A mineralogical description of the county of Dumfries / By Robert Jameson.

A

MINERALOGICAL DESCRIPTION

OF THE

COUNTY OF DUMFRIES.

Patrick Murray L. of F.

By ROBERT JAMESON,

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TO

A. G. WERNER,

THE FATHER OF MINERALOGY;

AND

RICHARD KIRWAN,

WHOSE INDEFATIGABLE EXERTIONS HAVE
CONTRIBUTED SO GREATLY TO THE
ADVANCEMENT OF MINERALOGY
IN THE BRITISH EMPIRE.

THIS VOLUME

IS DEDICATED BY THEIR OBEDIENT SERVANT,

ROBERT JAMESON.

College of Edinburgh,
Oct. 10, 1804.

ERRATA.

Page	Line	
17	8	that *to be cancelled.*
58		*for* druſſy, *read* druſy.
154	2	*after* in, *add* engen Räumen eingeſchloſſen war, wodurch ihr.-

PREFACE.

THE Duke of Buccleugh, with his uſual patriotic attention to the intereſts of Dumfries-ſhire, propoſed ſome years ago to the landholders of the county to have a Map of it made for their uſe; and, with the approbation of his Grace, Colonel, now Brigadier-General Dirom of Mount Annan, ſuggeſted that a Mineral ſurvey ſhould alſo be made of the county, in order to connect a knowledge of its foſſils and internal ſtructure with the land ſurvey which was then carrying on by Mr. William Crawford.

"The meeting unanimouſly approved "of the propoſal for the mineral ſurvey, "and voted their thanks to his Grace the "Duke of Buccleugh for having been "pleaſed to recommend it to their atten-"tion; and to Colonel Dirom for having "brought forward a plan ſo likely to be "uſeful to the county."

Upon that occaſion I was applied to by the General and by Colonel Wight

of Largnain, on the part of the county, to undertake the mineral ſurvey; but, being on the eve of my departure for Germany, I was under the neceſſity of declining to enter upon ſuch an inveſtigation. It being, however, the principal object of the gentlemen of the county to obtain information as to the probability of finding coal in the extenſive tract of country which lies between the rivers Eſk and Nith, they engaged two *coal viewers* from Northumberland, Meſſrs. Buſby, to make the ſurvey, to whom, both the late Dr. Walker, my predeceſſor in the chair of natural hiſtory, and myſelf, gave inſtructions, which, together with their report, are, I underſtand, in the poſſeſſion of the county.

Previous to my return from Germany, General Dirom had prepared a Tablet, containing ſections, and exhibiting a general view of the Mineralogy of Dumfries-ſhire, to be printed on the map of the county, and which, in a ſmall compaſs, contains much uſeful and intereſt-

ing information. But, as both the General and Colonel Wight conſidered what had been done as ſtill not affording the complete information which was expected by the landholders of the county, upon this important ſubject, I was again requeſted by theſe intelligent gentlemen to undertake the publication of a more detailed mineralogical deſcription of Dumfries-ſhire, which might accompany the county map, which was ſtill unpubliſhed. To this propoſal I acceded with pleaſure, not only from my deſire to promote ſuch uſeful inveſtigations, but alſo from its tending to carry into effect a plan which I had long in contemplation, of examining the mineralogy of every part of Scotland, and of offering, in this manner, the reſult of my labours for the information of the public.

INTRODUCTION.

In a country like Scotland, whoſe ſurface preſents ſo great a variety of rocks, and which agrees in many reſpects with the moſt important mining countries in other parts of the world, it is evident that many conſiderable mineral repoſitories are to be expected. Its ſituation, the ſtructure of its ſurface, and the abundance of water and coal which it poſſeſſes, render it peculiarly well adapted for carrying on with œconomy and profit the various operations of mining.

But as ores, coals, and other uſeful minerals are uſually hid in the bowels of the earth, we muſt endeavour by min-

ing to trace them out; and in theſe reſearches we muſt follow a determinate plan, founded on an accurate local knowledge of the diſtrict where the trials are made; otherwiſe in excavating galleries, driving levels, ſinking ſhafts, and putting down bore-holes, our operations will be uncertain.

Theſe operations muſt be conducted with ſkill, and their execution ſhould be ſuperintended by well educated and intelligent mine-engineers.

It is an opinion too generally credited, that the art of mining is eaſy and ſimple, and that little education, and no very great ſhare of practical knowledge is neceſſary for its ſucceſsful proſecution. But this aſſertion is founded on ignorance; for of all the arts with which man is occupied, there is none which requires more preliminary knowledge or more extenſive experience. A *mine engineer* muſt be well inſtructed in ſubterranean geo-

metry; he muſt be intimately acquainted with mechanics, hydraulics, and hydroſtatics, ſo that he may be able to judge correctly of the machines which are employed in conveying the ores from one part of a mine to the other, raiſing them to the ſurface, and ſtamping and waſhing them, alſo with the elegant and powerful machines uſed in draining mines; he muſt poſſeſs as much knowledge of architecture as will enable him to ſuperintend the conſtruction of the various kinds of building which are employed in ſubterranean works, and in the erection of the different day buildings, as engine, ſmelting, and waſhing houſes, and alſo that of canals, artificial reſervoirs for water, &c.; nor ſhould he be ignorant of the art of carpentry, particularly that ſpecies of it which is employed in conſtructing ſubterranean works. His knowledge of mineralogy muſt be correct and extenſive, in order to enable him to know and diſtinguiſh ſimple minerals, and to judge with accuracy of the

various mineral repoſitories; he muſt be acquainted with all the branches of chemiſtry, but moſt particularly with that of metallurgy; and he muſt not be indebted to lectures, books, drawings, and models alone for his knowledge; he muſt have aſſiſted for years in all the practices I have juſt mentioned. When this courſe of education is finiſhed, he ſhould be able conſcientiouſly to take charge of a great mine, or to eſtabliſh one in a country where there are few to aſſiſt him with knowledge or experience.

I could mention very many inſtances of the great loſs to proprietors and ſtates by the want of ſkill and experience in mine-engineers, but I ſhall at preſent mention only one, and it is very ſtriking. In Spaniſh America, according to Anton Zacharias Helms, the amalgamation of the ore continues an entire month, and in each operation there is a loſs of twenty-five pounds of mercury in the quintal, and a part of the ſilver remains in the

ore. At Freyberg the operation is finiſh- in twenty-four hours, the loſs of mercury does not exceed half an ounce, and a ſmall quantity of ſilver is obtained which was not even indicated in the cupellation of the eſſayer. Daubiſſon, a diſtinguiſh- ed pupil of Werner, in his maſterly deſ- cription of the mines of Freyberg, infers very juſtly from this fact that the pro- duce of the Spaniſh American mines might be greatly increaſed, nay nearly doubled *.

* As it may be intereſting to ſome of my readers to know the actual produce of theſe famous mines, I here ſubjoin an extract from the work of Daubiſſon already mentioned, containing an account of the re- turns made to the Spaniſh mint, in the year 1790.

	Cities.	*Provinces.*	*In gold.* *Livres.*	*In ſilver.* *Livres.*
a.	St. Jago	Chili	4,417,134	894,327
b.	Potoſi	Buenos-Ayres	1,833,728	24,367,668
c.	Lima	Peru	5,023,616	27,768,000
d.	Mexico	Mexico	3,843,629	106,706,140
			15,118,107	159,736,135

But independent of the employment which the reſearches I am now engaged in will afford to the miner, by the diſcovery of uſeful minerals, it will, I truſt, alſo prove a ſource of information to the mineralogiſt. Few countries ſo little explored as Scotland have afforded a greater variety of minerals, which allows us to hope that a more complete and accurate inveſtigation will increaſe the number of hitherto undeſcribed oryctognoſtic products. The geognoſt *, will obtain new facts, and

To this ſum, amounting to one hundred and ſeven-four million of livres, may be added the quantity of gold and ſilver not delivered to the mint, but which is worked for churches, convents, and other uſes, which is very conſiderable. Thus we may reckon that there is annually raiſed from the mines of Spaniſh America the value of two hundred million livres, or fifty million rix-dollars.

* Geognoſie not only makes us acquainted with the materials and ſtructure of the cruſt of the earth, but alſo with the hiſtory of the changes which it has experienced, thus forming a moſt intereſting branch

a more extenſive generalization of thoſe already known reſpecting the ſtructure and relative poſition of the maſſes of which the earth is compoſed, by an examination of the unexplored wilds of Scotland.

In the Mineralogical Deſcription of the County of Dumfries, which forms the firſt part of this volume, I have laid down

of *Natural Hiſtory*. But it is not confined to the hiſtory of the changes which the inorganic parts of the globe have undergone; it alſo developes thoſe numerous and wonderful alterations which the organic creation has experienced ſince it was firſt formed by the creator. Taken in this view, geognoſie ceaſes to be that unconnected, vague, and uſeleſs jargon which it was before the time of Werner; it is thus raiſed to the rank of the moſt important and intereſting of the ſciences. It unites all the branches of natural hiſtory, (I mean natural hiſtory commonly ſo called, which includes natural deſcription and the hiſtory of natural bodies,) and forms the link which connects the inveſtigations of the naturaliſt with thoſe of the aſtronomer, the one being employed in inveſtigating the ſtructure of the world, the other that of the univerſe.

the plan I intend to follow in all my future labours in this department of mineralogy. It is different from any hitherto propoſed, but from its concordance with the principles of the Wernerian geognoſie I truſt it will be found calculated to give a clear, diſtinct, and comprehenſive view of the external aſpect and internal ſtructure and materials of which a country is compoſed.

The Deſcription of Dumfries-ſhire, which I now preſume to lay before the public, is not ſo complete as to ſatisfy a well informed mineralogiſt; I truſt, however, that although incomplete it will be found accurate. The obſervations which it contains, conſidered in an œconomical point of view, ſhew that many extenſive tracts of the independent coal formation exiſt in different parts of the county; that limeſtone may exiſt in many places where it has not been hitherto expected; that from the ſhape of the mountains in the upper part of the

county, and the kind of rock of which they are compoſed, mineral repoſitories of different kinds, but particularly of lead ore, are to be expected; and that roof ſlate will be found in many parts of the tranſition country.

The geognoſtical obſervations make us acquainted, 1. With an extenſive tract of tranſition rocks, a claſs of rocks hitherto unnoticed in Great Britain *.

* I have traced the tranſition rocks from the northern extremity of the Pentland hills, which is about ſix miles diſtant from the ſhore of the firth of Forth, to Lang-robie in Dumfries-ſhire, about three miles from the Solway frith. The ſame claſs of rocks reaches from Langholm to Minihive, and at length terminates near New Galloway, where it is ſucceeded by primitive rocks. The Moorfoot hills near Edinburgh, which form one of the boundaries of the great coal field of the Lothians, are compoſed of tranſition rocks; and I have every reaſon to believe that theſe rocks continue nearly to the termination of the mountain range at St. Abb's head on the eaſt coaſt. Granite is ſaid to have been found at Faſſnet burn, which is in the tract I conſider

2. With a lead glance formation different from any deſcribed by Werner or any other geognoſt. 3. With a formation of pitchſtone, reſembling that of the iſland of Arran, which belongs to the neweſt floetz-trap formation. 4. With a coal formation which reſembles in many reſpects the old red ſandſtone, but which is moſt diſtinctly different as a formation. 5. With the occurrence of glance coal in the independent coal formation, and with a new ſubſpecies called *columnar glance coal.*

In the Notes and Illuſtrations there is a particular account of the occurrence of

to be tranſition. I ſuppoſe ſyenitic greenſtone has been confounded with granite.

Since writing the above, I have examined a ſuite of ſpecimens brought from Faſſnet burn and the neighbourhood of St Abb's head by Dr. Hope, and find my conjecture, reſpecting the extent of the tranſition rocks, and the nature of the ſuppoſed granite of Faſſnet, confirmed.

greenſtone in the independent coal formation, a diſcovery which ſupplies a link hitherto wanting in the Wernerian trap formation ſuite, and which ſhews that there is floetz-trap of different ages; and with a new graphite formation which differs from that hitherto known in its accompanying foſſils and rocks, and in its geognoſtic ſituation.

MINERALOGICAL DESCRIPTION

OF THE

COUNTY OF DUMFRIES.

Situation of the County—its Extent—Mountains—Valleys and Rivers.—Observations on the Formation of Valleys—and of the Phenomena presented by those in the County of Dumfries.—Springs.—Those of Moffat.—their Properties and Medicinal virtues.—Springs of salt Water.—Method of determining true salt Springs.—Conjectures respecting the Mineral Impregnations of Springs.—Of the frequency of Springs in Rocks belonging to the floetz-trap Formation.—Lakes.

Situation.

DUMFRIES-SHIRE is the moſt ſouthern border county of Scotland. It is bounded on the north by the counties of Lanark, Peebles, and Selkirk; on the weſt

by Kirkcudbrightſhire and part of Ayrſhire; on the ſouth by the Solway frith; and on the eaſt by the ſhire of Roxburgh and a part of Cumberland.

Where it is bounded by the ſhires of Kirkcudbright and Ayr it is mountainous, and equally ſo where it borders on thoſe of Lanark, Selkirk, and Roxburgh; but on the ſhores of the Solway frith it is low and comparatively flat.

Extent. It is about fifty miles long, and thirty miles broad.

Mountains. The ſouth of Scotland, according to General Roy, is traverſed by a chain of mountains which reaches from Galloway to the eaſt coaſt of England, including the Cheviot hills. A conſiderable portion of the upper part of this county is ſituated in this *chain of mountain groupes* *. The mountainous part of

* See Note A, at the end of this Part.

the county, however, cannot be conſidered as a part of one groupe, nor as a ſingle groupe, but as compoſed of ſeveral groupes and parts of others, whoſe oppoſite declivities fall into the adjoining counties. The determination of the length, breadth, height and ſhape of theſe groupes, and of their connections with each other, and with the great ſouthern chain, is an inveſtigation which would prove of much utility to the geographer and to the geognoſt. I regret that I have not been able, from want of leiſure, to ſatisfy myſelf reſpecting this important part of a geognoſtic inveſtigation; at preſent I muſt therefore reſt ſatisfied with ſtating a very few obſervations on the chains, and individual mountains of which theſe chains are compoſed. I hope, however, that my brother, who is now reſident in the county, will execute this very uſeful piece of inveſtigation.

Characters of the mountain chains and mountains.

The individual chains of which the groupes are compoſed have generally a narrow foot, a great acclivity, and a round-backed ridge or ſummit. The mountains of which theſe chains are compoſed have in general an inconſiderable foot, a great acclivity, and a very ſhort ſummit. The ſummit is generally round-backed or flattened; ſometimes it is rather conical, and in a few inſtances tabular; but in this county the frequent conical and alpine peaked ſummits are not to be obſerved; in this reſpect it forms a ſtriking contraſt with the mountainous country to the north of the firth of Forth *.

From the groupes of which the more elevated parts of the county are compoſed there proceeds a mountain arm that divides part of Annandale from the lower part of Nithſdale, or from that part of it which may be called the valley of Dum-

* Note B.

fries; and an elevated mountainous country divides the valley of Annan from the valley of Eſk.

Heights of mountains.

The higheſt mountain in the county is Hartfell, which was meaſured by the late Dr Walker; a number of others have been meaſured, and their heights are mentioned in the county map, from which the following liſt is extracted.

NITHSDALE.	Feet above the level of the ſea.
Wardlaw in Carlaverock -	326
Queenſberry Hill - -	2140
Cairn Kinnow, near Drumlanrig	2080
Black Larg, next Ayrſhire -	2890
Towns of Wanlockhead and Leadhills - - -	1564
Lowther, near Leadhills -	3130
ANNANDALE.	
Annan Hill - -	256
Repentance Tower - -	350
Burnſwark Hill - - -	740
Errickſtane Braehead - -	1118
Loch Skene - - -	1300
Hartfell, above the ſea -	3300

ESKDALE.

Langholm Hill - -	1204
Tennis Hill, in Tarres -	1346
Moſſpaul, in Ewes - -	820
Wiſp Hill, in Ewes - -	1836
Ettrick Pen, in Eſkdale Moor	2220

Low country. That part of the county which lies to the ſouth of what is ſtrictly to be conſidered the termination of the valleys of Annan and Eſk, or of a line drawn from Whinnyrig, by Ecclefechan, Craigſhaws, Solway bank, Broomholm and Muirburnhead is comparatively low and flat, and occaſionally marked by gently riſing round-backed low hills, which ſometimes approach to the obtuſe conical, as Repentance and Woodcock-air.

Dales. The county is divided into three river diſtricts *, named Nithſdale, Annandale, and Eſkdale, which are traverſed by the ri-

Rivers. vers Nith, Annan, and Eſk, that carry

* Note C.

nearly all the water which falls on the ſurface of the county to the Solway firth.

River Nith. The river Nith, which riſes in the upper part of Ayrſhire, enters Nithſdale by the foot of Carſoncone hill, and is poured into a rather circular? valley, which is occupied by the pariſhes of Kirkconnel and Sanquhar. This valley is ſurrounded by hills, excepting at its upper part, where the Nith enters from Ayrſhire, and at its lower part, near Elliock-bridge, where there is a paſſage through which the river forces its way. The river, after having traverſed the valley and collected all the water of this diſtrict, continues its courſe through the paſſage above mentioned, and winds among hills, until it enters into a nearly ſimilar valley, in which is ſituated the pariſhes of Morton, Cloſeburn, and part of the pariſhes of Penpont, Tyrone and Kier. This valley is about ſeven miles long and two broad, and is ſurrounded by hills, which in ſome places are of conſiderable height. Like the val-

Valley of Sanquhar.

Valley of Cloſeburn.

ley of Sanquhar and Kirkconnel, it is interſected at its loweſt point by the river Nith, which continues its courſe from this, through a hilly country, and in a rocky channel, until it enters the valley of Dumfries, through which it runs placidly until it pours the collected water of the diſtrict of Annandale into the Solway frith, near to Carlaverock caſtle. This valley differs from the preceding, in being completely open at its ſouthern or lower extremity, where it is bounded by the ſhores of the Solway frith, and in having a lengthened in place of a circular ſhape. On its weſt ſide it is bounded by the mountains of Galloway, of which the higheſt is the Criffle: on the eaſt ſide it is bounded by a mountain arm which ſeparates it from the neighbouring diſtrict of Annandale. Through the valley there runs a ſmall hilly ridge, which riſes at Carlaverock Caſtle and terminates at the town of Dumfries, and ſeparates the ſtream called the Lochar from the Nith. Beſides the valleys already mentioned,

Valley of Dumfries.

there are a number of lateral valleys that open into Nithſdale; of theſe the moſt conſiderable are Crawick, Yochan, Mennoch, Carron, and Skarr. Lateral valleys of Nithſdale.

The valley of Annan, commences above the village of Moffat, in the tremendous hollow of Erickſtæne, and terminates near the Manſe of St Mungo, a diſtance of twenty-three miles. Several lateral valleys terminate in it; of theſe the moſt conſiderable are Moffat and Dryffe; others of leſs importance are Kennel, Whamphry, and Evan. Beſides the valley of Annan and the lateral valleys that open into it, there is another valley in the diſtrict of Annandale, which opens without the valley of Annan. It is called the valley of Milk. It takes its riſe from the mountains called Milk Water-head, which are ſituated in the high country that ſeparates Annandale from Eſkdale, and terminates at Sorryſyke, a little way above the confluence of the water of Milk with the river Annan. Ex- Valley of Annan. Lateral Valleys of Dryffe, &c. Valley of Milk.

terior valleys of leſs importance are Mein and Kirtle.

River Annan. The river Annan riſes in the high mountains above Moffat *. and runs through the flat part of the valley of Annan (principally through alluvial land) until near the manſe of Saint Mungo, where it flows between and over rocks of the floetz-trap formation. From this point, which, as it is the termination, is alſo the loweſt point of the valley of Annan, it continues its courſe through the lower part of the diſtrict of Annandale, and after a run of thirty-ſeven miles from its ſource, it is poured into the Solway frith at Annan.

Valley of Eſk. This valley commences from the mountains called Eſk Water-head, and continues bounded by high hills to Broomholm, about four miles below Langholm; from

* From the north-weſt ſide of theſe mountains the river Clyde riſes, and from the north-eaſt the river Tweed; a proof that they are the moſt elevated points in the ſouth of Scotland.

this until its termination in the Solway frith it proceeds through a flat country, and is rather to be viewed as a deep river-courſe than as a valley. Several lateral valleys open into it, and of theſe the moſt conſiderable are Black Eſk, Meggot, Ewes, and Wauchope. Lateral valleys of Eſk.

The river Eſk riſes in the high country of Eſk Water-head, and runs among mountains to Broomholm, in its courſe being joined by the ſtreams of Black Eſk, Meggot, Ewes, and Wauchope. From Broomholm it flows through a flat country, and before it reaches the Solway frith it paſſes through a corner of Cumberland, and is joined by the river Liddel from Roxburghſhire and the Line of Cumberland. Its length is thirty miles in the county of Dumfries, but thirty-eight to the Solway frith. River Eſk.

The ſides of the valleys are in general ſmooth and covered with vegetation; ſometimes they are rocky and cliffy. Character of the ſides of the valleys.

Bottom of the valleys.

The bottoms of the valleys are ſometimes rocky, but more generally covered by alluvial or water-borne land. On the loweſt banks of the rivers, where the neweſt alluvial land is depoſited, there is found the richeſt and moſt productive tracts in Dumfries-ſhire.

The nearly incloſed valleys of Sanquhar and Kirkconnel, and of Cloſeburn and Annan are phenomena deſerving of our particular attention, from the information they convey to us, not only of the former ſtate of the earth's ſurface, but of the changes which it has ſtill to undergo. I ſhall employ this opportunity of mentioning ſeveral remarkable appearances of a ſimilar kind, which have been obſerved in this and in other countries, with the view of directing the attention of geognoſts to phenomena which are in many reſpects highly intereſting, and of rendering the explanation which I ſhall attempt to give of the formation of the valleys in Dumfries-ſhire more diſtinct.

Valleys on the river Don.

The river Don in Aberdeenſhire, according to the deſcription given by Dr Anderſon, in his Agricultural Report of that county, paſſes through ſeveral circular or nearly incloſed valleys. "The Don," he obſerves, "aſſumes a character in every "reſpect the reverſe of the Dee; at its "mouth its rocks confine it to a narrow "channel, and give to it there a gloomy "aſpect, which would convey the idea of "its flowing through a mountainous and "rugged country, where no ſpace was "left for forming even a commodious "road along its banks; but on aſcend-"ing on it for about one mile, the hills "recede from it, ſo as to form ſpacious "haughs on either ſide, through which "the river flows in a ſlow and majeſtic "courſe for many miles; nor is the pro-"ſpect here uniform, but agreeably di-"verſified, the hills above Inverury ap-"proaching cloſe to the river, through "which it ſeems to have forced its way "with difficulty, then all at once it opens

" into another ſpacious plain, from which " they recede on either hand to a great " diſtance, then it cloſes again; and, after " another temporary confinement among " rocks and hills and woods, it waters " once more another plain of great extent. " Such is the general character of this " river." The Rhone, in its courſe to the ſea, alſo paſſes through ſeveral valleys reſembling thoſe of the Don, Nith, and Annan. The Rhine alſo paſſes through ſimilar baſins or valleys during its progreſs towards the ocean.

Valleys on the Rhone and Rhine.

Valleys on the Danube.

The Danube, whoſe hiſtory has been ſo well illuſtrated by the Count de Marſigli, has its ſource in the mountains of Swabia, from whence it paſſes through Swabia, Bavaria, Auſtria, Hungary, and Wallachia, into the Black ſea. Swabia is a great circular valley, from which the Danube eſcapes by a narrow rocky opening into Bavaria; during its progreſs through Bavaria it paſſes through ſeveral

circular valleys into Lower Auſtria, which is alſo a circular valley. It flows through Auſtria, and at Preſburg, where the valley is nearly ſhut up, it forces its way through rocks and hills into Hungary, which is one of the moſt extenſive circular valleys in Europe. At the lower extremity of Hungary the river is again forced to ſeek its way through a narrow rocky channel at Oroſova, which is the only opening between Hungary and Wallachia. It now continues its courſe through Wallachia, and at length falls into the Black ſea. We have a continuation of this chain of valleys, although ſtill filled with water, in the Black ſea, ſea of Marmora, and the Mediteranean *,

Valley of Cachmere.

Mr Pennant, in the firſt volume of his Outlines of the Globe, when deſcribing the country of Cachmere, obſerves, "This "happy valley, this paradiſe of Hin-"doſtan, of the Indian poets, is of an

* Note D.

" oval form, about eighty miles long and
" forty broad, and was once ſuppoſed to
" have been entirely filled with water,
" which, having burſt its mound, left the
" vale nouriſhed to the moſt diſtant ages
" by the fertilizing mud of the river which
" fed its expanſe. This delicious ſpot
" is ſurrounded by mountains of vaſt
" height and rude aſpect, covered with
" ſnow and inchaſed in glaciers, in which
" this enchanting jewel is firmly ſet."

Valleys on the Elbe.

Bohemia is a great circular valley, whoſe bottom inclines towards its only opening above Königſtein, through which iſſues the river Elbe, carrying with it all the water that falls in Bohemia. Immediately below this narrow rocky outlet there is another ſmall circular valley, which extends from Königſtein to Pirna; at Pirna it is nearly cloſed up, the river forcing its way through a narrow rocky opening, and at length it iſſues into a very beautiful circular valley in which the delightful city of Dreſden is ſituated.

This valley, as we approach Meiſſen, becomes narrow, and the river Elbe again flows through a rocky channel until it eſcapes into the low country, through which it winds and traverſes the flats of Lower Saxony, and at length is poured into the North ſea at Cuxhaven.

Having now briefly mentioned ſome of the moſt remarkable inſtances of circular or incloſed valleys, which have been obſerved by geographers, I ſhall add a few obſervations on the formation of valleys, and ſhall then hazard a conjecture reſpecting the formation of the valleys of Sanquhar, Cloſeburn, and Annan.

Opinions reſpecting the formation of valleys.

Many different explanations have been propoſed reſpecting the formation of valleys, but the opinion which has been moſt generally adopted, is that which aſſerts that all valleys have been hollowed out of the ſolid rock by the action of running water. The following obſervations contain what ſome will conſider to

be the moſt probable explanation of theſe intereſting phenomena.

Valleys formed by mountain groupes.

1. Chains of mountain groupes are ſometimes diſpoſed in a circular form, ſo as to include great tracts of flat country, as is the caſe with Swabia, Hungary, Tranſilvania, &c. Theſe circular valleys are therefore evidently not the effects of running water.

Valleys formed by original inequalities.

2. *a.* Granite, the oldeſt rock with which we are acquainted*, has been formed with great inequalities, and theſe have given riſe to many of the valleys that now mark the ſurface of the earth. Although many of theſe original inequalities have been filled up by the depoſition of newer rocks as gneiſs, mica ſlate, clay ſlate, &c. yet many have remained in their original ſtate, or have been but partially filled, ſo that in either caſe there ſtill remained

* The opinion that granite is one of the newer rocks has been refuted in Nicholſon's Journal.

very great inequalities, not formed by the action of running water.

b. In many inſtances the newer rocks, as gneiſs, mica ſlate, and clay ſlate, after filling up the granite hollows, appear to have been depoſited in greater quantity in one place than another, and thus original inequalities, or mountains and valleys have been formed.

Valleys formed by the widening of great rents.

3. It is not improbable, from what we know of the natural hiſtory of rents, that in many caſes, particularly in the higher parts of the globe, immenſe fiſſures may have been formed, and theſe by the long continued action of water may have been faſhioned out into valleys*.

Valleys formed by the action of running water.

4. Neither is it to be doubted that running water has frequently hollowed valleys out of a ſurface not very deeply

* Werner neue Theorie von der Entſtehung der Gänge, ſ. 253.

marked b yoriginal inequalities, and that it has alſo, during a long courſe of ages, enlarged and deepened the original valleys.

We have thus valleys formed by the original grouping of primitive mountains, by the inequalities of the oldeſt rocks, by the widening of great rents, and by the action of running water. Having thus ſhewn how it is probable that many of theſe concavities have been produced, let us view the ſurface of the earth as it appeared on the retiring of the ocean, which formerly covered it to a great height *.

Appearance of the earth on the retiring of the ocean.

As the original ocean gradually diminiſhed and left the land uncovered, thoſe concavities which had no outlet would be left filled with water, and thus lakes would be formed; other inequalities

* In the third volume of my Syſtem of Mineralogy will be found Werner's demonſtration of the important fact that the ocean formerly covered the whole globe.

would, by collecting the waters precipitated on their ſurface, form the mighty original rivers. During the courſe of ages theſe original lakes and great rivers would, by the action of natural cauſes, gradually alter the earth's ſurface; lakes, by evaporation, or by their finding an exit by ſubterranean canals would become dry, and thus we would have in their ſtead rich valleys ſurrounded by mountains. In South America we have ſtriking inſtances of valleys of this kind, and alſo, but on a ſmaller ſcale, in Europe. Other lakes, and this appears to be the moſt common mode of change, by the deepening of their outlets and the filling up of their bottoms with gravel, &c. would at length diſappear, and what was formerly a great lake would be changed into a valley, having a river traverſing its bottom, and iſſuing by a narrow opening into the lower country. Others, according to Werner, appear to have opened to themſelves a paſſage in a very violent and ſudden manner.

Different ages of valleys.

But all theſe valleys are not of equal antiquity. After the water had diminiſhed to a pretty low level, it appears to have riſen again, to have covered the then exiſting ſyſtem of inequalities, and to have depoſited over the ſurface of the earth a mighty and univerſal formation (the floetz-trap formation). What were formerly longitudinal valleys, through which great rivers flowed uninterrupted to the ſea, were in many inſtances changed into inland ſeas or lakes, by the depoſition of the newer formation acroſs their communication with the ocean, others were entirely filled up, and thus on the retiring of the waters of the ocean, a nearly new ſyſtem of rivers and lakes and valleys made its appearance. The facts on which this opinion of the different ages of valleys is founded are numerous and concluſive, but cannot be detailed here.

Valley of Sanquhar formerly a lake.

The valley of Sanquhar and Kirkonnel appears to have been formerly in the ſtate of a lake, becauſe it is entirely ſur-

rounded by mountains, excepting at its communication with the valley of Cloſeburn, (which communication has been effected by the action of the lake emptying itſelf, and that of the river), and at Carſonconne-hill, where it borders on Ayrſhire. The valley of Cloſeburn has been formerly in a ſimilar ſtate.

Valley of Cloſeburn formerly a lake.

The valley of Annan, however, was probably at a former period a hollow in the tranſition rocks in which a great river flowed, (vaſtly greater than that which now exiſts), but by the depoſition of floetz-trap rocks acroſs its communication with the ocean, it appears afterwards to have been converted into an inland ſea or lake *. The water of the lake, after the retiring of the ocean,

Valley of Annan at one period a water courſe of a great river.

Afterwards a lake, and again a water-courſe of a river.

* To thoſe acquainted with the geognoſtic relations and hiſtory of the tranſition and floetz-trap rocks, the deſcription of the relative poſition of the rocks of this valley, contained in Chapter 2d, will render any further explanation of the above mentioned opinion unneceſſary.

appears to have worn a paſſage through the oppoſing rocks, and at length, as Profeſſor Playfair well expreſſes it, it has paſſed from the ſtate of a lake to that of a river. The river has gradually deepened its channel, and is diminiſhed in height and breadth. That the river formerly ſtood at a greater height, and poſſeſſed greater breadth than it does at preſent, is ſhewn by the great height of the original or high banks and their diſtance from one another.

The river is gradually diminiſhing.

SPRINGS.

The only ſprings deſerving of attention in this county are thoſe near the village of Moffat, which have been long well known on account of their medicinal virtues *.

* There is a chalybeate ſpring at Brow, in the pariſh of Ruthwell.

There are three ſprings, a ſulphureous, and two chalybeate.

The ſulphureous ſpring, or, as it is called, Moffat well, is about a mile and a half from the village of Moffat. It oozes out of a rock of compact grey wacke, which contains interſperſed iron pyrites. At a little diſtance there is a bog, which along with the pyrites in the grey wacke probably afford the ſulphureous impregnation to the ſpring. The water has a ſtrong ſulphureous ſmell, reſembling that of the ſulphureous waters of Harrowgate, but not quite ſo ſtrong. It has a ſlight ſaline taſte, and ſparkles when firſt taken from the ſpring, particularly when poured out of one glaſs into another. The ſides of the well are covered with a yellowiſh grey cruſt of ſulphur, and when the water has been allowed to ſtand ſome days without pumping, it becomes covered with a yellowiſh white film of ſulphur. According to the analyſis of the late Dr

Moffat well.

Qualities.

Garnet, a wine gallon of this ſpring contains,

Conſtituent parts.

Of muriat of ſoda (common ſalt)	36	grains
Sulphurated hydrogen gas	10	cubic inches
Azotic gas	4	do.
Carbonic acid	5	do.*

The water will not keep, however cloſely it is corked up, the ſulphurated hydrogen eſcaping; it ſhould therefore be uſed as ſoon as poſſible after it is taken from the well.

The water of this ſpring is much uſed in ſcorbutic and ſcrophulous caſes; and, it is ſaid, in certain ſtages of theſe diſeaſes, with good effect †.

Hartfell ſpaw.

The moſt conſiderable chalybeate ſpring, which is called Hartfell ſpaw, iſſues from a rock of alum ſlate, in a tremendous ravine on the ſide of the

* Garnet's Tour in Scotland, vol. 2.

† Dr. Johnſtone, in Garnet's Tour.

mountain of Hartfell, nearly five miles diſtant from the village of Moffat. Among the ſtrata of alum ſlate in this ravine, I obſerved frequently efflorescences of yellowiſh grey coloured natural alum; and Dr. Garnet mentions that he found cryſtals of natural iron vitriol. In the alum ſlate I obſerved maſſive and diſſeminated iron pyrites.

Dr. Garnet found that a wine gallon of Hartfell ſpaw contained Conſtituent parts.

Of Sulphat of iron (iron vitriol)	84	grains
Sulphat of alumina	12	do.
Azotic gas	5	cubic inches.

Together with fifteen grains of oxide of iron, with which the ſulphuric acid ſeems to be ſuperſaturated, and which it gradually depoſits on expoſure to the air, and almoſt immediately when boiled. The water of this ſpring, after heavy and continued rains, is always increaſed in quantity and ſtrength. This latter cir-

cumſtance is owing to the atmoſpheric water, during heavy rains, paſſing through channels in the alum rock more richly impregnated with the materials of the ſpring than thoſe it paſſes through during a long continued drought.

Dr. Garnet obſerves, "as the princi-
"pal mineralizers of this water are the ſul-
"phats of iron and alumina, it is evident
"that, if well corked, it will keep for
"months, and perhaps years, unimpaired
"in its qualities; hence it may be carried
"to a diſtance better than moſt mineral
"waters. As it keeps ſo well it is not ne-
"ceſſary to drink it on the ſpot, which
"would be very inconvenient, but it may
"be procured in Moffat in a freſh ſtate."

The Hartfell ſpaw, being a very power-ful tonic, is uſeful in diſeaſes of weak-neſs. Dr. Johnſtone remarks, "I have
"likewiſe known many inſtances of its
"particular good effects in coughs pro-
"ceeding from phlegm, ſpitting of blood,

" and ſweatings; in ſtomach complaints " attended with headaches, giddineſs, " heartburn, vomiting, indigeſtion, flatu- " lency, and habitual coſtiveneſs; in " gouty complaints affecting the ſtomach " and bowels; and in diſeaſes peculiar " to the fair ſex. It has likewiſe been " uſed with great advantage in tetterous " complaints, and old obſtinate ulcers *."

Chalybeate ſpring at Evan bridge.

The other chalybeate ſpring, which was diſcovered by Dr. Garnet, is near Evan bridge. He found it to contain in the wine gallon

Oxide of iron	2 grains
Carbonic acid	13 cubic inches
Azotic gas	2 do.

The quantities of iron and carbonic acid, which are the only ſubſtances of any conſequence, are very nearly equal to thoſe in the chalybeate of Harrowgate.

* Garnet's Tour.

From this circumſtance it cannot be doubted, that if this well were properly incloſed it would be a valuable addition to Moffat. It would agree with many conſtitutions in which the Hartfell water is improper, on account of its too great aſtringency and tonic power; and its vicinity to Moffat is a great advantage, as it can be drank on the ſpot by thoſe who reſort to the watering place *. On enquiry I found that no attention had been paid to this ſpring, which is probably to be regretted.

Springs of ſalt water.

I obſerved on the banks of the Solway frith ſmall ſprings, pouring out ſalt water, iſſuing from rocks belonging to the coal formation. Theſe, however, evidently derived their water from the frith, and are not to be confounded with true ſalt ſprings, which are only found in that ſeries of rock which is interpoſed between the neweſt tranſition and the ſe-

* Garnet's Tour.

cond ſandſtone formation, or in countries bordering on it. To determine whether or not a ſalt ſpring found on the ſea ſhore derives its contents from ſea water, or from a ſalt-bed or rock richly impregnated with ſalt, a chemical examination is not ſufficient, becauſe it often happens that ſalt ſprings, iſſuing from ſalt-beds, and not richer in ſalt than ſea water, are poured out on the ſea ſhore. To determine ſuch a point, therefore, we muſt examine the neighbouring country, with the view of diſcovering whether or not ſimilar ſprings occur inland, or if there is any appearance of the ſeries of rock already mentioned; if we diſcover theſe, we may then with complete ſafety conclude that the ſalt ſprings we have diſcovered are derived from ſalt-beds, or rocks richly impregnated with ſalt, and are therefore worthy of particular attention, although a chemical analyſis ſhould have ſhewn that they were not more productive than the waters of the ocean.

Method of determining true ſalt ſprings.

Sources of mineral impregnations of ſprings.

Obſervations.—All ſprings derive their water from the atmoſphere, and their impregnations in moſt caſes from the rocks through which they paſs. Thus the numerous ſalt ſprings in Cheſhire, Salzbourg, &c. can be traced to ſalt-beds or rocks highly impregnated with ſalt; calcareous ſprings to beds of limeſtone; and aluminous ſprings, like that of Hartfell, to rocks containing alum or its ingredients. The conſtant occurrence, however, of ſea ſalt in all ſprings, is more difficultly accounted for. Sea ſalt, or muriat of ſoda, has been diſcovered in white ore of antimony, which occurs venigenous in mica ſlate, in horn ore, which is found in gneiſs, in certain varieties of lead ore, and in one ſpecies of copper ore. Theſe are, however, but partial occurrences in compariſon of the univerſality of the phenomenon here alluded to. The Wernerian geognoſie teaches that, even during the depoſition of the tranſition rocks, marine animals and plants exiſted; conſequently the ſea muſt have

been in a ſtate ſomewhat ſimilar to what it is at preſent, conſequently muſt have contained ſea ſalt. We have therefore reaſon to expect that all theſe rocks contain ſea ſalt, and that this impregnation affords to the filtrating water of ſprings the ſea ſalt they are always found to contain.

Sea ſalt of ſprings derived from the rocks through which the water filtrates.

The analyſes of an able chemiſt, the late Dr. Kennedy, have ſhewn the preſence of ſoda and muriatic acid in baſalt, greenſtone, and ſandſtone; and more lately the celebrated Klaproth has obtained from baſalt, porphyry ſlate, and pitchſtone ſimilar reſults. As theſe rocks belong to one of the *univerſal formations*, theſe analyſes are to be viewed as ſupporting the concluſion drawn from the Wernerian geognoſie.

2. Dr. Garnet does not mention ſoda as a conſtituent part of the ſprings at Moffat; it is not improbable, however, that it may be diſcovered on a more care-

Soda probably a conſtituent part of the Moffat well ſpring.

ful examination becauſe almoſt all the ſprings iſſuing from tranſition rocks that have been examined have been found to contain a minute portion. As an inſtance, I may mention that the Graf Mitrowſky analyſed twenty ſprings iſſuing from the tranſition rocks of the circle of Olmutz in Moravia, and found that all of them contained a greater or leſſer proportion of ſoda.

Frequency of ſprings in floetz-trap rocks.

3. A greater number of ſprings iſſue from rocks belonging to the floetz-trap formation, than from thoſe of the tranſition or coal formations. In other parts of Scotland, particularly in the mountains of the iſle of Rume, I made a ſimilar remark. Werner obſerves that baſaltic hills are well calculated, by reaſon of their naked ſurfaces and compact texture to attract and condenſe vapour, and from their numerous perpendicular rents, and the bed of clay on which they uſually reſt, to conduct the condenſed vapour to form ſprings.

LAKES.

There are very few lakes in this county. In the neighbourhood of Lochmaben there are five, one on the north eaſt corner of the county called Loch Skene, another on the weſt ſide called Loch Urr, but none of them are remarkable for magnitude or beauty, nor do they preſent any phenomena deſerving particular notice.

CHAP. II.

Plan to be followed in describing the internal Structure of the County.—1. *General Disposition of the Stratification.*—2. *General Disposition of the Formations.*—3. *More particular Account of the different Formations.*—*a. Of the Transition Rocks.*—*b. Of the independent Coal Formation.*—*c. Of the Floetz-trap Formation.*—*d. Of the Alluvial Formations.*—*Of Peat.*

HAVING deſcribed the mountains and valleys which, taken together, conſtitute the phyſiognomy of the county, I ſhall now proceed to give an account, as far as obſervation permits me, of its internal ſtructure. Here we have 1ſt to aſcertain the general diſpoſition of the ſtratification. 2dly, That of the individual formations; and, 3dly, we muſt give a particular account of the formations and of the rocks of which theſe formations are compoſed.

I.

General diſpoſition of the ſtratification.

One of the moſt important relations which mountain groupes preſent us with, when viewing them on the great ſcale, is the general diſpoſition of their ſtratification ; to diſcover which, therefore, is an object of the greateſt importance to the geognoſt. If we confine our obſervations to one rock maſs, it is ſufficient to ſay whether it is in conformable or unconformable ſtratification ; its direction and dip are of very little importance if we do not extend our obſervations further. On the contrary, if our obſervations are to be more general, and if we wiſh to diſcover the general ſtretch and dip of the ſtrata of an extenſive diſtrict, we muſt make a number of individual and accurate obſervations, and from the ſum of theſe determine the general diſpoſition of the ſtratification. The general diſpoſition itſelf, however, has ſometimes its variations, and theſe muſt be noted and at-

tended to. An acquaintance with the ſhape of a mountain groupe will aſſiſt us very much in ſuch inveſtigations, as it is intimately connected with the general diſpoſition of the ſtratification of the maſſes of which it is compoſed. It is alſo of importance to know the fall or declivity of a groupe, as its direction and inclination is generally conformable, particularly in the older formations, with that of the ſuperimpoſed maſſes. Sometimes indeed there are exceptions to this rule, but theſe are eaſily explained.

I have to regret, however, that my obſervations have not as yet been ſufficiently numerous to enable me to ſtate with confidence the general diſpoſition of the ſtratification. According to my preſent obſervations, the general direction of the ſtrata appears to be from eaſt to weſt, and their dip to the ſouth, under various angles, but more generally very much inclined, particularly the tranſition rocks.

II.

General disposition of the formations.

Nearly the whole of the upper part of this county is compoſed of tranſition rocks. It does not, however, preſent all the ſpecies of rocks that occur in this great claſs in other parts of the world; I have obſerved only *grey-wacke*, *grey-wacke ſlate*, *flinty ſlate*, *alum ſlate*, and *tranſition greenſtone*.

The grey-wacke forms a very great portion of the upper part of the county, and ſometimes alternates with grey-wacke ſlate.

The flinty ſlate occurs in ſmall quantity; but on the borders of the county, at Leadhills, there are great beds of it.

Greenſtone occurs in beds in grey-wacke and grey-wacke ſlate, as between Whamphry and Langholm, and on the borders of the county, in the valley of Leadhills.

Alum ſlate occurs near Moffat and Kirkmichael.

Theſe rocks are the oldeſt in the county, and conſequently ſerve as a baſis for all the newer formations *.

The next claſs of rocks in point of age and extent is the *independent coal formation*, which lies either in hollows of the tranſition rocks, as the caſe is at Sanquhar, Kirkconnel, Cloſeburn, valley of Dumfries, Whitehill, Corncocke muir, Bauldcraig, and Chapelhill near Moffat, Cannoby, or pervades the low part of the county from the Eſk to the Nith, lying in conformable and unconformable ſtratification over the tranſition rocks.

The neweſt of the *univerſal formations* is the neweſt floetz-trap, which covers ſometimes the tranſition rocks, and ſometimes the independent coal formation.

* Note E.

In the lower parts of the county it consists of porphyritic greenstone, and amygdaloid, which extends from the bridge of Langholm to Denby in the parish of Dalton. In the upper part of the county, as between Whamphry and Langholm, it lies on the summit of transition mountains, and generally in the shape of *mountain caps*. Subordinate to it we find blackish coloured pitchstone.

The bottoms of the valleys are covered by the alluvial formations.

III.

Having now given a description of the physiognomy of the county, of the general disposition of its stratification, and the relative age and situation of its different formations, and thus drawn as it were an outline of its geognostic description, I shall now endeavour, as far as my obser-

More particular account of the different formations.

vations will allow, to render it more complete. To execute this in a ſatisfactory manner, many more obſervations are required than I have had an opportunity of making; I ſhall, however, firſt ſtate how the inveſtigation ſhould be conducted, and then the obſervations I have made.

Plan that ſhould be followed in giving a particular account of the formations.

To execute ſuch an inveſtigation we muſt trace correctly the bounds of all the formations; then delineate the moſt ſtriking features in the diſpoſition of their ſtratification; next muſt deſcribe their different ſtrata and beds, and laſtly the individual rocks. But in doing this, we muſt adopt a determinate order, we muſt not begin indifferently with any formation, but ſhould adhere to the order which nature appears to have followed in their depoſition, that is, according to their relative antiquity, proceeding from the oldeſt to the neweſt. But it is not enough that we have attended to all the circumſtances I have juſt mentioned, our

deſcriptions of the formations would be imperfect if we omitted an account of the *particular repoſitories*, as veins, ſtockworks, &c. contained in them. In general, however, if theſe repoſitories are of *after formation*, and occur in conſiderable number, it would be better to ſeparate the account of them from the deſcription of the rocks, and place it in a ſeparate chapter, as the introduction of ſuch deſcriptions diſtracts the attention, and prevents us obtaining a correct idea of the more general relations of the rocks. In deſcribing theſe *after repoſitories*, however, we muſt follow a determinate plan, as much ſo as in deſcribing the rocks. When we have not had repeated opportunities of determining the relative age, the peculiar characters, and the ſtructure of theſe different repoſitories, the moſt convenient plan of arrangement would be, that according to the age of the rock in which they are found; if, however, we have aſcertained theſe points, the natural arrangement is that according to

their relative antiquity. In conformity with the method now mentioned, I ſhall firſt give an account of the

Tranſition rocks.

A. TRANSITION ROCKS.

The tranſition rocks were formerly confounded with the primitive, until Werner by an attentive examination found that they contained mechanical depoſits, petrifactions, and, conſidered as a claſs, were more ſimple than the primitive. He alſo diſcovered that they were formed during the tranſition of the earth from its chaotic to its habitable ſtate, hence he denominated them *übergangſge-bürge*, *tranſition rocks*. This very important diſcovery has been confirmed by every ſucceeding obſervation, and the diſtinction here propoſed has been adopted by all geognoſts *.

Firſt diſcovered and aſcertained to be a diſtinct claſs by Werner.

* The objections of Profeſſor Playfair, are anſwered in Nicholſon's Journal.

The rocks belonging to this claſs are, according to Werner, 1. Grey-wacke, 2. Grey-wacke ſlate, or tranſition ſlate. 3. Tranſition limeſtone, 4. Tranſition greenſtone. 5. Tranſition amygdaloid. And, 6. Flinty ſlate. Of theſe ſpecies, as already mentioned, four only have as yet been obſerved in this county, viz. Grey-wacke, grey-wacke ſlate, tranſition greenſtone, and flinty ſlate. The alum ſlate already mentioned may be conſidered ſubordinate to the tranſition ſlate.

1. *Grey-wacke.* Is compoſed of frag- Grey-wacke.
ments of quartz and clay ſlate, which are from the ſize of a hen's egg, until from their minuteneſs, they are no longer viſible. The fragments are connected by a baſis of clay ſlate, which has uſually a bluiſh grey or browniſh colour. It is often traverſed by nearly cotemporaneous quartz veins; and, as Werner obſerves, the quartz ſolution appears often to have diſſeminated itſelf through it, which renders this rock ſo firm and hard. It fre-

quently alſo contains ſcales of mica, particularly when it approaches in characters to tranſition ſlate. The clay ſlate baſis diſtinguiſhes it from ſand ſtone, and from its uſual grey colour, it derived its name.

Its texture is to be obſerved becoming gradually fine grained, and verging on ſlaty; at length the eye can no longer diſtinguiſh any mechanical mixture, the ſlaty texture becomes more complete, and then it paſſes into

Grey-wacke ſlate.

2. *Tranſition, or grey-wacke ſlate.* This rock has been very generally confounded with primitive clay ſlate; from which, however, it is very well diſtinguiſhed by the following characters.

How diſtinguiſhed from clay, or primitive ſlate.

a. It has ſeldom a greeniſh or light yellowiſh grey colour, as is the caſe with primitive ſlate, but is uſually aſh and ſmoke grey.

b. It does not ſhow the ſilvery continuous luſtre of primitive clay ſlate, but is rather glimmering, which originates from intermixed ſcales of mica.

c. Quartz ſcarcely occurs in it in layers, but uſually traverſes it in the form of veins.

Further we do not find.

d. Cryſtals of felſpar, ſchorl, tourmaline, garnet or hornblende.

e. No beds of garnet, talc, chlorite ſlate, or magnetic iron ſtone are to be obſerved in it.

f. It contains petrifactions, particularly thoſe varieties that border on greywacke.*

* The petrifactions found in tranſition rocks, are of animals and plants of the lower orders, that probably no longer exiſt on the face of the earth.

g. It alternates with grey-wacke.

This ſlate, when nearly free of mechanical mixture, is excellently adapted for the roofing of houſes. Near Moffat, and in the vicinity of Langholm, there are workable ſtrata of grey-wacke ſlate, and in the higher parts of the valley of Eſk, and in the tranſition rocks behind Burnſwark, there are appearances of a ſimilar kind. There is no doubt, that a careful examination of the immenſe tract of tranſition rocks that occur in this county, will diſcover ſtrata of ſlate worthy of particular attention. My brother has promiſed to examine theſe rocks with this view.

Flinty ſlate.

3. *Flinty ſlate.* This foſſil preſents the following characters.

Colour is bluiſh grey.

Occurs maſſive, and in great beds.

Internally dull.

Fracture in the great imperfectly ſlaty, in the ſmall large ſplintery, paſſing into flat conchoidal.

Fragments indeterminately angular, pretty ſharp edged.

Strongly tranſlucent on the edges.

Hard.

Brittle.

Difficultly frangible.

Not particularly heavy.

It is frequently intermixed with tranſition clay ſlate.

4. *Common alum ſlate.* Common alum ſlate.

Its colour is greyiſh black.

Occurs maſſive.

Internally glimmering, bordering on faintly gliſtening.

Fracture pretty perfectly ſtraight ſlaty.

Fragments tabular.

Streak a little ſhining.

Soft.

Not particularly brittle.

Eaſily frangible.

Not particularly heavy; that is, from 2 to 4.

On expoſure to the air, a yellowiſh ſulphureous efflores̄cence ſometimes makes its appearance: natural alum ſometimes efflores̄ces on its ſurface.

Tranſition greenſtone.

5. *Tranſition greenſtone.* On the hanging or upper ſide of the Suſanna vein in the valley of Leadhills, I obſerved a bed of rock which at firſt I miſtook for porphyry, but which proved, on more attentive examination, to be greenſtone. It is almoſt entirely compoſed of felſpar, which has uſually a pale fleſh red, or reddiſh white colour: in it there is ſometimes imbedded grains of greyiſh coloured quartz, ſcales of iron black coloured mica, and cryſtals of pale fleſh coloured felſpar. Sometimes the baſis is in a ſtate of diſintegration, and then it reſembles porcelain clay.

It occurs in beds from three to twelve feet thick; and not only in the valley of Leadhills, but alſo in the mountains between Whamphry and Eſkdale muir.

Obſervations. In hand ſpecimens, this rock would be confounded with porphyry; but conſidering it in the great, we muſt, conſiſtent with our preſent knowledge of porphyry and greenſtone, view it as greenſtone (in which the hornblende is a wanting) or as felſpar. In the floetz formations, as will afterwards be more particularly mentioned, I have obſerved greenſtone almoſt entirely compoſed of compact felſpar, with a few interſperſed cryſtals of hornblende; yet we would not conſider ſuch a rock as a particular ſpecies, but merely as a variety of greenſtone. In other inſtances, I have met with beds, in which the hornblende was entirely a wanting; in ſuch caſes, we might probably venture to conſider it as felſpar, and as nearly analogous to the rock of Leadhills; although, in the great, we would view the one and other but as varieties of greenſtone, or as ſubordinate to it.*

This greenſtone in hand in ſpecimens might be miſtaken for porphyry.

Beds of greenſtone almoſt entirely compoſed of felſpar.

* Note F.

Mineral repoſitories in the tranſition rocks.

The only *particular metallic mineral repoſitories* † of conſequence that have been diſcovered in this country, lye in the tranſition rocks. They are ſituated on the borders of the county at Wanlock-head and Leadhills, and lower down at Glendinning in Eſkdale.

Belton-grain vein at Wanlock-head.

At Wanlock-head, I deſcended into one of the mines, into the vein called Belton-grain vein, which was at that time but lately opened. It ſtretches nearly N. and S., and dips to the E. under an angle of from 60° to 80°. Its width is from ſix to eight feet.

† Repoſitory.] By the term *particular mineral repoſitory*, which in German is *beſondere lagerſtätte der foſſilien*, and in French *gites particuliers des minerais*, is underſtood thoſe ſpaces in rock maſſes or mountains whoſe extent, in one direction at leaſt, can be obſerved, and which in general are occupied with materials different from the rock in which they occur. Under this denomination is included ſtrata, beds, veins, &c.

The following are the appearances preſented by the vein, in the different places I had an opportunity of examining. I regret my obſervations were not ſufficiently numerous to enable me to aſcertain its general ſtructure and peculiarities, and thus to determine its characters, as a particular depoſition or formation.

1. In ſeveral places, I obſerved the whole width of the vein filled with blackiſh brown coloured ochre of manganeſe, in which fragments of grey-wacke, which conſtituted the walls of the vein, were immerſed; in other places, the manganeſe contained cryſtals of quartz, and maſſes of lead glance*, and ſometimes druſſy cavities, which were lined with calamine and green lead ore.

* I uſe the term lead glance inſtead of the more uſual one galena, becauſe it is Engliſh, and expreſſes the moſt ſtriking feature in the external aſpect of the mineral.

2. At the north extremity of the firſt gallery, the ſtructure of the vein was as follows:—On the under, or lying ſide, lead glance; above it, layers of quartz, then layers of manganeſe ochre, and brown iron ochre; and laſtly, on the upper ſide, about two feet of debris, mixed with manganeſe.

3. At another place, at the depth of ſeventeen fathoms, on the under ſide of the vein, was a white clayey ſeam, (beſteg.) about an inch thick, above this a layer of ochre of manganeſe, about eight inches thick; then a layer of green lead ore, intermixed with calamine, about an inch thick; then a layer of lead glance, from four to five inches thick, which contained druſſes lined with calamine and white lead ore; to this ſucceeded a layer of granular quartz, from four to five inches thick; on this repoſed a layer of lead glance, about eight inches wide, having alſo druſſy cavities; over this there lay another layer of ochre of

manganeſe, a few inches thick, which contained interſperſed green copper ore; and laſtly, the upper or hanging ſide of the vein conſiſted, for a foot and half, of fragments of grey-wacke and grey-wacke ſlate, intermixed with ochre of manganeſe.

4. In another part of the vein, its ſtructure and materials was as follows: 1ſt, Sides of the vein were lined with a layer a few inches thick of ochre of manganeſe. 2d, To this ſucceeded layers of brown ochre of iron. 3d, Thin layers of calamine. 4th, Thin layer of lead glance, which was coarſe, ſmall and fine grained. 5th, Layer of browniſh coloured arenaceous quartz, of which the concretions were ſo looſe that it could be diſintegrated by the hand*; and, 6th, the middle of the vein was filled with manganeſe.

* Note G.

Lead hills. Leadhills, which is but a ſhort diſtance from Wanlock-head, alſo preſents many rich veins of lead glance. Of theſe the greateſt and moſt productive is the Suſanna vein.

Suſanna vein. This vein ſtretches nearly in the direction of the valley in which it is ſituated, and its fall is nearly conformable with that of the mountains. Its uſual breadth is about four feet; ſeveral years ago it was in one place about fourteen feet wide, but this was owing to a partial enlargement, or what the miners term *a belly*.

Its ſtructure is the ſame with that of Belton-grain at Wanlock-head, and its materials are nearly identical. The *vein ſtones* * are quartz, lamellar heavy-ſpar, calc-ſpar, brown-ſpar, and mountain cork. Its *ores* are lead glance, man-

* I uſe the expreſſion vein ſtones in preference to the term gangue, becauſe it has a determinate meaning.

ganeſe ochre, lead earth, ſparry iron ore, calamine, brown iron ochre, iron pyrites, copper azure, green lead ore, white lead ore, lead vitriol, and brown hematite.

The vein has ſometimes interpoſed between it and the rock in which it runs a thin ſeam of clay or loam; ſometimes this is wanting, and not unfrequently the matter of the vein is grown together with the rock which forms its ſides.

Like the veins of Wanlock-head, it often contains fragments of grey-wacke and grey-wacke ſlate.

Lead glance formation of Leadhills and Wanlock different from any enumerated by Werner.

The lead glance formation of Wanlock-head and Leadhills, is completely different from any enumerated and deſcribed by Werner, as is evident from the inſpection of the following deſcriptions, extracted from his admirable work on veins. "We "already know perhaps more than twenty "different formations of lead glance. I "have obſerved the following;

Different lead glance formations as determined by Werner.

" 1ſt *Formation.* Lead glance mixed
" with copper pyrites and native gold; in
" quartz.

" 2d *Formation.* Lead glance, with ſmall
" grained brown blende, and ſlate ſpar.

" 3d *Formation.* Lead glance rich in
" ſilver, with fine grained brown blende,
" and a little copper and iron pyrites; in
" quartz.

" 4th *Formation.* Lead glance rich in
" ſilver, with much black blende and
" arſenical and iron pyrites, ſometimes
" with a little copper pyrites, more rarely
" with ſparry iron ore; in quartz and
" ſometimes accompanied by a little
" brown ſpar.

" 5th *Formation.* Lead glance very rich
" in ſilver, with black blende, very little
" arſenical pyrites, common iron pyrites,
" and liverp yrites; in quartz and brown
" ſpar.

" 6th *Formation.* Lead glance very
" rich in ſilver, with a little black blende,
" common iron pyrites, dark red ſilver
" ore, brittle ſilver ore, white ſilver ore,
" plumoſe ſilver ore; in quartz, with
" much, generally fleſh red coloured,
" brown ſpar.

" 7th *Formation.* Lead glance poor in
" ſilver, with a great deal of common
" iron pyrites, black blende, and often
" red iron ochre; in quartz, and fre-
" quently with greeniſh clay, having in-
" termixed chlorite.

" 8th *Formation.* Lead glance rich in
" ſilver, with yellow blende, fahl ore, and
" common iron pyrites; in brown ſpar
" and quartz.

" 9th, *Formation.* Lead glance poor in
" ſilver, with radiated iron pyrites, and
" rarely brown blende; in heavy ſpar,
" fluor ſpar, ſometimes a little ca c ſpar,
" and quartz.

" 10th *Formation.* Lamellar lead glance " and compact lead glance, with a little " black blende, iron pyrites and ſparry " iron ſtone.

" 11th *Formation.* Lead glance, with " much brown blende and ſparry iron " ſtone, and alſo ſome iron pyrites, fahl " ore, and a little copper pyrites; in " quartz.

" 12th *Formation.* Lead glance, with much dark brown blende; in quartz.

" 13th *Formation.* Lead glance, with " ſmall and fine grained dark brown " blende, iron and copper pyrites, and " quartz.

" 14th *Formation.* Lead glance, with " copper pyrites; in calc ſpar.

" 15th *Formation.* Lead glance, with " much dark and a very little light red

" ſilver ore, cobalt, and native arſenic;
" in calc ſpar.

" 16th *Formation.* Lead glance, with
" calamine, and much brown iron ochre.

" 17th *Formation.* Lead glance very
" poor in ſilver, very ſmall in quantity,
" ſometimes diſſeminated, ſometimes in
" membranes, with copper pyrites; in
" calc ſpar*."

As the obſervations that follow the preceding excellent determinations will be of great uſe to thoſe who are inclined to purſue this intereſting branch of geognoſie, I ſhall inſert them here. " Parmi
" ces diverſes formations de galene (lead
" glance) il y en a cinq, que l'on voit
" principalement dans les Hartz: mais il
" eſt extremement difficile de pouvoir
" juger avec exactitude des ces formations,

Obſervations on the method of determining vein formations.

* Nouvelle theorie de la formation des filons, par A. G. Werner, p. 186 to 192.

" lorſqu'on n'a pas vu ſoi meme (et c'eſt
" les cas, ou je me trouve a l'egard des
" ces formations du Hartz) les gites meme,
" ou elles ſe trouvent ; car il ne ſuffit pas
" d'avoir vu des echantillons d'un forma-
" tion, pour pouvoir en juger ſainement ;
" il faut avoir vu exactement et pluſieurs
" fois les giſſemens ou local, ou elles ſe
" trouvent, avoir examiné l'ordre et l'en-
" ſemble des foſſiles qui appartiennent a
" une meme formation, avoir obſervé les
" variations, que cette formation eprouve
" en divers endroits, ainſi que la diſpoſi-
" tion des gites, qui les renferment. Ce
" n'eſt que par des obſervations exactes
" et repetées, par des comparaiſons faites
" avec ſoin, que l'on reconnoitra que deux
" formations, qui paroiſſent ſe reſſembler
" ne peuvent etre regardées comme une
" meme formation a cauſe des differences
" eſſentielles qu'elles preſentent ; que des
" variations qu'eprouve une meme for-
" mation doit la faire ſubdiviſer en plu-
" ſieurs autres ; que pluſieurs autres que
" l'on trouve enſemble dans un meme

" lieu ou gite, ne doivent cependant " etre conſiderées, que comme apparte- " nant a une meme formation principale. " Ainſi il pourroit bien ſe faire que ce que " j'ai dit ſur le formations du Hartz vint " à eprouver quelques corrections, ou " recevoir quelques additions. Peut-etre " en faiſant et continuant des obſerva- " tions ſoignées dans des pays differents " et meme eloignés les uns des autres " on decouvrira un beaucoup plus grand " nombre des formations de galene."

Produce of the mines.

According to General Dirom, the mines belonging to the Earl of Hopetoun produce annually 1400 tons, and thoſe of Wanlock-head, belonging to the Duke of Queenſberry, about 1000 tons, worth L. 20. per ton, or in all L. 48,000. yearly. The proprietors receiving every ſixth bar as lordſhip or rent.*

* General Dirom's Mineralogical Deſcription of Dumfries-ſhire, annexed to the county map.

Nearly at the entrance of the valley of Leadhills, there is a mighty rock maſs of flinty ſlate, through which none of the veins have been obſerved to paſs; indeed it is ſaid by the miners to cut them off.

Veins cut off by a rock maſs of flinty ſlate.

In the Hartz, and other mining countries ſituated in tranſition rocks, ſimilar appearances have been obſerved. Frieſleben, in his deſcription of the Hartz, ſpeaking of the interruptions produced in the mining field by flinty ſlate, gives the following inſtance which he himſelf obſerved. " Sie ſchneidet nun den Samſ-

Similar phenomenon in the Hartz mines.

" oner gang gegen Nw-ab; denn dieſer
" ſetzt zwar noch einige lachter in ſelbige
" hierein, kan aber wegen der feſtig-
" keit dieſes geſteins nicht ununterbro-
" chen in demſelben forſetzſen, ſondern
" ſetzt ſehr haufig ab, legt ſich niern-
" weiſſe wieder an, und iſt überhaupt
" ſchmall und taub; auch dauert dieſes
" gar nicht lange, ſondern bald ſchneidet
" ſich der gang in ihm gänzlich ab.
" Ein einziges mal fanden wir ihm ſo
" gar erz fuhrend in der Ruſchel (Kieſ-

" elſchièfer) dies war nahmlich in den " neufangner Fürſtenbau woſelbſt er ge- " diegen arſenick, roth giltigerz und " kalkſpath führte *."

As the ores of lead are the moſt remarkable mineral productions of this formation, I ſhall now give a ſhort deſcription, which will include all the varieties I had an opportunity of obſerving in the veins themſelves, or in the collection of Mr Taylor of Wanlock-head, the mine-maſter of the diſtrict.

I. WHITE LEAD ORE.

Its colours are ſnow white, yellowiſh white, and greyiſh white: from ſnow white, it paſſes through greyiſh white into aſh grey, and from yellowiſh white into cream yellow, and pale clove brown ?

* Bemerkungen über den Harz, von Johann Carl Frieſleben.—Zweiter Theil. ſ. 245.

1. It occurs in ſix-ſided priſms, acuminated on both extremities with ſix planes, which are ſet on the lateral planes. Sometimes the extremities of the acuminations are truncated; ſometimes the priſm is ſo ſhort that the cryſtal appears like a double ſix-ſided pyramid.

2. Sometimes in the form of four-ſided priſms, acuminated by four planes, which are ſet on the lateral planes, like zircon.

3. The ſix-ſided priſm is ſometimes much compreſſed and ſtellularly interſecting.

4. Long four-ſided table, bevelled on the ſmaller terminal planes, and the edge of the bevelment truncated. It ſometimes occurs in twin cryſtals.

The cryſtals are ſometimes columnarly aggregated, and this variety has been confounded with columnar heavy ſpar.

Externally its luſtre is ſplendent, ſeldom ſhining; internally it is from ſplendent to gliſning, and is adamantine.

Fracture is commonly ſmall conchoidal, but it ſometimes paſſes to fine-grained uneven, and even to ſplintery.

Fragments are indeterminately angular.

Is uſually tranſlucent, but in cryſtals ſemi-tranſparent. Streak is greyiſh white.

Is ſoft. Not very brittle. Eaſily frangible. Heavy. Specific gravity—7,2357. Chenevix.

Conſtituent Parts.

According to Klaproth, it contains—

Lead	77
Carbonic acid	16
Oxygen	5
Loſs, and water of cryſtallization	2
	100.0

Obſervations.

The columnarly aggregated variety has ſome reſemblance to columnar heavy

ſpar, but is eaſily diſtinguiſhed from it by fracture, luſtre, and weight, and alſo by its geognoſtic characters.

II. GREEN LEAD ORE.

Its colour is graſs green, which paſſes on the one ſide through piſtacio green, olive green, and ſiſkin green, into ſulphur yellow: on the other ſide, through aſparagus green into greeniſh white. Some varieties approach to leek green. The olive and piſtacio green colours are the commoneſt.

It occurs maſſive, ſometimes kidney-ſhaped and botroidal, but is moſt commonly cryſtallized.

1. Six-ſided priſm, having ſometimes the lateral and terminal edges truncated. When the truncations on the terminal edges increaſe, a ſix-planed acumination is formed.

2. When the lateral planes converge towards the extremities, an acute double ſix-ſided pyramid is formed.

The priſms are uſually low, and ſometimes hollow at the extremities.

Sometimes it occurs in beautiful velvetty druſſes.

Cryſtals are ſmall and very ſmall, ſeldom middle-ſized, and are often ſcalar-wiſe aggregated.

Externally it is ſmooth, and ſhining; internally gliſtening and reſinous.

Fracture ſmall-grained uneven.

Fragments indeterminately angular ſharp edged. Heavy.

In other characters it reſembles the preceding ſpecies.

Conſtituent parts of that found at Wanlock-head.

Oxyd of lead	80.
Phoſphoric acid	18.
Muriatic acid	1. 62.

Klaproth.

Obſervations.

1. This ſpecies, when it has a very pale greeniſh-white colour, is apt to be confounded with the preceding ſpecies; but we can always diſtinguiſh them by the following characters:—1. The fracture in this ſpecies is fine-grained uneven, but in white lead ore, is more or leſs perfectly conchoidal. 2. Its luſtre is reſinous, but that of white lead ore is adamantine. 3. It poſſeſſes greater ſpecific gravity than white lead ore. 4. Its cryſtals are often ſcalarwiſe aggregated, which is never the caſe with white lead ore; and 5. Its priſms are generally ſhorter than thoſe of white lead ore.

2. Mr. Klaproth having found phoſphat of lead or green lead ore of a greyiſh white colour, propoſes it as an objection to the naming of minerals from their colours. It muſt be remembered, however, that the name does not imply the conſtant occurrence of a green colour; it only intimates, that the green colour

is the moſt ſtriking feature in the external aſpect of the mineral, and that it occurs more frequently than any other colour.

III. LEAD EARTH.

1. SUBSPECIES.

White Lead Earth.

Colour is yellowiſh grey.

Occurs maſſive.

Luſtre is gliſtening, paſſing to glimmering and dull, and is adamantine, paſſing to reſinous. Fracture fine-grained uneven, paſſing ſometimes to conchoidal, ſometimes to fine earthy. Opaque. Streak brown. Soft, paſſing to very ſoft. Not very brittle, approaching to mild. Eaſily frangible and heavy.

Geognoſtic Character.

It occurs along with white lead ore.

II. SUBSPECIES.

Friable Lead Earth.

Colour is yellowiſh grey.

Is compoſed of dull duſty particles, that ſoil a little. It is meagre and rough to the feel.

Is more or leſs cohering.

Obſervations.

1. It is to be obſerved paſſing to the preceding ſubſpecies.

2. It occurs along with lead glance, white lead ore, and ſolid lead earth.

3. It is probably formed by the decompoſition of lead glance, becauſe it occurs almoſt always as cruſt on it.

IV. LEAD GLANCE.—GALENA.

Of this ſpecies, both the common and compact ſubſpecies occur. But of theſe, it is not neceſſary to give any deſcription.

LEAD VITRIOL—SULPHAT OF LEAD.

In the collection of Mr Taylor, there are ſome ſpecimens of the tabular variety mentioned by Klaproth, which contains in the 100 parts—

Oxide of lead	70	50
Sulphat of lead	25	75
Water of cryſtallization	2	25
	98	50

Klaproth's Beiträge.

Antimony mine of Glendinning.

About ten years ago, a vein of grey antimony ore was opened in Glendinning in Eſkdale. The working was continued for ſome time with much profit to the adventurers, but it has been lately given up, it is ſaid, owing to want of

ſkill in the miners and energy in the proprietors. The vein traverſes grey-wacke; but its extent, direction, dip, or width, I was not able to aſcertain, as the workings had fallen in. The *vein ſtones* are quartz, and calc-ſpar; the *ores* grey antimony, brown blende, fine-grained lead glance, and iron pyrites.

In the maſs of the vein, I found intermixed fragments of grey wacke and grey wacke ſlate. The ore of antimony is the radiated grey antimony, which, according to Bergman, contains in the hundred parts—Antimony 74,00; Sulphur 26,00.

This ore, according to the obſervations of Werner, is of a middle age. He has not obſerved it in the floetz rocks, nor in the older primitive.

The only other appearance of ore which I obſerved, was in the pariſh of Tundergarth, on the eſtate of Mr.

Murray of Murrayfield. The ore is iron mica; but as the ground was overgrown with graſs, and no trial of any conſequence had been made, I cannot at preſent give a more particular account of it.

Lead ore is alſo ſaid to have been found on the farm of Weſtwater, belonging to the Duke of Buccleugh, and in the eſtate of Broomholm, belonging to J. Maxwell, Eſq.*

Obſervations.

1. Although theſe are the only repoſitories of ores hitherto obſerved in this county, it is not to be doubted that a more careful examination of all its mountains and valleys may diſcover many others. Even if after a complete and careful ſurvey no metalliferous mineral repoſitories of conſequence ſhould be diſcovered, it does not follow that ores will not be found in theſe mountains; on the contrary, from

Obſervations to ſhew the advantages of a repeated examination of the ſame diſtrict.

* Note H.

the nature of the rocks of which they are compoſed, we have good reaſon for expecting, by the continual alteration produced on their ſurface by the action of froſt, torrents, &c. that many metalliferous repoſitories, at preſent hid from us, will by theſe great natural mining operations be brought to light. At the end of every year the ſurface of the county is in a very different ſtate from what it was twelve months before; it is therefore to be recommended to proprietors of landed property, who are ſkilled in mineralogy and mining, to examine their mountains and valleys every year, with the view of aſcertaining whether or not repoſitories of ore have been laid open.

Limeſtone to be expected in the higher parts of the county.

2. No limeſtone beds of any conſiderable magnitude have as yet been diſcovered in the tranſition rocks of this county. In other countries where tranſition rocks abound, great depoſitions of limeſtone have been obſerved: thus in the

Hartz, the famous quarries of Blankenberg are ſituated in rocks of this kind; it is alſo found in the tranſition rocks of Voightland, Bareuth, Upper Bavaria, and extends even to the Tyroleſe alps, and into Italy. In Scotland, conſiderable ſtrata have been obſerved in the mountains between Noblehouſe and the Crook. Theſe facts encourage us to expect limeſtone in the tranſition rocks of this county.

Tranſition limeſtone well ſuited for architectural purpoſes.

It is alſo worthy of remark that the limeſtone which occurs in theſe rocks is not only well calculated for the purpoſes of cement and manure, but on account of its beautiful colour delineations, and the great thickneſs of its beds, is admirably fitted for architectural purpoſes. Many of the fineſt ancient ornamental works and edifices are conſtructed of tranſition limeſtone *.

* In this limeſtone there often occur great veins of ochry, compact, and hæmatitical brown iron-ſtone, alſo brown iron-froth. The veins are uſually

Coal does not occur in tranſition rocks.

3. Coal, as will be more particularly explained afterwards, does not occur in tranſition rocks. Now and then ſmall beds of ſlaty glance coal * are found, but theſe in an œconomical point of view are of no importance.

Trials made for coal in tranſition rocks.

About half a mile from the manſe of Kirkmichael there is a rock of alum ſlate which has interſperſed through it iron pyrites. This appearance was conſidered as indicative of coal, and a trial was made. I have been informed that ſimilar trials have been made in other parts of the tranſition country: a knowledge of the rocks, however, would have prevented all ſuch unneceſſary experiments.

from two to three fathoms wide; the ore yields from forty to ſeventy per cent. of an iron which is excellently fitted for ſteel making.

* Slaty glance coal was formerly known by the name coal blende.

INDEPENDENT COAL FORMATION*.

Eigentliche Steinkohlen Formation of Werner.

Different formations of coal.

Coal occurs in ſingle beds in ſeveral of the older ſandſtone formations, but it is only found in quantity in the independent coal formation, the neweſt floetz trap formation, and the alluvial formations.

Rocks of the independent coal formation.

The rocks that conſtitute and characteriſe the independent coal formation, the only one that at preſent intereſts us, are, according to Werner, the following: 1. Coarſe conglomerate. 2. Looſely aggregated ſandſtone, which although it is ſometimes very ſolid, is always micaceous. 3. Slate clay. 4. Bituminous ſhale. 5. Lime-

* This formation is ſtiled independent, becauſe it exiſts independent of any other, whereas the coal found in the older ſandſtone, floetz-trap, and alluvial formations, is to be conſidered as ſubordinate to or dependent on them.

ſtone. 6. Marle. 7. Common indurated clay. 8. Clay iron-ſtone. 9. Porphyritic ſtone.

Different formations ſubordinate to the independent coal formation.

This formation, however, includes ſeveral ſubordinate formations, which are diſtinguiſhed from one another by the rocks of which they are compoſed, and their relative antiquity. Thus the neweſt of theſe formations is compoſed of looſely aggregated ſandſtone, conglomerate, and ſlate clay; one ſomewhat older of indurated clay, marle, limeſtone, and porphyritic ſtone; and another, ſuch as that of Mid Lothian, of ſlate clay, limeſtone, marle, ſoft ſandſtone, and greenſtone, which is probably the oldeſt.

The independent coal formation does not lie under the old red ſandſtone.

It was firſt aſſerted by the celebrated miner Lehman, that coal is uſually found under or in the *old red ſandſtone*, and ſince his time this opinion has been ſupported by ſeveral able mineralogiſts, as Karſten, Von Buch, Voight, and Frieſleben. Werner, however, has ſhewn that this poſi-

tion is falſe, and that the independent coal formation does not lie under the *old red ſandſtone* formation.

From the prevailing reddiſh brown colour of the ſandſtone in the lower part of the county, and its vicinity to the old red ſandſtone of Cumberland, I was for ſome time doubtful whether or not it might not belong to the ſame formation. A careful examination, however, convinced me that my ſuſpicions were unfounded, and that not only the ſandſtone in the lower part, but alſo that in ſeveral other places ſituated in the upper part of the county, belonged to the independent coal formation. As on the accurate determination of this point depends the probability of coal being found in this county, I ſhall endeavour in the following obſervations to give it all the elucidation of which I am capable. To do this I ſhall 1ſt, give a deſcription of the formation in this county. 2d, That I may be able to contraſt it with ſome

Plan to be followed in deſcribing the coal formation.

other well known coal formation, I ſhall next give a ſhort deſcription of the coal field of Mid Lothian; and 3d, I ſhall contraſt theſe two fields, and ſhew in what they differ and in what they agree, and if they are to be conſidered as part of the ſame formation.

COAL FORMATION OF DUMFRIES-SHIRE.

Stretch of the ſtrata.

The general ſtretch of the ſtrata of this formation in the lower part of the county is from eaſt to weſt, and the dip towards the ſouth, and ſeldom under a greater angle than 40°. In the higher parts of the county, the ſtretch and inclination of the ſtrata is very much varied, owing to their vicinity to the tranſition rocks.

Rocks of which it is compoſed.

The rocks of which it is compoſed are, 1. Sandſtone, 2. Slate clay, 3. Bituminous ſhale, 4. Limeſtone, 5. Clay ironſtone, 6. Coal, and 7. Limeſtone conglomerate.

1. *Sandſtone.* Colour reddiſh brown, brick red, ſometimes yellowiſh grey, greyiſh white, and ſometimes marked with reddiſh brown coloured delineations.

The grains of which it is compoſed, which are of quartz, are from the ſize of a poppy ſeed to that of a bean and even larger. When it paſſes into conglomerate, the fragments are larger, and beſides the quartz, contain fragments of amygdaloid, tranſition ſlate, grey wacke, and rarely hornſtone. Sometimes it alſo contains mica, which is frequently in ſuch quantity that it has a ſlaty fracture, or to ſpeak more correctly, it riſes in plates. Sometimes, as in the quarry between mount Annan and the village of Annan, alſo in the pariſh of Cloſeburn, the mica is ſo abundant that the ſandſtone approaches to that variety which is termed by Werner ſandſtone ſlate, and which occurs principally in the firſt and ſecond ſandſtone formations. The fragments are connected by a baſis of iron

clay, which is ſometimes in ſuch quantity that it paſſes into clay iron-ſtone.

It is more or leſs friable; that of Corncocke muir, Brown muir hill, and Cannoby is very friable; that quarried at the Cove is of good building conſiſtence; in other ſituations, as Ecclefechan, owing to the preponderance of a baſis of clay ironſtone, it is rather tough. Sometimes there are patches of ſeveral hundred ſquare feet of a greyiſh white coloured ſandſtone included in the reddiſh brown ſandſtone; of this there is a ſtriking inſtance at the Cove. We have it on a ſmaller ſcale in other parts, where the patches are not many feet, ſometimes only a few inches ſquare.

It ſometimes contains vegetable impreſſions or caſts reſembling thoſe found in the coal field of Mid Lothian.

Sometimes the ſandſtone, particularly that found in the coal depoſition of Can-

noby, conſiſts of ſpherical concretions, which are again compoſed of curved lamellar concretions *.

2. *Slate clay*, which lies between the beds of reddiſh brown coloured ſandſtone, preſents the following characters:

Colour yellowiſh grey, marked with ſpotted and clouded delineations of a pearl grey and cherry red colour.

Internally it is dull or glimmering, owing to intermixed ſcales of mica.

Fracture more or leſs perfectly ſlaty, ſometimes approaching to earthy.

Fragments indeterminately angular, ſometimes tabular.

Opaque. Soft. Mild. Eaſily frangible. Feels meagre.

At Ecclefechan, Repentance-hill, Whitehill, Cannoby, and Sanquhar, I obſerved greyiſh black and aſh grey coloured varieties, which contain numerous impreſ-

* Note I.

ſions of ſhells, and ſometimes alſo of ferns *.

3. *Limeſtone.* Its colours are bluiſh grey, pearl grey, and reddiſh brown.

Luſtre glimmering.

Fracture fine ſplintery and minute foliated.

Scarcely tranſlucent on the edges.

It contains numerous petrifactions, as milleporites, chamites, mytulites, trochites, entrochites, &c.

It is diſtinctly ſtratified, and the ſtrata are from ſix inches to ſeveral feet thick †. It frequently contains hollows, which are uſually filled with clay.

4. *Clay iron ſtone.* That of Ecclefechan preſents the following characters:

Colour brick red, and reddiſh brown.

Occurs maſſive.

Luſtre dull, or feebly glimmering, owing to an admixture of foreign particles.

* Note K.

† Note L.

Fracture fine earthy, even ſometimes paſſing to large and flat conchoidal.

Brittle, paſſing to mild.

Scratched pretty eaſily by the knife.

Heavy.

In the coal field of Cannoby, ſpherical ſhaped maſſes of clay iron-ſtone occur imbedded in ſlate clay. Theſe ſpheres are from a few inches to three feet in diameter, and do not differ in any reſpect from thoſe found in the coal field of Mid Lothian *.

5. *Limeſtone conglomerate.*

Is compoſed of fragments of compact greyiſh coloured limeſtone, quartz, and grey-wacke, cemented by a clayey baſis.

6. *Coal.*—The coal which is worked at Cannoby and Sanquhar, the only ſpot where it has been found in quantity, appears generally to be intermediate be-

* Note M.

tween ſlate and pitch coal, ſometimes inclining more to the one, ſometimes more to the other. Intermixed with it we frequently meet with

MINERAL CHARCOAL,

which preſents the following characters.

Colour greyiſh black.

Luſtre glimmering, bordering on gliſtening, and is pearly or ſilky.

Fracture fibrous; ſometimes ſhews the woody texture.

Fragments indeterminately angular, blunt edged, and partly ſplintery.

Soils ſtrongly. Soft, paſſing into friable. Light.

It occurs in thin layers in the coal, or diſſeminated through it.

More particular account of the diſtribution of the coal formation.

This formation, as already mentioned, occupies a conſiderable portion of the bottom of the valley of Sanquhar and Kirkconnel, and there it reſts on tranſi-

tion rocks. Several beds of ſlate coal are worked at Sanquhar and Kirkconnel; and the quantity raiſed is ſufficient to ſupply the county for many miles round. The depoſition here diſtinguiſhes itſelf from that of Cloſeburn, by the greyiſh white colour of its ſandſtone; greyiſh black colour of its ſlate clay, and the general thinneſs of its beds.

A little above Crawick bridge, Mr. Taylor of Leadhills pointed out to me a remarkable mineral, which may be denominated *columnar glance coal* *. It is to be obſerved paſſing to graphite, but not ſo diſtinctly as near Cumnock in Ayrſhire, where there is a graphite mine †. It forms a bed about four feet thick in the coal formation, and is traverſed by a vein (dyke ‡) of greenſtone. This vein, as is

* Note N. † Note O.

† Common miners in Scotland, ſtruck with the reſemblance of veins to walls, gave them the name, *dyke*. As this term is local, to ſay nothing worſe of

often the caſe, has produced a ſhift in the ſtrata.

Cloſeburn. A conſiderable portion of the valley of Cloſeburn is occupied by the ſame formation which extends in one direction from Drumlanrig to a little beyond Brown muir inn. The beds and ſtrata are thicker than in the valley of Sanquhar, and the ſandſtone and ſlate clay has uſually a reddiſh brown colour. At Cloſeburn and Barjarg there are conſiderable quarries of limeſtone, which afford good opportunities for examining this rock. The limeſtone is diſtinctly ſtratified; the ſtrata are from two to upwards of three feet thick, and frequently interpoſed between them we obſerve thin ſeams of bluiſh grey and reddiſh brown coloured clay. In ſeveral of the ſtrata there are irregular holes, which are ſometimes empty, but more frequently filled with a kind of clayey loam and brown

it, it ſhould be aboliſhed, and the univerſally underſtood and generally adopted word *vein* ſubſtituted in its place.

ochre of iron, intermixed with manganeſe. In this character the limeſtone agrees with that near Vogric in the county of Mid Lothian. Sometimes we obſerve in it beautiful dendritic brown iron hæmatites. I am indebted to the intelligent Mr. Monteith of Cloſeburn for ſeveral beautiful ſpecimens of this kind. The limeſtone is generally of a fleſh-red and pearl grey colour, and its fracture is fine ſplintery. It contains petrifactions of various kinds, particularly large ammonites.

Barjarg. The extenſive quarries of Barjarg do not differ from thoſe of Cloſeburn, and are moſt evidently part of the ſame depoſition. It is highly probable that this limeſtone will be found to extend through the whole of the coal formation of this valley.

Valley of Dumfries. A conſiderable portion of the lower and flatter part of the valley of Dumfries is compoſed of reddiſh brown coloured ſandſtone, belonging to the independent

coal formation, which is diſtinctly ſtratified, but contains no ſtrata of other minerals, excepting the ſtrata of limeſtone at Comlongan near the ſhore of the Solway frith.

Craigs near Dumfries.

The rocky cliffs near the town of Dumfries, called the Craigs, are compoſed of ſandſtone conglomerate, which reſts on the reddiſh brown ſandſtone, and evidently belongs to the ſame formation, becauſe we obſerve interpoſed between the beds of conglomerate thin beds of reddiſh brown coloured ſandſtone. This conglomerate is compoſed of angular and blunt-edged fragments of ſyenite *, grey wacke, and grey wacke ſlate, which are immerſed in a baſis compoſed of fragments of quartz, grey wacke, and grey wacke ſlate, which are connected together by a kind of iron-clay.

Coal formation in the diſtrict of Annandale.

In the diſtrict of Annandale we meet with patches of this formation as high up as Hartfell. The reddiſh brown co-

* Note P.

loured ſandſtone ſtretches from the baſis of Hartfell, the higheſt mountain in this county, towards Moffat, where it forms the beautiful eminence called Chapel-hill; it makes its appearance again at the Bald craig, about three miles ſouth-eaſt from Moffat. It is to be obſerved alſo between Moffat and Rae-hills, the ſeat of the Earl of Hopeton.

Corncockle muir.

At Corncockle muir, about three miles north of the burgh of Lochmaben, there are ſtrata of reddiſh brown coloured ſandſtone. Several of the ſtrata can be raiſed in flags and plates ſo thin, that they are uſed for paving, and even for roofing houſes.

The formation makes its appearance again at the Rotchel, below the manſe of Saint Mungo, and continues from that point to the ſhores of the Solway frith, and extends through the lower part of Annandale to Eſkdale. In the lower part of the diſtrict of Annandale, that is, beyond

the valley of Annan, there are ſeveral places where this formation is to be diſtinctly ſeen; with a ſhort deſcription of theſe I ſhall finiſh the account of its diſtribution in Annandale. The places are Kellhead, Ecclefechan, Brown muir, Brown muir hill, Repentance hill, Blacket rig, Cauldron lins, and High muir quarry.

Kellhead. At Kellhead there is an extenſive quarry, where a great rock maſs of limeſtone is expoſed: it is diſtinctly ſtratified, and ſtrata are ſometimes ſeparated from each other by thin ſeams of ſlate clay. In ſome of the ſtrata I obſerved ſmall cavities, reſembling thoſe in the limeſtone of Cloſeburn and Barjarg, filled with clay. It is traverſed by veins of calc-ſpar, and ſometimes there are ſmall cavities lined with cryſtals of calc-ſpar. The cryſtals have a yellowiſh grey colour, and their figure is a double ſix-ſided pyramid acuminated by three planes which are ſet on the alternate lateral planes. It alſo contains numerous petrifactions, as corallites, chamites, and mytulites.

Immediately behind the village of Eccle- Ecclefechan.
fechan, in the channel of the rivulet that runs by the limeſtone quarries, there are beds of clay iron-ſtone alternating with greeniſh grey and reddiſh brown coloured ſlate clay, and covered by reddiſh brown coloured ſandſtone. The beds of iron-ſtone are from three inches to a foot thick. Immediately above this we come to the *firſt limeſtone quarry*, where we obſerve thin beds of clay iron-ſtone, pearl grey coloured ſlate clay, and ſandſtone, reſembling that of Brown muir, lying on beds of ſlate clay that alternate with beds of limeſtone containing numerous petrifactions, but principally mytulites, chamites, and corallites. In the *ſecond limeſtone* quarry there are beds of limeſtone from one to two feet thick, alternating with beds of greyiſh black coloured ſlate clay, and of greyiſh white coloured ſandſtone. The ſlate clay is ſometimes ſo compact that the ſlaty texture is difficultly diſcoverable. Much mica is intermixed with the ſandſtone.

In the upper or third quarry the beds are compoſed of the ſame materials with the ſecond.

Repentance hill.

In 1791 a trial ſhaft was ſunk to a conſiderable depth in this hill, in ſearch of coal; it paſſed through ſeveral beds of greyiſh white and reddiſh brown coloured ſandſtone; of greyiſh black and reddiſh brown coloured ſlate clay, and in which there were beautiful impreſſions of ferns, and ſome thin ſeams of pitch coal *.

Brown muir hill.

Brown muir hill is compoſed of greyiſh white and reddiſh brown coloured ſandſtone, which is rather of a looſe texture, and ſometimes contains pretty large fragments of quartz, and alſo maſſes of clay. It alternates with beds of pearl grey coloured ſlate clay, which has much mica intermixed, and it contains vegetable impreſſions.

* See General Dirom's ſection in the county map, for a more particular account of this trial.

In the Brown muir there are ſeveral quarries, where the limeſtone belonging to this formation is well expoſed. In all theſe quarries the limeſtone is ſtratified, and between the ſtrata, as uſual, there are thin ſeams of greyiſh black, greeniſh grey, and mountain green coloured clay. The ſtrata are from ſix inches to three feet thick, and often preſent hollows filled with clay, like the limeſtone of Cloſeburn, &c. It contains ſimilar petrifactions with that of Cloſeburn, but ſome ſpecies in greater quantities than others, particularly the milleporites, which is found in great quantity, not only in the limeſtone, but alſo in the ſlate clay, and in no place more abundant and beautiful than in the limeſtone quarries on the eſtate of Brigadier General Dirom. Brown muir limeſtone.

Linbridge ford. In 1793, 4, and 5, according to General Dirom, trials were made at this place, with the view of diſcovering coal, and they appear to have reached the depth of 140 feet. The rocks Linbridge ford.

paſſed through were greyiſh white, yellowiſh grey, and reddiſh brown coloured ſandſtone; greyiſh black and reddiſh brown coloured ſlate clay; greyiſh black bituminous ſhale, and a bed of coal about four inches thick. For particulars ſee general ſection in the county map.

Blacket rig. At Blacket rig, which is ſituated on the border of the tranſition rocks, there is an extenſive limeſtone quarry, where the limeſtone, as uſual, is diſtinctly ſtratified, and the ſtrata frequently ſeparated from each other by thin ſeams of a bluiſh grey and mountain green coloured clay. The ſtrata are from two to ſix feet thick, and in ſome ſtrata the limeſtone is ſo intermixed with clay that it acquires a brecciated aſpect, and on working it ſeparates eaſily into maſſes of various ſizes. Such ſtrata are eaſily worked, and the limeſtone is conſidered to be of a better quality than the more ſolid ſtrata. It has the ſame external characters, and

contains ſimilar petrifactions with the limeſtone of the Brown muir.

Cauldron linns. About a mile and a half further to the eaſtward there is another quarry of limeſtone, called Cauldron linns. The limeſtone is diſtinctly ſtratified, and the ſtrata are ſeparated from each other by thin ſeams of clay, and in ſome ſtrata, from the intermixed clay, it has a brecciated aſpect. The ſtrata are from ſix inches to a foot and a half thick, and are very diſtinctly and beautifully *trough-ſhaped.* It has the ſame external characters, and contains ſimilar petrifactions with that of the Brown muir, &c. Cauldron linns.

High muir quarry. About half a mile to the north eaſt of this there is another quarry, called High muir. In it the limeſtone exhibits very beautiful *trough-ſhaped ſtratification.* The ſtrata are ſeldom above three feet thick, and are uſually ſeparated from each other by very thin ſeams of clay. In the upper part of the High muir quarry.

quarry the limeſtone is covered by thin ſtrata of greyiſh coloured ſandſtone, which contains much mica, and it alſo preſents very beautiful trough-ſhaped ſtratification.

It is probable that the limeſtone of Brown muir, &c. ſtretches through a great extent of the low part of the diſtrict of Annandale.

Coal formation in the diſtrict of Eſkdale.

Eſkdale, as I have already mentioned, is almoſt entirely compoſed of tranſition rocks, from its upper part to Langholm bridge. There the coal formation begins and continues through the whole of the lower part of this diſtrict to the Solway frith. Between Langholm bridge and Byre burn the ſandſtone is uſually of a greyiſh white and yellowiſh grey colour, and contains many vegetable moulds. The limeſtone is uſually bluiſh grey, and contains many petrifactions. The ſlate clay is uſually greyiſh black, and contains beds of globular clay iron-ſtone; and the bituminous ſhale has the uſual characters. Below Byre burn the brown-

iſh red coloured ſandſtone commences, and continues without any alternation of other rocks to the Solway frith. The ſtrata in the coal field of Byre burn are frequently trough-ſhaped. At preſent three beds of ſlate coal are worked*.

Having now detailed with ſufficient minuteneſs the characters of the different rocks of the coal formation of this county, I may now add, that its moſt ſtriking characters are, the reddiſh brown colour of the ſandſtone, the great thickneſs of

* The coal of Cannoby, Sanquhar, and Kirkconnel, is that variety of ſlate coal which contains much bitumen, and therefore, when inflamed, cakes; hence it is called caking coal. It is particularly uſeful for the forge and in domeſtic œconomy, but would not anſwer ſo well in other operations, as in ſmelting ores, &c. becauſe of its running ſo cloſe together. The varieties uſed for burning limeſtone contain much intermixed bituminous ſhale and ſlate clay; this ietermixture, in place of being detrimental, is of advantage, as the fire remains open during combuſtion. Even the bituminous ſhale, which is thrown away among the refuſe, might be uſed for burning limeſtone.

its ſtrata, the paucity of ſubordinate beds, and the thinneſs of its beds and ſtrata, when beds of iron-ſtone occur, of which we have examples at Ecclefechan, White hill, Byre burn, and Sanquhar.

COAL FORMATION OF MID LOTHIAN.

Coal field of Mid Lothian.

I ſhall now give a very ſhort account of the coal field in the neighbourhood of Edinburgh, or what is termed Mid Lothian.

The Edinburgh coal field reſts on tranſition rocks.

The baſis on which the coal formation reſts is tranſition rocks, and theſe agree very much in their characters with thoſe of Dumfries-ſhire. The ſtrata and beds are generally thin; they dip in various directions, according to the inequalities over which they are depoſited.

The rocks of which it is compoſed are, 1. Sandſtone, 2. Slate clay, 3. Limeſtone, 4. Clay iron-ſtone, 5. Limeſtone conglomerate, 6. Coal, 7. Clay ſtone, 8. Bitu-

minous ſhale, 9. Green ſtone, 10. Indurated marle.

1. *Sandſtone* is yellowiſh grey, aſh grey, greyiſh white, ochre yellow, yellowiſh brown, and ſometimes reddiſh brown, approaching to cochineal red*. The grains of which it is compoſed are uſually quartz, and are from the ſize of a poppy ſeed, to that of a bean, and even larger. Sometimes it contains mica, and grains of felſpar. The fragments are connected by a baſis of clay, which is ſometimes more or leſs impregnated with iron, and to which it in general owes its various coloured clay, and alſo interſperſed iron pyrites. Its compactneſs or ſolidity is very various, ſometimes it is friable, in other inſtances of good building conſiſtence, and ſometimes, although rarely, it has a baſis of quartz, and thus forms flinty ſandſtone.

* Note Q.

It often contains vegetable impreſſions, but the plants to which they belong have not hitherto been determined. Indeed no experienced botaniſt has, as far as I know, made them the object of his particular attention. It alſo frequently contains pieces of bituminous wood.

2. *Slate clay* is of various colours, but principally inclining more or leſs to black, and ſometimes, particularly where the reddiſh brown coloured ſandſtone occurs, it has a reddiſh or browniſh tinge.

3. *Limeſtone.* Colour uſually grey. Has a ſplintery fracture, and is ſometimes very minutely foliated. Is faintly tranſlucent on the edges. It often contains petrifactions of various ſpecies of ſhells, and ſometimes alſo, but rarely, vegetable impreſſions and pieces of bituminous wood.

4. *Clay iron-ſtone.* Of this no deſcription is neceſſary, as it reſembles completely that found in Dumfries-ſhire.

5. *Limeſtone conglomerate.* This is identical with that found in Dumfries-ſhire.

6. *Greenſtone* *. Its colours are uſually blackiſh green, and greeniſh black, and, when the felſpar predominates, greeniſh grey; it is even ſometimes nearly aſh grey. It is compoſed of hornblende and compact felſpar, and of which the hornblende uſually predominates; ſometimes, however, the felſpar predominates to nearly the entire excluſion of the hornblende †.

7. *Clay ſtone.* Colour ſmoke, aſh, and pearl grey, and from pearl grey it paſſes into browniſh red and brick red.

Occurs maſſive.

Fracture generally fine earthy, ſometimes ſplintery, and ſometimes inclines to conchoidal.

Fragments indeterminately angular.

* Note R.

† Note S.

Is opaque.

Soft.

Not particularly brittle.

Pretty eaſily frangible.

Feels rather meagre.

Does not adhere to the tongue.

8. *Bituminous ſhale.* Its colour is browniſh black.

Occurs maſſive.

Internally its luſtre is glimmering.

Fracture ſtraight ſlaty.

Fragments tabular.

Streak ſhining, but its colour is unchanged.

Very ſoft. Rather mild. Feels rather greaſy.

Eaſily frangible. Not particularly heavy, approaching to light.

9. *Indurated marl.* Colour yellowiſh grey.

Luſtre dull, and ſometimes glimmering, owing to intermixed particles.

Fracture earthy, and ſometimes ſlaty.

So ſoft as to yield to the nail.
Not particularly brittle.
Eaſily frangible.
Not particularly heavy.

10. *Coal.* Is uſually intermediate between pitch and ſlate coal; ſometimes beds of cannel coal occur, and very often we meet with native mineral charcoal.

From the preceding deſcription it appears that the coal field of Mid Lothian agrees with that of Dumfries-ſhire, in containing nearly the ſame kinds of ſtrata and beds; but the general character of the one is conſiderably different from that of the other. The ſtrata and beds in Dumfries-ſhire are thick, thoſe in Mid Lothian thin; the ſandſtone in Dumfries-ſhire is uſually of a reddiſh brown colour, whereas that of Mid Lothian is grey; clay iron-ſtone occurs abundantly in Mid Lothian, but ſparingly in Dumfries-ſhire; there occur beds of

General characters of the Dumfries-ſhire and Mid Lothian coal fields.

greenſtone and clay ſtone in Mid Lothian, but theſe have not been obſerved in Dumfries-ſhire.

The agreements of theſe two fields, however, by far exceed the differences I have juſt mentioned, and ſhew that the formation of Dumfries-ſhire belongs to the independent coal formation, and render it probable that it is of the ſame age with that of Mid Lothian. Thoſe to whom the geognoſtic data already mentioned do not convey conviction cannot with-hold their aſſent to the concluſion juſt ſtated, when they read the following note reſpecting the extenſive coal formation in Sileſia, belonging to the king of Pruſſia.

Coal formation in Sileſia.

In upper Sileſia the coal formation is compoſed of *thin ſtrata* of *greyiſh coloured fine-grained ſandſtone*, beds of ſlate clay, clay iron-ſtone, and coal, which is ſometimes ſix fathoms thick. In lower Sileſia,

on the contrary, the coal formation is compoſed of *thick ſtrata* of *reddiſh brown coloured ſandſtone*, which is uſually coarſe grained, and indeed ſometimes paſſes to conglomerate. Alternating with it we find beds of ſlate clay, and *thick and very extenſive beds of coal.* Thus the coal fields of upper and lower Sileſia preſent differences reſembling thoſe that diſtinguiſh Mid Lothian from Dumfries-ſhire, yet they are portions of the ſame formation. I have therefore no heſitation in concluding that the coal fields of Mid Lothian and Dumfries-ſhire belong to the independent coal formation; and as coal has been found widely diſtributed in the one field, we are entitled to believe it occurs in quantity in the other.

Coal fields of Dumfries-ſhire and Mid Lothian belong to the ſame formation.

The particular ſpots where trials for coal may be made with the greateſt œconomy and probability of ſucceſs can only be aſcertained by a careful ſurvey of every hill, valley, rivulet, ditch, road, &c. where this formation

occurs. My object in this memoir is not to point out theſe ſpots, but to ſhew, according to the principles of ſound geognoſie, that the floetz ſandſtone of this county is not to be confounded with the old red ſandſtone, ſecond ſandſtone, or third ſandſtone formations, but that it belongs to the independent coal formation; and therefore we are warranted in making trials for coal in any part of it, but with more probability of ſucceſs in one ſituation than another *.

NEWEST FLOETZ TRAP FORMATION †.

The rocks of this formation are, according to Werner, wacke, baſalt, greenſtone, pophyry ſlate, and grey ſtone; and,

* Note T.

† The German term flöetz, which I am under the neceſſity of uſing, becauſe we have no correſponding Engliſh word, is applied to all thoſe formations which are contained between the tranſition and alluvial rocks. It implies that theſe formations are characteriſtically

as ſubordinate to it, gravel, ſand, clay, flinty ſand ſtone, and coal. It is by him conſidered as the neweſt of the *univerſal formations*, becauſe it repoſes on all the others; and he has ſhewn that its internal ſtructure, external aſpect, and ſituation, can only be explained by a ſudden riſing and retiring of the waters of the ocean.

Floetz trap the neweſt of the univerſal formations.

In this county ſeveral rocks belonging to this formation are to be obſerved, but I have not in any inſtance ſeen the complete ſeries from gravel, through clay, wacke, to baſalt and greenſtone, as I have often witneſſed on the mountains of Germany *. Here we have only individual links of the formation, and of theſe I ſhall now give a brief account.

diſtinguiſhed by their frequent occurrence in beds (floetz). It is evident, therefore, that the words ſecondary, or tertiary, which have been propoſed by ſome mineralogiſts, cannot be admitted.

* Note U.

Nutholm hill. Nutholm hill, which riſes in three indiſtinct terraces above the manſe of Saint Mungo, is compoſed of porphyritic amygdaloid. This rock can be traced on both ſides of the river, down to the little hill called Whinny rig, where it terminates, and is ſucceeded by the coal formation. About a quarter of a mile weſt from Nutholm hill, on the banks of the river, the amygdaloid is to be obſerved lying on ſandſtone and ſlate clay, which is probably a portion of the coal formation. On the weſt ſide of the river amygdaloid does not ſtretch beyond the manſe of Dalton; the ground to the weſt of the manſe riſes pretty high, and is compoſed of tranſition rocks. On deſcending the ſouth-eaſt ſide of Nutholm hill towards the water of Milk the amygdaloid ſoon diſappears, and we do not meet with it again until we come to Barr hill, on its oppoſite bank. There it lies over a ſimilar ſandſtone with that obſerved on the banks of the river near to Saint Mungo, and the ſandſtone reſts on grey wacke. From

this hill it continues along the ridge by Newfield to Burnſwark, and is to be obſerved in ſeveral places lying on a coarſe conglomerate and ſandſtone, which again repoſes on very much inclined ſtrata of pretty compact ſmall grained greywacke. On the north-weſt ſide of Burnſwark, at a conſiderable height, I obſerved greyiſh coloured ſandſtone, marked with reddiſh brown coloured ſpots, and covered by ſlate clay; and on the north ſide, but higher up, I obſerved fragments of greyiſh white coloured ſandſtone, but the higher part of the hill is entirely compoſed of amygdaloid. Burnſwark.

From this account it appears that the lower part of Burnſwark is compoſed of ſandſtone, but the upper part of amygdaloid. Its baſis is grey wacke and grey wacke ſlate.

Nearly in the ſame direction with Burnſwark, above the limeſtone quarry called Blacket rig, the amygdaloid is to

be obſerved repoſing on tranſition rocks; and at Langholm bridge it occurs in a ſimilar ſituation. Thus it appears that the amygdaloid ſtretches acroſs the lower part of the county from Dalton manſe to Langholm bridge, which is its ſouth eaſtern extremity. In all this courſe it is confined to the boundary, or the meeting of the tranſition rocks with the coal formation.

In the upper part of Annandale, as far as I have examined it, there are no rocks of this formation.

Carſoncone hill.

In Nithſdale I obſerved rocks of this formation at Carſoncone hill, which makes part of the ridge that ſeparates the county of Dumfries from Ayrſhire; but in no other quarter of this extenſive diſtrict, although it is not to be doubted that a careful examination will diſcover it in many other parts.

At Todſhaw hill and the hills called Caſtle hill, Watch craig, and Wat carrick, near the manſe of Eſkdale muir, which are compoſed of compact grey wacke, there are ſeveral ſummits covered with greyiſh black coloured pitchſtone. The pitchſtone is unſtratified, and lies over the much inclined ſtrata of grey wacke. In the ſame hills there is porphyry ſlate, which, like the pitchſtone, occurs in globular and columnar diſtinct concretions. Sometimes *cotemporaneous* maſſes of pitchſtone, are to be ſeen incloſed in the porphyry ſlate or baſalt, and globular diſtinct concretions whoſe centers are pitchſtone, but the ſurfaces, of a ſubſtance much reſembling porphyry ſlate. We can alſo obſerve the tranſition from pitchſtone to porphyry ſlate or baſalt *. Pitchſtone in Eſkdale muir.

This pitchſtone, from its occurring along with porphyry ſlate, and lying over

* This pitchſtone, like that of Glencloy, in the iſland of Arran, will probably be found to contain

tranſition rocks is to be referred to the neweſt floetz-trap formation *.

Obſervations.

Werner has hitherto deſcribed but one pitchſtone formation, and it belongs to the primitive rocks. Several years ago I obſerved, in the highly intereſting iſland of Arran, pitchſtone alternating with floetz greenſtone that lay over the inde-

Werner deſcribes but one pitchſtone formation.

bituminous or carbonaceous matter. The pitchſtone of Glencloy, when powdered, emits a bituminous ſmell, and colours the ſulphuric acid ſlightly. (Mineralogy of the Scottiſh Iſles, vol. 1. p. 48.) Baſalt and other rocks belonging to the ſame formation contain, according to Klaproth and Lampadius, bituminous or carbonaceous matter; and Mr. Pepys has diſcovered carbonaceous matter in wood opal and wood ſtone. Parkinſon on Petrifactions, vol. 1.

* Dr. Reuſs of Bilin is of opinion that porphyry ſlate occurs in older formations than the floetz-trap; and Captain General Von Charpentier ſays that baſalt ſometimes occurs in primitive mountains. Both theſe obſervations, as I have ſhewn in my book on Mineralogy, are incorrect.

pendent coal formation *; afterwards I saw it in veins traversing floetz-trap rocks in the isle of Egg †, and among similar rocks in the isle of Mull ‡.

Pitchstone belonging to the newest floetz-trap formation.

Since that time Werner has examined the black pitchstone of Zwickau in Upper Saxony, which he considers to belong to a similar formation. Mr. Humbold, the celebrated and enterprising Prussian traveller, whilst on the summit of the Pic of Teneriff, observed beds of pitchstone among floetz-trap rocks; and I have seen in the interesting collection of Captain General Von Charpentier specimens of a similar fossil that was found in the basaltic country of the Veronese. We have thus proofs that this pitchstone is subordinate to the floetz-trap formation, and that it is widely distributed.

* Mineralogy of the Scottish Isles, vol. 1. p. 23.

† Ibid. vol. 2. p. 44.

‡ Ibid. vol. 1. p. 213.

ALLUVIAL ROCKS.

Characters of the alluvial rocks.

The formations belonging to this claſs of rocks are, as Werner obſerves, all mechanical, if we except calc-tuff, which is an undoubted chemical precipitate. It differs from the other claſſes of rocks in the want of connection among its depoſitions, the looſeneſs of the texture of the rocks of which it is compoſed, and the nearly total want of chemical precipitates. The number of its formations are alſo fewer.

Two alluvial formations.

In this county we have two very diſtinctly marked formations; the firſt, or oldeſt, is the great maſs of gravel which we find ſpread over the flat parts of the county, and through which the rivers now force their way; the ſecond, or neweſt, is that which has been formed by the operations of the rivers themſelves, and which is daily increaſing by the continual waſhing of debris from

the neighbouring mountains. To this period we may alſo refer the accumulations of peat, which are alſo daily increaſing.

In this alluvial land the only metallic mineral that has been diſcovered is *gold*. It was formerly waſhed for in the neighbourhood of Leadhills, and there is no doubt it exiſts in alluvial land in other parts of the county *. In Schwartzburg Rudolſtadt gold uſed formerly to be waſhed out of the alluvial land formed by the decompoſition of tranſition ſlate, as mentioned by Voight, who alſo obſerves, that it might probably ſtill be extracted with advantage, if proper waſhing machines were employed †. This remark alſo ap-

Gold found in alluvial land near the Leadhills.

* General Dirom, in his table annexed to the map of the county, informs us, that in the reign of James V. three hundred men are ſaid to have been employed for ſeveral ſummers in waſhing for gold, and to have collected to the amount of L. 100,000 ſterling.

† Voight's Kleine Schriften, b. 2. ſ. 136, 7, 8, &c.

plies to the alluvial land of Dumfries-ſhire.

Gold of Leadhills probably occurs in quartz veins.

In what kind of repoſitory was the gold of Lead hills formed, and in what ſpecies of rock are ſuch repoſitories ſituated? The alluvial land in which the gold grains are found is compoſed of fragments of tranſition rocks, hence we may conclude that they formerly exiſted in theſe rocks; and, as the grains are ſometimes found in quartz, and as quartz veins often traverſe tranſition rocks, it is not improbable the greater part of the gold is derived from quartz veins *.

PEAT.

The moſt conſierable accumulation of peat in this county is that in the valley

* All the gold found in Tranſylvania occurs in quartz veins that traverſe tranſition rocks, a fact which renders the above ſuppoſition more probable.

of Dumfries, named Lochar moſs. It extends from Tinwald to Cockpool, at the mouth of the Lochar. It appears formerly to have been a lake, and not an inlet of the ſea, as conjectured by ſome. There are other accumulations of leſs extent, as that of Kilmore, that which extends from Burnfoot to Nellsfield, Righead moſs, and ſeveral others in the lower part of the county. In the upper or mountainous part of the county it is found in conſiderable quantity in hollows between the mountains, and even on their ſummits.

Obſervations.

On the formation of alpine peat.

The accumulation of peat on the ſummits of high hills or mountains is a fact deſerving of attention. How are we to explain ſuch accumulations of vegetable matter in ſituations ſo far removed from all the uſual ſources of nouriſhment? Is it not probable that water and air ſupply theſe vegetables with nearly all the mate-

rials neceſſary for their growth, and that theſe accumulations are to be viewed as water and air altered by the powers of vegetation? It may be anſwered, that vegetables will not thrive in water and air alone. This is no doubt the fact with reſpect to the more perfect vegetables; but thoſe of the lower orders, as the Cryptogamia, of which alpine peat is principally compoſed, we know will grow and flouriſh in water. Others will object to this opinion, that vegetables do not poſſeſs the power of converting water into carbon, metallic, and earthy matters. The late experiments of Schraeder *, however, have ſhewn, what was long ago conjectured by Sir Iſaac Newton and other philoſophers, and even aſſerted by late experimentaliſts, that plants raiſed in diſtilled water af-

* Zwei Preiſſchriften über die eigentliche beſchaffenheit und erzeugung der erdigen beſtandtheile in den einheimiſchen Getraidearten. Berlin, 1800. ſ. 17. 18.

ford a vaſtly greater proportion of carbon, metallic, and earthy matters, than exiſted in the ſeeds from which they were raiſed, conſequently that theſe materials muſt have been formed from the water, or the water and air combined. The facts aſcertained by Schraeder receive confirmation from geognoſie.

NOTES

AND

ILLUSTRATIONS.

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NOTES

AND

ILLUSTRATIONS.

A.

On mountain groupes.

THE deſcriptions of the phyſiognomy of the earth's ſurface, as detailed in geographical works, in particular, what has a reference to the grouping of mountains, are often indiſtinct and imperfect. I ſhall, in proof of this, mention a few inſtances drawn from the deſcriptions of ſeveral modern geographers. By them Bohemia is deſcribed as a flat coun-

try, ſurrounded by a range of mountains; Norway is ſaid to be ſeparated from Sweden by a long and elevated chain of mountains; the Pyrenean mountains that divide France and Spain, the Uralian mountains that are interpoſed between Siberia and Ruſſia, and the mighty and long extended Altain chain which bounds Siberia on the ſouth and weſt, are alſo deſcribed as chains of mountains. By a chain of mountains, however, we underſtand in common language a collection of ſingle mountains linked together in a lengthened form. The mighty and extenſive elevations we have juſt mentioned do not correſpond with this definition, becauſe they are compoſed of many ſuch chains, which are arranged in a determinate order; we muſt therefore give them another denomination, and one which ſhall convey no erroneous meaning. If we examine them particularly we ſhall find that the mountain chains of which they are compoſed,

are not irregularly diſtributed, but are uſually arranged into groupes, and that each groupe has a central or more elevated chain towards which a number of lateral chains tend. We muſt therefore denominate the Pyrenees, Uralian mountains, great ſouthern chain of Scotland, &c. *chains of mountain groupes*, not chains of mountains.

B.

Parts of which a mountain is compoſed.

Almoſt every mountain has a *foot*, *acclivity*, and *ſummit*. By the *foot* we underſtand the loweſt and flatteſt part of a mountain. It ſometimes extends to a conſiderable diſtance, and then it riſes under an angle of 8° or 10°; when it is leſs extenſive, or has a ſmaller baſe, it riſes under a ſomewhat greater angle, but never greatly exceeds 10°. The mountains in wide valleys have generally a conſiderable foot, but thoſe in narrow valleys are leſs in extent. Sometimes, as

in mountains having a *mural aſcent*, there is no foot.

The *acclivity* or *aſcent*. By this we underſtand the ſpace contained between the foot and the ſummit of a mountain. It is uſually the ſteepeſt and moſt conſiderable part of it. Its inclination is more or leſs than 30°, and on this depends the greater or leſſer covering of ſoil. Upon an acclivity of 30° and upwards we find a good cover of ſoil; at 45°, however, the acclivity is too great to admit of a firm covering, ſo that on it the ſoil is looſe and much extended, yet ſtill ſufficiently coherent to admit of the growth of trees. Sometimes the acclivity is perpendicular, forming mural precipices, and it is either mural on one, two, or on all ſides, or on ſingle ſpots. Granite, porphyry, and ſandſtone afford inſtances of ſuch acclivities.

Summit. This is uſually the ſmalleſt part of a mountain, and its inclination is

generally leſs conſiderable than that of the acclivity. There occurs, however, exceptions to this; thus, there are ſummits that riſe more rapidly than the acclivity, and theſe are uſually very high, and almoſt of equal height with it, and are completely naked. Such lofty and precipitous ſummits are, in Switzerland, called peaks. The ſummit varies conſiderably in its ſhape; it is either tabular, round-backed, or obtuſe, acute, or ſhort-conical. Generally the ſhape of the mountain is characteriſtic of the rock of which it is compoſed. Thus gneiſs and tranſition rocks form flat or round-backed ſummits, clay ſlate conical ſummits, and baſalt and ſome other rocks ſhort and obtuſe conical ſummits. Granite and limeſtone often preſent extremely ſharp pointed ſummits, or peaks.

C.

River diſtricts.

The ſurface of the earth is, by rivers and their lateral ſtreams, divided into great portions, which are by hydrographers termed *river diſtricts*. Theſe diſtricts are generally very wide and flat troughs or concavities, in which the main river occupies the lower, and its exit from the concavity the loweſt point of the diſtrict. Thus the river Annan occupies the lower part of the diſtrict of Annandale, and at its exit into the Solway frith the loweſt point. In good maps we can trace out theſe diſtricts, by drawing lines along the points where the ſmall rivers and rivulets of the diſtrict take their riſe, and thus we obtain the boundary of the river diſtrict. Hydrographical maps of this kind afford to the geognoſt opportunities of making many intereſting obſervations.

D.

In the Allgemeine Literatur Zeitung, ſt. 90, the circular valleys through which the Danube flows are not unaptly compared with the ſpots on the ſurface of the moon. Thus Bavaria and Swabia are compared with the Mare Criſium, Auſtria with Newton, Bohemia with Plato, and Hungary with the Mare Imbrium. Schroeter, in his admirable work entitled *Selenetographiſche Fragmente*, gives us a very particular account of the diſpoſition of the mountains and mountain ranges on the ſurface of the moon; but he makes a very improbable conjecture when he ſays, that the circular ſpots are to be conſidered as craters of immenſe volcanos. Valleys of the moon.

E.

On formations.

All thoſe rocks which have been formed at the ſame period, and which agree in geognoſtic characters and relations, are ſaid to belong to the ſame formation. Thus wacke, baſalt, greenſtone, and porphyry ſlate occur together, and in ſimilar geognoſtic relations, and hence are conſidered to have been formed at the ſame epocha, and conſequently to belong to the ſame formation. But there are inſtances of the repetition of the ſame mineral at different epochas, and in formations of different ages and kinds. In ſuch a ſeries all its members have general points of agreement, and the individual ones bear characters, not only expreſſive of the period of their depoſition, but alſo of the circumſtances under which they were formed. Such a ſeries or formation is by Werner denominated a *principal formation ſuite.* Examples of it

we have in limeſtone, trap, and ſlate. To illuſtrate this highly intereſting obſervation, I ſhall mention the members of the limeſtone and trap ſuites.

Limeſtone formation ſuite.

The firſt member of the limeſtone formation ſuite is the white granular limeſtone, which occurs in gneiſs, mica ſlate, and clay ſlate. This limeſtone has large-grained diſtinct concretions, but in the neweſt clay ſlate the concretions become more minute, and it even approaches to compact. The tranſition rocks contain the ſecond member of the ſeries, the variegated limeſtone, which has leſs tranſlucidity than the preceeding, but more than the following members of the ſeries, and ſhews the firſt traces of petrifactions. The following or floetz rocks contain the third member of the ſeries, the grey floetz limeſtone, which is ſcarcely tranſlucent on the edges, and is full of petrifactions. It has ſome reſemblance to the limeſtone of the tranſition period, but only the moſt

diſtant to that of the primitive. How great is the difference between the granular tranſlucent primitive limeſtone and the dull earthy and nearly opaque floetz limeſtone! and yet both are members of a ſeries of chemical formations, which are ſtill not the moſt diſtant. Chalk is the neweſt formation of this period; it connects the foregoing members, which have been depoſited from the ocean, with the calc tuff, the loweſt link of this formation ſuite (if we do not include the coral rocks which are daily forming) which has been formed on the land. We have thus a complete ſeries from the earlieſt to the lateſt period, in which we obſerve a gradual diſappearance of the cryſtalline, and increaſe of the earthy aſpect, correſponding with the relative age of the different members of the ſuite, and the ſtate of the ſolvent, from which they were precipitated.

Trap formation ſuite.

In the trap ſuite although the different members have a great reſemblance to each

other, yet they all bear diſtinct marks of the period of their formation. The oldeſt or primitive greenſtone is highly cryſtalline, the newer or tranſition is leſs cryſtalline, and in the neweſt or floetz-trap it approaches to earthy, as ſhewn in baſalt, and more particularly wacke, as the loweſt link, or furtheſt removed from the highly cryſtalline primitive greenſtone.

F.

Method to be followed in inveſtigating and deſcribing a rock maſs or mountain.

In deſcribing a rock maſs, or mountain, we muſt be careful not to be too micrological in our obſervations, otherwiſe we ſhall fail in communicating a diſtinct picture of it. All that is neceſſary in ſuch inveſtigations is, firſt, to aſcertain the formation to which it belongs; ſecondly, whether it is ſtratified, diſpoſed in beds, in lying or erect maſſes; thirdly, the characters of the rock, and thoſe that appear to be peculiar to it, or

which diſtinguiſh it from rocks of the ſame ſpecies. By the firſt we aſcertain its age in relation to the other maſſes of which the cruſt of the earth is compoſed; by the ſecond its ſtructure in the great; and by the third its ſtructure in the ſmall, or in hand ſpecimens, and the characters that diſtinguiſh it from other rocks. Any thing further, any attempt at deſcribing every variety of the aſpect of a rock, is uſeleſs, and thoſe who perſiſt in ſuch unneceſſary diſcriminations are not acquainted with the method of conducting geognoſtical inveſtigations.

G.

Inſtances of looſely aggregated quartz.

Quartz, in a ſimilar ſtate of aggregation, has been obſerved in mineral veins in the Harz. Voight, on deſcending into the mine called Louiſa Chriſtiana at Lauterberg in the Harz, found that nearly the whole of the vein, which was about

nine fathoms wide, was filled with quartz in the ſtate of ſand. In this looſely aggregated quartz, tuberoſe-ſhaped pieces of copper ore are interſperſed, and the miners only uſe picks and ſhovels to ſeparate the ore from its vein-ſtone. *Vide* Voight's Kleine Schriften, b. 1. ſ. 168. Lazius in his deſcription of the Harz, mentions ſimilar appearances.

This looſe ſtate of aggregation is probably its original one, and not cauſed by alteration ſince depoſition.

H.

To ſhew how favourable the tranſition rocks, of which ſo great a part of this county is compoſed, are for the occurrence of ores, I ſhall mention a few inſtances of their metalliferous nature in other countries.

Tranſition rocks favourable for ores.

The Harz, which is one of the moſt conſiderable mining countries in Europe, contains a great extent of tranſition rocks, and in theſe the richeſt mineral repoſitories of that country are ſituated. Thus at Andreaſberg there are many extenſive veins of ſilver ore in tranſition ſlate; at Clauſthal there are veins from two to fourteen fathoms wide, which are compoſed of lead glance, black and brown blende, iron and copper pyrites, ſparry iron ſtone, white ſilver ore, red ſilver ore, brittle ſilver ore, fahl ore, and tinder ore, and the vein ſtones are calc-ſpar, quartz, and lamellar heavy ſpar.

The richneſs of theſe veins is aſtoniſhing. Frieſleben obſerved the Dorothea vein in the diſtrict of Clauſthal eight fathoms and a half wide, and compoſed of pure lead glance, ſo that, as he obſerves, it appeared like a quarry of ore. Frieſleben's Harz. b. 2. ſ. 159.

At Vereſpatack in Tranſylvania, gold is found in ſmall veins that traverſe grey wacke. Theſe veins are only about an inch in width, but from their great number they are worked with conſiderable profit.

In Piedmont and in Weſterwald there are alſo rich ſilver mines in tranſition rocks.

I.

On the occurrence of ſandſtone in globular diſtinct concretions.

The occurrence of ſandſtone in globular or ſpherical diſtinct concretions has been ſeldom obſerved; the only inſtances I am acquainted with are the following: In the iſland of Skye, near the harbour of Portree, the ſandſtone is compoſed of very large globular diſtinct concretions. Mineralogy of the Scottiſh iſles, vol. 2. p. 87. 88.

Reuſs, in his Mineralogical Geography of Bohemia, deſcribes, in the following

words, a ſimilar appearance: "The ſand-
"ſtone is ochre yellow, yellowiſh brown,
"and ſometimes browniſh black. Its
"baſis or cement is ſometimes clayey,
"particularly the ochre yellow; ſome-
"times it is *iron-ſhot*, as is the caſe with
"the browniſh black, and in ſuch varie-
"ties the baſis is a more or leſs diſinte-
"grated iron ochre, which connects the
"different angular and rounded quartz
"grains. It appears to lie in pretty (from
"two to four feet) thick horizontal beds;
"on a more near examination, however,
"we find that every bed is compoſed of
"compreſſed ſandſtone balls lying cloſe
"together, and that theſe balls are again
"compoſed of *thick* and *concentric lamellar*
"*diſtinct concretions*. The ſtructure of
"theſe concretions is rendered more
"diſtinct by their being alternately
"compoſed of ochre yellow, fine grained
"clayey ſandſtone, and of yellowiſh
"brown and browniſh black iron-ſhot,
"coarſe grained ſandſtone (or rather
"breccia). The long continued action

" of the atmoſphere on theſe ſandſtone
" balls, gradually diſintegrates the clayey
" ſandſtone, which, on account of its
" friability is the more eaſily effected.
" The rain waſhes it out, and then only
" the ſomewhat thinner lamellæ of the
" iron-ſhot ſandſtone remain behind. By
" this means the ſandſtone acquires a
" large veſicular corroded aſpect, thus pre-
" ſenting complete oval ſhaped, and
" ſometimes irregular veſicles. The ſur-
" face of the remaining iron-ſhot ſand-
" ſtone becomes brick red and reddiſh
" brown, owing to the increaſed oxida-
" tion of its iron." Reuſs's Mineralo-
giſche Geographie von Böhmen, b. 2.
ſ. 46. 47.

Obſervations.

The occurrence of ſandſtone in diſtinct concretions ſhews that a very conſiderable portion of the matter of which it is compoſed was, at the time of its formation, in a ſufficiently minutely divided ſtate, to allow it to form maſſes having a ſome-

what regular ſhape. Flinty ſandſtone affords another ſtill more ſtriking inſtance of the occurrence of ſandſtone with a chemical baſis. At Saliſbury craigs there are fine examples of this kind of ſandſtone.

K.

Importance of the knowledge of petrifactions.

No ſubject in geognoſie is more highly intereſting than the hiſtory and deſcription of petrifactions. It makes us acquainted with the various organized beings that exiſted during the different periods of the earth's formation; it points out the gradual increaſe and diſperſion of animals and vegetables; it diſcloſes to the botaniſt and zoologiſt whole myriads of animals and vegetables, that probably no longer exiſt on our earth; and it affords to the geognoſt very elegant illuſtrations reſpecting the different ages of the mineral

maſſes, of which the cruſt of the earth is compoſed.

Very long ago, petrifactions attracted the attention of naturaliſts, and firſt gave riſe to the forming collections of minerals, and to the more zealous ſtudy of geognoſie. At firſt they were viewed only as proofs of the tremendous deluge deſcribed by Moſes, and for a long time naturaliſts did not venture to conſider them as capable of affording any other explanations, reſpecting the hiſtory of changes which the earth has experienced. The rocks in which they were found, and the determination of their ſpecies were little attended to, the principal object of thoſe inveſtigators being to diſcover them in every rock, with the view of thus, from natural appearances, proving the univerſality of the deluge. A more careful examination, however, diſcovered that the greater number exiſted in rocks whoſe origin is anterior ſtill to that of the univerſal deluge.

Conſidered as proof of the Moſaic deluge.

Almoſt all the older writers as Lugd, Woodward, Mylius, Scheuchzer, Mendez da Coſta, and Volkmann, conſidered vegetable impreſſions as having been formed at the time of the flood. Very early, however, Leibnitz in his Hiſtoire des Sciences for 1706, p. 11. mentions as a very extraordinary circumſtance the occurrence of the impreſſions of Indian plants in German rocks; and Schulze in his Beſchreibung der bei Zwickau gefundenen Kraüter abdrücke, ſ. 47. in the firſt volume of the Neue Geſellſchaftlichen Erzählungen for the year 1758, contraſts the vegetable impreſſions found in the coal field of Zwickau with the figures of ferns drawn by Pluckenet and Plumier, but he does not deduce any concluſions from theſe compariſons. Mylius in his Memorabilia Saxoniæ Subterraneæ, p. 20, conjectures that ſome of theſe impreſſions may belong to exotic plants. Juſſieu in his valuable memoir, entitled Examen des Cauſes des Impreſſions des Plantes

Juſſieu's opinion.

marquées ſur certaines pierres des environs de Saint Chaumont, &c. at page 866, in the Hiſtory of the Academy of Sciences for 1718, ſays expreſsly that the originals of theſe plants muſt exiſt either in the Eaſt or Weſt Indies, becauſe they have the greateſt reſemblance to the ferns and marſh plants of thoſe countries, or *they no longer exiſt on the ſurface of the earth.* Many ſucceeding naturaliſts have adopted the idea that the greater number of vegetable impreſſions belong to ſpecies now extinct, and Werner, whoſe authority in ſuch caſes is ſuperior to that of all others, long ago concluded from his obſervations *that all the impreſſions found in the older formations belong to vegetables now extinct, and which flouriſhed and died in the countries where we now find them.*

Werner's opinion.

I ſhall not here enter into any illuſtration of this opinion, but ſhall earneſtly recommend the examination of the numerous vegetable impreſſions which are found in the coal fields of Scotland to

the careful ſtudy of botaniſts. To aſſiſt thoſe who are inclined to enter on this wide field of highly intereſting inveſtigation, I ſubjoin a liſt of authors who have treated of vegetable impreſſions.

Catalogue of authors who have treated on vegetable petrifactions.

1. The Hiſtory of the Academy of Sciences for 1703, 1706, 1708, and 1716; alſo for 1692, 1666, and 1699.

2. Acta Eruditorum, from 1710 to 1723.

3. Naturgeſchichte der Naſſawiſchen Lander von Cammerath Habel.

4. Weimariſche Magazin.

5. Herbarium Diluvianum.

6. Paulus Gerardus Moehring, Phytolithus Zeæ Linnæi in ſchiſto nigro duriusculo. Act. Acad. Nat. Curios, tom. 8, p. 448, and 450.

7. Knorr's Lapides Diluvii Teſtes, folio.

8. Jean Gottlob Lehman ſur des fleurs de l'Aſter Montanus ou Pyrenaique precoce, a fleurs bleues, et a feuilles de ſaule, empreintes ſur l'Ardoiſe. Hiſt de l'Acad. de Berlin. 1756, p. 127. 144.

9. Emanuel Mendes da Coſta, Account of the Impreſſion of Plants on the Slates of Coals. Philoſophical Tranſactions, vol. 50. p. 228. 235.

10. Geoffroy, Memoire ſur quelques Empreintes Foſſiles, Journal de Phyſique, tom. 28. p. 269. 271.

11. Tingry's Obſervations on ſome extraneous Foſſils of Switzerland. Lin. Tranſ. vol 1.

12. Jean Guillaume Bruguire. Sur les Mines de Charbon des Montagnes de Cevennes, et ſur la double empreinte des Fougeres qu' on trouve dans leur ſchiſtes. Journ. d'Hiſt. Nat. t. 1.

13. Notice ſur des Plantes Foſſiles de diverſes eſpeces qu'on trouve dans les couches foſſiles d'un ſchiſte marneux recouvert par des laves, dans les environs, &c. par Fujas St. Fond. Annales. Mus. Nat. p. 389.

14. Abhandlung über die Kräuter abdrücke in Schièferthon Sandſtein, &c. von von Schlotheim. Hoff. Mag. b. 1. ſ. 76.

15. Ure's Hiſtory of Rutherglen and Kilbride.

16. Lithophylacii Britannici, &c.

17. James Parſon's Account of ſome Foſſil Fruits and other Bodies found in the Iſle of Shepey.

18. Phil. Tranſact. vol. 50. p. 396. 407.

19. Parkinſon's organic Remains of a former World, quarto. It is to be regretted that Mr. Parkinſon has given ſo limited an account of the numerous vegetable impreſſions of the coal formations of Britain.

L.

On the diſtinction between ſtrata ſeams and accidental rents.

In making obſervations with the view of determining the preſence or abſence of ſtratification, we muſt be careful to diſtinguiſh between the *ſeams of the ſtrata* and *accidental rents*. The following obſervations will aſſiſt thoſe engaged in ſuch inveſtigations:

1. Strata are always parallel with the ſlaty ſtructure of the ſtone. In certain

porphyritic granites the cryſtals of felſpar appear to lay parallel with the ſtrata; the latter character, however, is by no means ſo deciſive as the former.

2. Strata can only be formed by parallel ſeams which have the ſame direction and extent through the mountain maſs. Where parallel rents occur in different directions in the ſame ſpecies of rock, as in granite, ſandſtone, limeſtone, &c. it is evident that they are to be conſidered as accidental.

3. The ſeams of tabular diſtinct concretions, which are often of conſiderable extent, muſt not be confounded with ſtrata ſeams, becauſe their extent is not ſo conſiderable, and in each groupe of concretions the direction is different. A good example of theſe ſeams is to be ſeen in the baſalt of the Caſtle rock of Edinburgh.

4. Where parallel rents have a different direction from the ſlaty ſtructure of the ſtone they are certainly accidental. Inattention to this circumſtance has led ſeveral mineralogiſts into error. I obſerved a ſtriking inſtance of theſe rents in a quarry of gneiſs, in the foreſt of Tharand in upper Saxony. The gneiſs, at firſt ſight, appeared to be diſpoſed in vertical ſtrata, and as ſuch it was viewed by De Luc; on a cloſer examination however, the apparently vertical ſeams proved to be merely accidental parallel rents perpendicular to the ſlaty ſtructure of the ſtone; therefore the ſtrata were horizontal not vertical.

5. Beds are always parallel with the ſtrata; theſe, therefore, point out the direction of the ſtrata.

6. Although the ſlaty ſtructure points out to us the direction which the ſtrata muſt have, it does not follow that a rock having a ſlaty ſtructure is ſtratified.

7. In ſandſtone, limeſtone, and ſalt, regular and very extenſive ſtripes are ſometimes obſerved, which have been confounded with true ſtrata ſeams. An attentive examination, however, always diſcovers them traverſing the real ſeams of ſtratification. Von Buch, in his deſcription of Landeck *, and geognoſtical obſervations made in Italy and Germany †; Frieſleben, in his obſervations on Thuringia ‡; and Sir James Hall, in the theory of the earth, publiſhed by the late Dr. Hutton of Edinburgh ‖, deſcribe ſtriking inſtances of ſtripes reſembling ſtratification. The following is the explanation of this phenomenon, as given by Von Buch. "Wahrſcheinlich liegt "die urſache in einer groſſen bewegung

* Verſuch einer mineralogiſchen Beſchreibung von Landeck, 4to.

† Geognoſtiſche Beobachtungen auf Reiſen durch Deutſchland und Italien.

‡ Geogn. Beobachtungen in Thüringen. Lempe. Mag. der Bergb. x. 93.

‖ Hutton's Theory of the Earth, vol. 1.

" der ſich bildenden maſſe, theils aus all-
" gemeinen urſachen, theils weil ſie in
" mehrere bewegung zugleich mitgetheilt
" werden könnte; durch welche ſie
" ungleichförmig abgeſetzt und genöthi-
" get wurde, mulden und hügel zu bilden;
" und ſo dieſe ſonderbaren zeichnungen
" hervorzubringen." Von Buch. Reiſen.
1. b. ſ. 161.

M.

Different iron ſtone formations.

The formations of iron are, according to Werner, more numerous than thoſe of any other metal, and are almoſt of every age. The magnetic iron-ſtone found in primitive mountains, and particularly in limeſtone ſtrata, is the moſt ancient formation of this metal with which we are acquainted; the red iron-ſtone formation is much newer; that of the brown and ſparry iron-ſtone ſtill of a more recent date; and the clay iron-ſtone is newer than any of the preceding. The mag-

netic iron ſand, and the clay iron-ſtone which occurs in the neweſt floetz-trap is of a very late formation; but the neweſt of all is that which is daily forming on the ſurface of the earth, and which we are acquainted with under the names of bog, marſh, and meadow iron ore.

N.

On the occurrence of glance coal in the independent coal formation.

Slaty glance coal, or coal blende, was conſidered to be excluſively confined to the primitive rocks, until I diſcovered it in the independent coal formation, in the iſland of Arran. Since that time it has been obſerved by Meuder in the independent coal formation, near the village of Brandau in the Saatzer circle in Bohemia. The following is the intereſting notice he has communicated on this ſubject:

" Es ergiebt ſich aus dem obigen, das
" die kohlenblende nicht den urgebirgen

" allein eigen iſt, wie man bisſher glaubte,
" ſondern das ſie auch den Flötzgebirgen
" zugehört. Nur vor einigen monaten
" uberzeugte ich mich mit eigenen augen
" von der wirklichkeit dieſer thatſache:
" ungefähr eine viertel ſtunde ſudweſtlich
" von dem in Böhmen in Saatzer Kreiſe,
" hart an der ſächſiſchen grenze gelege-
" nen dorfe Brandau befindet ſich ein
" kleines ſteinkohlen gebirge an und auf
" das daſige gneiſs gebirge halbmulden
" förmig gelagert. Es beſteht aus einem
" ſandſteine, welcher die ſteinkohlen-
" gebirge characſtiriſirt, und der, wie
" mir es ſchien, zunächſt auf dem gneus
" liegt; ferner aus ſchieferthon, der un-
" gemein ſchöne pflanzenabdrüke en-
" thält und in den ſandſtein vollkommen
" übergeht, aus brandſchiefer und aus
" mehrern ſchwachen thoneiſenſtein-
" flötzen. Mit dieſen flötzen von ſchief-
" erthon, brandſchiefer, u. ſ. f. wechſeln
" nun ganz ſchwache höchſtens 2 zoll
" ſtarke flötze oder lagen von der aus-
" gezeichnetſten *kohlnblende* ab; öfters iſt

" ſie bloſs eingeſprengt und angeflogen." *Jameſon's Mineralogiſche Reiſen durch die Schottiſchen Inſeln, &c.* überſetzt von H. W. Meuder. ſ. 33.

O.

Graphite*, or black lead, has been hitherto conſidered as excluſively confined to the primitive mountains. In Germany it is found in gneiſs, mica ſlate, and clay ſlate, uſually in beds, and ſometimes diſſeminated; in Greenland it occurs along with quartz and adularia; at Keſwick in Cumberland it occurs in imbedded maſſes in a rock which is ſaid to be clay ſlate; I ſuſpect, however, from the general nature of the rocks of that country, and from

New graphite formation.

* As the name black lead conveys an erroneous idea of the nature of the ſubſtance, Werner very properly aboliſhed it, and ſubſtituted in its place that of *graphite*. This term begins now to be uſed in England, and for many years it has been univerſally adopted in Germany.

ſpecimens I have had an opportunity of examining, that it is tranſition ſlate or fine-grained grey wacke. The graphite I am now to give a ſhort account of, on the contrary belongs to the floetz rocks.

The county of Ayr, in which this formation occurs, as far as I have had an opportunity of examining it, appears to be a large ſemicircular valley, bounded on the ſouth, eaſt, and north, by mountains of conſiderable height. Theſe mountains where they border on Kirkudbrightſhire, Dumfries-ſhire, and part of Lanarkſhire, are compoſed of tranſition rocks, which are frequently covered with portions of the neweſt floetz-trap formation. The lower and flat part of the valley is principally occupied by the independent coal formation, and the neweſt floetz-trap formation. The graphite which I am now to deſcribe is about four miles from New Cumnock, and is ſituated in the lower part of the county, but not far diſtant from the tranſition mountains. The beds

of rock are well expoſed, and the following is the order in which they occur, beginning with the uppermoſt. I muſt previouſly remark, however, that there are two ſections of the formation, one which is called the mine, where a gallery has been driven to procure graphite, and another at a little diſtance, but as they differ from each other only in the number of beds, I ſhall deſcribe them as one.

1. Thick bed of greyiſh white and yellowiſh white coloured ſandſtone, which is rather of a looſe conſiſtence, and contains much intermixed mica. In ſome parts it preſents globular and ſpherical diſtinct concretions, like the ſandſtone in the coal field of Byreburn. The upper part of the bed appears to be ſlaty, or rather in plates.

2. Immediately under the ſandſtone is a bed of ſlate clay, which is from ten to twelve feet thick. In ſome parts it paſſes

into a flinty foſſil that appears verging on flint, or flinty ſlate.

3. The next is a bed of greenſtone, which preſents globular diſtinct concretions. In it I obſerved maſſes of graphite.

4. Immediately below this bed of greenſtone is a bed of ſlate clay about twelve feet thick, which is alſo in ſome places flinty.

5. Is a bed of greenſtone in globular diſtinct concretions, from three to ten inches thick.

6. Bed of *columnar glance coal* from three to ſix feet thick, in which the columns are arranged in rows like baſalt. Intermixed, and often forming a great portion of this bed, we find *the graphite* *,

* It is worthy of remark that conchoidal, ſlaty, and columnar glance coal, natural mineral charcoal,

which is either compact, ſcaly, or *columnar* *. I obſerved maſſes of greenſtone imbedded in the coal and graphite, but whether they are to be conſidered as fragments, or as of cotemporaneous formation with them, I cannot with certainty determine. The latter ſuppoſition is the moſt probable.

7. Immediately under this remarkable bed of graphite and glance coal we meet with another bed of greenſtone.

8. Under the preceeding there is a bed of the rock reſembling flinty ſlate, which is from ten to fourteen feet thick.

and graphite, (probably alſo diamond) the only ſpecies of unbituminated carbonaceous minerals hitherto known, occur in rocks connected with the floetz-trap formation.

* A deſcription of this new ſubſpecies of graphite will be given in the ſecond volume of my Syſtem of Mineralogy.

9. The loweſt bed viſible is of ſandſtone reſembling N. 1. in colour, ſolidity, ſtructure, and ingredients.

On firſt examination, and before I had convinced myſelf of the exiſtence of greenſtone in the independent coal formation, I ſuſpected that theſe beds belonged to the floetz-trap formation. My friend, the late Dr. Mitchell, to whom I communicated a ſhort deſcription of this highly intereſting ſpot, gave it as his opinion that it belonged to the independent coal formation. On an attentive and repeated examination of this ſection, I found it, as Dr. Mitchell had conjectured, to be a part of the neighbouring coal formation *.

* Mr. Taylor, an experienced miner, informed me, that in ſinking for coal in the neighbouring coal field, a bed of greenſtone was cut through.

P.

On the occurrence of loose masses of syenite in the lower parts of the county.

In several places in the low part of the county pretty large loose blocks of water-worn syenite are to be observed lying on the surface of the coal formation. Water-worn masses of the same rock occur in the reddish brown coloured sandstone conglomerate, and the floetz-trap rocks, a fact which affords a sufficient explanation of the situation of the loose masses.

In the Alps, of which the celebrated Saussure has given so interesting, animated, and delightful a description, many masses of rock are found, far distant from their original situation. To explain this phenomenon many hypotheses have been contrived in the closet, which bear sufficient marks of the ignorance and presumption of their fabricators. Others, and among these the illustrious Saussure himself, have, after painful and minute examination of the Alps and other similarly con-

ſtructed countries, endeavoured, but unſucceſsfully, to unravel a difficulty which is eaſily ſolved by the *new Geognoſie*.

P. a.

On the diſtinction between ſtrata and beds.

Much confuſion has ariſen from the incorrect uſe of the terms *ſtratum* and *bed*; the following appears to be the ſenſe in which they are employed by the greater number of geognoſts, and is the meaning I have annexed to them in this work, and in my Syſtem of Mineralogy.

When a mountain compoſed of one ſpecies of rock is divided by means of parallel ſeams into maſſes, whoſe length and breadth are greater than their thickneſs, or into what may be called tabular maſſes, which extend through the whole mountain, it is ſaid to be ſtratified, and the individual maſſes are termed ſtrata. Of this kind of ſtructure we have in-

ſtances in granite, limeſtone, clay ſlate, mica ſlate, &c. But if the mountain, or mountain maſs, conſiſt of an alternation of different rocks, as of clay ſlate and greenſtone, or of gneiſs and limeſtone, it is ſaid to be compoſed of beds.

Q.

On the occurrence of red ſandſtone in the coal formation.

It has been aſſerted with conſiderable confidence by ſeveral mineralogiſts that reddiſh brown coloured ſandſtone, is never to be found in the coal formation. That this poſition is falſe is evident from the following facts;

1. In lower Sileſia, as already mentioned, nearly the whole of the coal field is compoſed of reddiſh brown and cochineal coloured ſandſtone, with which great beds of coal alternate.

2. In the coal field of Mid Lothian we have the following inſtances of ſimilar

coloured ſandſtone occurring in the coal formation:

a. In Dryden water, near Loanhead, there are ſeveral beds of reddiſh brown coloured ſandſtone, accompanied by ſimilar coloured iron-ſtone, in the coal formation.

b. Near Mr. Cameron's paper mills on the banks of the Eſk, there are thick beds of reddiſh coloured ſandſtone that evidently belong to the coal formation, and the ſame rock continues in the direction of the river, forming the pictureſque cliffs of Hawthornden and Roſlin, and extends even to Auchendinny bridge.

c. Immediately behind the manſe of Collington there is a beautiful ſection of the coal field. The ſtrata are ſemicircular, and have their convexities uppermoſt, or form what is called a *ſaddle*; they are of a reddiſh brown colour, and

alternate with layers of greyiſh black coloured ſlate clay, and reddiſh brown coloured clay iron-ſtone. On each extremity of the ſaddle reſt the more common rocks, *viz.* grey coloured ſandſtone, globular clay iron-ſtone, &c.

d. The rock on which Craig Millar caſtle is ſituated belongs to the coal formation of Mid Lothian. It is compoſed of horizontal beds of greyiſh and reddiſh coloured ſandſtone, that alternate with thin beds of reddiſh coloured ſlate clay and limeſtone conglomerate.

e. The hill called Saliſbury craigs belongs to the coal formation, and in it we obſerve repeated alternations of reddiſh coloured ſandſtone, clay iron-ſtone, ſlate clay, and limeſtone conglomerate.

R.

On green-ſtone.

1. Engliſh mineralogiſts continue to uſe the Swediſh word grunſten, or gronſten, and the German grünſtein, in place of the Engliſh term greenſtone; but without giving any reaſon for this preference.

2. It has been objected to the name greenſtone, that it is borrowed from a very fugitive and inſignificant character; and beſides, that ſtones anſwering in other reſpects to the character greenſtone, have ſometimes a faint or hardly perceptible trace of green. It would extend this note to a great length were I to enter into the diſcuſſion of the merits of colour as a diſtinguiſhing character of minerals. I can at preſent only ſay, that the degree of importance annexed to it by Werner is a ſufficient proof of its excellence. That greenſtone has not always a green

colour cannot be denied, but this circumſtance muſt not be urged as an objection to the name, as it is not aſſerted that this rock has always a green colour, the name only intimating that this colour is the moſt ſtriking feature in its external aſpect, and which always occurs in truly characteriſtic ſpecimens.

S.

The very intereſting fact of the occurrence of greenſtone in the coal formation has not before been noticed by any mineralogiſt. I ſhall therefore take this opportunity of mentioning a few inſtances of it I have had an opportunity of examining. On my return from Freyberg to Scotland, the firſt object that attracted my attention was the intereſting coal field in the neighbourhood of Edinburgh. I traverſed it in different directions, and the reſult of my firſt obſervations render-

On the occurrence of beds of greenſtone in the coal formation.

ed it rather probable that Saliſbury craigs, Arthur ſeat, Craig Millar, cliffs at Hawthornden, Craig Lockhart, and ſummit of the Pentland hills, belonged to the floetz-trap, and conſequently were of poſterior formation to the coal. I had, however, examined theſe appearances too ſlightly to enable me to judge deciſively on ſo important and intricate a point; and beſides, ſome circumſtances which I ſhall now mention excited a ſuſpicion that ſeveral of theſe appearances might be of different ages, or belong to different formations. The ſtrata and beds of Saliſbury craigs, Craigmillar and Hawthornden were too numerous, and often too much inclined to be referred to the floetz-trap formation; while on the other hand, the ſummit of Arthur ſeat, and Craig Lockhart, were unſtratified, or when the ſtratification could be obſerved was very thick and horizontal; characters that ſtrongly indicated a different formation, and one that could be

referred to the floetz-trap. I continued my reſearches, with the view of aſcertaining this point, when a careful examination confirmed my ſuſpicions, and I found that Saliſbury craigs, Craigmillar, and the cliffs of Hawthornden, belonged to the coal formation; but the ſummit of Arthur ſeat, and Craig Lockhart, to the neweſt floetz-trap formation.

The moſt intereſting obſervation which I made during this inveſtigation was that of beds of greenſtone in the coal formation; an appearance ſo unexpected that I was for ſome time doubtful whether or not the whole ſeries of ſtrata that accompanied theſe beds ſhould not be referred to the floetz-trap formation. The following are ſome of the inſtances of this fact which I had an opportunity of examining:

1. *Saliſbury craigs.* The loweſt part viſible of this hill is ſandſtone, which is covered by a bed of porphyritic green-

ſtone; over theſe beds there lie, in conformable diſpoſition *, many ſtrata of reddiſh brown coloured ſlate clay, ſimilarly coloured clay ironſtone, limeſtone, and ſandſtone. This great maſs of ſtrata and beds ſupports a bed of greenſtone about eighty feet thick, which forms what is called Saliſbury craigs. Over it there is diſpoſed a number of thin beds of greeniſh coloured ſlate clay, reddiſh coloured clay ironſtone, which ſometimes approaches to jaſper, and thick beds of reddiſh brown coloured ſandſtone. To theſe ſucceed beds of porphyritic greenſtone, which in ſome places paſſes into green porphyry †. Over theſe much inclined ſtrata and beds, that all evidently belong to the *coal formation*, there lie in

* Williams, in his Mineral Kingdom, informs us that whinſtone beds occur in the coal mines of Borroſtonneſs and Gilmerton. Probably greenſtone?

† This green porphyry is in ſome ſpecimens not greatly inferior to certain varieties of the antique green porphyry.

overlaying † diſpoſition, firſt a great horizontal maſs of trap-breccia, and then two beds of baſalt, the uppermoſt of which forms the ſummit of Arthur ſeat; theſe from their ſituation and characters are to be referred to the *neweſt floetz-trap formation.*

2. *Section of the coal formation below Caroline park.* About a mile weſt from Newhaven, immediately below the walls of Caroline park, there are a number of beds well expoſed by the action of the ſea. They are ſlate clay, flat ſpherical clay iron-ſtone, a black flinty † foſſil reſembling flinty ſlate, greyiſh coloured ſandſtone, and theſe alternate repeatedly with beds of greenſtone. The varieties of greenſtone which theſe beds preſent are de-

* When horizontal beds or ſtrata reſt on thoſe which are much inclined, I expreſs their ſituation by the term *overlaying*. Figure 2. in plate 4. repreſents an inſtance of this kind of ſtratification.

† This foſſil is frequently found in the coal formation. Although very unlike baſalt, it has often been confounded with it.

ſerving of notice. Some of the beds are almoſt entirely compoſed of compact felſpar, and then the greenſtone has a ſmoke or aſh grey colour; in other beds we can obſerve the gradation from greyiſh white to greeniſh black, by the increaſe of the quantity of hornblende.

3. *Section on the Collington road.* Half way between Edinburgh and the village of Collington, on the eſtate of Dr. Monro, is a quarry in which there is a bed of greenſtone about four feet thick, accompanied by ſlate clay, ſoft greyiſh white ſandſtone, &c.

4. *At Bell's mills* in the neighbourhood of Edinburgh, there is a bed of greenſtone about eight feet thick which reſts on ſlate clay, and is covered by ſlate clay, greyiſh white ſandſtone, containing vegetable impreſſions, all belonging to the coal formation *.

* On digging a foundation for the houſes in Lothian-ſtreet, a pretty thick bed of greenſtone was

T.

Obſervations on ſearching for coal.

The uſual directions which are given for ſearching for coal are not ſufficiently complete. The following ſtatement of the caſes that may occur in this inveſtigation will, I truſt, be found uſeful:

Caſe 1. Suppoſe we have examined a tract of country which we find to be compoſed of tranſition rocks, and rocks belonging to the neweſt floetz-trap formation; are we there to bore or ſink ſhafts, with the view of diſcovering coal? If we have aſcertained that the floetz-trap rocks repoſe immediately on the tranſition rocks, then the ſcarcity of fuel muſt be very great, or the appearances very promiſing, before expenſive trials ſhould be attempted; becauſe, in the floetz-trap formation we ſeldom find

obſerved in ſtrata reſembling thoſe of Saliſbury craigs.

more than one bed of coal, and the expence of mining is very great, owing to the exceſſive hardneſs of the ſuperincumbent rocks. But if we entertain a ſuſpicion that the independent coal formation is interpoſed between the tranſition and floetz-trap rocks, we ſhould continue our reſearches into the neighbouring diſtricts, where, if we diſcover the independent coal formation, and can trace it ſo as to demonſtrate that it lies under the floetz-trap rocks of the diſtrict we have examined, we ſhould then make borings, or ſink ſhafts, with the view of reaching the coal formation. This is illuſtrated by plate 1.

Caſe 2. In diſtricts where the independent coal formation exiſts, and where the *outgoing* of the coal is not to be obſerved, the borings and ſinkings muſt be conducted in the uſual manner. *Vid. William's Mineral Kingdom. Kirwan's Geological Eſſays. Dr. Walker's Letter to*

General Dirom. Mineralogy of the Scottiſh Iſles.

Caſe 3. If the diſtrict we have examined is compoſed of reddiſh coloured ſandſtone, accompanied with beds of copper-ſlate, foliated gyps, and limeſtone, we muſt not make any attempts to bore or ſink for coal, as no conſiderable beds of coal exiſt in this formation.

Caſe 4. If the diſtrict we have examined is compoſed of ſandſtone which has a variegated coloured aſpect, and contains neſts of clay, and is accompanied with fibrous gyps, ſandſtone ſlate, and roeſtone, we muſt not make any trials for coal.

Caſe 5. If the diſtrict is compoſed of fine white coloured architectonic ſandſtone, but contains no ſubordinate layers, as ſandſtone ſlate, gyps, roeſtone, clay iron-ſtone, ſlate-clay, bituminous ſhale, or limeſtone, we muſt not make trials for

coal, as this ſandſtone formation never contains any beds worthy of notice.

Caſe 6. Suppoſe a ſhaft is ſunk in the reddiſh coloured ſandſtone mentioned in Caſe 3, and that then a gallery is driven in a horizontal direction acroſs theſe ſtrata, with the view of diſcovering coal, and that beds of coal are diſcovered, we muſt not believe that theſe beds lie in the reddiſh coloured ſandſtone, and that therefore we are warranted to make trials for it in other quarters of this red ſandſtone diſtrict, becauſe we ſhall, on an attentive examination, find that we have paſſed into the coal formation. Errors of this kind have given riſe to the opinion that coal is found in the old red ſandſtone, and has been the cauſe of many expenſive trials having been made. This caſe is explained by Plate 2.

Caſe 7. Suppoſe we have diſcovered beds of ſlaty glance-coal (coal blende) in tranſition or grey wacke ſlate, we muſt

not from this conclude that black or common coal * is to be found, and make trials with the view of diſcovering it, as none occur in theſe rocks.

Caſe 8. If in the newer clay ſlate, ſlaty glance coal (coal blende) is found, we muſt not conſider it as indicating common or black coal, and ſhould not therefore make any trials in ſuch ſituations.

Caſe 9. Suppoſe we have diſcovered the independent coal formation, and have ſunk ſhafts into it to a conſiderable depth, without diſcovering workable beds of coal, we muſt be cautious not to increaſe the expence unneceſſarily by continuing the workings beyond the coal field on its ſides or bottom. This is illuſtrated by Plate 3.

* Werner divides coal into two ſpecies, *a*. brown coal, and *b*. black coal. The black coal includes all the ſubſpecies of coal which are found in the independent coal formation in Great Britain &c.

U.

It was Werner who diſcovered the tranſition of clay to wacke and baſalt. The following extract from his memoir on that ſubject, which is too little known in this country, is worthy of the particular attention of every geognoſt :

" L'Obſervation, toute-a-fait inatten-
" due, que j'ai faite l'eté dernier au
" mont *Schiebengberg*, ſur la rapport du
" baſalt a la roche que ſe trouve au-deſ-
" ſous, me parait devoir etre extemement
" intereſſante aux yeux de tous les geo-
" gnoſtes ſans prevention ; ſur-tout dans
" ce moment ou la diſſcuſſion ſur la na-
" ture et ſur l'origine du baſalte vient
" de ſe rallumer de nouveau. Deja de-
" puis long-tems, en paſſant aupres ce
" mont, j'avais vu de loin un monceau de
" terre blanche, qui etait preſque ſur ſa
" ſommité ; j'avais, dans les tems, de-
" mandé ce que c'etait, et l'on m'avait

" repondu que, dans cet endroit, il y
" avait un mine de ſable, dont les habi-
" tans ſe ſervaient pour la batiſſe de leurs
" edifices. Ayant depuis reflechi, com-
" bien une mine de ſable ſur le haut
" d'une montagne baſaltique etait un
" phenomene ſingulier, je reſolus de
" l'aller voir de pres, et je partis, accom-
" pagne de pluſieurs de mes eleves, pour
" cette petite excurſion mineralogique.

" Deja de loin, j'appercu ſur la mon-
" tagne, ou plutot ſur la ſommité, une
" echancrure aſſez conſiderable; je comp-
" tai bien trouver, dans cet endroit, la
" roche a nud, et voir ainſi la ſtructure de
" l'enterieur; la ſuite fera voir que je
" ne me trompais pas. Cependant je ne
" croyais trouver ici q'une couche de
" ſable envirronant le pied de la ſom-
" mité baſaltique, comme l'on avait cru
" generalement juſqu' ici que c'etait le
" cas au Pæhlberg, pres d'Annaberg.
" Mais, quel fut mon etonnement des que

" j'y arrivai ! au premier coup d'œil j'ap-
" percus une couche epaiſſe de *ſable quart-*
" *zeux* ; et, au-deſſus, quelques *couches*
" d'argile, enfin une *couche de wacke*,
" ſur laquelle le *baſalte* repoſait : avec
" quel etonnement, je vis ces trois couches
" s'etendre *preſque horizontalement ſous le*
" *baſalte*, et lui ſervir ainſi de ſupport ;
" le ſable devenir de plus en plus fin, et
" enfin argileux ſur le haut ; de ſorte
" qu'il paſſait formellement a l'argile,
" comme celle-ci paſſait egalement dans
" ſa partie ſuperieur a la wacke, et enfin
" cette dernier ſubſtance an baſalte ; en
" un mot qu'on avait ici le paſſage le
" plus parfait du ſable le plus pur au
" ſable argileux, de celui-ci a l'argile
" ſablonneuſe ; de la, par une ſuite gra-
" dué de nuances, a l'argile graſſe, a la
" wacke, et enfin au baſalte.

" A cet aſpect, il m'arriva ce qu' arri-
" vera certainement a tout naturaliſte qui
" verra ce phenomene ; les idees ſe ſucce-
" derent avec rapidité, et il me fut impoſſi-

" ble de ne pas m'ecrier : *ce baſalte, cette*
" *wacke, cette argile, ce ſable, ſont tous d'une*
" *meme formation ;* toutes ces ſubſtances
" ſont des *ſedimens*, des *precipités*, provenus
" d'une *meme diſſolution aqueuſe* qui couv-
" rait autrefois cette contrée : cette mer
" charria d'abord le *ſable* dans cet endroit,
" puis elle y depoſa l'argile ; le ſediment,
" changeant peu a peu de nature, devint
" enſuite de la *wacke*, et finalement un
" vrai *baſalte*.

" Je ferai encore, au ſujet de cette
" obſervation, et en peu des mots, les
" remarques ſuivantes : le baſalte, dans
" cette enchancrure, etait diviſé en
" priſmes preſque verticaux, et diſtincte-
" ment ſeparés les uns des autres : la
" diviſion priſmatique allait juſques a la
" couche de wacke, et ſe propageait dans
" une partie de ſon epaiſſeur. Cette
" wacke conſiderée en grand avait une
" texture ſchiſteuſe. On ne pouvait pas
" voir la partie inferieure de la couche
" de ſable, elle etait recouverte par le

" monceau de ſable retiré de la mine :
" mais ce ſable devint de plus en plus
" groſſier, et il degenerait enfin en un
" gravier a gros grains. Le gneis, qui
" conſtitue la maſſe de la montagne tout
" autour, paraiſſait a decouvert immedia-
" tement au-deſſous du monceau.

" Je ne puis ici m'etendre plus au long
" ſur cette obſervation ſi remarquable :
" j'en donnerai inceſſamment des de-
" tails plus etendus. Que dira de ceci
" la grande partie de nos mineralogiſtes,
" ſi epriſe de la volcanicité du baſalte !

" Quant a ce qui me concerne, je ſuis
" entierement convaincu ; que *tous les*
" *baſaltes ſont des produits de la voie humide,*
" *et qu'ils ſont d'une formation tres-recente.*
" *Qu' autrefois ils formaient tous une grande*
" *aſſiſe d'une immenſe etendue, qui recouvrait*
" *des ſols, primtifs et des ſols ſecondaires ;*
" *que l'action du tems en a de nouveau de-*
" *truit une grand partie, et qui toutes les*
" *ſommités baſaltiques en ſont les reſtes.*

" Je ferai bientot part au public de
" mon ſentiment ſur la nature et ſur la
" formation du baſalte, et je lui expo-
" ſerai toutes les raiſons ſur leſquelles il
" eſt fondé."

Freiberg, le 20 *Octobre* 1788.

Signé WERNER.

END OF PART FIRST.

ERRATA.

Page	Line			
3	24	*for* 3300,	*read* 2200.	
8	8	Annandale,	Nithſdale.	
11	16	river,	rivers.	
47	8	*after* find,	in it.	
52	8	*of the note, the word* ſtrata *to be omitted.*		
57	1	*for* ſparry iron ore,	*read* ſparry iron ſtone.	
id.	2	brown iron ochre,	ochry brown iron ſtone.	
74		*add* that from the year 1760 to 1798, this mine afforded 100 tons of regulus of antimony, valued at 84l. a ton, or 8400l.		
83	17	*for* village,	*read* town of Annan.	
87	18	ſpot,	ſpots.	
90		Brown muir inn,	Brown hill inn.	
143		ſandſtone,	this ſandſtone.	
153		Sir James Hall's obſervation not referring to ſtripes, *to be cancelled.*		
171	17	*for* floetz	*read* neweſt floetz-trap.	

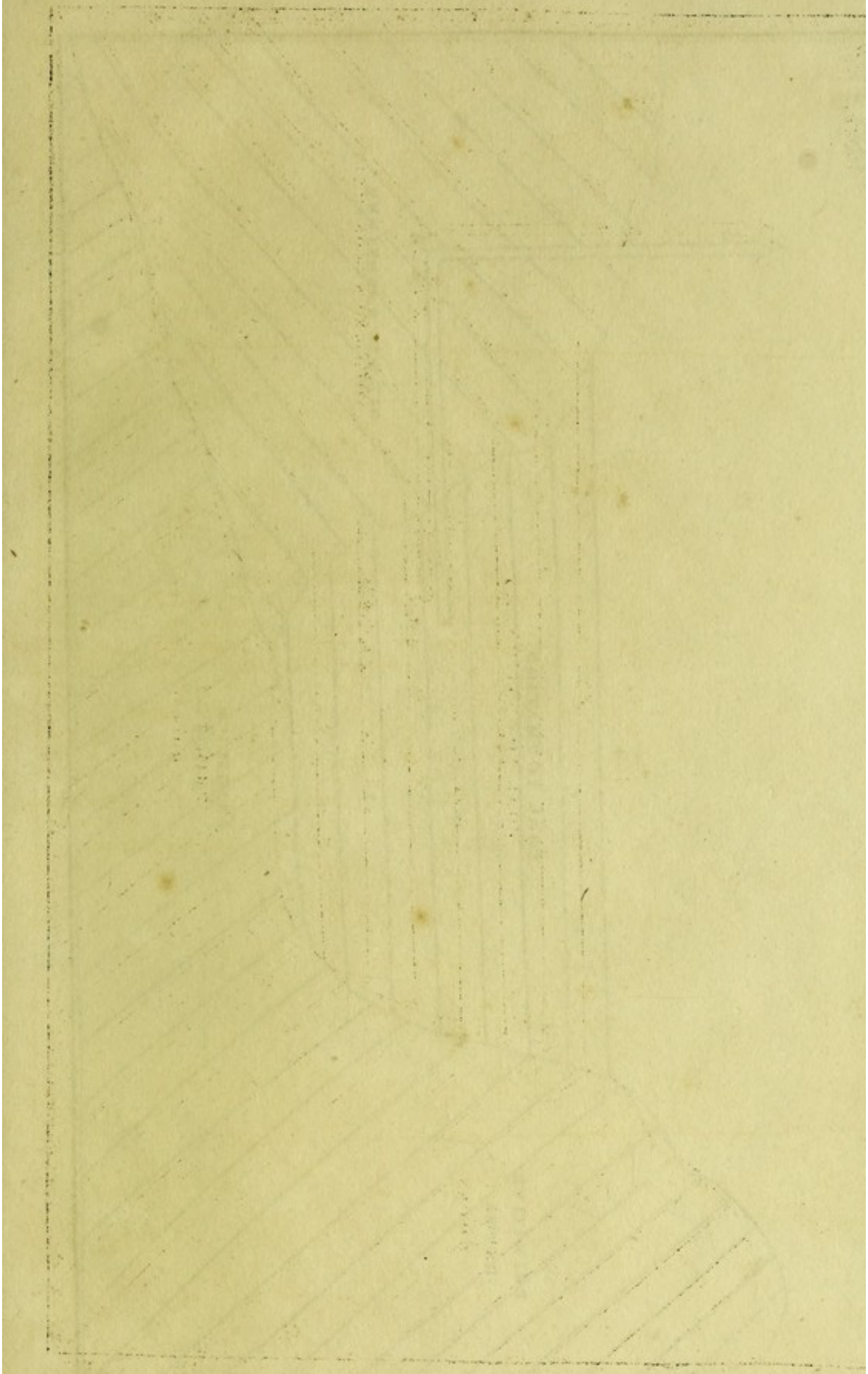
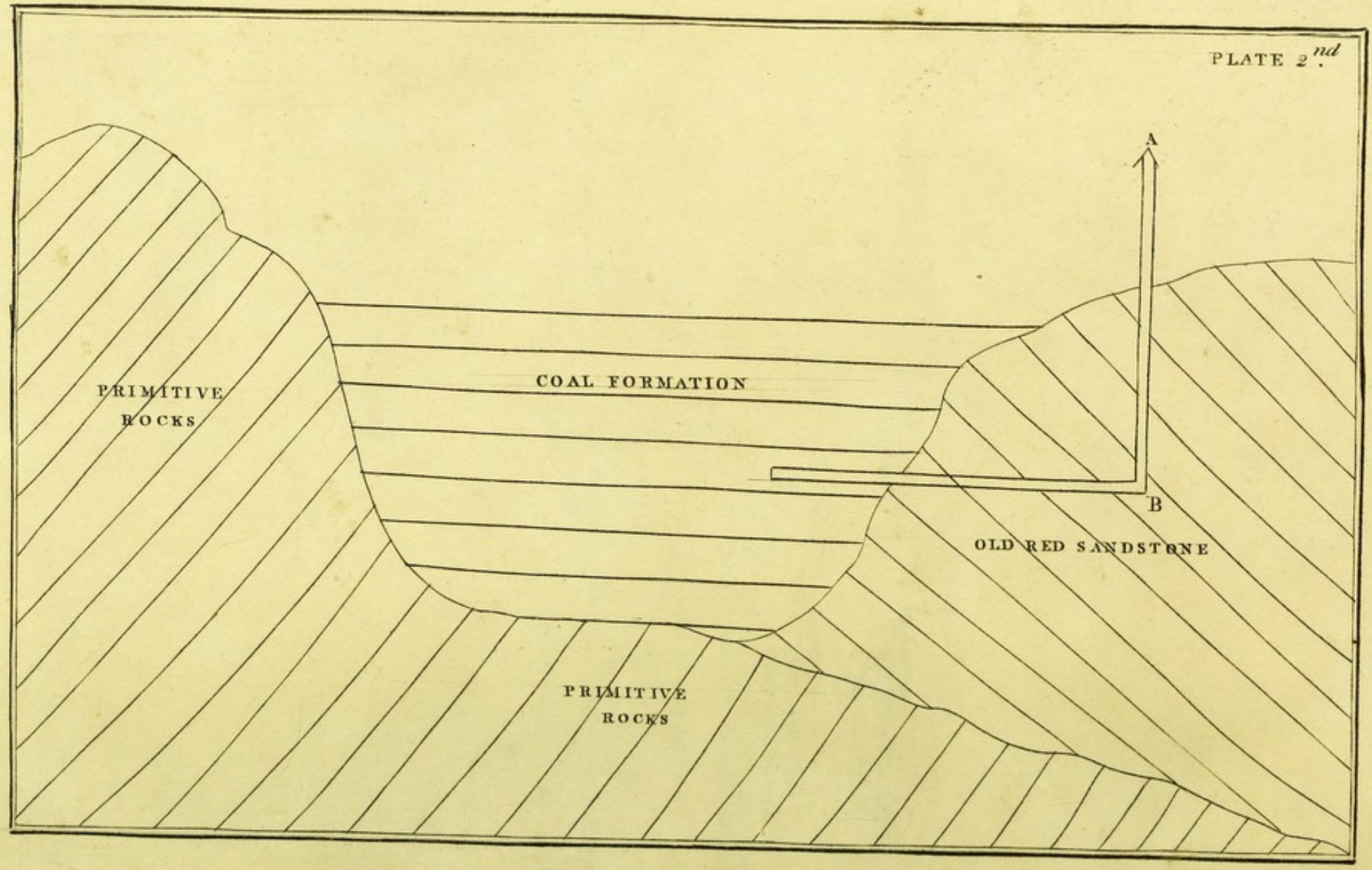


PLATE 2nd.


A
B
PRIMITIVE ROCKS
COAL FORMATION
OLD RED SANDSTONE
PRIMITIVE ROCKS

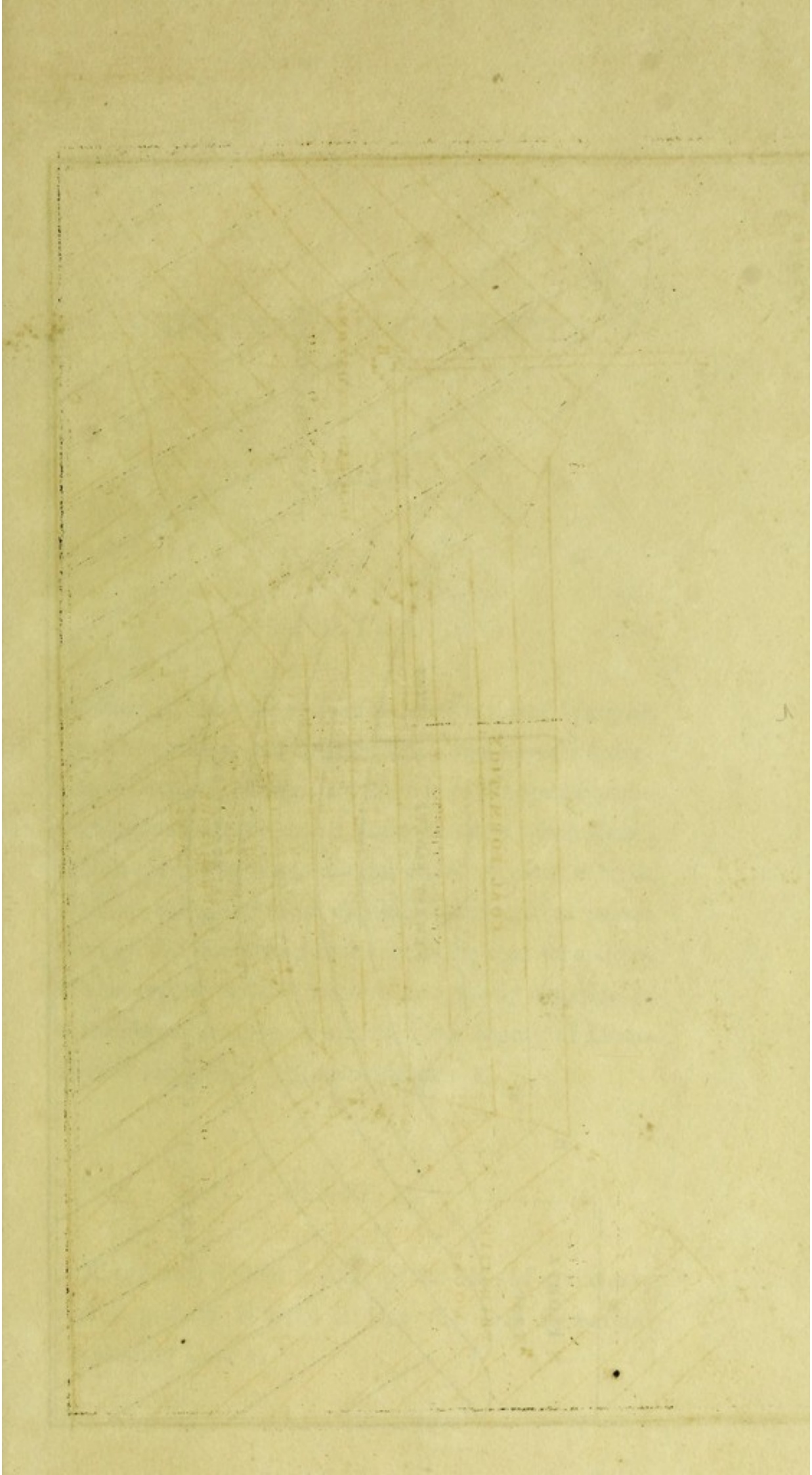
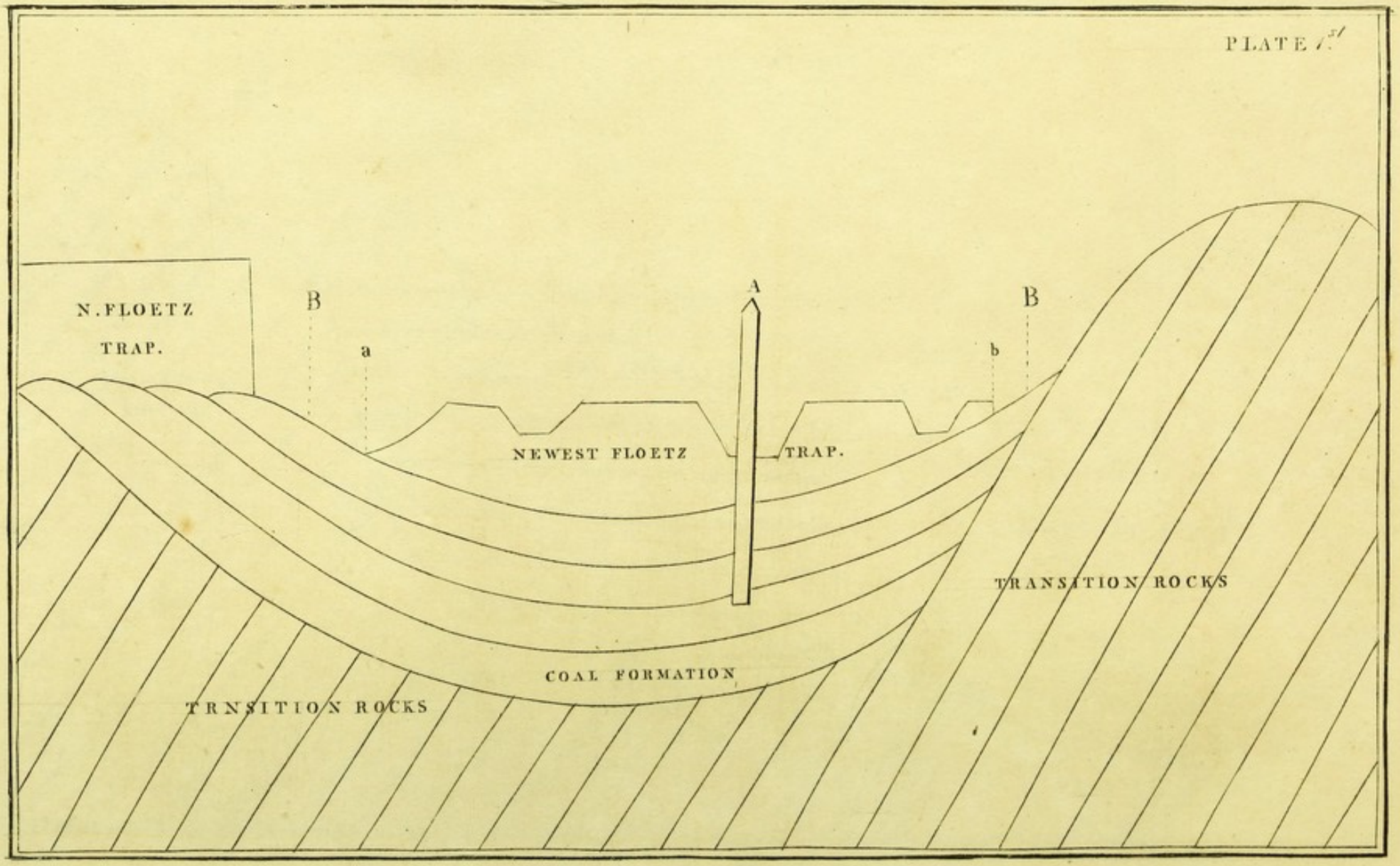


PLATE 1st


N. FLOETZ
TRAP.
B
a
A
B
b
NEWEST FLOETZ
TRAP.
TRANSITION ROCKS
COAL FORMATION
TRNSITION ROCKS

EXPLANATION OF PLATES.

PLATE I.

In Plate 1, the coal formation is represented lying on transition rocks, and covered with the newest floetz-trap formation, excepting at B, where it appears at the surface, and can be traced under the floetz-trap rocks, which cover the whole district *a*—*b*. A shaft is sunk at A, as being the most eligible situation, and passes through the floetz-trap rocks into the coal formation. It also represents the relative geognostic situation of the different formations of which the county of Dumfries is composed. Illustrating case 1.

PLATE II.

Represents a shaft A sunk in the old red sandstone, and a gallery B from it into the coal formation illustrating Case 6.

PLATE III.

Two shafts are represented passing through the coal formation into the subjacent transition rocks which never contain coal; illustrative of Case 9.

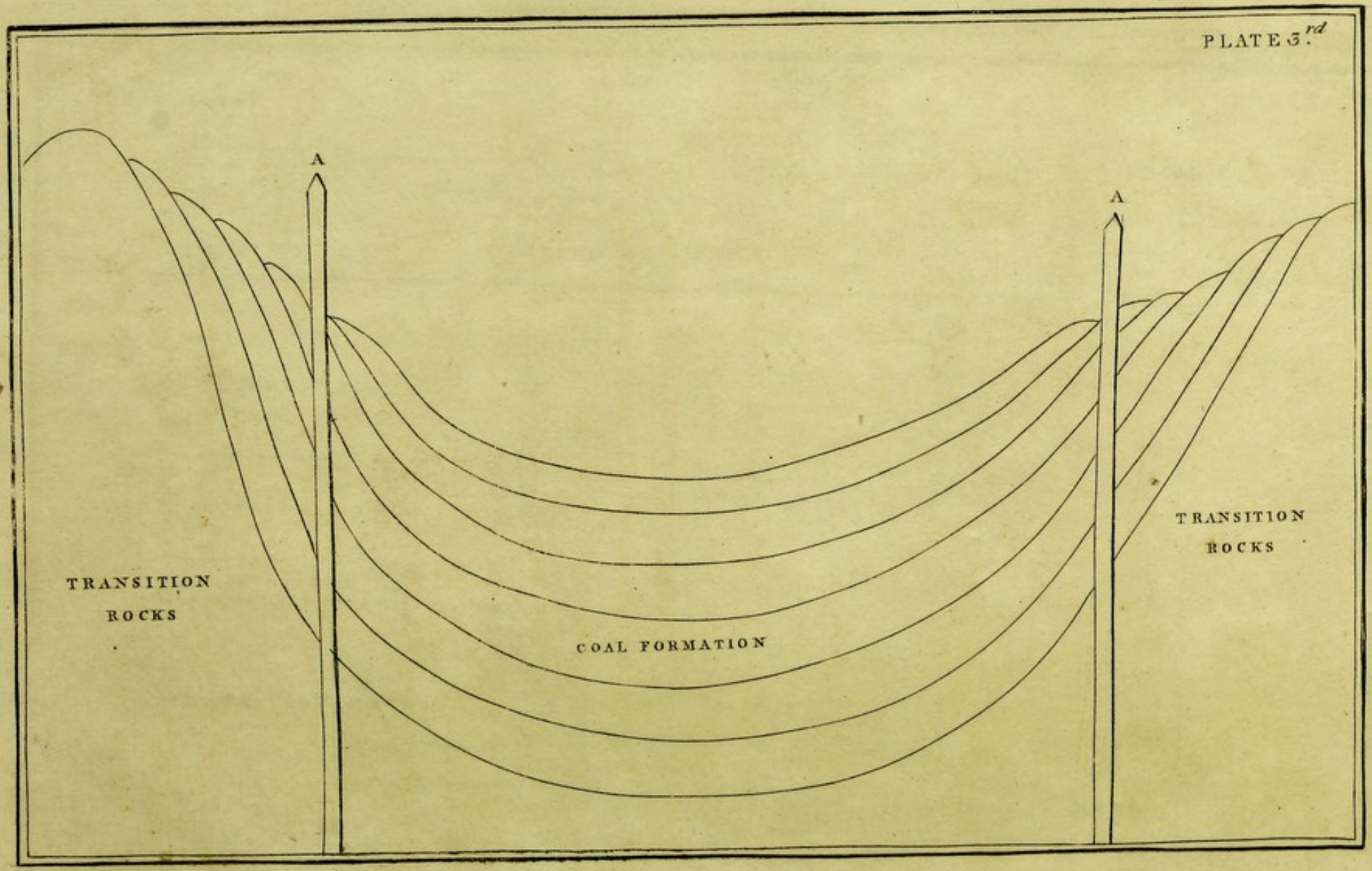
PLATE IV.

Fig. 1. Section of the country from the Solway frith to the frith of Forth, in which the mountainous country is composed of transition rocks, and the lower of rocks belonging to the coal formation.

Fig. 2. Represents the structure of the hill called Burnswark; and also instances what I term the overlaying disposition of the stratification.

Fig. 3. Different parts of which a mountain is composed; A foot, B acclivity, C summit.

PLATE 3rd



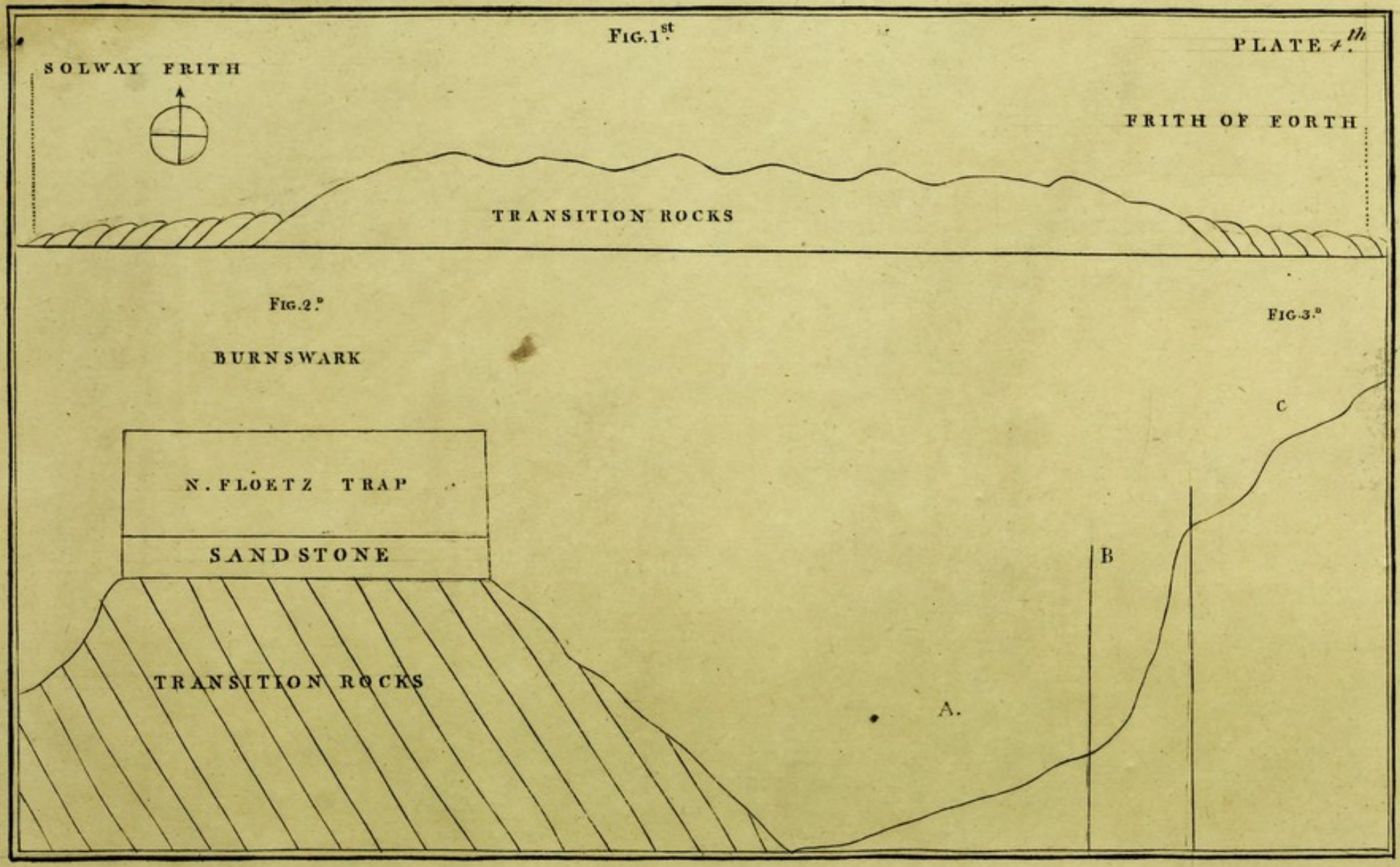


Fig. 1st
PLATE 4th
SOLWAY FRITH
FRITH OF FORTH
TRANSITION ROCKS
Fig. 2.o
BURNSWARK
N. FLOETZ TRAP
SANDSTONE
TRANSITION ROCKS
Fig. 3.o
C
B
A.