III.—*Chapters on the Mineralogy of Scotland. Chapter Sixth.*—
“Chloritic Minerals.” By Professor HEDDLE.

(Read 3d March 1879.)

“CHLORITIC MINERALS.”

There is no department of natural science which is so defective in its general scheme of arrangement as mineralogy ; and its sectional grouping is, if possible, still more defective.

Such correlations as are expressed by the terms, “the Micas,”—“the Felspars,”—“the Garnets,” &c., are only admissible if the substances united in such groups are included under one general formula, and function in a more or less similar manner as rock-formers.

Under such methods of arrangement as are in vogue, many substances are left to stand isolated as intermediates,—substances which frequently form important integers of a regular sequence. And when such groups are constituted upon the possession of merely some one general feature, it almost invariably results that there are linked together substances which have nothing else in common.

Mineralogy presents numberless examples of the misleading effect of being guided by mere externals ; and the more the *geognostic relations* of minerals are sought out, the more clearly do we see the false conclusions into which we are drawn when we are guided by externals alone.

To no group does this perhaps apply more emphatically than to that of the “*Chlorites*.” Of the twelve minerals which in our systems find a place therein, some are the products of mere solution, some of direct chemical change, some of metamorphic transmutation. Of these, some are found in sedimentary rocks, some in volcanics ;—in limestone, in serpentine, in schists, in granite, and in traps.

The extreme injudiciousness of founding a natural history group upon so trivial a character as *colour* alone, is shown by the laxity which has gradually crept in—by the expanding as it were of the name into “the chloritic group,” or “chloritic minerals.”

From the difficulty of discriminating between several substances which fall under such a term, there can be no doubt that the term has not unfrequently been adopted as a convenient cover for ignorance.

“I always say *chloritic mineral* when any of my students ask me what they are ; it covers a vast amount of ignorance.” This was the remark made to me by a teacher of geology when we were discussing the green substances

which plug the steam-holes of amygdaloids:—the deductions to be drawn from the present investigation will show that the term employed, instead of covering, *exposed* that which it was intended to conceal.

From the very frequent occurrence of difficultly-recognisable green minerals in volcanic rocks, it is to them that this term of “chloritic” is now *especially* applied; it is so applied in the belief and hope that the mineral is a chlorite of some kind, and this is conceived to be quite a sufficient amount of knowledge.

In proof that the case has, in the above, neither been misstated nor overstated, I beg to refer to a paper, entitled “Notes on the Occurrence of Chlorite among the Lower Silurian Volcanic Rocks of the English Lake District,” which was lately published in the “Mineralogical Magazine,” by Mr J. CLIFTON WARD, of Her Majesty’s Geological Survey.

In this paper, which is a record of much careful observation, Mr WARD very seldom uses the term chloritic mineral, and commits himself to the substance being chlorite itself. In this belief he is so confident that he states that the chlorite can be seen to pass into magnesian mica, and even into potash mica; he discusses the nature, or rather the stages of the metamorphism which accomplishes this change; and yet the paper not only does not state that any steps were taken to determine the actual nature of the substance treated of in this important speculation, but it bears internal evidence that neither analysis or any satisfactory test had been adopted for the determination.

In this memoir the mineral in question is directly referred to upwards of thirty times, and indirectly several times more; and yet, *if the evidence of Scotch rocks is not in absolute discordance with those of the English rocks*, I am able to say that, while at three of the localities mentioned,* it is possible that the mineral may be chlorite, in all the rest it is certainly a substance which has no connection therewith.

It is not meant to be insisted on that true metamorphism may not take place in volcanic rocks; but a study of Mr WARD’s admirably precise descriptions goes to show that *degradation*, or at least not metamorphism pure and simple, had altered the rocks he treats of—had filled their vesicles, and lined their nests. And, while decomposition and recomposition through degradation is not insisted on as the sole *possible* change, it has to be said that it is the only one which has as yet been clearly shown to alter such rocks.

But Mr WARD’s position, as he himself shows, is precisely that of the first petrologists of the day. He writes:—“Under the head of Diabase, ZIRKEL

* Great Gable, Eskdale, and Harter Fell. The fan-shaped crystalline groups of Harter Fell are very probably chlorite. The nests from the same locality, ranging up to 1 inch in diameter, composed of a “fibrous crystalline” mineral, can hardly be so. As these large nests, a single one of which would suffice for an analysis, can, with “a little careful hammering, be taken out whole from the rock,” it is much to be regretted that they were not examined; as a *fibrous* crystalline green mineral would in all probability prove to be either Kirwanite, or new.

remarks ('*Microskopische Beschaffenheit*,' p. 407), that the diffused greenish mineral seems to be chlorite, and probably a decomposition product of augite, and the same is very likely the case among the Cumberland rocks, for the larger augite crystals, which occur in considerable abundance among some of the lava-flows, are often replaced by," &c. Now, here surely is evidence of *a sufficiency* being obtainable for analysis. The eye can be educated to such a use of the microscope as to be able to trace a gradual process of decomposition, but never to determine the composition of an unknown mineral.

COTTA also is in much the same position. In defining diabase, and enumerating its components, he says, "and some chlorite." "The green colour of the rock is chiefly owing to its chlorite." "The most marked feature of its difference from dolerite is its chlorite, and its consequent green colour. If this chlorite be a product of transmutation, then all the original difference between diabase and dolerite probably consists in the level or depth of solidification."

It is significant that COTTA does not enumerate chlorite among the minerals accessory to diabase in its clefts and veins; while he says, "The vesicular cavities are filled with chlorite, glauconite, and the like." It is well known that the veins of a rock contain the materials of its general structure in giant-development of crystals, while its amygdules and druses contain the products of the transmutation thereof, through aqueous change and transfer.

Lately, however, clearer light is beginning to be thrown on the matter, for we have DANA supporting ROSENBUSCH when he says that chlorite is not an essential characteristic of diabase; and those who look in Scotland for chlorite in rocks in all other respects entitled to the name of diabase will certainly find none.

If we are to accept and found upon the above admissions—namely, that the amygdules of these so-called chloritiferous-volcanics contain the material which, diffused in minute granular or flaky condition throughout their mass, imparts the occasional green tint, then my analyses have determined that material to be in no way connected with chlorite except in colour.

The results of the following investigation go to show that the minerals usually thrown together under the term which I somewhat unwillingly adopted as the heading of this chapter, are to be grouped under two absolutely distinct heads. For the first the old term of *the chlorites* may be retained; to the second the term *the saponites* may be applied, from the unctuous feeling which is a marked characteristic of them all.

So far as the evidence of over fifty analyses and much contingent observation entitles me to speak, the members of the first of these groups are found only in sedimentary and metamorphic rocks, never occurring in volcanics; the second are confined invariably to the latter, never being seen in the former class of rocks.

The members of first are not decomposed by chlorhydric acid, and there is no peculiarity in the manner in which their constituent water functions.

The members of second are (with one exception) readily decomposed by chlorhydric acid, and the mode in which a portion of their constituent water is held in combination is anomalous.

The first are to be regarded as constituents of the rock mass which contains them,—paragenetic in time with the minerals associated with them.

The second are products of the degradation of the primal constituents of the rock, and are compounds of a more stable nature than the originals which yielded them through a destructive change.

It has to be admitted that the minute granular or crypto-crystalline nature of certain of these minerals renders them extremely difficult of discrimination, but the above may safely be used as leading-lines for the separation of the two classes, and the distinctions which will enable us in future to identify the individual members will be noticed after the consideration of the whole.

So far as I have yet ascertained, the following members of each of these groups occur in this country :—

Chlorites.

Glaucanite.
Talc-chlorite.
Penninite.
Ripidolite.
Chlorite.
Chloritoid.

Saponites.

Delessite.
Chlorophæite.
Hullite.
Saponite.
Celadonite.

THE CHLORITES.

Many of the denser “chloritic minerals” are so crypto-crystalline in their structure that we can call in the aid of neither the goniometer nor the polariscope in their determination ; we are thus confined for the most part to physical

and chemical characters. Sooth to say, the first of these lend hardly any aid, if they do not even somewhat tend to confuse.

As thus : Taking DANA as usual as our English guide, we find the following ranges of specific gravities

	from	to
Of Penninite	2·6	2·85
Leuchtenbergite,	2·61	2·71
Ripidolite,	2·65	2·78
Chlorite,		2·78 2·96
Pyrosclerite,		2·74
Epichlorite,		2·76
Delessite,		2·89
Strigovite,		3·144
Thuringite,		3·151
		to
		3·197

From out of these, no one of which in their fine-grained or ill-defined forms can easily be distinguished from the others, only the two last can be selected as standing in any measure apart.

But even as regards the three commoner species, I cannot say that the evidence of such specimens, as analysis indicates to me should be placed under each of these species, bears out the ranges of specific gravity as limited by DANA.

In allocating them by constitution alone we have little difficulty as regards true chlorite. Its low content of silica, and to a certain extent its lower magnesia and water, and its high alumina and ferrous oxide, enable us clearly to draw the line between it and the others.

But the larger amount of alumina in ripidolite is the sole feature of distinction between that mineral and penninite.

Allocating the varieties I have analysed in accordance with these lines, I find the specific gravities to have the following ranges :—

	from	to
Of Penninite,	2·59	3·099
Ripidolite,		2·823 2·959
Chlorite,	2·697	3·038

Supposing my allocation to be correct, this shows that the three species do not differ in gravity.

Searching for aid from geognostic relationships we find little or none, and are again brought painfully in face of one of the shortcomings of mineralogical works, a shortcoming which I have already alluded to in speaking of the

micas,—namely, the dearth of information accorded to us by them, relating to the special rocks in which minerals are found, and also as to the other mineral species which are associated with them.

Even the ponderous and classical work of DANA tells us no more than the following :—

Penninite, “ with serpentine ;”

Ripidolite, “ in connection with chlorite and talcose rocks in schists and serpentine ;”

Chlorite, “ same as for ripidolite.”

There is certainly no geognostic distinction in this, and the evidence of the specimens analysed by me, so far from importing more precision, has an opposite effect; for, while it widens the geognostic scope of the occurrence of these minerals, it does so at the cost of opening up the habitats very much to each and all.

I speak only from evidence drawn from specimens actually analysed, and the record runs thus :—

Penninite,—serpentinous belt in hornblendic gneiss ; ditto in mica slate ; in serpentine ; *pseudophite* in uralitic diorite.

Ripidolite, in actynolitic belt in hornblendic gneiss ; in steatitic belts in chlorite slate ; in granular limestone in mica slate.

Chlorite, in serpentinous belt in mica slate ; in intrusive granite ; in quartzose belts in mica slate ; in granular limestone ; in mica slate and gneiss.

Were we to lay weight upon numerical evidence, or frequency of occurrence in each rock, we should have to make the record more confusing still, by saying that chlorite most frequently affects granular limestones and quartzose belts ; while penninite and ripidolite affect “ chloritic rocks.”

Premising then in these general remarks that the fine-grained varieties are arranged in virtue of their chemical features, I now give the analyses of each, considering the three more important species first.

Arranged in the order of their content of silica, they stand as on page 58.

PENNINITE.

From Serpentine in Hornblendic Gneiss.

1. From the island of Scalpa or Glass, near Harris.

A small promontory and a short stretch of the adjoining eastern coast of this island consists of a bed of serpentine ; this is regularly interstratified with

the gneiss, which dips to the south-east. The serpentine along the coast is very inaccessible, on account of its extending but little inland from a line of precipitous cliffs. The small protruding point was many years ago chosen as the site of a lighthouse. The works connected with the cutting a foundation platform, and the building of a pier exposed the stratum, and showed its relations to the gneiss. This spot acquired some interest shortly after the building of the lighthouse, on account of the mineral zircon having been first here found in the British Islands by PATRICK NEILL in 1811. The crystals of zircon, which are very minute, lie imbedded in the mineral analysed. This constitutes a bed of about a couple of feet in thickness; its colour is a very dark green; the larger bed is divided into smaller, differing somewhat in structure. The general mass which contains the zircon crystals is hard, somewhat coarse and slaty; it carries veins of steatite, Dolomite, and thinner portions of chlorite itself, of a structure which is softer, minute-granular, or even scaly. The scales, however, are so minute that they are hardly recognisable, and this closeness of structure has led to its having been called potstone; at least potstone has been said here to occur, and this is the only substance which I found at the locality likely to have been mistaken for it.

The specific gravity of this finer-grained and purer variety is 3·099.

1·628 grammes yielded—

Silica, . . .	·465		
From Alumina, .	·036		
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	·501	=	30·405
Alumina, . . .			11·58
Ferric Oxide, . .			2·343
Ferrous Oxide, . .			10·71
Manganous Oxide, .			1·19
Lime, . . .			trace
Magnesia, . . .			30·634
Potash, . . .			·01
Soda, . . .			1·306
Water, . . .			11·743
			<hr/>
			99·921

1·3 per cent. of the silica were insoluble. It possibly contained a very minute quantity of magnetite, as crystals of this were seen in other specimens.

2. From half a mile south of the farm of Corrycharmaig in Glen Lochy, Perthshire.

The rock of the district is a mica-schist, with veins of a peculiar claret-coloured hyaline quartz carrying chlorite and rutile.

At the locality whence the mineral was taken, chromite had been wrought.

It occurred in a highly tortuous vein, which, with its veinstone, was about six feet wide. This vein runs in a general sense along the strike.

A considerable quantity of penninite lay about the old workings, but pure pieces were rare; it was also associated with picrolite and "baltimorite."

The first specimen I saw I obtained from the dealer DORAN, who sold it as Leuchtenbergite: this differed from any specimen I have seen either on the spot or elsewhere in Scotland. It consisted of a band or layer of foliated crystals of half an inch or more in thickness, said crystals lying transverse to the sides of the layer. Its colour was leek green. The specimens I obtained on the spot were of a dark-green colour: they all consisted of masses of foliaceous crystals of half an inch in size, but these all lay in parallel arrangement with the rock matrix. Their lustre was high, and not pearly. Specific gravity, $2 \cdot 895$.

1·542 grammes yielded—

Silica, . . .	·505		
From Alumina, .	·024		
	<hr/>		
	·529	=	34·306
Alumina, . . .			13·64
Chromium Sesquioxide, .			trace
Ferric Oxide, . . .			·364
Ferrous Oxide, . . .			10·305
Manganous Oxide, . . .			·227
Lime,			8·97
Magnesia,			18·041
Potash,			1·36
Soda,			·13
Water,			12·407
			<hr/>
			99·75

Insoluble silica, $6 \cdot 79$. Was apparently quite pure.

3. *Kammererite*.—This chromiferous variety I first found in Britain in the year 1848. It occurred in a granular massive form in considerable quantity in the great quarry of chromite at Hagdale in Unst, Shetland. Its colour is purple to bluish purple. It ordinarily contains nodules of the size of shot, which are quite granular, and probably differ in composition. These were removed. Rarely it is foliaceous, and still more rarely regular imbedded hexagonal crystals are to be seen; these are less than a quarter of an inch in size. They are pale violet in colour, and sometimes light green. They are readily cleavable into thin foliæ.

Of the massive variety, which was analysed, the specific gravity is $3 \cdot 099$.

The analysis on 25 grains yielded—

Silica,	29·894
Alumina,	12·931
Chromium Sesquioxide,	5·967
Ferrous Oxide,	1·955
Nickel Oxide,	trace
Lime,	3·54
Magnesia,	29·933
Potash,	1·156
Soda,	·974
Water,	13·266
Carbonic Acid,	trace
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	99·616

4. Five and twenty years after the first discovery of this very rare mineral in Unst, it was again obtained by Mr DUDGEON and myself among the vein-stones of a new chromite quarry which lay to the north-west of the House of Bunness, some two miles from the original locality. It was here occasionally in fairly well-formed crystals, which are elongated rhombohedra.

The cleavage foliæ of these crystals are optically uniaxial, or with a very slight axial divergence. Their colour is a bright purple. They are over a quarter of an inch in length and breadth.

1·3 grammes yielded—

Silica,	·401		
From Alumina,	·019		
	<hr/>		
	·42	=	32·307
Alumina,			7·497
Chromium Sesquioxide,			7·888
Ferrous Oxide,			2·076
Lime,			3·833
Magnesia,			32·153
Water,			14·246
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			99·90

Insoluble silica, 5·233. Was apparently pure.

At both of the above localities of Kammererite it was associated with a pulverulent substance of a light-yellow colour. Analysis showed this substance to be new. I have elsewhere described it under the name of *Hibbertite*.

5. *Pseudophite*.—This allomorph, which I now introduce as new to Britain, was obtained by Professor NICOL and myself from the east side of Beauty Hill, in Aberdeenshire.

It occurred in thin veins in a gabbro, which was composed of apparently a dark granular augite or uraltite, the crystals of which, of the size of large shot, were singly imbedded in a waxy-looking massive labradorite,—“Saussurite” (?)

The veins were sharply defined, but the labradorite was seen within an inch or so of the veins to become greenish in colour and *actually to pass by insensible gradation* into the mineral described.

The colour of this substance in the veins was pale sap-green: it was translucent, tough, and like slate-pencil, and had a specific gravity of 2·59. There were no associated minerals.

1·264 grammes yielded—

Silica, . . .	·431		
From Alumina, .	·008		
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	·439	=	34·731
Alumina, . . .			12·444
Ferrous Oxide, .			2·684
Manganous Oxide, .			1·17
Lime, . . .			1·595
Magnesia, . . .			34·098
Water, . . .			13·1
			<hr/>
			99·822

Insoluble silica, 6·834 per cent. The specimen analysed was perfectly pure.

Since the above analysis was made, my attention has been particularly directed to *pyrosclerite* by Professor KING of Galway, with a view to the correlation of the gneissic limestones of the west of Scotland with those of Connemarra in Ireland.

The Beauty Hill mineral differs from a specimen of pyrosclerite sent to me by Professor KING as from Elba, in the single respect of being somewhat harder, perhaps also in being a little paler in colour. But it is a question if the Elba mineral is truly pyrosclerite.

DANA makes pyrosclerite a micaceous mineral, with eminent cleavages; pseudophite he refers to as compact-massive, and without cleavages; in other physical characters, as well as in chemical composition, they are almost identical; and if, as is held, pyrosclerite occurs in a colloidal state, it is not easy to see how any line can be drawn between the two.

As regards the present mineral, considered in the light of the slight differences which do exist between them in their typical forms, it more agrees with pyrosclerite in hardness,—with pseudophite in gravity and in structure,—while its being apparently an alteration product of a *felspar*, is a feature which has as yet been assigned to neither. As certain of the “colloidal pyrosclerites” sent me by Professor KING, both from St Phillipe in the Vosges, and from Ireland, very much resemble pseudomorphs (set down as serpentine after

sahlite), which occurs in the Glenelg limestone, and also thin veins which cut the serpentine of Portsoy (set down as being precious serpentine), I shall, after analysing these, take this question up in treating of the serpentines.

RIPIDOLITE.

From Limestone in Mica Slate.

1. It is probably the continuation of the great bed of limestone which courses down Glen Tilt which crosses the Garry to the south of the village of Blair Athol, and which then curves westward by the Allt Bhaic.

A small quarry of this limestone has been wrought on the south side of the stream, under the slopes of the Hill of Tulloch.

The highly plicated beds of the lime contain scaly masses and rosette crystallisations of ripidolite associated with Biotite and quartz. The ripidolite is pale olive green in colour, and has a pearly lustre.

The rosettes have a hexagonal *arrangement*, but the structure is not sufficiently simple and evident to allow of the form being determined.

1·34 grammes yielded—

Silica,	·383		
From Alumina, .	·023		
	<u>·406</u>	=	30·298
Alumina,			19·397
Ferrous Oxide, .			8·232
Manganous Oxide, .			·373
Magnesia,			29·104
Water,			13·07
			<u>100·474</u>

Insoluble silica, 6·182 per cent.

A perfectly similar mineral occurs in a limestone quarry north-east of Edintian; this lime is probably the continuation of the Lude bed. The associates here are pyrrhotine, Biotite, sphene, and ilmenite.

From Chlorite Slate.

2. The southern half of the promontory of Hillswickness in the mainland of Shetland is composed of rocks which may be grouped under the above name.

At a point on the south-west shore of that ness, near the prominent Gardie Stack, there is a crevice called Sandy Geo. Stakes of wood are driven into the turf, from which the islanders suspend themselves by ropes while gathering sea-weed from the foot of the cliffs. By the exercise of extreme care, however, ropes may for a certain part of the descent be dispensed with, and a bed of steatite which protrudes from the slippery bank be reached. This bed has—as has another such in Shetland—been applied by the Shetlanders to the singular purpose of serving as a record of pledged vows—the names of the engaging parties being carved, with date attached, into the steatite. Numerous single individuals have, however, by the exercise of their graphic powers, profaned this sanctuary.

The locality is called the Klebber-names,—Klebber being the Norwegian name for steatite.

The greater mass of the steatite here, if it be steatite, is of a purplish-red colour. Disposed throughout it, and perhaps chiefly in those portions which are somewhat green in colour, are numerous isolated rosette crystallisations, nearly spherical in form, and the centre of each sphere is occupied by an octohedral crystal of magnetite.

As the crystals of the magnetite are of sharply and regularly developed form, of a fine blue colour and a high lustre, they contrast well with the ripidolite, the diverging plates of which are smooth, of high transparency, and a beautiful emerald green. There are thus formed specimens of so singular an appearance that the small size of their parts alone prevents their being regarded as among the most striking of Scottish minerals.

The form of the individual crystals of the fan-shaped radiations cannot, from their small size, be determined. Their minuteness also alone prevented investigation of their optical properties, for they were perfectly transparent.

1·275 grammes yielded—

Silica, . . .	·41		
From Alumina, .	·005		
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	·415	=	32·549
Alumina, . . .			13·95
Ferrie Oxide, . . .			·972
Ferrous Oxide, . . .			5·275
Manganous Oxide, . . .			·156
Lime, . . .			·79
Magnesia, . . .			32·785
Potash, . . .			·48
Soda, . . .			·062
Water, . . .			13·173
			<hr/>
			100·192

Insoluble silica, 4·819 per cent. ; loses 1·961 per cent. of water in the bath.

From Hornblendic Gneiss.

3. At the grandly picturesque headland of Cape Wrath,—or more correctly Rath,—the hornblendic gneiss of the west coast differs in its features very considerably from those which it possesses elsewhere, and which may be said to be almost unvarying. The dip here is low, and to the east or east-south-east. It is highly corrugated and folded, and it is rent and shifted and reagglutinated by an anastomosing and mutually intersecting series of granitic veins. Its own granitic belts, instead of assuming as elsewhere much of the character of a set of parallel dykes, with abrupt and sharply-marked surfaces, blend by insensible gradation into the ordinary material of the rock, which is here even somewhat of the nature of granite itself.

It is this greater consistency of the rock as a whole, this more intimate interpenetration and consequent firmer cohesion of its parts, coupled with the altogether unique manner in which its every layer is bound together by granitic cords of unusual toughness—interlaced in such a manner as to defy unravelling—that has enabled it to form so fitting a termination to a kingdom,—so enduring a rampart against even Atlantic billows.

Such are the features of the rock for about a mile to east and south of the lighthouse. Another feature has, however, to be noticed ; it is, within the space so included, much less characterised by the presence of particles of hornblende than is usual, being of a pinkish instead of a green cast of colour. This local deficiency of hornblende is, however, more than compensated for at a point about one and a half miles south of the lighthouse, where the strata have gradually increased their dip, and assumed a line of outcrop which is that normal to the rock in the south. Here the beds suddenly become almost alternately hornblendic and felspathic ; and as the intermediate felspathic bands have frequently yielded to the weather, those which are hornblendic stand erect in repeated sequence, simulating dykes of a dark igneous rock.

Just about the same spot also, in cove-like recesses of the older rock, the horizontal strata of that many-coloured conglomerate which has been assigned to the Cambrian epoch, make their appearance in outlying portions of very circumscribed dimensions.

In the second (in progressing southward) of these coves of the Cambrian Sea,—one which is now sentinelled on the north by a grand development of the black bands of the older rock, and on the south by an equally grand illustration of intrusively anastomosing granite,—my companion, Professor GEIKIE, and I hit upon an interesting mineral locality.

This is situated on the grassy bank, only some few feet below where the conglomerate reposes in horizontal and peacefully rectilinear beds upon the denuded gneiss, which dips from the under surface of these beds almost at right angles thereto.

The first of these erected beds to which interest attaches, carries hydrous anthophyllite, amianthus, and a jasper-like chert; the second, which is some twenty yards to the south, contains a layer of ripidolite in close association with lavender-grey steatite and actynolitic hornblende.

A year after our discovery of this mineral locality, the present writer found two other localities which lie in similar recesses among the rocks some little distance to the south. These contain the ripidolite in much larger quantity, but here its only associate is hornblende.

This ripidolite forms belts in the rock, which consist of a mass of nearly parallel scales, of about the size of peas. They have a greasy lustre, and a blackish-green colour. Specific gravity, $2 \cdot 823$.

$1 \cdot 102$ grammes yielded—

Silica, . . .	·331		
From Alumina, .	·011		
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	342	=	31·034
Alumina, . . .			14·845
Ferric Oxide, . . .			5·73
Ferrous Oxide, . . .			17·417
Manganous Oxide, . . .			·998
Lime, . . .			·355
Magnesia, . . .			17·422
Water, . . .			12·481
			<hr/>
			100·292

·802 per cent. of the water were given off in the bath. Was apparently pure; possible impurity, hornblende.

4. *Aphrosiderite*.—I retain for the specimens now to be noticed the name assigned to them by GREG, as their high content of iron entitles them thereto.

They occur in the chlorite-slate of the south-west of Scotland. An analysis probably of this variety from Bute by VARRENTRAPP is to be found in GREG and LETTSOM'S "Manual of Mineralogy." It occurs in large masses along with quartz in the scars on the east side of the Bishop's Hill above Dunoon. Here the structure is coarse and loose scaly, and the colour light green. Imbedded in quartz boulders which lie in the mouth of the stream (the Dirty Burn) which descends from these scars, the mineral is found in a brilliant dark-green minute

scaly form. It is here associated with wad and pyrite. Its specific gravity is 2·959.

1·381 grammes yielded—

Silica, . . .	·475		
From Alumina, .	·014		
	<hr/>		
	·489	=	35·409
Alumina, . . .			18·081
Ferric Oxide, . . .			·484
Ferrous Oxide, . . .			26·466
Manganous Oxide, . . .			·608
Lime, . . .			1·013
Magnesia, . . .			8·767
Potash, . . .			·977
Soda, . . .			·522
Water, . . .			8·028
			<hr/>
			100·355

The silica here is large in amount. In other respects the analysis is similar to that of the aphrosiderite from Bonschener analysed by ERLÉNMEYER. It is *possible* that in several of these minutely foliated chlorites there may be interstitial quartz, but it is not probable that it would have escaped notice in the grinding in the smooth agate mortar.

CHLORITE.

From Micaceous Gneiss.

1. The first occurrence I notice was in a serpentinous series of beds, which are interstratified with the gneiss of the north point of the Mainland of Shetland; this point is called Fethaland.

At a small bight termed Pundy Geo there is a bed of massive chlorite of a fine colour, which carries large crystals of magnetite. In association with this there is a picrolitic bed. The gneiss here being almost destitute of felspar, has much of the character of mica slate.

The chlorite here is of a very pure appearance: it has a minutely granular structure composed of foliated crystals confusedly matted together. Its colour is bright green. It is so pervaded with crystals of magnetite that a portion sufficiently free therefrom could not be got for the determination of the specific gravity.

1 · gramme yielded—

Silica, . . .	· 239		
From Alumina, .	· 004		
	<hr/>		
	· 243	=	24 · 3
Alumina, . . .			20 · 858
Ferric Oxide, . . .			3 · 567
Ferrous Oxide, . . .			16 · 718
Manganous Oxide, . . .			· 55
Lime, . . .			· 504
Magnesia, . . .			22 · 2
Water, . . .			11 · 547
			<hr/>
			100 · 244

From Mica Slate.

2. The great band of this rock which passes from north-east to south-west through the lower Highlands of Scotland is everywhere characterised by thin rifts and layers of quartz, which presents features which are markedly different in the different districts where the rock occurs; and there are three very characteristic *bands* of quartz which follow its strike, though not without frequent interruptions in the continuity of their course.

The rock itself is not possessed of well-marked features until in traversing westward we reach the neighbourhood of Ben Bhrackie. Here the quartz presents itself in nodules and laminæ; these are much flawed, and they are characterised by having every here and there a disposition to a yellow coloration, which is sometimes very brilliant. The yellow appears sometimes only disposed in spots, in either a milk-white or in a colourless variety. It has much the appearance of staining; but from the coloration appearing frequently in the interior of the stone and not on its surface, it can be no staining from without, even if we admitted that an outside stain could do more than lodge in cracks.

After having collected specimens of this bright yellow quartz from many localities, I have discovered it to be due to the decomposition of crystals of pyrite; these, now converted in greater part into limonite, lie in the centre of the coloured portions.

I have said that this yellow quartz is first seen on the hill of Ben Bhrackie ; it re-appears with even a red hue on the ridge to the east of the Hill of Tulloch, and it may be found here and again—notably on Ben Derag in Glen Lyon, Meall Luaidhe, and Meall Ghaordie (Girdy), along the whole ridge as far as the north slopes of Fiarach near Crianlarich, and the col between Ben Yoss and Ben Laoigh (Loy).

Parallel to but north of the belt of yellow quartz, there occurs a more strongly developed snow-white saccharoid variety ; but this is also found in quartzose gneiss, as on the east slopes of Carn Aosda and Carn Chrionaidh in Glen Clunie, and the south-east slopes of Ben Uran ; it is not in that rock, however, by any means so strongly developed as in the mica slate.

Of its localities in the latter rock, in none is it so strongly developed as in a knoll to the north-east of the summit of Meall Ghaordie ; on the south-west side of this knoll it forms layers of nearly a foot in thickness, and of a purity of colour which was quite equal to the snow out of which I once quarried it.

In a nearly parallel arrangement to the above yellow and white belts, but to the south of both, lies the third, which is quite as marked in its peculiar features.

In the most characteristic specimens, such as are found in the gorge of the Loch of Chat, between Meall Garabh and Ben Lawers, at the foot of the cliffs of Craig Cailleach, and in greatest abundance in the Creag Mohr of Glen Lochy, it may be said to present itself as a hyaline *colloidal* cairngorm.

I purposely use the italicised word to give force to the peculiarity of its appearance, which is that of a large mass of gum, being never crystallised, and having a more than ordinary vitreous lustre.

The colour here, in the finest specimens, is somewhat like that of the finer varieties of cairngorm, but it is very much more delicate, being of a pale brown, markedly dashed with an amethystine tint,—it might be almost called a watery claret.

When cut, it forms stones much to be preferred to any of the brown varieties of the cairngorm.

Now, this variety of quartz, in its finest specimens, carries filaments of rutile—*Venus' hair*—and chlorite. When degraded somewhat in colour it still carries chlorite ; and when still further degraded almost to a muddy white, when it is still somewhat hyaline, it carries ilmenite.

The range of this variety may be said to commence on the western slopes of Meall Gruaidh (Croy) ; to be chloritic and rutiliferous to near Crianlarich ; to carry ilmenite from Craig Cailleach, Ben More, and the group around the pic-

turesque Cruach Ardran, as far south at least as the slopes of Ben Ima; and to be chloritic from Ben Derag of Glen Lyon, probably nearly to Macrahanish Bay in Kintyre.

From this stretch I obtained specimens fitted for analysis and also for forming cabinet specimens from the following places:—The west slopes of Ben Derag; Craig-an-Lochan; south-west of Meall Ptarmichan; Cruach Ardran; and Ben Laoigh.

I do not, however, know of rich specimens beyond the south-eastern slopes of the Ben Laoigh.*

Of specimens from the above localities I analysed the following:—

2. From the west slopes of Ben Derag of Glen Lyon.—Associated with quartz: colour, grass-green; structure, matted fine crystals, very dense. Specific gravity, 3·002.

On 1·491 grammes—

Silica, . . .	·3645		
From Alumina, . .	·004		
	<hr/>		
	·3685	=	24·715
Alumina, . . .	21·566		21·657
Ferric Oxide, . . .	·615		
Ferrous Oxide, . . .	26·164		27·025
Manganous Oxide, . .	·47		
Lime, . . .	·45		
Magnesia, . . .	12·86		12·8
Potash, . . .	1·726		
Soda, . . .	·054		
Water, . . .	10·886		
	<hr/>		
			99·506

This is an *aphrosiderite*.

3. From beneath the cliffs of Craig-an-Lochan, Perthshire.—Occurs in quartz of a brown colour, as a confused mass of brilliant dark green minute crystals, rarely slightly brown from weathering; associated very rarely with ilmenite and large flat transparent foliæ of chlorite (?) of a lighter green, which are imbedded in quartz in single plates. Specific gravity 2·697.

* The Old Red Conglomerate at Callendar contains rarely quartz nodules, with chlorite, very similar in appearance to that of Cruach Ardran.

On 1·519 grammes—

Silica, . . .	·363		
From Alumina, .	·006		
	<hr/>		
	·369	=	24·292
Alumina, . . .			21·147
Ferric Oxide, . .			·101
Ferrous Oxide, . .			18·739
Manganous Oxide, .			·8
Lime, . . .			1·659
Magnesia, . . .			21·033
Potash, . . .			1·286
Soda, . . .			·564
Water, . . .			10·083
			<hr/>
			99·704

8·13 per cent. of the silica insoluble.

From Granular Limestone in Mica Slate.

4. The bed of limestone which appears near the house of Lude, running parallel to that of Glen Tilt, contains small imbedded masses of a pale olive-green colour, sometimes slightly browned. The structure is minute scaly, and the scales are so soft that the mineral has been thought to be “potstone.” Specific gravity 2·852.

1·4635 grammes yielded—

Silica, . . .	·332		
From Alumina, .	·019		
	<hr/>		
	·351	=	23·922
Alumina, . . .			22·976
Ferric Oxide, . .			1·106
Ferrous Oxide, . .			19·54
Manganous Oxide, .			·28
Lime, . . .			2·453
Magnesia, . . .			17·259
Water, . . .			11·784
			<hr/>
			99·39

5·67 per cent. of the silica was insoluble: possible impurity, lime.

5. In the same quarry, translucent quartz in layers rarely cuts the lime; and this quartz contains chlorite, which differs from the above only in being of a

bright-green colour. It was examined to see if the difference of the matrix affected the composition of the mineral to any marked extent. Its specific gravity also is 2·852.

1·396 grammes yielded—

Silica,	24·66
Alumina,	23·19
Ferric Oxide,	·636
Ferrous Oxide,	20·579
Manganous Oxide,	·29
Lime,	·4
Magnesia,	17·79
Water,	12·119
	<hr/>
	99·664

5·56 per cent. of the silica were insoluble.

The same quarry contains bands of a dark, dense, granular rock rather than mineral; this is perhaps entitled to the name of potstone.

6. A bed of limestone is seen on the highway about a mile east of Loch Laggan in Inverness-shire. This contains much very fine granular chlorite, of a grass-green colour. It is here very soft, and has a specific gravity of 2·834.

It contains, imbedded in its mass, large plates of brown Biotite.

1·586 grammes gave—

Silica,	26·25
Alumina,	19·22
Ferric Oxide,	1·67
Ferrous Oxide,	16·44
Manganous Oxide,	1·02
Magnesia,	24·35
Water,	11·67
	<hr/>
	100·62

Insoluble silica, 2 per cent.; possible impurity, Biotite.

From Chlorite Slate.

7. The stone of which the houses of Portsoy in Banffshire are built is obtained from a quarry of a very calcareous clay slate, situated on the sea-shore a little to the west of the town. Immediately to the east of this, the first rock seen is a chlorite-slate, or rock; this occurs as a high-tilted bed, dipping south-east. It contains fragmentary and angular masses of dense hornblende rock,

imbedded in a most peculiar manner, and occasional nodules and layers of plicated foliæ of chlorite. These are much intermixed with grains of quartz.

The colour of this chlorite is bright green, mixed with plates of a golden yellow; the lustre is high. It is soft and unctuous. The specific gravity of a portion, apparently nearly free from quartz, was 2·792.

25 grains yielded—

Silica,	26·71
Alumina,	20·424
Ferric Oxide,	3·472
Ferrous Oxide,	13·993
Lime,	·726
Magnesia,	23·896
Water,	11·17
	<hr/>
	100·391

The golden colour may be the result of peroxidation.

From intrusive (?) Granite.

8. The gneiss of the Girdleness, in Kincardineshire, is riddled on both sides of the point with tortuous intrusive veins of granite. One of these, cut across in sinking for the foundations of the new breakwater for the Aberdeen harbour, yielded, in small quantities, small crystals of orthoclase, with epidote and small scaly chlorite.

This chlorite is of a dark-green colour and a high lustre; it sheathes the crystals of orthoclase, which are pale red in colour. Decomposed crystals of pyrite are imbedded both in the chlorite and in the orthoclase. The specific gravity of the chlorite is 3·038.

1·304 grammes yielded—

Silica,	·315	
From Alumina,	·008	
	<hr/>	
	·323	= 24·769
Alumina,	20·164	
Ferric Oxide,	1·381	
Ferrous Oxide,	27·368	
Manganous Oxide,	·613	
Lime,	·901	
Magnesia,	13·343	
Water,	12·051	
	<hr/>	
		100·59

Loses 1·453 per cent. of water in the bath.

Chlorite occurs extremely rarely in Scotland in granite. One specimen of a substance which I take to be it was got at Rubislaw.

That the goniometer and polariscope can effect the discrimination of well-

crystallised or large-foliated varieties of these three minerals must be admitted; but of the specimens in the succeeding table (p. 80) the following would, after *mere ocular inspection*, be set aside as one and the same.

Scalpay, Bishop's Hill, Fethaland, Ben Derag, Lude, Loch Laggan, and Girdleness; these—which include the *three* species—would be generally regarded as fine-grained massive chlorite.

Craig-an-Lochan, Portsoy, and specimens from Vanlup, Hillswick, and Ben Laoigh, Argyll, would be regarded as large-grained foliated chlorite.

Corrycharmaig, Cape Wrath, and Blair Athol—which include *two* species—would be considered to be all ripidolite.

Again, Bishop's Hill, Ben Derag, and Girdleness, may, as regards the amount of iron, be all regarded as aphrosiderites.

As regards the amount of silica, alumina, and water, those ranked as chlorites seem to stand apart; but, in the other ingredients, the three seem so to run into one another, that the question arises whether one and the same substance be not trimorphic.

The finest rosette crystallisations of chlorite I have found in Scotland occurred at Glen Effoch in Tarffside, in mica schist; on the south-west slopes of Aonach Beg, Inverness-shire; and, along with sphene and fluor in limestone, at “the three burns” south of Gaulrig in Glen Avon. JAMESON mentions its occurrence in fine crystals upon the road from Ardsin to the harbour of the Small Isles in Jura.

CHLORITOID.

1. This mineral is inserted here on account of its name expressing some relation to those first considered, and also from its geognostic relationships being similar. I have also found passages in geological works in which “chloritoidal schists” and “chloritoidal rocks” were referred to, and I quite believe that the name was there employed under the supposition that the word was synonymous with chloritic. It is very probable that the mineral itself was quite unknown to the writers, the present notice being the first occasion on which it has been introduced as a British species.

I obtained it some twenty years ago at Vanlup, Hillswickness, Shetland, imbedded in quartz veins, in close association with kyanite and margarodite. The including rock is a margarodite-schist, generally considered a talc-schist.

The colour of the first specimen found was misleading as regards its nature, being clove or chocolate brown, from a partial peroxidation of its iron.

Its lustre was shining, slightly pearly. Streak greyish. Cleavage basal, perfect, but interrupted; parallel to two lateral planes, imperfect and rough.

Structure foliated. Was in rough lozenge-shaped crystals, which were apparently monoclinic. Brittle.

Hardness, 5·5 on the cleavage plane, 6· on the lateral. Specific gravity, 3·356.

On 1·305 grammes—

Silica,	·302		
From Alumina, . .	·029		
	<hr/>		
	·331	=	25·363
Alumina,			41·736
Ferric Oxide, . . .			3·895
Ferrous Oxide, . .			13·932
Manganous Oxide, .			·919
Lime,			·901
Magnesia,			6·82
Water,			6·571
			<hr/>
			100·137

Insoluble silica 4·58 per cent.

2. The above analysis having disclosed the nature of the substances which I had regarded as that which had been by some considered Babingtonite, I found upon breaking up masses of the rock that deeper-seated crystals were of a fine dark-green colour; and during a late visit to Shetland, in company with Mr DUDGEON, I refound the mineral, and was thus enabled to examine perfectly unaltered specimens.

These we obtained at the same spot, imbedded in reddish vitreous massive quartz-veins of mica slate, associated with margarodite and pale yellow sphene.

The colour was dark green, the lustre shining and pearly, the streak pale greenish-grey. The specific gravity from 3·313 to 3·462.

24·3 grains yielded—

Silica,	5·746		
From Alumina, . .	·2		
	<hr/>		
	5·946	=	24·47
Alumina,			41·336
Ferric Oxide, . . .			·383
Ferrous Oxide, . .			18·522
Manganous Oxide, .			·913
Lime,			·302
Magnesia,			6·8
Water,			6·98
			<hr/>
			99·706

Insoluble silica, 3·66 per cent.

TALC-CHLORITE.

The composition of this mineral is expressed, as shown by DANA, by the same general formula as that of pyrosclerite; but a considerable quantity of ferrous oxide here replaces magnesia.

Its specific individuality cannot be said to have been hitherto absolutely determined; it rests upon three closely accordant analyses by MARIGNAC, and an optical determination by DESCLOIZEAUX.

DANA, referring to the excess of its silica above that contained in ripidolite, remarks that "it is possibly ripidolite impure from mixture with talc;" but it is extremely improbable that DESCLOIZEAUX would not have detected such an admixture either while preparing plates for the polariscope, or during the employment of the instrument.

The mineral, I now notice, goes a certain length in aiding in establishing the species.

It was found forming a vein, which occurred on the foreshore, to the south of the Banks of the Nudister, at Hillswick, in Shetland. This vein was associated with a similar one of Biotite. The substance, being damp from recent marine submergence, could be raised in spadefuls. It formed a pulpy and slimy mass of minute glistening scales. These were floated in water to remove adhering salt, and being frequently examined during successive decantations, were seen to be absolutely free from talc, or any impurity.

Their colour was grass-green, with a peculiar bronzy or golden lustre in certain directions. Their lustre was more pearly than that of chlorite or ripidolite. They were exceedingly smooth to the touch.

1·3 grammes yielded—

		Marignac.
Silica,	39·81	39·87
Alumina,	11·432	11·91
Ferrous Oxide,	7·974	11·34
Manganous Oxide,	·259	...
Lime,	2·804	...
Magnesia,	25·648	28·76
Potash,	1·203	...
Soda,	3·152	...
Water,	7·913	7·98
	<hr/> 100·194	

The air-dried mineral lost at 212°, 10·945 of water in addition to the above; a feature sufficing to distinguish it from either ripidolite or talc.

A "chloritic mineral," differing from this merely in a greater brightness of colour and lustre, occurs a little west of Portsoy.

The average of MARIGNAC'S three analyses is appended for comparison.

GLAUCONITE.

1. In company with Dr GORDON of Birnie, Professor NICOL, and Mr DUDGEON, I found this mineral—new to Scotland—in a kind of cornstone quarry at Ashgrove, near Elgin.

It occurs, along with a manganesian calcite and well-crystallised pyrite, acting as an occasional cement of the nodular masses of lime. It is a very soft and friable, somewhat dull-green powder; rarely a bright light-green.

1·32 grammes afforded—

Silica, . . .	·644		
From Alumina, . . .	·004		
	<hr/>		
	·648	=	49·09
Alumina, . . .			15·206
Ferric Oxide . . .			10·565
Ferrous Oxide, . . .			3·056
Lime, . . .			·551
Magnesia. . . .			2·651
Potash, . . .			6·052
Soda, . . .			1·205
Water, . . .			11·641
			<hr/>
			100·017

Loses 6·03 of the above water at 212°. It was readily decomposed by acids. Glauconite possibly occurs in some of the silurian limestones of Ayrshire.

THE SAPONITES.

DELESSITE.

From Igneous Rocks of Old Red Sandstone Age.

1. At St Cyrus, north of Montrose, there is a great cliff (a raised beach being between it and the sea) composed of thick beds of conglomerate, with occasional interstrata of amygdaloid. This amygdaloid is studded with agates filling long pipe-shaped steam-holes. These agates are for the most part coated with light-green, translucent, vitreous-lustered celadonite; but the steam-holes themselves are also frequently entirely filled with Delessite.

The structure of the Delessite is scaly,—perfectly recognisable here from the large size of the scales; the colour is sap-green, sometimes passing into red. It is translucent, and scratches easily with the nail.

The specific gravity is 2·652.

The red variety is much of the colour of brick, and seems sometimes pseudo after natrolite; this may be bole (plynthite).

Some specimens of the green variety on being pounded become brownish-red during the progress; this seemed to be partly due to the presence of minute quantities of the red mineral.

Of the pure green 1·3 gramme yielded—

Silica, . . .	·419		
From Alumina, . . .	·006		
	<hr/>		
	·425	=	32·692
Alumina, . . .			13·435
Ferrie Oxide . . .			4·397
Ferrous Oxide, . . .			6·624
Lime, . . .			·861
Magnesia . . .			28·769
Water, . . .			13·245
			<hr/>
			100·023

Of the above water, 2·774 was lost at the temperature of 212°.

2. In the dense igneous rock above Bowling Quarry, on the Clyde, and between it and Glen Arbuck, this mineral occurs of a close, minutely-foliated structure, and a very dark-green, almost black colour. It is softer than the nail and has a specific gravity of 2·573. Its streak is pale green.

1·3 grammes yielded—

Silica, . . .	·401		
From Alumina, .	·015		
	<hr/>		
	·416	=	32·
Alumina, . . .			17·328
Ferric Oxide, . . .			1·187
Ferrous Oxide, . . .			12·446
Lime, . . .			1·569
Magnesia, . . .			20·423
Water, . . .			15·45
			<hr/>
			100·403

Loses 5·7 per cent of water at 212°; insoluble silica, 5·79 per cent.

3. From Dumbuck, on the Clyde.—Occurs in imbedded patches up to the size of beans, in a somewhat decomposing porphyritic trap, a little north of Dumbuck hill. These small masses are frequently irregular in shape, and do not seem as if they had filled cavities which had been pre-existent. The rock contains in association decomposing augite (Ferrite, of WALLACE YOUNG), olivine, and calcite.

The Delessite is of a very dark-green colour, but is markedly lighter in hue when first exposed; it is very soft, has a minutely-foliated structure, and a specific gravity of 2·598.

1·3028 grammes yielded—

Silica, . . .	·398		
From Alumina, .	·019		
	<hr/>		
	·417	=	32·014
Alumina, . . .			18·874
Ferric Oxide, . . .			1·181
Ferrous Oxide, . . .			12·087
Manganous Oxide, . . .			trace
Lime, . . .			1·389
Magnesia, . . .			19·643
Water, . . .			15·456
			<hr/>
			100·644

Lost 6·3 of water at 212°; insoluble silica, 8·893 per cent.

4. Occurs in a porphyritic amygdaloid, along with zeolites, at the Long Craig, Dumbartonshire. Colour very dark green, structure massive-granular, rarely glistening. Specific gravity, 2·656.

The first specimen I have from this locality was given to me by the late ALEXANDER BRYSON.

On 1·303 grammes—

Silica, . . .	·399		
From Alumina, . . .	·004		
	<hr/>		
	·403	=	30·928
Alumina, . . .			15·323
Ferric Oxide, . . .			3·162
Ferrous Oxide, . . .			15·309
Manganous Oxide, . . .			·383
Lime, . . .			1·375
Magnesia, . . .			18·649
Water, . . .			14·692
			<hr/>
			99·821

Loses 4·678 of water at 212°; insoluble silica, 2·727 per cent.

From Igneous Rocks intruded among the Coal Measures.

5. About a mile east of the town of Elie, in Fifeshire, two vertical basalt dykes cut tufa.

Small cavities in these dykes are filled with this mineral, which is associated with massive iserine, rarely olivine, and still more rarely fragments of pyrope. Its colour is dark green, it is very minutely scaly, and it is very soft. Its specific gravity is 2·672.

On 1·3 grammes—

Silica, . . .	·391		
From Alumina, . . .	·008		
	<hr/>		
	·399	=	30·692
Alumina, . . .			12·83
Ferric Oxide, . . .			1·627
Ferrous Oxide, . . .			18·315
Manganous Oxide, . . .			1·
Lime, . . .			1·593
Magnesia, . . .			18·6
Potash, . . .			·567
Soda, . . .			1·112
Water, . . .			13·773
			<hr/>
			100·109

Loses 3·389 of water at 212°.

There is every probability that this is the substance mentioned by MACCULLOCH, under the name of chlorophæite, as occurring in Fife.

It is to be observed of all these Delessites that they darken in colour after

their first exposure. The water which is given out when heated to 212° is recovered upon mere exposure to an atmosphere in a normal condition as regards its dampness.

There is so much of this mineral exposed upon the surface of the rock about Dumbuck that it cannot, in virtue of the manner in which it functions as regards the nature of the grasp with which it holds part of its water, but affect to a certain extent the state of the atmosphere in the neighbourhood,—moistening it while the sun heats up the rock, and dessicating it in cold weather.

6. There is an alkali-charged variety of this mineral which is found filling small nests in this tufa of Elie Ness near the old Summer-House. This is similar in all external characters to the others, but contains—

Silica,	33·863
Alumina,	6·589
Ferric Oxide,	1·232
Ferrous Oxide,	14·84
Manganous Oxide,	·246
Lime,	1·385
Magnesia,	18·988
Potash,	3·048
Soda,	5·274
Water,	15·07
	<hr/>
	100·535

Loses 5·556 of water at 212° .

Substances similar in general appearance to Delessite occur in thin veins in granitiform-diorite in a quarry west of New Leslie, in Aberdeenshire, and at the Mull of Oe in Isla.

CHLOROPHÆITE.

1. This species, established by Dr MACCULLOCH on specimens obtained by him from beneath the Scur More ridge of the hill of Creag-na-Stiarnin in Rum, has never been analysed.

From a general similitude in appearance, MACCULLOCH himself supposed that the saponite from Fife (? Elie) was the same, and he states that a specimen brought from Iceland by Major PETERSON was “similar in all characters.” Others have conjectured that certain substances more or less similar and similarly circumstanced were the same; but that all these conjectures were likely to prove correct was more than doubtful, seeing that they were based upon the substances having been said to be “chlorite-like minerals,” while the

chlorophæite of MACCULLOCH's description, and of the Scur Mohr of Rum, is as little "chlorite-like" as it is possible for anything to be.

DANA, in classifying a mineral from Farøe, which was analysed by FORCHAMMER, under the head of "Chlorophæite," cautiously adds—"The chemical identity of the original chlorophæite of MACCULLOCH from Scur More, with that of Farøe and the other localities has not yet been ascertained."

FORCHAMMER himself should have doubted their identity, seeing that he gives the mineral from Farøe a gravity of $1 \cdot 809$, while MACCULLOCH's mineral had a gravity of $2 \cdot 02$.

FORCHAMMER's mineral yielded—silica $32 \cdot 85$, protoxide of iron $21 \cdot 56$, magnesia $3 \cdot 44$, water $42 \cdot 15$; and is a totally different substance.

That MACCULLOCH's mineral, obtained at so near-home a locality as Rum, should, during the sixty years which have elapsed since its discovery, never have been analysed, was an enigma to the writer, until he noted the discoverer's statement, that the small quantities he himself obtained were got from fragments lying at the foot of the slope, for he "believed the Scur-More to be everywhere inaccessible." A personal inspection of the locality, and some experience of the impossibility of landing at the spot except during the very calmest weather, also aided in the explanation.

At the Scur-Mohr of Rum igneous rocks of an acidic, felspathic type (*syenite*, MACCULLOCH) have burst through and tilted strata of red "Cambrian" sandstone, while mixed beds of amygdaloid and basalt have overflowed these strata merely as far as the ruptured edges of the sandstone, and hang over their upturned slopes as a capping and encircling cliff.

At the northern end of the upturn, the angle of the tilt may be 45° ; at the southern, near the point of Bridianoch, it is about 78° ;—vast and unbroken sheets of sandstone rising here aloft to a height of about 800 feet.

Toppled pillars and lumps of amygdaloid from the impending cliff could find no resting-place on such a slope as this; and it was only when the waves had eaten out a shore terrace, and the gradually accumulating heap of *debris* crept up the gentler-angled portions of the slope, that the loose material assumed its own angle of rest. When the rich "trap-grass" clad it, however, the still falling materials were arrested before they reached the sea, to be grown over in turn, and serve to impede the fall of others; so that there has come to be a gradual sheathing and enveloping of the original rock-slope by a mass of loose material which is devoid of all attachment to its immediately sustaining base. Hence there are constantly recurring stone-avalanches,—the slope being over 1100 feet in height,—these leave gashes in its substance, the crossing of which broken ground may, through a slight disturbance, set much of the overhanging slope in motion.

Where grass-clad, the slope is, to well-tacketed boots, nothing beyond an

unusually tough hand-and-foot scramble ; but when the difficulties special to carrying heavy overbalancing hammers,—breaking rocks where there is little foothold,—and when that which is grasped is readily set upon the move,—be considered, it will not be wondered at that MACCULLOCH's mineral has never yet been analysed.

It moreover occurs in very small amount ; it would take many days' work to obtain a sufficiency of the perfectly unaltered *green* mineral. The writer in three days' hard-work obtained a sufficiency of what was either perfectly or moderately fresh.

To the excellent description of MACCULLOCH I can add nothing, except to emphasize some of his statements regarding that which is the most singular property of this mineral,—namely, the extreme rapidity with which it changes in colour when first exposed. From “the transparent yellow-green of the finest olivine” sometimes in the space of ten minutes it passes to a dark green-black ; and in other specimens from the fine brown-orange of cinnamonstone to the rich brown and brilliant jetty-lustre of asphalt. By instantly after fracture wrapping up the one-half of an olive specimen tightly in repeated folds of paper, and keeping it as far as possible from exposure to air, heat, and light, I managed to retain the colour for about three weeks, only to see it lose it in half an hour when finally exposed. The other half became perfectly black after less than an hour's exposure.

Dr MACCULLOCH has noticed it scaling off in concentric crusts ; the finest piece I obtained showed, when first broken, layers of successive depositions, some very light, some dark green ; this specimen could not at first have been distinguished from the celadonite which will be noticed as occurring at Tayport, in Fife. During ten minutes' exposure to sunlight this specimen, which at first was rather dull, had assumed a lustre like that of obsidian ; it had become in some of the layers dark green, in others black, and it had *rent through the whole thickness of its layers into rude hexagonal prisms*.

Specimens securely *bottled up* immediately upon extraction from the rock gave on analysis very little more of ferrous oxide than those which had been freely exposed ; the change of colour therefore is not due to peroxidation of the ferrous oxide, but must be due to molecular change ; and BREWSTER* has stated that he has optically determined that it is due to the mineral splitting up into a multitude of minute hexagonal prisms.

The material which I analysed was broken out of rude basaltic pillars ; some of it, perhaps one-fifth, was green when placed in the bottles ; none had changed further than to be rich asphalt brown, and this was still vitreous in lustre. It finally withers into a rusty brown or yellow friable lustreless powder.

The specimen was analysed ten days only after having been collected.

* Reference lost.

On 1 · gramme—

Silica,	· 356		
From Alumina,	· 004		
	<hr/>		
	· 360	=	36 ·
Ferric Oxide,			22 · 8
Ferrous Oxide,			2 · 462
Manganous Oxide,			· 5
Lime,			2 · 52
Magnesia,			9 · 5
Alkalies,			trace
Water,			26 · 463
			<hr/>
			100 · 254

Loses 19 · 227 of the above water at 212°. It was rapidly and perfectly dissolved in chlorhydric acid.

2. *The decomposed mineral.*—Dr MACCULLOCH was unable to ascertain the nature of the circlet of cliff which, like an Elizabethan collar, girdles the top of the Scur. He supposed it to be inaccessible. It can, however, be easily turned at its north-west corner by approaching it from the landward side, and is then found to consist from top to bottom of repeatedly alternating bands of basalt and of amygdaloid.

The basalt is in rudely columnar forms, and contains very sparsely distributed amygdules of the chlorophæite, of about half the size of an almond. Its beds are six to eight feet in thickness.

The amygdaloidal beds are little over a foot in depth. This is a more vesicular rock than I ever saw even in Farøe. There has been very much more of steam-hole cavity than of solid material; the amygdules are of about the size of swan-shot, and they almost coalesce with each other on all sides. They are for the most part plugged with decomposed chlorophæite and chalcedony; those on the surface being empty, from the nodules having dropped from their casts,—which nodules may be gathered almost in handfuls at the foot of the cliff.

I worked into this amygdaloidal bed as far as seemed safe under the overhanging and by no means firmly attached columns, but did not reach to a part of the rock where the chlorophæite was fresh, and had therefore to content myself with analysing the altered mineral.

Its colour is rich chocolate brown, it is friable and very soft, having all the appearance of being altered; and as the chlorophæite of the dense basalt may, when exposed or within an inch of the surface of the rock, be seen to pass into the ochreous variety, there can be little doubt that the mineral is the same.

Of this altered chlorophæite, 1·003 grammes yielded—

Silica,	·171		
From Alumina,	·007		
	<hr/>		
	·178	=	17·746
Alumina,			·535
Ferric Oxide,			49·672
Ferrous Oxide,			2·147
Manganous Oxide,			1·196
Lime,			3·07
Magnesia,			3·988
Water,			21·818
			<hr/>
			100·172

Loses 10·454 of the above water at 212°.

3. GREG and LETTSOM, in their “Manual of Mineralogy,” mention the Giant’s Causeway as one of the localities where chlorophæite is to be found. I am happy to be able, by an analysis of the mineral found there, to show that this, which must have been of the nature of a conjecture from similarity of appearance, was a correct inference.

That which I analysed was obtained by DUDGEON and myself at the basaltic point immediately east of the Causeway; it filled small druses, and also coated chalcedony.

It was much softer than the nail, deep rich brown in colour, unctuous to the touch; its streak was shining, and its structure very minutely granular. Its specific gravity is 2·278.

1·11 grammes yielded—

Silica,	35·995
Alumina,	10·485
Ferric Oxide,	11·89
Ferrous Oxide,	1·626
Manganous Oxide,	·077
Lime,	5·15
Magnesia,	10·517
Potash,	·338
Soda,	·761
Water,	23·203
	<hr/>
	99·997

It lost at 212° 14·156 of the above water. It was readily soluble in acids.

This is an aluminous chlorophæite. The specimen had been kept for several years, and may have lost some water.

HULLITE.

In the "Proceedings of the Royal Irish Academy," Mr HARDMAN has given a description and analysis of a mineral from Carnmoney Hill, Antrim, which he names after Professor HULL, but which *possibly* is merely a dessicated chlorophæite.

Mr HARDMAN states that "in physical characters it somewhat resembles the chlorophæite of MACCULLOCH, but is entirely different in composition." Seeing that no analysis of the chlorophæite of MACCULLOCH has ever been published, it is not easy to account for this statement; probably the analysis by FORCHAMMER of the mineral from Farøe was founded upon by Mr HARDMAN.

The description of the Carnmoney mineral *in all respects agrees* with the chlorophæite of the Giant's Causeway.

The analysis given is as in number 1.

	1.	2.
Silica,	39·437	35·061
Alumina,	10·35	9·211
Ferric Oxide,	20·72	18·421
Ferrous Oxide,	3·699	3·254
Manganous Oxide,	trace	
Lime,	4·484	3·987
Magnesia,	7·474	6·645
Water,	13·618	23·203
	<hr/> 99·782	<hr/> 99·782

Now, supposing this to be a chlorophæite partially dehydrated, either from exposure to a warm atmosphere, or from having been carried in the waist-coat pocket, or dried in the bath previous to analysis,—and suppose there is given to it the same quantity of water which the Causeway mineral contains, then the analysis would stand as in No. 2. This would clearly make it chlorophæite. The resemblance to this last mineral is altogether so close as to make it worth Mr HARDMAN's time to pick from the freshly broken rock, and secure in a bottle with greased stopper, a quantity of chips sufficient for a redetermination of the total water, and of the amount of loss at 212°.

1. The analysis of the following specimen, however, goes a long way to establish the specific individuality of Mr HARDMAN's mineral.

In the basaltic pillars embedded in the tufa of the Spindle at Kinkell, in Fifeshire, there very rarely occurs, filling small druses, a dark-green almost black mineral, which has in certain lights a slight brownish tint. It has a very minute granular structure, is dull, but the impression of the nail leaves a polished streak. It is very soft.

It is occasionally pseudo after analcime, and its associates are analcime, augite, and black lustrous titaniferous iron in angular fragments.

It was conceived to be possibly one of the substances called "chlorophæite from Fife" by Dr MACCULLOCH, and was considered to be Delessite.

·653 grammes yielded—

Silica,	·239		
From Alumina, . .	·013		
	<hr/>		
	·252	=	38·591
Alumina,			17·337
Ferric Oxide, . . .			15·97
Ferrous Oxide, . . .			n. d.
Manganous Oxide, . .			1·562
Lime,			3·944
Magnesia,			8·646
Potash,			·67
Water,			13·476
			<hr/>
			100·196

It lost 8·039 of the above water at 212°. It was readily decomposed by acids.

It was found to contain ferrous oxide, but there was not enough material for the determination of its amount. While this non-determination of the ferrous oxide leaves its composition in doubt, the claim of Hullite to rank as a species is considerably fortified by the circumstance of the analysis of this specimen having been performed so speedily after its extraction from the rock that there was no reason to believe that any more than a merely trifling loss of water had occurred.

It at the same time was so uniform in structure that it could not be regarded as a mixture, and its composition does not permit of its being ranked with either Delessite or chlorophæite.

SAPONITE.

From Igneous Rocks of Old Red Sandstone Age.

1. A little westward of the Tod Head, in Kincardineshire, there is a small boat-harbour called Gapol. Here the conglomerate rocks are broken through by, and interstratified with, igneous rocks; these are frequently amygdaloidal, especially on their upper surfaces. On the south-west side of the little harbour the rock is markedly serpentinous; and it contains between its beds veins of saponite of a fourth of an inch in thickness. The mineral has here a pale leek-green to a blackish-green colour, sometimes with bright red spots. It is unctuous and very soft. It frequently shows slickenside markings, which impart a false appearance of a fibrous structure, but it is devoid of any structure visible to a lens. Its specific gravity is 2·179.

The purest green was analysed; 1·3 grammes yielded—

Silica,		42·127
Alumina, .		7·245
Ferric Oxide, .		6·57
Ferrous Oxide, .		·189
Manganous Oxide, .		·129
Lime,		·798
Magnesia,		19·333
Potash,		·535
Soda,		2·094
Water,		21·069
		<hr/>
		100·139

Loses 15·746 of the above water at 212°; insoluble silica, ·061 per cent. Was perfectly pure, but might have derived some of the soda from sea water.

Some specimens during the pounding became brown, and were rejected in the fear that they might contain some chlorophæite, the most marked feature of which, as above noted, is that it changes from green to brown with extreme rapidity upon exposure. This darkening or browning during the pounding is a feature of the saponite obtained from several localities.

The above, and all the specimens which were examined, were readily decomposed by acids.

In the cliffs immediately to the south of the Tod Head this mineral occurs filling amygdaloidal cavities of small size; here it has a minute and ill-defined scaly structure, and is so frequently pervaded with red or brown portions that

it was not considered pure enough, or uniform enough, for being analysed further than by ascertaining the amount of the water; the determination of which showed that it was the same mineral.

2. From the parish of Kinneff, in Kincardineshire.—The road from Bervie to Stonehaven is, at a point a little north of where a side road branches to the church of Kinneff, cut on its west side into a small cliff of porphyritic amygdaloid,—the porphyritically disposed crystals being large twins of grey labradorite.

This porphyry has occasionally druses of considerable size, which are filled with large sheafy almost vermilion-coloured crystals of stilbite, smaller ones of Heulandite, and small radiating quartz crystals which sheath the two zeolites.

The quartz is sometimes also capped by spheres of saponite of about the size of shot. These spheres have a fibrous structure, a pale olive-green colour, and they are extremely soft.

Thrown into water they fall to pieces, expanding greatly; thus the specific gravity could not be ascertained. They were freed from quartz with extreme difficulty.

1·25 grammes yielded—

Silica,	.	.	.	.	42·1
Alumina,	.	.	.	.	5·948
Ferrie Oxide,	.	.	.	.	4·963
Ferrous Oxide,	.	.	.	.	·18
Manganous Oxide,	.	.	.	.	·088
Lime,	.	.	.	.	2·15
Magnesia,	.	.	.	.	20·977
Potash,	.	.	.	.	·276
Soda,	.	.	.	.	·464
Water,	.	.	.	.	22·932
					<hr/> 100·078

Lost at 212°, 14·092 of the above water; insoluble silica, 1·117 per cent.

3. At the same locality there was also found the same mineral in a massive form. It occurred beneath the investing layer of quartz crystals; it was very soft and friable, and was unctuous to the touch. It had a grey colour mottled with purple, being in appearance similar to Naples' soap. Its specific gravity is 2·28.

·9 grammes yielded—

Silica,	42·5
Alumina,	5·88
Ferric Oxide,	4·91
Ferrous Oxide,	·12
Manganous Oxide,	·122
Lime,	2·13
Magnesia,	20·742
Potash,	·188
Soda,	·456
Water,	22·752
	<hr/>
	99·798

Loses 14·52 of the water at 212°.

4. From Glen Farg, in Perthshire.—This specimen was given to me by the late ANDREW MURRAY, Esq. of Conland, as from the amygdaloid of that glen, where I have seen smaller pieces of it. The specimen was about two inches in length, and had been carved into the shape of a tiger. It was devoid of structure, much fissured, very soft, unctuous to the touch, semitransparent, and of an oily sap-green colour. Its specific gravity is 2·235.

1·3 grammes yielded—

Silica,	·472	
From Alumina,	·003	
	<hr/>	
	·475	= 36·538
Alumina,		9·396
Ferric Oxide,		2·852
Ferrous Oxide,		5·246
Manganous Oxide,		·153
Lime,		2·498
Magnesia,		21·615
Water,		21·681
		<hr/>
		99·979

Loses at 212° 12·961 of the water ; insoluble silica, 2·947 per cent. Was quite pure.

5. In making the curved cutting on the North British Railway, in Fifeshire, immediately landward of the Tay Bridge, beds some three or four inches in thickness of this substance of an impure description were come upon.

These beds were regularly interstratified with the igneous rock, here very friable and rotten. Apparently they consisted of a granular mixture of saponite with celadonite, and they carried softened and rounded granules of the rock matrix; their whole appearance conveyed the impression that they resulted from the decomposition of the rock.

A little eastward of this cutting a denser mass of the rock was laid open to afford a stance for the works connected with the building of the girders of the bridge. During the necessary blasting operations fine specimens of red chalcidony were obtained, and the rock here rarely afforded in its rents, veins and lumps of a pure saponite much resembling a soft steatite.

The colour is grass green, the structure dense and without any appearance of foliation; it is opaque, unctuous to the touch, and cuts like soft slate-pencil.

1·207 grammes yielded—

Silica,	42·839
Alumina,	4·828
Ferric Oxide,	6·496
Ferrous Oxide,	2·358
Manganous Oxide,	·2
Lime,	2·162
Magnesia,	21·812
Potash,	trace
Water,	20·698
	<hr/>
	101·393

Was apparently quite pure; lost 13·868 of the water at 212°.

6. In clearing rock for the foundations of, and obtaining material wherewith to build a pier and patent slip at the harbour of Tayport, in Fife, some four miles from the last locality, the upper bed of the igneous rock was found to contain an abundance of agates, occasionally diversified by large nodules, which had more the appearance of celadonite than saponite, but which probably contained both.

The lower bed was rendered strikingly beautiful in appearance by the quantity of lustrous white calcite which it contained; this calcite was sheathed with a thin skin of brilliant red carnelian.

A cutting, opened up some 400 yards west of this, in laying out the railway between Tayport and Newport, afforded the following substances:—Fibrous silky pilolite, highly lustrous and beautifully white; yellow jasper, with a dendritic structure resembling corn-stooks; druses, lined with an opaque mammillated and banded celadonite, and having a central core of translucent waxy saponite, and long pipe-shaped amygdulæ totally filled with the last-named mineral.

In order to be enabled to contrast the composition of the saponite from this locality with that of the celadonite, the former was picked from the centre of those cavities in which it was invested by the opaque celadonite.

The mineral here is very translucent, devoid of structure, much flawed, resembles a green wax, has a somewhat brownish-green tint, and is easily bruised by the nail.

Its specific gravity is 2·283.

25 grains yielded—

Silica,	40·111
Alumina,	6·49
Ferric Oxide,	5·612
Ferrous Oxide,	2·369
Manganous Oxide,	trace
Lime,	2·008
Magnesia,	21·666
Potash,	·321
Soda,	·21
Water,	21·6
	<hr/>
	100·387

Loses in bath 13·96 of the above water. I have lately found the mineral at this locality in thin veins, with a pseudo-fibrous structure due to interstitial fibrous calcite: in this form it is indistinguishable from the “Bowlingite” of Bowling Quarry.

In the foundation rock of Broughty Castle, on the north side of the Tay, saponite occurs both filling druses as a matted mass of fine scales, and also merely lining the druses in “rosettes” of minute crystals. These are of a brilliant dark-green colour, and in hexagonal combinations, apparently grouped like ripidolite. Their extreme softness is the only *physical* property by which they can be distinguished from that mineral. Their content of water at once determines their nature. In Roy Quarry, in Broughty Ferry, saponite occurs in quantity both in veins and filling small druses.

7. “From the Catkin Hills,” in Lanarkshire.—This was given to me by the late THOMAS BROWN, Esq. of Lanfine. It occurred filling small druses in a dense igneous rock; its structure was minute scaly; its colour a bright green; when bruised or scratched the streak is nearly white; its specific gravity is 2·279.

1·3 grammes yielded—

Silica,	41·341
Alumina,	10·532
Ferric Oxide,	1·859
Ferrous Oxide,	3·836
Manganous Oxide,	·087
Lime,	1·215
Magnesia,	21·073
Potash,	·05
Soda,	·37
Water,	19·481
	<hr/>
	99·481

Lost 15·61 of the water at 212° ; insoluble silica, 3·98 per cent.

8. From the Catkin Hills.—This specimen was sent to me by Mr JOHN YOUNG, curator of the University Museum, Glasgow, as being a portion of the very specimen, an analysis of which was published by the late WALLACE YOUNG in the “Transactions of the Geological Society of Glasgow,” as “a new fibrous green mineral.”

The portion analysed was minutely fibrous in structure, but was also coarsely pseudo-fibrous, from interstitial fibrous calcite.

Its colour was dark leek-green ; it was softer than the nail, giving almost a white streak, and it was in no way physically different from some of the specimens above described.

It yielded to acid (which was weakened so as to dissolve the interstitial calcite, with hardly any visible effervescence) 10·714 per cent. of calcite. With this amount of calcite its specific gravity was 2·288.

1·3 grammes freed from calcite yielded—

		Hannay.
Silica,	42·223	35·82
Alumina,	8·515	16·14
Ferric Oxide,	2·992	4·85
Ferrous Oxide,	4·876	6·99
Manganous Oxide,	·073	
Lime,	·919	4·87 calcite.
Magnesia	21·231	11·73
Water,	19·484	19·63
	<hr/>	<hr/>
	100·313	100·03

Loses 14·76 of the water in the bath ; insoluble silica, 4·238.

Mr JOHN YOUNG also sent a portion of the same specimen to Mr J. B. HANNAY, who has published an analysis of it (quoted) differing very markedly from the above; and he unites it with specimens of the same mineral (saponite) from Bowling Quarry—next to be noted—and has introduced it in the “Mineralogical Magazine” as a new mineral, under the name of *Bowlingite*.

Among the discrepancies which exist between Mr HANNAY’s analysis and the above, the most marked is the amount of magnesia, which, instead of the 21·231 per cent. obtained by me, amounts in his analysis to only 11·73. The late Mr WALLACE YOUNG, however, in his original analysis gives the quantity, according to one statement, at 20·95, according to another at 21·9.

9. From Bowling Quarry, on the Clyde.—The specimens were sent me by Mr HANNAY as his “bowlingite” upon my writing him of the discrepancy in our analysis of the above mineral, and of my doubts as to “bowlingite” being anything else than saponite.

The specimens were not to be distinguished from the vein-saponite of Tayport, in Fife. They were in the form of portions of a vein of nearly one inch in width. Colour, dark grass-green; structure, fine foliated, but with pseudo-fibrous markings like slickenside. Scratches easily with the nail; streak very pale green, almost white. Contained imbedded crystals of calcite. Specific gravity, 2·308, being the average of four pieces chosen as being those most free of calcite.

Was scraped down with the back of a knife, all gritty particles (calcite) being so removed.

On 1·3 grammes—

Silica, . . .	·487				
From Alumina, .	·008				
	<hr/>				
	·495	=	38·076	Hannay.	34·32
Alumina,			6·263		18·07
Ferric Oxide, . . .			4·362		3·65
Ferrous Oxide, . . .			4·975		6·81
Manganous Oxide, . . .			·23		
Lime,			2·972		5·14 calcite.
Magnesia,			21·461		9·57
Potash,			946		
Soda,			106		
Water			20·477		22·70
			<hr/>		<hr/>
			99·968		100·26

Loses at 212°, 12·315 per cent. of the water.

Mr HANNAY's analysis, which I have appended for comparison, shows (as in the case of the Catkin mineral) very marked discordance with mine in the magnesia and alumina.

Upon pointing this out to Mr HANNAY, and asking him to re-examine the substance, as I suspected some error had crept into his process, he furnished me with the following numbers as the average results of a new inquiry—*

Silica,	.	.	.	about 38
Alumina,	.	.	.	„ 20
Ferric Oxide,	.	.	.	„ 4
Ferrous Oxide	.	.	.	„ 7
Lime,	.	.	.	„ 3
Magnesia,	.	.	.	„ 10
Water,	.	.	.	„ 18

Which numbers are more accordant with those obtained by me, with still the marked exceptions of the magnesia and alumina.

The question of this being a new mineral depending upon the quantity of these two ingredients, I put a second portion of what Mr HANNAY had forwarded to me into the hands of Mr JOHN DALZIEL, who has worked in my laboratory for several years.

10. The specimen was hardly so pure as that previously examined, nor was it perhaps so absolutely free from calcite, though no effervescence could be detected when its powder was placed in acid.

1·301 grammes yielded—

Silica,	.	.	.	·474	
From Alumina,	.	.	.	·004	
				<hr/>	
				·478	= 36·741
Alumina	.	.	.	5·35	
Ferric Oxide,	.	.	.	5·938	
Ferrous Oxide,	.	.	.	6·962	
Manganous Oxide,	.	.	.	·076	
Lime,	.	.	.	3·056	
Magnesia,	.	.	.	20·215	
Potash,	.	.	.	·494	
Soda,	.	.	.	·206	
Water,	.	.	.	21·276	
				<hr/>	
					100·314

Lost at 212°, 12·965 of the above water.

* Undertaken I however understand by two of his students.

These numbers show that Mr HANNAY's process must throw down his magnesia too early in the analysis, so that it is set down as alumina; and as the analysis by myself and Mr DALZIEL of both the Catkin and the Bowling mineral agree with the others of saponite; and as the mineral is *absolutely identical therewith in appearance, in gravity, in hardness, in the peculiar manner in which the water is combined, and in all its physical and chemical properties*, we are forced to conclude that "bowlingite" can be nothing but saponite.

Saponite also occurs in very interesting specimens, which, according to information derived from PATRICK DORAN, from whom I purchased them, were obtained at Berry Glen, in Ayrshire.

Here the mineral is evidently crystallised, but the forms are minute, lustreless, and apparently somewhat rounded at the edges of the crystals. Small groups of minute crystals are disposed upon the summits of acicular crystals of "galactite" (natrolite).

The substances and order of deposition of these substances in the cavities which I have seen are:—"Cluthalite" (albite), cream-coloured galactite, red natrolite, saponite. The colour of the saponite is pale sap-green.

The same mineral (apparently) was found by Dr LAUDER LINDSAY in Corsiehill Quarry, on Kinnoul Hill, near Perth, disposed on the summits of radiating quartz crystals; here it is grass-green in colour, and of a minutely foliated structure; it also colours the quartz throughout, so as to form a *prase*.

Of the above localities affording saponite the following are all which afford any information as to the order of its deposition in the druses or rock-rents in which it is found:—

Kinneff—Heulandite, stilbite, quartz, saponite.

Tayport—Celadonite, saponite:—and Calcite, saponite.

Berry Glen—Cluthalite, galactite, natrolite, saponite.

Corsiehill Quarry—Quartz, saponite.

In the decomposition of the igneous rocks of the Old Red Sandstone age, therefore, the mineral (augite?) whose decomposition yielded the saponite would appear to have been the last to be disintegrated, the felspars giving way first, to yield zeolites.

From Igneous Rocks of Secondary Age.

11. From the Storr, in Skye.—It here forms the outer—the first deposited—layer, sometimes half an inch in thickness, of some of the druses which occur in the rock at the east foot of the "Old Man of Storr." Occasionally it alone fills the druse. When other minerals are present they are superimposed upon it.

It is seldom that any other than chabasite is here present, but as this is the

earliest formed of all the zeolites, all must be posterior in formation to the saponite.

This saponite is of a dark olive-green colour, passing into colourless. It is about the hardness of slate pencil—being here harder than at any other Scotch locality: it resembles a hard steatite. Its specific gravity is 2·296.

25 grains yielded—

Silica,		41·411
Alumina,		9·075
Ferric Oxide,		2·054
Manganous Oxide,		·107
Lime,		1·86
Magnesia,		22·8
Water,		23·433
		<hr/>
		100·722

It lost 13·652 of the water at 212°. Some specimens crackled and fell to pieces in water.

12. From the Quiraing, Skye.—The pathway which leads from the Uig Road to the Quiraing looks down upon a little grass-clad valley, at a distance about half a mile from that road. Large masses of fallen rock lie in this valley, out of which there are, or rather were, to be obtained the finest gyrolites and the largest crystals of apophyllite to be found in Skye or indeed in Britain. Along with these saponite occurs filling druses. The mineral, when these are freshly opened, is quite pulpy, but a day's exposure hardens it.

It is then milk-white and curdy-looking, being of almost a friable structure. Sometimes it is quite pure; sometimes a small amount of microscopic crystals of stilbite (?) are impacted in the mass. It is dull in lustre, but polishes with the nail.

It falls to pieces in water.

1·499 grammes yielded—

Silica,		42·504
Alumina,		5·055
Ferric Oxide,		·852
Manganous Oxide,		·224
Lime,		3·274
Magnesia,		23·954
Potash,		·171
Soda,		·45
Water,		23·679
		<hr/>
		100·136

Loses 15·536 of the water at 212°. Insoluble silica, 24·98 per cent.

13. The pathway to the Quiraing when followed northward from the last-mentioned locality winds round a projecting spur of rock ; in this druses of about two inches in diameter occur, which are totally filled with saponite. Here its colour is dull wax yellow. It is translucent—weathering white and opaque, but it readily reabsorbs water and becomes again translucent. It falls to pieces in water, with somewhat of a burst, in a manner similar to bole. It is softer than the nail, may be cut out of the druses like cheese, and is altogether very similar in appearance to common soap.

1·29 grammes yielded—

Silica,	.	.	.	.	40·329
Alumina,	.	.	.	.	8·717
Ferric Oxide,	.	.	.	.	1·972
Manganous Oxide,	.	.	.	.	·131
Lime,	.	.	.	.	2·8
Magnesia,	.	.	.	.	21·71
Water,	.	.	.	.	24·338
					<hr/>
					99·998

Loses 15·132 of the above water at 212°. Insoluble silica, 7·83 per cent.

Among the debris which occurs at the foot of a separate outlying ridge of rocks which lies north-east of the Quiraing saponite is found of the following colours:—Dark-brown, green, yellow, brown, light-green, and Venetian-red. It here is in dense structureless layers, also stalactitic and in minute crystalline spheres, but the forms are indistinct. A fine echo may give the name of Echoing Craig to this locality. The order of deposition of minerals here is—Saponite, chabasite, plynthite, calcite, Thomsonite, chabasite, apophyllite, analcime, mesolite.

It has thus to be remarked that while the saponite of the volcanics of Old Red Sandstone age has been the substance *last* deposited in the druses, that of the volcanics of the Lias and Oolite has been the *first*.

The inferences to be drawn therefrom will be considered in a future chapter on the Zeolites.

There can be little doubt that the “*prasilite*” of THOMSON (“*Phil. Mag.*,” III. xvii. 416, 1840) is saponite. He describes it is a leek-green mineral, soft as Venetian talc, and with gravity = 2·311. It is stated to contain silica, alumina, ferric oxide, magnesia, and about 18 per cent. of water. Its locality also was the Kilpatrick hills.

The marked feature of saponite is the extreme ease with which it loses part of its water when heated, and the speed with which it regains it upon cooling. If a quantity of the mineral half-filling a closely-stoppered bottle be placed in

the sun, the upper part of the bottle will speedily be bedewed with drops of water ; these will be reabsorbed, and the inside of the bottle be rendered perfectly dry by placing it in a cold situation. If some of the mineral be weighed, and then be carried for half an hour in the waistcoat pocket, it will be found to have lost from 6 to 7 per cent. of its weight thereby.

CELADONITE.

1. Occurs filling druses and coating chalcedony in close association with chlorophæite, in the basalt south of the Giant's Causeway.

Structure earthy, opaque ; colour, brilliant dark apple-green ; very soft, polishes with the nail. Specific gravity, 2·63.

Contained a little calcite, and was somewhat cavernous in spots, the cavities being slightly brown. The calcite and brown portions were cut away.

On 1·303 grammes—

Silica,	·73		
From Alumina, .	·005		
	<hr/>		
	·735	=	56·408
Alumina,			2·138
Ferric Oxide, . . .			14·073
Ferrous Oxide, . .			5·095
Manganous Oxide, .			·23
Lime,			·601
Magnesia,			5·909
Potash,			8·832
Water,			6·796
			<hr/>
			100·292

Loses 1·364 of the above water at 212°. Was almost *totally insoluble* in acids.

2. Occurs in bands of an inch or so in thickness in the amygdaloid of Scur Mohr in Rum. These bands seem to be large flat cavities. They have sometimes an obscure laminated structure, but the substance is impalpable, somewhat greasy and not granular. The thin layers which coat the surfaces of the agates seem to be the same substance ; and it can be distinctly seen in the specimens around to be the colouring matter of heliotrope. Its colour is apple-green, and its specific gravity, 2·574.

1·301 grammes yielded—

Silica,	·74		
From Alumina, .	·011		
	<hr/>		
	·751	=	57·725
Alumina,			·33
Ferric Oxide,			17·047
Ferrous Oxide,			3·729
Manganous Oxide,			·076
Lime,			·602
Magnesia,			3·843
Potash,			5·551
Soda,			·423
Water,			10·778
			<hr/>
			100·204

Loses 5·99 of the above water at 212°. Was very slightly acted upon by acids.

I believe that the green “skin” of agates will prove to be celadonite, and not Delessite, as has been generally supposed.

3. Found in the railway cutting about 400 yards west of Tayport, Fife. It usually fills small druses of about an inch in size, in porphyritic amygdaloid. Its colour there is a bright light apple-green; it is opaque, dull, and its structure is granular under the lens. Its specific gravity is 2·59.

Occasionally the mineral only coats the druse in mammillated layers. It then somewhat resembles malachite, having lighter and darker bands of colour. The interior of these druses is filled with the saponite, of which an analysis is given. The saponite has a colour and structure markedly different from that of the celadonite. Its colour is much duller than that of the celadonite, and slightly dashed with brown; it has a greasy or waxy lustre, and is semitransparent, while the celadonite is quite opaque. There is no passage of the one mineral into the other, and their line of junction is quite sharp.

1·3 grammes yielded—

Silica,	·674		
From Alumina, .	·011		
	<hr/>		
	·685	=	52·692
Alumina,			5·786
Ferric Oxide,			9·752
Ferrous Oxide,			5·366
Manganous Oxide,			·307
Lime,			1·163
Magnesia,			8·538
Potash,			6·212
Soda,			·388
Water,			10·485
			<hr/>
			100·689

Loses 5·048 of the water at 212°. Is insoluble in acids.

In an upper bed of the igneous rock, close upon the spot where a patent slip has been cut, amygdules of the size of the fist occur among others of agate : these amygdules are totally filled, not with concentric layers of chalcedony, but with celadonite. The concentric structure is evidenced by brownish bands ; the structure is granular, and the material of the layers is not so pure as that analysed above.

At Hare-Craig, on the opposite side of the Tay, this mineral rarely occurs in thin veins, of a very brilliant colour.

4. From the same line of railway, but near its western extremity, where it joins the Tay Bridge.

The mineral here is in veins, which frequently consist solely of a granular mixture of calcite with celadonite ; the pure mineral was obtained with difficulty. It was granular, but never in mammillated coatings. Its specific gravity was 2·598.

It yielded on 1·3 grammes—

Silica, . . .	·672		
From Alumina, .	·011		
	<hr/>		
	·683	=	52·538
Alumina, . . .			5·824
Ferric Oxide, . . .			9·714
Ferrous Oxide, . . .			5·4
Manganous Oxide, . . .			·307
Lime, . . .			1·292
Magnesia, . . .			8·307
Potash, . . .			6·497
Soda, . . .			·635
Water, . . .			10·413
			<hr/>
			100·927

Loses 3·879 per cent. of the water at 212°.

DELESSITE.

	S. G.	Loss at 212°.	Si.	Al ₂ .	Fe ₂ .	Fe.	Mn.	Ca.	Mg.	K ₂ .	Na ₂ .	H ₂ .	Total.
St Cyrus, Kincardine,	2.652	2.744	32.69	13.44	4.4	6.62	...	.86	28.77	...	...	13.25	100.02
Bowling Quarry, Dumbarton,	2.573	5.7	32.	17.33	1.19	12.45	...	1.57	20.42	...	...	15.45	100.4
Dumbuck, do.	2.598	6.3	32.01	18.87	1.18	12.09	tr.	1.39	19.64	...	...	15.46	100.64
Long Craig, do.	2.656	4.678	30.93	15.32	3.16	15.31	.38	1.38	18.65	...	...	14.69	99.82
Elie, Fifeshire,	2.672	3.389	30.69	12.83	1.63	18.32	1.	1.59	18.6	.57	1.11	13.77	100.11
Average,	2.63	4.562	31.26	15.56	2.32	12.96	...	1.38	21.22	...	...	14.52	...
Formula,	...	...	31.53	16.28	2.8	12.61	...	...	21.02	...	...	15.76	...

CHLOROPHÆITE.

Scur Mohr, Rum,	...	19.227	36.	...	22.8	2.46	.5	2.52	9.5	tr.	tr.	26.46	100.25
Giant's Causeway, Ireland,	2.278	14.156	35.99	10.49	11.89	1.63	.08	5.15	10.52	.34	.76	23.2	99.99
"Hullite" (hydrated),	...	...	35.06	9.21	18.42	3.25	tr.	3.99	6.65	...	...	23.2	99.78

HULLITE.

Kinkell, Fifeshire,	...	8.029	38.59	17.34	15.97	n. d.	1.56	3.94	8.65	.67	...	13.48	100.2
Carnmoney (Hardman),	1.76	...	39.44	10.35	20.72	3.7	...	4.48	7.47	...	...	13.62	99.78
Average,	...	...	39.	13.84	18.35	3.7	...	4.48	8.06	...	...	13.5	...
Formula,	...	...	38.77	12.44	19.38	3.55	...	4.04	8.72	...	...	13.1	...

SAPONITE.

<i>From "Old Red" Volcanics—</i>													
Gapol, Kincardineshire,	2.179	15.746	42.13	7.25	6.57	.19	.13	.8	19.33	.58	2.09	21.07	100.14
Kinneff, do. (green),	split	14.092	42.1	5.95	4.96	.18	.09	2.15	20.98	.28	.46	22.93	100.08
Do., do. (purple),	2.28	14.52	42.5	5.88	4.91	.12	.12	2.13	20.74	.19	.47	22.75	99.79
Glen Farg, Perthshire,	2.235	12.961	36.54	9.39	2.85	5.25	.15	2.5	21.62	...	...	21.68	99.97
Wormit Bay, Fifeshire,	...	13.87	42.84	4.83	6.5	2.36	.2	2.16	21.81	tr.	...	20.7	101.39
Tayport, do.,	2.282	13.96	40.11	6.49	5.61	2.37	tr.	2.01	21.67	.32	.21	21.6	100.38
Catkin Hills (scaly),	2.279	15.61	41.34	10.53	1.86	3.84	.09	1.22	21.07	.05	.37	19.48	99.48
Do., (fibrous) ("Bowlingite"),	2.288	14.76	42.22	8.52	2.99	4.88	.07	.92	21.23	...	...	19.49	100.31
Bowling, Dumbarton ("Bowlingite"),	2.308	12.315	38.08	6.26	4.36	4.98	.23	2.97	21.46	.95	.11	20.48	99.96
Do., do. (Mr Dalziel),	...	12.965	36.74	5.35	5.94	6.96	.08	3.06	20.22	.49	.21	21.28	100.31
<i>From Secondary Volcanics—</i>													
Storr, Skye (olive),	2.296	13.652	41.41	9.08	2.05	...	.11	1.86	22.8	...	...	23.43	100.72
Quiraing, Skye (white),	split	15.536	42.5	5.06	.85	...	.23	3.27	23.95	.17	.45	23.68	100.14
Do., do. (yellow),	split	15.132	40.33	8.72	1.97	...	.13	2.8	21.71	...	...	24.34	99.99
Average,	2.272	14.22	40.63	7.18	3.96	2.38	...	2.14	21.43	...	...	21.76	...
Formula,	...	...	40.81	7.5	3.88	2.62	...	2.04	20.61	...	...	22.73	...

CELADONITE.

Scur Mohr, Rum,	2.574	5.99	57.72	.33	17.05	3.73	.08	.6	3.84	5.55	.42	10.78	100.2
Tayport, Fifeshire,	2.59	5.048	52.69	5.79	9.75	5.37	.31	1.16	8.54	6.21	.39	10.48	100.68
Wormit Bay,	2.598	3.879	52.54	5.82	9.71	5.4	.3	1.29	8.31	6.5	.64	10.41	100.93
Giant's Causeway, Ireland,	2.63	1.364	56.41	2.14	14.07	5.09	.23	.6	5.91	8.83	...	6.79	100.29
Average,	2.598	...	54.84	3.52	12.64	4.9	...	.89	6.65	7.	...	9.62	...
Formula,	...	...	54.05	3.83	11.94	5.4	...	...	6.76	7.88	...	10.14	...

The above tabulation presents clearly to the eye the distinctive features of these five volcanic minerals, which are arranged therein in the order of their content of silica; and as no such extended research into the composition of these minerals has before been published, it is necessary, in the first place, to consider the formula of each.

This in the following tables is done by giving in the first column the average composition. This is followed by the calculation of atoms—the last column giving the percentages calculated from the formulæ which stand below :—

Delessite.

		Atoms.			
Silica, . . .	31·26	1·041	3·15	3	31·53
Alumina, . . .	15·56	·302	}	1	16·28
Ferric Oxide, . . .	2·32	·029			
Ferrous Oxide, . . .	12·96	·36	}	4·3	12·61
Magnesia, . . .	21·22	1·061			
Water, . . .	14·52	1·614	4·9	5	15·76

Formula—

Or generally—

Or atoms—

Chlorophæite.

		Atoms.			
. . .	36	1·2	1·2	3·5	36·24
Alumina, . . .	10·54	·205	}	·35	8·87
Ferric Oxide, . . .	12·04	·15			
Ferrous Oxide, . . .	2·04	·057	}	·7	2·42
Lime, . . .	3·83	·145			
Magnesia, . . .	10·	·5		2·	10·01
Water, . . .	25·83	2·87	2·87	8·	24·85

Formula not evident.

Atoms—

Hullite.

On the average, taking the ferrous oxide as in Mr HARDMAN'S analysis—

		Atoms.					
Silica, . . .	39·	1·3	7·89	8	38·77	39·67	
Alumina, . . .	13·84	·265	}	3	3	12·44	17·03
Ferric Oxide, . . .	18·35	·23				19·38	13·22
Ferrous Oxide, . . .	3·7	·103	}	4·04	4	3·55	3·63
Lime, . . .	4·48	·16				4·04	4·13
Magnesia, . . .	8·06	·403				8·72	8·92
Water, . . .	13·5	1·5	9·09	9	13·1	13·40	

Formula—

Or generally—

The Kinkell specimen gives the formula—

and the numbers in last column. These agree better with the results of that analysis than do those of the first formula with the average of both analyses.

Saponite.

		Atoms.					
Silica, . . .	40·63	1·354	1·354	7·1	7	40·81	
Alumina, . . .	7·18	·14	}	·19	1·	1	7·51
Ferric Oxide, . . .	3·96	·05					3·88
Ferrous Oxide, . . .	2·38	·066	}	1·33	6·5	6·5	2·62
Lime, . . .	2·14	·076					2·04
Magnesia, . . .	21·43	1·07					20·61
Water, . . .	21·76	2·42	2·42	12·75	13	22·73	

Formula—

Or generally—

Or atoms—

Celadonite.

		Atoms.				
Silica, . . .	54.84	1.828	1.828	8	8	54.05
Alumina, . . .	3.52	.07	} .228	1	1	3.83
Ferric Oxide, . . .	12.64	.158				
Ferrous Oxide, . . .	4.9	.136	} .616	3	3	5.4
Magnesia, . . .	6.57	.332				
Potash, . . .	7.65	.148				
Water, . . .	9.84	1.07	1.07	4.7	5	10.14

Formula—

Or generally—

Or atoms—

In the above investigation every substance, the nature of which was at all doubtful, of which I could obtain a sufficiency for analysis was examined.

In applying the results of the examination to the consideration of the geognostic relations of these minerals, those of the first or true chlorite type may be dismissed in few words.

With the exception of the occurrences of chlorite at the Girdleness and at Rubislaw in granite, the minerals of the first class are to be found *only in metamorphic rocks*.

Glauconite, occurring generally in rock which is believed to be of recent origin, may, by its occurrence, aid somewhat in the assigning the age of certain doubtful strata.

The second group, which I have called the saponites, belong *solely to igneous rocks*; and, from the mode of their occurrence, there is no room for doubt that *they result from the alteration of certain of the constituents of these rocks*—augite and olivine in all probability.

As regards our power of distinguishing them from each other, this is by no

means so difficult as their want of form and general similarity of appearance would at first sight lead one to suppose.

Delessite can be distinguished from chlorophæite by its dull lustre, its minutely granular structure, its opacity, and its colour—in the field ; and rapidly in the laboratory by its much higher gravity, its much smaller loss at 212° , and much smaller total content of water.

From the specimen of Hullite found at Kinkell, I could not by physical properties undertake to distinguish it ;—the darker varieties of Delessite at least much resembled that specimen.

From saponite, Delessite can be distinguished by its dark colour and granular structure and its opacity ; and in the laboratory by its high gravity and its water.

From celadonite it could not be distinguished either by its structure or opacity, or by its gravity, or satisfactorily by its water content ; but its colour, and its solubility in acids, at once suffice to separate the two.

Chlorophæite is readily recognised ; when fresh it resembles a green jelly,—when weathered it equally resembles drops of asphalt.

The Kinkell Hullite resembles a dark Delessite, and therefore does not resemble chlorophæite.

Saponite, in its usual green form, is easily known ; its extreme softness, greasy lustre, great translucency, and soapy structure suffice to define it in the field ; the extreme readiness with which it parts with and regains so large a quantity of water equally suffices in the laboratory, while its low gravity is of itself characteristic.

The white variety is by no means so readily identified ; halloisite, conite, the magnesian carbonate of lime, agaric mineral, and a peculiar superhydrated vein-serpentine, all closely resemble it.

Celadonite may at once be known by its insolubility in acids ; its loose granular or mammillated structure, its perfect opacity, and brilliant colour, are likewise well-marked characters.

Such are the minerals occurring in Scotland, which are without question to be referred directly to one or other of the above species. I now note certain which cannot be so unhesitatingly classed under any of these heads, and two which appear to be new.

1. About one hundred yards above the bridge of Cally, in Perthshire, a singular bedded boss of friable trap protrudes out of the north bank of the Ardle. This contains amygdules from the size of shot to that of a bean, filled with a dark, greenish-brown, soapy substance, which is much impregnated with both calcite and chalcedonic quartz. Its structure is minutely granular.

1·499 grammes gave—

Silica, . . .	·785		
From Alumina, . . .	·026		
	<hr/>		
	·811	=	54·702
Alumina, . . .			·83
Ferrie Oxide, . . .			2·599
Ferrous Oxide, . . .			9·82
Manganous Oxide, . . .			·24
Lime, . . .			5·71
Magnesia, . . .			16·34
Water, . . .			10·82
			<hr/>
			100·467

Loses 6·101 of the water in the bath; insoluble silica, 7·66 per cent.

The above is the analysis of the substance, purified as far as possible from its two associates, and it accords fairly well with celadonite; but I incline to regards its apparent similarity therewith as being fortuitous, and probably the result of imperfect separation from quartz, and I conceive that the mineral may actually be saponite, impure from chalcedonic admixture.

I take this view from its colour and lustre, from its being partly soluble in acids, and from finding that some portions gave a loss in bath of 12·447 per cent. of water, with about 9 per cent. of residual water; so if the substance analysed be not impure saponite, saponite itself must here occur.

2. In crystalline granular limestones which do not manifest well-marked features of alteration there are no minerals to be found, if we except such a common one as pyrite; but there are frequently also to be seen plates or interrupted layers of an ill-defined green mineral generally in too intimate a state of intermixture with the lime, or with included portions of the matrix, to permit of separation for analysis.

I was so fortunate as lately, in company with Dr AITKEN of Inverness, to obtain some of this substance from the limestone quarry of Reelig, near the Beaully Firth; this was sufficiently pure, and no more than so, for analysis.

Its colour is a somewhat dark green, its structure is granular, or foliated crystalline. It is softer than the nail. Its appearance is intermediate between chlorite and saponite. In pounding it became brown. It was associated with a slaty steatite, which contained layers of minute crystals of talc. Belts of banded and mottled steatite, like Naples' soap in appearance, also occur in the lime, carrying rarely crystals of calcite.

1·3 grammes of the green mineral yielded, when fused with Fresenius' flux—

Silica, . . .	·596		
From Alumina, . . .	·005		
	<u>·601</u>	=	46·23
Alumina,			13·159
Ferric Oxide, . . .			1·882
Ferrous Oxide, . . .			3·073
Manganous Oxide, . . .			·384
Lime,			7·753
Magnesia,			14·153
Water,			13·308
			<u>100·142</u>

Loses in bath 7·657 of the above water.

This looks very like a new mineral, but upon treating some of it with chlorhydric acid the greater part dissolved, leaving a small quantity of white silvery scales.

As saponite is soluble in chlorhydric acid, while talc is not, and as an admixture of a little talc with saponite would give a composition similar to the above, there can be little doubt that this is some such mixture.

The two substances which appear to be new are the following. I name them from their localities :—

BHRECKITE

Occurred in very small quantity in a large granitic boulder, which lay upon the west slope of Ben Bhreck, Tongue, Sutherland, and which I have already referred to as containing amazonstone and many other minerals.

Is a bright apple-green, minutely granular or scaly powder, nearly as brilliant in colour as celadonite. Is soft and friable.

Was disposed upon the surface of quartz crystals, and therefore was one of the last substances to solidify; its immediate associates were specular iron and strontianite.

The small quantity analysed was to all appearance pure.

On .484 grammes—

Silica,	.166			
From Alumina, . .	.003			
	<hr/>			
	.169	=	34.917	
Alumina,			7.158	
Ferric Oxide, . . .			12.713	
Ferrous Oxide, . . .			2.105	
Manganous Oxide, . .			.414	
Lime,			16.082	
Magnesia,			8.264	
Water,			17.768	
			<hr/>	
			99.655	

Of the above water 1.033 was lost at 212°. There were traces of alkalis, but there was not enough material to determine them upon.

The mineral was freely soluble in chlorhydric acid.

Silica,	34.917	Atoms. 1.164	8	36.28
Alumina,	7.158	.14	} .3	7.78
Ferric Oxide, . .	12.713	.16		12.1
Lime,	16.082	.574	} 1.04	17.69
Magnesia,	8.264	.413		8.46
Water,	17.768	1.974	13	17.69

Formula—

Or Atoms—

RUBISLITE.

This substance I found along with Professor NICOL in a deep part of the quarry of Rubislaw, near Aberdeen.

It was imbedded along with crystals of muscovite in an exfiltration vein.

It occurred in a solid lump, and also forming a "corded structure," pervading felspar, identical in appearance with that noted by me in felspar: it thus occupied the position of the oligoclase or albite which usually forms that structure.

Its colour was dark green, its lustre dull, its structure was minutely foliated to granular, its particles could be separated from each other by the nail, which left a streak paler than the original colour.

It was readily and totally decomposed by chlorhydric acid, silica alone being left.

Its specific gravity was 2.442.

1.3 grammes yielded—

Silica,	.488				
From Alumina, . .	.004				
	<hr/>	.492	=	37.846	
Alumina,				10.924	
Ferric Oxide, . . .				9.84	
Ferrous Oxide, . . .				9.005	
Manganous Oxide, . .				.461	
Lime,				4.221	
Magnesia,				8.	
Potash,				3.334	
Water,				16.132	
				<hr/>	99.763

Loses in the bath 8.571 of the above water. Before the blowpipe semi-fused into a vesicular brown slag.

This gives in atoms—

		Atoms.				
Silica,	37.846	1.2615		22	22	37.42
Alumina,	10.924	.212	} .325		4	11.68
Ferric Oxide, . . .	9.84	.123		6	2	9.06
Ferrous Oxide, . . .	9.005	.25	} .885		5	10.19
Lime,	4.221	.151			3	4.75
Magnesia,	8.	.4		16	7	7.93
Potash,	3.334	.071			1	2.67
Water,	16.132	1.792		32	32	16.31

General Formula—

Or Atoms—

Possibly there might have been some slight admixture of felspar. The replacement in the protoxides is confused.

This is very like a Hullite in which much of the iron is in the ferrous condition.

These two substances are noticed in the hope of more of them being found; the quantity obtained of both of them was very small.

SUPPLEMENT TO SAPONITE.

In a letter from Professor KING, received since the foregoing analyses of saponite were executed, he writes:—

“According to HAUGHTON, saponite occurs with serpentine in Cornwall. Some specimens I collected there I take to be the same mineral; but it is not ‘soft like butter or cheese’—it is hard, something like serpentine, and may be actually a white or cream-coloured serpentine. The specimen laid by for you will settle the point. I should like to see your saponite.”

This sentence led me to compare the specimens which I have of what I have called the “super-hydrated vein-serpentine” (page 109) with the descriptions of saponite given by DANA,—and my analyses of these specimens with the column of analyses to be found at page 472 of his work.

While the physical properties assigned to saponite by DANA agree perfectly with those of the specimens which I have analysed, and therefore warrant my assigning the name to the Scotch specimens, it cannot be said that the claim of certain of DANA’s specimens to the name is altogether beyond a doubt, and this on account of the most characteristic of the features of the Scotch mineral—namely, the low temperature at which it parts with some of its water—not having been observed in the specimens hitherto ranked as saponite. When, however, the *analyses* given by DANA are considered, there is no room for doubt that some of the substances analysed should not have found a place there, and there is even room for doubt if any but the *thalite* of OWEN should.

Nothing, but their having suffered such a loss of water as I have pointed out as likely to occur through exposure to heat during carriage, could entitle us to associate under one name substances varying in their content of water to such an extent as from 10·5 to 20·66 per cent.—a variation which so far explains, though it hardly justifies, DANA’s remark, that “analyses give naturally no uniform results for such an amorphous material.” Had it been said that the name had been applied to substances which, filling the steam-holes of volcanic rocks, were unquestionably the products of change or degradation,—possibly not always of the same nature, or of the same material,—such a remark might legitimately be made. It is, however, a fairer inference that the analyses give no uniform results, because *different substances* have been included under one name.

And this inference is borne out in a marked manner by a consideration of the peculiar substance which fills the rents in serpentine rocks; and this consideration leaves little or no doubt that the so-called steatite or seifenstein from Cornwall and from all serpentine rocks must be withdrawn from the species, and that the name must, as I have shown above, be in future confined to one of the materials which plug the amygdules or rarely the rents of *igneous rocks*.

The suggestion of DANA's that as, if we suppose the alumina to be present as *kaolinite*, the rest is a silicate allied to *aphrodite*,—*as if the mineral were a mixture of the two*,—I cannot regard as sound, for the two reasons that, according to DANA himself, neither kaolinite nor aphrodite occur in volcanic rocks (nothing of the kind is to be seen in the Scotch ones), and because, as he himself states, kaolinite is not decomposed by acid, while saponite is.

Any admixture “as kaolinite,” with a mineral soluble in acid, would after treatment therewith disclose itself by remaining as an insoluble residue.

The features, so far as I have yet attained to the recognition of them, whereby this super-hydrated vein-serpentine can be discriminated from saponite, are the very much smaller amount of its loss of water when heated,—its smaller content of water,—and a peculiar opalescence and girasol appearance, which it presents, when transparent varieties are looked through.

In five analyses of these “vein-serpentines” from Scotland which I have executed, I have found the quantity of total water to lie between 15·16 and 16·58 per cent.; and of this the loss at 212° ranged from 1·63, which was that of the lowest total, to 3·53, which was that of the highest.

The deduction of these losses, it will be observed, brings the residual water to about the amount normal to serpentine.

Such were the conclusions I had arrived at when the receipt of a box of Irish serpentines from Professor KING, containing specimens of the “saponite veins” of Cornwall collected by himself, enabled me by analyses to speak with more precision on the matter.

The specimens of the Cornish “saponite” were at once seen to be physically very similar to the paler-coloured vein-serpentines of Portsoy. Being apparently somewhat weathered they were opaque, and the girasol appearance could not be seen.

A weathered vein from the serpentine of Polmally, in Glen Urquhart, which was very similar, was analysed along with this Cornish saponite.

It is not necessary here to quote more than the content of water, and loss thereof at 212°: this was—

	Total water.	Loss at 212°.
Mineral from Cornwall, . .	14·133	1·166
„ „ Polmally, . .	15·162	1·626

This, taken in conjunction with a general accordance with their other components, shows that these specimens are similar to other vein-serpentines, and are quite distinct from the mineral which occurs in volcanic rocks.

As the specimen sent by Professor KING is quite similar to other smaller ones which I have seen in the Lizard serpentine, there is every probability that the mineral analysed by KLAPROTH, SVANBERG, and HAUGHTON was the same; and that of the substances classed under the head of saponite by DANA, only those narrated as filling geodes in volcanic rocks properly fall under the title.

SUPPLEMENT TO CHLORITE.

I have lately observed what I believe to be a chloritic mud occurring in a form in which it bears a great resemblance to glauconite.

The circumstances of its occurrence are of much interest, and the explanation of these circumstances is attended with no small amount of difficulty.

Immediately to the north of the village of Callander there is a cliff of conglomerate of the Old Red Sandstone; this is here formed of nodules, from the size of a walnut to that of the fist, of gneiss, mica slate, and quartz,—rocks of the immediate neighbourhood.

Rarely thin interstrata of a finer almost of a sandy grain,—more fitted for building purposes,—occur to the north-eastward of the village.

In several small quarries, opened with a view to work these gritty beds, the characters of the conglomerate may be studied. It has somewhat of a vitrified aspect, and is more broken up by “backs” and “cutters” than is usual to that rock. The dip is to the north-east; the backs run along the strike at distances of about six feet from each other; while the cutters, lying generally at right angles thereto, are much more closely adjacent to each other.

The backs, in those cases in which they have stood open, are invariably filled with one of the varieties of the substance to which the names of *reddle*, or *keely* or *keels* has been attached: the cutters are as invariably lined, and usually no more than lined, on each side with sheets of cockscomb barytes, which sometimes carry vitreous copper, malachite, and calcite.

The dull red of the vertical sheets of reddle is everywhere besprinkled with spots and blotches of a vivid green, of the colour of glauconite,—these spots are circular in form, or consist of a number of confluent circles, each circle being of about the size of a large bean.

The contrast of these colours is so striking as to arrest the attention of the passer-by; it is found upon examination to be due to the occurrence in the

pseudo-vein of reddle, of "concretions" of granular pale purple carbonate of lime, of a discoid form; and to these concretions being invested by the glauconite-like material, disposed in a laminated manner.

Portions of the calcareous concretions,—of their green coating,—and of the reddle, were examined in the laboratory, after isolation each from the others.

The concretions did not appear to have any structural arrangement of particles, being similar to a very fine-grained saccharine marble; they dissolved readily and totally in acid, without leaving any save a glauconitic residue; and neither they nor their associates contained any trace of barytes.

The glauconite-like matter was found to be insoluble in all acids; but after treatment therewith and agitation in much water, it separated into minute colourless pearly scales (like mica), and a green powder, which was also minutely scaly.

The reddle had a laminated arrangement of its particles parallel to the sides of the vein; it resembled a red sandy clay, and glistened with minute scales of mica. Treated with chlorhydric acid it yielded readily a ferruginous solution, but left behind the greater part of its bulk as a green powder, similar in appearance, and also in its insolubility similar to that which presented itself originally with a green hue.

From the evident admixture of scales of mica, it may be doubted if an analysis of these green powders—probably identical—would definitely disclose their nature; but the above chemical features sufficiently show that they cannot be any one of the saponites, unless it be celadonite, and their being the latter is contradicted by their scaly structure.

Their insolubility in acids equally proves that they cannot be glauconite; and, having regard to the occurrence in the conglomerate of quartz nodules with a chlorite which is very similar to that of Cruach Ardnan and the hills surrounding it, there is every probability that the green portion consists of chlorite alone.

While the impurity of this substance prevents a more accurate determination, enough has probably been attained to, in the direction of indicating several points of marked interest connected therewith.

The following questions present themselves for being answered:—

By what process were these veins filled? The ready reply,—neither by infiltration nor injection, but by exfiltration,—goes but a little way. Conglomerated rocks are more pervaded by a system of *inosculating holes* than by fissures,—but I broke many pieces of the rock without being able to detect in its cavities any green matter in the course of being transported to its resting place in the vertical rents; but an exfiltration of reddle-like matter may be observed, and this may obscure a concomitant chloritic transfusion.

Then, *What is the action whereby the segregating calcareous matter repels the hematitic*,—thus operating as a pseudo-bleacher?

And lastly, *How comes it that the one set of rents are lined with baryte, with vacuous interspaces; while that which lies at right angles thereto contains no trace of baryte, but is totally filled with a clay-like material?*

An explanation which may be said to lie upon the surface—namely, that the first mentioned set had been of earlier formation, and had been the seat of a process which had reached its termination before the formation and filling up of the latter,—does not meet the facts of the case, because the rock-rents which form the “backs” seem to have been antecedent to those existing as “cutters”; for the former pass numbers of the latter, while these but very seldom cut across the former.

The rock seems to be *still* purveying hematitic and chloritic matter to the cracks which form its “faces”;—*is there a polarity in the guidance of its decomposition*, acting so as to fill its minor and secondary rents with barytes and with copper,—enabling them at the same time to reject the slimy plug which chokes the backs, that they may at least aspire to the dignity of being true mineral veins?

Some questions of weighty mining import might possibly be answered through a study of this narrow field;—the points of chief mineralogical interest are the occurrence of a chloritic mud in a form simulating glauconite,—and the singular manner in which a large quantity of chlorite may be entirely masked by a comparatively small quantity of peroxide of iron.