop of large square pebbly blocks at Woodhouse scar to the W.S.W., and Birks Wood on the N. W., whilst the sides and bed of our far great Western valley are formed of alternating Craven shales and grits, surmounted by thin limestones and the lower and middle millstone groups, the mountain country of Studley Pike to the West, and Great Bouldsworth to the North, completing the uppermost member, and so crowning the entire series at the summit of drainage along the boundary of the county.

Thus we may, perhaps, be considered to be allied to and comprehended in the second and third members of Phillips's N. West Yorkshire Series, viz., the Millstone grit, and what he terms the Yoredale Rocks.

Situated to the westward of the proper coal tract of the West-Riding, the parish of Halifax, if not so fertile in its agricultural surface, nor so largely enriched with underground mineral stores as some more favoured districts, is nevertheless, to the Geologist, a region of some interest. Its physical aspect is bold and mountainous, whilst the deeply excavated sloping valleys contrast well with the outlines of the hilly ridges. The seams of coal are condensed and thin, but the quarries give employment to 1,200 persons, and furnish large supplies of the various kinds of freestone, flagstone, and slate of superior quality, not to mention the copperas works, black earthenware manufacture, and other subordinate branches of the arts dependent on mineral masses.

The outcrop of detached masses of Millstone grit, at several high points to the West of the township of Halifax, appears to have been taken away to form the walls and fences of the reclaimed moor lands in their vicinity, since we are now oftentimes unable to discover even their original sites, the subjacent strata displaying a coarse sandstone rather than a continuous pebbly grit; though these standing monuments prove it to have been there, and in immense quantities. Such is the case about a mile and a half hence to the West and North, from King Cross, by West End, to High Road Well and Camp End. Most of the blocks of Millstone grit described in Watson's History sixty-five years ago as the Druidical remains of this parish, will now be sought for in vain for the like reason. In the Upper High Road Well Moor, a coarse grit is now working out, in which a few fossil plants are found; and in the lower moor quarry is an abundant bed of more compact freestone.

To the south of this point, near Washer Lane, beneath the millstone is a valuable bed of calliard, or fine-grained grit, called "cutting stone," from which the Trinity Church was built; and all along that projecting scar millstone lifts, as they are termed, have often been abstracted to form ornamental rockeries, and serve for mills. At the opposite range of hills, across the Calder vale, is the township of Norland, with a massive outcrop of Millstone grit at Butterworth End; and a quarry of gritstone is worked beneath the moor, nearer to North Dean.

This formation constitutes an important feature of the scenery in this neighbourhood, and is readily discerned by its black and broken angular or rounded surfaces on the brow or sides of the boggy moor land hills; but its appearance at other prominent points than those already noticed, must be shown by a diagram of the system of drainage, correctly drawn for me by Mr. D. Kershaw, by which gentlemen from a distance will better understand the districts referred to than by local names, the course of the Calder being more generally known.

To the Westward of the township of Wyke, in Birstal, which forms the boundary of this parish on the east, the alternating clay, shales, coal, and sandstone suffer condensation, as may be partially seen in the excavation on the Bradford road, until they arrive at Halifax, when they, together with the rest of the upper grit group to which they belong, become extinct for some miles distance in the same direction. A belt of plate coal, however, is discernible from the railway line, situated within the middle millstone group in Norland, as also in Sowerby; and still further to the North a thicker seam is found in Midgley, but its extraction is rendered difficult, if not impracticable, from its dip and drainage; whilst still to the West beyond Hebden Bridge, and to the North of Heptonstall, the Millstone grit is more fully developed, overlying the Yoredale series. For reasons already assigned, any computation of the thickness of this formation, and its alternating grits, plate, and shales, would prove applicable only to a given point, their variable occurrence being unfavourable to any general accurate admeasurement. The upper Millstone grit itself usually occupies the highest ground, where its pebbly indestructible nature, affording little or no soil, together with the low temperature and humidity of the air, promotes the growth of heather, sedgy grass, mosses, lichens, and other cryptogamic plants; and in these localities it may measure from 70 to 150 feet, or more at Studley Pike and Bouldsworth.

The western part of this neighbourhood may be said to resemble in some degree the district from the Wharfe northwards to the Tees; for, although we have perhaps a less striking display of Millstone grit, no part of the superior or true coal measures is to be seen.

The parish may be, perhaps, best described according to the variations of its interior strata under three heads, although two would suffice, for in a limited space of eighteen miles from East to West such general geological distinctions must necessarily be arbitrary, for one class of rocks will be found to extend partially into the second, and this graduate into the third. Nevertheless there is a sufficient difference observable to justify these divisions, and characterise the localities comprised in them. The botanist, from the peculiar aspect of the vegetation found in each, dependent on the fundamental differences of the interior structure, would probably arrive at a similar topographical arrangement with respect to plants.

With a view to illustrate my subject, I have endeavoured to construct a diagram, which is intended to represent a *section* of the strata, from the extremity of the township of Shelf on the East, to near Todmorden on the West.

Here is Shelf, with an indication of its three workable coal seams, the one foot bed, the black bed coal, and the better bed.* This is an entire section of strata 120 yards from the surface, but it would occupy too much of your time to detail the particulars. At this point is the Back Clough Quarry, in Northowram, of handsome compact freestone; and here we have the Shibden and Boothtown seams. At this point we come upon the Halifax gravel, beneath which there is a coarse gritstone, sometimes containing fossils, as in this instance found in digging the cellaring of the buildings now in progress at Northgate End. The Halifax and Elland coal seams are analogous in several particulars, presenting some agreements in thickness, succession, quality, and nature of the accompanying strata, afterwards to be noticed. The

* See Pl. III.

Wyke coal field, with its two workable seams, may be said to partake of the peculiarities of the proper coal tract and our own inferior system, and form the connecting link between them. The Shelf coals are heavy, earthy, and one bed is encrusted with pyrites, whilst the hard and soft beds of Halifax would be valuable if thicker.

At Mytholmroyd and Hebden Bridge we come on to the Yoredale limestone series, and hereabouts there appear to have been considerable uplifting movements, the latter place situated upon the anticlinal axis, North and South of these disturbed strata. High Greenwood is one of Mr. I. Gibson's favourite localities for fossil shells, lodged in the plate and Nidderdale shales of the alternating grits and thin limestones. At Widdup and Gorpell is again a marked display of Millstone grit, and Great Bouldsworth caps the series. In Lumbert's Clough fossil fish are found, and Studley Pike completes the Millstone series on the South side of the river. Millwood is another source for fossil remains, found, I apprehend, in the Bolland shales beneath the main limestone, or uppermost member of the Yoredale rocks. At Foulclough, near Whitworth, is a soft bed coal; and beyond Gorpley, at Dalesgate, near Bacup, a hard bed, not unlike the two Halifax seams; whilst near Burnley, in Shedding Clough, and Overtown, is a five-foot coal below the gravel, somewhat analogous to the Mirfield and Wyke beds. Manchester and Leeds, I apprehend, work the same coals, and the fossils of the red marl at the first-named place, and in the Garforth Magnesian Limestone of the last, are identical.

When closely examined, our geographical area affords ample evidence of having been variously acted upon by diluvial and oceanic agencies, for it would be difficult to conceive that the small rivulets and atmospheric causes of waste would prove adequate to the formation of the valleys. The relative elevations of the parish, pleasingly diversified with a succession of continuous undulations, may be almost wholly ascribed to the defacing influence of water currents, proportioned to the local magnitude of the effects; and an inquiry into the existing drainage, together with the nature and position of the deposits, would seem to confirm this opinion. The ranges of hills are composed of arenaceous sandstones, sometimes surmounted by millstone, which would resist these forces; whilst the lines along the course of the valleys consist of the looser shales and argillaceous plate, formations readily worn through and acted upon by them.

As all our valleys situated to the North of the Calder take a direction nearly North and South, and the dip of the strata at this side Hebden Bridge is almost uniformly to the East, powerful diluvial action must have ploughed up the strata with a lateral excavating force in their formation, sweeping away the spoils over all opposing barriers. From what now occasionally occurs in mountainous districts even from torrents of rain and swollen springs, we may form a faint idea of the devastating effect of the passage of tumultuous waters when the levels of the country were differently adjusted; and the beds of gravel, the masses of granite lodged in sand at Mytholmroyd, and the bouldered stones still found along the track of the Calder, would indicate that these floods had taken that direction.

Here and there, at several parts of the country, the construction of the railways has rendered good service to Geology. At Millwood, Mr. Gibson, of Hebden Bridge, has been enabled by this means to make some important additions to his fossil cabinet; and the specimens of granite, graywacke, quartz, and scar limestone, just alluded to, were lately found in diverting the channel of the river at Mytholmroyd.

To the powerful agencies of seas and fresh water, by far the greater part of the phenomena presented to the observation of the geologist in the earth's crust are properly referred.

The structural changes which characterise the surface of the inorganic world are of aqueous and igneous origin. The first of these forces is still visible, though in a less degree in the present arrangement of our planet, silently destroying by chemical and mechanical action even the hardest rocks, and transporting the detritus to distant points, and even to the sea, to be consolidated into future strata, in the slow but unremitting mutations to which all matter is exposed.

The aqueous agents by the aëration of rocks and mechanical formation, are incessantly at work, reducing the inequalities of the surface to a level, and in circulating water from sea to land and land to sea. The atmosphere is the great communicating agent between the surface of the ocean and that of the land, and by means of *evaporation* we are supplied with water. The aqueous vapor in the air of this part of the country, though variable with the season of the year and other circumstances, will average at least 1 per cent. or 3¾ grains in each cubic foot. Highly elevated lands, which attract in proportion to their volume and density a larger quantity of this vapor than do the lower hollows and plains, are much exposed to atmospheric vicissitudes,—to frost, alternations of moisture and desiccation, to cold and heat. The ordinary action of beating rain is great, but water possesses the mechanical property of expansion during congelation, which, when it occurs in fissures and crevices of the rocks, exerts a power capable of rending asunder the heaviest and most compact strata, and thus exposes larger surfaces to be operated upon, so as to facilitate their ultimate reduction. But besides, water is the great, the universal solvent, and aided by the carbonic acid of springs, and that contained in air, which though variable, on an average amounts to about 1 part in 2000, it acts particularly on the earthy elements of stone. From these assaults the surfaces of all matter have no escape.

The Millstone Grit is durable, as the abbey walls of Kirkstall and Fountains Abbey, and of our own venerable Parish Church, which were wholly built of it, still amply testify, but every year a scale exfoliates, an atom daily crumbles into dust, as though to indicate its perishable nature.

The gradual absorption of oxygen by mineral masses exposed to the atmosphere is another source of decay, the effect of which is to disturb the combinations of the elements of rocks, and so to pulverize and render fit for soils even the hardest aggregate formations. A practice generally prevails in this neighbourhood of turning the small mountain rills upon the sloping pasture lands below in diverging rays, in such a manner as to irrigate the soil, and probably deposit a thin alluvial layer, consisting of these particles, together with decomposed animal and vegetable matter, for it is found to have a very fertilizing effect.

Much of the physical geography of our district must be ascribed to the augmented power of running water. The force and velocity of mountain streamlets, aided by the attrition of suspended sand and pebbles, which have often lost half their weight when in this dense medium, are such as to disintegrate their channels, and cause yawning chasms of large dimensions. The precipitous valley rising from Hebden Bridge to beyond Heptonstall, in this parish, affords an instance of this kind, in which the wasting power of the atmosphere and descending torrents is very conspicuous. Composed of alternate thin limestone, plate, shales, and gritstone, the strata have presented substances of different resisting capabilities to their forces. The gritstone would have long withstood their action, had not its base of plate and shale, (insidiously worn away by the searching subtle fluid) hurled destruction to the superincumbent mass. This alternate grit, plate, and limestone district, towards Todmorden, shows many holes and cavities in the rocks, and the valley of the Hebden, just alluded to, seems to have been scooped out by the ordinary water course, for on each side of the rivulet we find the same formations, as though no doubt there were once continuity in structure and unbroken surface.

Such is the destroying and transporting agency of atmospheric waters. 1st, in consuming away the solid substance of the rocks; and 2ndly, in conveying the detached fragments, mechanically suspended, from one part of the earth to another at a lower level, and ultimately to the sea.

Springs, being impregnated with foreign ingredients, derived from the strata and soils through which they pass, serve to augment this perpetual process in a two-fold manner; 1st, by their volume and gravity, and 2ndly, by their carrying off various mineral matters, which, being in a state of solution, are not, except by analysis, discernible.

The source of the *water* of springs is usually the filtration of *rain* through the loose alluvial soils and cracked joints of rocks. Having arrived at the water-bearing level so far on its vertical descent, it commences an horizontal course, and after having traversed the loosely laminated surfaces and fissures of continuous strata, it is again, either by a dislocation, or (as more commonly occurs with the springs of this parish) by meeting with softer argillaceous deposits on the sloping sides of the hills from breach of contiguity of stratification, thrown out by gravity, and the *vis a tergo*, upon the surface charged with saline ingredients from what has proved soluble in its tortuous subterranean course.

The loose soils, beds of gravel, and porous ragstone of this neighbourhood, readily absorb water, which descends until its downward progress is arrested by a stratum of clay, compact sandstone, or some other impermeable material, where it accumulates, forming a subterranean sheet of water, beneath which *bearing level*, practical well-sinkers know there is no occasion to go for a permanent supply of this fluid: indeed, it is seldom necessary to sink so far.

Artesian wells, commonly bored for in tracts of country whose strata are characterized by a basin form, as in the tertiary neighbourhood of London, by perforations through the clay and plastic clay to the subjacent chalk, owe the origin of their flowing fountains to the hydrostatic force of water thus locked up by uninterrupted beds of impenetrable material, preventing further vertical and lateral descent. On *Norland Moor* two or three *natural* springs of this kind are to be seen after the rains, shooting up their flowing streams into the air. The theory of such discharges is simple, and explicable perhaps best by reference to a section.

The loftier regions, attracting much of the moisture of the atmosphere, furnish lasting reservoirs of water, which descend in impetuous torrents, rivulets, or tranquil springs, and irrigate the land below. Rivers often obtain their sources from these summit ridges, as the *Calder*, into which our whole system of drainage flows, from the heights of Todmorden.

In common with most hilly districts, the parish of Halifax abounds with springs, some of which, from the medicinal nature of the substances held in solution, obtain the name of mineral or spa waters, whilst others, still containing more or less of foreign matter, (for there is not in nature a chemically pure water), are employed in domestic use. The saline ingredients of all these springs are to be ascribed to the neighbouring strata and alluvium, from which, at points of the easiest access, they topographically issue, and when they exude from a sandy gravel, or silicious matrix, as does the town water of this place, they are, properly speaking, pure, more agreeable to the palate, and have a greater specific gravity than other land waters.

There are several springs in the parish which are called spas, and have probably been stronger formerly in saline impregnation than they are found to be at the present day. The *Spa well*, a quarter of a mile south of Elland is the best of the class to which it belongs. It holds in solution sulphuret of sodium, or in common parlance, sulphuretted hydrogen and a free alkali. Below the Cragg, in Erringden, is another, slightly charged with the same gas, which I found to be nearly free from all saline matter. There are the *St. Helen's Holy-well* at Stainland, the *Swift Cross Spa* in Soyland, the *Upper Ellistone's farm* well in Greetland, the *Booth Dean Spa*, near the rocking stone in Rishworth, and the *Widdup Ochre Spring* in Heptonstall. These several springs, however, with two or three exceptions, being found, I believe, to vary with the temperature, dryness, or moisture of the seasons, may be regarded as the local products of certain strata permeated by atmospheric humidity.

The Horley Green spring is of a different character, and must have a specific notice.

The substances held in solution by these springs, to be regarded as of geological importance, are, silica, iron, lime, magnesia, alumine, and soda, all of which enter largely into the composition of the solid crust of the earth; and variously associated with these bases, are the carbonic, sulphuric, and hydro-chloric acids.

Considered under these heads, the town water already alluded to, derived from three springs, is an example containing silica, and to the absence of chalk and Magnesian Limestone in our district as a formation, we are indebted for its admirable fitness for domestic purposes. Over the grit and Halifax gravel is commonly a loose black peaty soil, but a sandy loam covers the flag and free stone of Northowram, Southowram, and North-east Elland. Has this clayey accumulation arisen from the disintegration of the one kind of rock, and production of the peaty vegetable soil been favoured by the other? We are justified in general in an affirmative answer to this question, but, in the present instance, the line of demarcation is so distinct that a few yards across the Hebble or Halifax beck display the peculiarities of each. The presence of a diluvial cliff on the one bank, or the existence of a great fault, whose axis runs North and South along this line, would solve the difficulty, but there are no grounds for believing either the one or other, and I therefore am inclined to refer the fact to the cause assigned, duly considering that the inclination of the strata is such that the same elevations of the two sides of the rivulet will not exactly correspond; in short, that to the East we are on a variation of the upper Millstone grit and shale group, whilst on this side we live upon the middle member of that formation, assuming my views to be correct.

The town of Halifax is abundantly supplied by the rains from two springs in Ovenden, from whence the water is conducted by drains, and collected into two large reservoirs, which were commenced by voluntary subscription in 1826, at the suggestion of Mr. Michael Garlick, for the charitable purpose of giving employment to the poor, who were then suffering from a general depression of trade. These reservoirs, situated nearly a mile to the N. West of the town, on high ground, will contain together upwards of five million gallons. Besides these, is the Well Head spring, with an average discharge of about 80,000 gallons per day, which, after having supplied several private residences at the south west end, is distributed from a large cistern to the lower parts, of the town.

The Dodgson Clough spring is one of the most simple forms of water collected under ground, having its efflux at the side of a hill, from a mere interruption to the contiguity of stratification. Along the ridge above is a peaty moorland soil, of but a few inches thick, and immediately beneath lies a deep bed of gravel, through the interstices of which the rain readily filters, passing through a loosely laminated consolidated gravel, a porous blue ragstone, as it is called, and the cracked grit, until it arrives at an impermeable freestone, which forms a barrier to further descent; and having coursed with the dip, along its bearing level for some distance, the subterranean stream is relieved by various springs, one of which issues at the point stated, with an average volume of about 50 gallons per minute.

During the long-continued drought of last summer, some scarcity was experienced, but these springs have a constant discharge, though variable in quantity, as also in temperature, with the seasons.

Silica is not found in large quantity in these springs, but in the absence of much lime it may be considered sufficient to characterize the water. It is a substance very sparingly soluble in cold water, though more abundantly so in hot, as is displayed in certain thermal springs, especially those in the island of St. Michael's, where the most perfect and genuine petrifactions are obtained by the deposit of *silicious sinter*, as it is called. Herbage, branches of ferns, and reeds, more or less minerally encrusted with silex, are found exhibiting the successive steps from the soft state to a more complete conversion into stone.

In a medicinal point of view, the *Horley Green spring* is perhaps the most important in the parish, its predominant ingredient affording us a striking example of the presence of iron.

This metal, so profusely scattered in nature, met with in almost every mineral formation, and disseminated in every soil, is in minute quantity held in solution by nearly every spring, and so copious is its impregnation in many instances, as to stain the rocks and herbage as it passes, and to bind together sand, clay, and gravel into solid masses. From an analogous process to that now going on, it may be reasonably inferred, that the sandstones and other rocks in the sedimentary strata of ancient lakes, estuaries, and seas, have very probably been cemented together and coloured by ochre, and that the present subaqueous deposits are undergoing the same course.

In primary formations the spathose, or sparry iron, is met with forming powerful veins in Gneiss, associated with quartz and copper pyrites. In the coal series of Wibsey and Bowling, there is a great abundance of the unlaminated carbonate or clay ironstone, and the sulphuret or pyrites is plentiful in the south-eastern parts of this parish, encrusting the coal, and interspersed in plates and shale.

The soils of the south-western acclivities of Southowram, with the adjoining parts of Elland, and the western bank of the Shibden valley, consist chiefly of a sandy clay, and the sub-strata alternate in shale, coal bands, loam, and flagstone; but so plentiful is pyrites in these districts, that green vitriol works are in active operation at the first-named places, and were erected some years ago in the last.

To this binary componnd mineral, the Horley Green spring, situated in the Shibden valley, owes, by chemical decomposition, its most prominent ingredient.

As analysed by one of our members, Mr. W. West, an imperial gallon of this water contains, of

Carbonic Acid Gas	5.5	Cubic inches.
Nitrogen........................	7.25	do.
Total, ...	12.75	do.

Grs.	
40·77	Sulphate of iron, dry, or 74.5 in crystals.
15.26	Sulphate of lime, or 19.3 in crystals.
5.	Sulphate of magnesia, or 10.25 in crystals.
.32	Chloride of calcium, or .59 in crystals.
.93	Silica.
1.22	Alumina.
63.5	Temperature 48.5 F.

As already observed, a certain uniformity prevails throughout the springs of this parish, in the nature of the neighbouring deposits, and the composition of the waters which pass through them, whose geological relations are thus rendered obvious.

Let us for one moment illustrate this position by very briefly inquiring into the sources of the above ingredients as found by analysis. But first, a word or two as to *temperature.*

The rains, it is well known, descend irregularly, but during the drought of last summer no perceptible change in the volume of this spring occurred throughout; its temperature in all the trials, undertaken at various seasons, which I have instituted, has been uniformly 48.5 of Fahr., from which it may be inferred, that the temperature is imparted by the strata through which it flows from some general cause independent of solar influences. This may be considered, perhaps, inconclusive, since the mean annual heat of the air is not stated, nor any computation made as to the rate of absorption of caloric by exposed mineral masses, and other circumstances connected with the subject.

For these investigations we had not time, but it is strongly corroborative of internal terrestrial heat, that all the *hot springs* of Britain rise through disturbed strata of the carboniferous system, chiefly below the coal, or through others which rest unconformably upon them, the average of seven springs affording an excess of temperature of 28° above that of the atmosphere, and the fact of those which have their efflux far distant from volcanic action, as in the Departments of the Arrièges and the Pyrénées Orientales, rising in granite, just at the boundary of that formation with the slates and other stratified rocks.

But to proceed in tracing the products of this spring as furnished by the analysis; and first, as to the gases. The neighbourhood of Horley Green abounds with pyrites, a mineral consisting of iron and sulphur, from the decomposition of which, by the hand of nature, aided by the presence of moisture and atmospheric air, the carbonic acid and nitrogen of the water are indirectly derived. The carbonic acid is most likely evolved by a second decomposition of a slaty calcareous marl, found associated with the pyrites, and the chemical action which ensues may be thus explained: the sulphur of the pyrites will, by the absorption of the oxygen of the atmospheric air contained in the water, (for all atmospheric waters are imbued with air,) be converted into sulphuric acid, a part of which will seize the base of the marl (lime) by superior affinity, to the disengagement of the carbonic acid with which it was previously combined.

The origin of the nitrogen, the other gaseous fluid, must be ascribed to its dissociation from the oxygen of the atmospheric air contained in the spring, prior to its reaching the pyrites. Nitrogen is of rare occurrence in cold springs, whilst atmospheric air is nearly universal. The oxygen, therefore, necessary to the sulphur becoming sulphuric acid must arise from this source disengaging the nitrogen; for, unlike most waters, this contains no atmospheric air, and must have lost it in the way supposed. In thermal springs nitrogen is very abundant, and has by some been regarded as sufficient evidence that they owe their elevated temperature to chemical action; but when it is considered that the temperature of these waters, when issuing at points of extreme displacement, is highest, and that they are by no means confined to volcanic regions, it must be inferred that their heat is derived from the depth of the channels in which they flow; and the atmospheric air which accompanies them being deprived of its oxygen, accounts for the pressure of the nitrogen, which returns to the surface. The bluish slate marl already noticed supplies both the lime and magnesia. The silica is taken up by solution from the sandstones, and the alumina from the clay.

Before quitting the Shibden valley, I must call the attention of the meeting to a spring situated behind the Lee, on the same range of hill, about a mile to the north of the one just mentioned. It is remarkable as being so charged with calcareous matter as to precipitate tufa or calc-sinter along its course, and completely whitewash the wall below, from which it falls in cascade. Destitute of limestone as a formation, in that neighbourhood, and very sparingly supplied, I believe, with the slaty marl already mentioned, whence comes this encrusting lime? Thermal springs, it is known, afford it even from gneiss and granite under circumstances easily explained, but cold ones, so far as I know, in lime stone districts only. Is it a gypseous spring? But it certainly contains the carbonate of lime, as well as selenite.

At Widdup, in Heptonstall, is a spring which deposits quantities of ochre, or peroxide of iron; and at Gorpley Clough, beyond Todmorden, there is one so largely charged with lime as to precipitate vast quantities of calcareous tufa, and occasion some formative changes in its vicinities. Stalagmitic-like masses are here found abundantly, of which *these*, presented to me by Mr. Gibson, are samples. Not far distant from this last place are frequent throws-up of strata of the Mountain Limestone, and attempts are now making, near Scaitcliffe, to work lead ores, galena having been found in interrupted beds and masses. To the solvent power of water, greatly charged with carbonic acid, percolating the various rents and fissures of their formation, these mounds of chalk must of course be ascribed, the excess of carbonic acid flying off on the spring *quitting* its subterranean laboratory. It is to the presence and solvent power of fixed air, or carbonic acid contained in the filtering waters, that the internal decomposition of rocks, and the *re-arrangement* of the particles observable in the various *fossil shells,* must be referred: this acid, on seizing their lime, (for which it has a great affinity,) deposits the silex, or iron, as the case may be, with which it was previously united, not being able to hold both in solution. Thus the calcareous matter of the shell is replaced by pyrites, or, perhaps, argillaceous earth, when it is lodged in shale, by flint when in the green sand, by carbonate of iron when in ironstone, by silica, or silicate of lime when in sandstone, and by carbon when in coal; whilst in Limestone rocks, the carbonic acid impregnating water, will dissolve and subtract all the constituent elements of the mass, shells as well, and leave holes, passages, and caverns sufficiently characteristic of this formation.

It is in this neighbourhood that Mr. Gibson, of Hebden Bridge, has so long laboured as a Botanist, and in search of fossil remains; and not in vain, having been rewarded by the discovery of many *rare*, and *some hitherto undescribed* shells in the Limestone shales, or rather in what I believe Phillips would term the Nidderdale and Bolland, or West Craven Lower Shales; the first occurring (supposing I am correct,) at High Greenwood, above the main Limestone, or first member of the Yoredale series, and the latter at Millwood, beneath it.

In a letter addressed to me he thus writes—

SIR, *Hebden Bridge, Feb. 8th,* 1840.

The following list of Fossils, found in the Limestone shales in the vale of Todmorden, has been drawn up from specimens contained in my own cabinet, and which have, with a very few exceptions, been found by myself. In a railway excavation at Millwood, near Todmorden, the shale is of a bluish grey colour, and very smooth to the touch; it contains several fossils not found in any other locality, particularly Goniatites proteus, which is in shapeless masses of dark-coloured Limestone. This stone is full of shells laid in every direction, and strongly cemented together, so that it is almost impossible to procure perfect specimens. In Hoolebottom Clough we meet with a few fossils of rare occurrence, but our favourite localities are Crimsworth Dean and High-green Wood, where most of the fossils recorded in the following list have been obtained. The shales here constitute three principal varieties; first, blue grey, coarse-grained, and micaceous, containing no organic remains, but iron pyrites in a nodular form; second, black, sandy, and coarse-grained, containing a few crinoidal columns; third, very dark-coloured and fine-grained, containing vegetable remains of different families, such as lepidodendron, calamites, &c. In this shale we find shapeless masses of hard Limestone, containing dicotyledonous wood, and a heterogeneous mass of shells, such as orthoceras, nautilus, goniatites, melania, buccinum, pecten, inoceramus, &c., some of them in a beautiful state of preservation.

Nucula
    cuneata
    lævis
    variabilis
Palustra
    minima
Lincina
    dubia
    orbicula
    lævis
Cypricardia
    obtusum
Modisla
    elongata
    rostrata
    minuta
    orbiculata
    longthorni
Mytilus
    lingualis
    variabilis
    Bellona
Serpula
    parvus
Inoceramus
    vetustus
    lævis
    tumidus
    radiatus
    Gibsoni
    scariosus
    elongatus
Avicula
    obliqua
    parva
    plagiostomordea
    trapezoidea
    orbiculata
    convexa
Pecten
    papyracea
    Julius
    substriatus
    obliquatus
    latissimus
Lingula
    parallela
    Ægis
Gervillia
    obtusa
Spirifera
    resupinata
Producta
    Martini
    antiquata
Astarta
    concentrica
Orbicula
    nitida
Patalla
    Greenwoodi
Peleopsis
    minutus
Natica
    lævis
Turba
    Greenwoodi
Cirrus
    minutissimus
    Gloveri
Buccinum
    imbricatum
    curvilineum
    rectilineum
    minimum
    productum
    elegans
    bullatum
Melania
    reticulata
    Turritelleforme
    Trochiforme
    Gibsoni
    rugifera
    excavata
Turritella
    tenuistria
Cerithium
    dimidiatum
Pleurotomaria
    deformis
Bellerophon
    complexa
Orthoceras
    cinctum
    giganteum
    ovale
    Breyuii
    arcuatum
    Steinhaweri
    acicularis
    Gibsoni
    obtusum
    microscopicum
    Browni

angulare	tumidus	Looneyi
reticulatum	undulatus	discrepans
anlatum	micronotus	stenolobus
Nautilus	reticulatus	Longthorni
subsulcatus	excavatus	paucilobus
tuberculatus	subsulcatus	Kenyoni
cyclystomus	dorsalis	paradoxicum
transversalis	Listeri	intermedius
Goniatites	Gibsoni	serpentinus
parvus	calyx	proteus
vesica	mutabilis	minutissimus
jugosus	splendidus	striolatus

Goniatites Striolatus, Phillips's Geology of Yorkshire, Part II. p. 234, pl. 19, fig. 14 to 19.

Subglobose sides (in adult shells) flattened, with very delicate striæ, septa with very wide-pointed dorsal sinuses, and very wide rounded lateral lobes. This species differs in its infant and adult conditions; the young shells are when 1½ lines in diameter, consisting of five volutions, the inner ones entirely exposed; when 3 lines in diameter, it becomes more gibbous, with the umbilicus acute and very deep; when 6 lines in diameter, the shell becomes orbicular, the diameter and thickness nearly equal, with constrictions and striæ slightly waved. Shell when 18 lines in diameter, back rounded, sides flattened, its thickness being equal to about one-third of its diameter, wholly covered by numerous divergent undulating striæ, arranged in sixes, near the umbilicus, which is small and rounded; constrictions, none apparent; as the shell increases in dimensions it becomes broader in proportion to its thickness. Greatest known diameter, 30 lines, or 2½ inches.

J. GIBSON.

I might say something as to the *scenery* of the Todmorden valley, much of the beauty of which depends on the facility of water in the shale on the one hand, and the cloud-capped resisting millstone on the other. But I must quit this interesting Yoredale district, and bring my paper to a conclusion in the township of Elland, where there is a sulphur spring of some value.

The distinct features of this locality, together with the arts and manufactures pursued in and around Elland, greatly assist in tracing out the Geological character of this neighbourhood. Thus, there are extensive stone quarries, generally containing three beds, of variable thickness, from 10 to 40 feet, the lowest, however, usually surpassing the upper ones in this respect, with a dip to the S. and S.E.; several collieries, two or three copperas works, and brick and black earthenware manufactures.

The quarries and collieries are all situated on, or in the vicinity of, the surrounding hills. The stone is of an arenaceous and argillaceous nature, apparently coloured by the peroxide of iron, and cemented by aluminous matter, being capable of fine lamination. It rarely contains any organic remains. At *Ainley top* to the south of Elland, on the Huddersfield road cut through the hill, several faults in the strata are very discernible.

The coal around Elland lies at a lower level than that of the two beds, but, as already stated, from the same fossils being found in each, and other circumstances, they are considered to be the same. It is found on both sides of the valley, although on different levels, from an intervening fault. There is both a hard and soft bed mined, the former lying nearest the surface, being distant from the latter usually about 30 yards. The average thickness of the hard bed is 24 inches, that of the soft bed about 20 inches. Both beds vary considerably, however, in this respect, dwindling down, here and there, to less than a foot. On the Elland edge and Ainley hills, the coal is usually obtained by sinking; that in the Southowram hill, or Elland Park, by running galleries under the hill, and commencing somewhat above the level of the Calder. In each situation both *hard* and *soft* beds are worked, and it has happened on more occasions than one, that the hard and soft beds, in consequence of *faults*, have been mined from the *same level.*

In the seams of coal and strata adjoining it, large quantities of lead ore mingled with iron pyrites and carbonate of lime, have been sometimes found. In sinking the shafts the section is as follows:—Soil, clay, band of carbonaceous matter, shale and clay, ragstone, blue-stone, Upper Sandstone bed; shale and clay, Middle Sandstone bed; shale and clay slates, Lower Sandstone bed; clay iron ore, being shale and clay mingled with bouldered ironstone; *hard bed* of coal, which in these situations is 100 yards from the surface. Thirty yards below this is the soft bed, to which it is necessary to cut through shale, slate, ironstone, and Sandstone rock. The coal of this district is invariably associated with a considerable proportion of iron pyrites, the presence of which, together with that of clay iron ore, gives a character to many of the springs and running streams.

The town of Elland, situated upon the Middle Sandstone bed, has both hard and soft water; the former is a never-failing supply, obtained by sinking.

The source of the sulphuretted hydrogen in the water of the spa well, will be readily understood from the peculiar character of its locality. It is in the immediate vicinity of a worked out coal seam, encrusted with pyrites and free sulphur, underlying the clay iron ore. A *fault*, of which there are many in this neighbourhood, brings the sulphur in contact with the iron ore, when the *water* is decomposed; its oxygen per-oxidizing the iron, and the hydrogen combining with a portion of the sulphur, give rise to the gaseous compound impregnating the spring. It must thus be regarded as on the line of axis of dislocation, and to this circumstance indebted not only for its chemical composition, but also its efflux as a spring at this particular point, since its flow is inconsiderable in quantity, and bearing level evidently superficial.

The Rev. W. Turner inquired whether any observations had been made as to the temperature of the spring, so as to say whether it was above the natural temperature of the district, or not?

Dr. Alexander believed that no experiment of the kind had been made. For his own part, he was inclined to think that the water derived its temperature from the strata, rather than from the atmosphere, its uniformity was so striking.

The Rev. W. Thorp observed, that from observations which had been made by Professor Phillips, he believed it did not follow that similar strata always produced similar water.

ON THE MUSEUM OF THE SOCIETY, AND ON THE VARIOUS OBJECTS WHICH IT IS DESIRARLE THAT IT SHOULD CONTAIN. BY T. W. EMBLETON, ESQ., MIDDLETON.

The establishment of a Museum in connection with the Society was suggested by the Earl Fitzwilliam, at an early period of the Society's existence, and its extension has at all times occupied the serious attention of the Council. The object of its establishment was to obtain a "complete and classified collection of the Fossils of the Coal Field, arranged according to the strata in which they were found, and of other Minerals, which would serve to throw light on the Geology of the district." In part, this object has been carried out. Apartments have been engaged by the Council at Wakefield, in which to place and arrange such specimens as may be presented to the Society, but they are ill adapted to the purpose; however, it is to be hoped that the members, the public generally, and the gentlemen of the county in particular, whose interest is so intimately and inseparably connected with the object which this Society proposes to investigate, will not long allow our "medals of creation" to remain hidden in the dusky recesses of a forsaken wool warehouse. But still, if a splendid Museum be erected for our present collection, much remains to be done, and much may be done, if we all work together, and really and truly do our best to render the Museum, (what I trust and hope it will be one day,) the boast of the West Riding. Some gentlemen say "I don't know of any thing worth sending to the Museum;" another says, "I have many specimens, but they are so common that they are sure to be rejected;" a third says, "I don't know what objects are required for a Museum." To them I would answer, every thing is worth sending; nothing is too common nor will be rejected; and in the sequel I will point out what are the various objects it is desirable the Museum should contain.

We have now I believe members in almost every town and village in the Riding; throughout a great part of the district the earth has been explored for coal, numerous quarries of Sandstone and Limestone have been opened out, numerous deep and extensive cuttings for canals and railways have laid bare large extents of strata. Many of our members are connected directly or remotely with these undertakings, and here the entire materials for the Geological Museum can be procured, and at no expense save that of sending them to the Museum. The specimens found are of no value to the workman, but he might readily be taught to distinguish and to preserve what is valuable for the Museum, and in a short time he would be brought to have a taste for searching for those trifles, as he would term them, which his employer wanted. You all probably remember the history of the discovery of the Burdiehouse fossils, by Dr. Hibbert, of Edinburgh. On the first remains being found, they were shown to the workmen employed at the quarries, who said they had never seen anything of the kind before; they were directed where to look for more, and at the next visit of the Doctor to the quarry, the workmen said "We have now got our eyes opened; how blind we must have been, not to have seen these things daily!" I remember a similar case in my own experience, where workmen had been absolutely touching daily for forty years valuable fossils, without being aware of their presence. The facilities, however, for obtaining specimens are very great in some instances. In a quarry, being a continuous excavation of the same rock, or at farthest of different parts of the same rock, we can, in a few months, by constant observation, obtain specimens of the several varieties of rock worked, and of the fossils appertaining to them. The same remark will apply to nearly the whole of the railway and canal cuttings, but we must remember that when they are completed, we are probably for ever debarred from robbing them of their organic treasures.

In a coal mine or in an ironstone mine, when once the shaft is sunk, we are precluded, as in the former case, from knowing the organic contents of the strata sunk through.

We still, however, have the roof of the coal and its floor, and the ironstone and its matrix for our researches, and these should not be neglected.

Now in the case of a particular rock, take a rock of sandstone for example—if we are in possession of specimens showing all its different aspects mineralogically, and of a complete suite of fossils which occur in it, shall we not be more able to identify it should it ever again appear in another part of the coal field, than if we were not able to refer to such specimens? and so with the various coals and ironstones. The contents of the Museum are not numerous nor have the donors been many. About 1000 specimens have been numbered and entered in the catalogue, and about as many more remain to be arranged; but these specimens, excellent and unique as many of them are of their kind, illustrate but a small part, and that imperfectly, of the coal field. They consist of a few remains of fishes and of shells, of various species of calamites,* sphenopteris, neuropteris, pecopteris, lepidodendron, ulodendron, lepidostrobus, sigillaria, &c., some of which are quite new; specimens illustrative of strata passed through in sinking shafts, and specimens of building stones. Having thus pointed out how the Museum is capable of being furnished, and having given a short summary of its contents, I shall next proceed to enumerate those objects which may be considered as essentially necessary to be obtained to render the Museum practically useful.

1st. *In Ichthyology*—

To have a complete collection of the fossil fishes, and their remains found in the district. We must request those of our members who are working coal to supply us with this desideratum, for it is on the roof of our coals that the greatest portion of these remains have hitherto been found; they do not frequently exist at any great height above the coal, but just where the coal separates from the stone. The search for them is best made when the coal has been recently removed and the roof smooth. We should be careful to note under what circumstances they exist in the greatest abundance, and whether, as up to this period has always been held, they are no where present in the roof of the coal except it contains a notable proportion of bitumen. Are they more frequent on the upper surface of the seams of Cannel coal than on seams of common coal? Are they more abundant when the roof approaches to the nature of Cannel coal or when it is only a bituminous clay? Do these strata derive

* One of the specimens, a calamite procured by Mr. T. Wilson, from the Falconar pit at Kexbro, is very valuable, as showing that the calamites have true phragmata, a fact which had been previously doubted. This fossil will be figured on the resuming of the Fossil Flora, by Henslow and Hutton.

their carbon from the imbedded remains? These are all highly interesting questions, but they cannot be solved unless our collection of specimens embraces a contribution from all the localities where the remnants of fishes exist. For these remains the iron-stones too should be carefully searched, for it is often the case that a tooth or coprolite forms the nucleus of the iron-stone. The most perfect specimens of fishes are in the Leeds Museum; the locality of one is uncertain, but the other is stated to have been procured from Low Moor, and I have myself seen pretty good specimens which have been obtained there; and to Low Moor I think we may look for a supply for the Wakefield Museum. Some strata at Middleton contain large numbers of teeth and scales, but no specimen of a perfect fish has been found. The same strata are found at various other places. I think similar specimens may exist there. The Flockton collieries, Rothwell Haigh, the roof of the Stanley shale coal, and many other places are rich in their remains; in fact, I may lay it down as a general rule, that they may be found in greater or less abundance over nearly the whole of the Yorkshire coal seams.

Conchology—

A series of fossil shells from all parts of the district—in order to determine not only their species, but to understand under what condition they have been deposited, or whether they have lived where they are now found. Some shells it is well known extend in a continuous layer for nearly a mile, but do they not extend even further? others are found imbedded in shale one by one in a peculiar manner, the hinge always being the lowest; others again are found in large masses of ironstone in the shape of flat or compressed balls; do we find the same species of shell in all places under precisely the same circumstances? and lastly, do we in the same stratum find shells and fish associated with entomostraca and vegetables? these questions cannot be satisfactorily answered but by a series of specimens.

Botany—

In fossil botany we have more need of a large assemblage of specimens than for the successful study of ichthyology or conchology; the investigation of this branch of science is attended with great difficulty. The materials at the disposal of a student of fossil botany, are not only disarranged by accidents which appear to have occurred to all other fossil remains, but they are those which would in recent vegetation be considered of little importance. There is an entire want of all those data which guide a botanist in the examination of recent plants. Not only the total absence of the parts of fructification and the entire destruction of the internal organization of the stem, but a frequent separation of the various parts, (as branches from trunks, and leaves from branches,) so that no one can tell to which trunk the branch belonged, or to which branch the leaf. The tree or plant cannot be reconstructed as a skilful anatomist would reconstruct the skeleton of an animal from its scattered bones; for we find many distinct species of plants having the same outline both of foliage and fructification, and this is all that the fossil botanist has, in many instances, to depend upon. Many favourable situations will no doubt suggest themselves for the collection of vegetable fossils. We should note also, the manner in which these fossils were imbedded in the stratum, whether their position was vertical or inclined; if inclined, the degree of inclination? whether, as in the case of some calamites and sigillariæ, any appendages resembling roots can be observed? whether they are found in masses, or spread regularly through the stratum in which they occur? whether the ferns are not found chiefly in rocks which contain little or no sand, or the reverse? and whether they are not often found in strata which are known gradually to change from pure clay to sandstone, being present only in the clay? thus showing the action of a current of water during their deposition: whether the large sigillariæ and calamites and lepidodendrons are filled up with the same substance as the adjoining stratum? In fact, the inquiries to be answered by a complete collection of the fossil vegetables accompanying the coal measures, are so many, so varied, so highly interesting and important, that an extended enumeration of them would far exceed the limits of this paper.

When, therefore, the members of the Society have placed in the hands of the Council a large collection of Yorkshire fossils, the Council will be able to procure similar specimens from other coal fields, by exchanging with other local Museums any duplicates that we may possess; and thus we shall not only be able to learn the Geological phenomena of other districts, but have the means of adding to the interest, and enhancing the value of our own Museum. But I would not stop even here; I would endeavour to obtain a complete suite of fossils both from the strata above and below the coal measures. It is well known that if we had anything to offer in exchange for fossils from the Silurian system, the Lias or the Chalk, we should soon have a very respectable collection of these fossils, for in many Museums in the south of England, where these fossils are collected to a considerable extent, they have few, if any, coal fossils; indeed, the specimens they do possess are generally of no practical utility, as in many instances their locality is not known; they would be very glad therefore to make an exchange with us, which would cost neither party any thing, but would greatly benefit both.

Being placed in this position, we could satisfactorily say whether the organic contents of this coal field are the same as those of Lancashire, or whether they were more similar to those of Staffordshire, or of Northumberland, or Durham?

whether any analogy exists between the flora of this and the Oolitic Coal fields? and lastly, whether all coal fields have been deposited under the same conditions? Surely these questions are not without universal interest to gentlemen who live in the heart of a large Coal district, and whose best interests, as I before said, are so much bound up and identified with all that may add to the better and clear understanding of the strata from which our minerals are derived.

Mineralogy—

An extensive collection of all the Minerals in the Coal field.

1st. Of Coal.—We should have specimens sent from each workable seam in the district; but by this I do not mean that one specimen from each seam will be sufficient, we should have all the varieties, and there are many, found in each seam. Take for instance, the Barnsley Thick coal: one specimen from this seam would not present all the characters that are observed in it. In transmitting samples of coal, great care should be taken to describe their property; whether they are *caking* or *free burning* coals; whether the ashes are white or brown.

Seams of coal may be searched for resins, which they sometimes contain.

Again, it may be inquired, under what circumstances is Cannel coal met with? Does it only occur in particular seams, or in all seams? Does it pass into common Coal, and at other times into Bituminous Shale? Why do certain fossils always accompany Cannel Coal? Many other questions of a similar nature cannot be answered, unless we have before us a large collection for examination.

Then, again, looking to other Coal fields, we may hope to obtain from them many treasures with which to compare our own, and correct our previously formed opinions.

But above all, it is essentially necessary to have Coal in all its various stages, from anthracite to recently decayed wood or peat. The extremes would be far apart, but I think we should be able to ascend step by step from the most perfect mineral to the most recent form of Carbon.

Coals from the vicinity of large faults should not be omitted. Then there are the cokes from the several varieties of coal.

2. Ironstone.—In the same manner, we shall have a collection of Ironstones and their matrices. A close examination of the modules of ironstone would in some instances afford us very beautiful crystals of Carbonate of iron, Sulphuret of copper, iron, lead, and zinc, and occasionally of quartz, or rock crystal; and not only the ironstone in its raw state, but we should have a series of specimens of iron in all the stages of its manufacture, as pig iron, bar iron, steel, &c.; the coke and coal used in smelting the iron, and the slags thrown off during the various processes that it undergoes. Nor would it be less interesting to have ancient iron and steel, and slags, to compare with our recent manufacture.

3. Lead.—Specimens of lead ore, and of its accompanying Minerals and Rocks. Lead in its several states of manufacture.

4. Copper.—Specimens of copper ore. For a complete collection of the ores of this metal we shall probably be indebted to some of our distant friends.

5. The contents of the fissures of the throws in the Coal fields, and the nature of the accompanying rocks.—Sulphuret of lead, iron, copper, and zinc, are sometimes found in throws, accompanied by carbonate of lime.

6. Salts, which are found in some coal mines, as sulphate of iron, sulphate of soda, &c.

7. Building Materials.—Sandstones from all the known quarries of the district, with a short description of their properties, and the use to which they are applied; and if they

are found in connection with any particular seam of Coal, what Coal?

Limestones for building, for mortar, for water cement; examples both before burning and after.

Brick clay and the brick it produces; fire clay and fire bricks; slates, flags, &c.

Sand used in mortar and for casting.

8. Road materials.—As gravel, slags, calcined sandstone, limestone, &c.

9. Various Soils, and the Manures applicable to them—Marl, gypsum, &c.

10. Mineral Springs.—Tables of analyses of their contents, and specimens of the matter, if any, deposited by them, and of the rocks by which they are accompanied.

The interesting question of the increase of temperature with depth, too, might be fully gone into by our members; the results, if collected and properly arranged, would be worthy of a place in any Museum.

Besides these various objects, the Museum would not be complete, and much of its usefulness would be wanting, if we had not a great number of tables of Borings and Sinkings, drawn to a scale, as recommended by the council at a former meeting.* Plans and sections of the direction and extent of faults. Models and plans of coal mines, and of the several methods by which they are worked and ventilated, from which an inquirer would be able to select that, which afforded the greatest safety to the miner, and the greatest proportion of coal to his employers. The different modes of draining mines,—by the common pump, force pump, hydraulic belt, &c.; and in fact models of machinery of all kinds employed in mining.

Nor should we neglect to pay our best and most earnest attention to the improvement of the Safety-lamp, by a fair and

* See the Report of the Tenth Meeting, p. 24.

unprejudiced examination of the numberless improvements, and alleged improvements, which have been made in the simple instrument of Davy. Probably even yet something may be effected in its arrangement that will render it more safe; but before we can do so, we must learn the defects of the original lamp, and test the reported defects of those which have been improved.

Models of steam engines, tables of their duty and of their consumption of coal and water, would be very useful.

Many other objects I have no doubt omitted, but which I could hardly notice in so short a list of desiderata as I have given you.

It now only remains for me, in conclusion, to observe, that having thus declared our wants, I have every expectation that the call will be responded to, and I doubt not before we pay another visit to Halifax, (and I hope the time is not far distant,) when the Museum will contain a complete series of the fossils and minerals of this neighbourhood.*

EVENING MEETING.

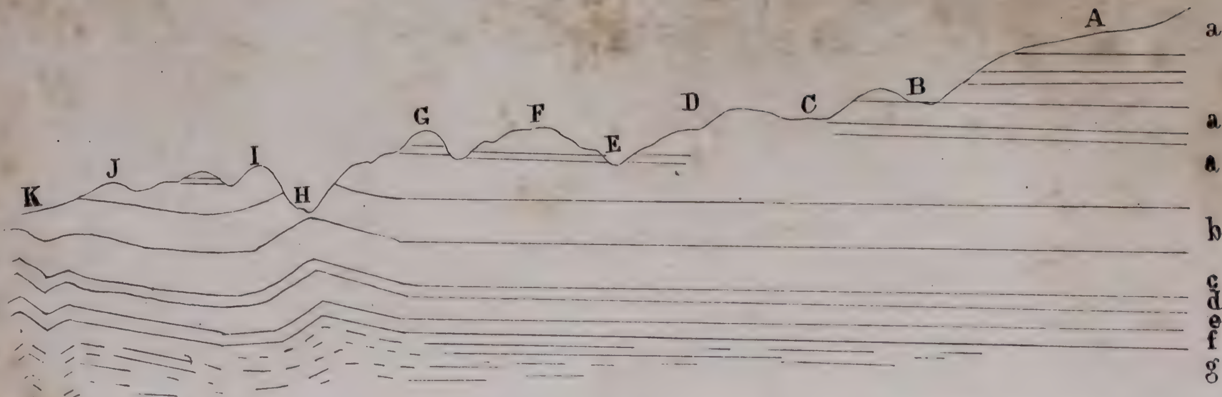
The evening meeting took place at seven o'clock, and was numerously attended.

Mr. Morton read a Paper "On the Vegetable Origin of Coal," in which he stated, in a clear and forcible manner, the usual arguments in favour of that theory.

* Gentlemen, desirous of contributing to the Museum, are requested to address their donations to the Curators at the Museum of the Society, in Westgate, Wakefield;—and as it is the wish of the Council that the collection should be greatly augmented before the Annual Meeting next autumn, it is important that the friends of the Society should place in the hands of the Curators the specimens intended for the Museum, at an early day, in order that they may be properly arranged prior to that meeting.

Geological Section of the Parish of Halifax from SHELF to TODMORDEN Displaying the Succession of Strata.

See p. 152.



A. Shelf with its 5 workable Coal Seams.
B. Shipden Dale and its Seam.
C. Halifax Hard and Soft Beds.
D. Pellon.
E. Luddenden with two Coal Beds.
F. Midgley.
G. Wadsworth.
H. High Greenwood on the Anticlinal Axis.
I. Heptonstall.
J. Crop Stones.
K. Todmorden greatly disturbed.

a. Millstone Grit Series.
b. Yoredale Rocks.
c. Lower Scar Limestone.
d. e. f. alternate Limestone and Red Sandstone.
g. Wacke.

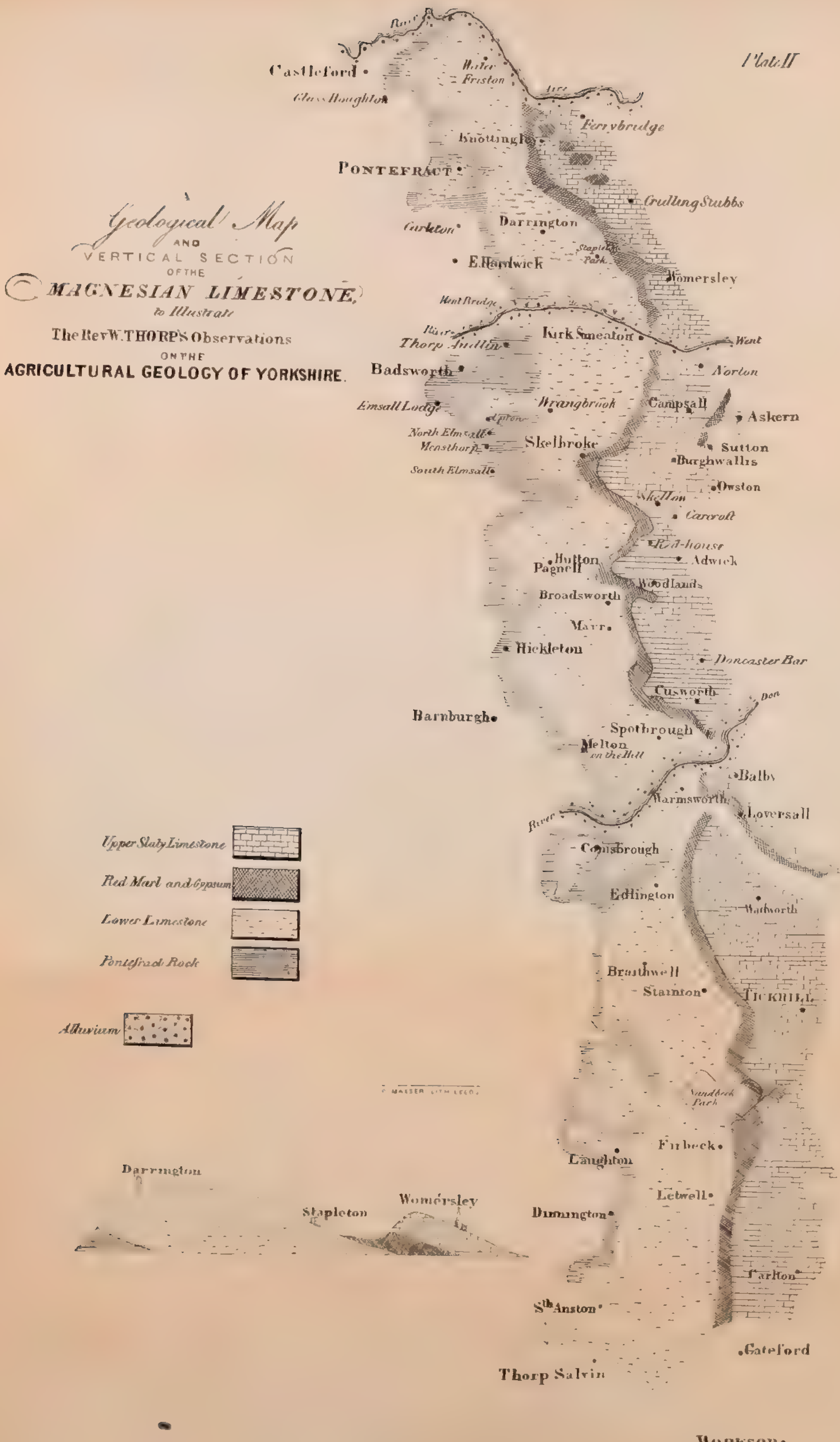


Plate II
Geological Map
and
Vertical Section
of the
Magnesian Limestone,
to Illustrate
The Rev W. Thorp's Observations
on the
Agricultural Geology of Yorkshire.
Upper Slaty Limestone
Red Marl and Gypsum
Lower Limestone
Pontefract Rock
Alluvium
Castleford
Water Friston
Ferrybridge
Pontefract
Cridling Stubbs
Darrington
E. Hardwick
Womersley
Kirk Smeaton
Went
Norton
Badsworth
Campsall
Askern
Skelbroke
Sutton
Burghwallis
Owston
Carcroft
Adwick
Broadsworth
Hickleton
Doncaster Bar
Cusworth
Barnburgh
Spotbrough
Balby
Loversall
Conisbrough
Edlington
Wadworth
Braithwell
Stainton
Tickhill
Sandbeck Park
Firbeck
Laughton
Letwell
Dinnington
Carlton
Sth Anston
Gateford
Thorp Salvin
Worksop
Darrington
Stapleton
Womersley

PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE FOURTEENTH MEETING, HELD AT LEEDS ON THE 3RD JUNE, 1841, IN THE HALL OF THE PHILOSOPHICAL AND LITERARY SOCIETY OF LEEDS.

On the motion of the Rev. SAMUEL SHARP, seconded by GEORGE SHAW, ESQ.,

The Rev. THEOPHILUS BARNES, Vice-President of the Society, took the Chair, and addressed the meeting as follows:—

Gentlemen,—It is at the earnest request of your Council that I have presumed to permit myself to take this chair, for I deeply feel how deficient I am in Geological or Polytechnic knowledge to preside in a public meeting of this Society. I shall, however, proceed with some confidence, relying on your kind indulgence and assistance.

I am told that this is but a small meeting, and certainly it is by no means as numerous as that which I last attended in this Philosophical Hall, but that was graced with the presiding talents and happy eloquence of the Vicar of Leeds. The smaller number of members present this morning cannot surely be attributed to any diminished interest in the objects of this Society, or to the mode in which those objects are sought to be promoted.

Those objects are best stated in the rules of this Society, passed at the last Autumn meeting, when our President himself was in the chair; and there I find that the first object is "the investigation of the Geology of the West-Riding, with the accuracy and minuteness necessary for the successful prosecution of Mining and Agriculture." Now when we consider how useful a thorough acquaintance with the structure of a district, the varying position of the under-strata, and the various qualities of the surface-soil, must be to all engaged in mining or agriculture, surely this object of our Society cannot fail in attracting all interested in or anxious to improve the prosperity of this extensive and populous Riding. Science with us will become a means of improvement and of commercial wealth. Coals are equally the cause and the support of manufactures. Iron is equally necessary to enable us to bring those coals cheap to market; while the improvement of that iron in its tenacity, elasticity, and durability, is essential to the efficiency of our mining and manufacturing operations.

It is with much pleasure that I can announce as a subject for your attention this morning, an accurate account of some experiments on the relative strength of pig-iron, of various mixtures and from different works, by Mr. Charles Todd. By combining our geological pursuits with such judicious experiments, we shall best show the happy result of correcting the science of the geologist by the practical facts of the working iron master.

Geology is now able to teach the landowner upon certain principles to decide where coal may probably be found, by pointing out, from experience, with what strata it is alone connected in this island. I recollect in my younger days, when this science was in its infancy, (at least in this country) that Mr. Northmore, in the immediate vicinity of Exeter, expended a large sum in sinking for coal; his miners were from Cornwall, and accustomed only to search into the bowels of the earth for metallic ores; but they were deceived by the dark and bituminous appearance of a black slate, to suppose that they were working through blue bind to a bed of coal. The waste of this capital would have been saved, if such a society as ours had existed in the South West of England.

Nor again can the second object of our Society have lost its interest with our members or the public, viz. the improvement of the arts of Mining and Metallurgy, their dependent manufactures, and the machinery and tools connected with them. This object opens indeed a large field for research and observation. Our Society has elicited some able papers from Mr. Leah, Mr. Hartop, and other members relative to some of these subjects, which will be found in the printed reports of our transactions.

We are indeed yearly more and more convincingly taught that science and mechanical skill must always work together in order to effect the happy result of cheap production, whether in manufactures or in agriculture. Our researches are intended to prevent an unprofitable expenditure in either.

I may here mention, that I have lately met with a confirmation of an observation made by Mr. Thorp in his elaborate and useful paper read at the last Autumn meeting (page 49), —that the nitrate of soda was found to be a beneficial manure on clay soils,—but I must add with this exception, that this mineral manure answered only on the crops of white corn, clover, and grass. The experiment to which I allude was made on a farm of four hundred acres at Kirkleatham, in Cleveland, where the liberal and intelligent proprietor makes many experiments on a large scale, and which he is always ready to exhibit and communicate to the public. The arable soil there is a strong red clay loam, and on this soil the effect of the nitrate of soda was most apparent and beneficial on the crops I have mentioned, but it had little or no effect on the beans, turnips, potatoes, white carrots, and mangel wurzel.

I may also mention, as connected with agricultural machinery, that a new drill, made at Dunnington, and exhibited in York, has been tried on this farm, which drops the manure and the seed at every ten inches, instead of sowing them in a continuous and useless row. The seed and the manure, as they fall from the feeding trough, are stopped by a little trap-door or valve, which falls when the wheels have advanced ten inches, and then is immediately thrown up and supported by a spring until it is again allowed to drop at the advance of another ten inches. By this ingenious contrivance no inconsiderable saving is made both in seed and manure; at least, both are deposited in full quantities where and where alone they are wanted.

It must be unnecessary to show that the good feelings of all must be deeply interested in the progress and extension of the remaining object of this Society, when I state that the third object to which we intend to direct our constant attention is the bettering the condition of the work-people connected both with mining and agriculture. Here both science and skill may best employ the study and the labours of the philanthropist; here we may hope to contribute to the health and safety of those employed in our mines and factories. Whatever diminishes the risk of life or health in any manufacture, or in the exertion of bodily labour, not only affords a high satisfaction to the humane consumer, but it diminishes also the cost of production, and thus becomes every way an object worthy of our best attention. Hence it was with pleasure that we listened to Mr. Morton's valuable remarks on the safety lamp, and to the suggestions thrown out on that occasion by other members, for improvements in that most valuable instrument in coal mines, the Davy lamp.

In the potteries at my own residence, the person who dips the biscuit ware into the glazing vat, the glaze being composed chiefly of white lead, is subject to paralysis of limbs and intestines, and all the diseases to which those who work in or with lead are so universally subject. Now the use of long gloves of caoutchouc would in a great measure remedy this evil, though in this case, as in that of the Davy lamp, it is to be feared that uneducated workmen prefer receiving higher wages to the better health and longer life which they might secure by the use of such safe-guards. But whether they use them or not, still let it be our pleasure as well as our duty to continue to point them out.

I have felt, as well as those who so ably took a scientific part in the discussion, much interested in the proposed geological section of the Yorkshire coal field, as connected with a section of that of Lancashire, and shall hope to hear to-day that progress is making towards its completion.

But this Society also looks forwards to the construction of a geological map of the West-Riding, a work which I am aware, if it be done with that accuracy which alone would do credit to our Society, or make it useful in future researches, must require much examination and much time to bring it to a satisfactory state of perfection. Still, as Professor Phillips has already so accurately delineated the mountain limestone district of the Riding, from Gruelthorpe to the Lune, and has also declared his intention of completing a geological survey of the island, I trust that with his assistance, and that of Professor Sedgwick, this work may be immediately commenced. I cannot despair of seeing this most interesting object attained, if we can continue to publish geological maps of particular districts in the neat and efficient style of those which accompany Mr. Thorp's elaborate papers "On the Agriculture of the new Red Sandstone District of the West Riding considered Geologically, with a Section of the Soil from the River Aire to Cantley, and on the Agriculture of the Magnesian Limestone, as connected with the Geology of a District extending from

Castleford to Thorp Salvin." I cannot but congratulate the Society that the Council have decided to publish all future papers with the same type and paper, and similarly illustrated with maps, drawings, sections, and diagrams. It adds not a little to the beauty and usefulness of these geological maps, that the groups are distinguished by appropriate emblems and not by colour. It would be desirable that the distinctive emblems adopted in these local maps and sections should be retained in all our future publications, and be as fixed in denoting geological formations and agricultural soils, as the lines in heraldry are to mark colours.

Before we proceed to the usual business of the meeting, I would advert to one point more,—the formation of a Museum at Wakefield, of the various specimens and models connected with the objects of the Society. Perhaps my attention has been more particularly called to this point by inspecting (as I have been permitted to do this morning) the valuable and interesting collection contained in the rooms above.

A collection of specimens from the coal and iron works alone, would form a most instructive school for future inquirers, and contribute greatly to aid and direct the pursuit of our geological researches.

I have a few specimens of septaria, containing organic remains, which were dug out in the cuttings of the York and North Midland Railway, near my residence, and which (if they are worth your acceptance) I shall be most happy to be permitted to place in your Museum : as also some curious shaped stones similar to those figured in Dr. Buckland's Bridgewater treatise, and called by him asaphons : his specimens came from Elsecar, and perhaps the finding them at Castleford may tend to show the identity of the coal beds at that place with those of Whitwood and Castleford.

I will not trespass any longer on your patience, but will request the Secretary to proceed with the business of the morning.

The following gentlemen were then elected Members of the Society:—

T. D. Bland, Jun., Esq., Kippax Park.
E. B. Denison, Esq., M.P., Doncaster.
C. Charnock, Esq., Holmfield House, Pontefract.
James Heywood, Esq., F.G.S., Acrefield, Manchester.
Mr. Timothy Farrer, Jun., Wragby.

The Secretary then read the following special report of the Council:—

REPORT OF THE COUNCIL OF THE GEOLOGICAL AND POLYTECHNIC SOCIETY, PRESENTED 3D JUNE, 1841.

It has not been the practice of the Council to lay a report before the Society, except at the Annual Meetings; but a question of great interest and importance has long occupied their attention, on which it is now desirable that the opinion of the Society should be expressed.

From its earliest establishment, the great object of the Society has been to pursue the study of local geology, and to direct the knowledge thus acquired to the advancement of every art to which it was applicable. No sooner, therefore, was it aware that the Yorkshire Agricultural Society had directed its attention to the important aid which geology might render to agriculture, and had appointed a committee of agricultural geology, than the council offered to lend it every assistance within the sphere of the Society's operations; and at the same time, they gladly availed themselves of an offer made by the Rev. Wm. Thorp, to draw up a report on the geology, as connected with agriculture, of particular formations in the West Riding. Of the very admirable manner in which these reports were executed, it is unnecessary for the Council to speak, since they have already called forth the warmest eulogiums of the leading members of the Yorkshire Agricultural Society, and have mainly led to their making the proposal which the Council now wish to receive the careful consideration of the Society.

It is proposed then that a joint meeting of the two Societies should be held once a year,—that at this meeting papers should be read on the application of geology to agriculture—and that the reading should be followed by discussions.

The Council, believing that such a meeting would be productive of very beneficial results, recommend that the Society should hold a Special Meeting at Hull in August, and it will then be seen whether the result of that experiment will be such as to induce both Societies to wish for its continuance in future years.

Mr. Embleton then moved "That a Special Meeting of the Society be held at Hull, on Tuesday, the 3rd of August next, concurrently with the Meeting of the Yorkshire Agricultural Society." In moving this resolution Mr. Embleton said he thought it right to state, that the Agricultural Society had expressed its willingness to give to the members of the Geological Society every accommodation they might desire. He thought it was for the interests of the two Societies that they should meet together. The connection between them was very intimate, for this Society would not only be able to point out to them the exact local geological position of the various soils, but the particular kind of manures applicable to them, so as to secure a proper treatment of the land; and the Agricultural Society, in return, would no doubt be quite willing to afford them whatever information would tend to promote the prosperity and usefulness of this Society.

Mr. Hartop seconded the motion, which, like all the subsequent ones, was carried unanimously.

The following were the other resolutions adopted:—

"That the thanks of the Society be given to the Philosophical and Literary Society of Leeds, for their kindness in affording the use of their Museum and Hall to the Society.

"That the thanks of the Society be given to Edward Sheardown, Esq., of Doncaster, for a donation of Fossils from the Northumberland and Durham coal field.

"That the thanks of the Society be given to the Royal Cornwall Polytechnic Society for a copy of their transactions."

Mr. WILSON exhibited a specimen of Dr. Albert's steam fuel.

Mr. EMBLETON read a paper, written by Mr. CHAS. TODD, of the firm of Shepherd & Todd, makers of locomotive engines, Leeds:—

EXPERIMENTS ON THE RELATIVE STRENGTH OF PIG IRON OF VARIOUS QUALITIES, AND FROM DIFFERENT MAKERS, UPON BARS 12 INCHES LONG, BY 1 INCH SQUARE.— BY MR. CHARLES TODD, RAILWAY FOUNDRY, LEEDS.

The following experiments were made with a view to ascertain the merits, in point of strength, of some of the different British pig irons which are brought into our market. Almost every manufacturer, or his agent, tells us that his own pig iron is the best and strongest which is made; and therefore, excepting an iron founder be mindful to test the iron which he buys, he is not only liable to be imposed upon, but to produce from his foundry such an article as may, from time to time, incur to himself serious pecuniary losses, and injure his reputation as a respectable tradesman and iron founder. They were also undertaken with a view to ascertain what mixtures of the different pig irons would give the strongest and soundest grain.

All the experiments here noted were made upon bars cast from the same model; taken from the sand without any dressing, such as chipping or filing; tested with the same apparatus, and uniformly with the same care. The dates of the experiments are also recorded.

1. In August, 1840, a bar of cast iron of the dimensions already stated, viz., 12 inches long by 1 inch square, made from the Bierley Company's regular No. 3 pig, sustained ere it broke, 24 *cwt.* Another bar was taken which was cast at the same time, and from the same metal, which broke with 25 *cwt.*

Note.—These two bars were cast in *green* sand.

With the same metal, and at the same time, were cast two bars in *dry* sand; one of which broke with 22 *cwt.*, and the other with 22 *cwt.* 3 *qrs.* In both these cases, the weaker bars seemed to be slightly unsound in the fracture, but the grain was strong and of a bright blue colour.

2. About this time two bars were cast in *green* sand, from the regular No. 3 pig, made at the Elsecar Iron Works, each of which broke with 21 *cwt.* 2 *qrs.* At the same time, and from the same metal, two bars were cast in *dry* sand; one broke with 20 *cwt.*, and the other with 20 *cwt.* 2 *qrs.* The fractures were very sound and fine grained.

Note.—The fractures of all the *green* sand castings presented a strong white skin on the surface of the bars, caused, it is presumed, by the moisture or dampness of the green sand moulds, the absence of which in the dry sand moulds is no doubt the reason why the green sand are stronger than the dry sand castings. But this advantage is only obtained in *small* green sand castings; for it is well known that large masses come out of dry sand moulds much stronger and more regular in their grain than out of green sand moulds.

3. May 6th, 1841.—Two bars were cast from the regular No. 3 pig of the Low Moor Iron Works, which broke, one with 18 *cwt.* 2 *qrs.*, and the other with 19 *cwt.*

Note.—The latter bar was cast while the metal was hot and fluid, which presented in its fracture a close short grain of a dull blue or gray colour; and the former was cast when the metal was cooler, and consequently not so fluid, but rather stiff, presenting in its fracture a number of small pores or air bulbs.

These comparative circumstances between running castings while the metal is hot and fluid, and when it is in a cooler and stiffer state, hold good, it will be seen, in other experiments made with other irons, and they suggest a very important consideration, as well for the iron founder as the iron master. For it is very probable many unsound castings have been made through a want of proper attention to the heat of the metal, when run into the moulds. This, of course, is attended with loss to the iron founder, and will sometimes furnish cause of complaint against the quality of the iron. In no case, therefore, should metal be run into the mould when it begins to appear cold and stiff.

In the following experiments all the bars were cast in *green* sand:—

4. Feb. 24th, 1841.—Two bars were cast from No. 3 pig, called "Summerlee" Scotch iron, made with the hot blast. They each broke with 17 *cwt.* 2 *qrs.*, presenting in their fracture an open grain.

5. About the same time, two bars were cast from No. 3 pig, called "Level" Staffordshire iron, which broke with 16 *cwt. each;* the grain in their fracture being soft and open.

All the above experiments were made with the *ordinary* No. 3 pig iron, as purchased in the market. We now come to experiments made with what is termed and sold for *strong* No. 3 pig iron.

6. In February, 1841, several bars were cast from the *Bierley* pig, which broke with an average weight of 25 *cwt.* 2 *qrs.;* the grain of the fracture close and gray; deflection considerable.

7. From the *Low Moor* iron, several bars broke with an average weight of 23 *cwt.* 2 *qrs.;* the grain of the fracture close, with an appearance strong, and deflection great.

8. From the *Elsecar* iron, several bars broke with an average weight of 24 *cwt.* 2 *qrs.;* the fractures presenting a very close light gray or blue grain, the deflection being slight.

The following are experiments which were made with *mixtures* of pig iron from different makers, which present results as curious as they are interesting, especially to the iron founder.

9. February 20th, 1841. Two bars were cast from five parts strong No. 3 pig, *Low Moor*, and one part strong No. 3 pig, *Elsecar*, which broke with a weight of 26 *cwt.* each; fracture close grained, and rather white or light gray.

Again, May 8th, 1841. Two bars were cast from five parts strong No. 3 pig, *Low Moor*, and one part strong No. 3 pig, *Elsecar*, which broke with 30 *cwt.* each; the grain of the fracture strong and very uniform. The metal was run in a good hot fluid state.

Other two bars were cast when the metal was cooler, and consequently not so fluid, from the same mixture, which broke, one with 23 *cwt.* 2 *qrs.*, and the other with 27 *cwt.* 2 *qrs.;* the fractures had a rich fibrous grain, but were specked with small air bulbs.

10. February 23rd, 1841. Two bars were cast from five parts strong *Bierley* No. 3 pig, and one part strong *Elsecar* No. 3 pig, which broke with 30 *cwt.* each; the grain of the fracture strong and rather close.

11. February 21st, 1841. Two bars were cast from four parts strong No. 3 pig, *Bierley*, and one part strong No. 3 pig, *Elsecar;* one bar broke with 30 *cwt.*, and the other with 33 *cwt.;* the fractures were strong or coarse, and fibrous in the grain, and of a dark blue or gray colour.

NOTE.—These bars were cast while the metal was in a good hot and fluid state.

Other two bars were cast out of the same ladle and mixture, but the metal was allowed to cool a little, and stiffen. They broke respectively with 22 *and* 23 *cwt.* The fractures also presented a grain filled with pores or air bulbs, the size of a very small pin's head.

12. February 23rd, 1841. Two bars were cast from four parts strong No. 3 pig, *Bierley*, and one part strong No. 3 pig, *Elsecar*, which broke with 29 *cwt. each;* the grain of the fracture gray, strong, and close.

The two following experiments exhibit the results of a greater number of mixtures.

13. In August, 1840, two bars were cast from *equal* parts of strong No. 3 pig, *Bierley* and *Elsecar*, and one-tenth part of *Firmstone's Staffordshire cylinder metal*, all "cold blast" iron; one broke with 31 *cwt.*, and the other with 29 *cwt.* Their fractures were close grained, aud of a clear gray colour. The weaker bar seemed defective in soundness in one of the angles of the square of its section.

14. February 22nd, 1841. Two bars were cast from a mixture of *seven* different metals, mixed in *equal* parts, namely, *Bierley*, No. 3, strong and soft; *Elsecar*, No. 3, strong and soft; *Firmstone's Staffordshire cylinder metal;* the "*Summerlee;*" and the "*Level.*" The bars broke with a weight of 20 *cwt.* 2 *qrs.* each; the fractures presenting a grain of a dull white colour, with a fibre neither hard nor soft.

From these experiments it will be seen that the Bierley pig iron is the strongest; the Elsecar is the next in strength; and the Low Moor is the next, when they are respectively used alone; that the pig irons called "Summerlee" and "Level," fall respectively very much in the scale of strength; that by a judicious mixture of pig irons of different makers, in their use for castings, a large increase of strength is obtainable—an increase equal to 50 *per cent.;* and that all these metals are considerably deteriorated in strength and soundness, when they are not run into the mould in a good hot and fluid state.

Railway Foundry, Leeds, May 8th, 1841.

The Chairman said, it was important to arrive at the greatest strength of iron, because in engines used both by sea and railroad the cranks were obliged to be formed at right angles, and not in the direction of the fibres of the iron. In these engines there were two cranks, and an axle was more likely to break than from one. Two or three accidents had occurred on the railroad from York to London, by the breaking of the axletrees, and apparently from want of uniformity of strength, so that the great object for makers of iron to aim at was to produce an article of uniform toughness and durability.

Mr. Hartop said that with respect to the subject to which the Chairman had alluded, the British Association had thought it a matter of so much importance as to induce them to offer considerable sums of money for the best essay upon it. He was sorry to say that the experiments which had been made by the British Association, from circumstances not under the control of the very able engineer by whom they had been conducted, had in a great measure, if not totally, failed, inasmuch as the party sending iron for the experiment, knew precisely what was going to be done with it; and Mr. Fairbairn had said that he experienced the greatest difficulty in obtaining iron that he could depend upon, and that in some cases he could not obtain it at all. Mr. Todd, from inclination, as well as from the intense interest he had manifested in the matter, had virtually accomplished that which Mr. Fairbairn could not accomplish with the materials at his command. Mr. Todd, also, had the opportunity which he had not failed to avail himself of, to obtain iron *not sent to him for the purposes of an experiment,* *but regularly purchased by him in the market for his own use as an iron founder*, and the importance of this was to be found in the fact that several results were entirely at variance with Mr. Fairbairn's experiments on iron from the same works. It did not prove that Mr. Fairbairn was incompetent to conduct such an experiment, but really and truly that he had not the means of doing so in such a satisfactory manner as Mr. Todd had done. The experiments were highly important to the iron founder, because, although the practice and effect of the mixing of irons made with different materials had been long known, it was not so with respect to the running it into moulds at particular temperatures. He was not aware whether any experiments had yet been made on this point, but the *strength of castings*, when the iron was run into them at a cool temperature, it seemed was much deteriorated. He could dwell longer upon the subject, from the interest which it possessed, but he hoped to hear some observations from gentlemen resident in Leeds, to whom the subject was quite of as much importance as to himself.

The Chairman inquired whether any philosophical report had been written upon the subject?

Mr. Hartop believed not. The mixing of two irons had a very considerable effect on the crystalization while cooling, by which it was, he thought, that the strength of the iron was very considerably influenced. Where a fracture took place in a casting on a large scale, there was invariably a flaw or defect in it, and it was astonishing what a material effect upon the strength of it a very small air bubble would produce. A bar of iron a ton weight had been known to break where an air bubble had existed to not a greater extent than a small pea. The Yorkshire iron had besides another advantage,—that the castings were more permanent in quality, as compared with most other irons, whether made by hot or cold blast. As an iron master, his experience had led him to find that soft iron would not last near so long as a hard and substantial iron, particularly as regarded steam-engine boilers. It was very well known that a boiler made from one description of iron would last eighteen or twenty years, and that a boiler made from another description would not last more than eighteen or twenty months, and therefore the production of iron of the greatest possible durability was an object of extreme importance.

Mr. Embleton moved "That the best thanks of this meeting be given to Mr. Todd for his valuable communication, and that the Council take into consideration whether they think it would not be desirable to recommend him to continue his experiments, not only on this iron, but on the Staffordshire and Scotch irons." He (Mr. Embleton) thought that Mr. Todd would be better able to come to a decision with respect to the merits of mixed irons than any other person. As yet, he had only tested the strength of two or three mixtures. It was a subject indefinite in extent, and it was probable that Mr. Todd might hit upon a mixture having the greatest strength of the Elsecar and Bierley bars, which averaged 30 cwts. He was of opinion, if a resolution to the effect he had mentioned emanated from the Society, Mr. Todd would gladly undertake the task of making the experiment.

Mr. Hartop seconded the motion.

The Chairman put the proposition, which was adopted unanimously. The Rev. Gentleman observed that their object ought to be to increase the strength of their own iron, rather than that of foreign production.

ON THE PRESENCE OF TITANIUM IN BLAST FURNACES.—BY HENRY HARTOP, ESQ.

Mr. Hartop presented a specimen of Titanium, which he said had first been discovered in the bottom of the Welsh iron works six or eight years ago, since which period more attention had been paid to it, and it had been found in many instances. The subject required a more thorough elucidation than he was able to bring to bear upon it; and he could only add, that the crystals of Titanium found in the works he alluded to, appeared to him to be produced to a greater extent in those furnaces into which large quantities of cold water had been introduced, while the materials in the hearth were very hot, for the purpose of more expeditiously cooling them: this was, however, contrary to the opinion of many scientific men, who thought they were formed by very slow cooling. The experiments which he had made, rather led him to suppose that this crystalization was caused by rapid cooling. The large specimen he now presented, which was a very rare one, only exhibited the cubes of Titanium, and the crystals of iron *in contact with that metal* were in beautiful parallelism, and much resembled those of moss. He might remark that he had never found such crystals except in contact with Titanium.

The Chairman supposed that, with regard to the hearth, Mr. Hartop meant that part which was outside the furnace?

Mr. Hartop replied, it was that part into which the iron fell, after being smelted from the ore, before it ran out. He was not aware of the relative specific gravity between iron and Titanium, but should think the latter the greater of the two, from the situation they are found in in the furnace hearth. He thought that the beautiful crystals he had described could not be formed at the time the iron was.

The Chairman remarked that they might be derived from oxygen or hydrogen.

Mr. Hartop said, he had a specimen of the ore of Titanium, from Cornwall, in which one beautiful cube might be seen.

Mr. Leah differed with Mr. Hartop in the conclusions he had arrived at, for whether by process of rapid or slow cooling, he had found the crystals spoken of.

Mr. West observed, that with respect to the crystalization spoken of, there was little reason to believe it was caused by what went in at the bottom of an iron furnace. It was much more likely that the crystals were formed by a process which could be more easily conceived than described, and to which a name had scarcely been given. In this case a substance descended through a very great mass of another material, in very small proportions, and the particles approaching each other, most probably caused the formation of these crystals. He merely offered this as an opinion, for in the present state of their circumscribed information, it was impossible to arrive at any definite conclusion.

ON THE OCCURRENCE OF SHELLS IN THE YORKSHIRE COAL FIELD.—BY HENRY HARTOP, ESQ.

Mr. Hartop alluded to some very interesting specimens of shells which had been found in the Yorkshire coal field. He thought he could show that some of the organic remains in the ironstone field had been suddenly fixed in the ironstone strata in which they were found, the muscles therein all being in a feeding position, while in another seam of ironstone, about 100 yards deeper, an immense number of muscles were found with every appearance of having been floated into that position when dead. There were specimens from other strata where large fishes were found in the act of eating smaller ones. If they got hold of fresh water muscles alive, it would be generally found that they were upon their edge. He now produced a specimen of muscles feeding, the appearance of which seemed to confirm the truth of the observation he had made.

The Chairman thought the specimens looked very much like as if the muscles had been fed upon by other fish.

The morning meeting then broke up.

At the evening meeting Mr. HOLMES, of Leeds, exhibited and explained a Safety Lamp, in which he had introduced a modification of the principle of Upton and Roberts' lamp, without being aware of what had been previously effected by other parties. Mr. Holmes's plan was, however, an improvement, inasmuch as it contained an apparatus for regulating the admission of air. The thanks of the Society were voted to Mr. Holmes for his communication, and he was earnestly recommended to continue his experiments.

The following paper was then read:—

OBSERVATIONS ON THE OCCURRENCE OF BOULDERS OF GRANITE AND OTHER CRYSTALLINE ROCKS IN THE VALLEY OF THE CALDER, NEAR HALIFAX.—BY JOSEPH TRAVIS CLAY, ESQ., OF RASTRICK.

The subject of drifted boulders has latterly very much engaged the attention of geologists, and as there is great diversity of opinion regarding the means by which they have been removed into their present situations, every additional fact which may throw light upon the subject is valuable. I was therefore much interested in hearing from Dr. Alexander's paper on the geology of the parish of Halifax, that in prosecuting the works on the line of railway, some blocks of granite had been found near Hebden-bridge, and this has led me to an examination of the bed of the river Calder, at Cromwell Bottom, about eight miles below the above-mentioned locality.

At this place the valley expands considerably in width, and the river, winding from side to side, exposes a good section of the strata through which it passes. The stream has cut through a deep alluvial soil, about six feet in thickness, beneath which is a bed of large pebbles, containing some boulders of considerable size, the majority of which are of coarse-grained sandstone from the millstone grit series, but mingled with these are many rounded fragments of granite and other crystalline rocks, whose original site is far distant. Some years since, the foundations of a mill were laid upon this gravel bed, but on its proving insecure, the gravel was found to be only a few feet in thickness and to be succeeded by a stratum of a soft peaty nature, so deep that a twenty feet pile did not reach the bottom.

This district of the West Riding is composed of very high ground, branching from the great summit ridge of England, and intersected by numerous deep valleys, whose general direction is nearly east and west. That the boulders could have been drifted over this mountainous country without leaving some traces of their course, is, I think, clearly impossible; and I may here remark, that on the adjacent hills *not a pebble of any kind can be found.* We must therefore look around for some other way of ingress; and before entering upon this branch of the inquiry I will briefly allude to those accumulations of drifted, or, as it is sometimes termed, diluvial matter, which overspread many parts of England, as well as of the Continent of Europe, and which have long engaged the attention of geologists. This drift exists in great abundance in the central and eastern parts of Yorkshire, the regular strata along the whole coast line being generally surmounted by it to a considerable depth. It is also plentiful in Lancashire. The composition of the detritus is remarkable. The bulk is usually clay, with rounded masses of rock of the greatest variety of formation and diversity of size, interspersed throughout without the slightest degree of stratification, immense blocks being confusedly mingled with small pebbles.* The action of water has usually been considered as the moving power; but as any current would naturally give

* For a minute description of this formation, see the 1st vol. of Professor Phillips's Illustrations of Yorkshire.

rise to some appearance of stratification, or at any rate to a sorting of the masses, the heavier parts first subsiding, recourse has been had to the theory of a violent rush of water, which, from the impetuosity of its course, would hurry onward in indiscriminate confusion every substance which came within its vortex. This has occasioned the use of the term diluvial, which has been used by many writers, but it is now rapidly giving place to the preferable appellation of *drift.*

There are many facts which militate against this theory. One fatal objection is, that the blocks have not always taken the same direction; for although it appears in general that they have a northern origin, which has given rise to the idea that the flood must have come from that point, yet this is far from being universally the case. Mr. Phillips, who has paid much attention to this subject, when describing the dispersion of the Shap Fell Granite, notices that at Stainmoor, directly *east* from Shap Fell, granite from Shap Fell and syenitic rocks from Carrock Fell have been drifted over the ridge. That barrier passed, the blocks are scattered to Darlington, Redcar, &c., and they have gone *(south)* down the vale of York. He then describes the course of the Cumbrian detritus *northward* to Brampton, and then *eastward* down the valley of the Tyne, though no streams now flowing there have any connection with the mountains from whence the materials came.

It is well known that after the last meeting of the British Association at Glasgow, M. Agassiz, in company with Professor Buckland, travelled through part of Scotland, where, as well as in the North of England, he detected many proofs of the former existence of glaciers of great extent. The large mounds of disturbed materials which abound in many of the valleys were pronounced by him to be moraines left by retreating glaciers, and in every respect similar to those now formed among the Alps.

I have carefully examined many of these mounds in the neighbourhood of Kendal, where they occur in great numbers; and in a short geological tour which I made into Teesdale a fortnight since, I saw them in still greater force; and I cannot think that any one, dispassionately viewing these heaps of unstratified matter, could attribute their origin to the action of running water.

The promulgation of M. Agassiz' theory has given rise to much discussion; and although some of the conclusions at which he arrives appear very doubtful, yet, so far as it supposes the existence of permanent snow and glaciers in the North of England and Scotland, it has met with the concurrence of many eminent geologists. Others, on the contrary, scout the idea of the climate of this country having ever been sufficiently rigorous to produce these effects. But when we refer to the actual condition of another part of the globe, in precisely the same latitude as England, this difficulty, in a great measure, vanishes.

To all who feel any interest on this question, I would recommend the careful perusal of the 13th chapter of Mr. Darwin's excellent work on the voyage of the ship Beagle, which was sent by the English government on a surveying expedition to the straits of Magellan and the coasts of South America. We there find accounts of glaciers of surpassing magnitude coming down to the water's edge in the latitude of Cumberland, and every means in constant activity which would be required to produce the effects under consideration.

It would be irregular at this time to enter fully into the consideration of the glacial theory; but I have thought it necessary to allude to it, in order to elucidate the opinions which I venture to express relative to the boulders to which I have called your attention.

That floating ice has been an agent in the transport of erratic blocks, is no new theory. It is distinctly laid down in Mr. Lyell's Principles of Geology, a work which has been held in deserved estimation for many years. It only remains to be proved that we have grounds for attributing the appearances which I have described to its action.

There can be no doubt that some different conditions would be required to produce the alleged alteration in climate. The relative proportions of land and water are proved to have a great effect, not only upon the temperature, but also upon the humidity and transparency of the atmosphere; and that various causes combine to determine the limits of perpetual snow, is evident from many facts detailed by Mr. Darwin, in the work before alluded to.

Referring you again to the 1st vol. of Mr. Lyell's Principles, you will there find proofs that at the commencement of the tertiary epoch a large proportion of Europe was submerged: this is in strict accordance with the acknowledged fact of the gradual elevation of land. Now, supposing that at the period when the erratic boulders were removed from their original site, the land had not attained its present elevation, (say by only 200 feet) and the occurrence of recent shells at a great height above the level of the sea fully warrants that supposition, let us imagine what effect this change of level would have upon the contour of England, and more particularly of this district. All the lower parts of the country would be under water; the mountains of Westmoreland and Cumberland would form a centre, from whence elevated ridges would radiate; the range of which Blackstone-edge is a part, with all its numerous branches, would form a tract of high land, while the valleys of the Tees, the Swale, the Ure, the Aire, and the Calder, would be narrow arms of the sea, penetrating far into the land, for none of these rivers rise rapidly until they approach their sources. The vale of York would be a shallow channel, beyond which the Northern Moorlands and Wolds would rise above the waves.

A corresponding change in climate would accompany this diversity in the conformation of the land and water; and although the average heat of this quarter of the globe might not be much different from what is now the case, yet the change would have a tendency to promote the increase of permanent snow and ice in northern latitudes. In short, it would approximate to that now in existence in the southern hemisphere. Icebergs detached from the mountainous regions would float upon the sea, depositing their spoils as they gradually melted; while some being drifted up the narrow inlets, would convey the fragments into situations where their presence cannot otherwise be accounted for. That the boulders in question were transported by this means, I have no doubt, but further investigation is necessary satisfactorily to establish the point; and I hope at some future time to be enabled to adduce much additional evidence in support of this view.

PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE SPECIAL MEETING, HELD AT HULL, ON THE 3RD AUGUST, 1841.

In consequence of an invitation from the Yorkshire Agricultural Society, it was resolved, that a Special Meeting of the Society should be held at Hull, on the evening previous to the Great Cattle Show of the former Society. In compliance with this resolution, the Society assembled at Hull, on Tuesday, the 3rd August. The members of the two Societies dined together in the Public-rooms, and then adjourned to the Theatre of the Literary and Philosophical Society of Hull, which, with the Museum, was kindly placed at their disposal.

At the Evening Meeting, Earl Fitzwilliam in the chair, the following paper was read:—

REPORT ON THE AGRICULTURAL GEOLOGY OF PART OF THE WOLD DISTRICT OF YORKSHIRE, AND OF THE OÖLITE IN THE NEIGHBOURHOOD OF NORTH AND SOUTH CAVE, &c.—BY THE REV. W. THORP, OF WOMERSLEY.

Professor Rennie has well said—" Next indeed to the " knowledge of what is best to be done in practice, is the " knowledge of the *reasons* why one mode of agriculture is " better than another mode. Now these reasons are in fact " *the science*, and the farmer who does not know a good and " satisfactory reason, beyond the use of wont or hap-hazard " experience, for adopting certain rotations of crops, for "liming one sort of soil and not liming another sort, for "planting or sowing thinly rather than closely, and in short "for all the various processes and operations, must be pro-"nounced to know little more than half his own business. "I think, therefore, (says he) no more important subject "can occupy the attention of the agriculturist, than an "inquiry into the reasons why the chief processes of agri-"culture are more successful in some circumstances than "in others; for if these reasons are once discovered, and "the facts connected with them established beyond con-"troversy, like many of the facts in practical chemistry and "practical mechanics, then the farmer will have a sure guide "in his operations, and will be as superior to the old farmer "of hap-hazard experience, as the modern mariner with his "compass is to the mariner of olden time, who dared not "advance out of sight of land, for fear of losing himself in "the pathless ocean."

In order, however, to discover the reasons why one mode of agriculture is better than another, it will be necessary to ascertain the difference of the circumstances under which these operations are performed, or to apply acknowledged principles to local circumstances; for, on a comparison of several modes of farming, it may be found that each has been made under a diversity of soils, subsoils, climate, manures applied, and crops produced; so that it becomes requisite to study the agriculture of particular districts in relation to these phenomena; or, in other words, to apply to the investigation of the subject the cognate sciences of Geology, Chemistry, and Physiological Botany.

In the last year a sub-committee of the Yorkshire Agricultural Society was appointed to obtain an essay on the Agricultural Geology of some part of Yorkshire, which should contain observations upon—1. The geographical limits of the geological formation. 2. Its general character, such as height of hills or ridges, depth of beds, &c. 3. Its chemical composition. 4. The plants which seem to thrive best upon it. 5. The manures which have been found most applicable, suggesting, if possible, others which, from their chemical properties, seem likely to supply deficiencies in the soil. 6. Insects and diseases which are found most destructive to the crops, with the remedies, where known.

Since the issuing of the sub-committee's first report, the lectures of Professors Daubeny and Johnston, and translations of the works of Liebig, Sprengel, Schœbler, and De Candolle, have appeared; and there is now being made, not only in England, and in Scotland by the Highland Society, but on the Continent of Europe, a general attempt to ascertain the first principles of agriculture by the aid of science, or to explain its phenomena by the known laws of matter, as exhibited in the sciences of geology, chemistry, and vegetable physiology; and in furtherance of these objects, the sub-committee present the following Report upon a tract of country contiguous to the important town (Hull) in which the Agricultural Society have the honour to meet.

The district over which the Report is made extends from Pocklington on the north, by Market Weighton to the river Humber on the south; and from Beverley on the east to North Cave on the west. It comprehends part of the extensive district of the Wolds, and that in the neighbourhood of Brantingham, North and South Cave, &c., as marked upon the map, which is enlarged from that by the Rev. W. Harcourt, in the Annals of Philos. vol. XI, page 435.

The Committee purpose, therefore,—

I. To examine the soils in connection with their geology over each of the beds subordinate to the Chalk and to the Oölitic series; to produce to the Society vertical sections of their thickness, &c. &c., and to project them upon a map of six inches to the mile.

II. To inquire what aid may be derived from Chemistry and Physiological Botany in the cultivation of these soils.

III. To describe the state of agriculture as at present existing, and offer some suggestions for its improvement.

1. *The Chalk series* consists of, in the descending order—

*Chalk	100 to 140 yds.	Total about 150 yards.
Chalk Marl	10 to 20 ,,	
Red Chalk	6 to 12 feet	

The uppermost stratum of chalk is well known as the Wolds, and requires no detailed geographical description; in the district described, its eastern boundary extends from Kilnwick, Lockington, by Beverley, Cottingham, to the Humber: from the Humber its western boundary is well marked by the lofty escarpment extending from North Ferriby, by Wauldby, Hunsley Beacon, Hessleskew, Goodmanham, to Warter and Kilnwick Percy. The great elevation of this district, which at Wilton Beacon is 809 feet above the level of the sea, has a material influence upon the climate of the Wolds,† which, from nearly a total absence of wood and shelter, is severe and variable; the winds being extremely violent and penetrating, and, by causing a rapid evaporation, greatly aggravating the effect of cold upon the vegetation.

The soil upon the chalk does not partake so much of the nature of the rock upon which it rests as might be anticipated, neither are all the soils formed by the decomposition

* Speeton Cliff is 400 feet thick.

† 600 feet in elevation diminishes the temperature equal to that of one degree of North latitude. (p. 44, Farmers' Series—Planting.) The annual mean temperature of Aberdeen for the last sixteen years is 47.22, while the mean temperature of London, by Humboldt, is 50.36. The first 300 feet in elevation reduces the temperature one degree of Fahrenheit, the next 295 feet one degree, then the next 277 feet one degree; or three degrees at 872 feet.

of the chalk rock; but it seems as if the calcareous matter being washed out, the remaining flints form the basis of the present soil. The analysis of the soil proves this to be the origin of one variety, as will be noticed in the sequel; for there is scarcely any carbonate of lime detected, not more than 1, 2, or 3 per cent., while the chalk rock contains 90 per cent. of that earth. In some parts of Bedfordshire, and at Highclere, in Hants, the soil is composed of more than two-thirds of flints; but on the chalk districts of Kent, Surrey, and Sussex, the soil is said to be composed of a red clay mixed with rolled flints, varying in some instances to a loamy clay, or to sand and gravel. Indeed, wherever in the south of England, and particularly on the south side of the Thames, the junction of the chalk with the tertiary beds is exhibited, the surface of the chalk along the line of superposition usually bears marks of having undergone a partial destruction subsequently to its consolidation; a bed of debris being spread over it, consisting chiefly of flints *washed out of its mass*, and the surface being irregularly worn into frequent cavities, many of them of considerable depth, filled with similar debris. There are examples of these cavities in every chalk quarry on the Yorkshire Wolds, proving that the chalk in this locality has undergone a similar kind of washing, by which there has been formed upon its surface a detritus consisting chiefly of flints. There are in this district two distinct characters of soil known agriculturally, i. e. *the deep* and *the shallow* wold land; and there is probably a third variety formed by *distinct deposits of clay*, with scarcely any intermixture of sand or pebbles. In the survey of the East Riding of Yorkshire, published by the Board of Agriculture in 1812, and drawn up by H. E. Strickland, Esq., the soil of the Wolds is said to be, with little variation, "a light, friable, calcareous loam, from three to ten inches "in depth; and on the hills covering a chalk rubble from

" twelve to eighteen inches thick, below which the chalk " rocks lie to an unknown depth." Mr. Legard, in a paper published in the Society's transactions, describes the soil at Neswick as " a strong clayey loam, the subsoil being a red- " dish clay, varying from two to three feet in thickness, and " resting upon the chalk." The *deep wold land* is always found reposing upon flat table land, or where the surface lies more level; and the same may be said of the isolated deposits of clay, but the *shallow wold land* is always found where the surface inclines more from the horizon, and particularly in the lines of the denuded valleys; the soil in these places becoming thinner and less intermixed with the debris of flints. In fact, the " reason" of the variety of the soil on the Wolds is easily explained by a consideration of the diluvial beds of Holderness, which lie upon the chalk; enormous masses of water have brought these beds of clay and boulders, not only over the Penine chain of England, at Stainmoor, but over the Hambleton hills and the western escarpment of the Wolds, furrowing out the latter into deep east and west valleys,—the degree of inclination of the chalk determining the velocity of these currents, and together with it, their motive power. Upon the more level and elevated portions, their influence has been feebly exerted, and the original debris of flints yet remains as the basis of the soil of *the deep wold land;* but upon the more inclined portions, not only has the original debris of flints been removed, but along with it great bodies of chalk, and by the degradation of the rock thus laid bare, the present soil of the *shallow wold land* is formed. Indeed, the position of the shallow wold land, which is often found reposing at the steep angle of thirty degrees upon the sides of the valleys, affords an additional proof of its being the result of the decomposition of the chalk rock, for it cannot in these localities be a sedimentary deposit, neither is it a portion of any of the tertiary beds which may formerly have existed. In many places it is not more than three inches thick, and the chalk itself is frequently ploughed up and intermixed with the soil. There is, however, considerable difficulty in explaining the presence of 63 per cent. of silica, while the chalk rock contains not 1 per cent., and also in the absence of calcareous matter, which is only 7 per cent. while that of the rock is 98 per cent. (Compare the analyses of the rock at Hessle, and the shallow wold soil of Bishop Wilton.) The embedded flints, however, which pervade the whole formation, resist the decomposition of the atmosphere, while the carbonate of lime is continually being dissolved by the rains and carried away into the subsoil,—hence, probably, the prevalence of the former, and absence of the latter earth.

The division between the *chalk* and *chalk marl* over this district must be considered rather arbitrary. The embedded flint nodules are found through the whole formation, and are here of an unusually light colour. In Elloughton dale are two beds of chalk marl, one yellow and the other red, the latter of which runs at the bottom of the chalk terrace as far north as Pocklington. Mr. Harcourt considers this thin red band the representative of the Cambridgeshire gault, from the presence of the small transparent belemnites described by Lister. The chalk marl is said by Professor Sedgwick to exist at Speeton, and the yellow and red beds alternating there to give the cliff a very singular character.

The Oölitic series consists of, in the descending order :—

1. Kimmeridge Clay, about.........	25 yds.
2. Kelloways Rock	5 „
3. Inferior Oölite	6 „
4. Lias	25 „

and is here characterized by the absence of the several members in its group, the Kimmeridge Clay being the only member of the *upper Oölite*, the Kelloways Rock that of the *middle Oölite*, while the inferior Oölite is the only representative of the beds of the *lower Oölite.* The Lias is, however, well developed at North Cliff.

The Kimmeridge Clay is immediately subjacent to the great mass of chalk, and is of little importance in an agricultural point of view, forming only a zone of wet land about 200 yards in breadth at the foot of the escarpment of the chalk. It is an exceedingly tenacious clay, which throws out the water of the chalk in great quantities at Newbald, Brantingham, Elloughton Dale, &c. This stratum suddenly disappears from under the chalk at Newbald. The ostrea deltoidea is the characteristic shell of this stratum.

The next subjacent beds are the *Kelloways Rock* and the *Inferior Oölite.* These beds were first discovered in this locality by the Rev. W. Harcourt and Professor Phillips, and, geologically considered, they would require a separate description; but since the crops produced upon them are in all respects similar, as well as the quality of the land, these two formations will be described together in the agricultural portion of this Report; and they are marked nearly the same in the map, the Kelloways Rock being a shade or two darker. The detailed section of these beds consists of—

Kelloways Rock	1. Brown sand and stone.
	2. White and yellow sand.
	3. Sandy shelly blocks of stone (large size.)
Inferior Oölite...	4. Irony balls in sand.
	5. Oölite in oblique laminæ.
	6. Oölite with the blue cores.*

* Strata in a well at Mr. Stephenson's farm:—

	yd.	*ft.*	*in.*
Soil	0	1	6
Fine Gravel	5	0	0
(Kelloways Rock) Rotten Rock	5	0	0
(Inferior Oölite) Grey Stone Rock	6	0	0
(Lias) Clay	2	2	0
In a quarry at the same place:—			
Soil	0	0	6
Sandy Rubble	1	0	0
Sand	0	2	6
Oölite Rock	1	0	0

The geographical limits of the Kelloways Rock are not easily defined. The rock, or rather the beds of sand of which it consists, being only three or four yards thick, forms a low continuous terrace from South Cave to South Newbald, ranging nearly in the line of the public road from the former place to the latter, the terrace usually extending to the west of it for a short distance. The soil of the Kelloways Rock is less intermixed with foreign debris than that of any other in the district, and may in all cases be said to have been formed by, and to partake of, the sandy nature of the subjacent stratum. The soil is even, if possible, more sandy than that of the Inferior Oölite, which contains 97 per cent., and the colour is generally dark brown. The extent of country formed by this rock is very small, upon an average a quarter of a mile in width, and extending in length from South Cave to South Newbald. Its sandy beds abound in casts of shells, and at the bottom of them are masses of a hard calcareous stone, marked by numerous remains of Gryphœa dilatata. The peculiar shell belonging to it is the Ammonites calloviensis.

The Inferior Oölite, from the south of Elloughton to the north of Sancton, forms rather an extensive tract of country. The bed No. 1 (irony balls in sand) composes the basis of the soil from near Welton to Everthorp, a distance of 5 or 6 miles, and no perceptible difference can be discovered throughout this portion of their range, between the agricultural character of this bed and that of the Kelloways Rock. Around Everthorp, the sandy beds being denuded, the second bed of the oölite, i.e. the oölite in oblique laminæ, comes to the surface, and alters the texture of the soil. Farther north the sandy beds again prevail, and are well exhibited, together with the variation in the quality of the land, half way between Newbald and Sancton, at Mr. Stephenson's farm. The two lowest beds of the Inferior Oölite are quarried as a material for the roads along the whole line of their extent, under the name of "grey stones," and in some places have been burnt for lime. The thickness of the three beds amounts together to about six yards. To the north of Ellerker, the middle term of the series disappears, and the formation consists of sandy beds in the upper portion, and oölitic stone in the lower. The shells characteristic of this rock are Terebratula spinosa, Turritella, Lima proboscidea, Trigoniæ.

The Lias is the lowest bed in the oölitic series, and which occupies a considerable portion of country in the district described in the Report. From Fangfoss, by Pocklington, where it forms a lofty escarpment behind the town, it extends to Londesborough, Goodmanham, and Market Weighton, producing at these places and around Kilnwick Percy, some of the best grazing pastures in the country. The beds usually presented consist of a mass of blue and yellow clay, varying from 50 to 60 feet in thickness; and the soil partakes greatly of the subsoil, the gradation from one to the other being only marked by the colour: indeed, as a general rule, the clay soils are seldom *intermixed* in Yorkshire with sand or debris, although frequently they are covered by it, and have boulders embedded in them. In the Lias clay beds there are, however, several loose stony beds, seldom approaching to the character of rock, which in places come to the surface, and form very excellent land. Upon the terrace to the east of Pocklington they have been partially quarried for road material, but from want of continuity have been only dug in circular pits out of the surface. From North Cliff to within a field's-length of North Cave, these stony beds form some of the best arable land in the neighbourhood, yielding excellent and heavy crops of all descriptions. To the east of this good land, which extends between North Cliff and North Cave, the upper stony beds of the lias have been washed away, and around Houghton plantation and Houghton common a great extent of ground is covered with loose diluvial drift sand of the same quality, and probably identical with the sands of the Warrens near Holme on Spalding Moor, Seaton Common, and Allerthorp Common. The clay beds of the Lias are immediately under the sand at Houghton, and are now used with great effect in marling the surface. From North Cave to the river Humber the clay beds again prevail, and are chiefly in grass. Opposite Elloughton the lias presents no separate escarpment, but is upon the same level with the great central plain of York: its clays are burnt for brick at Brough Ferry, and there is no doubt of its continuity as far as the banks of the Humber.

The Diluvial Beds of this district require a short notice. The drift sand of Houghton Common just noticed, and which is laid down upon the map, around Huncliffe toll-bar is a mass of chalk rubble covering the sandy beds of the Kelloways rock: near Everthorp is a similar mass, but of smaller extent: between North and South Cave, and to the south of Elloughton, the inferior oölite has been broken up, and is intermixed with foreign matter; and generally it may be said, that wherever the sandy beds of this stratum are visible, they have been disturbed and are intermingled with rounded detritus, but which has come no great distance, and is principally composed of the subjacent rock. The longer axes of all the detritus found, lie in a north and south direction, parallel with the direction of the present line of drainage, both of which no doubt are due to the action of the retiring diluvial waters, which were unable to surmount the terrace of the chalk formation of the wolds.

II. What aid may be derived from chemistry and physiological botany in the cultivation of these soils?

1. *Chemical Nature of the Soils.*—It might be supposed that a soil reposing upon the great chalk formation would be strictly calcareous, and that the predominating ingredient

would be lime; but the Agricultural Society having obtained analyses of several of the Wold soils, by Mr. J. Spence, of York,* it is found that the unchalked soil only contains of carb. of lime and carb. of magnesia, together $\frac{3}{10}$ of a grain per cent., while the chalk itself from Hessle Cliff contains 90 per cent. carb. of lime, $8\frac{5}{10}$ carb. of magnesia, together $98\frac{1}{2}$ per cent.; so that it is only by the consideration before

* Analsyses of Wold soils by Mr. J. Spence:—

DEEP WOLD SOILS.

"Chalked" Soil of Riplingham.

Mechanical Analysis.

Upon being diffused in water, there was deposited in $3\frac{1}{2}$ minutes:—

Sand	78.
Remained suspended and in solution	22.
	100

Chemical Analysis.

Water of absorption			4.
Matter soluble in water.	sulp. of lime	0.3	1.
	chl. sodium	0.1	
	veg. matter	0.6	
Matter destructible by heat, (veg.)			5.
Siliceous sand insoluble in nitric and sulphuric acid			74.
Alumina			3.2
Oxide of iron			6.5
Carbonate of lime			2.9
Phosphate of lime			0.4
Carbonate of Magnesia			1.
Potash existing in the soil as an insoluble silicate			0.6
Loss			1.4
			100

Unchalked Soil of Riplingham.

Mechanical Analysis.

Upon being diffused in water, there was deposited in $3\frac{1}{2}$ minutes:—

Sand	77 per ct.
There remained suspended, and in solution	23 "
	100

SHALLOW WOLD SOIL.

From Bishop Wilton.

Mechanical Analysis.

In $3\frac{1}{2}$ minutes	81.
Remainder	19.
	100

Chemical Analysis.

Water of absorption			9.
Matter soluble in water.	sulp. of lime	0.2	0.7
	chl. sodium	0.1	
	veg. matter	0.4	
Matter destructible by heat			10.
Siliceous sand insoluble in nitric and sulp. acids			62.1
Alumina			4.
Oxide of iron			6.4
Carbonate of lime			5.
Do. of magnesia			1.6
Phosphate of lime			0.1
Potash in combination with silica			0.1
Loss			1.
			100

Unchalked Lincolnshire Wold Soil from Saxby.

Mechanical Analysis.

Deposited in $3\frac{1}{2}$ minutes	88
Remainder	12
	100

offered, respecting the origin of these soils, that the absence of calcareous earths can be accounted for. The "*deep wold*" soils may then be more properly termed "*sandy*," for they contain as much as 77 and 78 per cent. of sand, 73 or 74 of which is siliceous,—the quantity of alumina being

(Unchalked of Riplingham continued.)

Chemical Analysis.

Water of absorption	5.
Soluble in water: sulp. lime abt. 0.1, chl. sodium do. 0.1, veg. matter do. 0.3	0.5
Matter destructible by heat, (veg.)	4.5
Siliceous sand insoluble in nitric and sulphuric acids	73.5
Alumina	2.1
Oxide of iron	10.0
Carbonate of lime and carbonate of magnesia	0.3
Phosphate of lime	0.1
Potash (existing as an insoluble silicate)	0.8
Loss	3.2
	100

(Lincolnshire Wold continued.)

Chemical Analysis.

Water of absorption	5.
Matter soluble in water: sulp. of lime	0.6
Matter soluble in water: chloride of sodium	0.1
Matter destructible by heat, (veg.)	5.
Siliceous sand insoluble in nitric and sulphuric acids	73.5
Alumina	2.8
Oxide of iron	2.9
Carbonate of lime	7.6
Phosphate of lime	0.1
Carbonate of Magnesia	0.4
Potash (silicate)	1.
Loss	1.
	100

Soil from Neswick contains 2 per cent. of calcareous matter; (query "chalked" or "unchalked.")

Chalk from Hessle Cliff.

Matter soluble in water: sulphate of lime and chloride of sodium.	0.3
Carbonate of lime	90.
Carbonate of magnesia	8.5
Silica	0.4
Alumina	0.1
Oxide of iron	a trace
Phosphate of lime	0.1
Loss	0.6
	100

Flint, by Klaproth.

Silex	98
Lime	0. 5
Alumina	0.25
Oxide of iron	0.25
Water	1. 0
	100

Chalk, by Bucholz.

Lime	56.5
Carbonic acid	43.
Water	0.5
	100

Chalk, near Marlborough. (Boyd.)

Lime	43.29
Carbonic acid	44.06
Water	11.40
Silex	0.25
Alumina	1.
	100

Another analysis of the Riplingham unchalked soil, for H. S. Thompson, Esq. gave of calcareous matter 2-10ths per cent.

(For Synopsis of the preceding Analyses, see end of this Report.)

very small, only 2.1 per cent.; and hence, together with the absence of calcareous earths, the "deafness," pulverulent state, or want of cohesion of these unchalked soils. The calcareous matter added by the operation of "chalking" may seem small in quantity, being $3\frac{6}{10}$ per cent. (carb. lime $2\frac{9}{10}$ + 1 magnes. = 3.9 — $\frac{3}{10}$ = 3.$\frac{6}{10}$ gain), but there is also added by chalking $1\frac{1}{10}$ per cent. of alumina, although it seems difficult to explain how this quantity could have been added; for the chalk at Hessle Cliff only contains $\frac{1}{10}$ per cent. of it. In the present state of our knowledge respecting the ingredients which constitute fertility, it would be premature to state the quantity of calcareous earths the wold soils should contain, to produce fertility; neither do we think it possible to state, from chemical analysis, which should be chalked, or which do not require that operation. For if one of the magnesian limestone soils, probably the most fertile upon the whole formation between Worksop and the river Aire, be compared with the *unchalked* soil of Riplingham, it will be found exceedingly similar in the ingredients which it contains: the unchalked soil of Riplingham contains $2\frac{1}{10}$ of alumina, that of the magnesian limestone $2\frac{4}{10}$ per cent., that of Riplingham $\frac{3}{10}$ per cent. of carb. lime, while that of the limestone contains $1\frac{8}{10}$ per cent. of *lime* (not carbonate); so that if a calcareous soil containing so small a portion of lime as $1\frac{8}{10}$ per cent. be pre-eminently fertile, it becomes exceedingly difficult to predicate whether the addition of so small a quantity of that earth would afford the increased productiveness. As a further corroboration of this opinion, the chalk soils of Neswick do contain 2 per cent. of calcareous matter, and yet the author of the paper in the Transactions of the Society states "that although the corn crops may be "permitted to follow each in their turn without variation, "yet the green or alternate crops seem by certain natural "laws to deteriorate, if recurring so frequently as once in every four years;" an effect not observed on the magnesian limestone soil, at least not upon the turnip crop.

In Lincolnshire, formerly, chalk was only applied to the more sandy soils, but it is now applied nearly indiscriminately to those termed more clayey. There is, however, a tract of land near Saxby, which has never required that operation: this land grows red clover productively once in nine years; five to six quarters of barley and five quarters of wheat per acre: the clover seeds also grow well for two years, and are always kept down that length of time. It is some of the best turnip land upon the Lincolnshire wolds. It is more "sandy" than the Yorkshire wolds, and contains 88 per cent. $73\frac{1}{2}$ per cent. of which is siliceous. The quantity, however, of carb. of lime and carb. of magnesia is ($7\frac{6}{10} + \frac{4}{10}$) per cent., so that the soil may be termed a "sandy calcareous soil;" and in this case the superiority does seem due to the quantity of calcareous matter contained in it; for that of aluminous earth is much the same as in the soils of the Yorkshire wolds, being $2\frac{8}{10}$ per cent. The quantity of calcareous matter is a little greater than that contained in some excellent *shallow* wold land from Bishop Wilton, being at this latter place carb. of lime 5 and carb. of magnesia $1\frac{6}{10}$, total $6\frac{6}{10}$; the water of absorption also in the latter is increased to 9 per cent.; and the quantity of alumina 4 per cent., is alone sufficient to account for its fertility, which would enable it nearly to produce grazing pastures, as will be seen in the sequel. (Compare the soils of Riplingham, "chalked" and "unchalked," Lincolnshire Wolds and Shallow Wold soil of Bishop Wilton, and that of the Magnesian limestone.—See also SYNOPSIS OF ANALYSES.)

It is probable that the chief value given to the soil by chalking, is derived from the consolidation or consistence given to it. Every farmer knows that chalked land feels more firm than unchalked, and does not slide away from under the feet while walking upon it. From the analyses of the chalked and unchalked soils, there does not seem given to the former any additional power to absorb water by the addition of the chalk, at least it does not appear in the analysis, although the power of containing water between siliceous sand, and lime in its fine state of carbonate, is by Schoebler's experiments as 25 to 85. Again, the firmness and consistency of pure clay in a dry state is represented numerically by Schoebler at 100; that of siliceous sand by 0, that of lime in its fine state of carbonate by 5, but in their wet or moist states, clay is 27, sand 3.8, while that of lime is 14.3, or about one-half of that of clay; so that in affording consolidation to any soil, two parts of lime are equivalent to one of clay; or, conversely, one part of clay will go as far as two parts of lime. Unfortunately, however, there are no comparative experiments before us respecting chalking and claying, although at Riplingham there are two distinct beds of clay, and the subsoil at Neswick is said to be clay. These clays are no doubt marls, and I can only add, from Hillyard, "that marl is a mine of manure for "those who are so fortunate as to have it for a subsoil; but "the desire of possessing it is lessened, because it generally "lies under an inferior surface of soil; *this applies more* "*decidedly to chalk.*" It is, however, certain that either marl or chalk added to a siliceous sandy soil, will not only give consistence, but exert the more proximate causes of increasing fertility, *by promoting the absorption of oxygen*, siliceous sand being represented by 1.6, clay 15.3, carb. of lime 10.8: also, *by increasing the absorption of moisture from the atmosphere*, siliceous sand being .0, clay 42.0, lime 31.0, and *by increasing the power of the soil to retain water*, siliceous sand being 25.0, clay 70.0, carb. of lime 85.0. Its power of retaining heat, however, will be diminished, while siliceous sand is represented by 100.0, clay is 66.0, and carb. of lime 61.0.

The Kimmeridge Clay,* from its analysis, might be termed a stiff calcareous soil, containing 12 per cent. of carbonate of lime,—a quantity greater than any found in the limestone soils of Doncaster, which affords another instance of the impossibility of judging of the productiveness of soils by their component parts. Mr. Spence, the analyst of these soils, remarks, "that this clay appears to contain every thing, unless free carbonic acid and water, that we are taught to believe essential to vegetable life: yet its mechanical constitution, from being almost impermeable to air and water, renders it nearly as sterile as the worst of soils. The silica in the specimen analysed is not siliceous sand, but impalpable; and the coarse particles being concretions of the impalpable parts, the entire constituents of the clay are finely divided matter."

The Kelloways Rock and the beds of the *Inferior Oölite*

* Kimmeridge Clay from Elloughton Dale.

Specific gravity.

Mechanical Analysis.

100 parts diffused in water.

Deposited in ½ a minute	31
Do. in 3 minutes longer	16
Do. in 10 hours longer	44
Remainder in solution or suspension	9
	100

Or if stated as the wold soils,

Deposited in 3½ minutes	47
Remainder	53
	100

Chemical Analysis.

Matter soluble in water. Sulphate of lime	0.2
Do. of potash	0.1
Chloride of sodium	0.2
Siliceous sand insoluble in nitric and sulphuric acids	54.5
Alumina	16.5
Oxide of iron	10
Carbonate of lime	12
Phosphate of lime	1.5
Carbonate of magnesia	1
Potash existing in the clay as a silicate	2.6
Loss	1.4
	100

The same analysed by Mr. R. Phillips, of the Museum of Economic Geology, No. 6, Craig's Court, London.

Silica	44.4
Alumina	22.1
Peroxide of iron	7.3
Carbonate of lime	15.
Carbonaceous matter	4.
Moisture and loss	7.2
	100

are strictly sandy soils, containing 97 per cent. of sand,* and many fields might be termed "blow away" sands. There is little doubt that by the addition of the Kimmeridge clay many of these lighter soils would be permanently improved, and as it lies contiguous to them on the whole range from north to south, it could be applied at little expense. The fertility of the land on the Kelloways Rock, and of part of the inferior oölite is amazing, considering that 97 per cent. of the soil is pure sand, and affords another proof of the fact before-mentioned.

Lias. It becomes an exceedingly interesting inquiry to ascertain how the soils upon the lias soil produce such excellent feeding pastures, while some of the clayey soils upon the New Red Sandstone formation, very similar in external characters, will scarcely produce grass at all, and that of the most inferior description. Now it is very probable, a priori, that as the richest natural pastures are found only comparatively upon a few soils, and these geologically distinct, that they should possess some common mechanical texture, or chemical ingredients, by which their fertility is maintained; and although certain soils, composed of various constituents, may produce large crops of grain and other *annual* crops, yet they are nevertheless unfit for the production of the superior perennial grasses. We therefore think it probable that the capability of a soil to produce the superior grasses, may be known by an inspection of its analysis, and that it will be found that any soil which contains from 5 to 9 per cent. of alumina will have this power. If there be less of alumina than 5 per cent., the soil will be too light and friable,—if it contain more than about 9 per cent., it will be too tenacious for this purpose. In Sinclair's experiments upon twelve different soils with the superior pasture grasses, it was found that all the plants vegetated,

* Deposited in 3½ minutes.

except upon the barren peat soil, but that after growing two years, all of them degenerated, except those having possession of two soils, viz. the rich alluvial soil and the rich clayey loam, the former of which contains 7, and the latter 5 per cent. of alumina. Upon the rich sandy soil with 2 per cent. of alumina, the produce began to decline in the second and third year, while on the two soils just mentioned it increased in quantity till the fifth year, and had continued in the same state, with a very trifling diminution in weight, when he wrote, and that without the application of manure.

There is abundant proof that the superior grasses will not flourish upon a soil with *less* alumina than 5 per cent.; for neither would they remain permanent on Sinclair's rich siliceous, which contained 2 per cent., nor on his sandy loam containing 3¾ per cent., nor on the vegetable mould, having 4½ per cent. Upon the magnesian limestone soils, as described by the Rev. W. Thorp, at the Doncaster meeting of the Geological Society, feeding pastures, or superior grass land, are only found, upon the whole tract between the rivers Don and Aire and Calder, in two localities, one in the neighbourhood of Pontefract, the other near Skellow: all the soils analysed from that extensive tract of country contained less than 5 per cent. of alumina, except that from the place near Pontefract where the excellent pastures occur, and which contained 5.9 of that earth. Out of ten rocks examined, only one contained more than 5 per cent., and that from a quarry contiguous to the pasture land of Skellow. And the reason of the non-adaptation of the limestone soils to grow the superior perennial grasses is now for the first time explained. That some of the best pasture lands do only contain that quantity of alumina, I may mention, in addition to the two of Sinclair's, the excellent grazing pastures of Sir Wm. Cooke, adjoining the river Don below Doncaster, at Arksey, Bentley, &c.: these contain 6.2. In a correspondence respecting the fertility of a piece of land at Wantage, in Berkshire, published in the Bath Agricultural Transactions, it is stated that the land was let at £14 per acre, and produced enormous crops without manure while under the plough, and most superior pasture when laid down to grass, in which state it had been for several years when the soil, and subsoil, and that of an adjoining meadow were analysed by Mr. Boyd. The soil of this excellent land contained 6 per cent. of alumina, the subsoil 5.2, and the soil of an adjoining meadow 5.5.—*(Bath Philos. Trans.)*

An excellent pasture analysed by Sir H. Davy, from the banks of the Avon, in Wiltshire, contained of alumina 6.2, chalk 6.3, siliceous sand 9 per cent.—*(Johnston on Manures, p.* 262.*)*

The soil of a rich natural pasture at Endsleigh, in Devonshire, which fattens on an average a bullock of 160 stone, and winters two sheep, contained 8½ per cent. of alumina, with no lime in it.—*(Ibid, p.* 241.*)*

A rich ancient pasture near Croft Church, in Lincolnshire, contains 6.1 alumina.—*(Ibid, p.* 244.*)*

Woburn Abbey Park, which produces the finest oaks in England, 7½ alumina.—*(F. S. Planting, p.* 49.*)*

To which may be added two excellent soils from Craven, given and analysed by J. Spence, both producing feeding pastures,—the one on the Millstone Grit containing alumina 5 per cent., and the other on one of the Chert beds 6 per cent. of the same earth.

The soil of the Lias in the district we are now describing contains 7 per cent. of alumina;* and it is well known that upon this stratum are found the best grazing pastures of

* Lias clay from Bellthorp (best grass land of the district) :—

Mechanical Analysis.

Deposited in 3½ minutes	90 per cent.
Remainder	10
	100

(Chemical Analysis next page).

Lincolnshire, Leicestershire, and Gloucestershire. These examples are sufficiently numerous to prove that a soil with less aluminous earth than 5 per cent. will not produce good grass; but it may nevertheless be possible that soils containing 10 or 11, or even 12 per cent. upon very dry subsoils, or that certain sandy soils with *less* alumina than 5 per cent. on moist or retentive subsoils, may have the same capability. Yet in Sinclair's experiments, neither the tenacious clay with 13.7, nor the clayey loam which contained 14.5, was possessed of this power, but the grasses degenerated upon them equally as much as upon the siliceous sandy soils.

The quantity of *sand* in some of the above specimens varies from 9 in the banks of the Avon soil, and 23 in the Arksey soil, to 69 per cent. in the Wantage soil. The quantity of *carbonate of lime* also varies from none, as at Endsleigh, and 5 per cent. as in Sinclair's rich black clayey, to 57 in the banks of the Avon soil: so that the quantity of sand or lime is indefinite in the rich grazing pastures. Of course the above rule can only apply to soils which are of sufficient depth, do not rest upon a wet subsoil, and which do not super-abound in peaty earth.*

Chemical Analysis.

Water of absorption		5.5
Matter soluble in water.	Sulphate of Lime	0.4
	Chloride of Sodium	0.1
Siliceous Sand, insoluble in nitric and sulphuric acids		54
Alumina		7
Oxide of Iron		7.7
Carbonate of Lime		15
Carbonate of Magnesia		7
Phosphate of Lime		0.6
Potash		2.1
Loss		0.6
		100

* Synopsis of soils producing the superior perennial grasses:—

		Sand.	Carb. Lime.	Alumina.
Sinclair's clayey Loam	(neither of which	47	2	14.5
Ditto tenacious clay	would produce them)	39	6	13.7

Manures.— It having been ascertained that the soils of the wolds, those of the Kelloways rock and inferior oölite, contain comparatively a very small proportion of alumina and lime;—and if not only firmness and consistency be imparted by these earths, but also the power of condensing and absorbing carbonic and ammoniacal gases is given to the soil,—it is easy to perceive the reason why these lands require a frequent application of manure, and particularly as they are always porous, so as to admit a free circulation of the atmosphere, which hastens the decomposition of the manures applied to them. Owing to these deficiencies, this land therefore becomes very expensive in the article of manures necessary to be applied in its cultivation, and the expense of providing manures is increased by the general practice of purchasing foreign manures, and neglecting the care and preservation of those which could be collected at home; and that the expense will increase, is probable from the present advanced price of bones and rape-dust, to which is to be added, the less effect from the same manures being placed unremittingly upon the same soils. It becomes then an important inquiry, whether any other manure equally valuable may not be procured as a substitute and at a less cost.

	(Continued from previous page.)	*Sand.*	*Carb. Lime.*	*Alumina.*
No. 1.	Sinclair's rich black clayey	41	5	5
2.	Ditto rich alluvial	46	5.7	7
3.	Magnesian Limestone (Pontefract)	17	Lime ...12.6, Mag. ...21.1	5.9
4.	Arksey, near Doncaster	23	L. & M. 7.6	6.2
5.	Endsleigh	37	0	8.5
6.	Wantage (Berkshire)	65.7	4.5	6
7.	Croft Church (Lincolnshire)	40	8	6.1
	Ditto, same soil 15 inches below the surface	69	4.75	5.2
8	Adjoining meadow	68.7	5.75	5.5
9.	Woburn Abbey Park	57.5	4	7.5
10.	Lias (Bellthorp)	54	15	7
11.	Banks of the Avon (Wiltshire)	9	57	6.2
12.	Craven soil on the Millstone Grit	76	3-10	5
13.	Ditto on Chert	76.7	15	6.

Liebig says:—" That the greater quantity of azotized " substances which are used as manures, the greater the " quantity of produce; and *that the chief art of agriculture* " *depends upon the collection and preservation of those* " *manures which contain ammonia in the greatest quantity.* " Now liquid animal excretions, if suffered to undergo the " process of putrefaction, contain the greatest quantity of " ammonia, and in that form of salts which has lost its " volatility; and when presented to the growing plants in this " condition, they are the most valuable of all manures, and " not the smallest portion is lost to the plants. It is all " dissolved by water, and imbibed by the roots."

Nitrogen, derived from ammonia or from nitric acid, is so essential to vegetable life, that it has been termed the *moving agent*, which acts under the influence of the living principle of the plant, moulding into shape the other elements.—Professor Johnston has beautifully pointed out the design intended by the presence of nitrogen in the germination of seeds, by the formation of *diastase*, (as named by Payen and Persoz,) by which the farina of the grain is converted first into gum and afterwards into sugar; but the use of nitrogen in the seed is not limited to this process, as intimated by the Professor, for by the elaborate experiments performed by Rigg, and published in the Philosophical Transactions, Part II. for 1838, it was proved that nitrogen predominates, when compared with the other part of the seed, in the germ and cotyledons of beans, peas, barley, and wheat, a large excess of nitrogen being invariably indicated in the germ. So that in the seed it possesses other uses besides the conversion of the starch into sugar; indeed, one part of diastase has the power to convert 2,000 parts of starch into sugar. Rigg found, moreover, nitrogen not only abounding in the germ, but that the chemical constitution of the rootlets, before the plumula extends the whole length of the seeds, as in the instance of malted barley, differs from that of the malt, and also from the constitution of the barley in its original state. The nitrogen of barley in its original state being

	1.3 per cent. or for 1000 prts. carbon,				32
Malt from the same ...	2.1	do.	do.	do.	50
Rootlets of maltd. barley	4.3	do.	do.	do.	106

So that in the germination of barley there is an increase of 38 to 50 per cent. upon the original quantity contained in the seed; and this element must be supplied from other sources than the seed. It, however, is not only necessary during the stage of the first development of plants, but in every after stage of their growth; being most abundant in the early periods, and gradually diminishing out of those organs which have the most important functions to perform in vegetation.

But nitrogen, or rather the ammonia from which it is derived, performs another most important function in vegetation, by carrying into the plant a very considerable portion of carbon by the roots; or in other words, ammonia makes available for plants such vegetable substances as simple straw, roots of clover, or any other decaying vegetable matter in the soil. This, however, is contrary to the received opinions of Liebig, Dr. Daubeny, and Professor Johnston. The learned Professor, in his third lecture on Agricultural Chemistry, says:—"These facts appear to justify the following conclusions:—*That plants derive their supply of carbon from the atmosphere, and that carbonaceous or decayed vegetable matters accumulate in the soil, because they are not in a condition to minister to the growth of plants. Plants, then, are not necessarily fed by the vegetable matter of the soil. In applying vegetable manure to the land, you do not necessarily add to the soil any portion of carbonaceous matter which you are afterwards to reap in the form of hay, corn, and straw.* Does this appear to be contrary to your preconceived opinions? Has your agricultural experience been "founded on other views? Your practice may have been "generally good, but you have explained its success on "wrong principles, and the application of these wrong principles may have led you into error in other cases."*

Now if this opinion of the learned Professor be true, how absurd must be the practice of the farmer in carrying innumerable loads of straw into his fields in the shape of manure! How much labour is in vain bestowed in collecting straw and stubble with which to compose his dunghills! How ignorant the farmers of all ages, who universally have set such great value upon straw; and how trifling the disputation whether straw in the shape of short dung or long dung be more advantageously employed! But by applying carbonaceous matter to the soil, that we do reap it back in the form of hay, corn, or straw, is proved by direct experiments of farmers. In those upon the comparative value of manures, for the Saxon and Prussian authorities, by Professor Hembsladt, of Berlin, and afterwards repeated, with unvaried success, by Professor Schübler, any soil, which yielded without manure three times the quantity of seed sown, yielded five times that quantity if manured with old herbage, as grass, leaves, straw, &c.

In some valuable experiments by Arthur Young on different manures,

Simple soil, without manure, produced	280	Bush. of Potatoes.
Dung, 32 cubic yards per acre	400	"
Barley straw, $1\frac{1}{2}$ tons per acre.........	300	"
Dung, 32 cubic yards, 480 gallons urine	520	"

These experiments alone prove that carbonaceous matter is reaped back from the soil.

But surely the learned Professor, as well as Liebig and Dr. Daubeny, have overlooked the existence of humic acid in

* Durham Advertiser, 12th Feb., 1841.

the soil, or rather its combinations with ammonia. Dr. Daubeny says that Liebig begins by showing, that vegetable mould contains in general two principles; the first of these, which is soluble in alkalies and in certain of the earths, has been termed *humic acid;* that humus, in common with all carbonaceous substances which contain a small proportion of hydrogen, when slightly moistened, undergoes a process of slow combustion, termed by him eremacausis; that when acted upon by earths and alkalies it is converted into humic acid, and combines with them; that humus can only be dissolved by water when in union with an alkali or an earth. "Hence," says Dr. Daubeny, "the amount of humus, or humic acid, which "enters the vegetable tissue, must at least be limited by the "quantity of earthy and alkaline matters which are absorbed; "and how small that quantity is, may be seen by reference "to the statement I have already made, as to the weight of "ashes in a given portion of a plant." (Lecture II., on Agriculture, pp. 53 and 54.)

But if lime, in combination with humic acid, enters into plants as humate of lime, which is on all hands agreed, surely ammonia, an alkali, must also unite with humic acid, and therefore be absorbed as humate of ammonia; and this in proportion to their respective atomic weights. It will therefore follow, that as all the carbonaceous or vegetable manure in a soil is continually being resolved into humic acid, so it is impossible for either caustic ammonia or the carbonate of ammonia, (the latter being the state in which the Professor erroneously says ammonia enters into plants,) to pass through any soil in which there is a trace of vegetable matter, without being converted into humate of ammonia. Now, the quantity of *carbon* in humic acid, according to Liebig, is from 57 to 72 per cent., and the quantity of humic acid in some soils, according to Sprengel, is 45 per cent. It is therefore clear, that a very considerable portion of carbon must obtain admission by the roots in the form of humate of ammonia, and that this substance is the vehicle by which carbonaceous matters, as fermented straw, &c., are rendered available and useful to vegetation.

The carbonaceous matter of manures also gains admission by the means of the *earths and alkalies* found in the ashes of plants, in the form of humate of lime, potash, soda, and united with the oxide of iron and manganese.

To show that no mean quantity of carbon does enter from the soil by means of humic acid, take wheat as an example, which, from Boussingault's table of the composition of cultivated substances, consists of 46.1 carbon, 2.3 nitrogen, 2.4 ashes; according to Rigg, averaged at six different periods of its growth, of 39.4 carbon, 2.5 nitrogen, and 3.3 residual or earthy and saline ingredients, and which residual, according to Davy, consists of 47 per cent. of silica and earthy phosphates, and the remaining 53 per cent. of lime, potassa, soda, oxide of manganese and iron, which two last have the same capacities of saturation with humic acid which lime has; the equivalents of lime being 28, potash 48, soda 32, nitrogen 14, ammonia 17.

Take Boussingault's analysis: wheat consists of carbon 46.1, nitrogen 2.3, and ashes 2.4—from which ashes deduct 47 per cent. for silica and earthy phosphates which do not combine with humic acid, and there will be 1.3 of ashes.

According to Mallagutti's formula of humic acid, and which agrees with Boullay, (see Thomson's Chemistry,—Ulmic Acid,) the atomic weight is 315.

Or 30	atoms of	carbon	180	or per cent.	57.15
15	,,	hydrogen	15	,,	4.76
15	,,	oxygen	120	,,	38.09
			315		100.

Therefore, as 14 (the atomic weight of nitrogen) is to 315, (the atomic weight of humic acid,) so is 2.3 of nitrogen in wheat, to 51.7, the quantity of humic acid united with the 2.3 of nitrogen, and which, at 57 per cent. of carbon, produces 29.4 carbon, introduced into wheat by means of ammonia.

Atomic weight of	Lime	28
" "	Potassa	48
" "	Soda	32
		3)108
		36

Then as 36 (the average atomic weight of lime, potassa, and soda) is to 315 atomic weight of humic acid, so is 1.3 weight of lime, potassa, soda, &c., in the ashes, to 11.3, the quantity of humic acid, which, at 57 per cent., produces 6.4 of carbon, introduced by means of the earths and salts in the ashes.

Or, carbon of wheat 46.1	
Nitrogen, 2.3, united with 51.7 humic acid, which last contains 57 carbon..............................	29.4
Potash, soda, earths, oxides,—1.3 uniting with 11.3 of humic acid, or 57 per cent........................	6.4
Total carbon introduced by humic acid...	35.8

So that, if ammonia passes through the soil, the plant must receive at least 35.8 parts out of 46.1 of its carbon directly by the roots, or about three-fourths of the quantity contained in it. Practically speaking, it is immaterial how carbon does reach the plant, provided it does arrive, and that farmers do not believe all their care about straw to be ineffectual; yet upon this subject Liebig contradicts himself: he says, page 15, " It may be affirmed with positive certainty " that manure neither serves for the production of the " carbon, *nor has any influence upon it.*" Yet, at page 47, he says, " Humus acts in the same manner in a soil perme- " able by air ; as in the air itself, it is a continued source of " carbonic acid. An atmosphere of carbonic acid, formed

" at the expense of the oxygen of the air, surrounds " every particle of decaying humus. An atmosphere of car- " bonic acid is therefore contained in every fertile soil, and " is the *first and most important food* of the young plants " *which grow in it.*" Professor Johnston, after saying in his third lecture that you do not add carbonaceous matter, which you are afterwards to reap back in the form of hay, corn, &c., commences his fourth lecture by saying, " It being " proved that plants *derive their carbon from the air*, the " next inquiry was, in what form did this carbon, which " formed so large a proportion of these substances, enter " into the circulation of plants? In the first place, it was " derived from the carbonic acid of the atmosphere entering " into them by the leaves, and in the second place, water " trickling *through the soil* and over the surface of the earth, " imbibing a considerable quantity of carbonic acid, and " *carrying it into plants by their roots*;"* so that by this account, manure in the shape of carbonic acid, does enter by the roots, and is reaped back in the form of hay, corn, &c.

The learned Professor asks, " Do grasses and trees derive " their carbon from the soil? Then how by their growth " do they increase the quantity of carbonaceous matter " which the soil contains?" The answer to this is, that grass increases the carbon because it is ploughed up; and the amount of carbon contained in the swarth is thus added to the soil; and that trees increase the quantity of carbon in the soil by the addition of carbonaceous matter contained in the stumps and roots left when they are cut down.

But he says, " on this point the rapid growth of *peat may* " *be considered absolutely conclusive.* A tree falls across " a little running stream, dams up the water, and produces " a marshy spot. Rushes and reeds spring up, and mosses " take root and grow. Year after year new shoots are sent

* Durham Advertiser, 12th March, 1841.

" forth, and the old plants die. Vegetable matter accumu-
" lates, a bog, and finally *a thick bed of peat is formed.*
" Whence have all these plants derived their carbon? The
" original quantity contained in the soil is increased ten
" thousand fold. Has dead matter the power of reproducing
" and multiplying itself? You will answer at once that the
" plants have grown at the expense of the air,"—and he
" then arrives at the following conclusion "*that plants derive*
" *their carbon from the atmosphere, that carbonaceous matters*
" *accumulate, &c.*" Now here is a most incorrect comparison and inference, that a monocotyledonous plant, the *sphagnum palustre*, of which peat principally consists, and which has the property of throwing up new shoots in its upper parts, while its lower extremities are decaying, and which *may* derive its carbon from the atmosphere; therefore all other cultivated plants must do the same! Why, the tribe of orchideæ will grow suspended by a string from the ceiling. Cacti, 8 feet high and 12 feet broad, will grow in the same pot of earth, not weighing two pounds, for ten years, and must therefore derive their carbon from the air; yet surely I am therefore not to arrive at the conclusion that *all* plants derive their carbon from the air in the like proportion.

Liebig also institutes a similar incorrect comparison between the carbon produced by a forest which is unmanured, and that derived from crops of manured land, and thence concludes that carbon must be derived by all plants from the atmosphere, and "that the quantity of carbon produced by
" *manured* land is not *greater* than that yielded by land not
" manured." Every farmer knows the latter proposition to be untrue, and that it would at once be refuted by the produce of a turnip crop unmanured, and one manured; but if it were ever proved that a forest did produce more carbon than cultivated plants, the general application would by no means follow; for there is every reason to believe that the source of

the carbon of different families of plants differs according to a fixed law, and that plants derive from, or exhaust the soil, not in proportion to the nutriment they contain, but in the inverse ratio to the surface of their leaves and green absorbing parts. It is certain that cacti, fungi, orchideæ, musci, and even forest trees, are much more independent of the soil than any of the cultivated crops.

One other remark respecting *gypsum*. Liebig, Dr. Daubeny, and Professor Johnston, suppose that the use of gypsum is to fix or to deprive ammonia of its volatility, (the Professor, however, gives it other uses); that a double decomposition takes place, and that sulphate of ammonia and carbonate of lime are formed. Now it is well known that gypsum is only beneficial to the clovers, grasses, and sainfoin, and is itself an essential ingredient of them: but if the effect were such as stated, it would have been found useful to all crops, and especially to those which contain nitrogen. But every solid foot of soil which contains 20 per cent of humic acid (and Sprengel states some contain 45 per ct.) is capable of fixing 12 lb. of ammonia by its humic acid alone,—a much greater quantity than is ever applied by manure, &c., while the clay and iron absorb it, and have a tendency to combine with it. Yet we are told that its use is to convert ammonia into the sulphate, while Dr. Daubeny says it is probable that plants have no power to decompose the sulphate of ammonia, and if they had, free sulphuric acid would be most injurious to their structure! The fact is, that straw and vegetable manure fix in the soil and economize the other valuable manures which contain ammonia, and hence another most important use of them.

Nitrogen derived from ammonia or the nitrates, being then such a valuable substance to vegetation in general, the most desirable object is the best mode of its preservation; for ammonia is so extremely volatile as to exhale at all known temperatures. Its volatility is diminished in some degree by combination with water, and still more so by combining it with carbonic acid, and most when combined with mineral acids; and the ammonia in recently voided urine is, in its free and uncombined condition, caustic and noxious to vegetation, and likewise so volatile that it will escape into the atmosphere as soon as it is produced. Evaporation of this valuable substance is then at all times proceeding from the stables, yards, and dungheaps, and an immense loss is thus sustained. Even as Sprengel states—that one cow in the year furnishes at least 15,000 lbs. of urine, and that from such quantity no less than 162 lbs. of ammonia could be obtained, and which would make 500 lbs. of sal ammoniac, the retail value of which in England would be worth £25.—Various expedients have been suggested for the preservation of the liquid manures containing ammonia, and to those who have written upon the subject, are the following references given; but all are agreed, and the constant practice on the Continent is, that before application the urine from cattle must be collected in one set of tanks, and the drainings from yards in another separate covered receptacle, and that the fold yards be made perfectly impervious to water on their floors, and the buildings spouted to carry away rain water.

In the Journal of the Royal Agricultural Society, vol. 1, part IV. is a very valuable paper translated from the work of Sprengel.

In the Farmer's Series on Flemish Husbandry, three numbers, written by Rev. W. Rham, is an account of the manner adopted in Belgium, and of the immense crops and produce obtained in that country.

In Professor Daubeny's lectures is much valuable imformation.

In a paper published by this Society, read by the Rev. W. Thorp, at Doncaster, is a comparison of English and Flemish culture, in which is shown the difference of crops grown on the Flemish system compared with those of the magnesian limestone of Doncaster, and the manures expended,—equal to twice the quantity of roots and green crops, and one-third more of grain, and that by manures collected and made on the farm.

Urine would be peculiarly adapted to the soils on the Wolds, in that it binds light and deaf soils, and renders them more consistent; while dung, bones, and rape dust, on the contrary, render them still lighter. Upon this subject I will only add from Sprengel, "Whoever mixes no water "with the urine, or who fails also to employ some neutraliz- "ing substance to combine with the ammonia which is pro- "duced in so great a degree during summer, suffers a loss "of manure which exceeds all belief. It is only a gaseous "substance, and not a solid material visible to the naked "eye, which thus escapes and is lost; but for all that, it is "of greater importance to the nourishment of plants than "perhaps any other portion of the excrements."

III. The state of Agriculture as at present existing upon these soils, and some suggestions for its improvement.

1. That upon the Wolds. The mode of cultivation upon the wold district, has already been given in detail in the Society's reports, by Mr. Legard, on a farm at Neswick, near Driffield; and also by Mr. Howard, in the Farmers' Series, upon the farm of Mr. Watson, at Wauldby. The rotation usually pursued is that of the alternate or four-course, viz:—

1. Turnips
2. Barley
3. Red Clover, or white clover seeds, with grasses
4. Wheat

Mr. Legard states, "that the corn crops may be permitted "to follow in the same rotation, but that the green or alter-

"nate crops seem by certain natural laws to deteriorate if "recurring so frequently as once in four years, and that it "has been found necessary to modify and subdivide the turnip "course, this crop being uncongenial to strong soil; but "still more essential has it been found to keep the land fresh "to seeds, for of all agricultural vegetables does the clover "family appear the most inclined to degenerate from too "frequent recurrence." Mr. Howard states "On the *deep* "*wold* land, corn does not yield so well, neither does it ripen "so soon, as where the soil is shallower; and it is land "unsuitable for turnips and barley; and that the turnips are "almost invariably attacked with a disease called 'fingers "and toes.'"

The remedies for these defects are indicated by the practice upon the other chalk districts in England. There is a difference between "fingery" turnips and those affected with anbury, or the true "finger and toes" disease: turnips grown on light, puffy soils, if repeated so frequently as once in four years, are often stunted and "fingery," and it is highly probable that this is caused as much by the effect of the rotation as by the repetition of the crop; for it has been exceedingly well observed, in answer to the Duke of Portland's letter, that the four-course system is not adapted to any light sandy soils, for it keeps them too pulverulent, friable, and deaf, and particularly with the manures now in use. But the true disease of "finger and toes" is caused by the larvæ of a beetle called curculio pleurostigma: the excrescence appears in the beginning of August, below the bulb, and resembles roots of ginger hanging upon them. If turnips attain the size of walnuts, they do not subsequently become affected; and soot, or lime, or the hydro-sulphuret of lime, 8 bushels per acre, are both said to be preventives; but the most certain and efficient mode is the use of chalk, as practised in the counties of Lincoln, Hampshire, &c. In Lincolnshire, chalk has been applied promiscuously to nearly every variety of soil, and with the most beneficial effects, not only on the turnip crops, but also on those of clover and barley. In North Hampshire, chalk has been used with great success upon the soils covering the chalk, the one *a binding clay mixed with gravel*, and the other *a gravel mixed with a less quantity of clay*. There is, however, a third variety of soil in that county not benefited by chalking, and which is a loose soil 4 to 7 inches deep, reposing on the chalk rubble. The effects of laying on chalk upon the gravelly soil has been most remarkable in North Hampshire, but in every instance most advantageous. " Previous to the appli-" cation of chalk, this soil, although manured, folded abun-" dantly, and trod well with sheep to condense the soil, was " extremely precarious in its produce, and the expense and " care bestowed upon it were rarely compensated by a cor-" responding return. The wheat grew freely at first, and " continued to bear a very favourable appearance until the " spring, when the ground assumed a spongy hollow texture, " the plant acquired a dark brownish hue, died in consider-" able quantities, and the remainder produced at harvest " from twelve to sixteen bushels per acre of light corn, with " the straw invariably stunted and blighted. After chalking, " these unfavourable tendencies of the soil were corrected. " The same land now produces from twenty-four to thirty " bushels of corn of excellent quality, and in no instance has " any recurrence of its former unhealthy condition been " observed. The mischief was not confined to the wheat " crop; the barley, oats, tares, and clover, suffered in the " same proportion, and have equally derived benefit from " chalking."* In Norfolk and Suffolk, clay or marl is used with good effect upon the crops, and is equal to that of chalk.

With regard to the reason of the *failure* of the *red clover*

* Report on North Hampshire, Farmers' Series, No. 7.

crop, and the remedy to be applied, there is much difficulty. The following are a few facts respecting its disappearance from certain soils. Around Hemsworth, the property of Sir Francis Wood, situated upon the coal measures of the West-Riding, the soil of which being a rather stiff clay, formed by the decomposition of the binds and shale of the coal strata, red clover after teazles always fails; but upon the magnesian limestone, a soil very similar in its composition to that of the Wolds, after teazles the growth of red clover is always certain; so that the continual treading by the feet of men in "spitalling" (which is merely cutting off the surface weeds) and in the reaping, imparts to the lighter soil of the magnesian limestone a degree of consolidation favourable to the growth of the plant, but which upon the clay soil renders it so stiff and coherent, that the destruction of the same crop follows. In a letter from the Duke of Portland to the editor of Bell's Weekly Messenger, he states that the clover failed on some sandy land which had been *boned* for turnips, while upon the other half of the same field, which had been manured with fold-yard dung, the red clover flourished in great perfection. In the one case, probably, the earthy undecomposed portions of the bones would have a tendency to keep open or render more friable the soil, while the dung in two years would have nearly disappeared from the soil. At all events, an excretion from the roots would have equally affected both parts of the field.

The red clover is naturally a tender plant; for all annuals which flower early, and whose seeds drop and germinate before winter, resist cold less easily than such as flower late, and whose seeds lie dormant in the soil till spring: and plants of a dry nature resist cold better than such as are watery. An alternation of wet and frosty weather during autumn and winter frequently destroys a considerable portion of the plants; and a dry and cold spring impairs their strength to such a degree, that no favourable weather will afterwards restore their vigour; and it is upon those soils which have the least power of retaining heat, (and which power is nearly proportionate to the absolute weight of given bulks,) that this effect is most visible. Those which are most puffy, pulverulent, or "deaf," or that are light in weight in proportion to a determinate volume, are the most affected with "clover sickness." Upon some of the stiffer soils of the new red sandstone formation, when drained, if the clover seed vegetates or is not killed by wet at the time of sowing, the crop seldom disappears in the winter and spring. Red clover is also frequently destroyed in the early period of its growth by the slug. If there be a luxuriant growth of straw, the clover is frequently drawn up and becomes weakened, so that it is unable to endure the rigour of a severe autumn and winter, even on soils best adapted to its growth; and it certainly succeeds the most favourably where the corn crop is light.

In confirmation of the opinion that clover is destroyed by cold, and does not disappear by reason of "clover sickness," or the land being "tired," the following additional proof is given. Mr. Turner, of Barton, near Exeter, states from the result of more than twenty years' experience, that in nineteen cases out of twenty, its failure is entirely owing to the stubble being fed bare after harvest, and the plant being so weakened thereby, as to prevent its standing the wet and cold of the succeeding winter; and that in every instance in which it has not been fed off in the autumn, that piece has been the admiration of every one the following spring.* Upon the whole, it may be questioned whether the crop of seeds, averaging in many places only about a ton per acre, and that principally composed of rye grass, which certainly has an exhausting effect on the wheat crop, would be better supplied by a crop

* Journal of Royal Agricultural Society, Vol. I, Part 4.

of spring rye and tares, or tares and turnips, or by carrots, one acre of the latter equalling in feeding value twenty-five of seeds.

The very general mode of sowing *rye grass* in so great a quantity in seeds for depasturage, has a very injurious effect upon the succeeding wheat crop. Sinclair says that rye grass impoverishes the soil in a high degree, if the culms, which are invariably left by cattle untouched, are not cut before the seed advances towards perfection. Rye grass is inferior in produce and nutritive powers to cock's-foot grass, in the proportion of five to eighteen; and inferior to meadow fox-tail as five to twelve; and inferior to meadow fescue in the proportion of five to seventeen. It also seeds very early, and unless the land sown be stocked heavily with cattle, it re-sows itself. It is also very tenacious of life, and all the cultivated varieties being perennial, it is necessary to expose the roots to the sun, or to clear them away from the field. Probably the best forage plants for "seeds" are a mixture of white clover, parsley, and a very small quantity of rib-grass, as used by Mr. Shawe, of Brantingham.

There are now some *suggestions for improvement* to be offered, and especially respecting the introduction of additional green crops to those now grown on these soils: for we may lay it down as an axiom, that as the perfection of stock husbandry is the production of the greatest amount of flesh from the smallest quantity of food, so that of culture is to obtain the greatest amount of produce, in the shortest space of time, from the smallest quantity of land. The improvements suggested are already performed in various parts of England, and therefore the land in those parts does actually produce the crops mentioned; and not only by the introduction of other green crops than those now produced is there a greater amount of produce, but the land, if they are consumed upon it, is thus manured in the cheapest mode.

H. Gawler, Esq., says, "A succession of tares and turnips "in the same year may be raised and consumed on dry land, "until it be made of any desired degree of richness."—*(P. 29, N. Hampshire Report.)*—And it is by growing great quantities of green food and roots that the Belgian outstrips the English farmer in the great number of stock kept, the dung collected from them, and, as a certain consequence, the corn produced. A beast for every three acres of land being with them a common proportion, and in small farms the proportion is greater,—hence on every 100 acres there ought to be 33 beasts, or an equivalent number of sheep—say 200. The Rev. W. Rham says, "The number of beasts fed on a "farm of which the whole is arable land, is surprising to "those who are not acquainted with the mode in which the "food is prepared for the cattle."—*(Flem. Husb. p. 59.)*

1. There is a practice pursued upon the chalk soils of Hampshire which deserves imitation over this district, and that is the sowing of a portion of land with *tares to be depastured by sheep.* It is well known that the farmers in Hampshire get better prices, and their lambs to greater perfection, than any farmers in England, and that by the following means. On moderately good soils, they begin to sow in September on the wheat stubbles *which are intended for late turnips the following season ;* the tares are sown at intervals of a fortnight up to the first week in November. When all the land which seems fitted to be fallowed by turnips is sown, the remaining portion of tares is sown on such strong land, after clover seeds, as is intended for wheat the following year : on this description of strong land tares are considered a good preparation for wheat. About the 1st of June they begin to feed off the sale-lambs, waiting if possible till the blossoms appear, in order for them to be ready for Overton fair on the 18th of July. Three folds or pitchings are set out, the sale-lambs go first, and have two or three pitchings a-day, crop-

ping off merely the tops or about three inches in length. The stock or ewe lambs follow next, and the stock ewes come last, and clean up what is left. A good description of wether lamb, five or six months old, will arrive upon this plan at the weight of fifty-six to sixty pounds, without corn or cake, and go to fold every night. Upon an average, half an acre will maintain 200 ewes and 200 lambs a-day in good condition, or ten acres, with a pound and a half of oil cake per head, will keep 250 sheep a month.—(*F. S.*, *Sept.*, 1840.)

On the Stenchcombe farm, in Gloucestershire, Mr. Dimmery commences eating off tares in the second week in May, and twenty acres keep him a flock of 850 sheep seven weeks, or until the 1st July; "which crop," says he, "is free of all "expense beyond the cost of seed, as the land does not "undergo more expense in preparing it for the turnip crop "than if it had not been sown with vetches; and the manure "left by the sheep, with what additional dung can be pro-"cured, always produces a good crop of late turnips. The "turnip sowing is generally finished by the middle of July."* The Rev. W. Rham grows turnips after tares, and if land is not clean, he strongly recommends potatoes, carrots, parsnips, or mangel wurtzel, to be sown the following year. Henry Gawler, Esq., in the North Hampshire Report, says:—"The "cultivation of tares is extending every year. They make, "with turnip crops, the arable farms support as much stock "as the grazing." And again, p. 29:—"A succession of "tares and turnips in the same year may be raised and con-"sumed on dry land, until it be made of any desired degree "of richness."

The land, after the tares are eaten off, is cleared for turnips. The portion first cleared (which, by Mr. Howard, of Melburn, is begun to be eaten as soon as the 15th May) is first ploughed and harrowed, &c., if not worked with Biddell's

* Journal of Royal Agricultural Society, vol. I., p. 389.

scarifier,* or with Finlayson's harrow, both of which collect and extirpate root weeds without cutting them in pieces. The land, if either of these harrows be used, is not to be cross-ploughed, which only tends to cut the twitch grass in pieces. By thus commencing the preparation of the tare stubbles in the first or second week of June, they will be as forward as the wheat-stubble turnip fallows, which are seldom worked and weeded before that time. And if the tares are sown on clean fallow,—any thing like those Lord Leicester is said to have; or if, like the Hon. Stanhope Hawke's land, upon which in a last crop not a bushel of perennial roots of couch grass can be found on twenty acres,—there can be little difficulty, by active farmers, in preparing the land for turnips after tares.

2. *Rape* on stubble would be another valuable crop gained on the present system. It is a hardy plant, and has a wider range of soils than turnips. It may be raised on the stiffer and somewhat moist clays. Professor Lowe says:—"It may "be sown after early peas and potatoes, and produce an "exceedingly good crop; that it is for this kind of interme-"diate cropping that the rape is in a peculiar degree "adapted, and if sown after a crop of corn upon the "ploughed stubble, will in the following spring yield a tole-"rable supply of green food."—p. 306.

3. *Spurrey* only requires five to six weeks to bring it to maturity, and in that time arrives at the height of twelve to fourteen inches. Lowe says it is extolled by all foreign writers as being very nutritious and excellent food for cattle, and gives a rich flavour to butter. It is sown on stubble, and

* By the use of Biddell's scarifier, there is said to be a saving of twelve per cent. in horse labour on a farm. In the preparation of tare stubble, the land ought to be scarified first with the chisel-points, and afterwards with the broad-blades, which cut the land clean. Both Biddell's scarifier and extirpating harrow are particularly adapted for cleaning stubbles, and bringing the soil to a fine state of tilth.

pastured off the same autumn. One light ploughing is given, and 24 lbs. of seed per acre sown. It is grown by Colonel Croft, near York.

4. The cultivation of *Rye, as spring food* for sheep, deserves particular mention. It is pursued extensively upon the chalk in Berkshire, and about Saffron Waldon, for the purpose of manuring the land for a turnip crop. Mr. Milburn, a most intelligent and active member of this Society, has lately, in a paper published in the Journal of the Royal Agricultural Society, introduced this subject to the notice of farmers,* the advantages of the cultivation of which are enumerated by him to be seven :—

1. Provision of excellent green food at a season when of all others it is most wanted.

2. It is produced without sacrificing any portion of the usual rotations pursued on the farm, and with little labour.

3. It will grow on any soil, but especially on poor loose sand, where every other green esculent is more or less uncertain.

4. It will bear any degree of frost and cold.

5. It is as inexpensive as any grass or leguminous crop, or perhaps less expensive,—the cost of production being 12s. 1½d. per acre.

6. It is readily consumed by stock.

7. It improves rather than deteriorates the soil.

5. The practice of sowing *turnips on stubble* deserves notice, not only because it is pursued in several counties of England on the chalk, and particularly in Hampshire, but because it is the general practice in Flanders; and in their admirable economy of land, by this mode of cultivating the turnip, the

* Seed two and a half bushels per acre, and one peck of rape seed. Earlier sown after harvest the better—seed not to be rolled. Begin to feed off the last week in March. Mr. Horncastle, of near Worksop, is stated by Mr. Reynolds, of Womersley, to have eaten off rye three times over, and that the last time was in May.

Flemish are enabled to grow not only one-third more corn than is grown upon the same quantity of land in England, but also nearly twice the quantity of roots and green food. In that country, as soon as the corn is cut, the portion of the field which is cleared, is ploughed and harrowed, liquid manure is poured over it, and the seed is sown; and in twenty-four hours an acre which was but just cleared, is again producing a fresh crop. When the turnips are fairly up, they are watered with diluted urine, and their growth is rapid beyond belief. They have been grown near Doncaster after stubble oats, averaging fourteen tons per acre, and around Bawtry of eight and nine tons per acre, and are constantly grown on the Trent side, near Carlton. Excellent crops have been produced when sown as late as the first week in September, and the white stone turnip is generally cultivated for this purpose. The common turnip, if grown from seed raised from turnips sown in spring, and ripened the same year, and if watered with urine, only requires ten weeks to bring it to maturity, and yet forsooth this crop, to the detriment of the whole kingdom, occupies one-fourth of the land cultivated on the four-course system for a whole year! and there is not the slightest shadow of a doubt that upon most of the light soils in England, by the use of liquid manure, this crop on stubbles could be successfully cultivated. Harvest commences nearly three weeks later than it should do, for wheat is in perfection for reaping as soon as the lower portion of the straw, one foot from the ground, is quite yellow, and while the upper portion of the stem and ear are yet green. In Scotland it is usually cut in this state, and Mr. Hannam, of North Deighton, has published the following statement:—

Time of reaping and condition.	Gross produce.	Weight of Straw.	Value of each.
No. 1, Aug. 4, (very green) ...	576	550	61s. per qr.
No. 2, Aug. 18, (raw)	736	475	63s. 6d. „
No. 3, Sept. 1, (ripe)	650	450	61s. 6d. „

Quarterly Journal of Agriculture, June, 1841.

Three weeks earlier harvest would afford ample time in any part of England, for sowing stubble turnips, besides other advantages. At all events we may lay it down as a rule, that he is a bad farmer who does not take every opportunity of introducing a green crop in his rotations; for we may learn from the history of agriculture, that it is to the adoption of this system that the present fertility of the soil is mainly to be attributed, and it is only by such management that the farmer can preserve his land in the same productive condition at the least possible expense.

6. *The Trifolium Incarnatum* (scarlet trefoil) has very unjustly got into disrepute: it has been successfully cultivated upon the chalk in Kent, and is a most valuable plant. It is superior to the vetch; for, in the first place, there is no expense in cultivating the land where there is a clean stubble: in the next, it produces double the amount of fodder, and makes as good hay as the red clover, frequently yielding 2½ tons per acre. The great mistake in the trials of cultivation has been in sowing the seed upon land which has been recently ploughed. It ought to be sown on stubble and harrowed in *without ploughing*, as the root requires solidity of soil. It should be sown in August or September, and the quantity of seed to the acre be about 14 to 16 lb. Some farmers use Finlayson's harrow to raise the mould, then level it with small harrows twice over, and finish with a heavy two horse roller, as the land cannot be made too solid. It is particularly useful in filling up vacant spots in cloverleys, where the young plants of red clover have failed.

The *feeding of sheep* upon turnips, and the use of additional artificial food, is upon the Yorkshire Wolds well understood. In Lincolnshire, barley and malt-combs are given at the beginning of the season; but oil cake is in general use, and the manure of the sheep fed upon it, is highly enriching to the land. Upon the Magnesian Limestone of the West Riding, where great flocks of sheep are kept, the turnip cutting machine is scarcely yet come into use, although it has been well proved that the sheep fed with turnips cut for them, will fetch from 5s. to 7s. per head above those which have to eat the turnips from the ground. As the quality of food is of much consequence, and the quantity ought to be adapted to the quality, and this again regulated by the cost of production, it may be of use to give a table which exhibits the results, by the distinguished agriculturist De Raumer, of the effects produced by an equal quantity of several substances in increasing the flesh, tallow, and wool of sheep :—

Lb.	DE RAUMER'S TABLE, SHOWING....	Increase in Flesh. Lb.	Produce in Wool. Lb.	Produce in Tallow. Lb.
1000	Potatoes, raw, with salt	46½	6½	12
,,	,, without salt	44	6½	11½
,,	Mangel Wurtzel, raw	38	5¼	6½
,,	Wheat	155	14	59
,,	Oats	146	10	42
,,	Barley	136	11½	60
,,	Peas	134	14½	41
,,	Rye, with salt	133	14	35
,,	,, without salt	90	12¼	42
,,	,, Meal, wet	129	13½	17½
,,	Buck Wheat	120	10	33
,,	Good Hay	58	7½	13
,,	Hay with straw, and without other fodder	31	15½	6½
,,	Oil Cake	116	15	26
,,	Straw of Vetches, Peas	29	7½?	13?
,,	Straw of Barley, and Oats	19½	,,	,,
,,	Straw of Wheat	14½	,,	,,

Proportion with respect to nutritive matter per acre (by Sinclair) in—

Common Turnip 14 — Or by Morton 1½ tons produce 30lb. of flesh: or according to the Womersley sheep farmers, one acre of ten tons of turnips will keep ten sheep for four months, each to gain 20 lbs. of flesh.

Swedes 16
Carrots 24
Mangel Wurtzel.. 28
Potatoes 63

It may be remarked of this table, that *grain* gives about three times the increase *in flesh* that roots and hay do, when given in equal weights: that grain produces about twice as much *wool*, and several times the amount of tallow. But as an equal weight of mangel wurtzel or turnips can be raised at an expense of about $\frac{1}{10}$ of what is required for the production of most kinds of grain, the superior economy, except for fattening, will at once be perceived. If this table be correct, the Lincolnshire plan of using barley instead of so much oil cake, is more economical. The present cost of 1000 lb. of oil cake is 98s., and that of barley 78s., but the feeding quality of barley is $136 + 60 = 196$, (while that of rape cake is $116 + 26 = 142$,) or about $\frac{1}{3}$ greater. A new species of barley from Peru, a small quantity of which is growing in Lord Hawke's garden, at Womersley, and some in Lord Lascelles' and Sir J. Johnstone's, is likely to become very valuable for sheep feeding; the quantity yielded is equal to from 3000 to 4000 times the quantity sown; the produce per acre 12 quarters. It is the Hordeum gymno-hexastichum of Lowe, and probably that cultivated in some parts of Germany; and on account of its productiveness termed by the French *orge céleste.* Lowe says that it is greatly esteemed, and deserves more attention than it has yet received: it is even now (1st Aug.) tillering fresh ears.

The *Wheat* grown on the Wolds does not produce so heavy and large a crop as on stronger soils, but the grain is even and fine. Three quarters per acre are reckoned a satisfactory return. It is said to be heavier after rape than any other crop. Finlayson's harrow is used in some places on the cloverleys, and the couch grass cleared and burnt: by this mode a cleaner fallow for the turnips, which succeed the wheat, is said to be made. In others a presser follows the ploughs, with a drill box attached. Wheat on the *deep wold* lands, is particularly subject to *mildew*, called there "*night ripening*;" but there is no doubt that this disease is owing to the attacks of minute *fungi*, with the natural history of which we are well acquainted. There are about five parasitic fungi which attack corn crops, the whole class of which grow upon some kind of organized matter, and none of them derive their nourishment directly from the soil or atmosphere, like other plants. It is doubtful whether they will grow on plants perfectly healthy, or if they do not always attack some part where disease or decay had already effected some alteration in the tissue. These fungi are exceedingly small, and the seeds of them (their sporules) smaller than the dust of the puff ball. The sporules of the Puccinia graminis, or mildew, are minute club-shaped bodies, which enter the plant through the pores (stomata,) and vegetate below the epidermis of the plant, which in their growth they raise and blister, and when arrived at maturity burst through it, and then form spots or irregular blotches of various colours. The Puccinia graminis attacks only wheat and barley; it makes its appearance on the upper leaf, and then on the lower leaves and stem, in the forms of white spots, similar to spots made by rain on new cloth. In a close moist (muggy) season it vegetates most rapidly; for in such weather the plants remain longer succulent, their pores expanded and their fibres relaxed. In a dry season the mildew is seldom seen. The crops on clayey soils are seldom attacked except in small patches, and it seems to infest crops growing on particular soils, and that in the following order.

1. Wheat growing on dunghills always attacked.
2. Peat, or moor soils.
3. Calcareous.
4. Calcareous loams.
5. Sandy soils.
6. Sandy loams.
7. Clays.

White wheat is always the earliest affected, and the bearded the last. The fungus is communicated from the soil to the crop. Its seeding time is from May to October. In the soil on which the seeds alight, they attach themselves, and either vegetate or remain until the following spring. The fungus spreads also by off-sets. As remedies to this fearful disease, there have been tried 5 to 6 bushels of salt per acre, and quicklime fresh slaked, applied early in May. These are said to prevent the communication of the mildew in the soil to the growing plant. The testimonies in favour of salt are Sir J. Sinclair, Mr. Sickler, Mr. J. Robinson, Mr. Wood, and Dr. Paris. On the sea side wheat is little damaged, yet three miles inward it is much affected. The Rev. E. Cartwright applied with good effect, 1lb. of salt dissolved in a gallon of water, and sprinkled on the diseased wheat: two men got over four acres per day: it is to be applied on a cloudy day or in the evening. Mr. Legard can produce one clear example in which wheat was attacked when barley was the preceding crop, and where it was not attacked on the other half of the same field, and in the same year, when oats was the preceding corn crop. More instances, however, are wanting to confirm this singular fact. Query—was the preceding barley crop attacked, which thus seeded the soil?

One other suggestion must be made, respecting *homesteads and horned cattle;* and this applies not only to the whole of the district described in the report, but to the greatest portion of the farms in England. There is scarcely one farmyard in ten, which is spouted round to keep off the rainwater which descends upon the roofs of the buildings; there is not one in a hundred which has its floor impervious to water; and fewer still which have the plane of the floor so inclined that the liquid portions shall drain off, and be collected in a reservoir, instead of being evaporated into the atmosphere. In addition to this reservoir, separate tanks* are required for the cow-houses and stables, with

* Mr. Brakenridge, of Bretton Lodge, can give an instance of a tank which cost £50, yielding an annual supply afterwards of £50 worth of manure.

partitions, to enable the recently made urine to be preserved until it is neutralized. But where is there a homestead which has all these conditions fulfilled? The total loss in England has been estimated at one-third of the value of the whole manure made, and this at £21,000,000, or the loss at £7,000,000 annually! If landlords were to have their yards constructed as above-mentioned, a tenant farmer, whatever might be his ignorance of manures, would be compelled to empty these reservoirs to get rid of the nuisance, and his prejudice would soon be dispelled by the benefit derived from the use of liquid manure. If chemistry teaches any thing valuable to agriculture, it is the above suggestion; and if it be true " That the chief art of agri- " culture depends upon the collection and preservation of " those manures which contain ammonia in the greatest " quantity," surely this ought to be done, and that by landlords. A landlord will loudly complain if a tenant sows two or three white crops in succession, while he will permit the same tenant to lose one half of his manure,—or rather he will not make his homestead in a condition to collect and preserve it; forgetting that the effect is the same in both cases, viz., a direct robbery of the land of its manures.

If *horned cattle* were made a greater object of attention on the Wolds, much benefit would result from them. The Wolds are decidedly adapted for sheep, but these always thrive best when the pastures are not wholly stocked by them. The grass is more equally eaten by a mixture of cattle. Besides which, to obtain the largest supply of good manure ought to be an object of the first importance to every farmer. " To the lover of agriculture," says Mr. Howard in " his excellent report of Wauldby farm, " it is really melan- " choly to see the waste of straw on the Wolds, probably " the produce of 200 to 300 acres of land. A farm-yard " well stocked with cattle and pigs, supplied to a moderate

" extent with turnips and other esculents, or a small quantity " of linseed, would furnish a certain profit, by the improve- " ment of live stock. This is only," says he, " a small part " of the advantage. The manure would be greater in quan- " tity, and in quality it would be improved tenfold. It is " impossible to obtain a succession of crops upon these " Wold lands without an ample supply of animal manure, " and every effort should be made to procure it, not only in " the pastures but in the yards." An ox kept stabled up, and fed on the Flemish plan by a mixture of turnips, barley meal, or rye meal, with boiling water poured over, in six months will double his own weight, and pay abundantly for the food he has consumed; but the principal advantage to the Flemish farmer is the liquid manure in his cistern, and the dung in his yard. Each ox will produce in this time as much of both kinds of manure as will supply two acres.

In connection with this subject is the *soiling* of a number of cattle in the homestead. Sir John Sinclair enumerates the advantages of this to be seven:—1. *Saving of land.* As reported to the Board of Agriculture, thirty-three head of cattle were soiled from the 20th May to 1st October, 1815, on 17½ statute acres, when it would have required 50 acres to have pastured them. The Hon. J. Quincy, in the "American Farmer," kept the same amount of stock, by soiling them on 17 acres of land, which had previously required 50 acres. 2. *Advantages of fences.* 3. *Saving of food.* Animals destroy their food by treading it down, by dunging, staling, and by lying down upon it, and this in proportion to the richness of the crop. 4. *The improvement to the stock kept in-doors.* 5. *The greater product of milk.* 6. *Increasing the quantity, and improving the quality of manure.* 7. *Obtaining a higher value for the produce of the soil.* To which may be added the making as much manure in the summer months as in the winter. Mr. Howard, the worthy secretary of the Agricultural Society, has practised this upon a large scale for a number of years. A field of 14 acres is divided by him into seven parts, and sown with barley, red clover, mangel wurtzel, winter tares, swedish turnips, spring tares, and turnips;—affording seven acres of winter food and seven acres of summer food for the cattle in the farm yard. He says—" There is no doubt that one " acre of these crops, carted green to the farm yard, and " given to horses and cattle in a cool stable, will go further " than four acres of the best grass land; and by the prac- " tice of soiling, an arable farm may be made to support as " much stock as a grazing one."—*Farming at Scoreby, p.* 26.

J. W. Childers, Esq.'s plan of winter fattening of sheep deserves mention. Sheep fed by him *in sheds* on turnips, with linseed cake ½ lb. per sheep per day, ½ pint of barley per sheep per day, a little hay, and a constant supply of salt, consume nearly *one-fifth less food*, and make *one-third greater progress* than those fed with the very same food in the open field. In ten weeks each lot becomes fat, so that three lots, in number according to the size of the shed, may be fed off in the winter, and each of these gain in that time from 33 lb. to 40 lb. per head, and pay from 15s. to 20s. each. In ten weeks, each sheep consumed ½ a ton of turnips, and thus every acre of 20 tons will feed 40 sheep; while on the usual plan of feeding alone on turnips out of doors, 20 tons will keep only 20 sheep, and it requires four months to get them fat, with a gain of only 20 lbs. of flesh each. The artificial food costs from 6d. to 10d. per week for each sheep, and the turnips, with this addition, thus go four times as far, or produce four times the amount of flesh; for on the out-door plan, on turnips alone, 20 tons produce only 400 lb. of flesh, (or 1 ton produces 20 lb., or one cwt. of turnips, 1 lb. of flesh,)—while on Mr. Childers' plan, ½ a ton produces 40 lb. of flesh, or one cwt. of turnips produces 4 lb. of flesh, to say nothing, on the old system, of the loss of time and the liability to disease. H. S. Thompson, Esq., of Kirby Hall, in a shed with a boarded floor, (which is requisite) and which contains 120 sheep, the cost of which was £25, has obtained the same beneficial results. Against this system has been urged the loss of treading to light land, but consolidation of the soil can surely be given by Crosskill's roller, and at a time when required. The quantity of manure* saved is greater; for sheep dung in winter is entirely washed away and evaporated from the surface in six weeks, and in summer when cloverleys are ploughed, very little of it can be seen. There is certainly a loss of urine to the soil, for although a portion is absorbed by the straw, some must soak into the floor of the yard. An asphalte floor made contiguous to the general tank of the homestead, would afford an immense supply of the gülle of Switzerland, if washed down daily with water. According to Block, 100 lb. of turnips, eaten by sheep, yield 15 lbs. of excrement, 100 lb. of hay 42 lb., 100 lb. of straw 40 lb., (fluid and solid,) and from 100 lb. of corn 49 lb. of dry excrement is derived. The dung and urine from every 20 tons of turnips will be therefore 60 cwt., and that from the barley, oil cake, and hay, 5 cwt. each, making a total for every acre of 75 cwt. of solid dung,—and the solid dung of sheep is equal, in effect, to half the quantity of bones, as will be shown. If the litter be regularly removed, an immense quantity of common manure would thus be made. This system certainly merits the attention of the strong-land† farmer, who can grow turnips, but cannot eat them off with sheep.

* "The manure obtained by shed-feeding is one-third more than that in the field. According to Morton, an acre of turnips (twenty tons) will keep 12½ sheep six months, and manure it well; but in the Report of the Harleston Farmers' Club for 1839, three acres of land are stated to have been dressed for turnips with the manure of twenty-four sheep, kept in a yard for six months on Swedes, hay, oil cake, and the crop of turnips was equal, if not superior, to any in the neighbourhood. Twelve sheep will therefore manure 1½ acres.—*Farmers' Magazine*, March, 1840.

† On soils that will bear the turnips to be fed off by sheep, a good plan is to open draw off one half of the crop—the remainder to be left for the stock ewes to be

Respecting the *Kimmeridge clay*, little can be said of its agriculture, from its limited range forming only a small portion of some fields, across which it runs in a north and south line. Besides its use as a marl for some of the lighter sands of the oölite, as before mentioned, it may be remarked, that it throws out from beneath the chalk immense bodies of water at Newbald, South Cave, Brantingham, &c., which, if their value were appreciated, would be converted to the purposes of irrigation. It is well known that the celebrated waters of the Itchen, in Hampshire, arise from the chalk; and that by waters derived from the same geological source in the three counties of Berkshire, Hampshire, and Wiltshire, are 35,000 acres of land irrigated. The waters in these dales even now rise at an elevation sufficiently high to irrigate a great extent of land, and in many places natural slopes are already made; but by the aid of some cheap mechanical power (as water wheels) a considerable portion of the chalk escarpment itself might be profitably watered, and that at little expense.

The Kelloways Rock and Upper Oölite produce here much greater crops than their analysis would lead to expect.— They are adapted to the growth of potatoes, particularly the Kelloways rock, but wheat, barley, seeds, and red clover, flourish well upon these sandy soils. Mr. Shawe upon these soils does not pursue the four-course system, but allows the seeds to remain two years, and hence they are under three restorative crops and two exhausting ones, and by these means are kept in a less pulverulent or "blow away" state than they would otherwise be. These lands are, however, capable of producing much more frequent crops, not only tares before

consumed on the field. In any case of carting them off, the turnips after the last hoeing should be earthed up by a plough with a mould board, so that the soil will not be poached by the cart wheels, which will then pass on the subsoil; the ridges being twenty-seven inches apart.

turnips, rye as spring food for sheep, and stubble turnips,—but they would grow in perfection the *white Belgian carrots*, and this too on the Flemish plan, viz., sown with a crop of barley, provided liquid manure could be applied after the barley crop were reaped,—the carrot seed being sown about two weeks after the main crop of barley. Upon Lord Ducie's farm, at Whitfield, 26 tons per acre were grown *without manure* on a plain surface: so that whether sown as a main or along with a corn crop, this carrot deserves a more extended cultivation; for not only does it yield a crop more valuable per ton than any other green crop, but it is raised at one-half the expense attending the growth of the turnip. It is said by the Yoxford farming club to be adapted to strong as well as mixed-soil lands.

The Lias affords two qualities of land over the district described; a strong calcareous soil by the *stony* lias, and a tenacious clay by the lias *clay*. The land formed by the *stony* lias is altogether arable, and produces heavy crops of grain, roots, and grasses. It is perhaps the best arable land in the whole district. Extending over so small an extent of country, we have not deemed it requisite to have the soil analysed; the loose rock, by the decomposition of which it is formed, is burnt for lime in some places, and therefore the soil will contain a considerable portion of that earth.

The Lias clay may be traced south across the Humber into Lincolnshire, Leicestershire, Northamptonshire, Gloucestershire, and Somersetshire,—the districts where the finest cheese is made, and great numbers of cattle and sheep are annually fattened. In some places it is a poor tenacious clay, and from the expense which attends the culture of this soil, the greatest portion of it is in pasture. The feeding pastures from Pocklington to Kilnwick Percy, those to the east of Market Weighton and around Hotham, are upon this bed of clay, which is identical with the basis of the soils in the southern counties before-named. The power of this land to produce good grass is well exemplified in some pastures belonging to Mr. Shawe, of Brantingham, and enhanced by a mode of managing grass land which deserves the highest commendation. This land, from neglect, had become greatly deteriorated, and the superior grasses had disappeared; but by the collection of the droppings of the cattle, and mixing them in different parts of the field with earth formerly dug from drains, and for a few years sowing a few of the best grass seeds mixed with white clover, and by draining, these pastures are now equal in fertility to any in the country.

The committee would suggest to any about to lay down grass, to learn if the soil be perfectly adapted for the purpose, (for inferior grass land is always of little value,) and that the exact quantity of alumina be learnt by analysis, as before stated.

In addition to the double crops in the same year, before mentioned, it may be added that early potatoes, followed by turnips, are very common near Edinburgh, and that turnips or rapes are also frequently obtained after clover when mown. The Middlesex Report recommends transplanted swedes, which, if got in early in August, after barley, and from a good seed bed, will be as forward as those sown in May. As a general rule, the green crops should be so regulated that the stock kept be always in a progressive state of improvement, and not barely existing, as is too generally seen; and this, too, with due regard to the market price. For instance, lambs, as mentioned, may be made of the weight of 60 lb., when six months old, when it may be more profitable to sell them; or *if they be well-bred*, by going from seeds or tares to rapes, then to turnips, and afterwards to swedes, they will make 45s. to 50s. each by the following March,—

but, if kept another year, would only make 20s. in addition, and consume as much food as in the previous period.

The following comparative statement shows the quantity of food raised on these soils on the present system, and that which might possibly be raised by the new one suggested, on 100 acres :—

DOUBLE CROP ROTATION.

	Corn.	Green Food.
Acres. 1st Year.	Bush.	Tons.
25 Tares, at 5 tons ...	—	125
25 Turnips, at 15 do.	—	375
2nd Year.		
25 Wheat, at 3 qrs....	600	—
25 Stubble turnips, at 10 tons	—	250
3rd Year.		
25 Barley, at 4 qrs....	800	
25 White carrots, at 26 tons............	—	650
4th Year.		
25 Wheat, at 3 qrs. ...	600	
25 Spurrey, at two tons, or Tares ...	—	50
100	2000	1450
Or, 1st Year.		
25 Spring tares or rapes, at 5 tons ...	—	125
25 turnips, at 15 tons	—	375
2nd Year.		
25 Barley, at 4 qrs. ...	800	—
25 Spring rye, at 4 tons	—	100
3rd Year.		
25 Clover...............	—	50
Or carrots (white)	—	650
4th Year.		
25 Wheat, at 3 qrs....	600	—
25 Stubble turnips, at 10 tons, or tares..	—	250
100	1400	900

PRESENT ROTATION IN USE ON LIGHT SOILS, AND AVERAGE PRODUCE.

	Corn.	Green Food.
Acres.	Bush.	Tons.
25 Turnips, at 15 tons.	—	375
25 Barley, at 4 qrs....	800	—
25 Clover, at 2 tons...	—	50
25 Wheat, 3 qrs.	600	—
100	1400	425

Manures bought.	£.
For 25 acres of turnips—bones ...	85
" barley—rape dust..	45
" wheat— "	30
	£160

Which produce 1000 tons of green food and 600 bushels of corn above the present rotation on every 100 Acres.

Which produce 475 tons of green food more than the present rotation, or with Belgian carrots instead of clover, 1000 tons.

BELGIAN ROTATION.

Acres.	White Crop.	Root and Green Crop.
	Bush.	Tons.
11 Oats	440	—
11 Clover	—	22
11 Rape and potatoes, 7 tons each	—	77 77
11 Wheat	264	—
11 Rye and turnips ...	352	110
11 Barley and carrots..	440	164
11 Buck wheat	—	44
11 Wheat	264	—
11 Rye and turnips ...	352	110
99	2112	604
English calculated at the same rate	1400	300
	712	304

Manure used and collected at home from thirty-three head of cattle:—
Urine......... 46,200 gallons.
Dung......... 364 tons.
Which produce one-third more corn, and twice the quantity of root and green crop.

Difference on 100 Acres.

So much, then, for the existing state of agriculture over this district. Many other suggestions may be added,—First, respecting economy in the use of *single horse carts*, which, if made on the Scotch plan, will enable one horse to draw one ton, and bear the weight on his back down hill, while three horses, in a clumsy waggon, rarely draw more than two tons, and the shaft horse bears all the weight down hill. Secondly, in *the feeding of horses*, which varies, as was stated at the Wrentham club, among different farmers, as much as 50 per cent., but which, on the general plan, consumes one-fourth of the produce of the farm, one horse consuming as much as will support a labourer, his wife, and two children. Thirdly, regarding *steam thrashing machines*, by which sixty bushels of grain can be thrashed out at the expense of one cwt. of coals, there being not one farm in Fifeshire of fifty acres without one; these grind the corn, hummel the barley, and steam the food for the cattle, &c. Fourthly, respecting *manures*,—in the manufacture of what are called portable manures,—the following one having been proved to be equal to 40 bushels of bone-dust for turnips, the cost of which is 20s., while that of the bones is £6: it consists of 1 ton of peat dust or ashes, 1 cwt. of soot, 1 cwt. of lime, 1 cwt. of salt, 14 lb. of saltpetre. The salt and saltpetre to be dissolved in fermented urine, as much as may be required to saturate and keep moist the whole heap: after the salts are expended, urine to be continued, and new ashes to be spread on the top to intercept the vapour. It is known that *sheep dung* when left on the surface of land, disappears by rain and evaporation in six weeks, and now (in August) upon seeds not 1-50th part of that which has been voided can be seen. Mr. Turner, of Tring, in Hertfordshire, for many years collected it off the land at 2½d. per bushel, and mixed it with crushed bones: after great experience he found 51 bushels of sheep dung equal in effect to 25 bushels of bones, or about half the value of bones; an acre of turnips (20 tons) will yield 60 cwt. of sheep dung=30 cwt. of bones, or 75 bushels in value. To which may be added the great value of *night soil* when mixed with powdered charcoal; of *salt** or *salt and lime* mixed together, one part of the former to two of the latter, and kept three months before using. Fifth, on the *quantity of seed sown*, particularly as compared with Belgium, respecting as well the *choice of seed*. And last, though not least, *perfect subsoil draining*, which is the foundation of almost every amelioration; but not the *soil* draining of 10 to 15 inches deep, except on impervious subsoils, but *subsoil* draining of 30 to 36 inches, wherever the subsoil is at all open or pervious. Mr. Hawkins, to the Sudbury Farmers' Club, says:—"I can prove that land will dry

* Salt, as proved by Sinclair.

45 tons of Spit Manure produced	49	bushels of	Wheat.
5½ bush. of Salt sown with seed and same quantity of dung, produced	95	Do.	Do.

Cuth. Johnson on Manures, p. 387.

quicker where the drains are 36 inches deep and 10 yards apart, than where only 20 inches and 5 yards." If the *subsoil* be wet, the soil will be the same.

Much might besides have been added respecting the *general and expensive habit pursued in purchasing bones and rape-dust*, upon many farms amounting to more than the rent itself. What says M. De Jough, in a letter from Holstein, upon the reasons why corn is produced cheaper on the Continent than in England? " It is an undeviating rule laid down in " our system here, *that a farm must support itself*, and work " on its own resources, i.e. that a farmer must not on any " account part with his cash, except for such things as " cannot possibly be produced on his farm." After saying that even a portion of wearing apparel and implements are made on the farm by purchasing wood and hiring an artificer, he then proceeds to say, " *The greatest considera-* " *tion and difference in the cost of producing corn more* " *cheaply on the Continent than in England, is in the pro-* " *duction of manure, which ought never to be bought, except* " *in the single instance when to be had cheap.* When the " distance is no more than about six or seven miles " from a large town, the purchasing of it should be " avoided if possible; for although a waggon load of dung " may be had in Hamburgh, for instance, at 1s. 5d., the " labour and time spent in fetching it, the expense of laying " it in heaps intermixed with heath, or grass sods, occasions " an outlay which ought to be avoided, and interrupts the " regular course of labour on the land. The Holstein " system of keeping as many cows as can properly be fed, " combines the means of making at the same time large " quantities of manure and large quantities of butter for " exportation. There are many large estates, either farmed " out or not, on which 200 to 300 head of cattle are kept, " which are fed in the stalls from November to the middle of

" May, and remain out in the pastures day and night from " May to the end of October; so that in fact the farmer has " only the manure made during winter; yet this is sufficient, " and sometimes more than sufficient, for his wants, and his " lands are constantly in the best order."

If, then, agriculture is to increase in prosperity, (and by prosperity we mean increased production without proportional expense in producing,) it will be by the adoption of some of the suggestions mentioned in the report. For by what mean has the rapid improvement and extension of the agriculture of Great Britain, since the year 1760, (only 80 years ago,) been made, so as to provide food for the increase of 10,000,000 of population, and be able to add, by its progress in that period, the enormous sum of £80,000,000 a-year to the free disposable income of the country? This rapid advancement, which is unprecedented in the history of wealth and civilization, was begun only so lately as the reigns of George I. and George II., by the culture of the turnip as a field crop by Lord Townshend and others; by the improvements in stock husbandry, and in the breeding and fattening of cattle,—and these not until the time of Bakewell of Dishley, and Culley of Northumberland. Within the last twenty-five years the quantity of wheat grown on the Wold district of Yorkshire described, and conveyed along the Driffield canal,* has been just doubled, that of flour increased four-fold, and the cultivation of oats been replaced by that of barley. On the other side of the Humber, the

* Quantity of produce conveyed along the Driffield canal:—

In 1819,	Wheat conveyed,	8,000 Qrs.	and 8,000	Sacks of Flour.
1838,	,,	15,000 ,,	32,000	,,

The quantity of wheat about doubled, and that of flour increased four-fold.

In 1819,	Oats conveyed, ...	20,000	Quarters.
1838,	,,	5,200	,,
1819,	Barley, ,,	5,000	,,
1838	,,	20,000	,,

The cultivation of oats being just replaced by that of barley.

Wolds of Lincolnshire from Barton to Spilsby, when Arthur Young wrote his survey, consisted of mere wastes, occupied by rabbit warrens. Could he now revisit these Wolds, he would hardly recognize a single feature of their former state. The warrens have disappeared, and in their stead are some of the finest farms and best managed land in England. In 1727, a field of eight acres sown with wheat in the vicinity of Edinburgh, was reckoned so great a curiosity, that it excited the attention of the whole neighbourhood, and numbers of persons came from a distance to see it! In 1763 (seventy-eight years ago) agriculture almost every where in Scotland was in the most barbarous state imaginable. Maxwell states that there was no rotation of crops; fallows were unknown except in one or two counties. Neither turnips, clover, nor potatoes had been so much as heard of, but corn followed corn in an unbroken series, and, as might be expected, the returns were only about three times the quantity of seed sown. Even in East Lothian, so late as 1757, neither turnips, potatoes, nor any cultivated herbage, formed any part of the system. The famous Lord Stair first introduced turnip culture into Scotland; but Dawson, of Frogden, commenced raising them on a large scale in 1763, and may thus be considered the real father of the improved Scotch husbandry; so that the grand improvement in modern agriculture —that by which it is distinguished from the old—*is the universal introduction and superior management of green crops.* But further, in what particular is the agriculture of Belgium, which has been celebrated for these six hundred years, and now termed the garden of Europe, at the present time so vastly superior to that of England and Scotland? How is it that the Netherlands,* being the most densely peopled country upon the face of the earth, can feed her own

* Population—In Holland ...... 224 on the square mile.
„ Great Britain 152 ditto—*Facts, by Sir R. Phillips, p.* 750.
„ China......... 177 ditto—*Neuhoff's Travels.*

population, and yet export nearly one-third of the produce; and with a soil inferior to our own, can sustain nearly twice the amount of human existence? It is by an extension of those principles which have been proved to be the foundation of English and Scotch agriculture; by their judicious selection of green crops, so that every acre of land shall be in a constant state of production,—hence economy of land; and in the management, application, and preservation of different kinds of manures, by which these crops are to be raised; or in other words, by the repeated and perpetual growth of carrots, turnips, rape, spurrey, buckwheat, clover, and potatoes, and by the most scrupulous care in the collection of every particle of manure. It is not the superior soil* and climate† of Belgium which give

* "The fertility of the polders, and of some deep rich loams in the province "of Hainault, and in a few spots in Flanders, has given rise to the notion, that "the fine crops generally observed through the whole of Belgium are owing "chiefly to a very superior quality in the soil. Travellers hastily passing through "the country, and observing the abundant harvests, naturally adopt this opinion. "But nothing is further from the real fact. The rich parts of Flanders are but "few in comparison to the poor, as an attentive examination and analysis of the "soil will clearly show. The average fertility of the land in the provinces of "East and West Flanders, and Antwerp, will be found much below that of our "inland counties, leaving Essex and Kent out of the question. If a fair com- "parison were made, it should be with the poor light soils of Norfolk or Lin- "colnshire, where industry and capital have overcome the natural poverty of the "land, and made it highly productive."—*(Flemish Husbandry, p. 9, Farmers' Series.)*

† The climates of Belgium and England vary not more than do the southern from the midland counties of England. According to Humboldt, the mean temperature of the year is

At Carlisle	48. 0
At Aberdeen	47.22
At London	50.36
At Brussels	51.80
At Amsterdam	51.62

According to Sir R. Phillips, *(Facts, p. 535,)*:—

	Winter.	Spring.	Summer.	Autumn.
Mean temperature of England,	40.6	50.2	64.3	51.
Ditto of Scotland,	37.	44.2	56.4	47.7
Ditto of London	39.56	48.56	63.14	50.18
Ditto of Brussels	36.68	53.24	66.20	51.08

So that in Brussels the winter is 4° colder; the spring 3°, the summer nearly 2°

her the advantage over England; but it is the superior skill, industry, and management of her farmers; so that the grand defect in the present state of farming in England and Scotland,—that in which they are behind not only Belgium, but China, Switzerland, and some parts of Germany and France, is the rigid adherence, on all lands, to nearly the same system, the production of only one annual green crop, instead of two from the same land, and particularly allowing the turnip to consume a whole vegetating season in its growth,—together with the total neglect and waste of the most valuable portions of the manures: and it is only by imitating the rural economy of these countries, by obtaining a quicker succession of green crops, by taking every opportunity to

warmer than the mean of England. The autumns are the same in both countries. The climate of Great Britain is, however, subject to considerable variation; there is frequently a difference of 4.8° degrees in different years at the same locality, and as much as 10° in the same month in different years. The mean temperature of 4.8 is capable, when added or subtracted for the whole year, of producing a decided difference in our seasons. But these variations of climate range through periodical times. Mr. Luke Howard, of Ackworth, says, "The extent of the periods, for want of a sufficient number of years of accurate observations, cannot at present be fully determined, but they have the appearance of being completed in *seventeen* years." In a paper about to be published in the Transactions of the Royal Society, Mr. Howard proves that "these cycles of temperature correspond with 223 synodical revolutions of the moon, or the return of this satellite to her nodes; i.e., a period of *eighteen* years: that there are nine years in which there is, with some fluctuation, a mean descending temperature, and nine of ascending temperatures; the years of low temperature being wet and unfruitful, and those of ascending, the contrary. That the present year of 1841 is the turning year from the cold to the warm series of years."

If this view of the seasons be correct, the northern portion of England will enjoy, during the nine warm years, a climate superior to that which the south of England had during the nine cold years; for the annual mean temperature of the extreme north of England (Carlisle) is 48°, while that of the extreme south (Sandwich) is 50°; and therefore there is a full answer to all objections respecting the double cropping performed in the south, which is said not to be capable of being effected in the midland and northern counties, because the climate of the south is so much superior; except it could be proved that these double crops are only obtained in the south during the nine years of ascending or warm temperatures, which it is impossible to prove. So that during nine years out of eighteen, the northern and midland parts possess the same, if not a superior climate, than the southern possessed during the preceding nine cold years.

The years of productiveness, as shown by the price of corn, seem to run in cycles of eight years of descending, and six years of ascending temperatures.

intercalate tares, rye, turnips, scarlet trefoil, Belgian carrots, &c., and above all, by landlords making homesteads in a condition capable of collecting and preserving every atom of manure, that the agriculture of Great Britain will be able to keep pace with her steadily increasing population.*

Mr. Ingham.—I should like to ask, whether Mr. Thorp does not think the climate in this country is very much against the possibility of growing green crops,—a crop of turnips, for instance, after a crop of corn? This is effected in some countries, but I doubt whether it could be done here. It strikes me that there is a difficulty on that point in the lateness of our harvests.

Earl Fitzwilliam.—The observation which has fallen from Mr. Ingham is well worthy of consideration. I should be glad to hear Mr. Thorp's rejoinder to it, and hope he

These periods are taken from James Wilson, Esq., on "The Influences of the Corn Laws." The seasons have *some* certain influence, but there are other perturbing causes which affect the price of corn.

Increasing Supplies and falling Prices.			Increasing Supplies and falling Prices.		
	s.	d.		s.	d.
1817	94	0	1830	64	3
1818	83	8	1831	66	0
1819	72	3	1832	58	8
1820	65	10	1833	52	11
1821	54	5	1834	46	2
1822	43	3—Warm period.	1835	39	4—Warm period.

Diminishing Supplies and rising Prices.			Diminishing Supplies and rising Prices.		
	s.	d.		s.	d.
1823	51	9	1836	48	6
1824	62	0	1837	55	10
1825	66	6	1838	64	7
1826	56	11	1839	70	8
1827	59	9	1840	—	
1828	60	5	1841	—	
1829	66	6—Cold period.	1842	—	—Cold period.

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* The increase of population in the United Kingdom is equal to 1½ per cent. per annum, or about 4,000,000 in every ten years; and as each person consumes £8 worth of raw agricultural produce, the agricultural progress, in order to feed our own people, must be equal to £32,000,000 in every ten years.

will explain the mode by which he conceives that system of culture should be carried on.

Mr. Ingham.—I once tried to procure a crop of rape upon stubble, but that failed.

Mr. Thompson.—A crop of winter tares might be sown in the first instance, followed by turnips, which would be valuable food for ewes and lambs in spring. Ewes will give more milk when fed on white turnips than on swedes.

A Member—What is to become of the barley crops after tares?

Mr. Thorp.—Barley after tares was not mentioned: but by tares being sown on stubble, eaten off in spring, and then sown with turnips, the soil would be in a good state for growing barley in the next year; for you have two green crops eaten off by sheep instead of one, and the land well manured.

Mr. Torre.—I perfectly agree with Mr. Thorp in regard to the great advantages to the country which might be derived from economy in manures; but I do not agree with him as to intermediate crops between stubble and turnips. I think we should be satisfied with one good crop; for the crops of turnips in the north produce more in one year than the crops in the south in four. I concur in the observation of Professor Johnston, that a man who professes to be a good farmer will never grow a bad crop. Upon all light soils, every practical farmer must know the difficulty of getting quit of all descriptions of rubbish, which he must do, to be a good farmer. I would ask, can this be done, if the farmer introduces after stubble a previous crop to his turnip crop? I have myself visited Belgium, but consider that national industry is only exhibited there upon a small scale as compared with England. Belgium has a climate which we do not possess in the north of England. When Mr. Thorp alludes to the Netherlands having a poorer soil than England, I do not agree with him. They possess greater facilities of producing late crops than we do. I have tried experiments with liquid manure, and prefer it mixed with an absorbent previously. A large landholder would find it difficult to water his farm with liquid manure. If he places the manure in tanks, he can apply absorbents to it, which is much better than watering the surface of the land, and there is less evaporation.

Professor JOHNSTON.—I have to congratulate the Geological Society of the West Riding upon the able paper which has been read by Mr. Thorp. It is impossible for me to do more than simply to express my general opinion upon that paper. It is by the accumulation of such observations as those which Mr. Thorp has made, in regard to the different districts of Yorkshire, and to the practical methods adopted in the cultivation of different parts, geologically considered, of this great county, that something like principle is ultimately to be arrived at. I agree with Mr. Thorp in a great degree, in so far as it was possible for any person to follow the paper which he read over in so cursory a manner. I shall, however, make one or two observations, which I hope Mr. Thorp will consider with that attention which he shows he is capable of applying to this subject, and, if he finds that they really have any weight in them, will adopt in so far as he thinks reasonable from what I shall mention. In regard to the quantity of carbon absorbed by plants from the atmosphere, Mr. Thorp's wish, I am sure, is to discover the truth : it is also my own. I have no opinions, on the one side or the other, to advance, except such as I believe in my conscience to be consistent with truth : and although Mr. Thorp has mis-stated the views which I have advanced in my published lectures, he has not done so intentionally I believe, but has taken the first parts of the views which I have stated, without giving due weight to the latter portion of them. My opinion is directly the reverse of that which Mr. Thorp has stated as having been brought forward by me. There are some physiologists who maintain that certain plants in particular situations are totally independent of the carbon of the soil. I have adopted the opinion that plants do derive a large portion of their carbon from the atmosphere; but the experience of every practical farmer proves that they do not derive the whole of their carbon from the air, a considerable portion being obtained from the soil, more or less, according to circumstances. The experience of all ages has proved, that the application of manure to the soil is necessary in order that plants may grow well.

There is another part of the paper that has been read to which I will advert: I refer to the effect of a certain quantity of alumina in the soil, in fitting it speedily for the growth of grass. I would beg to be understood clearly on this point. I do not know from my own experience whether or not a certain quantity of alumina is favourable to pasture lands; but this is clear, that such lands cannot be productive, whatever the quantity of alumina which they contain, whether five or nine, twenty or fifty per cent., unless they contain a large quantity of other materials, of other substances, which the grass itself contains. I attempted at Liverpool to illustrate this point. In all pasture lands, cattle are fed either for the purpose of fattening or for their milk, from which butter and cheese is obtained. These are carried off from the land in the same way as cattle are. The bones and other portions of the solid parts of animals are derived from the soil. Plants draw their inorganic matter from the soil in which they grow, and animals obtain theirs from the plants. So also the milk, transformed into butter and cheese, contains certain earthy substances,—in a proportion not much less than they are found in the general bulk of the animal,—and these are carried off from the soil. All earthy matter is derived from the soil. The inference is clear: if the soil does not contain a sufficient quantity of the particular earthy matters which enter into the bulk of animals, that soil cannot continue to fatten cattle. Among the substances especially required, alumina is not one. The soil yields little or no alumina to animals; but among those which it does yield, I may mention one substance contained in milk, and in the bones of animals, which is constantly required. It is a fact, that after land, containing a nearly invariable quantity of alumina, has ceased to be capable of large production, the addition of bone-dust restores fertility to it, and enables it to fatten cattle. This fact is well known in various parts of Cheshire. I do not mean to advance this in opposition to anything which Mr. Thorp has stated in regard to the value of soils which contain more or less of alumina, above or below 5 to 9 per cent.; but I state this point to show those gentlemen who have heard his paper, that there are other ingredients necessary, and that these must be present in a good pasture. Mr. Thorp has directed the attention of his audience to the Lias, and has stated that the best pasture lands are those which rest on the Lias. If there is any one geological formation richer than another in the earth of bones, it is the Lias. I need not point *your* attention to the organic remains of huge animals found in the rocky strata of the Yorkshire coast. Many of these rocks are full of the fragments of bones, particularly near Whitby and Scarbro'. These must exist in the land which, as Mr. Thorp has stated, is capable of producing good pasture, or rather of fattening cattle, and yielding plenty of milk, and so far this confirms the views which I have advanced.

It is only by a combination of efforts, Gentlemen, that we may hope to arrive ultimately at true principles, and then we may expect that agriculture, like other arts, will advance until it takes its station along with them. We see in Leeds, Manchester, Sheffield, and other large towns, the manufacturing arts advance with a rapidity truly astonishing, simply by the application of that intelligence which the inhabitants of these towns possess. Why, compared with these, does the art of agriculture seem almost to stand still? Because in this line of life men have not exercised that intellect which God has given them to the degree or in the way in which they ought. As we gradually advance, however, we shall be constantly obtaining further glimpses into nature, and be induced, I hope, to adopt the suggestions which she is ever willing to give us—is ever offering to us—is most assiduously pressing upon our attention every day of our lives, every spring, summer, and autumn,—but which, from the frequency of seeing them, we neglect to examine, and therefore do not understand.

Sir J. Johnstone.—I wish to ask one question: if it should be answered, it is possible that the two theories which have been advanced with reference to the quantity of clay in land, and the quantity of phosphates, may be reconciled. Can any person tell me whether the grasses which have been mentioned were changed before the application of bone manure, or whether they were the same grasses which had lost their virtue from the constant abstraction from the soil of those earthy matters which were necessary for fattening, and for the production of corn and milk? If it could be shown that the grasses had not been changed, but were the same grasses, still it may be true that a quantity of alumina is necessary for the best grass.

Professor Johnston.—The grasses were changed.

Sir J. Johnstone.—It does not much matter what kind of grass grows, or the quantity of alumina contained in the soil, for the application of bones will surely improve the pasture, as manure will ameliorate the worst of herbage on the worst of soils; but this is not the question; for Mr. Thorp, in the report, pre-supposes the existence of such vegetable and animal manures as are common to all soils. The inquiry is, what constitution or composition of soils is best adapted to the production of the best feeding pastures, when managed as grazing pastures usually are? A definite quantity of alumina, neither too much nor too little, may therefore be requisite, as well as the manures required.

Mr. MONTEITH.—I have seen the effects of bone manure in Cheshire. I have observed one part of a field in which bone-dust was laid: it was very different from that on which there was none, particularly among clovers. The grasses were much promoted in their luxuriance. You might perceive in that part of the field a greater degree of greenness than in other parts.

Mr. THORP in reply. In answer to the several observations made upon the report, and first to those of Lord Fitzwilliam and of Mr. Ingham, as to whether the climate affords the possibility of growing a second crop of turnips after harvest, I would recount how far north the practice does prevail. At Carlton on the Trent, not thirty miles south of Doncaster, situated upon the clays of Nottinghamshire, turnips on wheat stubbles form part of their regular course of cropping, and are always grown there. They are also grown frequently at Bawtry, ten miles south of Doncaster, and have been grown on the *north* side of Doncaster, at Almholme, averaging 15 tons per acre, and at all these places without the use of liquid manure. It was said at the Agricultural Meeting at Liverpool that turnips can be brought into broad leaf in forty-eight hours. The Rev. W. Rham says that in Belgium the ploughing and sowing of the turnips follow on the very heels of the reapers, and that the seed sown will be out and in rough leaf, when that which is sown two or three days later is only just coming up,—that the growth is rapid beyond belief from being watered, as soon as fairly up, with diluted urine,—that if sown in July, they are of full growth, and are pulled up and housed by the end of September,—and that Mr. Aelbrook sowed some in May, which were of sufficient size in August to be given to cows. (*Flem. Husb. p.* 89.) This year (1841) hundreds of acres of turnips had scarcely attained any size, many scarcely were hoed at the time, when large quantities of wheat were dead ripe on the 20th August. Had this wheat been cut as in Scotland, and that more profitably 14 days sooner (see p. 249), and the land sown with turnips and watered with urine, (which can be done so easily with Crosskill's water cart) I have not the slightest doubt that these later-sown turnips on stubbles would have been equal in value to the early sown. —Farmers have strange ideas respecting the climate of different places in England; we hear of the climate of London, that of the Wolds, or that of the western hills of Yorkshire, &c. According to Howard's observations, the mean annual temperature of the metropolis is 50.5°, while that of the country around London is only 48.5°; so that by an artificial elevation of temperature (as the reflection of light from the surfaces of walls, fires, &c.) the metropolis is hotter by 300 miles of north latitude than the adjoining country, and hence visitors to this city justly conclude that they have got into a much warmer climate. But according to Sir R. Phillips, there are only two degrees difference of mean annual temperature between the extreme north and south points of England; so that between places upon the same level there can be little variation in actual climate, particularly between parts of Yorkshire and the southern counties. The elevated portion of the Wolds and Western Hills will have a lower temperature than the surrounding country of a lower elevation, by a degree of Faranheit for every 300 feet in their vertical height, hence the Wolds will at all times have a colder climate than the plain of York by 1½ degrees; but winter tares sown on stubbles are constantly grown there, and do endure the rigour of the winter as may be seen from Mr. Legard's report of the Neswick farm. The *condition* of land, together with its *dryness* and *sandy nature*, have a far greater influence than climate upon the early maturity of the crops growing upon it; for instance the harvest three miles south of Doncaster and up into Nottinghamshire, is earlier by ten days than on the north side of Doncaster, or even than upon the magnesian limestone of the same latitude, because there is here a large range of sandy siliceous soils; silica having a greater power than any other earth of retaining heat: again, the harvest on the magnesian limestone, though at a higher elevation, is forwarder than on either the central plain of York on the east of it, or on the coal measure country on the west, because great flocks of sheep are kept upon it, and therefore it is in better condition than either of the other districts; and yet there are instances on the clayey soils of the plain of York, as upon the Hon. Stanhope Hawke's farm, which is well drained and in excellent condition, of the time of harvest being actually earlier than upon the limestone. The crops on sub-soil-ploughed land are considerably earlier. The grass lands upon the stiff undrained soils east of Doncaster and of Womersley hardly ever show a trace of vegetation until the first week in June, while those much further north as at Easingwold, Thirsk, and even near Newcastle upon the banks of the Tyne, are covered with verdour. At Edinburgh, the grass land made in high condition from drainings from the city, is as forward as any in England. A cold climate in the mouth of a farmer often becomes a false allegation for the neglect of draining and want of condition in the land. The observations of meteorologists, made with philosophical instruments, and registered for a series of years, are much less liable to error than the opinions and feelings of individuals, concerning heat and cold.

With respect to the observations of Mr. Torre; it is certainly true that one good crop is better than two bad ones; yet upon the Yorkshire Wolds, from the very nature of the soils, all the crops are comparatively light ones; yet Mr. Torre has offered no reasons why *two* light crops should not be grown instead of *one* light crop. That this is done advantageously on other chalk soils, in the south of England, has been shown. The observation that the crops in the north of England produce more in one year than the crops in the south in four, must be received with limitation, and the superiority of the north should be ascribed to the true cause. It is not due to the superiority in the mode of management that the Northumberland farmer is able to produce 40 tons of turnips per acre, while the Wold and south of England chalk farmer can only raise 15 to 20 tons, but to the productiveness of the soil. There is land at Bentley near Doncaster (some of which was analysed and described by me last year at Wakefield) which had not been manured in the slightest degree for thirteen years (only once limed) and which was then growing 15 loads of wheat per acre! and in a general way, no more than six light loads of poor manure, applied to these lands, produce such enormous crops that they become laid before harvest. But surely it would be very erroneous to compare the soils of Northumberland, geologically different, and many of them cropped on a six-course rotation,—or those of Bentley, which produce prodigious crops without scarcely any manure,—to those of the Wolds; or to infer that a similar mode of cultivation can be pursued on both, or from thence conclude that the Wold farmer should not endeavour to grow a greater quantity of produce in a shorter space of time. Considerable stress has been laid upon getting the land clean for turnips after tares; but it ought to have been shown by some sort of argument, that it could *not* be done: but that this *can* be done is proved by the practice of the farmers of Hampshire, and that not to a small extent, but on nearly the whole of their stubbles. In the first place, these tares are sown on the stubbles from the 1st of September to the 1st of November, at intervals, so that there is ample time to get the crop into the ground, and make previously a partial fallow: besides, winter tares are sown all over England to be mown for horses, and there is little difficulty experienced in getting them into the ground. Now, will land be cleaner in the following May by growing tares, or being uncleaned, growing no cultivated crop? Certainly it will be cleaner by having upon it tares, which act as a smothering crop. In fact, it is for the same reason that a crop of autumn-sown wheat is always cleaner than a spring-sown one, supposing both to be sown on clover-ley. The crop, whatever it may be, which first gets possession, keeps it. The tare crop is begun to be eaten off by sheep in the middle of May, and turnip-sowing generally is seldom completed before the end of the first or second week in July, or even later, so that surely there is adequate time in two months to eat off, and prepare the tare-stubble for turnips, which should be done at intervals as the ground becomes vacant. Stubble turnips could be only successfully cultivated by the use of liquid manure; which ought to be poured on the land before sowing the seed, and then afterwards as soon as the turnips appear on the surface. I disagree with Mr. Torre in the use of an absorbent for liquid manure; much will be lost and evaporated, and there will be the additional weight of the absorbent matter to be carried to the tank, and afterwards away to the field. Very little is yet known in this country of the use of liquid manures, and any single individual's experience is not to be relied upon. Mr. Torre is of opinion that the soil of the Netherlands is better than that of most parts of England. I can only refer to Mr. Rham's opinion, (given in a note p. 268), who has written on the state of the agriculture of the Netherlands, and who says, "that a fair comparison would be between the soils of Norfolk and the light soils of Lincolnshire." The fertility of a soil (e.g. the Kimmeridge clay) cannot be known even by its analysis, much less by a stranger passing over a country. With regard to the climates of Belgium and England, there is very little difference between Brussels and the mean of England; Brussels (a large town) is 4° colder in winter, 3° warmer in spring, 1.9° warmer in summer, and the temperature of Autumn is equal in both countries. In fine, it is not the climate, any more than the natural soil of Belgium, which cause their immense produce, but the superior condition of the land, made so artificially by repeated manuring: every crop with them is heavily manured, except buck-wheat, and that too with manure collected at home; while the English farmer (at least not one in a thousand) is unable to collect sufficient manure for one-fourth of his farm, viz. the turnip crop. As an instance of their heavy manuring, take the Alost rotation:—

1. Potatoes manured with			20 tons of dung per acre.
2. Wheat	,,	,,	3½ ditto, and 1800 gallons of urine.
3. Flax	,,	,,	12 ditto, 1800 ditto.
4. Clover	,,	,,	20 bushels of wood ashes.
5. Rye	,,	,,	8 tons of dung, and 1800 galls. urine.
6. Oats	,,	,,	1800 gallons of urine.
7. Buckwheat	,,	,,	No manure.

So that here 86 acres* out of the hundred are well manured with substances abounding in nitrogen, and that at the least expense; hence follow as the result of this heavy manuring, —1. An earlier harvest;—2. An exemption from smut, mildew, and other diseases of wheat, and the loss of turnips from the fly, (almost unknown in Belgium);—3. A saving of one-half in the quantity of seed sown, (the Flemish sow

* 58 acres average 7½ tons of dung and 1800 galls. of urine per acre.
14 do. average .... 1800 ditto ditto.
14 do. average .... 20 bushels of wood ashes ditto.
— 86 acres.

just one-half that we do);—4. A saving of nearly 30s. per acre now expended on foreign manures;—5. Greater weight of all kinds of crops. In fact, in England we wilfully neglect to adopt one of the most rational and practical means that can be devised for the purpose of increasing the quantity of our available manure, while at the same time we are importing manures from the Continent at a sacrifice of capital amounting to £500,000 annually; and even notwithstanding this, not one-fourth of our cultivated lands receive a due sufficiency!

I am extremely obliged by the favourable terms in which the Learned Professor Johnston has been pleased to speak of the report; and am as sorry that he should have thought that I had misrepresented his opinions. It has arisen from the fact, that in reading the report great portions have been necessarily omitted, and that I only read the first part of the Professor's views, and omitted the second, but from which report, when printed, it will be found that I have not given those opinions partially. When speaking of alumina in soils, I certainly meant, and hope I was so understood, that it was respecting the texture or earthy ingredients alone, and not of manures existing or applied to them. Nothing is clearer than that particular plants are adapted to particular soils: even in grasses, the cotton grass, and some of the bent grasses, together with different species of rushes, sedges, &c. inhabit wet soils; others, as the fescues, and the broom grasses, require a dry sandy soil. Alter the conditions under which each of these varieties of plants flourishes; make the wet soil dry by an addition of sand, or the dry soil retentive by the addition of alumina, and both of them will languish and ultimately disappear. Those grasses which are found in the superior grazing pastures require a soil neither too wet nor too dry: evidence has been produced to show that the condition of the soil favourable to the growth of these particular grasses depends upon the presence of a certain quantity of alumina. And the evidence, as far as it goes, proves this to be the only necessary condition, as far as the texture or earthy ingredients are concerned; for the quantity of silica and calcareous matter is indefinite. But it would have been as absurd in me to assert that the bare earthy ingredients in the best constituted soil, without the addition of manures, would produce the best grasses in the highest perfection,—as it would be in the Professor to say that either bones alone, or bones placed in a soil of simple sand or simple clay, would have the same effect. The Lias contains probably, from its organic remains, abundance of phosphates, and also the limited quantity of alumina; hence its superiority in the formation of grazing soils.

NOTE BY PROFESSOR JOHNSTON.

A copy of Mr. Thorp's printed paper having been transmitted to me before this concluding sheet of the above Report was sent to press, I am permitted to express my disappointment on finding that he has not altered that part of it (pp. 230 and 231) in which, as I stated verbally at the meeting, he had attributed to me views exactly the reverse of those contained in my published Lectures. (See Lecture IV., pp. 79 to 89.) The source of his error is to be found, as his reference to the *Durham Advertiser* shows, in his quoting my opinions from a newspaper report of my Lectures, when delivered, instead of turning to the copy prepared for the press by myself, and which was published on the 1st of July last. To this Lecture (IV.) I beg also to refer the reader for a correct statement of my views on another part of this subject, which Mr. Thorp professes to give in p. 235, quoting again from the same newspaper report. I think papers of the kind read by Mr. Thorp are likely to do far more good if confined to the statement and collation of facts, to the exclusion of all controversy.—*Durham, 8th November*, 1841.

NOTE BY THE REV. W. THORP.

Upon correcting for the press the last sheets, I find, without any previous knowledge, the above note by Professor Johnston appended, to which I beg leave to reply.

The *Durham Advertisers* alluded to were sent me by Professor Johnston himself, and therefore I presumed that they contained a true report of the learned Professor's opinions. The Lectures in that newspaper bear internal evidence of being corrected for the press by himself, or by some one well versed in the orthography of chemical nomenclature. By now "collating the facts" published in the Professor's Lectures (which I only received a short time ago), with those contained in the newspapers sent me by himself, it appears that subsequently to the delivery of the Lectures he has materially altered or modified his opinions; and yet without ever informing me at Hull that the Lectures published in the *Durham Advertiser* are erroneous, and those published by himself contain his corrected views, (both of which being indeed his *published Lectures*) he complains of misrepresentation, when I quote from a source afforded me by himself!—The origin of carbon in plants, according to the Professor's own words, "has an important practical bearing," and I beg leave to add, that controversy, as conducted in the meetings of this Society, often elicits truth, however unpalatable; and that I have yet to learn why we are to receive every dictum by the Professor without investigation.

SYNOPSIS OF ANALYSES OF THE WOLD SOILS.

Referred to at page 219.

Deep Wold Soil from Riplingham.	*Chalked.*	Do. from Do.	*Unchalked.*	Bishop Wilton *Shallow* Wold.		Lincolnshire Wold.		Magnesian Limestone. (from Campsall.)	
Water of absorption	4	......	5	......	9	......	5	......	$11\frac{2}{10}$
Matter soluble in water: Sulph. Lime......... $\frac{3}{10}$		Sulp. lime $\frac{1}{10}$		Sulp. lime ...	$\frac{2}{10}$	Sulp. lime	$\frac{6}{10}$		
Chloride Sodium ... $\frac{1}{10}$	1	Chl. sod. $\frac{1}{10}$	$\frac{5}{10}$	Chl. sodium	$\frac{1}{10}$	Chl. Sodium	$\frac{1}{10}$		
Vegetable matter... $\frac{6}{10}$		Veg. mat. $\frac{3}{10}$		Veg. matter	$\frac{4}{10}$				
Matter destructible by heat (vegetable)......	5	......	$4\frac{5}{10}$	......	10	......	5	......	$5\frac{5}{10}$
Siliceous sand, insoluble in nitric and sulphuric acids	74	......	$73\frac{5}{10}$	......	$62\frac{1}{10}$	......	$73\frac{5}{10}$	......	$72\frac{7}{10}$
Alumina	$3\frac{2}{10}$	... ..	$2\frac{1}{10}$	......	4	......	$2\frac{8}{10}$	... ..	$2\frac{4}{10}$
Oxide of iron	$6\frac{5}{10}$	......	10	......	$6\frac{4}{10}$	......	$2\frac{9}{10}$		
Carbonate of lime	$2\frac{9}{10}$	and carb. mag.	$\frac{5}{10}$	... ..	5	......	$7\frac{6}{10}$	.....	$1\frac{8}{10}$
Phosphate of lime	$\frac{4}{10}$	......	$\frac{1}{10}$	.. ...	$\frac{1}{10}$	... ..	$\frac{1}{10}$		
Carbonate of magnesia	1	......		......	$1\frac{6}{10}$	......	$\frac{4}{10}$	and iron	$5\frac{7}{10}$
Potash (existing in the soil as an insoluble silicate)	$\frac{6}{10}$	......	$\frac{8}{10}$	......	$\frac{1}{10}$	......	1	Potassa	$\frac{2}{10}$
Loss	$1\frac{4}{10}$	......	$3\frac{2}{10}$	......	1	......	1	......	$\frac{1}{10}$
	100		100		100		100		100

ADDENDA.

Red Clover is the foundation of the alternate system of husbandry, and there is no sacrifice that ought not to be made to secure a large crop. That land grows "tired," or is "sick" of clover, is one of the many traditions which the farmer has from his forefathers. One farmer will say that he can grow it every sixth or seventh year, and some that it can be only grown every twentieth year, while another will say that he can get good crops of white, with a mixture of red, every fourth year. These opinions are sufficient to show that red clover is never a certain crop, and the reason why it is so I shall beg leave to explain more fully. It is, as has been said in the report, always weakened and killed by the frost, and this more on some soils than others. The red clover (trifolium pratense) is a native (indigenus) of Britain, and is known to botanists only as a *perennial;* as a *biennial* it is unknown to them. The clover-seed used in this country is imported from France, or is raised from seed that was imported the year previously; and plants which are transported from a warmer to a colder climate, do not immediately accommodate themselves to the opposite conditions of the seasons in which they are placed, but for a while continue to show symptoms of flowering, at the same period of the year in which they had been accustomed so to do in their last native climate. Professor Henslow says that in some instances they are several years in accomplishing the change, and sometimes even die without effecting it. And it is in attempting thus to acclimate itself, that the stems of red clover through the autumn and winter are putting forth fresh leaflets, which as rapidly are cut off by the frost, until the "leaders" accompanying the floret are destroyed, and then the whole plant perishes. In this progress of acclimation or naturalization, the red clover becomes converted from a perennial to an annual on some soils, a biennial on others, and that most generally,—and upon some chalk soils, into a triennial plant. The native red clover, found in the vale of Aylesbury, and in Lincolnshire between Wainfleet and Skegness, does not push forth leaves except at the time in spring when all perennials begin to vegetate; and if seeds were collected from the places mentioned, of the perennial red clover already naturalised, and which in all its botanical characters is identical with the cultivated red clover, it would no doubt endure the rigour of the winter, and grow luxuriantly on lands adapted to its cultivation.

It is a question of considerable importance to learn how long the plants of the true perennial red clover would remain permanent without degenerating, and upon what particular soils,—whether on calcareous, or only on those adapted to the superior perennial grasses.

p. 223. Kimmeridge Clay from Elloughton Dale—specific gravity 2,100.

p. 242. In a large field of red clover on the Wolds, near Riplingham, we saw the headland which formed a passage to other fields, and which was well trodden and carted over, much superior to the rest of the field; the remainder being very thin of plants, which had also disappeared in circular patches.

ERRATA.

p. 226. For "Bath *Agricultural* Transactions," read "Bath *Philosophical* Transactions."

p. 234. For "humic acid, *or* 57 per cent.," read "humic acid *at* 57 per cent."

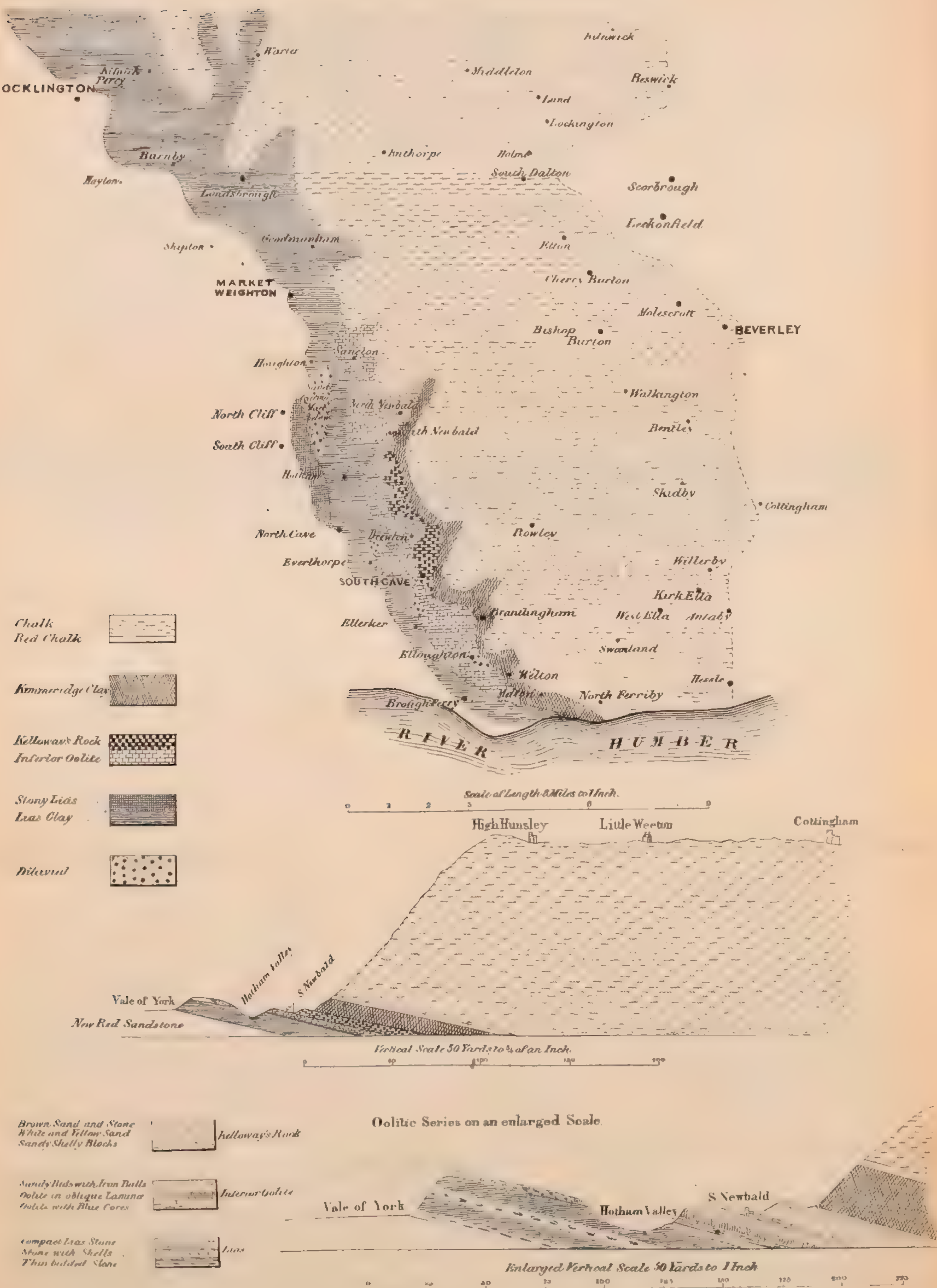
p. 246. For "*cleared* for turnips," read "*cleaned* for turnips."

GEOLOGICAL MAP AND VERTICAL SECTIONS.

To Illustrate The Rev W THORP'S Report on the

AGRICULTURAL GEOLOGY,

of the



PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE FIFTEENTH QUARTERLY MEETING, HELD AT WAKEFIELD, ON THURSDAY, THE 23RD SEPTEMBER, 1841.

On the motion of the Rev. Samuel Sharp, seconded by T. W. Tottie, Esq.,

Earl Fitzwilliam, the President of the Society, was called to the Chair.

The following gentlemen were elected Members of the Society :—

William Peel, Esq., Frickley Hall, Doncaster.
Walter Sorby, Esq., Rotherwood, Rotherham.
Richard Sorby, Esq., Rotherwood, Rotherham.
John Freeman, Esq., Huddersfield.
Thomas Firth, Jun., Esq., Huddersfield.
Foster Shaw, Esq., Huddersfield.
Rev. John George Morris, St. Austin's, Wakefield.
Mr. Joseph Abbott, Normanton, Wakefield.

His Lordship then called upon the Secretary to read the Report of the Council.

Before doing this, Mr. Wilson read a communication from that eminent geologist, Dr. Buckland, regretting his inability to attend the meeting, as he had contemplated doing, owing to an engagement he had previously made with a scientific gentleman, Mr. Hopkins, to examine the evidence of the action of Glaciers on the mountains of Cumberland and Westmoreland.

The SECRETARY then proceeded to read the following Report:—

REPORT OF THE COUNCIL OF THE GEOLOGICAL AND POLYTECHNIC SOCIETY OF THE WEST RIDING OF YORKSHIRE, PRESENTED AT THE THIRD ANNUAL MEETING, ON THE 23RD SEPTEMBER, 1841.

The progress of the Society during the past year may on the whole be considered satisfactory. At the close of the last annual meeting, the number of members was 280, since which time 68 new members have been elected; but, as within the same period there has been a loss by deaths and resignations of 22, the total number on the society's list at the close of this day's proceedings will be 326. The annual income of the Society will consequently be £211 18s.

The Accounts, as examined by the Auditors, are given at the end of the Report, and exhibit the income and expenditure of the Society classed under the most important heads, from the 1st January, 1840, to the 22nd September, 1841: they show a balance in favour of the Society of £15 13s. 9d.; that there are outstanding debts, recently incurred, to the amount of £72 14s. 2d., and that the subscriptions yet due are £251, leaving a final balance in favour of the Society of £193 19s. 7d. The amount of subscriptions yet due is undoubtedly very large; but, when it is considered that the smallness of the individual subscriptions, and the distance at which the Members reside from one another render it impossible to employ a paid Collector, it will be seen how difficult it is for the Treasurer to collect them; but at the same time this difficulty would be easily obviated by the Members regularly transmitting their subscriptions, either by a post-office order, or through the Society's banker.

By the publication of the Reports, the Members are from time to time made acquainted with the principal labours and proceedings of the Society. The papers that have been read during the past year have been in no way inferior in interest to any that have preceded them. Those which describe the Geology of Yorkshire, or speculate on the causes by which its actual condition has been produced, or offer suggestions for the improvement of the Arts, founded on Geological considerations, are the following:— "Illustrations of Yorkshire Geology," by Rev. W. Thorp; "Three Reports on the Agriculture of Yorkshire, Geologically considered," by the same gentleman; "A Report on the Geology of the North Midland Railway from Leeds to Darfield," by Messrs. Embleton and Morton; "On the Mineral Springs of the Parish of Halifax, Geologically considered," by Dr. Wm. Alexander; "On the Vegetable Origin of Coal," by Mr. Morton; "On the occurrence of Shells in the Yorkshire Coal Field," by Mr. Hartop; and "On the occurrence of Boulders of Granite and other Crystalline Rocks in the Valley of the Calder, near Halifax," by Mr. J. T. Clay.

The other communications which have been made to the Society have been—Mr. Hartop's "Observations on the occurrence of Titanium in Blast Furnaces;" Mr. Holmes's Description of an Ingenious Modification of Upton and Roberts's Safety Lamp; Mr. Todd's "Account of Experiments on the relative Strength of Pig Iron of various Qualities and from different Makers;" and Mr. Embleton's paper "On the Museum of the Society."

Of these papers, two seem to call for special remark. The paper of Mr. Embleton on the Museum contains an enumeration of the various objects which it is desirable that it should contain, and of the uses which they would subserve; and is intended as a manual, by consulting which, each Member, in his respective locality, may discover in what way he may best promote the objects of the Society. While on this subject, the Council cannot but express their regret that the Museum has not received those contributions from the Society at large, which might be made with so much ease by each Member, and which collectively would be of so much value to the Society. In the meantime, the Council would earnestly invite the Members to an inspection of their collection, which has been carefully arranged by Mr. Embleton, and will be found, even in its present imperfect state, well worth a visit.

The valuable papers of Mr. Thorp on Agricultural Geology have opened out a new field for the labours of the Society, the importance of which it is not easy to overrate, since thereby the Yorkshire Agriculturist will not only be made acquainted with the geological character of the soil he cultivates, but also with those principles of cultivation which the recent discoveries of science have suggested. So highly indeed have they been appreciated by the Members of the Yorkshire Agricultural Society, that they invited the Society to hold a Special Meeting at Hull concurrently with their Annual Meeting, for the express purpose of adding to their ordinary proceedings the discussion of the scientific principles of cultivation adapted to certain geological conditions. If the result of this Meeting shall be to give to the assemblies of the Agricultural classes a more scientific character, and to lead the great body of the cultivators of the soil to perceive the advantage which they may derive from the application of scientific principles to the art of Agriculture, the Society will have reason to congratulate itself on having lent its willing aid to forward so desirable a result.

The operations of the Society have not, however, been confined to the discussions which take place at its meetings.

Having obtained permission from the Directors of the Leeds and Manchester Railway, the Council have, by the assistance of Mr. Bull, procured a Section of the Cuttings on that Railway from Hebden Bridge to the Terminus at Normanton. A detailed description of the Geological and Mineral information thus displayed, will afford materials for the labours of a Committee, and may be expected to give interest to the subsequent Meetings of the Society. In the last Report it was announced that a section of the Yorkshire Coal field, from Northowram to Elmsall, was in contemplation: considerable progress has been made in the survey, and the completion of the undertaking may be looked for in the Spring.

The Council have only farther to report, that in December and March last the Society held its meetings for the first time in the towns of Doncaster and Halifax; that in both places it was received with the utmost cordiality, and obtained a considerable accession to its numbers; and in conclusion, to bespeak from the Members of the Society that cordial support and co-operation which can alone enable them to accomplish the objects for which they are associated.

ABSTRACT OF THE RECEIPTS & EXPENDITURE OF THE SOCIETY,

From 1st January, 1840, to 22nd September, 1841.

RECEIPTS.	£	s.	d.	£	s.	d.
Subscriptions from						
19 Members, for 1838 ..	9	19	6			
92 Members, for 1839 ..	48	6	0			
206 Members, for 1840 ..	108	3	0			
79 Members, for 1841 ..	51	3	0			
				217	11	6
Subscriptions for the Cases in the Museum				74	10	0
Sale of Reports....................				0	18	6
Loan from Earl Fitzwilliam, for the Purchase of Building Ground....				331	10	0
Interest allowed by the Bank......				2	5	3
Error of 2s. in the Cash paid to the Bank, 9th Jan. 1840..............				0	2	0
Balance in hand on 1st Jan. 1840 ..				79	17	6½
				£706	14	9½

EXPENDITURE.	£	s.	d.	£	s.	d.
Printing				14	6	4
Stationery				3	7	10
Advertising......................				22	4	8
Printing Reports........	57	1	2			
Carriage of Ditto........	2	8	9			
				59	9	11
Postages				15	5	7½
Carriage of Parcels and Sundries				8	4	11
Expense of Museum (Annual) ..				18	18	4
Expense of Museum (Extraordinary)				148	3	5
Purchase of Books and Map				23	16	0
Purchase of Building Ground....				359	16	9
Expenses of Meetings............				17	7	3
				691	1	0½
Balance in the Treasurer's hands	8	12	10			
Ditto in the Bank ..	7	0	11			
				15	13	9
				£706	14	9½

BENJAMIN BIRAM, Auditor.

ASSETS AND LIABILITIES OF THE SOCIETY, on the 23rd Sept. 1841.

ASSETS.	£	s.	d.	£	s.	d.
Subscriptions yet due						
for 1838..............	6	16	6			
for 1839..............	15	15	0			
for 1840..............	43	11	6			
for 1841..............	167	17	0			
				234	0	0
Subscriptions for Cases for the Museum				17	0	0
				251	0	0
Balance in the Treasurer's and Banker's hands				15	13	9
				£266	13	9

LIABILITIES.	£	s.	d.
Joseph Batty, for Cases for the Museum	35	8	0
Edw. Baines and Sons, for printing the Reports	25	12	2
Wm. Dodgson, for preparing Platform &c. for the Meeting	1	14	0
Stationery, Advertisements, and sundry small Accounts, estimated at	10	0	0
	72	14	2
Balance in favour of the Society ..	193	19	7
	£266	13	9

The following resolutions were then passed :—

1. That the Report of the Council be received and printed.

2. That the Accounts of the Treasurer up to 22nd September, 1841, showing a balance in favour of the Society of £8 12s. 10d., be passed.

3. That the next meeting of the society be held at Huddersfield, on Thursday, the 2nd of December.

4. That the thanks of the society be given to Earl Fitzwilliam, Rev. Theophilus Barnes, Mr. Henry Morton, and Mr. Farrar, for donations of fossils to the Museum.

The Secretary then laid on the table the list of names, proposed for the several offices at the June meeting, to be marked by the members: the following were selected :—

PRESIDENT.

EARL FITZWILLIAM.

VICE PRESIDENTS.

Duke of Norfolk.
Earl of Effingham.
Earl of Dartmouth.
Lord Wharncliffe.
Lord Stourton.
Viscount Milton.
Viscount Howard.
Hon. W. S. Lascelles.
Hon. J. S. Wortley.
Sir F. L. Wood, Bart.
Sir W. B. Cooke, Bart.
Rev. Dr. Scoresby.
Rev. T. Barnes.
T. W. Beaumont, Esq.
E. B. Beaumont, Esq.
C. J. Brandling, Esq.
T. D. Bland, Jun., Esq.
J. W. Childers, Esq.
Michael Ellison, Esq.
G. Lane Fox, Esq.
R. O. Gascoigne, Esq.
W. Bennet Martin, Esq.
J. G. Marshall, Esq.
J. S. Stanhope, Esq.
Godfrey Wentworth, Esq.
Rev. Samuel Sharp.

COUNCIL.

Mr. W. Billington.
Mr. J. Brakenridge.
Mr. Henry Briggs.
Mr. J. C. D. Charlesworth.
Mr. T. W. Embleton.
Mr. W. T. Hall.
Mr. Henry Hartop.
Mr. Henry Holt.
Mr. Charles Morton.
Mr. J. M. Stansfeld.
Rev. W. Thorp.
Mr. Geo. Wilson.

SECRETARY AND TREASURER.

Mr. Thomas Wilson.

CURATORS.

Messrs. T. W. Embleton and Henry Holt.

AUDITORS.

Messrs. B. Biram and G. W. Chambers.

The Rev. William Thorp, of Womersley, then read a continuation of his "Illustrations of Yorkshire Geology." The Council regret that they are not permitted to publish it, but they trust that Mr. Thorp will in some other form give to the world this valuable series of papers on the Yorkshire Coal field, the result of many years' laborious investigation of the mineral geology of this county.

Mr. Laurence, of Leicester, referred to several specimens of fossil fruits which he had brought from the coal formation of Lancashire. He wished to ask of any practical geologist who might happen to be present, whether similar specimens were found in the Yorkshire coal formation. He had never heard of any or seen them, and he was inclined to believe that they existed only in the locality near Bolton.

Mr. Sharp believed that similar fossils had been found in many other parts of the country.

Earl Fitzwilliam remarked, that it was very desirable that they should obtain as much knowledge as possible of the fossils contained in the different strata, that they might by that means be enabled to identify the various beds of coal in different localities. He believed that five or six years ago the remains of the scales and shells of fish were found imbedded in some of the coal seams. Now if they found the scales of fish in connection with a particular seam in the northern part of the Yorkshire coal field, and also found the same scales in a bed, even of different thickness, in the southern part of the coal field, it would be a strong reason for believing that the two beds were identical.

Mr. Sopwith observed, that although vegetable impressions were extremely abundant in the shales and other strata associated with coal, yet he believed that such impressions on the surface of the coal itself, were of rare occurrence, and he had met with persons of great experience and observing habits, who did not remember to have met with vegetable impressions in coal. He had lately seen some beautiful specimens distinctly marked on the surface of anthracite coal at a mine in Pembrokeshire, and these impressions he was informed were peculiar to one seam or vein of coal. He should be glad, therefore, to learn from any of the gentlemen present, whether in the coal seams of Yorkshire vegetable impressions were found on the substance of the coal itself, or chiefly, as in most of the coal fields with which he was acquainted, in the associated beds of shale, sandstone, &c.

Mr. Embleton remarked that Mr. Sopwith's question, whether fossil plants were ever found in the coal itself, could be answered in the affirmative. At Ardsley Colliery, in the Haigh Moor coal, impressions of the Stigmaria Ficoides are often found, and in some localities, in such numbers that the working of the coal is very much obstructed and its quality deteriorated; and an instance of fossils being found imbedded in coal is to be seen in the Stanley main coal, at the Groves Colliery, near Wakefield; indeed, the presence of fossils in coal was of frequent occurrence in Yorkshire, and was a sure sign of the inferiority of the coal. In answer to the observations made by his Lordship with respect to identifying strata by means of fossils, he was sorry to say that, with their present limited knowledge on the subject, the question could not be answered, for we have yet to learn the particular species of fossils that each stratum in the coal field contains. Take as an example the strata in the neighbourhood of Barnsley, where the thick coal has been sunk to at a considerable depth in many places, and where there are many collieries. We do not know in what order the fossils are found in the strata, nor do we even know what fossils they contain. How, then, can we answer this important question? for the same remark is equally as applicable to every other district of the Yorkshire coal field, as to the Barnsley district. If, however, every worker of coal, and those who have extensive tracts of mineral property, were to send to the Society's Museum, at Wakefield, specimens of fossils discovered in their collieries and estates, labelled with a particular description of the strata in which they were found, they might probably arrive at a solution of the problem which the noble lord had proposed; and not only would this important question be truly solved, but we should be able to ascertain if there be any fixed sequence in the depositions of these fossils—if certain plants always accompany certain shells—if fish are found in a perfect state only when the strata contain no entomostraca—and we should further be able to state the nature of the strata in which the various kinds of fossils are found; for he was inclined to think that the nature of the strata is in some way connected with the species of fossil found in it. Having thus related the state in which this interesting question now stands, it is hoped that the friends of the society will exert themselves, and follow the example of the noble President, in contributing largely to the present collection in the museum.

Mr. Wallen, F.S.A., of Huddersfield, read the following paper:—

AN ELUCIDATION OF THE GEOMETRICAL PRINCIPLES OF GOTHIC ARCHITECTURE.—BY WM. WALLEN, ESQ., F.S.A., ARCHITECT, HUDDERSFIELD.*

Architecture, as the eldest sister of the arts, naturally claims attention from the members of a Polytechnic Society. It has ministered alike to the necessities, the comforts, and the luxuries of mankind.

The architectural remains of the nations of antiquity

* Mr. Wallen is about to publish a work fully elucidating the principles of Gothic architecture. Subscribers' names to be forwarded to West-Parade, Huddersfield.

(the *unchanging* testimonials of their former greatness) oppose, in the strongest manner, the reckless conclusions of the atheist. Could we possibly conceive the entire removal of every relic of former days, what a blank would the page of history present! The writings of the poets, the historians, and the philosophers of old, would appear as so many visionary and Utopian productions; but the architectural remains which an all-wise God has permitted to exist so long after the removal of the nations by which they were reared, tend, in a remarkable degree, to corroborate the prophetical and historical part of holy writ, and to explain the writings of heathen authors. It may be truly said that the Acropolis of Athens, and its beauteous structures, vouch for Pausanias, the pyramids of Ghiza for Herodotus, while Rome owes its most lasting celebrity to architecture.

"Flinging back our thoughts upon the past," we cannot contemplate the ruin of empires without noticing the *peculiar* character of the remains of their former architectural greatness and splendour. In Assyria, Egypt, Greece, and Italy, we look in vain for the dwellings of the former inhabitants. Of the gigantic works erected for warlike purposes but few remnants exist; but of temples reared, whether to the true or false Gods, abundant remains are to be found in every country, fully proving the disposition of the human mind, in every age and under every clime, to acknowledge a supreme and superintending power.

Seeing, then, the importance which attaches itself to the *religious* structures of a country, as indicating the character of its inhabitants, we naturally inquire what is the style of architecture in which our own are enshrined; and we cannot hesitate to claim that as our *national style* which was so successfully practised by our forefathers from the twelfth to the sixteenth century. "Gothic or pointed architecture took "root and grew with the greatest vigour in Great Britain, "and in the provinces of France which were connected with "England: in this country, however, its course is the most "marked, and its advances are the most easily traceable." Nay, more than this, at the very period at which classic architecture was revived in Italy, the most gorgeous structures in the pointed style were erected in England; and we have sufficient proof, in the works of the sixteenth century, of the reluctance with which it was ultimately abandoned. It is moreover an undisputed fact, that the revival of Gothic architecture, at the present time, is *peculiar* to Great Britain.

Upon the various hypotheses which have been raised as to the precise origin of the Gothic style, it is almost needless to pass comment; many of them are sufficiently ingenious, but their very ingenuity increases in proportion to their probable departure from the simple truth. One circumstance is, however, especially deserving of notice, that every *practical architect* who has written upon the subject, is in favour of a *scientific* origin for the pointed arch.

Dr. Milner first directed public attention to the intersecting and interlacing arcades (so frequent upon Norman buildings) as probably originating the idea of the lancet or Early English style. This opinion is daily increasing in public favour. But however plausible the opinion, its correctness cannot be proved by perspective views, or without the reduction of these arcades to their elementary geometrical forms; and a careful examination of them will enable us to classify them very satisfactorily. Having devoted much attention to the subject, I think I shall be enabled to prove a constant recurrence to the intersecting principle throughout the whole series of windows of the Lancet or Early English style. In double, triple, and multiple windows I find that the acuteness or obtuseness of the curves forming the *lights* (i.e., the glazed parts) depends upon their connection with each other as a continued series of intersecting semicircles, or from their being parts of a composition, and from their not having been designed as individual features; and I shall hereafter exhibit Norman arcades, which are exact parallels thereto: thus endeavouring to prove that the same *geometrical* principles were acted upon by the architects of Norman and Early English edifices.

Before entering upon the consideration of the details of pointed architecture, a few observations must be made as to transition buildings, or those in which we find the attributes of the circular and pointed styles united.

If we look to the works of nature, we find "nexus utriusque generis," or links uniting every variety of organization, and these are remarkable for the total absence of beauty. Man, dissatisfied with the works of creation, has in every age pourtrayed ideal creatures, the offspring of his perverted imagination. Berosus, in noticing the monsters depicted upon the walls of the temple of Belus at Babylon, says they consisted of *hideous* creatures of *two-fold* principles.—*(Cory's Ancient Fragments of Phœnician Writers.)*

We shall find the same peculiarity both in sculpture and architecture, wherever a mélange has been attempted of parts having no affinity with each other. Cicero, in one of his letters to Atticus, condemns in the strongest terms the practice among the Romans, (in his time,) of importing Grecian statues, and subsequently altering and dedicating them to Roman heroes and citizens. (" Odi falsas inscriptiones statuarum alienarum.")

In Whalley, Roche, Romsey, Malmesbury, and Kirkstall Abbeys, the Temple Church, London; Steyning, and Shoreham churches, Sussex; Canterbury, Lincoln, Winchester and other cathedrals, we find excellent examples of architecture in a state of transition between the Norman and the Pointed styles; but however valuable they may be for the purposes of study, they must be acknowledged to be deficient in beauty, arising from the want of unity of expression,—the attributes of the circular and pointed styles being totally different.

Architecture may be considered as a language; whatever its style, the details form the words of which that language consists. That man would be thought insane indeed, who attempted to compose a poem in a language with whose rudiments he was but imperfectly acquainted; but the attempt would be no more insane than that of an architect attempting to design a sacred structure in the Gothic style, without a practical acquaintance with its real principles. That an ignorance of these principles does frequently exist, is evident from the strange anachronisms observable in many modern structures, in which the Early English, Decorated, and Perpendicular styles are found ridiculously introduced together, (but never blending,) bespeaking the absence of taste and of sound judgment, and above all, the want of *antiquarian* feeling in the designers.

In order to avoid these anachronisms, personal investigation of our ancient edifices is absolutely necessary; the principles of the pointed style can never be learnt from books, since they merely exhibit the style synthetically. Buildings are the books which must be studied; in them alone can we trace the little elegancies of composition with which the works of the *miscalled* "dark ages" are replete.

We must first analyze the details, then study the whole composition, and until this be done, our minds cannot be imbued with the feelings of the master-spirits of former ages. Until this be done, and we have imbibed the feelings by which they were actuated, Gothic architecture will be to us a *dead* language. But imbibing their feelings, we shall no longer become their copyists, but their successful imitators; we shall no longer imagine that "every pointed building must be a cathedral or nothing; nor shall we attempt to *copy* some vast church within a twentieth part of the space, and with a hundredth part of the money."

Proceeding upon the same profound principles by which they were regulated in their designs, we may hope to produce compositions, which, although not exhibiting all the pristine excellencies of the style, (but merely the hectic flush of its consumption and decay,) shall yet bear the partial impress of its former beauty.

PLANS.

In pointing out some of the geometrical principles of Gothic architecture, I shall commence by noticing the remarkable symmetry observable in the arrangement of the ichnography of three of our cathedrals.

The theory which I advocate is this, (and, I believe, it is peculiar to myself,) *that the* HALF WIDTH *of a structure* WITH AISLES *is to be considered as a normal or regulating scale, which, increased or decreased in geometrical progression, determines the principal points on the plan.*

If we take the plan of Romsey Church, (Hampshire,) and strike two circles, whose respective diameters equal half the width of the nave, and from the point where they touch each other (that is, the centre of the nave) we strike another circle of equal diameter, the extremities of the diameter of this last circle give the true line of the columns separating the nave from the aisles, and a continued series of similar circles, intersecting each other, will find the position of the centre of all the columns, the centre line of the external buttresses, and necessarily that of the windows.

The nave of Romsey Church is just three and a half circles (of half the width) up to the centre of the main pillars of the central tower. The tower is one circle, and the projection of the transept on each side half a circle.

The same arrangement is found to exist in several of our cathedrals of later date, (Romsey is a *transition* example.) I would, however, observe with respect to Romsey, that if we had taken a circle or square of the *whole width* of the nave, it would not have answered, although in small Norman churches *without* aisles, such as Adel, near Leeds, and Kilpeck, Herefordshire, the length of the nave is about two squares or circles of the *whole* width.

The width of the nave of York Cathedral is 106 feet (within the walls.) Taking a circle of 53 feet diameter (or half the width of the nave) we have the following result:—

Nave, 4 circles, ...	=	212	Feet.
Tower, 1 ditto	=	53	„
Choir, 4 ditto of 50 feet	=	200	„
An unequal portion at the East end		19	„
		484	

N.B. Britton gives 486 feet as the total internal length of the cathedral.

The transepts of York project in each case one circle of 53 feet from the external walls. By reference to the illustration, plate 1, No. 12, it will be seen that this mode determines the true position of all the columns, the size of the central tower, the centre of the windows and buttresses, and, in fact, all the important points in the Ichnography or plan. As this principle (of which I claim the *re*-discovery) gives the true symmetrical arrangement, it is evidently of *practical* utility; and the facility and certainty which it gives in planning a sacred edifice, may be imagined by the fact, that the laying down the plan of York Minster accompanying this paper, took me but one hour and a quarter.

I must not omit mentioning, that the nave, the transepts, and the choir, were erected at different periods; and as the symmetrical arrangement is observable throughout, it goes far to prove the *freemasonry* of the architects of the middle ages.

N.B. By reference to plate 3, No. 2, it will also be seen that the nave, transept, and choir of York are nearly equal, considering the centre of the tower as the centre of the length of the cathedral.

Again, the width of the nave of Lichfield Cathedral is 66 feet: proceeding as before, the half width is 33 feet.

	Ft.	In.
Nave, $3\frac{1}{2}$ circles of 33 feet	115	6
Tower, 1 ditto..........	33	0
Thickness of tower arches......	6	0
Choir, 4 circles	132	0
Projection of western towers	26	0
	312 . 6	

Britton gives 314 feet 6 inches from actual measurement!

N.B. The transepts of Lichfield project in each case rather more than one circle from the outward walls of the nave. (There is a remarkable divergence of the choir towards the north, which is immediately detected in the first circles beyond the tower.)

Again, the width of the nave of Salisbury Cathedral is 78 feet. Taking a circle of 39 feet, we have the following result:—

	Ft.	In.
Nave, 5 circles of 39 feet	195	0
Tower, 1 ditto	39	0
One aisle (half ditto)	19	6
Choir, 4 ditto	158	0
Lady chapel, 1 ditto	39	0
	450 . 6	

Britton gives 450 feet!!

The transepts of Salisbury project in each case one and a half circles of 39 feet from the outer wall, therefore

	Ft.	In.
Width of nave	78	0
Thickness of walls (No. 2.)	12	0
Three circles of 39, projection of transepts	117	0
	207	0

Britton gives 206 feet!!

N.B. Tintern Abbey, Monmouthshire, also corresponds in principle:—

Nave, 3 circles of half the width of the nave				117	Feet.
Tower, 1	ditto	ditto	ditto	39	"
Choir, 2	ditto	ditto	ditto	78	"
				234	"

The transepts project in each case one circle of 39 feet, from the inner face of the nave wall.

I beg to draw your attention to the form of the "Vesica piscis," (plate 1, No. 15,) and the constant use made of it by the early Christians. The Greek word Ιχθυς, which signifies fish (Latin, piscis) includes the *initial* letters of words denoting the exalted character of the Redeemer; and from this circumstance the early Christians made use of the fish as a symbol; and Tertullian (De Bapt., cap. 1,) writing to his followers, calls them "pisciculi," or little fishes. Among the several religious emblems which St. Clement, of Alexandria, (A.D. 194,) recommends to be engraved on the rings of the Christians of his time, is that of the fish, (Pœdag., lib. 3, cap. 2.) Saint Optatus Milevitanus also (A.D. 370) refers to the word Ιχθυς, as containing the initials of words representing the character of Christ. "Jesus Christ the Son of God, the Saviour." (Ιησους Χριςος Θεῦ Υιος Σωτηρ.) On the catacombs of Rome are found many representations of the fish. The Christians of the middle ages gave the name of *piscina* to the stoup containing the holy water. The cross, *the fish*, and many other secret emblematical marks, were placed by the freemasons upon certain stones belonging to the structures which they reared—(the cross is to be seen on a stone in Calverley Church, near Bradford)—and we constantly find, in pointed architecture, the figure of our Saviour, but especially that of the Virgin, inclosed in the geometrical figure termed "Vesica piscis," which was also the form of conventual seals, and is at the present day that of all ecclesiastical seals. In painted glass it was also introduced; and, not to notice other instances, two may be mentioned as occurring in the West-Riding, the one in Elland Church, near Halifax; the other in the Chantry Chapel of Thornhill Church, near Dewsbury; and there is in the possession of my friend, N. Scatcherd, Esq., of Morley, near Leeds, an alabaster sculpture, representing the Virgin, similarly enshrined, the rays diverging from every part of her body—(this relic formerly belonged to Sir Thomas More, the chancellor)—and the execution is exceedingly beautiful.

But my present object is to refer to the very singular application of the form of the "vesica piscis," which I have discovered in the plans of York, Lichfield, and Salisbury Cathedrals, determining in a most remarkable manner, not only the position of the centre line of the tower, but also the *exact* extent from north to south of the transepts. (See the Illustrations, Nos. 1, 2, and 3, plate 3.) From the plans it will be seen that the form of the "vesica piscis" is *similarly* obtained in each case, which is the more remarkable inasmuch as the distance from the west end to *the centre* of the great tower differs so greatly in the three cathedrals, that of York being 4½ circles of half the width of the nave, that of Salisbury 5½ circles, and that of Lichfield 4; and also, as the respective widths of the nave vary so much, (York 106 feet, Salisbury 78 feet, Lichfield 66 feet,) Salisbury and Lichfield have only one aisle to the transepts, while

York has two aisles. Speaking of York Cathedral alone, the nave, the transepts, and the choir were built at *three* different periods; and as the date of erection of the other two cathedrals also differs, the coincidence in principle so observable in the plans, is surprising, to say the least, and I think deserving of serious attention.

I cannot conclude these imperfect notices of the symmetrical arrangement in the plans of these cathedrals, without adducing further *practical* proofs of the science displayed by their designers.

It has been ably remarked, that "if science and taste be nothing, then may a brick clamp vie in beauty with the noblest effort of the architectural art." If science be deserving of consideration, then must we admire those structures the most in which it is most clearly developed, and wherein we descry proofs of the exercise of matured judgment in adapting the means to the obtainment of the desired end.

The pyramids of Egypt overawe the traveller by their mysterious form, and their gigantic proportions, while the purpose to which they *appear* to have been applied, so clearly points out a lavish waste of materials and labour, as to detract in some measure from the interest which they would otherwise excite.

The area upon which the great pyramid stands covers $13\frac{1}{2}$ acres. The pyramid itself may be considered as consisting of "*solid* masses unsubdued by time." It bears the stamp and impress of more than 3000 years, and has been calculated to contain six times the mass of stone in the breakwater at Plymouth—(one of the noblest monuments of modern engineering art.)

Upon calculation I find that this single pyramid covers a *greater* area than fourteen of our English cathedrals, (*i.e.*, exclusive of the chapter houses and cloisters.) The area covered by the base of the pyramid is 64,752 superficial yards; the collective areas upon which the following cathedrals stand amount to but 63,784 superficial yards,—viz., York, Salisbury, Lincoln, Chichester, Peterborough, Gloucester, Canterbury, Norwich, Wells, Worcester, Rochester, Lichfield, Durham, and Oxford!!

Considered *relatively*, we have in the one case simply an all-enduring monument of the building art,—in the other we have science carried to its utmost limit, which may be clearly proved.

The superficies of the *walls* of York, Lichfield, and Salisbury Cathedrals is about one-fifth their whole area. After what has been said with reference to these structures, we may safely assert, that the same principles were adopted in their erection. It has been observed, that "this mode of "estimating the merit of a building, (viz., the proportion of "the walling to the whole area enclosed,) renders it, in "some measure, independent of taste, whose applause is "intermitting. A great building with few materials, besides "the periodical approbation it will receive from the eye, will "have an uniform superiority by this rule."—*(Ware on Vaults.)* Mr. Gwilt, the editor of Sir Wm. Chambers's Architecture, states that "there is more constructive skill "shown in Salisbury and other of our cathedrals, than in all "the works of the ancients put together. The balance of "the thrusts of the different arches—the adjustment of "thickness in the vaultings, and the exceeding small ratio of "the points of support in these buildings to their whole "superficies—and added to these the consequent lightness "and elegance of form which they exhibit, leave us nothing "to desire in this respect."—*(Gwilt's Edit. of Sir William Chambers's Architecture.)*

Lest it should be imagined that the principles to which I have referred as existing in York, Salisbury, and Lichfield Cathedrals, do not apply elsewhere, I take this opportunity of stating, that many Continental structures exhibit the same, of which I may mention Milan Cathedral, Bayeaux Cathedral, and L'Abbaye aux Hommes, Caen. The great difficulty of obtaining correct ground-plans of ancient buildings, is a sufficient reason, I presume, (added to the circumstance of the few works to which a young provincial architect can have access,) for not adverting to other cathedrals and churches. I may also observe, that the frequent injury sustained by fire, the not unfrequent rebuildings, and the many examples in which different styles are found incorporated in one building, will account for the few examples I have produced upon this occasion. In conclusion I would say, the only question is whether the principles adverted to are deserving or undeserving of attention.

It has been boldly asserted by Mr. R. P. Knight, in his "Analytical Inquiry into the Principles of Taste," (2nd Edit., p. 162.,) that "if we ask what is meant by pure "Gothic, we receive no satisfactory answer; there are no "rules, no proportions, and consequently no definitions." And again, (p. 175,) that "the Gothic architects recognised "*no rules*, but worked merely for effect." It is, indeed, true that while we have beautiful artistical representations of our cathedrals, (in some instances the actual details,) while we have "Glossaries of Gothic Architecture," and Archæological Dictionaries defining the *names* of the details, we look in vain for works elucidating the actual *principles* of the pointed style. A grammar of Gothic architecture clearly developing its first principles is still a desideratum. But as no one, assuredly, would deny the beauties of the Greek and Latin writers, because they may happen to be written in a language which to him may be really *dead*, and therefore unintelligible; so must we maintain that *our ignorance* of the principles of Gothic architecture, is no proof that that style is *devoid* of principles.

Since the sixteenth century, Gothic architecture has been a dead language, and until lately, "unread of all men;" the smatterers in that language, at the period of its decline, were Torregiano, Sir C. Wren, Hans Holbein, and others, who (real Goths that they were) endeavoured to engraft upon the declining Gothic the young shoots of the Cinquecento style. And we may mention other veritable Goths at the period of the resuscitation of the style, viz., Battye Langly, Horace Walpole, and others, who, as *closet antiquaries*, vainly attempted a style of architecture, their utter ignorance of whose true principles is proved by their monstrous abortions. But a brighter period has arisen, and the works of a Barry, a Savage, a Cottingham, and of many other living architects, fully prove that upon their shoulders have fallen the mantles of the ancient freemasons!

But how has this arisen? Simply by these architects personally investigating our ancient structures. They have pursued the same course in reviving the practice of Gothic or rather pointed architecture, as did Vignola, Palladio, Fontana, Scamozzi, and others at the period of the "renaissance" of Roman art,—as did Steuart, Revett, and many later architects, in endeavouring to re-introduce the long-forgotten Grecian style. In all these cases personal investigation and research have led to the happiest results, nor need *any* despair of imbibing the spirit of the mid-eval architects, who will but study their incomparable works with devotion and industry. That these architects were regulated by sound principles cannot be doubted; and it is not for me to say how far I have discovered those principles in the plans which I have submitted to your notice. The cathedrals of York, Salisbury, and Lichfield are, however, three of the most beautiful of which England (or indeed Great Britain) can boast. I shall now endeavour to show the application of my theory to the exterior of one or two structures.

ELEVATIONS.

I have previously observed, that I consider the half width of the nave to be a normal scale, which, increased or decreased in geometrical progression, will be found to determine the general features of the plan, and in some instances of the elevation. The extreme difficulty and expense attending the obtainment of correct geometrical drawings, render it impossible to produce many examples: the object of this paper is, however, to *excite inquiry*, and not to sustain my theory dogmatically.

The normal scale of York Cathedral is 53 feet, (the whole width of the nave being 106 feet.) Britton gives the measured height of the western tower as 172 feet 3 inches. Now $53 \times 3\frac{1}{4}$ times = 172 feet 3 inches, (*i.e.* within one inch.) Again, Britton gives 198 feet as the total height of the central tower, and $53 \times 3\frac{3}{4}$ times = 198 feet 9 inches! the apex of the canopy over the great western window is 106 feet high, or 53×2; the apex of the gable is 119 feet 3 inches high, or $53 \times 2\frac{1}{4}$; the distance between the main buttresses of the central tower is 53 feet; the distance between the western towers, just below the cornice, is 53 feet; the height and width of the light of the great western window (that is, the head) is 26 feet six inches, or half of 53 feet. It may also be mentioned, that almost the whole of the horizontal lines on the western front occur at distances of 53 feet, or its subdivisions in geometrical progression. *Can this be chance?* The transept of Beverley Minster will be found to embody the same principles, and to have the same symmetrical arrangement.

Taking the side of a square of half the width of the transept internally, (or the diameter of a circle of the same extent,) as the normal scale, and applying it vertically on the elevation, we have the following result: the first line (see the numbers, plate 2, No. 13) cuts the apex of the aisle windows; the next line (marked 2) is the level of the springing of the second tier of windows; the third the centre of the window termed "vesica piscis;" the fourth and fifth lines find the position of the strings; the sixth the centre of the "wheel window;" the seventh the springing of the door-head, and so on; all the lines being subdivisions of the normal or primary scale. By drawing vertical lines from those on the base, (being *similar* subdivisions of the scale,) and forming an isosceles triangle, whose base and height are equal to half the width of the building internally, and drawing lines parallel to the sides of this triangle, it will be found that these lines, by intersecting the vertical and horizontal lines, determine every important point in the elevation: this will be clearly seen by reference to the geometrical elevation, plate 2, No. 10.

As the development of the *true* principles of Gothic architecture is my sole object, I am anxious not to conceal the knowledge of any fact tending to prove that the principle, or an approach to it, has been acted upon by others. Cæsar Cæsariani endeavoured to exhibit the use of the equilateral triangle as applicable to the plan of Milan Cathedral. To myself the equilateral principle (upon the plan) is unsatisfactory, and for the following reason. In Milan Cathedral it is quite true that the equilateral triangles used have *some* slight reference to the extent of the building; but the extreme intricacy of the lines is admitted, and precludes the practical application of Cæsariani's theory. Again, Milan and many Continental cathedrals have two aisles on each side of the nave, and as only one or two of our English cathedrals are so proportioned, this theory will not apply; but observe, if you please, that the principle I advocate does apply to Milan *equally* with York and other cathedrals. Rejecting the two outward aisles of Milan, the nave is four circles in length, and the projection of the transept half a circle! My attention was first drawn to the subject in 1835, whilst engaged in preparing for publication the History of the Round Church at Little Maplestead, Essex. This building has a circular west end and a semicircular apsis. The total length is 60 feet, the width of the circular part at the west end 30 feet, the diameter of the circular peristyle of pillars internally is fifteen feet, the height and width of the chancel fifteen feet. Here we have an example of symmetrical arrangement depending upon geometrical proportion. It will be seen that this arrangement involves the theory I have mentioned, and I may add, that it is equally applicable to the Temple Church, London, (another of the *round churches.)* It has been said, that "Nature, "after she has symmetrically formed and sketched out her "general figures, fills up the work with variety, grace, and "elegance;" and the attractive charms of the "tout ensemble" of a Gothic edifice, will be found to arise from the appropriate application of the ornamental accessories to a frame-work or outline, harmonious and symmetrical in its general proportions. I have endeavoured briefly (but too imperfectly) to adduce examples in the pointed style, in which certain defined principles are discoverable; and although the systems or principles may differ, (since the attributes of classic and pointed architecture are *directly* opposed to each other,) it is my firm belief, that the architects of the middle ages acted as strictly upon a scientific basis as those of antiquity; and I would beg to direct particular attention to what has already been observed upon this point, and a comparison of the theory mentioned, with that referred to by Mr. Gwilt as applying to classic architecture. "The art of "designing edifices (says he) consists in a proper arrange- "ment of the horizontal and vertical masses or voids whereof "they are composed, so that the *two together* may mutually "suit each other. The first arrangement is made on the "plan; the *next* is formed by a *transference* of the horizontal

" masses from the plan to the elevation and section. Al-
" though this system may appear to belong more properly to
" public or large buildings, than to private or small ones, the
" principles are the same in both; and if in designing even
" the smallest house, the student will keep in view that the
" use of the orders and their accessories may be applied to
" it, though omitted in reality for the sake of economy, he
" will invariably produce a work which possesses a grace far
" beyond the reach of the common artisan or builder. M.
" Durand, (in his 'Precis de l'eçon d'Architecture,') has
" carried the interaxal system to a great extent."

I now refer to one of *many* negative proofs of the importance of symmetrical arrangement of edifices of the pointed style. In Westminster Abbey the aisles are extremely narrow compared with the width of the structure, and this circumstance has been referred to by several antiquaries, although the cause of the imperfection has not been pointed out. The fact is, the pillars separating the nave from the aisles are not in their proper position,—the distance from the outward walls to the centre of these columns is *less* than a quarter of the whole width, and it is to this circumstance that I refer as the cause of complaint. Were it not invidious, I might mention several modern churches, in which in some cases the pulpits are scarcely seen from the galleries, and in others they can scarcely be seen from the aisles, and which defects I have traced by actual measurement to one of two causes,—1st. That the total width of the church does not warrant the introduction of aisles. 2nd. That the width of the church is sufficient, but the arrangement of the ground plan is deficient in symmetry, arising from the want of attention in determining the *relative* widths of the nave and aisles. Correctives to these evils might be found by reverting to the principles discoverable in the plans of the cathedrals to which I have already referred; and I can afford no clearer or more convincing proof that these principles are not *generally* known, than by noticing that Rickman (Attempt plate 4, p. 113,) in giving the plan of a cathedral, "not (says he) the plan of any particular building, but *composed* to introduce as many parts as it was expedient to describe," has altogether deviated from the arrangement alluded to in the disposition of the clustered pillars, and the relative proportions of the ichnography or plan.

Mr. Sopwith commented at some length npon the leading points brought forward in Mr. Wallen's communication, which he considered to be of great value, as tending to establish certain fixed proportions in cases where hitherto there had been no guide save mere imitation: hence it followed, that modern buildings were admired more from their close resemblance to some of the celebrated buildings of ancient times, than for their adherence to any definite proportions, such as Mr. Wallen and others had recently, and he thought successfully, endeavoured to establish. Previous to the meeting he had had an opportunity of closely examining the detailed drawings prepared by Mr. Wallen in illustration of this paper, and he thought it only due to the talented author of them to express in the strongest terms his admiration of their beautiful execution and accuracy of detail. He was of opinion that the principles of construction described by Mr. Wallen had been adopted by the builders of the several cathedrals to which he referred, but he did not consider that any one principle was applied generally to all buildings, but that different architects adopted different rules or systems of arrangement, and consequently the principles which applied to the Cathedral of York, would be found not to apply to all, though they might apply to many buildings of a similar style and magnitude. That this was the case, Mr. Sopwith said was fully established by a very ingenious treatise which had recently been published by Mr. Billings, in which the method of construction in Carlisle Cathedral was clearly developed. The subject was one of the greatest importance to the advancement of architectural science, for it would assuredly lead to the adoption of fixed principles, and remedy the numerous defects which arise from the practice of blindly following what has been done before, without any regard to the objects for which buildings are specially intended.

The following paper was then read:—

ON THE PRESERVATION OF RAILWAY SECTIONS, AND OF ACCOUNTS OF BORINGS, SINKINGS, ETC., IN ELUCIDATION OF THE MEASURES RECENTLY TAKEN BY THE BRITISH ASSOCIATION.—BY THOMAS SOPWITH, ESQ. F.G.S., NEWCASTLE-ON-TYNE.

The blank chart which accompanies this paper has been prepared by a Committee appointed by the British Association at Glasgow, in 1840, with a view to the collection and preservation of a regular series of sections of railway cuttings, which, by their intersection of mineral districts or of rocks presenting any remarkable geological features, may afford useful information, and be worthy of being kept as geological and mining records.

An object apparently so easy of attainment, and of such obvious importance and utility, seems scarcely to require comment, and it would appear more surprising that it should in any case have been neglected, than that any arguments should be required to enforce its general observance. The facts of the case, however, are a sufficient evidence that due attention has not hitherto been devoted to this interesting department of geology and engineering; for on many lines of railway no measures have been taken to preserve a regular and systematic record of the geological features presented during the progress of the works, and in other cases, where such details have been carefully measured and preserved, they have not been reduced to that uniformity of scale and colour which is indispensably necessary for an extensive series of sections of this description. To societies like the present, considerations of this kind cannot be too strongly urged or too often repeated, since it is only by the co-operation of numerous and influential parties that great public objects can be effected. At first sight, it may appear of comparatively small importance whether such details are kept or not, and it is very possible that in certain cases it may be difficult to foresee any practical inconvenience or loss as likely to result from the want of the particular information afforded by accurate sections. This may be the case under certain circumstances; but my object is now to show, that, as a system, the preservation of detailed drawings of railway cuttings, and of borings and sinkings, is of great importance; that it not only furnishes information of the greatest value in a scientific point of view, but is intimately connected with our national prosperity, and the continuance of our greatness both as an agricultural and commercial nation. I shall endeavour to impress on the minds of those present, and of all who take any interest in our proceedings, that there is an intimate connection between geological science and the prosperity of all nations which depend as much as we do on the subterranean products of the earth; that not only individuals, but communities, may be greatly benefited by a due regard to the practical results of science; and that the laws of physical science are never neglected without a corresponding injury to those whose pursuits require attention to the phenomena of nature. More particularly is it my object to show that extensive railway cuttings in mineral districts are instructive pages in the book of nature, opened by the engineer, and presented in an attractive form to the perusal of the geologist. Soon, however, the opportunity passes away; the silent operations of nature, clothing the rocks and soils in grasses, mosses, and lichens, shut the volume to the geologist, and open another page for the instruction of the botanist—exemplifying to the former the common but too often forgotten adage, that "opportunity neglected can seldom be regained."

In elucidation of the subject, then, I shall briefly advert to the rapid progress of geological science. Within the limits of living memory, nothing could be more vague and indefinite than the state of geological science, if indeed such a term can be applied to the small extent of what was then known. The first geological map of this kingdom appeared in 1815, and though it is extremely interesting and valuable, when considered as the result of the labours of a single, and in a great measure unassisted, individual, yet a single glance at that map will show, in a manner more striking than any verbal description, the vast progress made in a quarter of a century. The last edition of Mr. Greenough's Geological Map of England and Wales—Mr. Griffith's Map of Ireland—Mr. M'Culloch's Map of Scotland, and Mr. Murchison's beautiful Map and Sections of the Silurian region—are magnificent examples of what has been done, and are in all probability only an earnest of the still further advances to be made, in reducing the grand phenomena of the structure of the world to such practical results as tend to the welfare of its inhabitants. As regards general views, nothing can be more satisfactory than the rapid improvement here alluded to; the next steps are to attend with equal zeal to such details as are of practical utility.

The study of nature is, under all circumstances, a delightful and instructive pursuit, and all who have leisure to prosecute attentive studies therein, find greater interest as they advance from general views to minute details. In geology this is particularly the case, but with this important advantage, that whereas in botany, entomology, and various other branches of natural history, it is only occasionally that new and important practical results can be obtained, of such a nature as to have any direct bearing on the welfare of mankind,—in geological pursuits, the whole scope and object of inquiry is intimately connected with the very existence of the human race. The dust of which we are formed and to which we must return—the sustenance derived whether from animal or vegetable food—the raiment which we wear—the fuel which warms—the houses which protect us—the implements employed in agriculture, and mechanical arts—the trees which ornament the land and form the bulwarks of the ocean—all these have not a remote, but an immediate dependance on geological conditions. Climate greatly depends on the elevations and depressions of a district, and the conformation of its coasts and the navigation of its rivers are also dependant thereon. Thus there is scarcely any subject relating to the physical conditions which affect our comfort and prosperity that is not closely identified with geology; and hence it follows that detailed information on geological features must ever be considered as a valuable accession to human knowledge.

If the leading results of geological investigation are thus widely extended, it is equally obvious that its connection with agriculture and mining are of the first importance. In these departments it is that exact specific information should be collected, and for obtaining such specific information nothing can be more admirably adapted than the sections presented by railway cuttings, and by borings and sinkings. The exact nature and depth of the soil and substrata, the rocks and clays beneath, and in short the geological structure of the district, is matter of information, the value of which is now becoming more and more appreciated, and fresh discoveries of the relations existing between chemistry and agriculture may render an intimate knowledge of geological structure still more important. Railway cuttings afford this species of information in the most satisfactory manner, but they afford it only for a time. Even in an agricultural point of view it is worth the attention of the landowner to preserve such a record. What now appears merely interesting, may, in a more advanced state of science, be important, and carefully preserved sections may form a body of evidence indicating the direction in which drift has been carried, and thus leading to further generalizations connected with the sources whence the soil has been derived; for, as Professor Sedgwick has justly observed, it is not so much a knowledge of the geological structure lying beneath him, as a knowledge of the general law which has prevailed when the soils, or the materials which compose them, were distributed over the face of the country, that will benefit the agriculturist. Occasions may often arise when the agriculturist would gladly ascertain the general nature and disposition of the stratification; and the preservation of railway sections, in a local museum, would afford much valuable information of this kind. They would open to every farmer, in the vicinity of a railway cutting, an opportunity of learning a practical lesson in geology; and many, who from want of information or other causes, cannot now derive benefit from the actual sections on the sides of a railway cutting, may a few years hence appreciate the value of this information, and deeply deplore that the opportunity is lost for ever.

If railway sections are interesting and valuable, as indicating the nature of the earth's surface in relation to agriculture, they are still more important as regards the general nature of geological structure, and more especially the position and inclination of such rocks as are connected with mineral treasures. Geology is a science of facts, and the accumulation of well ascertained data is the surest, indeed the only way to arrive at correct conclusions. It will, therefore, appear at once that a collection of accurate sections cannot fail to throw much light on all investigations of geological structure. Who that has had even the passing glance which a railway transit affords of the magnificent sections on the North Midland Railway, but must be convinced of the importance of having them transferred to paper, and preserved as one of the most instructive lessons which art has yet afforded to the geologist and miner! while the extensive mining operations, which have been commenced by Mr. George Stephenson, point out more strongly than any comment, the close connection which exists between an exact knowledge of the conditions of strata and those subterranean operations which are essential to our existence as a nation.

The importance of preserving mining records has been duly appreciated by the British Association, and very satisfactory progress has been made by the Committee appointed by that body, at Newcastle, in 1838. Arrangements have been made in connection with the Museum of Economic Geology, under the able superintendence of Mr. De la Beche, and the subject will doubtless ere long receive the attention which it deserves, as one of the elements of our commercial greatness. To such records of the deep and rarely accessible parts of the mineral strata, the sections of railway cuttings, and of borings and sinkings, are a most useful auxiliary, and both are entitled to the attention not only of scientific bodies and parties locally interested, but to the notice of the legislature, upon whom it especially devolves to take every prudential measure that can promote the future prosperity of the kingdom.

To dwell upon, or even to allude to the exceedingly valuable nature of documents of this kind, must seem to every one conversant with the subject, like proving that light is better than darkness, or knowledge preferable to ignorance. The most eminent geologists and miners have expressed their opinions with great clearness, and with an earnestness proportioned to their conviction of the importance of the subject. I have quoted several of these opinions in a work which has been some time before the public; but, though there is a general concurrence in the utility and importance of such geological and mining records, there is far from being any active progress made in furtherance of the end in view. Individuals are with difficulty induced to labour for remote advantages; the engineer is too fully occupied with the immediate objects of his professional duty, to have much time to devote to the geological features of his work; and thus, until some further arrangements are made, comparatively little progress can be expected in obtaining accurate sections of railway cuttings.

In the mean time, however, the opportunity is passing away, and if much is not to be expected, still something may be done. In societies like the present, there are usually found many who have both the will and the power to labour in the field of science, and who probably only require to know the objects proposed, to devote a portion of their time and energies to them.

And here I will take occasion to remark, that in this respect, that is to say, in directing the labours of scientific individuals, the British Association has been eminently useful. Many persons, who prefer forming their opinions from the vague and distorted statements in newspapers, to inquiring and judging for themselves, are apt to form an erroneous idea of the proceedings of the British Association, and to suppose, that unless some new and astounding revelations in scientific pursuits or mechanical inventions are propounded at each meeting, the institution has failed in its objects. I think, however, it deserves attention, that the chief utility of its proceedings consists not in the assemblage of its members, nor in the matters which are incidentally brought before the sectional meetings, but in the encouragement which it munificently affords to useful objects in the various departments of art and science. The investigations of the ablest scientific men are pursued from day to day and from year to year, with funds furnished by the Association, and its harvest of science is not to be looked for in its crowded meetings and hospitable re-unions, but in the volumes of its transactions, which are yearly printed, and in the promotion of useful objects effected through the influence of its recommendation. The subject of this paper is an example of the latter. The chart which I now produce, is engraved for and under the immediate superintendence of the Committee appointed by the British Association, and I doubt not that in this district, so rich in mineral productions and so rich in natural sections, many highly interesting copies of such sections will be prepared before the next meeting of the British Association. These sections will form an important and useful portion of the Museum of this Society, and if lent for a short time to the Museum of Economic Geology in London, copies of them will be made for that Institution. In order to draw attention to the practical means of effecting these objects, I shall point out a few of the leading considerations which have had the attention of the Committee.

In the first place, then, uniformity is an essential element in a collection so extensive as this will necessarily be, if it receives the attention which the subject demands. In order to secure this, it was thought expedient to print a number of blank charts, to be supplied to all persons employed in measuring and delineating sections; so that, being bound in volumes on a regular and systematic arrangement, an easy reference might at any time be made. These blank charts are to be had on application to Mr. Jordan, at the Museum of Economic Geology, in Craig's Court, Charing Cross, London; or to the Secretary of the Institution of Civil Engineers, 25, Great George Street, Westminster, by any parties who are willing to contribute any share of information in the form of sections drawn and coloured on these blank charts.*

The scale on which these charts are constructed is 40 feet to an inch, which is as small as can be employed with clearness; and to have made it larger would have caused an inconvenient area to be occupied by the drawings. A stratum four feet thick thus appears one-tenth of an inch in thickness, according to this scale, and this is amply sufficient to represent any seams of coal or other conspicuous objects. The chart extends 800 feet in length and 600 feet in height, according to this scale. At first sight it may appear that as a scale of length this is unnecessarily large, as nearly seven sheets will be required to represent one mile of section. It must be kept in mind, however, that it is only in a few particular places that the cuttings present instructive sections, and that the desired collection by no means involves a continued drawing of many miles of cutting. If this were so, it would become necessary to adopt one scale for the horizontal distance, and a greatly enlarged scale of heights. Sections, thus constructed, are indispensable for engineering purposes, but ought to be avoided as much as possible in

* These blank charts will be furnished by the Secretary to any one who will undertake to fill them up

geological sections. The distortion of scale completely prevents the very intention of the section, which is to convey a correct idea of the relative thickness and inclination of strata. In surface models, where the intention is to afford a general idea of a district, it is sometimes desirable to enlarge the vertical scale, and this was done in the model of Dean Forest, which, on a former occasion, I had the honor of submitting to this Association. Since that time I have constructed a model of the principal coal field of that district on the natural scale: the result is, that though the latter is unquestionably the correct and most scientific mode of construction, yet it gives a fallacious idea of the nature of the surface—the steep hills and narrow valleys of that romantic forest sink into gradual undulations, which would never be recognised as the type of a picturesque country; and the two models, which are now placed in juxta-position, in the Museum of Economic Geology, afford a good practical lesson as regards the proportionate scales to be employed. To give to the mind a graphic idea of a country, the vertical scale should be increased about three times; but when the object is to convey to the mind clear ideas of the geometrical relations of the surface as they are in nature, and not as they are presented on the retina, then a uniformity of vertical and horizontal scale is to be observed. In geological sections, however, nothing but necessity can justify the distortion of scale, and the Committee, fully aware of the great scientific value of correct proportion, decided that the charts should be constructed accordingly, so that the drawings thereon should be a faithful transcript of nature.

Another advantage proposed to be gained by the form of chart engraved by the Committee is, that, ranging as it does 600 feet in height, it admits of each part of the railway being shown at its proper elevation above the datum line of the railway, and also the rate of ascent. Thus, if the datum or base line on which the sections of the railway were originally made, is Trinity high-water mark, the commencement of the railway may possibly be 70 feet above such datum. If the railway rises 30 feet in a mile, a line drawn from 70 on the left side to 74.5 on the right will represent at once the true inclination of the railway, and the height of each portion of it above Trinity high-water mark. On the next sheet, supposing the section continued, the line will begin at 74.5 on the left and rise to 79 on the right. If now an interval of ten miles occurs, in which there is no valuable geological information afforded, and in which the rate of ascent is uniformly 30 feet in a mile—if a drawing is to be made of a cutting at the end of the ten miles, the line of railway will begin at 79 ft. + 300 ft. = 379 ft. on the left hand, and rising to 383.5 ft. on the right. In this manner, at whatever part of the railway a cutting occurs, it may at once be placed in its true relation to the base or datum line. When the general section of the cutting is thus drawn along the chart, there will always remain a considerable portion of the sheet unoccupied—the deepest cuttings will rarely occupy more than two inches in height, and whether this is near the top, or middle, or bottom of the sheet, (according as it is more or less elevated above the datum line,) matters not, as there will in any case be space left for two purposes, viz., to delineate any remarkable developement of thin strata or other peculiarity of structure on an enlarged scale of four feet to an inch, and thus all inconvenience arising from the minuteness of the general scale is entirely avoided; and on a still larger scale of delineation, to represent any fossils that are found within the limits of the section. The latter may either be the true size of the fossil, or magnified or diminished according as the dimensions may render expedient.

A volume of accurate sections, with enlarged details of strata and accurate drawings of fossils, would be a valuable acquisition to every local museum; and as a knowledge of science advances, there is no doubt the means of extending it will rapidly increase. Thus in the compass of the last few months an admirable adaptation of the process of electrotyping has been made to a geological purpose, viz., the obtaining cheap and perfect fac-similes of fossil remains. By this process, several beautiful examples of which (produced by Mr. Jordan) were exhibited by him at the last meeting of the British Association, it is not too much to hope that local museums may be furnished at a small cost with accurate transcripts of the very best specimens of fossils, and this would add fresh interest and value to the drawings of fossils proposed to be kept in connection with the sections of railway cuttings.

Uniformity of colour is also highly desirable, but less important than uniformity of scale. Several specimen sheets have been prepared, and may be had on application, as already described. The colours used in Mr. Greenough's last edition of his geological map of England and Wales, or in Mr. Murchison's Silurian System, will afford a good scale of colour to those who are possessed of these works. The colours used in the Ordnance Survey may be adopted, or each artist may employ his own judgment, provided, however, that in every case each sheet shall contain a written description of the rocks, &c. represented by each colour, and also consecutive letters or figures to distinguish the colours on the section and reference. If this is carefully attended to, it is not of material consequence what colours are employed, since in copying, at any future time, this can be easily improved upon. It is not so much for nicety of detail, that attention is now urged, but for those more important geometrical data, which can only be obtained by measuring the strata while they remain exposed to view, and by accurately delineating them on a uniform scale.

The British Association has already granted a sum of £200 in furtherance of the objects I now treat of, and to this sum it is hoped that a further addition will be made if the progress of the collection shall prove to be commensurate with its interest and importance. It will be gratifying to the Committee, at the next meeting of the British Association, if the seed they have endeavoured to sow in the shape of blank sections, shall bring forth the good fruit of those accurate records which the talents and perseverance of many members of this Society are so likely to produce. Those who are interested in the mining operations of this part of the kingdom, cannot but see how valuable and how practically useful is every section that throws light on the stratification of the coal field—its inclinations, its disturbances. Not only are the great features of anticlinal and synclinal axes clearly developed, but even the lesser faults—the gradual thickening or diminishing of strata—the occurrence of rocks usually identified with particular seams of coal. All these are matters which closely concern the coal and land owner, independently of the more general advantages in a scientific point of view. Those gentlemen who have recently bestowed attention on the relations existing between geology and agricultural pursuits, would turn with ardour to pages so fraught with information as those I have endeavoured to describe. The approval of a Society established as this is, for the attainment of objects so closely identified with those which the British Association have endeavoured to encourage, will tend much to further the interests of geology, by directing attention more widely to the subject.

Equally important is it, that the members of this Society should use their influence in collecting and preserving copies of all borings and sinkings made in the district. The small chart which accompanies this paper is a convenient form for drawing such sections on a uniform scale; the lines and writing upon it sufficiently explain its object and mode of being used for drawing sections. The copper plate which I had made for my own use, is at the service of any member of this Society, and I have ascertained from the engraver, Mr. Collard, of Newcastle-on-Tyne, that impressions can be sent by post, pre-paid, at the cost of 10s. a hundred. By sending a post-office order, therefore, for 5s., 10s., or 15s., to Mr. Collard, 50, 100, or 150 copies of this lesser chart may be had at any place by post, without further expense. Contributions of accurate sections, in this or any other convenient form, will, in time, become a valuable local record, and tend to familiarize the public with those geological details, which, on a larger scale, are sought to be obtained from railway cuttings, and, on a still larger scale, from accurate records of mining operations. The charts which I have described, simplify the process and secure uniformity; the one can be had, through the munificence of the British Association, gratuitously, and the other for the mere cost of paper and printing; and, I doubt not, that if the opinions of the able and intelligent members of this Society coincide with those expressed in this paper, that at future meetings of this Society, and at the next meeting of the British Association, many of these engraved charts will picture forth with geometrical accuracy and graphic colouring, the important and highly interesting details of the geology of the midland districts of England, to be studied by the agriculturist, the miner, the engineer, the geologist, and by all who recognise in a correct knowledge of subterranean wealth, the strong foundations and only lasting means of preserving, what the late President of the Geological Society has justly termed, "our country's exalted position among the kingdoms of the earth."

T. S.

GEOLOGICAL MODELS.

Mr. Sopwith next exhibited and explained a series of geological models, which he has recently constructed for the purpose of facilitating the study of geology, and the nature of several phenomena which cannot be clearly understood without having recourse to solid forms, capable of being dissected and re-arranged in conformity with the existing types in nature which they represent. Owing to the length of the previous discussions, Mr. Sopwith's explanation of these models was not commenced until the hour of adjournment had arrived, and many persons were on the point of departure; it was therefore in a great measure confined to answering the inquiries of the noble Chairman, and to a brief description of the models given to his Lordship and a few members who remained. In consequence of the interest then expressed, Mr. Sopwith intimated his willingness to bring them forward the next time he should have the pleasure of attending one of the meetings of the Society. For the present, it may therefore suffice to say, that these models, twelve in number, were selected by Dr. Buckland from a series of models constructed by Mr. Sopwith, being such as that eminent geologist considered best adapted for the general student. They consist of nearly six hundred separate pieces of wood, fitted together so as to represent various conditions of strata—the effects of denudation, the displacement of strata by faults or dislocations, and the peculiar effects produced in valleys by the relative steepness of strata, as compared with that of the surface. Engravings of three of these models may be seen in the last edition of "Lyell's Elements of Geology," and sets of them have been prepared for sale, the particulars of which may be obtained on application to Mr. Sopwith, Newcastle, or to his agent in London, Mr. Tennant, 149, Strand. Of the utility of such models as lessons in geology, a high opinion has been given in Dr.

Buckland's annual addresses when President of the Geological Society; and the Institution of Civil Engineers, in October last, awarded a Telford medal in silver to Mr. Sopwith for his communication on the use of such models in connection with civil engineering and geology.

ELECTROTYPED COPIES OF FOSSILS.

Mr. Sopwith exhibited several specimens of fossils copied by the electrotype process, by Mr. T. B. Jordan, of the Museum of Economic Geology,* in London. The thin deposit of copper which is formed on the wax or plaster cast from the original fossils, conveys an exact idea of the minutest details of structure, and Mr. S. pointed out that by these means correct copies of the best specimens of fossils could be multiplied to an indefinite extent, at a small expense, and every village museum might thus obtain electrotyped fossils, corresponding to those which adorn the cabinets of the Geological Society, or of the most careful amateurs. He had also received from Mr. Jordan some beautiful specimens of copies of medals, which were laid on the table, and attracted much attention; and the application of this new and interesting art was shown to be capable of a still wider range, by an egg cup which had been entirely formed by the electrotype process. This specimen of Mr. Jordan's ingenuity shows very clearly that works of art of the most costly description can be multiplied to a great extent, and a richly ornamented urn, gold cup, or

* This Museum, established by Government in Craig's Court, London, is under the direction of Sir Henry De la Beche, whose arduous and untiring exertions have for many years been devoted to the practical applications of Geology to Architecture, Agriculture, and the Arts, and by whose zeal and judgment this establishment promises to be one of the most valuable additions to the means of acquiring a scientific knowledge of the various qualities of stone—the processes used in various manufactures, and in the various and extensive applications of Economic Geology.

teapot, may, by the sure process of the electro-deposit, be formed as soon and as cheaply as a design however plain. Polished copper plates for engraving upon can be deposited at a cost of three shillings per pound, and this price leaves a fair profit to the tradesman. Engraved copper plates can be copied for eight shillings for each pound of copper—that is to say, four shillings for the matrix, and four for the copy—as the first of these, containing the lines in relief, is nearly as heavy as the second, or copy for engraving from. Thus a copper plate, which has cost £100 to engrave, may be faithfully copied for as many shillings. The process is applicable to many elaborate forms of metallic vessels, and hence, Mr. S. observed, we may conclude that it will, ere long, find its way into the workshops of our manufacturers.

A vote of thanks was given to Mr. Thorp, Mr. Wallen, and Mr. Sopwith, for their respective papers.

At the conclusion of the meeting, Mr. Biram exhibited a model of an improved piece of machinery for landing coal corves.

PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE SIXTEENTH MEETING, HELD AT HUDDERSFIELD, ON WEDNESDAY, THE 2ND OF DECEMBER, 1841.

On the motion of THOMAS PITT, Esq., seconded by WM. WALLEN, Esq.

Dr. WALKER, of Huddersfield, was called to the chair.

The CHAIRMAN, after expressing his satisfaction at the visit of the Society to Huddersfield, and his conviction that, as its objects became more known in that town, it would be sure to receive more support—continued as follows:—It was quite natural that Huddersfield, which owed its position in the commercial world to its mineral wealth, should take a leading part in support of an institution so well calculated to improve their knowledge of the subterranean resources of the country, and to render these elements of art and industry accessible to the labour of man. It was impossible to explain in how many ways the study of geology was most desirable at the present period. He might rest its claims to support on the tendency of such studies to elevate the mind, to improve the reasoning faculties, and, above all, to raise their thoughts to the great Architect of the universe, who had so liberally provided for the wants of man. But on the present occasion he would endeavour to confine himself to the utility of the society in advancing the agriculture and commerce of the country.

He had been asked, "of what use are the meetings of this society, and what are its objects?" He would answer these *cui bono* philosophers by referring them to the papers which had been read within the last two years; and if he were called upon to select one individual whose papers were more especially deserving of notice, he should refer them to those masterly productions of Mr. Thorp, in which he had shown the intimate relation subsisting between the productive properties of the various soils and the nature of the subjacent strata. If the society had effected nothing beyond the production of those papers, it had done that which entitled it to the support of every friend to his country. It was gratifying to find that the alarms felt by some with regard to geology were fast giving way to a more correct knowledge of the subject, and so far from being a dangerous science, it had proved to be subservient to the truth as established in the sacred volume. Neither was it amiss to observe that geology had opened the eyes of a great portion of the community who had previously known nothing of the earth. What had geology shown? Why, that the earth was loaded with riches for the benefit of man, which, however, would have remained useless, unless they had been placed in their present position. Take building stone, for instance, which was accessible every where to the labour of man. They every where saw in the geological phenomena which presented themselves, proofs of their wonderful relation to the human race. How was it that they every where found coal associated with beds of iron ore, and, what was still more extraordinary, usually contiguous to lime stone, which was necessary to flux the iron ore? Without this advantage, they would have been incapable of availing themselves of a great part of their metallic riches. The same proof of design was seen in what were called faults in the coal strata, which rendered the coal more easy of access. Many such instances might be adduced, showing how much the population, the commerce, and the maritime power of the British empire depended upon these provinces of subterranean wealth, infinitely more important and valuable than all their colonies, whether in the East or in the West—provinces, which the chances of war could not wrest from them, and which required no military array to secure. He begged to remind the meeting, that formerly, in many parts of England, trials had been frequently made to reach coal by shafts sunk through strata, now known invariably to occupy an inferior position to the coal measures when both were present. How many thousands might have been saved, had such a society as this existed some years ago! How often had it happened that a little black slate or a piece of lignite had led to futile attempts, at immense loss, such as no accomplished geologist would have sanctioned! Look again at the advantages geology afforded in selecting building materials. Take for instance the various kinds of freestone; in some, the cementary matter was silicious, in others, calcareous, or oxide of iron. They might all look the same at the quarry, but in a few years' exposure to wind and wet, the difference was evident, either in the colour or porosity of the stone. But he would not detain the meeting with observations of this sort. He most strenuously recommended that specimens from every quarry should be sent to the Museum of this society, as well as from every coal pit, so that by collecting information from every quarter, they might glean some useful results. In foreign countries, where the capital invested in mining was much less than their own, the greatest advantages had accrued from schools of instruction for persons embarking in mining pursuits. The Geological Society afforded the best opportunities for improvement in this respect. He wished it to be understood, however, that the society was not merely for geological purposes, but under the polytechnic department, it opened its doors to the whole circle of the arts and sciences, and the meeting would that day have a paper on the subject of Gothic Architecture, which he was sure would give satisfaction to those who were present, and unfold some important views on the subject, which were little understood by architects in general.

The following gentlemen were elected members of the society :—

James Hammerton, Esq., Hellifield Peel, Skipton.
William Hey Dikes, Esq., F. G. S., Wakefield.
William Leatham, Esq., Heath, Wakefield.
Frederic Robert Jones, Esq., Birk House, Huddersfield.
Bentley Shaw, Esq., Woodfield House, Huddersfield.
Thomas Hardy, Esq., Birksgate, Huddersfield.
Thomas Nelson, Esq., Huddersfield.
George Simpson, Esq., Huddersfield.
John Clay, Esq., Huddersfield.
William Moore, Esq., Huddersfield.
Mr. George Hanson, Huddersfield.
Mr. Samuel Makin, Huddersfield.
Mr. John Moxon, Huddersfield.
Mr. Robert Welsh, Huddersfield.
Mr. Wm. Dewhirst, Huddersfield.

The following resolutions were also passed :—

1. That the next meeting be held at Sheffield, on Wednesday, the 2nd of March.

2. That the thanks of the Society be given to the Philosophical Society of Huddersfield, for their kindness in affording the use of their Hall on the present occasion.

3. That the thanks of this Society be given to the Local Committee, for their active exertions in making arrangements for the meeting.

Mr. West, of Leeds, in proposing the third resolution, said he was aware that it was not a common custom to make a speech on such a motion as this, nor had he any intention to do so, but a few words of truth and common sense the meeting would probably give him credit for. He had overheard a whisper from a gentleman in the room—"You haven't got all Huddersfield here;" and again, "The misfortune of these societies is, that you can't make them popular." Now, undoubtedly, they could not make useful and valuable statements of scientific facts and records of observations or experiments as popular as the ballad of Chevy Chase, which, although highly amusing, contained very little instruction. If the object of the local committee of this Society had been to fill the room to overflowing, they ought to have provided a paper on the genius of some particular author. He meant no disparagement to literature, for those who knew him would be well aware that he put in a claim to some interest in literary as well as scientific pursuits. If, therefore, they merely wanted to fill the room, they had better have had lectures on music, or have introduced two political partisans, which would, doubtless, have accomplished the object. The question was, not what would fill the room, but what would be most useful to the neighbourhood of Huddersfield, and particularly to the entire community of the West Riding. He believed that nothing which the society could do, would be more useful than the collecting and recording of real experiments and real observations. He should not have made these observations, if he had not thought it possible that the local committee and others interested in the society might imagine that they had not done their utmost, because "all Huddersfield" was not present at the meeting. He thought they had no need to be discouraged, and he therefore begged to move a vote of thanks to them for their arrangements.

The motion was seconded, and carried unanimously.

The Secretary stated that at the next meeting of the

Society it would be proposed that the Council have power to fix the June meeting so as to follow the meeting of the British Association in Manchester, in order that the meeting might have the presence of a number of distinguished geologists. Dr. Buckland had promised to attend.

Mr. Wilson then referred the meeting to Mr. Greenough's splendid Geological Map of England and Wales, which was exhibited in the room, and which the society had just purchased.

OBSERVATIONS ON THE YORKSHIRE DRIFT AND GRAVEL, BY JOSEPH TRAVIS CLAY, ESQ., RASTRICK.

At the June meeting of this Society, I read a short paper on the occurrence of boulders of granite in the vale of the Calder, near Halifax, when I alluded to those deposits of clay with erratic boulders which are generally known by the appellation of Diluvium, or Drift.

I have now to request your attention to a more particular inquiry into this formation, which is interesting both as indicative of considerable changes having taken place at a very recent geological period, and also from the great discussion and various theories to which it has given rise.

The accumulations of removed matter which occur very extensively, not only in many parts of Great Britain and the northern countries of Europe, but also on the continent of America, under all circumstances maintain a great similarity of constitution—their general character being the assemblage of pebbles and boulders of the harder rocks (more or less rounded by attrition), dispersed amidst a mass of clay or sand, without any appearance of stratification or order. This confused disposition of the fragments has given rise to the idea that a force of such power has been required, as would overcome the specific gravity of the various component parts; and as the action of a vast deluge has been thought to be the only one which could explain the phenomena, the term Diluvium has been, till lately, generally recognized.

In no part of Great Britain can this boulder formation be studied more effectively than in Yorkshire and Lancashire, both on account of the large extent of country covered by the deposits and the various aspects which they present to our view. I shall, therefore, almost entirely confine my remarks to instances which occur in these counties; and before entering into the discussion of any theory, I will endeavour to explain the varied forms which these accumulations of removed matter assume. For this purpose, I shall make three divisions, which I consider to be essentially distinct, both as regards their appearance and mode of deposition. These are—First, the immense *unstratified* mass of clay, interspersed with boulders and pebbles derived from distant rocks, which covers the vale of York, and conceals many parts of the regular strata in the east of Yorkshire and also in Lancashire. Secondly, the *stratified* deposits of sand and gravel which are frequently superimposed upon the first division. Thirdly, the hillocks and terraces of *unstratified* matter which occur in many of the northern valleys.*

My first division coincides with that termed by Mr. Phillips "the proper diluvium," and is accurately described by him in the first volume of the "Illustrations of Yorkshire," and also in his treatise on Geology in the "Cabinet Cyclopædia." At page 20 of the "Illustrations," he enters into a minute investigation of the diluvium of Holderness, and in the

* The recent deposits of fresh water origin, which are found in many localities, being attributable to totally different causes, are not referred to in this inquiry.

succeeding pages gives the result of a very careful examination of the coast line of Yorkshire, and describes the accumulations which are visible on many of the cliffs between Bridlington and the mouth of the Tees, tracing back to their native districts the various fragments. Thus Shap Fell has contributed its peculiar porphyritic granite; Carrock Fell its sienite and greenstone; the Grasmere Mountains their amygdaloidal and brecciated grauwacké; Kirkby Stephen its calcareous breccia; Teesdale its greenstone; and western Yorkshire its limestone, sandstone, and coal; other fragments are referred to Scotland and Norway. In addition to the great variety, the immense size of some of the blocks is deserving of notice, many weighing not less than three-fourths of a ton.

A deposit precisely similar occupies the whole of the vale of York, extending beyond the river Tees into Durham, for the observation of which the works on the Great North of England Railway offer great facilities. In Lancashire also, it occurs in abundance, particularly in the district of the Fylde and the neighbourhood of Preston.

From the description of the fragments of rock which I have just read, it will be evident that they have generally come from the north or north-west, which naturally gave rise to the idea that they were removed by the action of a violent flood having that direction; this also applies to the vast accumulations on the continent. Some years since Dr. Buckland wrote an elaborate work entitled, "Reliquiæ Diluvianæ," to prove that they originated from the deluge recorded in scripture; but on more mature examination, he was compelled to give up the idea. Still the theory that a flood of water was the agent, remained, and has been upheld by many geologists, among whom we have some eminent names; but its supporters have always found very great, and, I think, insurmountable difficulties, in their explanations.

No writer has entered more minutely into this subject than Mr. Phillips, and as his works are in general circulation, I will refer to them as explanatory of the line of argument adopted by those who entertain the diluvial theory. In the first volume of his Treatise in the Cabinet Cyclopædia, he discusses at much length the subject of drift and erratic boulders, and after detailing the localities and appearances assumed by the drift, he gives his judgment in favour of its having been removed by a sudden rush of water; but when he seeks for a cause by which the required quantity could be thrown over the land, he is obliged to assume the existence of forces of which we have not the slightest evidence.* A line of argument which requires such support, should not be received without the exercise of great caution; and I never read this section without the conviction that it must be unsatisfactory, even to its author.

Let us, therefore, enter into an examination of some of the difficulties which beset our inquiry,—and first, as to the direction which the boulders have taken. Some of them are of so marked a character, that we can determine with ease the rock from which they have been severed; and although we find that their general course has been from the north or north-west, yet that direction is by no means universal. According to Mr. Phillips's own showing, blocks of the peculiar granite of Shap Fell are found to the north and east of that mountain, proving the existence of some other force than a current of water from the north. One of the most notorious is in the main street in Darlington, (60 miles due east,) and as it weighs nearly two tons, we cannot ascribe the direction of its course to an accidental eddy.

Another embarrassing circumstance is the fact, that in many instances the boulders have pursued their course from the parent rock, with little regard to the obstruction which

* See Cabinet Cyclopædia, vol. II., page 272.

hill and valley have interposed: thus, the detritus from the Cumberland mountains has had to surmount the summit ridge of Stainmoor, which, at its lowest point, is 1400 feet above the level of the sea, or 900 above the vale below; and in Lancashire, Morecambe Bay has been crossed. But when we come to consider the depths of ocean which intervene between the mountains of Scotland or Norway, surely some other explanation is required.

The discovery of erratic boulders in the neighbourhood of Halifax, also adds to the confusion, for there appears to be no conceivable mode by which a current of water could carry them along the tortuous course which would be required to reach the upper parts of the valley of the Calder, and as all parties agree that they have not passed the summit ridge south of Stainmoor, they must have entered by the foot of the valley.

The same difficulty presents itself on the Lancashire side of the hill, for Mr. Thorp informs me, that boulders of a similar description have been found at Tintwistle, which is far removed from the direct course of a north and south current.*

I now come to my second division, viz.,—the superficial gravel and sand which frequently occurs above the principal body of drift. Mr. Phillips states his opinion, that both are due to the same agency, under different degrees of intensity; but when I consider the very marked distinction of one being, with scarcely any exception, devoid of the slightest appearance of stratification, while the other is subdivided into a multiplicity of clearly defined strata, I cannot concur in this view.

I again refer you to Mr. Phillips's "Illustrations" for a

* Since the meeting Mr. Wallen has informed me, that in digging the foundations for the new church at Holme Bridge, near Holmfirth, several pieces of granite were found.

very detailed account of the stratified deposits of the East coast, and will confine my remarks to other localities. I have attentively examined two very interesting instances of this class on the line of the great North of England Railway, where the gravel beds have been extensively worked for the purpose of obtaining ballast. At Cowton, about eight miles south of Darlington, the gravel is composed of pebbles of various sizes, intermingled with sand in continuous layers, the laminations constantly dipping to the south at a considerable angle. At Thirsk the constitution of the gravel is much more variable than at Cowton; many seams of sand of various colours, and great diversity of grain, with beds of rounded pebbles, lying at different angles, but generally not far from horizontal: many of the strata are very finely laminated, and are like successive tidal deposits, portions of which appear to have been afterwards removed, causing the succeeding layers to be arranged at a different angle,—altogether evidencing the existence of a long-continued and comparatively gentle action of water.

The predominant pebbles here are from the lias and oölitic hills to the east, with many lias fossils partially rounded; also traces of coal, and occasional small pieces of granite very much rounded, entirely different from the fragments enclosed in the subjacent stratum, which is the general red clay, interspersed with boulders, some of large size, and but little worn by attrition, affording undeniable proof that these appearances result from operations of a totally distinct character.

Since writing the preceding remarks, I have visited the coast of Lancashire, in order to see how far the deposits of drift in that district coincide with those already described, and it was satisfactory to find the distinguishing features of the two divisions strikingly marked. The cliffs north of Blackpool offer very favourable opportunities for examination, and we there see the peculiarities of this formation beautifully developed. About two miles north of Blackpool, at a projecting point of land, the main body of drift (Mr. Phillips's "proper diluvium") appears at the base of the cliff, with its well-marked characters, a hard red clay, with boulders and pebbles of granite and sienite of various kinds, and a vast diversity of other hard rocks, all interspersed without the slightest regard to size, varying from blocks weighing a ton, to pebbles the size of a marble. Above is a series of innumerable strata or layers of sand and gravel, differing greatly in colour and in size of grain; some of the divisions being pure fine sand, very valuable for building mortar, others entirely composed of pebbles: many of the beds have evidently been exposed to the effects of denudation, as was observed at Thirsk. Proceeding southward, the clay deposit is lost by the inclination, and re-appears after a short interval, again to sink beneath the level of the shore; and here I was surprised to find a deposit of clay and pebbles above the sand and gravel, the only apparent difference between it and the lower formation being a slighter degree of induration; and the action of the rain has had the effect of softening it to such a degree, that in many places masses have slipped over the face of the subjacent strata, in such a manner as to render it difficult to obtain correct observations.

Near Fleetwood I observed some beds of shells in the sand, several feet above high water mark, and I am informed that they occur in great abundance in the Blackpool cliffs.

Before attempting any explanation of the causes which have influenced these deposits, I will proceed to the third division of my subject,—the hillocks and terraces of disturbed materials, which occur in many of our northern valleys; and although they have till a recent period escaped attention, I believe they will furnish a clue by which we may unravel the difficulties which have hitherto surrounded our inquiries; and this brings me to a consideration of the keenly disputed glacial theory.

Many years since Mr. Lyell attributed the removal of erratic blocks to the agency of floating ice, and adduced other proofs of the former existence of a greater degree of cold than now obtains. In this view he has been supported by Mr. Murchison and some other geologists, but the subject did not gain general attention in this country, before the publication of M. Agassiz's observations on the glaciers of the Alps. After reading a paper descriptive of the phenomena which they exhibit, at the Glasgow Meeting of the British Association, he travelled through a considerable part of Scotland, in company with Professor Buckland, when he discovered many evidences of the former existence of intense cold.

The hillocks of detritus which occur in such immense abundance in many parts of his route, were pronounced by him to be identical with similar mounds now formed in the valleys of the Alps, by retreating glaciers, and which are known by the name of *moraines*.

A few miles above Middleton-in-Teesdale, on the division line of Yorkshire and Durham, are some very good examples. The ranges of hills on each side of the valley are flanked by smooth terraces of removed matter, completely concealing the true strata of limestone and sandstone, which form bold angular projections when left bare; and in many places large mounds, sometimes of such magnitude as to claim the appellation of hills, obstruct the course of the river, which has to wind its devious way at their feet. The miners have given the name of "slipped stuff" to this detritus, which contains many boulders of the harder rocks, as the basalt of Caldron Snout, interspersed amid a mass of finer matter, resulting from the disintegration of the softer rocks. In the valley of the Lune, near Sedbergh, also in this county, I have seen large tracts covered with the same formation. Near Kendal, erratic blocks of large size are frequent, and the whole line of country between that place and Lancaster is covered with drift. An examination of these districts will, I think, convince any one that the action of a current of water could not be the only agent employed, though in some of the lower situations, there are instances in which a subsequent arrangement of the materials has taken place.

I will not weary you with a detailed account of the various arguments brought forward by the partizans and opponents of the glacial theory, and will merely mention a few of the numerous facts which have been collected by individuals in distant localities, all of which prove that the temperature of the sea in these latitudes is now higher than it was at the time when these deposits were formed.

Mr. Smith, of Jordan Hill, near Glasgow, in his observations upon the superficial beds in that neighbourhood, describes them as being very similar to those in this county, viz., uppermost, sand; next, brick earth, interlaminated with sand; then a bed known in Scotland by the name of *till*, containing boulder stones. He then states that he has discovered, at an elevation of forty feet above the present shores, beds of shells, containing eighty-five per cent. of species now existing; those of extinct species resemble shells from Canada, and indicate a colder climate at the time the animals existed.

We have similar evidence from Mr. De la Beche and Mr. Austen, both of them geologists of high standing in the south of England. Mr. Austen, in describing the raised beaches which frequently occur on the coast of Devonshire and Cornwall, says that among the shells found in them, are species which do not now exist in those seas, but which inhabit more northern latitudes; and adds the converse fact, that a portion of those living at the present time, are inhabitants of the Mediterranean, and are *not* found in the deposits, clearly showing a gradual increase of temperature.

Having previously stated my objections to the diluvial theory, I must now express my dissent from some of the views broached by M. Agassiz, for it appears to me that he has carried his theory to an unwarrantable extent, when he infers that great sheets of ice resembling those now existing in Greenland, once covered all the countries in which unstratified gravel now occurs.*

Supposing the existence of a glacial state even to a limited extent, it is evident that very different conditions are necessary to those which now exist; one of the most powerful would be a different distribution of land and water; and I do not consider that in the observations which have come under my notice, sufficient attention has been paid to the unquestionable fact, that a great elevation of land has taken place since the commencement of the tertiary era. That there has been a very considerable rise in the surface of land within a comparatively very recent period, is evident from many facts which have been made known without any reference to the present inquiry. Perhaps no geologist has devoted so much attention to this subject as Mr. Lyell, and as his works are in the hands of every one who has paid the slightest attention to the science, I will only refer to a few striking instances. Thus we learn, "That beds of shells have been found at Preston, in Lancashire, 350 feet above sea, and on a mountain called Moel Tryfane, in Wales, near the Menai Straits, at 1,400 feet above that level, which contain species indisputably the same as those which now people the British seas; and although on more accurate examination some slight intermixture of the extinct testacea will appear, yet the geo-

* See Report of the Glasgow Meeting of British Association in the Athenæum, No. 682.

logist will always refer them to the most modern tertiary era." Instances of a similar kind, though perhaps not to the same extent, are numberless. The raised beaches on the southern coast have been already referred to; there at various levels are found on the sides of the cliffs, deposits of pebbles and sand, containing shells identical with living species. In Scotland Mr. Milne mentions their occurrence near Stirling, at an elevation of 100 feet.

On the continent of Europe, analogous appearances are abundant. In Sweden, horizontal beds of sand, loam, and marl, containing the same peculiar assemblage of testacea which now live in the Baltic, are found at an elevation of 200 feet, and in the neighbourhood of Christiana, in Norway, similar deposits reach an elevation of 600 feet.*

Under these circumstances, I think that I am justified in assuming, that a general elevation of land has taken place since the deposition of the drift which is the subject of our inquiry. What then would be the condition of the northern part of Europe? A large extent of the present land would be submerged, leaving only the higher districts above the level of the water, and a great and important change of climate would result.

Mr. Darwin's Researches,† to which I referred in my former paper, afford satisfactory evidence as to the influence which a great body of water exercises upon climate; for when we reflect that this country, and the inclement regions of Cape Horn and the Straits of Magellan are situated in the same latitude, we must be convinced that other elements than distance from the equator, must be taken into consideration. "The height of the plane of perpetual snow in any country, seems chiefly to be determined by the extreme heat of

* Lyell's Elements, p. 295.

† Journal of Researches into the Geology and Natural History of the various countries visited by H.M.S. Beagle. By Charles Darwin, Esq., M.A., F.R.S.

summer, rather than by the mean of the year. As the summer in Tierra del Fuego is so very wretched, we ought not to feel surprised at the fact stated by Captain King, that in the Strait of Magellan that line descends to about 3,000 or 4,000 feet. In the northern hemisphere we must travel fourteen degrees nearer the pole to meet with so low a limit, namely, between 60° and 70° on the mountains of Norway."

When in latitude 55° south, equivalent to Newcastle, he says, "Early in the morning we arrived at the point where the Beagle channel divides itself into two arms, and we entered the northern one. The scenery here becomes even grander than before. The lofty mountains on the north side compose the granite axis or back bone of the whole country. They were covered by a wide mantle of perpetual snow, and numerous cascades poured their waters through the woods into the narrow channel below. In many parts magnificent glaciers extended from the mountain side to the water's edge. It is scarcely possible to imagine anything more beautiful than the beryl-like blue of the glacier, and especially when contrasted with the dead white of an expanse of snow. As fragments fell from the glacier into the water, they floated away, and the channel, with its icebergs, represented in miniature the polar sea."

He afterwards describes some of the immense fields of ice which came under his notice, one of them twenty miles long and five broad. Yet even in this inhospitable climate, vegetation thrives most luxuriantly, and large woody-stemmed trees of Fuchsia and Veronica, in England considered and treated as tender plants, were found in full flower, within a very short distance of the base of a mountain covered for two-thirds down with snow, and with the temperature at 36°. Humming-birds were also seen sipping the sweets of the flowers, after two or three days of constant rain, snow, and frost.*

* Darwin, p. 272.

Presuming, then, that the facts I have previously stated sufficiently prove, that towards the close of the tertiary era, the elevation of the land in this quarter of the globe was considerably less than at present, there would be a preponderance of water similar to that now existing in the southern hemisphere. We may imagine a large proportion of Europe to be submerged, while the mountainous districts of Scotland, and of the northern counties of England, would be covered with perpetual snow, huge glaciers occupying the valleys, and bringing the spoils derived from the rocky summits to the shores of the sea, into which icebergs would be continually cast, and floating away covered with detritus, would deposit it in their course, either by grounding in shallow water, or by their gradual dissolution, thus giving rise to an unstratified mass of clay and boulders.

By the elevation of the bottom of the sea, the shallower parts would approach the surface, and now a new system of action would commence,—currents, and the rolling of the breakers, would affect the upper portion of the deposit,—stratification would result,—layers of sand and gravel, similar to those now found on sand-banks and sea beaches, would be formed, and some of those superficial appearances which have been considered most difficult of explanation would be produced.

If I am correct in attributing the origin of my first and second divisions to these causes, we may consider the hillocks and terraces in our northern valleys, comprising my third division, to be true *moraines*, left by the glaciers, as they retreated before the increased temperature attendant upon the gradual elevation of land; and thus the varied appearances under consideration will have resulted from the same general cause.

I am aware that many objections are urged against the adoption of the glacial theory: one of the most powerful arises from the profusion of fossil fruits and other vegetable remains of a tropical character found in the tertiary deposits; but when we reflect upon the existing Flora of South America, this difficulty vanishes; for the most luxuriant vegetation there flourishes in the immediate vicinity of perpetual ice; and if, in addition to this, the former configuration of the land caused some considerable rivers to take a northern course, the spoils of more genial climes would be brought to a higher latitude. I do not think it necessary to notice similar evidences afforded by mere ancient formations, as the coal measures; for it is, and probably for ever will be, beyond the limit of geological investigation, to trace the changes to which this globe has been subjected during the countless ages which have intervened.

Dr. Wm. Alexander, of Halifax, observed that the theories advanced by Mr. Clay, if not conclusive, were extremely interesting, and calculated, if pursued, to throw much light upon a matter which admitted of considerable difference of opinion. Whether it was possible that the erratic blocks spoken of might have covered the summits of icebergs, he would not take upon himself to say, but it seemed to him that they had more easy means of explaining that fact than some others connected with the question. He had hoped that Mr. Clay's inquiries would have led him to some investigation as to the little drifts in the beds of the Calder. If he was to give an opinion as to their formation, he should say that they had been transmitted in former ages, when there was not the same uniformity on the surface. Some persons attributed them to the existing water courses and channels, whilst others believed them to be the effects of the deluge. It seemed to him highly probable that that change which excavated the earth, might have brought along with it those erratic blocks. He should be happy to co-operate with Mr. Clay, in procuring such specimens as they were able, and in that way to throw additional light on the subject.

AN ELUCIDATION OF THE GEOMETRICAL PRINCIPLES OF GOTHIC ARCHITECTURE, PART II.,* BY WM. WALLEN, ESQ., F.S.A., ARCHITECT, HUDDERSFIELD.

NORMAN ARCADES (EXTERNALLY.)

In resuming the subject of Gothic Architecture, I shall first notice the intersecting and interlacing Arcades (so frequent upon Norman buildings), as probably originating the idea of the pointed arch, for I think little reliance is to be placed upon the *accidental* form of the arch seen upon the coins of Berengarius, King of Italy, or in the Mosaics, previously to the tenth century; and I make this remark the more pointedly, as the examples of windows in York, Lincoln, and Beverley Minsters are complete parallels to the Norman Arcades of Norwich Cathedral, Saint John's Church, Devizes, and other examples: omit the pierced lights in the former (which are of the thirteenth century), complete the *intercepted* portions of the intersecting circles, and the examples are identically the same in principle. (Compare Nos. 4 and 5, plate 1, with Nos. 6 and 7, plate 2.) The transition example, plate 3, No. 10, clearly proves this.

With such proofs as these before us, I think there can be little doubt that the intersecting Norman Arcade was *really* the source from which the idea of the Pointed Arch was derived; as in the examples of triple and multiple windows, it is clear that the architects *must* have drawn intersecting circles, in order to determine the degree of acuteness or obtuseness observable in the *lights*. (See plate 2, Nos. 2, 6, 7 and 8.)

* Continued from page 314.

Euclid, in his first problem, describes an equilateral triangle upon a given straight line (plate 1, No. 1), and this is done by striking two intersecting circles, having their centres respectively at the ends of this straight line, such straight line being therefore the radius of the circles. The arcs of these circles inscribing the triangle are two limbs of a *spherical* equilateral triangle. This is *generally* considered as the actual form of the lancet arch. I am prepared to prove that it is not so, and that the spherical *equilateral* triangle is seldom used in lights of the thirteenth century: for this I now assign reasons.

Euclid treats simply of *lines;* but, as in architecture *mouldings* are introduced, the equilateralism is *destroyed*, and difficulty has thereby arisen in ascertaining which are the normal or principal lines. The plan I have adopted is this—to consider the outline formed by *the light* (or glazed part of a window) as *the normal line*, and the successful application of this plan induces the belief that it is the only correct one.

It is evident that, in a continued arcade, the inner line can *never* be a portion of a spherical *equilateral* triangle, where mouldings are introduced, excepting in the instance in which the mouldings form a *mitre* (*i. e.* the diagonal junction of the mouldings—(see plate 1, No. 2), because the diameter of the enclosing circle forms the bases of two equilateral triangles *exactly*. I am only acquainted with one example approaching to this form, a very early one, in Anselm's Tower, Canterbury Cathedral. (See plate 1, No. 2; also Britton's Canterbury Cathedral, plate 22.)

I now proceed to show the impossibility of the spherical *equilateral* triangle existing under any other circumstances, by a reference to the Norman arcade in Malmesbury Abbey, (plate 1, No. 3.) Here we find the arches formed by intersecting bands, (in the architecture of the thirteenth century, label mouldings occupy the place of these bands); these bands lap over each other, so that the united or crossing band at the level of the springing is somewhat increased beyond the width of a single band. The width of these bands being *taken out* of the diameter of the enclosing circle, prevents the possibility of the pointed arches being otherwise than acute: let me remark that only *two* pointed arches are included under the enclosing semicircle. This semicircle is shown by a darker tint.

The next example is from Norwich Cathedral, and shows still more forcibly the correctness of my position. Here the width of *two* bands (nearly) is taken from the enclosing semicircle, so that the pointed arches are *more* acute than in the preceding example. (Plate 1, No. 4.)

The last example is from the Church of Saint John, Devizes. Here *three* pointed arches are included under the enclosing semicircle, leading to greater intricacy in the interlacing, and rendering the pointed arches *extremely* acute. (Plate 1, No. 5.) The properties of circles being alike, whatever their diameter, an useful key is here given to all the varieties of multiple windows having the same springing line.

I am not aware that these arcades have ever been viewed in a similar light to that in which they are now presented. They have been studied synthetically, but not *analytically*, (*i. e.* by considering the various forms obtained under *one enclosing semicircle*); and the important inferences which I shall hereafter draw from the peculiarities appertaining to these arcades, will, I humbly hope, induce others to direct their attention to the subject. It is clearly the duty of every architect (now that the study of Gothic Architecture has happily revived) to think for himself, to investigate for himself; to respect the opinions of his predecessors and his elders; but not to rest satisfied with an acquaintance with the dogmas of any particular school. After all our investigations, we can merely re-discover the long hidden principles of those who have preceded us, and no re-discovery can be made, unless we strip the *ornamental* from the *constructive* parts of our Gothic buildings. As there *must* have existed *principles* for the production of those "mysteries of a human hand," the cathedrals and abbeys of Great Britain, it should be our highest aim to discover them, to reduce them to their original element (simplicity), and then to disseminate a knowledge of them as widely as possible. Much of the public taste depends upon architects; they themselves can never be duly appreciated, until they render themselves appreciable; and they can only become so, when the mystical cloak is thrown off, and the desire is exhibited on their part to diffuse that general love of architecture which is so desirable, and which is so richly merited by the science itself,—reserving to themselves, as they always will do, that *more intense love*, which none but *the initiated* can ever hope to enjoy. The public *will* favour architecture, and "when it does not suit it to be Gothic, it will be furiously Grecian."

LANCET WINDOWS.

Windows, as the most important features in our Gothic structures, will next engage our attention. I shall separate them into single, double, and multiple windows; an arrangement which I am aware is quite novel, but which I think fully warranted, seeing that the arcs of the lights are not portions of *separate* circles, but of a series of *intersecting* circles.

The examples of single windows (Nos. 6, 7, 8, 9, 10 and 11, plate 1) clearly show that the spherical *equilateral* triangle was not the form invariably adopted. (Many of the examples are omitted in the plate.) The examples 10 and 11, from Chichester and Beverley Cathedrals, owe their acuteness to the circumstance of their being parts of a composition:

thus, in the case of Beverley, the arc forming the light is a portion of a circle, whose diameter is equal to one-fourth the width of the transept, the *centre* being the *side* of the buttress. (See also plate 2, No. 10, centres *a b*.) The example from Chichester Cathedral owes its great acuteness to the same circumstance; and I feel persuaded that wherever there exists a *deviation* from the customary form of the light, that deviation can only be accounted for by considering the window as part of a composition, and not as an individual feature of the building.

DOUBLE LANCET WINDOWS.

Here are ten examples of double windows, some of which are necessarily omitted on the plates. I shall only notice three of the most interesting. That from the nave of Lincoln Cathedral (plate 1, No. 13) presents two windows included between two principal and one subsidiary buttress. The arcs forming the lights are struck from centres occurring at the sides of the principal buttresses, (see *a*x, x*b*), and the whole is *proved* to be a composition, by the fact that the arcades or recesses filled in next the windows (to give relief), have their heads struck from the *same* centres. (See the concentric circles turned.) Another example from the transept of York Minster (plate 1, No. 14) has the arcs of the lights struck from the side of the smaller buttress. (See xx on the diagram.) Arcades are also introduced in *this* example as before, and also on the face of the larger buttress, the heads of which are struck from the *same* centre as the windows, (the diagram is too small to show this.) In another example from the south transept of York (No. 17), we find the centre to be the centre of the adjoining buttress. (See x on the diagram.)

TRIPLE WINDOWS.

Various examples of triple windows have the same springing line for the three lights; but the most interesting are those in which the central windows rise above the side ones. The windows of the Temple Church, London, are remarkably beautiful, and are thus arranged. (See plate 2, No. 1.) The central light is equilateral, the circles being completed and a vertical line drawn through the points of intersection, and two circles of *equal* diameter being drawn *touching* this straight line (and also the primary circles), the arcs of the side lights are found; and the centres of these last circles are also the centres of the mullions between the lights. An isosceles triangle being formed, whose base is the distance between the centres of the mullions, the sides of the triangle *produced* cut the sides of the side lights at the level of the sill. No arrangement could be more beautiful than this—none could be more scientific!

I must request especial attention to the principles upon which the two next examples are formed, as they are perfect parallels to the Norman arcades. No. 6 (plate 2) is from the south transept of York Cathedral; (the clerestory windows, or those over the great arches separating the nave and side aisles.) This example consists of three lights and two pointed recesses; the whole of which are formed by a series of intersecting circles. The label mouldings are so many bands crossing each other, but *intercepted* in execution: a reference to plate 1, Nos. 3 and 4, will prove the Norman arcades and these pointed windows to be formed upon the same principles, as in both instances we find *two* pointed arches under *one enclosing semicircle.* It is impossible to judge of the effect of these windows *stript of their ornamental accessories;* but I would mention that the pointed recesses or arcades, on the side of the three lights, are portions of circles of the same radius as the lights, (the arcades have no deeply receding jambs), and that great variety is thereby given in the "chiaroscuro:" remove the dotted lines from this example, and no one would detect the identity of principle upon which both the Gothic lights and Norman arcades are formed.

The next example is from the same cathedral, and exhibits the normal lines of the clerestory windows to the north transept. Here *three* acutely pointed lights are formed under *one enclosing semicircle.* (Plate 2, No. 7.) This triple window is identical with the Norman arcade of St. John's, Devizes. (See No. 5, plate 1.) "The Five Sisters," of York, (No. 2, plate 2), are formed upon the same principle; also, "the Seven Sisters," of Lincoln Cathedral, (No. 8, plate 2); but in these examples, *three* and *four* lights are enclosed under *one semicircle.*

How frequently have the various degrees of obtuseness or acuteness of Lancet lights been referred to as proofs of the whim and caprice actuating the minds of the designers of our Cathedrals! How immediately is the caviller silenced by the resolution of these exquisite examples into their simple and elementary lines! If such taste and judgment be discoverable in the mere normal lines, can we be surprised at the emotions which arise in our breasts, when contemplating the appropriate and beautiful decorations under which these lines are concealed?

The next example is a very beautiful one from Salisbury Cathedral. (Plate 2, No. 3). Two intersecting circles, forming the central window, determine the distance of the buttresses; and two other circles of *equal* diameter, struck from the centres of the buttresses, find the arcs of the four side windows, and render it difficult to decide whether this example should be considered as a triple or quintuple window.

MULTIPLE LANCET WINDOWS.

Nos. 2 and 8 (plate 2), the former "the Five Sisters of York," and the latter "the Seven Sisters of Lincoln Cathedral," prove a constant recurrence to the intersecting principle, and are, as before mentioned, multiple windows: thus *disproving* Rickman's assertion, that "they "are *separate* windows, having their heads formed from "*individual* centres."—(*Attempt, p.* 58, *Fourth Edition.*)

No description can be given of the singular examples from the gables of Salisbury Cathedral, (Nos. 4 and 5, plate 2). I shall, therefore, only remark, that they present the same evidences of design, and attention to geometric principles.

No. 15, plate 1, presents one method of forming the "vesica piscis," (fully explained in a former paper,) the name of a window having a symbolical representation of Christ, under the figure of a fish. This form was held in peculiar reverence by the early Christians, and occurs in the old Church of Romsey, Hampshire; St. Leonard's, Stamford; and in Salisbury and Beverley Minsters; and I have recently met with a curious example, (with *perpendicular* tracery) in Kirkstall Abbey; it is in the south transept, but at such a height as to be inaccessible. The vesica piscis also occurs in the upper part of the *Norman* front of the Cathedral at Angoulême, in France.

The last example of windows (plate 1, No. 16) is the very curious one in the gable of the south transept of York Minster. I have now shown, for the *first* time, the normal lines by which the form is obtained. A simple equilateral triangle, subdivided on each of its sides into three parts, gives the base of so many separate triangles, from which spherical equilateral triangles are readily obtained. The *notched* appearance in the outline is produced by the central triangle on each side being again subdivided into two smaller spherical triangles. In the diagram merely the outline is referred to, but it is not difficult to imagine the beauty of a *decorated* window of this form, with its tracery filled in to the six primary spherical triangles.

EXTERNAL AND INTERNAL ARCHED RECESSES, ARCADES, OR NICHES.

These arcades are frequently found in the interior of our cathedrals and larger churches. A very interesting series of Norman character may be seen in the chapter-house of Worcester Cathedral; and of transition examples I may notice the arcades to the circular part of the Temple Church, London. These arcades, externally, give great relief, as may be observed in Lincoln Cathedral, where they are of the Early English style. In York and Beverley Cathedrals, the clerestory is thus enriched, and a very interesting example occurs in the clerestory of Darlington Church, Durham. Arcades of decorated character are to be found in York Cathedral, and also on the exterior of the tower of Darlington Church, and on the chapel on the bridge, Wakefield; but the examples are almost infinite. In the perpendicular style these arcades may be said to be supplied by panelling.

My present object, however, is to point out the forms of the heads of Early English arcades. In the chapter-house of Lincoln Cathedral, they partake of the same character as the multiple windows, (three arches being included under one large semicircle—see Britton's 5th vol.,) as also do many other examples having simply the lancet or pointed head. It will only be necessary to notice a few examples with trefoiled heads, in order to show their dependance upon geometry. These examples are sufficiently alike in *principle* to show that these arcades may be correctly classified; and yet so *different* in contour, as to give a clear idea of the infinite variety of which they are susceptible, by a very slight alteration of the geometrical lines.

The first example is from Stone Church, Kent, (see plate 3, No. 4,) and is *unequally* foiled. The base or springing line being divided into two parts, two circles are struck of equal diameter, and from the tangential point as a centre, a third circle of the same diameter. The diameter of the last circles being taken as a base line, and lines drawn from its extremities through the intersections of the circles, an equilateral triangle is produced. By bisecting the radii of the two *outer* circles, and from these points, as the diameter, striking a fourth circle, the intersection of this last circle with the sides of the triangle, gives the centres of the upper limbs of the trefoil head, which it will be perceived approaches very nearly to a portion of a *single* circle. The lines of the label moulding over this trefoiled arcade are also struck from the centres of the two outer circles first-mentioned, so that by reference to the diagram, it will be seen that every point arising from the various intersections is of *practical* utility. Having measured this example myself, I can vouch for its correctness; and I would mention, that the mouldings of this arcade, which have an excellent effect, are produced by strictly *geometrical* forms of a very complicated character, (but which could not be reduced to the size of the plate.)

The next example is from York Cathedral, (plate 3, No. 7.) Here, by a slight variation, the head becomes *equally* foiled. The base line at the springing, is the diameter of a circle, and by striking two other circles of equal radius, from the extremities of the diameter, and forming two spherical equilateral triangles, the lower limbs are obtained: the points of intersection of these circles give the base of a third equilateral triangle, and are the centres from which the upper limbs are struck; so that the *inscribed* line of this niche or arcade is an equilateral triangle exactly.

The third example is from Lincoln Cathedral, (No. 6, plate 3,) which, although very different in appearance from that of Stone Church, differs only in one respect, viz., that the apex of the equilateral triangle is a centre from which both limbs of the upper foil are formed.

The fourth example is by far the most interesting; it is from Kirkstall Abbey, (No. 5, plate 3.) Had I not actually measured it myself, I should have been somewhat doubtful of the correctness of the diagram. This is a most excellent example, now fast falling to decay. It cannot be described, but it will be seen that it (curiously enough) includes the very same lines as those in the diagrams, showing the identity of principle in the plans of York, Lichfield, and Salisbury Cathedrals, (plate 3, Nos. 1, 2, 3,) and also those by which the window termed "vesica piscis" (plate 1, No. 15) is produced. The whole of these arcades display the use of geometry; and a careful attention in taking the admeasurements of others, would doubtless give rise to a very simple mode of classification, as to the variety of forms which the heads may be made to assume.

BUTTRESSES, FLYING BUTTRESSES, AND VAULTING.

I have already remarked, that the thick walls of Norman and Saxon buildings were capable of resisting the slight thrust of the vaulting, and that therefore the Norman buttress is merely a thin slab of masonry, introduced on the face of the wall for the purpose of giving relief by the light and shade which it creates, (this may be seen in Kirkstall Abbey, &c.) The projecting buttress arose from *necessity* so soon as the cathedrals were acutely vaulted; and connected with these buttresses are found some of the most beautiful ornamental accessories of the pointed style, such as pinnacles, niches, canopies, &c.

With respect to the caps of early English buttresses, which are triangular on the face, certain rules appear to have been observed, which have, I think, hitherto escaped notice. I find, both from actual measurement, and the examination of engraved geometrical drawings of acknowledged accuracy, that the side of the buttress-cap, if continued, *generally* cuts either the angle or the centre of the window-sills: two or three illustrations may suffice as corroborative of the fact—(some are omitted in the plate.)

In plate 1, No. 13, we have two principal, and one subsidiary buttress; the line of the cap of each, *when produced*, cuts the angle of the sills. This example is from Lincoln Cathedral. Again, in the example from York Cathedral, No. 14, we find the same circumstance occur; and again in No. 17, also from York Cathedral. In Beverley Minster transept, plate 2, No. 10, the line of the buttress-cap, A, produced, cuts the centre of the central window sill, and the line of the pinnacle, B, produced, cuts the sill at the same point.

Similar instances occur in Salisbury, Norwich, and other Cathedrals, in buttress-caps of the thirteenth century. The reason is, obviously, to give a pyramidical form to these features, the great object of attainment in the works of the middle ages, in which the impartial critic will find nothing arising from whim—nothing from mere fancy or caprice, but everything exhibiting the exercise of mature judgment and correct taste. The flying buttresses, or "arcs boutants," are, however, of much greater importance, and must be considered in connection with vaulting, from the introduction of which they naturally and necessarily arose.

VAULTING AND FLYING BUTTRESSES.

N.B. The letters of reference on the plan and section correspond.

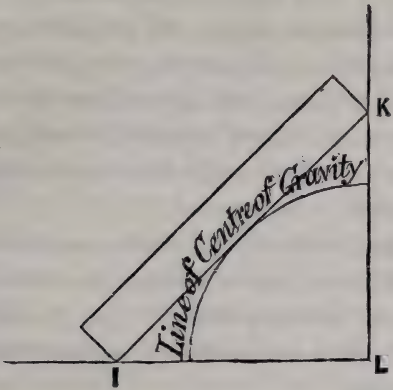
I have selected the vaulting of the nave of Salisbury Cathedral, on account of its simplicity. In many of our cathedrals, &c., the main rib is found to assume an undulating form, as in the case of the vault of the chapel of King's College, Cambridge, which "has been rather a subject of "wonder than inquiry. The vault of this chapel is divided "into parts, called severies, each severy subtending an "oblong, consequently the curves of the inverted quadrants "intersect each other before the quadrant of the circle is "completed, whence the intersections form an undulating "ridge or orbit. In an early investigation of vaulting, this "was attributed to error and defective workmanship, but it "has since been the cause of solid content and admiration."

No such undulation occurs in the main rib of Salisbury, but the circumstance has been referred to as a matter of interest in connection with the subject before us.

The main rib of the vaulting is shown in plate 3, No. 8, the lines A B C, converging to the point D, are the subsidiary ribs forming the groins, and dying into the pendant D, which is attached to the wall E E, (this is the clerestory wall E, on the section over the columns F, which separate the nave from the aisles.) It is against this wall E that the thrust of the vaulting is directed, and concentrated on the point D: this thrust would necessarily drive out the wall, were it not carried forward by the flying buttress G over the aisle roofs, and made to die into the wall buttress H.

The principle of the vaulting, and the use of the flying buttress, may be rendered more familiar by a very homely illustration. Let us presume that the several converging lines A B C are the ribs of an umbrella, the point D the point at which the snick or pin is introduced. Now so long as this pin remains fixed, the umbrella is expanded; the moment it is forced in by the hand, the umbrella collapses. I have simply introduced this illustration as a popular one, but must admit that the thrust of the vaults is in a different direction, which can only be withstood by corresponding resilience, and this is afforded by the flying and wall buttresses.

In order more clearly to understand the effective character of the flying buttress, as a medium of communicating the thrust from the vaulting to the wall buttress, let us refer to the annexed diagram.



Suppose I K to be a beam originally in a state of rest, against the wall K L. When the beam is moved between the planes I L, K L, so that the lower end I slides along the plane I L, and the upper end K down the plane K L, the centre of gravity will describe a portion of a circle, (the centre of gravity being in the middle between the two ends of the beam); and this may be proved *mechanically* by the use of a small paste-board model.

Now upon reference to the section of Salisbury Cathedral, it will be found that the curve of the sofite (or intrados of the arch) of the flying buttress, is regulated by the angle at which the buttress is placed against the wall E, and that it is a portion of a circle; also that the thrust of the vaulting at N O is carried forward by means of the flying buttress G, into the wall buttress H. That is, the direction of the centre of gravity is the same as the curve of the flying buttress, so that neither the wall E nor the buttress H is distressed. From the point P the wall buttress is wholly inactive, and the laws of gravitation are left to act unrestrainedly in a downward course *within* the body of the buttress.

We thus see that the extreme tenuity of the flying buttress does not militate against the effective performance of the duties assigned to it, and that the architect of the *miscalled* dark ages effected his object with the same apparent playfulness, but with the same unerring certainty as the Mexican hunter displays, when, singling out from the herd the devoted bull, he throws his "lasso" around his head for a few seconds, and then hurls the fatal cord with never-failing precision, and brings his victim to the ground!

Having thus briefly brought under notice some of the most important features of our Gothic structures, and I hope clearly proved their dependence upon geometry, I shall, in conclusion, make some remarks upon the ornamental accessories of the style.

Unlike its sister-arts of sculpture and painting, architecture addresses the judgment and not the passions. It is true that the reasoning faculty is called into exercise by means of the outward sense of sight, and that taste in architecture is inseparable from the pleasures of imagination; nevertheless, the aid of the imagination is called for lastly, so that the attributes of taste, as defined by Burke, are simply reversed in order.

It will be perceived, that in the illustrations of the two papers read before this Society, the diagrams have simply displayed the skeleton of Gothic architecture, and are without the charms of colouring, or the ornamental accessories. If they have excited any interest, it must have arisen from the proofs which they afford, that the style is not devoid of scientific principle, which has been denied it by so many of the early writers upon the subject. But some may be ready to exclaim, that Gothic architecture was the work of monkish times, and *must*, therefore, be barbarous. Let it not, however, be forgotten, that the term Gothic is a misnomer; that it arose with Evelyn*—was taken up by Sir C. Wren, and that

* "A certain licentious manner of building called *modern* or *Gothic*."—*Evelyn's Account of Architects and Architecture.*

the revilers of the style are only those who from prejudice have been disinclined, or from ignorance unable, to investigate its real principles. In the twelfth century, the learning which had characterised the centuries immediately preceding the Crusades, and had gradually dwindled away, was in the course of revival; the ray of light which first gleamed in the east, had diffused itself over the whole of Europe; and in the reign of Henry the Second (1154–1189) our language assumed a new character. "The English language was, in fact, then formed. A style of architecture founded upon the Saxon and Norman (but differing from both) was, if not invented, at least practised extensively in England, and by English artists."* Amidst surrounding ignorance and barbarism, the inmates of our monasteries devoted their lives to the service of religion, the preservation of literature, and the cultivation of the fine arts, whose bland and genial influence became apparent among the higher orders of society.

> "——— ingenuas didicisse fideliter artes
> Emollit mores, nec sinit esse feros."—*Ovid.*

It is not necessary for us to lay claim to pointed architecture as *peculiarly* our own; but the style having varied in every country, in its minuter features, in correspondence with the character of its inhabitants, we may proudly refer to England as that country in which the union of the sublime and beautiful has been fully carried out. In the time of Henry the Second, when the pointed style arose, Normandy was in our possession, and this Duchy contained Caen, Rouen, Bayeux, Abbeville, and other cities and towns in which the early pointed style was carried to great perfection. Anjou, Maine, Bretagne, and Guienne, were also held in fief of Lewis, King

* It has been recently discovered by means of some long-hidden records, that nearly the whole of the beautiful memorial crosses of Queen Eleanor, the beloved wife of Edward the First, were the work of Englishmen: they have hitherto been ascribed to *foreign* artists.—*See Gentleman's Magazine*, 1841.

of France, by the sons of Henry the Second, so that we cannot be surprised at the remarkable similarity in the details of Norman and English structures at this period. It has been already noticed (p. 297) that the pointed style advanced more rapidly and with more distinctive features in England, and those parts of France bordering upon it, than in any other country.

Those who would uphold the superiority of the continental cathedrals (at the present time) over those of Great Britain, seem entirely to forget one point,—that the impression made upon the mind by the former is heightened to a great degree by their accessories. Connected with a religion gorgeous in all its apparelings,—uninjured by the hands of the destroyer,—filled with paintings attractive to the eye, and by congregations whose garb is exceedingly picturesque from the variety of its colouring, and heightened in its effect by the southern sun, what a contrast does the continental structure present to our own minster, in which on every side we perceive the effect of the puritan spoliator or the modern Alaric, and in which, although

> "The storied windows richly dight
> Casting their dim religious light,"

may to a certain extent instil into the mind the feeling of devotion; yet that feeling has little else to give rise to its intensity, than the bold shadows cast by the deeply recessed moulding, and the awe-inspiriting grandeur of the edifice itself, which is the impress of its sacredness, and declares, in silent but eloquent language, that this is none other than the house of God!

In the works of the middle ages the most refined taste is apparent even in the minutest ornament, while the greatest science is displayed in the general arrangement. The architects of these structures were able, in the emphatic language of our great philosopher, Dr. Johnson, "to comprehend the vast and attend to the minute." In the decorations we find luxuriance without affected display, and delicacy and repose far removed from repulsive simplicity.

By those who would ascribe "the substitution of pointed "arches and enormous buttresses to ignorance of mathematical "science," we may expect to find the appropriate ornaments of the pointed style designated as consisting of "fantastical "capitals and whimsically-shaped windows, the mere offspring "of innovation." Sir James Hall has laboured hard to prove that the decorated tracery of the fourteenth century was the result of observation upon the platting of wickerwork, but we can obtain as gently-flowing lines by the aid of geometry, (by the interception of portions of these lines,) as by the compulsory bending of the willow.

I have dwelt at some length upon the subject of windows, as they betoken, in a peculiar manner, the various phases of the pointed style. The following may be received as a popular description of the variations made. It has been my endeavour to show the probability of the multiple Lancet window arising from the intersection of the semicircular Norman arcades. The Early English window may be said to include the Lancet, although the reverse is not the case; just as the fifth problem of Euclid includes the first problem, although the first does not include the fifth.

The two-light window appears to me to have arisen in the following manner. Two lancet windows being placed in juxta-position, and a circle introduced immediately over the jamb, (merely for the purpose of relief,) the simple inclusion of these three distinct features under one label moulding, formed the whole into a composition, and the lights being pierced, a *new* form of window was produced. This is, I think, evident on the west front of Salisbury Cathedral, (and also the Painted Chamber, Westminster,) where we find in the gable the lights and quatrefoils all pierced, but distinct from each other, and again the whole pierced and included under a label. This form of window is Early English or *geometric* decorated, the mouldings touching, but not blending with each other. Very fine examples are found in Tintern Abbey, Monmouthshire, Stone Church, Kent, and Durham and Lincoln Cathedrals, &c.

The transition from the geometric to the flowing Decorated style of window, appears to have arisen from the interception of a portion of the geometric forms; it is the peculiarity of this style, that the inscribed line of the window is an equilateral triangle. Even the gorgeous west window of York Minster may be resolved, without much difficulty, into severe geometrical forms. I cannot adduce a more remarkable instance of the *concealment* of these forms under the most playful tracery, than that exhibited in the windows of Little Maplestead Church, Essex. They consist of two lights trefoiled, with ogee quatrefoils over the same. The whole of the lines are perfectly meandering, (if the expression may be allowed,) and yet the centres by which they are struck occur at the angles of a regular hexagon!

The Perpendicular form of window evidently arose gradually and imperceptibly from those of Decorated character. The arch being now four-centred, and two of the centres being below the springing, the curve of the arch became depressed; some portion of the geometrical tracery was necessarily excluded, and short perpendicular tracery was introduced to supply the vacant space; and at length the arch becoming more and more depressed, the former subsidiary straight lines became the principal ones, and the curved lines were used merely as of secondary importance. This depression of the arch, thrusting the whole of the ornament into a confined space, gave an ungainly appearance to the windows, and transoms were introduced to give stability to the mullions, and for the more equal distribution of the ornaments.

This leads me to offer a few remarks upon the principles apparently regulating the mouldings of the pointed style, which, however varied, are all reducible to elementary forms.

In referring to the transition style, we find that the circular arch was not suddenly abolished, nor were its analagous mouldings and details. In the work of Bishop Remigius, in Lincoln Cathedral, the ornaments are all strictly geometrical. The distinctive character of Norman mouldings on the plan is this, that the lines are at right angles to each other, with chamfers at an angle of 45°, the circular columns or mouldings being attached.

The Early English mouldings (in transitu) present much of this character, but when the style had become perfected, we find the mouldings, however complicated, forming gracefully undulating lines. The columns or roll mouldings, when attached, consist of portions of two intersecting circles; and when straight faces occur, they have small hollows, with chamfered angles, to afford relief and keep up the characteristic lightness of the style. But a continuity of flowing lines would produce sameness, and "pall on the senses like a twice-told tale." The architects of this period, therefore, introduced occasionally, on the face of the column, a square fillet slightly projecting, but giving decision to the chiaroscuro.

The Decorated mouldings are not unlike those of the Early English style, but straight portions and bold quadrant hollows are frequently met with, (especially in door jambs.) Small reeded mouldings also occur, and the fillet on the face of the column, and the doubling of the roll moulding, is retained.

In Perpendicular mouldings the most prominent and distinguishing marks are bold hollows, sometimes circular, but more frequently elliptical; double reverse ogees are also very common.

In painting, the eye is charmed by appropriate colour, no less than by the management of the light and shade; by the latter, apparent prominence or distance is given, as may be required; and it has been observed by an ancient author—*(Theages Pythagoricus apud Stobæum)*—" That the con- "tour of the illuminated part of a figure should be blended "with and lost in the shade, since on this depends anima- "tion, tenderness, and similitude to truth."

Sculpture frequently calls painting to its aid, as may be observed in the monochromatic and polychromatic works of the ancients, no less than those of the middle ages.

But by what means, it may be asked, does Architecture produce those thrilling sensations of awe which we experience in the contemplation of our sublime cathedrals? Simply by the effect of light and shade.

Longinus, in his work on the " Sublime," observes, that "if we place in parallel lines, on the same plane, a bright "and an obscure tone of colouring, the former *springs* "*forward*, and appears much nearer the eye." Now, in Norman buildings the recession of the mouldings produces this very effect; but the mouldings being placed at right angles, however multiplied, a degree of harshness and severity in the shadows is the result—not to say, a great degree of sameness.

The superiority of the Gothic over the circular arch, in the projection of shadows, is thus beautifully explained by Mr. Kerrick:—" In the archivolt of a semicircular arch, "all the mouldings, however diversified and rich, will still "be all concentric semicircles, (see plate 1, No. 18), all "exactly similar to the arch itself; but in pointed arches "it is not so. Every moulding on the face of the arch is "concentric with its arch, *but not similar to it;* (see plate 1, "No. 19); no two are alike; they are respectively com- "posed of different portions of a circle, and each is a "different arch, (the internal being pointed, the external "nearly circular); the eye feels the pleasure it is naturally "formed to receive from the continued diversity, though "very few, perhaps scarcely any, of the spectators are at "the same time at all conscious of the cause." I may also add, that the greatest diversity is observable in the plans of Norman and pointed clustered pillars: of the former, some very interesting specimens occur in the nave of Kirkstall Abbey (transition); of the latter, I will only mention those in Darlington Church, Durham; in the north aisle, the first pillars are clustered, the second cylindrical, the third octagonal, and the fourth a plain cylinder; in the south aisle, the first and third are clustered, and the second and fourth octagonal.

Mr. Kerrick's observations as to the variety given in the light and shade by Gothic arch mouldings may perhaps be better understood by reference to plate 3, No. 4. The upper foils of the trefoiled head of the arcade are struck from two centres so close to each other as to render the foils almost portion of one and the same circle; if arcs of circles of less radius were struck, the foil would become exceedingly *acute*. We may readily imagine, that if from the centres of diagram No. 19, plate 1, two very large circles were struck, they would *appear* almost as a semicircle formed from one centre, —in the same manner as from the immeasurable distance of the stars in the firmament, (but reversing the position), they appear contiguous to each other, although probably millions of miles asunder, and the suns of separate systems equally important with our own.

The great advantage of Gothic Architecture over the Circular style, in the projection of shadows, is very evident in the mouldings of the thirteenth century, as their graceful contours allow the "liquid light" to melt imperceptibly into the shade: nay, more than this—a constant recurrence of the same regular forms, such as are perceived in Norman mouldings, creates a monotony; whereas the *half tone* of shadow produced by the ever-varying forms of Gothic mouldings present infinite variety and attractiveness to the eye of the artist and the man of refined taste.*

It must be evident from the preceding observations, that varied talent and knowledge are required in the reparation of our cathedrals and collegiate and parish churches; a general acquaintance with the peculiarities of the various styles of Gothic Architecture is not sufficient; it must be conjoined with deep antiquarian feeling, and an intimate knowledge of all the historical circumstances which have given rise to these variations. A modern Gothic church, although far from faultless, may escape the censure of the critic, from a knowledge of the parsimonious spirit of the founders, although the neglect of perfect synchronism is without excuse.

But the existence of anachronism, as exhibited in the different styles in our ancient churches, may be regarded as among their chief beauties; these varieties lead the mind into a delightful train of reflection, connected with the history of the several periods in which they were introduced, and of the county in which the structures themselves are situated.

All these churches necessarily require reparation from

* "We cannot but admire the consummate skill manifested by Gothic "architects in the conduct of their mouldings,—their curvatures are sometimes "abrupt, and sometimes gentle and easy, according to the degree of light that is "impinged upon them. If a number of small members occur together, appearing "as mere expletives, it is where they were certain to have the necessary effect of "softening the violence of a powerful shadow, or, in other words, of producing "those beautiful *reflecting* tints, apparently so much valued in the combinations "of mouldings by the Grecian architects. In those situations where the com-"position required it, and in the convexities where great effect was called for, "they are thrown either partially into shadow by a sharp fillet or some part of "their curvature, or entirely so by a bold separating torus advancing before "them."—*Cooper's Tintern Abbey.*

time to time. I am not speaking of *general* repairs, but such as apply to the restoration of a single window, a doorway, or other *individual* feature.

Generally speaking, the matter is left to the churchwarden, and his grand object being the attachment of his name to some conspicuous part of the church, denoting the year in which the structure was repaired and *beautified* under his superintendence—he proceeds boldly to his work. The *ruinated Gothic* window is removed, the jambs are repaired, and the spruce modern sash supplies its place, as in the clerestory of Calverley Church, near Bradford. The grotesque heads, serving anciently for the reception of the brackets to the hammer beams of the roof (long since destroyed), having been relieved of their weight, and appearing to his eye somewhat ghastly and unmeaning, are coloured "au naturel" by the village painter, and at once look smilingly and contented, or the reverse, as they may happen to have been carved by the original sculptor, outrivalling in some cases the facial distortions of "Tim Bobbin." This may be seen in Bluntisham Church, Hunts. The clerestory walls are painted to imitate stone, the joints (which the mason always endeavours to *conceal)* being clearly denoted by *strong black lines*, the painter receiving an extra allowance per yard superficial for the additional labour incurred, as in the recent beautifying (in 1841) of the Gothic church of Saint Paul's, Huddersfield. In some cases, however, the painter hits upon still further improvement, and by varying the colour and setting out the stones like a chess-board, he imitates to the life a *laminated surface* on the stone, such as would cause the *rejection* of the original on account of its *unfitness for use*, while the horizontal joints are run on continuously, no arch joints being shown, so that the masonry seems as though about to fall upon one's head.

This may be seen in Almondbury Church, near Huddersfield. The masonry externally, instead of being jointed with roman cement, is repaired in plaster, and then the joints are defined by a broad line of 1½ inch wide, as at Elland church, near Halifax. The clustered pillars of the nave receive the assistance of the plasterer, and alternate streaks of yellow, black and white, are introduced to distinguish the various mouldings, destroying the effect of light and shade, and thereby giving to the whole an appearance as pert and spruce as the creditable domicile of some tidy village schoolmistress. This may be observed in Lincoln and Bristol Cathedrals, Saint Cross Church, Winchester, and Londesborough Church, East Riding of Yorkshire. Is a sounding board thought requisite? the village carpenter supplies one with Roman pediments on each side, as at the beautiful little church at Lockwood, near Huddersfield. Is the ancient altar screen mutilated? some "pseudo antiquary" is called in, and after carefully looking at the details, and poring over "Battye Langley's Gothic," a sketch is produced, from which a piece of half-inch board is quaintly cut into crockets, and placed *horizontally* upon the old screen, uniting but not assimilating with it. This has recently been effected at Almondbury Church, and also at Hartishead Church, near Huddersfield; and these abortions are considered to be decided proofs of talent in the designers!

How different was the feeling in former days! If a church required re-pewing, it was done in the style of Gothic then prevalent, and became an historical incident in connection with the structure. In such a case, we can excuse the harmless vanity displayed by the official persons, in leaving their names to posterity. Thus, in the screen of Methley Church, near Pontefract, we have the donor and the churchwardens immortalized with their work:—

John Holland was my name,
Who gave six pounds unto this same
Richard Dickinson and Robert Fether
Church Wardens (were together) 1626
N. B. This worke was done with consience

And in good conscience we only wish that our modern improvers had proceeded thus: the donor's name, the cost of the work, the date of its execution, and the names of the churchwardens, all recorded in five lines!

But, to show to what an extent these ill-judged "beautifyings" are sometimes carried, it is not many years since "a churchwarden of Saint Stephens, Norwich, commenced "his reign by cleaning and painting the church, and at the "close of his labours, he rested his eye fretfully upon a "picture of the Last Supper. 'Boy,' said he to the "painter, 'I should consider myself wanting in duty and "veneration, did I suffer this church to be cleaned, and "our Saviour sitting before a *dirty* table-cloth: take your "brush and paint it *white* directly!' A few days after "this mutilation was discovered by the Rector, who sent it, "with tears in his eyes, to an artist, to be restored to its "pristine state."—*Elms's Arts and Artists.*

At a period such as the present, when a strong feeling is exhibited by the clergy of our venerable establishment in favour of the proper reparation of the structures under their care, the notice of these instances of Vandalism (most of which I have seen) may not seem misplaced.

If the windows of a church, whether Norman, Early English, Decorated or Perpendicular, have fallen to decay, and modern sashes be introduced, the whole character of the structure is destroyed; whereas the expenditure of a few pounds, from a feeling of *con amore* on the part of the clergyman and a few parishioners, (if you will, upon the voluntary system), would in a few years restore the mutilated or defective parts. The Church at Ranby, Lincolnshire, has been recently much improved by the insertion of Norman windows. The Early English Church, at Eynesford, in Kent, has been rendered perfect by the restoration of the chancel windows, and still further by the insertion of painted glass, chronologically correct in design. Littleborough Church, Notts, has also been partially restored. The Old Chapel at Flixborough, Lincolnshire, has had a doorway inserted, of character corresponding with the period of its erection: and several churches in the Isle of Wight have received judicious improvements and restorations.

I might instance many other churches which are at this time being restored to their original beauty, by the insertion of windows, doorways, &c., and in some cases by the removal of the inserted perpendicular tracery from Norman and early English windows. In such cases, the surveillance of an architect, however desirable, is not absolutely necessary; but I am persuaded (judging from my own feelings), no architect of the Gothic school would feel otherwise than delighted in affording his advice and opinion without charge, when the required restoration is trifling; or with the mere payment of travelling expenses, when a personal visit may become necessary. A hint from a practical architect may save much—a suggestion from the mere amateur may mislead, and will generally be attended with unnecessary outlay. No professional man will withhold his aid in the attempt to stem the torrent of innovation and bad taste which has already in too many instances swept away from our parish churches every vestige of by-gone days: the rubble walls, the storied brass, and the parish register being all that remains to bespeak connection with the past!

But how frequently is the font, used for the sacrament of baptism, thrown aside as lumber among the rubbish in the tower, as at Halstead Church, Essex, (a beautiful specimen), desecrated by being used as a cistern to "an old lumbering pump," as at Hammersmith, or otherwise unceremoniously rejected from the house of God. Fonts are historically interesting, apart from their consecrated use; for I hesitate not to say, that if any Saxon architecture exists, it is to be found in our crypts, and not unfrequently the ancient font was retained when the Norman structure was raised upon the foundations of the decayed Saxon church; there could be no motive for its destruction, but the highest, the holiest motives for its preservation. The font of Saint Martin's, Canterbury, that of Little Maplestead, Essex, and again that of St. Clement's, Southampton, are decidedly earlier than the buildings themselves; the first and last buildings have much of Norman character, and we learn from Doomsday Book that a church existed at Maplestead when William the Conqueror's survey took place, although the present church is the second, if not the third, erected upon the same site. I cannot, therefore, look lightly upon the circumstance of the font at Adel being removed to the church yard, while its place is supplied by an Italian marble font of Roman character, in style at variance with that of the church, and its introduction apparently uncalled for: at all events, the Norman font was once part of the *consecrated* furniture of the church, and this alone should cause its restitution within its walls, although it may not be re-used.

The following excellent remarks by Archdeacon Hare, in his charge to the Archdeaconry of Lewes, Sussex, cannot be too widely promulgated:—

"Your duty (says he, in addressing the churchwardens) "is to take care that the house of God in your parish shall "be such as befits the worship of God. You ought to feel "that it is a noble charge to take care of that house. It "ought to be your ambition, your glory, the wish of your "hearts, to see that house pure, and perfect, and beautiful; "to repair whatever injury it has sustained; to restore it "to its ancient integrity. The house of God belongs to "every inhabitant in your parishes—to the poor as much "as to the rich; it belongs to each one of you more en-"tirely, more lastingly, more unfailingly, than any other "property can—to you and to your children's children. "You will, perhaps, complain of the difficulty of raising "church-rates, and the dissensions which they breed; but "works of this kind, which belong to the decoration of the "church, may well be executed by voluntary subscription; "only take care that you yourselves are among the chief "subscribers. Do not talk of expense; make a beginning "at least; restore one window this year; let your successors "restore another next year. When the good work is once "entered upon, the desire of going on will increase rapidly; "for you will take more and more interest in that which "hitherto you scarcely thought about; your eyes will open "to discern the beauties of your churches; your hearts will "open to rejoice in them. In making alterations, however, "care should be taken, on the one hand, that they accord "with the general style of the architecture, and, on the "other hand, that they be suited to the great end and idea "of the building."

Shall we, as Protestants, be indifferent to the maintenance and reparation of our parish churches? Can we possibly feel lukewarmness upon the subject? If so, we may find aid proceeding from another and a very equivocal quarter. Yes, from the *Roman* Catholic laity, under the impression or at least the hope, that, at no very distant period, these venerable structures (for whose retention, for the use of a *purified* church, a Ridley and a Cranmer have suffered martyrdom,) will again be placed under the custody of the hierarchy and priesthood of Rome. The following extract from the *Dublin Review* (May, 1841) may well cause us to reflect deeply upon this subject:

"By the parish churches (says Mr. Pugin, a *Roman* "Catholic architect), the faith of our nation is to be sus-"tained and nourished; the parish church gives, in fact, "the history of the adjacent county. If the English Catho-"lics (Roman) avail themselves of *this feeling of attachment* "to the old parish church, which *exists among the great* "*body of the people*, wonderful good may be produced; but "if they neglect the *means* they are *bound* to employ to *turn* "this feeling to the *restoration* of the *old* faith, then it will "be found extremely inimical to the revival of *our* religion!"

Far be it from me to gainsay the *motives* expressed in this extract, but I breathe the fervent hope that Protestant feeling will render it unnecessary to receive aid from such a quarter; tendered as it must be from those who are so inimical to our *old* faith, handed down to us from the apostles, and whose author and finisher is Christ himself.

If we admire the Architecture of our ancient edifices, it is our *duty* to restore them to their pristine beauty, where decayed by time, or injured by adventitious circumstances; and as the feeling of ignorance is frequently the precursor of a desire to obtain knowledge, so may an enthusiastic feeling in favour of Gothic architecture, and of the preservation of the structures in which it is enshrined, be imbibed by a practical acquaintance with the glaring innovations which have arisen from the permitted exercise of a Vandal taste. "Our village carpenters and masons have too long con-"spired with ignorant churchwardens, in converting our fine "old churches into dens of ugliness and confusion." If Canova felt and declared that "it would be sacrilege in him "or any other man to presume to touch the works of Phidias with his chisel"—is it not more improper that the restoration of our Gothic structures should be any longer left to those who are, in most cases, utterly ignorant of even the merest rudiments of the style in which they have been erected?

Mr. West next read the following paper:—

ON THE DATA FOR A COMPARISON BETWEEN THE HEAT YIELDED BY COKE AND BY COAL.—BY WILLIAM WEST, ESQ., OF LEEDS.

I know, and I acknowledge all due weight to, the feeling which leads practical men to think very lightly of calculations which are not put to the proof by experiments, especially if they appear in any degree contrary to their own real or supposed experience on the great scale. Yet two good purposes may be answered by such calculations: since our processes and our machinery are all attended and interfered with by circumstances diminishing the calculated effects, our mechanical powers, by friction or atmospheric resistance, our chemical, by the need of time, or an excess of some elements for ensuring combination with the saturating quantity, our modes of applying heat, to radiation, and escape in various other ways—if we can show what the greatest possible amount of effect is which can be produced, we may prevent fruitless endeavours to exceed that amount. On the other hand, if we show that the effects produced fall below what calculation shows to be possible, by a quantity much greater than the ordinary defects of our proceedings in other cases prove to be unavoidable, we may prompt or encourage endeavours to reduce to a moderate standard these defects, and may furnish hints to others for new or improved applications of Science to the Arts. Such were the reflections which occurred to me when the well known opinion that coke equals, or very nearly equals, in its power as fuel, the coal from which it is obtained, was afresh brought prominently before me, at a period too near the time of our meeting to allow of its being submitted to any careful or detailed experiments. And though the data on this subject are accessible to every chemist, yet if practical men find anything like the difficulty in obtaining precise numerical statements from chemists which I find in obtaining replies to questions apparently simple, from workmen, in cases where there is no motive and no apparent wish for concealment, a short plain statement of the heating power, supposing the whole could be brought into use, of Coal, and of the Coke which it would furnish, may not be unacceptable.

The difference between various kinds of coal is not so material to this inquiry as it might seem; provided we exclude Anthracite, or other native combustibles approaching more nearly to coke than coal in their composition. For the earthy contamination, or ash, remains in the coke, and adds to the incidental expenses of its carriage, &c., not in proportion to the weight of this, but of the original coal.

I shall select, then, Newcastle coal, as analyzed by Thomas Richardson, of that place, with great skill and exactness. It consists, rejecting minute decimals, of

Carbon	88	per cent.
Hydrogen	$5\frac{1}{4}$	„
Nitrogen and Oxygen	$5\frac{1}{4}$	„
Ashes	$1\frac{1}{2}$	„
Total	100	

According to Despretz, the heat given out during combustion is, with certain exceptions which still bear close relation to the law, and which do not affect the question before us, directly in proportion to the oxygen consumed, whatever be the combustible, and that heat he found to be sufficient to heat $28\frac{3}{4}$ lbs. of water from freezing to boiling.

This is equal, taking the latent caloric of steam at 1000, to the evaporation of 5.175 of water already boiling.* Carbon, when fully burnt, forms carbonic acid, and combines with two atoms of oxygen, or 6 parts with 16.

88 parts, therefore, will combine with	234.6	and evaporate	1214.4 of water.†
Hydrogen combines with 8 times its weight of Oxygen, forming water.			
5¼ parts, therefore, combine with ...	42.	Oxygen, & evaporate	217.35 ,,
Total.....................	276.6	Oxygen combined	1431.75 of water

evaporated by 100 combustible portion of 100 parts of coal.

From this, a small deduction, the amount of which the analysis does not enable us to state exactly, is to be made for sulphur, (disregarded by many in such analyses, but undoubtedly present,) and for oxygen already existing in the coal. The amount cannot be so much as 5¼ parts of oxygen, or 27 parts of water evaporated.

Coal is stated by practical men with whom I have conversed, to leave rather more than half its weight of coke; then deducting two parts for ashes, 48 parts combine with 128 oxygen, and evaporate 662.4 of water. Experiments in the laboratory give 62.5; deducting 2.5 for ashes and other impurities, we should have 160 oxygen consumed, 828 water evaporated.

It appears, therefore, that coal, when burnt in such modes as to render all its combustible matter available to the fullest extent, must yield about twice the heat which can be given out by the coke alone resulting from it. Whether smelting furnaces, foundries, locomotive engines, and the other fires where coke is burnt, any or all of them, oppose difficulties to the application of such modes, which it is beyond the union of science with practical skill to surmount, remains yet to be decided.

* For, as 1000 : 28.75 : : (212 — 32 =) 180 : 5.175.

† As 6 : 16 : : 88 : 234.6, and 234.6 multiplied by 5.175 gives 1584.

The Chairman expressed a hope that some observations would be made upon this paper, as the question was one of very great importance.

Mr. Clay inquired whether the reason of coke being used instead of coal, for locomotive engines, was that more heat was obtained by the consumption of coke than by coal?

Mr. West said he quite understood that coke was used in the early commencement of railways because of the objections to the smoke from coal, but, independent of that, he believed that persons engaged in railway undertakings, thought there were either real or supposed advantages possessed by coke over coal. The object of his paper was to show, that whatever those advantages might be, they did not consist in coke giving out more heat than coal, but that in fact it only gave out about one half the heat.

Mr. Clay asked Mr. West if that would be his opinion, supposing there was an equal bulk of each in the fire-place?

Mr. West replied, that he did not at that moment carry the specific gravities in his head, but, apart from such considerations, he had no difficulty in saying, that coal must possess more heating power than coke, supposing the bulk to be equal, because of the hydrogen which it contained.

Mr. Briggs understood that attempts had been made to smelt iron with raw coal, but the metal was found to be very inferior. He had made the same attempt at Flockton colliery, but had not succeeded. The same coal, when they rendered it into coke, answered very well indeed for that purpose, but in a raw state the result was by no means so satisfactory.

Mr. T. Heaps observed, that three parts of coal were required to accomplish what one part of coke would do, and yet he understood Mr. West to hold the opinion, that coke did not contain the heating power which coal did.

Mr. West had not said that coal would supersede coke in the manufacture of iron, but in a very few words he had called the attention of engineers to the possibility of making it do so. There was no proof, perhaps, that coal might now, or indeed ever, replace coke in the iron manufacture. He had called attention only to the quantity of heat, and not to the intensity. It was possible that under proper management coal might be made to give out twice as much heat as coke, but it required so much longer time to reach the point of intensity which was needful. He believed that the Low Moor Company had used coal in place of coke to a very considerable extent, and he believed they found themselves neither better nor worse for it. What he wished to draw the attention of engineers to was, whether it would not be possible to smelt iron by coal, instead of the expensive system of coking, as adopted at present.

Mr. G. Hanson then exhibited a very ingenious model of an apparatus for ventilating mines, upon which he read a short paper. The apparatus—which is an application of the Archimedes screw,—is so constructed as to afford facilities for raising miners out of pits, along with the minerals, on a principle much safer than the present system of ropes. Mr. Hanson gave a practical demonstration, both as to ventilation and the conveyance of minerals by the apparatus.

The Chairman expressed his regret that there were not more discoveries of this description, as in the course of the preceding two months, twenty-one lives had been sacrificed in the West-Riding by coal-pit explosions. He agreed with Mr. Hanson, that the cost of such an apparatus ought to be no obstacle to its general adoption. Many lives were lost in consequence of the breaking of ropes, the use of which would be effectually superseded by such an apparatus as that of which a model was now produced. He thought that the government of the country, and all scientific institutions, were to blame for their apathy on this subject.

A vote of thanks was then passed to Mr. Clay, Mr. Wallen, Mr. West, and Mr. Hanson, for their respective communications, and to Dr. Walker for his kindness in presiding.

PROCEEDINGS

OF THE

GEOLOGICAL & POLYTECHNIC SOCIETY

Of the West-Riding of Yorkshire,

AT THE SEVENTEENTH QUARTERLY MEETING, HELD AT SHEFFIELD, ON THURSDAY, 3RD MARCH, 1842.

On the motion of HENRY BOULTBEE, Esq., seconded by WM. JACKSON, Esq.,

WM. VICKERS, Esq., was called to the Chair.

The following gentlemen were elected Members of the Society:—

RICHARD SOLLY, Esq., Sheffield.
HENRY RANGELEY, Esq., Sheffield.
P. BEAUMONT, Esq., Sheffield.
WM. PASHLEY MILNER, Esq., Attercliffe, Sheffield.
SAML. BARKER, Esq., Mexborough, Doncaster.
JOHN BROOK, Esq., Armitage Bridge, Huddersfield.
THOMAS BATTYE, Esq., Huddersfield.
JOHN TATTERSFIELD, Esq., Huddersfield.
Rev. J. R. OLDHAM, Huddersfield.

The following resolutions were then passed:—

1. That the next Meeting be held at Wakefield, on such day in the month of June as the Council shall fix.

2. That the thanks of the Society be given to the Master Cutler for the use of the Hall.

3. That the thanks of the Society be given to the Literary and Philosophical Society of Sheffield, for their assistance in making arrangements for the Meeting.

4. That the thanks of the Society be given to the Local Secretary and the Local Committee for their exertions in preparing for the Meeting.

The following communication was then made to the Society :—

ON THE USE OF WIRE ROPE AS A SUBSTITUTE FOR HEMPEN ROPE ON RAILWAYS AND IN MINING.—BY CHARLES MORTON, ESQ., WHITWOOD COLLIERY, WAKEFIELD.

It is peculiarly the business of the members of a Polytechnic Society to investigate the merits and failings of new inventions in mechanical science, and to publish the results of their inquiries. In pursuance of this object, I propose, on the present occasion, to lay before you such facts and information as have come to my knowledge relative to the application of *wire* ropes to railway and mining purposes; with a view of enabling the members to draw their own conclusions as to their utility and economy when compared with *hempen* ropes.

In order that I may do this as briefly and concisely as possible, I shall, in the first place, give an outline of the recommendatory statements published by certain patentees, setting forth the superiority of their ropes over the *hempen* ones, as regards lightness, strength, economy, and durability. In the next place, I intend to furnish you with a detail of some practical trials and experiments, instituted by different persons at different places, with a view of testing the accuracy of the assertions made by these patentees. And lastly, I shall venture to offer to your consideration a few reflections and suggestions which have naturally sprung up in my own mind during my short, and I fear somewhat imperfect, examination of the subject.

The first information that we have concerning the use of wire ropes, comes from the continent of Europe; and we learn that about ten years ago, round ropes, composed of twisted iron wire, were introduced into the silver mines of the Hartz mountains as a substitute for flat hempen ropes.—These commonly consisted of three strands, each strand containing five thick wires. The circumference of the largest wire rope did not exceed $4\frac{1}{2}$ inches, and the weight usually lifted by it was about half a ton. A hempen rope of equal strength was said to be four times the weight, and lasted only half the time,—the hempen rope being worn out in *one* year, and the wire rope in *two* years. The metallic surface was always kept well coated with tar to prevent oxidation, and the rope was never coiled over pullies or drums of less than eight feet diameter,—at least it was considered injurious to make use of smaller ones.

Three or four years since, an attempt was made in this country to supersede hemp, and to introduce iron wire, in the manufacture of ropes and cordage; and subsequently several patents have been taken out for this purpose: but those which have attracted the largest share of public attention, are Newall's, Smith's, and Heimann's; the first of Gateshead, and the two last of London.

Smith's patent consists of improved methods of combining any number of wires into strands, and twisting these strands into ropes of any required size. These ropes are perfectly flexible; and they can be spliced, knotted, and fitted in the ordinary way, as easily as hempen ropes. The effects of oxidation are prevented by a chemical preparation, by which the durability of the metal is greatly increased.

They are made either *round* or *flat;* the smallest of the round ones being one inch in circumference, and the largest six inches. The smallest of the flat ropes are three inches broad and 3-16ths thick, and the largest four inches broad by half an inch thick.

The patentee declares that his wire ropes are only *half* the size and weight of hempen ones for the same strength, and 25 per cent. cheaper; and his assertion is borne out by the results of certain experiments made by order of the Admiralty, to show the comparative difference between patent wire rope and hempen rope, as regards size, strength, weight, and price.

For example:—Smith's *wire* rope of two inches circumference was put to a strain of eight tons; its weight per fathom was 2 lbs. 10 oz., and its price per fathom 1s. 8½d. A hempen rope of equal strength was five inches circumference, weighed 6 lbs. per fathom, and cost 2s. 7½d. per fathom.

Take another example:—A *wire* rope, four inches circumference, and calculated to sustain twenty-four tons of breaking strain, weighed 12¼ lbs. per fathom, and cost 7s. 8½d. The hempen rope of equal strength was ten inches circumference, weighed 25 lbs. per fathom, and cost 10s. 11d.

The first of these illustrations shows the *wire* rope to be less than half the bulk and weight of the *hempen* one, and more than 30 per cent. per fathom cheaper. The second shows it to be about half the bulk and weight, and 27 per cent. per fathom cheaper.

The Admiralty report further states, that a two inch wire rope of Smith's manufacture bore half a ton more strain than a seven inch hemp rope, and was considerably less than half the weight. The wire rope, in this instance, would cost 1s. 8½d. per fathom, and the hempen rope 5s. 4d. per fathom.

Mr. Smith's prospectus contains a tabular view of the results of experiments made by Mr. Lewis, of Withy moor, near Dudley, from which it appears that a round rope of three inches circumference bore 16½ tons without breaking, but broke at 17 tons; and a flat rope, four inches broad by half an inch thick, bore 11 tons without breaking, but broke at 11½ tons. The round rope weighed 7 lbs. per fathom, and the flat one 7 lbs. 6 oz. From these trials it appears that with *equal weights* per fathom, the round rope possesses greater strength than the flat; for although the former was rather lighter than the latter, yet it bore 50 per cent. more weight suspended from the end of it.

From another table of tests, I find that Smith's round wire rope, $1\frac{1}{4}$ inch in circumference, is equal in strength to a hempen rope three inches in circumference, both bearing a strain of $2\frac{1}{2}$ tons. A two-inch *wire* rope, and a six-inch *hempen* rope, bear an equal strain of 8 tons. A three-inch *wire* rope, and a nine-inch *hempen* one, bear an equal strain of $15\frac{1}{4}$ tons. And a $4\frac{1}{2}$ inch wire rope is said to be equal to a 12 inch hempen one, both bearing a strain of $35\frac{1}{4}$ tons.

In these several instances the size of the hempen rope is nearly *three times greater* than that of the wire rope; and its weight per fathom is more than double, without any superiority in point of strength.

I am sorry it is not in my power to furnish you with similar data, relative to Newall's wire ropes; for although I have received information from quarters where they are now on trial, (the substance of which will be given in the sequel,) yet I have never seen any *authorized statement* of the size, weight, strength, cost, and durability of Newall's wire ropes, as compared with the hempen ones.* I would therefore avoid even the appearance of unfairness towards the patentee, by declining to give currency to theoretical speculations concerning his invention, which have been indulged in by others, and shall confine myself to the mere narrative of practical trials. These, however, will be more appropriately noticed in a subsequent part of this paper; and I proceed at present to describe Heimann's patent wire ropes, which are manufactured at Camberwell.

Smith's ropes (as before stated) are made entirely of *iron wire;* but Heimann's are composed partly of *wire* and partly of *hemp.*

A longitudinal heart or core of hemp is introduced, round which the iron wires are wound so as to produce greater compactness and evenness than can be attained in ropes made

* See additional observations at the end of this paper.

of wire only. They are made either with four or six strands, each strand containing eight wires twisted round a hempen core; and it is presumed that a greater strength is thus gained with the same weight of material employed. Another advantage is, that on a strain being applied to the rope, the core of hemp, from its greater elasticity, gives way in exact proportion with the wire strands; whereas if the core were made of the same substance as the strands, it would, from its being shorter, have to bear more than its due proportion of the strain; and would of course be more easily broken. The hempen cores are saturated in a chemical solution, which, it is said, effectually prevents the corrosion of the metallic wires.

The chief advantages possessed by these ropes over those of hemp, are stated by the patentee to be *less bulk* and *weight* for the same strength, combined with *greater flexibility*. Their prime cost is also less, and their durability greater. Indeed they are said to last four or five times longer than the hempen ropes. Flat wire ropes are manufactured at Camberwell on the same principle; but of these very little is either known or said.

From a statement of trials made at Woolwich, in October last, it appears that Heimann's $4\frac{1}{8}$ inch round wire rope, of six strands, with eight wires in each strand, and the wires No. 11 gauge, bore the same strain as a 10 inch hemp rope, (namely 20 tons) although the weight per fathom of the former was only $13\frac{1}{4}$ lbs., while that of the latter was 24 lbs. The price of the former is 8s. 4d. per fathom, of the latter 9s. 8d. per fathom.

In this instance, therefore, the *bulk* of the wire rope is nearly 60 per cent. less, its weight per fathom is nearly 50 per cent. less, and its prime cost per fathom is about 14 per cent. less, as compared with hempen rope of equal strength.

A smaller wire rope, $2\frac{3}{8}$ inches circumference, made of No. 16 wire gauge, bore the same strain as a four-inch hemp rope, (namely 7 tons) although the weight of the first was only $4\frac{1}{4}$ lbs. per fathom, while that of the last was $8\frac{1}{2}$ lbs. The relative prices are 3s. and 3s. 6d. per fathom. Here the size of the wire rope is about 40 per cent. less; its weight per fathom is 50 per cent. less, and its prime cost per fathom is 14 per cent. less, as compared with hempen rope of the same strength.

So much, then, for the statements of the wire rope *makers;* who, of course, are anxious to set off their own wares to the best advantage. Let us now turn to the experience of the *consumers*, and see whether the presumed superiority of wire ropes over hempen ones has or has not been verified by *practical trials.*

I shall first give you the experiments made with Smith's ropes by Colliery Proprietors, Railway Companies, and others:—

At Newton colliery, near Castleford, a round wire rope, four inches circumference, was introduced into the engine pit by Messrs. Stansfeld & Briggs, for the purpose of raising the pumps and other heavy weights. This rope was calculated to lift twenty tons; but in two months after its introduction, it broke with a weight of only five tons. This was the greatest strain to which the rope was ever put, and the fracture was occasioned not by a sudden jerk, but by a gradual and steady pull. The pulley over which it had to pass was two feet diameter, and the drum five feet diameter. This rope was nearly 200 yards in length, and cost 90s. per cwt. The breakage occurred upon the pulley, and probably the smallness of the pulley was in some measure the cause of the fracture; for experience has proved that small pullies and small drums are prejudicial to the action of wire ropes, by bending them *too sharply.* The rope was for the most part kept coiled upon the capstan, and was therefore preserved from the corrosive influence of the saline ingredients with which the water at Newton is impregnated.

At Emroyd, near Horbury Bridge, (another colliery belonging to Stansfeld and Briggs), a wire rope was used for drawing coals out of an upcast shaft. Its length was 90 yards, and its circumference about 2½ inches. This rope ought to have borne a strain of nine or ten tons; but the greatest weight ever lifted by it at one time was five or six hundredweight; and in the course of four or five months, the rope broke just as the engine was lifting the full corf from the bottom of the pit. The pulley here is three feet diameter; but the breakage occurred in a portion of the rope which seldom went over the pulley—that is, between the pulley and the pit top. As the fracture took place when the engine was starting, it may be said to have been occasioned by a sudden jerk. Corrosive vapours from the furnace below were continually ascending the shaft; and besides these, the rope was a good deal exposed to the action of chalybeate water; and although the metallic surface was at first coated over with a tarry or asphaltic composition, yet the bare wire was soon exposed to the process of oxidation, by the wearing away of the protecting substance; and when the rope was laid aside, after the breakage, the iron was found to have undergone very considerable corrosion.

Mr. Briggs also tried one of Smith's *flat* wire ropes at Flockton Colliery. It was 100 yards long, 3½ inches broad, and 3-8ths of an inch thick. Much difficulty was experienced in *keeping* this rope *flat*, its tendency being to *twist round*, in its passage up and down the pit. It was so light, as compared with a hempen rope, that a slight blast of wind blew it out of the pulleys; and on one occasion, when it was blown out, it got entangled among the wheels of the engine, and was so much damaged that it was laid aside as useless. Certainly this was not a fair trial of its merits; for, if proper means had been adopted for keeping the rope in its place, it perhaps might have worked satisfactorily.

I am informed that the Sheffield Coal Company have used Smith's wire ropes in three different instances,—two of them on short inclined planes, and one in a dry downcast shaft. The result in each case was *unfavourable*; for the company found that the hempen ropes previously used lasted four times as long as the wire ones.

In Cornwall, where horse gins are much used for drawing minerals, Smith's wire ropes are preferred on account of their *lightness*, which enables a horse to draw a greater weight of mineral than he could with a hempen rope. Some of them have been in use twelve months, without having suffered materially in point of wear.

An extensive coach-maker, in London, has used one of Smith's two-inch wire ropes for upwards of two years, for the purpose of raising and lowering carriages from the basement to the third story of his manufactory. The weight of the platform and carriage is a ton and a half; and the rope coils on a barrel only six inches diameter. This rope is said to wear uncommonly well, and to realise the expectations of the proprietor.

Smith's wire rope is favourably spoken of in the Report of the Blackwall Railway Company, in July last. The report says, "All the wire rope that we have hitherto used has been made by Smith, which has been found to answer exceedingly well."

In the neighbourhood of Newcastle-on-Tyne, Smith's wire ropes have been adopted, as well as those of other patentees; and Mr. Matthias Dunn, of that town, an eminent colliery viewer, says that they are working very satisfactorily in pits where *conductors* are used; but more especially on inclined planes. The flat ropes have not been much tried yet in that neighbourhood; but Mr. Dunn says that he has one at work which is going on favourably.

Newall's patent wire ropes have been successfully applied by the engineer of the Blackwall railway; they have also been introduced on the Durham and Sunderland railway. This line, like the Blackwall line, is worked by stationary engines; and one continuous rope stretches from Sunderland Moor to Ryhope, a distance of three miles, which, during the few months that it has been in operation, has given satisfaction to the engineer. The weight of Newall's wire rope on this railway is less than one-half that of a hempen rope; its flexibility is at least equal; and in point of durability there seems reason to believe that the wire rope will exceed the hempen; for, as yet, there is no appearance of chafing or wear on its surface. These ropes cost rather less, in the first instance, than hempen ones; and their increased economy will, of course, be proportionate to their greater durability. But this remains to be proved.

Heimann's wire ropes have been used for several years on the continent, and principally for mines, many of which are from 200 to 400 yards deep, and the average duration of the ropes is said to be three years.

In England, Heimann's wire ropes have not been used for more than nine or ten months. At Seghill Colliery, near Newcastle, one of his round ropes was laid in June last, upon an inclined plane, about a mile and a quarter long, and rising 1 in 45. The weight attached to the rope, and drawn up by the engine, is 90 tons. This rope is only three inches circumference, and is composed of 42 wires of No. 13 wire gauge, and weighs about 7 lbs. per fathom. The drum round which the rope is wound is nine feet diameter, and the sheaves or pulleys on the inclined plane are the ordinary sized cast iron ones. Owing to an accident which happened to the engine, this rope broke after it had been in use four months; but the workmen succeeded in splicing it again, and it has continued ever since to work in the most satisfactory manner. Mr. Carr, the viewer of the colliery, has expressed his belief that a well manufactured wire rope will last three times as long as a hempen rope, and he has determined to substitute the former wherever the latter is now used in the collieries under his control. The patentee says that the case just mentioned is the only breakage of his rope that has occurred.

It seems that wire ropes are becoming much used in Northumberland and Durham ; and the best judges in mining affairs, both here and elsewhere, are beginning to think favourably of them. Mr. Stephenson—whose great and deserved fame as an engineer gives peculiar weight to his opinion on this and all other questions connected with mechanical science—has adopted and approved the metallic ropes. At his Claycross Colliery and Crich Lime Works, there are several inclined planes on which the wire ropes are working well. One of these inclines rises 1 in 3, and runs with a very heavy load ; and the wire rope in this, and in the other places near Chesterfield, bids fair to surpass the hempen rope in economy and durability.

But the most signal instance of the successful application of wire ropes is to be found on the Blackwall Railway. The line is 3½ miles long, and a round wire rope, weighing 13 lbs. per fathom, stretches from one end to the other. The hempen ropes have been gradually removed, and a great reduction in the expense of working the railway has been effected by substituting wire ropes in their place.

A careful consideration of the preceding facts and experiments will, perhaps, justify me in offering a few conclusions and suggestions on this subject.

From the experience hitherto obtained, it is obvious that the wire ropes possess many advantages over the hempen ones. They cost less money, in the first instance, most assuredly ; for, although the present price of Smith's ropes varies from £70 to £80 per ton, and of Heimann's ropes from £65 to £100 per ton, yet their greatly diminished weight reduces their price per fathom below that of hempen ropes.

Another important advantage belonging to the wire rope is its *lightness*. In mining and railway operations, the saving of *weight* is the saving of *power*, and, in the same ratio, the saving of *expense ;* for several horse power may be saved in an engine, by the application of wire rope instead of hempen; and this becomes a matter of much greater moment, if the pit be very deep, or the inclined plane very long. On long inclines it is especially desirable to curtail weight and friction; for there are many planes, which ought to be *self-acting*, that are prevented from being so by the great weight of the rope. Take, for example, an inclined plane 1,000 yards in length. A four-inch hempen rope would weigh nearly a ton, while a wire rope of equal strength would weigh about 9 cwt. This additional weight of hempen rope might, where the inclination is small, prevent the incline from working as a *self-acting* plane; and in the case of an engine plane, the load upon the engine and the friction of the sheaves would be considerably increased.

As regards the durability of wire ropes, no very decisive opinion can be pronounced in their present imperfect state. They are, undoubtedly, capable of much improvement, and it is probable that, ere long, their greater economy will be demonstrated by their increased durability.

In their present condition, wire ropes seem well adapted for dry, smooth, and easy work; but for very rough tugs, or for wet situations, they are not so well suited.

They seem also to be more applicable for drawing weights along horizontal or inclined planes, than for lifting them perpendicularly.

The diameter of the pulleys and drums ought to be increased, when wire ropes are introduced, for they cannot be coiled round small barrels without injuring the texture of the wires. A three-inch wire rope ought to have pulleys and drums ten or twelve feet in diameter, and the thicker the rope is, the larger ought the pulley and drum to be.

I conceive that an upcast shaft may be more prejudicial to metallic ropes than a downcast; not only on account of the sulphurous and other corrosive vapours that are constantly ascending it, but because of the unequal temperature to which the metal is subjected, the ropes being for the most part hung in the hot shaft during the day, and coiled upon the drum in the open air during the night. This alternate exposure to heat and cold, occasioning alternate expansion and contraction of the wires, may probably, in course of time, operate injuriously on the rope itself.

The failings of the metallic ropes (more especially of those made by Smith) may perhaps be attributed to faults in the manufacture, and not in the principle. May not the wires of which the rope is composed have been unevenly stretched by the maker? and if so, they have not, when put in operation, undergone an equal degree of tension.

In spite of the varnish and tarry matter which have been applied to the wire rope to preserve it from oxidation, the metal has nevertheless been considerably corroded in the course of a few weeks. This corrosion is more injurious to the small wires than it is to the thicker ones, from which I should infer that a rope made of thick wires will be more lasting than a rope made of small ones.

An effectual anti-corrosive pigment, for coating the exterior of the wires and strands, would be extremely valuable in the manufacture of these ropes, and it can scarcely be doubted that the resources of chemical science will, ere long, supply this desideratum.

The subjoined Tables show the comparative weights, strengths, and prices, of wire and hempen ropes.

The first Table is Smith's, the second is Heimann and Kuper's, and the third is Newall and Co.'s.

SMITH'S TABLE.

Size of Patent Wire Rope.	Equal to a Breaking Strain of	Weight per Fathom.	Price per Fathom.	Size of Hempen Rope.	Weight per Fathom.	Price per Fathom.	Size of Chain.	Weight per Fathm.	Price per Fathom.
Inches.	*Tns. Cwt.*	*lbs. oz.*	*at 6½d.*	*Inches.*	*lbs. oz.*	*at 5¼d.*	*Inches.*	*lbs.*	*s. d.*
1	1 0	0 12	0 5	2	1 1	0 5½	0¼	3	1 6
1¼	1 15	1 0	0 6½	2½	1 8	0 8	0 5/16	5	2 1
1½	2 10	1 6	0 9	3	2 4	0 11¾	0⅜	8	2 8
1¾	6 5	2 0	1 1	4	3 15	1 8¾	0 7/16	12	3 6
2	8 0	2 10	1 5¾	5	6 0	2 7½	0½	16	4 0
2¼	12 0	3 8	1 10¾	6	9 0	3 11¼	0 9/16	20	4 9½
2½	12 0	4 8	2 5¼	7	12 3	5 4	0 11/16	27	6 0
2¾	14 0	5 8	2 11¾	7½	13 3	5 9¼	0¾	33	6 8
3	16 0	6 12	3 7¾	8	14 3	6 2½	0 13/16	36	7 6
3¼	18 0	8 0	4 4	8½	16 12	7 3¾	0⅞	42	8 9
3½	20 0	9 4	5 0	9	19 6	8 3¾	0 29/32	46	9 7
3¾	22 0	10 8	5 8¼	9½	21 12	9 2¼	0 15/16	50	10 5
4	24 0	12 4	6 7½	10	25 0	10 11¼	0 31/32	53	10 10½
4¼	27 0	14 0	7 7	10½	27 8	11 9¾	1	56	11 8
4½	30 0	16 5	8 10	11	30 0	13 1½	1 1/16	62	12 11
4¾	33 0	19 8	10 6¾	12	32 12	14 4	1⅛	70	14 11
5	36 0	22 5	12 1	12½	35 10	15 7¾	1 3/16	78	16 3
5¼	40 0	24 10	13 4	13	38 8	16 9¾	1¼	86	17 11
5½	44 0	27 8	14 10¾	14	41 10	18 3¼	1 5/16	96	20 0
5¾	50 0	30 9	16 6¾	14½	44 12	19 7	1⅜	108	22 6
6	54 0	34 0	18 5	15	47 8	20 9½	1 7/16	115	27 4
73½	all three equal.	256 13	139 1¾	184½	444 7	193 10¼	Diameter.	1020	221 10

P.S. The above Table is calculated for Rigging Rope ; the Hawser for Mining and Railway purposes is 10s. per cwt. more.

HEIMANN AND KUPER'S TABLE.

WIRE ROPES.						HEMPEN ROPES.		
Wire Gauge Number.	Size.	Weight per Fathom.		Strength.	Size.	Weight per Fathom.	
	Inches.	*lbs.*	*oz.*	*Tons.*	*Inches.*	*lbs.*	*oz.*
11	4⅛	13	5	20	10	24	0
13	3¼	8	3	13½	8¼	16	0
14	3⅛	6	11	10½	7¼	12	8
15	2⅝	5	2	7½	6	9	4
16	2⅜	4	3	7	4	8	8

NEWALL'S TABLE.

Comparative Table of the Size, Weight, and Cost of Hemp and Wire Ropes.

HEMP ROPES.				WIRE ROPES.			
Circumference in Inches.	Pounds Weight per Fathom.	Cost per Fathom.		Circumference in Inches.	Pounds Weight per Fathom.	Cost per Fathom.	
		s.	*d.*			*s.*	*d.*
3	2¼	0	10	1¼	1¼	0	11¼
4	4	1	6	1¾	2¼	1	7
5	6¼	2	4	2⅛	3½	2	2
6	9	3	4½	2½	5	3	2¾
7	12¼	4	7	2⅝	6¾	4	2½
8	16	6	0	3⅜	9	5	5¼
10	25	9	4½	4⅛	14	7	10½
12	36	13	6	4½	20	10	5

Sale Price of Wire Ropes.

lbs. Wt. per Fathm.	Breaking Strain.		Working Load.		Price per Cwt.
lbs.	*tons.*	*cwt.*	*tons.*	*cwt.*	*s. d. s. d.*
2	3	12	0	12	80 to 75
3	5	8	0	18	
4	7	4	1	4	75..70
5	9	0	1	10	
6	10	16	1	16	
7	12	12	2	2	70..67/6
8	14	8	2	8	
9	16	4	2	14	
11	19	16	3	6	67/6..65
13	23	8	3	18	
15	27	0	4	10	65..62/6
17	30	12	5	2	

[The following observations have been added since the reading of the paper at Sheffield. They refer more particularly to Messrs. Newall's wire ropes :]—

The first important trial of Metallic Ropes in this country was made on the London and Blackwall railway. Two sorts of wire rope were there placed in competition with hempen rope, the one made by Mr. Andrew Smith, the other by Messrs. R. S. Newall and Co. These ropes were at first applied to only a very limited extent, and merely as an experiment; but it was soon found that the wear and tear of the hempen rope was so much greater than that of the wire rope, and occasioned so much delay and inconvenience from the frequent breakages, that it was determined to abandon hemp altogether, and the whole line is now worked by several miles of wire rope. The competition between wire and hemp on that railway having terminated, the next question to be decided was, the respective merits of the ropes made under the different patents of Mr. Smith and the Messrs. Newall; and the superiority is now awarded to the *latter*.

The difference between these two ropes mainly consists in this,—that while in Smith's rope the wires are annealed, and are very numerous and small, and twisted together nearly in the same manner as an ordinary hempen rope,—in that of Messrs. Newall the wires are unannealed, few in number, and as large as the size of the rope will admit; and they are arranged *symmetrically* round a hempen core, which is wrought in the centre of each strand, and also in the centre of all the strands when twisted into a rope. The advantage of this symmetrical arrangement of the wires is obvious. They must all be of the same length, and each will therefore be subjected to the same strain, while, from the size and hardness of the wires, they cannot be easily cut through by friction.

This rope (which has been characterized by Mr. Robert Stephenson as "*the improved wire rope*,") is made on the same principle as that which is now used so successfully in Germany.

The following is a list of some of the wire ropes manufactured by Messrs. R. S. Newall, and now at work in this part of England:—

Mr. G. Stephenson.—On three inclines near Chesterfield, which are very steep. The ropes have been at work thirteen months, and they continue in excellent order.

Shrewsbury Canal.—On an incline: a 7 lbs. wire rope was substituted for a 26 lbs. hemp rope. It has been at work ten months, and is as yet unimpaired.

Townley Colliery.—On an incline 1300 yards long. The rope has worked six months without any symptoms of wearing. Horses were required to assist on this plane previous to the wire rope being used. Since then their assistance is not required.

Brandling Junction Railway.—Several incline ropes. The first of these ropes was put on seven months ago, and although working under disadvantageous circumstances, it is spoken of most favourably by the engineer, Mr. Coulthard.

Swadlincote Colliery, near Burton-on-Trent.—Six hundred yards of incline rope have been used nine months. The engineer, W. Woodhouse, reports very favourably on this rope.

Bolton and Leigh Railway.—A wire rope, a mile and a half long, has been working four months, and is giving satisfaction.

R. S. Newall and Co. have lately supplied ropes to the

Stanhope and Tyne Railway	3 miles.
Oldham Branch of the Manchester and Leeds Railway	1 do.
North Midland Railway	$\frac{3}{4}$ do.
Taff Vale Railway	$\frac{3}{4}$ do.
South Hetton Railway..................	2 do.

They have also sent out about twenty pit ropes, not one of which has yet been known to fail.

The Chairman observed that he had seen wire employed in the construction of a bridge in France, and a most beautiful specimen of ingenuity it was. That bridge had a span of 400 feet, and the low price at which it was erected was almost incredible. He really thought that they ought to have a wire bridge constructed above Lady bridge, in Sheffield, which, according to an estimate he had made, would not cost more than £600. In a conversation which he once had with Mr. Bidley, who lost his life at Liverpool, that gentleman stated a fact of great importance. He said that if wire or iron of any kind was painted after leaving the furnace, and before being exposed to the air, it would scarcely ever corrode. It was therefore a point to be attended to, that iron or wire intended for exposure to the atmosphere, should be coloured before the slightest corrosion takes place.

Mr. Dunn, of the Sheffield Coal Company, remarked that although to many persons present the question of wire ropes would doubtless be an uninteresting one, yet as the cost of ropes formed a heavy item of expenditure in all large mining concerns, he hoped he should be excused for trespassing a short time on the patience of the meeting, as he had used three wire ropes at the Sheffield Collieries, and could therefore give an account of ropes actually used. For a general remark, it is near enough the truth to say, that a wire rope, able to bear the same strain as a *best* hempen rope, will cost about the same amount of money,—the weight of the wire rope will be about one half the weight of the hempen rope. The ropes he tried were of Smith's patent, manufactured by Wm. Fox and Co. They were tried in three different situations,—one as a drawing rope, which may be called *a;* one on a self-acting Incline, *b;* one on a stationary Incline, *c.* The rope *a* worked over a 7 feet pulley, and was wound round an 8 feet drum; its weight was $4\frac{1}{2}$ lbs. per fathom: the weight of the hempen rope usually working in that situation was 9 lbs. per fathom. The wire rope was at work four months, and was then removed *nearly broken through.* The average cost of a hempen rope in that situation is 15s. per month; the cost of the wire rope was 60s. per month. The rope *b* worked over a pulley 3 feet in diameter; its weight was 4 lbs. per fathom: the weight of the hempen rope usually worked in that situation is 6 lbs. per fathom. The wire rope was at work four and a half months, breaking several times, and doing much damage. The average cost of a hempen rope in that situation is 14s. per month: the cost of the wire rope was 83s. per month. The rope *c* was wound round a drum 4 feet in diameter; its weight was 4 lbs. per fathom: the weight of the hempen rope usually worked in that situation is 6 lbs. per fathom. The wire rope was at work two and a half months, breaking in that time very often, and doing a vast amount of damage. The average cost of a hempen rope in that situation is 17s. per month: the cost of the wire rope was 160s. per month. So far the experiments made were decidedly against the wire rope, but he still thought that they would be made to answer. The failure in *Smith's ropes* appeared to arise from imperfection in their manufacture, and *principally* from the wires being each of a very small diameter. He found that after the ropes had been at work a short time, they had quite a *bristly* appearance, arising from the great number of broken wires. Having seen a specimen of Heimann & Kuper's *wire rope*, he observed that the wires were of much larger diameter than those in Smith's; the rope also appeared to be manufactured in a superior manner. He, in consequence, ordered one, and *put it to work in the same situation as the rope of Smith's (a); its weight was also the same as that rope:* it had now been at work four months, and did not show the slightest symptoms of wear, none of the wires being broken, all maintaining their position, and there being every appearance of that rope answering his expectation. It had been coated every three or four weeks with a preparation of tar and tallow. The advantage of wire ropes would, he thought, be mainly on Incline planes; and, if they could be made to endure the wear and tear of hempen ropes, which he now did not doubt, they would on long Inclines have a very decided advantage, as a wire rope *of half the weight* of a hempen one would bear an equal or somewhat greater strain.

Mr. Hartop observed that there was a great advantage in having a flat rope, whether of hemp or of wire, if it passed over a drum of large dimensions. He was disposed to think that they would be improved by having a greater weight of iron in them.

Dr. Holland inquired from what cause the wire rope had failed—whether it was from being previously oxidated or from friction?

Mr. Morton replied that it had failed under various circumstances; but in one particular instance which he recollected, the failure arose, first, from the smallness of the wires, and from their being oxidated throughout; and second, that the rope had been put over a drum of too small diameter, which ought not to be less than ten feet. With respect to the *cost* of wire rope, he believed it would cost less than those made of hemp. Mr. Hartop was of opinion that the wire rope wanted more iron in its composition, but he (Mr. Morton) thought it remained to be proved whether it did not possess enough already. Wire rope was recommended for its *lightness*, and if a large quantity of iron was introduced, it would not only increase the weight, but the cost also.

Dr. Holland inquired if any gentleman had made any experiments to ascertain the electricity evolved in the working of wire ropes. This was a principle of great importance, and might, if understood, throw much light upon the cause of failure in such ropes. The process was a chemical one, and it would depend on the amount of friction which the rope underwent, and the moisture to which it was subjected by alternation from a moist to a dry atmosphere.

Mr. Morton said he had not heard of any experiments having been instituted; but he conceived that very intense electrical action must necessarily ensue where wire ropes pass rapidly over metal pullies.

The CHAIRMAN thought there was considerable weight in the observations made by Dr. Holland, and he hoped that those members of the Society who felt interested in the subject, would think it worth while to direct their attention to it.

At the close of the preceding discussion, the CHAIRMAN called upon Mr. LEE, who came forward, and read the following paper:—

FOSSIL FOOT-PRINTS OF THE CARBONIFEROUS SYSTEM.—BY MR. WILLIAM LEE, SURVEYOR OF HIGHWAYS, SHEFFIELD.

I appear before the Society to some disadvantage, because that part of this day's entertainment which I have the honour to furnish, has already formed a portion of a paper read before the Sheffield Literary and Philosophical Society, and is, therefore, strictly speaking, not new.

I have only yielded to the solicitation of your secretary, on the assurance that, to a majority of this meeting, the information will be original, and not uninteresting.

My communication possesses one merit,—it will not be a very long one; and as I have no doubt that the subsequent discussion will be the more interesting part of the subject, I shall proceed without further preface.

I need not remind you that within the last fourteen years, foot-prints of animals upon sandstone have been found near Dumfries; at Hessberg, in Saxony; at various places in the counties of Lancashire, Cheshire, Salop, and Warwick; and also in the valley of the Connecticut, U.S. They have all been carefully examined and minutely described by the persons to whose researches we are indebted for their discovery.

They were all found in the *same division* of the secondary strata, which lies in the *middle region* of that large and widely extended series of sandstones and conglomerates, limestones and marls, which English geologists have usually designated by the common appellation of the *new red sandstone* group, including all the strata that are interposed between the Coal formation and the Lias. No foot-prints are recorded as having been obtained lower in the series; and, until lately, it was believed that no animals breathing by lungs existed during the formation of the Coal measures.

Before I proceed to mention the localities where I have found fossil foot-prints in coal strata, and to describe the appearance of the impressions, excuse me if I make two short quotations, for the purpose of showing the importance of these foot-prints.

Professor Phillips, in his Treatise, p. 118, has mentioned with approbation a speculation of M. Bronguiart, that probably during the formation of the coal-beds the atmosphere contained an unusual dose of carbonic acid gas, which he supposes requisite for the growth of such vast forests as must then have encumbered the limited surface of the land. He admits that such an atmosphere would certainly be *detrimental* to the life of animals breathing by lungs; but asks, "*what proof have we of the globe being then tenanted by* "TERRESTRIAL *animals?*" and adds, "Now, surely, it is "worthy of attention, that AFTER *the coal was deposited*, "reptile life began to be manifested, and finally to predomi-"nate."

This hypothesis has been elegantly expounded also by Mr. Burnet, Professor of Botany, in King's College, London, as follows:—"The office of ferns, and the other plants of the "coal formation, and the final cause of their predominance "in that period, would seem from numerous facts to be, that "by their assimilation of the carbon, and liberation of the "oxygen with which it was combined, they might purify the "atmosphere, and bring it into a condition in which it would "become respirable by reptiles, beasts, and man.

"That such was the primitive condition of the atmosphere, "and that it was thus gradually purified by the growth of "plants, seems to be not improbable, from the circumstance "that reptiles and other cold-blooded animals which can "endure and enjoy an atmosphere that would be fatal to "warm-blooded animals and man, are the earliest of which "any fossil remains are found.

"That the atmosphere at first was very greatly loaded "with carbonic acid, is probable *from reptiles not appearing* "*until after the coal formation.*"

I do not wholly protest against the hypothesis that carbonic acid gas was much more prevalent at that period than now; but I submit that these foot-prints tend materially to qualify the ingenious supposition of men very eminent for their attainments in natural science; and, I think, it will be conceded that they have an important bearing upon the condition of the atmosphere during the deposition of the coal strata.

Being at Brighouse in the year 1836, I visited the celebrated flag quarries of that vicinity, and in one quarry, between Brighouse and Rastrick, had the unexpected pleasure of finding some large slabs of stone covered with *foot-prints* of a small animal. Many of the tracks formed right lines up and down the surface, while some of them diverged across in an oblique direction to the right and left, the extreme angles formed not being greater than about 60°; proving quite satisfactorily that the animals had walked up and down a sloping beach of fine sand, to and from the water.

I also found abundant ripple marks of a breadth and size which showed that they were formed in shallow water.

From the recurrence of the tracks upon all the laminæ that I examined, being several feet in thickness, and from the form of the foot-prints, I concluded that this was, probably, once a still sequestered spot, occupied during a long period by a family of small gregarious reptiles. The upper surfaces of the stones contained indented marks, and the lower reliefs: the slabs vary in thickness from three quarters of an inch to two and-a-half inches; they appear to be highly compressed, and are hard and brittle; the stone is a greyish brown, fine, quartzose sandstone, laminated,—containing some scales of mica, and lies near the surface. The dip must be nearly 40° E.

At that time I felt considerable diffidence on the subject of proclaiming a new fact in the science of geology, and therefore contented myself with keeping only the small specimen which I now produce, containing one foot-print. (No. 1.)

I determined, however, to examine the rocks in *this* neighbourhood, and endeavour to find similar phenomena. I have not laboured without some success.

In September, 1839, during the excavation of the new coal pit, near the canal basin, in this town, and when the shaft was sunk to the depth of 270 feet, I discovered among some masses of fine grey quartzose sandstone, specimens containing impressions of foot-prints, (No. 2.) The surface was uneven, as though the water, at the time of its deposition, had been violently agitated. The hollows were filled with marl, which, being cleared away, disclosed, upon the largest stone eight continuous impressions of the hind feet of some small animal, deeply marked; the fore feet not being so distinct, but still perceptible. They show a stride of about an inch and a half distance, and, like those previously described, traverse the rock mostly in a direction either up or down the surface of the stratum. The points of some of the nails, *as may be seen*, are remarkably sharp and distinct; and the alternate impressions of the right and left foot may be distinguished. From some of the marks, backward, in the direction of the track, are indented lines scooped out, as though the feet had been drawn along the surface of the sand.

On carefully comparing these with the specimen obtained near Brighouse, I had the satisfaction to find an exact correspondence in the form of the foot.

In the early part of the year 1840, I found slabs of stone at Hill Bridge, near Owlerton, having upon them impressions similar to those already described. There are also marks upon them having the appearance of being caused by a heavy shower of rain, besides others for which I am unable to account. Between the slabs are occasionally found fronds of ferns, and also Calamites and Stigmaria, very much compressed. The stone is a hard silicious sandstone, approaching to the nature of calliard or gannister, with which the neighbourhood abounds. The laminæ are close and even. The beds vary in thickness from one and a half to ten inches. These stones are much used for flagging the streets here, (Sheffield,) and have, no doubt, attracted the attention of many persons by the singular inequalities of the surface. The foot-marks are not always present, nor are they then easily distinguishable, except by comparison with the other specimens, *when they are found, in form and size, entirely to agree*.

In May last (1841) I found upon the moors at Fullwood Head, five or six miles west from Sheffield, some beds of brown sandstone, covered with foot-prints, and also with what appear to be the tracks of worms—(No. 4)—the surfaces are otherwise exceedingly smooth and even. The beds vary from two inches thick down to one-sixteenth of an inch, and both the upper and lower surfaces are covered so abundantly with scales of mica, that it may frequently be scraped off with the fingers.

The foot-prints and worm-tracks occur on both sides of the slabs, *the indentations being always on the upper surface, and the reliefs on the lower.*

Upon one slab, I have, without much difficulty, decyphered nearly *forty* continuous impressions of the same track. The stride appears to be somewhat more than an inch, and behind the marks are frequently short furrows, similar to those already described, where the feet have been drawn along the surface. No *marl* or *clay* is found in connection with the stratum, the preserving agent in this instance being the interposed micaceous scales.

Stone from the neighbourhood, and out of another part of the same quarry, is well known in Sheffield, being used as common roofing slate.

At Walkley, about 1½ miles from Sheffield, I found, in September last, (1841), a stratum formed of exceedingly fine laminæ, containing similar foot-prints (No. 5). The mineral composition is the same as the last mentioned; scales of mica being interposed between the layers, which are so thin that the *same* impressions appears on both sides, on the upper as indentations, and on the lower as reliefs.

Many singular impressions, besides foot-prints, will be observed on this stone; these I attribute to the dropping of water upon the sand, and so numerous are they over the entire surface, that if I had not become somewhat familiar with the little reptile, whose footsteps I had previously so often followed, I should have doubted if I had detected him at all in this instance.

It is difficult to come to a satisfactory conclusion as to some of the marks; the progression of the deposit must, evidently, have been exceedingly slow; and yet the impressions made, as if by drops of water, continue without intermission through all the laminæ of which the stratum is composed. I think it very improbable that heavy rain continued to fall sufficiently long to produce the phenomenon; and from the additional fact that these impressions were found to cover but a very limited space, I am inclined to think that they were produced by droppings from the leaves and branches of some of those plants or trees, which at that period so thickly covered the surface of the earth.

In the month of November last, I obtained possession of a stone, which I know, from practical experience, to be from the neighbourhood of Thornset quarries, about 10 miles N.W. from Sheffield. (No. 7.) I had not the advantage of finding it *in situ;* nor have I been able since to visit the quarries in that neighbourhood. The stone is similar to that from Fullwood Head, excepting that the beds are thicker, and the scales of mica not so numerous. The little animal, whose feet-marks are upon it, is the one already so often mentioned. The impressions are deep; and it is remarkable that the same prints pass through many laminæ, appearing on the lower surface as reliefs. The specimens may be multiplied by splitting the stone.

Still more recently, on the 29th December last, 1841, I discovered abundant foot-prints of the same reptile, in a quarry recently opened, at Whirlow Bridge, on the edge of Dore Moors. (No. 9.) They are on a dark coloured, micaceous shale, very soft, and thin; they lie near the surface. The subjacent beds are covered with ripple marks, but have no foot-prints: the strata dip at about 25° to the East. During the same week, I found other similar impressions at Clough Field, about 1½ mile west of Sheffield, on smooth, thick, light-coloured flag-stone; but in this instance they are not numerous, though well preserved.

I have avoided, hitherto, any conjecture as to the character of this animal, except that I have used the term *reptile.* I may say, however, that I have minutely examined the feet of many recent reptiles, and have also made casts of some of them, and the result of my experiments is a firm conviction, that the tracks are those of either a small Lacertine, Saurian, or Batrachian. I am inclined to think the former.

I believe no doubt can exist as to the genuineness of all the foot-prints I have been describing; but I am fully aware of the great tendency which exists to speculate, and to draw conclusions from insufficient evidence, and I have, therefore, reserved until now a case in which the appearances are less conclusive.

In the month of October last, (1841), while making a common sewer in Holly-street, in this town, I observed a stratum of red sandstone, which is a somewhat uncommon occurrence among the Coal measures, and is conjectured by Professor Phillips to be formed from the detritus of the Old Red Sandstone. It was suggested to me, that it might possibly be an out-lier of the lowest member of the New Red Sandstone formation; but from its apparent connection with other strata of sandstones belonging indisputably to the Coal measures, I believe the colour is a local appearance, communicated probably by the cause assigned by the Professor.

I was induced, however, carefully to examine the stratum, and found a surface, upon which a layer of red marl had been precipitated. From my previous experience, I thought it likely that this might conceal some kind of foot-prints, and on removing it from the surface, I discovered a great number of depressions of various sizes, and of several forms. The workmen had to open but a narrow trench, and the stratum is very full of cracks and joints, so that I was unable to obtain very large specimens. The stone, as will be observed, is of an open grain, except in the indentations, where a smoothness is produced, as if by the soft cushions of feet pressing the surface of the sand. The yielding material has been evidently moved in various directions, and the appearances thus produced can, I think, only be ascribed to the agency of animated beings.

I have carefully compared seven or eight pieces, in my possession; and although the impressions are very much confused, I have no doubt that they contain foot-prints of much larger animals than those previously discovered in the sandstones of the Coal measures. The confused condition of these impressions forms no insuperable objection, for Professor Hitchcock, in his description of *Ornithicnites*, in the valley of Connecticut, says, "they are sometimes crowded like the impressions of feet on the muddy shores of a stream or pond, where ducks and geese resort." They could not possibly have been formed by any action of the water; and the supposition that they formed a bed for nodular concretions, is disproved by the circumstance that all the indentations were filled with clay or marl, which was deposited upon the whole surface of the stratum, and in the hollows, in thin horizontal layers; whereas, on this hypothesis, the substance should have been confined to the indentations, and formed of concentric coats. But, although I am confident as to the presence of foot-prints, yet, as some persons may doubt, and the subject is open for discussion, I think speculation as to the character of the animals would be premature; and I shall merely call attention to the resemblance between several of these marks, and the impressions found in the New Red Sandstone near Dumfries; and also point out the similarity between others and the web-footed reptile, whose track was first discovered at Hessberg, in Saxony. I have stated that in this case the appearances are less conclusive. I thought them, however, sufficiently important to warrant me in directing to the specimens the special notice of the geologists who are present, knowing that speculations become absurd only when contrary to facts, and that, in such matters as this, *careful induction* is the only way to arrive at truth.

I fear that to many of my hearers I have been tedious, by too minute a description of place and circumstance; but my object in being thus particular is to excite a spirit of inquiry among the geologists of the West-Riding, in many other parts of which, I have no doubt, fossil foot-prints may be found.

For the information of those who may choose to examine other localities, I beg to add, that the specimens from the coal-pit are about 25 yards above the Sheffield coal seam. The red stone from Holly-street overlies the calliard or gannister coal beds; and the impressions from Fullwood Moors, Hill Bridge, Walkley, Thornset, Whirlow Bridge, and Clough Field, are between the gannister beds and the Mill-stone Grit.

The geological position of the Elland Flag-stone, where I first perceived these foot-prints, *nearly* corresponds with the place of those found in this neighbourhood. They are, therefore, ALMOST *peculiar to the lower or gannister coal series*, and add another singular circumstance to the many curious phenomena already observed in that part of our coal-field.

And now I have only to thank the audience for the kind attention they have paid to my observations; and to say, that if I have been the means of adding one fact to the science which it is the object of this society to extend, I have not laboured in vain, nor have I wasted the time of this large and influential meeting, by bringing before your notice these unique but satisfactory proofs that reptiles existed upon the surface of the globe at the early period of the Carboniferous system.

ON THE EVIDENCE OF THE FORMER EXISTENCE OF GLACIERS IN GREAT BRITAIN.—BY THOS. SOPWITH, ESQ. F.G.S., OF NEWCASTLE.

Since the visit of Professor Agassiz to the meeting of the British Association, which was held at Glasgow, in September, 1840, a considerable degree of attention has been given by geologists to what has been called the Glacial Theory, or, in other words, to the study of the phenomena of existing Glaciers, and an examination of the reasoning of Professor Agassiz and others, by which it has been endeavoured to prove that the action of ice, on a scale of enormous magnitude, was an important means of effecting many geological results, which have hitherto been without any obvious explanation. This subject has received much attention from continental geologists, and has been admirably illustrated by the "Studies of Glaciers," published by Agassiz, in 1841; several papers have been read at meetings of the Geological Society of London; and the able reports of these, and of the proceedings of the British Association, together with reviews of Agassiz's work, and the popular character of his descriptions, have tended to familiarise the English public with a subject, which, two years ago, was considered in this country as a startling novelty.

The object of the present paper is to present a concise view of such leading features of what, for the sake of brevity, may be conveniently termed the Glacial Theory, as may be interesting to those who have not devoted much attention to the subject; to notice the researches which have been made with reference to the former existence of glaciers in Great Britain, and to point out the means by which further evidence can be procured in illustration of this curious and interesting subject.

As many of the papers hitherto read at meetings of this Society possess a high practical value, it may perhaps appear that the present subject is a deviation from this course; that it is leaving the plain and useful road of practical observation, for the regions of a fanciful theory; and that the question of Glaciers or no Glaciers, is more a matter of amusing speculation, than of actual observation and utility. I feel it due both to the Society and to the subject under consideration, to endeavour to remove these views, if any such are entertained, and, at all events, to request attention to a few considerations, which will, I trust, invest the subject with a general as well as with a local interest and utility.

I may observe, then, that the study of natural phenomena is never presented in a more attractive form, than when it is associated with accompaniments which excite surprise and admiration; and of this description the accompaniments of Glaciers undoubtedly are, inasmuch as they are associated with those stupendous chains of mountains, the very name of which inspires a feeling of sublimity, and the exploration of which never fails to impart the liveliest admiration and delight. It is in connection with the mountains and valleys of our own country, that the evidence of glacial action are to be sought for and examined; and the tourist of the highlands of Scotland, of the lakes of Cumberland, or the mountains and valleys of Wales, has a new source of interest afforded by this train of investigation. If the traveller gladly leaves his track to explore a few commonplace fields, because on or near them a battle was formerly fought, or an old castle, or Roman camp, formerly stood—is it not equally, if not much more interesting, to occupy his time and attention in examining the still more ancient traces of geological phenomena, inscribed in a legible manner on the surfaces of rocks, and by the frequency of such observations, throwing light on the detailed phenomena of the stupendous agency by which the surface of the earth has been moulded into its present form? In the mining districts, the subject has this peculiar local interest, that it is, in all probability, closely connected with the important features of denudation, which influence the conditions of the strata of the Coal Formation, extending, as is well known, not only to the present surface, but to a considerable extent below the surface. Few persons have an idea of the enormous amount of this denudation, or of the clearness of the evidence by which it is established; but abundant examples in the coal and lead mine districts show that a vast period of time, and the long-continued effort of stupendous agencies, could alone have produced the denudation which is so strikingly apparent.

Connected with the subject of Denudation, is that of the deposit of Drift, or diluvial deposit; and this strongly marked feature of our northern valleys is of great importance to the miner, inasmuch as the beds of coal are sometimes entirely cut off, or carried away, and their place supplied by such deposits; and, as will be seen by the sequel, such deposits are known to have a great resemblance to, and probably an immediate dependance on, the results of glacial action, as it is now to be observed in the valleys of Switzerland and other mountainous countries. The cause of those vast masses of detritus—the tracts of country through which they run—the laws by which they are governed—are all matters of immediate and practical interest in a country where so much depends on an intimate subterranean knowledge of geological phenomena; and it is only by a close and long-continued investigation of the phenomena presented to us that we can hope to arrive at such knowledge. The study of the Glacial Theory may indeed be considered as extremely interesting, if it were only to afford to the general reader a correct notion of the phenomena of the Swiss Glaciers, as described by Agassiz; it is of great interest to every tourist, by affording a constant subject for investigation in elevated regions, in traversing which for pleasure, the want of some object in view has often deprived the tourist of much of his expected gratification. In the oft-visited district of the Cumbrian Lakes—in the mountainous tracts of Wales, and the Highlands of Scotland—in short, in every mountain chain, and in every valley immediately descending from thence, the observer, who will look for evidences of former glacial action, may find at once a curious source of occupation and interest, and add to the stock of geological knowledge by new facts illustrative of the direction of the supposed glacial action, or of important conditions under which the surface of the earth has assumed its present form.

If any further apology were required for calling attention to the subject, it is to be found in a conviction that an attentive study of natural phenomena is the only sure path of philosophical investigation; and, however void of practical utility any discovery may at first appear, it is impossible to tell to what important results it may eventually lead. Who could have foreseen an acquaintance with the minutest wonders of the heavens from the child of a spectacle-maker amusing itself with convex glasses!—the marvellous results of steam machinery, from the steam issuing from a kettle!—or the illumination of our towns, from burning a piece of coal in the bowl of a tobacco pipe? One ingenious contriver of a steam ship was advised by a former President of the Royal Society to employ his time on some practicable scheme, and not on a visionary speculation; and thus it is, that the suspicion and distrust with which any novelty is commonly received, has tended to damp inquiry and retard science. I have been assured by that eminent geologist, the Rev. W. D. Conybeare, that his early investigation of the more recent strata of this kingdom, and especially of the Portland Oölite, &c., was treated as an idle occupation of time, and as leading to no useful purpose; whereas the progress of

Geology, since that time, has shown that the stability of our great public buildings depends on a proper selection from the rocks best adapted for building; and Mr. Wm. Smith, who shared in the obloquy of following such useless pursuits in the infancy of the science, was in his old age employed by Government, in conjunction with Mr. De la Beche and others, to examine the various strata of the United Kingdom, with a view to selecting the best stone for building the new Houses of Parliament.

The conditions under which we now find the surface of the earth have a close connection with agriculture, and it is of importance to obtain a correct knowledge of the composition of various soils. It is well known that soils, as regards their chemical constituents, are by no means immediately dependant on the rocks immediately subjacent to them, but that either diluvial, or some other vast agency has been employed, by which the constituent parts of soils, and even rocks of considerable magnitude, have been carried great distances. An extended knowledge of this may prove a valuable addition to that important connection of geology with agriculture which has been actively and ably promoted by societies of both these departments. That vast deluges of water have swept over the surface of the earth, and that considerable differences of level have prevailed while the process of denudation was being effected, has long been the received opinion of all who have considered the subject; but the theory of glacial action is one of the most interesting additions to this branch of geological investigation, inasmuch as it promises to explain phenomena which were previously not accounted for, and because it presents authentic and legible records,—if the evidences to be described in the sequel are rightly ascribed to glacial origin.

Before alluding further to the existence of former glaciers in England, it may be useful to take a brief survey of what the phenomena are which are observable in those countries where glaciers now exist, in order that the coincidence of the supposed evidence in Great Britain may be considered in immediate relation to the evidence afforded under conditions which do not admit of doubt.

It is unnecessary, however, to speak of the glaciers as regards the more obvious features which have always rendered them conspicuous in the sublime scenery of the Alps and other mountainous regions. Suffice it to observe, that the enormous masses of frozen snow and ice which fill the elevated valleys of the Alps extend over about 1,500 square miles, varying in length from a few hundred yards to 10 or 15 miles, and are of various breadth, seldom exceeding 2 miles: their thickness in some cases extends to 200 feet, and their surface and internal structure are modified by the form and temperature of the valleys in which they are situated. Iceland, Greenland, the southwest coast of America, and many other parts of the world, abound with glaciers; but the detailed phenomena attending them have in no instance been so accurately observed and so graphically described as in Switzerland. These phenomena are full of interest, and during the last two years they have been frequently alluded to in scientific publications, and also in others of a more popular nature. The splendid work of Agassiz, and especially the admirable plates which accompany it, afford a clear idea of the principal features of the Swiss glaciers. A brief and instructive epitome of this work has been prepared by Mr. Maclaren, who accompanied its author in his examination of the rocks near Edinburgh. The proceedings of the Geological Society of London, and the published reports of the British Association, contain many details, and a popular explanation of the chief phenomena of glaciers is also to be found under that head in the Penny Cyclopedia. Without repeating what is already so generally diffused and so easily accessible, it is only necessary to bear in mind that these enormous frozen rivers, as they may be termed, move forward with a slow motion and with an overwhelming force. Their surfaces become the depositories of the fallen fragments of the rocky valleys into which they descend. These accumulate, and are arranged either at each side of the valley, forming what are termed *lateral moraines*—in the form of united moraines, when they are called *medial moraines*—or at the end of the glacier, when it finally dissolves at the lower extremity, and thus deposits what is called a *terminal moraine.* But the principal circumstance attending the movement of the glaciers, so far as relates to the subject of this paper, is that they leave behind them a permanent record of their existence, legibly inscribed on the surface of the rocks over which they have passed. The nature of this record is very clearly exhibited in the plates of the "Study of the Glaciers," by Agassiz. It consists in the rounded and polished form of such rocks, and in the formation of numerous furrows, grooves, and scratches: these are admirably delineated in the plates, which are thirty-two in number; fourteen of them are finished lithographed drawings; fourteen are outline charts, or pictorial maps, whereon are engraved a brief explanation of the locality of each of the views; and the remaining four are detailed representations, which do not require an explanatory chart.

The first and second plates present a panoramic view of the glaciers of Mount Rosa, and, when united, exhibit a continuation of the great chain of mountains of that name, with the various glaciers descending from them, as they appear when viewed from the summit of Riffel, above Zermatt, in the valley of St. Nicholas. From an immense platform of ice, the Porte Blanche, there descend two glaciers, separated by a moraine; one of which Agassiz calls the Glacier Porte Blanche, and the other the Little Glacier of Gornerhorn. The Great Glacier of Gornerhorn descends from the same mass, and on reaching the valley, it is repelled by the descending glaciers of Mont Rose, and from these opposing forces results an *oblique moraine*, at the base of the grand glacier of Gornerhorn. Each mountain mass contributes its glaciers, which are to be distinguished by means of the moraines, or masses of broken rock, which are carried along the surface, and are not imbedded in the ice, but carried on its surface, and disposed with mathematical precision according to the resolution of forces acting upon it. As they descend the valley, they become gradually intermixed ; and in this we may trace at least one of the means by which the materials of distant mountains may be intimately blended together, and finally, by a further process of disintegration and combination, form the fertile soil of the lower valleys. The moraines, which in the more level portion of the glacier preserve each a separate course, are, by the steepness of the declivities, the ruggedness of the surface, and the vast number of crevices, mingled together. It may easily be supposed that the gradual descent of these enormous glaciers must have a great effect in abrading and polishing the surfaces of the rocks on which they impinge. The surface of Auf Platten is polished to a considerable height, whence Agassiz concludes, and apparently with much reason, that the glaciers formerly were of much greater extent than they now are.

In the continuation of this same valley, some of the most curious phenomena of the glaciers are found. The crevices change their direction as the glacier turns round an angle of the valley, and from being transverse they become longitudinal. The moraines from Gornerhorn, Mont Rose, and other mountains, are in a great measure intermixed, but Agassiz states that they may be distinctly traced by the different colour of the rocks from whence they have been derived.

At the inferior extremity of the glacier of Zermatt is a natural arch, by which the waters escape from it. The respective materials of moraines are to be distinguished by the colour of the rocks, and thus the several fragments can be traced to their origin. Lateral moraines are deposited on the cultivated fields, and the still more permanent record of the rounded and polished rocks is apparent on the rocks contiguous to the ice. The glaciers sometimes advance and sometimes recede: when they advance, the moraines are impelled forward; but when they recede, the moraines are left. They form, however, much less certain and durable records than the polished condition of the rocks; and it is important to bear this in mind when we come to consider the evidence of glaciers in Great Britain; at present, suffice it to observe, that there is strong reason to believe that they were rounded and polished by glacial action—by the grinding of ice, not by torrents of water; and that these rocks, lying far above the level of the present glaciers, furnish strong evidence of glaciers having formerly extended over vast tracts where they no longer exist.

In order that this grinding and polishing process may be rendered apparent, Professor Agassiz gives a view of the inferior extremity of the Glacier of Zermatt, in which the rugged appearance of the ice, when exposed to atmospheric influence, is apparent. As the ice is here detached in many places from the rocks, Agassiz was enabled to penetrate beneath its surface, and thus *observe the manner in which the polish of the rocks is effected by the movement of the ice*, which, in expanding, as it constantly does, from causes detailed in the published description by Agassiz, acts like a rasp upon the surface, while the gravel and abraded portions of rock adhere to the under surface of the ice, and determine the furrows, grooves, and scratches. Many beautiful examples of the rounded bosses or domes, into which the rocks are worn, are also shown. These rocks are situated on the very margin of the glacier, and as they *exactly resemble the rocks which the glacier is converting into precisely similar forms*, there cannot be a doubt that they owe this striking peculiarity of form—the roundness, smoothness, and grooving—to precisely the same cause. The conclusion is indeed so obvious, that it would scarcely seem to require any comment, were it not that it forms one of the strongest links in the chain of evidence for believing that similar causes operated to produce similar results, which, as will be noticed in the sequel, are plainly to be recognised in the elevated valleys of Great Britain, and especially in the mountainous region of Snowdonia, in North Wales.

When the ice of the glacier is wholly dissolved, the rocks which it carried on its surface are deposited across the valley, and unite the lateral moraines. The water rushes over the barrier or terminal moraine thus formed, and its torrent is not without a peculiar agency in wearing the rocks, near the margin of the stream; but this agency is altogether different from that of ice—so much so, that a mere glance is sufficient to distinguish the water-worn rocks from those which have been rounded, polished, and scratched by ice.

Simple glaciers, derived from *one* and not from *various sources*, like those already noticed, have their *lateral moraines* parallel and concentric.

An example is given by Agassiz of the formation of a *medial moraine* from the junction of two glaciers, and also of the movement of the entire mass; a cabin, constructed in 1827, at the base of the mountain, having since moved, with the glacier, a distance of about 4,600 feet.

Polished and striated rocks are found in localities where glaciers no longer exist, but where, from the inferences already alluded to, Agassiz concludes that glaciers did exist; and we thus advance another step to the evidence which is derivable from such records.

The appearance of the stria and polish, on a close examination, is admirably shown by Agassiz in an example on the southern side of the Jura, three leagues from Neufchatel, and *at a distance of more than twenty leagues from the nearest glaciers.* The entire surface of the Jura mountains is thus more or less rounded, and scratched and polished, and from the direction of these furrows and streaks, Agassiz has come to the conclusion that they were caused by descending glaciers, in the same manner as those which have been described in different specimens of polished rocks brought from various and distant localities, the polish being of the same nature. One example was detached by Agassiz from *under* the glacier of Zermatt. Another was obtained from the *summit* of Riffel, more than 600 feet above the surface of the glacier as it now exists; and in some cases the polish is so perfect that the forms of organic remains are distinctly seen.

The lithographic plates to which I have referred were exhibited by Professor Agassiz, at the meeting of the British Association at Glasgow in 1840. He then detailed the several particulars, by which he accounted for the formation of the peculiar forms of rock, and also for his opinion that such results could not have been caused by the action of water. From the evidence of the glaciers having formerly been of enormous magnitude in Switzerland as compared with their present extent, he was led to conclude that they must have been more extensively spread over the northern and central parts of Europe; and after the meeting at Glasgow, he accompanied Dr. Buckland on a survey of the valleys near Ben Nevis, and afterwards extending his investigations into Ireland and some parts of England, he came to the conclusion that distinct evidences of glacial action were traceable in various parts of Great Britain, and explained his views in a paper read before the Geological Society of London, on the 4th November, 1840.

Professor Agassiz, when at Edinburgh, accompanied Mr. Maclaren to a quarry on the south side of Blackford Hill, where the rock, for the space of ten or twelve feet in length, is smoothed and marked by stria or scratches; on seeing which, Agassiz instantly exclaimed, "That is the work of the ice." It is, therefore, not only from general reasoning that glaciers had probably existed in these kingdoms, but from the actual observation of phenomena apparently caused by glaciers, that Agassiz, Buckland, and other geologists, have arrived at the conclusion that they formerly existed here. Dr. Buckland, in the course of his investigations, has extensively examined several districts in Great Britain, having previously, in 1838, surveyed the phenomena presented on the south-east slopes of the Jura, and by actual glaciers in the Alps. On an attentive comparison of these with what he remembered to have observed in 1811, near Dunkeld, and in 1824, near Ben Nevis, he was convinced that they were of similar origin: and Mr. Calverley Trevelyan, of Wallington, in Northumberland, a zealous and accurate observer, who had examined the supposed evidence of glaciers in the highlands, has lately written to Dr. Buckland, expressing his conviction that they are precisely similar to the glacial phenomena which he has recently examined in Switzerland. In a paper read to the Geological Society, Nov. 18th, 1840, Dr. Buckland describes a terminal moraine, near Closeburn, in Dumfriesshire, formed of materials derived from the adjacent Lowder Hills, with fragments of granite, the nearest rock *in situ* of which is thirty miles to the north-west at Loch Doon. Its height varies from twenty to thirty feet, its breadth at the base is about one hundred feet, and its length nearly a quarter of a mile. In Aberdeenshire, Dr. Buckland found insulated tumuli and ridges of gravel occupying one hundred acres, which he considers to be terminal moraines. Both in Aberdeenshire and Forfarshire, Dr. Buckland observed many traces of what he considered to be moraines, more or less dispersed by the action of floods, such as would doubtless accompany the melting of large quantities of ice. Immediately above some of these supposed moraines, he found polish and stria on the porphyritic rock, near the summit of the hill, which he had no doubt was to be assigned to glacial action. For two or three miles up the valley, east of Blair Gowrie, there are vast longitudinal and insulated ridges of gravel, similar to lateral moraines, and there are equally evident traces of transverse or terminal moraines in the valley of the Lunanburn, to the west of that town. The mounds at Dunkeld Castle, forming part of the ornamented grounds—the detritus on the left flank of the valley of the Tay, in the valleys of the Tumel and the Garrie—all present the appearance of moraines, and are described in Dr. Buckland's communication to the Geological Society, read in November, 1840. In the same locality, numerous and very striking examples were also found of rounded and polished rocks, with flutings similar to those of which the plates of Agassiz's "Studies" convey so clear an idea. Two lofty ridges of gravel, near Taymouth Castle, cross the park at right angles to the sides of the valley, and are exactly similar in position and appearance to terminal moraines. A remarkable group of such mounds occurs on the high land dividing the valleys of the Tay and the Bran; these are thirty or forty in number, and vary in height from thirty to sixty feet; they are composed of unstratified gravel and boulders. These, Dr. Buckland observes, cannot be ascribed to the action of water, as they are placed precisely where a current of water, descending from the adjacent high lands, would have acted with the greatest velocity; and they exactly resemble the moraines in the valley of the Rhone, between Martigny and Löek.

In Strath Earn, the valley is flanked with ridges and terraces of gravel, and numerous rocks are rounded and guttered.

At Comrie, Dr. Buckland marked on a map the localities where glacial evidences might be anticipated, if the theory were correct, and the result exactly coincided therewith. Near Fentallich were rounded masses of greenstone, partially covered by moraines. At Kanagart, both lateral and terminal moraines were apparent. Immediately below the confluence of Glenlednoch and Glen Garron, a ridge of gravel, resembling a medial moraine, stretches along level ground. In Glen Turret, a vast lateral moraine is intersected by a deep ravine, which apparently must have been formed when the valley was filled with ice more than five hundred feet above the level of the present lake; and in several places in this locality, the rounded and polished rocks, furrowed, grooved, and scratched, afford strong evidence for believing that they owe their origin to ice, in the same manner as the rocks in the Alps, of which in form and features they are so exactly the counterpart.

On the north bank of Loch Earn are rounded and furrowed surfaces, and at Loch Earn-head is a group of conical moraines at the junction of two valleys, and at the very point where, if they had been brought by a torrent, they would have been propelled into the Loch. Their position exactly corresponds with that of a terminal moraine.

Mr. Lyell, who had long been acquainted with and perplexed by various phenomena of the boulders and detritus of Forfarshire, after the visit of Professor Agassiz resumed his examination, and having become convinced that glaciers existed for a long time in the Grampians, and extended into the low country, many of his previous difficulties were removed. The subject is not without its perplexities, for though on the one hand Mr. Lyell considers, from the evidence of fossil shells received from Canada, that the climate in the latitude of Quebec 36° 47″, (corresponding with the central part of Switzerland,) was far more intensely cold at one period than it now is; yet there is also evidence of the climate of Great Britain having formerly been much warmer than it is at present, of which the fossil trees which form a prominent feature in the collection of this society are a striking indication. It is probable that various alternations of temperature have taken place, and that an attentive examination of the evidences afforded by rocks and by their fossil contents, may throw much light on this interesting department of geological science.

In the valley of the South Esk, Mr. Lyell, in a paper read to the Geological Society of London, Dec. 2nd, 1841, minutely details a variety of conditions which strongly confirm the supposition, that its lateral mounds were derived from glaciers. An enormous mass of boulders on the southern side of Loch Brandy, clearly derived from the precipices which overhang the rock on the three other sides, furnishes another strong proof of the glacial theory. It is impossible, Mr. Lyell observes, to conjecture how the blocks could have been transported to their present position, except by means of a glacier. Near Loch Worral, also, Mr. Lyell found a moraine, extending several hundred yards in width, and twenty feet in depth, terminating in a number of hillocks and ridges, much resembling in shape some of the terminal moraines examined by him in Switzerland.

A great transverse barrier at Glenairn, resembling an artificial dam 200 feet high, and many similar features, are detailed at considerable length in the paper alluded to, all of them affording evidence of the former existence of glaciers in this part of the kingdom. Observations were made in Northumberland, Cumberland, and Westmoreland, by Dr. Buckland, on his return from Scotland; and during part of that journey I accompanied him from Newcastle to Whitfield, thence to Alston Moor, and over the Crossfell ridge of mountains into Cumberland. I had thus an opportunity of hearing a graphic description of the phenomena in Scotland to which I have briefly alluded; and when at Alston, I read with Dr. Buckland the Report of Professor Locke on the State of Ohio, in which he not only describes grooves and scratches precisely similar to those alluded to, but also gives a relief engraving of a specimen which leaves no doubt of its identity. Professor Locke says, that "the rectilinear course of these grooves corresponds with the motions of an immense body, the momentum of which does not allow it to change its course on slight resistances." It is at once evident that this description is exactly correspondent to the effects of glacial action; and it shows very clearly how strong an evidence is afforded by the mere physical conditions of the grooved and polished stone; for it would be impossible more correctly to describe the action of the glacier as witnessed by Agassiz, and recorded, there is much reason to conclude, on the rounded, and grooved, and furrowed rocks of Great Britain, as legibly as upon the rocks which in Switzerland are in juxta-position with existing glaciers. I forbear to speak of the observations made in the North of England by Dr. Buckland, because I trust in the course of the summer he will fulfil his intention of resuming the examination of the Cheviots and North and South Tyne, when the whole can be better explained by means of maps and diagrams, than it can by mere description.

During my journey with Dr. Buckland in October, 1840, he pointed out the most likely places for searching in order to discover traces of glacial action, and was about to examine the rocks in a quarry at Langley, when we were deterred by the quarrymen being on the point of firing a blast. On a recent visit which I made to this place, the workmen had just bared a considerable breadth of surface, and on washing it, the long lines of grooving were quite visible in a direction parallel with the valley, and the polish afforded a clear view of the fossil contents. The cover was a strong clay mixed with numerous boulders of sandstone and limestone, on one of which were numerous scratches. I procured two specimens of the rocks, which I left with Mr. Ord, at Whitfield, and even on these small pieces the polished surface and grooving were conspicuous. This example clearly shows that these peculiar features exist in the North of England, and I doubt not that when attention is more generally given to the subject, many more will be discovered.

If these features are entirely due to glacial action, it would seem natural to conclude that the hardest rocks and the highest altitudes would afford the best opportunities of observation. With this view it was thought by Dr. Buckland that the slate rocks and elevated valleys of Snowdonia in North Wales would present great facilities of observation, and I accompanied him in an examination of that district in October last.

Until I had an actual inspection of the rocks in various parts of North Wales, I had no idea of the close resemblance they bear to the forms which Agassiz has figured in his plates, and the impression produced on my own mind was, that this form could only be derived from the slow movement of solid masses of vast momentum. The weather was unfavourable for the general examination of the surface as regards mounds of earth, or the structure of supposed moraines, inasmuch as the ground was saturated by heavy and almost incessant rain; but on the other hand this very circumstance was peculiarly favourable for examining the rocks, the constant washing of which presented a clearer view of their features than would have been seen if they had been perfectly dry, and to this cause Dr. Buckland attributed the discovery of several phenomena which had escaped the attention of previous observers.

After examining the district near Ellesmere, which consists of vast masses of detritus, apparently derived from the valleys of the Severn and the Dee, and containing also numerous angular fragments of granite from Ravenglass and elsewhere, we proceeded up the vale of Llangollen, and observed the polished and grooved condition of the slate rocks. We saw also a curious fluted surface in a slate rock near the village of Llangollen; but this being on one of the divisions of stratification, was evidently owing to mechanical causes, by a horizontal sliding of one bed of the rock on the other—in a hand specimen the grooving bears a resemblance to glacial flutings, but when viewed *in situ* the difference is very obvious. In the vicinity of Pentre Violas and Yspytty Evan, vast masses of detritus are formed into rounded knolls and hills of considerable magnitude, and have the appearance of moraines modified by the action of water. About a mile from Llyn Ogwin, where the river Llugwy turns to the south-east, there is a series of mounds of earth and gravel covered at their summits with hundreds of large blocks of stone, and these, Dr. Buckland states, approach nearer to the condition of moraines undisturbed since their deposition by a glacier, than any other mounds of detritus which he has seen in North Wales. The stream from the lakes at Capel Curig falls into the Llugwy, near a lofty mound resembling a terminal moraine, and below this junction the rocks are rounded, grooved, and polished. Near Llyn Ogwin a great number of rocks are worn into bosses or dome-like shapes; the surface is in most instances much abraded or weather-worn, notwithstanding which the deep groovings may be traced, and the former existence of a polished surface is evidenced by the extreme smoothness and curved contour of the veins of quartz, which project from half an inch to one or two inches, and thus form an index to the amount of abrasion.

I may here observe, that the scenery of this district is such as to merit especial notice, and will amply repay the tourist who seeks for romantic and sublime features. The stupendous hills and lofty precipices which almost encircle the lake, present one of the wildest and grandest prospects of Snowdonia. In the midst of the recesses of these mountains is Llyn Idwal, a dark and gloomy lake, which seems the last retreat of the wildest and most unmitigated desolation. The waters of the Ogwin fall down over a rocky barrier about 200 feet in height, and along the valley numerous examples of the rounded bosses or dome-shaped rocks present themselves. Dr. Buckland, in a paper read before the Geological Society of London, December 15th, 1841, has given a minute detail of the several places in which the rocks presented features indicative of glacial action, and which he represented in a large map of the valleys of Snowdonia. They are especially conspicuous and abundant in the valley of Llanberris, near Pont Aber Glasslyn, and Drws y Coed.

From the extensive observations thus briefly alluded to in Dumfriesshire, in Aberdeenshire, in Forfarshire, and Snowdonia; from the concurrent observations made at different times by Professor Agassiz and Dr. Buckland, in Westmoreland and at Edinburgh; from the decided opinion of Agassiz, Buckland, Lyell, Trevelyan, and others who have compared the evidence of supposed glaciers in Great Britain with the undoubted evidence of existing glaciers in Switzerland, that they are in both countries precisely the same in character and origin; and from the explanation which is thus afforded of many phenomena hitherto unexplained, it is obvious that the glacial theory has become a problem of considerable importance in geology. It is necessarily mixed with the consideration of other questions, to enter upon which would far exceed the limits of this paper, my object in preparing which is not so much to advocate any particular theory, as to afford a view of what has been done towards establishing it in this country, and also to draw attention to the prosecution of further observations. I shall therefore briefly sum up those leading features which have reference to a practical result, and which are founded upon the phenomena which I have had an opportunity of observing.

Among the appearances which most strongly attest the former existence of glacial action, are—

The rounded form of rocks.—This I have seen in various parts of Wales to an extent of which I had no previous conception. In the vicinity of Llyn Ogwin, on the south side of the lakes of Llanberris, and near the mountain of Drws y Coed, the most prominent examples occur of rocks rounded into forms precisely similar to those delineated in the plates of Agassiz's work. When once the eye has become familiarised with these forms, it is difficult to resist the conclusion, that they are of similar origin, and the form of many of them is such as one can with difficulty comprehend to have been caused by water, especially one of which I made a drawing on the margin of Llyn y Gader, near Drws y Coed, but which it is easy to comprehend might be ground into this form by the pressure of enormous masses of ice.

The polished condition of rocks.—This occurs both on rounded rocks and on nearly level beds; it is evidenced in exposed rocks, where the surface is weather-worn, by the smoothness of projecting veins of quartz, and the carboniferous limestone at Langley presents a highly polished surface. This condition is exactly similar to the polish on specimens of Swiss rocks worn by glaciers.

Many of the rocks in North Wales present a furrowed or undulating surface, the curves of which are alternately concave and convex, and several feet in length. This feature is one which might possibly be caused by diluvial torrents, in which large quantities of gravel were contained; and it must be borne in mind, that it is of importance not too hastily to ascribe to glaciers what may in reality be due to the power of torrents, and the more so as these two causes must of necessity have been conjoined, since it is evident that if vast masses of glacial ice formerly filled these valleys, there must have been numerous and powerful torrents consequent on its melting. This is indeed so apparent in many cases, that Dr. Buckland has adopted the term of "diluvio-glacial," to express the phenomena of Snowdonia, considering that glaciers were only one of several powerful agents in determining the peculiar forms of rocks, and the distribution of blocks over vast distances from their original position. It has long been considered, that to powerful torrents from the north or north-west, are to be ascribed the transportation of rocks and shells over the western declivities of Snowdonia, and over various parts of Derbyshire and Shropshire. Floating ice-bergs are considered by the present President of the Geological Society to have been important agents, and torrents of a more local nature have doubtless been instrumental in the great work of denudation. Whether to these agencies,—the evidence of which is beyond all doubt, as the vast accumulations of drift in this neighbourhood, and in various parts of Great Britain, abundantly testify,—that of glaciers is correctly added, is a theory which, if it cannot yet be considered as fully established, is at least supported by evidence sufficiently strong to merit further investigation.

The groovings or large marks in rocks, similar to those which are formed by glaciers in Switzerland, are quite apparent on a vast number of rocks which I have examined, and I have never yet failed to find them in positions where they might be expected to be, if the theory of their being the record of the descent of a glacier is correct. In exposed rocks these groovings are often destroyed by the weather, which indeed is fatal to much of this kind of evidence, especially in soft rocks. Hence it is only where a rock has been laid bare by a new road or a quarry, that a favourable opportunity is presented. If in such situations the gravel or soil is removed from the upper surface of the rock, and the rock itself washed with water, the groovings become apparent. Those in the specimens I procured at Langley were quite prominent, even without wetting the rock, especially when viewed by a side light. They were precisely the counterpart of the engraved groovings described by Professor Agassiz, in Switzerland, and by Professor Locke, in America—so similar, indeed, that they have passed for the originals whence these engravings were made. Of these two engraved examples, the one, it must be borne in mind, was brought by Agassiz from *under a glacier*—the other was considered by Professor Locke to afford evidence of the motions of a body, the conditions of which he concludes must be the same as that of a glacier.

Besides the larger groovings, which vary in size from a quarter of an inch to one or two inches, there are numerous scratches such as would be produced by sharp angular points. Both these and the groovings are often continuous for a distance of several yards, and are sometimes suddenly broken off—as if the abrading angle had been snapped; and in one instance near Pont Aber Glasslyn, of which I made a drawing, the moving force which grooved and scratched the rock appears as if it had been forced aside by a projecting knob of rock.

Boulders with flat sides are found in Great Britain as well as in Switzerland, and the scratches on their surface seem to indicate, that they had been moved so as to come in contact with angular points in different directions.

The most probable places to look for these grooved, polished, and scratched conditions of rock, are on the sides of valleys, and especially where the rocks are of a hard nature; and in every instance which I have yet seen, the groovings have been parallel to the direction of the valley.

These marks are no way dependant on the strike of the beds, being in some cases oblique, in others directly across the *strike* of the beds in their level line, or a line at right angles to their greatest declivity or *dip*.

It is sometimes necessary to apply the touch as well as sight to distinguish the scratches, for in slate rocks the joints of cleavage present an appearance exactly similar to the scratches; one, however, to the touch is perfectly smooth, while the scratches or indentations may be very perceptibly felt.

In judging of *hand specimens*, it is difficult to distinguish the groovings, or flutings and scratches, from similar marks, which may be caused in a variety of ways. Observers must, therefore, be on their guard, for it is only when viewed *in situ* and upon a large scale, that these characteristics are to be relied upon.

The phenomena of large masses of drift have never been investigated minutely, and the introduction of glacial action as an important agent in their production and dispersion, is calculated to throw much light on the subject, by affording an agency of which clear records have been preserved, if the forms and groovings which have been described are rightly attributed to former glaciers.

Those who will pursue this subject by reading the work of Agassiz, or the details of further observations made by English geologists as inserted in the Transactions of the Geological Society, will find that much more might be said in relation to moraines. My object, however, has not been so much to enter on a description of all the phenomena, as to present the more prominent features. The lithographed drawings of Agassiz furnish to the observer, at a single glance, a clear idea of the undoubted evidence afforded by the rocks in Switzerland. I have drawings which exhibit the like forms as observed in various parts of this kingdom. The concurrent testimony of all who have examined both *in situ* is, that they are precisely similar. In Snowdonia are abundant evidences of some immense moving mass having descended each valley, and upon this coincidence, strengthened and confirmed by the collateral evidence of glaciers having formerly been of much greater extent than they now are—upon this close analogy and general prevalence of the phenomena here described, is based the supposition, that glaciers formerly occupied the valleys which have been described; and it is believed that further observations, made in the situations and in the manner I have alluded to, will furnish incontestible evidence of the former existence of glaciers in Great Britain.

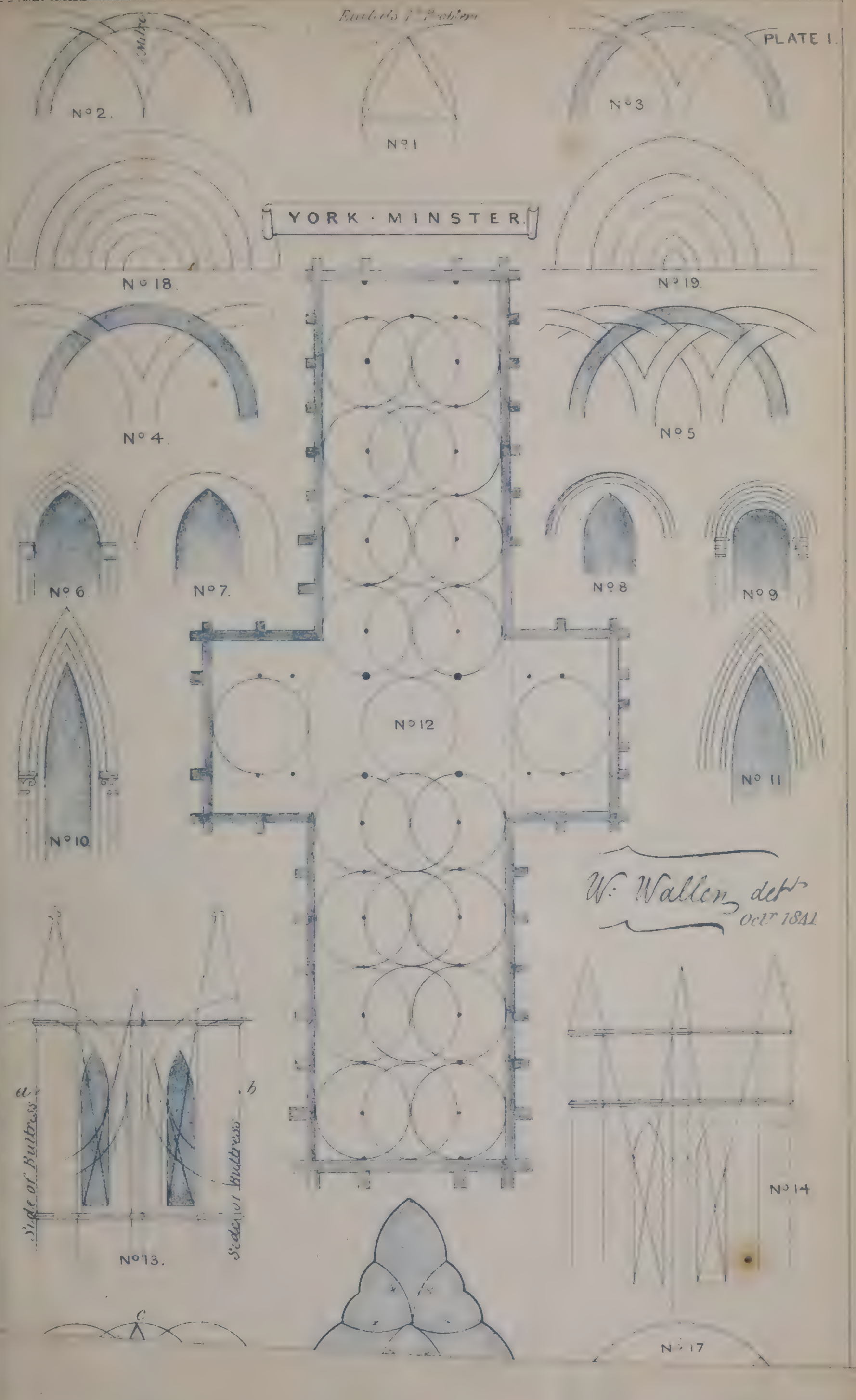

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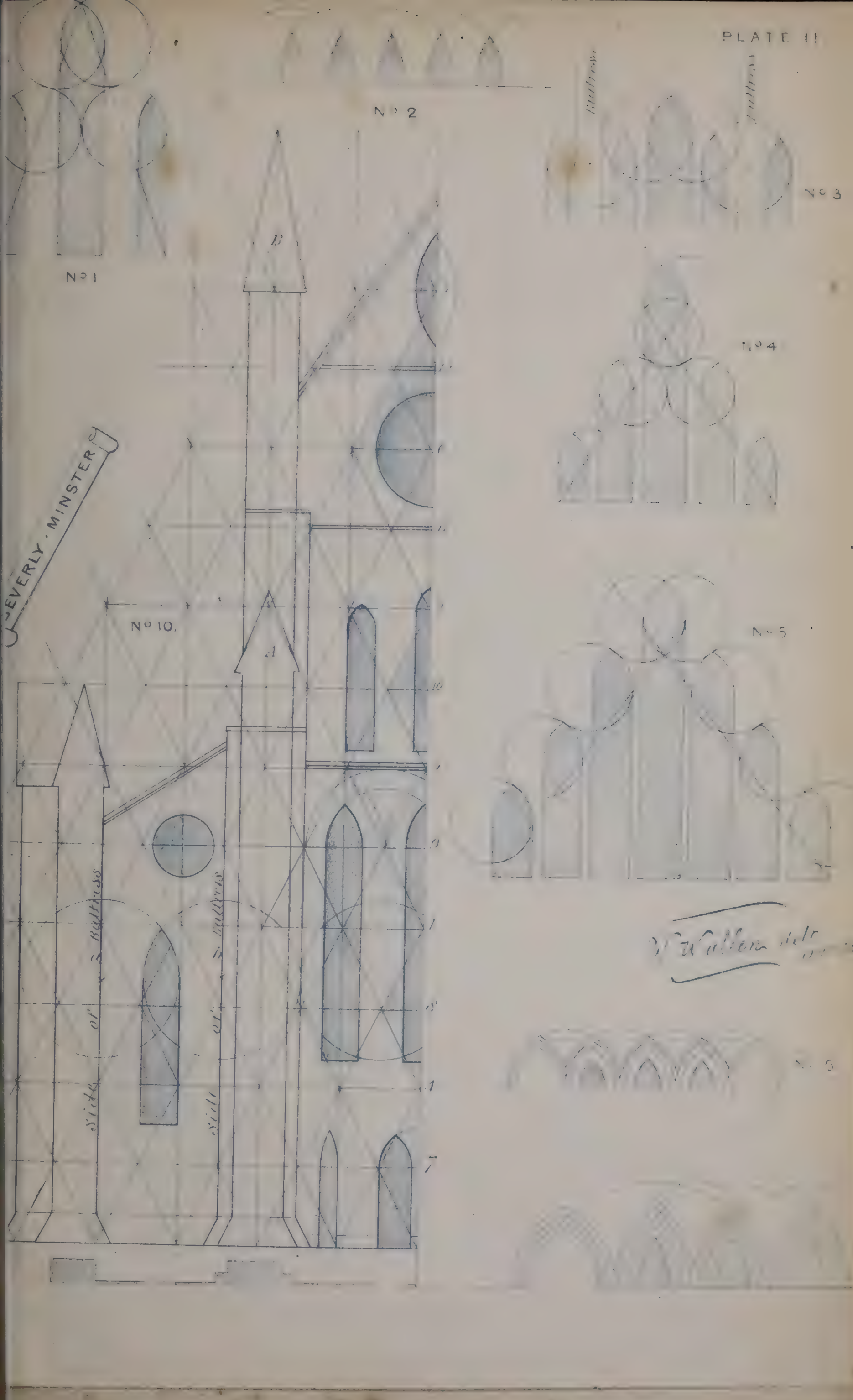
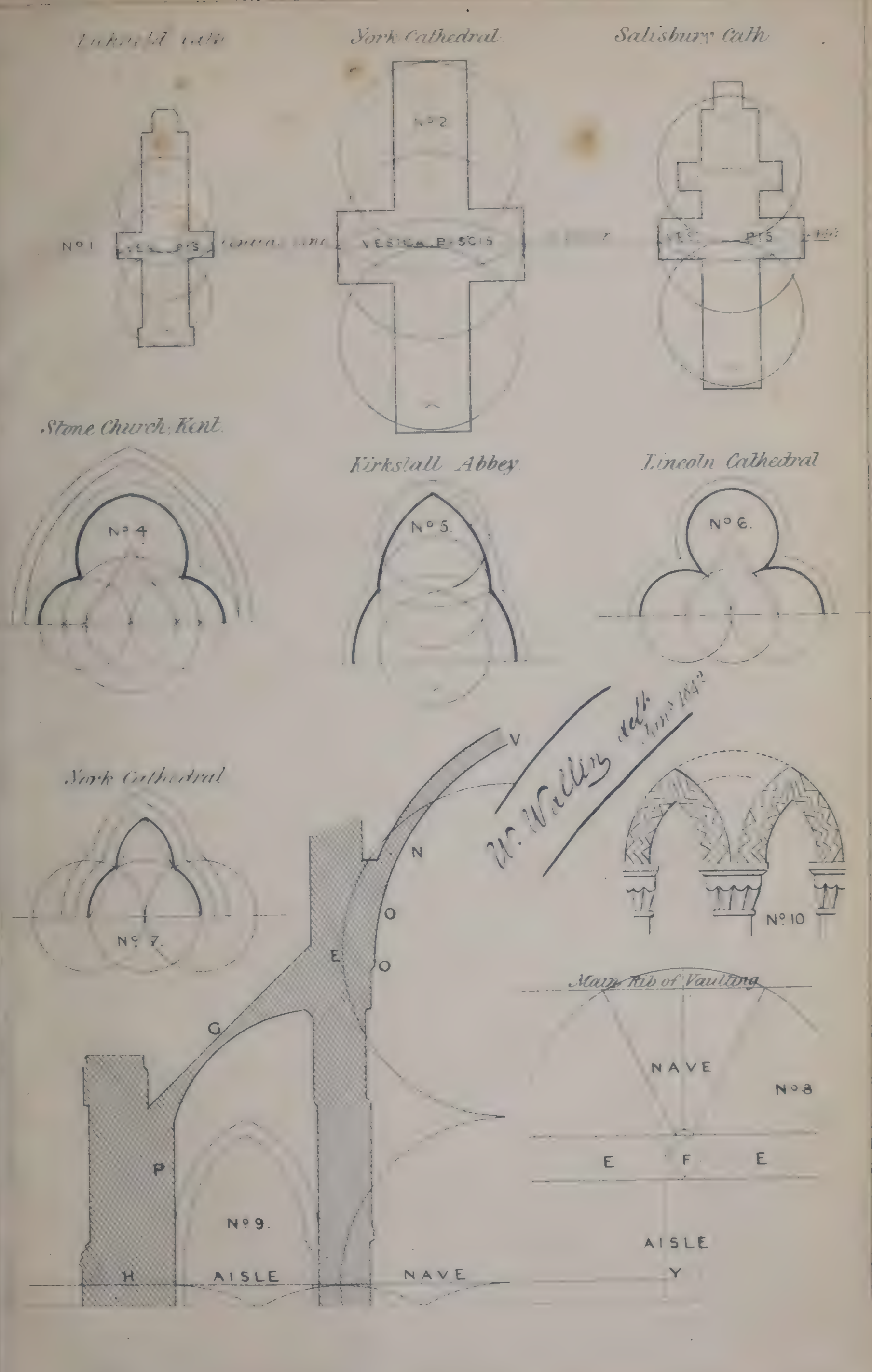
PLATE II

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