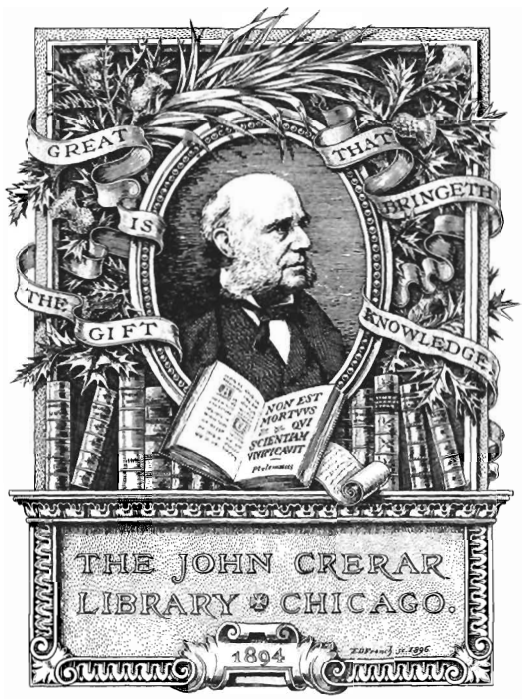
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1894

GEOLOGICAL TREATISE

ON THE

DISTRICT OF CLEVELAND,

IN

NORTH YORKSHIRE,

ITS

FERRUGINOUS DEPOSITS, LIAS, AND OOLITES;

WITH SOME

OBSERVATIONS ON IRONSTONE MINING.

BY JOS. BEWICK,

AUTHOR OF "REMARKS ON THE ORE AND IRONSTONE OF ROSEDALE ABBEY."

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TO

THE IRONMASTERS

OF

NORTH YORKSHIRE, DURHAM, & SOUTH NORTHUMBERLAND,

WHOSE WEALTH AND ENTERPRISE

HAVE SO LARGELY CONTRIBUTED TO THE DEVELOPMENT

OF

THE CLEVELAND IRON-FIELD,

THIS TREATISE IS

RESPECTFULLY INSCRIBED BY

THE AUTHOR.

In writing this Treatise the following works have been quoted and consulted, viz., Messrs. Young and Bird's "Geological Survey of the Yorkshire Coast," Phillips' "Geology of Yorkshire," Marley's Paper on the "Cleveland Ironstone," "Taylor's Statistics of Coal," Dunn on the "Winning and Working of Coal Mines," Greenwell on "Mine Engineering," and Hall on "The Northern Coal Field."

We take this opportunity, too, of acknowledging with gratitude the disinterested kindness of a few sincere friends, whose able assistance, and valuable suggestions, have greatly aided us in our literary undertaking.

PREFACE.

THE Author may be allowed, and, perhaps, expected to preface his work by a few words of explanation as to the motive for undertaking it, and the means by which his information has been obtained.

The science of geology became an attractive study and pursuit with the writer at an early period of his life, and for some years prior to his becoming acquainted with Cleveland, had been actively engaged in ironstone mining operations, as well as in researches for that mineral. The latter purpose brought him into the district in question upwards of twenty years ago, when he became at once highly impressed with the importance and immense value of this mineral field. Thus prepared for the undertaking every opportunity was embraced of obtaining information, devoting his leisure assiduously to the acquisition of an intimate knowledge of the district; and he flatters himself, from the care taken in his researches, that time will show the correctness of his views and statements.

Whilst the Author has no intention of claiming for the whole of his Treatise the character of an original production, he may be permitted to state that it contains much information not before presented to the public, chiefly obtained through his own personal exertions.

Hitherto the knowledge possessed by the public has been limited, and their notions vague, with reference to the ironstone deposits which the lias and oolitic rocks of North Yorkshire contain. It has been the Author's object to furnish more accurate information on this subject.

The vast importance of the Cleveland ironfield, destined, as it doubtless is, to exert an immense influence on the iron trade of the kingdom at large, has induced the Author to attempt to define more correctly its geographical limits, and to estimate its probable contents.

These objects are of themselves, we think, sufficient inducements for the Author undertaking the work, and, if any further motive were needed, he hopes it may be found in the additional information afforded to miners and future explorers.

Grosmont, 27th September, 1860.

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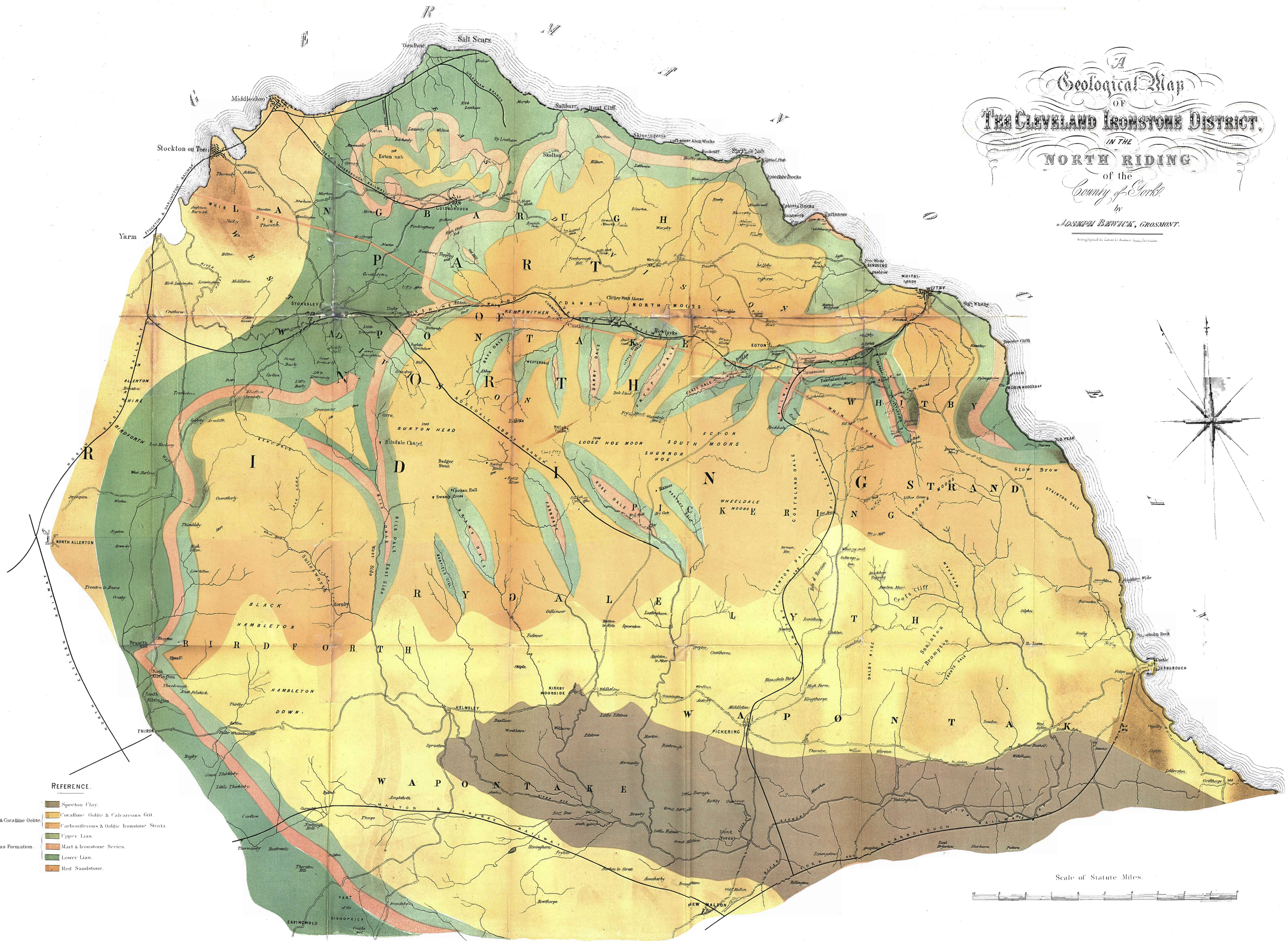
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Salt Scars
Dun Point
Middlesbro'
Stockton on Tees
Yarm
Saltburn
Hunt Cliff
Skinningrove
Loftsome Alum Works
Rockcliff
Staithes Jab
Josecate Docks
Victoria Docks
Cattaness
Skelton
Eston nab
CLEVELAND
BARGUGH
PARTISON
WHITBY
Big Whitby
Robin Hoods Bay
Stoxby Brow
Staithes Dale
Cromer Cliff
Old Peak
Cloughton Wyke
Hayburn Wyke
Ravenscar
Scarborough
Castle
Filey
Flamborough Head
Bridlington
New Malton
Malton
Pickering
Helmsley
Kirkby Moorside
Thirsk
Bagby
Easingwold
Part of the Bishopric
Bedale
Masham
Ripon
Harrogate
Knaresborough
Boroughbridge
Northallerton
Allerton
Bilsdale Chapel
Burton Head
Badger Stone
Cockan Hall
Swaine Cross
Loose Hoe Moor
Shunnor Hoe
Wheeldale Moors
Egton Moors
Egton
Grosmont
Falcondale
Rosedale Abbey
Cockayne Hall
Cockayne Dale
Hutton Rudby
Stokesley
Kempswithen
Clay Bank House
North Moors
Cleveland Hills
Cleveland Ironstone Formation
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Black Hambleton Down
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EXPLANATION OF MAP.

THE outlines of the map which accompany this work were taken from Greenwood's Map of Yorkshire, a work of acknowledged excellence, laid down from Col. Mudge's Ordnance Survey. We have been induced to take this map for our guide, not only on account of its acknowledged accuracy, but also from the scale being exactly that which we wished to adopt. Probably the spelling of the names of some few remote places may be somewhat different from that now in use. This, however, will not apply to any place of note or importance, as it has been compared with, and corrected by, maps of the county recently published.

We wish to explain to our readers, too, that as our chief object has been to render the ironstone measures as conspicuous as possible, the coloured delineations of these strata must be viewed as a slightly exaggerated representation when compared with the scale. Some little difference may also, perhaps, be observable, from the same circumstance, as regards the boundaries of the lias escarpment, &c., in some localities. Any little discrepancy of this nature, however, will not materially affect the general accuracy of the map, and, for all practical purposes, we can confidently recommend it as a correct guide.

ERRATA.

Page 19, line 27, *for* "work of our labour," *read* "work of our hands."

Page 41, line 9, *for* "tend," *read* "trend."

Page 47, line 4, *for* "six inches," *read* "nine inches."

Page 54, line 1, *for* "winning," *read* "mining."

Page 55, line 6, *for* "overlaps," *read* "overlies."

Page 60, line 27, *for* "the veins we have enumerated," *read* "the views we have enunciated."

Page 105, line 3, *for* "Sattersgate," *read* "Saltersgate."

Page 113, line 13, *for* "that," *read* "those."

A GEOLOGICAL TREATISE

ON

THE CLEVELAND DISTRICT.

INTRODUCTION.

On leaving the low flat land of the south-eastern part of the county of Durham—beneath which lies that rich deposit of fossil-fuel constituting the (supposed) southern extremity of the great coal-basin of Northumberland and Durham, which has added so materially to the wealth and prosperity of this country—the traveller, in his journey southwards, sees, far away in the distance, a range of lofty mountains, skirting somewhat the north-eastern boundary of North Yorkshire, known by the name of the Cleveland Hills, amongst which may be seen, towering above most of his fellows, the far-famed "Roseberry Topping." If the said traveller were to ascend to the summit of this mountain range, he would see spread out before him, as far as his eye could reach in a south-easterly direction, a wide expanse of undulating country, bleak, barren, and covered with heath, and constituting a large portion of the moor-land district of the north riding of the county. The strata found immediately beneath the surface of this desert-looking district belong to that class of rocks designated by geologists the oolites, being a portion of the secondary series, consisting

of alternating strata of sandstone, limestone, shale, ironstone, and coal. Beneath this, again, is met with the alum shale, or great lias formation, within which are contained those vast and extensive deposits of ironstone, which are, in all probability, ultimately destined to revolutionise, or rather, perhaps, to localise, the iron trade of the United Kingdom.

It will be the province of this Treatise to endeavour to describe, in detail, the various strata composing the group above enumerated, and, also, to give a brief historical sketch of the discovery and development of the Cleveland ironstone. This group occupies a geographical area of something like from 800 to 1000 square miles, about 500 to 600 of which may be said to contain the Cleveland ironstone within workable distances from the surface, the general configuration of which is of a mountainous character, its surface, comparatively speaking, consisting of a succession of mountain ranges running in a westerly and easterly direction, the highest of which is not more, we believe, than about 2000 feet above the level of the sea. In some places the strata continue over the axis of those ranges (anticlinal), *i.e.*, dipping in contrary directions, something like the roof of a house, or the unbroken wave of the ocean, imparting to the surface that undulating form and diversified appearance which is characteristic of this neighbourhood, and adds so much to the beauty of the landscape generally. We have a good example of this description of strata in the Vale of the Esk, where the village of Aislaby, situate on the summit of a portion of one of those ranges, has the strata dipping on both sides of it in contrary directions, in a westerly and easterly course. We more frequently, however, find the strata broken off at or near the axis of the mountain range, so that whilst the tops

of the hills are capped with oolitic rocks, the sides of the valleys expose the lias formation, well developed. And again, we sometimes find the whole series suddenly broken and disjointed by what is called a fault, a dyke, or a throw, and the strata which originally belonged to the highest in the series, and are frequently seen covering the mountain summits, are found, almost immediately adjoining, in the bottom of a valley or the bed of a stream, the displacement of the dislocated mass amounting, in many instances, to some hundreds of feet; and anon we shall find, in some localities, the lias completely denuded of the superincumbent strata. Where this is the case you will generally see the hilly ground assume a very smooth, even surface, sloping beautifully and gradually away on each side of some fertile valley, or forming the bottom of some rich alluvial plain.

The great and stupendous changes which have from time to time taken place upon the surface of our globe, appear to have been effected by agencies which are no longer in active operation on this portion of the earth, or, at least, their power and force must be very greatly diminished, for, although the configuration of the earth's surface is undergoing continual change, by the constant action of the ocean and rivers, together with the scouring waters of mountain streams and atmospheric changes, yet their operation is so slow and gradual, as to be imperceptible to the common observer, and the change produced in a generation by those agents is only perceived by the shifting of a stream, the slightly altered course of some unnavigable river, or the falling away of some overhanging portion of the cliffs of the sea. Those great eruptions which we see evinced in the dislocated and fractured condition of large portions of our earth's crust, must, therefore, have been produced by agents capable of exerting a power and force quite unknown

to any at present in existence, and it is now admitted, we think, by nearly all geologists, that those agents were fire and water—the alternate or combined action of volcanic upheaval and oceanic subsidence—but at what period of our earth's history those convulsive movements took place is a problem which science has never yet been able satisfactorily to grapple with, much less to solve. That they have occurred at different periods long anterior to the date of our chronology, proof sufficient, we think, is afforded us; and that they were subsequent to the deposition of the strata they have disturbed is also apparent; but beyond this there is little to guide us to a right conclusion as to the period of the action and cessation of those mighty agents.

We feel ourselves here impelled to make a few general remarks on the present state of the science of geology, as relevant to our purpose, though, in all probability, our doing so may lay us under the charge of presumption. A strong feeling, however, that we are only stating what is generally felt to be true, must be our excuse for doing so. That great progress has been made in this beautiful and fascinating science within this century, none who have read the modern and talented productions of our geological *savans* will for a moment dispute. Such profound thinkers and accurate observers as Cuvier and Buckland have done much to extinguish the fabulous theories and idle speculations that for a time obtained, by unfolding the fact that the history and progression of organic life is strictly identified with the deposition of the different series of consecutive strata. The discovery of this great truth enabled those eminent philosophers, and their numerous followers, to assign certain geological epochs to the formation of the earth's crust, during each of which animals of a certain type are known to have existed, evinced by their organic

remains found embedded in the strata; and each successive epoch, it is found, has been tenanted by animals of a more complex organisation, and a higher order of intelligence, until the creation of man.

Dr. Buckland has divided the earth's crust into four orders or systems, known by the names of the primitive, transition, secondary, and tertiary series, and each of these has been again subdivided by other geologists; and we may just mention here, that nothing can be more puzzling and perplexing to the geological student than the nomenclature of this science, crowded as it is with names as absurd as they are unmeaning, so far as comprehension and perspicuity of the subject is concerned, and it is admitted, we think, by nearly all who have paid attention to the subject, that nothing is more needed than an improved vocabulary of geological terms; but we shall again refer to this subject in another part of this Treatise. The identification of peculiar organic remains with certain chronological order of strata has been of the greatest practical use to both the scientific geologist and mining engineer, by enabling them, on examining the embedded impressions and organic exuviæ, to decide at once to what series, or member of a series they belong. Notwithstanding the progress that has been made in this science, however, we think we shall only be giving expression to an opinion that is pretty generally held, when we state that the advance does not appear to be commensurate with the time and talent bestowed upon it by gentlemen whose position, learning, and superior attainments, fully entitle them to the honours and distinction conferred upon them by the public. The reason for this, perhaps, may be partly accounted for from the circumstance that their labours have been chiefly confined to the study of certain facts and phenomena, the effects of manifest causes,

whilst the loftier and more subtile branch of cosmical science has been neglected; and the facts, which, in all probability, would have been developed, and amply rewarded the industrious investigator, competent of dealing with so abstruse a subject, are still sealed in secret, and, we fear, that little or no additional light will be thrown upon the science of cosmography, until some Newton shall discover to us a principle that shall teach us more than we know of the birth of matter, the home of electricity, and the laws of magnetism, and that the manifold theories of our geologists will continue as conflicting and perplexing as they are at the present day. In the meantime, however, we may state, with reference to dislocations, distortions, and fractures, that what to the careless and indifferent may appear confusion and disorder, to the closer observer is discovered to be contrivance and design. And that amidst the crash of volcanoes, and the subsidence of waters, there is strikingly manifested the power of the Great Creator, planning and contriving, fitting and preparing the earth for employing and sustaining its present inhabitants, first and foremost of which is His noblest creation—Man.

In entering on the work of description and delineation of the now important and particularly interesting district of Cleveland, we have to observe, that our plan will be to commence with the lowest member of the group (already noticed), and pursue the subject upward, taking *stratum*, *super-stratum* from the bottom to the top of the series, minutely describing each; thus we shall have brought under consideration, to begin with, one of the most important portions of the group we are about to particularise, viz., the lias formation; but before we proceed with our

description, we purpose inserting here a brief historical sketch of the discovery and development of the lias—now better known as the Cleveland ironstone—which this formation contains. We are urged more particularly to do this, from the circumstance that opinions the most erroneous have been promulgated, and conclusions the most fallacious arrived at, with reference to this subject.

How often has it happened, in the history of discovery and invention, that the authors of such have been entirely overlooked and forgotten, and the merit which was so justly theirs bestowed upon others, simply because they were in a position successfully to adopt the principle of the discovery, or advantageously use the mechanical invention, from which, in all probability, they realised riches and fame to themselves, and in many instances colossal fortunes; whilst the only benefit the real discoverers or inventors derived from their labours, after much patient study and practical investigation, was, but too frequently, poverty, and even ruin. Though it may not be so strikingly exhibited as in the picture we have just drawn, yet we think we shall, in tracing the history of the discovery and development of the Cleveland ironstone, show some analogy to it.

The first notice we have of the Cleveland ironstone occurs in a geological work, published in the year 1822, by Young and Bird—("Geology of the Yorkshire Coast")—a work which has been copied, more or less, and taken for a guide, by all subsequent writers on this subject. In describing the marlstone series, in which are found the vast ironstone deposits, the authors observe—"Having given a description of the main bed of the alum rock, let us proceed to a lower part of the rock, which we have stated to consist of imperfect seams or flat nodules of hard blue limestone, mixed

with or embedded in the alum shale. When the shale has descended about 180 or 200 feet, the embedded nodules or blocks become larger or more abundant, sometimes running in shale in lengthened rows approaching to seams. Like the courses of flint in the chalk, they do not form any continued stratum, but the flat masses are so numerous and broad that they may be traced in a kind of imperfect seams through a considerable space. . . . . Some of them abound in organic remains; others contain few or none." It will at once be seen by those who know anything about the geology of the Cleveland district, that the limestone here mentioned is neither more nor less than the upper portion of the ironstone deposit known as the "pecten bed," which is well developed in the part of the coast they are here describing. Speaking of what they consider the ironstone deposit, they observe—"The ironstone beds or seams of this portion of the strata bear a strong resemblance to those of Gristhorp and Burniston, consisting partly of solid seams, most of which are from five or six inches to eight or nine inches in thickness; partly of rows of nodules, having their interstices filled up with coarse shale. The seams abound in shells, and in some instances are so highly calcareous as to form a kind of ferruginous limestone. In most places, however, they contain a large portion of iron, which some have estimated at from 30 to 60 per cent. Quantities of the ore have been collected, and conveyed to Newcastle to be smelted at the foundries. In some places we find only three or four seams, in others twelve or thirteen, if not more. Some of the intervening beds of shale are only a foot or two in thickness. . . . In giving the series of the beds at Boulby, we have estimated these beds of ironstone (in the aggregate) at 15 feet in thickness."

From the foregoing quotations, it will be seen that the

main ironstone seams were considered by those authors as limestone, and that the thin nodular beds which accompany them, and which are very numerous on the coast, were alone considered ironstone, and that belief was shared (we believe) by many others for some years afterwards. With the exception of this mistake, however, in respect of the main ironstone seams, we have found this work singularly accurate in detail; and in this particular it has never been superseded by any subsequent publication of the same kind. In the year 1835, Professor Phillips published a second edition of his geological work on the Yorkshire coast, and thus refers to the ironstone—"In Boulby Cliffs, then, we have the whole series of the lias beds exposed, and are thus enabled to group the minuter parts of the formation into convenient natural divisions, and to apply them to complete other less perfect sections."

"Ironstone and marlstone series, consisting of ironstone bands, which are *numerous layers* of finely-cemented *nodules of ironstone*, often septariate, and enclosing coniferous wood, pecten, avicula, teribratula, twenty to forty feet thick;" in which, of course, is included the intervening shale. We see here, again, from this quotation, no indication whatever of the main bed having been met with, or rather noticed, for the learned author states the ironstone to consist of "*numerous layers of nodules.*" Hence we must infer that nothing was known of the main seam of Cleveland up to this period (1835), and that, consequently, Professor Phillips could have no idea of the extraordinary thickness and commercial value of this ironstone at that time.

Before we proceed further, perhaps it may be as well to inform the reader that ironstone was obtained from the Yorkshire coast, between Saltburn and Scarbro', by "The Tyne Iron Company," of Newcastle, as far back as sixty

years ago, and that they have continued to use it from that time up to the present day; and as, in all probability, it was owing, in some measure, to a certain unfavourable impression, occasioned we have been informed by a spurious admixture, which the early obtainments of this stone made upon that firm, that it remained so long undeveloped, it will be necessary as well as interesting that we should take some notice of their operations at that early period. Having for some years previously, used the nodular ironstone, described in Young and Bird's work, which they collected on the beach, the Tyne Iron Company, some time between the years 1815 and 1820 (we believe), commenced working the ironstone in different parts of the coast, between Saltburn and the Peak, south of Whitby, shipping it off during the summer months, as opportunity offered, by beaching vessels. The person who superintended those workings, from want of knowledge to enable him to discriminate between ironstone, dogger, and cement stone, shipped large quantities of the two latter along with the ironstone, both of which were not only worthless, but very injurious to the iron made in regard to quality; and it was not, we understand, till after a very large quantity of this objectionable material had been stocked at the works, that the mistake was discovered, which, of course, caused the company a very serious loss. To this adverse circumstance, perhaps, more than anything else, it may be attributed that the Cleveland ironstone remained so long undeveloped, for the *thick blocks of stone*, as well as the *large doggers*, after this were considered as fatally objectionable in iron-making, which, under the circumstances above-mentioned, was not much to be wondered at.

In connection with the discovery and development of

the Cleveland ironstone, we feel ourselves bound, in common justice, to notice the labours of an individual—a thoroughly experienced and practical man, as well as an expert miner—who was certainly the first person to bring this stone into public notice, and to devise the means of pushing it into the market, and whose exertions in this respect never ceased up to the day of his death, many years afterwards, his firm conviction being that pig iron could be produced from the Cleveland stone at less cost than in any other part of the United Kingdom. As the individual in question was the father of the writer of this Treatise, we shall content ourselves with a bare recital of the facts connected with his labours. At what period he first became acquainted with the Cleveland ironstone field we have no means of knowing; but we have some reason to believe it was about the year 1820, and as he afterwards, in the year 1824, along with his brother, John Charlton Bewick, had for some time charge of a boring that was made at Oughton, near Stockton-on-Tees,* it is only reasonable to suppose, whilst being so engaged and being so near to it, that he would make excursions occasionally to the Yorkshire coast, by which he would become better acquainted with the immense deposits of ironstone found there, which would only serve to strengthen his former opinion as to the vast superiority of North Yorkshire over every other district, as affording a cheap and unlimited supply of ironstone. But be that as it may, however, we shall proceed to notice the first survey he was employed to make of the Yorkshire coast, from Skinningrove to the Peak.

In the year 1827, the father of the writer hereof was

* A section of this boring, which was made on the property of George Fletcher, Esq., is in our possession. The object of it was to reach the coal of South Durham in the district south of Hartlepool, and he was very sanguine that it would have been met with had the experiment been fully carried out.

working an ironstone mine in the royalty of the Earl of Durham, at South Hylton, on the river Wear, near Sunderland, which, with another at Whitley, near Tynemouth, belonging to the Duke of Northumberland, also commenced and carried on by him, were about the earliest undertakings of the kind in the North of England. Previous to this, the ironstone required was obtained from the collieries of the Newcastle and Durham districts, from the old coal workings, by means of what was called "ridding," *i.e.*, turning over the refuse of the old workings and collecting the ironstone from amongst it, as well as in many cases tearing down the roof that contained, in some instances, thin bands or seams of that mineral. Being in the employ of the Birtley Iron Company, and carrying on for them the operations just mentioned, he was despatched by B. Thompson, Esq., the managing partner of the Birtley Iron-works, to make a survey, and report upon the ironstone found on the Yorkshire coast. He commenced his survey at the mouth of the Tees, and carefully examined the whole of the ironstone beds as he proceeded southwards along the coast, noting down at the same time the royalties where the stone was most accessible, and found in the greatest abundance, with the names of the proprietors, according to the instructions given him, till he reached Flambro', at which point his survey terminated. Within this range the royalty of the Marquis of Normanby, at Kettleness, near Whitby, was the one selected by him as most desirable for commencing operations upon, on account of the facility with which the ironstone could be worked—many acres of the pecten seam (heretofore considered to be limestone) being washed bare by the sea, and only requiring to be broken up and shipped off from the beach, the situation being favourably sheltered for the purpose. He returned strongly impressed

with the result of his survey, and was urgent with the company that workings should be commenced at Kettleness, representing that they could not fail to be advantageous to them. The Birtley Iron Company being desirous of possessing some further information on particular points of Bewick's survey and report, sent him again over the district mentioned, accompanied by Mr. Wm. Morris, then one of their overmen, and afterwards under-viewer, in Ouston Colliery—a sensible and intelligent miner, and acquainted with ironstone workings. Without being quite as sanguine as to the advantages held out by the report in question, he mainly confirmed it. However, some other matters diverted the attention of the company from prosecuting Bewick's well-advised proceedings. This was a great disappointment to him ; and often has he been heard, in speaking of the amazing quantities of ironstone that were so easily and cheaply to be obtained, to lament the failure that attended his effort to get his scheme put into operation, and he never ceased, when opportunity was afforded him, to press upon his employers that the Yorkshire district, of all others, was the one from which might be obtained an unlimited supply of cheap ironstone, and it certainly is to be regretted that his advice was not followed.

The abandonment of this undertaking by the Birtley Iron Company, at the present day may appear unaccountable; but it must be remembered that a large portion of this stone had already been condemned by the Tyne Iron Company, after they had sustained a very serious loss by it. And it is only reasonable to suppose that the Birtley Iron Company would naturally conclude that the thick bed which it was now proposed to work (so much resembling limestone), would, in all probability, turn out to be the inferior and rejected stone, and this, very possibly, might deter them

from proceeding in the matter. A reason, however, and I believe a chief one, was the fear that a sufficient number of ships would not be obtainable for beaching purposes, which subsequent experience proved to be well founded; for although shipments on the coast have, within the last few years, been very greatly increased, it is to be observed that this has only been accomplished at a very considerable cost, in the erection of piers and jetties to afford some degree of shelter for the shipping, and it yet remains to be seen whether the quantity of stone to be produced from this locality is such as to warrant so great an outlay. But, at all events, to have sunk so large a capital for such a purpose, at the period we refer to, would have been unwarrantable, and have been looked upon as an act almost of madness.

After those surveys, nothing more was heard of the Cleveland ironstone, with the exception of a few cargoes which the Tyne Iron Company continued now and then to receive of the rich nodular stone, till the year 1836. In the month of May in that year, a trial cargo reached the Tyne, sent by the Whitby Stone Company to the Birtley Iron Company; and a second, from the same firm, was sent to the Tyne Iron Company. The reports of these trials were very unsatisfactory, owing, in all probability, to a want of care in keeping the sample sent free from shale and other refuse and impurities. In the following year, however, another cargo was sent to the Birtley Iron Company, which was better liked. Mr. Joseph Bewick, sen., was then under the Wylam Iron Company, Messrs. Thompson Brothers, sons of his former master, and the arrival of those shipments in the Tyne appears to have aroused the attention of that firm, for in the year 1837 the junior partner (B. J. Thompson, Esq.), along with Bewick, again examined the Yorkshire coast, and so convinced was he

of the advantages to be derived from using this stone, that the Wylam Iron Company immediately took the royalties of the Marquis of Normanby, and in the following year, 1838, workings were commenced and carried on by Bewick, at Kettleness and Staithes, where, just eleven years before, he was so anxious to begin; and thus at last his ardent wishes were in a degree realised, and he soon gave his employers sufficient proof that his former representations with regard to shipments during the summer months had been correctly made, for in the course of only a few weeks he filled the stowage room of the works at Wylam with Cleveland ironstone. The stone, when mixed with hematite and other ores, was found to answer quite satisfactorily, and being obtainable at a much cheaper rate than their other supplies, Yorkshire was henceforth looked forward to as their main dependence for ironstone. They soon experienced, however, what had formerly been anticipated, viz., that during the autumn and winter months ships could not be had, and they were driven to the adoption of an inland working, from whence they might make shipments in the port of Whitby during such period, and they accordingly, in 1839, took a part of Mrs. Clark's royalty, and commenced mining operations at Grosmont.

In giving this historical sketch of the original development of portions of this mineral field, it is only right and just that the proceedings of others in the attainment of it should be recorded, without which the difficulties that had to be encountered before its commercial value and national importance were ascertained and acknowledged would never become known, and it is with pleasure that we give due honour to those pioneers who elicited, to a very considerable extent, the mineral wealth of Cleveland, which has subsequently become of such incalculable importance.

In the year 1836, the romantic and secluded dales of Eskdale, Goathland, and Newtondale, rich in wild and magnificent scenery of surpassing beauty, and hitherto but little known to the public at large, and in many places almost inaccessible but to the more daring few, who penetrated their rocky steeps and winding streams in pursuit of piscatorial recreation, or in search of that geological and botanical lore which they were so well calculated to afford, were traversed by a railway from Whitby to Pickering, a distance of twenty-four miles, one of the early undertakings of the elder and illustrious Stephenson. At the distance of six miles from the port just named, this railway intersects the ironstone seams which are visibly exposed at Grosmont, and which are identical with the main Cleveland seam; and beyond this again, at the further distance of a short mile, the basaltic dyke, which we shall have hereafter to notice more at large, is also cut through by it; and in the immediate vicinity, and contiguous to the railway, is the great sandstone rock overlying the lias formation. With a view to turning these deposits to some good and profitable account, and to create traffic for the railway, twenty-four of the leading gentlemen of Whitby and the neighbourhood, numbering amongst them the name of Stephenson, formed themselves into a company, designated the "Whitby Stone Company," and commenced working the sandstone and whinstone (basalt) quarries, and also the ironstone mines. The sandstone was sent to London and other markets, to be used for building purposes; the whinstone was disposed of for paving streets and Macadamizing public roads; and the ironstone was sent to the Tyne for supplying the works of the Birtley Iron Company; and, as we believe, one object was also to give increased employment to the labouring population of the district, it is much to be regretted that a larger mea-

sure of pecuniary success has not attended their persevering and praiseworthy undertakings. The proceedings of this company, as having been established a year previous to those of the Wylam Iron Company, first call for notice.

This company, as has already been stated, sent their first cargo of ironstone to the Birtley Iron Company, in the spring of the year 1836. This cargo was obtained from the pecten seam at Grosmont, where, in the following year, their mining operations were commenced, and have continued to be actively carried on up to the present time (1859), under the management of Mr. John Waddington. We deem it proper to mention here a statement that was made to us, many years ago, with reference to the discovery of the main beds of ironstone in the locality of Grosmont, by a gentleman of the name of Wilson (not now living), then one of the partners of the Tyne Iron Company. Speaking of the first openings that were made here, he said—"I was staying at Scarbro' for a few weeks, when I saw, in one of the York papers, a paragraph stating that some valuable ironstone had been discovered in the neighbourhood of Whitby, joining the Whitby and Pickering Railway near the tunnel (Grosmont), which had been lately opened out there, and having nothing particular to do, I went over to examine it, when I found it to consist of nothing more than two or three thin layers of nodules, which could never pay for working. Leaving the drift they were driving in the side of the hill, and crossing the rivulet adjoining, I observed that the bed of the stream was composed of a thick bed of ironstone full of fossil shells, and taking hold of a large piece, I held it up to the gentleman who showed me the working [in all probability, Mr. King, the then manager of the company], and said to

him, There, look you, that is good ironstone, and here you have plenty of it." He added, "I was astonished at the thickness of the band." From this conversation, which took place in the office of the Tyne Iron Company, as before mentioned, many years ago, it would appear that Mr. Wilson was really the first person to draw attention to the pecten seam in the Grosmont district.

As has already been observed, the first cargo of this stone sent to the Birtley Iron Company, and another to the Tyne Iron Company, made a very bad impression upon both of these firms, and the report made to the Whitby Stone Company was accordingly very unsatisfactory; and it was not till the following year, after a further trial had been made, that the Whitby Stone Company were able to make a contract with the Birtley people for a regular supply; and it was only after long and patient perseverance that they were able to send away anything like the quantity of ironstone they were able to raise. Thus it will be seen that the Whitby Stone Company were the first vendors of the Cleveland ironstone.

Having already mentioned that the Wylam Iron Company commenced their mining operations on the coast at Kettleness, in the year 1838—the year after the Whitby Stone Company may be said to have fairly commenced their workings at Grosmont (for it was not till 1837 that they were able to introduce their stone into the market)—we shall next proceed to notice the period when we first became connected with the working of this ironstone in the Grosmont district. This occurred in the spring of the year 1839, and never shall we forget the impression the sight of those immense beds of ironstone made upon us when first we saw them. Some idea, however, may be formed, when we state that the mines we had previously

had under our charge were from four to five feet as the compass of the workings in height, containing from twelve to fifteen inches of ironstone, the remaining three-fourths being entirely refuse, and to be mainly brought out and deposited on the surface, accumulating immense heaps of spoil, damaging and disfiguring the land upon which it was deposited, the working price alone in one of the mines being 4s. 6d., and in another 7s. per ton; but here we saw before us a solid mass of ironstone four feet six inches thick, and the working price of which was afterwards only 1s. per ton. We were lost for a time in wonder and amazement, which, in the exuberance of the unbounded delight of youth, ended in a loud fit of laughter, and the tales we had so frequently listened to in the days of our boyhood, and looked upon as amusing fictions, or highly-coloured truths, were now vindicated as great facts in the reality before us.

Our labours commenced in the royalties of Mrs. Clark, at Grosmont, where the ironstone seams are most favourably situated for working, and being brought into immediate connection with the port of Whitby by rail, every facility was afforded for making shipments freely; and though we foresaw obstacles to be overcome and difficulties to encounter, yet, with all the energy and sanguine feeling of a youthful mind, we anticipated a future big with success and prosperity; and although we have much to thank a kind Providence for, in blessing the work of our labour, yet, in looking back to the time when we first broke the surface, just twenty-one years ago, we must admit that, in increasing our vend and ramifying our connections, those difficulties and obstacles have been such as were never contemplated at the time.

Our first shipments were made to the Tyne Iron Company

before alluded to, who received them with the caution that might have been expected from what they had formerly suffered. We have often been surprised to meet with statements, not only spoken, but written, by persons who ought to have known better, respecting this and other firms rejecting the first samples of ironstone sent them, as being "nothing but dirt," though of excellent quality, leaving it to be inferred that they were ignorant of the quality of the stone, when, in all probability, a large portion of the sample forwarded to them was in reality "nothing but dirt," in consequence of the samples being selected by persons who knew nothing about ironstone. The report of the Tyne Iron Company was that, as a mixture, the stone would answer their purpose very well, but would not make the best foundry iron alone—an opinion which they have never had reason to change after their long subsequent experience. Contracts were immediately entered into with Mrs. Clark, and from that time to the present they have got their chief supply of Yorkshire ironstone from her. It will not be out of place to relate here a little anecdote having a connection with this engagement. After having completed our arrangements for a supply, the managing partner of the firm expressed a hope that we had not undertaken to supply a quantity of ironstone we were unable to work, viz., 10,000 tons per annum; in answer to which we observed that, before the year was over, we had little doubt of being able to raise three or four times that quantity. The observation thus made subjected us to a severe rebuke from that gentleman, accompanied by a well-intentioned admonition, to the effect that nothing was more disadvantageous to a young man than to make unguarded and exaggerated statements. We endeavoured to assure him that there was, we believed, no exaggeration in the statement we had made,

in proof of which we had only to mention further that we had ascertained, from careful experiments, that two seams of ironstone in Mrs. Clark's royalty would produce the unheard-of quantity of 20,000 tons per acre. This announcement appeared only to make things worse, and he expressed very great doubts of our being able to fulfil even the engagement we had entered into, being apparently convinced that we were wrong in our calculations, and were labouring under a false impression. We merely mention this occurrence to show the great difficulty we had in convincing people at this period of the enormous quantity of ironstone an acre of ground contained, which appeared to them fabulous. We had by this time thoroughly examined the locality of Grosmont, and had made ourselves perfectly acquainted with its geological features, as well as the districts immediately adjoining to it, and had arrived at the conclusion that out of the two ironstone deposits which the lias formation contains, only one was of any real commercial value, viz., that found in the marlstone series, identical with the North Cleveland deposit. The other, which we took upon ourselves to designate *the top bed of the lias formation*, was considered, after being tried by the Wylam Iron Company, too coarse and silicious for the making of good saleable pig iron.

In the year 1840, we, along with our relative, Mr. J. Bewick, sen., made a more minute survey of the coast north of Whitby, as far as Skinningrove, and afterwards of a portion of the Cleveland Hills, and other localities with which we were still unacquainted, and the conclusion we came to was, that the lias formation increased in thickness towards its north-west boundary and outcrop, and with it the ironstone beds also; but that the increased thickness of the latter was owing, in a great measure, to the intervention

of portions of shale, in consequence of which the stone must become depreciated in quality, and that its value would, of course, be much diminished. This seemed to be particularly the case at the outcrop of the ironstone seen at Slapewath, near Guisbro', as well as in that found skirting the front of the hills in Mr. Chaloner's property, where it is now so extensively worked, which appeared, as it cropped out to the surface, to be much mixed and interspered with shale;* and we may remark that there was evidently a great difference, in this respect, between the stone found here and that at Skinningrove, for although the latter was much thicker, and appeared to be more open and porous in its fracture, it was quite free from shale. We should be doing an injustice to the memory and judgment of our parent, however, were we not to state that his opinion did not coincide with ours with reference to the quality of the Cleveland ironstone. He was decidedly more favourably impressed, as regards its quality, than we were, and subsequent experience, if the reports which have reached us can be relied upon, substantiates the accuracy of the estimate he had formed of its quality. Our own opinion was this, that as the ironstone beds in the vale of Esk were thinner, heavier, more compact, and freer from shale and other impurities, they would yield a larger portion of iron, and being connected with the port by railway, must be in the most favourable situation for carrying on mining operations successfully, which at the time, no doubt, was the case. We have deemed it only right that we

* Since the above was written, we were much surprised, after all we had heard to the contrary, in a recent visit we paid to these mines, to find the opinion here expressed so fully confirmed, by observing large portions of the ironstone produced there "much interspersed with shale" and other impurities, and, we were told, the difficulty there is in freeing it from this mixture is very detrimental to it, and greatly retards its sale in the market, whilst the ironstone at Skinningrove, Upleatham, and Eston, is comparatively free from this pernicious mixture. Thus vindicating the correctness of the opinion we formed of it nearly twenty years ago.

should make this admission honestly and candidly, in order that the facts of the case may be fairly laid before the public. We may just mention, in noticing these geological excursions, that although we did not examine the hills in the Eston district, no doubt whatever remained on our minds as to the ironstone being found there. In fact, wherever we had the sandstone rock for a guide, we could calculate to within a few feet the position of the ironstone beds.

We have already mentioned our having made a contract with the Tyne Iron Company for ironstone supplies. This occurred in the latter part of 1840; and during 1841 the iron trade was flourishing, and our prospects were of the most cheering description. Our stone was now fairly introduced, and was making its way in the market, and we were looking forward with great confidence to an increased vend, when in the year following (1842), especially the latter part of it, the whole aspect of commercial affairs became suddenly changed for the worse, and ere the year closed the iron trade was in a most depressed condition, which, as will be remembered, proved disastrous to many. There had been a vast expansion of the iron trade in Scotland during the few preceding years, owing to the discovery of the black band ironstone in many new districts, where it could be worked very cheap, and also to the introduction of the hot blast, patented by Mr. Neilson, of Glasgow, by using which a much greater production, with a greatly diminished consumption of coal, was obtained from the furnace. By these means the Scotch ironmasters were enabled to make pig iron at about one-third the former cost, and to far outdo any other part of the United Kingdom. The great increase in the make of Scotch pigs was

followed by the declension in our production, and, beyond doubt, was the cause of the stagnation we have noticed.

The black band ironstone about this period (1843) was discovered on the east coast of Scotland (the first discovery having been in the Glasgow district), not far from the estuary of the Forth, in Fifeshire, and a persevering attempt was made to introduce it into the Newcastle and Durham districts, which so far succeeded, at one time, as to make it probable that it would entirely supersede the Cleveland stone.

The Tyne Iron Company were so convinced of this, that they would gladly have cancelled the contract they made with us; and, we believe, the Birtley Iron Company held the same opinion. Be that as it may, the Whitby Stone Company and Mrs. Clark agreed to suspend shipments to them for two years, in the hope that, at the end of that time, things would take a more favourable turn, which, very fortunately, was the case. We are thus particular in dwelling upon the past, even at the risk of being considered tedious to the reader, in order to show the discouragements we experienced in our endeavours to introduce this stone into the markets of the North, and it will be seen, from what has been stated, that after it had been used for three years at the ironworks in the neighbourhood of Newcastle, in large quantities, it was all but rejected by them. We thus see that every new mineral field, no matter what its characteristics may be as regards quantity and quality, requires time to establish its worth before it can gain the confidence of consumers: this, in fact, is an axiom applicable to all new undertakings.

Up to the year 1843, there were only five furnaces in what might be called the Newcastle and Durham dis-

tricts, at which the Cleveland stone had been used, viz., two belonging to the Tyne Iron Company, situate at Lemington, near Newcastle—the oldest and the only furnaces in operation, previous to 1827, between the Frith of Forth and the West Riding of Yorkshire; one at Wylam, belonging to Messrs. Thompson Brothers; and two at Birtley, near Chester-le-Street, the property of the Birtley Iron Company. In this year, however, Messrs. Losh, Wilson, and Bell, who were then, as now, large consumers of pig iron at their rolling mills and foundry at Walker, all of which they had to purchase, erected a small experimental furnace, chiefly with the view, in the first instance, of using up a large stock of mill cinder, the vast accumulation of a long series of years, but eventually with the intention of using the Grosmont stone as a mixture, as will be seen by the following extract from a letter we received from I. L. Bell, Esq., of Newcastle-on-Tyne, then the manager of these works :—"It was certainly not," he says, "any consideration of the value of the Whitby stone that led me to build No. 1 furnace at Walker, although the fact that cheap stone could be had from that neighbourhood certainly influenced me subsequently in my operations at Walker; and from no one did I obtain more information than your late father, in whose intelligence and veracity I placed great reliance. No. 2 furnace was built at Walker more especially in reference to Whitby stone than No. 1." This furnace, when finished, was supplied also with stone from the mines of Mrs. Clark, which was the means of our becoming acquainted with the gentleman whose letter we have just quoted, and forming a business connection with the firm he then represented, which has continued uninterruptedly to the present time. Mr. Bell

having been furnished with the lowest price at which the Grosmont stone in its raw state could be put on ship board at Whitby, lost no time in making a series of experiments—first, to ascertain the yield of the stone from the furnace; secondly, the quality of the iron produced from it; and thirdly, the best means to be used for bringing down the cost price of the stone to as low a figure as possible. With a view to effect a saving in the carriage, it was proposed to calcine it at the works at Grosmont, and forthwith extensive calcining operations were commenced there; but although we succeeded in reducing its original weight about 28 per cent., using in the process, along with a very small portion of coal, nothing but the refuse ashes made at the Walker Iron Works; still the saving thus effected was more than balanced by the loss sustained by breakage, &c., in loading first into waggons, next into shipping at Whitby, and finally discharging in the Tyne. The burning of the stone at the mines at Grosmont was, therefore, discontinued.

After using the Grosmont ironstone for about twelve months, Mr. Bell's first impression, like that of the other ironmasters, was, that cheaper and better iron could be produced from the Scotch black band, and he accordingly for a time abandoned a Cleveland supply for one from Scotland. This, to us, was a great disappointment, the result being so very different to what we had anticipated. A further trial and a better acquaintance with the Cleveland stone led Mr. Bell, however, to form a more correct estimate of the value and importance of this mineral; and to Messrs. Bell Brothers, more than to any other firm, is due the merit of having more fully and effectually developed, at this period, the ironstone field of Cleveland. It

was, no doubt, owing to the examinations and surveys which a younger member of that firm caused to be made in different localities of the district, that the extent and position of the ironstone beds became better known to the public. These experiments were superintended by Mr. Joseph Bewick, sen., who was then, and continued to be till his death, their mining agent ; and we have little doubt that they led the way indirectly to an earlier development of the stone in the North Cleveland district, than would have taken place had these experiments never been made.

As we before stated, the black band ironstone, the workings of which had hitherto been almost entirely confined to the Glasgow district, had been recently discovered in the county of Fife, not far from the Forth, from which shipments could be made, and the stone delivered in the Tyne at a much cheaper rate than heretofore. This discovery, no doubt, greatly influenced Mr. Bell in leaving Yorkshire for the Scotch stone. Both Messrs. Bulmer and Co. and Messrs. Losh, Wilson, and Bell, secured ironstone royalties in that region, which they continued to work for some time ; and had it not been that the stone failed to realize their expectations, both as regarded production and quality, it would, in all probability, have become a more formidable rival to the Cleveland stone in the markets of the north, if, indeed, it had not entirely superseded it.

The iron trade in 1842 and 1843 had been, as before observed, in a most deplorable condition, during which Scotch pigs were quoted as low as 35s. per ton at Glasgow. The Cleveland ironstone had been entirely abandoned by the consumers in the north, and with the exception of the stone sent to Messrs. Losh and Co., in the latter part of 1843, from Mrs. Clark's mines, no shipments were made

from Whitby, the mines of both that lady and the Whitby Stone Company were completely at a standstill, and, to all appearance, the efforts which had been made to turn the vast masses of ironstone, with which that district abounds, to some profitable account, were likely to result in complete failure. Towards the latter part of 1844, however, returning prosperity dawned upon the iron trade, and, before the close of the year, was more strongly manifested ; and 1845 opened with much brighter prospects, which were soon followed by a great and unexpected rise in the price of pig iron, which advanced from the very low figure before quoted to £6 per ton, and the gloom and disappointment previously experienced were soon dispersed by the cheering hope of returning prosperity. This sudden rise in the price of iron was owing to the immense consumption created by the large railway undertakings, the building of iron steamers, gas and water works, and the prosperity of trade generally.

These increased demands and the extraordinary rise in the price of iron gave a great impetus to the iron trade generally, and the make and manufacture of iron throughout the country were prodigiously augmented, and numerous new furnaces were erected with marvellous rapidity in different parts of the United Kingdom. This improved state of things, so suddenly and unexpectedly manifested, was not long in being felt in the Cleveland district. Our old friends returned to us, fresh contracts for longer periods and larger quantities were entered into, and the mines at Grosmont were soon in full operation again, and were carried on with increased vigour, and to a much greater extent than heretofore.

In the year 1846, we had added to our customers Messrs. Bolckow and Vaughan, now amongst the largest

iron-makers and manufacturers in the kingdom, whose names will always be closely associated with the opening of the ironstone in the Eston district of North Cleveland. This firm had erected four blast furnaces at Witton Park, in the county of Durham, during the previous year (1845), looking to the coal and lead districts for their chief ironstone supply, as well as to the Whitby stone to be used as a mixture. Our contract with them was for 36,000 tons of ironstone, to be delivered in three years. This contract increased Mrs. Clark's vend to 30,000 tons per annum; and although she has been in a position, since that time, to work double that quantity, she has seldom been able to exceed it, the limit occasioned to the shipments being chiefly attributable to the wretched condition of the harbour at Whitby, which is so much silted up with mud and other *debris*, that no ship of any size can leave the port with a full cargo. The consequence is, that the carrying trade between Whitby and the Tyne, in reference to ironstone, is confined almost entirely to small craft. The larger ships, that may call by chance or be driven in by stress of weather, either leave the port in ballast or take in but a small portion of stone. The risk, therefore, that would attach to the guaranteeing the shipment of large quantities of ironstone, such as we are capable of producing from our mines, is such that no prudent person would venture to undertake it; and until some improvement is made in the harbour, this deplorable state of things must continue. We shall, however, have occasion again to refer to this subject further on in our work, and shall, therefore, proceed with that portion of it more immediately connected with our undertaking.

The whole of the iron-works in the neighbourhood of Newcastle, as well as those of Messrs. Bolckow and Vaughan

on the Tees, were now supplied with what Cleveland ironstone they required almost entirely from the Grosmont district, and the vale of Esk was looked upon at this period as the most favourable locality for cheaply and extensively working this deposit. This was owing, in a great measure, to the facility which the railway communication between the port and our mines afforded for making shipments at all seasons of the year, for, notwithstanding the vast quantities of stone met with to the north of Whitby along the coast, very accessible, and which could at that period have been advantageously worked, no reliance could be placed upon the beach as affording a regular and steady means of supply, owing, as had from the first been anticipated, to the great uncertainty there was of obtaining beaching ships for that purpose, without incurring a very large outlay in erecting breakwaters and jetties for sheltering and loading vessels, which none of the ironmasters, who were practically conversant with their business, felt themselves justified in doing. Most of the royalties, therefore, which were not already taken, and which were most favourably situated for working in the neighbourhood of Grosmont, were secured by the Birtley Iron Company and Messrs. Losh, Wilson, and Bell, both of which firms commenced mining operations in the vale of Esk about this period. The workings of the former are still in operation; but Messrs. Losh and Co., finding they could purchase their stone quite as cheap as they could work it, abandoned their undertaking.

It may now be asserted, without fear of contradiction, that the superiority of the Cleveland ironstone, compared with any other then known, for making iron at a low charge in the districts of Newcastle and Durham, was fully and satisfactorily established; in proof of which we have

only to mention the fact, that the managers of that large and unfortunate undertaking, the Consett Iron-works, notwithstanding that they were so unfavourably situated (as to distance) for using it, were induced, in the latter part of 1849, to seek a supply of stone from the Cleveland district, first from the Whitby Stone Company and Mrs. Clark, at Grosmont, and ultimately from the mines which they themselves established on the coast at Upleatham.

Having now traced the history and development of this ironstone (perhaps too circumstantially for the general reader), *from what we consider its earliest discovery, as connected with the practical application of it to the production of iron*, we deem it unnecessary to proceed further in detailing the proceedings of other parties, which, along with those of would-be-discoverers of the Cleveland ironstone, much of which had been surveyed and reported upon nearly twenty years before, became very numerous after the year 1846, and continued to increase in different localities up to the time of the North Cleveland openings at the outcrop, in 1850, by Messrs. Bolckow and Vaughan, who connected the South Durham coal-field by rail with the Eston district, where the main seam of ironstone was found to be of the enormous thickness of sixteen feet, and who, through the exertions of their mining engineer, Mr. Marley, at the expiration of not many months, were able to raise from their open quarries and mines together, the amazing quantity of from 1,000 to 2,000 tons of ironstone daily. The great sensation and excitement in the public mind which these operations occasioned at the time will still be fresh in the minds of many. The immense thickness of the beds discovered, the surprising quantity of stone produced daily from them, together with the low cost

of obtaining it, formed a common topic of conversation amongst the iron manufacturing community in almost every part of the United Kingdom, and it was easy to perceive from newspaper reports, and extracts from lectures, &c., that the public generally had hitherto known little or nothing of the ironstone field of North Yorkshire, and that Messrs. Bolckow and Vaughan were generally identified with it as its real discoverers. It will be seen, however, from what has been stated, that at the time of the ironstone openings in the North of Cleveland, every difficulty which attended its introduction into the markets had been previously overcome—all prejudice with reference to its suitable properties had been removed—its range and boundary had been pretty well defined—its quality well tested—the number of tons contained in an acre of ground had been correctly ascertained—the cost of winning and working it perfectly understood—and a vast amount of other information connected with it, which nothing but time and practical experience could afford, had been obtained, all which Messrs. Bolckow and Vaughan were doubtless acquainted with at the time they commenced their mining operations, and which, of course, would help to increase their confidence in the use of the stone. Too much praise, however, cannot be awarded to these gentlemen for the spirited manner in which they entered into, and carried on their gigantic proceedings, and we sincerely trust that that measure of success will always attend their undertakings which they so well deserve. In conclusion, we would just remark, that there are circumstances connected with the Cleveland ironstone, and the iron trade generally, which, at the time referred to, tended very importantly to its extraordinary success, viz., the requirements of iron by new sources of demand, to the meeting of which the application of the hot blast to its

reduction very materially contributed. These new calls were railways, iron ship-building, gas works, water supplies to towns, &c., as before noticed.

These, collectively, created so enormous a requirement for iron, that, in a comparatively short period of time, the production was more than doubled. In the whole of this, the hand of Providence is strikingly apparent; without the aid of resuscitated Scotland, and the Cleveland field of ironstone, the supply of iron could not have been afforded, and yet these districts together would have done but little without the hot blast. The Scotch iron trade, we have been informed, had in a great measure become defunct, from its requiring about six tons of coal to make a ton of pigs, which afterwards took only one-quarter of this quantity; this, together with the discovery of the black band, completely revived it.

It has been well ascertained that this stone produces what is termed cold short iron, viz., iron wanting toughness, which fault is corrected by an admixture of hematite ore, obtained from Cumberland, a comparatively small proportion of which suffices.

The discovery of the ironstone fields of Scotland and Cleveland has certainly been the cause of reducing the price of iron to its present low figure. The prodigious quantity, too, which these two regions are capable of producing, is such as amply to meet the extraordinary requirements which the new sources of demand have created. How wisely is all this mutual and general dependence ordered—how apparently is design manifested!

We shall now proceed with our delineation of the series of strata composing the group of rocks belonging to the district we have undertaken to examine and classify in

geological order, giving a brief description of each stratum as we proceed, pointing out its geographical situation on the surface, and its geological position in the series ; and for the better illustration of our subject we have prepared two large sections of the strata which we are about to describe. The first is a synoptic table, representing at one view the whole group, in their geological order and stratified form, commencing with the lower lias, as seen between Grosmont and Sleights Bridge, in the Vale of Esk, and terminating with the oolitic limestone in the neighbourhood of Pickering. The second is a section of the strata as they are seen to exist in the Vale of Esk, Lealholm, Castleton, Commondale, and Kildale, showing, as accurately as the nature of the ground will admit of, the different dislocations, undulations, denudations, &c., which occur in the strata in this route between Whitby and the north-west boundary of the lias formation. The line we have thus chosen for our chief section will take us through the centre of the Cleveland ironstone field. We have preferred following this route, from the circumstance, that whilst the oolitic and lias rocks have been very elaborately illustrated by sectional drawings along the whole line of the sea coast, first, by Messrs. Young and Bird, next by Professor Phillips, and again by Mr. Marley, the mining engineer to Messrs. Bolckow and Vaughan, the interior of the country has been almost entirely neglected in this respect, and, although this will entail upon us a great amount of labour, we shall yet consider the time well spent, if we succeed in giving—as we hope to do—a correct delineation of the different strata as they are seen to exist in the vales through which we pass, by which our readers will be able to see at a glance the true position of the iron-

SECTION No. 1.

SECTION

OF THE

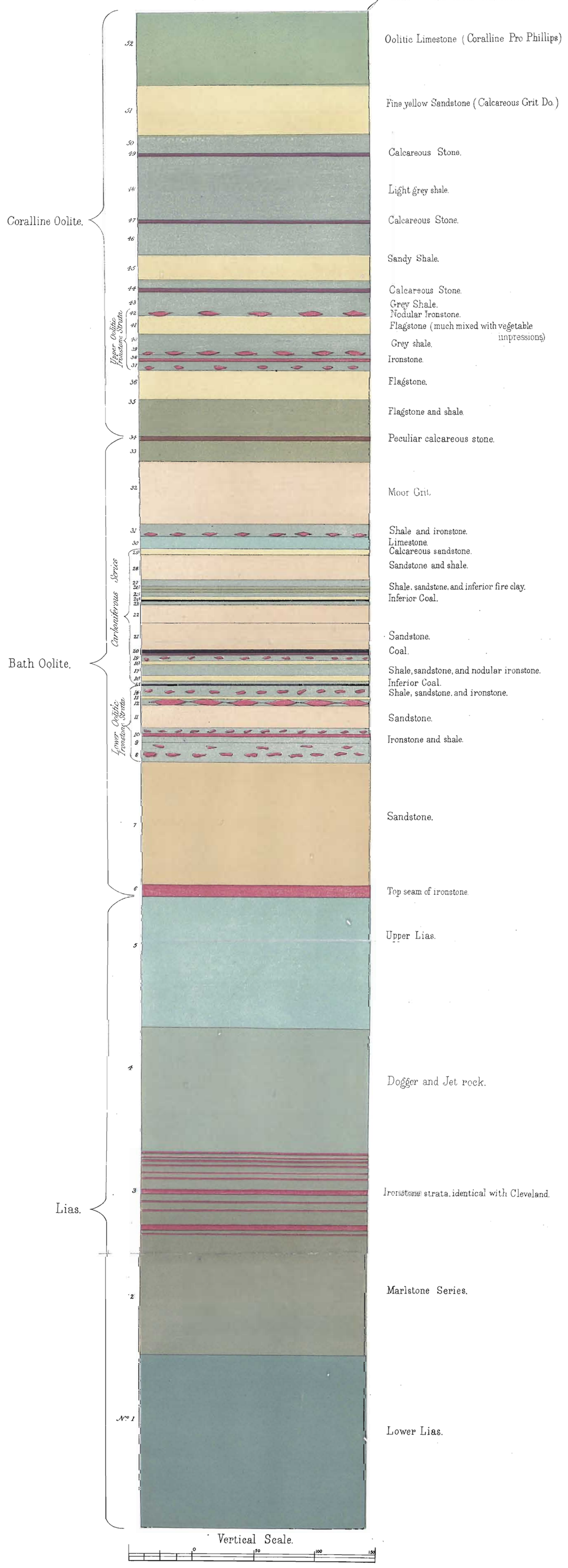
LIAS AND OOLITES OF NORTH YORKSHIRE,

AS SEEN IN THE VALES OF

ESKDALE, GOATHLAND, AND PICKERING.

Lithographed in Colours, by Andrew Reid, Newcastle.

by Jos. Prestwich, Jun.



stone beds, where they are to be met with by the sides of the valleys, or where they are buried beneath the surface of the plains; and the expense so frequently incurred, by making useless trials and experiments to find the stone where it really does not exist, will, we hope, through the information thus afforded, in future be avoided.

LIAS FORMATION.

Notwithstanding all that has been written by our geologists and mining engineers, in reference to the lias formation, its true geological position in North Yorkshire is at present really unknown. Whether it rests upon, or overlies, or alternates with the red sandstone and magnesian limestone, or whether, as some suppose, these latter rocks, along with the entire carboniferous series, are wanting in the district, and, in consequence, the lias will be found, in all probability, resting upon the millstone grit, are problems which nothing but experimental investigation can solve. Judging, however, from the very uneven character of the stratification of the lias, assuming, as it does, what may be termed the wave-shaped form, we may infer that the rocks upon which it rests may also be of a very uneven character. When fully developed, its thickness, in the district under notice, may be stated to be from 600 to 700 feet, including, of course, the marlstone series. It occupies, geographically, a considerable part of the north-eastern portion of the north riding of the county, bounded by the German Ocean. Commencing at Peak, on the coast, about eight miles to the south of Whitby, it traverses the whole of the coast northward as far as Huntcliff, about fifteen miles north of Whitby, forming bold and stupendous cliffs, and scenery of surpassing grandeur. From this point it

passes away into the interior of the country, which it traverses in a south-westerly direction, and its high and bold escarpments are seen overlooking the low, flat, delta land south of the River Tees, and, being capped by the rocks of the oolites, form the mountain range mentioned in our introductory observations.

This rock is divided into what is called the upper and lower lias, and the strata intervening them are termed the marlstone series, in the higher portions of which are contained the ironstone seams. The lower lias (see section No. 1), therefore, first demands our consideration. This portion of the rock, with the exception of a very thin scattering of ironstone nodules contained within it, interspersed here and there, is very barren. It consists of a strong blue shale, and is much coarser than the upper lias. Professor Phillips states, this rock, when fully developed, to be 500 feet thick; we have nowhere, however, found it approach to anything like that thickness. In the vale of Esk, between Grosmont and Sleights, where it attains its greatest height in that neighbourhood, we found, from actual measurement, it was not more than 130 feet thick, and we are much in doubt whether this height will be much, if at all, exceeded, either at Boulby or Huntcliff, on the coast, where it is seen to great advantage. It is at the Peak, south of Whitby, however, that it attains its greatest thickness, and there, owing to an extensive dislocation of the strata, this rock is found in juxtaposition with the upper lias, and what is termed the inferior oolite. From a section given us by Mr. Hall, the agent of the Swainby ironstone mines in the neighbourhood of Stokesley, we found there were 300 feet of level between the ironstone beds and the plain below, and if we take off 100 feet for

the thickness of the marlstone series below the ironstone, we shall have 200 feet left as the thickness of the lower lias in that locality. The lower lias is covered by the marlstone rock (see section No. 2), the thickness of which, including the ironstone strata, in the Grosmont district, is about 160 feet. This rock is very easily distinguished from the upper and lower lias, by its being coarser and more silicious in its composition, and, generally, when exposed to the atmosphere, its aspect is tinged with a yellow hue, but, when broken, it presents a grey fracture. The first 100 feet of this deposit, both as regards valuable mineral products and fossil organic remains, are barren in the extreme, for, with the exception of a few thin layers of nodules of iron or cement-stone met with here and there throughout this mass, and a few stray impressions of shells, we have generally found both of them all but absent. This rock, on reaching the ironstone beds, becomes more assimilated to that portion of the upper lias comprising the jet, dogger, and alum rock, assuming a dark blue colour, and, when broken, presenting a finer fracture than the lower portions of the same rock. The ironstone strata are, again, easily distinguished from the lower portions of the marlstone series, from the following circumstance, viz., at intervals, varying from a few inches to a few feet, are to be found, in the shale intervening the ironstone bands, finely laminated partings, filled with tiny but very beautiful fossil impressions, chiefly of the bivalve species, and some of them belonging to the family of pectenites. When large slabs of this shale are first brought from the mine they present a most beautiful appearance, the face of them frequently being one complete mass of these impressions, resembling very much the small pattern or design seen on

a table cloth, with this difference, of course, that the former are the organic remains of antediluvian animals, which existed, in all probability, at a period that would carry us back far beyond the date of our chronology, and enjoyed life in that early period of the history of our earth, undoubtedly, as much as is permitted to the animal creation of the present day, the bottom of the ocean of that epoch having become the bed of their final repose, whilst the latter are but the mere figures of design.

THE MAIN IRONSTONE DEPOSIT.

It frequently happens that the ironstone seams by the sides of valleys and ravines are covered over with soil, brushwood, or herbage, which render it very difficult at times for those who are in search of them, especially if they should not be conversant with the geology of the district, to find out their whereabouts from the great similarity there is between the lower portions of the upper lias (designated the dogger rock), and the shale containing the ironstone seam. In such a case, the organic impressions above referred to are a sure guide to their discovery; and we may mention here, for the information of our readers, that we have generally found them most abundant between what is known in the Grosmont district as the avicula and pecten seams, between which there are upwards of thirty feet of shale intervening.

The great commercial value and vast importance of the deposit we have next to notice, it would be very difficult to over-estimate. Its great extent, its enormous produce, its easy accessibility, the extraordinarily low cost at which it can be obtained, its easy conversion into iron, and its contiguity to the great northern coal-field, where

the paucity of this mineral may be said to have been grievously felt, render its value really above all estimate as an accessory thereto, and unitedly they hold out a hopeful promise of centralising our staple trade of iron production. There can be no doubt of the consumption of iron, vast as it is, greatly increasing, both at home and abroad, seeing that new sources of demand are yearly manifesting themselves. Enormous, however, as the requirements will undoubtedly be, there need be no apprehension of the demand being met, since the discovery of this unequalled deposit.

As we before observed, the geographical extent of this mineral field, as far as at present can be ascertained, is supposed to be between five and six hundred square miles; at least this may be considered as an approximation to the truth, the accuracy of which, before the completion of this treatise, we hope to be able in a measure to test. Within this area it may fairly be asserted, we think, that the ironstone will be found at a workable distance from the surface, every acre of which we consider we are justified in estimating as containing, on an average, about 20,000 tons. In some localities—such, for instance, as Eston, Upleatham, Skelton, &c.—this quantity will doubtless be greatly exceeded, whilst in others the workable quantity will fall short of it; but, on the whole, we are disposed to take the above quantity as the average yield per acre for the area above-named. The mining operations which have, within the last few years, been commenced and carried on upon so large and extensive a scale in North Cleveland, by different companies, and the many experiments which have recently been made in other localities, have greatly added to the knowledge we previously possessed respecting this ironstone. It has now been ascertained that, throughout its geographical extent,

it is very irregularly diffused, its thickness varying very much in different localities; and the same may be said with reference to its quality, which is found anything but uniform, a great difference in this respect being observable even in the same mine within a limited extent. The difference between its maximum and minimum yield being from four to six per cent., the cases which exceed this range may be considered exceptional, and its average yield in iron may be taken at from twenty-eight to thirty per cent. (See tables of analyses.)

Commencing at Peak, on the coast south of Whitby, which at present may be considered the southern point of this field on the coast line, the ironstone seams are traceable along the side of the hills and the face of the cliffs as far as Hawsker, to the north of Robin Hood's Bay, beyond which they descend somewhat rapidly below the level of the sea, and on reaching Whitby they are still further depressed below the bed of the ocean, in consequence of an extensive dislocation met with there, which we shall have again more particularly to notice. Continuing along the coast northward from Whitby, the ironstone seams are next met with at Kettleness, where the pecten seam is seen at the bottom of the cliff on the beach, which we had occasion before to refer to as the site of the early operations of our relative on behalf of the Wylam Iron Company. Beyond this they again disappear below the sea level, and are entirely lost sight of, till, on approaching the romantic fishing town of Staithes, they are again seen emerging from the ocean's bed, and ascending higher and higher in the bold and rugged cliffs which face this portion of the coast until Boulby is gained, in our northern progress, where the finest section of the ironstone strata is exclusively afforded us; passing onward, they

are, for the last time, seen occupying the higher portion of the cliffs at Huntcliffe. Here they retire from the coast, and are traceable from Skinningrove along the front of the hills of Upleatham and Eston, beyond which they fall back into the interior of the country, skirting the face of the lias escarpment, running in a south-westerly direction as far as Arncliffe, beyond the Swainby iron mines, and traversing in their course the whole of the Cleveland Hills. From this point they tend to the south-east, by way of Osmotherly, Easingwold, &c., and soon afterwards disappear below the oolitic rocks. (See map.)

We have before observed that the thickness of those ironstone seams varies much in different localities. Between the Peak and Whitby they are much thinner than in any other portion of the coast; but at those two points, it ought to be remembered, the strata are much disturbed, which may have influenced those between them, and caused the diminution in the thickness of the ironstone. Between Kettleness and Boulby, although there is a great thickness in the aggregate, yet the deposit is so separated and divided by the intervention of shale, that the workable quantity really obtainable is very much reduced in consequence. In the north portion of the Boulby estate, however, we have the first indication of the various ironstone strata composing the main seam showing a tendency to unite in one mass, and this becomes still more decided at Skinningrove and Upleatham, so that by the time they reach the Eston hills they have entirely united, and the whole mass has swollen out to the unheard-of thickness of eighteen feet, most of which is of good quality.

We thus see that, whilst the ironstone at its supposed southern boundary has very greatly diminished in thickness, at its northern extremity it has attained its greatest

height; and as it is quite apparent, we think, although not proved, that the country between Skinningrove and Upleatham is traversed by a dislocation of considerable magnitude, it may be that the same disturbing causes which, in all probability, may have acted so detrimentally on the southern portion of the field, may have produced just the contrary effect at its terminating point at the northern. It is a singular fact, too, that while the two extreme points (north and south) are apparently subject to the same disturbing causes, the ironstone deposit should, at each of those points, be found at pretty nearly the same height above the level of the sea, thus forming itself into a large basin, the centre of which would appear to be immediately on the north side of Whitby, where the ironstone measures are buried far beneath the bed of the ocean, and where a portion of the sandstone which belongs to the carboniferous series forms the cliffs of this part of the coast, adjoining to Whitby harbour, where the river Esk empties itself into the sea.

This would be the proper place to give a description of the ironstone in the Grosmont district, were it not that we purpose giving a delineation of the strata of the interior of the country, as seen exposed in the vale of Esk, and other valleys which intervene between it and the south-western boundary of the field, in the Stokesley and Thirsk districts, which, of course, will include Grosmont. This will take us through the centre of this important mineral field, and will enable us, we trust, to elucidate its general features and peculiar characteristics in a more clear and intelligible form than has hitherto been made public. This general section will form the subject of a part of the second portion of the present treatise.

Having thus briefly described the geological features and

local peculiarities which characterise the main Cleveland ironstone seam, as it presents itself on the coast line between its south and north boundaries, we shall next proceed to notice those which distinguish it along its western outcrop, as far as the information we possess will enable us to do so, which will confine the observations we have to make on this part of the subject chiefly to the hilly district between Eston and Swainby mines, from which it will be seen that the same decrease in the thickness or quantity of the deposit occurs here as is manifested on the coast. Commencing at the Eston mines, and crossing over to those of Normanby—both of which are situate in the range of the Eston hills—we find that there is already a great diminution in the thickness of the seam. In the former it is from sixteen to eighteen, and in the latter from ten to thirteen feet thick. Leaving those mines, and crossing over the valley to the other side, and examining the seam where it is at present worked by Messrs. Pease, at the Hutton and Codhill mines, situate in the next mountain range to the south of Eston, and where it is found at a much greater elevation above the level of the sea, we find that a further diminution of quantity is evidenced here also, the workable thickness of the seam being only six feet; and we have been told, too, that its quality is also deteriorated. We are disposed to think, however, that this may be more owing to an impure mixture than a depreciation of the quality of the pure stone, the seam here being much interspersed with shale, and strongly impregnated with the obnoxious mineral pyrites, or sulphate of iron, fully confirming the opinion we formed of this stone nearly twenty years ago. Pursuing our journey southwards, we next come to the valley of Kildale, where we find the same declension in the thickness of the seam,

which is found here to be much split and divided by partings of shale, the thickest portion of it not averaging more than about three feet. This royalty was for some time in the possession of Messrs. Bell Brothers, of Newcastle-on-Tyne, the younger member of which firm—John Bell, Esq.—than whom no one has taken greater pains, for many years past, to make himself acquainted with the nature and extent of the Cleveland ironstone, and to whom we are indebted for the information we possess in relation to this royalty—after a thorough examination and due appreciation of its value in regard to quantity and quality, advised the abandonment of it, which accordingly took place. He also tried the top seam in the same estate, but with the same unsatisfactory results. Another experiment has been made in this district, in the royalty of Ingleby Greenhow, but this was also abandoned, as affording no prospect of a remunerative result. It only remains for us to notice the seam as it is met with at the Swainby mines, situate about six or seven miles to the south-west of Stokesley, where it so much resembles that seen at Kildale, that to describe it in detail would only be a repetition of what we stated with reference to the stone found there. Being nearer to the coal, however, and greater railway facilities being afforded, this stone has been worked for some years past by Messrs. Holdsworth and Co., of the Stockton Iron-works, and their workings are still in operation. A section of this stone, given us by Mr. Hall, the agent to those mines, as also one of the Kildale stone, will be found inserted in another page; but we shall again have some observations to make on the ironstone of this district in the second part of our treatise.

From what we have advanced with reference to the irregular distribution of this deposit, it will be seen that

the ironstone along the western escarpment, like that on the coast, diminishes in quantity as it extends to the south, and an opinion prevails, from this circumstance, that the field will be found to extend no great distance southwards before it exhausts itself; and had the evidence thus afforded been corroborated by the explorings that have been made, and the mines which have been in active operation for so many years in what may be termed the central portion of the field, viz., in the Grosmont and other districts, this hypothesis might have been looked upon as a moral certainty; but we have no such corroborating testimony afforded us in those districts, for, with the exception of the range of broken and detached hills fronting the coast between Skinningrove and Eston, with a portion of the Skelton estate, we have nearly as great a thickness of ironstone, in the aggregate, at Grosmont, as is met with in the other districts of North Cleveland; for example, at the Hutton and Codhill mines, near Guisbro', the aggregate thickness of the deposit (according to the section given in Mr. Marley's paper on the Cleveland ironstone, read before the Institute of Mining Engineers, at Newcastle-on-Tyne, in June, 1857) being fifteen feet eight and a half inches, whilst at the mines under our charge at Grosmont the aggregate thickness is thirteen feet ten inches—(see sections)—showing a difference of only one foot ten and a half inches in a distance of about eighteen miles, in a south-easterly direction. The workable thickness of the seam at Hutton and Codhill is six feet one inch, and at Grosmont it is six feet nine inches, with this difference, however, that at the former places it is worked in one seam, whilst at the latter it is divided into two, designated the pecten and avicula seams, distant from each other some thirty feet, which difference in working, however, does not alter the productive yield of

the whole. Then, again, the united thickness of the pecten and avicula seams—as proved in an examination made by Mr. J. S. Prat—in Fryupdale, some six or eight miles to the *south-west* of Grosmont, was found to be ten feet, the quality of which, it is stated, is very good. We may just mention here that the produce of Mrs. Clark's mines, from the pecten and avicula seams, practically ascertained, is about 20,000 tons per acre, and that they are capable of raising 2000 tons per week; but as we shall have to notice them more in detail in the second part of our treatise, we shall reserve what we have got to say concerning them till that part of our subject comes under consideration. The name avicula is given to the lower seam from the numerous fossil impressions found embedded in it of the shell "avicula cygnipes." It averages about three feet nine inches in thickness, and is divided into four distinct strata by horizontal partings, one of which is a complete concretion of shells, chiefly of the bivalve species and family of pectenites. The other seam, which is about three feet thick, is designated the "pecten," from the predominating fossil which it contains being the "pecten sublævis," and from it large and beautiful specimens of that fossil are frequently obtained. Nests, too, of the tiny but beautiful fossil terebratula are numerous also in this seam. There is one subject connected with this deposit which we can never think of without some degree of regret, and that is, that one-half of this valuable mineral is not workable, from the circumstance of its being so much divided by the intervention of partings of shale, which render the mining of it unremunerative, and the stone, therefore, valueless. At Codhill and Hutton mines, in the neighbourhood of Guisbro', the seam is, as we have already stated, fifteen feet eight and a half inches

thick, only six feet one inch of which can be profitably worked ; more than one-half of the whole is consequently lost; and at Grosmont we have thirteen feet ten inches, only six feet six inches of which is obtainable from the same cause. This is a lamentable fact, for which at present there appears no remedy. In the mines at Normanby, Eston, and Upleatham, no loss is sustained beyond the ordinary working per centage.

We think the foregoing remarks with reference to the productive yield of the North Yorkshire ironstone field in different localities, where it has been examined and proved, justify us in arriving at the following conclusion, viz., that whilst the contour line along the south coast and western escarpment of the field strongly indicates that there is an exhausting point—at no very great distance from the place where it is last seen at its out-crop (accelerated, no doubt, by the dislocation), on the coast near Peak, and from its disappearance beneath the oolitic rocks on the west—at which it may terminate; yet, forasmuch as there is no corresponding diminution or thinning-off in the central and south-eastern portions of the field, it would be premature to assert, until these portions are more fully explored and developed, that such is the case. The enormous thickness which the seam attains at its northern boundary, and which practical examination has already proved to be of only limited extent, comparatively speaking, has probably been caused by some local peculiarity not easily accounted for—possibly by the action of oceanic currents during the period of its deposition; whilst its great attenuation at its southern extremity may have been occasioned by the dislocated and disturbed condition of the strata in that locality.

Having now traced the geographical extent, the geolo-

gical characteristics, the local peculiarities, and the irregular distribution of this extensive and important iron field, and contrasted the thickness of the deposit in the different localities where it has been examined and proved, we shall for the present conclude our observations with a few general but brief remarks, recapitulated from our foregoing description. 1st.—That the figure of this mineral field, as represented by its coast contour line, is that of a basin, having its centre in the neighbourhood of Whitby, with its edges extending to Eston on the north and the Peak on the south; that it is intersected by dislocations of considerable magnitude, the principal of which occur at the Peak, Whitby, and another, in all probability, on that part of the coast lying between Skinningrove and Saltburn, and we are not quite sure whether there may not be yet another at Sandsend, a few miles to the north of Whitby. We are disposed to think there may. 2nd.—That the strata comprised within this basin are subject to local undulations of a minor character, and denudations to a considerable extent, the latter occurring in the dales and valleys so numerous throughout the district. 3rd.—That the ironstone deposits are very irregularly diffused throughout the extent of this field, and while it is much attenuated at its southern outcrop, it is swollen out to an unequalled and extraordinary thickness at its northern extremity, but that those large accumulations heaped together in one mass, are localised and confined to but a limited area, when compared to the whole extent of the field, which area embraces part of the royalties of Skinningrove and Skelton, and the whole of the two detached hills of Upleatham and Eston fronting the sea coast and the Tees estuary. 4th.—That whilst there are strong indications of the chief deposit of ironstone exhausting itself at

no great distance beyond the point where it is traceable to the south, yet, in its present imperfectly explored and undeveloped state, it would be premature to assert that such is the case.

In conclusion we have only further to remark, that there can be no doubt that the district we have marked out above as containing the thick portions of the deposits of ironstone, is capable of furnishing an enormous supply of cheap ironstone for a long period of years to come, and, surprising, indeed, is the circumstance of the already amazing quantity which is produced daily at the mines and quarries even now established there—those of Messrs. Bolckow and Vaughan alone averaging nearly two thousand tons per day —but there is a limit to their supply; and as it cannot fail, we think, to be both instructive and interesting to the generality of our readers, but especially to those interested in the iron trade, to know how far this district is calculated to meet its present and future requirements, we propose, if we are fortunate enough to obtain the necessary information to enable us to do so, in the second part of our Treatise, devoting a few pages to the consideration of this important part of the subject. We shall, also, make the attempt to obtain a more accurate estimate of the area and produce of the field at large than has yet been made public.

UPPER LIAS OR ALUM ROCK.

It is well known that the upper lias is the great depository of alum, and for a long period works for its manufacture have been carried on in the Whitby and Cleveland districts. The oldest and first work of this kind, established and carried on by our own countrymen, was, we believe, that erected by the ancient family of the Chaloners, near Guisbro', but, indeed, that which merits the greatest claim

to antiquity is one which, in ages long gone by, had its existence at Grosmont, a remnant of which is still to be seen. Nothing, however, is known as to the date of its erection, but it is generally supposed to be a work of the Romans, and as a proof of its great antiquity we may just mention that oaks, the growth of centuries, are now standing upon the heaps of refuse belonging to that work, and others which appear to have grown on the same place have gone to decay. An interesting account of this work will be found in Young's "History of Whitby."

The alum works at present in operation are confined chiefly to the coast, viz., those belonging to the Marquis of Normanby, situate at Sandsend and Kettleness, north of and near Whitby, those of John Westgarth, Esq., at Boulby, and those at Lofthouse, the property of the Earl of Zetland, and although the beautiful and wonder-working science of chemistry has discovered a process whereby this article can be produced from chemical compounds, by which its value has been much reduced in the market, still the works we have just noticed are in full operation, and carried on spiritedly, and, we trust, remuneratively to their owners.

The upper lias consists of a fine dark blue shale finely laminated, and, excepting occasional pieces, remarkably free from extraneous matter. Some portions of it are very bituminous, so much so, indeed, that it is easily ignited, and instances are even on record where spontaneous combustion has taken place in heaps of this shale, owing, doubtless, to the large quantity of pyrites (sulphate of iron) which it contains. When once ignited it calcines itself, a necessary preliminary in alum making. The thickness of the upper lias is about two hundred feet, the first one hundred of which, covering the ironstone strata, consist of strong blue shale, especially the lower portion of it, locally termed the

jet rock, from which the finest specimens of that beautiful mineral are obtained; the other portion is named the dogger rock, from the large massive nodules found therein, of a kind of inferior cement stone, of no commercial value, the same, in all probability, which were shipped to the Tyne Iron Company for ironstone, as before noticed. The remaining one hundred feet is properly termed the alum rock, being that from which the largest portion of alum is extracted, and consists of the fine bituminous shale before described. From the soft and yielding nature of this shale it is easily acted upon by streams, rivers, and atmospheric changes; and it is, doubtless, owing, in a great measure, to this circumstance, together with the irregularity of its stratification, that we so frequently see the districts where it abounds so much divided into rich and fertile valleys and secluded dales, as well as the beautiful and mound-like hills with which they are frequently surrounded. The many wild and rocky ravines which are connected with those dales, some of which are almost inaccessible, owe their origin to the never-ceasing operations of the mountain streams, whose excavations are so much facilitated by the softness of this material, laying open, on the one hand, the valuable minerals this formation contains, and, on the other, adding beauty and diversity to the landscape.

The marvellous profusion and great variety of fossil organic remains found imbedded in the lias formation, all belonging to animals that once inhabited the "briny deep," and the study of which is so admirably instructive to the geological student, at once establish the conviction that this sedimentary deposit is of marine origin. It would carry us far beyond the limits of our present treatise were we to attempt to give even a brief account of the animal exuviæ found embedded in the strata we are describing in

detail. We may just mention, however, that it is the lias formation which contains the fossil remains of those gigantic antediluvian monsters, the ichthyosaurus, plesiosaurus, and that curious animal the pterodactyle, as well as a great variety of ammonites, &c., &c. Those who may wish for further information on this subject, we refer them to the works of Buckland, Phillips, Hawkins, and others. The upper lias being a portion of the rocks we have already described, it will be unnecessary for us here again to trace its boundary, as that would only carry us over the same ground we have already treated somewhat at large. (See map.)

JET ROCK.

Jet, as well as alum, and the vast masses of ironstone, are found in the lias rock. Jet and cement stone, commercially speaking, may be considered, next to ironstone, the most valuable minerals the lias contains, the former of which, from the beautiful and delicate ornamental articles manufactured from it, has made Whitby so well and widely known. Jet may safely, we think, be classed amongst the carbonaceous substances, and may be considered a vegetable product of the finest kind. It is found in small patches, from an eighth of an inch to a few inches in thickness, in the top and bottom portions of the upper lias, and though the best portions of it occasionally realise the extraordinary price of from 12s. to 14s. per lb., we have been told it is yet too thinly scattered in the shale to render mining for it remunerative, though several attempts to do so have been made, all of which have, we believe, resulted in failure and disappointment. Whether this can be traced to a want of knowledge as to the lead, or direction, the "lines of jet," as they are called, follow, on the one hand, or the

want of a proper systematic plan of proceeding, in prosecuting their mining operations, on the other, we have no means of ascertaining. We think, however, that a mineral so valuable ought to stimulate those interested in the jet trade to make further exertions for its development in this respect. We are of opinion, that a well devised plan, judiciously and vigorously prosecuted, might, in all probability, be attended with success. The mode of obtaining jet, at present, in the neighbourhood of Whitby, is by extracting it from the face of the cliffs on the sea coast, and by the sides of valleys and old quarry workings in the interior of the country. Its commercial importance to the town of Whitby will be best understood when we state, on the authority of a gentleman interested in the trade, that the annual amount realised from jet ornaments, including, of course, their gold and silver settings, was £50,000.

CEMENT STONE

Is also obtained from the upper lias, as well as scattered and interspersed promiscuously throughout the shale. It is found in layers, consisting of nodules of various sizes, which so much resemble ironstone in their general aspect as to be not unfrequently mistaken for it by strangers. Its specific gravity, however, is less, neither does it show the presence of iron by oxidation, like ironstone, when exposed to the atmosphere.

This stone is obtained much in the same way as jet ; all attempts to mine for it have proved, we understand, comparatively speaking, futile. This mineral brings from twenty to thirty shillings per ton in the market, and we are impressed with the belief that, in some localities where the ground on which the spoil heaps are deposited is of little

value, cement winning, under good management, might be rendered a good and safe investment. We have often wondered, with the facilities which railways afford for doing so, that no attempt has been made to establish works for the manufacture of alum in the interior of the country—the works at present in operation, with the exception of those near Guisbro', being, as we before stated, situate on the sea coast, and access to them by shipping very frequently impossible, which places them in a very disadvantageous position—where the alum rock, jet, and cement stone might, we think, be worked from the same mine. It is from this stone that the celebrated Mulgrave cement is produced, the process of making which is very simple. The stone is broken and calcined, and afterwards ground to a fine powder, in which state it is used as cement. At the works at Mulgrave there are a variety of articles made from it, both ornamental and useful, such as vases, chimney pots, tiles, pipes, &c. There are frequently found embedded at the core of those cement nodules, the fossil remains of some one of the ammonites, so familiarly known in the neighbourhood of Whitby as the "snake stones."

TOP SEAM OF IRONSTONE.

We have next brought under our consideration another deposit of ironstone, known by the name of the top seam of the lias formation, marked in section 1, No. 6. In all previous geological works, wherein the subject we are now describing is treated (Mr. Marley's paper excepted), it has been referred to as the "dogger," and is classed by Professor Phillips with the inferior oolite. Believing it, however, to belong to the period of the deposition of the lias, we ventured, some time ago, to designate it the "top seam of the lias formation," by which name it has ever

since, we believe, been generally known amongst practical men. Our reasons for giving it this appellation will be found at the end of our description of this deposit.

This inferior ironstone is generally found intervening the alum shale and the great sandstone rock which immediately overlaps it. It is even more irregularly distributed than the main seam, for, whilst the latter varies very much in its thickness, it is never altogether wanting; but this, from its very frequently alternating with the sandstone, is not unfrequently absent, or existing only in type. It is, however, to be met with throughout the whole of the lias district to the north of the oolitic escarpments, generally resting upon and occasionally descending into the alum shale, and there are few of our valleys or glens in which it may not be discovered in some shape or other. It is seen from one to twenty feet in thickness, and then again is sometimes entirely wanting; but more generally it is found to average from eight to fifteen feet. It is sometimes met with presenting a decidedly oolitic aspect, its composition resembling very much, when magnified, the roe of a fish, and when found exhibiting these features, it frequently contains groups or nests of very small fossil shells, and is also rich in iron, yielding from thirty to thirty-six per cent. of that metal. It very seldom continues to any extent under this favourable aspect, however, and is more generally discovered presenting a coarse, hard, silicious fracture when broken, and, as a whole, is of little or no real commercial value, seldom averaging more than from fifteen to twenty per cent. yield of iron. We know no mineral better calculated to deceive strangers—and believe it has already frequently done so—for even when met with in the hard and coarse condition which we have described, the blocks extracted from it are very frequently (espe-

cially at or near the outcrop) enveloped in an external coating, consisting of a substance containing from thirty to forty per cent. of iron, whilst the core, on the contrary, is nothing but an arenaceous mass of no value whatever; and as the richer and more valuable portions of this seam are also surrounded by a similar covering, and the features of the two are so much alike, it is not easy for strangers to discriminate between them; but it certainly appears in the most treacherous garb when calcined, for when seen in this state, even by practical and experienced men, there is no detecting its inferiority till tried in the furnace. There can be no doubt, indeed, that large portions of this deposit, in some localities, are rich in iron; but the great difficulty lies in properly selecting it, for there is very frequently a great difference in quality between the top and the bottom of the seam, one portion of it being of good quality, while the next subjacent block will be all but worthless. Hence its inappreciable value, and the difficulty of working it to profit or using it in iron-making to advantage. As far back as the year 1840, a few cargoes of this ironstone were collected on the beach south of Whitby, by Bewick, when in the employ of the Wylam Iron Company, and forwarded to their works at Wylam, near Newcastle-on-Tyne, for trial, the result of which was very unsatisfactory. This ironstone, within the last five or six years, has been very much engaging the attention of speculative individuals, and notwithstanding the adverse opinion given by experienced and practical parties every way competent to judge as to its commercial value, which, indeed, only appeared to increase the number and ardour of the adventurers, joint stock companies (limited) were formed, royalties were taken, and mining operations commenced and carried on somewhat extensively up to a recent period, but these

have nearly all hitherto resulted, as was anticipated, in failure and disappointment. No doubt this rage for mining was in a large measure occasioned by the sensation and excitement which the opening of the main seam at Eston, in North Cleveland, caused, and subsequently by the discovery of the magnetic ore at Rosedale Abbey, which at first was stated to be identical with the top seam, but which a careful examination proved to be a local deposit of an extraordinary and peculiar kind, which, in all probability, will be found of a very limited extent. A well arranged and substantial iron-work has, within the last few years, been established by the Whitby Iron Company (Limited), at Beckhole, near Grosmont, for the purpose of using the top seam of ironstone for making pig iron, consisting of two blast furnaces, with all their necessary appendages, which, however, have not yet been put into blast; but as soon as a revival in the iron trade takes place, it is expected that this will be immediately done.*

The working of the top seam has been attended with greater success on the coast, near Hinderwell, where mining operations have been carried on in it for some years past, and we believe profitably, by Messrs. Thomas Seymour and Co. in the first instance, and more recently by Messrs. Palmer and Co. Here the seam is divided, the lower portions of it being interstratified with the lias; and where this is the case, the quality of the stone is generally improved. There can, however, be no dependance placed upon its continuing for any distance thus separated; and we are informed that the stone is so much diminished in

* Since the above was written, this Company has entered into a contract with Mrs. Clark for a supply of ironstone from the avicula and pecten seams, with the intention of using a portion of the top seam as a mixture. They intend being in blast in the beginning of May, and we sincerely wish them every success.

thickness at the extremity of the latter company's mines, as to render the working of it profitably next to impossible. This has compelled them, we understand, to sink to the main seam, which they are now (1859) working somewhat extensively there.

We may just mention, whilst noticing this stone, that, some years ago, we made a somewhat extensive trial of it in Mrs. Clark's estate, the greater part of which contains it, varying in thickness from eight to fifteen feet—more, however, to satisfy one of our friends in the iron trade, than with the expectation of deriving any immediate advantage from it—and, as we anticipated, its coarse and silicious character and inferior quality, on an average, quite precluded it from superseding the main seam, which our friend thought it might do. The per centage of iron which it contained, according to a series of chemical analyses, ranged from fifteen to over forty per cent. We shall have occasion again to notice this stone in the second part of our work.

It may be mentioned as a fact, deduced from personal observation and experiment, that whilst the main seam of ironstone is greatly increased in thickness at and on approaching its northern boundary, the top seam, on the contrary, towards the same point, is found to be very greatly diminished in quantity, so much so, that along most of the lias escarpments in North Cleveland it is found only a few inches in thickness, and that, on approaching the southern extremity of the field, the main seam would appear to thin off, while the top seam attains to a very great thickness, for, after leaving North Cleveland and proceeding southwards, by the time we reach Eskdale, and other valleys connected with it, we find it swollen out to twelve, fifteen,

and, in some instances, as in Northdale, one of the tributaries of Rosedale, to the enormous thickness of twenty feet.

We cannot close our observations on the top seam without referring to a subject that has engrossed a good deal of attention in these parts for the last two or three years, viz., the experiments which have been made at Rosedale Abbey in this seam, upon which we have already given a sufficient exposition of our views, in a short paper we read before the members of the Institute of Mining Engineers, at Newcastle, "On the Ore and Ironstone of Rosedale Abbey;" our impression in reference to the *quantity of magnetic ore*, the nature of the deposit, and other circumstances, together with the *quality* and *position* of the top seam, being opposed to the opinion of those gentlemen under whose supervision the borings and driftings have been made, with a view to prove and develope the nature and extent of the magnetic ore, and to satisfy scientific enquiry in reference thereto; and we cannot help feeling regret that they should have ceased their researches at a point which leaves the controversy still undecided, though it might have been satisfactorily determined in a very short time, and at a very small further cost, which would at once have set the matter at rest, and freed it from that doubt and uncertainty which still beset the minds of many individuals interested in its solution. This is the more to be regretted, as, in all probability, after a large expenditure of money, time will show what a very small outlay might have now unfolded. In the meantime, we may state, that a further examination of the locality referred to only serves to confirm all our former views on this subject, viz., that the magnetic ore is a local deposit of an extraordinary and peculiar kind, composed of a material whose original condition

appears to have been changed by the action of heat, and, in this respect, as well as in its formation and position, bears a striking analogy to our volcanic or basaltic dykes. For instance, the assertion that the magnetic ore "had been proved in two localities, two miles apart," is now acknowledged to be an error, and the supposition that it was a "disjointed patch of the top seam" is also admitted to be incorrect; and, again, in the main drift, driven a considerable distance in the heart of the ore, and apparently in a direction lengthwise of it, another opening has been made, transversely, to prove its width, and, after being driven to the distance of fifteen or sixteen yards, the bottom portions of this drift cut through the ore and intersect the alum shale, evincing, very clearly, we think, that it soon exhausts itself in that direction, and it now only remains to be seen whether it is simply a basin or a vein, and whether the borings that have been made there have penetrated the magnetic ore seen at the quarry by the side of the valley, or whether they have stopped short in the oolitic ironstone above it. Our opinion is, that they have only reached the latter deposit, and have not yet penetrated the magnetic ore, and that the rich portions of the latter deposit will be found not to average more than from thirty to forty yards in width, or even less; whilst the extent to which it may run lengthways cannot at present be ascertained, as it may terminate at a short or extend to a considerable distance. Should the veins we have here enumerated prove correct, the question arises whether the quantity of magnetic ore obtainable from an area—the accessible portion of which is so limited—together with the best portions of the top seam, found in such abundance in its immediate vicinity, be such as to justify so large an expenditure of capital as must be incurred in the making of an

expensive railway, eleven miles in length, solely for the purpose of developing and carrying away the produce of this mineral field. This is a question for others, and not for us, to decide; and as we have already given our views on this district, in the 6th volume of the "Transactions of the Institute of Mining Engineers," with discussions thereon, we beg to refer thereto those of our readers who may wish for more information on the subject; and, in conclusion, we beg further to state that the observations we have here made are but an endorsement of what we have there advanced.

The top seam, which is seen to great advantage on both sides of the valley of Rosedale, averaging there from twelve to fifteen feet in thickness, has had more attention paid to it, and has been more thoroughly examined in that locality than in any other we are acquainted with, owing, in all probability, to the circumstance of its having at first been considered identical with the magnetic ore, portions of which it very much resembles. In Northdale (a branch of Rosedale), as we have already remarked, it is twenty feet thick, much of which is of good quality; indeed, we consider this district equal to any in the quality of the stone (Rosedale on the coast excepted), and superior to most other localities where it has yet been examined; but is, in any locality, very variable and capricious, and we feel strongly impressed with the belief that its average yield in iron will fall far short of that of the main seam.

In taking leave for the present of the top seam, we shall, as before intimated, proceed to give our reasons why we designated this deposit the "top seam of the lias formation." This appears to be the more necessary from the fact that there are those who differ with us as to the propriety of the change, whose opinions on this subject should not, we

think, be passed over without some explanation. In the first place, then, we presume we have proof sufficient that it is contemporary with the lias formation. Evidence of this is afforded, we think, by the circumstance that we have found embedded in it fossil remains, identical with those which the lias contains, not only as regards genera and species, but also surrounded by the same material substance, such, for instance, as the ammonite, &c., from which, we think, we may fairly assume that it is a marine deposit. Secondly, it is sometimes met with occupying a place within the lias shale, *i.e.*, resting upon and covered by that rock, as seen at Northdale, near Rosedale Abbey, as well as at Rosedale on the coast, clearly manifesting that the two are contemporary. Then, again, this stratum, with few exceptions, is covered by the great sandstone rock, varying from fifty to a hundred feet thick, the deposition of which, we have reason to suppose, belongs to a geological epoch more recent than the lias period, from the circumstance of its containing the impressions of a variety of land plants, together with coaly partings or beds abounding with vegetable remains, which could only have existed on the earth and grown under the genial influence of solar heat, thus furnishing us with conclusive evidence that it is a terrestrial deposit, and that, during the period of its formation, the ocean had subsided and left our earth in the enjoyment of an interval of repose, during which its sandy surface had been partially covered with a scant vegetation, until, by another convulsive movement, it was again submerged beneath the waters of the deep. The argument we have thus adduced in support of our views with reference to the geological date of the ironstone in question is, we trust, sufficient to convince our readers that we were justified in classing it with the lias period, and that the proper point for drawing

the line of demarcation between the series (lias and oolite) is the one indicated; but we must confess, that by far the greatest inducement we had for making this change was to avoid confusion in mistaking one seam of ironstone for another.

As we promised, in our introductory chapter, again to refer to the subject of the nomenclature of geological science generally, and the remarks we have just made have some reference thereto, we do not know that we can do better than insert here what we have got to say on that head, which, we must be permitted to observe, we do with considerable diffidence; and we trust that the great need of an improvement, in this respect, will be admitted as in some measure a defence against the charge of presumption or vanity, which, we are afraid, our hardihood in this instance will lay us open to, especially when we state that we feel it incumbent upon us to divide and add fresh names to a portion of the oolitic series, which come next under our consideration, in order that the several deposits belonging to them may be clearly and comprehensively understood, and more readily and distinctly recognised, by those who are not already acquainted with them.

Why a science so attractively interesting and instructive as Geology has become, should continue to be cumbered with a vocabulary which is generally felt to be incongruously made up, as it is, of so many unmeaning words and inappropriate terms, the derivation of which would puzzle the most competent lexicographer, is beyond our comprehension; and we know we are only expressing what is very generally acknowledged to be true, when we state that nothing is more called for than an improved vocabulary of geological terms or names. We know of no greater boon that any one of the talented *savans* of the science

could give to the reading and thinking part of the community, than a work that would supply this great desideratum, and we hope the hint here given may find an echo in the proper quarter.

One great object we have in view in publishing the present Treatise, is to make it practically useful to the district it professes to delineate and particularise; and in seeking to attain this desirable object, the mistaken notions which at present prevail with reference to the various deposits of ironstone which exist in the lias rocks of North Yorkshire, stood much in our way. Until a very recent period, it was only known to a very few that the richest portions of those ironstones were found in the oolitic rocks, though not in quantities sufficient to compete with the lias seams; but whenever an ironstone deposit was met with, it was invariably classed with the latter deposit. This, we need not say, frequently led to the most erroneous conclusions, and not unfrequently to most serious mistakes, as to the productive yield and value of the minerals, and much expense was very frequently incurred in developing them, before the mistake was discovered.

The publication of Mr. Marley's paper, the few brief remarks which it called forth from us on the ore and ironstone of Rosedale Abbey, and the discussions which followed thereon, did much to enlighten the public mind on this subject, but, notwithstanding this, the geological positions of the different ironstone deposits are yet but imperfectly known and understood, and it is in order to render them more clear and intelligible in this respect that we now venture to introduce a local nomenclature, applicable to the district under consideration, which has of late become of such vast importance in a commercial point of view. With this aim before us we propose to designate the sand-

stone found immediately overlying the top seam the "great sandstone rock," and the blue grey shale resting upon it, which contains the first ironstone deposit found above the lias, the "lower oolitic ironstone strata," and the strata between these and the flagstone rock above them, which is identical with the Kalloway rocks, the "carboniferous series," and the next ironstone deposit, which is still higher in the series, being found in the light grey shale, corresponding with the Oxford clay, the "higher oolitic ironstone strata." These are the extent of all the terms we propose to make, which, we feel confident, will be a great improvement; and whilst we can hardly expect that they will meet with universal approval, we trust they will secure the approbation of a large portion of our readers, as they have already done that of many of our friends.

OOLITIC SERIES.

No. 1, *or Great Sandstone Rock, marked No.* 7 *in section* 1.—Leaving the lias formation, we have next brought before us the oolitic rocks, still belonging to and forming a part of the secondary period, the first member of which is the great sandstone. This rock is seen covering the lias and capping most of the highest ridges throughout the whole district north of Whitby, and resting upon the top seam of ironstone, as has already been stated. Its thickness is very variable, but, generally speaking, it runs from about forty to a hundred feet, and the only instance that has yet come to our knowledge of its being entirely wanting, occurs in the cliff south of Whitby, where its substitute is found to be a rock of sandy shale, composed, in all probability, of the *detritus* of the shale and sandstone. It is this rock that has chiefly supplied the stone for building the magnifi-

cent and rarely equalled pier at Whitby, as well as furnished the London and other markets of the south with excellent building stone ; Covent Garden Market, we are told, having been built with it, as well as numerous other public works. Quarry workings have been carried on in this rock, we understand, for upwards of a century, which have been much extended within the last twenty years by the Whitby Stone Company. A better example of its durability, we think, cannot be afforded, than is furnished us by the ruins of Whitby Abbey, where, after so many centuries exposure, on a high and rocky cliff overlooking the sea, the sharp edges of the carved stonework, unless damaged by accident, are quite distinct and in a good state of preservation. Though there is so prodigious a quantity of this sandstone, it is much infected with coaly partings, rents, and fissures, and, in many places too, contains large patches of shale, which very much detract from its value, and, from these causes, good sound blocks of large dimensions are not readily obtained in large quantities from it. As to quality, too, the beauty of its external appearance is much deteriorated by small iron particles found interspersed throughout considerable portions of it. The coaly partings, and large patches of shale too, mentioned above, met with in working this stone, add very much to the expense ; indeed, altogether, it is by no means so valuable as might be supposed, judging from the massive quantities in which it is found. It contains the impressions of a variety of land plants, for a description of which we beg to refer our readers to Professor Phillips' geological work on Yorkshire.

LOWER OOLITIC IRONSTONE STRATA.

We have again brought under our consideration another

deposit of ironstone, which is the first met with, according to our classification, in the oolitic series (see No. 8 and 9, section 1) and these we have named the lower oolitic ironstone strata.

Grey Shale.—There is found resting upon the sandstone rock we last described a deposit of grey shale, from twenty to thirty feet thick, the lower portions of which are generally very coarse and arenaceous, and very frequently contain layers of ferruginous nodules of no commercial value, whilst there is met with, in the upper portion of it, a band of ironstone (No 10, section No. 1) of very superior quality, averaging from one to one foot six inches in thickness, and we have been told of an instance where it is met with over two feet thick. This band is also frequently accompanied by rich nodules, interspersed in the subjacent shale. This ironstone, like so many more found in the strata belonging to the oolitic rocks, is very irregularly diffused, and, in many localities, is entirely wanting. It is seen in Goathland skirting the hill side along "Allan Tofts," and descending into the deep ravine between Beckhole and "Danholme," where, at a place called "Wark Brig," it is seen to advantage, and from which we took our section. Nowhere, however, have we seen it look more promising, in the neighbourhood of Grosmont, than in Stonegate Gill, a deep and rugged gully, situate between the town of Egton and the village of Lealholme Bridge, the beck which runs through it forming one of the tributaries of the Esk, which it joins between Glazedale End and Lealholme Bridge. We have never, however, met with this ironstone in any locality in quantity sufficient to hold out the least prospect of its being profitably worked. A persevering attempt to work it, we have been informed, was made a few years ago at Ingleby Greenhow, but was ultimately abandoned as impracticable, though it is so rich in quality there as to contain upwards of 40 per

cent. of iron. Notwithstanding the great and striking difference between this ironstone and that found in the lias, it has yet not unfrequently been mistaken for it by strangers. It is never seen in any part of the hills or cliffs, that we know of, to the north of Whitby, unless, indeed, the measures containing it be immediately adjoining the harbour to the north, where the grey shale may be observed, bereft, however, as far as can be seen, of the ironstone, and, with this exception, it never shows itself along the coast, neither has it yet been met with in the neighbourhood of Guisbro'. In going over a portion of the Skelton Estate, in company with a gentleman well acquainted with the geology of the district, we had reason to suppose that its place was occupied there by a nodular band of stone, composed chiefly of silex, which we found in abundance on the slope of the hills, on the surface, exactly in the situation where this ironstone ought to have appeared.

It may, perhaps, be worth mentioning here, that this ironstone, for that period, seems to have been somewhat extensively worked in ages long gone by, in all probability during the Roman sway, as appears from the heaps of scoria that may yet be met with in many parts of the district, and in the immediate vicinity of this ironstone, from which we may fairly assume that it was from this deposit they obtained their supply of ore for ironmaking. As we shall, however, have occasion to refer to this subject again, in the second part of our work, we shall reserve what we have further to say on it for that portion of our Treatise. This band of ironstone, with the nodules which accompany it, as seen in section No. 1, must be considered as an exaggerated representation, not being exactly in accordance with the scale. The importance of the ironstone measures, we hope, will justify us in giving a little more prominence to them.

The Second Sandstone Rock.—The ironstone strata which

we have just described are succeeded by another rock of sandstone (section 1, No. 11), which, like that before noticed, is also very irregularly deposited throughout the series, varying from a few feet to from twenty to thirty in thickness. This sandstone, when sound, is of fine quality, and has been partially worked by the Whitby Stone Company at Allan Tofts, in Goathland, but its geological position in the series being so much higher than that of No. 7, section 1, it is generally not so accessible, in consequence of which it cannot be so cheaply conveyed to the railway in this neighbourhood as the sandstone obtained from the rock we first noticed. The uncertainty, too, of its maintaining its thickness for any distance causes it to be almost entirely neglected by the quarry workers. It is best developed at Allan Tofts and Water Arc, in Goathland, and also in Stonegate Gill before mentioned.

Immediately above this sandstone another deposit of ironstone is occasionally met with, (section 1, No. 12) which is still more irregularly distributed than the one last described, so much so, indeed, that were it not that it is indicated by stray nodules, containing the same fossil impressions, and occupying the same geological position, in other districts, it might with propriety, we think, be termed a local deposit. It consists of flattened nodules, chiefly of a large size, the thickness of which varies from a few inches to upwards of two feet. Sometimes it is found of good quality, but more frequently coarse and silicious, and ever and anon alternating with the sandstone, in the midst of which it is found. This ironstone is easily distinguished from the oolitic first named, not only by its inferior quality, but also by the difference of the impressions of organic remains they contain, for whilst the former abounds in small marine shells, the latter contains vegetable

impressions, which much resemble the cane or reed. This ironstone is seen to the greatest advantage at Danholme,* and, again, between there and Goathland Mill. It is almost unnecessary for us to observe, that this ironstone, too, has never yet been found in quantity sufficient to allow it to be worked with profit. There is found intervening the ironstone just described, and a deposit of blue grey shale found above it, a thin bed of very finely laminated sandstone, occasionally mixed with shale, about two feet six inches in thickness. The bed of blue grey shale which rests upon it is from nine to twelve feet thick, (section 1, Nos. 12 and 13) in which are found layers of coarse nodular ironstone, and also strong traces of fire clay, and on the top of which is seen about two feet of very dark blue shale, a portion of which is mixed with coal, which may be considered as indicating the position of the lowest coal seam (section 1, No. 15) worked in our moorland district; seen also by the side of the stream between Danholme and Goathland Mill.

We may now be considered as having reached what we think may be designated, very properly, the carboniferous series of the moorland district of North Yorkshire; in entering upon which, our description must be regarded as entirely applying to that portion of it from which our section is taken, though sections of the same will be furnished from other localities, in the second part of this work, from which, while it will be seen that there is a considerable difference in the united thickness of these strata generally, as may very readily be conceived from the variableness of

* A name given to a group of houses romantically situated on a piece of flat land at the bottom of a deep ravine, at the confluence of two mountain streams, and so completely secluded by the bold and rocky precipices overhanging it on every side, that when you once reach it, all ingress to, or egress from it, appear next to impossible. The rural and picturesque beauty of this lovely spot is not more pleasing than the kindness and hospitality of its worthy and unsophisticated inhabitants.

those we have already described, as well as some little local difference in detail, yet it will readily be recognised that the general character of the strata is identical.

Carboniferous Series.—The rocks composing, and found associated with, the coal-bearing strata in the district above mentioned, comprise that portion of section 1, which extends from No. 15 to 29, both inclusive, consisting of sandstone and shale, with a few layers of thin ironstone nodules interspersed here and there in the shales, the united thickness of the whole being about one hundred feet. The strata found intervening the first and second coal seams, viz., Nos. 15 and 20, consist of sandstone, blue and grey shale, Nos. 16, 17, 18, and 19, in section 1. In the higher portions of the shale joining the coal seam is found a thin layer of ironstone nodules of very superior quality, but in very small quantity.

Coal Seam No. 2.—The next, (section 1, No. 20), which is the only workable one in this district, is thicker here (near Goathland Mill) than in any other locality where we have yet seen it, being from eighteen to twenty inches, much of which, however, is of very inferior quality. In years gone by, this coal was somewhat extensively worked here, and the chief supply for domestic purposes, as also for the purpose of lime burning, was obtained from it; but railways having supplied this and other districts with cheaper coal and lime than could be thus obtained, these workings have long since been abandoned.

The Third Sandstone Rock.—The coal seam (No. 20, section 1) is overlaid by the third sandstone rock (section 1, Nos. 21 and 22), which, in fact, forms the roof of the old coal workings. The thickness of this sandstone at Goathland Mill is about thirty feet, some twenty of the lower portion of which is good sound stone, but the remainder is

of a slaty, unsound character, divided by beds of sandy shale. This rock is again covered by alternating strata, consisting of thin beds of sandstone and shale, with a seam of coal a few inches thick. The strata are indicated in No. 1 section, from Nos. 23 to 27, both inclusive. No. 23 represents the position of the third coal seam, though here there is little more than a tracing of it to be seen. No. 26 is a bed of fire clay, of inferior quality, about two feet six inches in thickness, and the rest are thin beds of shale and sandstone.

What we may term the *Fourth Sandstone Rock*, belonging to the carboniferous series (section 1, No. 28), rests upon the strata last noticed. This, however, is much more shaken and unsound than any of the others previously described, and is divided by a stratum of grey shale, from four to five feet thick, a part of which is of good quality. About five feet of the upper portion of this rock, which rests upon the shale just mentioned, evidently contains a good deal of lime ; we have, therefore, distinguished it as calcareous sandstone, and this brings us to the conclusion of what we have termed the carboniferous series.

We may just mention, in taking leave of these strata, that although there are, almost invariably, indications of three seams of coal in the series, we have never seen more than one of them of workable thickness in the same locality, the average thickness of which seldom exceeds from twelve to eighteen inches, but is even very frequently below twelve inches ; whilst the other two are little more than mere tracings of seams a few inches thick. We may just mention, that what we have here stated as the result of our own personal examination, with reference to these coal seams, has been fully corroborated and confirmed by some of the oldest coal miners in the district. This coal (No. 20)

has been worked at Maybecks, Goathland, Stonegate, Lealholm, Danby, Fryup, Blueworth, and Northdale, in Rosedale, &c., and it still continues to be worked at Danby, Fryup, and Northdale.

It is a singular coincidence, and one, we think, worth mentioning, that we have in this inferior coal district, especially in the western portion of it, a type of the great coal-field of Durham and Northumberland, and the strata immediately associated with it; *e.g.*, the coal-bearing strata of our moorlands are overlaid by limestone and *red* sandstone in the district to the west of Rosedale, which very singularly correspond, as regards substance and colour, with the new red sandstone and magnesian limestone that overlie the coal measures in the county of Durham.

The whole of the strata which we have described above the lias formation, the united thickness of which measured, as accurately as the nature of the ground would admit of, is about three hundred feet, as represented in section No. 1, are seen occupying the sea cliffs and hills forming the coast north of Scarbro' and south of Whitby, where, however, they swell out to a much greater thickness than in that part of the interior of the country from which our section is taken; but to the north of the latter place, with the exception of the lower portions of them, they are seen to retire from the coast, forming the heath-covered escarpments of the higher ground of our moorland districts, and occasionally skirting the valleys of the mountain ranges. The whole series, however, varies very much in thickness, and, as we have more than once before observed, is very irregularly distributed, much of the intermediate strata found in one locality being entirely absent in another.

The carbonaceous strata are covered by rocks of limestone, sandstone, and shale, and comprise the remaining

portion of the group which forms the subject of the first part of our Treatise, the first member of which consists of a bed of inferior limestone.

This stratum (section 1, No. 29) is found immediately above the sandstone we last noticed. In Brocklebeck, in Goathland, it is found about twelve feet thick, much of which, however, can hardly be termed limestone, and yet we have no other suitable term to apply to it. It is also met with in Larpool Woods, near Whitby, on the north-west of the great dislocation there, as well as in many other localities. It varies very much in its thickness, occasionally alternating with the sandstone and shale, and in some places, we have been told, it presents itself as a coarse, inferior calcareous ironstone. It is, perhaps, seen to the greatest advantage in the deep and rocky ravine which takes its rise on the high moorland near the inn at Saltersgate, and communicates with Newtondale, where it is seen about twelve feet thick, forming a portion of the bold and rugged cliffs of that wild and romantic valley. In many localities where it is met with it contains a vast quantity of fossil shells. We may mention, too, that we have occasionally seen a nodular bed of ironstone resting upon it, but as it is so seldom met with, and is of no value or geological importance, we have neither noticed it nor several others of a like description in our No. 1 section.

The inferior limestone is overlaid by ten or twelve feet of blue shale in the locality from which our section is taken (No. 30), but, with the exception of the ironstone nodules before mentioned, found occasionally at the bottom of it, it contains nothing worth noticing.

There are few who have rambled over the heathery heights of the higher portions of our moorlands but will have observed occasionally large quantities of a hard, coarse

description of sandstone, scattered about in detached blocks, or heaped together in large masses, their blanched surfaces assuming a light grey colour from the exposure of ages. This rock is found resting upon the blue shale and limestone we last described: when fully developed, it is from forty to fifty feet thick, and when broken presents a hard, gritty fracture, from which circumstance we have designated it the moor grit. (See section 1, No. 32.) It is commonly known by the name of "white flint." It occupies most of the higher portions of the moorland; and to the unyielding nature of this material—which is completely impervious to the action of the atmosphere and the vicissitudes of the seasons—we think, may be attributed that sterility which so much characterises the soils of those wastes, and gives to the whole of our moors that bleak and forbidding aspect which they present. This rock, too, like so many of those we have previously described, is frequently seen to gradually change its character, alternating with the shales and sandstones. In some localities, blocks of considerable size might be obtained from this rock; but from its hard and refractory character, it is of no commercial value, and is seldom used, we believe, for any other purpose than that of road-making, for which it affords a very good and durable material. We may just mention that many of the rude Druidical stones, known by the name of "bride stones," met with on the moors of our own neighbourhood, are composed of this stone. This rock is seen to advantage between Goathland Mill and Brocklebeck.

The rock we last described, in Brocklebeck, is overlaid by about sixteen or seventeen feet of shale and sandstone (see section 1, No. 33), and above this, again, is seen a very peculiar kind of stratum (to us a nondescript), only some two or three feet thick (see section 1, No. 34);

which, from its position in the series, we are disposed to think may be a type of that rock which Professor Phillips calls cornbrash, though the absence of organic remains would hardly warrant our holding such an opinion. It appears to be a calcareous substance.

Immediately above the thin bed last mentioned, we are again presented with sandstone, portions of which are separated by beds of shale (section 1, Nos. 35 and 36). This rock, however, differs very much from those we have before described, inasmuch as it assumes the fissile form, or laminated shape, constituting our flagstone rocks. It appears, as nearly as we could ascertain from the nature of the ground when we measured it, to be from twenty to thirty feet thick, including, of course, the partings of shale, and from its geological position it agrees with the Kalloway rocks of Phillips. This rock is seen to much advantage immediately beneath the bridge which crosses Brocklebeck, on the turnpike road running between Whitby and Pickering, where large slabs of it are laid bare by the scouring effects of the stream. Though it is covered with heath immediately to the west of Brocklebeck, it still continues its course along the moor escarpment fronting the vale of Goathland; and on reaching the ravine running down from Saltersgate to Newtondale, it is again met with well developed, beyond which it still continues along the sides of the valley, where excellent sections of it are afforded, till it descends below the level of the plain.

This brings us to what we have designated the "upper oolitic ironstone strata," embracing that portion of the series between Nos. 37 and 42, both inclusive. We have reason to believe that this deposit of ironstone has not hitherto been known to the public—certainly not in the Grosmont and other districts adjoining. It is found near the foot of

a large deposit of light grey shale, which we shall have next to notice; but what its geographical extent may be, we have no means of knowing, as it has never been properly examined, and is buried several feet below the heath-covered surface of our moorland. It is only met with in the bottom of the streams running from the moors into the vale of Goathland, on the south side of that valley; and we obtained specimens of it also, many years ago, on the site of the "Killing pits," to the south of Goathland chapel, which, we believe, are nothing more than the rude remains of mining operations carried on in this deposit, in that bleak and barren region, in ages long gone by. We shall again have occasion to refer to those singular and interesting remains of antiquity in another part of our work. The deposit consists of a band of ironstone from a foot to fifteen inches in thickness, at its outcrop in the bottom of the stream (in all probability, it may be much thicker under a great weight of superincumbent strata), and a layer of nodules, which, also at the outcrop, we averaged at nine inches. The band and nodules are separated by about three feet of fine soft shale. This, in our opinion, is by far the richest ironstone our district contains; and although the quantity may appear too small to afford a prospect of working it with profit, yet, from the free and soft nature of the shale coexistent with it, we are by no means sure that this is the case; besides, it may increase in thickness on penetrating further into the hill, and, from its excellent quality, we think it might be used to great advantage as a mixture with our leaner stones. It is never seen in the valley of the Esk, owing to its cropping out to the surface at a considerable distance to the south of it. In fact, we have never met with it (except at the Killing pits before mentioned) on the north side of Goath-

land vale. We have little doubt of its being found at no great distance from the surface, on the moorland south of the Whitby and Pickering turnpike, and to the west of Sillhoe and the east of Saltersgate.

The ironstone strata last described are overlaid by a bed of sandy shale (section 1, No. 45), from ten to thirteen feet in thickness, portions of which are a complete mass of vegetable organic remains, chiefly of the reed species. This rock is a sure guide to the discovery of the upper oolitic ironstone.

The next member in the series which claims our attention is a large and extensive deposit of blue grey shale, from 120 to 150 feet thick, including the upper oolitic ironstone strata, and also the sandy shale we last referred to, and three calcareous bands or beds of stone, Nos. 44, 47, and 49—the other, Nos. 43, 46, 48, and 50, consisting of the shale itself. This rock occupies the whole of the high moorland ground to the south of the Whitby and Pickering turnpike road, commencing at the south of Sillhoe, and terminating on the west of Saltersgate Brow, where it becomes covered with the sandstone (calcareous grit), passing which, it is again seen sweeping round the hill sides of the romantic dell of Hole of Horcum, continuing its course by way of Leavisham, beyond which it gradually descends below the level of the plain. This deposit agrees with the Oxford clay of Phillips, and we have no doubt it continues its course from Saltersgate Brow, in a south-easterly direction, across our moors to Scarbro', where, in the cliff immediately below the Castle, an excellent section of it is obtained, as well as on the coast south of Scarbro', between Filey Bridge and Gristhorpe Bay.

The light grey shale last noticed is covered by a fine

soft yellow sandstone (section 1, No. 51), corresponding with the calcareous grit of Professor Phillips. It is first met with in the district adjacent to Grosmont, at Blakey Topping and Saltersgate Brow, and is also seen resting upon the grey shale, and fringing the hill sides of Hole of Horcum, from whence it passes away by Lockton, Leavisham, &c., until it meets the oolite (coralline) limestone a few miles from Pickering. It is again met with in the neighbourhood of Malton, and a little further on, in the vicinity of Castle Howard and Kirkham, it is seen to advantage. At the latter place an ironstone deposit is found associated with it, which, judging from the specimens we have examined, appears to be a very calcareous product. A recent attempt has been made to work this ironstone, but, we believe, hitherto without success.

Excellent sections of the sandstone under notice are obtained between Filey Bridge and Gristhorpe Bay, on the coast south of Scarbro'. From Castle Hill, on the north side of Scarbro', the escarpment of this rock traverses our moorlands in a north-westerly direction, by way of Sillhoe, Blakey Topping, Saltersgate Brow, Leavisham, Lestingham, &c., and terminates at Black Hamilton, its western boundary. This is a calcareous deposit, and in some localities the stone is so soft that you may almost cut it with a knife, and, in this respect, resembles very much the Caen stone of France. It affords an excellent building material, for, though so soft when first extracted from the quarries, it has the peculiar property of hardening by exposure, and from its unvarying and uniform colour—deep yellow—adds great external beauty to structures built of it. The railway stations at Pickering and Malton, and many private residences in the town of Scarbro', afford good examples in this respect. The lower portions of this

rock very frequently alternate with the Oxford clay, whilst the upper portions are occasionally observed to change with the limestone; and in the valley between Leavisham and Pickering it is difficult to say how, or where, the sandstone terminates and the limestone commences. In Hole of Horcum, where we obtained our section, it appears to be from thirty to forty feet thick.

The deposit we have next to describe viz., the oolitic or coralline limestone (section 1, No. 52) which immediately succeeds the sandstone last mentioned, completes our first section. This rock, in the neighbourhood of Pickering, to which our section particularly refers, is about sixty feet thick, and is first met with in our route at Lockton, about half way between Saltersgate and Pickering, and is afterwards seen edging the sides of the valley between Raindale and Pickering on each side of the railway. The northern escarpment of the coralline oolite, commencing at Scarbro' Castle, traverses, in the first instance, our moorlands, directing its course by way of Silphoe, Lockton, and Cropton, beyond which it descends into the rich and highly cultivated districts of Kirby Moorside and Rivaulx, terminating at Hambleton, on its north-western extremity, from whence it sweeps round to the south-east, and shapes its course towards Wass, Oswald Kirk, Gilling, Malton, Settrington, and, finally, disappears beneath the blue shale, upon which the chalk rocks rest, in the vicinity of Langton Wolds.

This rock is extensively worked at the places above-enumerated, and also in other localities not named. Its predominating color is grey, though it occasionally assumes a light yellow, and patches are met with, though rarely, we understand, of a blue color. When broken, it generally presents a coarse oolitic fracture, and in some districts it is

found to contain a large portion of arenaceous matter, in consequence of which its quality becomes much depreciated. The coralline oolite teems with organic remains in great variety. Professor Phillips enumerates no less than one hundred and twenty species, consisting chiefly of marine shells, amongst which the ammonite predominates. We have been told that this rock is deficient in that important constituent carbonate of lime. It is, however, very extensively used by agriculturists as a fertiliser, and by builders as a cement. Extensive lime-works are established at Pickering from whence Grosmont and the adjacent districts are well supplied.

Having now finished our description and delineation (verbal and sectional) of the groups of rocks which form the subject of the first part of our Treatise, it only remains for us to conclude with a few general remarks.

We have already stated that our first (or No. 1) section can only be applied to the localities from which our measurements were taken. The constant tendency the oolitic strata have to alternate with each other by gradual transition, and the total absence of a group of rocks in one locality, which are seen well developed in another, preclude the possibility, in a geological district so liable to change, of making a general section applicable to any considerable (geographical) extent of surface. It is, therefore, only by personal investigation and continued research that you can become thoroughly acquainted with the geological features and local peculiarities of the Cleveland district. There is, however, always present some characteristic rock, which presents, as it were, a key to the whole, as, for instance, the inferior or blue limestone, seldom if ever absent, which is found intervening between the carboniferous series and the moor grit, Kelloway, or flagstone rocks. Then again,

the position of the lower oolitic ironstone strata between the coal measures and the lias formation is another sure guide in the identification of the subjacent strata.

Though the Speeton clay forms no part of our section, a large portion of it will be found delineated on the map which accompanies this work. We, therefore, think it demands from us, in conclusion, a few brief remarks. The valley containing this aqueous deposit forms a great part of the extensive vale of Pickering. It appears to have been originally an estuary of the ocean, at no very remote period of the history of our earth. There can be little doubt, we think, but that its entrance from the sea was at Filey Bay, from whence it penetrated into the interior of the country for a distance of something like thirty miles, its waters covering a considerable area. Commencing at Filey Brig, and going westward, its northern extremity appears to have been bounded by the coralline oolite, running in the direction of Seamer, Brompton, Pickering, Kirby Moorside, and terminating at Sproxton, its western point. The existence of this extensive deposit of clay is, we think, easily accounted for. Assuming that when the waters of the ocean retired from this portion of the ancient coast, a general rising of the land adjoining the beach would naturally occur, a dam would then be formed, by the accumulation of oceanic *debris* at the mouth of the estuary, which would thus be converted into an inland lake, and, in process of time, would become silted up by the *detritus* conveyed into it by the overflowings of the ocean and the turbulent waters of inland streams, until it was completely filled up to its present level, forming the low, flat, delta land of that district.

SECTION OF
The Strata as seen in the Vales of
Eskdale, Commondale and Kildale,
by
JOSEPH BEWICK, GOSMONT.

Engraved by Edward Weddell from Drawings

PART II.

We commence the second portion of our undertaking with a few introductory observations.

In the first part of this work we minutely described the whole of the consecutive strata of the group of rocks which forms the subject of our Treatise, and we now purpose giving a brief description of the strata, as seen in the valleys of Eskdale, Commondale, and Kildale, more especially, however, with a view to pointing out the true geological position of the ironstone seams throughout this route. In order to make the subject as clear and intelligible as possible, we have, by dint of much time and labour, prepared a large section, exhibiting at one view the entire strata as they are met with in these valleys, and indicating, at the same time, their undulations and dislocations in different localities. We have been more particularly induced to make these valleys the subjects for illustration, from the circumstance that, whilst the coast contour line of the Cleveland iron-field has been most elaborately illustrated by Messrs. Young and Bird, Phillips, and Marley, the interior of the country has been entirely neglected. As we have before remarked, the undertaking has entailed upon us much labour. If we succeed, however, in presenting our readers with a faithful delineation of the strata in the valleys referred to, we shall consider the time and labour

bestowed upon them well spent. The route we have thus laid down will take us through the centre of the Cleveland iron-field, every acre of which may be estimated to contain about 20,000 tons of ironstone. It does not require the prophet's gift to penetrate the mist which envelopes the future, and to foretell what will occur at no distant period We foresee the time when legitimate and successful enterprise will be carried on along the green and sylvan slopes of our beautiful dales, affording adequate employment to thousands and tens of thousands of the children of toil. The time is not far distant when, in all human probability, the sound of ponderous machinery and busy industry will be heard in our vales. We can, indeed, assure our readers that there is nothing visionary in this anticipation of events, which already give signs of their approach: iron-works have been erected and are in operation, and iron of good quality has been produced, and we sincerely trust that every success will crown the efforts of those pioneers, and that a bright future may be in store for them. The fact is, the vale of Esk, from its superior geographical position, must ultimately become one of the chief sites for working and developing the Cleveland iron-field, and the Port of Whitby will doubtless become the chief outlet for the raw and manufactured material. Much, of course, requires to be done before this takes place, but we have no doubt that all that is necessary to attain so desirable an object will ultimately be accomplished.

Before we commence our description of No. 2 section, it appears necessary to inform our readers that in traversing the route we have marked out, we shall find the strata by no means so well defined as on the coast line. A large portion of them will be found covered with alluvial deposits, herbage, brush-wood, &c. We are, however, impressed

with the belief that, notwithstanding this, such a section cannot fail to be of the greatest value to the district generally, embracing as it does some of the most important portions of the iron-field, which are clearly and distinctly indicated on the section in question.

With these few remarks we shall now proceed with our description of No. 2 section, making the Port of Whitby our starting point. First of all, however, we have to notice the strata on the north and south of the port. We have already mentioned, in the first part of our work, that, owing to a dislocation of considerable magnitude, the lias formation is buried far beneath the ocean in and immediately to the north of the harbour. From this circumstance the cliffs are composed of the sandstone and shales belonging to the coal measures, the same which in other localities contain the lower oolitic ironstone deposits, though here they appear to be absent. Very excellent sections of these rocks are afforded us in the deep cutting, leading from the pier to the new town, on the west cliff, in the upper portions of which may be seen, thinly scattered, the coarse ferruginous nodules we noticed in the first part of our work. Little or nothing is seen of the lias formation to the north of the port till Sands End is reached, where it forms the bold and lofty cliffs which there overlook the sea.

On the south side of the mouth of the harbour the upper lias is seen partially developed, with the top seam of ironstone exposed to view, which here, however, is very thin, and a little farther on still it is observed to descend very nearly to the level of the beach in the neighbourhood of Saltwick and Hawsker. Beyond this point, however, they suddenly and rapidly rise again, and before they reach the romantically situated town of Robin Hood's Bay, they attain a high elevation, forming the bold and prominent cliffs in that neighbourhood. Immediately to the north of Bay Town

the ironstone and marlstone series are seen skirting the cliffs till they reach Ness Point, from whence they suddenly sweep round the grassy slopes of Fylingdales. Directing their course inland by way of Bay Church and the Village of Raw, and continuing their course southwards, through the whole of the estate of Robert Berry, Esq., they again approach the coast in the neighbourhood of Stow Brow, continuing their course in a southerly direction till they are exhausted by the upheaval of the great dislocation near Peak. It is proper to observe that nowhere among the green and sloping hills of Fylingdales have the ironstone seams been discovered that we are aware of. The hill sides are completely covered with a green sward, so that the existence of the ironstone deposit is assumed rather than proved. We have, however, little doubt that they do exist, but whether they will be found of a workable thickness, and of good quality, are queries which nothing but an experiment can solve.

The lower lias is well developed in the cliffs immediately adjoining Bay Town, though the inlet or bay is completely denuded of these rocks, and the low, flat lands in the immediate vicinity of the town are covered with rich alluvial soils.

With these few brief remarks on the strata to the north and south of Whitby, we shall next proceed with the consideration of our section, commencing at the harbour's mouth, and describe the rocks as met with—right and left—along the banks of the Esk. Before we proceed we will just mention that the river Esk has its rise some sixteen or seventeen miles to the west of the Port of Whitby, and, after being fed and increased by several small tributary streams, directs its sinuous course through a country of surpassing beauty, consisting of rich and fertile valleys, heathery hills and rocky glens, wooded slopes and mountain ranges, together with rich alluvial plains, all conspiring to lend a

charm to scenery seldom equalled, and nowhere excelled. After many meanderings the river Esk empties itself into the German Ocean at the Port of Whitby.

It is along this stream our section will lead us, beginning, as before stated, at the mouth of the harbour, near the east pier (see No. 2 section), where we have the upper lias partially developed, upon which rests the top seam of ironstone, though here it is very thin indeed compared with other localities. Immediately overlying the top seam is a thick deposit of coarse sandy shale, instead of the great sandstone rock, which here happens to be wanting; a very unusual occurrence, and one which does not again occur throughout our entire route. In all probability the lias was first denuded of the sandstone, the place of which was subsequently occupied by the shale in question, composed, probably, of the *detritus* of the sandstone and shale. The height of the cliff at this point is about 150 feet.

These strata are dipping, at an easy inclination, in a south-westerly direction, in a line running nearly parallel with the harbour for a distance of something like three-quarters of a mile, when apparently a displacement of the whole strata takes place. This is occasioned by the dislocation before referred to, which, we believe, is a down-throw of considerable magnitude, to the north-west. It has been asserted by Phillips, and the opinion is held by others, that this dislocation follows, in its course, the bed of the Esk. With due deference to authority so high, we beg to differ from this opinion, being impressed with the belief that it crosses the harbour in an oblique direction, commencing at or near the battery on the north-west side adjoining the pier, and leaving the harbour on the south-east side, in the vicinity of Spital Bridge, and then, in all probability, directs its course up Spital Bridge Beck. The great magnitude of this

dislocation will be best understood when we state that the blue or inferior limestone, which, in Goathland, is nearly 300 feet above the lias, is found, we have been informed, some twenty feet below the surface in the shaft recently sunk in Whitehall Woods, adjoining Messrs. Turnbull's ship-building yard. The strata in this neighbourhood are very much shaken, and very unsound. A little beyond the shaft just mentioned, the strata, which hitherto have maintained their dip in a south-westerly direction, suddenly change, and are seen rising in that direction, so that on reaching Cock Mill Beck the limestone found in the shaft has reached the surface. About a mile west of this point, in the neighbourhood of Sneaton, the Kelloway rocks are met with. These rocks, from their fissile character, and hard and compact composition, produce flagstones of excellent quality, and of considerable size. This stone was formerly worked somewhat extensively by the Whitby Stone Co. in this neighbourhood, under the management of Mr. John Waddington, but within late years the works have been all but abandoned. These rocks are also met with skirting the base of some of the moor escarpments in Goathland, and are seen to advantage in Brocklebeck, but are still more completely developed in Newtondale.

To the west of Cock Mill Beck the ground changes its character ; instead of bold and lofty cliffs, we have low, green hills, sloping gently from the margin of the river to a considerable distance inland. The hills surrounding the prettily situated village of Ruswarp, on the north of the Esk, are much bolder than those on the south side, but they are all under cultivation. None of the strata are, therefore, visible in this neighbourhood, being completely covered by rich pasturage and productive soil.

It is quite evident, however, that the strata continue to

maintain their rise in a westerly direction, for at the distance of about three-quarters of a mile from this point, a little to the west of the Chain Bridge which spans the Esk, and immediately adjoining the Railway, is seen, edging the sides of the valley, the top seam of ironstone, with the sandstone rock resting upon it. These rocks are here maintaining a westerly rise. Their thickness, however, cannot be ascertained owing to the large quantity of thick brush-wood which covers them. The ground to the westward of this again becomes low on the south-side of the vale, and is covered by thick alluvial deposits of clay, sand, and gravel, rendering entirely invisible the rocks upon which they rest. Extensive denudations of the strata appear to have occurred in this locality, occasioned in all probability by the scouring effects of the waters which at some period of our earth's history, must have flowed in considerable quantities, and with great force, from the high moor land, down the valleys of Little Beck and Iburndale, forming now, as then, one of the tributaries to the Esk.

At the confluence of these two streams, near Sleights Bridge, which crosses the Esk, the marlstone and ironstone series are seen rising rapidly, still in a westerly direction, at a considerable angle, and soon attain an elevation of some hundreds of feet above the level of the plain. The village of Sleights, so pleasantly situated, is built upon this undulation or depression of the strata. At Blue Bank—a designation derived, no doubt, from the colour of the shale—to the south of Sleights village, we have an extraordinary development of the whole series of the lias, marl, and ironstone formation, presenting a thickness of something like five hundred feet from the plain below. At this point (Blue Bank), the whole series to the east and north are completely truncated; the eastern escarpment fronting the vales of

Iburndale and Little Beck, and the northern that of the Esk valley. We have never been able to satisfy ourselves as to whether the rapid undulation of the strata which occurs between Ruswarp and Blue Bank be accompanied by another dislocation or not. In the absence of any decided proof of such an occurrence we are disposed to hold the opinion that such may be the case, and, in all probability, the direction of its course may be north and south, reaching the coast in the neighbourhood of Sands End on the north, (where we see the lias formation suddenly displaced, while between this point and Whitby it is entirely buried beneath the bed of the ocean), and following, in a southerly direction, the valleys of Iburndale and Little Beck. This opinion, we may add, receives strength from some trials that were made in searching for the main seam of ironstone on the north side of the Esk, and to the east of Sleights Bridge; which, however, was never found, and the strata, we were told, was one confused mass of loose shale, and strongly indicated the proximity of a dislocation. We mentioned that the whole of the strata on the south side of the valley were suddenly broken off at the axis of the ridge at Blue Bank; directly opposite, on the north side of the Esk, and at about the same elevation, above the level of the valley, we have an example just the reverse. Here the whole series present the continuity of their stratified form, over the mountain axis, unbroken, the strata exhibiting two dips, one portion being depressed to the west, whilst the other portion inclines to the east. From this peculiar circumstance the sandstone rock which rests upon the lias, and forms the surface covering of this high ground, is again met with in the bottom of the valley in the neighbourhood of Ruswarp, having at the distance of not more, we should think, than a mile and a half in a direct line,

descended from a height of between four and five hundred feet to the level of the plain. The village of Aislaby stands upon this anticlinal axis, and has long been celebrated for its stone quarries, from which has been obtained some of the finest building stone the district of Whitby is capable of producing. We regret to say, however, that those quarries have been almost entirely abandoned for some years past, which is, doubtless, in a great measure to be attributed to the many fresh quarries which railways have caused to be opened out in different parts of the kingdom, creating thereby a fierce and too often a ruinous competition.

The same circumstance which occasioned the sandstone rock to descend to the level of the plain, caused, also, the main seams of ironstone, identical with those of Grosmont and Cleveland, to fall to the level of the valley in the neighbourhood of Sleights Bridge, contiguous to the railway. The seams here are much divided by the intersection of shale, and the stone is very tender. They have been worked to some extent by the Eskdale Ironstone Company, but at present (1859), their workings are suspended.

Returning to our section, after this slight digression, at the point where we left off, viz., Blue Bank, we have first to notice that we are now entering upon that portion of the vale of the Esk known as Eskdaleside. And here we have again to notice the complete change which takes place in the dip and rise of the whole series, which are here depressed, and dip to the west instead of the east, at an easy angle of about 1 in 24. The portion of the valley between Blue Bank and Grosmont affords by far the finest sections of the lias formation to be found between this point and the western boundary of the iron-field, as it is here more fully developed, and presents, therefore, a greater height of

the series to our view than in any other part of the vale. About half-way between Grosmont and Sleights Bridge is the point where the greatest development of the lias takes place. Here we have about 130 feet of the lower lias exposed to view, and the thickness of the marlstone rock which rests upon it is about 100 feet more.

As we before stated, the chief object of our Treatise is not only to give a full description of the rocks in the district, but, more particularly, to point out the situation and true geological position of the ironstone deposits, not only in the route immediately before us, but also in the adjacent valleys, for it is our wish that our work should, in this respect, be a sure guide, and one that can be safely relied upon. We have, therefore, next to notice the geological features of the valley of Iburndale.

This dale, which sends down a tributary brook to join the Esk, near the Sleights Station, about three miles from Whitby, runs in a southerly direction for a distance of between two and three miles. The land at the foot of the valley is low, flat, and uninteresting, but, on ascending the stream, you enter a deep gorge, exposing the bold, dark blue rocks of the lias, which present, on every side, wild, romantic scenery, rendered all the more striking by being backed by the well-known waterfall of Falling Foss, and the brown and purple clad heights of our moorlands. Here we have the sandstone rock, the upper lias, and ironstone strata well developed. The sandstone, which produces blocks of large dimensions, and, we believe, of good quality, is worked somewhat extensively by Mr. Waddington, of Whitby. It is impossible not to see that the time will come when the ironstone in this locality will also be extensively worked. But, at present, while in other districts ironstone is obtained in such enormous quantities, and so

very cheap, there would be no chance of bringing that above referred to into the market at anything like a profit. Having said thus much for the minerals of Iburndale, we must again return to our section.

The ironstone measures are seen skirting the side of the valley, along Eskdaleside, between Blue Bank and Grosmont, dipping, as we before stated, at a slight angle of about 1 in 24, till they sink below the bed of the Esk at the latter place. It is at Grosmont, too, where the railway intersects the ironstone seams, at the distance, as we have already mentioned in the first part of our work, of six miles from the port. Grosmont thus became the most favourable locality for working the ironstone, because of its easy accessibility, and from the facility which the railway afforded for carrying the produce of the mines to the port. The position, too, of the ironstone seams being so favourable for working, rising as they do regularly and gradually in a south-easterly direction, at the angle above-named, caused all the royalties most accessible in this district to be taken. The consequence has, therefore, been, that the whole of the mining undertakings have hitherto been confined to this district, where they have been carried on with much spirit for the last twenty years. The mines at present (1859) in operation are those of the Whitby Stone Company, Mrs. Clark, and the Birtley Iron Company. The annual produce of which has hitherto been something like the following:—

	Tons.
The Whitby Stone Company about ..	30,000
Mrs. Clark	30,000
The Birtley Iron Company	10,000
Total.....	70,000

With the exception of the works before mentioned, near

to Sleights Bridge, the ironstone on the north side of the Esk in the Grosmont district has not yet been disturbed. Perhaps this may be owing to its being, generally speaking, farther removed from the railway, and being more unfavourably situated with regard to its stratification, which is depressed to the north. The fact, too, of the strata being covered and fronted with large masses of alluvial deposits, consisting of clay, sand, gravel, and other river *debris*, must render the winning and working of them much more expensive than that of the ironstone seams on the south side of the valley, which rise very gently from the workings. There can be no doubt, however, of the existence of the seams on the north side of the Esk, and, in all probability, they will be found much the same as those on the south side as regards quantity and quality, and we have no doubt but the time will come when they also will be extensively worked; but, at present, for the reasons already stated, it would be a hazardous undertaking, and, in all probability, result in disappointment, both to the adventurer and the land proprietor.

We have already stated, that nowhere does the upper lias appear to greater advantage than in Eskdaleside, where the dark blue cliffs overlook the plain below. Resting upon the lias, and fringing the hill sides throughout the whole distance between Blue Bank and Grosmont, is seen the top seam of ironstone, averaging from twelve to fifteen feet in thickness, and although there are portions of it tolerably rich in iron, it is, generally speaking, coarse and silicious, and of but little commercial value. From Grosmont it directs its course up Goathland valley, where it (the top seam) is seen cropping out along the edge of the slopes, dipping in a westerly direction until it reaches Beckhole, beyond which it sinks below the level of the

plain. We may mention, however, that the Whitby Iron Company are at present using a small portion of this stone in mixture with the main seam, and are making pig iron of good quality, but we rather think the iron would be much improved if less of this arenaceous material were used. Immediately overlying the top seam of ironstone in this part of the Esk valley, and crowning the heights on both sides of it, is seen the sandstone rock, swollen out to a great thickness, which in some places, as at "Lowther's Crag," is not less than one hundred feet. From its bold and rugged aspect it throws a peculiar grandeur over the whole outline of the scenery of the district, which is so justly celebrated for its picturesque beauty. This sandstone has been extensively worked in the neighbourhood of Grosmont, but within the last few years the quarries, like those at Aislaby, have nearly all been abandoned, the only one at present in operation being that of Mr. John Bolton, which produces beautiful stone of first-rate quality. Many of the quarries in the district have been exhausted, whilst the rock in others takes so much uncovering, from the great thickness of clay and soil resting upon it, as to render the working of them unremunerative. The immense facilities, too, which railways have given to the working of building stone, as we before noticed, in different parts of the country, have created so much competition in this article as to render it, except under very favourable circumstances, scarcely worth working. The extended use, too, of bricks as a building material, since the duty on them was repealed, has very much tended to their substitution for building stone. To these circumstances, perhaps, more than to anything else, may be attributed the great falling off in the working of sandstone quarries in the neighbourhood of Whitby, a district which undoubtedly abounds in good building stone,

which in many situations is easily obtainable, and we have no doubt, when a well-judged encouragement is given, by a reduction of railway charges, and better facilities are afforded for loading, &c., at Whitby, that a revival of the quarry workings will again take place.

Before leaving Grosmont we must step a little out of our way to notice the doings of two companies recently established in the vale of Goathland. We have already briefly noticed one of them, but since these remarks were written the prospects of the company have greatly improved, and, we think, it is but an act of justice to them that we should again advert to their present proceedings.

We would premise, however, that at no great distance from the foot of Goathland valley the ironstone measures disappear below the bed of the stream, so that the ironstone is no longer obtainable in that quarter by open levels. In order, therefore, to the prosecuting of mining operations in this locality, it is necessary to adopt the more expensive process of sinking shafts and erecting steam power for pumping the water and bringing up the produce of the mine.

At Beckhole, about two miles from Grosmont, as we have previously stated, "The Whitby Iron Co.," (Limited), erected two blast furnaces, with all their necessary appendages. For a long time the company were beset with difficulties, which, however, a more enlightened management enabled them to surmount. One of their furnaces has been put into blast, and they are making pig iron of good quality from the ironstone of the district, and their prospects, before so gloomy, are now wearing a more cheering aspect. The other furnace will soon be in operation, when, it is expected, the company will get on prosperously, if the iron trade takes that favourable turn which it is hoped it will do.

Between Beckhole and Grosmont another company has

been formed, and another work is about to be established. Here they have erected a powerful steam engine, and sunk a shaft to the main seams, which they have reached, we understand, at the depth of thirty and thirty-five fathoms. We are told that it is their intention to erect two blast furnaces immediately, with a view of becoming pig iron makers. The success of these two undertakings, the first of the kind in the Whitby district, will, no doubt, be the means of inducing other parties to erect works of a similar description. Thus, the minerals of our district, the working of which has hitherto been so limited for want of demand and harbour accommodation, will be more fully developed, and employment for the working classes will be very greatly increased.

Leaving Grosmont and continuing our journey up the Esk, we find that the whole of the strata assume a nearly horizontal position. This is greatly owing to a turn in the river, which now directs its course very nearly in the water-level line of the strata; the upper lias, in consequence, is seen exhibiting a great thickness for a considerable distance up the valley, (as will be seen by referring to the general section, No. 2), viz., between Grosmont and Glazedale End. The top seam of ironstone is but seldom visible between these two points, owing, in all probability, to its being covered with herbage and brushwood. It, however, shows itself at Snowden Nab, and again in West Arncliff; we have, therefore, not hesitated to show it on the section throughout the whole distance.

It is in the vicinity of Arncliff that that curious enclosure is seen, designated the "Holy Intake," a name which it, no doubt, derives from the numerous pits or holes contained within it. The order and regularity observable in the formation of these excavations is surprising: they are from

eight to ten feet in diameter, formed in regular rows, and have evidently been sunk several feet deep. Dr. Young, in his "History of Whitby," concludes that they have been an ancient British village, but, with every deference to his opinion, we believe, if they were carefully and thoroughly examined, they would turn out to be nothing more than the remains of ironstone mining operations, perhaps of the Romans, or Romanized Britons; for the ground which they occupy is precisely that which may be expected to contain the lower oolitic ironstone beds which would be found at or near the surface, rendering them all the more accessible and easy to work, either by open cast or what is called "bell-pit fashion." The neighbourhood, too, affords abundant evidence that iron-making has been carried on here somewhat extensively for the period we refer to, evinced in the heaps of scoria, which, not many years ago, were to be seen in several places, and a few of which are still to be met with in some few localities. The depth of a great many of these excavations precludes the probability, and, indeed, the possibility, of their ever having been the abode of human beings, but there is nothing singular in these appearances, as like occurrences are to be seen in different parts of the kingdom. The view we have thus taken of this curious inclosure may not, perhaps, be relished by our antiquarian friends, but we believe it to be the correct one, and we shall mention a circumstance which adds strength to the opinion we have here expressed. Many years ago, in one of our geological rambles, we remember meeting, at Egton Grange, which is not far from the "Holy Intake," with what appeared to be the remains of a rude smelting furnace, in the bottom of which we found, mixed amongst the slag, several pieces of charcoal, a convincing proof that charcoal had been the fuel used in

smelting, and we may reasonably infer that the mineral from which the iron was made would be obtained in the immediate vicinity of the smelting operations. We may just notice, further, that in many of the dales adjacent to the route we are now traversing, are to be seen remains of works similar to those we have just described, to particularize which would be too tedious and of little or no interest to the general reader. They, however, clearly demonstrate the fact to us, that the mineral which has of late years added so much to the wealth of the North Riding of Yorkshire, and placed it amongst the first iron-making districts in the kingdom, was not unknown to our forefathers; who, in all probability, were taught the art of iron-making by that enterprising people the Romans, who first conquered and subdued, and afterwards civilized us.

Before taking our leave of these relics of a former age, we venture to mention another occurrence similar to that of "Holy Intake," which, we think, affords us still stronger testimony that these rude and primitive excavations have been made in extracting the minerals. The other work we allude to is situated on the high moorland ground to the south of Goathland Chapel, and known by the name of Killing Pits, derived, it may be, from "kiln" and "pits." These excavations are also very numerous, and formed in parallel rows, something like those at "Holy Intake," though of a much ruder description, neither are they so large, nor have they penetrated to the same depth. They extend for a considerable distance along the brow of a hill covered with heath, the interior of which is composed of grey shale, identical with, we believe, the Oxford clay of Phillips. The upper oolitic ironstone is found near the bottom of this rock, and as we obtained specimens of it on the margin of some of these pits, we may fairly assume

that they were made in extracting this mineral. The date of these workings would, in all probability, carry us back to the Roman period of our history, when this bleak and barren region was the site of busy industry ; and numerous heaps of scoria, before referred to, found in so many localities, prove that iron-manufacture has been carried on extensively, for that remote period, in North Yorkshire.* In concluding our remarks on these old and interesting remains, we may state, that so convinced were we that they were such excavations as we have described, that they led us, several years ago, to search for and ultimately discover the upper oolitic ironstone deposit, and it is a fact we think worth recording, that the people of these regions, whether Romans or Britons, at that early period, have apparently always selected the richest of our minerals for the purpose of iron making.

Between Egton Bridge and Glazedale End a fine section of the great sandstone rock is again afforded us, where, in Arncliff on one side of the river and Limber Hill on the other, it is seen in massive blocks of enormous dimensions. Following the wild and rugged paths which lead through the well-known woods of Arncliff—so famous for "pic-nics" and so widely celebrated for their beauty and picturesque grandeur—you meet with pile after pile of monster blocks of stone huddled together in wild confusion, just as they have fallen from the high cliffs above. This has been caused by the waters of the Esk, at a period long antecedent

* It may be new to many of our readers to mention that the process of smelting and manufacturing iron into a serviceable state by the Romans, at the period adverted to, was extremely simple, though laborious—it was as follows. Into and upon an open hearth, similar to our present blacksmiths' hearth, but much larger, and blown into in the same manner, they heaped a charge of iron ore, charcoal, and lime, and continued to work at the compound unceasingly, adding fuel thereto, and running off the scoria from time to time, until, after a protracted space of time and labour, they brought out of the fire iron in a pure, malleable state, freed also of its carbon, which, by hammering, they converted into weapons of war and agricultural implements.

to the present, undermining the sandstone by wearing and washing away the soft alum shale upon which it rests, the consequence of which has been that avalanche after avalanche has occurred, precipitating large masses of these gigantic blocks into the abyss below. It is extraordinary to behold the wide-spreading oak growing and flourishing out of some of these large blocks, many of which have been rent in twain by the swelling of the roots, throwing a peculiar grandeur over the wild and magnificent scenery which characterize this locality, and which has been transferred to the canvass of artists from almost every part of the kingdom.

About mid-way between Grosmont and Glazedale End, and near Egton Bridge, we have a fine section of the basaltic dyke. It is not so well developed on the south side of the valley—the side which our section represents—as it is on the north side. We have, therefore, ventured to delineate it as seen there. It is well known that this dyke is first met with on the moorland near to Maybecks, not far from the coast. From this point it takes its course in a north-westerly direction across the moors and the vale of Goathland till it reaches Egton Bridge. Here it changes its direction, crossing the Esk at Glazedale End, and continuing along the south of the valley in a course nearly due west. On reaching Commondale it appears to branch a little to the north again, directing its course by way of Kildale, Nunthorpe, Stainton, and Preston, on the Tees, from whence it enters the county of Durham, and terminates at Cockfield Fell, in the coal district. It is not met with at the surface throughout this distance, but is only seen in certain localities. For miles together it has never been met with at all, whilst anon you will find it capping the highest of our moorland, as at Sillhoe to the south of Goathland. There can be no question but

that this dyke is of volcanic origin, for it has in many places completely calcined the subjacent strata in its passage through the crust of the earth. The basalt has been extensively worked in this neighbourhood by the Whitby Stone Company and Mr. John Waddington, and more recently by Messrs. Robert Wise and Company. It is chiefly used for paving stones and macadamizing roads, for which purpose it affords an excellent material. The force with which this molten matter has been ejected from the bowels of the earth appears to have been very unequal. In some places you meet with it a hundred feet beneath the surface, or even more than that, and again you will find it, as we remarked above, covering the surface of our highest ground. Where the greatest force has been exerted you will generally find large quantities of round nodules, differing very much in size at and near the surface, and some of them as round as a cannon ball. These nodules may not improbably have been formed much in the same manner as shot, that is, the molten matter after being thrown with great force high in the air in a state of liquidity, and the resistance it met with causing separation and concretion in descending, it might assume the round nodular shape. On examining these nodules, you will invariably find that they are surrounded by an external coating, much more compact and harder than the core. This, we presume, might be the consequence of the chilling effect of the air on the surface of the nodules. There is another singular circumstance connected with the formation of this dyke. In working the quarries in this rock, the workmen not unfrequently find a *bottom* to it, working the whole mass before them; and after the rock is extracted, a large open space is left, very much like a railway cutting. How this basaltic matter removed the immense quantity of lias rock that

must have been displaced when it was deposited, is most difficult satisfactorily to account for. They not unfrequently, also, in working the quarries, lose the rock entirely. It would thus appear that this volcanic matter has not been upheaved through *one* continuous severance, but may have been forced through rents at some distance from each other.

The main ironstone seams between Grosmont and Glazedale End are buried beneath the level of the Esk; but, owing to the strata assuming a nearly horizontal position, they will be found at no great distance from the surface between these two points—probably not more than from a hundred and forty to a hundred and sixty feet. We have no doubt that the time will come when a fine field of ironstone will be remuneratively worked between these two places.

In the adjacent valley of Glazedale, the ironstone measures are covered by rich productive soil, under excellent cultivation, so that there is no possibility of seeing the main ironstone deposit without sinking to it. The upper lias, however, is well developed throughout this dale, and the top seam, too, is seen to advantage along the sides of this valley, resting upon which is seen also the sandstone rock, again capping the high ridge overlooking the vale.

Leaving Glazedale, and following the windings of the river through rich pastures and fertile soils, for a distance of about two miles, brings us to the romantic hamlet of Lealholm Bridge, pleasantly situated on the grassy slopes by the side of the stream. Between Glazedale End and Lealholm Bridge very little of the strata can be seen. The land adjoining the river becomes low and flat, and the sides of the valley consist of smooth sloping hills, covered with green sward and rich soils. At some distance from the Esk the hills become bolder, and portions of the strata

are here and there exposed to view, from which you at once perceive that a complete change has taken place in their angle of depression, for, instead of being nearly horizontal, like those between Grosmont and Glazedale, they are now seen dipping very rapidly in a north-westerly direction, so that, by the time they reach Lealholm Bridge, the whole of the lias formation is buried below the level of the plain. Owing to this sudden change in the dip of the strata, we find in this neighbourhood the oolitic rocks and the coal measures occupying the hillside immediately above the level of the Esk, and on both sides of the valley. A little beyond Lealholm Bridge you enter one of those deep and rocky ravines so characteristic of this district, known by the name of Crunkley Gill. (See section 2). Here again we have the sandstone rock rising nearly perpendicular on both sides of the Gill, we should say at least one hundred feet thick from the bed of the stream to the top of the cliff. Blocks of an immense size are scattered here and there in the bed of the stream, the waters of which are seen rushing and foaming through them, forming, with the bold and rugged outline of the rocky cliffs, a scene of such grandeur, as, to the lover of nature, is perfectly fascinating.

Beyond this point the strata, instead of continuing to dip in a north-westerly course, are found to be gradually rising in that direction, and by the time they reach Fryup End the top seam is seen skirting the hill sides in that locality. There can, therefore, be no doubt but that the village of Lealholm Bridge is placed in the centre of a geological basin, with the strata rising on one side to the south-east, and on the other side to the north-west; whilst immediately to the south of the village we have the oolitic rocks and the coal measures well developed. About a mile to the south-west of Lealholm Bridge, and upon the high

moorland, at a place called Shaw End, is found a rock of sandstone, in every respect resembling the calcareous grit met with in the neighbourhood of Sattersgate and Pickering. It is very soft, and of a deep yellow colour. Should it turn out to be identical with it, it will be very remarkable, because all the intermediate strata between the coal measures and the calcareous grit are here, to all appearance, absent,—that is, the inferior limestone, the moor grit, the Kelloway rocks, and the Oxford clay. We examined this sandstone very carefully, but the nature of the ground is such as to prevent you from coming to any positive conclusion. We think, however, as far as we are able to judge, that there is a want of conformity between this sandstone and the strata upon which it rests. There is, perhaps, no portion of the dales where the effects of the action of water operating upon the different strata are more visible than in this neighbourhood, especially in the adjoining dales of the Fryups, of which we shall have to speak by-and-bye. In all probability, therefore, this locality was denuded of the strata before-mentioned previous to the deposition of this sandstone. Though so far removed from the railway, and accessible only by roads of the most hilly and painful nature, this rock was somewhat extensively worked, a few years ago, by Mr. John Waddington, of Whitby, who for a time supplied the London markets with it. The expense of leading, however, rendered the abandonment of it inevitable.

We have now arrived at one of the most romantic, and, to the geologist, most interesting portions of the dales,—we allude to the dales of Great and Little Fryup. We know of nothing so well calculated to gratify the geological student as a day's ramble up these dales, where the stupendous effects of nature's handy-work are so manifest, in the

formation of valleys, the laying open and unfolding the various strata, and rendering accessible the valuable mineral products which they contain. Both Great and Little Fryup communicate with the Esk. The former is from two to three miles long, running in a southerly direction into our moorlands. Both of them have evidently been formed by the operation of powerful currents, which, it is easy to imagine, would roll over the mountain heights with irresistible force into the plains below, deepening and enlarging these valleys by wearing down the soft and yielding lias shale, sweeping and carrying everything before them, and depositing the *debris* in the depths of the ocean, there to accumulate, consolidate, and again be formed into another class of rocks.

The vales of the two Fryups are separated by a high mountainous ridge, of a pretty considerable width at the foot of the vales, but they approximate so nearly to each other, at the head of Little Fryup, that a flood in these valleys, at some remote period of the history of our planet, appears to have forced through the barrier which divides them, leaving an immense gap in the ridge in question. This is sufficient to give us some idea of the power and force of these devastating currents.

In Great Fryup we have the upper lias and the ironstone measures fully developed, though the latter, in many places, are covered over with soil and vegetation. Their position, however, is easily ascertained by those who are acquainted with the geological features of the district, in fact, the main seams have been proved by Mr. J. S. Pratt, of Stokesley, and although we have no faith in experiments made by borings, to prove the thickness of ironstone seams in strata like the marlstone, where it is so easy to mistake a stray nodule for a portion of the seam, yet, it has been confi-

dently asserted that the pecten seam is here six feet thick, and the avicula seam four feet four inches thick. They are very accessible, and could be worked by day levels, but they are so unfavourably situated for commanding a market for their produce, that we are afraid they must remain sometime longer undisturbed, unless the making of the Cleveland Railway should be the means of bringing cheap coke into the district, which might induce parties to erect blast furnaces and smelt the stone on the spot.

We have a beautiful section of the top seam in Great Fryup, seen high up in the cliff, protruding from underneath the sandstone, and fringing the side of the valley throughout the whole length of the dale. It averages about twelve feet in thickness, and we do not know that we have seen the quality of this deposit, as met with here, surpassed in any other locality where it exists. Should the main seam of ironstone prove to be as thick as the borings represent it to be, what an enormous quantity of this valuable mineral must be contained in the lands adjoining these dales.

Immediately overlying the top seam we have, as usual, the sandstone rock, and above this again, sloping down the side of the valley, are to be seen the shales and sandstones belonging to the coal measures. The coal has been worked in this locality for many years past.

Although in describing the strata between Fryup-end and Danbydale we shall be doing little more than repeating what we have already stated with reference to Fryupdale, the rocks we have to deal with being in every respect the same; yet, as we pledged ourselves to point out the position of the main ironstone seams wherever they are met with at or near the surface, we feel ourselves compelled to proceed with our description. Though we must acknow-

ledge that in doing so we incur some risk of becoming too monotonous for the generality of our readers. We shall, however, be as brief as is consistent with a true delineation of the rocks in question.

Leaving Fryup, and continuing our route up Esk valley, it is observable that the strata once more assume a nearly horizontal position, and, proceeding onward a little further, we again perceive that the dip is entirely changed, the whole series inclining to the west, and, on arriving at Danbydale, the sandstone, which crowns the heights of Danby Crag and Ainthorpe, is found to have descended into the plains beneath. (See section 2). Between Fryup and Danbydale a great thickness of the upper lias is visible, whilst the ironstone measures are covered and fronted with masses of clayey soil and brushwood, so that they are here completely hidden. We may mention, however, that we believe the main ironstone seams between Fryup and Ainthorpe will be found very nearly on a level with the bottom of the valley. The top seam is but very indifferently developed between the two places above referred to, and, as far as we have been able to judge, it appears to thin off very much.

Before proceeding further up the Esk, the adjacent valley of Danbydale demands of us some notice. Although there can be no doubt of the existence of the ironstone seams in this vale also, yet, from the circumstance of their being completely covered with sward and soil, it is impossible to speak as to their thickness and quality ; even the upper lias is but seldom visible here, especially on the west side of it. On the east side the top seam is seen edging the side of the valley, and on approaching the dale head it becomes more fully developed. The lias rock is also occasionally

visible, and, it is scarcely necessary to observe, that the sandstone, which is never absent in these dales, covers the surface on both sides of the vale.

There are none of the dales that can at all be compared with Danby for beautiful scenery and extensive tracts of fine land, composed of rich alluvial soils, which are very fertile and productive. Most of the farmers are freeholders, and the land, generally speaking, is in a high state of cultivation, in fact the agriculture of this locality will contrast favourably with that of any of the surrounding districts.

Leaving Danbydale we proceed onward to the town of Castleton, but here again we are prevented seeing any portion of the strata composing the hill upon which the town stands. From the river up to the town is one green grassy slope, and there is no chance whatever of seeing what the rocks beneath consist of without breaking the surface. We regret this all the more, for we are impressed with the belief that there is an extensive dislocation in the immediate neighbourhood, which we should like much to have made out.

The North Yorkshire and Cleveland Railway is now nearly completed to Castleton, and we understand that there is every prospect of its being continued to Grosmont by the North Eastern Railway Company. The completion of it cannot fail to be of the greatest advantage to the people of the dales through which it passes, not only in furnishing them with an abundance of cheap fuel, and an easy access to market towns, from which they are in a manner shut out, but also, in all probability, developing the immense mineral resources of the surrounding districts.

Leaving Castleton and proceeding westward, you at once observe that all trace of the lias formation, and the sandstone which overlies it, has disappeared, having evidently been thrown down far beneath the bottom of the valley,

whilst the oolitic rocks are seen cropping out by the side of the hill immediately adjoining the west of the town. In the side of the hill, on the brow of which stands Hoe Farm, at the foot of Danbydale, a considerable thickness of the upper lias is visible. The distance between this point and the west end of Castleton is only short, and although the strata are dipping in that direction, we are yet fully persuaded that the lias and sandstone could not have descended so low in the series, within so short a distance, unless they had been displaced by some extensive dislocation. The whole series in this immediate locality strongly indicate the existence of a dislocation of considerable magnitude. The rocks, which are much shaken and very unsound in the valley adjoining the terminus of the railway, and also near to the confluence of the two streams of Westerdale and Commondale, are seen resting upon their edges. They are very much contorted and disturbed in every direction. We made a careful examination of the surrounding neighbourhood, with a view to discover this fault, but without eliciting anything very satisfactory. The fact is, the hills and dales here are all covered either with vegetation or brushwood, which renders a successful examination next to impossible. We remember, on one of our geological excursions, paying a visit to the village of Westerdale, where we observed the strata very much twisted and disturbed. There were, also, several pieces of ironstone scattered about in different directions, chiefly belonging to the thin beds found between the pecten and avicula seams, indicating the disturbed condition of the strata in this neighbourhood, which, in all probability, directs its course in a south-westerly and north-easterly direction. We were induced to extend our rambles for some distance up one of the dales southwards, where we found the whole series regularly stratified again, and

very nearly in a horizontal position. Before we returned we discovered the outcrop of the two principal seams, but so much corroded as to render it impossible to give an opinion as to the thickness and quality of the stone.

We may just mention, before taking our leave of this portion of the valley, that as the basaltic dyke is observed to traverse the district, it is a question with us whether or not it may be a disturbing element in this locality. After a strict investigation on the spot we were unable to determine this to our own satisfaction. Whether this may be so or not, we are quite convinced that the sudden disappearence of so great a thickness of strata can only be accounted for by supposing that it must have been broken and disjointed by some internal eruption. We hope, however, that a further investigation, which we purpose making, may be the means of throwing more light on the subject, and ultimately enable us to unfold the mystery.

On entering Commondale, the heather-clad hills rise to a considerable height on both sides of the vale. This valley is traversed by the railway, in the cuttings of which are to be seen the coal measures, still in the same dislocated and disturbed condition described in the preceding pages. The rocks are either resting on their edges or lying at an angle of 30 or 40 degrees with the horizon. Although the sides of the valleys in many places are covered with vegetation, and their summits clad with heath, we are still enabled to recognise the different rocks of which they are composed. They consist of the upper sandstone and shales connected with the coal measures, above which are seen the inferior limestone, which, we have been informed, has been wrought to some extent in this district. On the surface of the high ground may be seen scattered about, or huddled together in heaps, the hard grey rocks of the moor grit. The vale of

Commondale runs in a northerly direction for a distance of between two and three miles. The sides and summits of the hills forming it are composed of the rocks above described. On referring to section No. 2, it will be seen that we have there exhibited the strata as if bereft of all vegetation, whilst a large portion of it is covered with a green sward. This we made no hesitation in doing, after we had satisfied ourselves as to the identity of the rocks composing these hills, all of which are so well known to us. The geological features of Commondale being much the same throughout the valley, there is nothing beyond what we have already stated that requires any further notice from us, for to describe these rocks again, after so minutely treating them in the first part of our Treatise, would only be a waste of time, as well as tedious and uninteresting to our readers. We may mention, in conclusion, that a very valuable deposit of fire-clay, of great thickness, has, it is asserted, been recently discovered in this locality, which is said to be of most excellent quality. A Joint Stock Company (Limited) has been formed to work and manufacture it into a variety of useful articles, and the works, we are told, are to be carried on upon a large scale.

At the head of Commondale the valley suddenly sweeps round from north to west, which takes us into the vale of Kempswithen. This deep glen, which owes its origin to the occasional violence of mountain streams, is excavated through a large tract of high moorland ; its slopes can only boast of a scant vegetation, whilst the surface of its high ridges is thickly studded with the purple heath, through which protrudes rough and rugged blocks of sandstone. In this still and secluded valley you might well suppose you were "out of humanity's reach," were it not that you see before you the railway twisting its serpent-like form round the

projecting portions of the hills by the side of the stream. The hissing, puffing, and rapid motion of the wonder-working locomotive along this dell, at once tell you that industry and enterprise have reached this bleak and desolate region. These large tracts of moor waste do little more than afford shelter and sustenance to the wild moor fowl, which, in your moorland rambles, is ever rising before you, uttering his well-known note, and with rapid flight gracefully skimming the surface of the heathery heights, whilst their rocky interior teems with minerals more valuable than gold.

The strata in the vale of Kempswithen are not in that shattered and disturbed condition which is so characteristic of that of Commondale. They maintain great regularity in their stratification, and are rising at an easy angle in a westerly direction. As you proceed up the valley you see first one rock of sandstone and then another rising gradually along the side of the hill until they reach the surface, when on arriving at Kildale the upper lias peeps out from beneath the sandstone at the bottom of the plain. Before we proceed further we must return to a deposit, which comes within our description, but which appears for a time to have been overlooked.

We have taken no notice of the lower oolitic ironstone deposit since we left Arncliff. It was not, however, because we thought it absent in the districts we have last delineated, but in consequence of its being concealed from view by a thick covering of alluvial or surface soil, which prevented our examining it and speaking with confidence as to its quantity and quality. We have no doubt, however, but that these rich bands and nodules of ironstone will be found occupying their proper geological position, *i.e.*, intervening between the great sandstone rock (overlying the lias) and the coal measures, but as to their thickness and quality we know nothing.

In our No. 2 section, illustrative of the strata on the south or right side of the valleys we have traversed, we have taken little or no notice of the rocks on the north or left side of them. We may just state, however, for the information of our readers, that we do not suppose that there will be any difference in this respect, beyond the fact that the ironstone seams are not so favourably situated for working on the north (as we before stated), as those on the south side. They are, also, more liable to be banked up and fronted by large accumulations of *debris*.

On entering the vale of Kildale a great and pleasing change is at once observable. Sterility, so characteristic of our moorland, gives place to rich green pastures and productive soils, and the shelter afforded by the surrounding high and lofty hills adds much to the fertility of the district.

Commencing at the low end of Kildale, we have the great sandstone rock skirting the side of the valley in blocks of huge dimensions, whose rough and rugged aspect gives an air of grandeur to the whole scene. They continue to rise gradually to the westward, rising higher and higher in the series until they crown the summit of the bold escarpment overlooking the Cleveland plains.

The top seam of ironstone, which to the west of Fryup gradually diminishes in thickness, seems, throughout the vale of Kildale, to be entirely wanting. We made a long and strict search in different parts of the valley, but without discovering the least trace of it, with the exception of a few small nodules which occupy its place. We have, therefore, left it out of this portion of our section. It would thus appear that, as this deposit approaches the north-western boundary of the iron-field, it becomes much attenuated, and on reaching it has only a typical existence.

The upper lias at the entrance of the vale is seen emerging from the level of the plain, and rapidly swells as

it directs its course westward, and soon attains its full thickness. This dark blue rock is seen lining the valley for a considerable distance, and ultimately forms a prominent object in the western front of the great mountain chain.

The jet rock, upon which the upper lias rests, contains, we understand, in this locality, vast quantities of this valuable mineral, and jet workings have been carried on very extensively along the north side of the valley.

Before we proceed with our description of the ironstone seams in Kildale, it is necessary to state that they are not visible on the south side of the valley, being buried beneath the surface soil. They are, however, seen on the north side, where trials have been made in them in several places. This being the case, we considered ourselves justified, as there can be no doubt of their existence, in delineating them on our section. In the first part of our work we referred to the experiments made by John Bell, Esq., in the Kildale estate, but since then we have made a further examination of the district, the result of which we now purpose to lay before our readers. There can be no doubt but Mr. Bell was perfectly justified in relinquishing this royalty when he had the refusal of that of Skelton. There is no comparison whatever between the two. In the Skelton estate the main seam is fifteen feet thick without the dogger; at Kildale it is divided into two seams by the intervention of a *stratum* of shale. The top bed of this deposit, according to the section given me by Mr. Bell, is five feet thick, separated by a parting of shale of one foot ten inches. The bottom bed is three feet six inches thick, divided into three strata, the lower stratum being two feet eight inches in thickness, with five feet three inches of shale between. Mr. Bell considers, also, that the quality of the stone at Skelton is superior to that of Kildale. Be that,

however, as it may, when we consider the immense difference in the quantity of stone produced in each royalty, and possessing at the same time greater railway facilities, and a much shorter run to the Tees, it does not require one moment's consideration as to which royalty Mr. Bell would make choice of. Notwithstanding this, however, it by no means follows that the ironstone seams at Kildale cannot be worked remuneratively, as they are very favourably situated for such a purpose, rising at a slight angle to the west. We certainly did not make a close examination of them, our object being simply to prove their existence and to describe their geological position, but it did appear to us that a large quantity of the stone might be worked by day levels.

After what we stated in the first part of our work in reference hereto, we thought it only right that we should make the foregoing observations. We have no interest, directly or indirectly, in doing so, and the parties concerned in the development of these minerals are perfect strangers to us,—our only object being that a true account of them should be laid before the public. We shall certainly not be surprised to hear of blast furnaces being erected in this locality before any very lengthened period passes over, seeing the facilities which the railway affords for the obtainment of coal, coke, and lime, for smelting purposes.

We shall conclude our description of No. 2 section by making a few remarks on alluvial deposits, or what is now better known as "drift," and on the geological peculiarities which characterise the strata we have delineated.

Alluvial deposits, or ocean and river drift, consist of clay, sand, gravel, and other *debris*. They cover the plains and produce the rich soil of the low, flat delta land by the side of our rivers, designated by farmers "holme land."

The sides of our valleys, too, in many places are fronted and banked up to a considerable height by these heterogeneous accumulations. When carefully cut into they are frequently found to consist of regular strata, and the currents which have produced them, it has been ascertained, have moved in different courses at different periods. Much of this *debris* consists of foreign material, and must have been brought a considerable distance from the place where it is deposited. We ourselves have found amongst it, by the side of the Esk, excellent specimens of what we considered the red granite of Devonshire. Hence, the current that transported it hither must have flowed in a north-easterly direction. On another occasion, whilst we were sinking a shaft through one of these gravel beds the workmen dug up the antlers of a reindeer. We were sent for, and hastened to the spot, and had them, with some other bones, carefully removed, when, to our astonishment, we found that the ends of the antlers had been *sawn* off. They were found between seven and eight feet from the surface, and the pit they were discovered in is a considerable distance from the river Esk. From this circumstance we may readily infer that this animal lived at a time long anterior to our historical period. These antlers are now in the Whitby Museum, and a drawing of them, which we had made, was sent to Professor Phillips, at York, by the late Henry Belcher, Esq., of Whitby. The opinion of the Professor we have now forgotten, but we believe that it was his impression that the animal in question belonged to a somewhat remote period. Returning to the oceanic drift, we have to observe that, whilst immense accumulations line the banks on the north side of the Esk, occurring in different localities, forming hills occasionally of considerable height, spreading over a vast

extent of surface, the south side is comparatively free from these gravel beds. We have made these deposits the subject of *minute* study, and have arrived at the conclusion that they owe their origin to strong oceanic currents running in a north or north-easterly direction. In support of this view, we shall mention a fact which, in all probability, may have escaped the observation of many, viz., that the whole of the dales which communicate with the Esk are situated on the south side of the valley. Between Danby and Whitby there is not one on the north side. Now, we think the inference to be drawn from this circumstance is, that the same currents which swept off certain portions of the surface of our terraqueous globe, laden with foreign *debris*,—scouring and tearing down the cliffs on the south side of the valley,—having once opened a channel, whereby the continued action of these mighty waters penetrated deeper and deeper, wider and wider, into the rocks of the soft and flexile lias, ultimately formed them into dales, nearly, in all probability, of the magnitude we now see them. When the waters retired, they would doubtless leave behind a large quantity of muddy *detritus*, constituting the soil and adding beauty and fertility to these romantic vales. Were the origin and formation of our rivers and valleys thoroughly investigated, we think we should discover that during each geological epoch there were vast oceanic currents rolling over the surface of our planet, *in one particular direction*, excavating and forming our mountains and valleys, our lakes and our rivers, our hills and dales, and that these potent waters were used for wise and beneficent purposes. There can be little doubt, we imagine, that there is a great difference in the date of the origin of our rivers and valleys. It will, no doubt, have been observed by many, that all our navigable and innavigable rivers on the east coast

have their source in the west and their outlet in the east, showing that at the period of their formation the general direction of the then existing currents was from west to east. The origin of these rivers, we presume, belong to a more remote period than that of the smaller tributary streams and cross valleys which intersect them. An unmistakeable proof of this being the case is, we think, afforded in the valley of the Esk, where the waters, rushing into it from the south, deposited on its northern banks, as before observed—which appear to have acted as a barrier to their further encroachment—from time to time, immense quantities of *debris*. Now, if the valley had not been already formed this could not have been the case. We hope the few remarks we have thus made may be the means of inducing others to investigate more fully this interesting and important subject.

With the alluvial deposits we conclude our description of No. 2 section. It is more than probable that many of our readers may be disposed to view some portions of this description as a repetition of No. 1 section of the first part of our dissertation, viz., the lias and ironstone formations. It will be remembered, however, that in our exposition of these rocks in the first part we treated the subject generally, the whole extent of the ironfield, &c., coming under our consideration. We had to point out their geographical extent, their geological position, and the local peculiarities which characterise them. Whereas, in our delineation of No. 2 section, our chief object has been to point out the position of the main ironstone seams in the valleys we traversed, as well as those adjoining, showing where they were most accessible, and where they could be won and worked to the greatest advantage. The information thus made public cannot, we think, be otherwise than valuable,

especially to strangers who are not acquainted with the geological features of the district, by enabling them to discover these deposits, without spending much time or incurring any great expense. If, therefore, we have, while directing attention to the localities where the main ironstone seams are most favourably situated for mining, been led into some little iteration, which could not very well be avoided, we trust the knowledge thus revealed will, in some measure, extenuate the offence.

It may not be amiss, perhaps, before leaving this part of our subject, to glance at the peculiarities which characterize the formation of the strata between Whitby and Kildale, as delineated on No. 2 section. On inspecting the section it will be seen that there exist within this range three extensive undulations of the strata, in the centres of which the ironstone series and the lias formation are plunged far beneath the level of the plane, on each side whereof, however, the strata are seen rising in contrary directions. These undulations occur first between Whitby and Sleights, secondly at Lealholme Bridge, the village of which appears to be placed in the centre of the basin, and thirdly in Commondale. It is probable, too, that each of these occurrences may be accompanied by some disturbance of the strata, the dislocation in the port of Whitby having already been proved, whilst the amount of displacement of the other two has yet to be ascertained. From the diverse opinions held by individuals as to the direction the Whitby fault takes, and in the absence of anything like a satisfactory solution of it, we have not ventured to represent it either on our map or section. When we come to thoroughly examine the nature of these undulations, and dislocations also, we cannot help being struck with the beautiful arrangement unfolded to us—so evidently the work of the Great

Designer—for, as the late Dr. Buckland so admirably expresses it in his charming work, "the Bridgewater Treatise," localising and preserving our mineral fields. We behold, with wonder, that just when the ironstone seams, for instance, have reached the exhausting point at the surface, they are made to descend again at a gradual inclination, which would soon carry them to a depth below the surface that must place them quite beyond the reach of human enterprize, but, ere they reach a point so low, they are seen gently rising to the surface again. We thus discover, in what are looked upon as contortions, displacements, and eruptions of the earth's crust, a wise and beneficent design.

Having now brought our description of No. 2 section to a conclusion, we purpose, in the next place, to proceed to the consideration of the extent of the area of the Cleveland ironfield. We wish our readers to understand, however, that our calculations and estimates must be looked upon as only an approximation to the truth, for, though every pains have been taken to arrive at accurate conclusions, yet, in the present but partially developed state of large portions of the field, it would be mere presumption to state positively that in every instance we assume to be correct. We may be permitted to observe, however, that we believe the result of our investigations will not be far from, and, on the whole, within the truth.

THE EXTENT OF THE MINERAL FIELD.

The many exaggerated statements we have heard made with reference to this subject renders it, we think, necessary that some attempt should be made to arrive at something like a correct conclusion in a matter of such vast importance. There is nothing so seductive or so well calculated to mislead, as gilded facts, they are infinitely more dangerous than

pure fiction. The latter is easily detected, whilst it is difficult in the former case to separate the one from the other. This, in some measure assuredly applies to the accounts which, from time to time, have been given in regard to the quantity of stone assumed to be obtainable from the Cleveland ironfield.

In entering upon the consideration of this subject we may be permitted to state that we have been at much trouble to furnish ourselves with data upon which we might safely base our calculations. The result of our investigation is as follows, viz., that the gross area of the field will not exceed thirty miles by sixteen, within which it may fairly be expected that the stone will be met with at a workable depth, and in quantities sufficient to be profitably worked. From this superficial area, however, we must deduct the denuded portions of the field, which, from a careful calculation, we estimate at not less than sixty square miles. These denudations occur in the numerous valleys by which the field is intersected on every side, and also along the outcrops of the ironstone deposit, where much of it is frequently of no value. We must, also, to ascertain its nett produce, deduct the quantity of stone lost in mining, &c., which, it will be seen, is pretty considerable. Hence we have $30 \times 16 - 60 = 420$ square miles. Now, if we set down every acre of land as containing 20,000 tons,—(some portions of the Eston district will produce nearly double this quantity, but then there are other localities where the produce will be much below it; so that, if we take this as the average of the whole, we believe we shall not be far from the truth)—which we have found to be the average yield of the pecten and avicula seams in the mines of Mrs. Clark, we shall be able to ascertain pretty accurately what an acre or a square mile of ground will produce. It is well

known that the method of mining practised in the Cleveland and Grosmont districts is the bord and pillar system. One-third of the whole is generally extracted in working the bords,* and the loss sustained in doing so in the Cleveland district is estimated at seven per cent.; with us at Grosmont it is not so much. We were also told by one of Messrs. Bolckow and Vaughan's overmen, a person of considerable experience in ironstone mining, that in removing the few pillars they had worked at Eston a loss of twenty per cent. was incurred. Owing to the great height of the seam at Eston we may assume that the loss in working pillars there will be greater than in other districts where the seams are much thinner. We are, therefore, disposed to take the average loss in working bords at seven per cent., and the loss in removing pillars at twelve per cent., throughout the whole field. In taking this average we feel sure we shall be within the mark. The total loss, therefore, in an acre of ground, will be as follows :—

	Tons.
Loss of seven per cent. upon one-third of the quantity	466
Loss of twelve per cent. upon two-thirds of the quantity	1600
Total loss in an acre of ground....	2066

The nett quantity of ironstone obtainable will, therefore, be 20,000 tons — 2066 = 17,934 tons per acre × 640 acres per mile × 420 square miles = 4,820,659,200 tons, the gross quantity obtainable by calculation. We will assume that 200 blast furnaces, making each 200 tons of pig iron weekly, for fifty full weeks in the year, draw their supplies from this source, say then 200 furnaces × 200 tons × 50 weeks × $3\frac{1}{2}$ tons to the ton of pigs = 7,000,000 of ironstone consumed per annum. Next, 4,820,659,200÷7,000,000 = 680 years of time during which the main seam of ironstone

* In some instances one-half; but this is only done where you have a light cover, and can only be practised safely to a limited extent.

may be supposed to meet the assumed demand. Two hundred blast furnaces are a large number, but, when it is considered that this is the cheapest iron-making district in the United Kingdom, indeed in the world, and that so many as sixty-eight furnaces have been erected for the use of the Cleveland ironstone within the last sixteen years—fifty-four of which have, in fact, been constructed within the last ten or twelve years—we are disposed to think that, had we taken double the number for our calculation, we should not have outstepped probability. It must not be overlooked, however, that the above estimates refer solely to the main seam, leaving the top seam, as well as the lower and upper oolitic ironstone deposits intact. It would be difficult to estimate approximately, by a course of figures, what might be likely to be drawn therefrom, but, we feel well assured, that after the main seam workings have progressed for any considerable length of time, say a century, or, perhaps, two, these will be brought into play; and our decided impression is, that the above 680 years' duration may be extended to 800 or 900 years. It is proper to be observed that hematite ore* is used in mixture with this ironstone to improve the quality of the iron, which will so far affect the quantity above shown to be required as to reduce the amount in some degree. But where is the fuel to come from to smelt this prospective produce of ironstone from Cleveland, for the great coal-fields of Durham and Northumberland have been estimated

* The recent discovery of large accumulations of ferruginous sand in Lincolnshire, is, we have been informed, likely to supersede the necessity for the use of this expensive mixture. This sand, used in the proportion of one-third to two-thirds of Cleveland ironstone, produces, we understand, iron of the first quality, quite equal to that made with a large mixture of hematite ore; and should this deposit equal the anticipations of some of the ironmasters of the North, it will prove of very great value to the consumers of the North Yorkshire ironstone, by materially reducing the cost of making pigs. However, until it has been more completely developed and tested, it would be premature to pronounce any decided opinion as to its merits, especially as such deposits are very capricious.

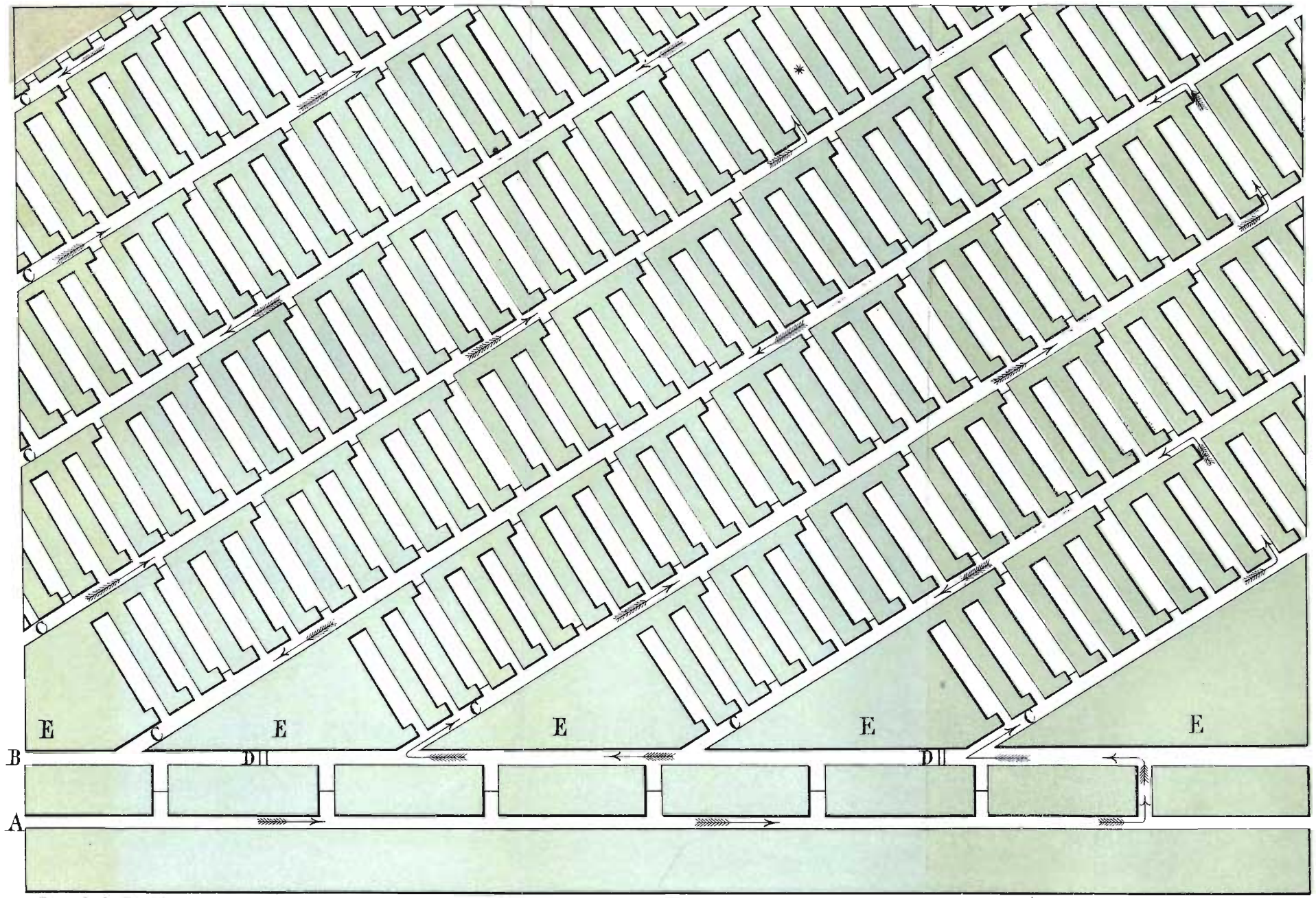
to last between three and four hundred years only, by three competent authorities, viz., Messrs. Taylor, Greenwell, and Hall, who differ but immaterially in their calculations. This truly startling view of a subject, on which depends, beyond all question, the transcendant welfare and glory of the British nation and people, would lead us to conclude at once that Cleveland will produce ironstone to outlast the supply of fuel by double the time the latter is likely to endure, at least so far as regards its neighbouring coal-fields. Other districts there are, it is true, in Great Britain and Ireland, of important extent and amount, but, we believe, none of these have been thought likely to outlast our Great Northern Coal-field.*

With the foregoing observations on the extent of the Cleveland Mineral-field, and the enormous quantity of ironstone which it contains, we may be considered as having concluded the geological portion of our Treatise.

* The problem, however, remains yet unsolved, as to whether the Great Northern Coal-field exists below the lias formation in North Yorkshire. The interest which attaches to this subject has greatly increased within the last few years, especially since the further development of the Cleveland Iron-field. The solution of this question is certainly of national importance; and, as any information that can be elicited on a matter of such vast importance cannot fail to be interesting to our readers, we purpose making a few remarks on the subject at the conclusion of our volume.

No. I.

PLAN OF BOARD AND PILLAR WORKINGS.



Drawn by Jos. Bewick

EXPLANATION.

⟶ Shews the direction of the air currents circulating round the mine

* The ⤴ should point in at Asterisk. not as drawn.

⊏⊐ Stoppings by which the air currents are controuled, directed, and kept in their proper course.

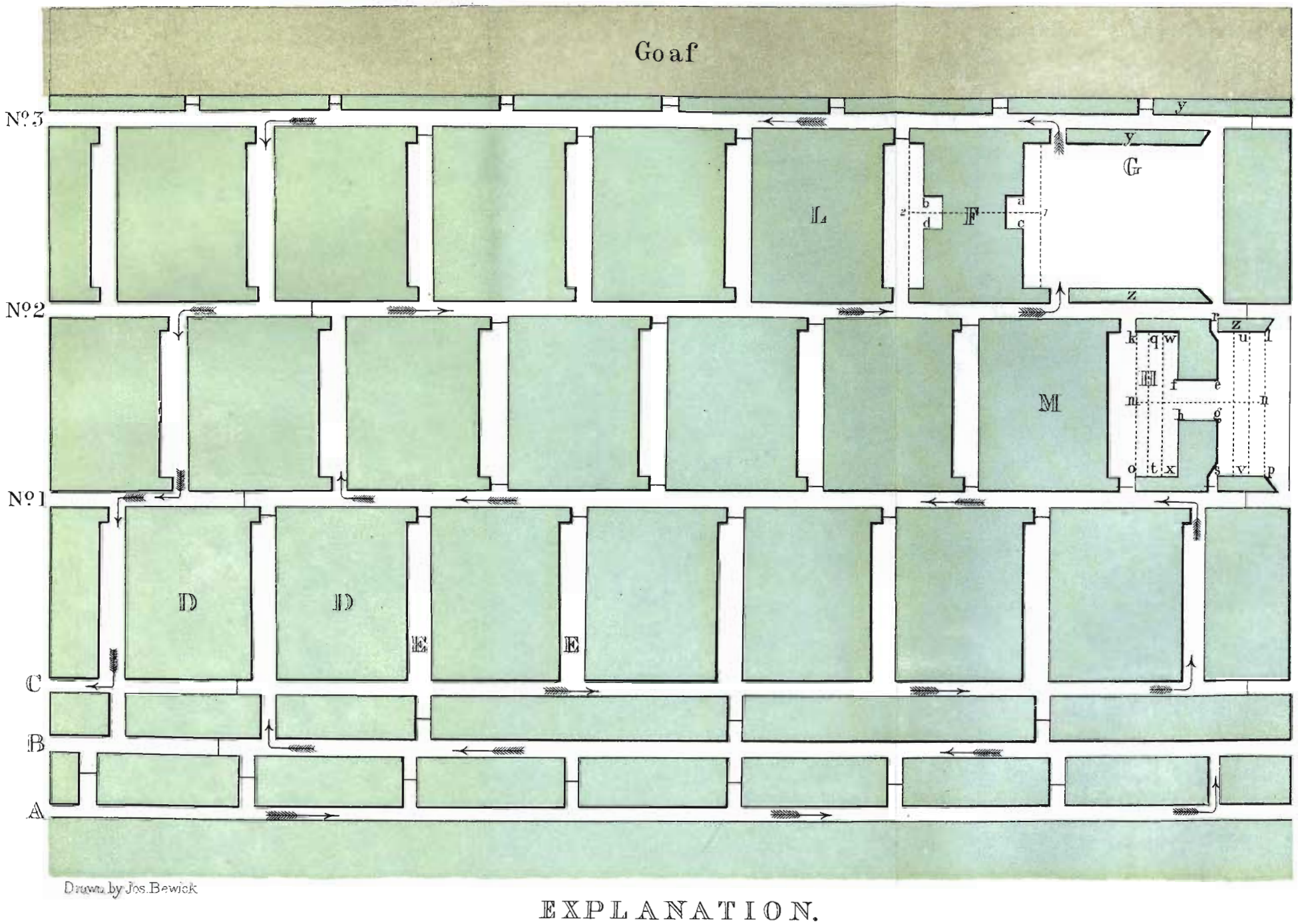
‖ ‖D D* To regulate the air currents, and to allow the produce of the mine to be brought along the level B.

* Read Doors to regulate &c.

Lithographed by A. Reid, Newcastle.

No. 2.

PLAN OF LARGE PILLAR WORKINGS.



EXPLANATION.

Shews the system of ventilation by coursing the air round the workings.

Stoppings by which the air is made to traverse the various ramifications of the mine.

G ___ Exhausted Mine.

Lithographed by A. Reid, Newcastle.

IRONSTONE MINING.

In order to give as practical a character as possible to our work, we purpose adding some observations on ironstone mining to our geological dissertation. In treating this subject we shall lay before our readers the result of a long practical experience in the working of iron mines, contrasting the ordinary system, which at present almost universally prevails, with an improved method of working what is technically called a hard seam; to explain the meaning of which it is but necessary to observe, that when the ironstone seams are overlaid by a great thickness of superincumbent strata, the immense increase of pressure renders them much harder and more compact, and thus greatly increases the expense of working them.

The science of mining is so intimately connected with that of practical geology, that there cannot be, we think, any incongruity in our adding this article to our Treatise. On the contrary, we are disposed to view it as a natural sequence, the absence of which would render our volume incomplete.

Before we enter upon the consideration of our subject, we feel it incumbent upon us to make a few general observations on the proving and letting of ironstone royalties, and to address a few words of advice to the owners of them, by way of caution against the too common practice of placing in the hands of inexperienced persons the proving

and reporting upon the minerals which their property may contain,—persons who are totally unqualified to give an opinion on a subject possibly of great importance; for, even when the existence of the minerals may have been ascertained, they may be incompetent to form an estimate of their commercial value, and thus the statements they in general make to their employers are mere conjectures, and would not, for one moment, bear the searching scrutiny of a practical and experienced mining engineer; yet it too frequently happens that the fate of a royalty depends upon such hazardous surmises. All mineral leases, it is well known, between the lessor and lessee are generally drawn up conditionally; the conditions being that the lessee is to be allowed a certain time to prove the existence of the minerals, their quantity and quality, and then he decides as to whether it is calculated to prove a good undertaking; and it not unfrequently happens that, after having the royalty in his hands for a year or two, he concludes, without perhaps giving any very satisfactory reason, that they cannot be remuneratively worked. The lease is therefore abandoned, and the royalty condemned. How important it is, therefore, that the lessor should appoint some competent person to see that these trials and experiments have been properly prosecuted, and that a correct estimate, based upon the result of the trials and experiments, has been made by the lessees, as to the value of the minerals the royalty contains, in order that a character may not be given to it which it really does not deserve.

Nothing is of more importance to the owners of mineral property on the one hand, and mining adventurers who may wish to lease it, on the other, than that the experiments to prove its value should be judiciously conducted and properly made and reported upon, for it is on the result of

such experiments and reports that the character of a royalty and the prospects of a mine depend. There is no doubt but many a royalty has been abandoned as worthless which, if placed in the hands of an intelligent and experienced person in the first instance, would, in all probability, have proved valuable to the owner and profitable to the adventurer. We have constantly brought before us the disastrous failure of some Joint Stock Company or other, whereby numbers of honest individuals, who, allured by fictitious statements and exaggerated prospectuses, had put their all into the concern, are completely ruined. The facility which the passing of the Limited Liability Act affords to the formation of such schemes has caused them to become more numerous than ever. Many of them become defunct before they get fairly into operation, whilst others go on for a lengthened period which only makes the crash in the end all the more terrible.

The cause of all this is generally either wilful misrepresentation on the part of the concoctors of the scheme, or the absence of scientific and practical knowledge in the managers or directors. To render mining speculations safe and successful it is of the first importance that the management of them should be placed in the hands of a practical man, who has been educated and trained to the profession from his youth. It frequently happens that the profits of such undertakings in a great measure accrue from the saving effected on a variety of little things, connected with the mining operations in detail, which nothing but practical experience will enable the manager to make.

It is quite possible that such undertakings, even when in the hands of the most prudent persons, may, from a combination of circumstances over which they have no control, result in failure. This, however, is, generally speaking, the

exception, and not the rule. We have often been surprised to see gentlemen of considerable intelligence, and, in the management of their own business matters, acute, penetrating, and discreet, led away by the misrepresentations of persons who, they must know, are all but totally ignorant of the working of mines; and you will see these very gentlemen, despite of the continual failures which are ever occurring around them, embark their capital with apparently every confidence that the speculation must be a successful one, when, to every person who is at all conversant with such matters, it is quite clear that the only result to be realized is disappointment, with a total loss of capital. The many delusive schemes, too successfully promulgated in every part of the kingdom, which, whilst they have been the ruin of hundreds of individuals, duped and deluded by the crafty inventors of these fearful bubbles, have also done great injury to legitimate enterprise, have induced us to make the foregoing remarks. We may observe, in concluding these preliminary remarks, that though mining operations require the greatest care and attention on the part of directors and managers to render them safe and remunerative, yet, when energetically and prudently conducted, they are a good and safe investment. We would strongly advise those who may be disposed to embark their capital in mining speculations to employ some respectable mining engineer (and there are plenty of such to be had) to institute a searching inquiry into the position and prospects of the concern before they do so. Were this more frequently done by the public the formation of these abortive schemes would meet with less success.

We may mention, for the information of our readers, that the main ironstone deposit may fairly be expected to be met with above the level of the Esk, on the north side

of the valley, between the mines near Sleights Bridge and Grosmont, to a greater or less extent, in the following properties, viz., in the estate of Henry Walker Yeoman, Esq., in the farms of Mrs. Thistle, Mr. Charles William Noddings, Messrs. Richard and John Smith, in the estate of the late D'Oyly Sanders, Esq., and that of Mr. Wm. Wilkinson. Beyond Grosmont the main seams disappear below the level of the Esk, but will be found, we may presume, at no great distance below the surface in the farms of Mr. Francis Yeoman and Mr. John Robinson, and at no great depth in most of the large Egton estate, belonging to the Elwes family, as well as in that of Richard Smith, Esq., of Egton Bridge. We should have been glad to have given publicity to the freeholds wherein the ironstone deposit will be found to exist in the adjacent valleys, but the great difficulty we experienced in obtaining accurate information as to the names of the owners of many of them, and lack of time for further inquiries, reluctantly compelled us to pass them over in silence. We think, however, we have, in a preceding portion of our work, sufficiently indicated, generally, the localities in these valleys where the ironstone may be expected to be met with.

Our observations on the working of the ironstone mines in the Grosmont district will, in the first instance, be directed to the winning of the mines. This preliminary process is of comparatively easy accomplishment in this locality, owing to the favourable position of the ironstone seams. This is generally achieved by day levels, or by sinking shallow shafts, and in neither case, where judicious economy is observed, does it require any considerable outlay. The bord and pillar, or post and stall, system of mining, as they are generally designated, being that which prevails in this neighbourhood, we shall content ourselves with taking the

mines at present under our supervision as illustrative of the district. We wish to observe, however, that whilst the general plan of working the mines may be considered the bord and pillar system, there is yet a vast difference observable in laying them out, with their various ramifications, and ultimately in extracting the whole of the stone. We shall have occasion to notice, as we proceed, the differences in working on this system. As we have already observed, the ironstone seams in this district are rising from the bed of the Esk in a south-easterly direction, at an inclination of about 1 in 24. The winning of these seams, in Mrs. Clark's estate, is effected by a pair of dip-levels, commencing at the lowest point of the river, and driven into the hill in a south-westerly direction till our boundary is reached. See plate 1, figure 1, which is a portion of one of our old plans, representing the system we pursued for many years in our operations. Out of these levels A B, were driven headways C, C, C, C, C, C, C, C, from six to eight feet wide, following the direction of the natural partings or joints of the stone, and all about two chains distant from each other. Out of these headways were again set-off, at right angles, bords eight, ten, and twelve yards apart, according to circumstances, thus dividing the mine into pillars of eight, ten, and twelve, by from forty to forty-four yards. These bords, at the commencement adjoining the headways, are set off at nine feet wide, and after being driven to the distance of four yards, they are gradually widened out to eighteen feet. By adopting this simple method, you form a barrier to your headways, from four to five yards in thickness, which protects and strengthens the whole of the workings, and effects an immense saving both in timber and stone. By way of further adding to these supporters, we only hole every third bord into the headway next adjoining on the

rise side, leaving a barrier of thirty yards in length unbroken, which, of course, forms a strong support to the whole of the surrounding workings, and enables you to remove your pillars between the headways without any difficulty, and with very little loss. You are able, too, to keep your mine always well ventilated, by coursing your air up and down the headways; and as these are so well supported, the current is never interrupted or impeded in its course by "falls" and "creeps." In proof of what has been stated, we have only to mention that, although our workings have extended to the distance of about three-quarters of a mile — no great distance, certainly — we have never yet found it necessary to have recourse to the furnace as an auxiliary to our ventilation. Sometimes, during the sultry weather in summer, we have found it requisite to use a large lamp filled with fire, to prevent stagnation; but even this is but seldom needful. The great thing to be attended to, to keep up a good current of air, is to see that your stoppings are air-tight, and to make your intakes and return air drifts a good size, as straight as possible, and free from interruption. D D are doors, placed so as to keep the air currents in their proper courses whilst circulating round the various ramifications of the mine. The produce of the mine being brought along the level B, doors instead of stoppings are placed to allow of ingress to and egress from the mine. E, E, E, E are pillars of ironstone, left for the purpose of protecting and supporting the levels A B.

With regard to the best method of working out the pillars under the bord and pillar system, we would observe that we have, at different times, adopted a variety of plans, the mention of two or three of which will suffice. One of these was to commence and work off one-half of

the pillar from the top to the bottom of the bord, and bring the remaining half back with you. The second method was to extract the middle portion of the pillar, and work off each end, together with the headways and barriers. The best and most economical plan, however, and the one which we now generally adopt where this system is put in practice, is to begin at the bottom of the *bord* and work the whole of the pillar before you to the rise of the workings. We have extracted a considerable area of pillars by this method, and ascertained, by careful observation, that our loss of stone was not more than from five to six per cent. This may appear, to many, almost incredible, but such is the fact. Our loss of timber, however, as may be supposed, was somewhat great, but we always take care, as far as possible, to see that the value of the timber left behind is not equal to the value of the stone that must have been left for the support of the mine. It is only right, too, that we should mention that, at the period we refer to, we had a body of first-rate workmen, many of whom were as dexterous miners as ever handled tools, which, of course, is of incalculable advantage in working out pillars. The loss which occurred in removing our headway barriers, from the immense pressure of the surrounding goaf, was, however, much greater, yet we do not think it would average more than ten per cent. We would further observe, that we have found, from long experience, that in working pillars by the system we are now describing, it is highly essential, in an economic point of view, to commence as far to the dip as possible, and work off to the rise. By working in this direction, and taking care that the goaf be well drawn—*i.e.*, removing, as far as possible, all the props and other supporters, in order that the roof may fall freely behind you—the pillars are not overweighted by undue pressure, in

consequence, as may easily be supposed, of the superincumbent mass having always a tendency to fall and press most severely on the dip or low side of the workings, which, of course, relieves the pillar of stone which is on the rise side of the goaf.

We wish particularly to state, however, that the system of working which we have just described as the one we adopted for so many years is only applicable where the cover is comparatively light, or where the ironstone is found near the surface, and soft to work. Where this is the case, there is but little difference between the working price of the stone in a bord, headway, or mothergate, so that the winnings and other narrow work are comparatively inexpensive. Where the superincumbent strata, however, increase to a great thickness the pressure, of course, becomes much greater, owing to which the ironstone is rendered much harder and more difficult and expensive to work. Under these circumstances, to continue so many narrow excavations would become too expensive, and, if persevered in, would not fail ultimately to destroy the economy of the workings.

The working price of the ironstone under the system we have described, and at the period we refer to, was from 9½d. to 1s. 2d. per ton of 22½ cwts., delivered into railway wagons; the headways being 2d. per ton more than the bords and barriers, and the bords and barriers 1d. per ton higher than the pillars.

We mentioned in the preceding pages that there is a great difference in working or extracting the ironstone under the bord and pillar system of mining. Whilst we have shown our preference for having our headways, levels, &c., driven narrow, there are others who have no narrow work at all. The plan they adopt is to commence a sheth

of bords near to the dip levels, and after driving them for a distance of twenty or thirty yards, a holing or opening is made at right angles from one bord to another, which is continued across the whole sheth. This opening serves the two-fold purpose of a ventilating drift and a bordgate. The bords are still continued in the same direction beyond this bordgate for thirty yards more, when another communication is made intersecting each bord at right angles again, and thus the workings are continued till the boundary of the property is reached. It is hardly necessary for us to make any comment upon the loss which occurs, and the disorder which prevails, in pursuing such a system. In working the pillars in a mine of this description you must either leave nearly one-half of them behind you, or in attempting to remove the whole of them you will, in all probability, bring a sudden creep upon your workings—*i.e.*, a sinking of the roof and a rising of the thill or floor of the mine, crushing the pillars and causing a considerable loss of stone and timber, and not unfrequently of tramplates also. We were once induced to adopt this plan when our winnings became more expensive, but after experiencing a state of things much the same as above described, we were glad to abandon it. The fact is, such a system, in our opinion, ought never to be tolerated, either by the lessee of the mine or the owner of it.

The long wall, as it is called, mode of mining, has never been introduced in this district, nor in any of the mines, we believe, in North Cleveland. The ironstone deposit in the Grosmont district being divided into two workable seams, only thirty-one feet apart, renders this system of working totally inapplicable to this locality. In the low seam (the avicula) there is no refuse made to pack and form your tram and rolleyways with, through the old waste.

Besides, in order to work the pecten seam (only thirty-one feet above the avicula) to advantage, it is necessary to leave, for a time, a certain portion of the pillars and barriers in the avicula workings, until the stone in the pecten immediately overlying them be worked off, otherwise the pecten seam would be so much fallen and shaken as to render the working of it impossible. We could adduce other reasons why *vendors of ironstone* should avoid the adoption of the long-wall system of working, but sufficient has been said, we think, to show that it is totally unsuitable for this district.

As we before intimated, when our workings had penetrated a considerable distance into the hill, the thickness of the superincumbent mass of rocks very greatly increased, which produced a great increase of pressure upon the ironstone seams, rendering them much harder, and, of course, more difficult and expensive to work. This change in the character of the ironstone, rendered a change in our system of working imperative. The bord and thin pillar method of working, even with some modifications and improvements, was no longer applicable to the altered state of things. The bords, from being fast at both sides, and from the hard and compact nature of the seams, were almost past working, and very few miners could be met with who could work them. The waste, too, from small chippings, was also great. We left no means untried to discover a remedy for this evil, and, after several modes had suggested themselves to us, we were led to the adoption of the plan represented in plate II., fig. 2, which we have found a great improvement upon the old system. Although it is now about four years since we first commenced working upon this plan, yet, from the very slow progress we made, in the first instance, with our winnings, even when worked

"double shift," owing to the hard nature of the material, and, latterly, to the almost entire suspension of that portion of our workings, in consequence of the depression of the iron trade, we have only been able to carry it into operation to a limited extent; our experience has, nevertheless, been sufficient to convince us of its great superiority over every other plan which has preceded it. The chief feature in this method of working, and what constitutes its great advantage, is that, when once the large pillars are won, there is always a loose or open side to work by, which greatly facilitates the extraction of the ironstone. We shall now proceed to describe it more in detail; we may mention, however, that we only commenced winning, a few months ago, that part of the mine which plate No. II. represents, the workings of which, however, will be laid out exactly in accordance with that plan. The goaf, &c., we have added illustratively, and as explanatory of the system we intend in future to pursue.

A is our water-level, as also our intake air-drift, driven about eight feet wide, its dimensions being eight feet by four, and its area thirty-two feet. B is the return air-drift, and is also intended to be our rolleyway, driven six feet wide, and five feet high, to admit small ponies, its area being, therefore, thirty feet. This rolleyway forms a junction with our main horseway, along which is conveyed the whole produce of the mine to the railway wagons outside. C is a bordway, out of which are set off bords E E, two chains apart. Between the bordway C and the rolleyway B a barrier of stone is left, twelve yards thick, for the support and protection of the latter. The bords E E are driven to the distance of sixty yards where they intersect No. 1 headway. The same thing is again repeated out of No. 1 and No. 2 headways. We thus divide a large area

into pillars of the following dimensions, viz., 60 × 40 = 2,400 square yards, containing about 4,800 tons of ironstone. Though sixty yards is a great length to drive bords without holings, yet we have found no difficulty in ventilating them. We divide our mothergates and headways with canvas brattice until a junction is formed between the bords and the headway, and a proper circulation secured. It is not at all necessary that so large an area as represented on No. II. plan should be won before you commence working your pillars; you can work them close up to within a bord's length of the face of the headway if you like, which is another great advantage this method of working possesses. We would recommend, however, that a separation be made between the broken and whole work, by leaving a fair proportion of pillars standing between the two. By doing so you avoid all confusion and disorder amongst the putters, &c., and it enables you to carry on the whole of your workings in a more orderly and methodical manner, which must be more satisfactory to the superintendent.

It too frequently happens, that the proprietors or lessees of mines in their anxiety for a return on the capital expended, commence extracting the ironstone for sale before the mine is at all properly won—and, in all probability, remove portions of the stone which ought to remain for the support of the shaft, levels, and chief roads of the mine. Nothing can be more pregnant with disastrous results to the whole undertaking, than proceedings of this description, and the superintendent of every mine ought strenuously to oppose the premature extraction of the mineral, and insist upon a proper portion of it being left untouched for the protection of the workings, otherwise he will have the main roads crushed and overweighted on all sides, entailing

upon the concern an endless and serious expense in constantly renewing and repairing them. It would be all the better if a royalty could be thoroughly drained and won to the extreme boundary, before workings were commenced, and so work out the field homewards. This, however, would require not only a considerable outlay, but a long period of time would elapse before working operations could take place, or any profits could be realised to the owners. Neither is such a proceeding necessarily called for. With the exercise of proper caution and foresight, coupled with a systematic and well-arranged plan of proceeding, a large portion of the royalty may be safely worked simultaneously with the draining and winning of the mine, which is certainly better calculated to give satisfaction to the owners.

But to return to the further explanation of plate No. II. Let us suppose that we have an area equal to that represented by the diagram, won and laid out as there shown, and the pillars ready for removing. We commence first by working out pillar G. This done, we next proceed to the extraction of pillars F and H, and our mode of doing so is as follows :—In each pillar are placed eight men; two at K pillar H, two at *l*, two at *o*, and two at *p*. Each of these two men work off before them a breast of stone, about five yards wide, from the side of the pillar, till they meet each other at *m* and *n*, conveying the ironstone they work into the headways through the openings K *o* and *l p*. They then turn round and work off another five yards backwards, as represented in pillar F by the letters *a b c* and *d*, and also by the dotted lines in pillar H, until the headways barriers are reached at *q t u v;* after which the proceeding is again repeated. Forasmuch, however, as the great pressure from the surrounding goaf (which

this portion of the pillar joins) may cause a heavy falling of the roof, and so render it impossible to convey the ironstone through the openings *l* and *p*, a remedy against such a contingency is provided by making a narrow holing through the barriers *r* and *s*, just sufficient to admit a rolley, through which the remainder of the ironstone worked from the inside of the pillar is conveyed to the main ways. If requisite, a similar opening may be made at W and X, which, however, we have not as yet found necessary ; the open space between the *outside* of the pillar in course of being removed, and that next adjoining, being too limited in its area to cause any great pressure or falling of the roof, such as to prevent the ironstone from being conveyed to the main ways through the openings at *k* and *o*. The eight men having met again mid-way for the second time, now cut through to each other at *f e* and *h g*, and if the bords have been driven straight in the first instance, and the workmen carefully looked after to see that they do not take more than five yards at one "lift," there will be, for each of the four men, ten yards to take back with them. This thickness of pillar is quite sufficient to resist any pressure that may be occasioned during the working of it out. Should there be reason to suppose, however, that the pillar, from any irregularity of working, is much thinner than at first was calculated upon, the workmen ought to "hole" through to each other *before working back the first time;* and if it should prove to be so, they should take the whole of it back with them at once, even if it should be a somewhat inconvenient thickness, otherwise you may lose in the end a considerable quantity of ironstone. These pillars having been removed, the adjoining ones L M, must next be commenced with, simultaneously with which should be worked out also the barriers *r s* and *y z*. These

barriers ought never to be more than a pillar length behind the other workings, otherwise they become crushed and over-weighted by the pressure of the surrounding goaf, which may cause a large portion of them to be lost.

In the observations we have made above, explanatory of our new method of working the ironstone, when from great pressure it has become hard and refractory to deal with, we wish to add, that when once the working of the pillars is commenced they should never be allowed to stand for any length of time, but ought to be worked off with as little delay as possible. If this rule be strictly observed, we venture to predict that all "creeps and crushes" will be avoided, and that the whole of the ironstone will be extracted with a very small loss.

Pillar working would be greatly facilitated, too, by making a proper selection of workmen well qualified for the post assigned them, which would also prevent endless bickering and much dissatisfaction between masters and men. When workmen are well paired and equally skilful, as may be supposed, they work with more spirit and energy, and take greater delight in their work. On the contrary, when two men are "unequally yoked," the more skilful of the two becomes disheartened and dissatisfied, and is always complaining. He takes no interest in his work; and as he is, in all probability, watching the first opportunity to better himself, he cares very little how his work is performed. The place he works in, which, if he had had a partner equal to himself, would have been straight and orderly, is in all respects the reverse. His timber is not properly drawn from the waste, and is very irregularly and improperly placed. In fact, everything betokens carelessness and indifference, and it is quite clear that the interest of his employers occupies but little of his thoughts. These matters,

which to many may be considered too trifling to be cared for, we assure our readers, require the constant eye of the master, to see that they are all arranged, as far as possible, to the satisfaction of the workmen. We have never hesitated to consult such of our workmen, as long experience and good conduct entitled to give an opinion, not only as to the arrangement of little things, but on matters of greater import; and whether we coincided with their opinion or not, it showed them we valued it. Besides, this kind of open and plain dealing between master and men has a tendency to cultivate mutual confidence in each other, and to strengthen that bond of union which ought always to exist between them. We have, on several occasions, to prevent misunderstanding, when we have found it necessary to reduce wages, or to resist the application for an advance, committed to the trust of some of our workmen information of an important and confidential character, and we never, in a single instance, found the trust we thus reposed in them betrayed. It is with pleasure we thus bear testimony to their good faith and praiseworthy conduct.

We do not know that it is necessary, after the description and explanation we have given, to make any further remarks on our new mode of mining. We trust our description has been sufficiently clear to bring it within the comprehension of the generality of our readers, for that has been our earnest desire. We would further observe, however, that no plan, no matter what its merits may be, will ever succeed, unless it be well looked after by both manager and overmen. The situation of the latter is a very important one, the duties of which can only be satisfactorily fulfilled by an experienced, industrious, and intelligent miner. He has to keep a careful watch to see that all is going on properly in the interior of the mine, and to see that the instructions of his chief are

implicitly obeyed; that no unnecessary loss of timber and stone occurs, and that the stoppings for regulating the ventilation of the mine be air-tight; that nothing impedes or interrupts the air-currents as they circulate round the workings; and a variety of other little matters connected with the regulation of the works generally. It is absolutely necessary, also, that the manager should be thoroughly acquainted with every portion of the interior of the mine, and, when in full operation, should give close attention, to see that all is going on to his satisfaction. The more a master is interested in his work (and if he is not so he is not fit for his situation), the more the workmen become interested in it also.

In concluding our observations on ironstone mining we wish to make a few further remarks on the necessity of keeping a true and accurate record of the mining operations, and to add a few words, also, on the ventilation of ironstone mines, applied more especially to those of the Cleveland district.

PLANS AND SURVEYS.

The necessity for having clear and well executed plans, accurately delineating the subterranean operations of the mine, will, we think, be admitted by all who are interested or engaged in mining operations, whether they be coal or ironstone. The want of such documents has frequently been very much felt, especially where mines and royalties have changed hands, leaving much, if not all, in doubt and uncertainty as to the extent and direction of the excavations. Apart from this consideration, however, no one can conduct a mine with any degree of certainty, precision, or success, without having the surface of the royalty and the interior of the mine accurately mapped. The want of these, where

mines are at all extensive, must inevitably lead to great confusion, and, in all probability, to the committing of serious mistakes in working beyond the proper legitimate boundaries. A miner working without plans is very much like a seaman sailing without charts. We consider it just as necessary to have well kept plans, recording your subterraneous proceedings, and showing the state and condition of the mine, as it is to have well kept books, showing your commercial transactions and the financial position of the whole concern. This, of course, belongs entirely to the chief, or superintendent's department, who ought at all times to perform this part of his duties, so essential to the well-being of the undertaking, efficiently and punctually. We need scarcely say that no one ought to have the management of a mine of any extent who is not thoroughly conversant with surveying, levelling, mapping, and planning, in all their branches. In the absence of this knowledge, the success of the mine, to a considerable extent, will be at the mercy of subordinates. We should put no faith in subterraneous surveys and plans that were not made under the manager's immediate supervision. It is true that most of the overmen of the present day are well acquainted with the use of the circumferentor, and are quite capable of keeping the driftings in their proper course, and, also, laying them out on the surface; it would, however, we consider, be hazardous, to say the least of it, to leave the registering of an extensive survey, with all its intricate traversings, notes, and observations, entirely in their hands. Besides, if they were so employed, you must, to secure neatness and correctness, engage the services of a draughtsman to plot and draw the plan; we consider, however, that surveying and planning, properly speaking, form no part of the duties of an overman, but essentially belong to the manager, who ought to devote certain portions of his time and attention to the

execution of them. There are those who will probably tell you that in large and extensive undertakings their time can be better disposed of—this, however, we are prepared to question. Nothing, we think, can be of greater assistance to such a person than an accurate and well executed plan of his own doing, by which he becomes perfectly acquainted with every part of the mine, and, by referring to it from time to time, he can direct or hear any explanation from those under him. He would thus save himself many a journey underground, and be left more at liberty to attend to other matters requiring his attention.

Plans which are intended to form an historical record of the mining operations carried on in any royalty may be laid down on a scale of either two or four chains to the inch. As the former, however, shows the workings more distinctly than the latter it is the one we should recommend, and it is scarcely necessary for us to observe, that the surface and subterraneous plans should be on the same scale. A lucid explanation should not only be given on this plan, but a full description should also accompany it, either written or printed (the latter is preferable), narrating any peculiarity that may have been observed during the progress of the workings, whether there be any diminution in the quantity, or depreciation in the quality of the ironstone, and, if so, pointing out on the plan where such were first observed, and *vice-versa*. The difference in the working price occasioned by the increased hardness of the stone should also be noticed. Dislocations, their course, and the amount of displacement they have occasioned, and in what direction, should be correctly delineated and fully described. Your plans would then become useful works of reference not only to yourself but to any who may succeed you, in the event of death, removal, or any other fortuitous circumstance.

Where mines are held under lease, plans should, at all reasonable times, be accessible to the lessor, or his or her agent—indeed, this is usually provided for—in order that the lessor may be satisfied that the mine is conducted in a judicious and workmanlike manner. Rough working plans should also be copied from the general plan laid down upon a large scale, not less than one chain to the inch, for the guidance of the overmen, or other workmen, on all occasions.

In a hilly district like ours, where the surface is so uneven, it is of great importance that you should be provided with a section, the line of which should be directed through the centre of the workings, showing the nature and height of the superincumbent strata, which will enable you to judge with certainty as to the size your barriers ought to be to sustain the weight they have to bear. In the event, too, of your having shafts to sink, or borings to make, you are able, knowing the character of the rocks you have to sink or bore through, to calculate with great precision the cost of such an undertaking. We have one such by us, which we find useful and convenient to refer to occasionally. The different heights of the superincumbent strata are ascertained by the use of the spirit-level, and the mode of procedure is as follows. You can commence either at the bottom of your shaft or the mouth of your level, and take the different heights on the surface by the process of back and fore-sights, care being taken that your instrument throughout the survey be placed as near as possible mid-way between the different points of observation, measuring accurately, at the same time, with the chain, the distance between the station you commenced with and the one you terminated at. This done, you next proceed to draw your diagram, which is formed as follows. Draw a horizontal

line the whole length of your sheet of paper, designated the "datum line," upon this erect your perpendiculars, which gives you the heights accordingly as they are registered in your field-book, and which you note by placing the number of feet contained in each of them on the surface line; draw a strong hair-line from one perpendicular to another throughout the whole of your survey, noting, at the same time, any particular objects, such as railways, rivers, houses, woods, &c., which will then pourtray, in profile, the form and appearance of the surface. This completed, you must next ascertain the angle of depression or inclination of the seam—dip and rise—along the line of section, and delineate it on the same accordingly, as well as any dislocation, or "swally" (a minute undulation) that may occur; you will thus have exhibited a profile of the strata which the royalty contains between the seam you are working and the surface, showing all the inequalities of the latter. The line of this section ought to be accurately marked on the surface, by driving into the ground strong wooden pegs, about an hundred yards apart, in order that you may at any time, if necessary, level in any direction from it. We may mention, that in drawing the section it is not necessary to pourtray the whole of the superincumbent strata in colours without you think proper. We would recommend, however, that all ironstone seams, bands, and nodules, whether workable or not, should be properly represented on it, and, perhaps, by a strong line, indicate the thickness of different rocks comprising the strata, such, for instance, in our district, as the "dogger, upper lias, and sandstone rocks." You can also show upon it the extent of the exhausted portion of the mine, &c. We consider a drawing of this description not only useful to refer to, but a most valuable adjunct to your general plan.

VENTILATION OF IRON MINES.

In concluding our observations on ironstone mining, we feel impelled to say a few words on the all important subject of mine ventilation—a subject which has for a long period engaged much of our attention—and to state, after mature deliberation, the conclusion we have arrived at is, that the system adopted in coal mines has been too closely copied in the ventilation of iron mines. The nature of the two gases disengaged in working coal and iron differ so widely from each other, both as regards composition and density, as to require, in our humble opinion, to be very differently dealt with in their expulsion or withdrawal from the respective mines. The most deadly enemy engineers have to combat and constantly struggle with in the working of coal mines is, as is too well known, that fearfully dangerous and subtle gas designated carburretted hydrogen. This gas is evolved in large quantities in some of the seams in the Durham and Northumberland coal-field, causing, but too frequently, despite the talent, skill, and untiring perseverence of some of the first mining engineers in the world, those disastrous explosions which we see constantly chronicled in the journals of the day. It is dreadful to contemplate the number of valuable lives thus sacrificed—immortal souls swept into eternity without a moment's warning, by these direful accidents—men whose daily toil carries them far beneath the surface of the earth, penetrating farther and farther into the dark, dangerous, and rocky recesses of the globe, in the extraction of that valuable fossil fuel, the element which has made England's commercial greatness the envy and admiration of the world. Carburretted hydrogen gas being much lighter than our atmosphere, has

always a tendency to rise above it, whilst carbonic acid gas is heavier than common air, and, therefore, has a tendency to fall below it. It is the difference in the specific gravity of these two gases that renders a different system of management, in our opinion, necessary in most effectually ridding the mine of their baneful presence.

As the principle of ventilating coal and iron mines is precisely the same—though, of course, the expensive system of splitting, dividing, and distributing the air through the extensive ramifications of the former, as at present practised in the large collieries in the north, is in the case of the latter unnecessary and uncalled for—we shall, by way of illustrating our theory more clearly, have briefly to describe the system adopted in ventilating the former. The principle upon which all ventilation is based is simply by connecting two columns of air with each other. This is achieved by driving two adits, or levels, parallel with each other, a connection between which is formed by cross drifts intersecting them at intervals. This connection is extended as the mine extends, and by this means the air is carried and distributed, by a systematic arrangement, throughout every part of the mine. In the two adits above-mentioned are placed the downcast and upcast shafts, and, by way of destroying the equilibrium of the two columns of air, the upcast is placed some distance in advance of the downcast shaft. At or near the bottom of the former, which is always sunk on the rise side of the latter, is placed the furnace for heating and rarefying the air, and thus becoming an exhausting medium, as also a powerful auxiliary to thorough ventilation. The balance of the air-columns being thus broken, by making the adit on the rise side the shorter of the two, and, as air naturally makes its exit at the nearest outlet, it becomes, with the assistance of the furnaces, what is termed the out-

take, or return air-drift, into and along which is conveyed the whole of the contaminated air which the mine contains. Seeing, then, that the inflammable gas evolved in coal mines is much lighter than our atmosphere, and therefore, as we before stated, has always a tendency to rise above it, it will, we presume, be patent to all conversant with the subject, that by making the return air-drift on the rise side of the intake, the escape of such gas from the mines must be greatly facilitated. We have no doubt but the system of ventilation, so admirably arranged and carried out in detail, in the large first-class collieries in the north, is the best which scientific skill, combined with large practical experience, has yet been able to devise.

Whilst we have thus endeavoured to show that the system of ventilation pursued in the large mining establishments in the north is perfectly consistent with scientific principle and philosophic truth, we shall have next to prove that the system of ventilating iron mines is not so much in harmony with the laws of nature. This incongruity, we have no doubt, has been entirely owing to our too blindly imitating the system we have in part attempted above to describe, without duly considering the nature of the gas produced in such mines. As we have mentioned above, the gas which engineers have to deal with in working coal mines is *lighter* than our atmosphere, whilst just on the contrary, the gas disengaged in such large quantities in our iron mines, is *heavier* than atmospheric air, and from this circumstance alone we think we shall be able satisfactorily to prove, that for the purpose of more effectually clearing the mines of this deleterious compound, it is necessary that the *direction* of the circulation of the air-currents should be just the reverse of those in coal mines.

The following explanation, we think, will be sufficient to point out the advantage to be gained by reversing the

air-currents in the case of iron mines. With few exceptions, every stratum of rock, from its angle of depression, forms an incline plane of greater or less inclination with the horizon. As all heavy bodies, from the mere force of their own gravity, have a tendency to move *down* a plane, it is only reasonable to suppose that the carbonic acid gas, whose specific gravity is *heavier* than that of common air, will always move, when circumstances admit of its doing so, from the rise to the dip of the workings, just as the carburetted hydrogen gas, from its lightness, when disengaged from the coal, escapes to the rise of the coal workings. This being so, it is manifest that the best and most effective mode of forcing it from the mine is by sweeping it from the rise to the dip of the workings, to accomplish which it is only necessary to shorten your *dip* level or adit, and there to place your furnace instead of the *rise* level, when it at once becomes the return air-drift, and the rise level the intake. In adopting this plan, it is presumed that the whole of the workings will be on the rise side of the levels. If it should so happen, however, that the workings were extended to the dip, beyond the intake and return drifts, it would be just as easy to rid the mine of any gas that might accumulate there, as it is under the existing system to free the mines of it—the air at present being coursed from the dip to the rise of the workings. Though we have nothing to complain of as regards the ventilation of our mines, yet, had we known, when we first commenced operations, what experience has since taught us, our works would have been laid out in accordance with this plan, for we are quite convinced that it will be found to be a great improvement upon the system at present pursued.

The quantity of gas produced in working our mines is very great, and, in our pillar workings, adjoining the goaf or exhausted portion of the mine, is at times exceedingly

troublesome, especially in warm, sultry weather. It accumulates occasionally in such dense and vast quantities, that a candle will not burn within a few yards of an air-current—an air-current so strong that you could scarcely carry a candle in it without its being blown out. We remember, some years ago, whilst working some pillars on the rise side of the old waste, and close adjoining to it, when, on one occasion, the carbonic acid gas forced itself up to the face of the pillars, and obliged the workmen to retreat. We examined the mine in this instance, along with the overman, and were enabled to make some very interesting experiments with the candle, from which we found that the gas rose in the old workings precisely in the same way that water would have done under similar circumstances. Commencing on the floor of the mine, just at the point where the gas had risen to, we were able to follow the level line which it formed on the lower or dip side of the workings, till it nearly reached the roof—filling the mine exactly in the same way as an inundation of water would have done. Between this level line and the roof, the candle not only burnt clear, but the flame of it indicated a slight air-current passing round the face of the pillar, and on the surface of this dense body of gas. The instant the candle was passed below the said level line, it was extinguished as suddenly as though it had been plunged into water. The most extraordinary circumstance, however, connected with this accumulation of gas, was, that in the pillar next adjoining the one the experiments were made in, though not worked up so near the headway as it was, the workmen were not at all interrupted in their work for want of air. We were puzzled to account for this extraordinary occurrence, for the two places joined and were holed into each other, till we found that the place last mentioned was, to use a nautical

phrase, to the windward of the one the experiments were made in, and in which the current of air, though weak, was sufficient to resist the approach of this heavy column of gas, whilst in the latter, though only a few yards between them, it became too feeble to resist the attack of its more powerful antagonist. These experiments were chiefly interesting as showing us the contention and constant struggle going on between two natural forces to gain the mastery over each other, and that between the two pillars above alluded to, the resistance of each, at that particular time, was equal. Of course, we need not tell our readers that this phenomenon is produced by the peculiar state and condition of the atmosphere, and the feebleness of the air-currents circulating in that particular quarter. We wish it to be understood, also, that it was an isolated occurrence, confined entirely to the working of three or four pillars, and by no means applies to the whole mine. These experiments afforded us, also, satisfactory proof that you can have strata in a mine composed both of atmospheric air and carbonic acid gas, for here we had an open space in the mine filled with these two gases; the latter, from its being the heavier of the two, resting upon the thill or floor of the mine, whilst the former was found resting upon it. We, of course, are quite aware that what we have related above only confirms facts that have long been known, but yet we never before saw them so strikingly exhibited. The occurrence we have described in the preceding pages will, we trust, show that the quantity of carbonic acid gas evolved in the working of our mines is very considerable, and that without the exercise of proper caution in the first instance in laying out the workings, as regards their thorough ventilation, it will not only become troublesome, but the atmosphere in which the men work will be so laden with

it as to render it anything but wholesome. We are thus particular in dwelling upon this part of our subject, (and perhaps our doing so may lay us under the charge of being unnecessarily tedious, and that much of what we have stated was uncalled for), because we are anxious to impress upon the less experienced the necessity of paying every attention to a matter of such importance to the well-being of the mine, which, we are afraid, in many instances, is too much disregarded. It is thought by many that, because the gas produced in iron mines is not inflammable, and, therefore, not so dangerous as carburetted hydrogen, it is unnecessary to pay much attention to the airing and purifying of such mines. Nothing can be more erroneous than such an impression, for although it is quite true that iron mines are exempt from those terrific explosions which so frequently occur in our coal mines,—the source of so much sorrow to the hearts and homes of honest poverty—yet it is not the less necessary that their sanitary condition should be properly looked to. In a well ventilated mine the workmen pursue their employment with more vigour, as well as pleasure, than in one where, perhaps, they are half stifled for want of sufficient air; besides, the health of a large body of useful men claims no small share of the attention of a manager, who ought certainly to prevent, as far as possible, any unnecessary suffering being endured by them from such a cause. We know that there are times, after everything has been done to secure good ventilation, when in some particular portions of the mine a want of air will be felt, but this will only be for a short duration, and, generally speaking, under a prudent and judicious manager, will but seldom occur.

The few general observations we have made, in the preceding pages, upon Ironstone Mining, we trust may not

be altogether without their use. They, of course, are not addressed to persons who are already perfectly versed in the science, and thoroughly initiated in the arcana of mining minutiæ, but rather to those of limited experience in such matters, who are looking forward to, or about entering upon, the management of such undertakings. To such persons we hope they may prove of some value; and we can assure them, if the few simple rules we have thus ventured to recommend be fully adhered to in the conducting of a mine, they can hardly fail to lead to successful and satisfactory results; whilst, on the other hand, if they be unheeded, and a disregard of system be pursued, it will not fail ultimately of producing results that will end in disappointment and dissatisfaction to all concerned in the undertaking.

HARBOUR IMPROVEMENTS.

Amazing as has been the increase of mining adventure in the Cleveland district within the last few years, there is yet every probability of its rapid and further extension. This important region appears as much as ever to be attracting the attention of the enterprising capitalist, for we see new works springing up with marvellous rapidity in various parts of the district. We endeavoured to show, in a former portion of our Treatise, that the port of Whitby, from its favourable situation, ought to become the great outlet for a large portion of the produce of this iron-field, both raw and manufactured. Before this can be done, however, the obstructions which at present so much impede the exportation of this mineral must be removed, in order that shipments may be made on a much larger scale. We have found, from long experience, that without the removal of these hindrances, this desirable object will never be attained, and the immense mineral resources we possess in our own immediate locality must, to a considerable extent, remain undisturbed. We cannot, therefore, forego the temptation which the present opportunity affords us of making a few remarks on the subject, in the hope that they may lead to an effort being made to have these serious obstructions removed.

Nothing, we think, is more to be regretted than that the Grosmont district, containing, as it does, some of the most

valuable and most accessible portions of the iron-field—the locality, in fact, where first this valuable mineral was worked and made known to the public—should, at the present moment, be prevented from more fully developing the vast mineral resources it possesses, and keeping pace with other districts in furnishing the markets with a cheap and abundant supply of these minerals. This is the more to be deplored, when we consider that the sole bar to our district gaining the position it ought to occupy in the trade, is owing to the present wretched condition of our harbour at Whitby, on the one hand, and the want of facilities for loading ships at a cheaper rate, and giving them quicker despatch in taking in their cargoes, on the other. The outlay in making these necessary improvements would, no doubt, be somewhat considerable; but, when compared with the enormous sums expended in other quarters for similar purposes, would only be light. Nature, it must be admitted, has most effectually done her part, and what yet remains to be done is of easy accomplishment, were funds provided. Were these improvements, so long and loudly called for, but once completed, the immense impetus that they would give to the trade and commerce of the port and surrounding districts, it is impossible at present to foretel.

Great, however, as the increase would undoubtedly be, it would still be materially augmented when the North Yorkshire and Cleveland Railway is completed to Grosmont, and the contemplated deviation about to be made, in Goathland, on the Whitby and Pickering Branch, is finished. When this deviation is made, a thorough locomotive line will be secured between the two latter places, and the incline plane, up which, at present, the passengers and traffic are conveyed by a stationary steam engine, causing much

detention to both, will be done away with. A very greatly improved communication will then be opened between the port of Whitby and the manufacturing districts of the west riding. Whilst the opening of the North Yorkshire Railway will directly connect us with the South Durham coal-field in the north, producing the best coke in the country, which, when compared with its present cost, will be procured at a greatly reduced price, and will certainly tend to the extension of iron-works in this district. In fact, were convenience and accommodation afforded, and encouragement given, it is far from improbable that Whitby would become a considerable shipping port. We have been informed, there are occasions when a large fleet of light colliers, in proceeding northwards, are detained for a considerable time in Whitby and Bridlington Roads, by contrary winds, which, could they have taken in their cargoes at Whitby, would have been able to make their passage to London before they reached their destination in the north. The coals, in all probability, would be a little higher in price at Whitby than at Middlesborough, owing to the difference in railway dues, by reason of the increased distance, but this would, we have no doubt, be more than compensated for by obtaining a higher price for them, from the scarcity of ships that would, in all probability, be then in the market. The difference, too, in the port charges between Whitby, Hull, and the Tees, would be so great—even allowing that an advance must necessarily be made at the former place, in consequence of the capital to be expended in making the needful improvements and necessary accommodation—as to induce many parties to ship both goods and coals at Whitby in preference to either of the other places. We have no doubt but considerable traffic would be derivable from these sources alone, but the

chief object in making the improvements above referred to, would be the further development of the ironfield in our own district, which, at present, is almost entirely shut out from market. This is owing to the want of a sufficient amount of shipping to carry the ironstone to the markets of the north as "*back freight.*" As we have already, in a former portion of our work, somewhat largely dwelt upon the extent of this field—the quantity of ironstone it contains, its accessibility, and the facility afforded for working it to almost any extent, from its favourable position—we shall only again present it to our readers so far as is necessary for a clear exposition of our views on this subject. In our description, we stated that every acre of ground, on both sides of the Esk, contained about 20,000 workable tons of ironstone, much of which was exposed at the surface along the sides of the valley, rendering it easy and inexpensive to win, and readily and cheaply worked, and the only hindrance to this being done is, as we have just stated, the want of carrying craft. In fact, the carrying trade, at present, between Whitby and the Tyne, is confined entirely to a few small vessels of light draught of water, the aggregate tonnage of which has been greatly reduced within the last few years, owing to the heavy losses at sea, so that they are more scarce than ever. The consequence is, that the whole of the workings at present in operation are shipping little more than a tenth part of the ironstone capable of being raised in the district. The average tonnage of the ships we load will not exceed from sixty to seventy tons; whilst all the larger vessels, on their return passage from the Thames and other southern ports, pass by our harbour in ballast, simply because, if they were to enter it and take in but a small quantity of ironstone, the chances are that they

would be detained for a considerable time, from a want of water to carry them out again. We are, consequently, unable, from this cause, to avail ourselves of the advantage which these ships would afford for conveying our minerals to market at a cheap rate, and the large export trade, which would otherwise be established, is lost to our port, and the greatly-increased traffic which would necessarily accrue to the Railway Company, from the minerals being worked on a much larger scale, is at present lost to all parties interested in the question.

What we have thus advanced will, we trust, be sufficient to show that the deepening of the bar outside, and the removal of the extensive bank of mud (known by the name of the "Bell") inside of the harbour, ought not, for the sake of increasing the trade of the neighbourhood, and benefiting the town of Whitby itself, be any longer delayed. For, until the improvements we have suggested be completed,* no material advance can be made in the path of progress. Unless a greater depth of water can be afforded in the harbour, so as to admit vessels of a much larger draught than at present frequent the port, all our efforts to improve the trade and commerce of the district will prove futile. What we have suggested above for effecting this desirable and truly very important object, would, we believe, fail if the tide could not be allowed to flow uninterruptedly up the river Esk until it reached its level. If the impediments which at present prevent the progress of the tidal current were removed, a considerably increased volume of water

* The result of this proceeding would be a very considerable accession of quay and wharfage accommodation higher up the river, as also of space on both sides for business erections, which must necessarily augment incalculably the value of property in quarters at present shut out, thereby affording to the port a convenience and means for business which there is every reason to believe it will require if the suggestions that are offered be but attended to and carried out.

would be received into the harbour, and cause the tide to flow to a considerable distance up the river, and in its ebb would scour and cleanse it in rushing back to the ocean. At present from the want of the ingress and egress of a more considerable body of water the tidal current outward is of so ineffectual a nature as to cause the deposition in the harbour of sand and other *debris* brought into it from the sea, which, from time to time, has caused the accumulation we now see, forming, as it has done, the muddy bank above referred to, which, at low water, is so unsightly an object, (and certainly anything but conducive to health) as seen from almost all parts of the town. This is another good reason, we think, apart from the interruption it causes to navigation, why it should be speedily removed. Having said thus much with reference to deepening and cleansing the harbour, we shall next proceed to add a few words as to the improvements so greatly needed in loading ships, &c.

The next great obstacle which so much impedes the sale and exportation of our minerals, is the want of loading facilities at the shipping places, and the high rate of railway toll we have to pay on the carriage of them; for, although a reduction has lately been made, they are yet too high.

We very much question, if a thorough search of the whole kingdom was made, whether anything could be found at all approaching the wretched and deplorable condition of the quays and wharfs from which ships are loaded at Whitby. Any one who beholds the primitive and expensive method we are obliged to adopt there in loading vessels must be surprised that we have been able to maintain our ground for so many years past in competing with the North Cleveland people in the markets of the north.

Every facility is afforded them for working and shipping their stone, and the railway dues they pay upon the produce of their mines are much less than ours.

In order to show the disadvantageous position we are placed in, when compared with the above district, in this respect, we have only to mention that Messrs. Pease and Bell Brothers have their ironstone taken from their mines and put free on board in the Tees, a distance of seven miles, for eightpence per ton, wagons and loading inclusive, whilst the cost upon our ironstone—the distance between the works and the port being only six miles—in the items of dues, wagons, loading, &c., is 1s. 3d. per ton, which, when the difference as regards distance is taken into account, is one-half more than is paid by the North Cleveland mine proprietors. Whilst we have just grounds, we think, for writing on this subject in the language of complaint, we are at the same time desirous, as far as possible, of avoiding the use of language that is at all calculated to give offence. Seeing, however, the unfair and unfavourable position we are thus, and have so long been placed in, for successfully competing with other parties, who at present possess all the advantages we ask for, we must be excused for saying that the state of things we have above described is, in the present day, really a disgrace to all connected with them. The full development of our mineral resources is not only thus completely frustrated, but a positive injury is in consequence inflicted upon the neighbourhood at large, which can no longer be passed over in silence. We trust, however, that as we have already laid a statement of these grievances before the railway board of directors, no further remonstrance will be needed, but that a remedy will ere long be found for the evil complained of.

We trust that what has been stated in the preceding

pages will satisfactorily show to all unprejudiced persons that there exists an absolute necessity for the alterations and improvements we have there suggested. Should the observations we have ventured to make unfortunately remain unheeded, it is easy to foresee the lamentable consequences that must flow from such indifference; whereas, if they meet with a favourable reception from those who are most interested in their completion, they will not fail to enhance the value of property, and greatly increase the trade and prosperity of the district.

There can be no question, we think, but that the party whose interest it is to stir in this matter is the North-Eastern Railway Company, who would not only be greatly benefited, in a pecuniary point of view, by the expenditure of a moderate outlay, but would also render themselves more independent, by having there an excellent harbour of their own, second to few on the east coast, for the export and import of goods, and traffic of all descriptions. We say a harbour of their own, because, now that they have secured the North Yorkshire and Cleveland, they have nothing to apprehend from any competing line. The port of Whitby is most favourably situated for a ready and expeditious communication with the French, German, and Baltic ports, to which we send large quantities of the iron produced in this country, and which is still likely to be greatly augmented. In fact, we are impressed with the belief, that when the improvement before adverted to is made on the Whitby and Pickering Branch, and the North Yorkshire and Cleveland Line is completed, the increase of traffic which they will occasion, from various sources, will be such as to render the making of the harbour improvements a matter of absolute necessity with the North-Eastern Company; and we are disposed to think that the share-

holders could nowhere invest a portion of their capital to greater advantage, as well as to increase the value of their whole concern. We cannot help thinking that the elements of a considerable commerce, and the source of a large traffic, which the region round about Whitby possesses, has hitherto been almost entirely overlooked. This, perhaps, may be partly accounted for from its isolated position, and from the bad impression which the premature and injudicious attempts to work certain minerals in the district have made, all of which, as was plainly seen would be the case, resulted in failure and disappointment. The immense sensation, too, which the ironstone openings in North Cleveland caused at the time, coupled with the enormous thickness of the seams in the Eston district, led people unacquainted with the subject to believe that the mines in the locality of Whitby must of necessity be abandoned, from their inability to compete in the market with these above-mentioned. We have only to state that, so far from this being the case, the only hindrance to a very greatly increased annual vend is, as we before stated, the scarcity of shipping, which has caused a great rise in the freight from Whitby and the beach to the Tyne. From the latter place, parties have been paying as high as 3s. 6d. per ton, being quite equal to a coal freight, which, in the present state of the iron trade, makes the ironstone become exceedingly expensive. Formerly, except on extraordinary occasions, we could obtain a plentiful supply of vessels at 1s. 6d. to 2s. per ton; and we have no doubt that, if the water in the harbour was of sufficient depth to admit a larger class of ships, we should again see the freight down to these more reasonable figures, with a plentiful supply of vessels, which would at once, beyond all doubt, remove the impediments to our making shipments from different

localities to an almost unlimited extent. We have been induced to make these observations solely with a view of placing before the public the present position of the ironstone trade of our district, and we shall greatly rejoice if what we have advanced should be the means of expediting the removal of the incubus which so greatly trammels our present shipments.

COAL DEPOSITS.

It is hardly possible for any author, who professes to treat on the geology of Cleveland, to avoid entirely all reference to the subject of coal, and, in compliance with the strongly expressed wishes of many friends, we purpose, in concluding our treatise, to briefly advert to the subject.

Amongst all the mineral products with which the crust of our globe teems, socially, commercially, and beneficially considered, none are of such value and importance to the whole family of man as coal. It is to this bituminous compound we owe so many of the social comforts we enjoy around the domestic hearth. It is through its potent agency that we extract the valuable metallic substances from other more refractory minerals, which constitute the elements of our country's greatness, and have gained for her the proud position she at present holds amongst the nations of the earth. In fact, it may be said, that it is owing to this inflammable substance that England's artizans are without rivals in the manipulation of all that is most useful to mankind, which, together with iron, form the basis of that immense wealth and colossal enterprise which so much distinguishes our country, and has made her the wonder, the envy, and admiration of the world.

The formation of this substance, now admitted by all, we believe, to be of vegetable origin, has been a subject of much speculation and controversy amongst naturalists and geologists. There are many who admit the truth of its

origin, and yet cannot possibly conceive how such an immense mass of vegetable matter, as would be required for the formation of our coal-fields, could ever be produced through the ordinary course of nature. We must confess, that we were, for a length of time, puzzled and perplexed, like many others, to satisfactorily account for the formation of these enormous depositories of fossil fuel, when it occurred to us, that at the period of their deposition no terrestrial animals were then in existence to feed and fatten on the profuse vegetation which then, as now, adorned the earth. We have proof, too, that at that period our planet was surrounded by a highly rarefied atmosphere, evinced by the gigantic size and prodigious quantity of vegetable organic remains found imbedded in, and associated with, the coal deposits, such as are now only met with in tropical climes. We may, therefore, conclude that vegetation, at that period, would be of very quick growth and exist in great profusion. When we consider, too, that it grew for no other purpose than decomposition and decay, it is easy to conceive with what marvellous rapidity this decayed vegetable matter would accumulate, which, through a long series of years, became more and more consolidated, forming ultimately the black and glossy rocks, which were eventually to contribute so much to the health and happiness of mankind.

If the views we have enunciated above be accepted, they will, we think, remove much of the difficulty which met us in accounting for the requisite quantity of vegetable matter for the formation of our coal-fields. We remember that, a short time after making, what we considered, a discovery as to the non-existence of terrestrial animals during the carboniferous period, we wrote Professor Phillips on the subject, when we found the idea was not an original one, and had already been noticed in one of his works.

There is nothing that we can conceive of greater interest to geologists and mining engineers, and certainly nothing of greater importance to the owners of the soil, and in fact to the whole of the North Riding, than a satisfactory solution to the long vexed question as to the existence or non-existence of the South Durham coal field, at a workable distance, beneath the lower lias in the region of North Yorkshire. The opinions on this subject are as numerous as they are various, and, of course, all of a speculative or theoretical character. There are those who boldly assert their strong conviction that coal will be met with within a workable distance of the surface, whilst there are others who are equally strong in their belief that the whole of the coal measures are wanting in that portion of the county, and a third party will tell you that the carboniferous series are there buried far beneath the reach of human industry. It follows, as a matter of course, that where so great a variety of opinions prevail, some one of them must of necessity prove correct. Nothing, however, but a practical experiment can unfold to us the true prophet, for it is only by such means that the problem can be solved. We shall more fully explain the views held by each of these parties on this interesting and important subject, but before we do so we wish to refer to the experiments already made in different localities in our own district, in search for coal, in order to shew to our readers that for want of geological knowledge, the money so spent (with one exception) was completely thrown away.

The first of these experiments, we have been informed, was made many years ago in the neighbourhood of Ruswarp, by Col. Wilson, of Sneaton Castle, and when we tell our readers that the whole of the strata they there bored through, could have been seen exposed to view in many of

the adjoining localities, it is not at all to be wondered at that after expending a large sum of money it should result in failure. Owing to the want of records we have not been able to ascertain to what depth this boring penetrated, or what was the object the party had in view in making it. Whether, however, it was made to prove the thickness of the moorland coal in our own district or to inform themselves of the nature of the strata beneath the lias, the situation was equally ill-chosen. For, in the first instance, as we have just stated, the rocks they cut through could have been seen by the sides of many of the valleys adjoining, without incurring the least expense in making experiments. If the latter was their object, a worse selection with respect to locality could not have been made, because the strata they commenced the boring in at the bottom of the plain, are to be seen capping the high moorland ground a few miles to the westward. In fact, had the boring been commenced in the bottom of the valley, a little to the west of Sleights Bridge instead of Ruswarp (vide section No. 2), they would have begun some five or six hundred feet lower down in the series; or, in other words, instead of commencing in the oolitic rocks, they would have begun about one hundred and thirty feet into the lower lias. This injudicious proceeding, we think, very clearly illustrates the necessity of placing such undertakings in the hands of intelligent and professional men.

We will insert here a short paragraph for the guidance of those who may hereafter be engaged, or in any way interested in such undertakings.

To begin with, before a boring is commenced, the whole district ought to be carefully examined by a competent professional man, not only with a view of selecting the most desirable situation, but also to examine the state and

condition of the strata surrounding that which it is intended to experiment upon; noting their angle of depression, the direction of the inclination or dip and rise, and to see that the rocks are free from dislocations, contortions, &c.; or if such are found to exist, to ascertain the amount of the twisting or displacement they occasion. And it may happen, too, that by examining the strata in the adjoining localities, you may be able to discover the nature of those it is intended to examine by boring, which might very materially assist you in making your calculation as to the cost of the operation, &c. This done, the boring should be placed in the hands of a good, practical, and experienced person, and samples of every stratum cut through numbered, labelled, and carefully kept for the testing and inspection of the superintendent.

We would observe, in closing this paragraph, that borings made for the purpose of ascertaining the quantity and quality of the ironstone, in a district like Cleveland, are not at all times to be relied upon, especially if they are conducted by parties who are not intimately acquainted with the stratification and character of the rocks peculiar to this portion of the county. The truth is, you may very frequently be boring in shale, strongly impregnated with iron (but, of course, not in quantity sufficient to make it worth working), and almost as hard as ironstone itself, which may be easily mistaken for it. The liability there is, too, of meeting with nodules of ironstone in the borehole, probably of considerable thickness, which, of course, are always registered as bands of ironstone, renders this mode of examining such strata extremely fallacious.

The second boring we have to notice was made in Newtondale, rather more than half way between Whitby and Pickering, which was under the superintendence of that

illustrious character the elder Stephenson. This boring—a section of which is in our possession—proceeded to the depth of one hundred and ninety-three feet and was then abandoned, nothing but a very small seam of coal, a few inches in thickness, having been met with, the same, in fact, which is seen throughout the moorland district. Indeed this boring affords a very excellent section of the shales and sandstones found associated with that inferior coal. What Mr. Stephenson's object was in making this experiment we have never been able to ascertain, the answer to all our enquiries being always the same—to find coal. This, of course, we very readily agreed to, and as Mr. S.'s geological knowledge must have convinced him of the folly of boring in such a situation for the purpose of ascertaining the nature of the strata below the lias formation, we may fairly assume that his object was to prove the thickness and quality of the moorland coal in that locality, no doubt thinking there was a probability of the seams becoming thicker as they descended farther below the surface; be that as it may, the experiment failed to realize the hopes of its promoters. We have not the date when this experiment (nor indeed any of them) was made, but we rather think it would be about 1835, during the making of the Whitby and Pickering Railway. The next trial of the same description—which is the last we shall have to mention—was commenced at Grosmont, unaccountable as it may now seem, in the ironstone strata between the pecten and avicula seams, and after penetrating to the depth of sixty or eighty feet, shared the same fate as its predecessors. To show how little was then really known of the geology of the district we may just mention (which will be seen by again referring to No. 2 section), that by going a distance of two or three miles to the eastward, where the lower portions of

the bold cliffs which front the valley are formed of the lower lias, they would have seen, fully developed to view, nearly two hundred feet of strata, all of which are below the bottom of their borehole. A well-known geologist (considered a high authority in such matters) was consulted, by one of the gentlemen concerned, as to whether the locality was a suitable one for such an undertaking, and we have a copy of his letter at present in our possession, wherein he gives it as his opinion (at the same time holding out no prospect of coal being found) that the locality chosen for the boring operations was the best that could be selected in the district for making such an experiment. We could very well, in connection with this subject, have inserted his letter in this place, but as some, perhaps, might think we had given it publicity for another purpose, we forbear. We have noticed these borings more particularly with a view to show that none of them were at all calculated to add to the knowledge we possess as to the nature and character of rocks below the lias formation, or as regards the existence or non-existence of the Durham Coal-field in North Yorkshire. In fact, we consider that these experiments resulted in nothing but a waste of time and money.

We trust, after this explanation, all who are interested in the solution of this most important question may be induced, when the period arrives, to render their assistance to some well organized project for thoroughly examining, by a deep boring, the strata below the lias in this district. At present, nothing is known for certain as to whether the new red sandstone and magnesian limestone pass underneath the lias formation, or alternate with it, and nothing can be known until an experiment is made, such as we have above suggested.

We stated, in the preceding pages, that a variety of

opinions are, at present, entertained upon this subject, and mentioned three as particularly demanding our notice. The theory of the first is, that the Durham coal-field will, in all probability, exhaust itself by the time it reaches the river Tees, because it is found that the whole of the coal measures are rising in a southerly direction to the south of Hartlepool, but, as they very justly observe, there is no reason why they should not descend below the lias rocks again on the south of that river, and continue through the lias district. The second party are quite agreed with the first as regards the change in the dip and rise of these strata, and also as to the point where, in all probability, they exhaust themselves. They argue, however, from the circumstance of the coal seams edging out to the surface to the south in the Auckland district, that between that point and the west-riding coal-field, in the neighbourhood of Leeds, the whole of the coal measures are absent. Their views are strongly corroborated, too, by the fact that at a point on the river Tees, in the neighbourhood of Croft, and also at Knaresbrough, the magnesian limestone is seen resting upon the millstone grit (the rock upon which the carboniferous series rests), placing beyond doubt the fact that the coal measures are wanting in that neighbourhood. Supported by this striking occurrence, their opinions appear to lean to the belief that the lower lias on the south of the river Tees may also be found covering the millstone grit, and that there too the coal measures will have no existence. The theory of the third party is, that the whole of the carboniferous series will be found maintaining their angle of depression or dip in a south-easterly direction from the south of Hartlepool, so that by the time they reach the lias district of North Yorkshire, will have descended so far beneath the surface as to be unworkable. We think,

however, that the facts above adduced, showing that the seams of coal are seen cropping out to the surface on the north of the river Tees, ought at once to have extinguished this geological myth, which we believe, nevertheless, has still its supporters. As practical experience has, however, already dispersed many of these misty and fanciful speculations, we hope that from the same indisputable source, the reality with regard to the existence of the coal-field in the lias district will, ere long, be unfolded.

Having, as far as we are able, explained the opinions which at present prevail with regard to the South Durham coal-field extending into North Yorkshire, we, perhaps, may be permitted to state the conclusion we have arrived at with reference to the solving of this interesting problem. Without holding any very strong or decided opinion on the subject, we desire to say, that after long and careful consideration, we are impressed with the belief that there is just as great a probability of coal being reached, at a workable distance from the surface, in our district, as there is for supposing it has no existence at all; and that a subject of such vast importance should no longer remain shrouded in the doubt and mystery which at present surround it, but that a public experiment ought to be made at the expense of those who would be most benefited in the event of coal being found.

The fact of the red sandstone and magnesian limestone having been discovered in the river Tees, and again at Knaresborough, resting on the millstone grit, ought not to deter the landowners, and others interested in the matter, from supporting a well-devised scheme that shall be calculated to afford a final and satisfactory solution of a subject of such vast importance to the whole of the region of North Yorkshire. It is quite possible, nay, probable, that the

millstone grit and other older rocks may have been stripped of large portions of the carboniferous series by the denuding effects of oceanic currents in ancient seas; just as we now behold that much of the lias formation has been swept away from the same cause, for any one at all conversant with such matters must perceive that at an antecedent period this formation must have extended far beyond the escarpment which at present marks its northern boundary. There is, therefore, nothing utopian in supposing that the coal measures, at a period further removed still from the present time, suffered in like manner from oceanic encroachments, especially in situations like that of the estuary of the Tees, where, from internal upheaval, in all probability, they appear to have been so much exposed to the violence of turbulent and wasting currents. Such denudations, however, are generally local, and their geographical extent, comparatively speaking, limited. To maintain, therefore, that the whole of that portion of the North Riding occupied by the oolites and lias is entirely bereft of this valuable fossil-fuel, simply because it is wanting in the localities adverted to, is an assumption so extravagant, paradoxical, and unwarranted by elicited facts, as to be scarcely worth controverting. Whilst we think it would be exceedingly presumptious for any one positively to assert that coal will be found at a moderate depth in the district in question, we have no hesitation in reiterating what we have already stated, viz., that as the subject is of national importance, it is every way worthy of a public experiment, and that the knowledge (limited as it is) which we at present possess in respect to this matter, points just as favourably to a successful issue as an adverse result.

We are glad to be able to lay before our readers the following remarks on the subject we have above adverted

to, made by a gentleman of great experience, and perfectly conversant in such matters, which were received by us after our own observations were penned. It will be seen that they fully corroborate the statements we have made, and coincide with the views we entertain, as to coal being found beneath the lias in North Yorkshire. They are from the pen of Mr. P. S. Reid, mining engineer, Pelton Colliery, near Chester-le-Street, under whose supervision, during the latter part of the time, the experiment at Kirkleavington, on the property of Viscount Falkland, was made, which circumstance adds much value to his opinion.

REMARKS ON THE PROBABILITY

OF

REACHING THE COAL MEASURES

UNDER THE LIAS AND OTHER FORMATIONS

IN NORTH YORKSHIRE AND CLEVELAND.

Many attempts have been made to prove by boring the continuation of the Durham Coal-field into Yorkshire. Hitherto all have been unsuccessful, and to this date the practical termination of the coal-field of the two northern counties may be said to be defined by a line drawn from South Wingate Colliery to Bishop Middleham, and thence by Little Chilton, Old Chilton Pit, Leasingthorne, and Eldon, to the Shildon district.

At the South Wingate Colliery, Bishop Middleham, and Old Chilton Collieries, coal was reached by sinking, but in each case was found so unsatisfactory and uncertain in its thickness, quality, and position, as to cause its working, in each case, to be abandoned.

The various trials to the south of these places do not prove, whilst, at the same time, they do not disprove, the continuation of the coal-field, inasmuch as none of them, after passing the new red sandstone rocks, have perforated more than a few feet of the magnesian limestone lying below it.

Until the latter strata be passed through, and a sufficient distance more be bored to confirm the existence of the strata below it, and prove their nature, it must be confessed that no proof exists that the coal measures are not continuous under the lias, &c., and that they do not unite the two important coal-fields of Yorkshire and Durham.

It is true that denudation, or other causes, may have swept them away in the estuary of the Tees; yet, as the gap to be filled up between the southernmost coal of the Durham field and the northernmost known of that of Yorkshire, exceeds sixty miles, it would be premature to conclude, upon such evidence as we now possess, that this denudation extended over the whole of that space, so as completely to destroy the continuity of the coal seams from Durham southward.

To enumerate the numerous facts which bear upon the point in question, we may assume what is a well-established fact, that at Pierce Bridge, on the Tees, west of Croft, we have in the bed of the river, cropping out below the red sandstone and magnesian limestone of that district, a rock which is no other than the millstone grit, this leaves the question of "how far to the eastward it may continue to maintain its position," for solution.

At Croft, where Sir William Chaytor began his boring for coal, and only reached a depth of ten fathoms, the hole was abandoned on tapping a sulphureous spring, which forms the mineral water of that place to this day.

Farther to the eastward, on the side of the Tees, near Eryholme, a boring was put down, in 1807, by the late Mr. Allen, of Blackwell Grange. This hole reached the depth of one hundred and eleven fathoms four feet six inches—the last six fathoms *only* being through magnesian limestone. This boring would have been pursued deeper,

had it not been for an accident, which fastened ninety fathoms of rods in the hole, where they remain to this day.

Similarly, at Dinsdale, at the Fishery, and at Woodhead on the Tees, several holes were put down by General Lambton, or the late Lord Durham, the depth of the holes being respectively 10, 66, 16, and 74 faths. 1 ft. 4 in.

From what can be learnt, only the two deepest of these holes touched the magnesian limestone, and when this is said, it must be understood that it was a rock answering to the description of this stratum when bored to, but which was not finally passed through nor chemically analyzed.

Why it was not, in these two deep holes, pursued farther we are not informed.

The next point, with reference to date, in which an attempt was made to prove coal was at Oughton, near Hartlepool, about two miles west of Seaton Carew, where, after boring to a depth of 108 fathoms, the magnesian limestone was cut by Mr. Wm. Coulson, of Durham, and a large feeder of water tapped, which flows from the top of the hole, and after boring five fathoms more, or in all 113 fathoms, the undertaking was abandoned.

The latest attempt was that made about sixteen miles to the south of this point, at Kirkleavington, by Lord Viscount Falkland, who, after much trouble and expense, reached a depth of 119 fathoms, leaving off in red sandstone at this depth. It was stated by Mr. Lewis Thompson, who had charge of the upper part of the hole during its progress, that several beds of magnesian limestone had been met with, but, as considerable quantities of red rock were afterwards found, it may be concluded that this was not the true magnesian limestone strata, but merely some isolated bands of that nature. This hole is still open, although Lord Falkland ceased to prosecute it in 1858 for a time, stipulating, that if others liked to proceed with it they

could do so at their own cost, they having the use of such apparatus as was left on the spot.

Having enumerated the various attempts which have been made to prove coal, it must be confessed that there is ample field for further investigation, so long as the magnesian limestone is not passed through at such moderate depth as to determine the strata below it available for coal mining, and also assuming that it is that of the coal measures, and not of any of the rocks below them, the subject of the possibility of coal being found in Cleveland must be held as "*not proven.*"

With reference to the depth at which coal mining can be advantageously carried out, we have ample proof in the mine of Monkwearmouth, and elsewhere in England, that there is no difficulty in doing so to the depth of 300 fathoms below the sea-level. Assuming, therefore, that the greatest depth bored below high-water mark does not exceed 100 fathoms, we have a depth of 200 more to go before we could conclude that the working of a colliery in Cleveland would be impracticable.

One point must be noted in the various attempts to bore in the district in question, and that is, the inefficiency of the means adopted to attain great depths.

A second is, in the choice of position for an attempt of so much importance ; this is of the utmost moment, as the fact of success does not depend upon simply one boring, so much as proof of the coal measures over an extended area, in which nothing will be more conducive than a number of well chosen and judicious points. This must, again, depend upon an intimate knowledge of the various faults which affect the overlying strata, as this again must, in all probability, equally apply to the coal or other strata below these rocks.

There are many points connected with this last subject

which have been brought to my notice during the various investigations on Viscount Falkland's behalf, which cause me to express an opinion that the strata under the Cleveland hills will be situated, so far as I can see, rather to favour the opinion that the coal measures may be conveniently placed for their chance of being of use, should they ever be discovered.

It will be agreed, however, that the matter is almost one of national importance. Favourably as the iron mines of Cleveland are placed for economic production, a few coal mines, placed so centrically as to enable a still further saving of 5s. per ton on the price of production of pig iron, is a subject of such importance as to demand of the ironmasters their most serious attention.

With reference to the value of these mines to the landowners, it ought to be borne in mind that a discovery of such importance would treble the value of a very large tract of country.

It is, therefore, for the interest of all to unite in a project which will fix a point of so much interest, and to endeavour, by a well-concerted series of borings, to ascertain whether or not the coal measures, or some other rocks of a less promising nature, exist below those already so valuable for the ironstone mines in Cleveland.

The cost of so important a work would, no doubt, be great; but, apportioned, as it would be, over so large an area, and amongst so many wealthy and influential parties, it would be so lightly felt as to make the matter of non-success of trivial importance.

APPENDIX.

The following section, from which No. 1 coloured section is constructed, it must be remembered, can only be applied to the immediate localities to which our survey and measurements refer. A notification of such places will be found in the margin. The liability of the oolitic rocks to change their character, either from alternation or gradual transition, renders them exceedingly capricious, and, therefore, precludes the possibility of making a general section of the consecutive strata the true representative of any great extent of surface :—

A Tabular Synopsis of the Strata forming the Oolitic and Lias Group in the Vales of Eskdale, Goathland, Newtondale, and Pickering.—From actual survey by Jos. Bewick.

Where seen.	Nos.	Names of Strata.	Ft.	In.
Goathland, Brocklebeck, Ellerbeck, Saltersgate Brow, Hole of Horcum, Newtondale, Lockton, and Pickering.	1	Oolitic limestone	60	0
	2	Fine yellow sandstone	30	0
	3	Grey shale	16	0
	4	Calcareous grit	3	0
	5	Light grey shale	54	0
	6	Calcareous grit	1	6
	7	Light grey shale	25	0
	8	Sandy shale	20	0
	9	Light grey shale	8	0
	10	Calcareous grit	1	0
	11	Light grey shale	16	0
	12	Ironstone nodules	0	9
	13	Flagstone, containing impressions of reeds	13	0
	14	Grey shale	15	0
	15	Nodular ironstone	0	9
	16	Grey shale	3	0
	17	Ironstone (good)	1	3
	18	Grey shale	3	0
	19	Ironstone nodules	0	4
	20	Sandstone, mixed with shale	23	0
	21	Shale and flagstone, iron nodules, &c.	34	0
	22	Calcareous grit	2	0
	23	Sandstone and shale	17	0
	24	White grit, occasionally mixed with quartz	45	0
	25	Blue shale	10	0
	26	Blue limestone, inferior	12	0
		Carried forward	414	7

Where seen	Nos.	Names of Strata.	Ft.	In.
		Brought forward	414	7
Between Goathland Mill and Danholme.	27	Calcareous sandstone	5	0
	28	Sandy shale	4	6
	29	Fine laminated sandstone	4	6
	30	Sandstone rock	5	0
	31	Sandstone and shale	6	6
	32	Dark blue shale, with traces of coal (No. 3)..	1	4
	33	Blue shale	3	9
	34	Inferior fire clay	2	6
	35	Sandstone	2	0
	36	Sandy shale	1	0
	37	Coaly shale (No. 2)	1	10
	38	Sandstone	4	0
	39	Grey shale	1	8
	40	Inferior coal	0	6
	41	Sandstone, mixed with shale	15	0
	42	Sandstone rock	20	0
	43	Coal, No. 1 (mixed with shale).....	1	9
	44	Grey sandy shale	1	0
	45	Ferruginous nodules	0	6
	46	Blue shale, mixed with fire clay and ironstone nodules.....	3	0
	47	Sandstone, mixed with iron nodules	2	0
	48	Grey sandy shale	7	6
Between Danholme and Beckhole.	49	Sandstone rock	5	0
	50	Dark shale, with tracing of coal seam (No. 1)	2	0
	51	Dark shale, mixed with iron nodules and fire clay	9	0
	52	Sandstone	2	6
	53	Ironstone (irregular arenaceous bed)	2	0
	54	Grey shale	2	0
	55	Sandstone rock (No. 2).....	18	0
	56	Fine laminated sandstone	2	6
	57	Grey shale	0	10
	58	Nodular ironstone	0	4
	59	Grey shale	4	3
	60	Ironstone bed.....	1	0
	61	Grey shale	4	0
	62	Fire clay	1	6
	63	Grey shale, mixed with ferruginous nodules	16	0
	64	Sandstone rock (No. 1).....	80	0
Grosmont	65	Top seam	12	0
	66	Upper lias shale	100	0
	67	Dogger rock	100	0
		Carried forward	872	4

Where seen.	Nos.	Names of Strata.	Ft.	In.
		Brought forward	872	4
Grosmont	68	Ironstone	0	6
	69	Shale	3	6
	70	Ironstone	0	4
	71	Shale	2	0
	72	Ironstone	0	10
	73	Shale	3	1
	74	Ironstone	1	8
	75	Shale	4	4
	76	Ironstone	0	6
	77	Shale	3	10
	78	Ironstone	0	6
	79	Shale	1	7
	80	Ironstone	0	6
	81	Blue shale	4	0
	82	Ironstone } pecten seam {	1	0
	83	Shale } pecten seam {	1	6
	84	Ironstone } pecten seam {	2	0
	85	Shale	4	0
	86	Ironstone	1	0
	87	Blue Shale	7	6
	88	Nodular ironstone	0	6
	89	Blue shale	18	0
	90	Ironstone (avicula seam)	3	9
	91	Blue shale	2	0
	92	Ironstone, in nodules	0	9
Eskdaleside	93	Marlstone rock	95	0
	94	Lower lias	140	0
		Total	1176	6

Section of the Main Seam at Grosmont.—From actual survey by Jos. Bewick.

Nos.	Names of Strata.	Ft.	In.
1	Ironstone	0	6
2	Shale	3	6
3	Ironstone	0	4
4	Shale	2	0
5	Ironstone	0	10
6	Shale	3	1
7	Ironstone	1	8
8	Shale	4	4
9	Ironstone	0	6
10	Shale	3	10
11	Ironstone	0	6
12	Shale	1	7
13	Ironstone	0	6
14	Blue shale	4	0
	Carried forward	27	2

Nos.	Names of Strata.		Ft.	In.
		Brought forward.....	27	2
15	Ironstone	pecten seam	1	0
16	Shale ...	pecten seam	1	6
17	Ironstone	pecten seam	2	0
18	Shale		4	0
19	Ironstone		1	0
20	Blue shale		7	6
21	Nodular ironstone		0	6
22	Blue shale		18	0
23	Ironstone (avicula seam)		3	9
24	Blue shale		2	0
25	Ironstone in nodules		0	9
		Total	69	2

Section of the Main Seam, as proved in No. 1 *Shaft, at the New Winning of Messrs. Bell, Brothers, at Skelton.—(Furnished by John Bell, Esq.)*

	Ft.	In.
Dogger	3	0
Sulphur band	0	6
Thick block.....	9	4
Shale	4	0
Ironstone	0	9
	17	7

Section of the Lias Formation at Swainby.—(Furnished by Mr. Hall, Agent to the Mines.)

	Ft.	In.	
Blue shale.....	14	0	
Ironstone	6	8	
Blue shale.....	168	0	
Ironstone	2	6	Forming the working in the pecten seam.
Shale	1	8	
Ironstone	1	4	
Shale.....	11	0	
Ironstone	3	0	Avicula seam.
Marlstone, and lower lias	300	0	
	508	2	

Section of the Main Seam at Kildale.—(Furnished by John Bell, Esq.)

	Ft	In.
Dogger	0	11
Shale	1	1
Sulphur band	0	9
Ironstone	3	0
Shale	1	10
Ironstone	2	0
Shale	2	3
Ironstone	0	9
Shale	0	3
Ironstone	0	1½
Shale	2	9
Ironstone.....	2	8
	18	4½

A General Section of the Strata at Eston, in Cleveland.—(Furnished by John Bell, Esq.)

	Fm.	Ft.	In.
Yellow clay	1	0	0
Blue clay	0	4	0
Red freestone	0	3	0
White freestone	2	4	0
Brown freestone	2	3	0
Freestone and shale	5	4	0
Yellow freestone	0	3	0
Freestone and shale	1	0	0
Light shale	2	3	0
Blue shale	0	3	0
Shale and freestone	3	3	0
Dark shale	0	3	0
Yellow freestone	2	1	0
Light blue shale	0	3	0
Freestone	10	1	0
White freestone	1	4	0
Light shale	2	3	6
White post	0	5	6
Light shale, with coal	2	0	0
Dun stone	0	4	0
White freestone	1	5	0
Shale	2	0	0
Grey freestone	2	3	0
Shale	0	3	0
White freestone	7	3	6
Blue shale	1	2	9
White freestone	4	5	9
Shale	2	0	0
Ironstone	0	0	2
Shale	0	0	9
Ironstone	0	0	4
Shale	0	1	9
Ironstone	0	0	4
Shale	0	1	0
Ironstone	0	0	8
Alum shale	25	1	0
Jet shale	5	0	0
Shale	3	4	8
Shale and ironstone	1	3	7
Ironstone	0	0	7
Shale	0	0	2
Ironstone	2	0	9
Total	103	3	9

The following sections have been extracted from Mr. Marley's paper on the Cleveland Ironstone, read before the members of the Institute of Mining Engineers, Newcastle-on-Tyne, in June, 1857.

Section of Strata at Hutton-Lowcross or Codhill Ironstone Mines.

JET ROCK.	Ft.	In.	Ft.	In.
Many pyritous nodules, very much flattened	20	0		
Hard compact shale, very sandy; a few small nodules, very barren in fossils	30	0		
Carried forward			50	0

	Ft.	In.	Ft.	In.
Brought forward.....			56	0
MAIN IRONSTONE BED.				
Ironstone (nodule band)	1	4		
Dogger band, very much mixed with shale	1	2		
Sulphur band or pyrites	0	2		
Ironstone	0	2½		
Sulphur band or pyrites	0	2		
Ironstone block, good	3	5		
Ironstone band, mixed with shale	0	5		
Ironstone block, good	2	8		
Shale	0	8		
Ironstone	0	4		
Shale	0	8		
Ironstone	0	3		
Shale	0	3		
Ironstone	0	3		
Shale	0	3		
Ironstone	0	6		
Shale	0	3		
Ironstone	0	4		
Shale	0	4		
Ironstone	0	6		
Shale parting	0	0		
Ironstone, good	1	0		
Shale	0	2		
Ironstone, good.....	1	6		
Shale	2	0		
Ironstone	0	4		
Shale	0	2		
Ironstone, good	1	6		
			20	9½
Shale			5	0
			75	9½

Total ironstone, 15 feet 8½ inches.

The average Working Section of Hutton-Lowcross or Codhill Main Bed is as follows:—

	Ft.	In.			
Top block of ironstone	2	7½	No. 1 in analysis hereafter given.		
Parting	0	0			
Middle block of ironstone, viz.:—					
Ironstone, 9½ in. friable					
Parting occasionally	1	9½	No. 2	ditto	ditto.
Ironstone (very compact), 1 foot					
Bottom block of ironstone	1	8	No. 4	ditto	ditto.
	6	1			

Section of the Main Ironstone at Normanby Mines.

	Ft.	In.	Ft.	In.
Dogger or top band of ironstone.....	2	6		
Sulphur or pyrites	0	2		
Main block of ironstone	8	0		
Bottom ditto	0	9		
			11	5

Section of the Main Seam at Eston Mines.

Shale roof dips South 5 East about 2 inches to the yard.

	Ft.	In.	Ft.	In.
Main ironstone bed, having an occasional parting about 3 feet from the top, and a regular parting about 2 feet from the bottom	13	0		
Blue shale	5	0		
Ironstone	2	2		
			20	2

Section of Strata at Belman Bank Mines, near Guisbro'.

	SHALE ROOF.	Ft.	In.	Ft.	In.
Left to support roof as far as possible.	Dogger band of ironstone	1	0		
	Shale	0	10½		
	Dogger band of ironstone	0	4¾		
	Sulphur band of pyrites, intermixed variously with dogger band	0	9		
				3	0¼
	Top block of ironstone	3	5½		
	Dogger band of ironstone	1	11		
	Bottom block of ironstone	1	10		
				7	2½

Section of Strata at Boulby, near Lofthouse, Cleveland.

SHALE ROOF.	Ironstone. Ft.	Ironstone. In.	Shale. Ft.	Shale. In.
Dogger band of ironstone	0	5	0	0
Shale	0	0	1	4
Top block of ironstone	3	2	0	0
Shale	0	0	1	1
Bottom block of ironstone	2	5	0	0
Shale	0	0	3	7
Ironstone	0	7	0	0
Shale	0	0	0	7
Ironstone	0	7	0	0
Shale	0	0	0	5
Ironstone	1	0	0	0
Shale	0	0	0	7
Ironstone	0	5	0	0
Shale	0	0	0	0
	8	7	7	7

Section of the Strata in the Signal Cliff at Staiths.

		Fm.	Ft.	In.		Fm.	Ft.	In.
1	Soil	0	0	0		0	4	0
2	Reddish clay	0	0	0		1	4	0
3	Alum rock	0	0	0		1	1	0
4	Jet rock	0	0	0		1	5	0
5	Blue Shale	0	0	0		10	1	0
6	Ironstone dogger	0	0	6		0	4	0
7	Blue shale	0	3	6				
8	Ironstone	0	3	0	main bed or seam	1	0	5
9	Blue shale	0	0	7				
10	Ironstone, with two blue shale partings	0	2	10				
11	Blue shale					0	1	0
	Carried forward					17	2	5

		Fm.	Ft.	In.	Fm.	Ft.	In.
	Brought forward				17	2	5
12	Ironstone	0	0	3			
13	Shale (blue)	0	0	3			
14	Ironstone	0	0	3½			
15	Blue shale	0	1	6			
16	Ironstone	0	0	5			
17	Blue shale	0	0	5½			
18	Ironstone	0	0	4½			
19	Blue shale	0	0	2½			
20	Ironstone	0	0	6	1	5	2
21	Blue shale	0	0	5½			
22	Ironstone	0	0	7			
23	Blue shale	0	0	3½			
24	Ironstone	0	0	3½			
25	Blue shale	0	0	4			
26	Ironstone	0	0	5½			
27	Blue shale	0	3	0			
28	Ironstone	0	1	6			
29	Blue shale	1	3	9			
30	Ironstone	0	0	10			
31	Blue shale	2	3	0	10	0	7
32	Ironstone	0	2	0			
33	Blue shale	5	3	0			
	Sea beach, total fathoms				29	2	2

Aggregate of ironstone, including the shaly partings, in No. 10 is 13 feet 10 inch.

Section of the Strata in the Rosedale Cliff, at Rosedale Docks, on the Coast between Staithes and Runswick Bay.

		Fm.	Ft.	In.	Fm.	Ft.	In.	Fm.	Ft.	In.
	Soil							0	3	0
	Clay							2	2	0
	Freestone							4	2	0
	Fire clay							0	4	0
	Freestone shale							0	5	5
	Blue shale							0	0	10
Ironstone seam known as the top seam.	Ironstone dogger	0	0	3						
	Blue shale	0	2	2						
					0	2	5			
	Top block ironstone (very good)	0	1	6						
	Parting	0	0	0						
	Bottom block ironstone (very good)	0	2	10						
					0	4	4			
								1	0	9
								10	0	6
	Cement dogger	1	4	0						
	Alum shale or rock	26	4	0						
	Jet dogger	0	1	0						
	Jet rock	3	1	0						
	Blue shale, exposed	2	0	0						
								33	4	0
	Sea beach							43	4	6

Section of the Main Seam of Ironstone, viz.:—

		Ft.	In.	Ft.	In.
Intended as the working part.	Top block of ironstone	2	9		
	Shale	0	8		
	Bottom block of ironstone	3	1		
				6	6
	Shale	0	3		
	Ironstone	0	3		
	Shale	0	3½		
	Ironstone	0	6		
	Shale	0	5		
	Ironstone	0	5½		
	Shale	0	4½		
	Ironstone	0	6		
	Shale	0	5½		
	Ironstone	0	7		
	Shale	0	3½		
	Ironstone	0	5½		
				4	10
				11	4

Section of the Strata of the Top Seam at the Victoria Iron-works, or Wreck Hills, North of Runswick.

	Ft.	In.
Soil	0	0
Freestone	0	0
Irony shaly sandstone	9	0
Ironstone dogger band	0	3
Very coarse irony sandstone	1	3
Shale	2	6
Main band of the seam, known as the top seam	1	4
	14	4

Alum, shale, &c., about 40 feet to sea level.

Below this the company have sunk a shaft, about twenty-six fathoms farther down to the main seam, and, I understand, with the following as a section:—

	Ft.	In.
Dogger ironstone band	1	2
Shale	1	9
Top block, ironstone	1	11
Shale	1	9
Bottom block, ironstone	3	10
Shaly parting	0	0
Shale	1	0
Ironstone	1	0
	12	5

The strata seems to be rather dislocated here.

Section of the Strata of the Top Seam at Raithwaite, South of Sandsend, near Whitby.

	At Outcorp. Ft	In.		20 or 30 Yards farther into the Solid. Ft	In.
Conglomerated ironstone	6	6	..	1	0
Ironstone	5	0	..	5	0
	11	6		6	0

BLAST FURNACES.

State of the Blast Furnaces of the district on the 1st October, 1860 :—

	In.	Out.	Total.
Eston—Bolckow and Vaughan	9	—	9
„ Clay Lane Company	2	1	3
„ Samuelson and Company	2	1	3
Cargo Fleet—Jones, Dunning, and Co.	—	2	2
„ Cochrane and Company	3	1	4
„ Gilkes, Wilson, Pease, & Co.	3	2	5
Middlesbrough—Bolckow and Vaughan	3	—	3
„ Snowdon and Hopkins	2	—	2
Port Clarence—Bell Brothers	5	1	6
Norton—Warner, Lucas, and Company	2	1	3
Stockton—Holdsworth and Company	2	1	3
Darlington—South Durham Company	2	1	3
Witton Park—Bolckow and Vaughan	4	—	4
Stanhope—Weardale Iron Company	—	1	1
Towlaw—Weardale Iron Company	4	1	5
Consett—Derwent Iron Company	10	8	18
	53	21	74
All places—September 1st, 1860	52	22	74
„ July 1st	52	22	74
„ April 1st	53	16	69
„ January 1st	51	18	69
„ October 1st, 1859	51	16	67
„ July 1st	54	13	67
„ April 1st	59	8	67
„ January 1st	58	9	67
„ October 1st, 1858	53	12	65
„ July 1st	49	14	63
„ April 1st	43	20	63
„ January 1st	43	19	62
„ November 1st, 1857	55	7	62

The following tables of analyses are also taken from Mr. Marley's paper before referred to.

ANALYSES OF THE BED OR SEAM KNOWN AS THE TOP SEAM OF CLEVELAND IRONSTONE.

No. of Analysis.	Names of Mines and description of Ore.	By whom Analysed and when made.	Protoxide of Manganese.	Water.	Carbonaceous matter.	Phosphoric Acid.	Sulphur.	Sulphuric Acid.	Silicic Acid.	Potash.	Protoxide of Iron.	Carbonic Acid.	Carbonate of Lime.	Metallic Oxide, &c.	Clay.	Sand, Clay, Earthy Matter.	Silica.	Peroxide of Iron.	Alumina.	Lime.	Magnesia.	Loss by Heat.	Totals.	Metallic Iron.	Remarks.
1	Rosedale on the Coast ..... Oolitic, light Sandstone colour, unburnt ...	W. Crowder, F.C.S. Newcastle, 1856.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	10·30	52·60	7·40	3·78	1·26	24·66	100	36·82	These were at first, viz., April, 1856, given as Rosedale Abbey but corrected in the January, 1857, Paper.—See both Papers already referred to, *i.e.*, Mr. Crowder's, named in the Analyses of the main seam ironstone
	burnt		....	....	....	....	....	....	....	....	....	....	....	....	....	....	14·90	65·00	11·00	5·29	3·81	....	100	45·50	
2	Do. ..... unburnt ...	"	....	....	....	....	....	....	....	....	....	....	....	....	....	....	30·35	39·90	5·60	4·23	1·47	18·45	100	27·93	
3	Raithwaite—Samples taken by Mr. Crowder ..... Light coloured	Do., 1857.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	44·75	....	....	....	....	....	....	22·09	
	do.	"	....	....	....	....	....	....	....	....	....	....	....	....	....	....	68·85	....	....	....	....	....	....	16·69	
	Rotten	"	....	....	....	....	....	....	....	....	....	....	....	....	....	....	58·15	....	....	....	....	....	....	22·60	
	do.	"	....	....	....	....	....	....	....	....	....	....	....	....	....	....	49·45	....	....	....	....	....	....	29·72	
	do.	"	....	....	....	....	....	....	....	....	....	....	....	....	....	....	32·45	....	....	....	....	....	....	34·70	
	Do. Samples sent by Proprietors ..... Light coloured	"	....	....	....	....	....	....	....	....	....	....	....	....	....	....	36·35	....	....	....	....	....	....	25·69	See Mr. Crowder's Jan., 1857, Paper for details. This mine is an example of analyses not showing the state of the bulk.
	do.	"	....	....	....	....	....	....	....	....	....	....	....	....	....	....	21·00	....	....	....	....	....	....	34·26	
	do.	"	....	....	....	....	....	....	....	....	....	....	....	....	....	....	37·20	....	....	....	....	....	....	32·27	
	Dark coloured with shells	"	....	....	....	....	....	....	....	....	....	....	....	....	....	....	18·35	....	....	....	....	....	....	34·09	
	Dark rust red col. & rotten	"	....	....	....	....	....	....	....	....	....	....	....	....	....	....	14·00	....	....	....	....	....	....	41·86	
	do.	"	....	....	....	....	....	....	....	....	....	....	....	....	....	....	12·45	....	....	....	....	....	....	45·25	
	do.	"	....	....	....	....	....	....	....	....	....	....	....	....	....	....	18·00	....	....	....	....	....	....	33·60	
																	12 to 68							16·69 to 45·25	Averages.
4	Beckhole— 12 Samples top to bottom	Messrs. Richardson and Browell of Newcastle, 1856.	....	....	....	....	....	....	....	....	....	....	....	....	....	20·0	....	51·00	6·00	2·92	....	19·0	98·92	35·00	
	Do. 26 Samples	W. Crowder, F.C.S., Newcastle, 1856.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	31·70	Metallic Iron, varying from 22·40 to 49·80 per cent.
	Do.	J. H. Henry, F.R.S., of London, 1856.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	38·00	States it ought to yield 40 of grey pig iron from furnace.
5	Fryupdale—J. S. Pratt, Esqr.'s Breckon and Plews Farm	T. Richardson, Esq., of Newcastle Oct. 9th, 1855.	....	....	....	....	....	....	....	....	....	....	....	....	42·5	....	....	....	....	2·2	....	15·0	....	29·4	
6	Thirak District—Rev. C. Johnston's Boltby Ironstone	Jos. Spence, Esq., York.	....	....	....	....	....	....	....	....	....	....	25·	56·	....	....	24·0	....	....	14·0	6·0	....	100	....	Equal parts.
	Do. ..... mixed Samples	Messrs. J. Spence and B. Holden.	....	....	....	....	....	....	....	....	....	....	20·	....	....	....	....	43·	....	....	....	....	....	30·08	Mixed samples taken every 12 inches from end or face of drift. Specific gravity:— 1st. Nodular band, 2·60 2nd. Upper block, 2·38 3rd. Lower do. 2·42
7	C. H. Elsley's Ironstone	W. West, F.R.S., of Leeds.	....	....	....	....	....	....	....	....	....	31·0	....	....	....	....	8·5	....	6·0	9·75	2·75	....	100	42·0	It has been suggested that the 42 is peroxide, and so equal to about 30 metallic,—but I think this not so.
8	Rosedale Abbey Ironstone .... Black Ironstone	W. Crowder, F.C.S., Newcastle, 1856.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	5·70	64·90	9·25	3·53	0·99	16·15	100·52	45·43	See Mr. Crowder's Paper of April, 1856.
	do.	"	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	79·30	....	....	...	....	....	55·51	
	Quarry—Magnetic dark blue Ironstone, 10 Samples ..... Average	Do., 1857.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	7·66	61·63	....	....	....	....	....	43·14	
	Minimum		....	....	....	....	....	....	....	....	....	....	....	....	....	....	6·20	55·0	....	....	....	....	....	34·75	
	Maximum		....	....	....	....	....	....	....	....	....	....	....	....	....	....	8·90	71·12	....	....	....	....	....	49·78	See January, 1857, Paper.
	Average of dark blue magnetic	Mr. George Steward, Pupil of Mr. Crowder.	....	1·34	....	....	....	....	4·50	....	33·55	10·26	....	....	....	....	....	31·40	16·05	2·35	1·29	....	100·74	48·07	
		Mr. John Pattinson, of Clarence Iron Works.	0·69	3·76	0·84	1·41	0·03	trace	6·95	trace	33·85	10·36	....	....	....	....	....	32·67	3·15	2·86	1·59	....	98·16	48·17	
	Black Ironstone	T. Richardson, Esq., Newcastle.	....	....	....	....	....	....	....	....	....	....	....	....	13·05	....	....	....	....	3·04		11·75	....	56·00	Oxide Iron, 75·45.
	Shaft and Drift near the Quarry ..... Thin Scrap—blue inside and brown out	W. Crowder, F.C.S.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	6·70	64·25	....	....	....	....	....	44·97	
	Blue Nodule inside of do.		....	....	....	....	....	....	....	....	....	....	....	....	....	....	7·40	53·89	....	....	....	....	....	37·72	See Mr. Crowder's January, 1857, Paper.
	Thick brown Scrap		....	....	....	....	....	....	....	....	....	....	....	....	....	....	8·90	50·17	....	....	....	....	....	35·11	
	Blue Nodule inside of do.		....	....	....	....	....	....	....	....	....	....	....	....	....	....	7·85	64·25	....	....	....	....	....	44·97	
																	7·66							43·14	Averages.
	Light blue Nodule with its Scraps from "Sheriff's" Drift .. Nodule, Centre	Mr. E. C. Northcott, Pupil to Mr. Crowder.	....	4·80	....	...	trace	trace	....	....	35·25	16·25	....	....	....	....	9·65	12·22	14·10	2·38	3·95	....	....	35·94	See Mr. Crowder's Paper of January, 1857.
	Scrap, 1st	"	....	15·50	....	....	trace	trace	....	....	4·97	trace	....	....	....	....	8·20	50·63	18·70	trace	1·41	....	....	39·30	This affords a good example of the error of taking an analysis alone of samples as a criterion of the bulk.
	do., 2nd	"	....	17·50	....	....	trace	trace	....	....	1·24	trace	....	....	....	....	10·95	54·65	14·22	0·48	0·27	....	....	39·22	
	do., (outside) 3rd	"	....	15·40	....	....	trace	trace	....	....	....	trace	....	....	....	....	8·20	60·05	15·45	1·15	0·72	....	....	42·03	
	5 Samples from "Sheriff's" Drift, of Brown Ironstone ..... Average	W. Crowder, F.C.S.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	11·84	53·66	....	....	....	....	....	37·56	
	Minimum		....	....	....	....	....	....	....	....	....	....	....	....	....	....	8·70	50·15	....	....	....	....	....	35·10	See Mr. Crowder's Paper, Jan., 1857.
	Maximum		....	....	....	....	....	....	....	....	....	....	....	....	....	....	15·00	57·05	....	....	....	....	....	39·93	
	Average of equal parts of above		....	11·50	....	....	trace	trace	....	....	2·50	1·70	....	....	....	....	12·20	51·50	14·50	1·93	1·16	....	97	38·01	

ANALYSES OF THE MAIN BED OR SEAM OF CLEVELAND IRONSTONE.

No. of Analysis.	Names of Mines and description of Ore.	By whom Analysed.	Date when made.	Carbonic Acid and Water.	Silicate & Aluminate of Iron.	Moisture and Loss.	Loss by Heat.	Chloride of Potassium and Sodium.	Silicic Acid.	Sulphur.	Insoluble residue of which 96·8 is soluble in dilute caustic potash, and consists of oolitic concretions.	Organic Matter.	Water in combination.	Bisulphide of Iron.	Sulphuric Acid.	Silica soluble in Hydrochloric Acid.	Phosphoric Acid.	Oxygen.	Carbonic Acid.	Potash.	Carbonate of Magnesia.	Magnesia.	Carbonate of Lime.	Lime.	Alumina.	Silica.	Manganese.	Protoxide of Manganese.	Peroxide of Iron.	Protoxide of Iron.	Carbonate of Iron.	Metallic Iron.	EXTRAS. Loss by Roasting or Calcining.	Silica.	Alumina, with a trace of Peroxide of Iron.	Tetanic Acid.	Lime.	TOTAL.	REMARKS.
1	Eston Mines Hard Grey	Dr. Maugham, of London	1850	....	....	2·20	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	4·60	....	7·20	9·60	....	....	23·47	....	52·93	42	22·8	....	....	....	....	100	Dr. Maugham stated these samples ought to yield at least 35 per cent. out of the furnace.
2	do. Crust or Shell	do.	do.	....	....	2·00	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	7·60	10·40	....	....	40·46	....	39·54	47·4	17·00	....	....	....	....	100	
3	do. Bottom of Main Block	do.	do.	....	....	2·00	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0·12	....	2·60	....	7·60	15·20	....	....	35·58	....	36·90	42·7	16·4	....	....	....	....	100	
4	do. Top block of Seam	do.	do.	....	....	2·00	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	5·00	10·60	....	....	51·13	....	31·27	50·88	18·0	....	....	....	....	100	
5	do.	Wm. West, F.R.S., of Leeds	Feb. 1851	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	15·0	....	....	....	....	3·0	15·0	22·0	....	....	....	....	....	45·00	....	....	....	....	....	100	
6	do.		1853	....	....	2·25	....	....	....	....	....	....	....	....	....	....	....	....	....	....	trace	....	3·50	....	7·50	12·50	....	....	30·0	....	44·0	41·00	....	....	....	....	....	.....	Statement, see G. C. Greenwell on Mine Engineering, 1853.
7	do.	Hugh Taylor, Esq., Cramlington.	1854	....	37·964	....	....	1·052	7·257	....	....	3·151		....	traces	....	....	10·867	24·939	....	7·228	3·504	10·292	5·803	6·499	7·257	traces	....	21·057	47·818	43·487	36·951	....	....	....	....	....	100·023	See Vol. III., Pages 24 and 25 of the "Transactions of the North of England Mining Institute," where the results are given singly and combined.
8	do.	A. Dick	1856	....	....	....	....	....	....	....	1·64	trace	2·97	0·11	traces	7·12	1·86	....	22·85	0·27	....	3·82	....	7·44	7·86	....	....	0·95	3·60	39·92	....	33·62	....	1·50	About 0·10	0·03	trace	100·41	See Memoirs of Geological Survey of Great Britain, and of the Museum of Practical Geology, 1856.
																																		1·63 Insoluble Residue.					
9	do. 1 Top of Main Block	W. Crowder, F.C.S., of Newcastle.	1857	....	....	....	....	....	....	trace	....	....	3·69	....	....	....	2·08	....	25·26	....	....	3·19	....	1·70	10·62	10·90	....	....	3·55	39·01	....	32·83	....	....	....	....	....	100	See W. Crowder on the average composition of Rosedale, Whitby, and Cleveland Ironstone, in the Edinburgh New Philosophical Journal, January, 1857. Average of the last seven analyses here given, Mr. Crowder drawing attention to the minimums and maximums under the three heads averaged.
	2 Intermediate	do.	do.	....	....	....	....	....	....	trace	....	....	5·80	....	....	....	1·02	....	16·38	....	....	2·72	....	2·52	13·83	11·95	....	....	6·73	39·05	....	35·10	....	....	....	....	....		
	3 do.	do.	do.	....	....	....	....	....	....	trace	....	....	4·70	....	....	....	2·49	....	26·16	....	....	3·19	....	traces	12·66	6·0	....	....	3·95	40·85	....	34·54	....	....	....	....	....		
	4 do.	do.	do.	....	....	....	....	....	....	0·09	....	....	5·07	....	....	....	3·87	....	22·96	....	....	5·35	....	05·8	9·88	7·65	....	....	1·20	43·35	....	34·54	....	....	....	....	....		
	5 do.	do.	do.	....	....	....	....	....	....	trace	....	....	5·13	....	....	....	·02	....	25·32	....	....	5·48	....	traces	14·28	7·55	....	....	....	41·22	....	32·06	....	....	....	....	....		
	6 Bottom	do.	do.	....	....	....	....	....	....	0·13	....	....	9·14	....	....	....	2·50	....	5·54	....	....	2·31	....	1·56	17·87	19·90	....	....	1·55	39·50	....	28·73	....	....	....	....	....		
	* 7 Marine Shelly part	do.	do.	....	....	....	....	....	....	0·10	....	....	9·07	....	....	....	1·88	....	41·54	....	....	1·80	....	8·56	12·72	19·5	....	....	2·45	24·93	....	21·10	....	....	....	....	....		* This shelly part is only occasional.
																	2·39									11·98						31·27						.....	Averages.
10	do. Average of the same stone as Mr. Crowder's Nos. 1, 2, 3, 4, & 5	N. Samuelson, F.C.S., of Liverpool	do.	....	....	....	22·20	....	....	0·350	....	....	....	....	•	....	0·257	....	....	....	....	2·357	....	1·00	8·00	11·00	....	....	54·836	....	....	38·38	....	....	....	....	....	100	• • • These ores never contained any free sulphuric acid.
	Same as Mr. Crowder's No. 6	do.	do.	....	....	....	15·20	....	....	0·350	....	....	....	....	•	....	0·231	....	....	....	....	0·785	....	1·00	12·00	19·00	....	....	51·434	....	....	36·00	....	....	....	....	....	100	
	† do. do. 7	do.	do.	....	....	....	17·20	....	....	2·666	....	....	....	....	•	....	0·561	....	....	....	....	1·642	....	3·360	12·00	23·50	....	....	39·071	....	....	27·30	....	....	....	....	....	100	† This shelly part is only occasional.
11	Upleatham Mines Roof	W. Crowder, F.C.S.	do.	....	....	....	....	....	....	traces	....	....	3·50	....	traces	....	0·45	....	25·70	....	....	3·70	....	3·35	6·00	17·49	....	....	traces	41·00	....	31·85	....	....	....	....	....	101·19	.....See W. Crowder as above.
	Thill	do.	do.	....	....	....	....	....	....	0·06	....	....	5·00	....	traces	....	2·55	....	15·50	....	....	3·15	....	1·40	12·15	20·50	....	....	7·00	34·00	....	31·36	....	....	....	....	....	101·31	
	Stone intermediate	do.	do.	....	....	....	....	....	....	traces	....	....	2·80	....	traces	....	1·50	....	25·38	....	....	3·45	....	7·55	8·10	14·35	....	....	3·50	33·37	....	28·42	....	....	....	....	....	100·00	
	do.	do.	do.	....	....	....	....	....	....	traces	....	....	4·44	....	traces	....	traces	....	19·18	....	....	2·10	....	2·80	18·00	12·95	....	....	2·10	38·43	....	31·36	....	....	....	....	....	100·0	
	do.	do.	do.	....	....	....	....	....	....	traces	....	....	3·20	...	traces	....	2·70	....	24·20	....	....	2·80	....	3·35	11·20	7·80	....	....	6·50	38·25	....	34·30	....	....	....	....	....	100·0	
	do.	do.	do.	....	....	....	....	....	....	traces	....	....	3·00	....	traces	....	0·50	....	25·10	....	....	2·40	....	5·00	12·20	7·45	....	....	5·80	38·25	....	33·81	....	....	....	....	....	100·0	
																	1·28									13·42						31·85						.....	Average.
12	Normandy Mines Top 3 feet	do.	do.	....	....	....	....	....	....	....	....	....	4·52	....	....	....	1·04	....	22·38	....	....	3·23	....	4·56	3·90	23·50	....	....	1·43	35·08	....	28·28	....	....	....	....	....	100·04	.....Ditto.
	Bottom 8 feet	do.	do.	....	....	....	....	....	....	....	....	....	4·37	....	....	....	1·66	....	22·29	....	....	3·39	....	6·35	0·41	11·95	....	....	3·69	39·05	....	32·96	....	....	....	....	....	99·16	
13	do. Top 3 feet	Mr. John Pattinson, of Clarence Iron Works.	do.	....	....	....	....	....	....	0·40	....	....	3·69	....	trace	....	1·40	....	25·00	....	....	3·84	....	5·82	6·92	15·24	....	0·96	0·47	33·86	....	26·66	....	....	....	....	....	97·60	.....Ditto.
	Bottom 8 feet	do.	do.	....	....	....	....	....	....	0·14	....	....	4·45	....	trace	....	1·07	....	22·00	....	....	4·16	....	7·77	5·92	10·36	....	0·74	2·60	38·06	....	31·42	....	....	....	....	....	97·27	
																	1·55									12·80						30·62						.....	Average.
14	Hutton Low Cross or Codhill Mines 1	W. Crowder, F.C.S.	do.	....	....	....	....	....	....	traces	....	....	4·90	....	traces	....	2·66	....	25·18	....	....	1·12	....	4·20	3·79	20·90	....	....	1·70	35·55	....	28·84	....	....	....	....	....	100	See W. Crowder, as above, and also in a previous paper in the said Edinburgh New Philosophical Journal, for April, 1856, entitled "On the Chemical Composition of the Cleveland Ironstone Beds." Mr. Crowder gives more detailed analyses of each band, as also of the shale bands, making them nearly equal to the ironstone, and which subject is worthy of further enquiry, he stating one of the shales to contain 29·40 of metallic iron. In the same paper Mr. Crowder shows the loss by calcining in the working stone to be 23·90 to 27·40 per cent. The beds of sulphur pyrites named in the section in this paper is stated by Mr. Crowder to contain "30·25 per cent. of sulphur = 56·71 bisulphurate of iron, and is about the same quantity as is found in the Wicklow pyrites used on the Tyne in the manufacture of oil of vitriol."
	2	do.	do.	....	....	....	....	....	....	trace	....	....	2·58	....	0·31	....	1·92	....	32·72	....	....	0·49	....	2·70	3·71	12·80	....	....	2·41	40·36	....	33·46	....	....	....	....	....	100	
	3	do.	do.	....	....	....	....	....	....	trace	....	....	6·11	....	traces	....	0·67	....	26·32	....	....	traces	....	3·08	9·86	16·55	....	....	....	37·41	....	29·10	....	....	....	....	....	100	
	4	do.	do.	....	....	....	....	....	....	trace	....	....	4·89	....	0·07	....	5·05	....	23·47	....	....	2·98	....	7·39	4·95	15·65	....	....	1·80	35·75	....	27·45	....	....	....	....	....	100	
	5	do.	do.	....	....	....	....	....	....	0·05	....	....	1·45	....	0·02	....	2·01	....	28·40	....	....	4·80	....	3·00	3·79	13·00	....	....	5·16	38·39	....	33·46	....	....	....	....	....	100·07	
	6	do.	do.	....	....	....	....	....	....	1·60	....	....	1·45	....	0·30	....	0·96	....	32·50	....	....	3·70	....	3·80	3·44	7·20	....	....	4·25	40·86	....	34·75	....	....	....	....	....	100·06	
																	2·21									13·86						30·09						.....	Averages.
	Small Dust of Burnt or Calcined Stone	do.		....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	13·00	....	....	....	53·35	....	....	37·34	....	....	....	....	....	.....	From Mr. Crowder's paper of April, 1856.
	Masses do. do.	do.		....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	37·85	....	....	56·10	....	....	39·27	....	....	....	....	....	.....	
15	do. No. 1 Top Block	Messrs. Richardson and Browell, of Newcastle.	Apr. 1857	26·92	....	....	....	....	....	0·01	....	....	....	....	....	....	0·57	....	....	....	....	2·40	....	5·51	8·20	14·50	....	....	0·88	40·93	....	32·52	....	....	....	....	....	99·92	Samples taken in the mines by Mr. Richardson himself, and averaged as per section of average working, 33·09.
	No. 2 Top of Middle do.	do.	do.	20·30	....	....	....	....	....	0·13	....	....	....	....	....	....	1·08	....	....	....	....	1·01	....	6·88	13·51	18·35	....	....	0·46	40·14	....	31·57	....	....	....	....	....	101·06	
	No. 3 Bottom do.	do.	do.	27·60	....	....	....	....	....	0·12	....	....	....	....	....	....	0·80	....	....	....	....	0·72	....	5·04	8·90	10·05	....	....	0·46	44·10	....	34·65	....	....	....	....	....	97·79	
	No. 4 Bottom Block	do.	do.	22·06	....	....	....	....	....	0·00	....	....	....	....	....	....	1·28	....	....	....	....	3·23	....	4·48	11·00	13·10	....	....	0·93	43·17	....	34·30	....	....	....	....	....	99·19	
																																33·09							
16	Sleights Bridge 1	W. Crowder, F.C.S.	1857	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	10·0	....	....	41·20	....	....	28·84	....	....	....	....	....	.....	See Mr. Crowder's Work in January, 1857, as before named. He does not show whether from the Pecten or Avicula bed.
	2	do.	do.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	9·0	....	....	43·55	....	....	30·48	....	....	....	....	....	.....	
	3	do.	do.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	8·5	....	....	42·20	....	....	29·54	....	....	....	....	....	.....	
	4	do.	do.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	11·6	....	....	43·55	....	....	30·48	....	....	....	....	....	.....	
																										9·8			42·62			29·83	....	....	....	....	....	.....	Averages.
	* Analysis of equal weights 99·81 = per oxide			....	....	....	....	....	....	traces	....	....	2·50	....	traces	....	....	....	28·00	....	....	4·40	....	4·85	12·15	9·35	....	....	traces	38·56	....	29·99	....	....	....	....	....	(*)	
17	Tunnel Stone near Grosmont Station 1	do.	1857	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	15·70	....	....	36·75	....	....	25·72	....	....	....	....	....	.....	See Mr. Crowder's paper, January, 1857.
	2	do.	do.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	12·20	....	....	45·50	....	....	31·85	....	....	....	....	....	.....	
	3	do.	do.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	15·50	....	....	45·15	....	....	31·60	....	....	....	....	....	.....	
	4	do.	do.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	17·00	....	....	36·06	....	....	25·23	....	....	....	....	....	.....	
																										15·10			40·86			28·60	....	....	....	....	....	.....	Average.
	* Average of equal weights 101·40 = pro and per oxide			....	....	....	....	....	....	....	....	....	2·30	....	....	....	....	....	27·00	....	....	2·10	....	5·85	12·30	15·00	....	....	1·80	55·55	....	28·91	....	....	....	....	....	(*)	