present surface features, consisting of valleys, watersheds, and escarpments, mainly originated while the land was under the sea—while the valleys formed inlets, the watersheds straits, and the escarpments sea cliffs.

SOME OBSERVATIONS ON COAL AND COAL MINING, AND THE
ECONOMICAL WORKING OF OUR COAL FIELDS. BY MR.
WALTER ROWLEY, MINING ENGINEER, LEEDS.

At our meeting in Pontefract last November, our honorary secretary, Mr. William Sykes Ward, expressed a wish that some members of this Society would contribute papers on the most economical mode of working Coal Mines. My only apology as an amateur geologist, and so young a member of this Society, for complying with Mr. Denny's request to prepare these observations (and at the same time continuing a series of papers so ably inaugurated by our friend Mr. Tew, and which I trust will be continued by many present), is an earnest conviction that the best way to assist each other in the pursuit of knowledge, is by every member contributing, out of the storehouse of his own experience, those results which circumstances and his daily occupation have given him the best opportunity of investigating; hence the subject of my paper, prepared with considerable diffidence, but with a hope, that with your assistance, we may exert our utmost to stem that tide of "wilful waste" which in the end will make "woful want" of a commodity the most valuable that a nation can possibly possess as a source of national wealth.

The writer, on the present occasion, will pass over the geological introduction by which this paper might be preceded, and thus avoid the charge of having presumed to linger on ground where often, mining engineers fear to tread, lest they come in collision with our geological *savans*, who, during the last few years, by their valuable

books and papers (indicating a wonderful progress in this beautiful and fascinating science), have assisted the mining engineer to an incalculable extent.

As a basis upon which to build the argument of my paper, I have selected the Middleton Main Seam of Coal as being one of the most important and substantial seams in the whole series, considering the area it occupies and the average thickness it attains to (nearly 4 ft.), in the Yorkshire Coal Field.

My illustrations represent the two generally-recognised systems of working the above seam; and the figures and deductions that I may hereafter make, are taken from personal knowledge of the results actually obtained from the working of the above seam under both systems in the same district.

For simplicity in discussion, and as comprising all we require for the purpose of this paper, I shall condense the various modes of working Coal in Yorkshire into two systems, viz., "pillar and stall" and "longwall" with pack-gates, for all the recognised modes of getting Coal are but modifications of either one or the other of these two systems.

I shall first refer to "pillar and stall," and, here in passing, it may be interesting to mention that the most primitive mode of getting Coal seems to have been associated with this idea. Even so far back as the Roman occupation in this country, at any rate, it is recorded on incontestable evidence, during the Anglo-Saxon period of about the 9th century, where evidence has been collected of the Coal having been obtained in this rude form, better described as consisting of getting a piece of Coal and leaving a piece alternately. At the same time, in justice to the Romans, who were an exceedingly practical and skilful race, we must remember that they were limited to "basset" workings, and, consequently,

had not any other alternative. Had they worked at greater depths, and possessed a proper roof, they might very probably have adopted some system of longwall. This historical record is the parent of the present system of "pillar and stall," greatly altered and improved, but still retaining the impress of its origin; hence, perhaps, may arise the reluctance in many minds, to change a system that has grown with them, and been handed down to them from their forefathers, for one that has been long practised with uniform success in the Coal Fields of Derbyshire and the Midland Counties.

The combination of this system of "pillar and stall," as practised in the Yorkshire Coal Field, may be described as "Banks and Pillars," as illustrated in my plan of that method, and marked No. 1, the distinguishing feature of which consists of getting a certain portion of the Coal, and leaving the remainder as pillar, to support the roads, and prevent any movement in the ground or roof of the seam. The Coal thus left is either permanently lost, or left until some remote period in the history of the mine, to be either partially or totally removed. In either case the results are equally unsatisfactory, for, generally, when it is got afterwards, the length of time that it has borne the pressure of the superincumbent strata, renders it almost worthless. Being mostly crushed into small Coal, it is almost impossible to work such pillars at a profit, hence arises the momentous question: What is the best mode of getting a given seam of Coal? upon which decision, in opening a colliery, depends whether it shall be an absolute loss, or a remunerative profit to the owner. For if the workings of a mine are badly set out and unskilfully conducted at the commencement, the consequences are an unremunerative investment of capital and frequently-occurring accidents; hence, how important it is in colliery operations, that the mode of getting the Coal, and the

discipline inaugurated at the beginning, should be carefully carried out afterwards.

The plan that I have made of pillar workings is, I think, one of the most economical that such a system will admit of, the ventilation having the advantage of supplying each district or sets of banks with its own separate portion of air, instead of the objectionable plan of carrying the air round the mine in a single current. On my plan the direction of the ventilation is shown by the arrows, and I have also marked the necessary air crossings and stoppings, etc. You will notice that the air is passed up the pillar board, on one side of the bank, along the crossgate, and into the return air road. I should first have mentioned that the preliminary operations of the mine consist of roads or endings being driven in pairs, following the cleavage of the Coal, at distances varying from twelve to twenty chains, according as the nature of the roof will admit of, and between these endings the Coal is got in banks of different widths, varying according to circumstances, from forty to sixty yards. Every set of banks consisting of some four or five boards, each about ten yards wide, out of which the Coal is brought, and conveyed along the main board into the ending leading to the pit bottom. A pillar of Coal is left between these banks, of about forty yards in width, which is brought back when the banks are finished.

The area of Coal occupied in this way, in the form of pillars, is not less than 50 per cent. of the entire area of the Coal field; and the production, instead of being about 6,000 tons per acre in the seam now referred to, four feet thick, would realise only about 3,000 tons of Coal until such time as the pillars are removed; then again, this system produces a large proportion of slack or small Coal, by reason of the holing required, and it being got facing the cleavage of the Coal. This, with the increase of slack produced in working the pillars, will often raise the percentage of small

Coal to 40 and even 50 per cent., thus leaving little more than 3,000 tons of large Coal yielded per acre.

You will easily understand what a fearful loss this must be in an extensive Colliery, where such Coal will only realise in the market from 2s. 6d. to 3s. 6d. per ton; consequently, where there is not a sufficient manufacturing demand at hand, and it will not readily make into coke, it is found better to save the carriage of it by leaving a portion in the goaf along with any other refuse obtained in getting the Coal. The refuse in many Collieries is very considerable, particularly where the seam of Coal is divided by partings of shale and earth. This is an item of very serious trouble and expense in many mines. It would be a great gain to the country if the Coal dust, which we see accumulated in heaps at all large collieries, could, either by improved mechanical arrangement, be consumed as Coal, or manufactured into artificial fuel. The former expedient has been attempted by Mr. Thomas Russell Crampton, at Woolwich, with his Coal Dust Furnace; and the latter alternative by mixing dry pitch with the same, under a process invented by M. Chagot, the engineer to some Coal Mines in Saône et Loire, France, both experiments resulting in a fair measure of success.

Holing in the Coal is, at all times, *productive* of much *waste*; consequently, where the ground or base of the Coal is of a soft nature (more usually so than otherwise) the holing should be made in the seam of under clay usually existing below the Coal.

I now come to the brief consideration of "Longwall" workings, as illustrated in my plan marked No. 2., the distinguishing feature of which is the extraction of the whole of the Coal (after leaving sufficient for the support of the shafts) in the first process of working, by means of long continuous faces. The preliminary operations of this system

usually consist of a pair of levels being driven east and west of the shaft, out of which, as the Coal proceeds to be got, artificial roads are made thirty or forty yards apart, according to the nature of the roof. These roads are made by being packed on either side with the *débris* obtained in the getting of the Coal. The roads are always kept close up to the face, and the failure of this system on some occasions where it has been introduced in Yorkshire, has arisen solely from these walls not being built in a solid and substantial manner, for unless they are, the roads through the goaf and the bank face are sure to be buried, as well as endangering the ventilation. If this be properly done, and with anything like a suitable roof and competent management, I do not fear any failure.

At the face of the Coal, the men are protected by one or two rows of props, and here I may remark in passing, that these wood props, intended for safety, are often a source of danger when worked under incompetent or unskilful management, for you may have too many of them as well as too few. In Longwall, our object, after securing the safety of the miner, is to let the roof gradually bend down upon the goaf, and throw all possible weight upon the face, to facilitate the economical getting of the Coal.

As the face of the Coal advances, the hindermost props are brought forward, and the roof let down; the sooner and the better; the longer your face of Coal, and of course the greater will be your supply, which can be made very great under this system; but to arrive at perfection in quality, as well as quantity, I would in most cases have the Coal worked or broken off at right angles to its natural cleavage, or, as it is commonly called, "end working." Any person not conversant with this end way of getting Coal, will understand my meaning by examining an ordinary block of wood; if you break it off with the lines of cleavage, it produces thin

splinters of wood; if broken off at a right angle to its natural formation, or on the end, you obtain large cubical blocks of the same. It is just the same with Coal; unless so worked, we cannot obtain that maximum quantity of large Coal so much to be desired, for instead of 30 to 50 per cent. of slack in bankwork, I have known it reduced in one instance, where the Coal is riddled in the pit, to under 6 per cent. for the average of one year's workings in Longwall got endway. This increased yield of round Coal will far more than compensate for any slight extra cost incurred in getting, which the following figures, calculated from the seam referred to, and strictly correct, will show to be very slight indeed.

To avoid going over unnecessary commercial ground, I have only calculated the items of cost up to such a stage in the getting of the Coal, as when the charges become the same under both systems. The following figures, therefore, represent not the actual profit obtained, but only the difference in favour of one system over the other. In working this seam in Banks and Pillars, I find that 60.88 per cent. of large Coal, and 39.12 per cent. of slack, was obtained, which cost in getting 2*s.* 1*d.* per ton; this, taken at the respective sale prices of 7*s.* and 3*s.* 6*d.* per ton, realised £28 2*s.* 9*d.*; or an average of 5*s.* 7.53*d.* per ton.

Working the same seam by Longwall, I found that 81.75 per cent. of large Coal, and 18.25 per cent. of slack, was obtained, which cost in getting 2*s.* 3*d.* per ton; this, at the above sale prices, deducting the slight difference in cost of getting, amounts to £30 18*s.* 7*d.* per hundred tons; or an average of 6*s.* 2.23*d.* per ton. Now, assuming an average weekly production of 3,000 tons of Coal (which a modern well-arranged Colliery, where the discipline is good, ought to attain without any difficulty), we have a difference in favour of Longwall of 6.70*d.* per ton, which is equal to £83 15*s.* per week, or a saving of £4,355 on one year's production.

This is under the result actually realised, as the writer, in these calculations, has assumed the same sale price for Coal got by both methods, whereas, Coal got in large cubical blocks (as obtained under this system of Longwall on end), is worth at least 6*d.* per ton more than the same Coal got boardway.

In presenting these returns to you, I may possibly be charged with having selected an exceptionally favourable Coal seam; such, however, is not the case, as the "Middleton Main" is certainly not the most economical Coal in the series, so far as concerns its economical adaptation to Longwall workings. I do not say these gratifying results can be obtained in every seam of Coal, but I do believe, after a very careful investigation of the subject, that there are few seams where such a system could not be adopted with advantage; and the analysis I have given from results actually obtained in the same bed of Coal, show what an important part the method employed bears in the economical working of our Coal fields.

The ventilation, under this system, is obtained as follows, and is characterised by its remarkable simplicity:—The workings of the pit are divided into districts, to each of which is supplied a separate current of fresh air, which is delivered at the face of the Coal without that waste in its journey, which is involved in any system of pillar workings. The air, after travelling over the limited district assigned to it, passes into a return air course made through the goaf; into these roads there are cross roads from the intake air courses, to furnish a limited quantity of fresh air, for rendering any obnoxious gases harmless in their passage to the upcast shaft, thus purifying the goaf without adulterating the air passing along the face of the Coal.

All the main roads used in working, and for the passage of air, should be constructed as large as possible, so as to obtain

economical haulage and adequate ventilation. Corners and projections in the sides and roof of the roads, should be avoided as much as possible, for if the roof is irregular, you will see by observing the line along which the air travels, as shown in my illustration marked fig. 1, that these cavities above you, do not get any ventilation except by an artificial arrangement of brattice cloth. Carburetted hydrogen gas, being lighter than air, ascends and accumulates in these places, therefore the more regular in shape you can keep your roads, and the safer and more economical it is.

Where two returning currents of air join each other, the junction should not be made at right angles, as is shown in fig. 2, and as is usually the case, but effected in the manner illustrated in fig. 3, where you will observe that the two currents, at the point of junction, have both the same direction, and therefore assist each other, instead of the objectionable plan of meeting at right angles, where one current must naturally impede the course of the other.

In pillar and stall workings there is the absence of this valuable current of fresh air, just at the place where it is most wanted, as no proper quantity of air can be obtained in banks of such limited area, situate out of the main air roads. This system of ventilation is economical in other ways, in addition to the increased safety afforded to the miner, inasmuch as it dispenses altogether with the large outlay consequent upon the driving of long narrow roads, unprofitable in themselves as well as detrimental to the physical health of the workman; it thus affords to the proprietor the quickest return for his invested capital.

The ventilation under any system of pillars, is attended also with greater risk, on account of the large area of goaf shut up between these pillars, where the explosive gases accumulate, and are a constant source of danger in fiery mines.

Reference to the Reports of Her Majesty's Inspectors of Coal Mines, show very conclusively the relative safety of these two systems of getting Coal, which, taking the average nature of the Coal seams in various districts, will be a strictly just and reasonable comparison.

The number of accidents from falls of roof and Coal in the Yorkshire Coal Field, amounted in 1869 to 59 per cent. of the accidents from all causes. This refers to a district where "Longwall" is the exception, and some form of bankwork the usual method employed.

Mr. George Fowler, in a recent paper read before the Institute of Civil Engineers, has very ably analysed this important inquiry. He finds that, "Out of a gross tonnage of 198,636,043 tons obtained by pillar work in 1866, 1867, and 1868, the casualties by falls were 814, or 231,739 tons of Coal for each life lost. Of a gross tonnage of 22,899,000 tons extracted by the longwall plan, the casualties were 75, or 1 life for every 305,320 tons. If the latter ratio existed in pillar work, the casualties would have been reduced from 814 to 614, or a saving of 200 lives." This happy feature in longwall is produced by the absence of those small and weak pillars of Coal which we find in all pillar or bankwork; on the other hand, Longwall attains its smaller percentage of accidents from the fact that the roads are built well and there only being a limited area of roof exposed to the workman; the worn out and bad roof being allowed to bend itself and settle upon the old goaf, and, as I previously explained, utilised to help in getting the Coal. As the miner advances, there is always a new roof to protect him which has never done any duty before. Then, again, there is another arrangement very general in Longwall mines, which, the writer thinks, greatly helps to bring about these results, viz., that the building of the packwalls, and the timbering and supporting of the roof, in Longwall mines, are

usually attended to by skilled men whose duties are confined to this work, and not by an unskilled hewer of Coal, whose only object is to economise his own time and labour. I have observed this evil wherever men are allowed to timber and build the roads for themselves. This beneficial rule might be made more general and perfect, even in Longwall mines, than it is at present. The importance of this portion of Coal mining being done well, we can all well understand when we remember that the existing drain upon the lives of our miners cannot be traced to explosions, for the heaviest item is due to falls of the roof.

In 1868 and 1869, the deaths by explosions in the British Coal Fields amounted to 411, whilst by falls of the roof we find 911, or more than double. The public take but little heed of the latter, because of the comparative smallness of the event, when a fall of roof is recorded, and one or two lives only, lost; but they do take heed of explosions, on account of the disastrous consequences which usually follow, although in themselves of rare occurrence; but the colliery manager, who has an eye to a good balance at the end of the year, knows the ultimate cost of these frequently-occurring accidents, which only take one or two lives at a time, but which justify the writer in making rather more than a passing reference to.

Associated with the miners' duties just referred to, comes the use of gunpowder in collieries, which, like the packing and timbering, should devolve upon one man skilled in the use of the same, and a close observer of the presence of the smallest portion of gas; for, when the miner has this dangerous weapon in his own hands, he is tempted to use too great a quantity than is absolutely necessary to separate the mass of Coal worked upon from the solid, instead of bringing it down with as little fall as possible; and so, while protecting himself, avoid the possibility of disturbing the ordinary ventilation of the mine.

This rule would, I think, help to produce a greater immunity from explosions of gas, for most of them are traced to the incautious practice of firing shots in the neighbourhood of accumulations of gas; hence the importance of this duty being attended to by an intelligent workman—and it can be practically carried out more effectually under the necessary discipline of “Longwall,” than by any other method.

The writer is of opinion that the extension of this system of “Longwall” in Coal mining, is the pioneer paving the way for the working of this mineral at greater depths than we are accustomed to at present, for under no system of pillar workings could we get adequate ventilation at such depths as necessity will compel those following after us to venture to, for when we come to work at depths of 1,200 yards and upwards, we shall strive to convey all the air we can collect direct to the working faces unimpaired, avoiding all circuitous air courses, which would so diminish as to render the ventilation totally inadequate.

Associated with this portion of my subject, I may state that the deepest mines in existence, where we may collect evidence as to the temperature under the above circumstances, are Rosebridge Colliery, in Lancashire, 806 yards deep, the normal temperature of the Coal at that depth being 93 deg., while the temperature of the air passing through the workings is 78 deg.; at Denaby Main Colliery, 440 yards deep, the deepest and nearest mine to Doncaster, the temperature of the air passing through the workings averages about 68 deg.

In Belgium, Coal Mining has descended to a depth of nearly 1,200 yards, and from some observations that I made during a recent visit to the Coal fields of that country, and also from personal experiments that I have made at depths up to 500 yards, I have found the average increase of tempera-

ture to be about 1 deg. Fahr. in 76 feet; and from experiments made at depths from 500 to 1,000 yards, and furnished to me by Monsieur Lambert, Inspector of Mines at Charleroi for the Belgian Government, and to whom I am greatly indebted for his valuable assistance, I calculate them to indicate an increase of 1 deg. in 125 feet, showing for our encouragement, that at increased depths the temperature does not increase at the same rapid ratio that it does at shallower depths, which, as we proceed under the Trias and Permian formations, I anticipate to become still more favourable, inasmuch as these deposits produce little or no heat, being generally very cold, and in some districts very wet. At the same time, therefore, in working Coal at these depths, it is not at all improbable that this temperature in some instances may be considerably reduced by natural causes, such as the evaporation of water passing through the overlying strata, combined with the most perfect mechanical and general arrangement of ventilation.

This subject of the ratio of increase of temperature of Coal mines at increased depths, bears a most important and interesting part in the economy of our Coal fields in the future, and as it is one that chemists and engineers have somewhat investigated of late, I hope some member of this Society will contribute a paper on that subject.

There is another insuperable barrier to pillar workings at increased depths, in addition to the ventilating difficulty just referred to, viz., the pressure of the superincumbent strata upon such pillars of Coal, which will necessarily increase the deeper we go. At the same time, in investigating this subject, we cannot draw an infallible rule for the rate of increase, which is regulated a little by the material passed through; for instance, if the sinkings pass through any rocks of great thickness and extent, the pressure might be somewhat relieved thereby. A cubic foot of rock sand weighs 156

pounds; of shale or bind, 160 pounds; and of Coal, 82 pounds. Mr. Fowler calculates that the "Average weight of these in different localities may be taken at 144 pounds per cubic foot of the Coal measures, which represents a pressure of one pound per square inch for each vertical foot of strata. A Coal seam, therefore, 1,000 feet deep, will have a dead loading of 1,000 pounds per square inch upon it as it lies untouched."

I think these calculations to be as near as it is possible to arrive at, not forgetting that there would be an increased local pressure, varying according to the system of Coal mining employed; it would therefore be impossible to preserve any pillars of Coal, however large they might be, if once disturbed; and even if it were possible to get such pillars, it would only be at a loss; hence "Longwall" suggests the removing of this pressure from the Coal on to a well constructed artificial goaf, built as the workings proceed.

The writer is convinced that "Longwall" will pave the way for a revolution in the detail of Coal mining, which must come sooner or later, viz., the extensive use of machinery in Coal getting. The public have before them at the present time, a great variety of inventions, aiming to do this successfully: some arranged for baring, and some for breaking down the Coal, and some aspiring to do both operations. The motive power employed is often hydraulic, and in some instances compressed air. Mr. Grafton Jones's breaking-down machine, and the machines of the West Ardsley Coal Company, are the most successful representations of such inventions that have appeared up to the present time, but as Mr. Jones's machine is only a substitute in most instances for the use of powder, and although it may be very valuable in some seams as a mechanical wedge for breaking down the Coal where the use of powder damages the same, or creates danger by the probable existence of fire-damp, still the baring of the Coal

is the work of greatest value; consequently, no machine that does not do that work, can become of general application, at any rate, I think, in the Yorkshire Coal Field. Therefore, although there have been many inventions of merit introduced, still the machines of the West Ardsley Coal Company are the only practical illustrations existing of what has been done up to the present time, and I venture to express an opinion that the inventors and owners of the pick-machine, judging by the measure of success already obtained, seem destined in the end to solve the problem of how to get Coal without the immense amount of manual labour and waste of time at present required. A description of these machines, and the results obtained, would afford ample material for a most interesting paper; on this occasion, I have not time to make more than a passing reference to them. I hope some friend will take this subject up, and deal with it in that comprehensive manner that its importance entitles it to.

These machines, in time, as the practical application of them becomes better understood, will surely, however slowly, ripen to perfection, and no system of getting Coal is so peculiarly favourable—nay, I may venture to add absolutely necessary—to the economical adoption of machinery, as that of “Longwall,” by reason of the long-continuous face of Coal open, to which there will always be a direct highway from the pit bottom, for the easy conveyance of compressed air, or any other motive power employed. The use of machinery will rather tend to increase the amount of ventilation than otherwise.

I now come to the net results obtained by the extension of this system of Coal Mining by Longwall on End, which I believe to consist of the following:—

1st. Economy in its results to the proprietor, from the increased market value of the product attained, and the soonest return for his invested capital.

2nd. Economical ventilation, and increased safety to the miner.

3rd. Simplicity, and less liability to accidents; and—

4th. An increased quantity of useful Coal from the same area. This is the national gain all desire, and which, the writer believes, will be best obtained by the diffusion of improved mining knowledge concerning such a system, rather than by legislative interference.

To our local friends in the neighbourhood of Doncaster, the economical working of our Coal field is a matter of great interest, standing, as at present we do, upon those Coal measures underlying the Permian Rocks, a section of which I have added to my illustrations, calculated from what I consider the most reliable data; their value and extent may be estimated by one fact, viz., that in this section are represented all the seams belonging to the Yorkshire Coal Field, numbering nearly 40, with an aggregate thickness of nearly 90 feet, at least 30 feet of which will be workable sooner or later in this district.

Those seams underlying the Permian formation, *already worked*, I have distinguished on my section, and also added the locality where such Collieries are situate.

The above rocks will have to contribute the Coal Fields of future generations; at the same time, situated as the *upper* portion of this Coal field is, within a practicable depth, I do not see any reason why it should not contribute its share to the requirements of the present century, and I express my astonishment that it has not already been developed, and thus locally derive the advantage of the excellent colliery sites which are to be found in the vicinity of Doncaster. My own opinion has been confirmed by a friend of mine, of great commercial experience in the Coal trade, that Doncaster is unequalled in its Geographical position by any colliery district in the kingdom. With a willing and liberal

proprietary, I think it possible that enterprising capitalists can be found to develop such vast resources.

With regard to the *lower* or *deeper* portion of our Coal fields, the longer they are left untouched, and the better it will be for us, for increased depth in working Coal will involve increased outlay in winning the same, which will result in increased cost to the consumer.

Interesting as the study is, of the exhaustion and probable duration of our Coal Fields, yet, as it is an unavoidable consequence of a great consumption, we cannot help its gradual exhaustion; let us, then, look more rigidly after what is left, and so tide off, to the latest possible period, the exhaustion of a mineral so essential to our existence as a great and flourishing people; for, should we ever be dependent upon importation for our supply, I think the evil day predicted by Mr. Stanley Jevons, in his exceedingly clever argument, will have arrived, when England will have to give way in its manufactures and commerce, to some country whose mineral resources have been but little broken into.

At the same time, it is not at all improbable when we think of what an age of discovery we now live in, and the increased light that a future generation may possess, that the use of Coal may be superseded altogether by some discovery in chemical science.

In conclusion, I would venture to hope that the friends of this Society will lend a helping hand to extending, somewhat more than hitherto, the acquisition of improved knowledge in mining operations, by giving such papers a larger share in its labours and researches; for, fascinating as geology is as a study, the commercial application of the science should never be lost sight of.

Papers would be very valuable on some of the details of mining, such as the various mechanical arrangements in use, including engines, safety hoists, etc., the relative merits of

furnace and mechanical ventilation, Coal getting and Coal-breaking machines, safety lamps and explosions, and accidents generally, the lighting of Coal mines, and underground haulage, and any other information which either the geologist, chemist, or engineer has the opportunity of collecting, thereby mutually assisting each other in our efforts to mitigate, in every possible way, the commercial uncertainty and physical dangers which too often are associated with the subject the writer has selected on the present occasion.

BRITISH PIT DWELLINGS IN THE NEIGHBOURHOOD OF DONCASTER,
BY THE REV. SCOTT F. SURTEES, M.A., SPROTBRO.

I am about to treat of a subject of interest to one and all—by some it would be called an era pre-historic—to point out to you how the earlier races who inhabited this island defended themselves from the rains and frost of this unequal climate, how they banded themselves together in tribes for mutual security and family life. I am about to speak of their dwellings, at a time when the wild beasts roamed through the vast forests of this part of the country; when the deer, and the wild boar, and herds of British cattle wandered in droves amongst heaths, woods, and marsh-lands. Professor Phillips' "Yorkshire," the highest authority we have, states as follows, p. 187: "We find the great Irish elk, the red deer, the fallow deer, the *bos longifrons*, the common ox, the goat, the sheep, the horse, the boar." Yet the tribes who inhabited these sea-coast districts were far from savages. They traded with their neighbours, bartered their commodities, they worked and smelted iron, they had metal rings for money, they had chariots and darts. Of the tribes of Britain one of the most important, if not the most important, were the Brigantes; the regions peopled by them