A MINERALOGICAL DESCRIPTION OF THE COUNTY OF DUMFRIES.

Patrick —— Murray S. o/f.

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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* druffy, *read* drufy.
154	2	*after* in, *add* engen Räumen eingefchloffen 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 intereſting information. But, as both the General and Colonel Wight confidered what had been done as ftill not affording the complete information which was expected by the landholders of the county, upon this important fubject, I was again requefted by thefe intelligent gentlemen to undertake the publication of a more detailed mineralogical defcription of Dumfries-fhire, which might accompany the county map, which was ftill unpublifhed. To this propofal I acceded with pleafure, not only from my defire to promote fuch ufeful inveftigations, but alfo 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 refult of my labours for the information of the public.

INTRODUCTION.

In a country like Scotland, whofe furface prefents fo great a variety of rocks, and which agrees in many refpects with the moft important mining countries in other parts of the world, it is evident that many confiderable mineral repofitories are to be expected. Its fituation, the ftructure of its furface, and the abundance of water and coal which it poffeffes, render it peculiarly well adapted for carrying on with œconomy and profit the various operations of mining.

But as ores, coals, and other ufeful minerals are ufually hid in the bowels of the earth, we muft endeavour by mining 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 geometry; 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 repofitories; he muft be acquainted with all the branches of chemiftry, but moft particularly with that of metallurgy; and he muft not be indebted to lectures, books, drawings, and models alone for his knowledge; he muft have affifted for years in all the practices I have juft mentioned. When this courfe of education is finifhed, he fhould be able confcientioufly to take charge of a great mine, or to eftablifh one in a country where there are few to affift him with knowledge or experience.

I could mention very many inftances of the great lofs to proprietors and ftates by the want of fkill and experience in mine-engineers, but I fhall at prefent mention only one, and it is very ftriking. In Spanifh America, according to Anton Zacharias Helms, the amalgamation of the ore continues an entire month, and in each operation there is a lofs of twenty-five pounds of mercury in the quintal, and a part of the filver 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 refearches I am now engaged in will afford to the miner, by the dif-covery of ufeful minerals, it will, I truft, alfo prove a fource of information to the mineralogift. Few countries fo little explored as Scotland have afforded a greater variety of minerals, which allows us to hope that a more complete and accurate inveftigation will increafe the number of hitherto undefcribed oryctognoftic products. The geognoft*, will obtain new facts, and

To this fum, amounting to one hundred and feven-four million of livres, may be added the quantity of gold and filver not delivered to the mint, but which is worked for churches, convents, and other ufes, which is very confiderable. Thus we may reckon that there is annually raifed from the mines of Spanifh America the value of two hundred million livres, or fifty million rix-dollars.

* Geognofie not only makes us acquainted with the materials and ftructure of the cruft of the earth, but alfo with the hiftory of the changes which it has experienced, thus forming a moft interefting 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 compofed, mineral repofitories of different kinds, but particularly of lead ore, are to be expected; and that roof flate will be found in many parts of the tranfition country.

The geognoftical obfervations make us acquainted, 1. With an extenfive tract of tranfition rocks, a clafs of rocks hitherto unnoticed in Great Britain *.

* I have traced the tranfition rocks from the northern extremity of the Pentland hills, which is about fix miles diftant from the fhore of the firth of Forth, to Lang-robie in Dumfries-fhire, about three miles from the Solway frith. The fame clafs of rocks reaches from Langholm to Minihive, and at length terminates near New Galloway, where it is fucceeded by primitive rocks. The Moorfoot hills near Edinburgh, which form one of the boundaries of the great coal field of the Lothians, are compofed of tranfition rocks; and I have every reafon to believe that thefe rocks continue nearly to the termination of the mountain range at St. Abb's head on the eaft coaft. Granite is faid to have been found at Faffnet burn, which is in the tract I confider

2. With a lead glance formation different from any defcribed by Werner or any other geognoft. 3. With a formation of pitchftone, refembling that of the ifland of Arran, which belongs to the neweft floetz-trap formation. 4. With a coal formation which refembles in many refpects the old red fandftone, but which is moft diftinctly different as a formation. 5. With the occurrence of glance coal in the independent coal formation, and with a new fubfpecies called *columnar glance coal.*

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

to be tranfition. I fuppofe fyenitic greenftone has been confounded with granite.

Since writing the above, I have examined a fuite of fpecimens brought from Faffnet burn and the neighbourhood of St. Abb's head by Dr. Hope, and find my conjecture, refpecting the extent of the tranfition rocks, and the nature of the fuppofed granite of Faffnet, 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 Propertis 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.

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 Situation.

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 confider-ed as a part of one groupe, nor as a fingle groupe, but as compofed of feveral groupes and parts of others, whofe oppo-pofite declivities fall into the adjoining counties. The determination of the length, breadth, height and fhape of thefe groupes, and of their connections with each other, and with the great fouth-ern chain, is an inveftigation which would prove of much utility to the geo-grapher and to the geognoft. I regret that I have not been able, from want of leifure, to fatisfy myfelf refpecting this important part of a geognoftic inveftiga-tion; at prefent I muft therefore reft fa-tisfied with ftating a very few obferva-tions on the chains, and individual mountains of which thefe chains are compofed. I hope, however, that my brother, who is now refident in the county, will execute this very ufeful piece of inveftigation.

Characters of the mountain chains and mountains.

The individual chains of which the groupes are compofed have generally a narrow foot, a great acclivity, and a round-backed ridge or fummit. The mountains of which thefe chains are compofed have in general an inconfiderable foot, a great acclivity, and a very fhort fummit. The fummit is generally round-backed or flattened; fometimes it is rather conical, and in a few inftances tabular; but in this county the frequent conical and alpine peaked fummits are not to be obferved; in this refpect it forms a ftriking contraft 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 compofed there proceeds a mountain arm that divides part of Annandale from the lower part of Nithfdale, 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
Moffpaul, in Ewes - -	820
Wifp Hill, in Ewes - -	1836
Ettrick Pen, in Efkdale Moor	2220

Low country. That part of the county which lies to the fouth of what is ftrictly to be confidered the termination of the valleys of Annan and Efk, or of a line drawn from Whinnyrig, by Ecclefechan, Craigfhaws, Solway bank, Broomholm and Muirburnhead is comparatively low and flat, and occafionally marked by gently rifing round-backed low hills, which fometimes approach to the obtufe conical, as Repentance and Woodcock-air.

The county is divided into three river Dales. diftricts *, named Nithfdale, Annandale, and Efkdale, which are traverfed by the ri- Rivers. vers Nith, Annan, and Efk, that carry

* Note C.

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

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-

River Nith.

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 lefs importance are Mein and Kirtle.

River Annan. The river Annan rifes in the high mountains above Moffat *. and runs through the flat part of the valley of Annan (principally through alluvial land) until near the manfe 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 alfo the loweft point of the valley of Annan, it continues its courfe through the lower part of the diftrict of Annandale, and after a run of thirty-feven miles from its fource, it is poured into the Solway frith at Annan.

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

* From the north-weft fide of thefe mountains the river Clyde rifes, and from the north-eaft the river Tweed; a proof that they are the moft elevated points in the fouth 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-courfe than as a valley. Several lateral valleys open into it, and of thefe the moft confiderable are Black Efk, Meggot, Ewes, and Wauchope. Lateral valleys of Efk.

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

Character of the fides of the valleys. The fides of the valleys are in general fmooth and covered with vegetation; fometimes they are rocky and cliffy.

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 Auftria, which is alfo a circular valley. It flows through Auftria, and at Prefburg, where the valley is nearly fhut up, it forces its way through rocks and hills into Hungary, which is one of the moft extenfive circular valleys in Europe. At the lower extremity of Hungary the river is again forced to feek its way through a narrow rocky channel at Orofova, which is the only opening between Hungary and Wallachia. It now continues its courfe through Wallachia, and at length falls into the Black fea. We have a continuation of this chain of valleys, although ftill filled with water, in the Black fea, fea of Marmora, and the Mediteranean *.

Valley of Cachmere.

Mr Pennant, in the firft volume of his Outlines of the Globe, when defcribing the country of Cachmere, obferves, "This "happy valley, this paradife of Hin- "doftan, 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

D

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 inftances the newer rocks, as gneifs, mica flate, and clay flate, after filling up the granite hollows, appear to have been depofited in greater quantity in one place than another, and thus original inequalities, or mountains and valleys have been formed.

3. It is not improbable, from what we know of the natural hiftory of rents, that in many cafes, particularly in the higher parts of the globe, immenfe fiffures may have been formed, and thefe by the long continued action of water may have been fafhioned out into valleys*. Valleys formed by the widening of great rents.

4. Neither is it to be doubted that running water has frequently hollowed valleys out of a furface not very deeply Valleys formed by the action of running water.

* Werner neue Theorie von der Entftehung der Gänge, f. 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 thefe valleys are not of equal antiquity. After the water had diminifhed to a pretty low level, it appears to have rifen again, to have covered the then exifting fyftem of inequalities, and to have depofited over the furface of the earth a mighty and univerfal formation (the floetz-trap formation). What were formerly longitudinal valleys, through which great rivers flowed uninterrupted to the fea, were in many inftances changed into inland feas or lakes, by the depofition of the newer formation acrofs their communication with the ocean, others were entirely filled up, and thus on the retiring of the waters of the ocean, a nearly new fyftem 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 conclufive, but cannot be detailed here.

Valley of Sanquhar formerly a lake.

The valley of Sanquhar and Kirkonnel appears to have been formerly in the ftate of a lake, becaufe it is entirely fur-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 efflorefcences 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 circumſtance 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 *."

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

Chalybeate ſpring at Evan bridge.

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.

Method of determining true falt fprings.

cond fandftone formation, or in countries bordering on it. To determine whether or not a falt fpring found on the fea fhore derives its contents from fea water, or from a falt-bed or rock richly impregnated with falt, a chemical examination is not fufficient, becaufe it often happens that falt fprings, iffuing from falt-beds, and not richer in falt than fea water, are poured out on the fea fhore. To determine fuch a point, therefore, we muft examine the neighbouring country, with the view of difcovering whether or not fimilar fprings occur inland, or if there is any appearance of the feries of rock already mentioned; if we difcover thefe, we may then with complete fafety conclude that the falt fprings we have difcovered are derived from faltbeds, or rocks richly impregnated with falt, and are therefore worthy of particular attention, although a chemical analyfis fhould have fhewn that they were not more productive than the waters of the ocean.

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 ftate fomewhat fimilar to what it is at prefent, confequently muft have contained fea falt. We have therefore reafon to expect that all thefe rocks contain fea falt, and that this impregnation affords to the filtrating water of fprings the fea falt they are always found to contain.

Sea falt of fprings derived from the rocks through which the water filtrates.

The analyfes of an able chemift, the late Dr. Kennedy, have fhewn the prefence of foda and muriatic acid in bafalt, greenftone, and fandftone; and more lately the celebrated Klaproth has obtained from bafalt, porphyry flate, and pitchftone fimilar refults. As thefe rocks belong to one of the *univerfal formations*, thefe analyfes are to be viewed as fupporting the conclufion drawn from the Wernerian geognofie.

2. Dr. Garnet does not mention foda as a conftituent part of the fprings at Moffat; it is not improbable, however, that it may be difcovered on a more care-

Soda probably a conftituent part of the Moffat well fpring.

ful examination becaufe almoft all the fprings iffuing from tranfition rocks that have been examined have been found to contain a minute portion. As an inftance, I may mention that the Graf Mitrowfky analyfed twenty fprings iffuing from the tranfition rocks of the circle of Olmutz in Moravia, and found that all of them contained a greater or leffer proportion of foda.

Frequency of fprings in floetz-trap rocks.

3. A greater number of fprings iffue from rocks belonging to the floetz-trap formation, than from thofe of the tranfition or coal formations. In other parts of Scotland, particularly in the mountains of the ifle of Rume, I made a fimilar remark. Werner obferves that bafaltic hills are well calculated, by reafon of their naked furfaces and compact texture to attract and condenfe vapour, and from their numerous perpendicular rents, and the bed of clay on which they ufually reft, to conduct the condenfed vapour to form fprings.

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 defcribed the mountains and valleys which, taken together, conftitute the phyfiognomy of the county, I fhall now proceed to give an account, as far as obfervation permits me, of its internal ftructure. Here we have 1ft to afcertain the general difpofition of the ftratification. 2dly, That of the individual formations; and, 3dly, we muft give a particular account of the formations and of the rocks of which thefe formations are compofed.

I.

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-

General diſpoſition of the ſtratification.

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.

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*.

General diſpoſition of the formations.

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 confifts of porphyritic greenftone, and amygdaloid, which extends from the bridge of Langholm to Denby in the parifh of Dalton. In the upper part of the county, as between Whamphry and Langholm, it lies on the fummit of tranfition mountains, and generally in the fhape of *mountain caps*. Subordinate to it we find blackifh coloured pitchftone.

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

III.

Having now given a defcription of the phyfiognomy of the county, of the general difpofition of its ftratification, and the relative age and fituation of its different formations, and thus drawn as it were an outline of its geognoftic defcription, I fhall now endeavour, as far as my obfer- 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 defcriptions of the formations would be imperfect if we omitted an account of the *particular repofitories*, as veins, ftockworks, &c. contained in them. In general, however, if thefe repofitories are of *after formation*, and occur in confiderable number, it would be better to feparate the account of them from the defcription of the rocks, and place it in a feparate chapter, as the introduction of fuch defcriptions diftracts the attention, and prevents us obtaining a correct idea of the more general relations of the rocks. In defcribing thefe *after repofitories*, however, we muft follow a determinate plan, as much fo as in defcribing the rocks. When we have not had repeated opportunities of determining the relative age, the peculiar characters, and the ftructure of thefe different repofitories, the moft convenient plan of arrangement would be, that according to the age of the rock in which they are found; if, however, we have afcertained thefe 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 *übergangſgebürge*, *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 clafs are, according to Werner, 1. Grey-wacke, 2. Grey-wacke flate, or tranfition flate. 3. Tranfition limeftone, 4. Tranfition greenftone. 5. Tranfition amygdaloid. And, 6. Flinty flate. Of thefe fpecies, as already mentioned, four only have as yet been obferved in this county, viz. Grey-wacke, grey-wacke flate, tranfition greenftone, and flinty flate. The alum flate already mentioned may be confidered fubordinate to the tranfition flate.

1. *Grey-wacke.* Is compofed of frag- Grey-wacke. ments of quartz and clay flate, which are from the fize of a hen's egg, until from their minutenefs, they are no longer vifible. The fragments are connected by a bafis of clay flate, which has ufually a bluifh grey or brownifh colour. It is often traverfed by nearly cotemporaneous quartz veins; and, as Werner obferves, the quartz folution appears often to have diffeminated itfelf through it, which renders this rock fo 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 effloreſcence ſometimes makes its appearance: natural alum ſometimes effloreſces 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 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 prefented by the vein, in the different places I had an opportunity of examining. I regret my obfervations were not fufficiently numerous to enable me to afcertain its general ftructure and peculiarities, and thus to determine its characters, as a particular depofition or formation.

1. In feveral places, I obferved the whole width of the vein filled with blackifh brown coloured ochre of manganefe, in which fragments of greywacke, which conftituted the walls of the vein, were immerfed; in other places, the manganefe contained cryftals of quartz, and maffes of lead glance*, and fometimes druffy cavities, which were lined with calamine and green lead ore.

* I ufe the term lead glance inftead of the more ufual one galena, becaufe it is Englifh, and expreffes the moft ftriking feature in the external afpect 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

manganefe, a few inches thick, which contained interfperfed green copper ore; and laftly, the upper or hanging fide of the vèin confifted, for a foot and half, of fragments of grey-wacke and grey-wacke flate, intermixed with ochre of manganefe.

4. In another part of the vein, its ftructure and materials was as follows: 1ft, Sides of the vein were lined with a layer a few inches thick of ochre of manganefe. 2d, To this fucceeded layers of brown ochre of iron. 3d, Thin layers of calamine. 4th, Thin layer of lead glance, which was coarfe, fmall and fine grained. 5th, Layer of brownifh coloured arenaceous quartz, of which the concretions were fo loofe that it could be difintegrated by the hand*; and, 6th, the middle of the vein was filled with manganefe.

* 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.

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

The vein has fometimes interpofed between it and the rock in which it runs a thin feam of clay or loam; fometimes this is wanting, and not unfrequently the matter of the vein is grown together with the rock which forms its fides.

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

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

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

I

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 calc 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 òbſervé 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 confiderées, que comme apparte- " nant a une meme formation principale. " Ainfi il pourroit bien fe faire que ce que " j'ai dit fur le formations du Hartz vint " à eprouver quelques corrections, ou " recevoir quelques additions. Peut-etre " en faifant et continuant des obferva- " tions foignées dans des pays differents " et meme eloignés les uns des autres " on decouvrira un beaucoup plus grand " nombre des formations de galene."

According to General Dirom, the mines belonging to the Earl of Hope-toun produce annually 1400 tons, and thofe of Wanlock-head, belonging to the Duke of Queenfberry, about 1000 tons, worth L. 20. per ton, or in all L. 48,000. yearly. The proprietors receiving every fixth bar as lordfhip or rent.*

Produce of the mines.

* General Dirom's Mineralogical Defcription of Dumfries-fhire, 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.

Similar phenomenon in the Hartz mines.

"Sie ſchneidet nun den Samſ-
"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 luftre is fplendent, feldom fhining; internally it is from fplendent to glifning, and is adamantine.

Fracture is commonly fmall conchoidal, but it fometimes paffes to fine-grained uneven, and even to fplintery.

Fragments are indeterminately angular.

Is ufually tranflucent, but in cryftals femi-tranfparent. Streak is greyifh white.

Is foft. Not very brittle. Eafily frangible. Heavy. Specific gravity—7,2357. Chenevix.

Conftituent Parts.

According to Klaproth, it contains—

Lead	77
Carbonic acid	16
Oxygen	5
Lofs, and water of cryftallization	2
	100.0

Obfervations.

The columnarly aggregated variety has fome refemblance 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 ſcalarwiſe 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.

I. 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.

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 Antimony mine of Glendinning.

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 grafs, and no trial of any confequence had been made, I cannot at prefent give a more particular account of it.

Lead ore is alfo faid to have been found on the farm of Weftwater, belonging to the Duke of Buccleugh, and in the eftate of Broomholm, belonging to J. Maxwell, Efq.*

Obfervations.

Obfervations to fhew the advantages of a repeated examination of the fame diftrict.

1. Although thefe are the only repofitories of ores hitherto obferved in this county, it is not to be doubted that a more careful examination of all its mountains and valleys may difcover many others. Even if after a complete and careful furvey no metalliferous mineral repofitories of confequence fhould be difcovered, it does not follow that ores will not be found in thefe mountains; on the contrary, from

* 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 ironſtone, 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.

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. 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-

Different formations of coal.

Rocks of the independent coal formation.

* 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 poſition 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 Cannoby, confifts of fpherical concretions, which are again compofed of curved lamellar concretions *.

2. *Slate clay*, which lies between the beds of reddifh brown coloured fandftone, prefents the following characters:

Colour yellowifh grey, marked with fpotted and clouded delineations of a pearl grey and cherry red colour.

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

Fracture more or lefs perfectly flaty, fometimes approaching to earthy.

Fragments indeterminately angular, fometimes tabular.

Opaque. Soft. Mild. Eafily frangible. Feels meagre.

At Ecclefechan, Repentance-hill, Whitehill, Cannoby, and Sanquhar, I obferved greyifh black and afh grey coloured varieties, which contain numerous impref-

* 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 tranſition 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 manganefe. In this character the limeftone agrees with that near Vogric in the county of Mid Lothian. Sometimes we obferve in it beautiful dendritic brown iron hæmatites. I am indebted to the intelligent Mr. Monteith of Clofeburn for feveral beautiful fpecimens of this kind. The limeftone is generally of a flefh-red and pearl grey colour, and its fracture is fine fplintery. It contains petrifactions of various kinds, particularly large ammonites.

The extenfive quarries of Barjarg do Barjarg. not differ from thofe of Clofeburn, and are moft evidently part of the fame depofition. It is highly probable that this limeftone will be found to extend through the whole of the coal formation of this valley.

A confiderable portion of the lower Valley of Dumfries. and flatter part of the valley of Dumfries is compofed of reddifh brown coloured fandftone, 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. 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.

Craigs near Dumfries.

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

Coal formation in the diſtrict of Annandale.

* 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.

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. Corncockle muir.

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 Ecclefechan, in the channel of the rivulet that runs by the limeftone quarries, there are beds of clay iron-ftone alternating with greenifh grey and reddifh brown coloured flate clay, and covered by reddifh brown coloured fandftone. The beds of iron-ftone are from three inches to a foot thick. Immediately above this we come to the *firft limeftone quarry*, where we obferve thin beds of clay iron-ftone, pearl grey coloured flate clay, and fandftone, refembling that of Brown muir, lying on beds of flate clay that alternate with beds of limeftone containing numerous petrifactions, but principally mytulites, chamites, and corallites. In the *fecond limeftone* quarry there are beds of limeftone from one to two feet thick, alternating with beds of greyifh black coloured flate clay, and of greyifh white coloured fandftone. The flate clay is fometimes fo compact that the flaty texture is difficultly difcoverable. Much mica is intermixed with the fandftone. Ecclefechan.

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 brownifh red coloured fandftone commences, and continues without any alternation of other rocks to the Solway frith. The ftrata in the coal field of Byre burn are frequently trough-fhaped. At prefent three beds of flate coal are worked*.

Having now detailed with fufficient minutenefs the characters of the different rocks of the coal formation of this county, I may now add, that its moft ftriking characters are, the reddifh brown colour of the fandftone, the great thicknefs of

* The coal of Cannoby, Sanquhar, and Kirkconnel, is that variety of flate coal which contains much bitumen, and therefore, when inflamed, cakes; hence it is called caking coal. It is particularly ufeful for the forge and in domeftic œconomy, but would not anfwer fo well in other operations, as in fmelting ores, &c. becaufe of its running fo clofe together. The varieties ufed for burning limeftone contain much intermixed bituminous fhale and flate clay; this ietermixture, in place of being detrimental, is of advantage, as the fire remains open during combuftion. Even the bituminous fhale, which is thrown away among the refufe, might be ufed for burning limeftone.

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. Bituminous 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 eafily 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.

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

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 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 compofed of *thick ftrata* of *reddifh brown coloured fandftone*, which is ufually coarfe grained, and indeed fometimes paffes to conglomerate. Alternating with it we find beds of flate clay, and *thick and very extenfive beds of coal*. Thus the coal fields of upper and lower Silefia prefent differences refembling thofe that diftinguifh Mid Lothian from Dumfries-fhire, yet they are portions of the fame formation. I have therefore no hefitation in concluding that the coal fields of Mid Lothian and Dumfries-fhire belong to the independent coal formation; and as coal has been found widely diftributed in the one field, we are entitled to believe it occurs in quantity in the other.

Coal fields of Dumfries-fhire and Mid Lothian belong to the fame formation.

The particular fpots where trials for coal may be made with the greateft œconomy and probability of fuccefs can only be afcertained by a careful furvey 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

tranfition rocks is to be referred to the neweft floetz-trap formation *.

Obfervations.

Werner defcribes but one pitchftone formation.

Werner has hitherto defcribed but one pitchftone formation, and it belongs to the primitive rocks. Several years ago I obferved, in the highly interefting ifland of Arran, pitchftone alternating with floetz greenftone that lay over the inde-

bituminous or carbonaceous matter. The pitchftone of Glencloy, when powdered, emits a bituminous fmell, and colours the fulphuric acid flightly. (Mineralogy of the Scottifh Ifles, vol. 1. p. 48.) Bafalt and other rocks belonging to the fame formation contain, according to Klaproth and Lampadius, bituminous or carbonaceous matter; and Mr. Pepys has difcovered carbonaceous matter in wood opal and wood ftone. Parkinfon on Petrifactions, vol. 1.

* Dr. Reufs of Bilin is of opinion that porphyry flate occurs in older formations than the floetz-trap; and Captain General Von Charpentier fays that bafalt fometimes occurs in primitive mountains. Both thefe obfervations, as I have fhewn 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 mofs. 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 fea, as conjectured by fome. There are other accumulations of lefs extent, as that of Kilmore, that which extends from Burnfoot to Nellsfield, Righead mofs, and feveral others in the lower part of the county. In the upper or mountainous part of the county it is found in confiderable quantity in hollows between the mountains, and even on their fummits.

Obfervations.

The accumulation of peat on the fummits of high hills or mountains is a fact deferving of attention. How are we to explain fuch accumulations of vegetable matter in fituations fo far removed from all the ufual fources of nourifhment? Is it not probable that water and air fupply thefe vegetables with nearly all the mate- On the formation of alpine peat.

R

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.

CONTENTS.

NOTES

AND

ILLUSTRATIONS.

A.

THE defcriptions of the phyfiognomy of the earth's furface, as detailed in geographical works, in particular, what has a reference to the grouping of mountains, are often indiftinct and imperfect. I fhall, in proof of this, mention a few inftances drawn from the defcriptions of feveral modern geographers. By them Bohemia is defcribed as a flat coun- On mountain groupes.

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.

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

Parts of which a mountain is compoſed.

S

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 lefs confiderable than that of the acclivity. There occurs, however, exceptions to this; thus, there are fummits that rife more rapidly than the acclivity, and thefe are ufually very high, and almoft of equal height with it, and are completely naked. Such lofty and precipitous fummits are, in Switzerland, called peaks. The fummit varies confiderably in its fhape; it is either tabular, round-backed, or obtufe, acute, or fhort-conical. Generally the fhape of the mountain is characteriftic of the rock of which it is compofed. Thus gneifs and tranfition rocks form flat or round-backed fummits, clay flate conical fummits, and bafalt and fome other rocks fhort and obtufe conical fummits. Granite and limeftone often prefent extremely fharp pointed fummits, 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.

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

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

which diftinguifh it from rocks of the fame fpecies. By the firft we afcertain its age in relation to the other maffes of which the cruft of the earth is compofed; by the fecond its ftructure in the great; and by the third its ftructure in the fmall, or in hand fpecimens, and the characters that diftinguifh it from other rocks. Any thing further, any attempt at defcribing every variety of the afpect of a rock, is ufelefs, and thofe who perfift in fuch unneceffary difcriminations are not acquainted with the method of conducting geognoftical inveftigations.

G.

Inftances of loofely aggregated quartz.

Quartz, in a fimilar ftate of aggregation, has been obferved in mineral veins in the Harz. Voight, on defcending into the mine called Louifa Chriftiana 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 atmofphere on thefe fandftone " balls, gradually difintegrates the clayey " fandftone, which, on account of its " friability is the more eafily effected. " The rain wafhes it out, and then only " the fomewhat thinner lamellæ of the " iron-fhot fandftone remain behind. By " this means the fandftone acquires a " large veficular corroded afpect, thus pre- " fenting complete oval fhaped, and " fometimes irregular veficles. The fur- " face of the remaining iron-fhot fand- " ftone becomes brick red and reddifh " brown, owing to the increafed oxida- " tion of its iron." Reufs's Mineralogifche Geographie von Böhmen, b. 2. f. 46. 47.

Obfervations.

The occurrence of fandftone in diftinct concretions fhews that a very confiderable portion of the matter of which it is compofed was, at the time of its formation, in a fufficiently minutely divided ftate, to allow it to form maffes having a fomewhat 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 fur certaines pierres des environs de Saint Chaumont, &c. at page 866, in the Hiftory of the Academy of Sciences for 1718, fays exprefsly that the originals of thefe plants muft exift either in the Eaft or Weft Indies, becaufe they have the greateft refemblance to the ferns and marfh plants of thofe countries, or *they no longer exift on the furface of the earth.* Many fucceeding naturalifts have adopted the idea that the greater number of vegetable impreffions belong to fpecies now extinct, and Werner, whofe authority in fuch cafes is fuperior to that of all others, long ago concluded from his obfervations *that all the impreffions found in the older formations belong to vegetables now extinct, and which flourifhed and died in the countries where we now find them.* Werner's opinion.

I fhall not here enter into any illuftration of this opinion, but fhall earneftly recommend the examination of the numerous vegetable impreffions 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 Cofta, Account of the Impreffion of Plants on the Slates of Coals. Philofophical Tranfactions, vol. 50. p. 228. 235.

10. Geoffroy, Memoire fur quelques Empreintes Foffiles, Journal de Phyfique, tom. 28. p. 269. 271.

11. Tingry's Obfervations on fome extraneous Foffils of Switzerland. Lin. Tranf. vol 1.

12. Jean Guillaume Bruguire. Sur les Mines de Charbon des Montagnes de Cevennes, et fur la double empreinte des Fougéres qu' on trouve dans leur fchiftes. Journ. d'Hift. Nat. t. 1.

13. Notice fur des Plantes Foffiles de diverfes efpeces qu'on trouve dans les couches foffiles d'un fchifte 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 Schieferthon Sandftein, &c. von von Schlotheim. Hoff. Mag. b. 1. f. 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 fandftone, limeftone, and falt, regular and very extenfive ftripes are fometimes obferved, which have been confounded with true ftrata feams. An attentive examination, however, always difcovers them traverfing the real feams of ftratification. Von Buch, in his defcription of Landeck *, and geognoftical obfervations made in Italy and Germany † ; Friefleben, in his obfervations on Thuringia ‡ ; and Sir James Hall, in the theory of the earth, publifhed by the late Dr. Hutton of Edinburgh ||, defcribe ftriking inftances of ftripes refembling ftratification. The following is the explanation of this phenomenon, as given by Von Buch. " Wahrfcheinlich liegt " die urfache in einer groffen bewegung

* Verfuch einer mineralogifchen Befchreibung von Landeck, 4to.

† Geognoftifche Beobachtungen auf Reifen durch Deutfchland 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 magnetic 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.

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

" 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 charactirisirt, 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 Kirkudbright-ſhire, Dumfries-ſhire, and part of Lanark-ſhire, 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, fcaly, or *columnar* *. I obferved maffes of greenftone imbedded in the coal and graphite, but whether they are to be confidered as fragments, or as of cotemporaneous formation with them, I cannot with certainty determine. The latter fuppofition is the moft probable.

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

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

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

* A defcription of this new fubfpecies of graphite will be given in the fecond volume of my Syftem of Mineralogy.

9. The loweſt bed viſible is of ſand-ſtone 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 loofe maffes of fyenite in the lower parts of the county.

In feveral places in the low part of the county pretty large loofe blocks of water-worn fyenite are to be obferved lying on the furface of the coal formation. Water-worn maffes of the fame rock occur in the reddifh brown coloured fandftone conglomerate, and the floetz-trap rocks, a fact which affords a fufficient explanation of the fituation of the loofe maffes.

In the Alps, of which the celebrated Sauffure has given fo interefting, animated, and delightful a defcription, many maffes of rock are found, far diftant from their original fituation. To explain this phenomenon many hypothefes have been contrived in the clofet, which bear fufficient marks of the ignorance and prefumption of their fabricators. Others, and among thefe the illuftrious Sauffure himfelf, have, after painful and minute examination of the Alps and other fimilarly conſtructed 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 inſtances 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.

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; On the occurrence of red ſandſtone in the coal formation.

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 greenſtone.

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 refearches, with the view of afcertaining this point, when a careful examination confirmed my fufpicions, and I found that Salifbury craigs, Craigmillar, and the cliffs of Hawthornden, belonged to the coal formation; but the fummit of Arthur feat, and Craig Lockhart, to the neweft floetz-trap formation.

The moft interefting obfervation which I made during this inveftigation was that of beds of greenftone in the coal formation; an appearance fo unexpected that I was for fome time doubtful whether or not the whole feries of ftrata that accompanied thefe beds fhould not be referred to the floetz-trap formation. The following are fome of the inftances of this fact which I had an opportunity of examining:

1. *Salifbury craigs.* The loweft part vifible of this hill is fandftone, 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 † difpofition, firft a great horizontal mafs of trap-breccia, and then two beds of bafalt, the uppermoft of which forms the fummit of Arthur feat; thefe from their fituation and characters are to be referred to the *neweft floetz-trap formation.*

2. *Section of the coal formation below Caroline park.* About a mile weft from Newhaven, immediately below the walls of Caroline park, there are a number of beds well expofed by the action of the fea. They are flate clay, flat fpherical clay iron-ftone, a black flinty † foffil refembling flinty flate, greyifh coloured fandftone, and thefe alternate repeatedly with beds of greenftone. The varieties of greenftone which thefe beds prefent are de-

* When horizontal beds or ftrata reft on thofe which are much inclined, I exprefs their fituation by the term *overlaying.* Figure 2. in plate 4. reprefents an inftance of this kind of ftratification.

† This foffil is frequently found in the coal formation. Although very unlike bafalt, 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.

The ufual directions which are given for fearching for coal are not fufficiently complete. The following ftatement of the cafes that may occur in this inveftigation will, I truft, be found ufeful: Obfervations on fearching for coal.

Cafe 1. Suppofe we have examined a tract of country which we find to be compofed of tranfition rocks, and rocks belonging to the neweft floetz-trap formation; are we there to bore or fink fhafts, with the view of difcovering coal? If we have afcertained that the floetz-trap rocks repofe immediately on the tranfition rocks, then the fcarcity of fuel muft be very great, or the appearances very promifing, before expenfive trials fhould be attempted; becaufe, in the floetz-trap formation we feldom find

obferved in ftrata refembling thofe of Salifbury 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 difcovering it, as none occur in thefe rocks.

Cafe 8. If in the newer clay flate, flaty glance coal (coal blende) is found, we muft not confider it as indicating common or black coal, and fhould not therefore make any trials in fuch fituations.

Cafe 9. Suppofe we have difcovered the independent coal formation, and have funk fhafts into it to a confiderable depth, without difcovering workable beds of coal, we muft be cautious not to increafe the expence unneceffarily by continuing the workings beyond the coal field on its fides or bottom. This is illuftrated by Plate 3.

* Werner divides coal into two fpecies, *a*. brown coal, and *b*. black coal. The black coal includes all the fubfpecies 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 inattendue, que j'ai faite l'eté dernier au mont *Schiebengberg*, ſur la rapport du baſalt a la roche que ſe trouve au-deſſous, me parait devoir etre extemement intereſſante aux yeux de tous les geognoſtes ſans prevention; ſur-tout dans ce moment ou la diſſcuſſion ſur la nature et ſur l'origine du baſalte vient de ſe rallumer de nouveau. Deja depuis 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, demandé 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'apercu 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.

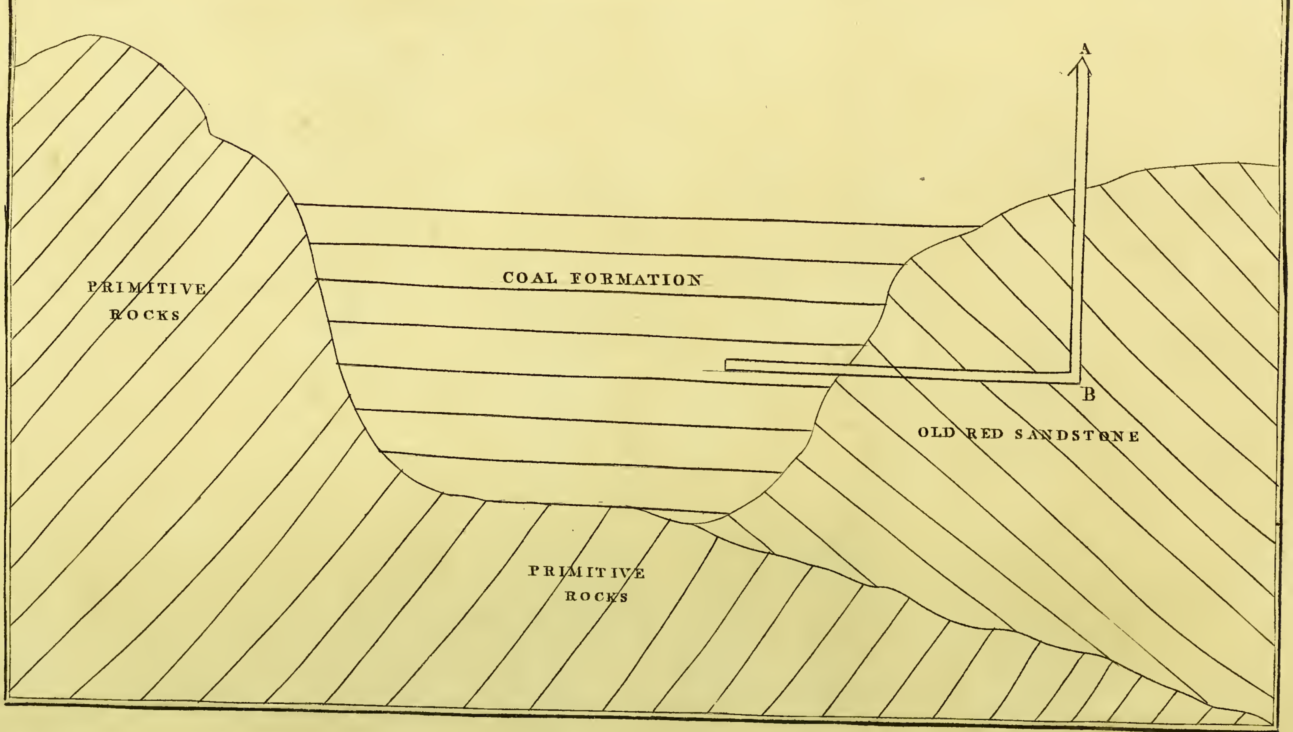
Signé WERNER.

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
COAL FORMATION
OLD RED SANDSTONE
PRIMITIVE ROCKS
PRIMITIVE ROCKS

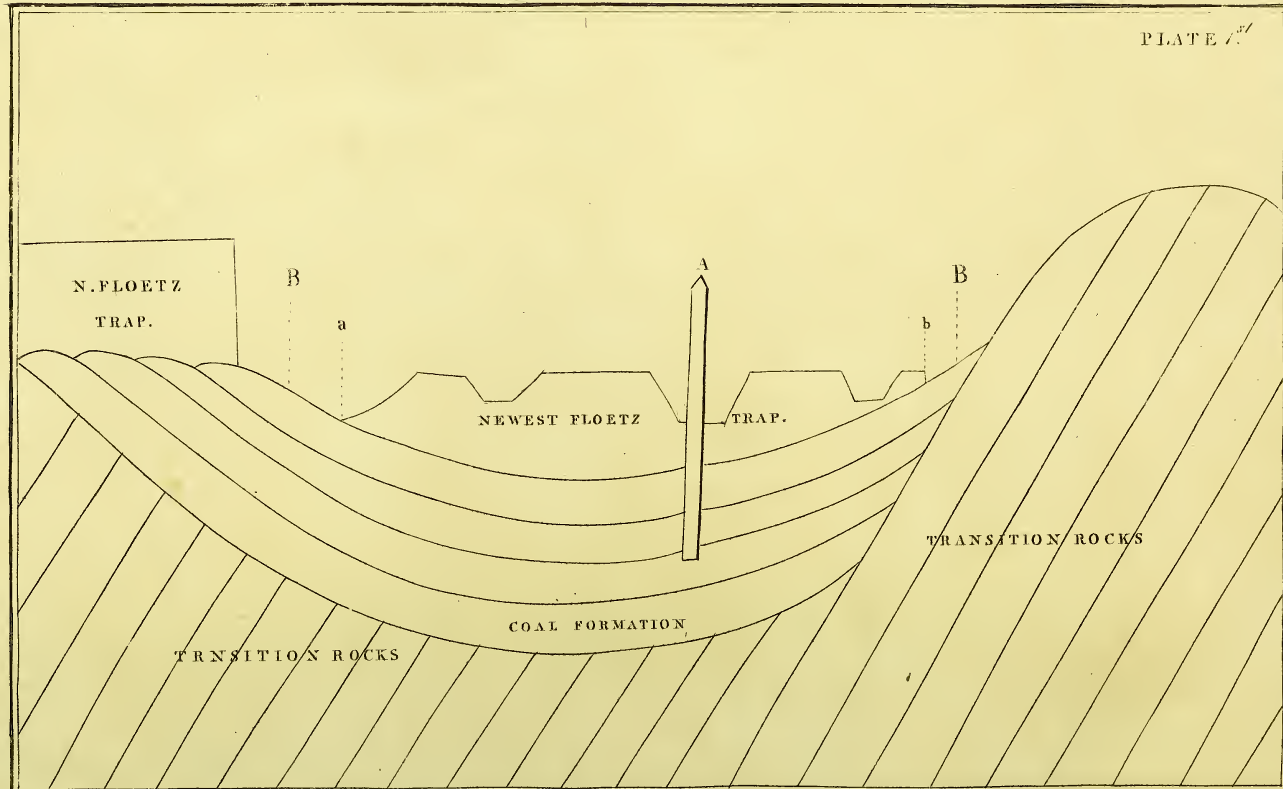


PLATE 1.st
N.FLOETZ
TRAP.
B
a
A
B
b
NEWEST FLOETZ
TRAP.
TRANSITION ROCKS
COAL FORMATION
TRNSITION ROCKS

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.

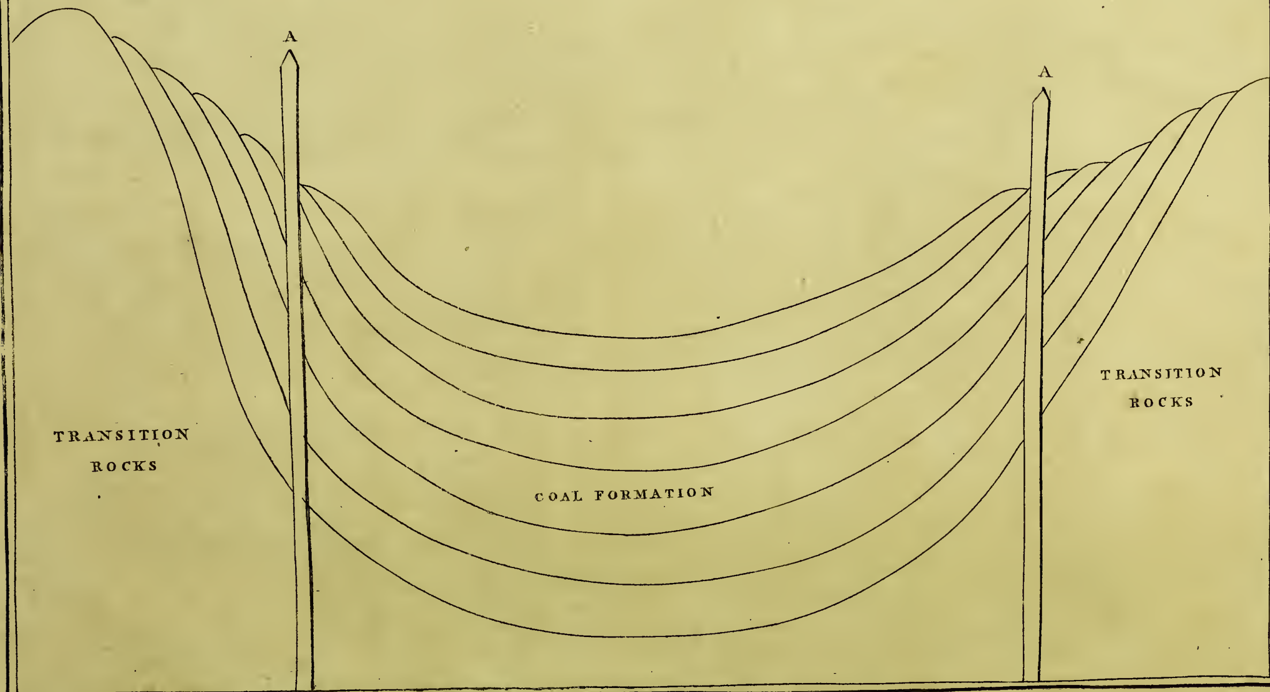


PLATE 4th.

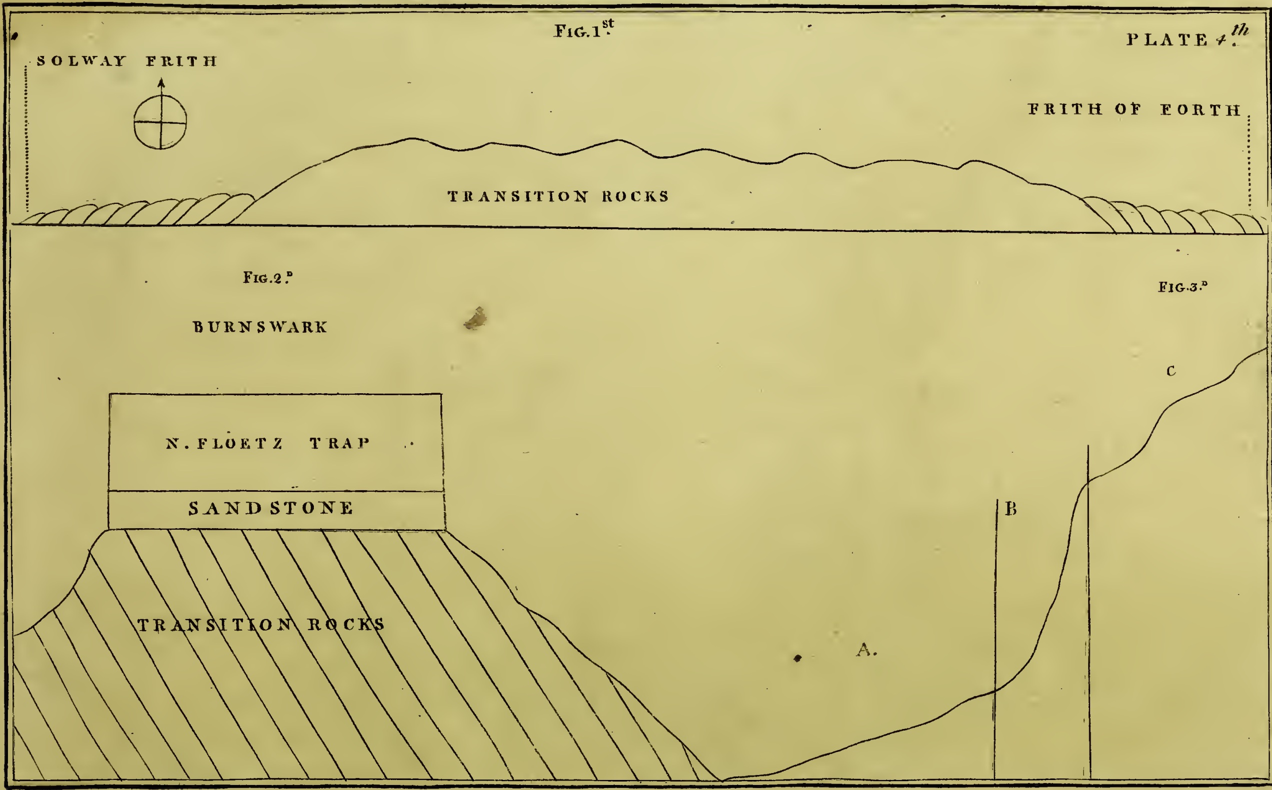


Fig. 1st.
SOLWAY FRITH
FRITH OF FORTH
TRANSITION ROCKS
Fig. 2d.
BURNSWARK
N. FLOETZ TRAP
SANDSTONE
TRANSITION ROCKS
Fig. 3d.
A.
B
C