I. *A DESCRIPTION of the STRATA which occur in ascending from the PLAINS of KINCARDINESHIRE to the SUMMIT of MOUNT BATTOC, one of the most elevated points in the Eastern District of the GRAMPIAN MOUNTAINS. By Lieutenant-Colonel IMRIE, F. R. S. EDIN.*

[Read 5th March 1804.]

THE most mountainous parts of Scotland are situated in its western and north-west districts. From those parts of the country, several chains of mountains branch off, and continue their courses in various directions, and to various extent. The most extended of those chains is that of the Grampians. This chain takes its rise from nearly about the centre of the above alpine district, and continues its course in a direction almost due east, or perhaps a little to the south of that point, until it disappears in the German Ocean, betwixt the towns of Aberdeen and Stonehaven.

THIS chain, in its eastern district, consists of three ranges, running nearly parallel to each other; the two lateral ranges being considerably lower than the central one. To the lateral mountains are attached a range of lower hills, that slope down into undulated grounds, which skirt the adjacent plains.

THE general shape of the individual mountains composing those three ranges, is oblong, rounded, and sometimes flattish on the tops; their length is always in the direction of the chain,

chain, that is to say, from west to east: and I have observed, not unfrequently, that the western ends of those oblong mountains are more bulky than their eastern extremities, and that they slope and taper in some degree towards this quarter. Their general covering is that of a coarse gravelly soil, produced by their own decomposition; and the produce of this soil is heath. But upon some of the heights in the central range, I have found beds or layers of that species of turf called *Peat*, from fifteen to twenty feet in thickness, which repose upon the gravelly soil that there covers the native rock.

AT this eastern part of the Grampians, where I am now about to endeavour to give a description of the stratification, the mountains seldom show any considerable extent of naked rock.

IN their course to the eastward, as they approach the sea, they begin to contract in breadth, and cover much less space of country; and where they finish their course at the sea, their height will scarcely entitle them to the appellation of hills: but although they become so diminutive in height and in breadth, yet the materials of which they are formed continue the same as those which compose the ranges where they are in their greatest altitude, and their exterior characters, as to form and figure, also continue the same.

AMONG the rivers which have their source in the Grampians, that of the *North Esk* is not the first in rank as to size, nor is it the most diminutive. At a considerable distance from the plains in the interior of the mountains, a small lake called *Loch Lee* is formed, in a rocky basin, by a rivulet, and some springs and rills flowing from marshy grounds. From this lake the *North Esk* issues, not in a very considerable flow, but, being soon joined by other streams and alpine torrents, it swells to a considerable size, and continues a course from this lake almost due east, betwixt the central and south lateral ranges of the mountains, for an extent of about seven miles: it then skirts Mount-Battoc, and being

ing there impeded in its eastern direction by some of the hills forming the basis of that mountain, it then changes its course, almost at a right angle, and from thence flows in a due south direction. In this last direction, it opens a way for itself through the south lateral range, and enters the plains of Kincardine, and Forfar shires, where it immediately becomes the line of division of those two counties. It leaves those plains by a hollow betwixt the two low hills of Garvoke and Pert, and after a course of nearly thirty miles from its source, it joins the sea somewhat to the eastward of the town of Montrose. It is in the bed of this river that I have examined the strata of the Grampians of which I am now to give a description. The section extends about six miles, from the horizontal grit or sandstone in the plain, to the granite of Mount Battoc, which is one of the mountains in the central range, and one of the highest of the chain in that part of the country. My direction, in this examination, is about due north, piercing through, almost at right angles, the strata of the mountains, which are here nearly in a vertical position.

IN this short stretch of six miles, a great deal of matter highly interesting to geology presents itself. In it, we pass from the secondary horizontal strata of the newest formation, to the vertical, contorted, primary strata of the oldest date, and terminate with granite, the primitive rock in the conception of many geologists. Thus, it embraces a complete range of the fossil objects, which in this part of Scotland intervene between that which is deemed the oldest and what is accounted the most recent in point of formation. From the various strata standing in a position vertical, or nearly so, and the river North Esk, cutting across these strata, at right angles, the succession is uncommonly well exhibited to view, and a fair display of the structure of this country, and of the materials composing it to a great depth, is open to the attentive observer. In addition to this fine display of the succession of strata, the arrangement of them will
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be found to offer some very curious and important facts, particularly the gradual elevation, and the final perfect vertical position of the sandstone and puddingstone, as well as the rather unusual manner in which the secondary and the older strata meet each other.

IN the series here to be described, the repeated occurrence of rocks of the *wbin* and of the porphyry formation, respecting the origin of which opinions are so much divided, adds considerable interest; especially when the form and situation in which they occur, and the condition of the contiguous rocks, are taken into consideration.

IN the account which I am now about to give, I shall endeavour to lay down a fair representation of the facts as Nature presents them, unbiassed by any of the prevailing theories of cosmogony. I shall avoid every geological discussion whatever, leaving it to others to draw those conclusions, in relation to their own speculations, which they shall imagine the facts to warrant.

IN that part of the plains of Kincardineshire from which I take my departure, the native rock consists of Siliceous Grit or Sandstone, which is here divided into an immense number of beds or layers, of various thicknesses, from one inch to four feet, solid stone. In many places, gravel of various sizes is found imbedded in this grit; which gravel consists mostly of water-worn quartz, and small-grained granites. The colour of the general mass of this grit is a dark-reddish brown, and in some few places it shows narrow lines and dots of a pearl-grey colour. The component parts of this grit consist of small particles of quartz, and still more minute particles of silvery-lustred mica: these owe their cohesion in mass to a martial argillaceous cement, to which this rock also owes its colour. Those lines and dots of pearl-grey colour, generally occur in the most solid and thickest beds
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of the rock: they are formed of the same materials with the other parts of the stone; but into them the ferruginous staining matter has not apparently been able to penetrate, and they derive their present greyish appearance from the natural colour of its particles of quartz, which are here *per se* of a bluish-white tint. This rock, in the plain, is perfectly horizontal in its position; but upon its approach towards the undulated grounds, which here form the lowest basis of the Grampians, it begins to rise from its horizontal bed, and, gradually increasing in its acclivity *towards the mountains*, it at last arrives at a position perfectly vertical.

FOR the first quarter of a mile from where this grit begins to leave its horizontal position, the rise is very gradual; but after that distance, it becomes more rapid, and in a mile it gains its vertical position.

WHERE this grit or sandstone rock is in its most solid state, and where its position is perfectly vertical, betwixt two beds or layers of it, there occurs a bed of Whinstone forty feet broad.

THE main body of this bed of whin intersects none of the layers of grit, but stands upright betwixt two of them, to both of which it is closely joined. The river, at this place, has, in its passage, worn down this bed of whin equally with that of the adjoining grit, and a perpendicular face of it can be examined upon each side of the river, from fifty to sixty feet in height.

UPON examining the section of this bed, I found upon the east side of the river two branches, which sprung from the main body of the whin, nearly where the water of the river at present washes the base of its perpendicular surface. One of those branches springs from the right side of the trunk, and the other springs from the left side: they at first diverge from the trunk as they ascend, and where they push out laterally, they intersect the contiguous strata, and penetrate them in a zig-zag manner; but at last, in a position betwixt two of the layers of the grit, they continue

tinue their direction upwards, decreasing in their diameters as they ascend, until they finish their course near to the superficial soil which here covers the rock. The grit contiguous upon both sides to the bed of whin, is considerably harder and more compact than it is in any other part of the stratification; and that angle of the grit which lies between the body of the whin and its branches, is more indurated than the strata of the grit upon each side.

THIS species of whin is not very compact in its texture. Its fracture is somewhat earthy, and is of a brownish-black colour; but it has a considerable degree of induration, and has some specks of lustre in it. Having passed this bed of whin, the grit continues in the same position as immediately before the whin occurred; but, soon after, the gravel, which I have mentioned to be in some places imbedded in the grit, increases in quantity, and at last the strata are formed of a rock composed entirely of that species of gravel, and which may be called Gravel-stone or Plum-pudding-rock. This aggregate constitutes a stratum four hundred yards thick. Its stretch is nearly from west to east, and it is vertical in its position. Its composition consists of quartz, porphyries, and some small-grained granites, all of which have evidently been rounded by attrition in water: they are

are of a vast variety of size, from that of a pea to the bulk of an ostrich egg. These are all firmly combined by an argillaceous ferruginous cement. In some parts of this gravel rock, are to be seen thin lines of a fine-grained grit, stretching through it from west to east; it is by those lines alone that the verticality and the stretch of this mass is discoverable. Its general colour, in mass, is that of a ferruginous red.

THIS plum-pudding rock is immediately followed by a succession of strata of fine-grained grit, in thin layers: it has a very considerable degree of induration, and is of a dark ferruginous brown colour. This deviates a little from the vertical position, and inclines to the south: the stretch is from west to east, and its extent towards the north is two hundred and sixty yards. To this rock immediately succeeds a species of Porphyry, the principal mass of which consists of an indurated argil. Its colour is of a purple or lilac brown: its induration is very considerable, and its fracture is rough and earthy. The materials which are imbedded in its mass, consist of small particles of quartz, felspar, blackish-brown mica, and specks of iron ochre; all of these are but thinly scattered. The space in the course of the river occupied by this porphyry is two hundred and twenty yards: its stretch is nearly from west to east, and it inclines in a small degree to the south. The rock which succeeds to this porphyry, and which is in contact with it, is difficult to describe; and this difficulty arises from the great disorder of the stratification, and the variety of materials composing it. The strata of this bed do not succeed each other in a regular manner. Portions of them of various dimensions lie together, but very variously disposed: some are vertical, some horizontal, some dip to the south, one only to the north, affording a solitary instance of a northern inclination of the strata in this field of examination.

THE materials of this mass of confused stratification, are of very different descriptions. In one place, a quartzose stone

abounds, of a granular texture: it here, in general, resembles a fine-grained, highly indurated, and compact quartz sandstone: sometimes, however, it approaches to hornstone, and even sometimes to quartz in mass. Much of it has a white colour: the rest is tinted of an ochery brown, of different shades. In other places, the stratified matter consists of a stone of a laminated texture, with undulating lamellæ of a ferruginous tint, looking like an indurated shale; and various gradations of both kinds present themselves. This jumble is in thickness three hundred yards; and to it immediately succeeds a very narrow stratum of Argillite, which is of a greenish-grey colour, and very thinly lamellated.

THIS argillite is succeeded by a bed of Whin, thirty-three feet broad. This whin is of a dark blackish-brown colour, and is of a more compact texture, than the whin which I have described occurring in the grit, and is possessed of more induration: the materials of composition are nearly the same in both.

ITS general stretch is nearly from west to east; but in this stretch, where it has been exposed to the eye by the river, it is somewhat curved, and presents its convex side to the mountains. To this bed of whin succeeds a narrow stratum of Argillite, perfectly similar to that which I have just now described upon its southern side. To this succeeds a seam of Limestone, six feet broad. This limestone is of a pale blue colour, and is much intersected by small veins of quartz trending through it in all directions.

IN this limestone, I was unable to trace the remains of any animal or vegetable production. Its position is vertical, and it is immediately succeeded by another narrow stratum of argillite, thinly lamellated.

To this narrow stratum of argillite succeeds a bed of Whin, seventy-five feet broad. This whin is, in its texture, more compact; and its fracture displays a smoother surface than either

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of the two former whins which I have had occasion to mention. Its colour is of a dark-bluish black. In tracing, with my eye, its vertical cracks and fissures, I thought I could perceive a rude tendency to prismatic forms. It is vertical in its position; and its stretch is from west to east.

THIS bed of whin is succeeded by an Argillite of shivery texture, and confused stratification; but as it recedes from the whin, and approaches the mountains, it becomes regularly stratified. This stratum of slate is of great extended thickness; and it contains a vast variety of colour and of tint. The colours are, pale greyish-blue, yellowish-green, reddish-brown, purple and black, with a great variety of tints of all those colours; but the predominant colours are the greyish-blue and the yellowish-green; of which two there are two sorts; the one soft, and the other much indurated. The soft is thinly laminated, and frequently passes over into the highly indurated sort, in which the appearance of the laminated texture is almost lost.

IN this long succession of argillite strata, some substances occur that are heterogeneous to its rock, such as jaspers, limestone, &c.

THE jaspers are in general of a blood-red colour, and are much veined with white quartz: they occur in large amorphous masses, and in nests, of elliptic forms, of great variety of size. One of those bodies of jasper, in the elliptic form, has been cut through by the river, and is now to be seen in the face of the perpendicular rock, upon each side of the stream. Its size is thirty feet long, by ten broad: the points of its transverse axis are sharp; and it stands upright in the argillite. The masses of this matter which occur amorphous in the argillite, are of great magnitude. I have traced one of those for thirty yards in extent. All of those jaspers are of great induration, and take a high polish. Both the amorphous and the elliptical formed masses are found imbedded, where the argillite is of a greenish-grey colour,

thinly lamellated, of a silky lustre, and saponaceous to the feel: it clings round those masses in all their variety of direction, and of course its texture is there much twisted. When the argillite stratification has extended its thickness to near three quarters of a mile, the limestone which I have mentioned above then occurs, in a bed of twelve feet thick. Its colour is bluish-black; and it is much pervaded by veins of quartz, and of calcareous spar; the last of those are, in many places, of considerable breadth, and are of a pale flesh colour. Where this limestone has been wrought, I observed it forked; that is to say, the bed is there split or divided into two, by the intervention of an argillaceous body. Upon each side of this bed of limestone the argillite occurs of two colours. That which is next to, and in contact with the limestone, is black, of a shaly texture, soils the hand, and has veins of ferruginous-coloured quartz trending through it. The argillite which is more remote from the limestone is of a dark purple colour.

IMMEDIATELY after this narrow bed of shale, the argillite re-assumes its greenish-blue colour, and slaty texture, and becomes highly indurated: here some specks of granulated quartz begin to appear, thinly scattered in its mass, and, soon after, it is seen to pass over into an aggregate rock, chiefly composed of grains of quartz, felspar, and minute particles of mica. The particles of quartz and of felspar seldom occur in this aggregate larger than the eighth of an inch: these have very little the appearance of having suffered attrition: they are much mixed, and are frequently seen to take lineal directions; and in those lines the particles of felspar have frequently a compressed appearance, and an eye-like form. This rock, in mass, has a greyish-blue colour: it is of great induration, and although lamellous or slaty in its texture, a cross fracture is often more easily obtained than one with the lamellæ. Its cross fracture is pretty even, but appears more granular than foliaceous. This rock occurs frequently in
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the district of blue clay slate, and may almost be said to alternate with it. I have been perhaps more minute in the description of this rock than it deserved; but I have been so, because doubts have arisen relative to what name ought to be given to this aggregate. In all my geological researches, I have found this rock only twice; once, where I have here described it; and, again, near to Banff, on the Moray Frith. In both of those situations, the aggregates are of the same composition, and similar in position: they both lie among blue clay slate.

IN this long alternation, two substances occur which are heterogeneous to the rocks among which they lie. The first of those, is a bed of compact Felspar, of great induration. This bed is ten feet broad: its stretch is nearly from west to east: its position is vertical; and it stands between two of the layers of the blue clay slate. Its colour is of a reddish-brown, with a small admixture of purple; and its general fracture is conchoidal, somewhat rough, but not earthy.

NOT far distant from this bed, an appearance occurs worthy of some notice. Where the aggregate and the blue clay slate are alternating, a surface of considerable extent of the aggregate rock is exposed to view, parallel to its stratification. This surface is regularly undulated in small undulations, bearing a very strong resemblance to those that may be seen upon the sand of the sea-beach, when recently left by the tide. After passing the bed of compact felspar, the blue clay slate and aggregate rock again alternate; but here the blue clay slate predominates. Near to this, the second substance heterogeneous to those alternating rocks occurs. It is a bed of Whin, the form of which is somewhat singular. It consists of a principal trunk, which the river, here cuts nearly at right angles. Upon the east side of the river, this principal trunk is seen to split into three branches; and those three take an eastern direction, between the strata of the aggregate rock and the blue clay slate, where those two rocks are of great induration. The
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breadth of this bed of whin is thirteen feet; and where it splits, its three branches are, six, four, and three feet in diameter. The trend or stretch of this bed is from west to east; but upon the west side of the river, it curves somewhat to the south-west. Its composition is nearly the same with the three other beds of whin which I have before mentioned. It is of a brownish-black colour, and, when placed in certain directions, it shows specks of lustre. It is vertical in its position, has a great degree of induration, and its general fracture is roughly conchoidal.

UPON passing this bed of whin, the river ceases to be deeply imbedded in the rocks; but the aggregate rock and the clay slate still continue to be seen for a short distance, in a shelvy acclivity, where they are lost to view in a long narrow plain, deeply covered with a bed of gravel, composed of the debris of the interior mountains. The river here flows over this bed of gravel for a considerable space; and upon this narrow flat, we pass through between two of the most elevated points in the south lateral range of this part of the Grampians. Although the obstruction of this mass of gravel cuts off from inspection the continuity of the last-mentioned rocks, yet the broken and abrupt sides of the mountains, close upon each hand, clearly points out, that this part of the south lateral range is entirely composed of micaceous schistus. Here, we are deprived of the junction of the micaceous schistus with the two former rocks; and the loss of all
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such junctions are always to be much regretted in mineralogical research.

HAVING passed over this narrow plain, I advanced towards a second range of hills, which here form the basis of the central and highest chain. It is at this place where the river so suddenly changes its course from east to south, and where I was under the necessity of leaving its bed, to continue my northern direction towards Mount-Battoc. This, however, I was enabled to do to great advantage, by following up the deep cut bed of a winter torrent, which led me into the direction which I wished to follow.

UPON entering the bed of this torrent, I found that the basis of the hills here entirely consisted of micaceous schistus, much veined with quartz, and much twisted in its texture. The stretch of this rock is here nearly from west to east; and it has a southerly dip of 45 degrees.

IN passing through among those hills towards the central range, I found in several of the beds of the torrents large blocks of reddish-brown porphyry, with scattered masses of micaceous schistus and granite.

IN tracing up one of those torrents, I saw the micaceous schistus rock and the porphyry both exposed to view, near to each other; and, soon after, in the bed of the same torrent, I came to a cascade which had laid bare both those rocks at a point where they are in contact; and near those a second bed of porphyry made its appearance, in the front of a near hill. From my first view of those, and from their relative positions, I was led to imagine, that they might here alternate in vertical position; but upon more minute inspection, I found that the porphyry constituted vertical dikes, stretching nearly from south to north; which course cuts the line of direction of the Grampians here almost at right angles: and, on the contrary, I found that the micaceous schistus which flanked those dikes of porphyry, had a regular stretch
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from west to east, and a southerly dip. To endeavour to have these appearances more fully explained to me, I directed my steps to the brow of that hill, where I had observed the rock laid bare; and in passing along the fronts of the hills from east to west, I soon came to a dike of porphyry similar to those which I had immediately left. This dike is sixty feet broad, stretching nearly from south to north, and flanked upon both sides by micaceous shistus, stretching and dipping as before described. In proceeding farther along the faces of those hills, I found several other dikes of porphyry, of various breadths, and at various distances from each other; but all of them similar in their lines of direction, and the micaceous shistus always interposing between them, through which they seemed to rise. The porphyries of those dikes are generally of a ferruginous colour, tending sometimes to an orange-red, and of various tints of those colours. They have great induration, are coarse-grained, and produce a rough fracture. The particles of quartz which are scattered in their principal masses, are small, amorphous, and are of a ferruginous colour. The particles of felspar are of a light tint of the same colour, and are mostly crystallized. The surface of those dikes are in many places bare, and exposed to the eye for long extents, in their lines of direction; and in all those lines of direction which I have traced, I have never found any of them alter in their breadths, in their verticality, nor in their directions. Their surfaces, in general, consist of oblong square blocks, now loose and unconnected with each other; and, in many places, the lines of fracture of those blocks are so straight, that one might almost suppose that they had been disjoined by the hand of art.

I HAVE often observed, in this district, and in other parts of the Grampians, that the loose and outlying blocks of both granite and of porphyry, (which have not been worn down by attrition),

erition), consist, in general, of oblong square shapes. This observation, when I first made it, led me to imagine, that those rocks here were perhaps stratified. I have, however, as yet, not been able to trace real stratification of those rocks in this district of the Grampians.

UPON some of the summits of those hills which here form the basis of the central range, I first discovered the granite in solid rock. In those situations, the granite is only seen in patches, where the superincumbent rocks have worn off it. These superincumbent rocks, which I here found in contact with the granite, are of two different compositions, and occur on the summits of different hills. The one of those rocks, and the most prevalent one, is the micaceous schistus; the other is the granitelle, or a mixture of quartz and shorl. In some parts of this last-mentioned rock, I perceived a small admixture of hornblende: where this appears in the composition, it perhaps ought to receive the appellation of granitine. In those elevated situations, I found both of those rocks, (especially the micaceous schistus), in a state of decomposition, and fast leaving the granite exposed to the eye.

FROM those appearances, it is to be inferred, that the interior of those hills is composed of granite, which is but thinly coated by the superincumbent rocks.

UPON leaving these hills, which, I have already said, form the basis of the central chain of the Grampians, I regretted very much, that all my endeavours proved abortive to trace out the whole extent, in line, of any one of those dikes of porphyry which intersect their sides. I constantly lost them under peat or other soils, before I could trace them to their contact with the granite. It was my anxious wish to see how those two rocks of porphyry and granite connected with each other at their junction.

IN pursuing my researches towards the summit of Mount Batic, I proceeded up the bed of a torrent, which, after heavy rains, dashes down the immediate side of that mountain. In this bed, the blocks of micaceous schistus and of porphyry, (which I had seen so abundantly scattered among the hills that I had just left), totally disappeared, and no outlyers of any kind were to be seen, excepting some granites, which were scattered in large masses; and in every part, where the torrent had carried off the superincumbent soil, the granite was to be seen in solid rock.

IN my progress towards the summit of this mountain, I fell in with a large face of the native granite rock exposed to the eye. By the cracks in this face being in long-extended horizontal lines, it had at first the appearance of being stratified; but upon a nearer and more minute examination, I found that it was not stratified, and that the cracks which gave it that appearance were only superficial.

AROUND this face were scattered large blocks of granite, which were mostly in oblong square shapes.

SOON after passing this precipice, I gained the summit of the mountain, which, though not very highly elevated, is in this part of the chain the highest of the central range. It is about 3465 feet above the level of the sea; and is entirely composed of a coarse-grained granite, in which short sometimes occurs; and its felspar is very generally crystallized.

HAVING here finished the extent of my intended investigation, I beg to be permitted to add, that the line which I have here given the description of, has been traced with much attention, and the true position of each fossil has been most scrupulously attended to, and is correctly placed in the annexed plate.

I WISH that some more able pen than mine, would take up the further description of this extended field of geology, so worthy of investigation ; but if none will come forward for that purpose, I may at some future period presume to give to this Society more extended, and more general lines of description of the Grampians, than that which I have now had the honour of submitting to their examination.