

# TRANSACTIONS.

I.—*Chapters on the Mineralogy of Scotland. Chapter Fifth.—The Micas ; with description of Haughtonite, a new Mineral Species.* . By Professor HEDDLE.

(Read 3d February 1879.)

## MUSCOVITE.

Muscovite is so easily recognised by its optical properties that the only cases which seemed to me to call for analysis were those which, from being possessed of characteristic colour, were of special interest.

Of these the most singular is a variety found rarely in the great vein of Ben Capval, Harris ; it occurs in crystals of a peculiar green tint, the crystals are small and have somewhat of a pearly lustre.

On 1·2 grammes—

Silica, . . .	·511		
From Alumina, .	· 6		
	<hr/>		
	·517	=	43·083
Alumina, . . .			32·858
Ferric Oxide, . . .			·736
Ferrous Oxide, . . .			2·764
Manganous Oxide, . . .			·083
Lime, . . .			1·073
Magnesia, . . .			·333
Potash, . . .			9·084
Soda, . . .			·847
Water, . . .			9·122
			<hr/>
			99·983

Loses in bath 2·793 of the above water.

It would thus appear that the ferrous oxide is the source of the colour.

The iron of muscovite has hitherto been almost invariably set down as being in the ferric state :—it is very probable, however, that its condition had not been often determined.

The amount of water is here high ; most analyses of micas would seem to have been executed on material dried at 212°.

Two other delicately-tinted micas may be suggested to future investigators for examination ; namely, a brilliant-lustred yellow mica, from Struay Bridge in Ross-shire, and a somewhat rose-tinted variety, from Glen Skiag in the same county.

Muscovite is not so markedly typical of granites in Scotland as elsewhere, being largely replaced by the dark-coloured micas ;—doubtless some dark grey muscovite may exist, but I have never myself found such, or any of a brown or black colour.

The finest specimens of muscovite in Scotland are found at the following localities :—

Large rosette crystallisations occur in a very quartzose vein to the west of Bigsetter Voe, in Mainland, Shetland ; still larger at Loch Glass, in Ross-shire, at Glen Skiag in the same county, and at Struay Bridge in Inverness-shire. A crystal 15 inches in length was found in the very singular vein, if vein it should be called, in Glen Skiag. The windows of the smaller houses in Duffus are said to have been at one time “ glazed ” with sheets of muscovite.

I have determined the optic angles of the following micas :—

*Axis in plane of longer diagonal.*

Rich brown, great vein of Rubislaw, . . . . .	67° 45'
Yellow green, great vein of Ben Capval, . . . . .	72° 15'
Light brown, third vein east of Portsoy, . . . . .	64° 30'
Pale rose, Glen Skiag, . . . . .	71° 45'
Silvery, exfiltrative vein, Rubislaw, . . . . .	69° 5'
Light brown, Loch Glass, . . . . .	71° 40'

In taking the specific gravity of the Glen Skiag mica, it was found that after having been boiled in water—to expel air bubbles—and being suddenly cooled, its specific gravity was 2·832 ; but after lying for twenty-four hours in water, its specific gravity was only 2·782. Upon being suddenly cooled after boiling, the mica seems to contract beyond its normal condition ; there being a difference of ·05.

A specimen of the Rubislaw mica, treated in the same way, gave after boiling and sudden cooling a specific gravity of 2·813 ; after lying in water for four hours, of 2·783. Here there would appear to be the same undue contraction, resulting from the sudden cooling, though not to the same extent.

The larger plates of mica contain imbedded substances which will be afterwards noticed.

Muscovite chiefly occurs in veins, either intrusive or exfiltrative ; in these

it invariably presents itself in larger crystals than those which are present in the general mass of the rock; and it would also appear to be present in these veins in a greater total relative amount than in the parent rock itself. This, should it be so, is not altogether difficult of explanation, if we are entitled to regard the rock as *the parent* of the vein.

To the granitic belts of metamorphic rocks, and the intrusive granitic dykes of all rocks, such a term of relationship could only be very indirectly applied; but to the exfiltrative veins of granitic rocks themselves, there is every reason to believe that the word fittingly applies.

Such veins, in the old terminology of the science, were called *contemporaneous*,—a word somewhat puzzling in its application, and misleading at the best.

A disquisition by Professor JAMESON on these “contemporaneous veins” forms the first of the publications of the Wernerian Society.

It would appear to have been JAMESON’S purpose to show the distinction between these veins and what we would now call *metallic lodes*; though it is not altogether clear that his description would not in some respect include injected veins therewith.

He thus defines them :—

“1. *True veins* traverse different strata, and are confined to single beds or strata only in those cases where the strata are of uncommon thickness. Their direction is not tortuous, and they seldom give off many branches. The mass of the vein is generally distinctly separated from its walls: it is frequently disposed in beds or layers, and these are parallel with the walls of the vein. The beds of these veins are so arranged that the newer beds are contained in the older. They often contain fragments which lie promiscuously, and are either acute angular, blunt angular, or rounded. Lastly, the materials of true veins are more or less different from the rock which they traverse, and the same vein contains several formations.

“2. *Contemporaneous veins*.—Their course is tortuous, and they give off numerous branches. The mass of the vein is generally intimately mixed with, and passes into that of its walls, and differs but little in its component parts from that of the rock which it traverses. They never contain more than one formation, and when they contain apparent fragments the structure of these is ever conformable to that of the contiguous rock. Lastly, they traverse but single beds and strata, and are observed to wedge out in every direction, and consequently have no outgoing above, below, or laterally, intimating that they have not been filled from above or below, but are as it were a secretion from the rock itself.”

The above, so far as it goes, is an admirable description of exfiltrative veins, but it hardly sufficiently draws a line of demarcation between them and injected veins; while the illustrations which JAMESON supplies show unmistakably that he had confounded exfiltrative veins both with injected veins and with the granitic and other bands or belts of rocks.

Such bands in gneiss are instanced as illustrations, as are also the quartzose and micaceous bands of mica slate; and these are placed in the same category with the “veins of calcspar which traverse transition-limestone.”

Perhaps nothing could better show the objectionable character of the term *contemporaneous* than JAMESON'S statement that "serpentine contains contemporaneous veins of asbest, talc, steatite, and lithomarge."

In JUKES' "Manual of Geology" the name is confined to their occurrence in intrusive rocks, but the above quotations from JAMESON will show that the word originally had a much wider application. The authors of the most recent edition of this work propose to "retain the name for the purpose of expressing that the veins belong to the same intrusion as the masses which contain them."

While the very name of *vein* is objectionable, there is little hope of setting it aside, or, sooth to say, of getting a more fitting word from our own language; but it is the adjective to which strong exception must be taken, if contemporaneous is held to be at all synonymous with simultaneous. It is more than difficult to conceive of any one of the structures to which the term has been applied being paragenetic in time with the rock-masses in which it is imbedded.

Of such of these structures as occur in volcanic rocks, we read in JUKES' "Geology :"—

"They seem in certain cases to have been produced from some movement of the whole mass during consolidation, whereby yet fluid portions were injected along cracks or between divisional planes of the mass.

"In other instances, where they are found to merge into the surrounding rock along both their bounding surfaces, they rather suggest the idea of segregation and crystallisation of the mineral along particular lines."

The former of these modes of accounting for their formation is certainly adequate to explain the mode of filling up of crevasses,—especially volcanic rents,—in lava streams or other plastic igneous rocks; while the second may suffice for rectilinear, though hardly for branching or angularly tortuous veins: but it is evident that the above explanations are intended to be restricted to veins in igneous rocks; and as regards their occurrence in metamorphic rocks, where they are not only immensely more numerous, but very much more important as bearing upon the nature of metamorphism itself, no such modes of explanation can meet the facts of the case.

Putting out of consideration, meanwhile, the granitic bands or layers of hornblendic gneiss, and also the intrusive dykes which cut and ramify throughout them, we observe of these so-called contemporaneous veins, where they show themselves in their extraordinary development in the grey granite of Aberdeenshire, that they present three features which are unvarying :—

*First*,—That though their course may be in the main tortuous or curving, it, if followed sufficiently far, will suddenly become angular and zig-zag; as if, though the general solidity and cohesion of the rock mass was only such as to enable it to rend by tearing, it in certain of its parts was so rigid that it had been cracked or split.

*Second*,—The occurrence in the veins of fractured, and occasionally of apparently floating angular fragments of the rock, likewise points to an actual solidification of the rock previous to the disruption and envelopment of the fragments.

*Third*,—The gradual increase in the size of the crystals which fill these veins as they approach the centres thereof, the frequent capping of the quartz crystals (a recognised proof of intermittent growth), and the fact that any free crystalline summits which may be present invariably point to these centres, show that a sudden injection from without, and consequent more or less uniform and rapid cooling and solidification, could not be the manner in which the rents were filled. The relationship of the vein to the rock mass itself also negatives injection. There is no *line of separation* between the vein and the rock; the granular structure of the rock is, in narrow space it is true, but still *gradually* augmented in size; and this ampler crystalline structure of the vein seems to grow out of, to be rooted in the substance of the rock.

The change of structure takes place within the space of an inch, but within no part of that inch can the stroke of a hammer effect a separation.

The information conveyed by the hammer is indeed of a most instructive description.

Granular though the structure of granite is, its grains do not lie in confused arrangement. It may not be to the smallest extent *bedded* in the quarry, though it generally is; but granite has a perfect cleavage and cross cleavage, so determinate in their directions that the workmen speak of *the bedding* of even such quarries as present great faces of apparently perfectly continuous and unvarying rock.

These cleavages result from a general polarity in the crystals of felspar, which have their axes, and hence their cleavages, lying in the main in one direction. Thus the quarryman by blow and cross blow cuts the rough paving stone, so as to leave himself only the narrower faces to “dress to square.”

But, inasmuch as the crystals of felspar which grow out of the rock to fill these exfiltrative veins do so at right angles to the sides of the vein, and as no one of the cleavages of felspar is at right angles to its main axis, the hammer blow cannot effect a separation throughout any part of the space wherein this rectangular riveting of the two structures is effected.

It would be far from easy to adduce any evidence which could more conclusively show that the present contents of these veins had *exuded* from the rock mass itself; and it need hardly be noticed in this connection that these veins never contain a single mineral substance which is not to be found in the rock mass itself; though, in the latter, many of these substances are of difficult recognition from their comparatively very small magnitude.

There is a fourth feature, moreover, which is not infrequent, namely, that

the veins are cut by others. In one of the smaller openings of the granite quarry of Anguston this is admirably seen : here a darker shaded, finer grained, and narrower set of veins cuts others, which are wide, and which are paler in colour than the ordinary granular rock.

The numberless quarries which pockmark Aberdeenshire afford unusual facilities for studying its "grey granite;" such study, whenever entered upon, tends to the conclusion that the granite results from the metamorphism of the gneiss in which it is everywhere embosomed, and with which it is so intricately wrapped up.

In this district the metamorphism appears to have taken place under three different sets of circumstances.

In the first of these,—by what may be called a gradual incrementation of the granitic over the normal gneissic structure.

In the second,—by an abrupt and, as read by the eye alone, an inexplicably sudden transition of the latter into the former.

In the third,—by a general fading or softening away of the transmutable into the transmuted.

Throughout the whole of the gneiss of central Scotland, and more especially in these districts where the rock exhibits the clearest marks of alteration, it is pervaded by granitic bands, which, there is reason to believe, have not unfrequently been considered to be intrusive or injected veins.

That they are not so, but are merely the segregation of certain of the mineral constituents of the rock—like consorting with like—is evidenced by the following four facts.

These bands or layers of felspathic and quartz matter invariably follow implicitly every flexure of the rock (developed and disclosed by the adjacent micaceous layers), never cutting across these or branching to the smallest extent. They do not maintain anything of a uniform width, but repeatedly diminish and expand, in accordance with the abruptness or looseness of the folds into which the rock is thrown. Though highly felspathic, and often markedly crystalline, they exhibit unmistakably in some portion of their bulk a laminated arrangement of particles, which becomes more and more distinctly pronounced as it passes into the ordinary structure of the rock. The blow of a hammer recognises no point at which the two structures are of facile separation; the transition of the one into the other being so gradual that no two persons would agree as to the point where each terminates,—and a hand-breadth would not cover the debatable space.

The ingredient of mica, moreover, is markedly *deficient* in these so-called granitic bands.

I instance the north-east side of the hill of Scoltie, near Banchory, as a locality where such "veins" may be studied, specially in connection with the first of these changes; because about a couple of miles north of this, in the railway

cutting west of Banchory, this gneiss is *becoming granitic* through a regular increase in the number and in the volume of these granitic bands. Here also there is a marked change in the nature of the bands themselves; they no longer exhibit the laminated structure, but are throughout their whole extent true granite of a uniform fine grain; and although the hammer can still discover no line of separation, yet a finger's breadth will here cover the space through which the structures pass from one to the other.\*

In following the line of railway to its next cutting, nearer to the Hill of Fare, the granitic bands will be seen progressively augmenting in width, and the gneissose bands dwindling to evanescence.

For such as I have now described, and also for the more rectilinear modification thereof which occurs in hornblendic gneiss, I would propose the term *bands of metamorphic segregation*.

The second mode of change is well seen in the quarries at Tillyfourie.

The gneiss, which here presents bold features,—being highly contorted, broadly banded, the bands showing an abrupt contrast in their coloration,—passes into granite with an abruptness which is quite startling.

There is not a trace of interstitial skin or intermediate mineral body; most assuredly there has been no intrusion of the granite here,—the one rock ceases to be, and the other commences along *no line* which can be seen or felt; there is no portion of space in which the one can be said to be in contact with the other; the continuity is everywhere unbroken, the material continuous, the eye alone appreciating a marked change of colour and of structure, for the openings between the foliæ of the gneiss suddenly cease to exist, but this they do not along a rectilinear but a wavering course. A hammer blow rends the rock in any direction, the line of fracture crossing the zone of changed structure at all angles, and the straight course of the fracture being uninfluenced in the so doing. The only modification of this structure is, that occasionally the dark mica of the granite has its plates disposed in arrangement somewhat parallel to the course of the transition, within the space of an inch or two from the unchanged rock.

The third mode of change is seen in the several quarries of the Stony Hill of Nigg; here a fine-grained, plicated, and darkly-striped gneiss may be traced, with gradually fading layers, into a uniformly granular, dark grey granite. In many of the Aberdeenshire quarries, moreover, semiangular fragments, large and small, of the darker and more micaceous layers of the gneiss, are found imbedded, rounded in their outlines into kidney-form (“*neres*”), and darkening the granite in their immediate vicinity by a quantity of the black-mica (Haughtonite) which these “*neres*” contain. It would

\* While confounding these bands with “contemporaneous veins,” JAMESON saw clearly their marked features. He writes—“These veins do not present the slaty structure which is one of the discriminating characters of gneiss when it occurs in strata; hence contemporaneous veins, filled with common granular, or what may be called granitic gneiss, have been confounded with true granite.” Thereby meaning common or eruptive granite.

appear that the plates of the black mica have been loosened from the surfaces of the neres, and have become impacted in the adjacent substance of the granite, but have remained unresolved into smaller crystals; the metamorphism being arrested, or incomplete at these points.

Of the metamorphism of this granite, however effected, the exfiltrative veins would appear to have been one of the last stages.

How often the grey granite may have been depressed to the zone of metamorphism we cannot say, any more than we can how often the aquo-thermal agencies had to operate upon it; but, during some one of the subsidations, it is rational to conceive of its having been rent by pressure, and that subsequently—perchance forthwith—the rents were filled up, not by any sudden injection from their open terminations, but *by a process of transfusion from all points of the surface of the rent*, a transfusion of the plastic or soluble matter of the rock itself,—endosmose and exosmose exercising their resistless force. The resulting plug is thus—to use JAMESON'S words—“*a secretion from the rock itself.*”

DAUBREE'S experiments have shown that in the presence of water a temperature of 400° C. sufficed for the alteration of silicates,—crystallisation of silica and of felspar,—or for the actual formation of the latter and of mica, through the action of alkaline silicates on argillaceous rocks. Considering the changes which would result from aquo-thermal action in the light of these experiments, and knowing that the repeated action of heated water upon the more highly siliceous rocks invariably results in the greater adhesion of water for the alkalies,—progressively abstracting them, to leave more and more highly-aluminous silicates,—it is not difficult to understand how the amount of mica in these exfiltrative or exudation veins should be in excess of its proportion in the parent rock. For, if the general mass of that rock be held in solution through aquo-thermal action,—or if not in actual solution, in a condition favourable to chemical change, the rock upon solidification must yield a mass which is less alkaline as a whole; and as in the case of granite it is the orthoclase which is the alkali-bearing mineral, it is this which would suffer loss. The resolidifying material, after the watery abstraction of some of the alkali, could no longer attain to the production of so much felspar,—some of which would be degraded, so to speak, into an increase of the amount of mica.\*

Now there is what may be called a physical-outcome of this change.

In virtue of this abstraction of alkali from orthoclase, and consequent increase of free silica and formation of mica, there results the production of a less alterable, that is, a more enduring material; and if it be the case that granite-veins contain more mica than does the rock which they intersect, these veins must necessarily be more enduring than the granite itself.

\* The alkali-charged waters are, however, potent, even at low temperatures, to change clay slates and argillaceous gneiss into granite, and so to *extend the sphere of the metamorphism.*



The protrusion of granite veins above the ordinary level of the rock—quite a familiar fact—may be partly due to their less minutely granular, that is, less uniformly porous and loose-grained structure; but the almost invariable protrusion of the plates of mica, even above the quartz, in granite veins, vouches unmistakably for the greater endurance which that mica must impart.

The not unfrequent occurrence of loose blocks of large-grained granite in straight line across a heath-covered or grass-clad surface points also to a former vein, which had longer resisted the denudation due to atmospheric decay than had the inclosing rock.

This is a subject which, as a whole, has certainly not engaged the amount of attention which it merits. Probably the following structures have to be discriminated, and have been more or less confounded with one another:—

*Ingredients same as those of the Rock-Mass itself.*

1. *Plugging pre-existent Rents.*

*Contemporaneous plugs of rents in igneous rocks*

intersect rock in curving and angular manner; structure *smaller* than that of the rock-mass; both branching and intersecting; formed by sudden injection.

*Veins of exfiltration*

intersect rock in curving and angular manner; structure *larger* than that of containing rock; both branching and mutually intersecting; formed by a single continuous process.

*Metalliferous veins*

frequently intersect more than one rock-mass; generally rectilinear but angular; structure larger than that of containing rock; branch, and cut rocks of different natures; formed by intermittent actions, diverse in their natures, and markedly so in their products.

2. *Not filling pre-existent Rents.*

*Bands of dominant crystalline action*

accordant with the floor or surface of igneous flow; structure larger than that of containing rock; neither branching nor intersecting; frequently spherulo-radiate in structure.

*Bands of metamorphic segregation*

accordant with flexures of rock strata; structure larger than that of containing rock; neither branching nor intersecting; of ever-varying thickness in plicated rocks.

*Veins of seggregation*

angular, and intersecting rock strata; structure larger or smaller than containing rock; both branching and intersecting; generally acuminate at their terminations.

*Ingredients not the same as those of the Rock-Mass*

intersect more strata than one, in all directions and ways; frequently branch and intersect each other.

a. *Granitic dykes*, structure *larger* than including rock; frequently fill faults.

b. *Trap dykes*, structure *smaller* than including rock; fill rents.

## MARGARODITE.

*From Gneissose Rocks.*

1. From a stratum of kaolin which occurs at Mouwick, Lambhoga, Fetlar, Shetland.

Kaolin is not found in many localities in Shetland, but when found it occurs in considerable quantities. Mouwick and Grunies' Geo in Fetlar, the burn of Tractagill, and the trough which runs north from Weesdale Hill are the chief localities. It has been in these islands used as a Fuller's-earth, and for white-washing houses. In all of the above localities it has a glistening appearance, which seems in all to be due to its containing, like that found at Mouwick, a quantity of minute scales of margarodite. Of this the kaolin of Mouwick yields to elutriative processes about one-fifth part. This margarodite has a faint yellow colour, a pearly lustre, and is very unctuous to the touch. It may by continued friction be reduced to very minute scales, but not to an absolutely impalpable powder like talc; this is a physical mode of discrimination between these minerals.

1·302 grammes of this margarodite yielded—

Silica,	. . . . .	·655	
From Alumina,	. . . . .	·006	
		<hr/>	
		·661	= 50·768
Alumina,	. . . . .	31·711	
Ferric Oxide,	. . . . .	1·315	
Manganous Oxide,	. . . . .	·23	
Lime,	. . . . .	·946	
Magnesia,	. . . . .	·786	
Potash,	. . . . .	5·11	
Soda,	. . . . .	·53	
Water,	. . . . .	7·969	
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			99·347

It absorbs ·89 per cent. of water.

The "kaolin" also contains a quantity of grains of angular quartz.

2. From Vanleep, Hillswick, Shetland. Occurs, associated with reddish coloured kyanite, in the quartz veins of a very micaceous gneiss; it is imbedded along with ripidolite (?) in crystals, or crystalline plates, among the interlacing crystals of the kyanite

Colour almost white, sometimes very pale greenish: lustre very high pearly, almost equal to talc.

Crystalline system the orthorhombic, form like muscovite,—optic axis in plane of longer diagonal of the crystal,—optic angle  $67^{\circ} 5'$ .

A twin crystal, with two intersecting systems of rings, is in the author's possession.

A small quantity was treated with sulphuric acid, and a similar quantity with hydrochloric.

The sulphuric acid seemed rapidly to decompose the mineral, the silica rising in light clouds when stirred.

The hydrochloric acid was rapidly turned yellow; but, even after repeated evaporation with fresh quantities of acid, perfect decomposition could not be effected; the mineral remaining as a heavy white powder.

Specific gravity  $2.825$ ; H.  $2.25$ .

$22.87$  grains yielded—

Silica, . . . . .	45.426
Alumina, . . . . .	29.652
Ferric Oxide, . . . . .	8.328
Manganous Oxide, . . . . .	.022
Lime, . . . . .	.788
Magnesia, . . . . .	1.702
Potash, . . . . .	6.94
Soda, . . . . .	2.267
Water, . . . . .	5.293
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	100.418

Insoluble silica,  $5.68$  per cent.; possible impurity, kyanite.

Was examined under the supposition that it was Damourite.

3. It is very probable that most of what has been regarded as talc-slate in the Highlands of Scotland will in almost all cases prove to be margarodite-slate, or other hydrated mica-slates.

HIBBERT mentions many such slates as occurring in the Shetlands. One, which he specially draws attention to, he says is to be found a little to the north of Vanleep in Hillswickness. He describes the pellicular form, brilliant pearly lustre, and remarkable unctuousity of the mineral to which the schistose character of the rock is due. He also notes the want of elasticity in the "pellicles." These pellicles were analysed specially to ascertain if so-called talc-slates were of the nature assigned to them in the name.

The pellicles were picked from the more quartz bands of the rock, as there they seemed always to be of increased size.

They had little or no elasticity, but this I find to be not unusual with margarodite.

18·5 grains yielded—

Silica, . . . . .	45·421
Alumina, . . . . .	30·3
Ferric Oxide, . . . . .	6·874
Manganous Oxide, . . . . .	·816
Lime, . . . . .	·6
Magnesia, . . . . .	2·6
Potash, . . . . .	6·088
Soda, . . . . .	2·01
Fluorine, . . . . .	1·06
Water, . . . . .	5·011
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	100·78

4. From Botriphnie, Banffshire. Is the matrix of kyanite, in a specimen ticketed by ABRAHAM CLARK of Portsoy.

Lustre very splendid, colour white ; appeared to be in six-sided plates. r

On 11·011 grains—

Silica, . . . . .	45·103
Alumina, . . . . .	29·9
Ferric Oxide, . . . . .	7·87
Manganous Oxide, . . . . .	·031
Lime, . . . . .	·62
Magnesia, . . . . .	·723
Potash, . . . . .	7·836
Soda, . . . . .	2·556
Water, . . . . .	5·512
Fluorine, . . . . .	tr.
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	100·151

Possible impurity, kyanite.

Was thought Damourite.

*From Granular Limestone.*

5. Occurs in the limestone quarries in the balloch between Glenbucket and Glen Nocht, Aberdeenshire.

Is associated with pyrite, pyrrhotite, rutile, and actynolite. Occurs in rosette groups of crystals ; colour white ; lustre silvery ; very much resembles talc,—for which it was taken, until the hardness was tested.

1·141 grammes yielded—

Silica, . . . . .	·505	
From Alumina, . . . . .	·022	
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	·527	= 46·18
Alumina, . . . . .	31·83	
Ferrie Oxide, . . . . .	4·1	
Lime, . . . . .	1·66	
Magnesia, . . . . .	1·23	
Potash, . . . . .	8·81	
Soda, . . . . .	1·31	
Water, . . . . .	5·714	
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		100·834

Absorbs 2 per cent. of water ; possible impurity unknown.

Loses its water at the temperature afforded by a Bunsen burner,—talc requires a blast furnace for its dehydration.

Both the stratum of limestone which first shows itself on the coast of the Moray Firth, at Sandend, in Banffshire, and which passes up among the flags of the Vale of Deskford, Glen Rinnes and Strath Avon, cuts the high ground at Inchrory and Loch Bulg, and possibly reaches the low country through Glen Tilt,—and that which first appears at Boyne-mouth, coursing to the east of the quartzite and causing the ballochs of Glenbucket, Glen Nocht, Strath Earnan, and Tornahaish, afford this brilliant margarodite. Throughout it simulates talc, and has as its unfailing associate pyrrhotite,—less frequently rutile, and sahlite or actynolite.

#### MARGARODITE.

	Si.	Al <sub>2</sub> .	Fe <sub>2</sub> .	Mn.	Ca.	Mg.	K <sub>2</sub> .	Na <sub>2</sub> .	F.	H <sub>2</sub> .	Total.
Lambhoga, with Kaolin . . .	50·77	31·71	1·32	·23	·95	·79	5·11	·53	...	7·97	99·35
Vanleap, Shetland, with Kyanite,	45·43	29·65	8·33	·02	·79	1·7	6·94	2·27	...	5·29	100·42
Vanleap, Shetland, with Quartz, .	45·42	30·30	6·87	·82	·6	2·6	6·09	2·01	1·06	5·01	100·78
Botriphnie, Banffshire, . . .	45·1	29·9	7·87	·03	·62	·72	7·84	2·56	tr.	5·51	100·15
Glenbucket, Aberdeenshire, . .	46·18	31·83	4·1	...	1·66	1·23	8·81	1·31	...	5·71	100·83

#### *Black Micæ.*

Most geological works enumerate among the constituents of certain granites and gneisses,—“a dark magnesian mica,”—“a brownish-black magnesian mica,”—or “a greenish-black magnesian mica,”—as the case may be ; but do not specify what the mica is.

Mineralogical works, again, present us with three “dark magnesian-micas,”—phlogopite, Biotite, lepidomelane. Mineralogical works, one and all, are unsatisfactory as regards the amount of information they convey as to the habitudes of minerals,—their lithological habitats.

Phlogopite there is some precision as to; it is said, to be “especially characteristic of serpentines, and crystalline limestone, or dolomite.” Biotite, or the micas placed under that heading, would, on the authority of said works, appear to occur almost everywhere. Lepidomelane is given as occurring in syenite, granite, and quartzite.

Dr HAUGHTON has imported some precision into this question, as regards the dark granitic-mica, so far as Ireland is concerned; but the conclusion he arrived at does not, singularly enough, apply to Scotland. And again, while I have not yet met with a single specimen of phlogopite in Scotland, I find that it must, as regards this country, be said of Biotite, and not of phlogopite, that it is “especially characteristic of crystalline limestones,” seeing that, with the exception of margarodite, and it only rarely, I find no other mica in that rock.

The dark magnesian mica, which, in Scotland, is specially characteristic of granites, will be shown to be a new, or at least an unrecognised species.

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## PHLOGOPITE.

I have not yet, by analysis, been able to show that phlogopite occurs in Scotland.

The light-brown Biotite from the limestone of Shinness—the analysis of which is given below—is in appearance very similar to some foreign phlogopites; but upon this proving to be Biotite, all resembling it which were not analysed were considered to be Biotite also.

In specimens of granular limestone from the Vosges, there is a mica named phlogopite by Professor KING, which is so similar to the limestone-mica of Glen Elg, that it is possible that the latter may prove to be this most highly magnesian species. It however occurs in so small an amount in the lime, that a special visit to the locality could alone ensure a sufficiency for analysis.

## BIOTITE.

*From Granular Limestone.*

1. The limestone, which is the near associate of the serpentine of Polmally, in Glen Urquhart, appears in greatest amount, at a height of 700 feet, in the hill above Milltown. The somewhat schistose gneiss, which here carries the lime, is thrown into endless and most intricate folds, which are laid bare in the numerous limestone quarries which are sprinkled over the hill-face; several of these, and markedly the most northerly, show a peculiar granite vein or belt, which generally cuts but occasionally follows the bedding of the lime. This vein consists of little quartz, and much of a bluish white, opaque, fatty-lustered andesine, carrying imbedded crystalline plates of Biotite.

Any associated minerals belong to the lime.

The Biotite is in plates of an inch or more in size, of a dark pinchbeck brown colour, a shining lustre, sometimes somewhat greasy.

Its specific gravity is 2·867.

1·3 grammes yielded—

Silica, . . . . .	·476	
From Alumina, . . . .	·037	
	<hr/>	
	·513	= 38·692
Alumina, . . . . .	17·661	
Ferric Oxide, . . . . .	·255	
Ferrous Oxide, . . . .	12·952	
Lime, . . . . .	1·163	
Magnesia, . . . . .	17·538	
Potash, . . . . .	8·917	
Soda, . . . . .	·126	
Fluorine, . . . . .	·522	
Water, . . . . .	2·137	
	<hr/>	
	99·963	

Insoluble silica, 1·391 per cent. Possible impurity unknown.

A similar vein in the large quarry carries, in addition to the above minerals, crystals of delicate green apatite, crystals of brown sphene, of grammatite, and of dark-green Allanite.

2. Found in a quarry on the north side of the road about a mile east of Laggan Inn, Inverness-shire.

The lime, which has a north-north-east and south-south-west trend, contains little else than a fine-grained chlorite, and this is immediately associated with the Biotite, which is usually imbedded in the former in thin plates of an inch or two in size. Its colour is bronzy.

On 1·2 grammes—

Silica, . . . .	·458	
From Alumina, . . .	·016	
	<hr/>	
	·474	= 39·5
Alumina, . . . .		15·036
Ferric Oxide, . . .		·244
Ferrous Oxide, . . .		10·229
Manganous Oxide, . .		·75
Lime, . . . .		1·4
Magnesia, . . . .		18·461
Potash, . . . .		9·366
Soda, . . . .		·618
Fluorine, . . . .		·73
Water, . . . .		3·214
		<hr/>
		99·558

Insoluble silica, 2·531 per cent. Possible impurity, chlorite.

3. From the limestone at Shinness, Sutherland. Biotite, similar in appearance to the last, is to be seen rarely at this locality. More frequently it occurs in dark-brown almost black plates which sheathe sahlite, and still more frequently in the form which was chosen for the analysis,—namely, in small crystals superimposed on one another, so as to present a foliaceous structure.

It was in immediate association with sahlite and brown sphene.

The crystals were of a light greyish-brown colour, and a greasy lustre ; they were suspected to be phlogopite.

1·3 grammes yielded—

Silica, . . . .	·513	
From Alumina, . . .	·004	
	<hr/>	
	·517	= 39·769
Alumina, . . . .		16·676
Ferric Oxide, . . .		·653
Ferrous Oxide, . . .		6·73
Manganous Oxide, . .		·615
Lime, . . . .		2·196
Magnesia, . . . .		20·923
Potash, . . . .		6·5
Soda, . . . .		·476
Water, . . . .		5·398
		<hr/>
		99·936

Insoluble silica, 1·74 per cent. Possible impurity, sahlite or sphene.



## 4. From granular limestone at Glen Beg, Glen Elg.

At about one-fourth of a mile to the north-east of the hamlet of Balvraid, the limestone contains Biotite (in association with the hydrated labradorite—noticed in Chap. II. of this series), necronite, and balvraidite.

The mineral is generally immediately in association with the balvraidite.

Its colour is rich chocolate brown, its lustre brilliant.

1·28 grammes yielded—

Silica, . . . . .	39·46
Alumina, . . . . .	16·45
Ferric Oxide, . . . . .	·39
Ferrous Oxide, . . . . .	10·
Manganous Oxide, . . . . .	·53
Lime, . . . . .	1·59
Magnesia, . . . . .	19·
Potash, . . . . .	8·22
Soda, . . . . .	·26
Fluorine, . . . . .	·32
Water, . . . . .	3·34
	<hr/>
	99·56

Possible impurity, balvraidite.

*From Hornblendic and Serpentinous Rocks.*

5. Hornblendic gneiss, highly contorted and fractured, occurs in the peninsula of Hillswick, in Shetland.

At the point called the banks (*i.e.*, shores) of Nudista, a bed—simulating a vein of precious serpentine—protrudes, just north of the spot where these “banks” rise into rocky cliffs.

This bed is in contact on the south with one of matted anthophyllite; while it carries, partly in its centre and partly on the side opposite to the anthophyllite, another consisting of actynolite with a matrix of snow-white talc; this latter, in passing shorewards, loses the actynolite, and gradually merges into a soft talc-chlorite, as it reaches and passes beneath high-water mark.

Just about this point a considerable portion of the bed—here almost pulpy from absorbed water—consists of Biotite.

It is in a very loose and incoherent state, much resembling a friable talc.

Its colour is bronzy brown; it is translucent in thin fragments.

The scales fall asunder in water, so that the specific gravity could not be determined.

1·657 grammes gave—

Silica, . . . . .	·634		
From Alumina, . . . . .	·026		
	<hr/>		
	·660	=	39·803
Alumina, . . . . .			14·185
Ferric Oxide, . . . . .			2·594
Ferrous Oxide, 11·373, . . . . .	11·748,		11·578
Manganous Oxide, . . . . .			·24
Lime, . . . . .			·097
Magnesia, . . . . .			18·32
Potash, . . . . .			8·43
Soda, . . . . .			2·11
Fluorine, . . . . .			·56
Water, . . . . .			2·52
			<hr/>
			100·437

7·905 per cent. of the silica were insoluble; possible impurity unknown. The larger than normal quantity of soda was, doubtless, due to marine submergence. In the larger quantity of ferric oxide which replaces alumina this Biotite differs from the others.

*From Edenitic Rock.*

6. At a turn of the road a little south-east of the Free Church of Milltown, Glen Urquhart, the serpentine appears at the surface, and here there is a small quantity of a very peculiar rock.

This is composed of large pale-green crystals of edenite, of the form of actynolite; these are bedded in a mass of plicated crystals of what has more resemblance to talc than to Biotite; their usual colours being a very pale green, little removed from white, and they are devoid of elasticity. As accessories, there occur thick veins of hydrous-anthophyllite, thinner ones of fibrous Wollastonite, garnet with imbedded zircons, and crystalline granules of a new mineral resembling chondrodite in appearance. This talc-like Biotite is unusually soft, softer indeed than the nail; its specific gravity is 2·781: occasionally it passes into flat and elastic plates of a rich brown colour, and high lustre.

The pale-coloured yielded on 1·3 grammes—

Silica, . . . . .	·51		
From Alumina, . . . . .	·005		
	<hr/>		
	·524	=	40·307
Alumina, . . . . .			12·582
Ferric Oxide, . . . . .			1·809
Ferrous Oxide, . . . . .			3·335
Manganous Oxide, . . . . .			·384
Lime, . . . . .			7·581
Magnesia, . . . . .			21·
Potash, . . . . .			6·561
Soda, . . . . .			·953
Water, . . . . .			5·738
			<hr/>
			100·25

Loss in bath .454 per cent.

The amount of iron only was determined in the dark brown plates; these contained of ferric oxide 4.913, and of ferrous oxide 19.802 per cent., this large amount replacing lime and magnesia.

The large amount of lime in the pale variety is singular, taken in connection with the small amount of that earth contained in the Biotite found in limestone from a near-adjacent quarry. (See analysis No. 1.)

### *Biotite.*

	S.G.	Si.	Al <sub>2</sub> .	Fe <sub>2</sub> .	Fe.	Mn.	Ca.	Mg.	K <sub>2</sub> .	Na <sub>2</sub> .	F.	H <sub>2</sub> .	Total.
Glen Urquhart, .	2.867	38.69	17.66	.25	12.95	...	1.16	17.54	8.92	.13	.52	2.14	99.96
Laggan, . .	...	39.5	15.04	.24	10.23	.75	1.4	18.46	9.37	.62	.73	3.21	99.55
Shinness, . .	...	39.77	16.68	.65	6.73	.62	2.2	20.92	6.5	.48	...	5.4	99.95
Glen Beg, . .	2.85	39.46	16.45	.39	10.	.53	1.59	19.	8.22	.26	.32	3.34	99.56
Hillswick, . .	...	39.8	14.19	2.59	11.58	.24	.1	18.32	8.43	2.11	.56	2.52	100.44
Milltown, Urquhart	2.781	40.31	12.58	1.81	3.35	.38	7.58	21.	6.56	.95	...	5.74	100.25

The latest published analyses of Biotite show that the iron is almost totally in the state of protoxide, and the above analyses put the matter beyond doubt.

The above Biotites were optically uniaxial, or biaxial to a very small extent—1° to 2°.

## LEPIDOMELANE.

### *From Gneiss.*

1. This mica—which Haughton has the credit of first introducing as British, if not of firmly establishing as a species—I have only found in Scotland at two localities. The first is near the north shore of Loch Shin, in Sutherland.

Not a little of the gneiss of central Sutherland is, in this neighbourhood, hornblendic. A bed of hornblendic rock occurs immediately over the limestone of Shinness, like it, with a northerly dip; to the north, and superior to this, again, a hornblendic gneiss stretches west and east for several miles.

The country is for the most part covered, but the rock has been exposed here and again in the drain cuttings made in connection with the great improvements at present being undertaken by His Grace the Duke of Sutherland.

Masses of rock, raised on the farm of Achadhaphriz, contained, imbedded in a felspathic and hornblendic base, crystals of sphene, very rarely of rutile, more commonly of apatite, and plates of from two to three inches in length of lepidomelane.

Colour yellowish brown to chocolate brown. Easily cleavable, but only in small pieces, being brittle; slightly biaxial; of a muddy yellow-brown by transmitted light.

Reduced to powder with comparative ease. Specific gravity, average of three pieces, 2·971.

On 1·3 grammes—

Silica,	.	.	.	·51	
From Alumina,	.	.	.	·015	
				<hr/>	
				·525	= 40·384
Alumina,	.	.	.	.	12·11
Ferric Oxide,	.	.	.	.	14·523
Ferrous Oxide,	.	.	.	.	3·03
Manganous Oxide,	.	.	.	.	3·146
Lime,	.	.	.	.	1·033
Magnesia,	.	.	.	.	13·
Potash,	.	.	.	.	7·128
Soda,	.	.	.	.	1·801
Water,	.	.	.	.	3·567
					<hr/>
					99·722

Insoluble silica, 2·856 per cent.; possible impurity unknown.

The “glass” formed by the fusion of the mineral with Fresenius flux is of a very dark, almost black, colour.

*From Exfiltration Veins in Granite.*

2. Is one of the numerous minerals which accompany the Amazonstone in the vein in the “syenetic” granite, a boulder of which was found on Ben Bhreck, Tongue, as described in Chap. II. The lepidomelane was found in considerable quantity, in plates of an inch or two in size.

The appearance was very similar to the last. The colour was of a deep rich brown; it cleaves into somewhat larger foliæ than does the mineral from Achadhaphriz, these foliæ are almost opaque, slightly biaxial, and crush with ease. Specific gravity, 2·965.

1·3 grammes yielded—

Silica,	.	.	.	·511	
From Alumina,	.	.	.	·01	
				<u>·521</u>	= 40·076
Alumina,	.	.	.	12·408	
Ferric Oxide,	.	.	.	13·474	
Ferrous Oxide,	.	.	.	2·668	
Manganous Oxide,	.	.	.	·615	
Lime,	.	.	.	1·076	
Magnesia,	.	.	.	14·661	
Potash,	.	.	.	7·57	
Soda,	.	.	.	2·153	
Water,	.	.	.	5·293	
				<u>99·994</u>	

Loss in bath *none*; insoluble silica, 2·879 per cent. The “glass” is of the same pitchy blackness as that from the last locality.

### *Lepidomelane.*

	S. G.	Si.	Al <sub>2</sub> .	Fe <sub>2</sub> .	Fe.	Mn.	Ca.	Mg.	K <sub>2</sub> .	Na <sub>2</sub> .	H <sub>2</sub> .	Total.
Achadhaphriz, . . .	2·971	40·38	12·11	14·53	3·03	3·15	1·03	13·	7·13	1·8	3·57	99·72
Tongue, . . .	2·965	40·08	12·41	13·47	2·67	·62	1·08	14·66	7·57	2·15	5·29	99·99

### HAUGHTONITE.

#### *From Dykes in Hornblendic Gneiss.*

Lepidomelane—the ordinary black mica of the granites of Ireland—has been shown to be extremely rare in Scotland. There is another black, indeed much blacker mica, which is extremely common; this, however, is a perfectly different, in fact an unrecognised, if not an altogether new mineral.

I give the occurrence, description, and analyses first, and consider the question of specific-individuality later.

Two huge vertical granitic dykes cut the north-eastern foot of the great hill of Roneval in Harris; the most southerly of these runs from Loch Finsbay through the hill, striking towards the west shore; the other is seen half-way between this and Scur Ruidh.

The white orthoclase of these veins is plentifully studded with crystalline masses of magnetite, and intersected by large plates of a dark brown-black mica, which are disposed more or less parallel to the sides of the vein, so as to exhibit only their edges on its glaciated section.

These edges are frequently eight to ten inches in length; some, measured by my confrere Mr DUDGEON and myself, were fifteen and sixteen. This mica splits readily into plates of considerable size, being tough, and not brittle like those of lepidomelane.

The plates transmit light of a dark brown-black colour, and are slightly biaxial. The mineral is powdered with extreme difficulty; the powder is black, with a slight shade of green.

The specific gravity is  $3 \cdot 03$ .

$1 \cdot 34$  grammes gave—

Silica,	.	.	.	$\cdot 486$	
From Alumina,	.	.	.	$\cdot 012$	
				$\cdot 498$	$= 37 \cdot 164$
Alumina,	.	.	.	$\cdot 15 \cdot 006$	
Ferric Oxide,	.	.	.	$7 \cdot 689$	
Ferrous Oxide,	.	.	.	$17 \cdot 353$	
Manganous Oxide,	.	.	.	$1 \cdot 044$	
Lime,	.	.	.	$1 \cdot 128$	
Magnesia,	.	.	.	$8 \cdot 88$	
Potash,	.	.	.	$8 \cdot 18$	
Soda,	.	.	.	$1 \cdot 605$	
Water,	.	.	.	$2 \cdot 121$	
					<hr/>
					$100 \cdot 16$

The specimen seemed absolutely pure. The glass was of a light olive brown colour over the Bunsen; of a light blue after having been subjected to the heat of the blast furnace.

The state of the oxidation of the iron and its quantity were twice determined,—on both occasions by the action of calcium fluoride\* and sulphuric acid,—a stream of carbonic acid being passed, during the whole process, through the apparatus.

On the first occasion  $\cdot 1178$  grammes yielded of ferrous oxide,  $17 \cdot 26$  per cent.; on the second  $\cdot 172$  grammes yielded of ferrous oxide,  $17 \cdot 443$  per cent.

\* My assistant, Mr DALZIEL, finds it advisable to use a mixture of potassium fluoride and calcium fluoride—the former being in excess. Less calcium sulphate is thus formed, and the platinum crucible is more speedily emptied of its contents.

In the ascertaining the percentage of water, it was found that the heat of the Bunsen produced no change of colour or of molecular state; the heat of the blast, however, caused some agglutination.

1·499 grammes lost ·022 in water-bath; over the Bunsen for two hours, lost ·0238; over the blast for a quarter of an hour, ·0318. The water is, therefore, retained with extreme tenacity.

## 2. From the great vein of Ben Capval.

Though this vein and those parallel to it, which cut the strata on the south shore of Harris between the Toehead promontory and Huishinish House, afford this mica, it occurs in these north and south veins in such very small quantities as to constitute a marked point of distinction between them and the radiating veins which intersect Roneval and the adjacent country.

Towards its northern extremity, the Capval vein afforded a sufficiency for analysis. The crystals here are of only an inch or two in size, elongated and diverging, jet black, rarely slightly rusty. They are biaxial to a small extent.

Their specific gravity is 3·071.

25 grains yielded—

Silica, . . . .	36·806
Alumina, . . . .	15·22
Ferrie Oxide, . . . .	7·611
Ferrous Oxide, . . . .	17·353
Manganous Oxide, . . . .	·96
Lime, . . . .	1·54
Magnesia, . . . .	8·784
Potash, . . . .	8·31
Soda, . . . .	1·342
Water, . . . .	2·47
	<hr/>
	100·396

Possible impurity unknown.

## 3. From Loch Roag, Lewis.

The road which passes along the north shore of Loch Roag skirts a small fresh-water lake called Loch-na-Muilne.

Granitic veins cut the gneiss on its northern banks, and in these and in similar veins in the cliffs, and in the highest knoll which is to be seen to the north-west, the mineral is to be found in plates of an inch or two in size. It is associated with pinkish orthoclase, pale blue oligoclase, fatty quartz, and occasionally hornblende. Its colour is dark brown to black.

1·3 grammes yielded—

Silica, . . . . .	·468	
From Alumina, . . . . .	·006	
	<hr/>	
	·474	= 36·461
Alumina, . . . . .	17·253	
Ferric Oxide, . . . . .	4·18	
Ferrous Oxide, . . . . .	15·325	
Manganous Oxide, . . . . .	·538	
Lime, . . . . .	·689	
Magnesia, . . . . .	12·23	
Potash, . . . . .	9·204	
Soda, . . . . .	·657	
Water, . . . . .	3·385	
	<hr/>	
	99·922	

Loss in bath, ·325.

4. From Foinaven in Sutherland. The mineral occurs in bundles of interlocking plates, imbedded in great veins, at a height of 750 feet, on the west slope of the hill. The associates are large crystals of orthoclase, and oligoclase. The Haughtonite is here jet black in colour, and of an extremely brilliant lustre.

It seemed to be in hexagonal crystals.

Its specific gravity is 3·032.

1·2 grammes yielded—

Silica, . . . . .	·428	
From Alumina, . . . . .	·013	
	<hr/>	
	·441	= 36·75
Alumina, . . . . .	17·858	
Ferric Oxide, . . . . .	2·781	
Ferrous Oxide, . . . . .	15·175	
Manganous Oxide, . . . . .	·416	
Lime, . . . . .	·933	
Magnesia, . . . . .	11·166	
Potash, . . . . .	9·437	
Soda, . . . . .	1·247	
Water, . . . . .	4·232	
	<hr/>	
	99·995	

Loses ·967 per cent. of water in the bath. It is reduced to powder with extreme difficulty.

5. From Rispond, Sutherlandshire. The mass of graphic granite which occurs in the gneiss at the north side of Rispond harbour has been described in Chap. II.



The other associates of the Haughtonite are here oligoclase and magnetite.

The crystalline plates are here generally of only an inch or so in size ; occasionally, however, they are much larger. They are of a deep black colour. All other characters and reactions agree with those of the Roneval mineral.

The specific gravity is 2·99.

1·3 grammes gave—

Silica, . . . . .	·457	
From Alumina, . . . . .	·028	
	<hr/>	
	·475	= 36·538
Alumina, . . . . .	22·282	
Ferric Oxide, . . . . .	2·433	
Ferrous Oxide, . . . . .	16·009	
Manganous Oxide, . . . . .	·784	
Lime, . . . . .	1·249	
Magnesia, . . . . .	10·	
Potash, . . . . .	8·264	
Soda, . . . . .	·794	
Water, . . . . .	1·506	
	<hr/>	
		99·856

Insoluble silica, 3·791 per cent. Possible impurity, oligoclase.

*From Micaceous Gneiss.*

6. The gneiss of the hill of Clach-an-Eoin (Yone), situated between the mouths of the Navir and the Borgie, in Sutherland, exhibits on its glaciated front a peculiarity of structure which I have not seen described. In feeble, comparatively very feeble development, something of the same kind is to be seen in the gneiss of Boggierow quarry near Portsoy,—at Strath Virick Bridge, near Arguish,—and at Innisbae, on the Dirrymore road in Ross-shire.

At the first, and possibly also at the second of these localities, the structure may be regarded as a mere modification, or a badly-developed instance of porphyritic arrangement in the felspathic portion of the stone. At Boggierow the crystals of the felspar, if crystals they be, are devoid of all edges and angles, appearing rather as kernels or nodules, of some half inch or so in size. Of these there is here no definite arrangement whatever,—they are promiscuously scattered throughout the mass.

As regards the size and want of angularity of the felspathic portions of the Innisbae rock, the above also holds ; but there is here no promiscuous scattering—no absence of arrangement. These felspathic kernels lie in regular layers

accordant with the micaceous lamination of the rock, following obediently that lamination where it has been crumpled \*

This approaches, though it does not come up to,—it resembles, though it is really different from what is to be seen at Clach-an-Eoin.

The study of the Boggierow rock leaves the impression that the felspathic portion had attempted to arrange itself as crystals, or had been crystals, porphyritically disposed. Such a conclusion will hardly apply to the Innisbae rock; the felspathic matter is certainly not porphyritically disposed when it is confined to a regular arrangement in layers; and such a conclusion certainly will not apply at all to what obtains at the northern locality. First, it will not apply in *size*; the individual collections of felspathic matter, to which inches applied at the other localities, are here of the dimensions of feet and yards. Second, it will not apply as to *internal structure*; a certain amount of rough cleavage which is to be obtained in the first cases showed that each—all being much of a size—was to be regarded as an individual mass, of which the components were *its molecules*; here nothing like cleavage is to be got; the components are crystals, granules, plates, promiscuously agglutinated, and forming masses of greatly varying size. Thirdly, it cannot apply as to *shape*; there is here no trace of geometric form, for the masses are lenticular.

The strike of the rock is north by east and south by west; it stands nearly vertical; its bedding is well shown by the parallel disposition of its layers of black mica; it is singularly free from all plication; but, between the bedding of its mica sheets, there occur in marked abundance, but at quite irregular distances, parallel arrangements of the segregated feldspar of the rock, disposed like the glands on a duct, or ganglia on a nerve, the enlargements being of ever-varying size.

In one respect the comparison with ganglia on a nerve is not satisfactory; the felspathic bands are generally not continuous, but the juxtaposition of the two micaceous layers which lately sheathed what I have represented under the figure of ganglionic enlargements, leads, in straight course, to the next, and not far separated lenticular mass.

There can be little room for doubt that this is a modified development of that segregatory process in virtue of which the felspathic material of gneissose rocks so frequently arranges itself in layers or bands. As these bands consist of a material more plastic than the less fusible quartz and mica, they are, in the ordinary case, when plicated, thinned off to nothing at the more compressed flexures, only to re-appear in ampler development among the loosened or more drooping folds. But at Clach-an-Eoin we have no plications to compress or

\* Something very close to this is given by COTTA as his description of typical porphyritic gneiss,—“In the otherwise uniform schistose mass there occur at intervals large egg-shaped crystals of orthoclase (sometimes amorphous), round which the foliated texture bends itself with a wavy sweep.” Ruskin, in treating of the rock-structure of the Alps, gives an admirable drawing of such gneiss.

loosen ; and the portions of the rock where the felspar thins off are actually the least compressed of the whole. This is seen by the opening out of the micaceous layers there, and in the immediate vicinity.

Can it be that the metamorphism—for it is a district of considerable though not extreme metamorphism—has rendered the more fusible material so plastic that cohesion has here been tugging hard to cause it to assume actually a spherical form, and has been baffled only by gravitation (acting before the rock was tilted), which flattened out the sphere into a lens-like shape,—or rather retained in a lens-like shape, that which without its action would, through the operation of cohesion, have assumed the form of a sphere ?

But the description is as yet faulty. I have used the recognised geological term “lenticular” as the adjective altogether most applicable—but the relative proportions of these masses, which vary from the size of a goose’s egg to that of a grampus, is a length about twice as great as their breadth. As they, however, thin away also somewhat as they merge into their connecting band, they present in section an appearance so similar to that of an eye, that it appeared to my fellow-workers, Dr JOASS and Mr DUDGEON, that it would be most fitting that we should, meanwhile, designate what I have described as an *occulitic structure*.

The black mica, which so clearly defines the rock layers, is here Haughtonite.

Towards the north-east cliff of the hill it is to be found in plates of some inches in size ; these plates protrude edgeways from the quartz veins of the rock, are much weather-worn, and have the colour and lustre of tarnished metallic lead. They are associated with garnet, rutile, ilmenite, and chlorite.

The colour of their cleavage surfaces is clove-brown ; red-brown by transmitted light ; they are uniaxial, or very-slightly biaxial.

Specific gravity (average of three specims), = 2·96.

1·3 grammes yielded—

Silica, . . . . .	·453	
From Alumina, . . . . .	·013	
	<hr/>	
	·466	= 35·846
Alumina, . . . . .		21·539
Ferric Oxide, . . . . .		4·467
Ferrous Oxide, . . . . .		18·306
Manganous Oxide, . . . . .		·307
Lime, . . . . .		1·249
Magnesia, . . . . .		8·076
Potash, . . . . .		7·759
Soda, . . . . .		·794
Water, . . . . .		1·956
		<hr/>
		100·299

Insoluble silica, 3·648 per cent. ; possible impurity, quartz.

*From Intrusive Veins in Gneiss.*

7. The following specimen was found by Mr JAMES WILSON of the Geological Survey, and I examined it at Professor GEIKIE's request.

It was imbedded in a very pale lavender almost white orthoclase, which forms a vein which in a semicircular curve cuts the schists to the north of the Kinnaird Head lighthouse.

The orthoclase is interesting not only from its rare colour, but also from its showing in an unusually distinct manner, the structure described by me in my paper on the feldspars,—it is probably DESCLOIZEAUX' *microcline*.

Radiated cleavandite is imbedded in bundles of divergent crystals at the surfaces of the orthoclase; its colour is the same, or somewhat paler.

The mica is in foliæ of half an inch in size. It is black in mass, but when cleaved thin it has a fine, dark, grass-green colour. It is very slightly biaxial. It powdered with unusual facility, being brittle. Its specific gravity is 3·126.

1·2 grammes yielded—

Silica, . . . .	·42		
From Alumina, . .	·008		
	<hr/>		
	·428	=	35·666
Alumina, . . . .			17·947
Ferric Oxide, . . .			7·191
Ferrous Oxide, . . .			18·063
Manganous Oxide, . .			2·
Lime, . . . .			1·4
Magnesia, . . . .			1·5
Potash, . . . .			9·273
Soda, . . . .			3·81
Water, . . . .			3·2
			<hr/>
			100·05

The portion examined seemed quite pure: the possible impurity was the felspar, in which it was imbedded.

This specimen is remarkable on account of the small quantity of magnesia which is present.

*From Intrusive (?) Veins in Granite.*

8. From the granite quarry of Cove, Kincardineshire. Occurs in veins, in elongated crystals, which lie frequently imbedded in and parallel to the

longer diagonal of crystals of muscovite. It calls for the exercise of some force to separate the plates of the two micas. This is somewhat singular, seeing that they are so seldom associated even in the same rock, not to say locality.

Colour very dark brown. Uniaxial, or axial divergence small.

1·3 grammes yielded—

Silica, . . . . .	·431		
From Alumina, . . . .	·03		
	<hr/>		
	·461	=	35·469
Alumina, . . . . .			18·798
Ferric Oxide, . . . .			4·611
Ferrous Oxide, . . . .			19·188
Manganous Oxide, . . .			·643
Lime, . . . . .			·904
Magnesia, . . . . .			7·007
Potash, . . . . .			8·188
Soda, . . . . .			·238
Water, . . . . .			4·97
			<hr/>
			100·016

Possible impurity, muscovite.

The “glass” of this mineral was of a dingy green colour, slightly tinged with yellow.

The state of the oxidation and quantity of the iron was twice determined. First on ·4 grammes by hydrochloric acid and fluorspar; secondly, on ·1407 grammes by sulphuric acid and fluorspar, yielding identically the same amount.

#### *From Exfiltration Veins in Granite.*

9. A mass of fine-grained granite occurs on the west shore of Harris, opposite to Taransay, forming a point of land which lies intermediate between Nishibost and Borge.

This granite has many veins, plentifully studded with jet black crystals of this mica.

These crystals are here some inches in size, of somewhat unusual hardness, and of high lustre.

They are seemingly of great purity, though occasionally coated with a loose ochrey rust.

They are biaxial to the extent of 2° to 3°. Their gravity is 3·05.

1·3 grammes yielded—

Silica, . . . .	·445	
From Alumina, . . .	·012	
	<hr/>	
	·457	= 35·154
Alumina, . . . .		16·704
Ferric Oxide, . . .		5·961
Ferrous Oxide, . . .		19·063
Manganous Oxide, . .		1·016
Lime, . . . .		·818
Magnesia, . . . .		7·461
Potash, . . . .		9·243
Soda, . . . .		1·259
Water, . . . .		3·133
		<hr/>
		99·812

Possible impurity unknown.

*From Exfiltration Veins in Syenitic Granite.*

10. From an exfiltration vein in the so-called syenitic granite of Cnoc-dubh, about a mile east of Lairg, Sutherland.

The associated minerals in this vein are quartz, orthoclase, oligoclase, sphene, and Allanite. Colour dark green. Lustre greasy. No plate large enough and transparent enough to determine the optical properties could be got; nor could a portion large enough for determining the specific gravity be found.

On ·72 grammes—

Silica, . . . .	·245	
From Alumina, . . .	·011	
	<hr/>	
	·256	= 35·555
Alumina, . . . .		16·694
Ferric Oxide, . . .		1·883
Ferrous Oxide, . . .		18·037
Manganous Oxide, . .		·694
Lime, . . . .		2·722
Magnesia, . . . .		8·472
Potash, . . . .		9·896
Soda, . . . .		·105
Water, . . . .		5·714
		<hr/>
		99·772

Insoluble silica, 10·546 per cent. No fluorine; possible impurity, ortho- or oligoclase. Some lighter-green plates had a slight appearance of decomposition.

*From Diorite.*

11. For long I had fruitlessly endeavoured to procure specimens such as could be analysed of the black mica which occurs throughout the dioritic rocks of Banffshire, in some localities sparsely, in others in large amount.

In the summer of 1878, along with Mr PEYTON, lately of Portsoy, I, however, by the merest chance obtained, on the west shore of the Bay of the Durn, a large mass thereof, consisting of interplated crystals: it apparently formed a part of a vein; it was attached to diorite, and passed somewhat into it.

The colour was brown, somewhat bronzy; the crystals, of about half an inch in size, were twisted among each other, and so had a glimmering, somewhat greasy lustre. Specific gravity 3·074.

On 1·3 grammes—

Silica, . . . . .	·425	
From Alumina, . . . .	·018	
	<hr/>	
	·443	= 34·076
Alumina, . . . . .	17·339	
Ferric Oxide, . . . . .	3·613	
Ferrous Oxide, . . . . .	18·703	
Manganous Oxide, . . . .	·384	
Lime, . . . . .	3·23	
Magnesia, . . . . .	10·538	
Potash, . . . . .	6·78	
Soda, . . . . .	1·193	
Water, . . . . .	4·052	
	<hr/>	
		99·905

Loss in bath, ·217 per cent.

12. The next specimens differ from the foregoing in containing more magnesia. They were obtained out of a granitic mass which lay on the south side of the road which runs along the side of Loch Stack, Sutherland. The mass lay towards the west end of the loch; it appeared to have fallen from the cliff on the north side of Ben Stack, but whether it was from an intrusive vein or from a band of metamorphic segregation could not be ascertained; it had much of the appearance of the former.

It was in plates of some inches in size; colour, brownish black; greenish on being crushed; lustre not very high.

The only associates were the quartz and felspar of the granitic vein. Specific gravity, 3·05.

1·3 grammes yielded—

Silica, . . . .	·445	
From Alumina, . .	·019	
	<hr/>	
	·464	= 35·692
Alumina, . . . .	20·086	
Ferric Oxide, . . .	2·233	
Ferrous Oxide, . .	14·011	
Manganous Oxide, .	1·	
Lime, . . . . .	1·895	
Magnesia, . . . .	14·769	
Potash, . . . . .	7·381	
Soda, . . . . .	·529	
Water, . . . . .	2·465	
	<hr/>	
	100·058	

Insoluble silica, 3·448 per cent. Possible impurity, quartz; no fluorine.

These micas were not all examined for fluorine, but it was not found in any of those which were examined.

#### HAUGHTONITE.

	S. G.	Si.	Al <sub>2</sub> .	Fe <sub>2</sub> .	Fe.	Mn.	Ca.	Mg.	K <sub>2</sub> .	Na <sub>2</sub> .	H <sub>2</sub> .	Total.
Roneval, . . . .	3·03	37·16	15·	7·69	17·35	1·04	1·3	8·88	8·18	1·6	2·12	100·17
Capval, . . . .	3·07	36·81	15·22	7·61	17·35	·96	1·54	8·78	8·31	1·34	2·47	100·40
Loch-na-Muilne, .	...	36·46	17·25	4·18	15·33	·54	·69	12·23	9·2	·66	3·39	99·92
Foinaven, . . . .	3·03	36·75	17·86	2·78	15·18	·42	·93	11·17	9·44	1·25	4·23	99·99
Rispond, . . . .	2·99	36·54	22·28	2·43	16·01	·78	1·25	10·	8·26	·79	1·51	99·86
Clach-an-Eoin, .	2·96	35·85	21·54	4·48	18·31	·31	1·25	8·08	7·76	·79	1·96	100·33
Kinnaird Head, .	3·13	35·67	17·95	7·19	18·06	2·	1·4	1·5	9·27	3·81	3·2	100·05
Cove, . . . . .	...	35·47	18·8	4·61	19·19	·64	·9	7·01	8·19	·24	4·97	100·02
Nishibost, . . . .	3·05	35·15	16·7	5·96	19·06	1·02	·82	7·46	9·24	1·26	3·13	99·81
Lairg, . . . . .	...	35·56	16·69	1·88	18·04	·69	2·72	8·47	9·9	·11	5·71	99·77
Portsoy, . . . .	3·07	34·08	17·34	3·61	18·70	·38	3·23	10·54	6·78	1·19	4·05	99·9
Ben Stack, . . . .	3·05	35·69	20·09	2·23	14·01	1·	1·89	14·77	7·38	·53	2·47	100·06

The two micas which follow, though probably belonging to the same species, are, on account of their differing somewhat from the others, meanwhile placed apart.

13. The first occurs on the west coast of Sutherland, about a mile and a-half south of the lighthouse at Cape Wrath.

In two of the small indentations of the coast, beds of the red conglomerate are to be seen covering the tilted strata of the hornblendic gneiss. The more southerly of these little bays may be additionally recognised by several striking granitic veins which intersect the dark hornblendic rock. On the north side of an indentation immediately to the south of this, a bronzy mica is to be found, plentifully interspersed in a brownish white felspar (oligoclase).

Its physical characters are the same as those of the micas already noted. It is in rich dark-brown crystals of an inch in size. It seemed slightly altered at the edges, but these were cut away from the portions analysed; still from



the loose state of the rock I conceive that alteration and peroxidation may have extended to the centre of the crystals, and that specimens from a greater depth will altogether accord with Haughtonite.

Its sole associate was the felspar.

1·3 grammes yielded—

Silica, . . . . .	·44	
From Alumina, . . . .	·004	
	<hr/>	
	·444	= 34·153
Alumina, . . . . .		14·837
Ferric Oxide, . . . . .		10·961
Ferrous Oxide, . . . . .		13·474
Manganous Oxide, . . . .		1·384
Lime, . . . . .		1·809
Magnesia, . . . . .		10·307
Potash, . . . . .		7·93
Soda, . . . . .		2·136
Water, . . . . .		2·8
		<hr/>
		99·971

14. The following does not accord with the others as regards the quantity of alumina, which is here much larger ; in other respects it seems the same. It occurs in comparatively small amount on the southern slopes of the hill of Clashnaree, in Clova, Aberdeenshire.

It is associated with red andalusite, labradorite, fibrolite, and margarodite, which minerals occur not in veins, but in layers or bands of the rock. The mica is of a brilliant lustre, and a bronzy-brown colour. A sufficiency for analysis was got with much difficulty, and it may not have been altogether free from gauge, and possibly also from labradorite.

1·2 grammes yielded—

Silica, . . . . .	·448	
From Alumina, . . . .	·02	
	<hr/>	
	·468	= 39·
Alumina, . . . . .		25·096
Ferric Oxide, . . . . .		6·514
Ferrous Oxide, . . . . .		9·801
Manganous Oxide, . . . .		·666
Lime, . . . . .		·933
Magnesia, . . . . .		6·166
Potash, . . . . .		7·084
Soda, . . . . .		1·626
Water, . . . . .		3·466
		<hr/>
		100·332

## BLACK MICAS.

	Si.	Al <sub>2</sub> .	Fe <sub>2</sub> .	Fe.	Mn.	Ca.	Mg.	K <sub>2</sub> .	Na <sub>2</sub> .	H <sub>2</sub> .	Fl.	Ti.	Totals.
<i>Biotite—</i>													
Glen Urquhart, .	33·69	17·66	·26	12·95	...	1·16	17·54	8·92	·13	2·14	·52	...	99·96
Loch Laggan, .	39·5	15·04	·24	10·23	·75	1·4	18·46	9·37	·62	3·21	·73	...	99·55
Shinness, .	39·77	16·68	·65	6·73	·62	2·2	20·92	6·5	·48	5·4	...	...	99·95
Glen Beg, .	39·46	16·45	·39	10·	·53	1·59	19·	8·22	·26	3·34	·32	...	99·56
Hillswick, .	39·8	14·19	2·59	11·78	·24	·1	18·32	8·43	2·11	2·52	·56	...	100·64
Milltown, .	40·31	12·58	1·81	3·35	·38	7·58	21·	6·56	·95	5·74	n.d.	...	100·25
<i>Haughtonite—</i>													
Roneval, .	37·16	15·	7·69	17·35	1·04	1·3	8·88	8·18	1·6	2·12	...	...	100·17
Capval, .	36·81	15·22	7·61	17·35	·96	1·54	8·78	8·31	1·34	2·47	...	...	100·40
Loch-na-Muilne, .	36·46	17·25	4·18	15·33	·54	·69	12·23	9·2	·66	3·39	...	...	99·92
Foinaven, .	36·75	17·88	2·78	15·18	·42	·93	11·17	9·44	1·25	4·23	...	...	99·99
Rispond, .	36·54	22·28	2·43	16·01	·78	1·25	10·	8·26	·79	1·51	...	...	99·86
Clach-an-Eoin, .	35·85	21·54	4·48	18·31	·31	1·25	8·08	7·76	·79	1·96	...	...	100·33
Kinnaird Head, .	35·67	17·95	7·19	18·06	2·	1·4	1·5	9·27	3·81	3·2	...	...	100·05
Cove, .	35·47	18·8	4·61	19·19	·64	·9	7·01	8·19	·24	4·97	...	...	100·02
Nishibost, .	35·15	16·7	5·96	19·06	1·02	·82	7·46	9·24	1·26	3·13	...	...	99·81
Lairg, .	35·56	16·69	1·88	18·04	·69	2·72	8·47	9·9	·11	5·71	...	...	99·77
Portsoy, .	34·03	17·34	3·61	18·70	·38	3·23	10·54	6·78	1·19	4·05	...	...	99·9
Ben Stack, .	35·69	20·09	2·23	14·01	1·	1·89	14·77	7·33	·53	2·46	...	...	100·06
<i>Foreign do.—</i>													
16. Brand, .	37·18	17·53	6·20	15·35	·31	·79	9·05	5·14	2·93	3·62	...	2·47	100·57
17. Brand, .	37·06	16·78	6·07	15·37	tr.	·57	9·02	5·96	2·86	3·77	...	3·64	101·1
18. Hartzburg, .	36·17	18·09	8·7	13·72	...	·52	11·16	7·59	tr.	2·28	·36	...	98·59
Schwarzwalder,*	33·6	15·	4·99	19·29	...	3·36	11·62	7·53	·51	4·58	tr.	...	100·48
Tyrberger,†	35·5	18·01	9·24	12·11	tr.	3·02	10·86	9·18	1·93	...	...	...	99·85
Cape Wrath, .	34·15	14·84	10·96	13·47	1·38	1·81	10·31	7·93	2·14	2·8	...	...	99·79
Clova, .	39·	25·1	6·51	9·8	·67	·93	6·17	7·08	1·63	3·47	...	...	100·33
<i>Lepidomelane—</i>													
Achadhaphriz, .	40·38	12·11	14·53	3·03	3·17	1·03	13·	7·13	1·8	3·57	...	...	99·72
Tongue, .	40·08	12·41	13·47	2·67	·62	1·08	14·66	7·57	2·15	5·29	...	...	99·99

In the above table I have inserted three analyses by other observers—16, 17, 18—from DANA's list, and two from a more recent source.

A condensation of this table gives the following averages of the composition of these micas,—from which averages the oxygen ratios are calculated; the Irish lepidomelane being the average of Dr Haughton's analyses :—†

\* *Hebenstreit*. From gneiss, with axial angle small.

† *Hebenstreit*. From the granite of the Tyrberger water-fall; specific gravity, 3·07. *Zeitschrift für Krystallographie und Mineralogie, Zweiter Band, erstes heft.*

‡ One or two of the Haughtonites were not included in calculating the average, their analysis having been very lately executed; as they agreed with the others, their exclusion does not effect the result.

*Biotite.*

		Oxygen.		
Silica,	. . . . .	39·35	20·99	20·99 . . . . 21
Alumina,	. . . . .	16·46	7·67	} 7·78 . . . . 8
Ferric Oxide,	. . . . .	·38	·11	
Ferrous Oxide,	. . . . .	9·98	2·28	} 14·95 . . . . 15
Manganous Oxide,	. . . . .	·47	·1	
Lime,	. . . . .	1·3	·4	
Magnesia,	. . . . .	18·98	7·59	
Potash,	. . . . .	8·25	1·4	
Soda,	. . . . .	·37	·08	
Water,	. . . . .	3·5	3·1	

*Haughtonite, Scottish.*

		Oxygen.		
Silica,	. . . . .	35·93	19·16	19·16 . . . . 19
Alumina,	. . . . .	18·06	8·41	} 9·78 . . . . 10
Ferric Oxide,	. . . . .	4·55	1·37	
Ferrous Oxide,	. . . . .	18·06	3·8	} 12·67 . . . . 12·5
Manganous Oxide,	. . . . .	·81	·18	
Lime,	. . . . .	1·49	·42	
Magnesia,	. . . . .	9·07	3·63	
Potash,	. . . . .	8·49	1·44	
Soda,	. . . . .	1·12	·29	
Water,	. . . . .	3·27	2·91	

*Haughtonite, Foreign.*

		Oxygen.		
Silica,	. . . . .	35·9	19·1	19·1 . . . . 19
Alumina,	. . . . .	17·08	7·96	} 10·07 . . . . 10
Ferric Oxide,	. . . . .	7·04	2·11	
Ferrous Oxide,	. . . . .	15·17	3·36	} 12·34 . . . . 12·5
Lime,	. . . . .	1·65	·47	
Magnesia,	. . . . .	10·34	4·14	
Potash,	. . . . .	7·08	1·2	
Soda,	. . . . .	1·64	·42	
Water,	. . . . .	2·85	2·75	

<i>Lepidomelane, Scottish.</i>										
			Oxygen.							
Silica,	.	.	.	40·23	21·46	21·46	.	.	.	21·5
Alumina,	.	.	.	12·26	5·71	}	9·91	.	.	10
Ferric Oxide,	.	.	.	14·	4·2					
Ferrous Oxide,	.	.	.	2·85	·63					
Manganous Oxide,	.	.	.	1·89	·42	}	12·43	.	.	12·5
Lime,	.	.	.	1·08	·6					
Magnesia,	.	.	.	13·83	5·33					
Potash,	.	.	.	7·35	1·25					
Soda,	.	.	.	1·97	·51					
Water,	.	.	.	3·93	3·49					

<i>Lepidomelane, Irish.</i>					Oxygen.				
Silica,	.	.	.	36·62	19·53	19·53	.	.	20
Alumina,	.	.	.	17·5	8·15	} 15·38	.	.	15·5
Ferric Oxide,	.	.	.	24·09	7·2		.	.	
Ferrous Oxide,	.	.	.	2·70	·6	} 6·89	.	.	7
Manganous Oxide,	.	.	.	1·31	·3		.	.	
Lime,	.	.	.	1·35	·4		.	.	
Magnesia,	.	.	.	4·81	1·92		.	.	
Potash,	.	.	.	8·7	1·48		.	.	
Soda,	.	.	.	·31	·08				
Water,	.	.	.	2·37	2·11				

These ratios show, firstly, that, as is usual in the micas, the oxygen ratio of the bases is, in each of the above, in excess of that of the silica.

Secondly, that the ratios of the sesquioxides to the protoxides in Biotite and Irish lepidomelane are inverted; being in Biotite only half of that of the protoxides, while in the Irish lepidomelane it is twice as great as that of the protoxides.

The foreign and Scottish Haughtonite is evidently the same compound; and this is one which stands intermediate between Biotite and Irish lepidomelane; the oxygen of the protoxides and sesquioxides being in Haughtonite more nearly equal in amount than in either of the other species.

And what I have called the Scottish lepidomelane is, as regards the balancing of the oxygen of the bases, more closely associated with Haughtonite than it is with the Irish lepidomelane.

That which really, however, constitutes the distinguishing features of these micas is the state of oxidation or the iron.

In Biotite the relative proportion of ferrous to ferric oxide is as 25 to 1; in Scottish Haughtonite as 4 to 1; while in lepidomelane these proportions are

altogether inverted, being in the Scottish lepidomelane as 1 to 5, and in the Irish as 1 to 9.

A consideration of the foregoing tabulation also makes manifest the following additional chemical distinctions between these minerals.

Biotite differs from Haughtonite in containing an amount of magnesia which is twice as great as that of the protoxide of iron ; the iron also is in Biotite present almost solely in the ferrous state ; while in Haughtonite the relative proportions of the above protoxides are fully more than inverted, there being also a considerable quantity of iron in the ferric state.

In all, the alkalies and water are present in about the same amount ; nor do the proportions of the silica and alumina differ largely.

Altogether, there can be no question that the substance standing in an intermediate position in the table is distinct ; and I conceive that it is most fitting that it should be named after the gentleman who first analysed the black micas of Ireland, and so established the specific individuality of the mineral which stands next to this in the system,—happily fitting also, seeing that it exists as the distinctive mineral of one of the varieties of granite, a rock in the study of which Dr HAUGHTON has for long been closely engaged.

The geognostic position of these minerals is for the most part well marked.

As the plates or crystals in which they are found are usually of extreme tenuity, it is not easy to obtain, under the ordinary circumstances of local collecting, a sufficiency for analysis, and hence the unimpeachable evidence afforded thereby is not great in amount ; nor is it, in the absence of characteristic specimens, easy to distinguish between the three species. The instances, however, that I shall adduce in addition to those analysed, have, for the most part, been established by partial examination or fairly satisfactory proof.

Every case in which there is doubt will be notified.

The four first analyses show Biotite to occur in association with granular limestone. In Glen Urquhart, in a most peculiar granitiform belt in the centre of the lime ; \* also, near Milltown, in a singular rock, in association with edenite and Wollastonite ; at Loch Laggan, imbedded in chlorite, in the lime ; at Shinness, immediately in contact with sahlite, &c., at the junction of the lime with the inclosing rock ; at Glen Beg, in contact with two known and a new felspar ;—these may together have formed a belt similar to that at Urquhart. Additional limestone localities are the following :—In the most westerly of the two great beds which traverse the North of Scotland, I only know of it at Redhythe, where it is associated in the limestone itself with talc, pyrrhotite, and rutile. In the most easterly it occurs at Glen Gairn, with prehnite and coccolite, at

\* This peculiar granitiform belt I have seen cutting limestone strata elsewhere in Scotland,—as at Laggan near Dulnan Bridge, Inverness-shire ; and Boultschoch, in Aberdeenshire. This belt always carries Biotite, and the felspar in two of these cases has upon analysis proved to be Andesine.

the junction of the bed with the gneissose matrix. At Crathie, in similar association. In the great bed which traverses the country down Dee side, it occurs here and again, as in the openings on the Leac Ghorm Hill, in Boultschoch quarry near Abergeldie, and in Craigs, Muir, and Midstrath quarries—in all being imbedded in a granitic belt very similar in appearance to that at Glen Urquhart; this belt is, in the three last quarries, composed of little quartz, much fatty lustred white orthoclase, and little of the mineral itself.

It is likewise found in the limestone of Froster Hill, near New Meldrum; along with blue malacolite, near lime, at Allt-Cailleach, Coyle Hills; along with zoisite, pyrrhotite, sahlite, and the usual lime minerals, at Dulnan Bridge south of Grantown; and along with similar minerals and cinnamonstone at Allt-na-Gonolan, in the same neighbourhood—at both localities in limestone.

Its occurrence with ripidolite at Hillswick, near the junction of what has been called hornblendic gneiss with micaceous rocks, is somewhat exceptional; but that first-named rock, which I shall elsewhere describe, is new to me.

Biotite is thus seen to occur generally associated with granular limestone. This is probably also the dark mica which occurs as an accessory mineral in hyperyte and tufa. It is nowhere associated with another mica.

Passing to Haughtonite, we find it, in the specimens analysed, a component of granitic veins, whether these be intrusive or exfiltrative. Extending the evidence, it is to be noted as occurring in specimens equally characteristic with the above, in Rubislaw, Anguston, Sclatney, and other quarries in the “grey granite,” and the large, distinctive crystals are always in the veins.

At Blirydine, Brathans, and many other places, it is seen in the felspathic bands of the gneiss.

In these situations it may be regarded as replacing muscovite, which very rarely, as at Cove, accompanies it. *In every case where it occurs in exfiltration veins, oligoclase is also present*; less frequent associates are sphene, Allanite, and in one locality (Anguston) ilmenite; what may be called chance associates are beryl, apatite, tourmaline, and garnet.

But besides its position in the exfiltration veins of the grey granite, it goes largely to form the mass of that rock itself. If the word granite be confined to a compound of quartz, orthoclase, and muscovite, then must “grey granite” lose all title to the name; for though quartzose in spots, as a rule it contains comparatively little quartz, hardly any muscovite, and not the excess of orthoclase normal to granites,—being composed in greatest bulk of oligoclase, quartz, and Haughtonite, with smaller quantities of orthoclase. The distinctive feature of the rock is the large quantity of this black mica.

In the ascertaining the nature of the dark mica of grey granite, it will not suffice to evade the trouble of picking out the minute scales from the general mass of the rock, by making use, instead thereof, of a portion of those curious

dark micaceous patches which so frequently occur in grey granite—called *neres* by the quarrymen.

These somewhat kindey-shaped masses most frequently show an angularity of form,—they also almost invariably have the dark mica, which is their chief constituent, arranged in a laminated manner, parallel to their longer diagonal, whatever be the position of that diagonal,—whether horizontal or vertical. These facts alone would lead us to regard them as being not concretions in the rock, but *fragments of gneiss*;—*unresolved*, if the word is admissible—unresolved or residual fragments of the gneiss, the metamorphosis of the general mass of which resulted in the granitic paste which now holds these fragments imbedded.

Till however the actual nature of these “*neres*” is placed beyond question, any evidence derived from them must be received with caution.

Examination, to the extent of ascertaining the relative proportions of the two oxides of iron in the minute black scales of the rock itself, shows that Haughtonite is *the* mica of the grey granites of Aberdeenshire.

I have only lately been able to offer analytical evidence as to its second mode of occurrence; namely, as *the* mica which occasionally replaces hornblende in diorite.

Typical diorite has no mica. In perhaps the most important mass of diorite in Scotland, that namely which, showing itself first in the north in the vicinity of Portsoy, stretches up the country as far as Morven, the character of the rock changes repeatedly and even suddenly to a marked extent.

This diorite, however, which is most simple in its composition in its northern portions, I have elsewhere shown to be not typical even there; for *labradorite* is there, as it is throughout, the species of felspar characteristic of the rock; indeed, it is the only felspar to be found therein.

The repeated changes which take place in the rock seem to result from the substitution of augite and Haughtonite for hornblende in the first place,—of hypersthene for that Haughtonite in the second,—and from the removal of all the chief ingredients, except labradorite and Haughtonite, in the third. Marked as such changes are, and absolutely dissimilar as are the extremes of such rocks, the gradual steps of the transmutation can be detected, leading to the conviction that all must be regarded as but varieties of one great rock mass.

Such has been the conclusion of MACCULLOCH, of CUNNINGHAME, and of NICOL, who unite in laying them down with one colour,—that colour indicating an igneous rock of the granitic type.

Of this, however, there is, as I have pointed out in my paper on hornblende, considerable doubt; I therein considered the amount of information to be derived from the augitic and hornblendic ingredients of the rock, and we have now to see what light may be thrown upon it by its mica. The chief

difficulty lies in connection with the question of the whole rock so coloured constituting one mass, unless it be admitted that the rock has at different points suffered a varying amount of metamorphism.

The rock where first seen, near the old battery at Portsoy, consists of a grey striated labradorite and a grey brown (red by transmitted light) hornblende, with extremely rarely a speck of menaccanite. Here the rock is of a very coarse grain; it carries occasional veins of labradorite, and in these only is Haughtonite here to be seen. As this rock passes to the eastward, the labradoric ingredient increases in quantity, the hornblende becomes light green and uralitic, and the rock is altogether much finer in structure. This is, however, the only change which can be here detected, and an examination of the rock in all its relationships, and a consideration of all its appearances, leaves no room for doubt that it has a stratified structure, and is here of a metamorphic nature.

Upon the west side of the Bay of Durn, however, a rock of a somewhat similar nature to this appears, the two being separated by bands—well seen at the Harbour of Portsoy—which have a minute crystalline and perfectly schistose structure.

The evidences as to the rock on the Durn Shore being a metamorphosed, and not an intrusive mass, are by no means so clear; and its constituent minerals also differ considerably.

The small amount of felspar here visible is, indeed, the same; but the hornblende has given place, apparently entirely, to a mixture of augite and hypersthene, both being in minute crystals, with rare and minute occurrences of Haughtonite. Now it is the union as laid down in geological maps, of this rock with that previously described, which has not been, and, from the covered-up state of the country inland, probably cannot be proved; so that here at the outset, as regards this locality at least, it cannot be shown that the hornblende is *replaced* by augite and Haughtonite, for the rock may be intrinsically different—may, in fact, be of the nature of a non-chloritic diabase.

In the more southerly portions of this last rock, and also to the eastward, a gradual increase in the quantity of Haughtonite and disappearance of the hypersthene is obvious; and when we get further south, the rock which appears to be the continuation of one or other, or perchance of both of the above, becomes pervaded with exfiltration veins, in which the Haughtonite again gives place to true hypersthene. This is to be seen on the west slopes of Craig Buiroch and at Retannach. The occurrence of a labradoric pitchstone gives countenance to the view that the rock is here volcanic.

As a rule, Haughtonite and true hypersthene do not occur in the same locality; the rock on the west side of the Bay of the Durn, and that on the north side of Barra hill, however, contain both. Pyrite is a rare accessory at the first, pyrite and menaccanite at the second of these localities.



In many localities the augite and hypersthene both give place to the mica, the felspar only remaining the same; these transmutations occur repeatedly. At the Barry granite quarry near Knock the mica is hardly to be seen, at the Bin of Huntly augite and hypersthene replace it entirely. Where the rock appears on the south side of the Burn of Craig, near Towanrieff, the labradorite has again the mica as its sole associate. A loose block or two of a similar rock occurs at New Merdrum near Rhynie; in these the crystals of both minerals are over an inch in size.

Up the valley of the Blackwater, a bed of diorite, with occasional specks of doubtful hypersthene, or in its place of a black mica, is to be seen. There can be little doubt that it is the same belt of rock which reappears at Glenbucket and Colquhanny, and here hornblende, with a little Haughtonite, is again present, menaccanite and sphene also occurring.\*

The lithological position of the new mineral is, therefore, clearly defined and altogether distinct from that of Biotite; they never occur together, or replace each other in the same rocks.

Of lepidomelane this cannot, to the full at least, be said.

Though I have never found it in association with Haughtonite, one of the specimens analysed was taken from an exfiltration vein in a rock very similar to that which at Lairg carried the Haughtonite; the other lay bedded in the felspathic belt of a hornblendic gneiss.

It is possible that lepidomelane may also be the dark mica of other gneisses,—*ex grege*, of the peculiarly bronzy gneiss of Tiree, which carries garnet.

Chemically quite different from the former micas, this is not clearly separated from the last in its modes of occurrence, being found, though only once, in an exfiltration vein. Still in Scotland it does not, as in Ireland, pertain to the granites, being here probably solely a gneissic mica.

Be this as it may, these geologic relations go to establish very clearly the specific individuality of Haughtonite.

Two important distinctive properties remain to be noticed,—crystalline form, and chemical features.

\* Localities in which it is doubtful whether the black mica is this species or Biotite are the following:—

At Badnagauch on the Deskery there is a rotting syenite, which is riddled with exfiltration veins composed of large crystals of labradorite and hornblende, with a hydrated Biotite (?), menaccanite, sphene, and Allantite as accessories.

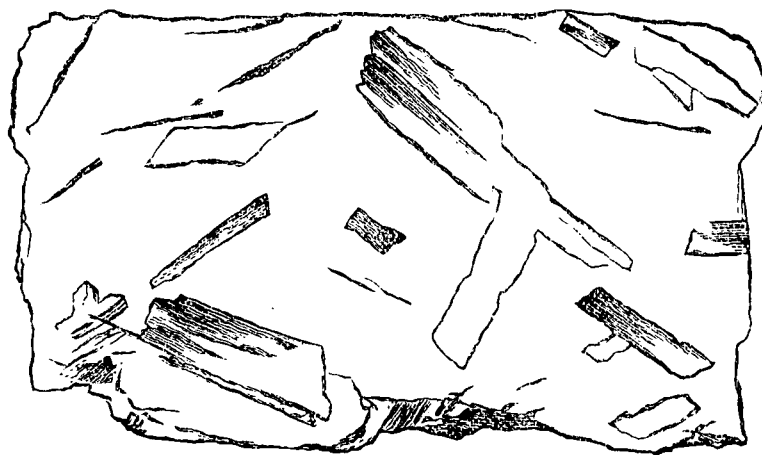
In the hyperite of Scur na Gillean in the Cuchullins, and of Halival in Rum, a black mica is rarely seen, which is most probably Biotite.

Scales of a dark brown uniaxial mica, which occur in tufa at Kinkell and Kineraig in Fife, I also set down as Biotite. Haughtonite probably is the brown mica which, in somewhat small quantity, is found in the andalusite layers of the gneiss of Clashnaree, Glendarff, and other hills of the Clova district. The associates here being andalusite, quartz, fibrolite, and labradorite. The composition of the mineral from this locality does not altogether accord with that of the generality of specimens, and its occurrence in gneiss is somewhat exceptional.

I have noted, as regards the optical properties of Haughtonite (where its extreme opacity permits of observation), that it was found to be biaxial, though only to a small extent— $2^{\circ}$  to  $3^{\circ}$ . It is not this fact so much as the *habit* of its plates, which induces the belief that it is *orthorhombic* in form.

Distinct, or at least free, crystals I have not met with. In many instances it is found in plates devoid of regular form and definite appearance: this is the case at Roneval, Nishibost, Rispond, and Clach-an-Eoin; but at most of the localities in which it occurs in exfiltration veins in granite, the crystals are disposed in lengthened, radiating, somewhat fan-shaped arrangements, with oblique terminations; these crystals are frequently three or four inches in length, by a fourth of an inch in width: they so occur at Lairg, Rubislaw, Cove, the graphic granite and the adjacent granitic vein at Portsoy, at Blir-drine, and at Craig Burn, near Rhynie.

The accompanying sketch of a Craig specimen, expresses a not unusual appearance.



The peculiarity of the association with the muscovite of Cove has already been noted.

Before the blowpipe, the three species function differently, though to but a slight extent. All give with fluxes the iron reaction,—Biotite to the smallest, Haughtonite to markedly the largest extent. All fuse to a black magnetic bead,—Biotite with ease, Haughtonite with considerable difficulty,—lepidomelane, again, standing intermediate. The Biotite bead is but feebly magnetic; that of lepidomelane distinctly so; that of Haughtonite powerfully so.

Under the breath of the blowpipe flame the plate of Biotite, even if brown, whitens; that of lepidomelane pales; that of Haughtonite, if of a pale tint, or however black, becomes still blacker from increased opacity.

Under the action of acids, thin scales of the three substances are affected in the same order. When treated in the cold with hydrochloric and sulphuric

acids, it is found that the former acid decomposes all; leaving scales of glistening silica in times which bear for the three, as arranged B.L.H., about the proportions of 1, 2, and 4. Sulphuric acid splits up the larger flakes into fungoid masses, accomplishing the same decomposition in times about 3, 5, and 9. When *gently heated*, however, the action of the sulphuric acid overtakes the more immediate action of the hydrochloric, the thorough decomposition being accomplished by the former in a considerably shorter time.

As might be expected from the large quantity of ferrous oxide in its composition, Haughtonite is subject to change on exposure.

At the one locality of Nishibost, the edges of the foliæ are covered with a bright red rust; elsewhere there is the development of first a dark green, and ultimately of a light green colour; the foliæ at the same time becoming friable and talcose;—the incipient change is well seen at Lairg, in Sutherland, the completed one at Blirydine, Kincardineshire.

When it occurs as the cryptocrystalline constituent of granites and granitites, there can be little doubt that the peroxidation of the mineral is a chief cause of the rotting and disintegration of these rocks.

Granites, with feeble cohesion of their parts to a considerable depth, and which crumble rapidly into fine gravels, are to be seen at the south-east foot of Morven, and along Culbleen in Aberdeenshire. At Strontian in Argyle, whole banks of such gravel have to be dug through before anything like rock is reached. The springs of these districts are highly chalybeate: the changed mica has become bronzy or ochre-coloured, and talcose to the sense of touch. Peroxidation is in such cases the agent of waste.

One other question remains to be considered: seeing that the marked distinction between Haughtonite and lepidomelane lies in the state of oxidation of the iron, may the latter mica not be merely weathered or peroxidised Haughtonite?

As regards the Achadhaphriz and Ben Bhreck specimen, the answer is a distinct negative; from both localities the specimens were perfectly unaltered. The Achadhaphriz block had been broken up but a few days before the plates were removed from it; the Tongue boulder was split up by dynamite immediately before the collecting of what was analysed; and the associated minerals were all unchanged.

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*Altered (?) Black Mica.*

*From Exfiltration Veins in Syenite.*

The exact nature of the specimens now to be described it is not easy to assign, as they may have undergone more or less change.

They occur in the rocky bank of a road-cutting, which had been made only

about a year before the writer obtained the specimens; this rock cutting was about 20 feet in depth, and it was nearly at this greatest depth that the specimens were gathered. The locality is near the farm of Badnagauch, on the Deskery, in Aberdeenshire. The rock is the syenite of Morven, here much decomposed—being almost gravelly. Through this rock numerous anastomosing exfiltration veins occur; there is also an intrusive porphyry vein. The exfiltration veins had not suffered nearly so great an amount of change as the rock mass; indeed, except as regards the mica, there was little or no change in them. They contained large crystals of dark-green hornblende; large and finely-shaped crystals of labradorite, a few, apparently, of muscovite; granules, the size of peas, of menaccanite; foliæ of the mineral in question of about an inch in size; sphene and Allanite rarely. None of these minerals, with perhaps the exception of the mica, showed any appearance of change. It was in dark-brown, rather dull crystals, which in parts were somewhat softened and bronzy; the amount of change did not, however, appear to be great. The crystalline foliæ were somewhat loose. The specific gravity, taken on the mineral in its ordinary state, was 2·63 to 2·645; after being boiled to expel air it was 2·845.

1·302 grammes yielded—

Silica, . . . . .	·42	
From Alumina, . . . .	·01	
	<hr/>	
	·43	= 33·026
Alumina, . . . . .		13·167
Ferric Oxide, . . . .		26·075
Ferrous Oxide, . . . .		2·009
Manganous Oxide, . . .		·153
Lime, . . . . .		1·634
Magnesia, . . . . .		4·831
Potash, . . . . .		4·02
Soda, . . . . .		1·161
Water, . . . . .		13·882
		<hr/>
		99·95

Was apparently pure. It contained no fluorine. The portions which appeared to have suffered some change were, as far as possible, cut away.

It lost in bath 5·731 of this water; the greater amount of this was lost in half an hour—the whole in half a day.

This composition is unquestionably nearer to that of lepidomelane than to Biotite; indeed, it is like a hydrated lepidomelane. The writer is disposed, however, to regard this as a fortuitous resemblance. It is difficult to believe the mineral to be merely a hydrated mica; these are not prone to excessive alteration, and the duration of the exposure could hardly have been suffi-

cient to have effected any marked change. If it be a hydrated mica the amount of change is much greater than mere appearance would indicate, and care was taken to exclude, as far as possible, the altered portions. It may be an altogether different substance, intermediate between Voightite and Jollyite.

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### PIHLITE.

This species, hitherto unrecognised as British, is possibly not uncommon. Probably it is the chief material of the very peculiar schistose rock, which, plentifully studded with imbedded crystals of andalusite, forms the trough of the small sandstone basin of Lumsden and Kildrummy.

A very similar rock, only carrying crystals of actynolite instead of andalusite, occurs stretching from north of Mulben up the valley of the Burn of Achanachy. The rock of the first of these localities is largely quarried in the Coreen hills and in Glen Mid Clova, being used in the district as a paving, and also to a smaller extent as a building stone.

It is, doubtless, due only to the perfect seclusion of the district that the peculiar excellences of this rock are elsewhere unknown, seeing that it possesses qualities which fit it for its use as a paving stone, which are superior to those of both Caithness and Forfarshire.

Splendidly bedded, and with a most convenient dip, it can with the greatest possible facility be raised in slabs of large dimensions, of any required thickness, from an inch to a foot or more.

Quarried on the very summit of a hill, the trouble from water is so small that the little that occurs is actually stored for drinking purposes, and the carriage is aided by gravitation through a descent of some 900 feet.

The stone itself, being in its general mass formed of a material which yields to blows, is readily cut and fashioned; but this material, being acted upon by atmospheric agencies with extreme tardiness, "resists exposure;" while, inasmuch as its softer mass is everywhere studded with closely-packed crystals of one of the hardest mineral bodies known, it long resists the wear and tear of friction; and, as these enduring crystals project above the softer portions of the stone, slipping on its surface is noways to be feared.

The flags are, moreover, full of beauty. The micaceous particles which form the layers are arranged not in flat, but in minutely undulating disposition; they reflect a tremulous lustre, something between a nacreous glimmer and a silver sheen, while the dark brown of the andalusite crystals stipples this with a peculiarity which is quite unique.

The writer was formerly acquainted with a gentleman whose most suc-

cessful research in geology consisted in his once having discovered "an unquestionable specimen of petrified maggots" in a pigstye, and whose faith therein was only slightly shaken after a dire amount of argumentation. Had he cast eye on one of these slabs, he would, in all probability, have believed in petrified maggots to the end of his days.

The specimens of this mineral which were analysed were got in North Glen Clova, where it is somewhat rare. They were specially selected on account of their being much lighter in colour, and hence apparently purer than those ordinarily procurable. This lightness of colour might, however, be due to incipient weathering. In appearance they were very similar to the paragonite of Monte Campione; indeed, they were supposed to be that mineral. They were scaly in structure and cream-coloured; soft and somewhat unctuous when rubbed along the lamination of the scales, but rough when rubbed across it.

They contained throughout their mass minute almost invisible crystals of magnetite; these were separated, it is believed absolutely, by crushing, repeated edulcoration, and sifting with a magnet.

The mineral absorbed ·579 per cent. of moisture. When slightly heated in powder before the blowpipe, there was a slight decrease in bulk and the assumption of a brown colour; when highly heated the contraction is very marked, and the powder agglutinates and shows traces of vitrification, the original colour being restored.

The two specimens analysed differed very slightly in appearance.

	On 1·3185 grammes.	On 1·584 grammes.
Silica, . . .	58·323	61·1
Alumina, . . .	26·455	26·516
Ferrous Oxide, . . .	2·29	2·556
Lime, . . .	·467	·669
Magnesia, . . .	·568	·694
Potash, . . .	5·973	n. det.
Soda, . . .	1·688	n. det.
Water, . . .	4·847	4·23
	<hr/> 100·611	

Insoluble silica of first, 1·842 per cent.; of second, 1·584 per cent. Possible impurity, magnetite or quartz.