MAP
OF THE
ASHBY-DE-LA-ZOUCH
Coal Field,
the area of which is denoted by a shaded line, with descriptions of the
MINERAL CONTENTS
of its borders.

A COLLECTION

OF

GEOLOGICAL FACTS

AND

PRACTICAL OBSERVATIONS,

INTENDED TO ELUCIDATE THE FORMATION

OF THE

ASHBY COAL-FIELD,

IN THE PARISH OF ASHBY-DE-LA-ZOUCH AND THE NEIGHBOURING DISTRICT;

BEING

THE RESULT OF FORTY YEARS' EXPERIENCE AND RESEARCH.

BY EDWARD MAMMATT, F. G. S.

ILLUSTRATED BY A MAP AND PROFILES, COLOURED SECTIONS OF THE STRATIFICATION AND ONE HUNDRED AND TWO PLATES OF VEGETABLE FOSSILS, AFTER DRAWINGS TAKEN FROM NATURE, BY ROBERT IRONMONGER.

ASHBY-DE-LA-ZOUCH:

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TO THE MOST NOBLE

THE MARQUIS OF HASTINGS.

MY LORD,

THE knowledge of your Lordship's liberal and enlightened views in desiring that discoveries interesting to society should never be withheld, although arising from modes of trial made at your expense; and the hope that the details recorded in this Volume might interest inquirers into the Principles of Geology, a subject now much studied; have been my principal inducements to publish the following Facts and Observations.

In addition to the experience obtained by me in early life, when engaged in arduous mining speculations, I must particularly acknowledge the great practical advantages gained under the auspices of your illustrious Father, through the most liberal and unbounded confidence he placed in me, while charged with the care and direction of his mining interests. The same confidence having been continued by your Lordship, makes me desirous of expressing my obligations to you, and also my consciousness that the only return I can offer, or which you expect, is a faithful discharge of the duties confided to me by your Lordship. I trust, however, that the dedication of this Volume may be accepted, as a small tribute of gratitude from,

MY LORD,

With the greatest respect,

Your Lordship's obliged Servant,

EDWARD MAMMATT.

OVER-SEAL COTTAGE,
NEAR ASHBY-DE-LA-ZOUCH,
August 1st, 1833.

PREFACE.

Not many years since, the details of a Mine would scarcely have attracted the attention of one reader in twenty of those who are now disposed to examine them: some, out of curiosity; others, from a desire to attain knowledge of a subject so much discussed in society; and, some few, from interested motives.

Mining of all descriptions, is a slow operation, and men seldom live to see much change in the methods of working; neither do they generally consider the importance of attending to information derived from other localities, although applicable to their own. In deep mines, the Shafts are not numerous. This is owing, on the one hand, to the heavy expenses of sinking them; and, on the other, to improvements in the mode of raising coal and other minerals to the surface. The process of coal-mining requiring observation, therefore becomes almost wholly confined to one bed, its floor and roof. It is only in situations where great irregularity in the measures prevails, that the energies of those having property at stake, are called forth to prevent ruin to that property; and, by this circumstance, they are led to contrive remedies for surmounting difficulties.

When coal and other minerals were raised from beds near the surface, shafts were frequently sunk; but, as the same measures were passed through, nothing new was elicited; whereas, in deep mines, the shafts are so placed as to endure for twenty or even fifty years. Hence it is obvious, from the depth of mines, and from other reasons combined with the slow progress of changes in such operations, that a long period must pass away before details can be collected. Owners and workers of mines might mutually aid each other, if they would publish exact records of all the minutiæ appertaining to the strata; and, by the same means, the sciences of Mining and Geology would be rendered more clear and useful as well as entertaining, by a right application of the satisfactory results which would thus be obtained.

The Facts relating to that part of the Ashby Coal-Field, which is described in the present volume, were originally collected for private use, and without any view to their future publication. But, on considering that scarcely any Work, hitherto published, contains details of management, or adverts to the causes of irregularities, or suggests means of removing difficulties, the present writer was induced to believe that if the series of observations made on this Coal-Field, during a long period, were thrown together, they might confer some practical benefit on those who conduct the processes of mining in the immediate district; and, at the same time, assist the praise-worthy exertions of those philosophers who are now labouring to promote geological inquiry.

After the promulgation of the important doctrine originated by Mr. William Smith, that *every stratum has its own peculiar fossil*, much research was made in the Ashby Coal-Field, whenever a shaft was sunk or adit driven, otherwise than in the coal seams. This led to an endeavour to identify strata, by preserving drawings of fossils found in any new situation; and the accuracy with which it was necessary to delineate these, led to an examination of their peculiarities of character, so little agreeing with those of the vegetable forms now in existence in this climate. The drawings for this Work were made by an Artist on the spot, who had access to the Fossils immediately on their being raised to the surface; but, though they are most faithfully delineated, their use is yet incomplete without a botanical arrangement. The only aid afforded in the annexed Lists, consists in a reference to some analogous descriptions and figures of vegetable fossil remains, in recent publications.

To the Geologist, the facts here described, may furnish a step to the acquirement of more accurate notions regarding the stratification of this country; and, as the vicinity of Ashby abounds with a remarkable variety of strata bordering on Charnwood Forest, the same account may contribute to a development of that apparent anomaly in the configuration of this district, with which so many inquirers have been puzzled.

The Author has long been aware of the absolute necessity of accumulating Facts, and of noting Phenomena in different and distant localities, before engaging in any attempt to found a general Theory as to the arrangement and formation of the crust of the Earth. The confounding of effects with causes, and the visionary notions unsupported by inductive truths, entertained by more than one writer, have done but little to forward the improvement of Geology. Indeed, it is becoming more evident every day, that much time must yet elapse, and much information must be obtained, before a correct System of this most important science can be established. Many of the details recorded in this Volume were collected thirty years since, and may tend to shew the difficulty of reconciling speculative hypotheses with the discoveries of scientific investigation. With a view to promote this, the Author bequeaths his Collection of Facts and Observations for the use of the practical geological inquirer.

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A

COLLECTION OF FACTS

RELATING TO THE

ASHBY COAL-FIELD.

INTRODUCTORY OBSERVATIONS.

It is remarkable, in the history of Geological Theory, that so few writers have given details of the observations upon which their conclusions are founded. This is one reason why few works of the kind have practically benefited the Miner. Whilst some jumble together the strata of a district; others, rambling through kingdoms, extend their theories all over the Globe. It is no wonder, then, that such theories should succeed each other rapidly, since every district affords the grounds of speculation for new ones; and these, in their turn, are upset by the facts ascertained in the actual discoveries of the working observer. Hitherto, so great has been the inutility of many valued writings on the subject, that they are seldom read by practical miners; who, knowing that the chief inferences were drawn from wrong premises, are disinclined from paying attention even to such facts as have been partially collected. The manner too, in which these facts were stated, and mixed up with deductions to support a theory, prevented a confirmation of them separately. A further hindrance to the developement of a true state of the facts, arose from the too frequent incapability of miners to shew, in the language of science, the fallacy of such inferences, and from the difficulty of employing terms used locally, so as to be understood by general readers. Thus, the labours of the *scientific* inquirer were rendered worse than useless, and the knowledge gained by the *practical* miner was lost to the former, and almost to society; as, in many cases, it perished with him.

Until science lent its aid to the miner, in draining lower than the valleys admitted, by the Steam-Engine and other powers, the process of raising any mineral was confined to a few plain workmen, whose only object was to trace the mineral through its various ramifications in the earth, at the cheapest possible rate; without being able, in many cases, to give reasons for the adoption of measures calculated to produce effects which the chemist and mechanic alone could explain. This peculiar tact, in anticipating or remedying obstacles was often lost; because the person exercising it, being interested in the mode adopted, and jealous of competitors, too often concealed his practice. Another circumstance operated very powerfully, and still continues, although in a less degree; namely, the caution used in almost all mines of not recording the situation of the mineral, as to thickness, dip, breaks, and other collateral information, with a view to prevent a neighbouring miner from taking advantage of it, as a rival. The consequences of this procedure have frequently recoiled upon the party making the omission, even during a lease; and have caused an immense expense afterwards, in proving what might have been recorded.

Usually the Lessor of a mine binds the Lessee to pay a sum of money annually, or otherwise, with a few restrictions as to the mode of working, and of quitting at the termination of the lease; but he seldom obliges him to register proceedings as to water, rocks, faults in the strata, quality, or any other fact regarding the state of the mine: now, all this would be of the highest importance to the Lessor, or his successor, and ought to be included in every similar engagement. No section of a Shaft, descriptive of the strata and their appendages of hardness, thickness and dip, is required for the purpose of being a guide afterwards in other situations; and, indeed this precaution is sometimes so totally neglected by the Lessee or his bailiff, that, upon a future perforation, the appearances are almost forgotten, and evils recur which might have been guarded against. Neither is a plan of the workings, nor a section to shew dislocations in the strata and their hadings, required to be made and preserved as a guide in working another seam; but which seam is probably not granted to the Lessee who, consequently, has little or no interest in it. At the termination of the lease, therefore, or at a cessation of the winning, the future mode of operation is a speculation, which, although not capable of being reduced to any certain rule, might yet have been rendered more practicable by inferences drawn from former proceedings, if these had been recorded.

One of the greatest evils, as well to the immediate worker as to his successor, is, that of allowing the water to pursue its course to the deepest part of the mine. This evil ought to be prevented by collecting the water from the several strata whence it issues, and then raising it from reservoirs by a regulated power. By such a process, much inconvenience, labour and expense, in lifting it from the bottom of the mine, would be avoided. All these considerations, so important to the owner of the mine, if correctly detailed, would add greatly to the stock of geological knowledge. In such records, also, would be perceived phenomena irreconcilable to many theories, and inexplicable by any hitherto promulgated. Details of this kind would aid in arriving at more correct views of the structure of the crust of the globe; but, they must be collected for successive generations, in a diversity of situations, and in various strata, before any decisive conclusions should be attempted to be drawn from them, as premises.

Under-ground sections carefully made, with indications of all the changes of substance, form and quality, and also the most minute and accurate descriptions of the strata and their accompaniments; as, for example, where any extraneous body occurs, and particularly the delineation of the Fossils in every plate or laminæ of each stratum: these, accurately and repeatedly taken, can alone lead to the attainment of exact principles.

Geological inferences, unconnected with the art of Mining, seldom interest the practical miner; he is therefore averse to collecting facts, as before observed, both by inclination and by reason of the expense. Societies, however, might well devote a portion of their funds to the encouragement of such researches, and these should be made by persons of their own selection. Information now is more courteously given than formerly: owners and lessees would, in general, be glad to furnish it, not only from civility and as friends to science, but as it might lead to results favourable to their own interests. The London Geological Society possesses much valuable information of this nature, and has published many instructive papers and geological sections accompanied with descriptions. It is most important, that such publications should be continued. Mineralogy and Geology are so nearly allied, that the one must owe much to the other; and, although a mineralogical detail might be considered as appertaining to the former science alone, it would nevertheless lead to geological deductions which could not be otherwise obtained. Mineralogy, therefore, should always be studied by the Geologist.

The Ashby-de-la-Zouch Coal-Field and its borders, have been touched upon, by various writers. Some have ventured assertions respecting its formation; others have more wisely considered it as not easily explained, and have admitted the necessity of gaining further information. Upon a reference to the Map in this Work, it may be of some use to any person deputed by a Society, or other inquirer, to be informed of the peculiar central position in which Ashby is placed, for the point whence to examine both the Coal-Field and the surrounding borders. In a radius of five to ten miles from Ashby, he would be enabled to examine groups of strata assembled in the most extraordinary manner, such as few places in the kingdom could furnish. For instance, in whatever direction he set out, he would pass over a few miles of coal measures requiring his utmost attention to discover the change of stratification, produced by the numerous and extensive faults. After passing such measures, he would enter upon a totally different formation: but, to shew a part of that diversity which a Geologist would be interested in, let his *first* route be north-westwardly. After passing the coal measures, he would find the abrupt ground and capped hills of sand and marl bordering the east bank of the Trent; and, in the *next* route, a little to the north, he would explore Bradby and part of Hartshorn. In the former, he would find sand-knolls and conglomerate; and, in the latter, short round hills flanking and parallel to the sandstone and marl, east of Trent, abounding in quartz, gravel, and flints: these last are so abundant as to have formerly been selected for glass-making and pottery. *Thirdly*, He would pass a high ridge of coal measures, and almost suddenly find large masses of metalliferous mountain limestone, abounding with great variety of encrinites, productæ of enormous size, and other organic remains, indicative of the character of this rock in Derbyshire. This limestone is nearly horizontal, disposed in beds with calcareous earth intervening, affording lead and the usual metallic accompaniments of that rock. *Fourthly*, In a line very little east of north from Ashby, and about the same distance as the mountain limestone, that is, about five miles, he would be astonished at a new feature immediately bordering the coal-measures, viz. the magnesian limestone of Breedon and Cloud-Hill, surrounded by red marl. These strata incline at a very small angle from the perpendicular, and are of very peculiar construction. The stone itself is full of druses, and the most compact is full of small holes of all shapes similar to those in bread. Madrepores of various kinds abound, as m. ananas, m. musica, &c., all which are quite foreign to their neighbours in the blue limestone on the west. The whole of these rocks are stratified, but have very much the semblance of hot matter suddenly cooled in water. *Fifthly*, Farther to the east, and at nearly the same distance, he would examine the continuation of the group of magnesian limestone at Barrow-Hill, Gracedieu, and Osgathorpe, arranged nearly in horizontal layers. *Sixthly*, To the east, he would suddenly, after passing the coal measures, find a short border of red marl, backed by the vertical strata of sienite of Charnwood Forest. Should he prolong his route in this line, about ten miles after passing the Charnwood Hills, he would come upon the lias flanking the east bank of the Soar, the range of which stratum across the kingdom, Charnwood Forest seems not to have disturbed. *Seventhly*, Upon taking a southerly course, he would soon pass the outcrop of the coal strata and enter upon a marl district extending from Bagworth by Bosworth, Congerstone, Twycross, and Appleby. *Eighthly*, By turning in a westwardly course, he would find conglomerate rock and sandstone at Measham and Oakthorpe. And *lastly*, to the northwest, quickly passing the coal outcrop, he would arrive at the horizontal sandbeds and grit bordering the east bank of the Trent, capped with many conical mounds and extensive tracts of marl and red earth.

In order to shew the difficulty of adopting any System to be applied practically, the following details of such facts and phenomena as appear to deserve the consideration of the Geologist, have been observed and collected at one of the principal workings in the Ashby Coal-Field, for the purpose of bringing them under his attention so as to enable him to endeavour to reconcile them with some theory already advanced, or to induce him to defer his decision until a reference to more facts shall have given plausibility to a new one.

Before describing the proposed details, it may be well to give an outline of the supposed extent of the Coal-Field and its borders; but the reader is not to rely upon the conjectural part of this outline, because the sequel will shew that no reliance can be placed on conjecture, and that experiment alone can prove the actual state of the Formation. The immediate portion of the Coal-Field, in the particular description hereafter given, lies in the parishes of Measham, Oakthorpe, Donisthorpe and Willesley, and on Ashby-Woulds: the greater outline however may be traced; it has been partially proved. Its boundary is nearly as follows.

The high land on the east side of the river Trent, forms the western border of the Coal-Field, which commences at Bradby and runs eastwardly through Hartshorn, near Ticknall, Calke, Staunton Harold, Lount, Coleorton, Newbold, Thringstone, Swanington, and Whitwick. On the north of Bradby and Hartshorn, its borders are alluvial sand-knolls and gritstone: at Ticknall, Calke, and Staunton Harold, the blue mountain limestone: at Lount and Coleorton, the magnesian limestone of Breedon and Cloud-Hill: at Newbold and Thringstone, the limestone of Barrow-Hill and Gracedieu: and, at Whitwick, it is bordered by the sienite of Charnwood Forest. To return to Bradby, the Coal-Field thence stretches southwardly by Brizlincote, Newhall, and Stanton, and is bordered by sandstone and marl: it then bends south-west by Castle-Gresley, Linton, and Over-Seal, limited by high ground of sand and gravel, diluvial; wherewith portions of the coal strata are frequently capped: thence, it continues south of Donisthorpe and Oakthorpe, and by the high ground upon which Measham stands, where sand-hills and hard conglomerate rock form the boundary: in this direction, it proceeds south-eastwardly, skirting the north side of Snarestone, where sandstone abounds: thence, it passes north-eastwardly, through Swepstone and Heather to Ibstock, re-approaching Charnwood Forest: from Ibstock, it again turns to the south by Nailstone and Newbold Verdon; edging, at some distance, the primitive rocks of Charnwood Forest until it is lost in the gypsum or marl strata west of Leicester.

The area within the space now described, is very considerable: it includes not less than thirty-five to forty thousand square acres. The surface of this area is exceedingly diversified in hill and valley, although seldom in conformity to the line of stratification: no limestone appears within it, nor any remarkable rocks, except those which usually accompany coal, chiefly sand-grit, but not free. It contains no stone hard enough for roads, and little which stands well in buildings, without great care in laying it in the same position it had in its original bed. Gravel, abounding in hæmatites, is found in isolated patches upon the coal strata, sometimes capping extensive portions at the outcrop.

The quantity of Coal contained in this area cannot easily be estimated with accuracy: it is not difficult, however, to calculate the immense quantity that might be depended upon for supplying fuel. If all the known beds or seams of Coal, exceeding twelve inches in thickness, were calculated upon, as capable of being raised by the application of labour and machinery now in use, the area described, after allowance for faults, would yield one hundred and fifty thousand tons per annum (the present estimated consumption) for ten thousand years. The great waste in this Coal-Field, by leaving all the Slack and much Small Coal in the gobbing, may be obviated, if the article increases in value, and the present fashion of burning lump coal only, should be changed. The small coal might be used in furnaces, retorts for gas, stoves, and all places where an open fire is not necessary. The quantity of this coal which is wasted, often amounts to a fourth of the whole bed: the cheap, although soft, good coal, is only employed for burning lime, and might be raised to a great extent.

The outcrop of the Coal in the parishes adjoining Ashby, has been worked at early periods. In Measham, where the bed was not more than forty or fifty feet from the surface, indications of ancient workings were found, in stone hammer-heads, and large wedges of flint with hazel withes round them; also wheels of solid wood about eighteen inches in diameter. In the north-west corner of Ashby parish, in South Wood, and at Heath-End, very extensive remains of iron furnaces appear: the surface is exceedingly broken, and scoriæ fill a valley of considerable size.*

The Drainage shews, that nearly the whole area of the Coal-District is an appendage to Charnwood Forest: this fact will more clearly appear, by tracing the following lines on the Map.

The West side of the Coal-District is thus drained. A ridge, commencing at the abrupt eastern bank of the Trent, near Newton Solney and Bradby, pursues a winding course forming part of the border of the Coal-Field, through Midway-Houses, in the line of the road from Burton-upon-Trent to Ashby; thence, by Butt-House, deviating to Several-Wood and Smisby; and thence, over Ashby Old Parks to Coleorton, where the ridge again diverges much to the south, rising gradually from the Trent to a height of

* There is no date for this, or tradition. The vicinity was probably occupied by the Romans, as various pots of Roman Coins have been discovered in it. With respect to the Woulds, however, there does not seem to have been much ground broken for mining. A singular pathway, or causeway, called "Leicester Headland," runs across the Woulds in a direction nearly east and west, about ten feet wide, and raised throughout with a red clear gravel which must have been brought from some distance, as no such gravel is found in the neighbourhood. Tradition states that this is part of a road which originally stretched from Leicester to Stapenhill; at which latter place, it is also stated that one of the earliest Christian churches was built, and that burials took place there from Leicester. It may, however, have been a passage from the Abbey at Leicester to that at Burton-upon-Trent.

four or five hundred feet. The water, on the north side of this ridge, has a rapid descent into the Trent, of about five to eight miles in length; whilst that, on the south, takes a south-west direction, giving rise to small brooks and rivers, of which the Mease is one: this, after joining the Tame, falls into the channel of the Trent at Wichnor, having a course of thirty miles. The continued line of ridge to the east, leaning towards, and terminating upon, Charnwood Forest near Bardon, discharges its waters, on the south side, by several branches into the river Anker, which unites with the Tame at Tamworth.

Another ridge commences near Bardon Hill, passing by, and probably bounding, the Eastern verge of the Coal-formation, where it is deeply seated under the marl of Bagworth; thence it proceeds to Barleston, Bosworth Park, Sutton Cheney, Stapleton, Barwell and Burbage near Hinckley, almost in a southerly direction. The drainage of this ridge, on the west, is conveyed by numerous brooks, into the Anker; and, on the east side, into the river Soar near Mountsorrel, joining the Trent near Sawley. The first part of the eastern drainage, by Bagworth and its vicinity, has an exceedingly circular route into the Soar, round the base of the *primitive formation* of Charnwood Forest by Thornton, Desford, Glenfield, Thurcaston, to Mountsorrel.

Notwithstanding the various mines which are worked within the area of this Coal-Field, its internal formation is but little known or understood; and indeed, to investigate this thoroughly, would require much labour and perseverance. The Sections hereafter introduced, will give some notion of the great derangement which part of the Field has undergone: but, the immense extent of the dislocations can only be ascertained by examination below the surface; for, they are not indicated upon it, except occasionally by a slight change in the soil.

It is a fact deserving particular notice, that, when the deranged state of the strata is considered throughout even a moderate extent of the Coal-Field, the surface should not partake of the same derangement. A comparison of the present state of the surface with that of the interior, affords a complete proof of the denudation which must have taken place, *after* the strata were consolidated and subsequently disrupted. It has been observed, that the drainage is wholly to the Trent; but the scooping out of many valleys in the Coal-Districts could have been effected, neither by the streams now passing through them, nor by casual storms occasioning local inundations. Some of the valleys in the Clay strata or clunch, are smooth and lengthened out: others are rather precipitous: and, in many instances, they take their direction through the outcropping of the strata, by which the alternations of the seams of Coal, Ironstone and Sandstone, are exposed on each side of the valley, at the proper corresponding levels. Here is another proof, that, in these instances, denudations did take place *after* the strata had acquired their present position and declination. The supposition of a small power, acting for an indefinite period, is favoured by the circuitous and uniform fall of the water in the valleys, through the Coal-District: but, such a power is totally inadequate to smooth down the asperities caused by the dislocations of the strata; these asperities, therefore, must have been removed by a tidal current, deep and long continued. If the existing inequalities of surface had been owing to the quiet, yet constantly acting, streams which now run over them, immense alluvial tracts must have occurred more or less in every valley: whereas, for many square miles of easy undulating surface, with hills and valleys, varying from fifty to four hundred feet in level, few alluvial deposits are found, and those of small dimensions. The seams, traced to one thousand feet deep, are defined on the surface, whether in the bottom of the valley or on the summit of the hill:

consequently, the power of denudation must have been immense, and its pressure uniformly exerted. Assuming that the present high ground of the country, was the highest in relation to the ocean, prior to the cause by which it was denuded, a tide acting over it would, by the pressure of the fluid according to its velocity, give an uniform declivity from points which opposed the greatest resistance to the greatest depth of the valleys where the least resistence was opposed. Their circuitous direction favours this idea, as the currents in the ocean now produce, in depths and velocities, all the phenomena of hills and valleys.

The inequalities upon the surface of the earth, whether easy and smooth, abrupt or precipitous, are no guide to the miner, and often mislead him. A line of fault, one foot or one thousand feet of fall or rise in the strata, is not perceived upon the surface, in some districts: and the most broken surface is often found, where the greatest regularity and uniformity prevails below. This leads to the conclusion, that water has flowed violently over the surface subsequently to the formation of slips: and, in respect to valleys, that many of an extraordinary form on a large scale, are to be attributed to the same causes which produced similar results on a small one.

In mountainous countries, where deep valleys abound with lakes, earthquakes are usually regarded as their cause; but whether or no they were scooped out when nearer the centre of the earth, or in the position they now occupy, they were most undoubtedly produced in general by water, and by water alone. Neither were the areas of the lakes a necessary consequence of earthquakes, or subsidencies, or elevations of adjoining parts; but they were occasioned by the particular action of water, and by the nature of the substances acted upon, according to the position in which they lay, in the course of the stream.

In the mining districts of Derbyshire, and in several other rocky mining districts, it is ascertained that the surface, however *apparently convulsed*, in that it exhibits deep gullies, chasms, and precipitous façades, has little reference to the interior. The stratification of the rocks proceeds as uniformly beneath the highest pinnacle, as under the deepest valley. One instance may be adduced at Matlock High-Tor, where the Derwent runs at the base, in the line of a supposed slip, or chasm, down which the river has easily worn its passage. Now this is not the fact, for it flows over a solid bed.*

Let the section of any brook or river be examined through a considerable extent of its course, and the cascades and lakes therein, whether the fall is uniform or otherwise, will be found most abundant and surprising. In the Trent, these cascades and deep lakes are very numerous. In that portion of it which divides Derbyshire from Leicestershire, there are several places where the river is from sixty to eighty feet wide, whilst its depth is not more than one foot, on the average. Here, the stream flows at the rate of five or six miles per hour over a bed of gravel which stretches across its channel. In a few yards, the bed of the river suddenly deepens so as to form a cascade of fifteen or twenty feet, or more, with a sandy or muddy bottom, and this depth is continued for one hundred yards, more or less. Through this distance, the stream here forming a lake, moves at a very slow rate, until its velocity is again accelerated on reaching another bed of gravel, of the same description as the former. Whether the mild streams of the summer rain flow, or the more violent currents of winter floods when the volume of water is greatly augmented, and its depth over the gravelly shallows as well as deep places considerably increased, these deep places,

* See Farey's Derbyshire, Vol. I. page 129, plate 5.

or pools, in the channel of the river remain unchanged. Although it is notorious, that the gravel is carried away from their upper sides, through them, and hurried forward; yet are these pools never filled up, but retain, year after year, an equal permanent depth. Now, all this seems to prove, that even the slow progress of the stream, in deep water, is fully adequate to carry on the gravel, by reason of the altitudinal pressure.

The gravel of the Trent is carried onward in an extraordinary manner over impediments: thus, at King's Mills near Castle Donington, each winter's flood deposits many thousands of tons of it, at the foot of a weir. For a mile or more, this gravel is rolled along the bottom of the mill-pond, which is in many places twenty or thirty feet deep; and, immediately before passing the weir, it ascends the bed of the river, forming the inner side of the weir, at a rise of one in three or four, although the gravel itself may ascend diagonally at a less angle. The accumulations at the foot of the weir, are carried forward by heavy floods: in some seasons, these accumulations are immense for some months, until removed by succeeding floods.

Another phenomenon contributes to remove the gravel-beds and banks of rivers, down their course. In the Trent, and other streams having such beds, a curious transport of the gravel therein is effected; and, at times, this is carried on to an enormous extent, by means of what is usually called "ground-ice."

The formation of this singular phenomenon is thus explained. When the temperature of the air is much below 32° Farenheit, and the wind blows hard from the north or north-east, it meets the current of the river, and produces spray; this is caught by the wind, and becomes icicles: again, the water is, by the current, thrown into small whirls, the edges of which being elevated, are also caught by the wind and converted into icicles, which are thus formed in deep waters as well as in shallows. These slender icicles unite at all points and angles, and float downwards, until they pass over gravelly shallows, the uneven bottom of which causes the water so to roll over as effectually to mix that portion containing the icicles, with the rest which flowed underneath. The small icicles rest in the several eddies behind the gravel stones and uneven portions of the bottom; and, uniting together, they adhere to the stones and to the bottom, until a mass of ice has so accumulated that its buoyancy overcomes the weight of the loose gravel or stones to which it is attached. When this takes place, the whole rises in the water and swims along. Where the gravel is cemented, or adheres to the bottom, icicles continue to accumulate until large masses are raised and float off. These masses are carried rapidly down the stream; and, being driven against each other, a perpetual change in their volume succeeds. If gravel is thus separated, then the ice with its decreased burden rises higher above the surface: again, when ice is detached in part, the residue, losing its buoyancy, sinks beneath the surface: soon, however, this portion regains more icicles, re-ascends and resumes its journey. The quantity of gravel and ice thus moving down the stream is truly astonishing; it seems to fill the river, and will impede a boat. Thus, large masses are moved through deep water, and distributed for miles lower down the stream than where they were taken up.

The opinion has been maintained, that the formation of ground-ice takes place at the bottom of rivers; but, an attentive observer will soon discover that this process goes on at the surface only. For, in some gentle eddies in very deep water, the icicles may be seen in an accumulating and adhering mass, without a single particle of any earthy or other matter in it. This mass reaches from the surface nearly to the bottom, and appears like a beautiful light body of snow in the stream. These icicles are never formed on a muddy bottom, nor is mud alone ever attached to the floating masses.

The icy spiculæ produced upon the ruffled surface of the deep water of the pond in the Trent at King's Mills, on arriving at the weir, where the velocity of the current is much increased, are, by the commotion thereby occasioned, whirled to the bottom of the stream and upon the surface of the stone-work of the weir. This is not only full of interstices, in which the water forms very small counter-eddies, but a water-plant, called *Ret*, attaches itself to the stone-work, rendering it still more unequal. The small spiculæ insinuate themselves first into these interstices, where they soon adhere and accumulate; and, as the bulk of aggregated ice thus rises, it becomes an impediment which constantly increases, by fresh accretions, until it forms a wall or dam on the weir-top. This wall presents the most singular, beautiful, and fantastic shapes; it is often ten or fifteen inches in thickness, and half a yard or more in height; and it adheres so firmly to, and is fixed in, the interstices of the stone-work, as to resist the force of repeated strokes with an ordinary Trent boat-pole. Although the weir is nearly two hundred yards in length, not a space will be free from ice, which surmounts it so completely as to cause the water in the pond to rise and overflow the adjacent lands to an alarming extent: and this can only be remedied by breaking down forcibly a portion of the icy barrier.

By similar modes of operation, although upon a grander scale, the lakes of mountainous countries may have been scooped out, in consequence of their being situated in a peculiar line of current, or because of the measures there acted upon, being less dense than others in the course of the stream. The fact of lakes now filling up by the depositions of sediment quietly passing into them, has no reference to the origin of such lakes, or to the original situation of the valleys, where they were excavated.

If it were proved in any case, that faults crossed the head or foot of a lake, so that subsidence or elevation could be shewn, there would be some reason for calling in an earthquake, or some other powerful cause, as the instrument of their formation. This however is not the case: the proof, as far as it goes, tends to establish the regular continuity of the strata under lakes or valleys, with few exceptions.

Strong adhesive Clay, such as constitutes a great part of Coal-formations, seems to resist the action of water better than many rocks. Some of the highest parts of the Coal-measures in Yorkshire, as well as many places of England besides, consist of Clay, and are not acted upon by water, even in narrow gullies, so much as rock. The tops of some of the highest hills in Yorkshire, Derbyshire, Scotland, and in other districts, are getting higher every year by the growth of vegetable matter upon them. The waste from these hills is inconsiderable and takes place only in the exact track of the gullies or narrow discharges of the water, the colouring matter of which is derived entirely from the peat and other vegetables, and flows as an infusion merely, with little mud or debris.

In rocky valleys, frost and lightning reduce the precipices until a slope of debris is formed, the surface of which is still further reduced by frosts; lichens then accumulate, and give rise to a thin black coat which becomes a pabulum for stronger plants: these, in time, are succeeded by shrubs; and, ultimately, the whole is covered with vegetation, and increases in bulk almost imperceptibly, through all after-ages.

Bare rocks, which are not equally compact throughout their substance, and situated in gorges or deep valleys in a mountainous district, undergo a remarkable diminution of surface, by the action of the wind. This produces an honeycomb-appearance, occasioned by a perpetual whirling of small particles in any inequalities of the rock. From time to time, the triturated portion is forced out by rain, and adds to the debris abraded upon a larger scale. These effects of the wind's action are seen in church-porches, and at the angles of high sandstone buildings, where its velocity is necessarily increased. The same kind of erosion takes place in the vicinity of roads or dusty plains. Even the balustrades of Westminster Bridge are considerably worn, and will in time become too thin to be safe; but, this is effected by the rush of wind across the bridge, carrying dust and sandy particles with great force through the interstices, and striking the pillars, as it passes. The fossil-shells in the Portland stone being harder than the matrix, shew the extent to which this abrasion has already gone, the balustrades having been worked smooth when erected.

From a view of the present surface of the Ashby Coal-Field, and of the surface which it must have exhibited aforetime, it is impossible to conceive the height which the latter might have reached, above the existing sea-level: and, whilst it would not be difficult to shew that several hundred feet have been washed off, there is probability in the conclusion that many thousand feet were so removed.

In describing the drainage of the Coal-Field and adjoining districts, it appears that the valleys can all be traced to Charnwood Forest, and that the fall from thence is in every direction. There is much reason to doubt whether the mass whereof these hills are composed, was formed prior or subsequent to the origin of the secondary strata by which it is accompanied: for, if prior, then it may be conceived that all the Coal strata bordering thereon, with many others, once existed to a great thickness upon them, and that the present rocks of Charnwood Forest were exposed by a denudation which may have lowered the whole surface of the country, by sweeping away, not only the superincumbent strata, but an immense quantity of this *primitive* mass, leaving it abraded and jagged. Had it been a subsequent formation, the result of volcanic agency, then the force by which it was fused and its contents protruded through the overlaying strata, might have converted part of such strata into rock, and thrown the remainder at a little distance into the inclinations in which they are now deposited around it, leaving its own top and the shattered portions of these strata to be torn away and worn by attrition into gravel, sand, marl, and clay, by the undoubted denudation it has undergone, whether suddenly, in a year, or gradually since the creation.

Having attentively examined the profiles and sections, let us ask the questions: When did these dislocations happen? At one time, or at successive periods? How awful the appearance! What magnificent desolation! What power softened the asperities of the surface, and so perfectly abraded the frightful overhanging precipices, so completely filled up all the horribly gaping chasms of inconceivable depths, as that not one of them now remains to tell they ever existed? What but the tumultuous action of a deluge, could have carried away the tottering tops of the shriven and fissured peaks that were either left upon a tilted base, or forced up by an internal acting power: what but the gradual retirement of a deluge, forming an easy declination to the ocean, could have substituted a smooth, undulating and accessible surface, abounding in soils of various qualities moulded from the intermingled ruins, and each adapted to the production and sustenance of an infinite diversity of vegetables and animals.

Let successive world-makers exercise their invention in fabricating ideal systems, it will be a long time before they produce a better view of the earth's existing constructure than that given by the first Geologist, when he assures us, that on "the seventeenth day of the month, the same day, were all the fountains of the great deep broken up;" that "the waters prevailed upon the earth one hundred and fifty days;" that "the waters returned from off the earth continually, and after the end of the one hundred and fifty days, the waters were abated;" and that "the waters decreased continually until the tenth month." Has any one system, hitherto published, given a more probable account of these extraordinary operations than the outline sketched in these passages? Before rejecting, without evidence, the descriptive facts enumerated by the above-quoted writer, it would well become his opponents to prove, that he was an uneducated person: but, if he was an educated person, then either to shew, that the modern Europeans are wiser than were the Egyptians of old; that they know better how to cut out blocks of stone in the solid, and to move them; to raise obelisks, and build pyramids; to cut canals, and turn the courses of rivers; to erect walls, towers, and temples; to make inimitable dyes, and to arrest the decomposition of the dead: or to shew, what people were employed for these purposes by the Egyptians, whilst they themselves knew little of Astronomy, or of any other science or art. Can it be shewn that this historian obtained all his knowledge from the Israelites by tradition, or when he was at school under the care and direction of his princely patroness?

The following Facts and Observations relate principally to the Moira Colliery upon Ashby Woulds. The detail of them may be uninteresting except to those who are attracted by the novelty of the subject, or who have a desire to acquire local information, as a means of promoting the objects of geological science.

CHAPTER I.

ON THE PRINCIPLE, THAT EVERY STRATUM HAS ITS OWN PECULIAR FOSSIL.

The three Sections of the Shafts relate to a small portion only of the Ashby Coal-field, in the parishes of Donisthorpe and Ashby-de-la-Zouch; and, being upon the same scale, they shew the variations in the thickness of each stratum. The shafts are about a mile asunder, and marked in the Map. Throughout the extent proved, the strata vary little in appearance, colour, hardness, or extraneous substances: they differ chiefly in the fossils they contain. Heretofore, the miner had no guide, save his own long-practised and often dearly-purchased experience, in deciding where he should sink a shaft, or how he should proceed to recover the Coal where a fault or slip intervened: but he was unable to impart the knowledge thus acquired, because appearances and descriptive terms could not be expressed to a stranger, so as to assist him in deciding in the same manner. This faculty of practical observation in Mining, resembles some others which are difficult of comprehension. The celebrated land-drainer, Elkington, scarcely ever missed effecting drainage; but, to others he could not communicate his ideas of the requisite means; and, undoubtedly, part of this difficulty arose from the various situations, to be acted upon, differing so much that the mind was obliged, in each case, to employ different reasonings to which extensive practice gave confidence. So, in a great degree, it is with mining; although certainly, this purpose would be effected better by a careful scientific study.

When it is considered, how few shafts are sunk in deep mines and how small a portion in each stratum is passed through, as each foot or even inch, in sinking, may perforate a new plate or stratum whereof the character requires a study; and, when it is also considered, that this portion is broken up by a glimmering light and almost always in water; that it is discoloured with the blasts of gunpowder constantly used (for the clay is so compressed at these depths as not to be got without gunpowder); that it is cut into small pieces, in extracting a space only seven or eight feet in diameter; and that, when raised to the surface, it is immediately poured down a sloping bank of debris, covered by a succeeding quantity and mixed with the superficial mass, it is no wonder that records of facts are not preserved. Another cause of not registering observations, is this: it may happen that several feet shall be loosened in the day, and sent up during the night, including peculiarities of fossils, or extraneous substances, which no ordinary workman would think worthy of attention. In such cases, years might elapse before an opportunity again occurred of recording the like appearances. Mr. William Smith originally suggested the fact, that each layer or stratum has its own peculiar fossil. The knowledge of this fact has been of the greatest practical use in the Ashby Coal-Field; and, although the generality of its application, as a principle, has been doubted, if not denied; yet, since it holds good for some miles, it must be of extreme importance to the miner.

Upon the most careful comparisons made at several shafts, some *general* appearances conduce to identify each stratum, although the *fossil* appearances, and the colour and accompaniments of ironstone may have varied.

It is quite probable that, of several shafts sunk through the same stratum abounding with fossils, each shaft may produce a dissimilar species of them, in that particular space; whereas, if a greater extent of surface, in the direction of the laminæ, were examined, the whole would be discovered; sometimes separated, sometimes mixed.

It is not clearly ascertained whether or no some of the fossils, vegetable or animal, are repeated; the similitude between them however is great; but the species of each may be found to vary upon minute examination. The alternations of the seams of indurated clay, sandstone, coal, and ironstone, might lead to the inference, that fossils of a similar kind would be repeated; but this does not appear to be the case, as fresh species and families commonly occur.

By comparing the number of a particular stratum in the Section of the Coal Shaft, No. 3, with the corresponding number of the fossil delineated in the Plates, it will be perceived, that however similar the particular stratum may be, in colour, density, or quality, to another stratum alternating in another part of the Section; yet, the fossils generally differ. It may, and doubtless does happen, that several strata, perforated by a shaft, do not yield a single specimen of their fossils in the diameter of that shaft; when, probably, at a few feet horizontally in the same measures, a variety of such remains would be exposed. Again, any stratum yielding a particular fossil only, in the space excavated, might, upon further search, contain others agreeing with those found in the same kind of seams. This shews how hasty conclusions, drawn from isolated facts, may lead to error.

CHAPTER II.

ON THE EVOLUTION OF CARBURETTED HYDROGEN GAS, AND ITS MANAGEMENT.

It is not exactly ascertained in what state this gas is evolved, in the Ashby mines. Whether it exists in large or in small quantities, however, it is scarcely perceptible to the smell, and its odour is rather agreeable than nauseous. It accelerates respiration a little; causes a tingling in the nose; and affects the eyes; although this is not always the case. It is most abundant upon first opening a work, and in driving the adits for air or horseways. Whenever it is necessary to drive an adit up-hill, the greatest care and labour are required to prevent accidents, by impelling atmospheric air, either with forcing-pumps and pipes, or with fans (provincially, Blow-Georges) and side-cuttings, called Ricketings, to the extremity of the adit.

Experience has proved that, whether in driving adits or in getting the Coal, it is safest to work down-hill. By this method, accidents rarely happen, and inflammable air seldom accumulates; a circulation being kept up so long as the horses and men with burning candles are there. Even when in a quiet state, or independent of any artificial means, the gas from its levity will escape, in the upper part of the adits, over the common air, if the ricketing is good. This cannot always be depended upon; for, at some seasons of the year, the state of the weather is such as to cause a stagnation of air throughout the work. A Davy-lamp is directed to be always used, upon entering any adit or work which has not had horses, workmen, or burning candles in it, for the preceding hour. In the adits, if left only for some minutes, the accumulations of gas are occasionally so rapid as to be dangerous.

During the working or getting of the Coal, notwithstanding the quantity of gas which is then liberated, few accidents occur; because the circulation, kept up by the consumption of atmospheric air for a great number of horses, and men with their candles, prevents stagnation. The candles are directed to be constantly placed at some distance from the roof; for, if this is at all broken down, although the rush of good air is great, the bell-form inequalities in it generally contain inflammable air; and, where these inequalities are not large, the boys in passing frequently fire them for sport. The workmen, upon any occasion of the gas being ignited, fall immediately flat upon their faces, and thus often escape injury, although the fire rolls over them.

The adits vary from five to six feet in height, and the coal-work is about six feet. The greatest danger arises from the ignition of gas in the workings. This sometimes happens, at an extremity, in particular weather; for then, an explosion takes place in consequence of the general diffusion of *inflammable* air throughout them, so as to leave no space for *common* air alone to rest in. The workmen cannot avoid an incidental explosion of this kind; and, as they work naked to the waist, their burns are very severe, although seldom fatal.

Where it is fired in the adits and gangways, the inflammable air is generally in a mixed state: it occupies the upper part of the area only; and, for this reason, a lighted candle may be carried along the floor in safety: but, when the flame is inadvertently communicated to the under surface of the gas, volumes of fire roll off in succession until the whole is consumed. These are carried to the general discharge current, from the increased circulation then induced by rarefaction and expansion.

Another method of expelling the inflammable air, is this: in short distances from the main current, upon entering an adit, a workman crawls upon all-fours without a light, keeping his head low to prevent breathing the gas, or a mixture of it, and fastens a hook with a string through it, in the roof at the extremity of the opening. He then returns in the same manner to its entrance, with the two ends of the string in his hand: to one of these ends, he fastens a lighted candle fixed in clay on a board; with the other, he draws the candle to the extremity in good air, and thus raises it to the hook in the roof, when its flame ignites the gas at that point. This ignition immediately occasions a rush of atmospheric air along the floor to the same point, and the whole of the gas, fired or not, is driven out, the workmen keeping to the windward side of the entrance of the adit, in the line of the main current. Sometimes, from the quantity of gas, this rush is so very great as to cause a sort of shock, forcing open the doors for regulating the air, and producing a blast through the avenues so strong as to blow out all the candles. This method has very seldom been resorted to since the Davy-lamp came into use; for, upon that indicating the presence of gas, other means are employed for expelling it, and preventing its noxious effects. This is accomplished either by impelling common air to the end of the adit, or by mixing the gas with so much respirable air, as to render it innocuous.

Mixing the airs was successfully practised before the Davy-lamp came into use. The method was this: upon a workman coming to the adit, and suspecting the presence of inflammable air, he stripped off his flannel shirt; and, without a candle, buffetted and mixed the air, top and bottom, throughout the extent of the adit, continuing the process until, by his sensations, he supposed a light could be introduced. It will be easily imagined that young or careless workmen frequently failed in this, and suffered in consequence. When the gas is thus accidentally ignited, the heat is intense; and, although it be a mere flash, it inflicts a deep and painful burn. A flannel jacket or shirt, however, is often sufficient to save the skin, whilst exposed parts may be extensively injured.

Where the evolution of this gas was abundant in an adit; and, where the circulation proved slow, yet with atmospheric air enough for the purpose of supporting life well; light was thrown upon the works by the introduction of a wheel armed with large flints, at its outer circumference. This wheel upon being brought in contact with steel rods, and briskly turned round, caused a flow of brilliant sparks which was sufficient for giving light to the workmen, but would not ignite gas.

The Davy-lamp has extreme merit; yet, notwithstanding the best precautions, accidents will happen. That person, therefore, would also be entitled to very great praise who could discover the means of remedying or alleviating the sad torture of being flayed, and of preventing the consequences of such a suppuration as takes place in the cure. Goulard's extract is kept at the works, but this cannot be applied quickly on every occasion. The application of carded cotton, in close compacted pads; and, latterly, flour dredged over the whole space burnt, with the dredging continued as long as moisture appeared, have been recommended, until a cure is effected. If the exclusion of air from the scorched parts is important, the latter expedient seems likely to answer; and flour, for the purpose, can always be kept in every work, so as to be ready for instant use.

It has already been observed, that, in this mine, the carburetted hydrogen gas is not very perceptible to the senses. Often, indeed, the workmen cannot perceive it even when in the midst of the danger it may create. Notwithstanding the constant use of the Davy-lamp, accidents do occur; it would, therefore, be a very useful discovery, if any substance could be found which, on being placed in the works, might generate a strong scent by attracting the gas. The ammoniacal odour of artificial gas is perceived before it is sufficiently mixed with common air to make it explode; and, if the atmosphere of this mine could be tainted with any particular smell, this would be a notice of the state of the air in the passages.

Most of the accidents happen in a morning, when the men first enter on their work. These accidents result from the circulation having been slow, or perhaps suspended, during the night. Wherefore, if the men, upon quitting their work in the evening, could leave in the different parts of the mine any composition which, in the morning would indicate whether or not the gas prevailed, that would be a warning: but, if there could be found a substance, cheap and plentiful, and capable of absorbing, neutralising, or decomposing the hydrogen as it issued, the remedy would then be complete.

A few of the rocky strata yield inflammable air, but not in abundance. In one of these, at a fissure in the shaft, it was fired in passing and burned until buffeted out. Upon the coal being got near the shaft this effect ceased; in consequence, probably, of some dislocations which cut off the feeders. Some of the seams of coal do not yield inflammable air; or, if they do, it is in such small quantities as not to be perceived.

Hitherto, it has not been ascertained by actual experiment, whether this air exists in the Main Coal, under a pure gaseous, or a liquid, or condensed form. When an adit is newly driven, small portions of water exude for a while, and then subside. At the same time, air is evolved from numerous pores or fissures, with or without water, and its issue is attended with a considerable noise on every side, like the hissing of snakes, as the workmen say, or the sound from a tea-kettle on the fire. After some months, this noise ceases, except in a few instances. These fissures are narrow and of very little extent: they are technically called pin-cracks. The coal is impermeable to water in all directions, and can resist its pressure at any altitude, in a few yards of thickness.

How far it might be practicable to render this gas useful in mines, was perhaps never thought of: to get rid of it, has hitherto been the only object of care; but the time may arrive when it will be made applicable to the general purposes of mining. In the mean while, the safest way of using it in mines would probably be, to erect a gasometer on the coal-pit bank where the refuse coal could be used, and to conduct the gas by proper pipes, down the shafts and along the gang-roads and levels under ground, and even in the workings.

In the Ashby mines, an instance lately occurred where this gas might have been made useful, with a suitable apparatus. A passage was driven to some distance in the solid coal, for the purpose of ventilating a portion of the workings; and it afterwards became necessary to stop this opening closely at both ends, with clay dams kept wet, according to the usual mode of preventing the circulation. After a while, the inflammable gas accumulated to such an extent as, by its pressure, to force the dam. Luckily, however, this happened at a time when there was no light in the avenues of discharge, and the air passed off without occasioning any injury. This adit again became partially filled with inflammable gas; and, to prevent circulation or further access of this gas, the dam was carefully renewed, and the following contrivance adopted. Through its structure and at the floor, a pipe was laid with its outer end immersed in a small pool or basin of water about ten inches deep, in the shape of an inverted cone; and, as the gas collected, it expelled the common air through the pipe in bubbles, at the surface of the water. In a short time, all the atmospheric air was discharged, leaving the inflammable gas alone in the adit; for, as this gas, by its specific gravity, occupied the upper part of the passage, it forced out all the lower stratum of air. This was proved, by the bubbles at length taking fire upon the application of a lighted candle. As soon as the pressure within increased, a discharge of the gas took place, through the water, in considerable quantities, at intervals; and, men being at work near the discharge, it took fire in passing their lights, and alarmed them. To obviate this firing, a pipe was inserted in the upper part of the clay dam, by which the gas escaped as it formed; and, constantly mixing with the passing current of air, it was rendered innocuous. A stop-cock, fixed in this pipe, might have allowed these gaseous accumulations to be drawn off, for the use of the mine.

The dreadful accidents which occur in the northern, and other mining districts of England, afford a perpetual warning to all miners, wherever this gas abounds. To guard against the evil effects of its rapid accumulation at the Moira Colliery, the adits for horseways and air are driven out a long time before the coal is worked, and sometimes for a mile in length. By this method, the mass is freed from sudden issuings of the gas when the coal is wrought out. In driving these passages, the fresh air is copiously supplied, and must traverse the space where the workmen are, and thus its circulation carries out with it the inflammable gas very much diluted. Holes are bored in the roof and sides, where this is supposed to abound; and, out of these, a quantity issues for indefinite periods, sometimes for a few days or weeks, and sometimes for years.

Some persons are of opinion, that this liberation of gas deteriorates the quality of the coal in the mine; but this opinion can be conjectural only, because the quality varies in a few yards, by compactness, tenderness, or some slight difference to be observed only by those who are working the mineral, or are in the habit of closely examining it. But this deterioration in mines is not to be compared with that which takes place upon the coal, when brought to the surface and exposed to the changes of weather, as wind, rain, sunshine, and sudden alternations of temperature by evaporation. Hence, in some seams, the decomposition or disunion of structure proceeds so actively as to reduce a well stacked body of coal to a mere heap of rubbish in a year or two.

It is a fact, however, that previous tapping or boring of the masses, does lessen the danger to the men, when getting the coal, as less gas is then found in the workings. The best protection against the accumulations of this deleterious gas, and also against the direful consequences of its being fired, is, the precaution of having the ascending column of air by a shaft, the bottom of which is the highest part of the mine; and of carrying the supplies, by proper means, to its deepest part, from the down-blowing shaft.

Still the difficulty remains, of proving whether this gas exists in the coal in a solid, liquid, or aëriform state, and is liberated by removing the immense pressure; or, whether the introduction of common air and its accompanying moisture, produces chemical changes on the surface and in the small crevices of the mineral. By the force with which it is sometimes evolved from chinks and fissures, the former might be inferred: by the slow issues from others, and by the surface of the coal in the adits or elsewhere, when exposed to the atmosphere, being partly decomposed and losing some of its adhesive bituminous qualities, the latter may be inferred.

Where water lies and some muddy matter is collected in the levels, upon a man walking in it and disturbing the bottom, bubbles arise in abundance, and are often fired, as they float on the surface, by the workmen. No peculiar smell is then perceptible.

However long these level adits may continue to be used as passages, both of air and water, no change takes place so as to render the water impure, or to produce other than the carburetted hydrogen gas. For the purpose of providing for an early repair of their defects from decay or injury, the state of these adits is occassionally examined.

CHAPTER III.

ON THE COMMON AND SALINE WATERS, IN THE MINES.

The Moira Mines do not pour out large volumes of water. This circumstance arises chiefly from the extraordinary number of faults which intersect the strata in various directions, are accompanied by slips, and thus become barriers to the springs. From the depth of the Shafts, which varies from seven to eleven hundred feet, it is particularly desirable to have as few of them as possible; not only to save the expense of sinking them, but likewise to avoid the chance of promoting the descent of water by the perforations.

The principal part of the fresh water is found within three hundred feet of the surface, and that in no great abundance. It is kept down by a pump, the working-barrel of which is nine inches diameter, with a six-feet stroke, operating four or five hours in a day. Below this depth, very little, if any, *fresh* water exudes.*

* The water is raised from the mine by a large pumping Engine which consists of a cylinder fifty-three inches diameter, two outer beams, the one twenty-four feet long and connected with the pumping apparatus in the deep pit; the other, twenty-three-and-a-half feet long, connected with the upper shaft. One shaft is two hundred and fifty-two-and-a-half yards deep, and contains four lifts of pumps; all the working barrels of which are seven-and-a-half inches diameter, and the pipes ten inches. The lowermost of these four lifts is twenty-two yards; the second, forty-nine yards; the third, forty-seven yards; and the fourth, or uppermost, is forty-one yards in length. This fourth lift delivers the water into a cistern, connected with a pipe which conducts it under

In working the Main Coal, a little salt water oozes out; and, although it *bleeds* as the work advances, this bleeding generally soon ceases. In some few places it continues to issue in small dribblings; and these, collectively throughout the extent of the Moira coal-mines, do not, in the twenty-four hours, exceed fifty hogsheads which are conducted to the common reservoir.

As far as common observation goes, this Mineral Water is the same in every part of the Ashby Coal-Field hitherto worked; but, with a view to ascertain its precise nature and elements, a sufficient quantity of it was submitted to Dr. Ure, for chemical examination. The doctor has long maintained the highest reputation, as an erudite and practical expounder of the Chemical and Geological sciences; for this reason, his detail of the processes by which he determined the constituent principles of the Ashby Mineral Water, as it is evolved in the mine, SECTION III., must be as

the Engine-house to the basset shaft, where it is emptied into a cistern fixed on a frame. This water is altogether salt; and, when these pumps are at work, a clack is shut in the cistern, at the bottom of the basset shaft, to prevent the fresh water from feeding the upper lifts. The basset shaft is ninety-six yards deep, and contains three lifts of pumps, the working-barrels of which are seven-and-a-half inches in diameter, and the pipes ten inches. The lower lift is forty-nine yards; the second is thirty-eight; and the third, or uppermost, is a force-pump of ten yards. The cistern at the bottom of the basset shaft, is six feet deep, and connected with a reservoir, cut in coal, and made to hold four or five days' water. When this water is lifted, the rods in the deep shaft are disjointed at ten feet below the surface, and the weight is balanced by two beams with arch-heads, placed in the side of the shaft. A drain to the brook takes off about ten yards of fall.

The average quantity of *Fresh* water occupies the Engine with the lifts in the basset shaft, only about nine hours in a week. The average quantity of *Salt* water alone, employs the Engine about one-and-one-third of an hour per day, or about ten hours per week. The topmost lift delivers the water into a cistern about ten yards down the shaft; which, when *fresh*, runs over at the top of the cistern and down the drain to the brook; but, when *salt*, it is forced into the Bath Reservoir by a forcing-pump connected with the lower part of the cistern, which is supplied by the Engine lifting *salt* water alone. The *fresh* water is pumped up, at about seven strokes per minute; the *salt*, at five-and-a-half strokes per minute: so that the fresh yields ninety-one gallons per minute, and the salt seventy-one gallons per minute whilst working, or about ninety hogsheads per day.

interesting as it is conclusive. It is given in the subjoined Letter;* and the important results of his elaborate Analysis appear in the following Table.

One imperial gallon contains

	GRAINS.
Bromides of Potassium and Magnesium	8.0
Chloride of Calcium	851.2
Chloride of Magnesium	16.0
Chloride of Potassium	.0
Iron, as a Protochloride .... a trace	
Chloride of Sodium	3700.5
Grains	4575.7

The above 8 grains of Bromides are equivalent to 6 grains of Bromine.

* *London*, 13, *Charlotte Street, Bedford Square*,
16th May, 1834.

Edward Mammatt, Esq.

Sir,

I have devoted many days, in conjunction with my Son (who has lately returned from the French and German Universities), to the analysis of the Saline Water you sent me some time ago, and have the pleasure of transmitting you an account of the results.

Taste of the water, simply and strongly saline. It is pellucid and colourless. Specific gravity at 60° F. 1.04647, distilled water being 1.00000. It is without any remarkable impregnation of a gaseous kind, and contains no sulphates, affording no trace of sulphuric acid by nitrate of barytes. 1000 grains of it evaporated to dryness, yield of gently ignited saline matter 62½ grains, being 6¼ per cent.

During the ignition, the odour of Bromine is perceived. When a concentrated state of the water, of specific gravity 1.205, is mixed with starch and a few drops of sulphuric acid, and boiled into a paste; aqueous chlorine poured over this paste in a wine-glass, produces very soon a beautiful golden-coloured ring round the top of the paste, indicating the presence of Bromine.

One gallon imperial and two-thirds, of the water being evaporated to one-fifth of its bulk, began to deposit crystals. It was cooled and exposed to a current of chlorine gas till its colour assumed the maximum yellow tint of which it was susceptible. This liquid was agitated with a pint of Ether, which seized the *Bromine* and rose with it to the surface in a deep yellow stratum.

This ethereous solution of brome being carefully separated and tested by my new method of

Bromine was detected in the Ashby Mineral Water, in 1829, by Dr. Daubeny, Professor of Chemistry in the University of Oxford, by an experimental process instituted for that purpose: an account of his investigations was communicated to the Royal Society, and afterwards published in the Philosophical Transactions.

As the origin and composition of the Ashby Mineral Water may give rise to speculative remarks, it is necessary to detail all the facts appertaining to its presence and qualities. Generally, it makes its appearance in any adit in the coal, as soon as driving commences. In some places, it is more abundant than in others; and, in a few, none of it appears. The coal is said to *bleed;* because, for the most part, the water soon ceases to flow. This never spirts, nor comes out with any force, upon the pressure being removed; but, it rather oozes, and is invariably accompanied with a

analysis, indicated 10.3 grains of brome; a result verified by evaporating the neutral compound of it and potash, to dryness, and igniting the bromide of potassium. Hence, a gallon of the water contains 6 grains of brome, in the state of bromide of sodium, besides a very little bromide of magnesium. I took every method to detect the presence of iodine, but could find none.

One gallon of the water contains four-and-a-half cubic inches of air similar to the atmospheric, with a slight excess of azote: 6 grains of magnesia, partly in the state of hydrobromate, but chiefly in that of a muriate: 851.2 grains of chloride of calcium: and altogether of saline matter, chiefly chloride of sodium, 4575.7 grains=0.6537 of a pound avoirdupois.

It is a valuable peculiarity of your Water, the being entirely free from sulphuric salts which, in my opinion, constitute the principle of crudity in mineral waters, and often counteract the deobstruent virtues of the other ingredients.

By the test of muriate of platina, carefully applied to the mother waters of your Saline Springs, no *potash* salt is indicated; and, therefore, I have placed a cypher opposite to muriate of potash *(chloride of potassium)*, to denote its absence.

The Iron being in the state of *protoxide*, acts more kindly on the human frame than in that of *peroxide;* and therefore, though the quantity be small, it may prove tonic from its ready absorbability by the lymphatics or lacteals.

I am, Sir,

Your obedient Servant,

ANDREW URE.

gentle hissing noise, as if air was escaping at the same time. It issues chiefly from small crevices (pin-cracks), and seems to be charged with inflammable air, which escapes as the water trickles down the coal. Sometimes the gas is in such abundance, that it may be fired; and, when ignited, it resembles a stream of burning alcohol. In driving an adit in the solid coal to any distance, not so much as a drachm of water is found at any one point, and very little oozes from the roof or floor of the opening; but what is very remarkable, on a lump of coal being detached, water soon afterwards begins to be extilled from the crevices of the seam.

Immediately *over* the coal-measures from which the Mineral Water exudes, is a stratum of exceedingly fine fire-clay, called Tow, about eighteen inches thick. This is not permeable to water. Immediately *under* the coal, lies a stratum of soft clay, eight inches thick; and, directly *below this*, is another layer of fire-clay, compact, and several feet in thickness. This last measure also is impermeable to water.

The bed of Coal, although it contains *pin-cracks* which seldom extend many inches, has also the partings called slines, and those called cleavings, in the direction of the bed; yet, the coal-measure itself is so little permeable to water laterally, that a few yards of it are sufficient to confine the water of old workings.

Now, out of these facts, which are absolute, the inquiry necessarily arises: How and whence, is this water derived? Did it pre-exist originally as a saline fluid in the stratum; or, is it a recent composition, resulting from a new chemical combination of its elements? If this water was pent up in these crevices when the coal originally was formed, or even subsequently, it would very soon be drained off and exhausted. If the oxygen of the atmosphere furnishes one of the ingredients of water, the other abounds in the coal; but, whence come the saline and other substances so regularly and uniformly combined with it? Were these substances ever in solution before? Were they deprived of their oxygen, during the mysterious process by which the coal was formed? Are they now re-produced, by the accession of oxygen from the common air? Some persons contend that this salt water comes into the line of the faults from beneath, and diffuses itself in the coal. Although the coal near the faults, at particular spots, yields water; nevertheless, this comes not from above, nor from beneath; it neither drops downwards, nor boils upwards; but, it issues in minute oozings, at the sides. When a fault has been perforated, water is seldom or ever found therein, so long as the confusion of strata, occasioned by the break, remains. On the other hand, when the parallel strata set in, the coal yields this saline water at almost every part. The fault might be a rent to an immense depth, but the line of slip is filled up, and glazed by the pressure: hence, in the greater number of instances, where salt water is found and continues to run, the source or formation of this fluid cannot be traced to the faults; for, although near some of these, the water is abundant; yet, for the most part, the borders of the faults, and the faults themselves, are altogether without water, and constitute actual barriers to it in every direction.

That the coal contains or acquires Soda, is practically proved by the fact, that Potters are unable to use it in burning their ware, in consequence of its putting on the salt glaze, or vitreous coating of soda. It also abounds with pyrites, which is dispersed through the cleavage or bed, in small pieces called figs, from their resemblance to that fruit in a compressed state.

Salt water is found in one or more of the sandy rocks in the superincumbent strata, but to no great extent, and it contains much less muriate of soda than that which issues from the coal.

The contiguity of the Worcestershire and Cheshire Salt Works prevents the Salt made at Ashby Woulds from being profitable; for, although the fuel is cheap for evaporation, the extraneous matters, in this water, require an expensive process to purify it, in order to render the muriate of soda fit for culinary purposes. It is used in Baths, both at Moira and at Ashby-de-la-Zouch, and these have proved remarkably beneficial in numerous cases, particularly in rheumatic, paralytic, and scorbutic complaints. Its internal use, in small repeated doses, accelerates the discussion of scrofulous swellings, and that sort of tumour on the neck, called *bronchocele;* and this effect has been attributed to the powerful agency of bromine on the animal economy.

During several hundred years, this seam of Coal was worked from the basset, or outcrops, to the depth of one hundred yards, where it neither abounded in inflammable air, nor in salt water. The former rarely existed in the adits, and still less frequently in the workings; the latter did not appear at all, and has been found only in the mine since the workings were conducted at an increased distance from the surface, and where great faults or slips intervened to cut off the supply of water. At a change of temperature of the air in the mine, to a lower degree, the roof of the coal *sweats* salt water. This appearance is not altogether without its use; for, it is an indication to the workmen to adjust their openings for the better circulation of air, not only for their own safety, but to allow the candles to burn freely. In some sudden alterations, the doors for regulating the admission of air require to be set wide open, so that the passage may be as clear as possible.

CHAPTER IV.

ON THE POLARITY OF STRATA, AND THE GENERAL LAW OF THEIR ARRANGEMENT.

Polarity of the Strata, is a subject which hitherto has not been much considered. The extraordinary uniformity in the direction of the slines and of the partings of the rocky strata, seems to have been determined by the operation of some law not yet understood. The partings of the coal may be first considered, as they have been proved to a great extent in different parts of the Coal-Field.

These partings or slines are smooth-sided, and run parallel to each other. Sometimes they are clear, sometimes have a little smutty or sooty substance in their interstices. They are nearly vertical; or, if the coal-seam inclines, they form a square with its inclination. They are numerous in some parts of the Field; and, in this case, the coal is got with more ease, and in forms more square than where they do not abound. In other parts, they are very seldom found; and then, the coal having no natural divisions, is torn from the mass by force of wedges, and comes out of the work in uncouth conchoidal pieces.

Wherever these slines appear, their direction is 23° west of north by the compass, whatever way the stratum may incline. The coal between them has an arrangement of lines all parallel to the slines, by which it may be divided. This is called the *end* of the coal. At right angles with these, another arrangement of lines prevails. These, with the lines of cleavage, commonly called the bed, give a cubical or parallelopipedal arrangement to the coal.

The thick compact masses of compressed clay, known by the names of Clunch, Bind, Stony-Bind, and Ball-Ironstone layers, which are impermeable to water, but repeatedly alternate with coal, sandstone, or any other open measures, have no such slines or divisions. On the contrary, the seams of the coal, sandstone, and beds of ironstone, with which the alternates are made, have the same partings in the same directions. The sandstones which are full of cracks and divisions, have their partings running in the same direction upon the *end*, or northwardly and southwardly: whereas those which run eastwardly and westwardly observe no parallelism, although they ramify into the other. This arrangement holds the same, whether the strata in which it exists are at one foot or one thousand feet, from the surface.

Wherever the direction of slines varies, this variation may be owing to a tilt in the strata, subsequently to their primary formation. These slines have had their origin *after*, and not *during* the deposition of the strata. This is proved by the fact, that, whether in the coal, the shale, or the sandstone seams, no fossil vegetable has been discovered within the parting, or impressed upon the sides, whilst those seams themselves abound with vegetable impressions in the bed or horizontal cleavings. The direction of partings or slines varies at different Coal-Fields, but they preserve parallelism. They may have had their origin at periods very different; evidently, however, they were all formed under the same law. The right-angled direction to these partings is called the *face* of the coal, or quarry, because the workmen must face them as the easiest way of working.

Many of the Derbyshire and Nottinghamshire coal-measures, have their slines in the same arrangement as the strata in the mines upon Ashby Woulds, and this is also preserved in those of Coleorton, about five miles to the westward.

Wherever the strata, abounding with these slines, reach the surface, they give out much water; but, if they are surrounded by, or intermixed with faults, they produce inconvenience only in first passing through them, by causing great delay and expense in pumping until the reservoirs are exhausted. After this they yield very little, because their connection with the surface, or with an unbroken bed, is cut off.

CHAPTER V.

ON THE INDURATION OF THE STRATA, AND THE QUESTION, WHETHER THEIR CONSOLIDATION BE THE RESULT OF PRESSURE OR OF CHEMICAL ACTION; WITH REMARKS ON THERMAL SPRINGS.

INDURATION of the Strata appears to have taken place, and it is equally plain that the process was completed, under different circumstances. This induction is founded on the fact, that some of them possessing nearly the same quality, have not become indurated in the same degree The great beds of Clunch, or compressed clay, as well as the more pure beds of Fire-Clay, have not undergone any perceptible change since their first deposition, except compression from the weight of superincumbent measures. Besides, they are all impermeable to water.

Some of the beds of coal, particularly the thin ones, are close and have scarcely an open sline in them, although they all exhibit the same arrangement of slines, cross partings, and the cleavage of the laminæ of the bed. Others, and indeed most of the thick beds, contain greater open spaces in the polar or crystalline distributions of their parts, and they have additional small vertical cracks which are probably the results of induration. Where these strata reach the surface, they yield an immense quantity of water, which necessarily descends into the mine. The sandstone rocks, whether thin or thick, are generally full of vertical crevices, besides the more regular partings or slines described in the polar arrangement. These crevices preserve their width, generally from top to bottom. Now, the proof that these cavities were formed after the deposition of the sand-rock itself, is this: they are clear, although covered by a clay which must have been washed into them, if these openings had been in existence whilst the sand-rock stratum was the surface. The superincumbent clay cannot be forced into the cavities on account of its tenacity and denseness; neither can it conform itself to the lessened surface of the rock, because this would occasion corresponding cracks in the clay. It is generally observed, however, that the upper and lower surfaces of all the strata so indurated and creviced, have a smooth polished parting, called a *shed*, at top and bottom. The sheds may be accounted for, by the concentration and actual sliding sideways, of the indurated parts. The manner in which this induration produces crevices, may be seen in almost any sand-rock alternating with earthy strata, or in limestone beds, alternating with compact beds of marl; the latter being waterproof, and the former full of crevices.

Induration, proceeding from arrangement of the parts of strata themselves, is different from that caused by compression. The several clunches, bind, fire-clay, and other measures allied thereto by a mixture of sand and clay, are so hardened in deep mines as to assume all the qualities of stone. They require to be loosened by gunpowder, preparatory to their being worked by the maundril; nevertheless, an exposure on the surface, to the atmosphere, for a few weeks, sometimes for a few days only, will moulder them to powder or convert them into puddle.

Besides the crystalline or polar arrangement, several important results may be attributed to the desiccation of the newly formed mass. Many of our hardest marbles, particularly the Devonshire, owe their beauty, when polished, to the ramifications of veins intersecting the stone. These veins differ in magnitude, in some degree proportioned to their number. Whether occasioned by convulsive shakings, or by induration, separations of the mass have taken place: and, on water percolating these divisions, it would fill them up by the deposition of calcareous matter freed from grosser substances, and thus render the whole mass compact and solid, as it is now found. Where this veiny marble occurs, it is subject, notwithstanding its veins, to have partings or slines running parallel to each other, and these are often filled up with earthy matter from the surface, or with calcareous spar, so as to close the openings completely. In the metalliferous mountain limestone of Derbyshire, the sparry deposit is frequently of great thickness, not only in the several beds, which are often separated by a layer of earth, but also in the great fractures, which contain lead ore.

That all the strata of the earth, no matter what their nature or description, have been soft, or flexible, or comminuted, or fluid, or gaseous, is a proposition which cannot be doubted. But much controversy has been occasioned by the inquiry, whether they were indurated by cooling; or, by merely losing their water and gaseous matter; or, by parting with their caloric of fluidity. Hereafter, perhaps, it may be discovered, that the combined agency of fire and water was employed chiefly in accomplishing the processes of induration.

If the interior of the earth has been partially melted by heat, these vacancies may have been produced, sufficient to account for the immense dislocations which the strata have undergone, whilst the mass was cooling. On the other hand, those strata which either now lie in an horizontal position, or at any angle with the horizon, although parallel to each other, and which cannot be referred to any other origin than a quiet deposition in water, may owe their partings and other separations to the gradual consolidation and induration of the mass. The effects, on the different strata, of either of these two causes might be calculated, according to their susceptibility of compression. The spaces produced by the contraction, in drying, of matter which has been deposited by water, will account for the lateral partings, and the immense vacuities in the interior, as well as for the greatest dislocations observed in mining. In many instances in Derbyshire, the caverns are occasioned by the separation of parallel beds; in others, by ruptures in the strata, having above, below, and on their sides, bell-like forms, owing doubtless to the action of water.

That partings of the solid strata, near the surface, occur every where; that fractures accompanied by slips or faults are found every where; and, that large caverns abound in many places, are facts generally known; but, to what depth these divisions may reach, is not known. If the cause of the dislocations exist far beneath the surface, and far below where the operations of man have penetrated, it may be inferred that the vacuities are extensive as well as deep-seated. Wherefore, it may be inquired, whether water has contributed to fill up these recesses, or to increase them, according to their situation and circumstances, or probably to both?

The cause of Thermal Springs has occupied the attention of many persons; but their researches have not led to any satisfactory conclusion. Their origin, however, is generally ascribed to volcanic agency, or a regular central heat. That some springs are thrown to the surface by faults, where different strata come in contact, is a well known fact. Few waters issue as uniform springs, which are not more or less impregnated with earthy matter, held in solution. Some of this, for instance the tufas, ochres, and many other concretions, is deposited as soon as it arrives at the surface; and this deposition may be owing, in part, to alteration of temperature or diminished pressure. But, should a body of water, holding in solution one substance abstracted from a stratum through which it has percolated, flow over another of a different nature also soluble by such water, new affinities may take place and precipitations occur, so as to fill up openings with apparently extraneous matter. If, in the process, crystals are formed, and water is partly taken up, heat might be liberated in quantity sufficient to impart to uniform streams an uniform heat, as indicated at their issue upon the surface.

The probability of thermal springs being occasioned by the escape of the caloric of fluidity of water, during the crystallisation of substances in traversing different strata, is strengthened by the fact, that, with us, most of such springs occur at or near faults or dislocations. In rocky districts, springs very opposite in their nature, are frequently brought in contact; and thus, consequently, water may perform an important part, by bringing together substances whose affinities will operate in producing new combinations. In these instances, no matter at what depth, the caloric of fluidity of water escapes, and must necessarily elevate the temperature of the surrounding medium. When the immense masses of tufa, stalactite, and other sparry concretions found in crevices and breaks; when the quantities of matter removed by running water from the crevices of one stratum and deposited in another; and, when the impossibility of all this being accomplished without loss of caloric from the water, are considered, it will be easy to account for the origin of warm springs. The quantity of some springs is so little affected in dry or in wet seasons, as to afford reasons for inferring that a considerable proportion of the rain which falls and percolates the earth, is consolidated in forming matter, the result of its combination with different substances decomposing the constituent parts of the water.

Melted matter, basalt, or other known volcanic products, appear to have burst through the strata, forming immense dykes for a great extent. The vacuity occasioned by contraction after cooling in the interior, may have been the cause of great dislocations in the superior strata, as the melted matter abated in heat. Some openings, even of large size, as well as many small fissures, were filled up by water, carrying in the debris of the adjacent strata, as is found in the coal-measures; or, they now remain the passages of volumes of water effecting important consequences: for, if passages do exist, it is probable that water would not be quiescent in them; and that, in some places, they may be enlarging the openings by their action, and in others, filling them up.

The consequences upon the density of the strata, arising from compression referrible to the superincumbent mass, are not uniform; for, if thick beds of sand or other rock harden and contract, they may form an immense series of arches, and thus produce waving lines in the strata below, by causing much pressure upon abutments, and little on the arches. In such cases, according to the thickness of these beds of stone, the arches will be of great extent. Thus, after an accumulation of strata upon hardened rocks, such partial pressure may take place upon the strata below, as to throw them into little faults and slips. As a proof of this, it is often observed that, where the coal has been excavated, leaving a space of five or six feet, at a depth of five or six hundred feet from the surface, such surface continued undisturbed, In this case, the coal was got, for one hundred yards in breadth, and few props were used for five or six weeks, until a space had been excavated of nearly one hundred yards square: when, on a sudden, the roof indicated pressure by portions thereof being detached with great force and noise: this disturbance will continue for an hour or two, during which time the men retire from the face of the work. Afterwards, there is little pressure, until an equal space has been excavated, when similar indications are repeated. The roof closes a little almost daily; but, at these periods of greater pressure, it almost wholly closes, and yet not regularly through the space excavated.

Several rocks exist between the coal and the surface, each from four to fifteen yards thick, as well as distinct beds of clunch or clay, still thicker. As this closing of the roof does not lower the surface (although there are exceptions named hereafter), it may be inferred that the superincumbent rocks and the accompanying strata, form successive inverted arches of one hundred yards span, near the coal, decreasing towards the surface which the smallest arch does not reach. It is evident, therefore, that an immense additional pressure must be thrown upon the abutments on each side of the workings so excavated: and, that it is so, is further proved by the following facts. Upon each side of these workings, a horseway with a rail road and an air adit, in the solid coal, are formed. To protect these, no care is required, upon first driving, because the pressure is equal; but, as the workings proceed, a rib of coal, several yards in thickness, is left between them and this adit. Notwithstanding this, when the periodical pressure takes place, the adits are often disturbed, pieces of coal detached, and the roof is crushed and splintered. After a time, when the pressure subsides, or rather when the slip, or break, ceases to move, these defects are repaired with wood, sometimes with brick; and, upon workings taking place on the opposite side of the adit, by which another weight is thrown upon the coal contiguous, the necessity for repairs is increased.

When the coal has been worked out on both sides of these ribs, an attempt is sometimes made to get out the ribs themselves, but it seldom rewards the miner; for, the coal is found shattered and dislocated. The extraction of these ribs causes no depression of the surface, as the two sides of the arches find a bearing upon each other, by a short sliding near the coal; and, of course, a conformity by short dislocations in the rocks above. In the same Coal-Field, where the seam is worked at a depth of more than seven hundred feet, the surface occasionally sinks. This occurs where the coal is freest from faults or slips; and, being got out almost uniformly, the whole superincumbent strata subside, yet there is not more than six inches or a foot of subsidence apparent upon the surface; so that rests take place on the margin of the excavated part.

The word *convulsion* is frequently used, both by theorists and practical men, in speaking of these faults. It certainly is, in most cases, misapplied; for, the term implies all manner of violent disorder, in which no rule or guide could be observed. There is method, however, in all these slips. It has been stated, that the strata preserve their parallelism; that the slips or faults are often parallel to each other, whether the leaps be up or down; that they often proceed in regular slips; and that, after short distances, they resume their regular course, leaving some spaces elevated into a tabular mass, and others depressed. These masses are often too narrow to be wrought, and sometimes continue for a great distance. May not contraction or induration of deep strata have caused vacuities affecting, on a large scale, the upper strata which have thus slipped, rather than been convulsed? Cavities in rocks and in other strata, may have been produced by pent up air, or by the developement of air upon a change of the density or alteration of their component parts. An instance occurred at Wednesbury, where, by the sudden irruption of water into a mine, a number of men were shut up in an ascending drift, and lived for several days until the water was pumped out, when they were extricated unhurt. The altitudinal pressure of the water had concentrated the air, but could not force it off through the dense strata. A similar instance occurred at Oakthorpe, in the Ashby Coal-Field, where a body of water suddenly filled a shaft and the workings; but a length of drift, or adit, there retained its air; and this, after several weeks reduction of the water by pumping, regained its equilibrium with the atmosphere, preserving dry and uninjured all the tools and clothes of the workmen. Another instance of the same kind is reported in the Gloucester Journal of May, 1833. It is that of five boys being pent up at Ledghill near Stapleton, in a part of the mine elevated above the bottom of the shaft for ascending, which was occupied by a sudden irruption of water; these boys, after remaining six days and nights without food, were liberated in health, to their astonished friends.

Some of the strata, having all the characters and solidity of rock, are used occasionally for roads or buildings; but such strata often deceive the workmen; because, in a few years, sometimes in a few months only, their cohesion is deranged. Even in the very best beds, the stone, indurated as described, is seldom to be trusted from any Coal-Field; and, whenever used in buildings, it should be most carefully laid in the same position it occupied in its original bed. Freestone, properly so called, is seldom found in coal districts; there is generally a cleavage in it, as well as variety of compactness in the texture of the laminæ of the bed. The borders of Coal-Fields, however, often abound in freestone.

If it can be assumed that all strata when formed, were at the surface and subject to the present atmospheric pressure only, some scale of reduction of their volume by desiccation, or hardening, may be attained. If that of clay be taken, such as the clays of the English Coal-Fields, by whatever name they are called, whether Bind, Clunch, Tow, Metals, Shale, or Blaes, it is shewn by Wedgwood's scale, that its compression or shrinking will amount to one-fourth of the original bulk: and, even then, that this will be of less specific gravity, or less compactness, than many rocks. Hence, taking any Coal-Field of ten miles long, five broad, and one mile deep, extensive cavities must necessarily have been produced so as to occasion slips, breaks or faults, with tilts of beds, until the maximum of density was attained. Strata may have dried in succession, notwithstanding faults run through many of them in a continued line; for, the first break would continue to widen, and thus tend to derange an upper layer at the same line. In this way, the consolidation of lower strata, in shrinking, may have caused rents through all the superincumbent beds, independent of the smaller slips or cavities in these same beds. Besides, so long as water continued to flow over and denude the surface, at an enormous pressure, the lateral shrinking might not be completed.

Modern Geologists seem to have satisfied themselves that there exists, or has existed, some law of superposition or arrangement of strata, which is never inverted. As none of the systems promulgated at present, are sufficient to account for all appearances, it would seem that, if more local facts could be collected, these might tend to a better elucidation of the subject, and would be much better than calling in fire, water, variable temperature, volcanoes and earthquakes, for forming valleys and ranges of strata for miles in the line of bearing.

CHAPTER VI.

ON THE DIP, OR INCLINATION OF THE STRATA.

As far as has been proved by workings, the whole strata of the Ashby Coal-Field generally preserve their parallelism. Like many others, this Field will probably be found to constitute a basin, or trough. So far as is already known, it represents the shape of a spoon, the tip of which stretches nearly south, and is lengthened out into the parishes of Swepstone and Snarestone, as exhibited in the Map. In this direction, the rise of the measures is about one in ten. On the west, the rise is more abrupt: this is shewn by the main-coal basseting in a line from the north end of Measham village through that of Oakthorpe. On the east, the rise is still more abrupt: this is shewn by the main-coal basseting from the highest part of Thing-Hill in the north-eastern boundary of Measham parish, along the south limit of Willesley, where the trace is lost, from high sand rocks projecting and apparently tilting the measures to an angle of about forty degrees. On the western side, the coal is thrown down by faults; and, consequently, its extent is prolonged considerably, instead of basseting in the original direction; and, although it has various swamps and elevations, yet on the whole it preserves its parallelism. On the north, the strata dip at a small angle, so as to lie almost flat; and the north basset has not been yet ascertained. This may probably have its termination in the face of, or a little under, the long and high range of gravel and sand hills which extends, in the line of the road from Burton to Ashby, from Winshill by Bradby, through Hartshorn to Tadsor-Field.

The Sections of the Shafts shew that the strata preserve nearly their respective distances and thickness, as well in the regular dip, as in their occasional elevations and depressions. It is difficult to ascertain whether these waving lines were so formed originally, or whether they did not result from distant or contiguous dislocations of the strata, when the masses would conform to their new bearings by an almost imperceptible series of slips. This latter supposition is supported by the circumstance of the coal being found tender, sooty, or dusty, and with short shining slips in its masses at intervals: and, this supposition is still further supported by the occasional conformity of the waving lines of the coal to the waving lines upon the surface of the land. For, as the measures are entire from the surface downwards, this conformity proves that the waving strata were owing to faults or slips which caused a new bearing; and, it proves also, that subsequently to this new bearing, the strata in the greater part of the Coal-Field were carried off in laminæ completely by a denudation of the surface, which left no debris or trace behind it.

Notwithstanding this general uniformity of the dip, it is often disturbed by the faults which intersect the Field in all directions. In some places, the coal is found a little thinner or a little thicker, without its dip being altered: in other places, and frequently, the dip is altered considerably when near a fault, and the miner is thus taught one rule by which he ascertains whether the coal has taken a higher or lower position. In considerable dislocations on either side, whilst the great mass remains parallel, the portions nearest the fault, and those within it, will sometimes be contorted or drawn out, and the strata thinned and bent downwards or upwards, with scarcely slips and breakings enough in it to produce a disjunction. The whole space of such faults, however, will be quite filled up with various portions of the strata, so crushed and ground as to alter the very nature of the substances.

On the borders of the coal-strata, the diluvial deposits do not seem to derange the ordinary dip of those strata: but, the diluvial matter itself, consisting of sandy or conglomerate measures, has generally a contrary dip; for, although in many cases, the gravel-beds and sand-deposits present the appearance of a mere confused mass, nevertheless a close examination shews the direction in which these beds and deposits had been formed, and thus proves that the edges of the coal-strata were abraded, and that the mixed pebbles and debris were lodged against them in layers, by which the surface was rendered uniform.

CHAPTER VII.

ON THE FACTS WHICH PROVE THAT FAULTS ARE THE RESULT OF A GENERAL LAW, RATHER THAN OF EARTHQUAKES.

Faults in the Strata of the Ashby Coal-Field are very numerous; more so, perhaps, than in any other district. Some of these are extensive openings and dislocations, called leaps; others, are mere slips or bends: their depth varies from a few inches to one hundred yards perpendicular, or more. Some of the breaks run parallel to each other, to a great distance; others take a transverse direction, seemingly without order. For the most part, the faults do not alter the parallelism of the strata, even upon the largest scale. Sometimes the slips resemble steps, each of which may be a few feet only, or a few yards in extent; the strata still keeping parallel between the slips. Moreover, some of the faults range for miles: others branch out of the larger faults, and terminate in a point. Some slips cross each other in their course, and then produce what is technically called a *shift*. Some of the openings are mere *gashes*, or simple separations, on either side of which the Coal remains level: these are filled up with sooty coal and clay. The two sides of the Fault are generally so crushed in slipping, as to resemble a mirror; and, for the most part, the space between the sides, consists of coal, stone and clay, ground to powder. But, when a fissure is wide, then the lumps of coal, stone and clay, are less comminuted, and distinguishable separately. The matter between the sides comes principally from superior strata; the inferior, however, sometimes seem to have been forced upwards, in a slight degree, into the fault, by an enormous downward pressure. In such instances, no cavities occur.

The nature of a slip is shewn by its inclination. If, upon the first appearance of the fault, the slip goes aslant downwards, then the coal is gone down; if upwards, the contrary is indicated; and, by this rule, the seam is discovered again. In many cases, the large faults have branches which vary in thickness, in breadth and in extent, so as to throw the coal up or down, for a little way, until the branch fault thins itself out to a thread, where the coal remains unbroken. Occasionally, as was before observed, the waving line of the strata corresponds to that of the surface, rising and dipping in the same manner, and nearly in the same degree; but, although this is the case in a few places on the Woulds, the same observation does not apply to the other parts of the same seam. If this correspondence were found correct to a moderately uniform extent, it would tend to prove that the superficial variations were made at the same period as the internal undulations. Excepting this instance, the surface has little conformity to the dip of the measures.

The slips do not appear to hold any metal worth pursuing, although lead is occasionally found both in them and the measures. In working a seam of coal in Measham, at about eighty yards deep from the surface, and twenty-seven yards below the main coal, a considerable quantity of lead ore was found in fissures of the coal, and in slips passing through it. A sparry substance accompanied the lead ore, in general, although the ore was sometimes intermixed with the coal only, adhering to it. The coal adjoining this ore, was not at all altered in quality. The fissures where this ore appeared, were thin and wrought for some distance in the superior strata, but without profit. In another situation, also in Measham, towards the outcrop of the main coal, and where the cap of gravel was about twenty yards thick, much lead, connected with sparry concretions, was found in sinking a shaft through the conglomerate deposit; and, where water had been poured over the bank-earth or debris of the shaft, the lead ore was washed clean, and shovelled up in quantities.

Ironstone is not found in the Faults; but it abounds, in all its various forms, through the whole stratification.—The origin of Faults has given rise to much controversy; but, until they have been far traced, and more accurately investigated; and, until facts are noted in numerous situations, an unobjectionable theory of their production cannot be formed.

From varied observations of Faults in Coal-Fields, there is much reason to conclude, that they are not the effect of volcanic convulsions or earthquakes; but the result of a quiet, uniform, natural law of operation; namely, that of Induration.

Faults in Coal-Fields, which so perplex the miner in coal-getting, seem to be exactly of the same nature as the slips or faults in strata abounding in mineral veins, which veins themselves constitute the slips. But, whether the mineral be copper, lead, or tin, the ore is found principally in the faults. Whether these ores, with their accompanying earths and crystals, entered the faults from above, or from below, has been doubted. In some of the metalliferous limestones of Derbyshire, lead veins called rake-veins, pass in slips through several beds, between which a considerable thickness of amygdaloid *(tufa)* occurs. This is supposed to have been injected while in a melted state, between the laminæ of the beds of limestone; but, it is quite as probable, and as consistent with many other phenomena of the like kind, that the amygdaloid has been compressed when pliable, and that the lateral contractions were made by such compression. This is exactly similar in effect to what occurs in the earthy, and marly beds of the lias, in many limestone beds, and especially in sandstone beds alternating with marl, as already described.

If it should be found that the slips, or faults, in coal-strata, in limestone rocks, in sandstone, in slate, and in almost all rocks, are universally of the same nature; and, if proper allowance be made for the composition of the substance, for its declination as to the bed, and for its other local relations, must not the origin of faults be referred to some general law of nature? Cannot induration alone account for it? Volcanoes and Earthquakes are not proved to be so uniform in their action as to produce the effect. If the process of desiccation, compression, and induration be strictly investigated in its natural bearings, its results will explain the phenomena of slips in all their modifications throughout the Ashby Coal-Field. They extend to a depth altogether beyond our reach: the deepest mines in the earth prove their continuation downwards; and, on the surface, they are traced for miles. In like manner also, the same process may account, not only for the small slips and dislocations, but for all tilts and declinations of strata. It will even account for the vertical position of entire masses, for the position of masses reversed for short distances, and for the sudden depressions of surface, both in mountainous districts, and on the sea shores, where the depths of the sea are generally proportioned to the height of the strata lying with their beds nearly vertical.

CHAPTER VIII.

ON THE COAL SEAMS, AND THE UNIFORMITY OF THEIR DISTANCES FROM EACH OTHER.

Coal Seams preserve their thickness, quality, indicative characters, and relative distances, to a surprising extent, in this Field. In proving uncertain ground, a knowledge of the position of a deep coal is gained, when a seam is found which corresponds to a seam proved in another part of the Field, although very distant. This information might probably be attained by observing the composition and nature of other parts of the strata, the peculiarities of which seldom interest the miner so much as coal. It may be useful to a geological inquiry, to describe minutely the precise character of any one or more coal-seams, as this is sustained through an extensive district. Towards the basset or outcrop of these, their quality and texture often vary; frequently also, they are different near to, and in, a fault. Such dissimilarities, however, are not so great as to prevent those accustomed to see them, from being able to identify every portion of the seam. The alteration consists in parts of the measures being crushed, much broken, dull, and thinner or thicker than the rest, in putting on a sooty appearance, and in being often largely mixed with pyrites and sparry matter, sometimes with thin beds of bat or stone, for very short spaces.

Two seams are here selected for a detailed description, because they may be at once recognised in any part of the Field hitherto proved. These are, the seam called the Main Coal; and that called the Five-feet Coal, lying seventy yards above the former. As far as fact has been proved by the workings, extending over eight or ten square miles, the Main Coal, from its southern, eastern, and western bassetings, to the depth of one thousand feet on its northern side, has the characters described in the following Table.

No.	*Local Name*	*Quality.*	*Ft.*	*In.*
1	Roof Coal	Spires, a dark slaty structure	0	11
2	Stone Coal	Spire and dice-coal, mixed	1	7
3	Dicey	Dice, breaks into cubes or parallelopipeds	0	5
4	Grisley	Dice, small cubes with pyrites	0	5
5	Spires	As No. 1	0	11
6	Dicey	As No. 3	0	7
7	Hard Seam	As No. 1, but more compact	0	1½
8	Dicey	As No. 3	0	4½
9	Slating	As No. 7	0	1
10	Holing	As No. 3, but not so compact	1	0
11	Scalps	Dice, with two seams of spire	0	6
12	Grounds	Dice and spire mixed, very stout	0	11
13	Under grounds	As No. 1	0	4
14	Roof Coal	Dice	2	2
15	Hard Seam	Spire, compact	0	1
16	Soft Seam	Dice	0	4
17	Hard Brown	Spire, compact	1	0
18	Hard, mixed	Spire, compact	0	6
19	Holing	Dice, tender	1	2
20	Sods	Spire	1	0
			14	5

The last seven Nos. include what is called the Nether Coal; but this, in consequence of its being a little inferior to the upper in quality, is not got for sale at the Woulds. The terms used in the preceding Table are quite arbitrary, although perfectly well understood by all persons employed in the working of coal. Were the same measure accurately represented in a drawing, even this would not be easily comprehended; because, dulness and brightness of appearance alone cause shades of difference, and these would not shew quality correctly.

The Five-feet Coal-seam, having a strong bind for its roof, over which is a grey stone with clunch clay for its floor, has the subjoined characters.

No.	*Name and Quality.*	*Ft.*	*In.*
1	Dicey coal, with a seam of spire of one inch	1	8
2	Hard Spire coal	1	9
3	Dicey coal, soft	0	5
4	Soft Fire-clay	0	5
5	Soft Dicey coal	0	6
		4	9

Although the characters of this seam are such as can be distinguished by the workmen, throughout this and the neighbouring Coal-Fields, yet is the measure not so uniform as that of the Main Coal. The stratum of fire-clay, five inches in thickness, is often wanting and its space wholly filled with coal.

The arrangement of the beds of these two seams, particularly that of the Main Coal, is so uniform, as to shew it to be the result of some fixed law operating during a quiescent state of the original mass. Those parts of the bed called spire, are supposed to contain a little more earthy matter than the dicey portion. They are also more concentrated, and their specific gravity is different.

In the present state of the coal trade, and in the use of this coal, two important advantages arise from this alternated structure: viz. the bands of spire hold the mass together; and, although easily divided, it is sold in as large lumps as human strength can move; in pieces weighing from half a hundred pounds' weight to half a ton. When stacked for sale, the weather has little effect upon it; whereas the dicey parts, if not protected by the spirey, would be crumbled to pieces by the atmosphere. For this reason, its quality is little deteriorated by a year's exposure. Many coals, which burn well upon first coming out of the mine, become little better than peat after twelve months' exposure to the air. It is another quality of the bands of spires, that, when the coal is consuming, the spire retains its form, or nearly so, not only while the hydrogen is passing off in smoke or flame, but also whilst it is in the state of red coke. It thus furnishes a steady luminous heat for a long time, and prevents the dicey part from being consumed too rapidly. The latter, from its easy divisibility into cubes, admits the air, and consumes quickly; and, by expanding and protruding its crozzled coke, it gives out a short but intense heat.

Besides these valuable qualities, another may be considered, which is of no small importance as it regards durability, and consequently economy. Thus, whenever it is desirable to suspend the consumption of fuel, if a piece of the spire seam is laid horizontally in the grate, this piece will retain the fire for a whole day, and only requires breaking up, to put the lump in an active state of combustion.

CHAPTER IX.

ON THE FOSSILS, AND THEIR USE AS A GUIDE IN MINING.

Fossils in this Coal-Field may be regarded, with very few exceptions, as appertaining to the vegetable world: but, whether they can all be considered as the production of land, or fresh-water plants, remains to be proved. Two shafts are each more than one thousand feet deep, and abound throughout almost every stratum, with vegetable Fossils. A few beds only contain small shells *(myæ ovalis)*, and these are confined to a layer of about two inches thick. In general, the shells are filled with the bituminous shale, in which they are imbedded; occasionally, they are broken, or crushed together; but, for the most part, they seem to have been filled under slight pressure, and thus consolidated. The study of these Fossils is as interesting in a geological view, as it is important for practical mining purposes.

The Fossils, depicted in the accompanying Plates, appear to belong to vegetable classes produced in a climate much hotter than that of England; and, in character, they greatly resemble Plants now found within the tropics. Two self-evident inferences result from observation of their structure and abundance. *First*, that their period of existence must have been very remote, and vast denudations have since taken place, by which the overlying masses, known to be formations over the Coal (the abraded and broken edges of which being the remains and proofs of such denudations), now border the coal district. *Secondly*, that the present theories, so laboriously constructed, are totally inadequate to explain the origin of these formations; and, that further diligent research, astronomically and otherwise, will bring to view more rational conclusions as to the causes of these phenomena.*

* The collection of Facts stated in this volume, will prove how deficient the information is, from which the Geologist can form just notions of the constitution of the earth; and, that the inquiry must be pursued with diligence and accurate delineations in all countries, until a mass of evidence be brought together that shall establish a theory less liable to objection than any yet published. The theory last promulgated, that the present state of the earth is owing to causes now in operation, is as liable to be upset as any of those by which it was preceded. The form of the crust of the Globe may be owing to *causes now in operation*, and probably is so; but certainly not to those lately stated in the "Principles of Geology," which have been so repeatedly refuted. Conjecture never can establish a theory, like Facts; and, until the former can be wholly laid aside, doubts and counter-theories will continue to arise in frequent succession, until facts shall put the question at rest, on the sure foundations of pure and positive induction.

Some phenomena of the earth seem to be agreed upon, as—

I. That the axis of the Earth has not been subjected to any change.

II. That its surface, as far as the same has been examined, is composed of the remains of a former state of the globe.

III. That over the whole surface hitherto explored, there are undoubted and abundant marks of water having flowed.

IV. That some parts have undergone an overflow of sea, and others of fresh water.

V. That the Climate has been much hotter than at present, as evinced by the character of vegetable Fossils found in the coal-formation.

VI. A central heat is supposed to be established by the researches made in France, and in mines on the Continent; and, that this heat feeds the volcanic districts, occasions thermal springs, and is the cause of that uniform state of the earth's temperature, in which, at stated depths, it is found.

VII. That the position of vast and extensive ranges of strata, the order of which is never inverted, appears to have been regulated by some quiet *law of operation now in action*.

Before attempting to comment upon the preceding Positions, it may be well to repeat the observation, that the Geologist has not obtained information on some general points, sufficient to enable him to arrive at any rational or unexceptionable conclusion regarding them. Has it occurred to him to ascertain?

In the year 1802, a portion of the Ashby Coal-Field was wrought below the level which drained the mine to the pumps of the engine, and continued to be so wrought for twenty years. This was a new mode, in that district; and, by it, an immense quantity of coal was raised from below the level of

First. Whether the surface of different parts of the ocean, is at the same distance from the centre of the Earth?

Second. Whether the Mountains, in different parts of the globe, have their respective summits as much farther removed from the centre, and above the average surface of the seas in their vicinity, as a survey of their height would indicate?

Third. If the mean density of the Earth exceeds that of water, as five to one; and, if the quantity of surface of the northern hemisphere in land, exceeds that of the southern as 420 to 130; what effect is this likely to produce upon the diurnal or annual motion of the earth?

Fourth. Currents exist in most parts of the globe, and some of them are of extraordinary length and force. Their causes are not satisfactorily defined. Among these, the earth's rotatory motion, winds, tides, and others, have been reckoned; but, hitherto, has any one thought of examining whether many of these currents are not produced by a change of level? Take the Gulf Stream for an instance. The course of this is supposed to extend about 4000 miles, and its velocity is estimated at an average of three miles per hour. Now, this rate could only be maintained by a fall of 1000 feet in the specified distance.

Fifth. M. De la Place seems to have satisfied himself, that no astronomical deviation or change will ever be discovered to cause changes in the earth, or to alter its axis. This notion, however, exposes him to be charged with inconsistency, after he had detected some errors and made some discoveries in the philosophy of the earth's orbit. Is there then, no *other cause now in operation* but these with which he is acquainted? None, which shews that the Earth stands fast, subject merely to have its surface and circumference alone disturbed?

It may be observed, with reference to the foregoing propositions—

I. That although M. De la Place has satisfied himself that no change has taken, or ever can, take place in the earth's axis, as regards the equator; yet, he must admit that the *Earth's surface* is operated upon in different ways, by the rotatory motion upon its axis, especially if that should be found to oscillate and vary much.

II. The similarity of strata over the surface, affords a proof of a gradual *law of operation now in action;* because, it is consistent with some portion of the present surface as to vegetable forms as well as animal, referrible to climate.

III. Every part of the earth's surface exhibits decided marks of having been overflowed by streams copious and deep, and necessarily powerful, and moving at rates of velocity by the force of which the whole has been modelled. This mighty overflow of water has formed the most extensive and uniform valleys; abraded the rough and rocky strata, and converted their the pumps of the Engine Shaft, fifty yards perpendicular, and to more than a mile in horizontal extent. The mine in general was very dry, the only water found in it, being salt and in small quantities. During the workings, great difficulty was experienced in passing faults, in finding the

debris into planes and fine accessible slopes; fitting it for the sustenance of vegetable and animal life, and consequently for the use of man. It has denuded vast portions of previously-formed solid masses, and exposed a variety of surfaces adapted to different purposes; and, it has done all this, to an extent and depth that are at present but lightly estimated: yet, that such results are certain, is proved by the fact of spaces extending over many miles having been swept away between the regular beds and their outliers.

IV. It may be remarked, that the existing state of the earth's surface may be owing, in some parts, to the sea having retired last; in others, to marshes and low land having prevailed for ages, and covered, to considerable depths, what the sea had left as a surface; or, to a denudation having removed all that the sea had deposited at its previous periodical overflowing.

V. The state of vegetable fossils does not indicate a higher degree of heat as to climate, than is now found between the tropics; and, it is the best inference, that the sites of these fossil vegetables have been in the same situation as the tropics now are, and that by causes *now in operation*, although *these* are not seen by the admirers and advocates of the theories of Hutton and some others.

VI. There is no probability in the idea of a general internal heat, which has lately found some strong advocates, and seems confirmed, as they suppose, by certain experiments and observations of M. Cordier, in France. Besides, in all the copious extracts of the author of the "Principles of Geology," and in his laborious investigations into the extent, effects, and proofs of volcanic influences, his researches shew that depression has equalled elevation, and that, in one instance only, is there anything like evidence of an upraising, on a large scale. This upraising is stated to exist on the coast of Chili, but the account of it is so scantily vouched, as to render its extent doubtful. Moreover, this may be owing to a change in the level of the sea adjoining that coast, by an alteration in the force of the current upon its borders, attributable to a shorter passage for the stream, by removal of banks or other obstacles, at the bottom of the sea at some distance. The increase of heat, at increase of depth, ought to be found in deep seas either in the water itself, or in the bed of the sea, a portion of which adheres to the weight at the end of the sounding line. This, however, is not the case; and, in the trials made, the increase of the heat of the earth is attributed to other causes* than to imaginary internal fires.—As to Thermal Springs, although they may abound in districts with volcanoes now in action, or having lately been so, yet are there springs found in many other places, and are referrible rather to the course of water in the earth from one stratum to another.†

* See the Chapter on Temperature, in this Volume. † See the Chapter on Induration.

coal again, and in driving adits the shortest way to it. Here it was, that the very important doctrine of Mr. William Smith, came to be of the greatest practical use. Then, as at present, that scientific and indefatigable Gentleman's acquaintance was happily enjoyed by the manager of the Colliery; and, by observing the particular fossil plants in the several strata, he was enabled to trace the height or depth to which the dislocated beds had passed. By this method, not only an immense expense was saved, but the operations were rendered almost certain.

Many of the alternating seams were so nearly alike in structure, colour and density, as to be scarcely distinguishable; but the fossil plants or impressions, wherever they could be seen and examined carefully, indicated the particular stratum; so that, upon finding a slip, although the hading might shew whether the coal was gone up or down, the distance could not be known. By driving an adit in a right line through the breach or slip, the regular measures were arrived at; and, upon proceeding a little way in

VII. The uniformity which prevails in the strata, over a vast extent of country, sometimes unbroken, and if broken, having its line of bearing continued, furnishes an argument against the theory of volcanic causes; and, the regular overlying tends to prove the existence of a long and quiet period or periods, during which, the earth was passing through a change that perpetually goes on, has periodical returns, and is, in fact, a *cause now in operation.*

It is quite evident, therefore, that the causes to which the form of the earth's present surface has been attributed, are totally inadequate to effect it, and that others must be sought for. A periodical return of waters over the surface, and a change in the position of the axis of the earth, however caused, by which probably all parts of the surface are brought into situations which would alter the climates, seems a probable theory; and, how far that of Sir John Byerley will be found applicable, time and a thorough research will shew.

As the contents of this Book are designed to shew facts, the Notes are only intended to explain or give examples by way of elucidation or corroboration; but the inquiry into the phenomena of the Ashby Çoal-Field, and particularly of its borders, may be an excuse for stating conjectures drawn from facts which, although not capable of proof at present, may ultimately lead to useful investigations. If queries, put in this way without reasoning upon them, produce one favourable result, the inquirer's purpose is fulfilled; as every step, however small, is important.

them, it was soon ascertained to what height or depth the seam of coal had slipped; either, by the decided character of the stratum itself, in which the adit was driven; or, more certainly, by the peculiar fossil impressions it contained.

As a Record for the information of those carrying on the Moira Coal-Works, drawings were made of the impressions in particular strata, accompanied with a sketch of the colour and composition of the substance in which they were found. For the most part, these drawings were made within a day or two of the Fossil being extracted, during the sinking a shaft, by an artist employed for the purpose. Some of them are delineated in the Plates at the end of the volume; and, the number annexed to each specimen or figure, refers to a corresponding number in the Section of Shaft No. III. shewing in which stratum each Fossil is found.

The writer of these remarks, not being skilled in Botany, has not attempted to describe the classes to which fossil plants belong: he can only vouch for their being faithfully drawn, and leaves to others, conversant in that science, the task of giving them names and places. The only aids he offers to the botanist, consist in an attempt, in the short description accompanying the Plates, to compare some of the figures with those so well delineated and scientifically described by Martin, Parkinson, Brongniart, Sternberg, Lindley and others.

The alternating beds which are liable to quick decomposition, do not retain their impressions many days, particularly the delicate ones, unless covered with varnish and protected from the atmosphere, or water. In the sandstone beds, the impressions continue longer. The larger kinds of fossil plants are much better preserved, as their interior is generally of the same substance as the matrix in which they are imbedded; and they are not so flattened as the same description of plants in the bind. Whether in the stone, however, or in the bind, or in any stratum whatever, the bark with all its minute tubercles, or forms, is preserved entire; and this bark, whether its thickness be one inch or one-thousandth part of an inch, is coal.

In some of the black shale, the quantity of vegetable forms makes up nearly the whole mass. There does not appear earthy matter sufficient to make them adhere together, and the several plants, although so fragile as not to bear their own weight for two inches in a piece, may be separated in their flattened filaments, or in laminæ of great breadth and length. This sort of shaly substance is seldom thicker than six or eight inches.

In the sandy measures, alternating frequently with bind, very thin laminæ of coaly matter are found. This is so much comminuted, that few impressions or figures are defined upon it; nevertheless, it is a distinct layer or lamina, by which the stone may be divided. The intermediate spaces in the sandstone are free from coaly impressions, whether such spaces be each a quarter of an inch or several feet, in thickness.

The vegetable and other impressions are found well defined, and are longer preserved, in ironstone. Most of the balls of ironstone have a vegetable impression at the nucleus; and the flattened ironstones, called *pot-lids*, frequently contain them; but they are seldom seen in the beds or layers of ironstone where these occur. Iron ore, or ironstone, never appears in the faults, except as part of the debris or heterogeneous mixture which had been washed into the chasm occasioned by the slip. In some of the thick sand rocks, the layers of vegetable fossils are mixed with soft friable earthy matter. In this, which varies in thickness from a few lines to six or eight inches, the fossils lie over and athwart each other, in all directions, as in the black shale: and, although these sand rocks are full of crevices, the result of induration, yet the vegetable forms are never found in such crevices as pass entirely through the stone bed.

CHAPTER X.

ON IRONSTONE, AND ITS EXISTENCE IN ALMOST EVERY STRATUM OF THIS FIELD; AND ON FIRE-CLAY, WITH ITS USES.

Ironstone abounds more or less in the several alternating beds of clay, clunch, bind, and stony-bind, but rarely in the gritstone, or sandstone. Occasionally, it is found in a regular course for some miles square in particular strata, about two inches thick; in others, it is divided into rounded portions, from six to twelve inches in breadth, and one inch to an inch and a half in thickness, with a space of some inches between them. These rounded portions are provincially termed *pot-lids;* and, as well as the thinner layers or seams of ironstone, are in general solid, and shew but few vegetable impressions. In other portions of the measures, the ironstone is conglomerated, and consists of small nodules of all possible shapes, not larger than walnuts. But where the ironstone is richest and most abundant, it consists of large nodules of the size of potatoes; and these often contain some vegetable impressions, particularly at the nucleus. Others, having a smooth compact exterior, are full of cracks within; and these are wide at the centre of a nodule, but close before they reach its outside. Such cracks are sometimes empty, sometimes filled with lime, or crystal of lime, and occasionally with water which is very salt. They have all the appearance of having been cracked interiorly, by induration.

It must be observed also, that these ironstone balls or nodules, although tolerably round, shew no marks of attrition. They have indentations all over them, and these resemble the eyes of potatoes. They do not lie promiscuously, but in horizontal rows regularly arranged, in the stratum which contains them; and their distribution is very similar to that of the chert or flint balls and nodules which are found in chalk strata. Most of the balls and *pot-lids* have concentric layers, and a nucleus of some organic substance.

Where the ironstone beds are continuous for a considerable space, they preserve a remarkable uniformity in thickness, and this seldom exceeds two inches. These seams almost universally have a smooth *shed* or parting at top and bottom, occasioned no doubt by the lateral sliding of the ironstone during the progress of contraction, which leaves small vertical crevices in them.

Fire-Clay is so called, from the intense heat it will bear before fusion. Seams of it abound in the Ashby Coal-Field; and, there are very few coal-measures which do not rest upon it, as the Sections will shew. Some of these seams are a few inches thick, and others several feet. In several, this clay is very pure; and, for the most part, it contains many impressions of aquatic plants.

The immense quantities of yellow pottery-ware, made at Ashby Woulds from one stratum only, shew the great importance of these seams of Fire-Clay. This stratum is about four feet in thickness, and it lies immediately under a bed of coal three feet six inches thick: it contains a very small quantity of iron. This is shewn by the colour of the ware, after having been subjected to a heat of 6500° F., or 40° Wedgwood. The present manufactures, at all the different works upon this seam of Fire-Clay, yield about ten thousand dozens of Pots per week. These are sent to all parts of Great Britain, America, and to other countries, in nearly the following proportions.

	DOZENS.
To London and the South of England	3000
To Hawkers, at the Works, sold in the Midland Counties	1500
To other parts of England	4000
To America and the West Indies	1000
To Scotland	300
To Wales	200
And of black and fancy ware, to various places..........	300
Total, weekly	10,300

Near the seams of coal, the Fire-Clay is generally full of leafy impressions. It is very yielding in texture, where the thickness does not exceed twenty or thirty inches; but, when thicker, it is more compact. The clay, taken from thin beds, becomes quite soft in the open air, in a few days; but, it is the ordinary custom to spread the highly indurated clay taken from the thick beds, in an open space exposed to the atmosphere for two years, or to grind it in a mill. Fire-Bricks and Plates are made on the Ashby Woulds in great quantities for iron forge-mills; and the coarser clay serves for *saggers*, in which the finer ware is baked.

From the circumstance, that so many cases occur where a tolerably pure Fire-Clay lies immediately under, and in contact with, a bed of coal, it may be inferred that such clay stratum could not have been the *soil* where grew the vegetable matter which produced the coal, unless this vegetable matter was a moss, a peat, or some small aquatic plant; because, in the clay, there is no appearance of roots, or trunks, or other vegetable impressions beyond slender leaves, as of a long grass.

The fact, that particular strata accompany the *Main Coal* for many square miles, would support the idea that an immense flat was originally covered with the substance of this Fire-Clay many feet thick ; and that, upon this flat, there took place an uniform growth of a distinct single vegetation which must have occupied the position for a long period, and thus furnished the substance which composes the *Main Coal.* The alternations of Fire-Clay and Coal-seams would favour the notion, that their materials were originally mixed together in a fluid ; and that those of the former, by their gravity, would first subside ; whilst the vegetable matter, or those of the latter, would undergo a more gradual and quiet deposition. Hence, by a repetition of the process, the alternations of the strata would be produced. Besides, it may be supposed that, if the strata of coal had derived their origin from the growth and destruction of a forest, some portions of them would have been thicker than others and altered in quality, or have retained at least some trace of forest trees : whereas, on the contrary, the most extraordinary uniformity in quality, compactness, and thickness of the seams, prevails to a great extent.

CHAPTER XI.

ON THE TEMPERATURE OF THE MINES.

It is now generally supposed, that heat increases as depth is attained; or rather, that the Earth itself increases in heat, in some ratio, from the surface; but, the difficulty of establishing this supposition is almost insurmountable. In sinking shafts, through strata yielding water, at Donisthorpe, and in the Ashby Woulds Coal-Field, to a depth varying from five hundred to eight hundred feet, the thermometer, upon remaining in the streams, has pretty uniformly indicated 46° F. at all depths, and under all states of the atmosphere. But, when tried in the working parts of the mine, and in the adits leading thereto, a great diversity of temperature is uniformly observed: it then partakes of the heat in the mine, by its exposure to the rarified air. The water is also affected by quantities of pyrites; and, sometimes, it attains a heat so great as to emit steam. Where reservoirs for water are constructed, either for the purpose of its being pumped out, or for accumulations in the levels and old workings, the temperature of the water varies much; whether it be subject to the entrance or discharge of air into or out of the mine, whether it traverses a short course or a circuitous one, and whether it passes through the debris of the workings or not. When the state of the air at one thousand feet deep, is compared with that upon the surface, and allowance made for the quantity of heat in a cubic foot, compressed into less compass at that depth, the degree indicated by the thermometer may be accounted for, to a certain extent: but, if to this, the various circumstances contributing to produce an alteration of temperature, are considered, the difficulty of solving the question will become apparent.

Upon consideration of the various circumstances under which the temperature of a mine is taken, whether in the solid earth, in crevices closed up, in a stream of issuing water, or in the atmosphere of the mine itself, there are no data upon which any increase of heat can be assumed to be a consequence of increase of depth. From the fact that 44° to 46° F. indicates the ordinary heat of water in these mines, it may be inferred that this is the true temperature of the earth, at similar depths. It is never found lower than 44° F.; and, in all the variations above this, it is not difficult to trace their cause.

Water on the surface has its maximum of density at 42° F., whilst the barometer stands at thirty inches; nevertheless, the indication of heat may, at the same time, be 46° F. or more upon water at one thousand feet deep. But, so long as water exists in the crevices and chasms of rocks, and in different strata, it must contain so much caloric as to keep it liquid: hence, the inference is, that the whole mass, however great, must be kept moving perpetually by accessions from the surface in one direction, to its egress in another, at a lower level. If a portion of the flow contains a single degree of heat above or below 42° F. or the maximum of density, this portion must change its place; if it is above 42° F. the excess will be communicated to a portion at the maximum, and this, no longer remaining so, must consequently ascend to give place to that at the maximum. On the other hand, if a portion of the flow is below 42° F. the heat will pass from the portion at 42° F. to that below it; and the specific gravity of this, being thereby made lighter than that at the maximum of density, although colder, it must also ascend to make room for that which is at the maximum.

If this is a correct view of the subject, there is no need to call up fires from the interior to produce degrees of cold towards the surface. Neither can cold prevail at the bottom of deep seas, to convert the whole into ice, which has been asserted; nor can the temperature of the interior of the earth be otherwise than accordant with the exact uniform maximum of density of water at any depth, when altitudinal atmospheric pressure and other circumstances are considered. If springs flow colder than 42° F. it is because their issue is replaced by denser water nearer the maximum, although warmer; and this coldness may be caused by the conversion of solid into liquid by water acting on a large scale as a solvent which would absorb heat: but these causes are rarely observed.

The first series of the following records was made at two Shafts eighty yards asunder, north and south; the one airing the other by means of adits driven at different depths between the shafts whilst sinking. According to the state of the wind and depth of each shaft, the air sometimes entered by one and sometimes by the other. Three men with two candles were in each shaft, and the circulation was so regulated, as to be merely sufficient for supplying the men and their lights, and for expelling the smoke when gunpowder had been used.

The latter records were made at three working Coal Pit Shafts; and, at each of these, the experiments were made about mid-day. In these shafts, the air seldom alters its direction: the Engine shaft is the blowing one to the Bath Pit; and the Marquis Pit, the blowing shaft to the Rawdon Pit. In all these works, the air traverses some miles under ground.

Temperature of the Hastings and Grey Shafts on Ashby Woulds, taken on the 31st October, 1831:

	North Shaft.		*South Shaft.*
At the surface	51° F.	....	51° F.
At 104 yards deep	54	....	54
At 208 yards deep	59	....	58

The next record, is at the same shafts, on the 8th of March, 1832.

	North Shaft.		*South Shaft.*
At the surface	42° F.	....	42° F.
At 50 yards deep	45	....	49
At 280 yards deep	54	....	58

Whilst a part of the temperature, in its increase from the surface, may be accounted for by the altitudinal pressure, that in the south shaft may acquire its additional heat by being the discharge shaft.

A third record, at the same shafts also, was made on the 20th August, 1832. Four men with four burning candles were in the works.

	Barometer.		*North Shaft.*		*South Shaft.*
At the surface	29 inches.		69° F.	..	69° F.
At 175 yards deep	29.5	......	59	....	58
At 350 yards deep	30	......	56	....	60
At 360 yards deep, in an adit out of the current ...					63
Immersed in water collected at the bottom of the shaft					59

July 24th, 1833. At the North Shaft only:

	Barometer.		
At the surface	29.5 inches.		65° F.
At 175 yards deep	30.4	....	65
At 350 yards deep	31	....	60

July 29th, 1833. At the North Shaft only:

	Barometer.	
At the surface	30.2 inches.	75° F.
At 175 yards deep	30.9	69
At 350 yards deep	31.4	63

September 10th, 1833. At the North Shaft only, and in an adit driven 200 yards from the bottom, containing four men and lads, one horse, and four candles.

	Barometer.	
At the surface	29.5 inches.	56° F.
At 175 yards deep	30.2	57
At 350 yards deep	31	58
In an adit 200 yards from the shaft	31	62

Temperature at a work called The Bath Pit.

	1826. Aug. 25. FAH.	1831. Nov. 4. FAH.	1833. Aug. 1. FAH.	1833. Sep. 9. FAH.	1833. Sep. 10. FAH.	1833. Sep. 20. FAH.	1833. Oct. 4. FAH.	*Barom.* October. Inches.
At the surface	76°	44°	66°	55°	56°	55°	55°	29.5
At 100 yards deep	76	60	65	63	62	62	65	30
At 230 yards deep	75	66	67	67	65	65	66	31
Horse road between shaft and work		75		70	72	72	71	
In workings 1200 yds. from the shaft		70	69	70	69	70	71	
In the floor or gobbing		64	69	68		66	67	
In salt water in the air-way			64	63		63	63	
		No.	No.	No.	No.	No.	No.	
Men and Lads in the pit		50	79	80	80	80	82	
Horses		30	23	23	22	24	23	
Candles, lighted		90	110	110	100	100	100	

These observations were made between one o'clock and five o'clock in the day. This is an air-drawing shaft. The workings are from twelve hundred to fifteen hundred yards distant from the shaft bottom.

Temperature at a work called The Marquis Pit.

	1826. Aug. 25. FAH.	1833. Aug. 5. FAH.	1833. Sep. 6. FAH.	1833. Sep. 19. FAH.	1833. Oct. 5. FAH.	*Barometer.* Inches.
At the surface	79°	62°	57°	50°	55°	30
At 120 yards deep	78	60	55	51	56	30.5
At 246 yards deep	68	59	55	53	58	31.2
Horse road between shaft and work		60	60	57	60	
In workings	73	69	67	68	69	
In the gobbing or floor		67	68	68	65	
Salt water in the air-way		63	61	61	60	
In the ingress air-adit			66	64	66	
In the egress air-adit		69	68	67	68	
		No.	No.	No.	No.	
Men and Lads in the pit		81	81	80	80	
Horses		21	21	21	22	
Candles, lighted		100	96	100	100	

These observations were made between one and five o'clock in the day. This is an air-blowing shaft. The workings are from eight hundred to twelve hundred yards distant from the shaft bottom.

Temperature at a work called The Rawdon Pit.

	1833. Aug. 7. FAH.	1833. Sep. 7. FAH.	1833. Sep. 21. FAH.	1833. Oct. 3. FAH.	*Barometer.* October. Inches.
At the surface	64°	56°	50°	54°	30
At 120 yards deep	64	68	66	67	30.5
At 240 yards deep	73	73	73	73	31.2

	1833. Aug. 7. FAH.	1833. Sep. 7. FAH.	1833. Sep. 21. FAH.	1833. Oct. 3. FAH.
Horse road between shaft and work......	72°	74°	74°	75°
In the workings	67	71	68	68
In the gobbing........................	66	65	65	65
In salt water in the way................	62	60	60	60
In the air-way to the work..............	68	67	67	66
In an adit after passing the work	69	72	72	72
	No.	No.	No.	No.
Men and Lads in the pit...............	70	70	70	70
Horses...............................	11	11	12	12
Candles, lighted	95	100	100	100

The above observations were made between one and five o'clock in the day. This is an air-drawing shaft from the Marquis Pit. The workings are from six hundred to twelve hundred yards from the shaft bottom.

By the preceding records, it will be perceived how difficult it is to form any scale of temperature. The water appears to vary very little in the mine, whatever the air may be at the surface: and, in the workings, the air is so regulated as to render the temperature very nearly the same, both in winter and in summer. The radiation of the brick-work of the shaft frequently warms the cold air in passing; and, on the contrary, it absorbs extra heat in the discharge. Whenever the quicksilver in the barometer is low, at twenty-eight inches and a half, the circulation requires much management; and, like the presage of a storm at sea, such a state of the barometer is reported to the bailiffs underground, that they may be on their guard either against the accumulation of inflammable gas, or carbonic acid gas.

CHAPTER XII.

MODE OF WORKING THE SEAM OF MAIN COAL.

THE Moira coal is got in long work; or, as it is termed, in ends or banks. A railway is generally formed in the solid Coal upon the *end*, or sline direction, of the bed; and, the works proceed on either side of it, in lines perpendicular thereto, if practicable, The length of a work extends from eighty to one hundred and twenty yards. This is divided into two parts; and the length of each part varies according to the inclination of the bed; the basset, or rising side or bank, being the longest. In this division, a railway is carried between the banks for the purpose of bringing the coals to the main railway in the solid coal. This side railway is continued only so far as may be thought proper to extend the work upon the face of the bed; and it is protected on either side by brettices of wood, on the back of which and next the gobbing, is a wall of well-tempered clay, lengthened daily as the work is advanced. The use of this clay wall is, to prevent the air from circulating through the cavity of the work, or the gobbing, which consists of the Slack or small coal left behind, and roof coal mixed with *Tow* that had fallen in. In a few weeks, without this precaution, the gobbing would spontaneously take fire. The *tow*, when mixed with the slack, is probably a principal cause of this combustion.

The air for the supply of the workmen is transmitted, at each end of the work or bank, in an adit purposely made in that portion of the solid coal which is not wrought for sale. When the work has proceeded to the desired extent, the side railway is taken up, together with as much of the brettice wood as can be removed with safety; and the workmen then proceed to get another line, parallel to that cleared out. Horses are used in the work, as well as in the side railways and main road to the shaft. The line of the work is kept nearly straight, and is then technically said to be of a thread; but, if the coal is tender, and the roof crannied, then the work is carried on in set-offs, called *buttocks*, by which the roof is better supported, although the coal is more broken in getting. Three rows of props, called puncheons, are set to protect the men, in the face of the coal wall. The first row is about four feet from the wall, and the other two rows are immediately behind it, at a foot or two asunder.

The part of the seam wrought for sale, is six feet thick; and, about the centre of this, is a soft dicey bed of eight inches. This is holed or excavated as far as a man can, with effect, use a maundril or pick, about thirty-six inches. When a considerable length of the seam is thus holed, wedges are inserted in a line at the roof, a foot or ten inches from the *tow* over the coal. These wedges are long and thin, and are driven up by hammers with long shanks; and, it frequently happens that they may be driven a foot into the coal, at intervals of a foot, before the coal will break off; sometimes obliquely, at other times perpendicularly, with the point holed to. The mass thus detached is cleared away first; then, the wedges are set in at the floor and the lower part of the coal wall is forced upwards by the same process, and with the same results. This also is always cleared away before the men leave their work. In their absence, and at night, men are appointed to throw back the small coal or slack into the waste or gobbing, to bring forward the puncheons, to make the brettices and their accompanying clay walls, and to lay the railway as far as the work has proceeded. These men likewise clear all the railways from small coal, and put all things in repair, and ready for the next day; the horses being in the care of men especially appointed.

The regulation of the air, as it regards clearing the mine of carbonic acid gas or inflammable air, as well as to guard against spontaneous firing of the gob, requires more than ordinary attention. These complicated and expensive processes render it impossible to furnish the Main Coal at a cheap rate, as the consumer will only take lumps; and, for this reason, small coal is left in the work and on the bank, equal to one third or fourth part of the whole seam. The lower part of the seam, called Nether Coal, about six feet thick, is altogether left: this is an excellent coal and very little of it has been gotten; but it will afford a supply for many centuries to come.

Notwithstanding the uniformity which prevails in the stratum called the Main Coal, throughout its extent, from its southern, eastern, and western bassets to the Woulds, the intervention of Faults has been regarded as the cause of some variations; inasmuch as the same seam at Swadlincote and Gresley varies in quality and appendages, by having a stony bed or layer introduced between the Main Coal and Nether Coal, dividing the seam and differing in its thickness from six inches to six feet. Another remarkable variation is, that, at the two last-named Collieries, the lower part of the seam, called Nether Coal, is of better quality than the upper; and accordingly it is gotten, whilst the chief part of the upper seam is left. The Coleorton seam of Main Coal is probably the same bed, and is divided about the middle of the seam by a sandstone or shale, of variable thickness. In one part it is nine inches, but it gradually increases in thickness, in a wedge-like form, for a mile, until the two seams of coal are separated sixty feet.

The workmen employed in and about the Moira Colliery, do not appear to suffer from any particular disorder calculated to shorten life. Those underground, at the coal wall, are generally in a temperature varying from 65° F. to 75° F. and work naked to the waist, for the most part free from wet. The horses also underground are sleek and healthy, never being subject to wet, nor to any considerable change of temperature. The smoke of Engines and large fires upon the pit banks, is considered healthful by the men themselves, rather than otherwise.

Inhalation of the smoke of pit coal is not yet proved to be detrimental to longevity, although so much *fuss* is made about it. Indeed, since coal has been used in London, it is notorious how little the dense masses of people, confined within this overgrown metropolis, have suffered by any pestilence. It may be that the quantity of sulphur and carbon inhaled may contribute to keep the body in a better state of health. The more likely cause however, is, the immense rush of fresh air required constantly, and especially in a morning, through every house, and often through every room in every house, to supply the fires; the construction of the fire-places being such as to pass five times the quantity of air necessary to keep up combustion.

When the air is apparently stagnant in the valley of the Thames and surrounding country, a strong current is found to set in on every side of London, along the streets leading from the country, in a morning. This current is, no doubt, occasioned by the rarefaction in the high chimneys over so many thousand fires just kindled, and must be a cause of the introduction of fresh air to an immense extent which would not otherwise flow. This rarefaction also produces in London other phenomena; amongst which, when the atmosphere is in a light state, and clouds are passing over at a height which does not allow them to condense and fall in rain; these accumulate in passing over London and either remain as a dense fog, or drop in small rain all day long, scarcely clearing once, the country at a little distance having very little rain. The rise and fall of the tide undoubtedly aid the circulation and change of air; but their influence is scarcely equal to one-four-hundredth part of that effected by the chimneys.*

The subjects stated in the preceding Chapters might, for the most part, have been considerably lengthened out; but any further detail of them would nevertheless have proved uninteresting to general readers; and, as no particular system is intended to be enforced by reference to the Facts here enumerated, the reader is left at liberty to draw his own conclusions.

As matter of information, there may be propriety in stating that the strata have very lately been bored to the extent of three hundred feet below the Main Coal, in the shaft, Section No. III.; but no opportunity has yet occurred of discriminating the Fossils which these strata contain. Five seams of coal, however, are found to exist in the depth thus proved. Three of these seams exceed three feet in thickness; and therefore, under the

* Let it be supposed that the Thames removes a column of air fifty miles long, three hundred yards broad, and six feet deep, twice in a day and night, and that the whole of this column is applied to London, it would then amount to 5,702,400,000 cubic feet.

Miles. Ft. in a mile. Feet. Broad. Deep. Tides.
50 × 5280 = 264,000 × 900 × 6 × 4 = 5,702,400,000.

Suppose also, that the Houses in London and the valley of the Thames, amount to 400,000, that each house has ten chimneys, that these average each forty feet in height, and contains two cubic feet in each foot of height; then, as soon as the morning fires are lighted, the ventilation begins and a change of the whole volume takes place every ten seconds; so that, in one hour, there would pass and be a complete change of twenty times as much air as the tides displace in twenty-four hours.

Houses. Chim. Heat. Cub. ft.
400,000 × 10 × 40 × 2 = 320,000,000.

Cubic feet. Times per min. 1 Hour. Per day.
320,000,000 × 6 × 60 = 115,200,000,000 × 20 = 2,304,000,000,000.

present system, they might be raised to the surface for sale. But, their quality seems likely to remain the cause of their being left ungot, until some generations shall have passed away.

In point of thickness, and of distance from the Main Coal and from each other, these seams may appertain to, or be a continuation of, the stratification of Coleorton, Swanington, Whitwick, Snibston, and the neighbouring mines; and, if the Fossils in these were duly compared, some rational conclusion respecting their identity, might be drawn.

To prove ground, so as to determine its belonging to a formation at some distance, can only be done correctly by sinking a shaft. Any endeavour to attain this end by boring, must necessarily prove unsatisfactory and inconclusive, and ought never to be relied upon. Besides, it is often fraught with as much expense as sinking, if the depth is considerable.

Every year produces some changes in a coal mine, which are worth recording; but, if passed unnoticed at the time, they are soon forgotten, and new management too often annihilates all *traditional* records.

EXPLANATION OF THE MAP, PROFILES AND SECTIONS, AND SECTIONS OF THREE COAL PIT SHAFTS.

EXPLANATION OF THE MAP.

The Map exhibits the supposed extent of the Coal-Field, generally denominated the Ashby Coal-Field, with its borders. It is impracticable to delineate precise limits, even where the measures have been proved; because, in some places, the coal-measures are suddenly cut off by great faults. In others, the outcrops do not appear, by reason of large portions of conglomerate, or marl, overlying the bassets. In others again, diluvial matter, of sandstone and gravel, seems to be deposited upon the denuded portion of the coal-measures; and, in a few instances, alluvial matter caps the coal bassets, for short distances.

The Map also shews, in the Coal-Field and surrounding districts, the course of drainage. This affords a proof that the coal-measures had been denuded simultaneously with the other regular strata. It further shews that, during the process of drainage, deposits were formed in some few places upon the coal-measures themselves, but especially on their borders, by extensive masses of sand and gravel. This drainage is wholly to the Trent, and the highest land upon the borders of the Coal-Field is on Charnwood Forest, which rises about eight hundred feet above the lower Trent level.

EXPLANATION OF THE PROFILES.

The situation of the Strata, delineated in the Plates of Profiles is marked on the Map by the letters A to K, and refers chiefly to the bed of Main Coal.

The Profiles are intended to shew, in various lines as marked on the Map, the surface of the ground and dislocations of the strata where these are proved; and, as near as may be, the nature of the faults in those lines. A few beds of coal only are delineated, and these beds have a number corresponding with the same number of the same bed, in the Section of Shaft No. III.

The first line, marked on the Map from A to B, commences at the extreme southern basset of the main bed of coal at the river Mease, where it divides Swepstone from Measham, and terminates at the Tamworth road, about three hundred yards from the north end of Measham village, at the cottages called "Little Measham," or "Pot-Kiln Houses."

The next line begins at B on the Map, runs through part of Measham and Oakthorpe liberties, and ends at the Bramborough brook, which divides Oakthorpe from Donisthorpe at C.

The third line commences at C and passes over a part of Donisthorpe, enters Ashby Woulds, and terminates at the Turnpike Gate at the east end of the Reservoir of the Ashby Canal marked D on the Map. These three lines are nearly continuous, and extend, in the whole, about five miles upon the direct dip of the coal measures, nearly north, and consequently, upon the *end* of the coal. The faults shewn in these are not at right angles with the lines, but chiefly cross them diagonally.

The fourth line begins at Thinghill in the parish of Measham at E, which is the eastern basset of the main coal; and, passing the cottage at B, ends west of Measham Church at F, which is the western basset of the coal seams. This line crosses the first line from A to B nearly at a right angle, and shews the spoon-shaped form of the measures.

The fifth line commences at a high ridge of land east of the head of the Lake in Willesley Park at G, which is a continuation of the eastern basset of the main coal, and terminates at Oakthorpe at H, near a Public House, the sign of the Gate, the cellar of which house is hollowed out of the same seam of coal, in a prolongation of its western basset.

The sixth line begins at the new Work about to be opened on Ashby Woulds at a spot on the Map marked I, and passes near Barrett Mill in the parish of Over-Seal, to a spot marked K on the Map, where broken strata and gravel are substituted for coal measures.

In order to shew the very extraordinary changes which have taken place, both in the strata themselves and on the surface, the strata in the last Profile are restored to the position they occupied previously to the period when the slips and faults took place, which slips and faults must have occurred before the surface was denuded and made uniform and easy of access, as the same Profile now shews.

To give Profiles and Sections of other parts of the Ashby Coal-Field with any accuracy, there must be recorded details of facts ascertained in their local situations; but, if such are ever described, they will go far to remove the difficulties of proving the formation of the whole Coal-Field, which has heretofore been represented as almost insurmountable, by the most eminent Geologists who have visited the district.

EXPLANATION OF THE THREE SECTIONS.

The situation of the three Shafts, the Sections of which are given, is marked on the Map by the letters L No. 1, M No. 2, and N No. 3, the latter of which has been taken with great accuracy.

The numbers in the Section No. III. correspond with the numbers marked at the several fossils, in the Plates of Fossils; by which it will be at once ascertained where any fossil has been found, and what is its depth from the surface.

If the Strata in shafts, in other parts of the Ashby Coal-Field, were to be as accurately delineated as this has been, much important information would be obtained, for the owner, the worker, and the geological inquirer; heavy expenses of trials might be avoided; and the risk of uncertain results considerably lessened.

REFERENCES OF THE FOSSILS.

LIST, N°. I.

This List contains the Fossils found in the Shaft, Section III. They are depicted in the accompanying Plates No. 1 to No. 70 inclusive, and the numbers marked at the several figures of the Fossils correspond with the numbers of the Strata in the same section.

The subsequent References are not intended to shew, with accuracy, the class to which the Fossils individually belong, but merely to direct the attention of Botanists to a comparison of these with the figures of Plants which are given in various modern Works,* in different countries. The Author is aware of his incapacity to perfect a Fossil botanical arrangement; but takes this mode of easing the path to such an undertaking, for those who may be desirous of pursuing it; and, towards this, he trusts the following Lists will not be unworthy of attention.

* The following are the Works referred to:—Organic Remains of a Former World; by James Parkinson. Three vols. 4to: London, 1804.—Petrificata Derbiensia; or, Figures and Descriptions of the Petrifactions of Derbyshire; by William Martin, F.L.S. Quarto: Wigan, 1809.—Essai d'un Exposé Géognostico-Botanique de la Flore du Monde Primitif; par le Comte Gaspard Sternberg: traduit par le Comte de Bray. Folio: Ratisbonne, 1820-3-4-6.—Histoire des Végétaux; ou Recherches Botaniques et Géologiques sur les Végétaux renfermés dans les diverses Couches du Globe; par Adolphe Brongniart, M.D. Quarto: Paris, 1828.—The Fossil Flora of Great Britain; or, Figures and Descriptions of the Vegetable Remains found in a Fossil State in this Country; by John Lindley, F.R.S., L.S. & G.S., and William Hutton, F.G.S. Octavo: London, 1831. Published in Parts.

Plate.	No. of Fossil.	
1	14	Fig. 6, pl. 96 of Brongniart; and No. 1, pl. 26 of Sternberg.
3	16	Pl. 18 of Lindley, the Asterophyllites Longifolia; also fig. 3, tab. 35 of Sternberg; it is described by him as a fresh-water plant, and ranged amongst the Myriophyllites.
4	25*b*	Pls. 32 to 36 of Lindley, the Stigmaria Ficoides; also figs. 1 and 2, tab. 12 of Sternberg; and tab. 11, 12, & 12* of Martin.
5	31	Fig. 2, pl. 19 of Martin.
6	37	Pl. 70 of Lindley, the Sigillaria Organum.
7	38	See No. 25*b*, and No. 55 of this volume.
11	55	Pls. 32 to 36 of Lindley, the Stigmaria Ficoides; figs. 1 & 2, tab. 12, and page 23 of Sternberg, the Variolaria Ficoides; and tab. 11, 12, & 12* of Martin, the Phytolithus Plantites. Lindley considers the species as bearing an analogy to the Euphorbiaceæ or Cacteæ of the present day.
	60	Fig. 1, pl. 14 of Brongniart, the Calamites Decoratus.
12	61	Exhibits the same characters as No. 55 of this volume.
14	74	Pl. 59 of Lindley, whose figure is the Sigillaria Oculata; and also fig. 2, tab. 12 of Sternberg.
17	101	Is nearly the same as No. 16 of this volume.
18	112	This is a specimen of the Neuropteris Gigantea. Pl. 52 of Lindley, and pl. 69 of Brongniart.
19	118	Another specimen of Sigillaria Organum. Pl. 70 of Lindley.
21	79	Represented by Lindley, pl. 59, as the Sigillaria Oculata.
	135	Figs. 1 & 2, pl. 4, Vol. I. of Parkinson; also fig. 2, tab. 53, and page 48 of Sternberg; its construction indicates a Pteris. Sternberg regards this species of Fern as an Aleutopteris Vulgatior.
22	144	Fig. 2, tab. 16, and page 29 of Sternberg; he considers it as a Lepidodendron Dichotomum.
24	256	Pls. 32 to 36 of Lindley; figs. 1 & 2, tab. 12 of Sternberg; tab. 11, 12, & 12* of Martin; and fig. 1, pl. 3 of Parkinson.
25	249*a*	Pl. 52 of Lindley, which is the Neuropteris Gigantea; tab. 22, and page 32 of Sternberg, the Osmunda Gigantea; and pl. 69 of Brongniart, the Neuropteris Gigantea.
26	338	Pl. 75 of Lindley, the Favularia Tessellata; and fig. 8, pl. 5 of Parkinson.
	357*a*	The same as pl. 37 of Lindley: with him, afterwards, it is the Pecopteris Adiantoides.
28	358*d*	Fig. 2*a*, pl. 54, and page 197 of Brongniart, the Sphenopteris Gracilis; also fig. 5, pl. 4 of Parkinson.
29	357*c*	Pl. 94 of Lindley, the Pecopteris Nervosa; also fig. 6, pl. 5 of Parkinson.

Plate.	No. of Fossil.	
	357*d*	Figs. 1 & 2, pl. 4, Vol. I. of Parkinson; and fig. 2, tab. 53, and page 48 of Sternberg; also fig. 7, pl. 84, and page 275 of Brongniart, the Pecopteris Lonchitica.
32	120	Fig. 1, tab. 10, and p. 22 of Sternberg, the Lepidodendron Rimosum; likewise, fig. 6, pl. 1, Vol. I. of Parkinson.
	370*a*	Pl. 18 of Lindley, the Asterophyllites Longifolia; also fig. 3, tab. 35 of Sternberg, a fresh water plant, ranged amongst the Myriophyllites.
33	330*a*	Figs. 1 & 2, pl. 14 of Lindley, the Asterophyllites Tuberculata; and figs. 3*a*, 3*b*, tab. 48, and page 46 of Sternberg, a genus intermediate between the Equiseta and Grasses; the Volkmannia Distachia.
34	330*b*	Pl. 18 of Lindley, the Asterophyllites Longifolia; and fig. 3, tab. 35 of Sternberg, a fresh-water plant, ranged amongst the Myriophyllites.
35	19*a*	Figs. 1 & 2, pl. 4, Vol. I. of Parkinson; fig. 2, tab. 53 of Sternberg; and also fig. 7, pl. 84 of Brongniart. See Nos. 135 & 357*d* of this volume.
	25*f*	Tab. 19 of Martin, a Phytolithus (Osmunda Regalis).
36	193*a*	Tabs. 1 & 2, and page 19 of Sternberg.
	193*b*	Tab. 6, and page 21 of Sternberg, the Lepidodendron Obovatum.
	150*a*	Fig. 1, pl. 14 of Brongniart, the Calamites Decoratus.
37	406	Pl. 52 of Lindley, the Neuropteris Gigantea; tab. 22 of Sternberg; and pl. 69 of Brongniart. See No. 249 of this volume.
38	147	Seems to be of the same class with the preceding.
40	256	Figs. 1 & 2, pl. 4, Vol. I. of Parkinson; fig. 2, tab. 53 of Sternberg; and fig. 7, pl. 84 of Brongniart. See Nos. 135 and 357*d* of this volume.
	A256	A portion of the Lepidodendron Selaginoides; pl. 113 of Lindley; also fig. 1, tab. 17 of Sternberg.
42	157	A portion of the Calamites Cannæformis. Fig. 1, pl. 21 of Brongniart.
	164	Pl. 52 of Lindley; tab. 22 of Sternberg; and pl. 69 of Brongniart.
44	254	Fig. 3, pl. 53 of Brongniart, the Sphenopteris Trifoliata.
45	222	Is of the same family as the next.
	223	Pls. 32 to 36 of Lindley; figs. 1 & 2, tab. 12 of Sternberg; and tab. 11, 12, & 12* of Martin; also fig. 1, pl. 3, Vol. I. of Parkinson.
46	257	Fig. 7, pl. 4, Vol. I. of Parkinson.
	262	Figs. 1 & 2, pl. 14 of Lindley; and figs. 3*a* & 3*b*, tab. 48 of Sternberg. See No. 330*a* of this volume.
47	306 & 311	Fig. 2, tab. 53 of Sternberg; also figs. 1 & 2, pl. 4, Vol. I. of Parkinson, and likewise, fig. 7, pl. 84 of Brongniart.
48	232	Pls. 32 to 36 of Lindley; figs. 1 & 2, tab. 12 of Sternberg; and also tabs. 11, 12, & 12* of Martin. See No. 55 of this volume.

Plate.	No. of Fossils.	
	233	Fig. 2, tab. 11, and page 23 of Sternberg, the Lepidodendron Trigonum.
50	273	Pl. 18 of Lindley, and fig. 3, tab. 35 of Sternberg.
52	284	Pls. 32 to 36 of Lindley; figs. 1 & 2, tab. 12 of Sternberg; and likewise, tabs. 11, 12, & 12* of Martin.
53	323	Fig. 1, tab. 26, and page 33 of Sternberg, a species of Polypodium.
	330	In Stony Bind. The upper left-hand impression corresponds with figs. 1 & 2, pl. 14 of Lindley, the Asterophyllites Tuberculata; and figs. *3a* & *3b*, tab. 48, and page 46 of Sternberg, a genus intermediate between the Equiseta and Grasses; the Volkmannia Distachia. The middle impression with leaves agrees with pl. 69, and page 240, of Brongniart, the Neuropteris Gigantea. The central long impression corresponds with pl. 18 of Lindley, the Asterophyllites Longifolia; and with fig. 3, tab. 35 of Sternberg, a fresh-water plant, ranged amongst the Myriophyllites.
	346	Fig. 6, pl. 1 of Brongniart, a species of the genus Confervæ.
	356*a*	Fig. 1, pl. 19 of Lindley, the Bechera Grandis; and fig. 1, tab. 49 of Sternberg, who also, at page 46, names it the Bechera Grandis.
	359	Fig. 2, tab. 53, and page 48 of Sternberg, who places this species of Fern under the name Aleutopteris Vulgatior; its construction indicates a Pteris Figs. 1 & 2, pl. 4, Vol. I. of Parkinson; and fig. 7, pl. 84 of Brongniart; he describes this, at page 275, as the Pecopteris Lonchitica.
54	357	Figs. 1 & 2, tab. 6, and page 21 of Sternberg; the Lepidodendron Obovatum; also pl. 19 of Lindley.
56	347	Fig. 1, pl. 14, and page 128 of Brongniart, the Calamites Decoratus.
57	358	Pl. 52 of Lindley; tab. 22 of Sternberg; and pl. 69 of Bronguiart. See No. 249*a* of this volume.
	324	A portion of the Lepidodendron Selaginoides. Pl. 113 of Lindley, and fig. 1, tab. 17 of Sternberg.
58	319	Fig. 1, pl. 19 of Lindley; and fig. 1, tab. 49 of Sternberg.
	321	Pl. 52 of Lindley; tab. 22 of Sternberg; and pl. 69 of Brongniart.
59	370	Tabs. 1 & 2 of Sternberg, the Lepidodendron Dichotomum.
60	356	Fig. 4, pl. 18 of Brongniart, described by him, at page 135, as the Calamites Steinhaueri.
	355	A portion of the Calamites Cannæformis. Fig. 1, pl. 21 of Brongniart.
61	147*a*	Fig. 3, pl. 57 of Brongniart, the Sphenopteris Latifolia.
63	144*a*	The centre impression agrees with tabs. 1 & 2 of Sternberg; and with pl. 112, of Lindley, the Lepidodendron Sternbergii. The lower impression seems to be a Sphenophyllum, and agrees with pl. 13, part 2 of Lindley, the Sphenophyllum Erosum.

Plate.	No. of Fossil.	
64	145*a*	Pl. 69 of Brongniart, the Neuropteris Gigantea.
65	61*a*	Branches of the Neuropteris Gigantea.
	109*a*	A decorticated specimen of the Sigillaria Reniformis. Pls. 57 & 71 of Lindley.
66	235	Specimens of different species of Calamites. Pls. 14 to 27 of Brongniart.
67	1 & 2	Fig. 4, pl. 18 of Brongniart; the Calamites Steinhaueri.
68	4	Figs. 80 & 81 of Lindley; the Bothrodendron Punctatum.
	5	Pl. 77 of Lindley; and figs. 7 & 8, pl. 15 of Brongniart, the Calamites Approximatus.
69	6	Pl. 19, and page 128 of Brongniart, the Calamites Cruciatus.
70	8, 9, & 10	Portions of the Calamites Cannæformis, and Calamites Steinhaueri; also pls. 18 and 21 of Brongniart.

LIST, N°. II.

This List includes the Fossils found in a Stone-pit on Ashby Woulds, and figured in Plates No. 71 to 87 inclusive. This Stone-pit does not appear to be a regular bed: it is part of an extensive deposit, and lies about two hundred yards above the Main Coal Seam.

Plate.	No. of Fossil.	
71	1	Pl. 70 of Lindley, the Sigillaria Organum; also figs. 1 & 2, tab. 13, and page 23 of Sternberg, the Syringodendron Organum.
72	3	Fig. 1, pl. 26, and page 122 of Brongniart, the Calamites Radiatus.
73	4	Tab. 28, and page 39 of Sternberg, the Lepidodendron Appendiculatum.
	5	Fig. 6, pl. 2, and page 401, Vol. I. of Parkinson, a specimen of the petrified Larch Tree, Laricites.
74	6	A specimen of the Lepidodendron, which resembles the figs. in tab. 2 of Sternberg.
	7	Pl. 59 of Lindley, the Sigillaria Oculata.
75	8	Tab. 50 of Martin, the Phytolithus Imbricatus, (see his tab. 14); also fig. 2, pl. 7 of Lindley, the Lepidodendron Dilatatum; and the upper left-hand fig. pl. 2 of Sternberg.
77	10	Bears the same character as No. 8 above.
78	13	Pl. 55 of Lindley, the Sigillaria Pachyderma.
79	14	Figs. 4 & 5, tab. 14 of Martin, the Phytolithus Imbricatus; see also his tab. 50.

Plate.	No. of Fossil.	
80	17	Fig. 8, pl. 5, Vol. I. of Parkinson; and pl. 75 of Lindley, the Favularia Tessellata.
82	23	A Lepidodendron. Tab. 50 of Martin; and fig. 2, pl. 7 of Lindley; also the upper left-hand figure of pl. 2 of Sternberg.
83	24	A specimen of the Sigillaria Organum. See No. 1 of this volume.
84	25&26	Tab. 50 of Martin; fig. 2, pl. 7 of Lindley; and pl. 2 of Sternberg.
85	27	Pl. 70 of Lindley; and figs. 1 & 2, tab. 13 of Sternberg.
86	30	Fig. 1, tab. 6, and page 21 of Sternberg, the Lepidodendron Obovatum.
87	31	Pls. 32 to 36 of Lindley, the Stigmaria Ficoides; also fig. 2, tab. 12, and page 23 of Sternberg, the Variolaria Ficoides; and tabs. 11 & 12* of Martin, the Phytolithus Plantites (verrucosus).

The following Plates, No. A 1 to A 15 inclusive, are descriptive of Fossils taken from the Stone-pit at Ashby-de-la-Zouch.

No. of Plate.	
A 1	Pl. 70 of Lindley, the Sigillaria Organum; also tab. 13, page 23 of Sternberg, the Syringodendron Organum.
A 2	The upper impression is a Lepidodendron, see fig. 8, pl. 75 of the preceding List. The lower resembles tab. 27 of Sternberg, a Lepidolepis.
A 3	Tabs. 1 & 2, and page 20 of Sternberg, the Lepidodendron Dichotomum.
A 6	The lower right-hand impression agrees with fig. 3, tab. 17, and page 30 of Sternberg, as a species of plant approaching the Lithoxila of Volkmann.
A 7	Tab. 50 of Martin; fig. 2, plate 7 of Lindley; and pl. 2, of Sternberg.
A 8	Pl. 70 of Lindley; and figs. 1 & 2, tab. 13 of Sternberg.
A 9	Pl. 4 of Lindley, also fig. *c*, pl. 112, the Lepidodendron Sternbergii; and pls. 1 & 2 of Sternberg, the Lepidodendron Dichotomum.
A 10	The left-hand impression corresponds with tab. 27 of Sternberg: a portion of a large Tree, differing from the Lepidodendron, and called Lepidolepis by this author.
A 13	The right-hand impression agrees with figs. 1 & 2, tab. 6, and page 21 of Sternberg, the Lepidodendron Obovatum; also pl. 19 of Lindley. The left-hand impression corresponds with fig. 1, pl. 14, and page 123 of Brongniart, the Calamites Decoratus.

GLOSSARY

Of Terms used in the Coal-Mines of Measham, Oakthorpe, Donisthorpe, and Ashby Woulds, in the Ashby Coal-Field.

Abattis—Walls or ranges of branch or rough wood, placed crossways to keep passages open for roads or air.

Adit—An opening, drain, or gangway, driven in coal or other strata, for conducting water, air, or workmen.

Air-Gates—See Adits.

Basset—The outcrop or point where any bed reaches the surface.

Basin—Depressed portions of the strata.

Beds—Seams of the strata, thin or thick.

Bind—Clay indurated.

Blow-George—A fan used underground, turned by a boy, to force air in a particular direction.

Brettices—The same as Abattis.

Byard—A strong broad piece of leather, crossing the breast and extending down the back of the men or lads drawing the dans in low works underground.

Cank-Stone—A species of whinstone, often containing silex and iron.

Cannel-Coal—A light bituminous coal.

Chert—A siliceous mineral, approaching to flint, petrosilex.

Chisel—An instrument used in boring, at the end of boring rods, as a drill.

Choke-Damp—Carbonic acid gas.

Clay, Fire or Potters—An earth of various qualities; a pure white clay, free from mineral tints, bears a strong heat without fusing.

Cleats—Wood wedges four or five inches square, tapered at one edge.

Cleavings—Horizontal divisions of the seams, or in the direction of the laminæ.

Clot—Indurated clay, not flaky, or disposed to separate in layers.

Clunch—Clay, much compressed.

Cobbles—Lumps of coal, from the size of an egg to that of a foot-ball.

Crozzling—This takes place when small coal aggregates in burning.

Cutters—Natural divisions of the strata, chiefly running at right angles with slines.

Dans—Small trunks or sledges used in the works only, and drawn by men or lads from the coal-wall to the gangroads.

Dice Coal—A soft easily-divided coal, arranged nearly as dice.

Dip—The point of the compass to which the bed inclines from an horizontal line.

Dog-Belts—A strong broad piece of leather round the waist, to which a chain is attached passing between the legs of the men or lads drawing dans in low works.

Duns—The same as Tow.

End—The directions in which slines or partings run.

Face—Board, or bank; the direction in which the coal is wrought, being at right angles with the slines.

Faults—A dislocation in the strata, whether a break, or slip, or the introduction of some extraneous mass.

Fire-Clay—Clay not fusible at a very intense heat.

Garland—A circular trough in the shaft to convey water into a pipe or in a particular direction.

Geodes—Large nodules of ironstone, hollow at the centre.

Gobbing—The slack, roof-measures, and other refuse, thrown back into the excavations made in getting out the coal.

Hading—The direction of a slip or fault.

Helver—The handle, or that part of any tool, as a hammer, pick, or hatchet, by which it is held in the hand.

Holing—An undermining of the bed of coal.

Horn-Coal—A line at any angle between *end* and *face*.

Jacks—Wood wedges 6 inches by 4, tapered at one broad edge, so that when driven up they cannot start again.

Maundril—A pick with two shanks and points, used in getting coal.

Measures—Synonymous with beds, seams, layers, and strata.

Minge-Coal—Where spire and dice coal alternate.

Muscle-Band—Black bituminous shale in which muscle shells are imbedded.

Mushy-Coal—Where a sooty substance pervades coal, or where it is crushed.

Nodules—Rounded, irregular shaped lumps.

Nooper—A tool with a hammer-head at one shank, and a curved pick at the other, used by repairers underground.

Outcrop—Exposure of a stratum at the surface.

Partings—Similar to slines, but the term is applied to any direction.

Puncheons—Wood or iron props used to support the roof.

Ramilly Clot—Indurated clay with sand intermixed.

Ricketing—A side gutter in an adit, cased up in front, by which air is carried.

Ringer—A crow-bar of iron.

Rubble—Small stone, broken or disjointed stone.

Sagger—Coarse fire-clay, used in making open pots, in which the pottery ware is baked or fired in a kiln.

Scud—A very thin layer of soft matter, whether of carbon, clay, or other comminuted substance.

Septaria—Balls of stone, the interior cellularly constructed.

Shed—A thin smooth parting, where both sides are polished.

Skips—Iron or wood frames, on which coals are raised up the shafts

Slack—Small coal, under the size of an egg.

Slines—Partings or divisions in solid strata, having a parallel direction.

Slips—Masses of strata separated vertically or aslant.

Sloam—A clay or earth to hole in, often under coal.

Spire-Coal—A strong, slaty, compact coal.

Stamping Maundril—A heavier maundril than the common one, used at first whilst the men can keep nearly upright until the holing is far wrought in, when a common maundril is resorted to.

Stint—A measure of work used underground, two yards long and one broad, which each holer clears before he moves to another place, and which is proved by a boy appointed among the men for that purpose. This boy is colloquially called "The Judge."

Stone-Bind—Indurated clay and sand mixed.

Stony Clunch—Compressed clay with sand layers interspersed.

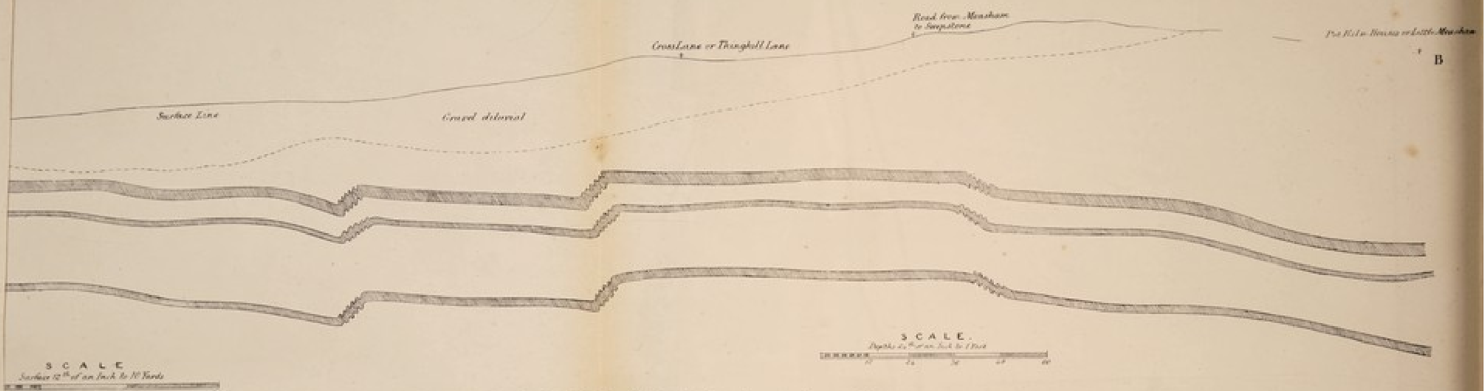
Sump—A concave space at shaft bottom, for water or rubbish.

Thurls—Short adits between air-adits and gangways or works, or between two adits that ventilate each other.

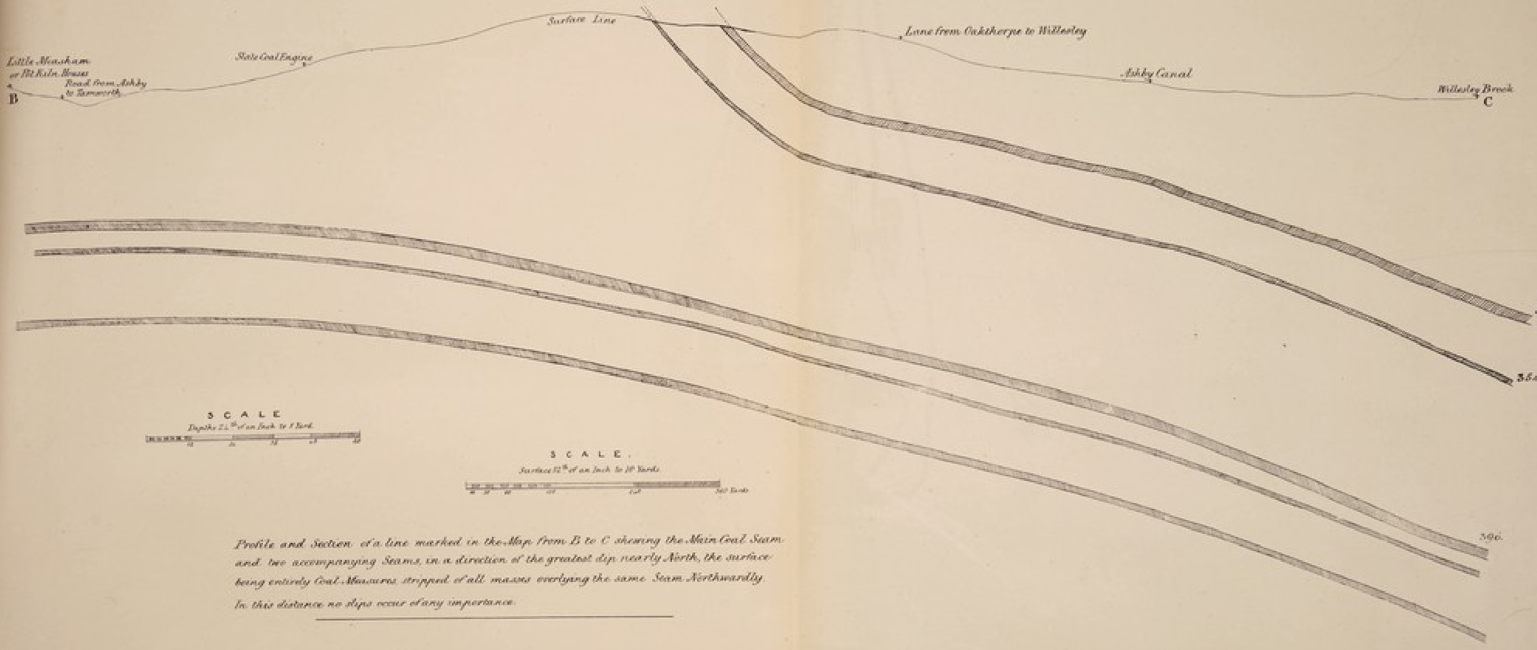
Tow—Duns, a soft fine fire-clay, with a soapy feel, supposed to be the cause of spontaneous firing in the gobbing of main coal.

Wastes—See gobbing; wastes therein apply to furrows or divisions in the rubbish.

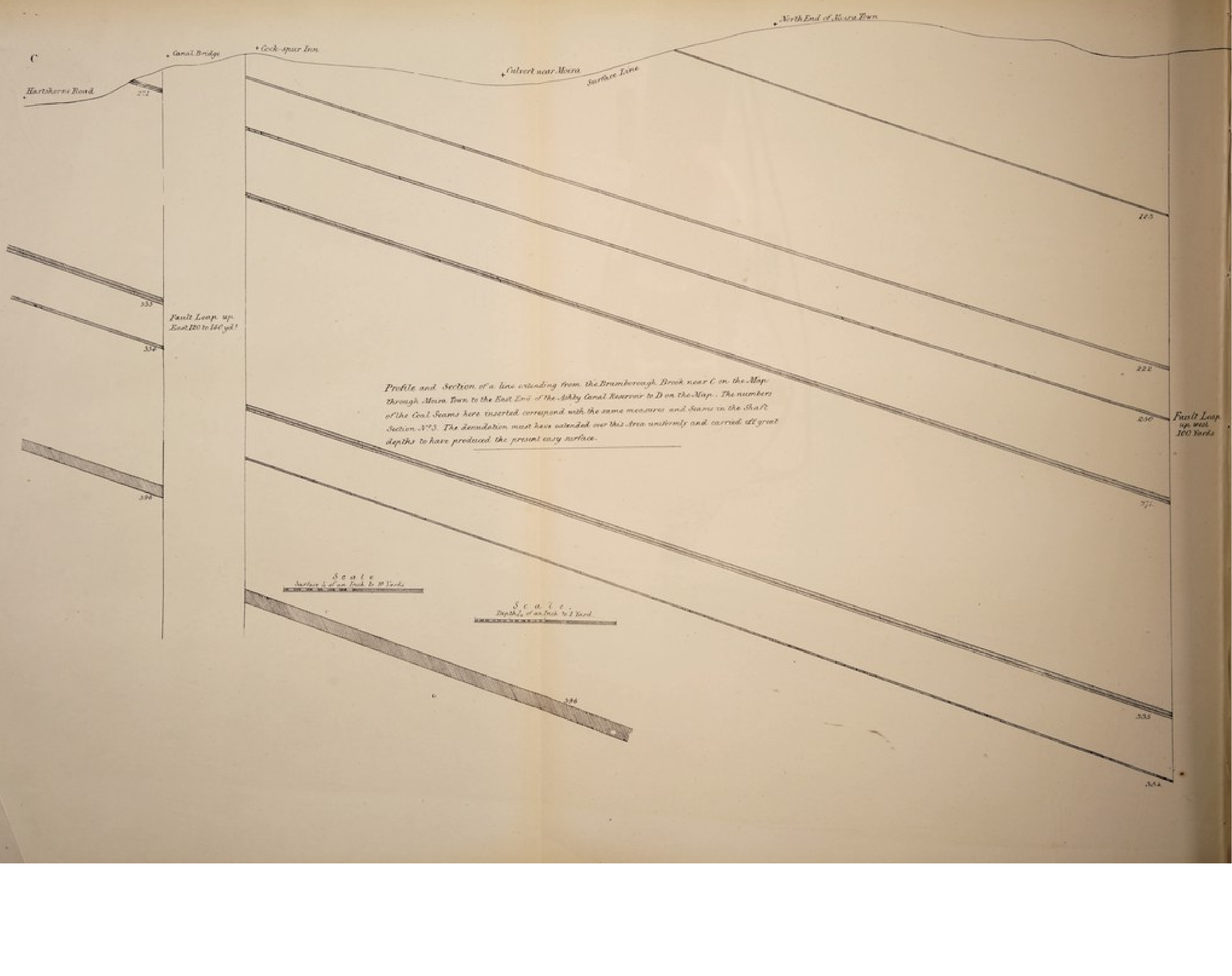
Winning—Sinking shafts, and opening the coal-work.

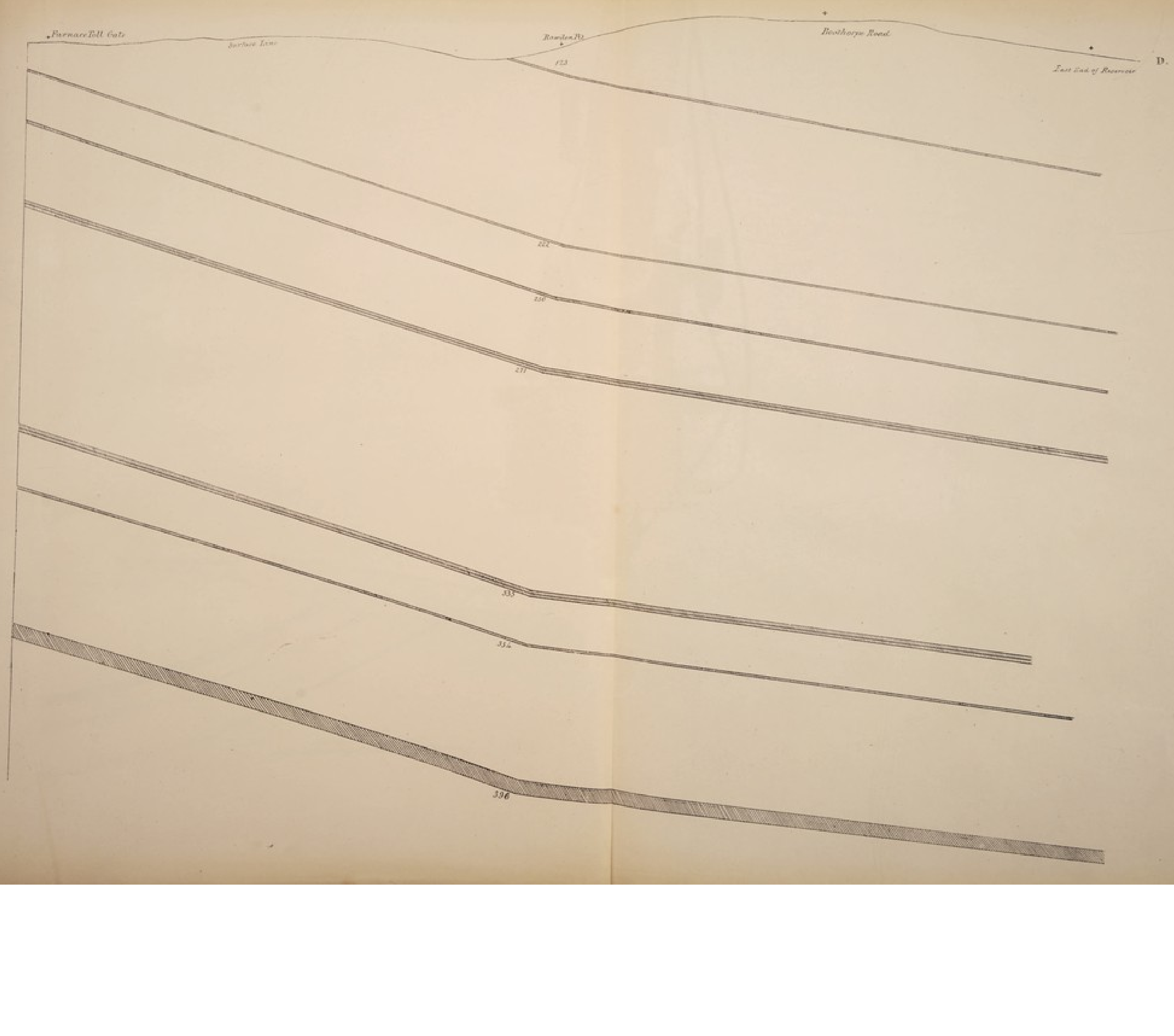


Profile and Section of a line marked on the Map from A to B in Measham Parish only, showing the waving lines and short dislocations of the Strata as they approach the surface. The distance between the Surface and the dotted line is a diluvial deposit of Gravel and Sand of a very mixed nature, occasioning a tract of as good land as any in Derbyshire over the Coal. Immediately below the gravel the Coal measures set in, and dip with the Coal corresponding as far as they extend with the measures in the Shaft Section No. 3.

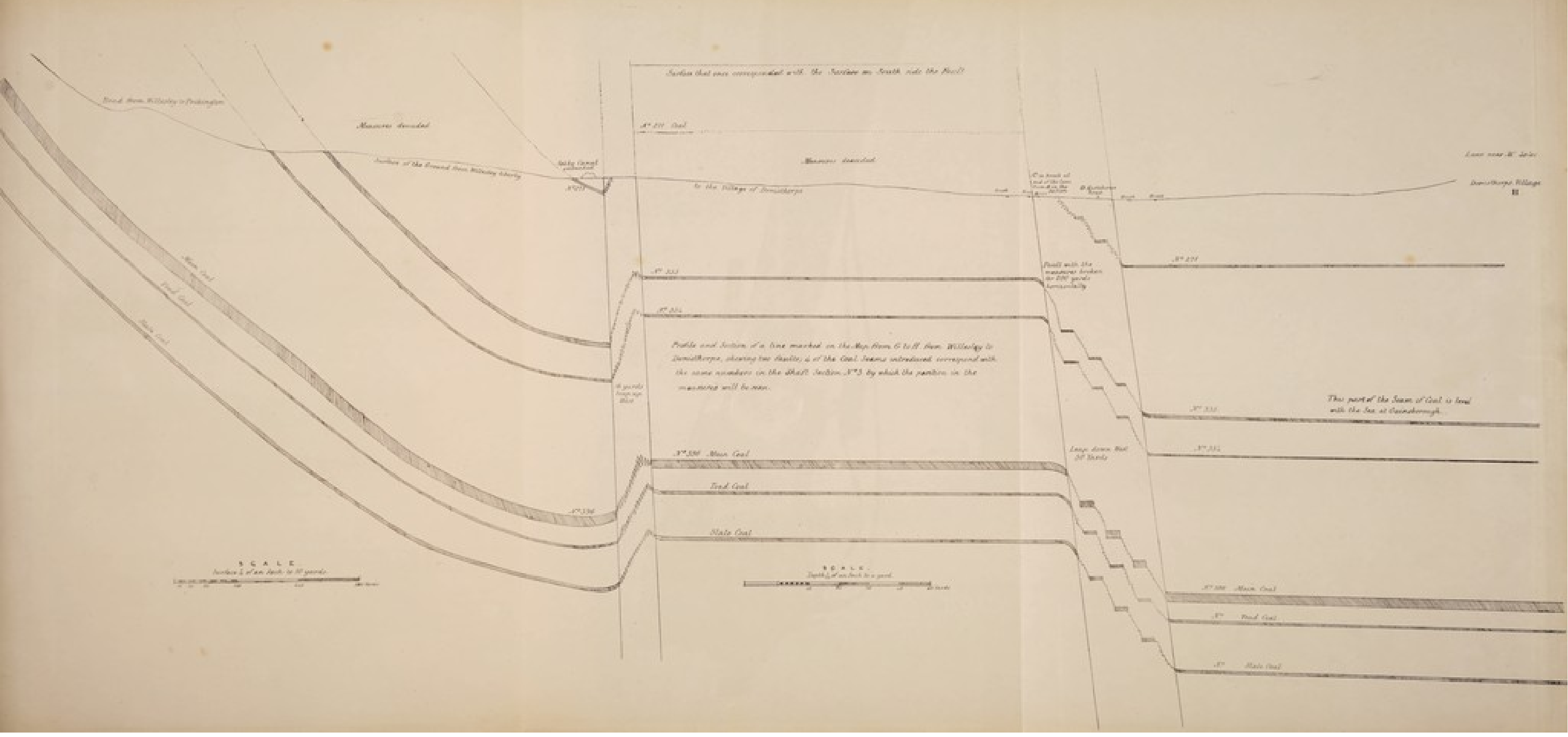


Profile and Section of a line marked in the Map from B to C shewing the Main Coal Seam and two accompanying Seams, in a direction of the greatest dip nearly North, the surface being entirely Coal Measures stripped of all masses overlying the same Seam Northwardly. In this distance no slips occur of any importance.

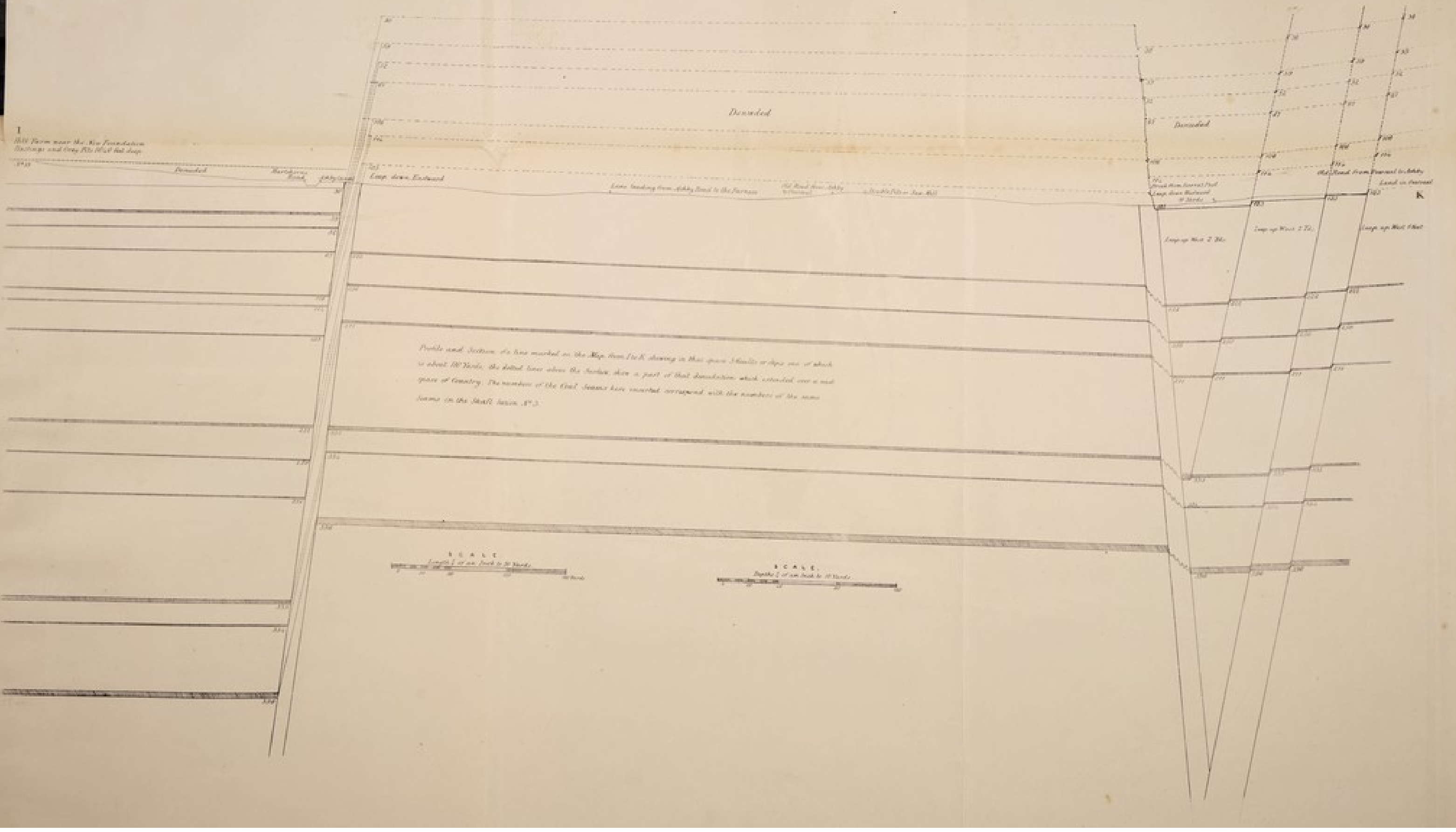

C
Hartshorne Road
Canal Bridge
Cock-spur Inn
Culvert near Moira
Surface Line
North End of Moira Town
Fault Leap up East 120 to 140 yds.
Fault Leap up west 100 Yards
Profile and Section of a line extending from the Bramborough Brook near C on the Map through Moira Town to the East End of the Ashby Canal Reservoir to D on the Map. The numbers of the Coal Seams here inserted correspond with the same measures and Seams in the Shaft Section No. 3. The denudation must have extended over this Area uniformly and carried off great depths to have produced the present easy surface.
Scale
Scale


Furnace Toll Gate
Surface Line
123
222
396
D.

Profile of Surface from Thringhill to a Field West of Measham Colliery marked on the Maps from E. by B to F. and Section of the Measures showing the position of the Main Coal, and two other Coals from East to West.



Section that once corresponded with the Surface on South side the Fault
Measures denuded
Measures denuded
Surface of the Ground from Willesley to Denisthorpe
Ashby Canal
To the Village of Denisthorpe
Denisthorpe Village
Main Coal
Tent Coal
Slate Coal
No. 333
No. 334
No. 334
No. 271
No. 330 Main Coal
Tend Coal
Slate Coal
Profile and Section of a line marked on the Map from G to H from Willesley to Denisthorpe, showing two faults, & of the Coal Seams introduced correspond with the same numbers in the Shaft Section No. 3 by which the position in the measures will be seen.
This part of the Seam of Coal is level with the Sea at Gainsborough.
Leap down East 50 Yards
Fault with the measures broken
Main Coal
Tend Coal
Slate Coal
SCALE
SCALE



I
Denuded
Leap down Eastward
Denuded
K
SCALE.

N°. I.

SECTION OF THE STRATA

IN A SHAFT ON THE EAST SIDE OF THE VILLAGE OF DONISTHORPE,

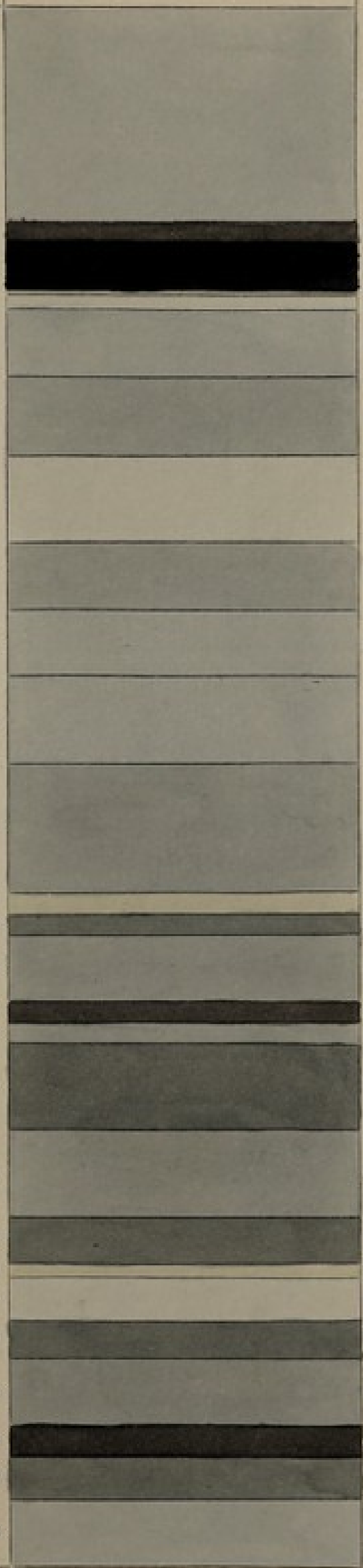
In the County of Derby.

TAKEN IN 1799.

SCALE—$\frac{1}{12}$ of an Inch to 1 Foot.

Mineral Names of the Strata.	*No. of Seam.*	*Thickness of each Stratum.* FT.	IN.	*Colours of the Strata.*	*Local Names of the Strata.*
		6	0		Bank raised of mined Earth.
Soil		2	0		Soil, rather stiff.
Brick-Earth		1	6		Clay, white and waxy.
Earth, with much Carbon ..		6	0		Black Shale, in thin tender laminæ, jointy and yielding water.
Clay, with much Carbon ...		3	6		Black Bind, not jointy, yielding no water, crumbling in the air.
Sandstone, with much Carbon		4	6		Black Stone, hard and jointy, burns to a white bat, resists the air for some years.
Indurated Clay		9	0		Blue Bind, full of vegetable impressions interspersed with thin laminæ of Ironstone.
Indurated Clay with Carbon		2	0		Black Bind.
Sand-Rock		9	0		White Stone very hard with open clefts, yielding water, thin seams of Coal interspersed.
Clay, unmixed		3	0		Fire-Clay.
Sand-Rock, with thin soft seams in it		5	0		Rammel and Stone, yields water, many vegetable impressions.
Rock, indurated Clay and Sandstone and Clay		6	0		Rammel, Stone and Clot alternating.
Sand-Rock		12	0		Hard Stone, open fissures, yields water, resists tools, stands the weather.
Carried forward..	....	69	6		

Mineral Names of the Strata.	*No. of Seam*	*Thickness of each Stratum.* FT.	IN.	*Colours of the Strata.*	*Local Names of the Strata.*
Brought forward ..	....	69	6		
Indurated Clay		15	0		Blue Bind, with little Ironstone, full of vegetable impressions, a few thin seams of Sandstone ¼ inch thick, yields no water.
Inflammable Earth		1	6		Hard Black Bat, jointy, burns with much flame.
Coal	271	3	6		Coal, tender, jointy, much water.
Pure Clay		0	4		Scud of Fire-Clay.
Sandstone		1	0		Sandstone, yielding water.
Indurated Clay		4	8		Blue Bind.
Sandstone and Clay		5	6		Ramilly Clot.
Sandstone		6	0		Hard Stone, yields water.
Sandstone with tender seams		4	6		Ramilly Stone.
Indurated Clay		4	6		Blue Bind with black sheds and Ironstone.
Indurated Clay		6	0		Blue Bind, with sheds of Coal ¼ inch thick, full of vegetable impressions and Ironstone.
Sandstone and Clay		9	0		Ramilly Clot.
Iron mixed with Sandstone..		1	6		Cank Stone.
Indurated Clay		1	6		Clot.
Indurated Clay and Sand ...		4	6		Stony Clot.
Shale and Coal mixed		1	6		Black Bat and Coal alternating.
Clay and Sand		1	6		Ramilly Clot full of black sheds.
Indurated Clay		6	0		Clot with nodules of Ironstone.
Clay and Sandstone		6	0		Ramilly Clot, Coal sheds, jointy, no water.
Indurated Clay		3	3		Clot.
Whin Stone		1	0		Cank Stone.
Sandstone		3	0		Hard Stone.
Indurated Clay		2	9		Clot.
Sandstone and Clay		4	6		Ramilly Clot.
Shale		2	3		Black Bat fine grained, full of Ironstone.
Indurated Clay		3	0		Clot with Ironstone.
Indurated Clay		4	6		Blue Bind with Coal sheds and Ironstone.
Carried forward ..	....	177	9		



Mineral Names of the Strata.	*No. of Seam*	*Thickness of each Stratum.* FT.	IN.	*Colours of the Strata.*	*Local Names of the Strata.*
Brought forward	....	177	9		
Bituminous Earth		0	6		Black Bind.
Inflammable Shale		1	0		Bat.
Bituminous Earth		1	9		Black Bind.
Inflammable Shale		0	6		Bat.
Coal	303	2	0		Coal.
Indurated Clay		16	0		Ramilly Clot with Ironstone.
Coal and Black Shale		4	0		Coal and Bat mixed.
Indurated Clay		7	0		Ramilly Clot.
Whin Stone		0	7		Cank Stone.
Indurated Clay		4	0		Clot.
Coal, Shale, and Sandstone		3	0		Coal mixed with Bat and seams of Stone.
Coal, Shale, and Sandstone		3	0		Yielding water and gas.
Sandstone		0	9		Hard Grey Stone.
Inflammable Shale		3	0		Strong Black Bat.
Indurated Clay		4	0		Clot with Ironstone.
Inflammable Shale		0	5		Black Bat.
Indurated Clay		9	0		Ramilly Clot with Ironstone.
Indurated Clay		4	8		Clot.
Indurated Clay and Sand		4	6		Clot and Ramilly Stone.
Sand-Rock		4	0		Sandstone, open, yielding water.
		2	6		Ramilly Stone.
		2	0		Grey Stone.
Indurated Clay		5	7		Ramilly Clot with Ironstone, much water.
Whin Stone		0	9		Cank Stone.
Indurated Clay		3	0		Broad Clot.
Coal	335	4	0		Coal. *(This point is level with the high water mark at Gainsborough.)*
Black Clay		0	6		Black Bind.
Indurated Clay		4	8		Ramilly Clot.
Sandstone		6	9		Ramilly Stone with Ironstone.
Indurated Clay		4	6		Clot with Coal sheds.
Carried forward	....	285	8		

Mineral Names of the Strata.	*No. of Seams*	*Thickness of each Stratum.* FT.	IN.	*Colours of the Strata.*	*Local Names of the Strata.*
Brought forward	....	285	8		
Sandstone		5	6		Ramilly Stone.
Sand-Rock		1	6		Hard Grey Stone.
Sandstone		3	10		Ramilly Stone.
Sand-Rock		0	7		Grey Stone.
Sandstone		10	4		Ramilly Stone with Ironstone and Coal sheds.
Sand-Rock		3	0		Grey Stone.
Coal	354	2	3		Coal, Cannel lies close to the Stone.
Pure Clay		2	3		Fire-Clay.
Sandstone and Clay		6	9		Ramilly Clot with Ironstone.
Indurated Clay		5	4		Broad Clot.
Indurated Clay		6	0		Clot with Ironstone.
Indurated Clay		5	8		Broad Clot.
Indurated Clay		22	2		Clot with Ironstone, small sheds of Coal and Sandstone alternating.
Grey Sand-Rock		28	0		Hard Stone, yielding no water.
Carried forward	....	388	10		

Mineral Names of the Strata.	*No. of Seam*	*Thickness of each Stratum.* FT.	IN.	*Colours of the Strata.*	*Local Names of the Strata.*
Brought forward	....	388	10		
Indurated Clay		9	1		Clot with Ironstone.
Sand-Rock		4	6		Hard Stone.
Sandstone		9	0		Ramilly Stone.
Indurated Clay		6	0		Clot.
Whin Stone		2	0		Cank Stone.
Indurated Clay		33	0		Blue Bind interspersed with Coal sheds, and nodules of Ironstone.
Coal		3	0		Ryder Coal.
Fine Fire-Clay		2	0		Tow.
Coal		8	0		Main Coal.
Coal	396	3	0		Nether Coal.
		3	0		
		471	5		

The lower side of the Coal, No. 396, is 201 feet below high water mark at Gainsborough.

*** The "Nos. of Seams" inserted here are intended to shew the corresponding Strata with the same numbers in Section III.

Dip to the North 4 inches in a yard.

N°. II.

SECTION OF THE STRATA

FOUND IN SINKING THE RAWDON SHAFT AT MOIRA COLLIERY,

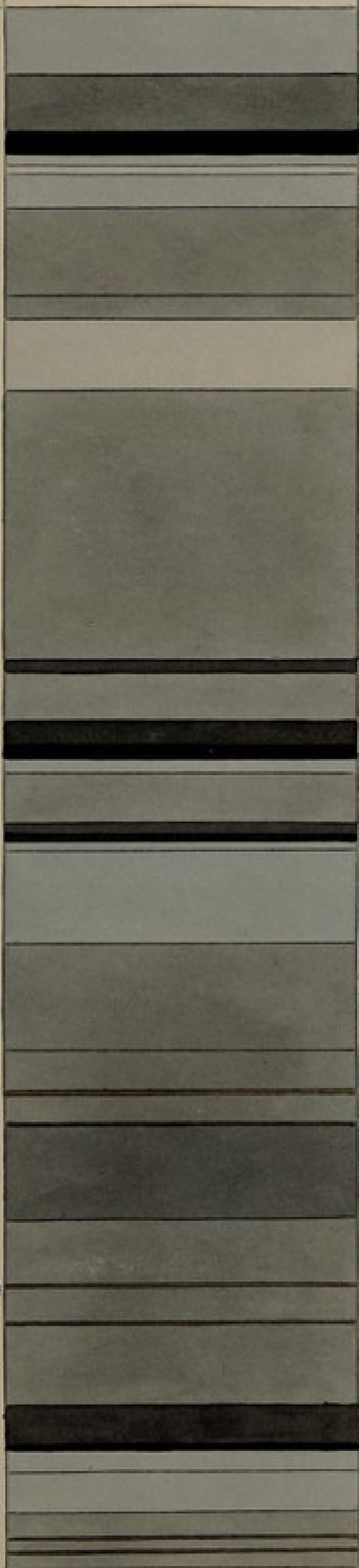
ON ASHBY WOULDS, NEAR BOOTHORPE,

In the Parish of Ashby-de-la-Zouch.

SCALE—$\frac{1}{12}$ of an Inch to 1 Foot.

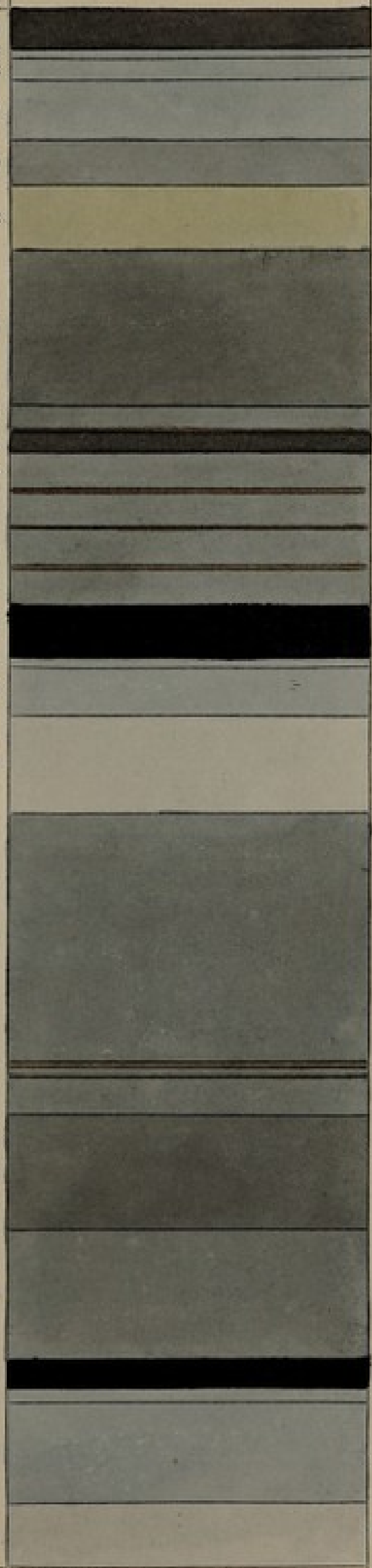
Mineral Names of the Strata.	*No. of Seam.*	*Thickness of each Stratum.* FT.	IN.	*Colours of the Strata.*	*Local Names of the Strata.*
Soil and Clay		4	3		Soil and Clay.
Inflammable Earth		1	0		Black Shale.
Indurated Clay		1	0		Blue Bind.
Coal		1	3		Smut of Coal.
Indurated Clay		5	2		Tender Blue Bind.
Ironstone		0	3		Ironstone Seam.
Indurated Clay		6	2		Tender Blue Bind.
Ironstone		0	1		Ironstone Seam.
Indurated Clay		2	0		Tender Blue Bind.
Coal		2	2		Coal.
Clay		3	0		Soft White Clunch.
Clay, slightly indurated		4	2		Tender Blue Bind, not very compact.
Inflammable Earth		2	0		Black Bat mixed with sheds of bright and dicey Coal.
Clay		0	6		Soft White Clunch.
Indurated Clay		2	4		Clunch.
Sandstone		3	9		Light-coloured Sandstone.
Indurated Clay		5	4		Strong Blue Bind.
Sandstone Rock		4	0		Grey Sand-Rock.
Indurated Clay and Sand		1	6		Stony Bind.
Sand-Rock		1	0		Grey Rock.
Clay		1	6		Tender Blue Bind.
Ironstone		0	2		Ironstone Seam.
Clay		2	0		Tender Blue Bind.
Ironstone		0	1		Ironstone Seam.
Clay		2	7		Tender Blue Bind.
Ironstone		0	3		Ironstone Seam.
Clay		0	10		Tender Blue Bind.
Ironstone		0	1½		Ironstone Seam.
Clay		0	10		Tender Blue Bind.
Indurated Clay		6	6		Tender Blue Bind.
Ironstone		0	2		Ironstone.
Indurated Clay with Balls		2	6		Tender Blue Bind, with layers of balls of Ironstone.
Inflammable Earth		0	6		Black Bat.
Carried forward	....	68	11½		

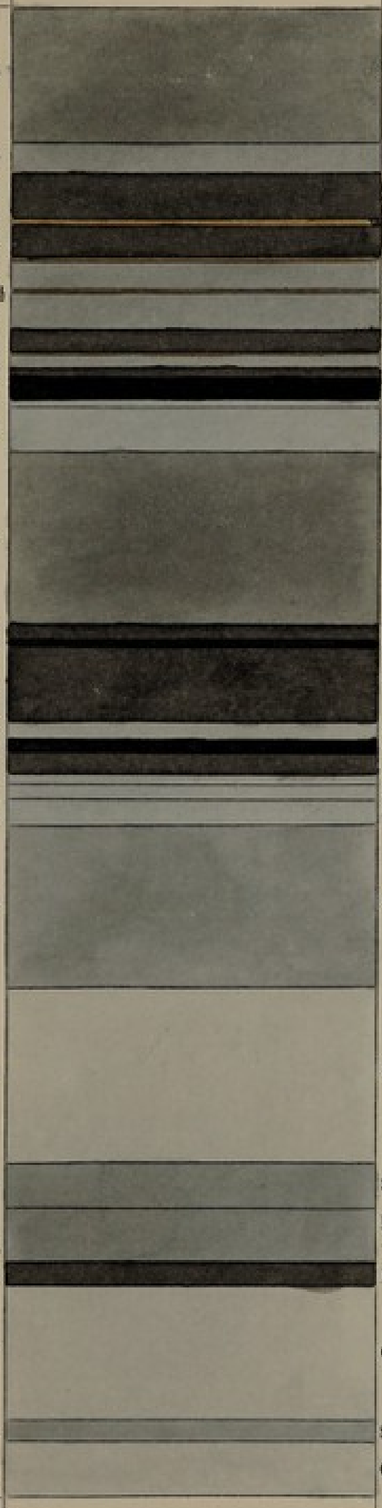
Mineral Names of the Strata.	*No. of Seam.*	*Thickness of each Stratum.* FT.	IN.	*Colours of the Strata.*	*Local Names of the Strata.*
Brought forward	....	68	11½		
Clay		4	6		Soft Clunch.
Clay		4	0		Blue Bind interspersed with layers of Ironstone.
Coal		1	8		Coal.
Clay		0	9		Soft Clunch.
Grey Rock		0	6		Grey Stone.
Indurated Clay		2	5		Stony Clunch.
Indurated Clay		6	0		Stony Bind.
Clay		1	7		Tender Blue Bind.
Grey Rock		5	0		Grey Sandstone.
Indurated Clay		18	6		Strong Blue Bind.
Inflammable Earth		1	0		Black Bat.
Indurated Clay		3	6		Stony Blue Bind.
Inflammable Earth		1	9		Black Bat.
Coal		1	1		Coal.
Clay		1	0		Soft Clunch.
Clay		3	4		Tender Bind.
Coal—Inflammable Earth		0	9		Black Bat.—Coal.
		0	[illegible]		
Clay		0	6		Soft Clunch.
Indurated Clay and Ironstone		6	5		Stony Clunch with layers of balls of Ironstone.
Indurated Clay		7	5		Stony Bind.
Indurated Clay		3	0		Strong Blue Bind.
Ironstone		0	2		Ironstone.
Clay		2	0		Strong Blue Bind.
Ironstone		0	1		Ironstone.
Indurated Clay with balls of Whin Stone		6	6		Strong Bind with balls of Cank.
Indurated Clay		4	7		Strong Blue Bind.
Ironstone		0	1½		Ironstone.
Indurated Clay		2	6		Strong Blue Bind.
Ironstone		0	1		Ironstone.
Clay		5	8		Strong Blue Bind.
Inflammable Earth		2	10		Black Bat.
Coal		0	5		Coal.
Clay		1	3		Soft Clunch.
Clay		2	10		Stony Clunch.
Ironstone—Clay		1	10		Strong Blue Bind.—Ironstone.
		0	1		
Clay		0	[illegible]		Bind.—Ironstone.
Ironstone		0	1		
Clay		[illegible]	1		Bind.
Carried forward	....	176	10		



Mineral Names of the Strata.	*No. of Seam*	*Thickness of each Stratum.* FT.	IN.	*Colours of the Strata.*	*Local Names of the Strata.*
Brought forward . .	. . . .	176	10		
Ironstone		0	1½		Ironstone.
Indurated Clay alternating with seams of Ironstone.		1	9		Strong Blue Bind.
		0	2		Ironstone.
		3	3		Strong Blue Bind.
		0	1		Ironstone.
		1	2		Strong Blue Bind.
		0	1½		Ironstone.
		1	7½		Strong Blue Bind.
		0	0½		Ironstone.
		0	6		Strong Blue Bind.
		0	1		Ironstone.
		1	8		Strong Blue Bind.
		0	1		Ironstone.
Indurated Clay		6	0		Strong Blue Bind.
Inflammable Earth		0	6		Black Bat.
Coal		3	0		Coal.
Clay		0	8		Soft White Clunch.
Clay and Ironstone		5	0		Stony Clunch with layers of balls of Ironstone.
Indurated Clay		4	1		Strong Blue Bind.
Indurated Clay		8	6		Strong dark Blue Bind.
Whin Stone with Ironstone .		1	4		Cank Stone.
Clay		2	1		Strong Blue Bind.
Ironstone		0	1		Ironstone.
Clay		4	8		Strong Blue Bind.
Ironstone		0	1		Ironstone.
Clay		4	7		Strong Blue Bind.
Ironstone		0	1		Ironstone.
Clay		0	1		Blue Bind.
Ironstone		0	½		Ironstone.
Clay		3	5		Dark Blue Bind.
Ironstone		0	1		Ironstone.
Clay		1	0		Tender Blue Bind.
Black Shale		1	7		Black Bat.
Clay		1	6		Tender Blue Bind.
Coal		1	9		Coal.
Clay		1	0		Soft Clunch.
Indurated Clay and Ironstone		5	6		Hard Clunch with layers of balls of Ironstone.
Sand and Clay		1	8		Stony Clunch.
Indurated Clay		10	10		Strong Blue Bind.
Clay		3	4		Tender Blue Bind.
Ironstone		0	1		Ironstone.
Clay		5	9		Tender dark Blue Bind.
Coal		0	2		Coal.
Sandstone		18	6		Sandstone, containing a variety of Vegetable Fossils.
Carried forward . .	. . . .	285	1		

Mineral Names of the Strata.	*No. of Seam.*	*Thickness of each Stratum.* FT.	IN.	*Colours of the Strata.*	*Local Names of the Strata.*
Brought forward	....	285	1		
Black Shale		2	9		Black Bat.
Clay		0	6		Soft Clunch.
Clay and Sand		1	6		Stony Clunch.
Indurated Clay and Sand		4	2		Stony Clunch.
Indurated Clay		3	0		Stony Bind.
Whin Stone		4	6		Cank Stone.
Indurated Clay		10	7		Strong Blue Bind.
Indurated Clay		1	8		Bind.
Ironstone		0	1		Ironstone.
Black Shale		1	3		Black Bat.
Clay		2	6		Bind.
Ironstone		0	2		Ironstone.
Clay		2	3		Bind.
Ironstone		0	1		Ironstone.
Clay		2	5		Bind.
Ironstone		0	2		Ironstone.
Indurated Clay		2	7		Strong Bind.
Coal		3	8		Coal.
Clay		0	8		Soft Clunch.
Indurated Clay		3	6		Stony Clunch.
Grey Sand-Rock		6	6		Grey Sandstone.
Indurated Clay		16	9		Strong Blue Bind.
Ironstone		0	2		Ironstone.
Clay		0	1		Bind.
Ironstone		0	1		Ironstone.
Clay		2	8		Bind.
Indurated Clay		7	8		Bind, with thin beds of Ironstone, interspersed with vegetable impressions.
Indurated Clay		8	10		Strong Blue Bind.
Coal		2	0		Coal.
Clay		1	0		Soft Clunch.
Indurated Clay		7	0		Stony Clunch.
Sand-Rock		4	6		Grey Stone.
Carried forward	....	390	8		





Mineral Names of the Strata.	*No. of Seam*	*Thickness of each Stratum.* FT.	IN.	*Colours of the Strata.*	*Local Names of the Strata.*
Brought forward	....	390	8		
Indurated Clay		9	0		Strong Blue Bind.
Indurated Clay		2	0		Bind, with balls of Ironstone.
Inflammable Shale		3	1		Black Bat.
Ironstone		0	4		Ironstone.
Black Shale		2	2		Black Bat.
Ironstone		0	2		Ironstone.
Clay		1	10		Tender Blue Bind.
Ironstone		0	1½		Ironstone.
Clay		2	9		Strong Blue Bind.
Black Shale		1	4		Black Bat.
Ironstone		0	1		Ironstone.
Clay		0	8		Tender Bind.
Shale		0	6		Black Bat.
Coal		1	5		Coal.
Clay		0	6		Soft Clunch.
Indurated Clay		3	0		Stony Clunch.
Indurated Clay		11	1		Strong Blue Bind.
Black Shale		1	0		Black Bat.
Coal		0	6		Coal.
Black Shale		5	1		Black Bat.
Clay		1	3		Soft Clunch.
Coal		0	11		Coal.
Black Shale		1	6		Black Bat.
Clay		0	9		Stony Clunch.
Clay		1	0		Soft Clunch.
Clay		2	0		Stony Clunch.
Indurated Clay		10	5		Strong Blue Bind.
Grey Sand-Rock		11	4		Grey Sandstone.
Indurated Clay and Sand		3	0		Stony Bind.
Clay, with balls of Ironstone		3	6		Bind, containing balls of Ironstone and vegetable impressions.
Inflammable Shale		1	8		Black Bat.
Grey Rock		9	0		Grey Sandstone.
Indurated Clay		1	6		Stony Bind.
Grey Rock		3	7		Grey Sandstone.
Carried forward	....	488	8½		

Mineral Names of the Strata.	*No. of Seam.*	*Thickness of each Stratum.* FT.	IN.	*Colours of the Strata.*	*Local Names of the Strata.*
Brought forward	....	488	8¼		
Indurated Clay and Sand		15	4		Stony Bind.
Ironstone		0	2		Ironstone.
Clay, with balls of Ironstone		10	11		Blue tender Bind, with balls of Ironstone.
Ironstone		0	1		Ironstone.
Black Shale		2	9		Black Bat.
Ironstone		0	1		Ironstone.
Indurated Clay		4	9		Stony Bind.
Ironstone		0	1		Ironstone.
Clay		0	11		Tender Blue Bind.
Sand-Rock		2	9		Grey Stone.
Indurated Clay		10	8		Bind, mixed with seams of Sandstone.
Indurated Clay		1	10		Bind.
Ironstone		0	1		Ironstone.
Clay		2	6		Bind.
Ironstone		0	1		Ironstone.
Clay		3	0		Bind.
Coal	335	4	6		Coal.
Clay		1	0		Soft Clunch.
Coal		0	6		Coal.
Indurated Clay		6	0		Hard Clunch.
Clay		1	7		Bind.
Clay		4	4		Tender Blue Bind.
Ironstone		0	1½		Ironstone.
Coal — Clay		1	1		Tender Bind. — Coal.
Coal — Shale		0	4½		Black Bat. — Coal.
Coal		0	4		Coal.
Indurated Clay		3	4		Stony Bind.
Sand-Rock		2	0		Grey Stone.
Indurated Clay and Sand		19	0		Stony Bind, with impressions of rushes.
Sand-Rock		2	6		Grey Sandstone.
Carried forward	....	592	0¼		

Mineral Names of the Strata.	*No. of Seam*	*Thickness of each Stratum.* FT.	IN.	*Colours of the Strata.*	*Local Names of the Strata.*
Brought forward	....	592	0½		
Indurated Clay and Sand ...		8	5		Stony Bind.
Coal	354	2	7		Cannel Coal.
Clay		5	0		Black Soft Clunch.
Indurated Clay		4	7		Stony Clunch.
Indurated Clay		6	0		Clunch, with balls of Ironstone.
Sand-Rock		2	0		Grey Sandstone.
Indurated Clay............		22	1		Strong Blue Bind.
Clay, alternating with beds of Ironstone..........	364 to 387	0	3		Ironstone.
		1	7		Bind.
		0	2		Ironstone.
		2	3		Bind.
		0	2½		Ironstone.
		1	8		Bind.
		0	½		Ironstone.
		0	7		Bind.
		0	1		Ironstone.
		2	6		Bind.
		0	1		Ironstone.
		0	7		Bind and Ironstone.
		1	11		Strong Blue Bind.
		0	¾		Ironstone.
		0	½		Bind.
		0	1½		Ironstone.
		2	11		Bind.
		0	2		Ironstone.
		1	4		Bind.
		0	2		Ironstone.
		1	9		Black Bat.
		0	8		Ironstone.
		1	1		Dark Blue Bind.
		0	4		Ironstone.
Indurated Clay	388	7	0		Dark Blue Bind.
Clay, alternating with beds of Ironstone		0	1½		Ironstone.
		0	4		Bind.
		0	4		Ironstone.
		0	1½		Bind.
		0	1		Ironstone.
		27	4		Dark Blue Bind, alternating with beds of Ironstone, interspersed with vegetable impressions.
Ironstone		0	1		Ironstone.
Carried forward	....	700	1		

Mineral Names of the Strata.	*No. of Seam*	*Thickness of each Stratum.* FT.	IN.	*Colours of the Strata.*	*Local Names of the Strata.*
Brought forward	....	700	1		
Indurated Clay	390	3	0		Dark Blue Bind.
Indurated Clay mixed with and alternating with, beds of Ironstone	391	15	4½		Bind, mixed with balls and thin beds of Ironstone.
		4	7		Dark Blue Bind.
First Ryder Coal	392	3	1		First Ryder Coal.
Inflammable Shale		2	0		Black Bat.
Second Ryder Coal	394	1	2½		Second Ryder Coal.
Bat		1	3		Tow.
Main Coal	396	14	0		Main Coal.
		744	7		

N°. III.

SECTION OF THE STRATA

IN THE HASTINGS AND GRAY COAL PIT SHAFTS, ON THE WOULDS,

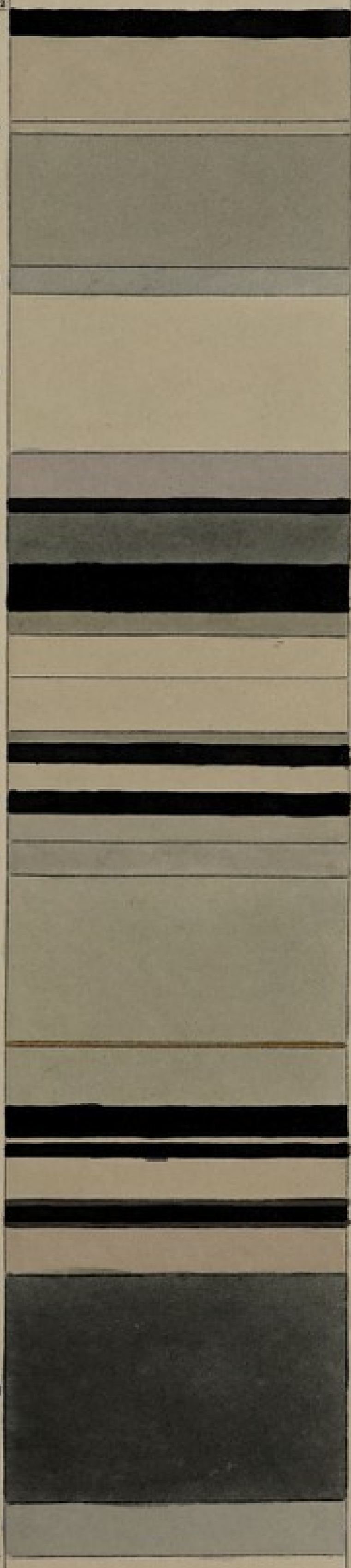
In the Parish of Ashby-de-la-Zouch.

1832.

SCALE—$\frac{1}{12}$ of an Inch to 1 Foot.

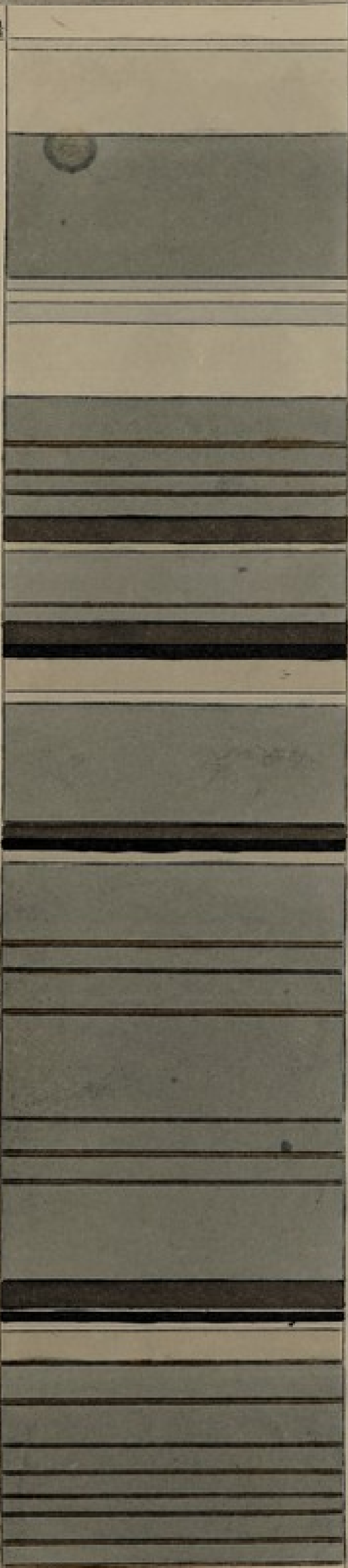
Mineral Names of the Strata.	*No. of Seam*	*Thickness of each Stratum.* FT.	IN.	*Colours of the Strata.*	*Local Names of the Strata.*
Raised Earth		6	0		Pit top, raised.
Soil	1	0	9		Soil.
Brick Earth	2, 3, 4	3	11		Yellow Clay, mixed with Rubble.
Coal	5	0	4		Coal Smut.
Clay	6	3	0		Fire-Clay.
Clay	7	2	1		Yellow Bind, with Ironstone.
Clay	8	4	0		Fire-Clay, with seams of Smut.
Coal	9	0	6		Coal Smut.
Clay	10	6	0		Dark Fire-Clay.
Sandstone	11	1	0		Brown Sandstone.
Indurated Clay	12	9	3		Blue Bind.
Indurated Clay	13	3	0		Bind, with seams of Coal Smut.
Clay	14	1	6		Fire-Clay.
Coal	15	0	4		Coal.
Clay	16	6	4		Fire-Clay.
Clay	17	6	0		Fire-Clay, with balls of Cank and Ironstone.
Clay	18	2	0		Dark Fire-Clay.
Clay	19	1	0		Light-coloured Fire-Clay.
Coal	20	0	6		Coal.
Indurated Clay	21	3	8		Clunch.
Ironstone	22	0	2		Ironstone.
Clay	23	0	9		Bind, with Pyrites.
Ironstone	24	0	1½		Ironstone.
Clay	25	3	4		Bind, with balls of Ironstone and Cank.
Ironstone	26	0	1½		Ironstone.
Clay	27	0	6		Blue Bind.
Ironstone	28	0	1½		Ironstone.
Clay	29	1	2		Dark Blue Bind.
Carried forward..	....	67	5½		

Mineral Names of the Strata.	*No. of Seam.*	*Thickness of each Stratum.* FT.	IN.	*Colours of the Strata.*	*Local Names of the Strata.*
Brought forward	....	67	5½		
Coal	30	1	10		Coal.
Clay	31	6	1		Fire-Clay, light coloured.
Sandstone, with Iron	32	1	0		Brown Stone.
Indurated Clay	33	9	6		Clunch, with balls of Cank and Ironstone.
Sandstone	34	2	0		Sandstone with Lead Ore.
Indurated Clay and Sand	35	11	0		Strong Bind and Sandstone mixed, with nodules of Ironstone.
Indurated Clay	36	3	3		Strong Blue Bind.
Coal	37	1	0		Coal.
Indurated Clay	38	3	9		Black Clunch.
Coal	39	3	3		Coal.
Clay	40	1	10		Fire-Clay, dark coloured.
Clay	41	3	0		Fire-Clay, light coloured.
Clay	42	4	0		Fire-Clay, dark and light coloured.
Clay	43	1	0		Fire-Clay, dark.
Coal	44	1	3		Coal.
Clay	45	2	2		Fire-Clay, light.
Coal	46	1	9		Coal.
Indurated Clay and Sand	47	2	0		Stony Clunch.
Indurated Clay	48	2	6		Strong Blue Bind.
Indurated Clay	49	11	6		Strong Bind.
Ironstone	50	0	2		Ironstone.
Indurated Clay and Sand	51	4	4		Stony Bind.
Coal	52	2	2		Coal.
Clay	53	0	6		Clay, dark coloured.
Coal	54	1	0		Coal.
Clay	55	3	0		Fire-Clay.
Shale	56	0	6		Black Bat.
Coal	57	1	0		Coal.
Shale	58	0	3		Black Bat.
Clay	59	3	4		Fire-Clay, with small balls of Ironstone.
Indurated Clay and Sand	60	16	7½		Stony Blue Bind, with balls of Cank and Ironstone.
Indurated Clay and Sand	61	4	0		Stony Bind.
Carried forward	....	178	0		



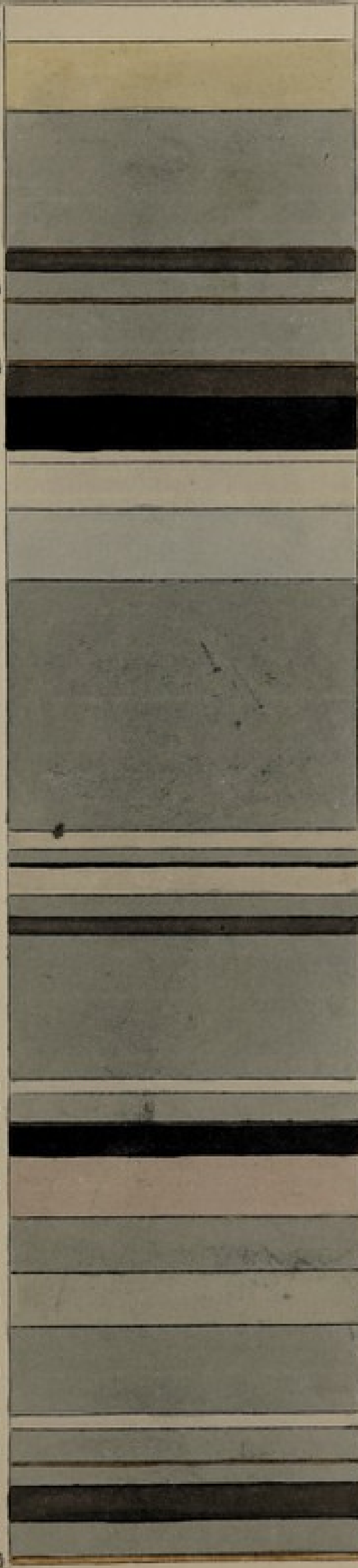
Mineral Names of the Strata.	No. of Seam.	Thickness of each Stratum. FT.	IN.	Colours of the Strata.	Local Names of the Strata.
Brought forward	....	178	0		
Coal	62	1	8		Coal, mixed with seams of Bind.
Clay	63	3	10		Fire-Clay, dark coloured.
Indurated Clay	64	2	0		Stony Clunch.
Clay	65	1	6½		Fire-Clay.
Ironstone	66	0	2		Ironstone.
Coal	67	2	5		Coal.
Clay	68	5	0		Fire-Clay, dark coloured.
Coal	69	2	9		Coal.
Indurated Clay	70	1	6		Clunchy Fire-Clay.
Coal	71	1	0		Coal.
Shale	72	1	0		Black Bat.
Indurated Clay	73	4	0		Clunch, with balls of Ironstone.
Coal — Shale	74	1	3		Black Bat. — Coal.
Coal — Shale	75	0	4		
Shale	76	0	11		Black Bat.
Shale — Clay	77	0	[illegible]		Fire-Clay. — Black Bat.
Shale	78	0	[illegible]		
Coal	79	0	4		Coal.
Indurated Clay and Sand	80	6	1		Stony Clunch, interspersed with balls of Ironstone.
Indurated Clay	81	5	2		Strong Blue Bind.
Shale	82	0	4		Black Bat.
Clay	83	1	7		Blue Bind.
Cank, or Whin Stone	84	0	6		Cank Stone.
Clay	85	1	3		Blue Bind. Ironstone. Blue Bind. Ironstone.
Clay, alternating with Ironstone	86 to 92	2	5½		Bind. Ironstone. Bind. Ironstone.
Clay	93	2	7		Bind, with nodules of Ironstone.
Clay — Ironstone	94	0	[illegible]		Ironstone.
Clay	95	0	[illegible]		Blue Bind.
Clay	96	3	0		Blue Bind, with balls of Ironstone.
Indurated Clay	97	8	0		Strong Blue Bind.
Coal and Shale	98	0	2		Coal and Black Bat.
Coal	99	1	7		Coal.
Indurated Clay	100	9	3½		Clunch.
Indurated Clay	101	5	0		Strong Clunch.
Shale	102	0	6		Black Bat, with seams of Coal.
Coal	103	0	8		Coal.
Clay and Stone	104	0	6		Stony Clunch.
Clay	105	3	6		Fire-Clay, with Ironstone.
Coal	106	2	3		Coal, mingy.
Clay	107	4	2		Fire-Clay, with balls of Cank.
Coal	108	1	5		Coal, soft.
Clay	109	0	8		Brown Fire-Clay.
Clay	110	2	3½		Fire-Clay.
Indurated Clay	111	1	6		Stony Clunch.
Indurated Clay	112	10	5		Strong Blue Bind.
Shale	113	1	2		Black Bat, with seams of Stone.
Carried forward	....	285	0¾		

Mineral Names of the Strata.	*No. of Seam*	*Thickness of each Stratum.* FT.	IN.	*Colours of the Strata.*	*Local Names of the Strata.*
Brought forward	....	285	0¾		
Coal	114	2	7		Coal, soft.
Clay	115	1	0		Brown Fire-Clay.
Indurated Clay	116	7	9		Clunch, with balls of Ironstone and Cank.
Indurated Clay and Sand	117	13	0		Strong Bind, with Sandstone.
Sand-Rock	118	12	0		Grey Sandstone, mixed with seams of Bind and seams of very thin Coal.
Indurated Clay	119	2	0		Strong Blue Bind.
Sand-Rock	120	6	11½		Grey Stone, with black seams.
Indurated Clay	121	5	3½		Strong Blue Bind.
Ironstone	122	0	3		Ironstone.
Coal	123	2	6		Coal, soft.
Indurated Clay	124	4	0		Clunch.
Indurated Clay	125	2	0		Blue Bind.
Coal	126	2	0		Coal, mixed with Bat.
Indurated Clay	127	2	8		Clunch.
Sand-Rock	128	5	0		Sandstone, with seams of Bind.
Indurated Clay	129	4	8		Stony Bind.
Ironstone	130	0	1		Ironstone.
Indurated Clay	131	2	7		Stony Bind.
Ironstone	132	0	1		Ironstone.
Indurated Clay and Stone	133	8	4		Bind, with seams of Stone.
Indurated Clay	134	2	0		Strong Blue Bind.
Ironstone	135	0	2		Ironstone.
Clay	136	2	8		Blue Bind.
Clay: Ironstone	137	0	2		Ironstone.
Clay	138	1	0		Blue Bind.
Clay: Ironstone	139	0	1		Ironstone.
Clay	140	4	4		Blue Bind, with Ironstone mixed.
Indurated Clay	141	2	2		Strong Blue Bind.
Coal: Shale	142	0	1		Black Bat.
Coal	143	0	1		Coal.
Indurated Clay	144	2	11		Clunch.
Clay	145	1	4½		Bind.
Ironstone: Shale	146	0	6		Black Bat.
Ironstone	147	0	3		Ironstone.
Ironstone: Shale	148	0	3		Black Bat.
Coal	149	1	4		Coal, mingy.
Fire-Clay	150	1	8		Fire-Clay.
Indurated Clay and Sand	151	2	0		Stony Clunch.
Carried forward	....	393	0¼		

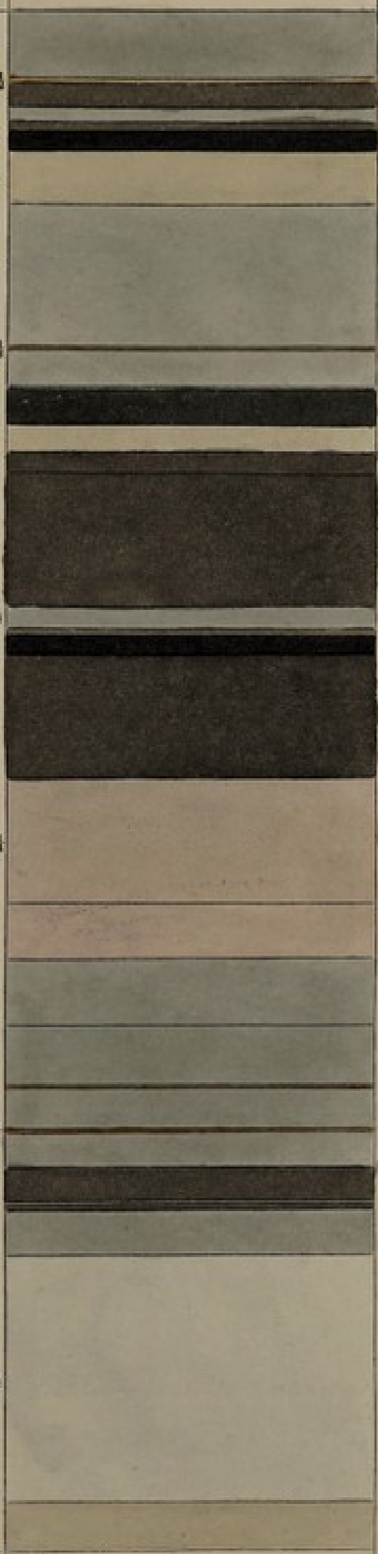


Mineral Names of the Strata.	*No. of Seam*	*Thickness of each Stratum.* FT.	IN.	*Colours of the Strata.*	*Local Names of the Strata.*
Brought forward	....	393	0¼		
Sandstone	152	0	8		White Stone, with specks of Ironstone.
Indurated Clay and Sand	153	6	0		Bind, with seams of Stone.
Indurated Clay	154	10	2		Strong Blue Bind.
Indurated Clay and Sandstone	155	1	0		Stony Bind.
	156	0	10		Stone.
	157	1	5		Stony Bind.
Sand-Rock	158	5	4		Stone, mixed with sheds of coaly matter.
Indurated Clay	159	3	2		Blue Bind.
Clay, alternating with seams of Ironstone	160	0	2		Ironstone.
	161	1	9		Bind.
	162	0	1		Ironstone.
	163	1	0		Bind.
	164	0	1		Ironstone.
	165	1	6		Bind.
Shale	166	2	0		Black Bat.
Whin Stone	167	0	6		Cank Stone.
Indurated Clay	168	3	9		Blue Bind.
Ironstone	169	0	1		Ironstone.
Clay	170	1	1		Bind.
Shale	171	1	7		Black Bat.
Coal	172	1	0		Coal.
Clay	173	2	6		Fire-Clay.
Clay, Whin Stone, and Ironstone	174	0	10		Bind, Cank, and Ironstone, mixed.
Clay	175	8	7		Blue Bind.
Ironstone	176	0	1		Ironstone.
Shale	177	0	10½		Black Bat.
Coal	178	0	9		Coal.
Clay	179	0	10		Soft Clunch.
Indurated Clay	180	5	5		Clunch, mixed with balls of Ironstone.
Clay, alternating with seams of Ironstone	181	0	2		Ironstone.
	182	1	10½		Blue Bind.
	183	0	1		Ironstone.
	184	2	8		Blue Bind.
	185	0	2		Ironstone.
Clay	186	7	5		Bind, with balls of Ironstone and Cank.
Clay and Ironstone	187	0	1		Ironstone.
	188	2	1		Blue Bind.
	189	0	2		Ironstone.
	190	1	8½		Blue Bind.
	191	0	1½		Ironstone.
Clay	192	7	3		Blue Bind.
Shale	193	2	0		Black Bat.
Sandstone	194	0	2		Brown Stone.
Coal	195	0	7		Coal.
Clay, alternating with seams of Ironstone	196	0	6		Black Clunch.
	197	2	2½		Strong Clunch.
	198	0	1		Ironstone.
	199	2	5		Blue Bind.
	200	0	2		Ironstone.
	201	3	0		Blue Bind.
	202	0	1		Ironstone.
	203	1	7		Blue Bind.
	204	0	1		Ironstone.
	205	1	6		Blue Bind.
	206	0	1		Ironstone.
	207	1	2		Blue Bind.
	208	0	1½		Ironstone.
	209	1	9		Blue Bind.
	210	0	1½		Ironstone.
	211	1	4		Blue Bind.
	212	0	1		Ironstone.
Carried forward	....	498	10¾		

Mineral Names of the Strata.	*No. of Seam*	*Thickness of each Stratum.* FT.	IN.	*Colours of the Strata.*	*Local Names of the Strata.*
Brought forward	....	498	10¾		
Clay, alternating with seams of Ironstone	213	2	4		Blue Bind.
	214	0	2½		Ironstone.
	215	1	7		Blue Bind.
	216	0	2		Ironstone.
	217	0	11		Blue Bind.
	218	0	1		Ironstone.
	219	0	1		Blee Bind.
	220	0	2½		Ironstone.
Shale	221	1	2		Black Bat.
Coal	222	3	2		Coal. (Dickey Gobler.)
Indurated Fire-Clay	223	2	0		Clunchy Fire-Clay.
Indurated Clay	224	8	2½		Stony Bind, with two beds of Ironstone 1 inch each.
Clay, alternating with beds of Ironstone	225	2	6		Blue Bind.
	226	1	11½		Ironstone.
	227				Bind.
	228				Ironstone.
	229				Bind.
	230				Ironstone.
	231	1	0½		Bind.
Sand-Rock	232	1	6		Grey Stone.
Whin Stone	233	1	6		Cank.
Sand-Rock	234	1	7		Grey Stone.
Sand-Rock	235	6	0		Grey Stone, with fossil impressions.
Indurated Clay and Sand ...	236	8	1		Strong Stony Bind.
Indurated Clay	237	3	2		Strong Blue Bind.
Clay, alternating with beds of Ironstone	238	0	2		Ironstone.
	239	3	11		Blue Bind, with balls of Ironstone.
	240	0	0¾		Ironstone.
	241	1	4		Bind.
	242	0	2		Ironstone.
	243	0	11		Bind.
	244	0	1		Ironstone.
	245	3	3		Blue Bind.
	246	0	2½		Ironstone.
	247	0	7½		Bind.
Shale	248	2	4		Black Bat, with Shells.
Clay	249	1	1		Tender Bind.
Coal	250	2	10		Coal.
Clay, with Ironstone	251	6	0		Fire-Clay, with balls of Ironstone.
	252	0	1		Ironstone.
	253	6	1½		Blue Bind.
	254	1	1		Tender Bind.
Coal	255	1	7		Coal.
Sand-Rock	256	11	6		Grey Stone, with various vegetable impressions.
Shale	257	2	10		Black Bat.
Coal	258	0	2		Coal.
Clay	259	0	6		Soft Fire-Clay.
Indurated Clay	260	4	7		Strong Clunch, with Ironstone.
Sand-Rock	261	6	2		Grey Sandstone.
Carried forward	....	604	6½		



Mineral Names of the Strata.	*No. of Seam*	*Thickness of each Stratum.* FT.	IN.	*Colours of the Strata.*	*Local Names of the Strata.*
Brought forward . .	. . . .	604	6½		
Whin Stone	262	5	0		Cank Stone.
Clay, with Ironstone	263	9	9		Blue Bind, containing balls of Ironstone.
Ironstone	264	0	1		Ironstone.
Shale	265	1	6		Black Bat.
Clay	266	2	0½		Blue Bind.
Ironstone	267	0	2		Ironstone.
Clay	268	4	0		Blue Bind, with balls of Ironstone.
Ironstone	269	0	2½		Ironstone.
Shale	270	2	3		Black Bat.
Coal	271	3	11		Coal.
Clay	272	0	9		Fire-Clay, with a few balls of Ironstone.
Sand-Rock	273	3	3		Grey Stone.
Indurated Clay and Sand . . .	274	4	11		Stony Bind.
Indurated Clay	275	17	5		Strong Blue Bind.
Clay, intermixed with Ironstone, Shale, and Coal . .	276	1	4		Blue Bind, with thin beds of Ironstone and Shells.
	277	1	0		Bind.
	278	0	1		Coal.
	279	2	0		Bind and Bat, with nodules of Ironstone.
	280	1	7		Bind.
	281	1	2		Bat, with Ironstone.
Indurated Clay	282	10	1		Blue Bind.
Sandstone	283	1	0		Grey Stone.
Clay	284	2	0		Blue Bind.
Shale	285	0	2		Black Bat.
Coal	286	1	8		Coal.
Clay	287	4	6		Fire-Clay, mixed with balls of Ironstone.
Indurated Clay	288	3	9		Blue Bind.
Indurated Clay and Sand . . .	289	4	0		Stony Bind.
Indurated Clay	290	6	0		Blue Bind.
Sand-Rock	291	1	0		Grey Stone.
Clay, alternating with Ironstone, Shale, &c.	292	2	6		Blue Bind.
	293	0	1		Ironstone.
	294	1	5		Blue Bind.
	295	2	7		Black Bat, interspersed with Shells and Stony Bind.
	296	2	7		Blue Bind.
	297	0	4½		Ironstone.
Carried forward . .	. . . .	710	8		



Mineral Names of the Strata.	*No. of Seam*	*Thickness of each Stratum.* FT.	IN.	*Colours of the Strata.*	*Local Names of the Strata.*
Brought forward ..	....	710	8		
	298	4	7		Blue Bind.
Clay, alternating with Ironstone, Shale, &c.	299	0	2½		Ironstone.
	300	1	8		Black Bat.
	301	1	0		Bind, with a few balls of Ironstone.
	302	0	6		Bat, with Shells.
Coal	303	1	4		Coal.
Clay	304	3	6		Fire-Clay, with balls of Ironstone.
Indurated Clay	305	9	7		Strong Blue Bind.
Ironstone	306	0	1½		Ironstone.
	307	2	6		Blue Bind.
	308	0	1		Ironstone.
	309	2	4		Black Bat, with seams of Coal.
	310	1	9		Fire-Clay, with balls of Ironstone.
	311	1	5		Black Bat.
Clay, alternating with seams of Shale, Coal, &c.	312	9	0		Black Bat, with small balls of Ironstone and Cank Stone.
	313	1	6½		Blue Bind.
	314	0	4		Black Bat.
	315	1	4		Coal.
	316	8	1		Black Bat, with seams of Ironstone and Sandstone.
The measures rather confused by a Fault crossing the Shaft	317	8	2½		Stony Bind, the lower part mixed with balls of Cank Stone.
	318	3	7		Stony Bind, with Ironstone and Cank balls.
	319	4	6		Blue Bind, with balls of Ironstone and Cank.
	320	4	0		Blue Bind.
Clay, alternating with beds of Sandstone, Whin Stone, Shale, and Ironstone	321	0	1		Ironstone.
	322	2	10		Blue Bind.
	323	0	1½		Ironstone.
	324	2	4		Blue Bind.
	325	2	4		Black Bat.
	326	0	1		Ironstone.
	327	0	3		Black Bat.
	328	3	0		Stony Bind.
Sand-Rock	329	16	8½		Grey Sandstone.
Clay and Sand	330	3	2		Stony Bind.
Carried forward ..	....	812	8¾		

Mineral Names of the Strata.	*No. of Seam*	*Thickness of each Stratum.* FT.	IN.	*Colours of the Strata.*	*Local Names of the Strata.*
Brought forward	....	812	8¾		
Sand-Rock	331	10	11¼		Greỳ Sandstone.
Clay, with Ironstone	332	2	0		Blue Bind, with thin beds of Ironstone.
	333	0	0½		Ironstone.
	334	0	9		Blue Bind.
Coal	335	4	2		Coal.
Shale	336	0	2		Black Bat.
Coal	337	0	8		Coal.
Clay and Sand	338	4	5		Stony Clunch.
Clay, alternating with Shale, Ironstone, and Sand	339	0	3		Grey Stone.
	340	0	11		Bind, with Ironstone.
	341	0	1		Ironstone.
	342	2	2		Bind, with balls of Ironstone.
	343	0	1		Ironstone.
	344	0	11		Bind, with balls of Ironstone.
	345	2	7		Blue Bind.
	346	0	9		Coal and Bat.
Sandstone Rock, with seams of Clay and Ironstone	347	1	1		Grey Stone.
	348	2	0		Stony Bind.
	349	2	9		Grey Sandstone.
	350	9	7		Stony Bind, with impressions of rushes.
	351	9	5		Stony Bind.
	352	0	2		Ironstone.
	353	2	10		Stony Bind.
Coal	354	2	6¼		Coal, Cannel.
Indurated Clay, mixed with Sand beds, Ironstone in beds, and balls of Fire-Clay	355	8	9		Clunchy Fire-Clay, with balls of Ironstone.
	356	3	9		Fire-Clay, with Ironstone.
	357	6	8		Stony Clunch, with balls of Ironstone.
	358	3	4		Strong Blue Bind, with balls of Ironstone.
	359	2	4		Dark Bind, with balls of Ironstone.
	360	4	0		Strong Blue Bind, with balls of Ironstone.
	361	1	7		Stony Bind.
	362	1	0		Grey Stone.
	363	9	9¼		Stony Bind, with balls of Ironstone and rush-like impressions.
Indurated Clay, with many alternations of Ironstone	364	1	10		Stony Bind.
	365	0	1½		Ironstone.
	366	0	9½		Blue Bind.
	367	0	1½		Ironstone.
	368	3	7½		Blue Bind.
	369	0	3		Ironstone.
Carried forward	....	921	11¾		

Mineral Names of the Strata.	*No. of Seam*	*Thickness of each Stratum.* FT.	IN.	*Colours of the Strata.*	*Local Names of the Strata.*
Brought forward	....	921	11¾		
Indurated Clay, with many alternations of Ironstone	370	1	6		Blue Bind.
	371	0	2		Ironstone.
	372	1	9½		Blue Bind.
	373	0	3		Ironstone.
	374	2	3		Blue Bind.
	375	0	3		Ironstone.
	376	2	10		Blue Bind.
	377	0	2		Ironstone.
	378	1	7½		Blue Bind.
	379	0	2		Ironstone.
	380	1	5		Blue Bind.
	381	0	1		Ironstone.
	382	1	11		Blue Bind.
Shale, Clay, and Ironstone, alternating with Whin Stone	383	0	8		Black Bat. — Ironstone, with Shells.
	384	0	2½		Black Bat, with Shells.
	385	0	10		Cank and Ironstone, mixed with Shells.
	386	1	8		
	387	0	10		Blue Bind.
Indurated Clay	388	7	6		Dark Blue Bind, with sheds of Ironstone.
Indurated Clay, with seams and balls of Ironstone	389	13	6		Dark Blue Bind, with seams of Ironstone.
	390	7	4		Dark Blue Bind, with thin seams of Ironstone.
	391	19	1		Dark Blue Bind, with balls of Ironstone.
Coal	392	2	11		First Ryder Coal.
Tender Fire-Clay	393	2	3½		Dark Fire-Clay.
Coal	394	0	6		Second Ryder Coal.
Fine pure Clay	395	1	0		Tow, or fine Fire-Clay.
Coal	396	11	3		Main and Nether Coal, being nearly of equal thickness, the upper half only wrought.
Clay	397	1	6		Dark Fire-Clay.
Coal	398	0	4		Coal.
Clay	399	3	6		Fire-Clay, with balls of Ironstone.
		1011	3¾		

MEASURES BELOW THE MAIN COAL,

ASCERTAINED BY BORING.

SCALE—$\frac{1}{12}$ of an Inch to 1 Foot.

Mineral Names of the Strata.	*Thickness of each Stratum.* FT.	IN.		*Local Names of the Strata.*
Sand-Rock	20	9		Sandstone.
Indurated Clay with Ironstone ..	5	6		Bind, alternating with Ironstone.
Coal	3	6		Coal, (called Toad Coal).
Indurated Clay, with balls and seams of Ironstone	20	0		Alternating Strata of Bind and Ironstone.
Sand-Rock	9	7		Sandstone.
Indurated Clay, with beds of Ironstone	28	5		Bind, alternating with beds of Ironstone.
Shale	3	0		Black Bat.
Indurated Clay................	1	7		Bind.
Coal..........................	3	8		Coal, (called Slate Coal).
	96	0		

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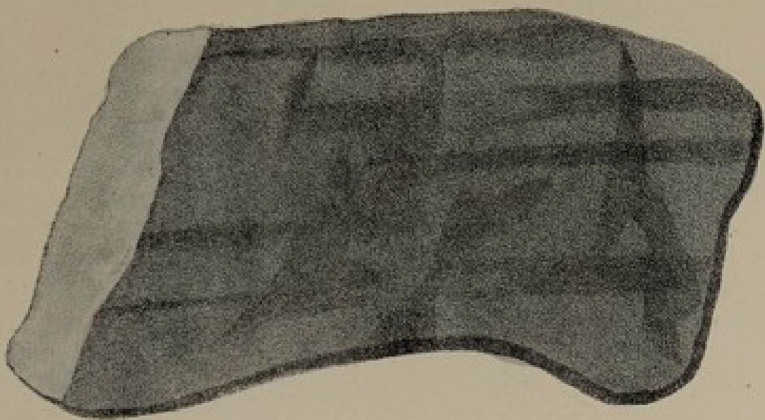

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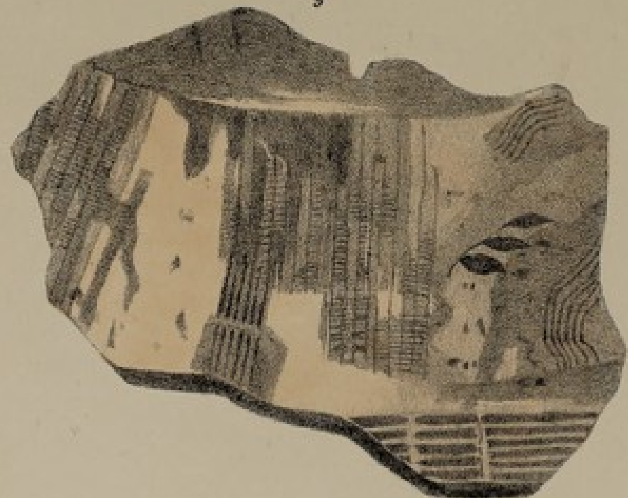

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Pub. by Geo. Lawford, Saville Passage, London, 1834.

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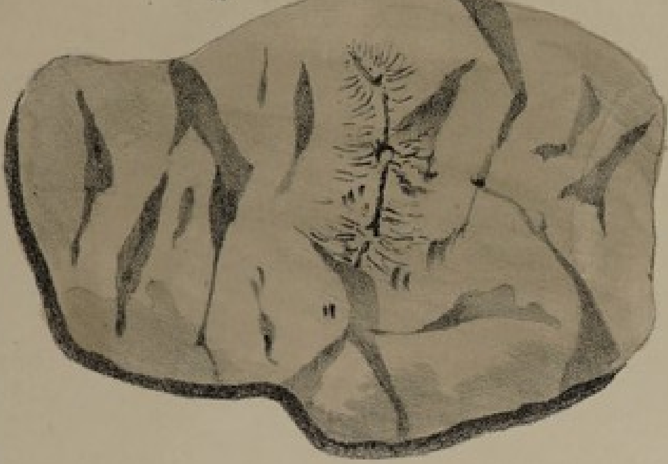
16



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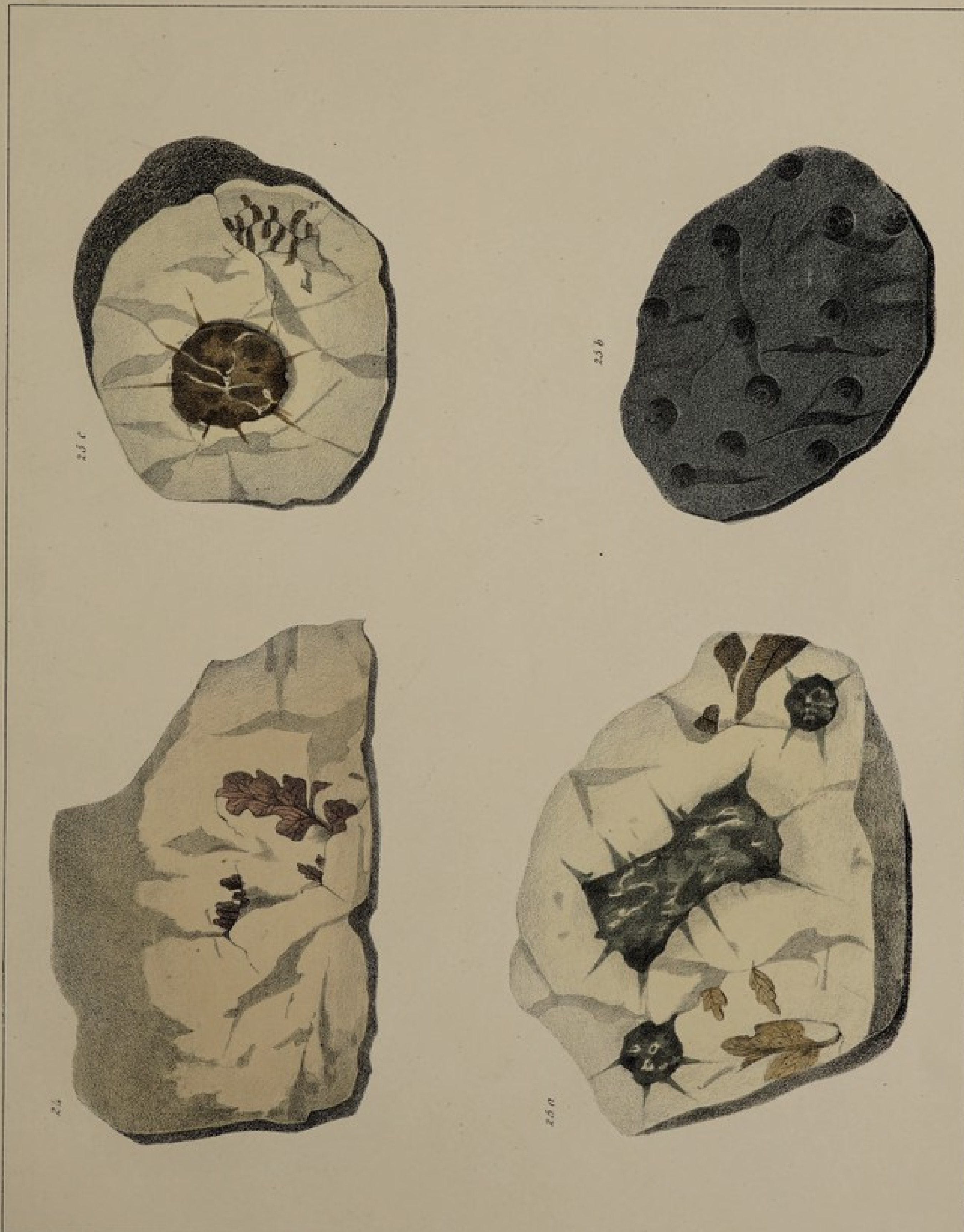

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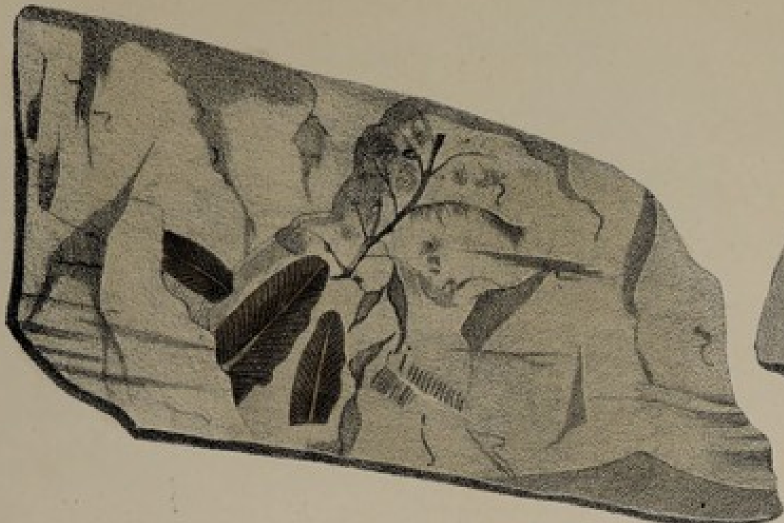

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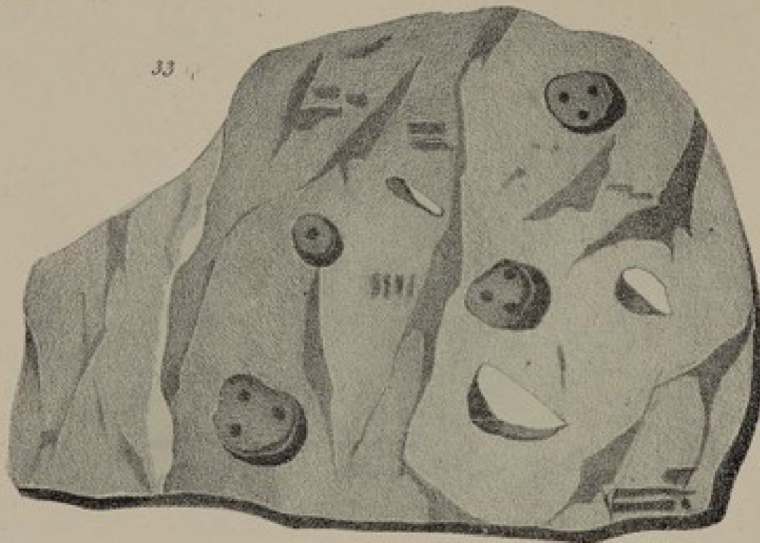

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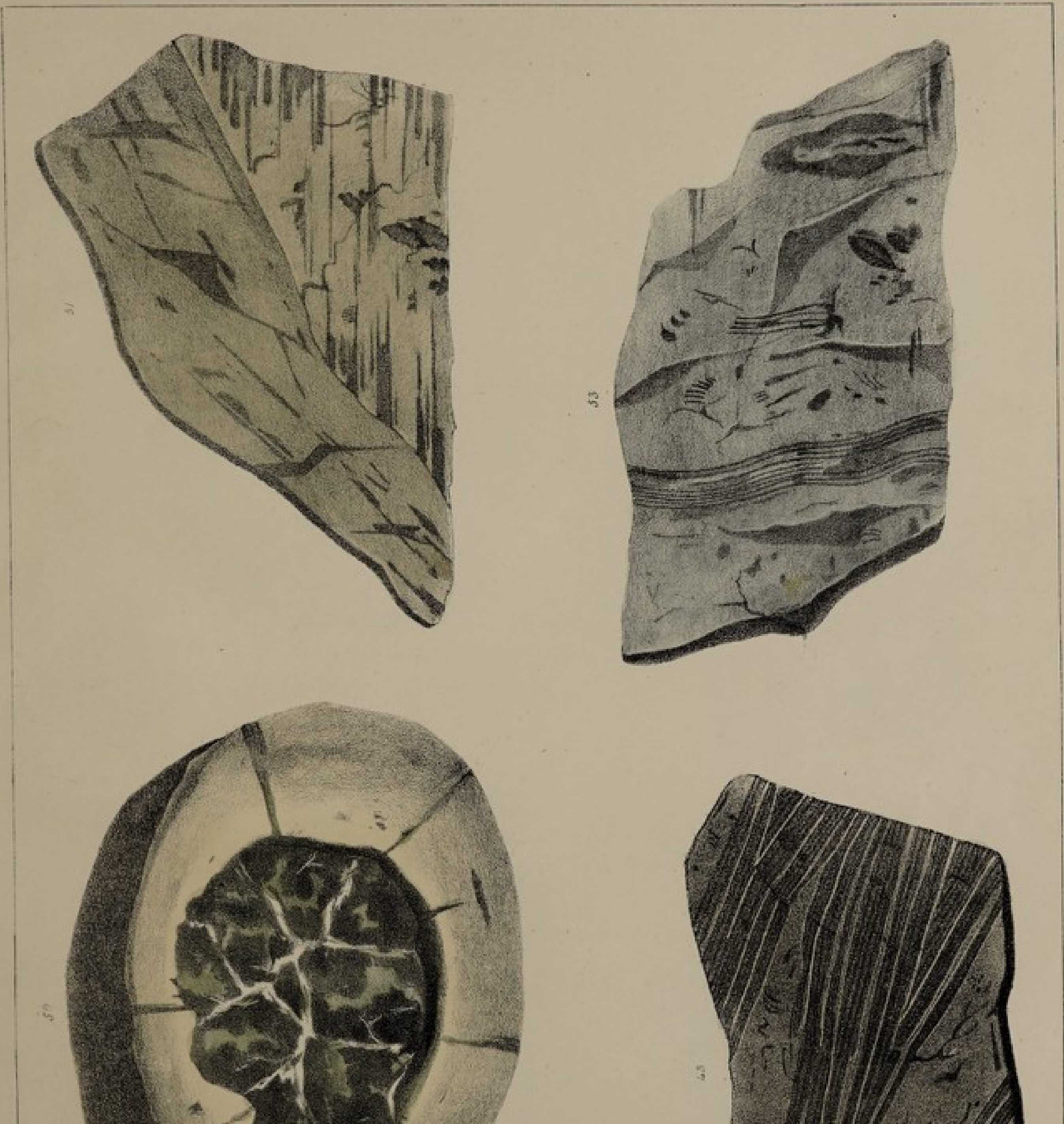

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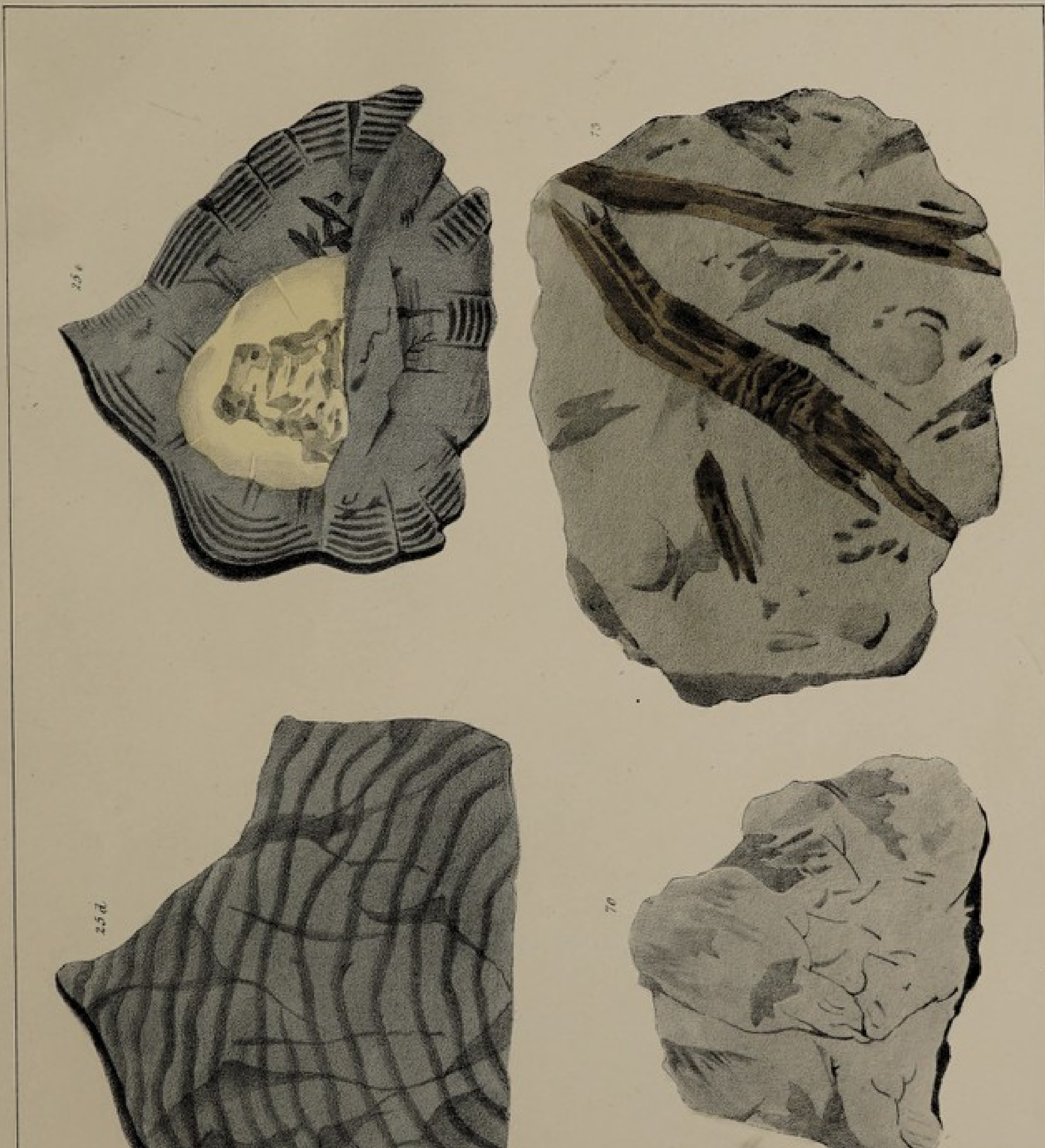

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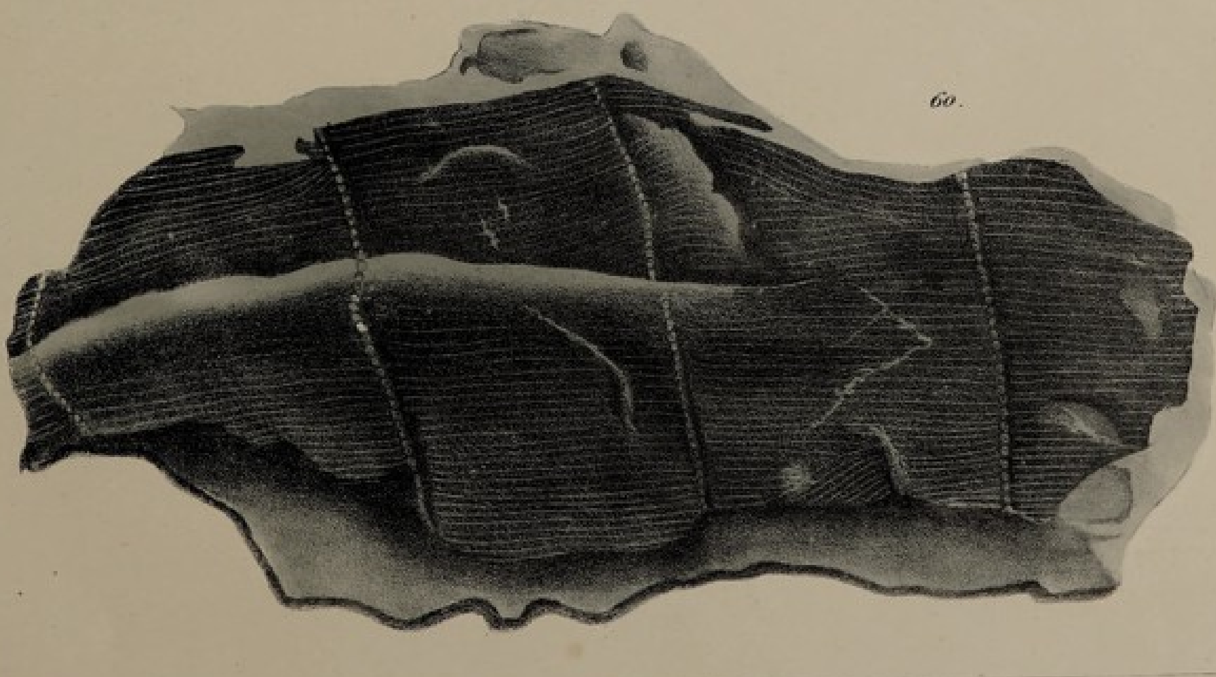

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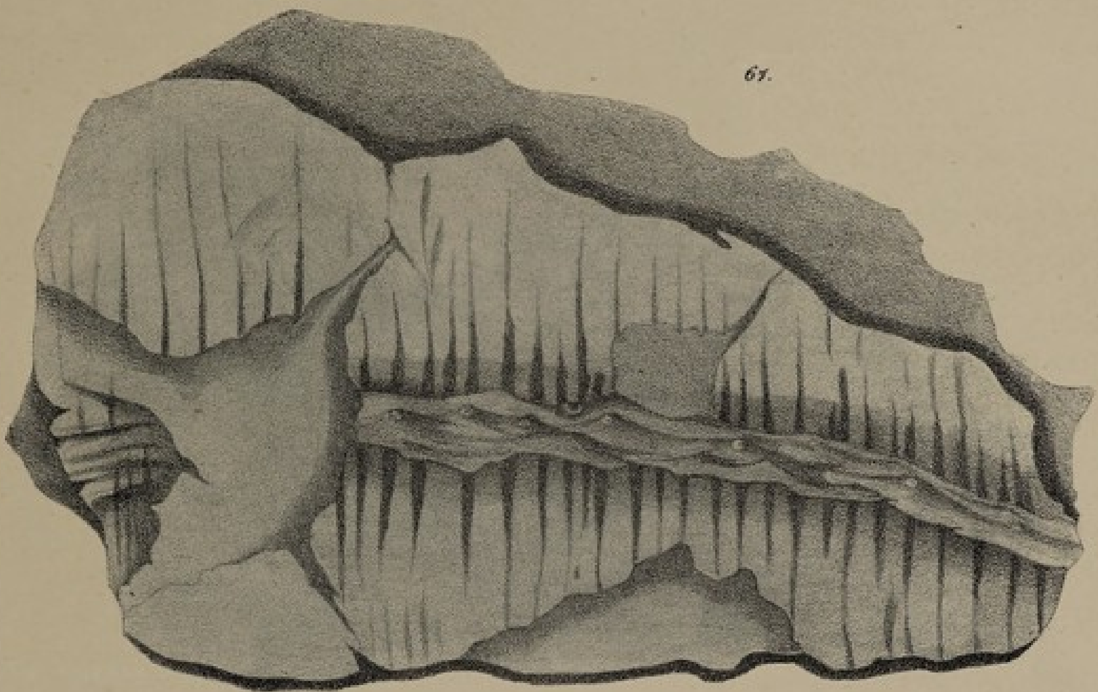

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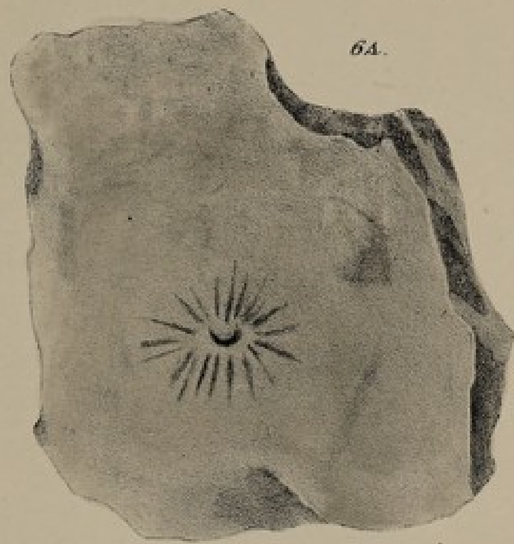

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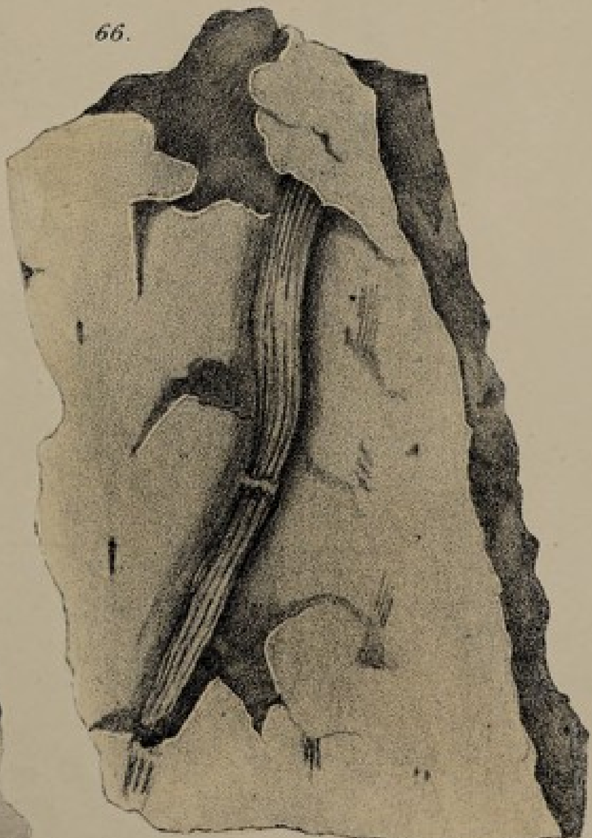

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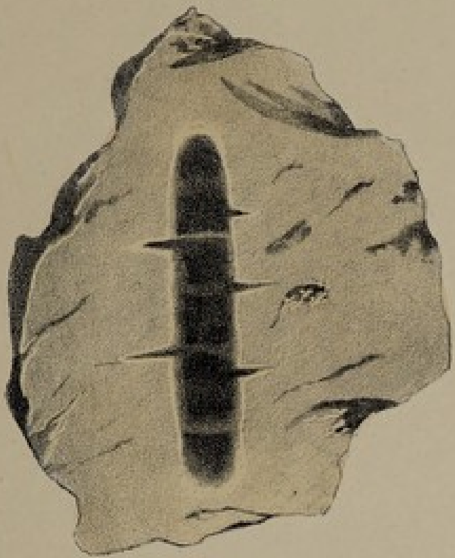

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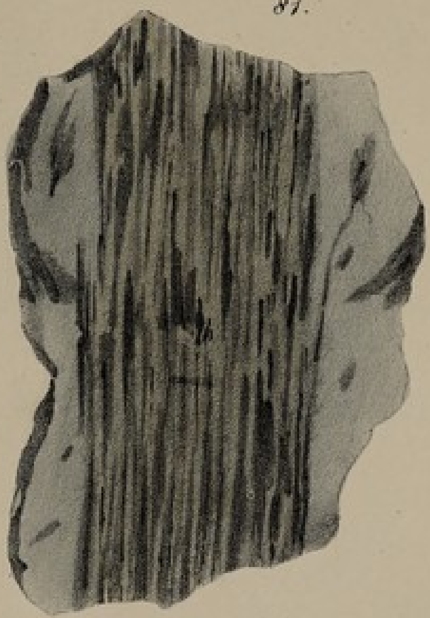

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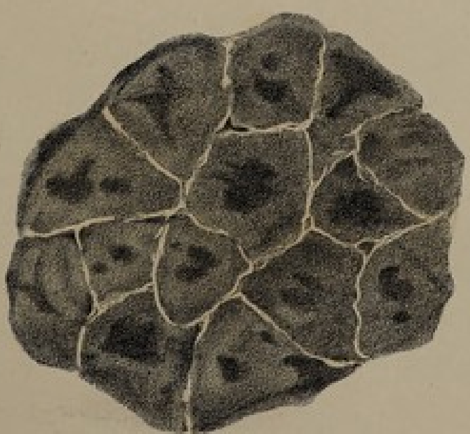

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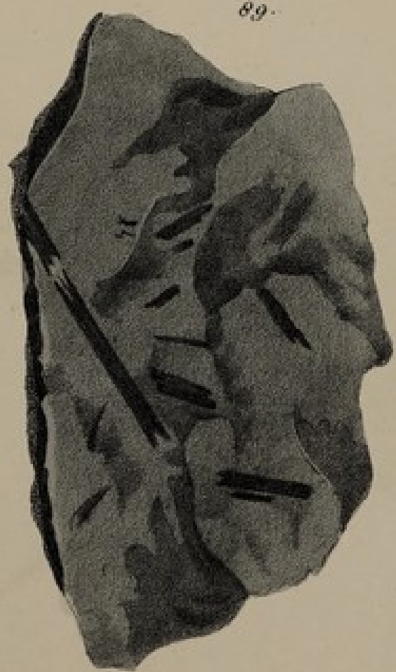

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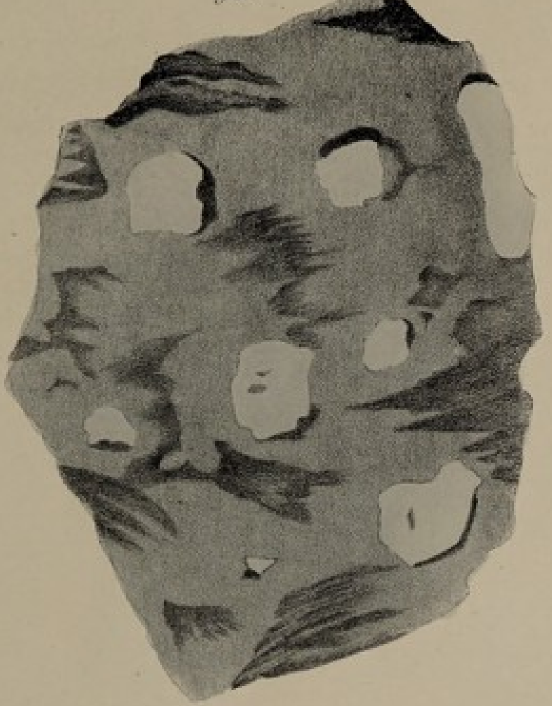

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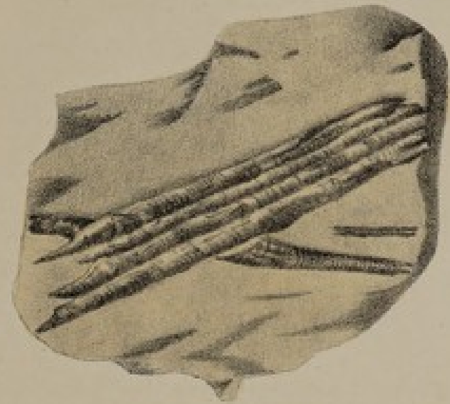

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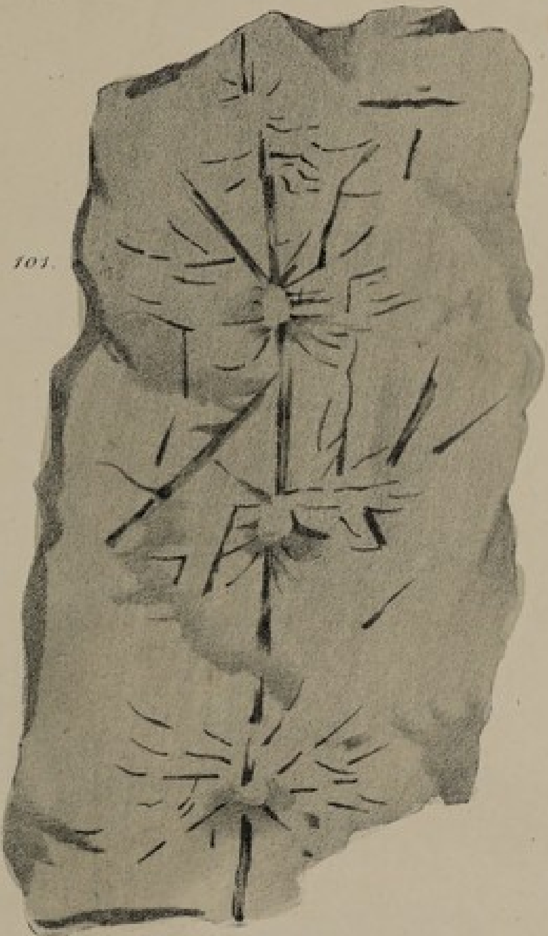

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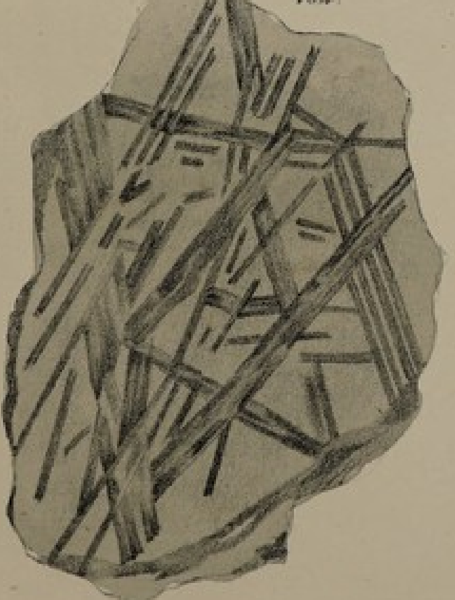

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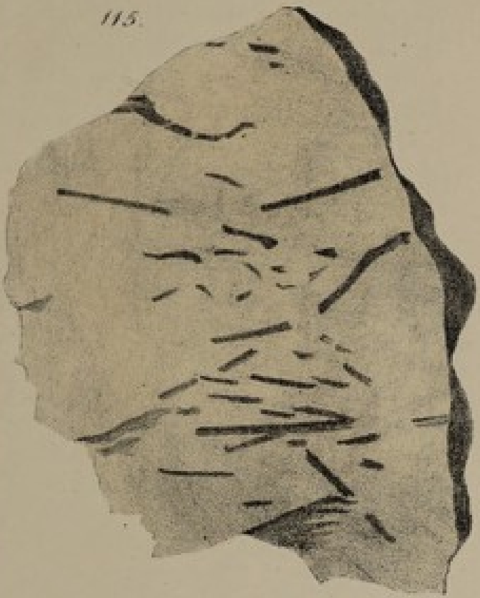

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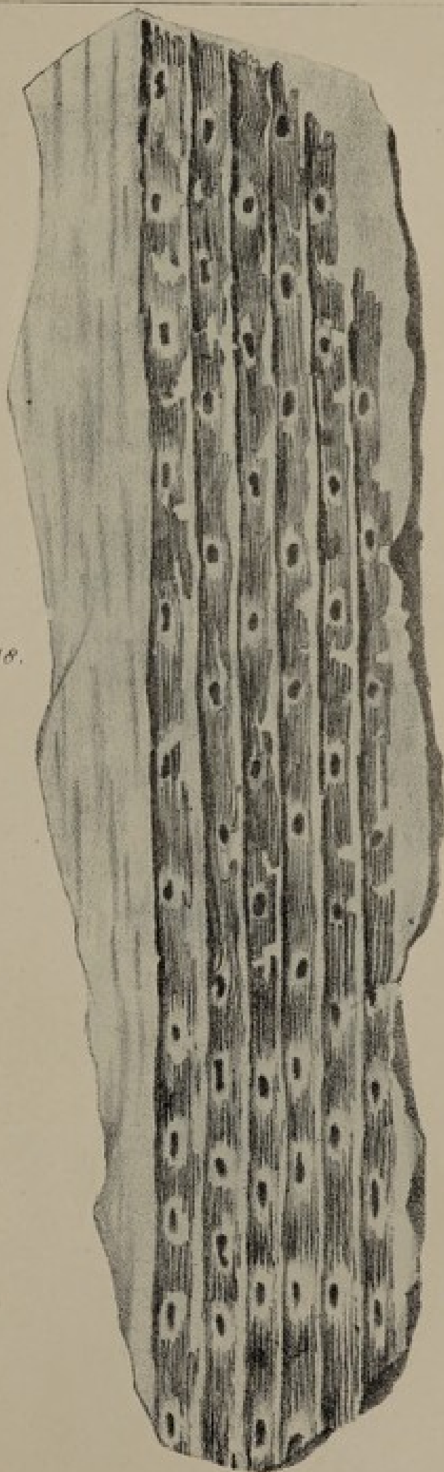

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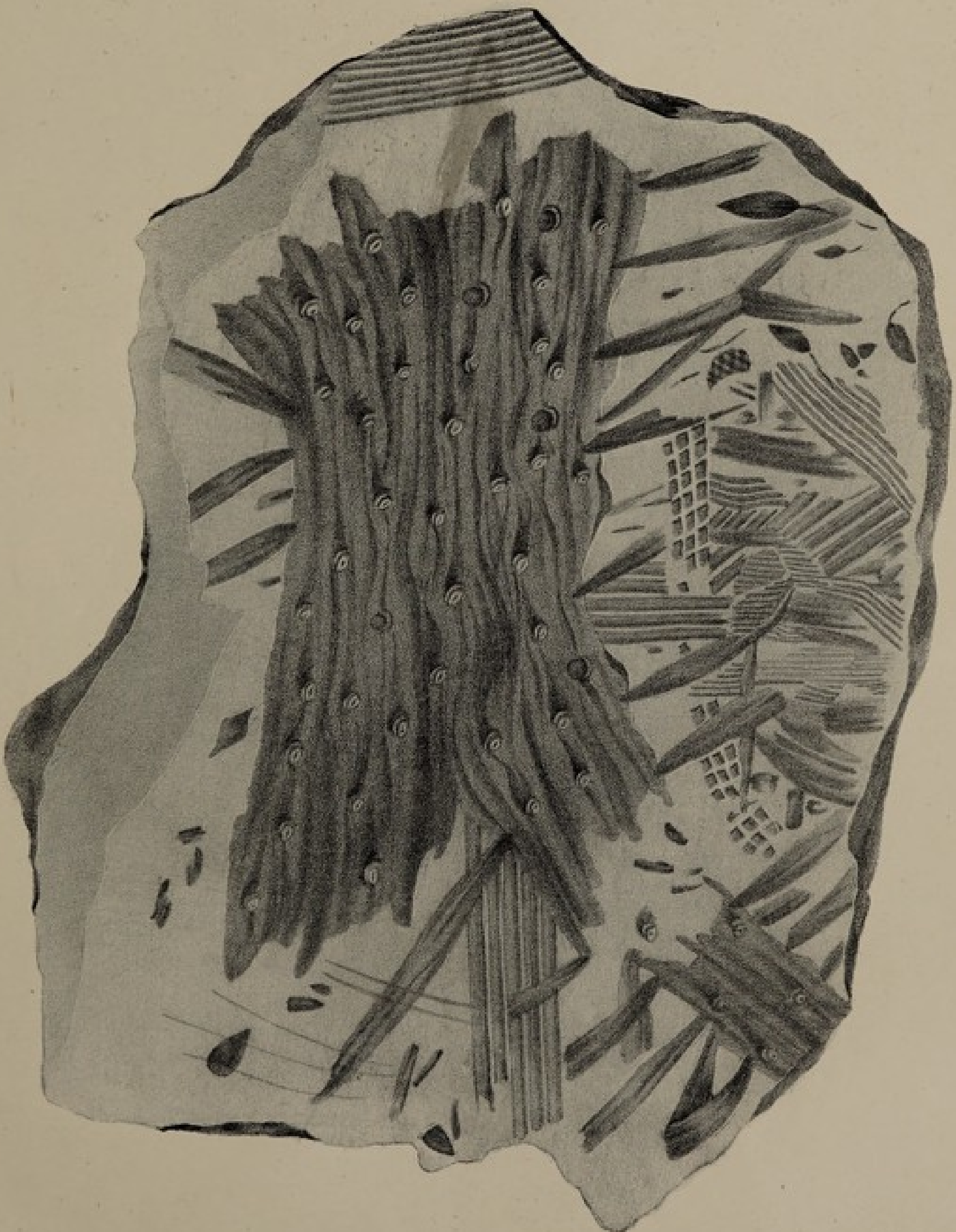

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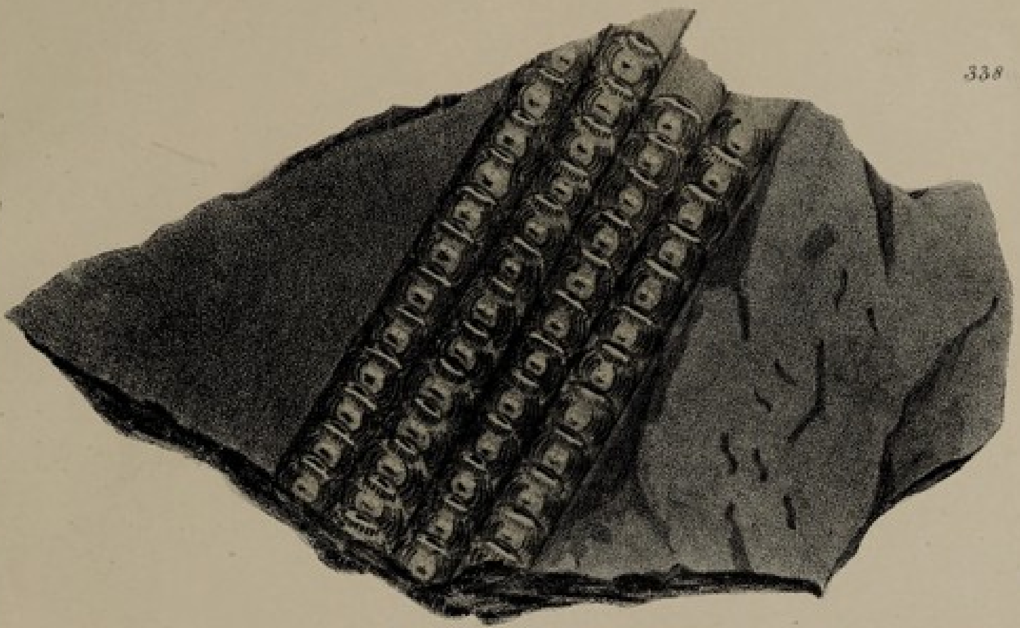

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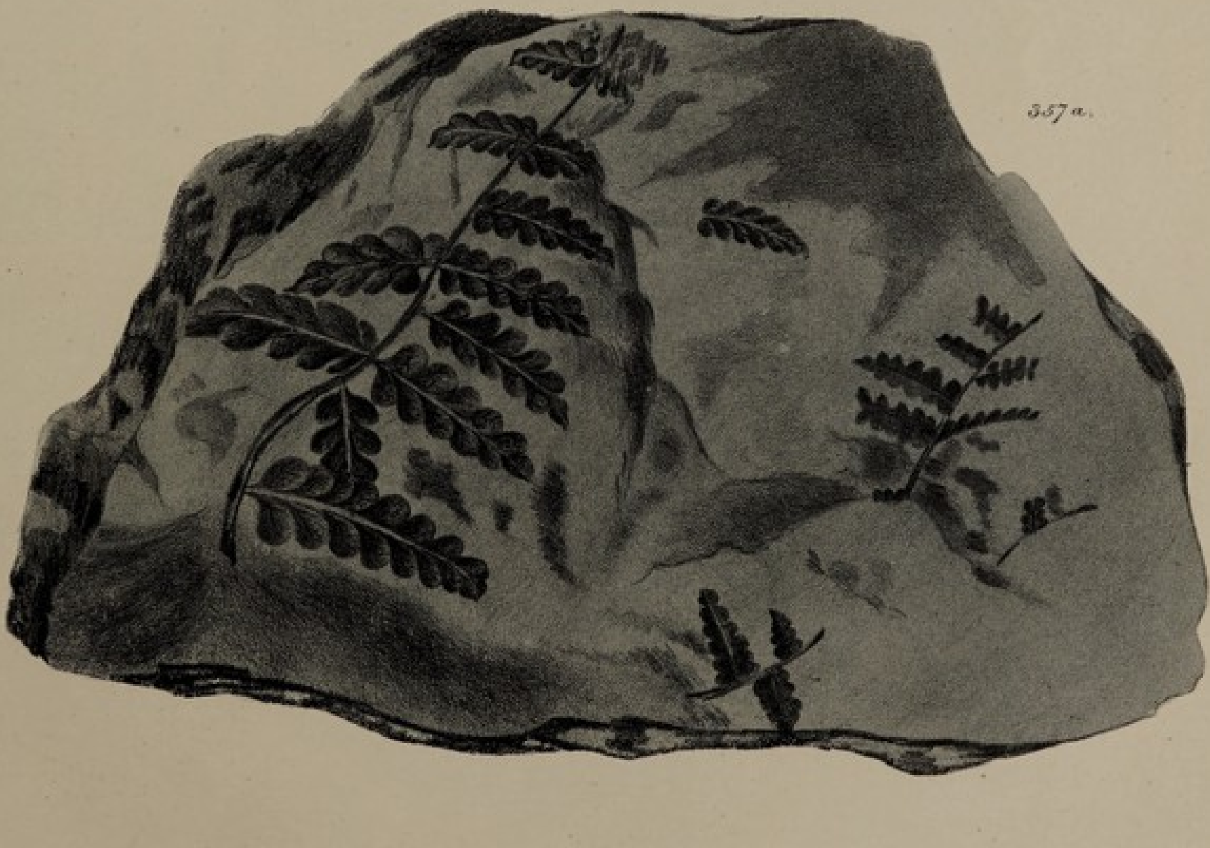

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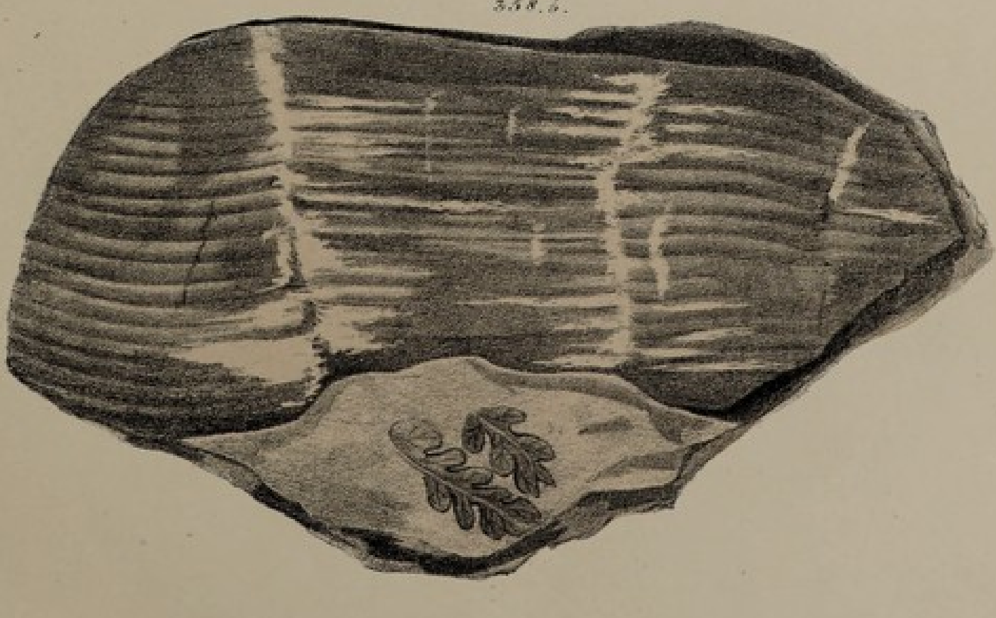

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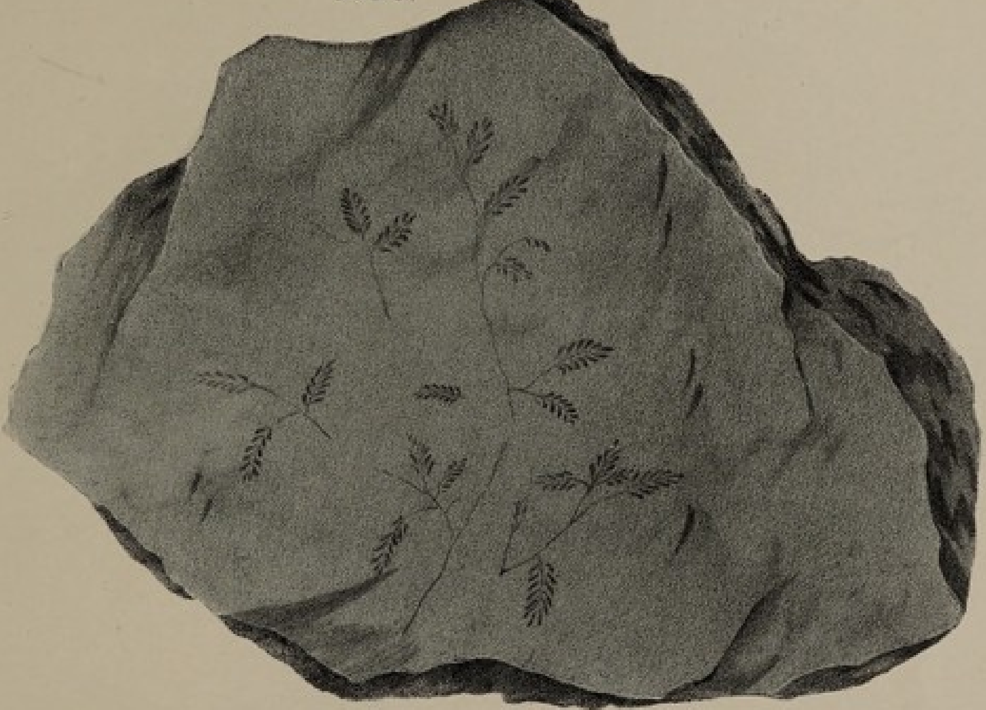

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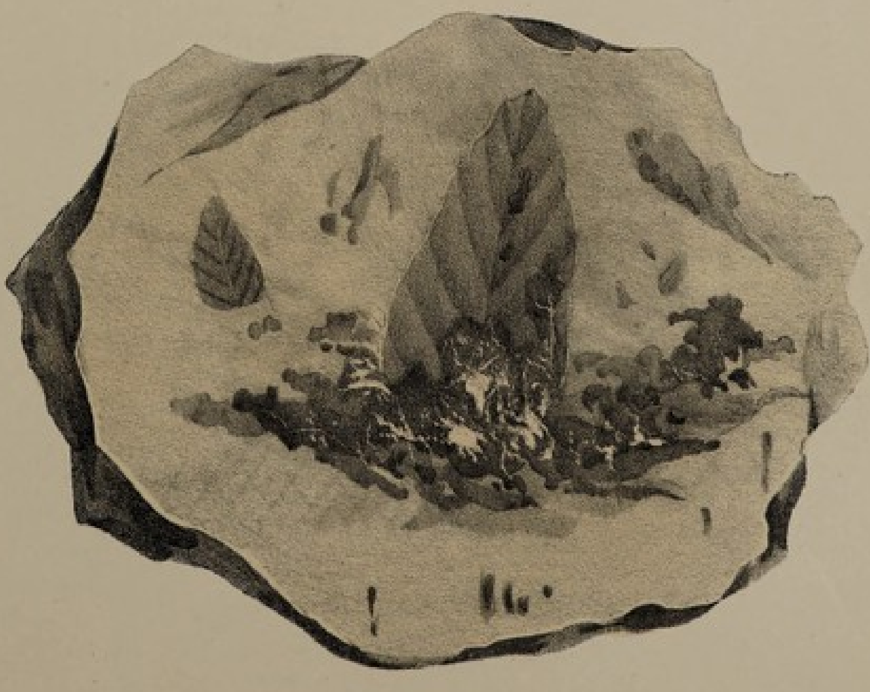

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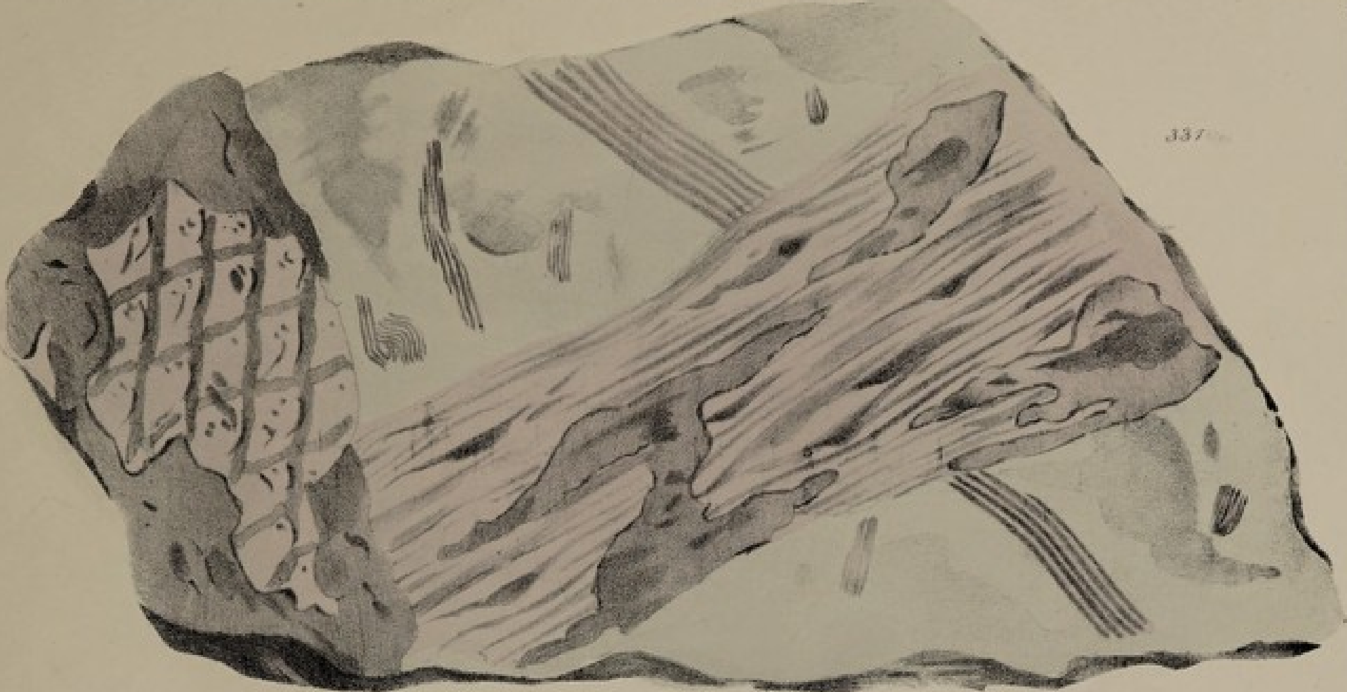

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Madeley Lith.

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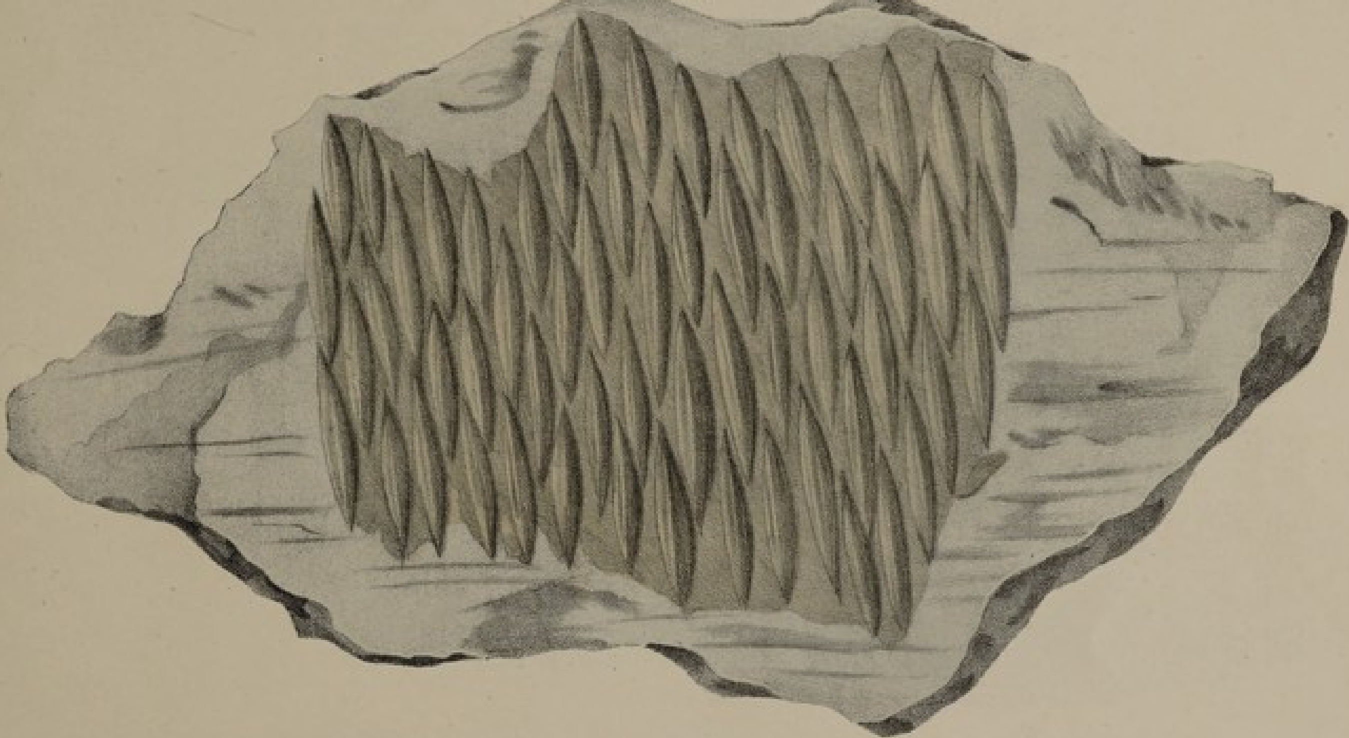

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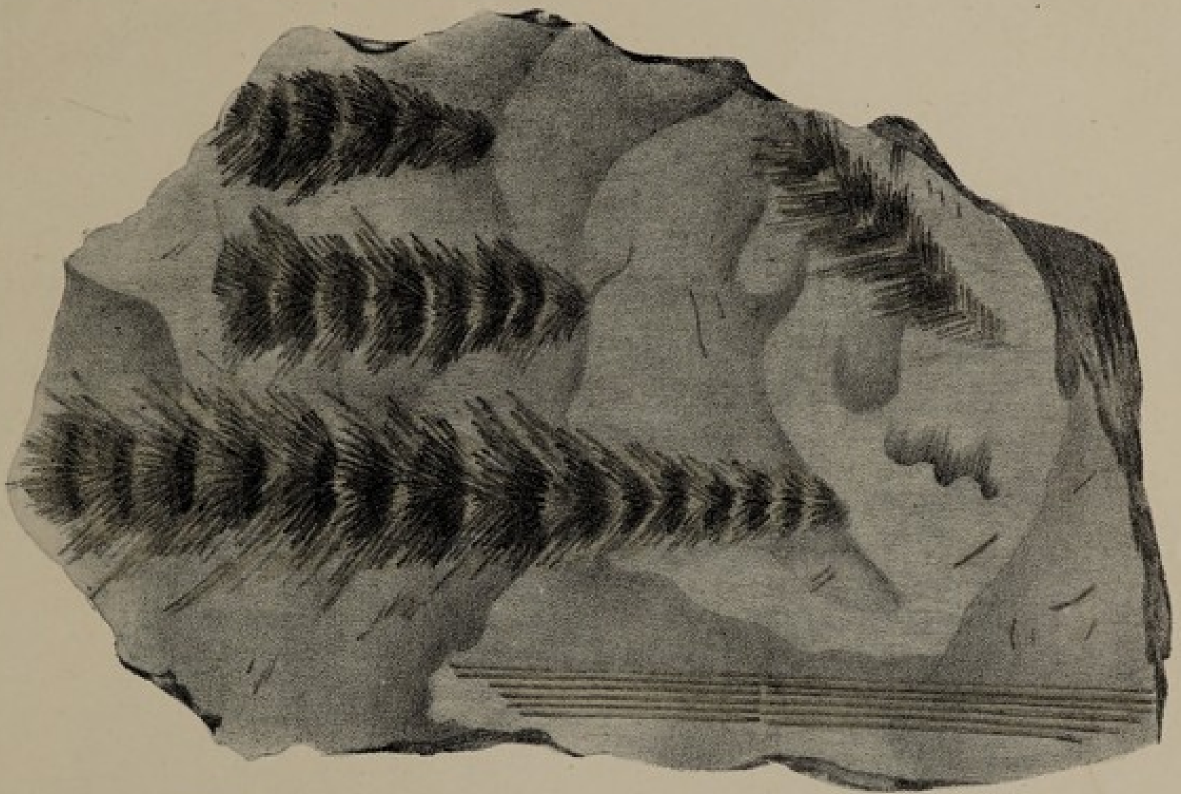

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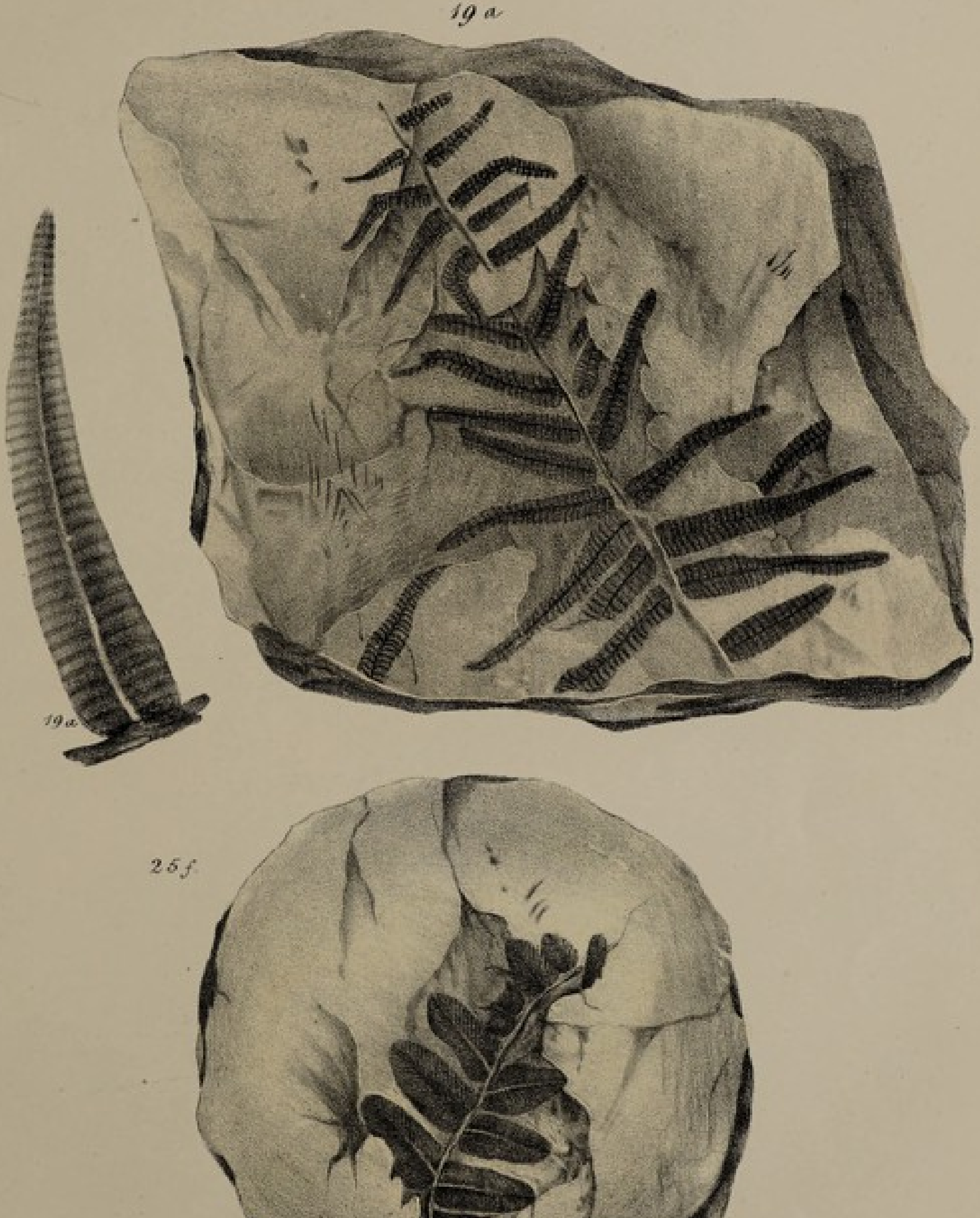

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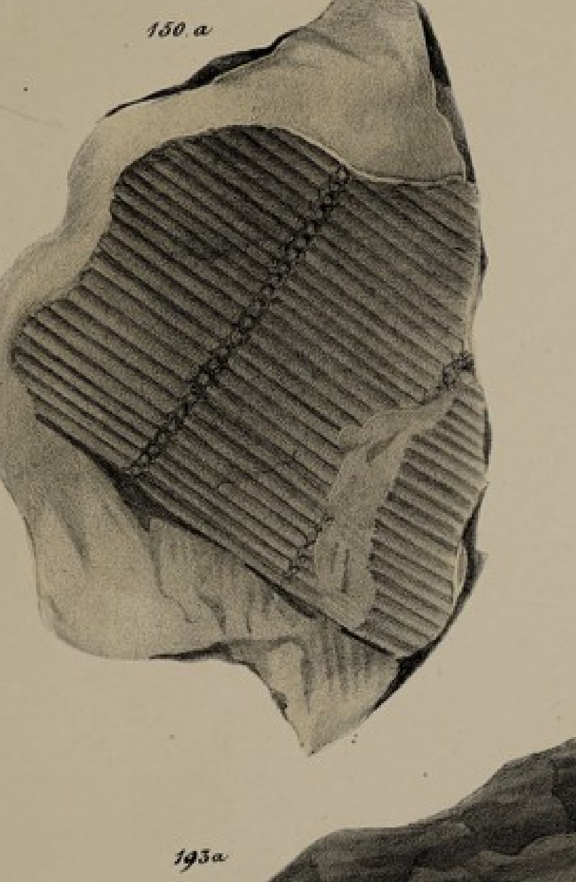

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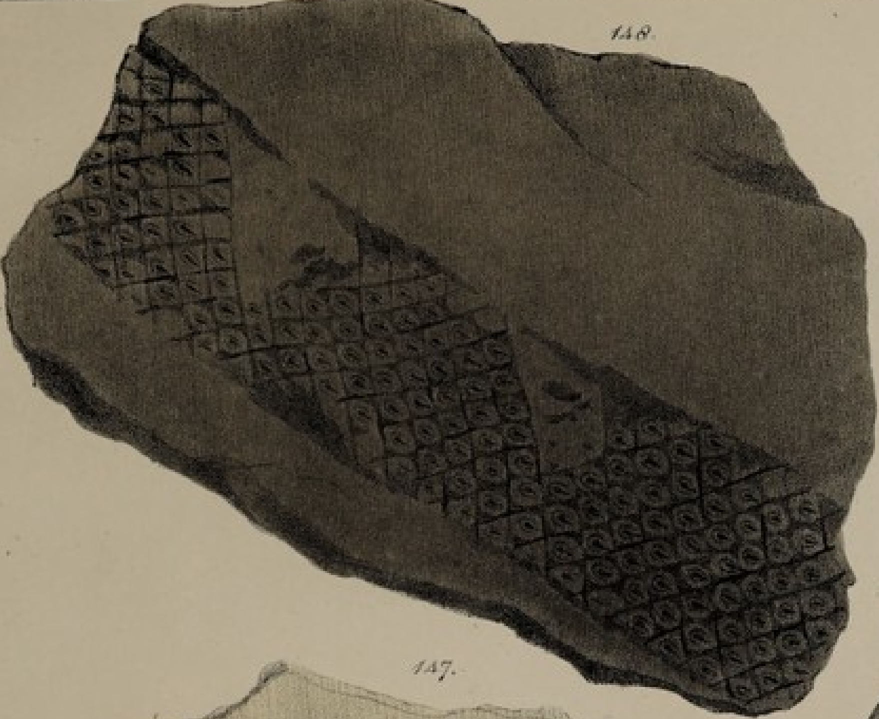
148.



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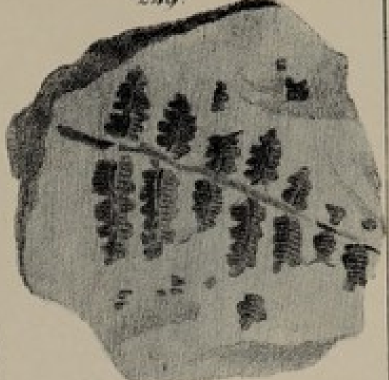

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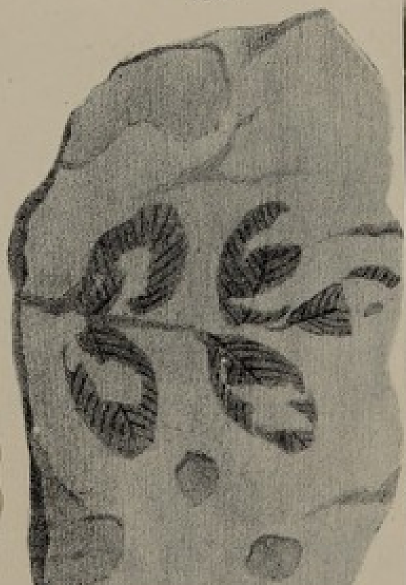

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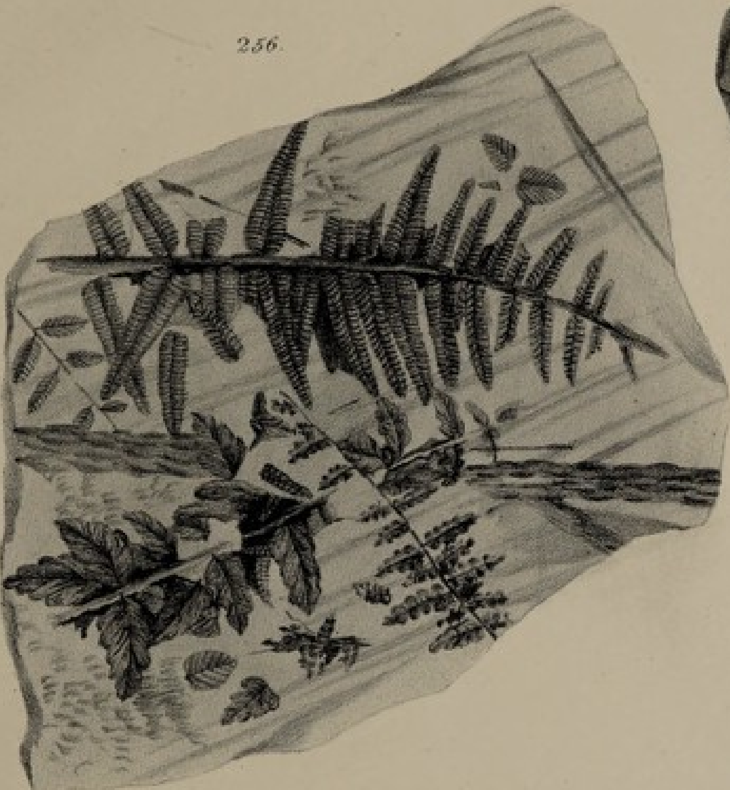

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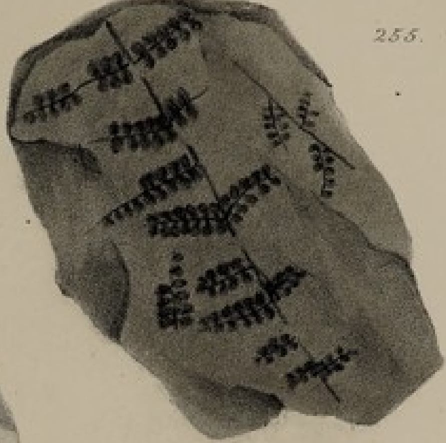

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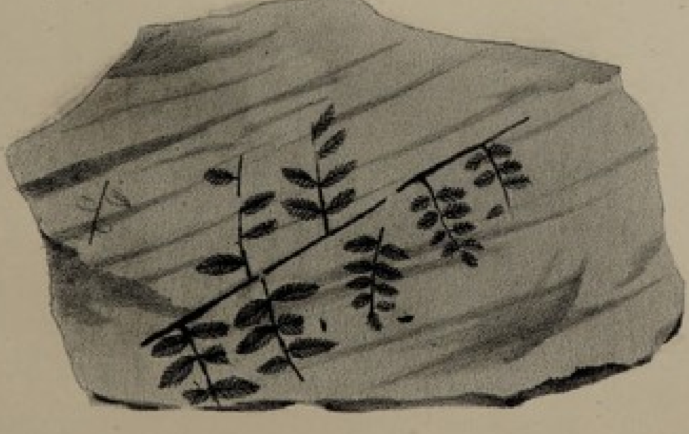

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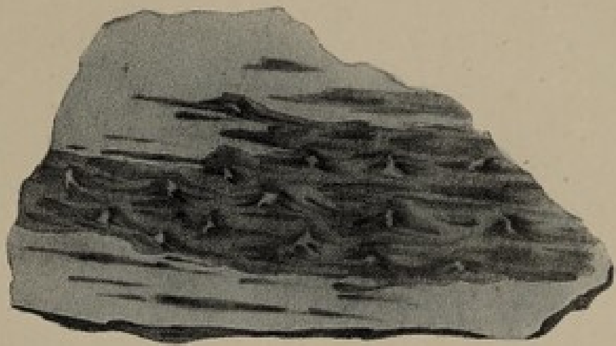

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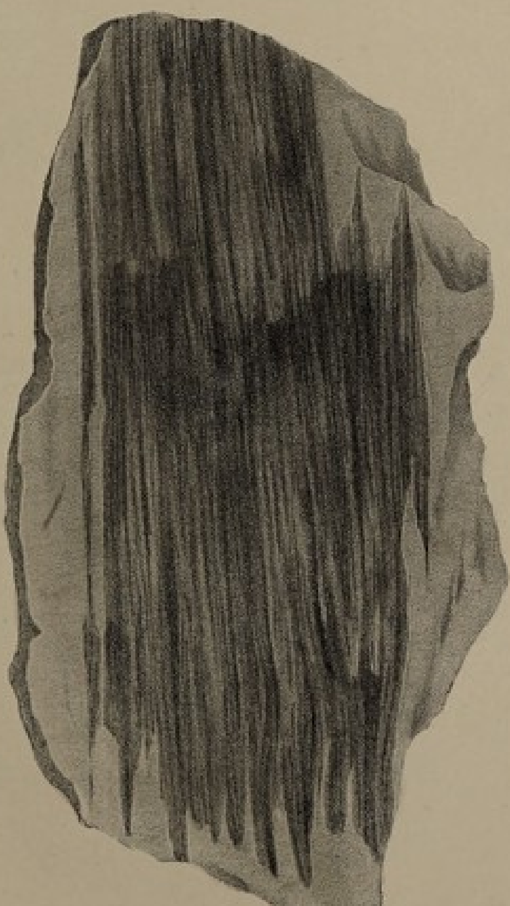

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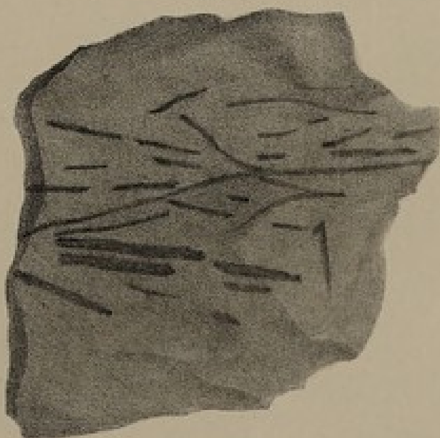

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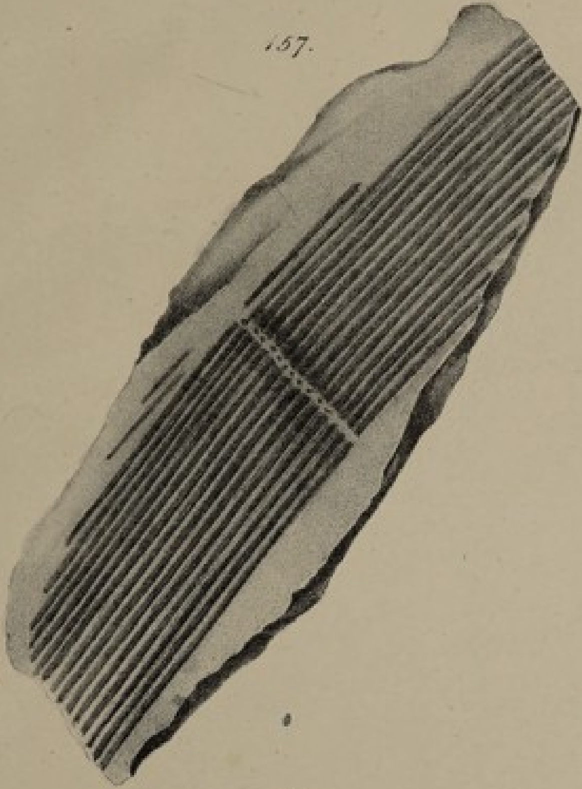

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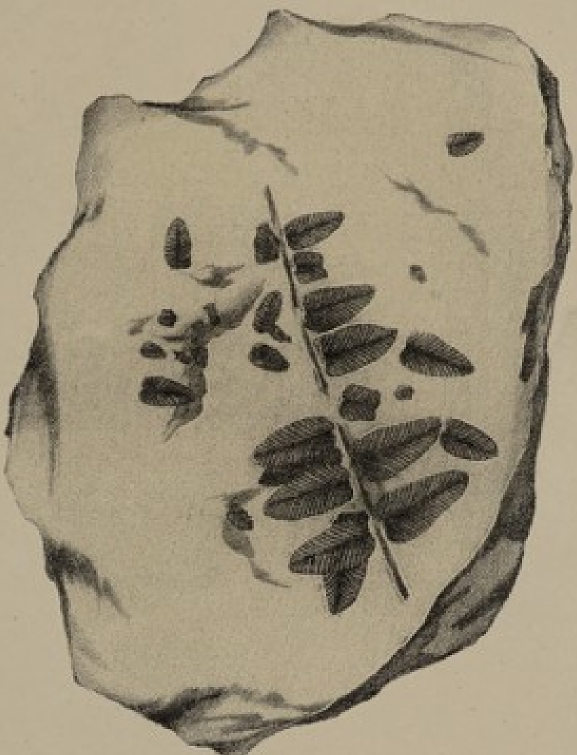

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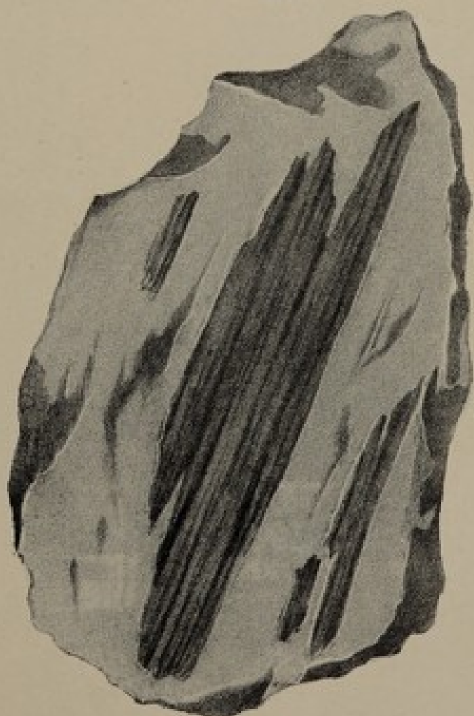
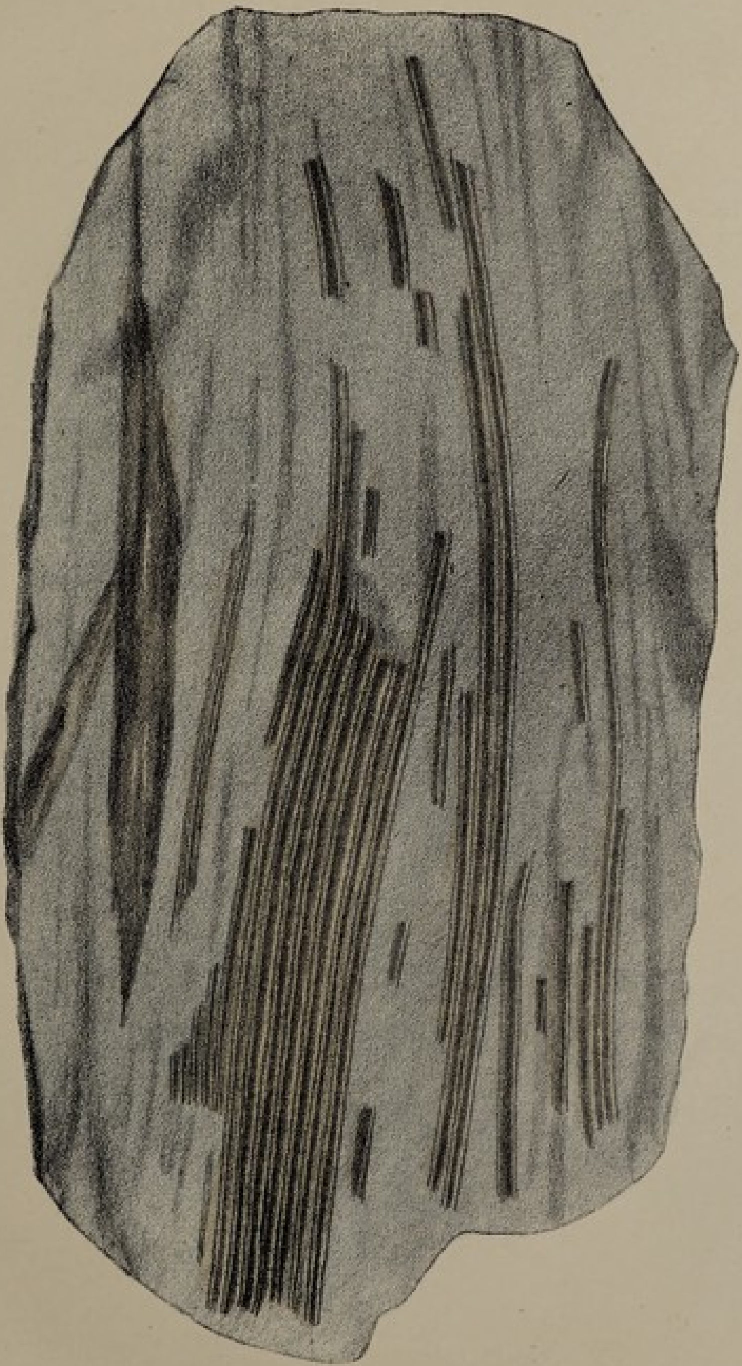


Pub by G. Lawford. Saville Passage. 1834.

236.



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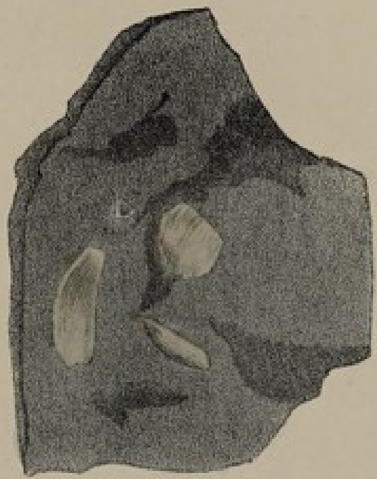

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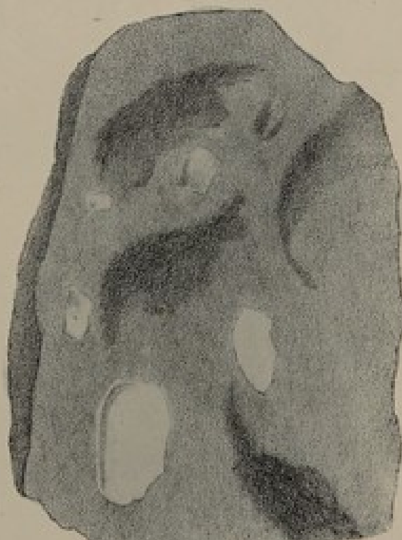
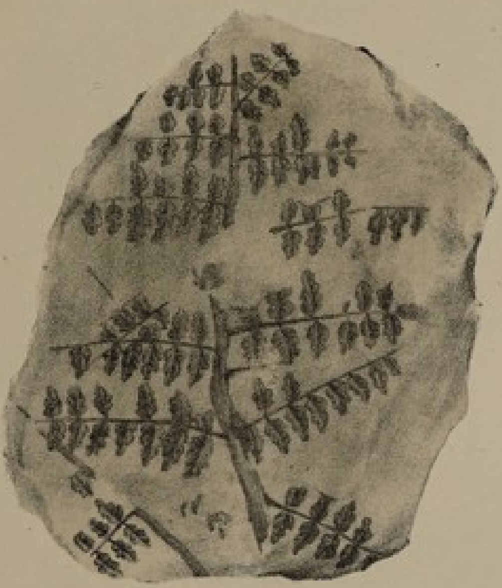


Pub by Geo. Lawford Saville Passage, 1834.

Madeley lith.

234.



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Pub. by Geo. Langford, Saville Passage 1834.

Madeley Lith.

223.

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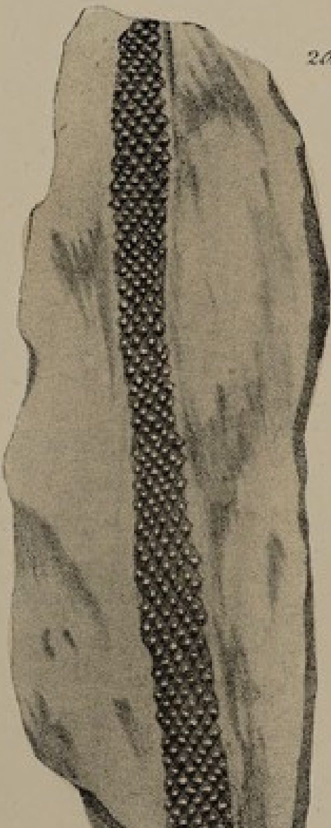
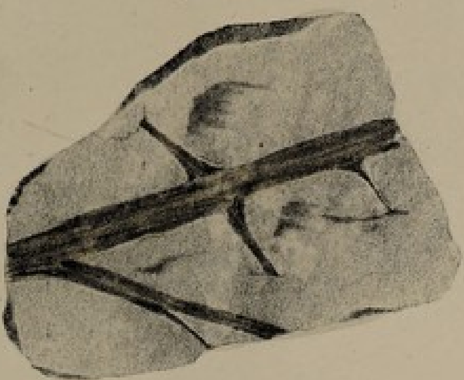


Pub by Geo Lamford Saville Passage 1834.

Madeley lith. 3 Wellington S^t Strand

259.



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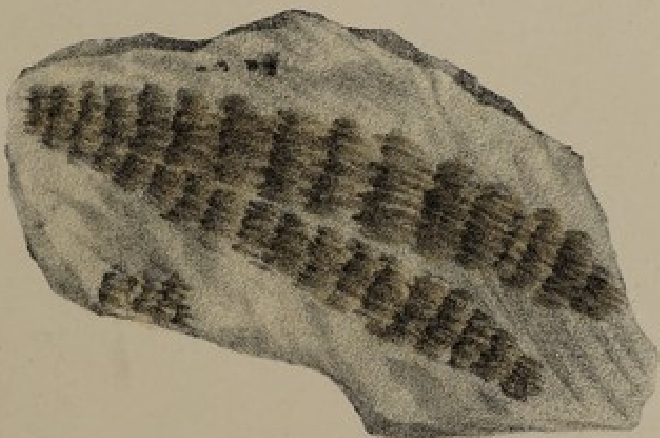

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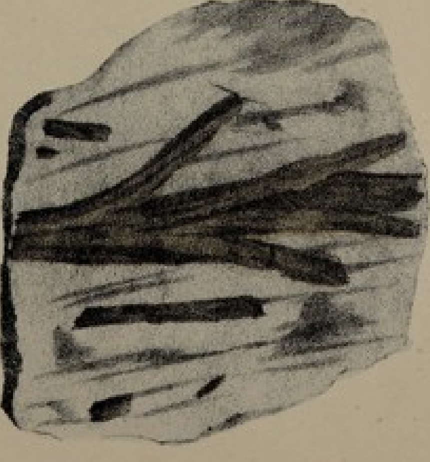
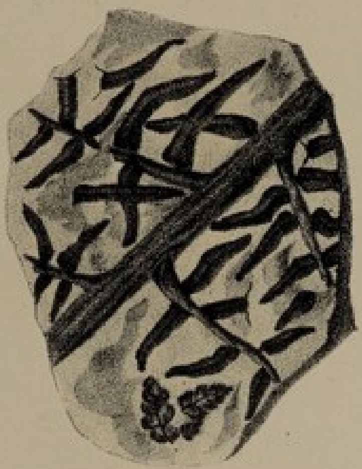


Pub. by Geo. Lawson, Saville Passage 1832.   Madeley, lith. 3 Wellington St. Strand.

306.



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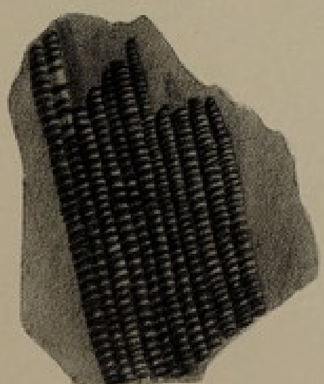

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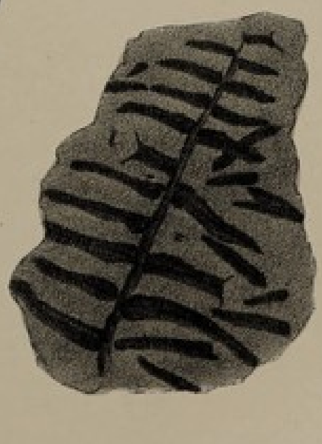

Pub. by G. Lawford. Saville Passage. 1834. Madeley. lith.

232.

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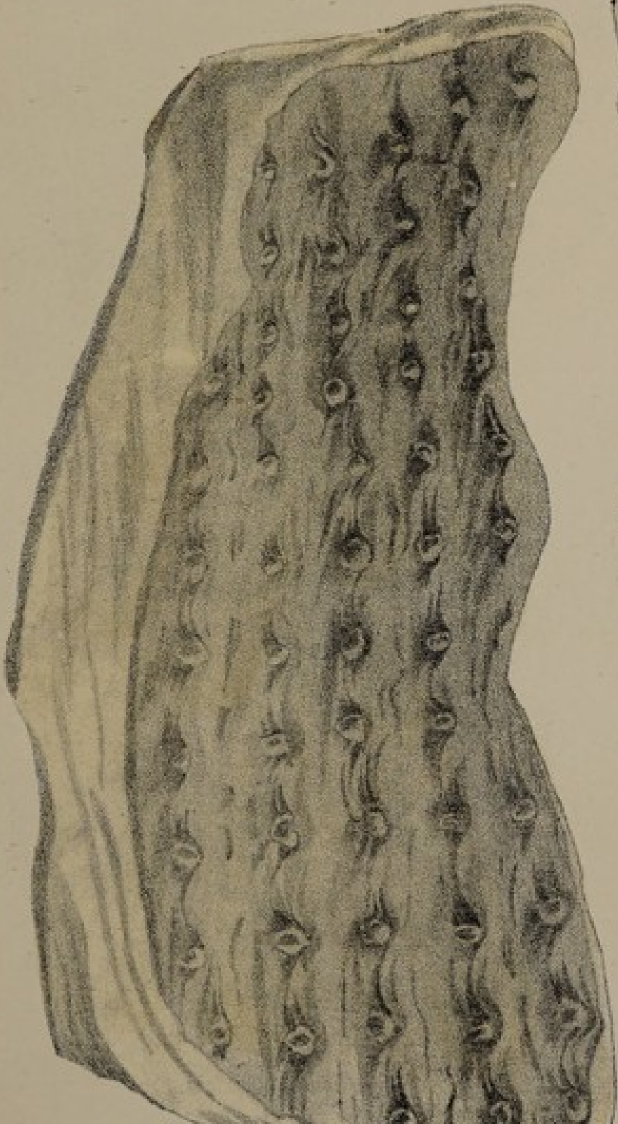
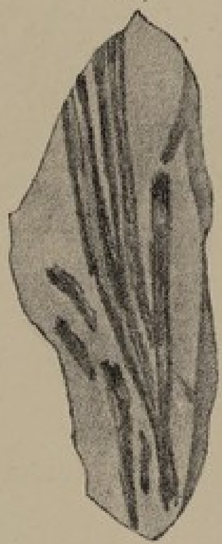


Pub. by Geo Lanford, Saville Passage. 1834.

Madeley Lith. 3 Wellington St. Strand.

281

287



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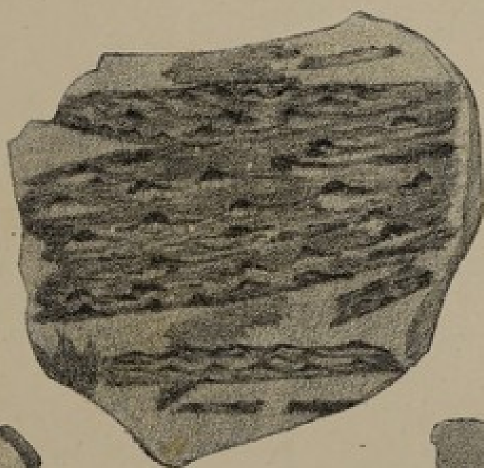

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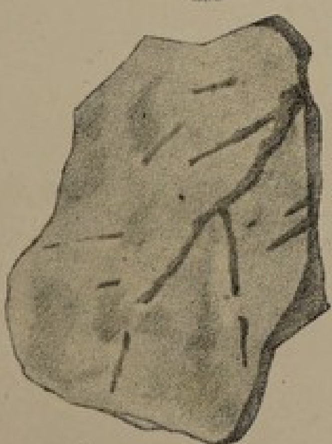

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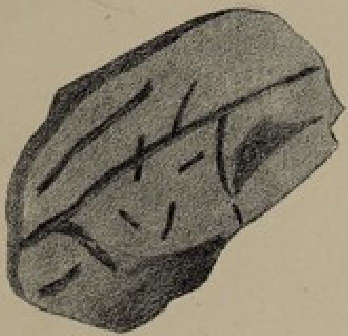

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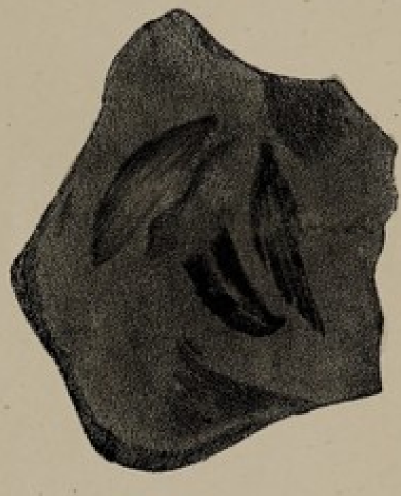

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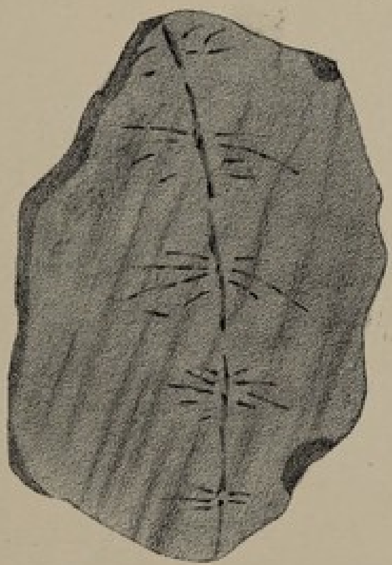

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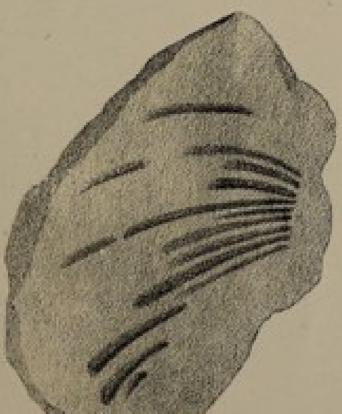

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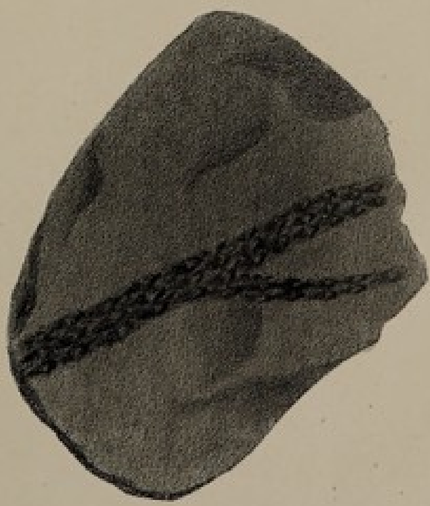

Pub. by Geo. Lawford Saville Passage. 1834.

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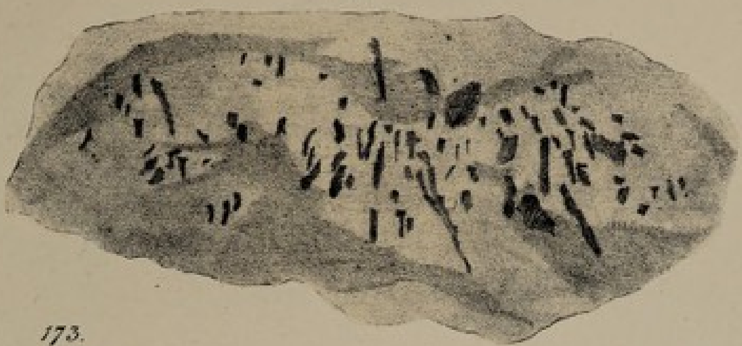
181.



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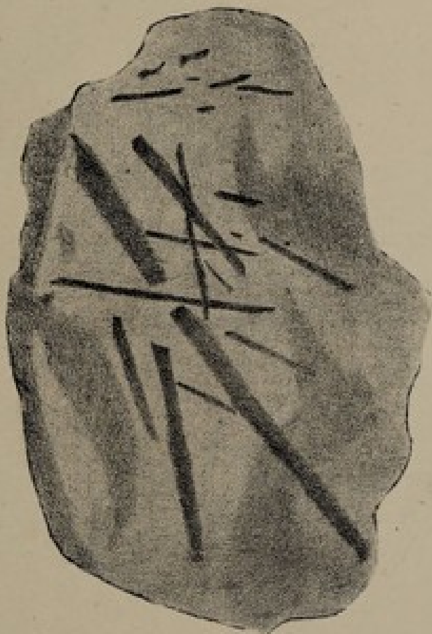

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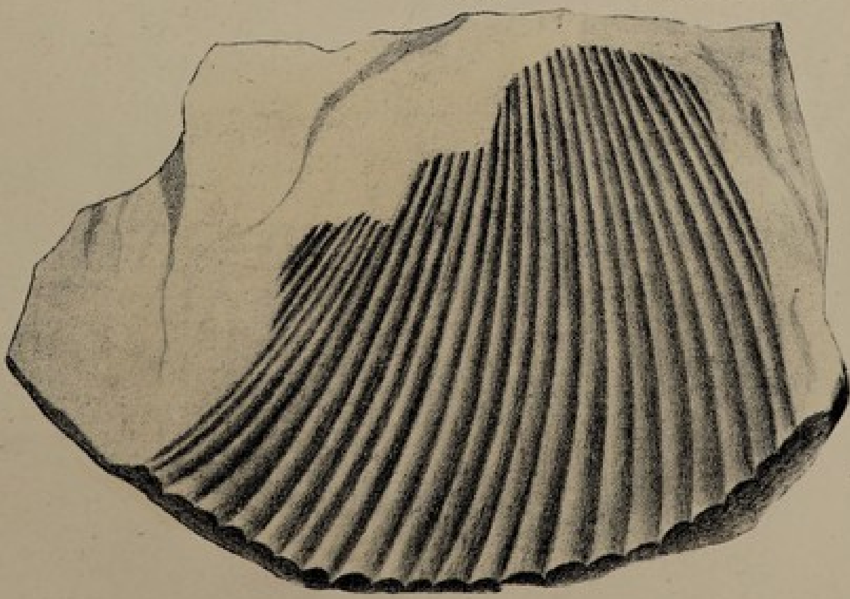

Pub. by Geo. Lawford Saville Passage 1834.

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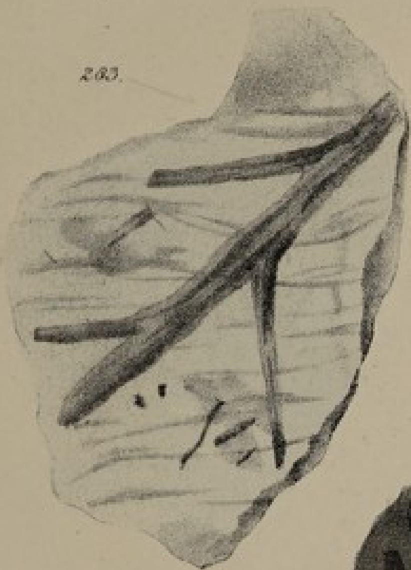
263.



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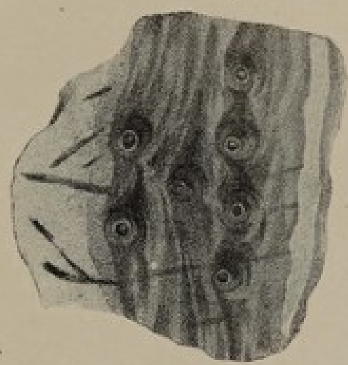

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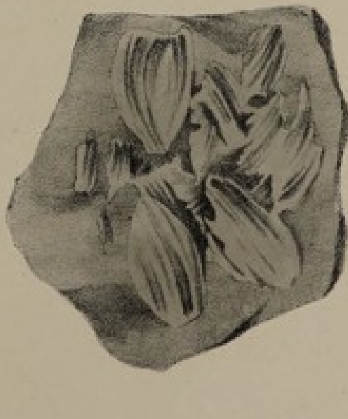
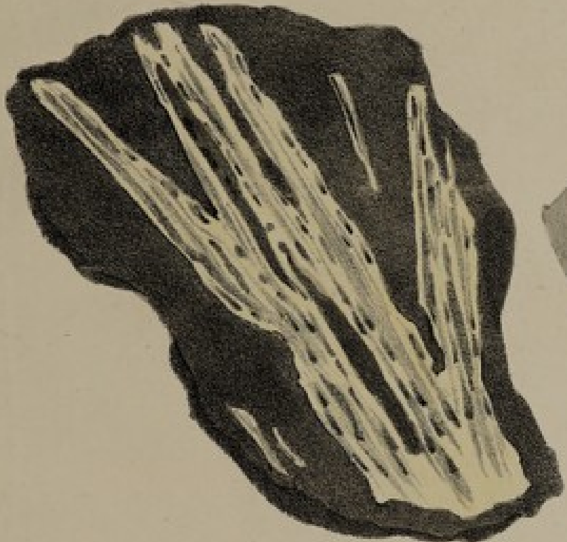


Pub^d. by G. Lawford. Saville Passage. 1834.

346.



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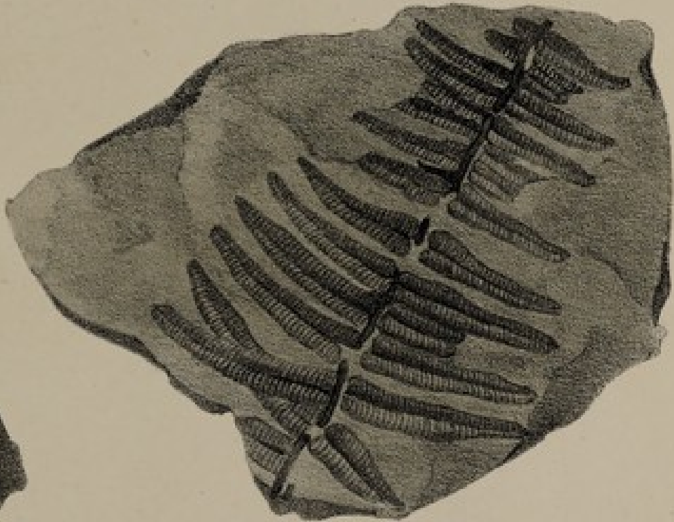

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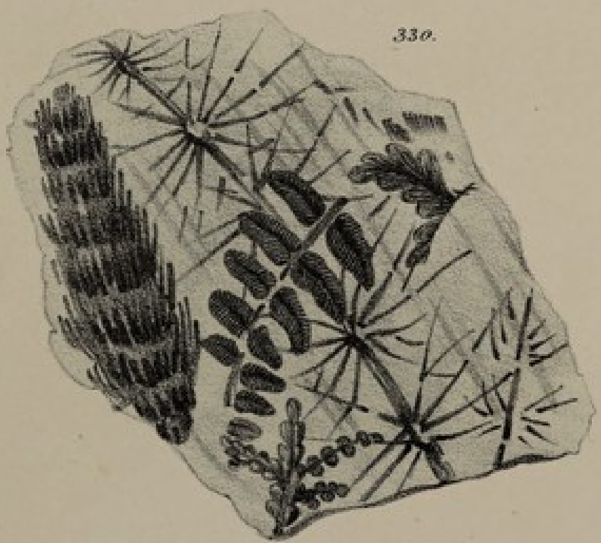

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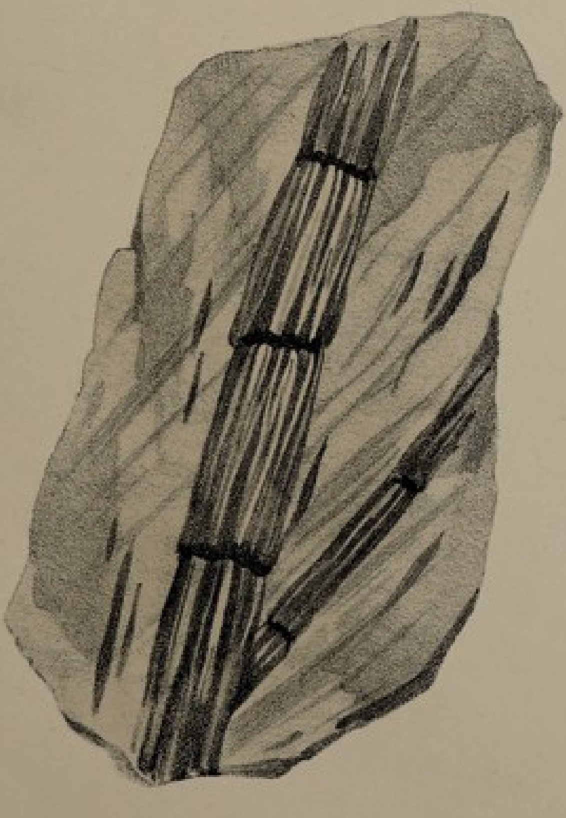


323.

Pub by Geo. Lawford. Saville Passage. 1834.

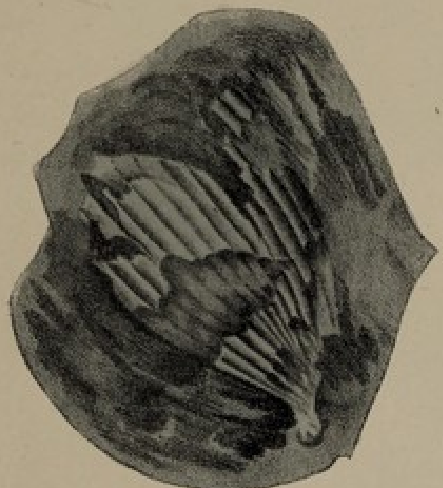
Madeley lith. 3 Wellington S.t Strand.


357.

Pub: by Geo. Lawford, Savile Passage. 1834

Madeley lith. 3 Wellington St Strand.

391



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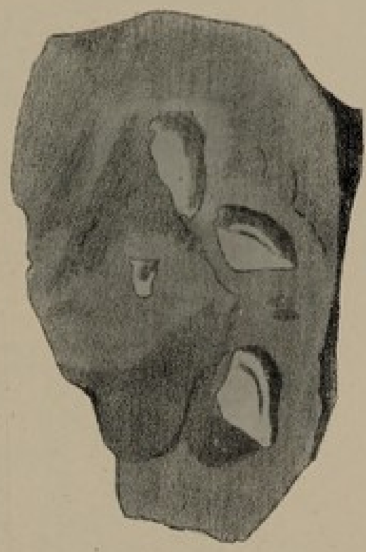

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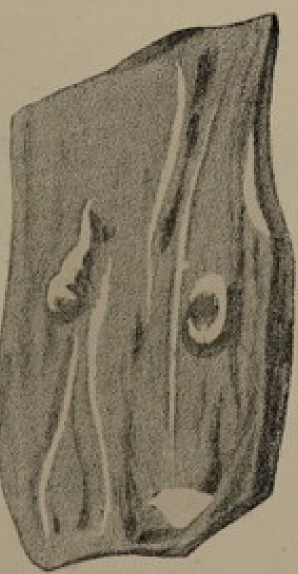
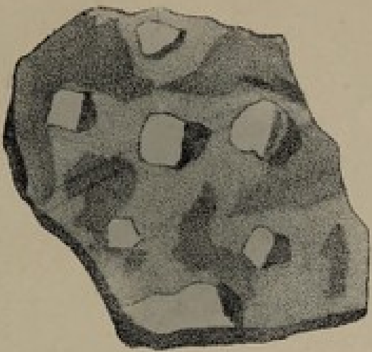


390.

Madeley Lithog.

Pub. by Geo. Lansford. Saville Passage. 1834.

344.



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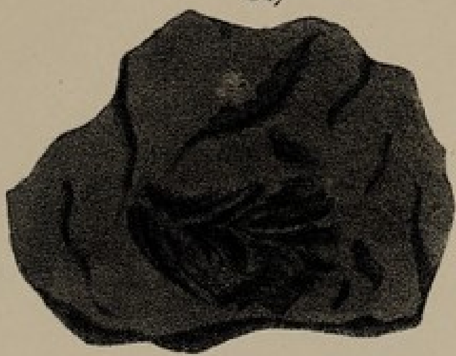

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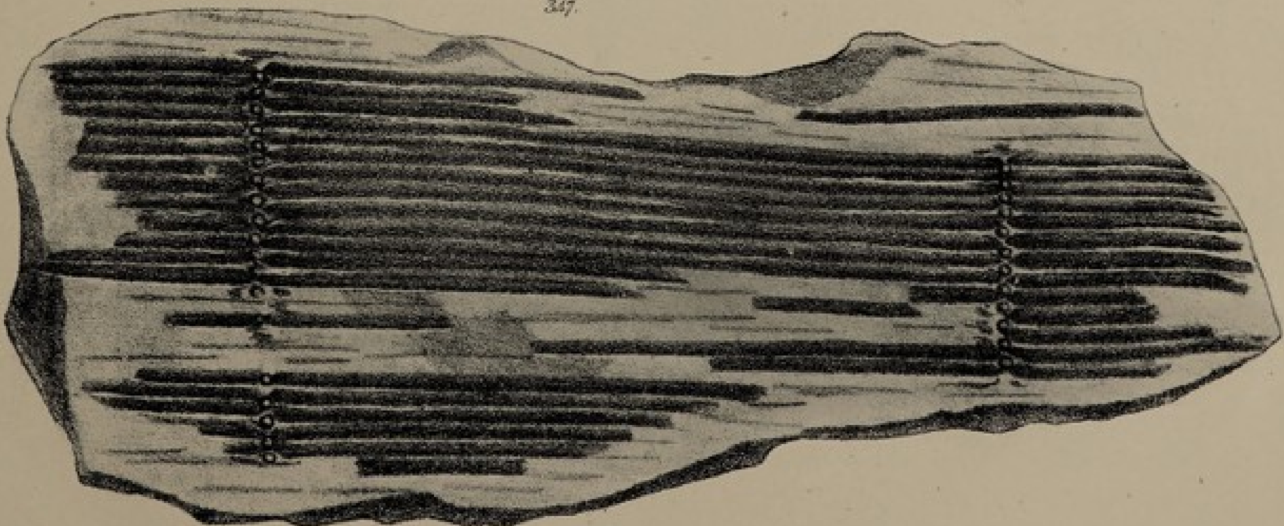

Pub. by G. Lamford Saville Passage 1834.

Madeley lithog.

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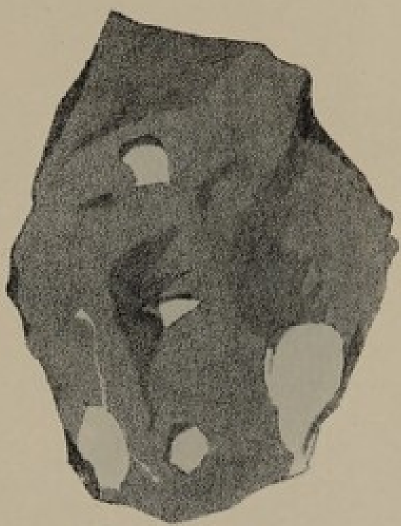
360.



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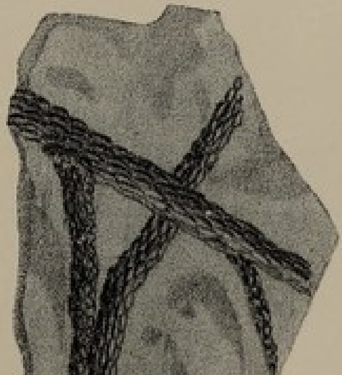

Pub. by Geo. Lawford. Saville Passage. 1834.

Madeley Lithog.

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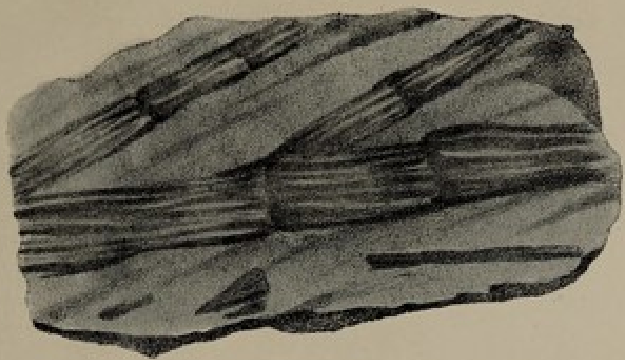

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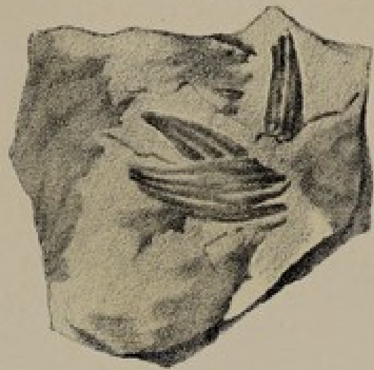

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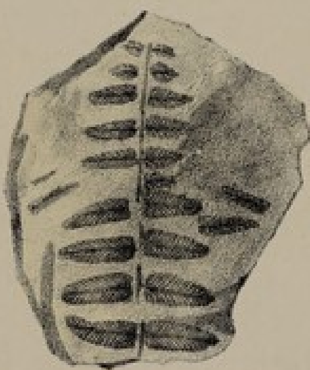

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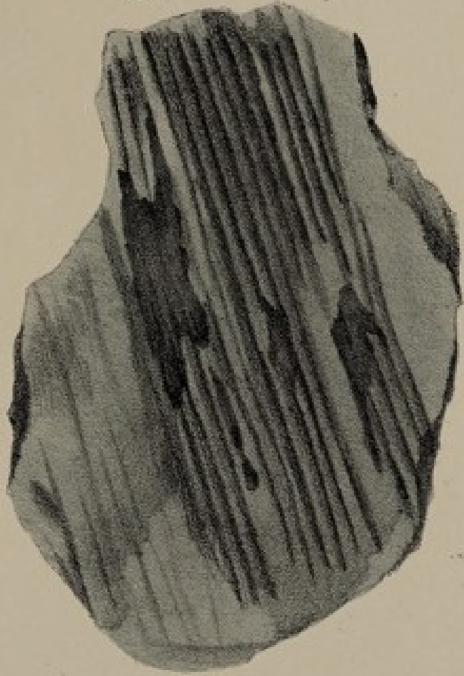
Pub. by Geo: Lawford, Saville Passage 1834.

363.



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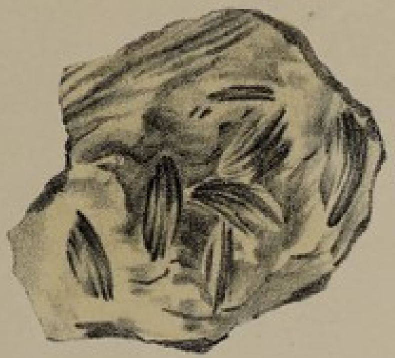

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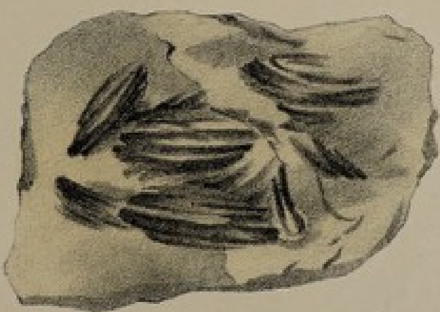

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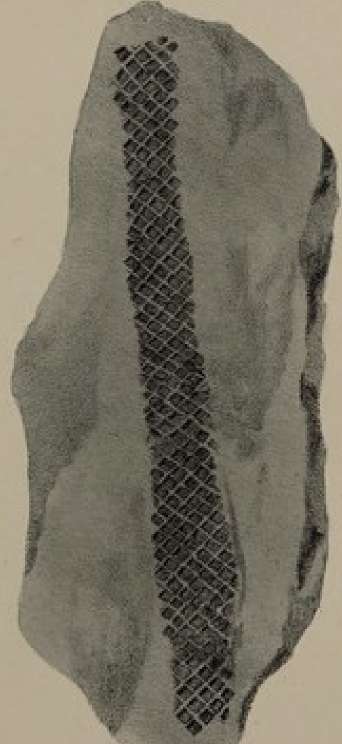

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Pub by G. Lanford Saville Passage. 1834.

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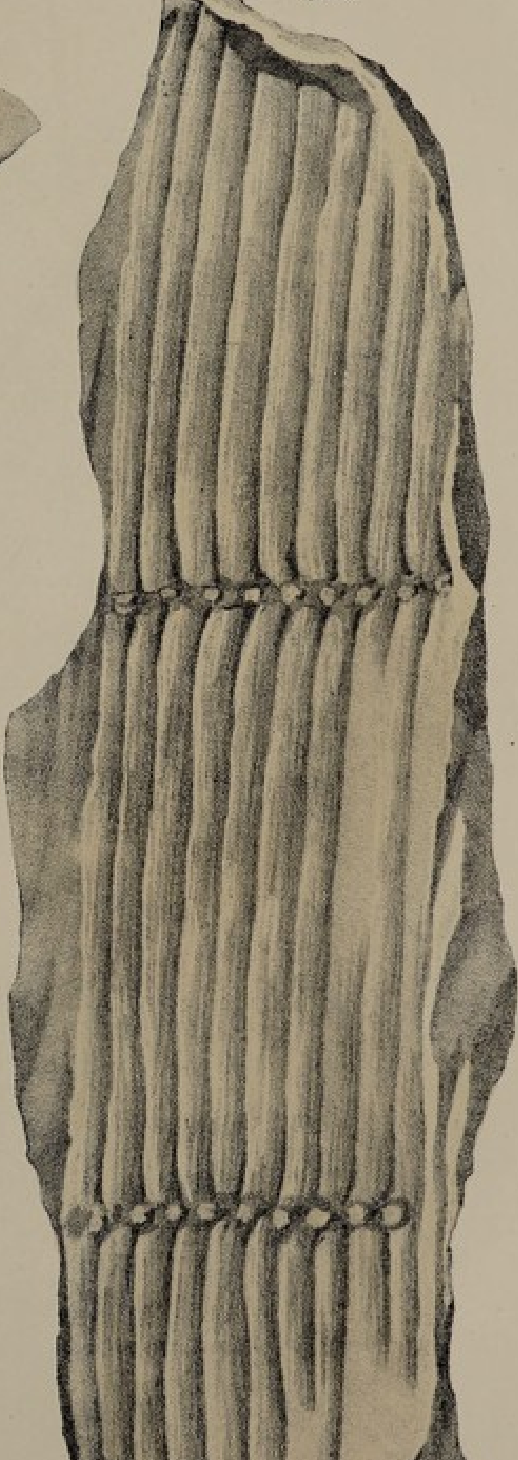

354.

Pub. by Geo. Lawford. Saville Passage 1834.

Madeley Lithog.

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Pub^d. by [illegible]

Robt. Ironmonger del. Pubd. by Geo Lawford, Saville Passage, 1834. Madeley lith. 3 Wellington St. Strand

Robt Ironmonger. del.   London. Pub. by Geo. Langford, Saville Passage 1834.   Madeley lithr 3 Wellington St Strand.

145 a

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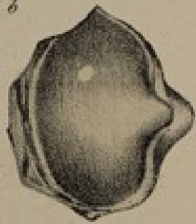

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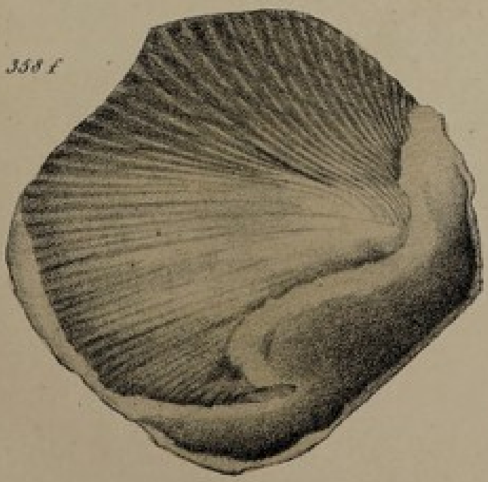

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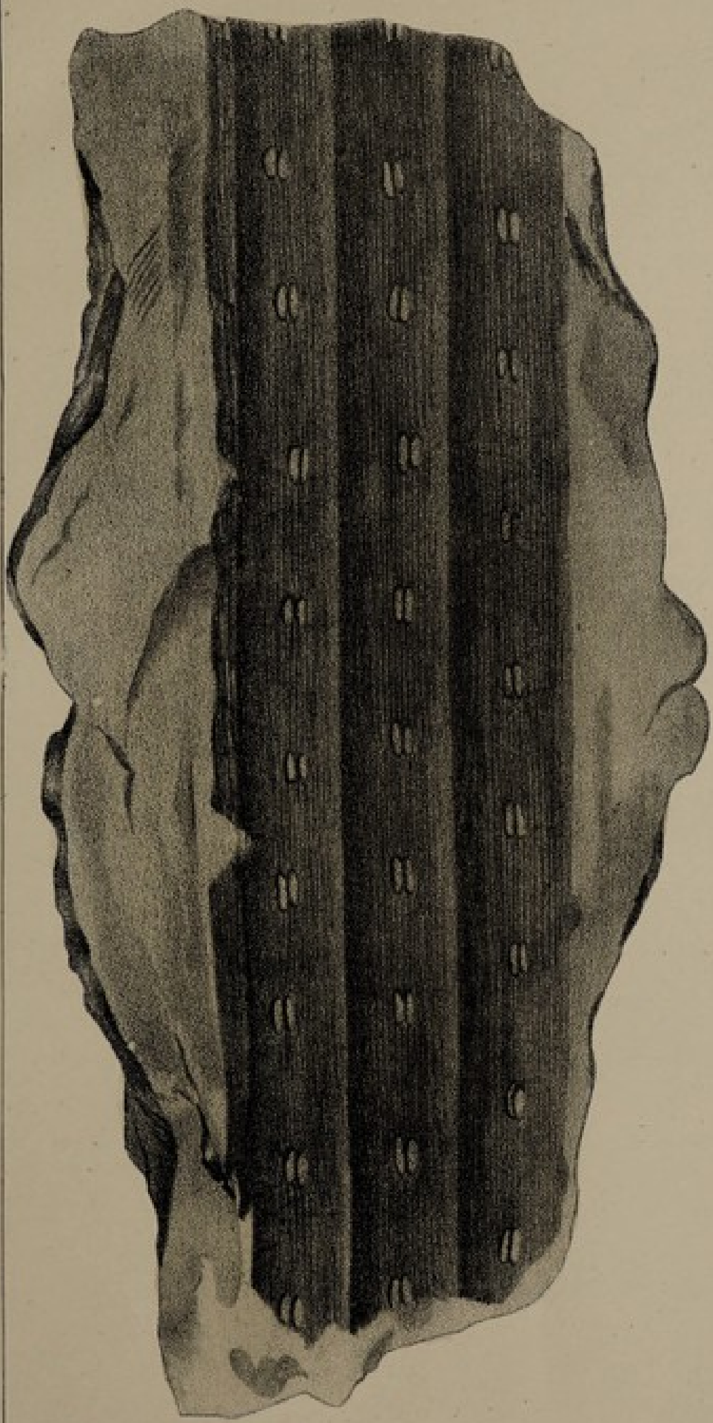
Rev. Ironmonger d.t Pubd by Geo. Lawford, Saville Passage, 1834. Made' by lith. 3 Wellington St Strand.

109 a



61 a

Robt. Ironmonger del. Pubd. by Geo. Lambert, Savile Passage, 1834. Madeley lith. 3 Wellington St. Strand.

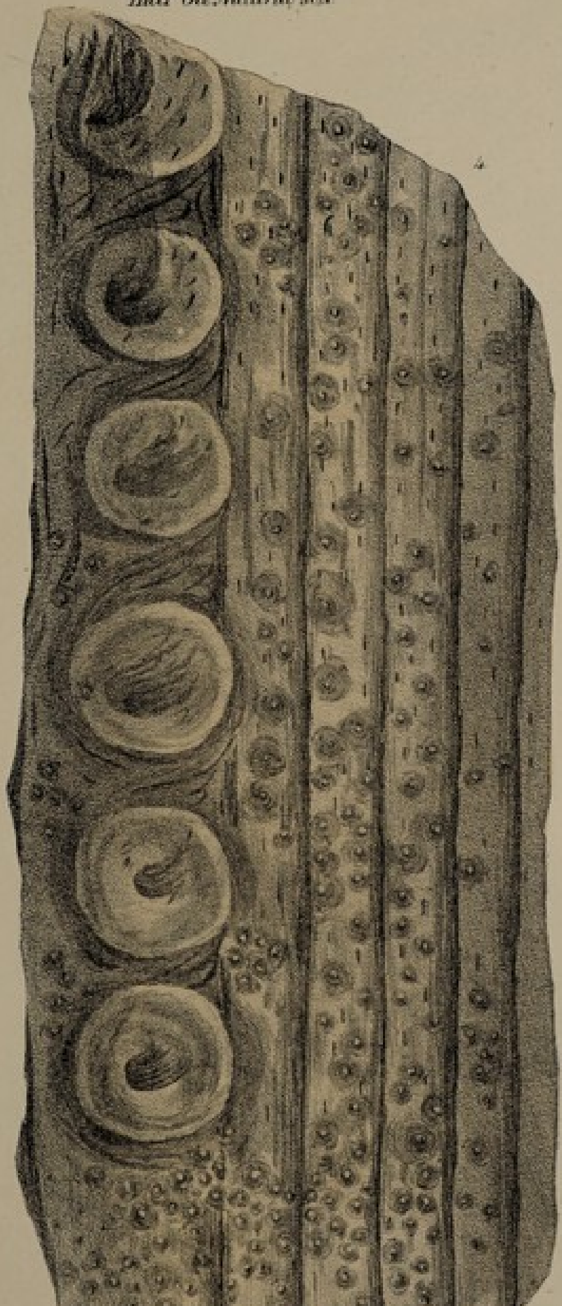
Robt. Ironmonger del.

Pubd. by Geo. Lawford, Saville Passage 1834.

M. Gauci lith. 3 Wellington St. Strand.

Robt. Ironmonger del. Pubd. by G. Lawford, Saville Passage, 1834. Madeley lith. 3 Wellington St. Strand.

Half the Natural size



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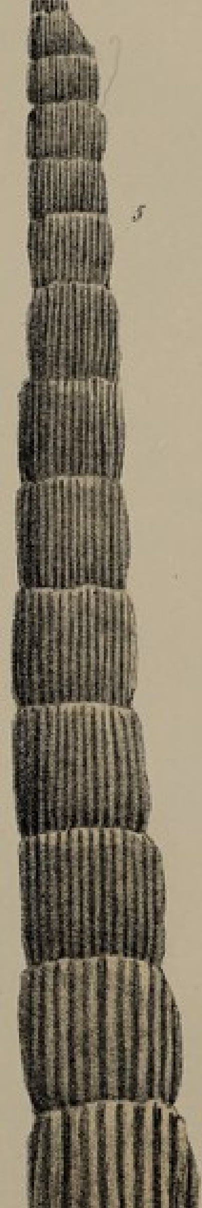

Robt Ironmonger del. *Pubd by G. Lawford, Saville Passage.* *Madeley lith. 3 Wellington St Strand*

Full Size

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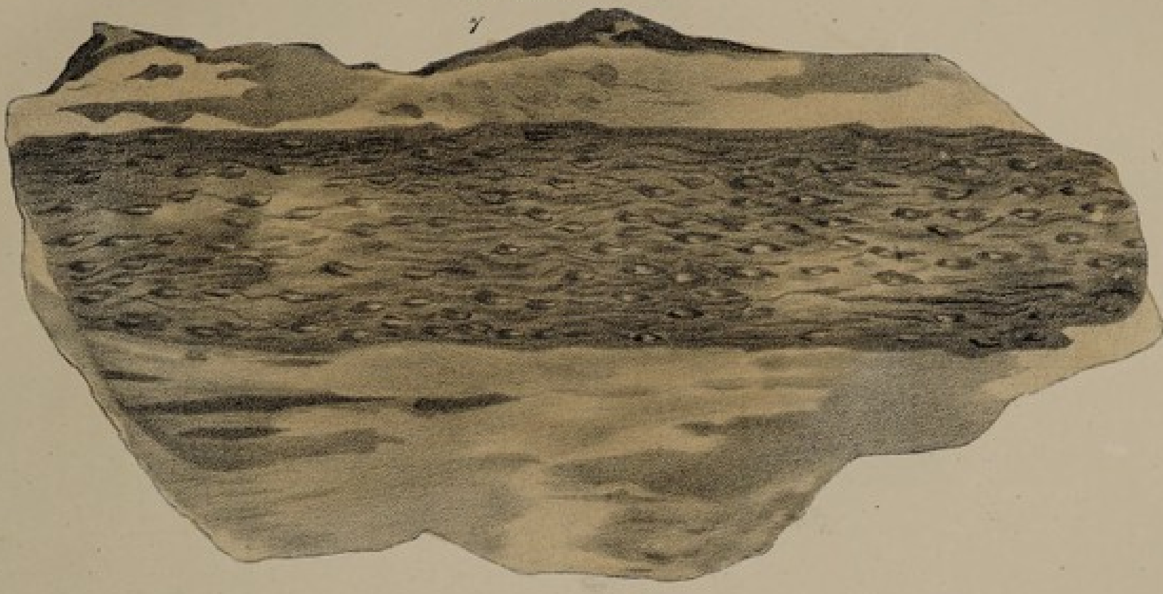

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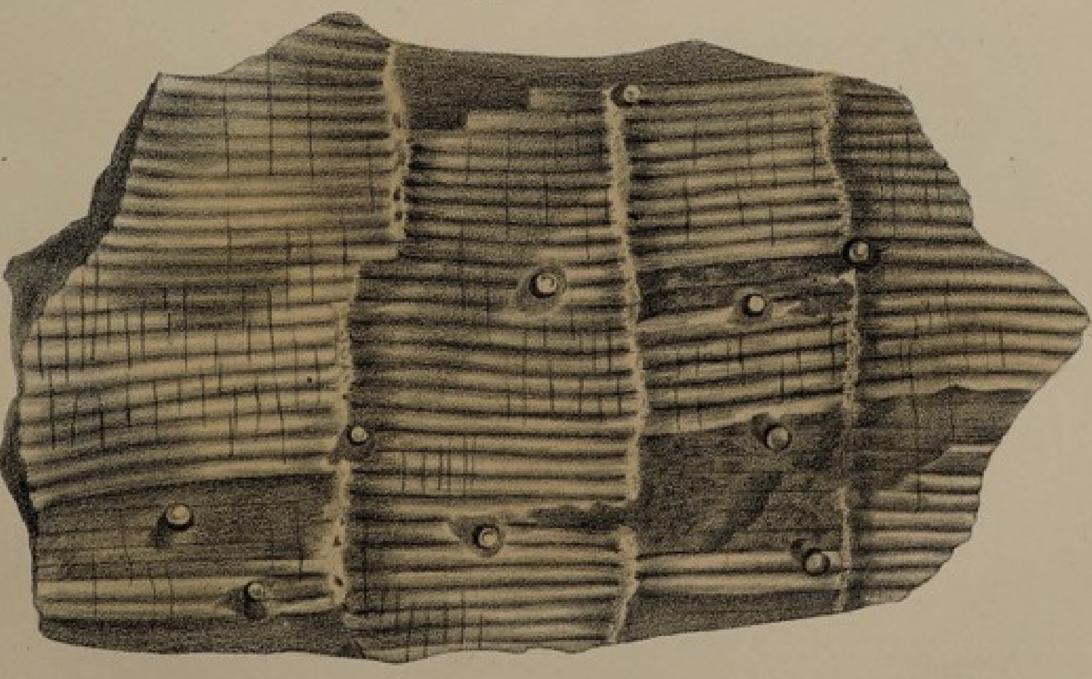

Robt. Ironmonger del. Pubd. by Geo. Lawford, Saville Passage, 1834. Madeley, lith. 3 Wellington St. Strand

Half the natural size

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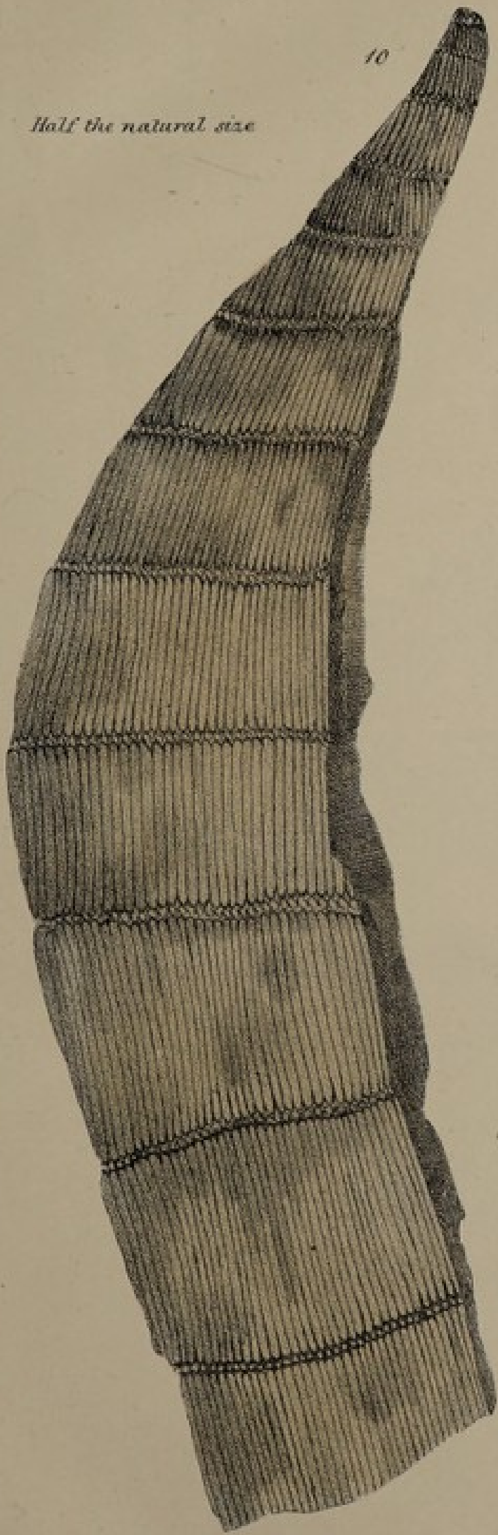

Full Size

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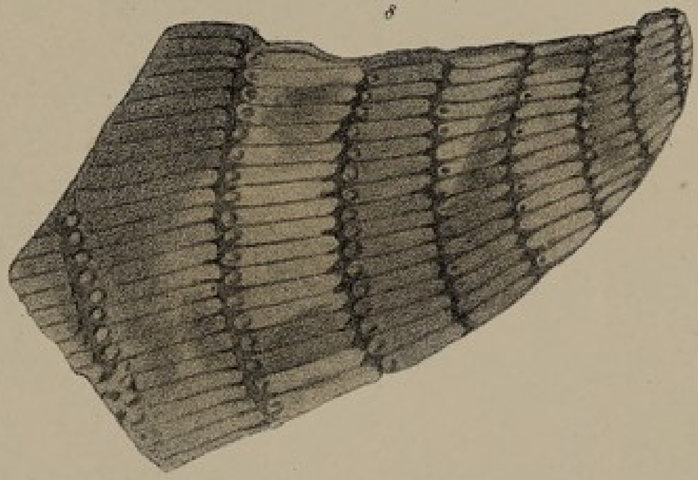

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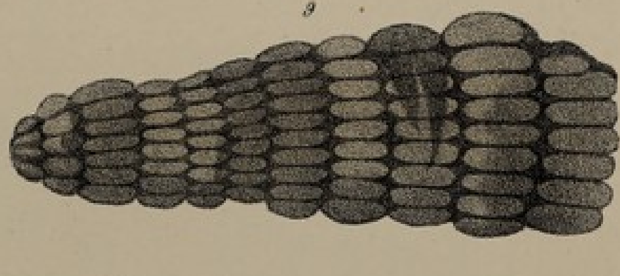

Robt. Ironmonger del. *Pubd. by Geo. Lamford, Saville Passage, 1834.* *Madeley lith. 3, Wellington St. Strand.*

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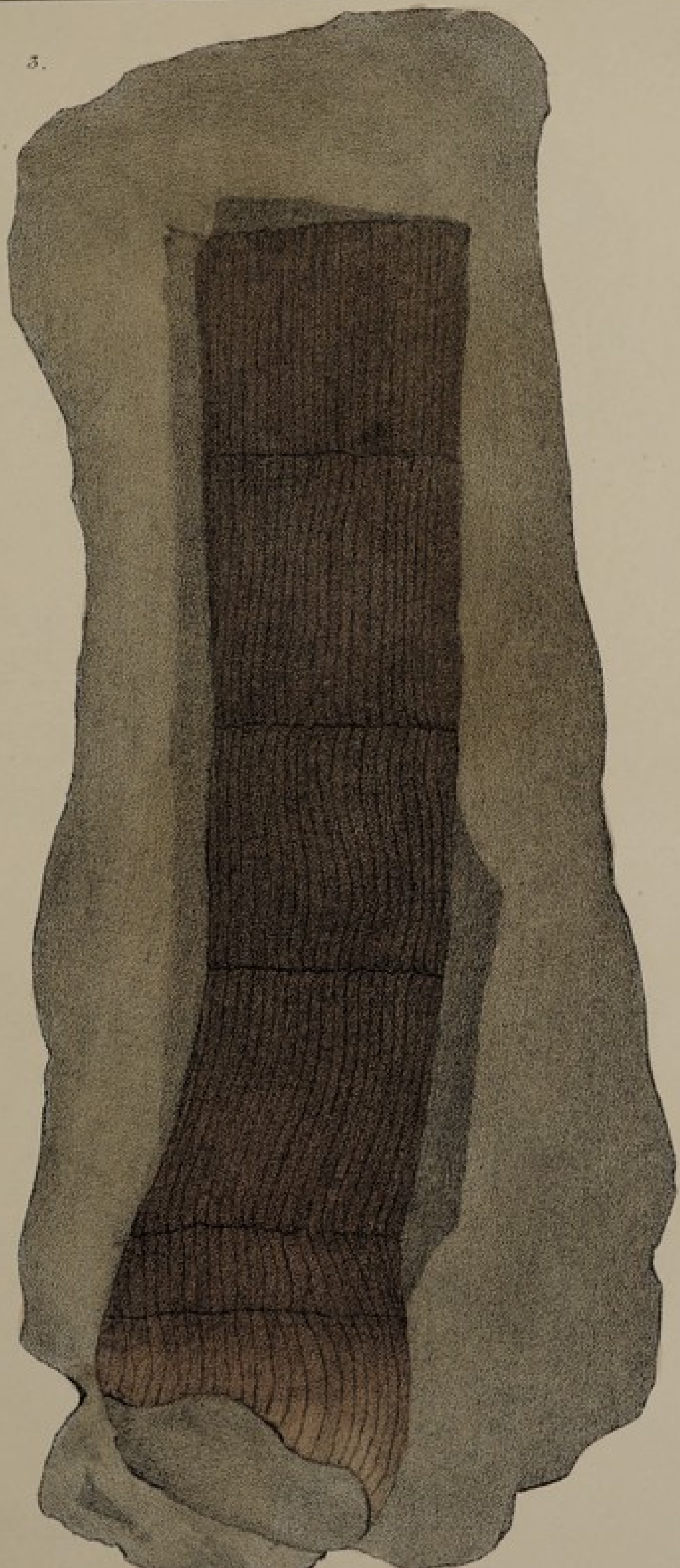
G.E. Madeley, lith. 3 Wellington St. Strand.

Pub^d by Geo. Lawford, Saville Passage. 1834.

3.



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Madeley lith.

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Pub. by Geo. Lumford Saville Passage 183.

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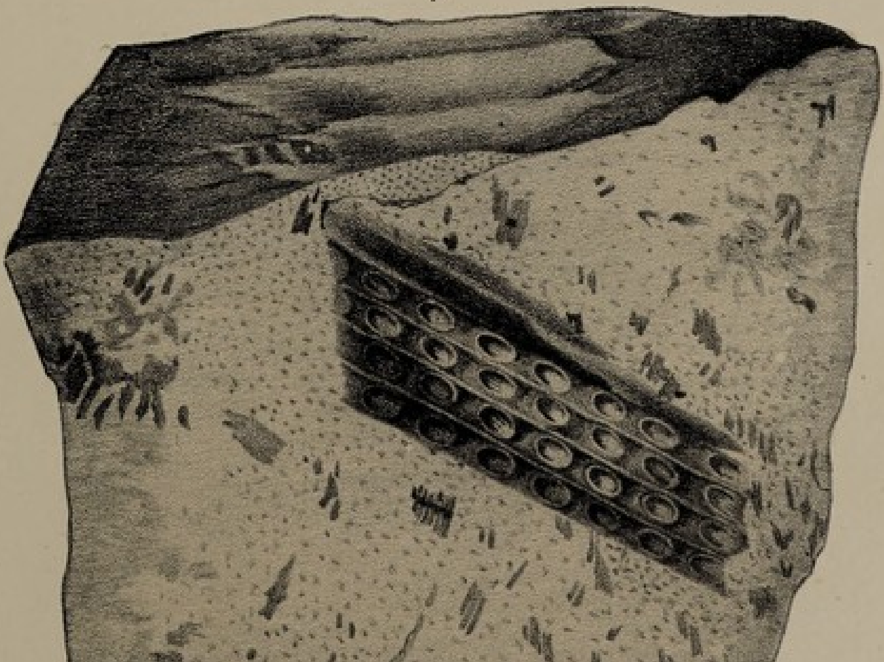
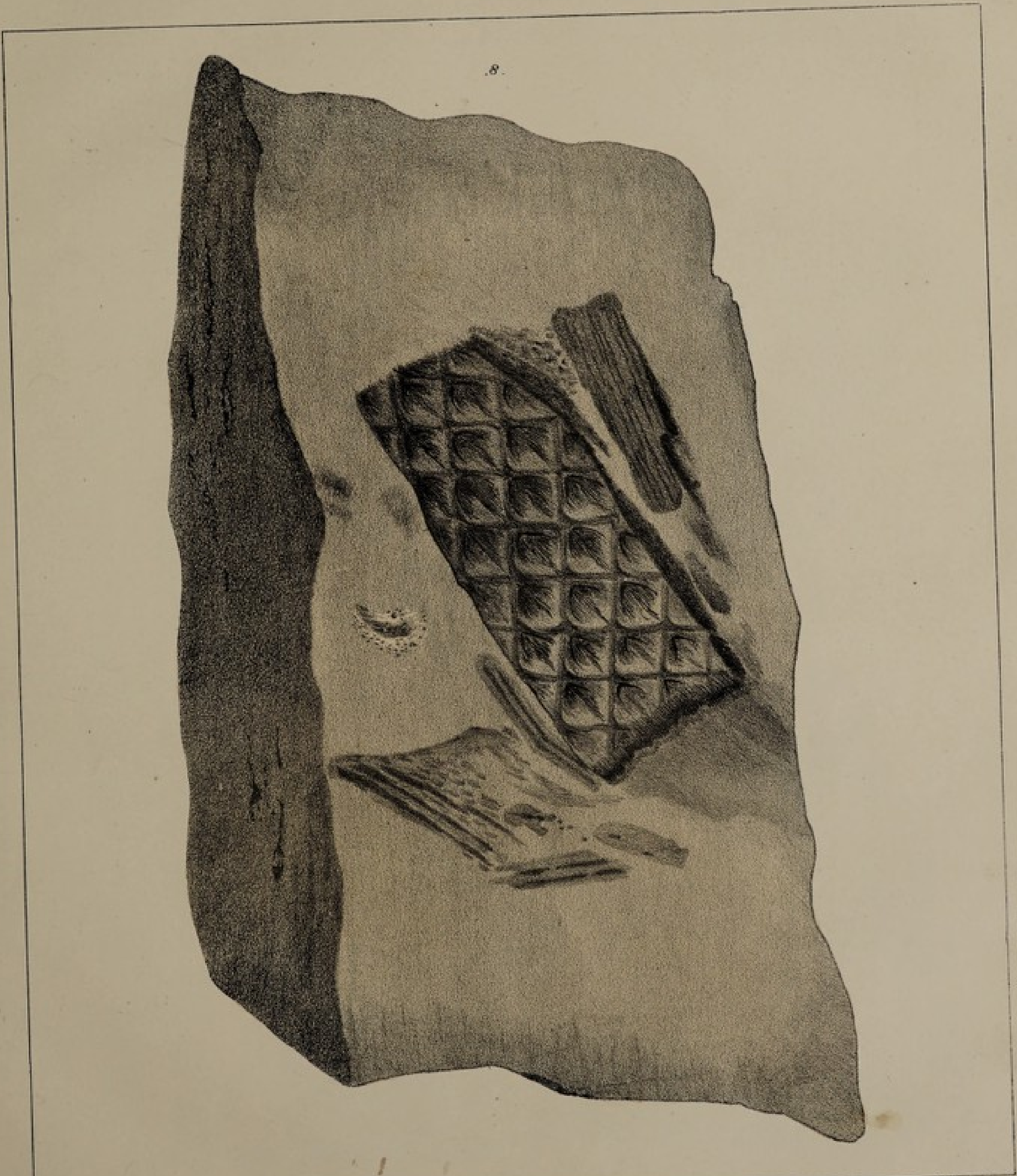


Pub. by Geo. Lawford, Saville Passage. 1834.
Madeley lith. 3 Wellington St. Strand.



Pub. by Geo. Lawford, Saville Passage. 1834.

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G. E. Madeley, lith. 3 Wellington St. Strand.

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Pub. by Geo. Lawford, Saville Passage. 1834.

Madeley Lithog.

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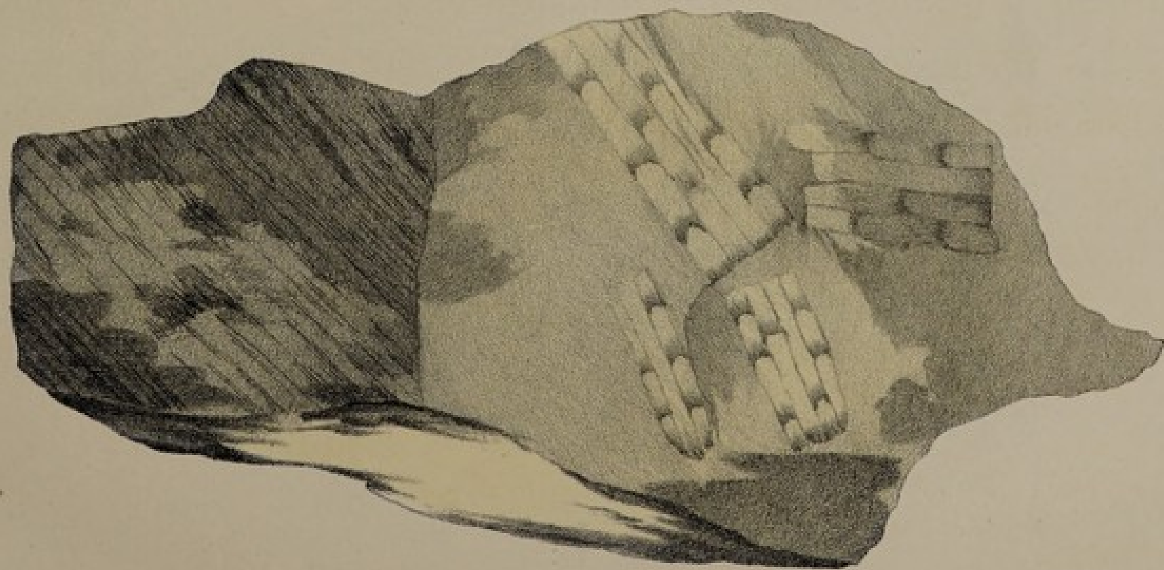

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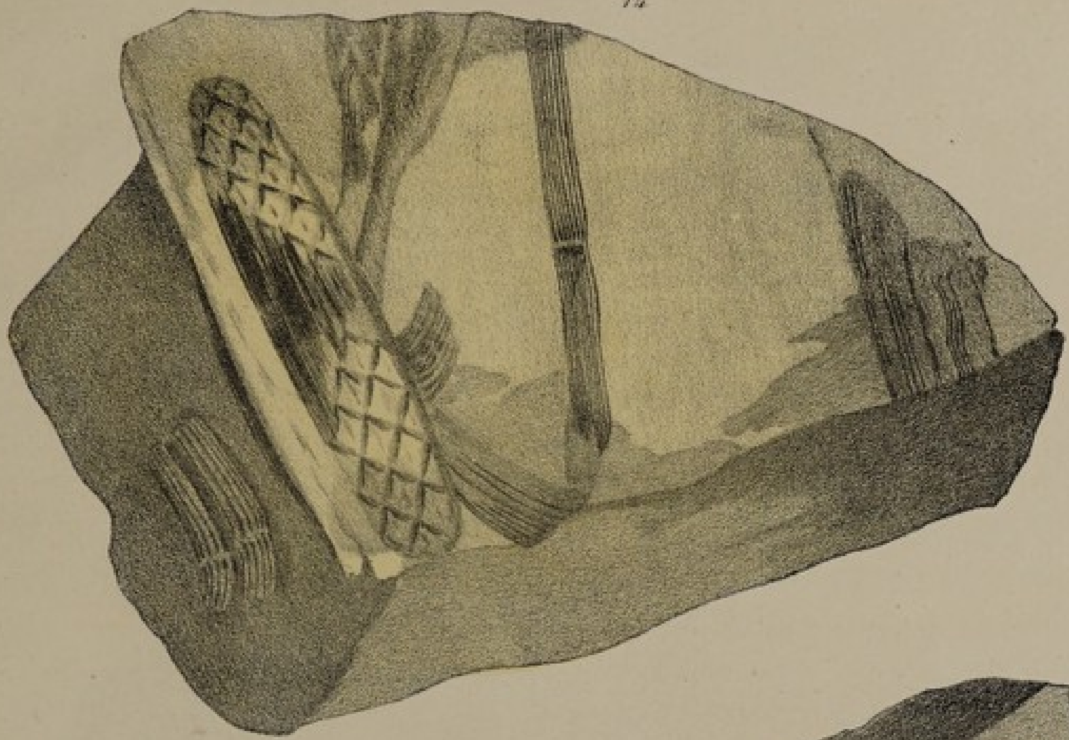
Madeley, Litho 3 Wellington St Strand.

14



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Moira Stone Quarry.

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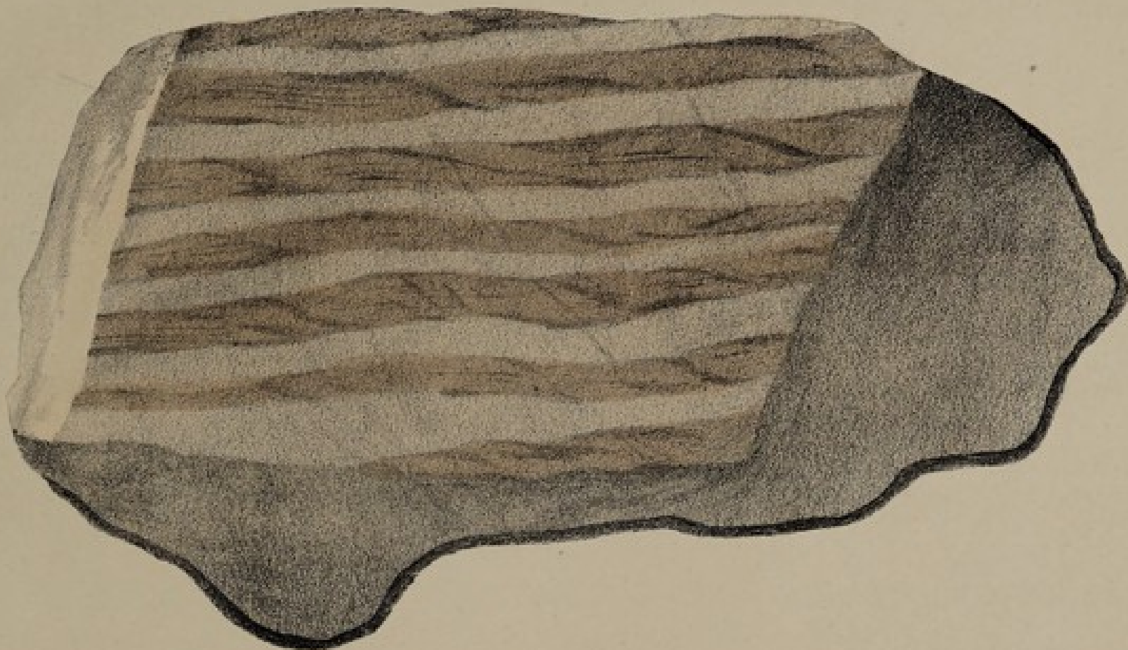
G. E. Madeley lith. 3 Wellington St. Strand.

Pub^d by Geo. Lawford, Saville Passage. 1834

20.



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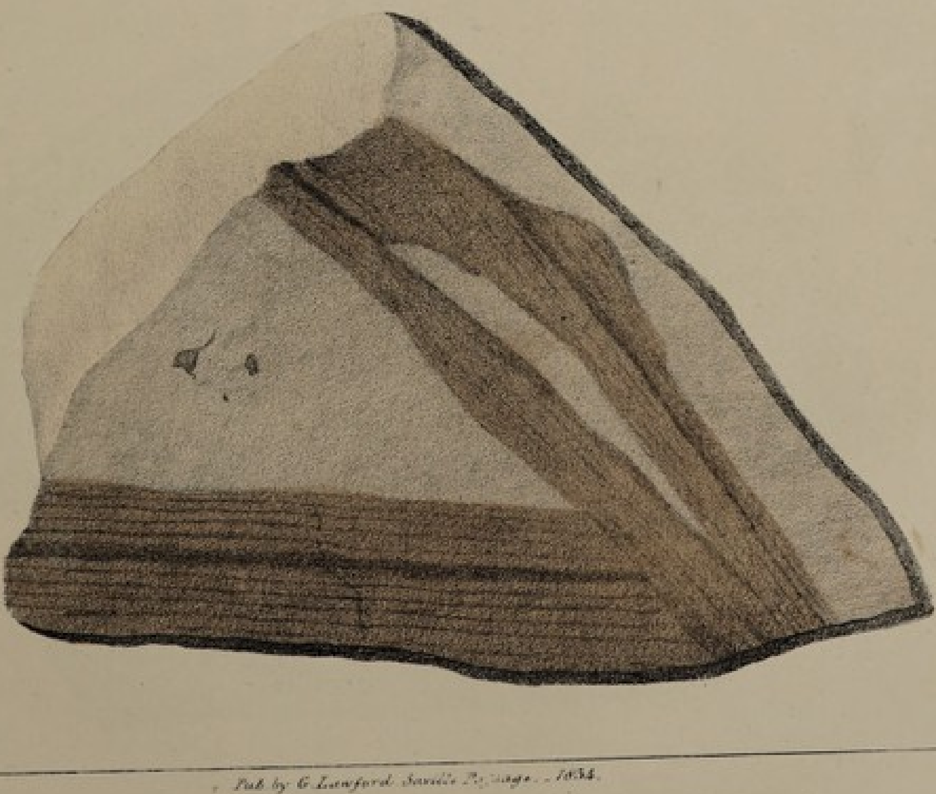

Madeley litho.

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G. E. Madeley, Lith. 3 Wellington St. Strand. Pubd. by Geo. Lawford, Saville Passage. 1834.

(Moira Stone Quarry.)

24.

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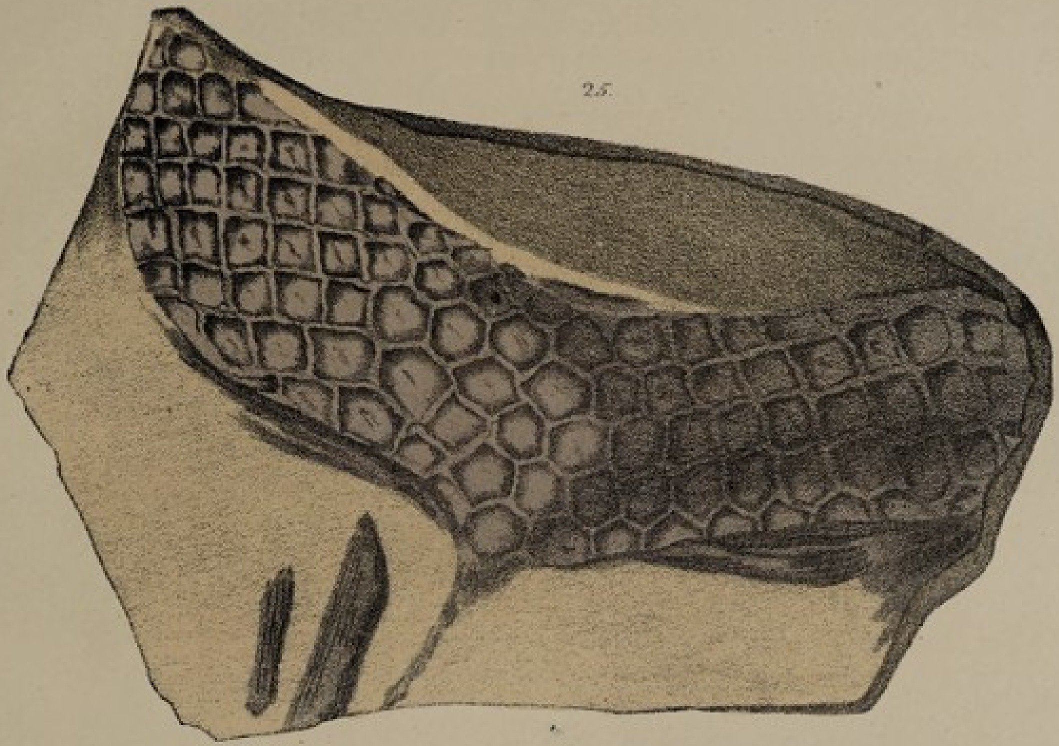
25.



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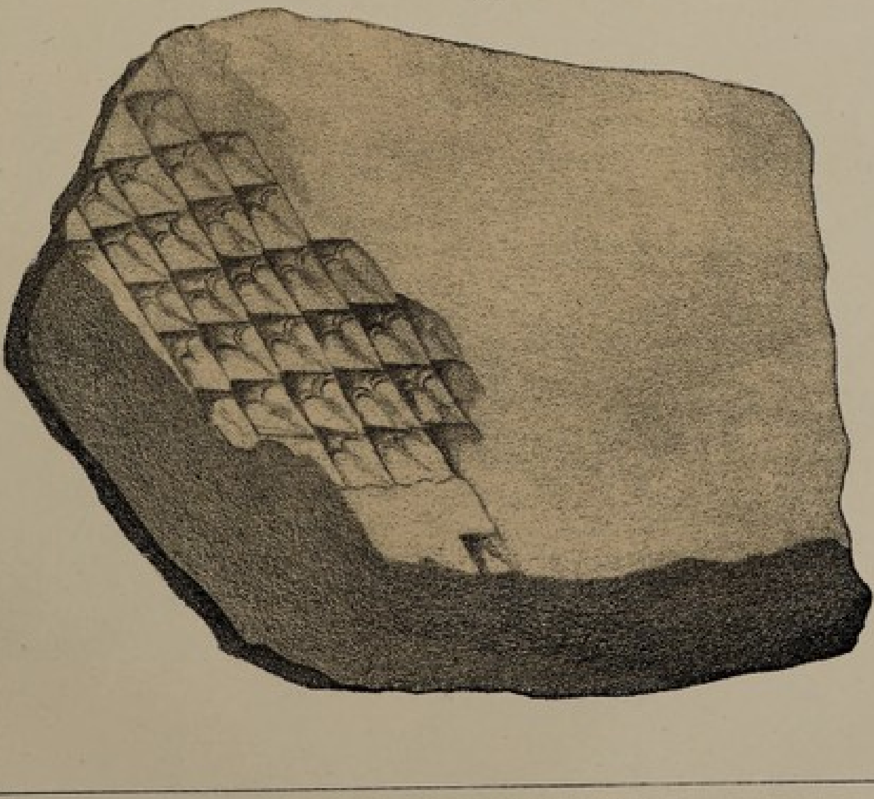

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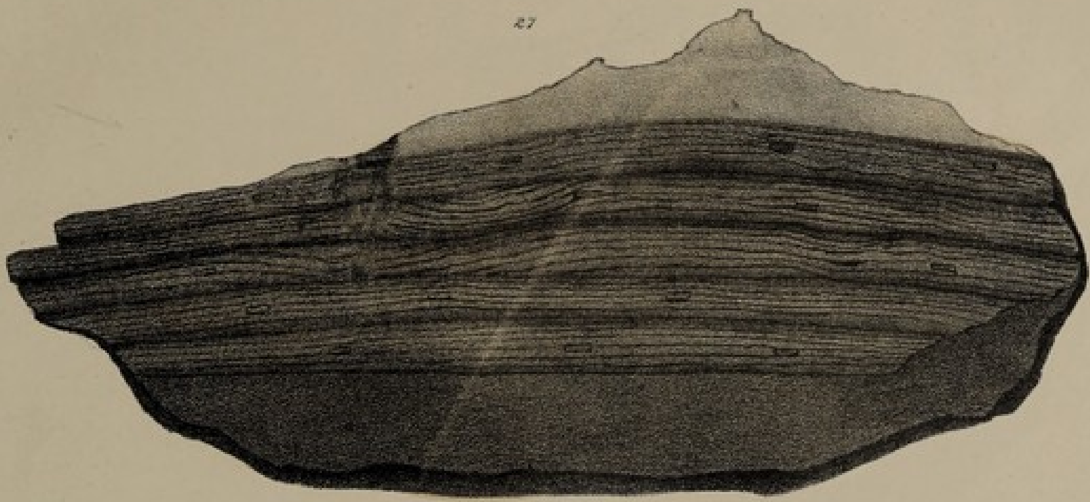

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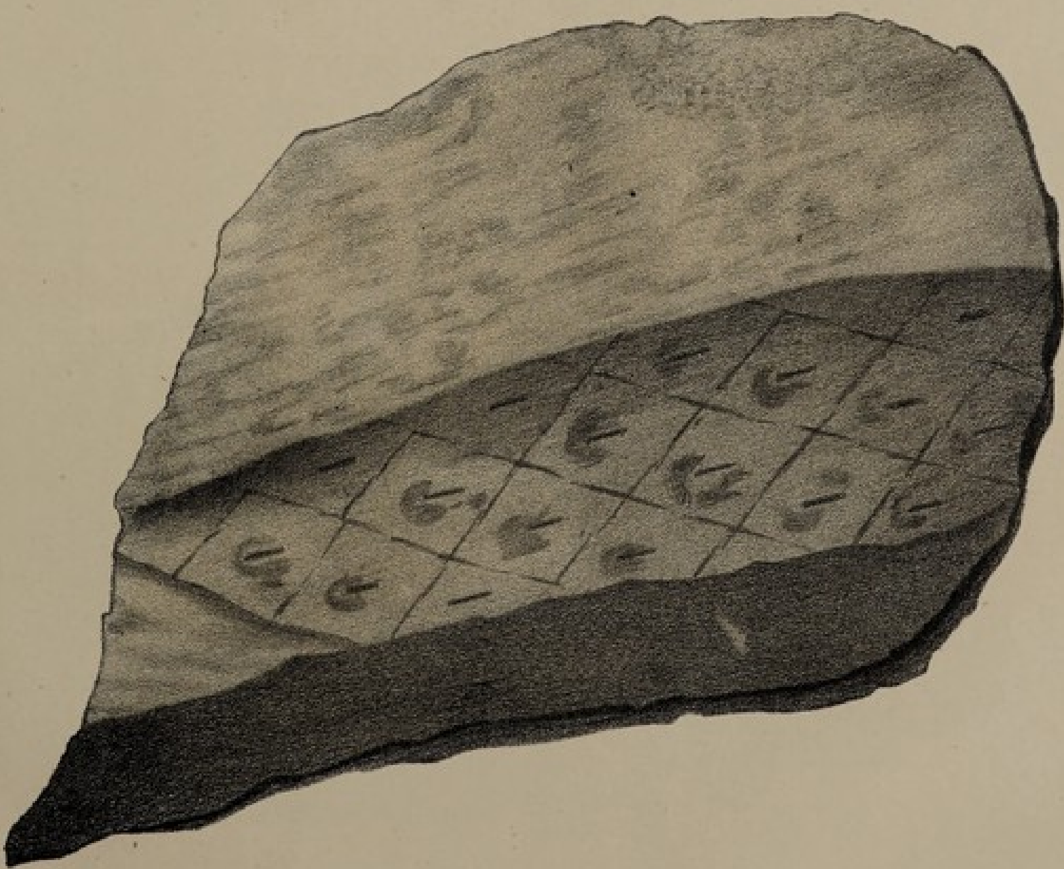

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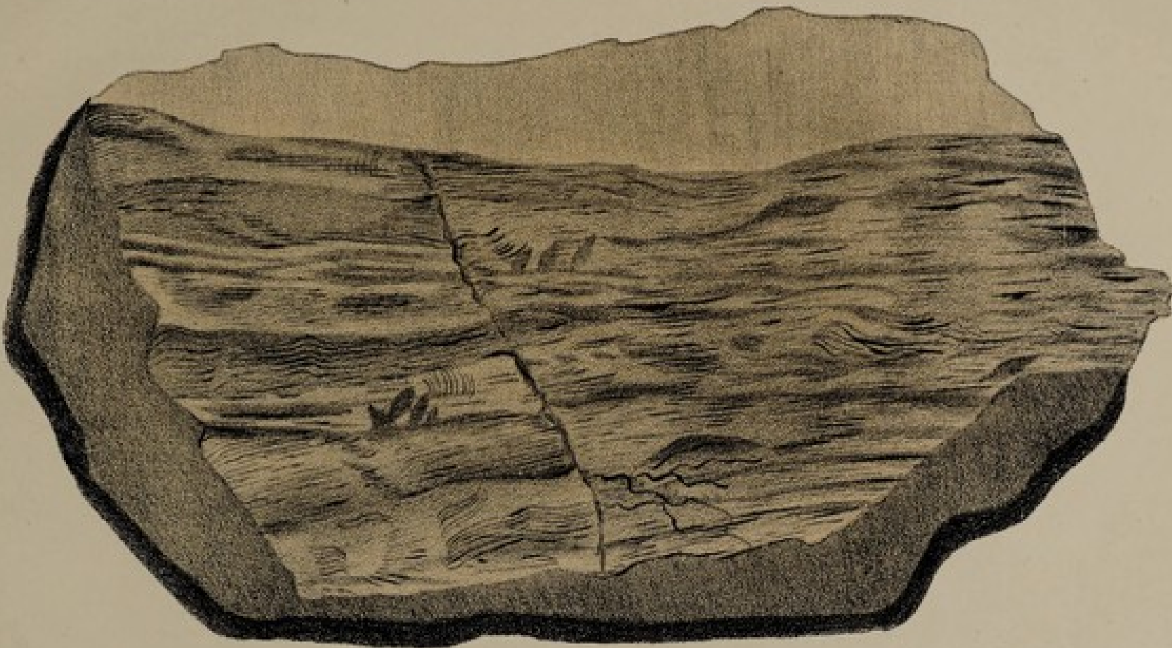

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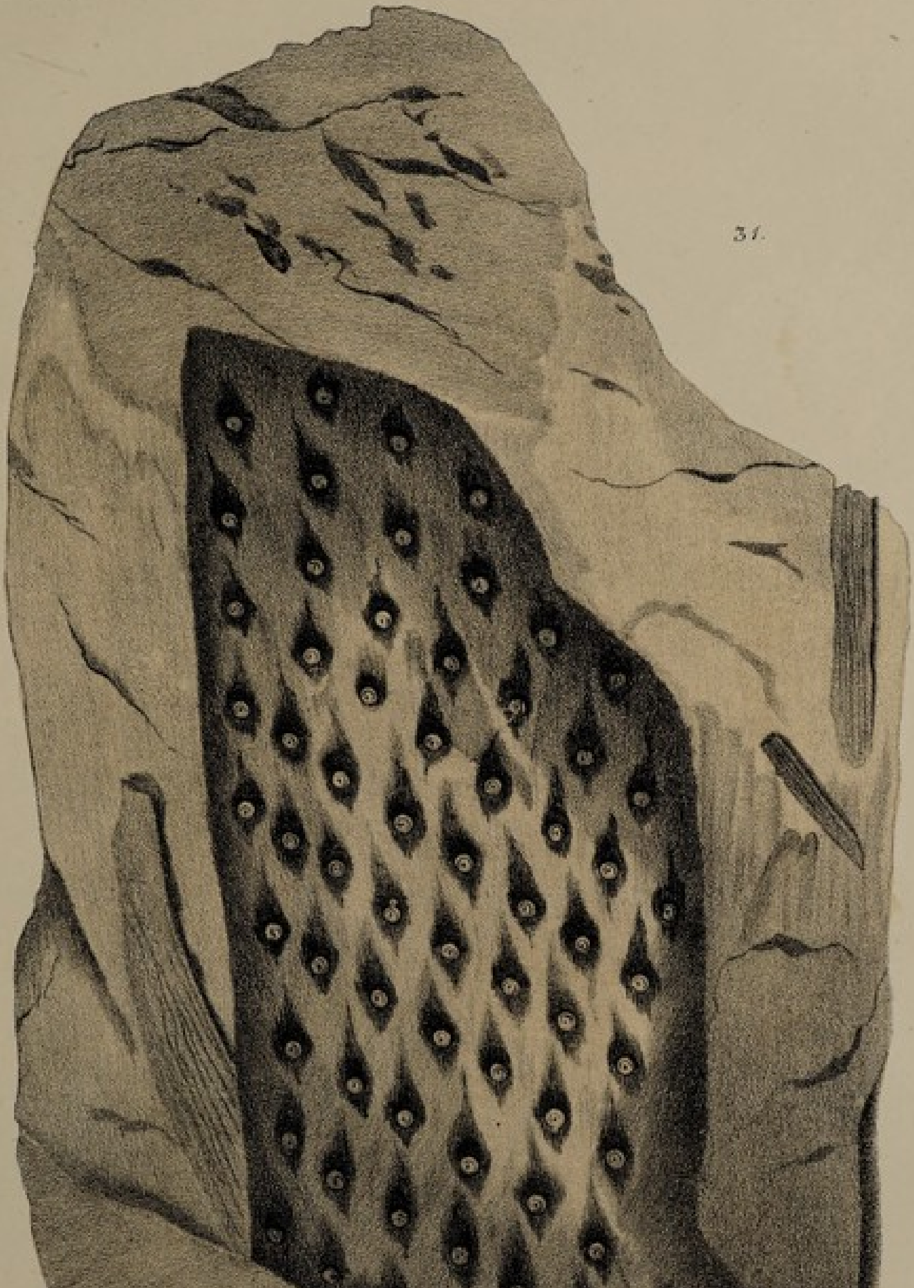

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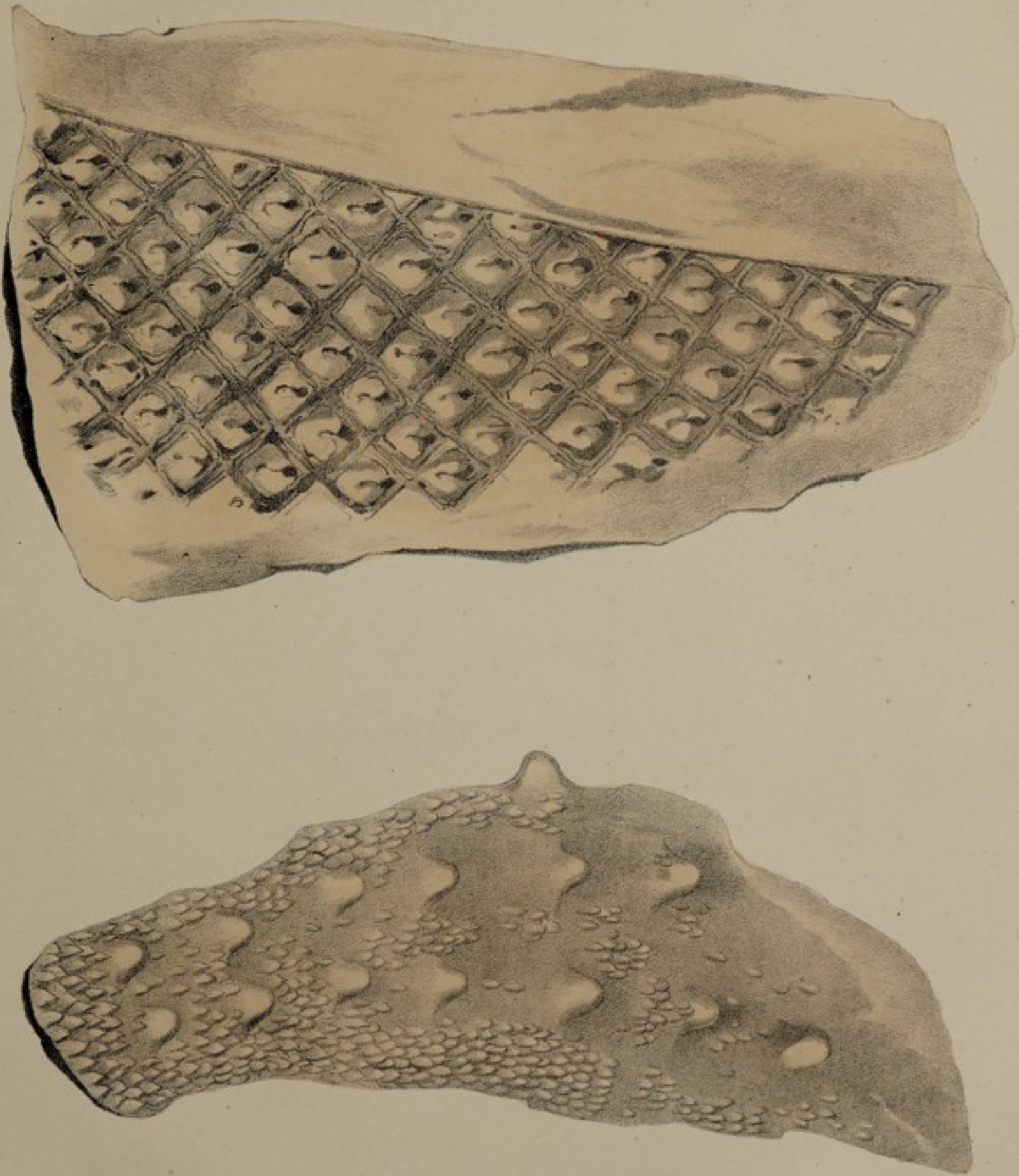

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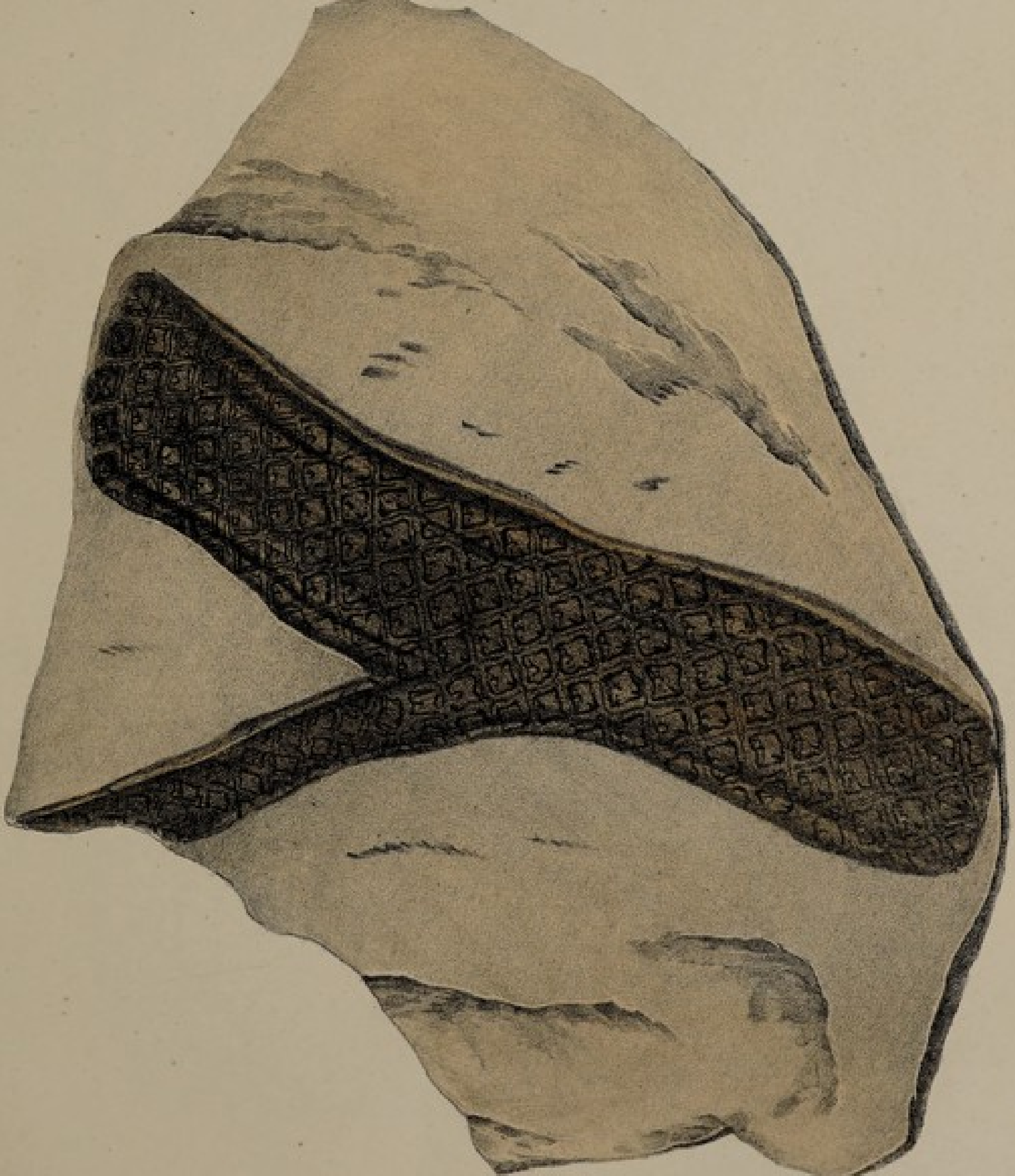

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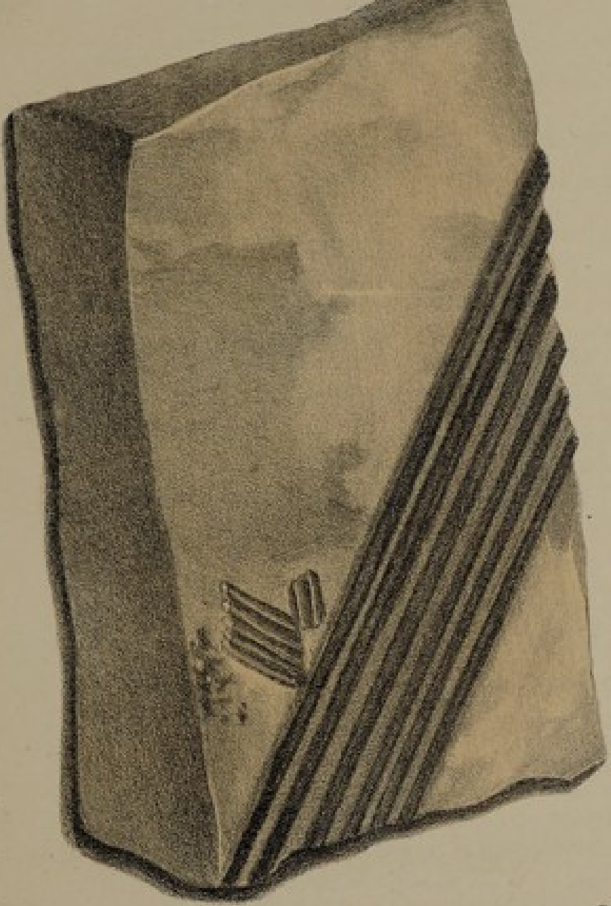

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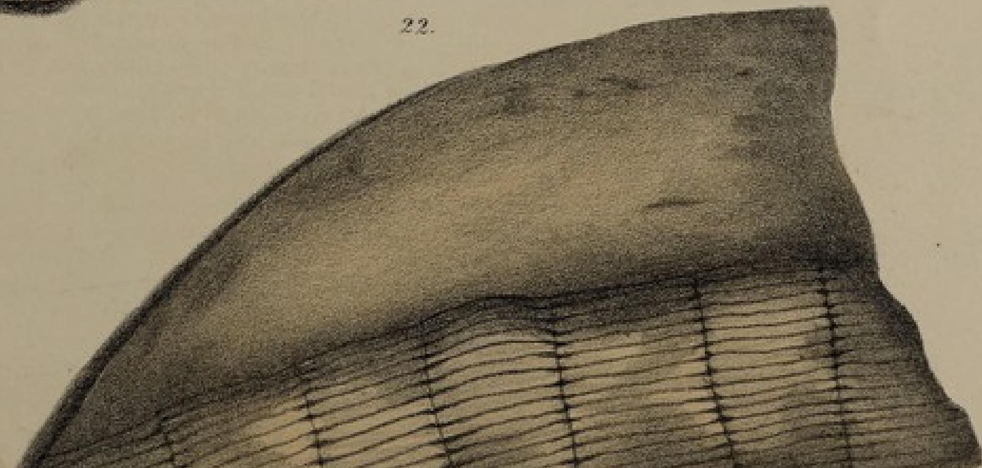

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