ORKNEY AND SHETLAND.

ISLAND OF UNST.

Geognostic features.

IT would have been well if the consideration of the geognostic features of Unst had gone along with that of the adjacent island of Fetlar, inasmuch as the strata met with in Unst are but the more widely spread developments of those which are to be seen, in more condensed form, in the latter island. The size of page, however, not permitting of a map which on a useful scale of projection would admit both, the more northerly island must stand alone.

Unst is entirely composed of that class of metamorphic rocks which, at present, are referred to the lower-silurian epoch.

The metamorphism is of two degrees, or stages:—that primary, or more purely *physical* metamorphism, which produced arenaceous gneissoid rocks, quartzites, micaceous schists, and crystalline gabbros;—and that secondary, or *chemical* transmutation, which converted the more schistose varieties of the former into talcose and chloritic schists; and the crystalline gabbros into serpentine and limestone.

As is usual throughout the other parts of Shetland, and of Scotland, the earlier formed of these rocks lie to the westward; and, as elsewhere in Scotland, the general strike has a north-east and south-west direction; though in Shetland it has less of an east and west tendency than that normal to the rest of the country.

As the general dip of the gneissose rocks of Shetland is to the west, it would appear that it represents the ascending curve of one of the folds into which that rock is thrown, as it passes eastward from its first normal dip. At no great distance in Yell the westerly fall is prevalent; and as in Unst we have, within a short space, a succession of westerly and easterly dips, followed by a decided and terminal fall in the latter direction, it would appear that within the island we have a crumpled anticline; and this is immediately succeeded by the superposition of a rock which is a more recent variety of the same general series.

It is a somewhat constant feature of the gneiss of Shetland that it is abnormally deficient in felspar; composed thus chiefly of two substances which are almost unalterable under the ordinary agents of exposure, it possesses the character of unusual durability.

It is due doubtless to this fact, taken in conjunction with the direction of the strike, that it forms the enduring backbone of the group of islands; giving to them dimensions which are greater in a north and south direction, than those at right angles thereto; and forming for some of them a protecting buttress against the western ocean. At first sight this may seem to be due merely to the amount of submergence; it resolves itself into the same thing in the end, being but a question as to what kind of rock has resisted longest the various processes of denudation, and the different agents of decay.

There is no county in Scotland which presents us with so many varieties of rock as Shetland; and there is no one of the islands which has so many of these equally condensed in space as Unst; and, as the points of junction of different strata are one of the richest fields for minerals, Unst, therefore, should yield these abundantly.

The geographical configuration of the island of Unst is,—a sea board on the west, which, in a general sense, is a straight line;—a deep and direct central trough;—and a markedly indented and undulating sea board on the east. On the north and south the sea finds its way, as deep "Voes," far inland; running up the great central depression. All of these features are immediately dependent upon its geological conformation.

In the more southerly main-island we find, interstratified with the gneiss, three great beds of limestone. Here, as elsewhere, these beds, through aerial waste, form trough-shaped hollows among the more enduring strata; and in insular positions their washed out terminations are represented by bays which thrust themselves far inland.

The most easterly of these limestone beds occurs, in the mainland, to the eastward of all the gneiss; lying between it and the mica schist. The undoubted representative of this bed occurs in Unst in a precisely similar position, forming the great central trough; this is cut out here and again into narrow lakes; and forms, as its northern continuation, the deep and lengthy arm of the sea called Burra-Fiord.

There is every reason to believe that the straight and precipitous line of western cliffs have been formed by the washing away of the prolongation of the central of these lime strata; for, in the projecting westerly promontory of Houlan Ness, limestone is still to be found,—a prolongation of which, north and south, would exactly skirt the coast.

It is a peculiarity of all the formations of the larger, or mainland of Shetland, that, after a general north and south strike maintained for many miles, they gradually uniformly sweep round to the eastward in their outgoings. This same feature is to be observed in the rocks of Unst; and the deep bays on the eastern coast are found to occur either at the junctions, —the weak points—of the strata, which have curved round so as to meet that coast at an angle,—or in the hollows between the hill ranges of these strata.

Thus the most northerly of these bays—Norwick—lies in the junction between the mica schist and the serpentine; Haroldswick, between two hill ranges of the serpentine; Balta Sound is formed partly in this latter manner, partly by the junction between the serpentine and the diallage; a continuation of which junction line severs the island of Balta from Swinaness; and lastly, the Bay of Vere lies in the hollow between the gabbro and a series of strata, of which a chloritic slate is perhaps the most prevalent.

There is a rock, the relationships of which are obscure, which has not yet been noticed. It presents itself in but small extent in the south-west corner, forming a precipitous headland. The peculiar colour of this rock has given the name to this headland, the *Blue Mull*. A rock—indeed a Mull—very similar to, though on a grander scale than this, also occurs in the south-westerly corner of the mainland, forming the Fitfel Head.

There has been considerable discussion as to the nature of this rock, —certain geologists calling it mica slate,—others clay slate. Cornish miners termed it killas; Hibbert speaks of its unctuosity, inclining to consider it talc slate.

Hibbert correctly noted its easterly dip at the Fitfel Head; but considered it as merely a detached portion of the clay-slate, which extends from Quendal Bay to Deal, though he assigns to the general mass of that rock a westerly dip.

I have to remark in the first place, with regard to the dip of the clay slate of Shetland, that I believe Hibbert has, in many places, mistaken *cleavage* for dip; and in the second, that I was unable to find in the great mass of the clay-slate, the peculiar features of the Blue Mull and Fitfel rock. The relationships of the Fitfel mass to the other rocks of the district cannot be well made out; as it is cut off, in the first place, by a granitic intrusive rock; and the first true clay slate to the east is, for many miles, covered with a great deposit of shifting sand.

The Blue Mull rock dips generally to the east, and seemed to me to abut against the gneiss, through a fault; but I was unable, on account of surf, to reach the actual junction.

A rock which possesses the mingled features of mica, clay, and talcose schist, describes itself, so far at least as to render further description difficult except to say that it has a light blue color, glistens with minute scales of mica, and that it appears to have an argillaceous basis. I should describe it as very unlike mica slate; and as tending *in appearance* most to a talcose slate. But it is so similar to, though it may be said to be an extreme development of a rock occurring nearer home, so to say, that further description may not be called for. The rock I refer to also has led to a hesitancy in its describers; it occurs, ill-developed, in Glen Rinnes; well-developed, though not by any means so strikingly so as in Shetland; in the parish of Boharmin Bauff; in Glen Mid Clova, and the Coreen Hills, in Aberdeenshire. At the two latter localities it is studded with crystals of andalusite. Of the basis, perhaps a tenth part was found to consist of a mixture of minute garnets and magnetite; while the remainder was found on analysis to be composed wholly of minute scales of *pihlite*. I incline to believe that the Blue Mull and Fitfel rock will prove to consist largely of this, or a somewhat similar substance.

The Glen Rinnes rock occurs far west, that is low down in the gneissose series of Banffshire: I was never myself able to find its actual contact with the more easterly quartzite; but its dip is certainly to the east, and Hay Cuninghame states that he has actually seen it dipping under the quartzite, to the south of Tomantoul.

If this be a rock *sui generis*, its position so low down in the gneissose series might have no further interest than that attaching to a new member of that series; but, as *the* rock which in Scotland carries andalusite, staurolite, and some other substances it is worthy of a special investigation.

The gneiss of Unst forms a somewhat uniform belt of about 11 miles in length, by 2 in width, consisting of a hilly ridge running north and south, and forming a cliffy bulwark against the western ocean. This seems never to repose peacefully at its feet, but to be unceasingly seathing and grinding among the rocks of a shore, which, for ruggedness and absolute repulsiveness of appearance, can have few equals.

To the east the gneiss falls into a valley, which is somewhat monotonous, from the too frequent repetition of the lakes which, in a somewhat swampy manner, fill its hollows, or represent the former outcrops of its limestone. A continuous mass of the latter lines the eastern shore of the Loch of Cliff, for a distance of about three miles. Underlying this line at its northerly extremity, on the shores of Burra Voe, there is a small patch of a rock regarded by Hibbert as quartzite; probably more correctly an unusually quartzose mica schist.

To the eastward of the lime, or of the "lime sinks" in the valley, there are thin and mostly concealed beds of chloritic and micaceous schist; which latter suddenly expands greatly in thickness,—rises into a hill nearly 1000 feet in height,—and curves round to the eastward, forming the bluffy headlands of the whole north of the island.

This again is one of those rocks of an intermediate nature. It is of a very close and fine grain; and the mica seems to be nearly as small in the particles, and in almost as granular a condition as the quartz. The mica is sometimes also very small in quantity, the rock assuming the character of a sandy grit. Hibbert found much magnetic disturbance at the top of the hill, while the magnet of the writer was unconscious of any disturbance; nor was any cause thereof to be found, for the few exposed stones on the hill top carried minute garnets, and no visible magnetite.

The junction of the schists with serpentine appears at the head of the bay of Norwick, a little west of the small rock called the Ting of Norwick; it is not altogether well seen, being subject to be covered up by shifting sand; I incline to think that there must be a fault at the junction.

The serpentine which follows is of the dense massive uniformly coloured variety; that which also weathers with a rusty crust. It does not here appear with the serrated peaks which are so characteristic of this rock in many districts; the whole of this side of the country presenting glaciated contours. As a serpentine, it is, from its dull colour and the total absence of variegation, devoid of beauty altogether; here and there small patches exhibit a rich deep green, and are translucent; but the uniformity of the tint precludes its application as an ornamental stone. It is also singularly deficient in veins of the precious variety; the few which occur will be mentioned among the minerals.

The serpentine is succeeded to the east by a ridged, if not a stratified gabbro, consisting solely;—so far as I know, of labradorite or an equivalent felspar, and augite.

The labradorite is an impalpable granular variety, containing some anorthite; the augite is of a light-green colour, tending towards diallage.

This gabbro is, in turn, succeeded by strata of a somewhat mixed nature; but, from its general prevalence, they may be grouped under the name of chlorite slate.

Skirting the south east shore, near the point of Muness, serpentinous rocks again curve in; these form the commencement of a rock much higher in the series than that already noticed; being the prolongation of the large mass which forms the Vord hill in Fetlar, and the Island of Haaf Grunay.

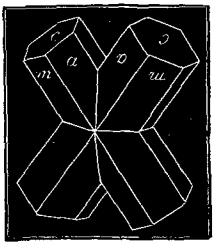
In the north-east corner of Unst there appears a rock of a nature intermediate between hornblendic-granite and syenite. It is markedly porphy-

ritic, containing very distinct crystals of felspar, one or two inches in length; these are embedded in a crystalline paste which shews hornblende and epidote.

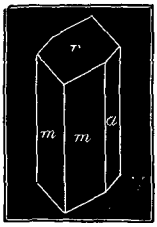
Minerals of the Gneiss.

A patch of this rock, lying between the south-end of the Loch of Cliff, and the rocky sea board in the vicinity of the little creek of Woodwick, approximates, to some slight extent, to the character of a mica-slate. Felspar is still present, but only in small amount; the rock, however, is unmistably gneiss.

Staurolite is found in this rock in three localities: on the sides of a little knoll which overhangs the sandy beach at Woodwick (Hb.); on the hill of Snuegar (H.); and near the summit, on the west side of the hill which lies between Woodwick and the Loch of Cliff (D. and H.)



The staurolite of this rock occurs only in minute crystals of about three-eighths of an inch in length; it is, however, of a rich-brown colour, and a high lustre. The forms are *m c*, *m c a*, *m c a r*, this last is the Saint Andrew's cross twin; and *m a r*, with the last face hemihedral as in figure. As the crystals which have been exposed by disintegration of the rock are those which are best seen, and, as this somewhat brittle mineral rapidly loses its terminations, the face *c* is but rarely present.



Kyanite is also to be found in association with the staurolite at the last mentioned locality (D. and H.) It there occurs in blue-grey radiating crystals of about one inch in length, which, instead of being as usual imbedded in quartz, form a band in the rock. *Magnetite* and *garnet* are here associates (D. and H.)

Minerals of the Mica Slate.

On the west side of the Hill of Saxavord, near its junction with the quartzite, Hibbert found *magnetite* in specimens of half the size of the hand.

At a spot called Ureh near the west of Braewick, a little above where a small stream, the Ness-Muir burn, slides over the rocks, gold was said to have been found in decomposing slate, along with iserine. The story given in connection with its discovery is altogether incredible. Mr.

Dudgeon of Cargen, the author, and two of the so-called "most successful diggers" spent the greater part of a day in an absolutely unsuccesful search. The author afterwards found that, in the islands generally, the whole story was considered to be altogether unworthy of belief. The granular magnetic mineral which, in small quantity, is met with in washing the sands of the afore-mentioned stream, shows under the microscope of a pitchy blackness. The grains are but little attrited, bearing the impression of the quartzoze granules with which they are associated. They rarely show forms, these are certainly not octohedral, but apparently rhombohedral, with truncated angles. In all probability, therefore, they are *ilmenite.*

The quantity obtained, during the "gold washing" of four persons for a day, was about 3 grains in weight.

A black iron sand is somewhat sparingly found (D. and H.) among the ordinary silicious sands of the Dale burn, about the spot where it turns to the northward.

This proved on analysis to be a new chromiferous variety of *magnetite.* It is of a blue-black colour, decidedly but not strongly magnetic; under the microscope it seems much split or cleaved, of hackly fracture, and shows no forms. It was, as far as the small quantity obtained permitted, separated from silicious and non-magnetic sand, by repeated stirring up in water and decantation, and ultimately by the magnet.

When magnified, it then appeared to be, with the exception of an admixture of silicious grains, uniform.

On analysis it afforded :—

	1.		2.	
Ferric oxide	57·285	..	62·464	
Chromium sesqueoxide	9·4	..	10·25	
Ferrous oxide	24·944	..	27·199	
Manganous oxide	·4	..	·436	
Lime	1·12			
Silica	7·2			
	100·349		100·349	(H.)

2 gives the proportions, abstracting the silica and lime, as these are undoubtedly present from mere mechanical admixture.

The question is, can this be an admixture of magnetite with chromite? No one point connected with it favours such a view. Its geographical and geological position does not; it is found about two miles from the nearest chromite, with more than one hill ridge between; its altitude is greater than that of the chromite; and the stream which sweeps it from its parent rock, flows from a hill of mica schist.

It was physically purified by the magnet, which readily abstracted it from the silicious admixture: chromite is, at most, and that only rarely, feebly magnetic.

Its powder had a uniform blue-black colour; the crushed powder of chromite is brown.

Lastly, an admixture of chromite with magnetite would not yield the per-centages above given. The analysis points rather to a replacement of ferric oxide by chromic oxide, though it is not altogether accordant with that.

This magnetite was so difficult of decomposition, that comminution under water, with repeated decantation was had recourse to. Towards the conclusion of the process, the pestle was found to jump over a number of particles, which no force could reduce to powder, though several were found to be flattened out by the pressure into thin scales. These were thoroughly washed, and found to be strongly magnetic. When placed in an acidified solution of a copper-salt, they became instantly coated with the red metal. They readily dissolved in acid, without residue; and gave the tests for iron. In the pounding of the magnetite it had never been touched by an iron or steel tool; and, from the time when they were collected, to that in which they were examined, they were never out of the writer's possession; these grains, therefore, are *native iron.*

The occurrence of grains of this substance in a metamorphic rock is new,—frequent as is the occurrence in rocks of an igneous nature; and the occurrence of metallic iron in a rock primarily of a sedimentary nature is difficult to explain; but until a laminable magnetic substance, which precipitates a salt of copper, and gives the iron reactions, can be shown to be other than iron, this must stand for such. The grains had been protected from atmospheric action by a coating of magnetite,—a substance lately proposed and patented for this very purpose.

In the hill foot, about three-fourths of a mile to the north-west of the houses at the head of Norwick bay, there are several quartzose bands, running north and south; one of these carries pale blue rosettes of radiating *kyanite* (D. and H.)

A little to the east of the Bridge of Balliasta, in the more chloritic varieties of this rock, and near their junction with the limestone, there occurs a substance or combination, of a unique appearance; and one which is possessed of great peculiarity, if not beauty.

Upon a groundwork of a greenish yellow colour, and impalpable structure, there are sprinkled sparsely, or profusely,—as the case may be,—bright green crystals of hornblende of the size and form of ears of corn. (D. & H.)

It was the writer's fortune once to be acquainted with an individual who maintained that he had discovered *petrified maggots*. So marked was the resemblance to these here, that had the said individual seen these specimens, it would have proved no easy task to undeceive him.

The appearance of the cross fracture of this stone is very different from that of its more readily obtained cleavage.

It is seen to consist of successive layers of a foliaceous paste, each of which layers carries its sprinkling of hornblende crystals; the effect produced somewhat resembles an irregularly printed page.

When the stone is soaked in strong acid, the yellow paste darkens somewhat in colour, is loosened in structure,—swelling up,—and is seen by the aid of the lens, to consist of a multitude of minute crystals of talc.

Minerals of the Porphyritic Syenite.

This rock contains imbedded crystals of *orthoclase* of about two inches in size; these lie in a granular paste of felspar, quartz, hornblende, and perhaps epidote.

The rock is a very beautiful one, and might be utilized for ornamental purposes.

Minerals of the Serpentine.

Ting of Norwick.—This islet, connected with the land by a sand bank, is composed of junction rocks,—if I may coin a name for substances of an intermediate nature, which are difficult to specify. In old works this spot is indicated under the title of "Bay of Norwick," as the locality,—the only British locality,—for Breunnerite.

With difficulty a single specimen was obtained. This had a grey colour, and was in readily-cleavable crystals of an inch in size. The specific gravity was 2·91, the cleavage angle 106° 6′.

Its analysis yielded:—

Carbonate of	Lime	51·804
,,	Magnesia	37·998
,,	Iron	7·82
,,	Manganese	2·314
Quartz (insoluble)		·02
		99·956 (H.)

This is *Ankerite*, and, so far as known to the author, the only locality of that mineral in Britain.

Along with the ankerite, there is to be found *talc* (D. and H.) of a yellow colour, and in a columnar form, suggesting pseudomorphism after kyanite.

Talc, in somewhat weathered specimens, is to be found in a vein which runs east and west about half a mile north-east of the houses at the head of Norwick Bay. Good specimens would doubtless be obtained by quarrying.

Quin Geo.—(New locality, D. and H.) This geo or bight is situated on the north-east of Norwick Bay. There are two geos, a north and a south: the ruins of a chapel indicate the spot.

From the north geo there were obtained, but only after a considerable amount of blasting, specimens of apple-green talc, perhaps finer than those procurable from any other locality.

The lustre and colour could not be surpassed in beauty. The associated minerals were dolomite, breunnerite, and jet black crystals of magnetite; as the dolomite was in highly translucent white crystals, the contrast with the talc was very beautiful.

The specific gravity of this talc is 2·76. Its analysis yielded:—

Silica	62·5
Alumina	·454
Ferrous oxide	·529
Nickel oxide	trace
Magnesia	31·842
Water	4·789
	100·114 (H.)

The *Dolomite*, mentioned as associated with this talc, occurred in primitive crystals of over an inch in size. The cleavage angle of these crystals is 106° 17′. The specific gravity, 2·865. Its analysis yielded:—

Carbonate of Lime	52·548
,, Magnesia	43·772
,, Iron	1·972
,, Manganese	1·369
Insoluble (talc)	·1
	99·76 (H.)

As has been mentioned, associated with the above, *Breunnerite* is to be found. It occurs in pale-brown rhombohedral crystals, not quite so large

as those of the Dolomite, in which, or in the talc, it is imbedded. Its specific gravity is 3·093; its cleavage angle 106° 50′. Its analysis yielded,

Carbonate of	Magnesia	91·394
,,	Iron	6·784
,,	Manganese	·78
Silica		·6
Alumina		·136
Insoluble (talc)		·096
		99·76 (II.)

Of these three asssociated minerals, the talc usually occupies the position contiguous to the rock matrix.

Besides the above, there also occurs here *fibrous talc* (?) in veins of one and a half inches in thickness; the pseudo fibres being transverse to the vein: the mineral is white and silky.

Magnetite, rarely in jet black crystals of the form *o d*, of one fourth of an inch in size, a perfect polish, and consequent high lustre.

Brucite, in small specimens, rarely. These all occur in *North* Quin Geo.

In *South* Quin Geo there are to be found rolled pebbles of *serpentine* of the precious variety, containing imbedded pseudo crystals of diallage, which, though fully converted into serpentine, retain the foliaceous appearance of the former mineral. These "pebbles" are of but small size, rarely larger than an orange, but they are the finest ornamental serpentine to be found in Unst.

Hagdale.—This name is usually applied to the shoulders of a hill overlooking on either side the Bay of Haroldswick and Balta Sound. The *dale* opens into a small bight on the south side of Haroldswick; here *native copper*, and either *chrysocolla or malachite* was formerly found: the author was unsuccessful in finding more than indications of their occurrence.

On the shoulder between the hill of Heyoags and Keen Hill, a great quarry of *chromite* (Hb.) was formerly wrought. After sinking to a depth of about 86 feet the ore ceased; many thousand tons were here obtained.

It unquestionably, judging even from the appearances to be seen at the spot, formed part of a vein. This vein runs somewhat to the north of due east and west from the point where it is first seen, thus being nearly synchronous with the strike of the rock as shewn in the hill ranges. The vein does not everywhere carry ore,—that occurs only occasionally as "bunches." This vein has been wrought, here and there, along a stretch of perhaps a mile and a half; it throws one or two offsets, in the neighbourhood of the house of Buness.

The chromite is found extremely rarely in octahedra; these sometimes occur in the mass of the rock,—sometimes isolated and imbedded in a foliated soft green mineral (pennite ?). At this quarry there were found the following minerals.

Emerald Nickel (H.) in fine specimens rarely, these generally pass into globular *Genthite* (H.) The emerald nickel is probably the result of the decomposition of minute specks of *Pentlandite* (H.) which are to be seen in the massive chromite. *Pennite* of a pale green rarely coats the shrinkage cracks of the chromite (H.)

Chrome Ochre (McC.) in bright yellow pulverulent layers, which shade off into green. *Arragonite* (H.) in radiating crystals, form *m a p x k v*, of half an inch to an inch in length. Massive granular *Kammererite* (H.) in considerable quantity, and rarely in hexagonal plates of a pale purple, passing into green. *Williamsonite* (H.) rarely. *Pennine* (D. and H.) in small but highly beautiful and perfect crystals *b o*, of an apple green colour, and a lustre nearly as high as that of talc. A foliated green mineral very similar to *grastite* is rarely imbedded in the chromite (H.)

There also occurs a scaly bronzy-brown substance, rarely coating cracks of the chromite; this I have not a sufficiency of for examination, and I can hardly hazard an opinion as to its nature. It may be a brown talc, or Biotite,— or a brown kakoxine, for it appears to be sub-fibrous.

The serpentine, when it approaches the chromite, and especially when it is intersticially lodged between the granules of that substance, usually assumes a lighter colour, passing at times into a bright yellow, and becoming denser and somewhat granular in structure.

A portion of this,—unusually pure, from being somewhat in the form of a vein,—for which I am indebted to the veteran meteorologist, Dr. Clouston, of Sandwick in Orkney, yielded on analysis,

Silica	31·854
Alumina	·988
Ferric oxide	7·464
Chrome oxide	3·073
Manganous oxide	·614
Lime	·631
Magnesia	37·09
Carbonic acid	1·178
Water	17·02
	99·912 (H.)

Granules of chromite were visible during the pounding of the mineral; while the analysis shews a mixture of magnesite. Deducting from the

above, proportional quantities of these, and again calculating to the same total, there is obtained,

Silica	34·461
Ferric oxide	6·757
Manganous oxide	·628
Lime	·585
Magnesia	38·961
Water	18·529
	99·912

This is evidently a serpentine, mixed with about 12 per cent. of Brucite; so that this yellow gangue cannot be considered as a simple mineral, but as merely a light coloured serpentine carrying Brucite, which latter has become somewhat carbonated. It is not usual for the iron to be in the ferric condition—but we have analyses giving it as such.

The massive Kammererite is granular to foliaceous; it has occasionally nodules the size of shot, which are quite granular, and may be different in composition. Its colour is pale purple to bluish purple. Rarely, imbedded hexagonal foliated plates are to be seen. The foliæ split across the crystals, which are less than the quarter of an inch in diameter. The specific gravity is 3·099. The analysis yielded,

Silica	29·894
Alumina	12·931
Sesqueoxide of chromium	5·967
Ferrous oxide	1·955
Nickel oxide	tr.
Lime	3·54
Magnesia	29·933
Potash	1·156
Soda	·974
Water	13·266
Carbonic acid	tr.
	99·616 (H.)

I also found, imbedded in the purple Kammererite, in patches about the size of beans, a substance which I believe to be new. As I have not yet obtained a sufficiency of this substance in a perfectly pure state for a thorough investigation, the following notice of it must be considered as merely preliminary.

It occurs as a loose powder of a fine lemon yellow colour, which contrasts beautifully with the purple of its matrix.

In endeavouring to obtain enough for analysis, a portion of that matrix was unavoidably scraped off along with the powder.

This matrix, being Kammererite, was insoluble in weak acid. The yellow powder, which was freely soluble, consisted solely of carbonates of lime, iron, and manganese, a trace of chromium, magnesia, and water. It lost in the water-bath 1·006 per cent. of moisture. Its analysis yielded,

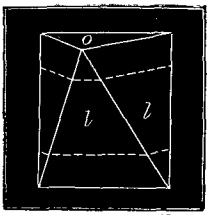
Lime	22·57	
Ferrous oxide	2·561	
Manganous oxide	·461	
Chromium oxide	trace	
Magnesia	21·059	
Carbonic acid	20·177	
Water	12·478	
Insoluble (*Kammererite*)		20·678
	79·306	(H.)

This, made up to 100 parts, gives,

Lime	28·459		29·94
Ferrous oxide	3·229	30·366	
Manganous oxide	·583		
Magnesia	26·554		32·09
Carbonic acid	25·442		23·53
Water	15·733		14·44

This evidently does not come under the formula of any known mineral: it may point to the formula 2 CaO, CO_2 + 3 (MgO, H_2O),—the per-centages of which are given in the second column. Should the analysis of purer specimens prove it to be a distinct substance, I would propose to name it *Hibbertite*, after the discoverer of Chromite in Unst.

The more recently opened quarries above Buness have yielded finer and larger specimens of the same substance, in the same association. Also



Kammererite (D. and H.) in fairly well pronounced crystals, of the form depicted; these are nearly half an inch in length. The foliæ are hardly thin enough to show the optical properties well, but it is uni-axial, or if bi-axial, the divergence is very small. The colour is a fine rose purple. Its analysis afforded,

Silica	32·307	
Alumina	7·497	
Lime	3·833	
Chromium Sesquioxide	7·888	
Ferrous oxide	2·076	
Magnesia	32·153	
Water	14·246	
	99·9	(H.)

A specimen of what was thought the richest chromite from this quarry was analysed. It was a very crystalline mass, almost in isolated octohedra; the crystals were separated from each other by foliated pennite. (?) These crystals were jet black and of high lustre. After most careful picking, small grains of translucent quartz were still visible; the quartz seems to occur only in the interstices of the chromite. This certainly is a singular fact. I have never been able to find any quartz imbedded in the serpentine.* There was obtained,

Ferrous oxide	17·519=19·465	Fe_2O_3
Manganous oxide	·499	
Chromium Sesquioxide	44·555	
Lime	1·286	
Alumina	23·741	
Silica	11·088	
	98·688	(H.)

In accordance with the usually received view, I have tabulated the iron as protoxide; but by no method of decomposition could I obtain it except as sesquioxide; even the process which I have given for the determination of ferrous oxide,—which decomposed the mineral with extreme difficulty,—yielded the iron as ferric oxide.

It has to be remarked also, that in the later analyses by Starr, and by Garrett, they give the iron as present in the state of ferric oxide; and that in the analysis of the light yellow serpentine from Hagdale, which was stated above to contain chromite, no protoxide of iron was found.

I am well aware how repulsive such a fact must be to the theory of isomorphism: I can only state what I got, and say that I do not see how any peroxidation could have occurred; and that I cannot otherwise explain the large loss.

Arragonite occurs not unfrequently, coating this chromite. The yellow serpentine is here the vein stone (D. and H).

Swinaness.—As we approach this point, the serpentine gradually becomes less massive, and altogether less uniform in structure: a certain amount of rough bedding, or lamination parallel to the line of its junction with the adjacent gabbro, is also occasionally visible. The actual junction with the latter rock is nowhere, on the north side of Balta Sound, to be seen; the North Channel, or northern entrance to the Sound occupying the junction.

* My assistant, Mr. John Dalziel, tells me that two specimens of chromite which he analysed contained about 20 per cent. of silica.

Along the line of hollows which represent the junctions of the beddings of the altered rock, exfiltration veins are to be seen. These generally are of calcite, occasionally crystallized in "nail-head," and other common forms. One of these veins contains *Brucite* (Hb.), which occurs in large foliaceous sheets, and also in botryoidal masses (H.) The latter mode of occurrence I believed to be unknown elsewhere. The curvilinear outline lies at right angles to the sides of the vein, which is about one and a half inches wide. The rounded forms are composed of successive layers of the mineral, which also shows somewhat of a columnar or rudely fibrous structure, at right angles to the lines of separation of the layers. The mineral very rarely shows the outlines of superimposed hexagonal crystals. It seems here to lose water on exposure, more rapidly than it becomes carbonated; for I have found that specimens which had become dull and somewhat earthy looking, had their brilliancy restored by being plunged in water. And this restored brilliancy they have not again lost.

We have the following old analyses of the Brucite of Swinaness, and I add one of the foliated variety.

Mg.	Fe.	Mn.	Cu.	$\dot{H}_2.\ddot{C}.$	
69·75	..	..	..	30·25=100	Fyfe
67·98	1·57		..	30·96=100·51	Thomson
66·67	1·18	1·57	·19	30·39=100	Stromeyer
67·987	4·13	3·06	tr.	30·995=99·701	H.

Loses, ·188 p.c. in water-bath.

Even the most transparent specimens effervesce slightly in acid. The specific gravity of the foliated variety is 2·336, of the botryoidal, 2·37.

The foliated variety occasionally exhibits a parallel lineation; this represents the edges of crystals which are greatly prolonged in a direction transverse to the main axis.

The botryoidal variety sometimes appears to result from the superposition of piles of crystals, as in globular mica.

A brown powder occurs very rarely in cavities of the Brucite, and,—imbedded on this,—minute highly lustrous crystals of the extremely rare *hydro-magnesite* occur (H.)

The same substance, in an earthy form, coats Brucite, and seems to impregnate nail-head calcite (form *e b*), rendering it dull and chalky. I have not found the quantity of magnesia in these crystals to be constant. About the centre of the Ness a vein of pale green serpentine carries finely developed rhombic-dodecahedral striated crystals of *magnetite* (H.)

A vein of what may be called *precious serpentine* is to be found at this spot (Hb.) It consists of a matrix of rich dark green oily looking serpentine, studded with pseudomorphosed, dull, light green crystals of

foliaceous diallage. It is sufficiently ornamental for the fashioning of letter-weights, and small articles which do not require a large, or boldly-diversified pattern, or a striking contrast of colour.

Asbestus, of a dark green colour,—and specimens approaching in character to *mountain wood* occur among the rocks on the south shore of the Ness. (D. and H.)

It has been said that here the character of the rock manifestly approaches to that of gabbro: there are few spots where the *latter stages* of the transition of gabbro into serpentine can be better studied than here. In a little inlet on the north-east shore, the passage may be seen almost in hand specimens. Some of these, besides the ordinary transmuted diallage, contain a transparent smaragdite-green highly lustrous substance, in fissured crystals, this I believe to be *diaclasite*.* This has apparently suffered no change whatever; and I have elsewhere found that, in an association of diallage with this mineral, the former is sometimes perfectly changed into serpentine, while the latter has suffered almost no transformation.

Along with this diaclasite there occurs *amianthus* in interlacing fibres of a blue grey colour (D. and H.) This has been by Hibbert mistaken for hypersthene.

Minerals of the Gabbro.

The great mass of the gabbro of Unst consists of an admixture of minute crystals of diallage, and of a labradoric mineral, which would generally receive the name of "Saussurite."

So crypto-crystalline is the structure of this gabbro that, were it not for the ridged nature of its hills, it might, in the larger island, be considered to be of an igneous nature.

An inspection of the rock in the islands of Balta and Hunie conclusively, I believe, negatives such a view. Here and there, in the few places in which the rock is exposed in Unst, its laminated structure is disclosed by a parallel banding imparted to it by the segregation of layers or lines of more amply developed crystals of its two component minerals; but it is only in the above smaller islands that this is seen in its most pronounced development. So marked and sudden indeed is the appearance of belts of giant crystals of the diallage, that the high tilted beds are, at first sight, set down as exfiltration veins.

Two of these pseudo-veins are admirably exposed on the south side of a geo, which faces a ruined Brough (H.) Protruding through the turf, they form two easily discerned ridges, which strike north-east, and are cut off by the cliff of the south side of the sea-hewn geo.

* Circumstances prevented me from getting a sufficiency of this for analysis. I recommend it as worthy thereof to those who may have the opportunity of so doing.

Both of these enduring beds are striking objects:—both consist of a granular matrix of white or pale blue felspar. In the one, this matrix is studded with large dark green platey crystals of hornblende, of half the dimensions of the palm of the hand; the second is similarly studded with equally large foliaceous crystals of light green diallage.

The felspar which carries the hornblende is lavendar blue; that carrying the diallage is opaque white.

These belts are within a few feet of each other; and, in the occurrence of the two minerals in the same rock,—in the same matrix,—and in such close contiguity, we have the strongest conceivable argument,—were such now necessary,—against the view which regards augite as the igneous representative of hornblende.

As so crucial an illustration of the fallacy of such a view is perhaps unique, the minerals of both veins were analysed.

The lavendar blue felspar, associated with the hornblende, was occasionally white on its surface. Its specific gravity was 2·95. Both it and that associated with the diallage were so minutely granular as to show no structure to the lens. It contained,

Silica	52·212
Alumina	29·64
Ferric oxide	·48
Magnesia	·263
Lime	12·428
Potash	·443
Soda	3·998
Water	·111
	99·575 (H.)

That which was associated with the diallage had a specific gravity of 2·954. It contained,

Silica	53·136
Alumina	29·992
Ferric oxide	·248
Magnesia	·208
Lime	12·296
Potash	·472
Soda	3·86
Water	·21
	100·422 (H.)

The two minerals are evidently the same. But what mineral is it? These analyses accord admirably with the composition of labradorite, but the gravity is somewhat high. To leave no room for doubt, especially as the mineral would, if not absolutely determined, be classed as Saussurite, slices were examined by the microscope. It was found to consist of a general mass of a delicately striated felspar, sprinkled here and there with patches of a minutely granular substance; and this last was identical in appearance with the anorthite, which occurs in the adjacent island of Fetlar. The high gravity is therefore due to this admixture of anorthite.

There may be some question as to the particular plagioclastic felspar with which it is mixed; but although the deviation from the composition of typical labradorite is perhaps not so great as the amount of admixture visible in the microscope would lead us to expect, yet the composition is not at all what such an admixture with *oligoclase* would afford; and as there are no grounds for supposing the presence of andesine, I do not hesitate to consider the general mass of the substance to be labradorite.

As the result of simple inspection, this mineral would have been pronounced *Saussurite*;—as the result of analysis it would have been declared *labradorite*;—as the result of microscopic inspection, aided by analysis, it is declared to contain a quantity of *anorthite*, mixed with a larger quantity of a plagioclastic felspar,—probably labradorite: so we are left in the position of earnestly desiderating some optical test for the discrimination of the various plagioclastic felspars, especially when they are in a crypto-crystalline form.

The hornblende from this locality is in large, dark-green, dull, somewhat foliated crystals; these show their rifts filled with calcite, probably from incipient alteration. Its specific gravity is 3·112; its cleavage angle 124° 27′. It contained,

Silica	45·866
Alumnia	8·779
Ferrous Oxide	14·151
Manganous Oxide	·133
Lime	9·818
Magnesia	14.4
Potash	·821
Soda	1·43
Water	2·301
Carbonic Acid	not det.
	97·699 (H.)

The very fine diallage of the second vein is of a grass-green colour; its structure is foliated; it has not so much of the pseudo-metallic lustre as is generally seen in this variety of augite. Its specific gravity is 2·965. It contains,

Silica	50·233
Alumina	5·845
Ferrous Oxide	5·223
Lime	11·23
Magnesia	21·586
Potash	1·199
Soda	·582
Water	4·167
	100·074 (H.)

It is the general rule that when hornblende and augite are associated in a rock which is showing an incipient serpentinous change, the augite is markedly more prone to that change than the hornblende: it is here the opposite; the thin rifts of calcite in the hornblende proved its alteration, while the diallage is apparently unaltered.

The eastern coast of Balta is suffering much from the assaults of the waves, being cut into deep "geos," one of which threatens to separate the island into two, to the serious detriment of the excellent roadstead of which it is the breakwater.

In one of these geos the officers of the survey found a vein of amianthus, of unusual, if not unrivalled excellence. The length of the fibres is but small, being seldom over four inches, never over a foot. It is, in mass, of an olive-green colour. Its excellence lies not so much in the flexibility of the fibres,—for they are of such extreme tenuity as to be brittle, which is a detriment to their application to certain of the purposes to which this substance is put,—but in their extreme softness, and freedom from impurity. With very slight pressure between the fingers, in which they are almost impalpable, they can be rubbed down to a pulp, which has all the unctuosity, and far more softness than that of French chalk. As a lubricant, the mineral from this locality would be of high value.

The collector must descend between the walls of the geo, keep on the parapet which winds along its south side, and turn the corner of the cliff southwards, gaining a platform on the eastern side,—this is the site of the vein.

The specific gravity of this amianthus is 2·949. It contains,

Silica	56·153
Alumina	1·539
Ferric Oxide	·388
Ferrous Oxide	3·111
Manganous Oxide	·769
Lime	11·716
Magnesia	22·461
Potash	·188
Soda	·692
Water and Fluorine	2·5
	99·517 (H.)

In close association with this amianthus, the writer found a most peculiar variety of the same substance: so different in appearance in most respects, that it must be regarded as an allomorph.

It occurs in a layer immediately in contact with the amianthus; the layer being about a couple of inches in thickness.

Its appearance is that of a fissile schist, which may readily be split up into laminæ of extreme thinness. Its colour is a pale pea-green; it is translucent in thin fragments, and altogether so similar in appearance to *antigorite*, that it was, without hesitation, regarded as that mineral.

Being of extreme toughness, and naturally splitting into axe-shaped fragments, it would, by Dana, be classed as *nephrite;* and, in composition, it would stand immediately central in his list of analyses of that substance.

It is altogether dissimilar to the amianthus with which it is associated; but its most remarkable peculiarity is, that where it is exposed to the air, it passes into it:—the amianthus appearing to *grow* out of the solid and fissile stone.

Moreover, although this stone may be scraped down into powder by the knife, like steatite or slate pencil, yet if it be crushed or beaten in a mortar, it is immediately matted into a felt of amianthoid fibres.

The laminæ of this stone have a rough cleavage in two other directions, forming angles somewhat near those of hornblende.

Its powder and cut surfaces are both very smooth. Its specific gravity is 2·957. It contains,

Silica	55·734
Alumina	·045
Ferrous Oxide	5·203
Manganous Oxide	·008
Lime	13·241
Magnesia	22·696
Potash	·138
Soda	1·12
Water	2·438
	100·625 (H.)

In the main passage of this geo there are to be obtained most interesting specimens, which show, when analysed, the gradual passage of asbestus into serpentine.

The mineral occurs in veins (H.): there is not in the specimens any appearance of change; they are quite unweathered, quite fresh, and to all appearance undergoing no alteration, except in this, that the comparison of different specimens shows a gradual fading of the characteristic appearances of the one mineral, and a gradual assumption of the features of the other; and, secondly, that in the specimens in which the latter is well marked, there is generally more or less fibrous calcite lodging between the filaments of the mineral.

As a general description of these, they may be said to occur in dark-green, finely fibrous masses, of a greasy lustre, and unctuous feeling: but it would be difficult to pronounce whether they were asbestus or picrolite.

A specimen presenting the extreme of each appearance was analysed; the second specimen was more lustrous, more serpentinous, and somewhat less fibrous.

The specific gravity of the first was 2·693; of the second 2·634.

	1ST.	2ND.	
Silica	50·193	50·076	
Alumina	2·099	1·876	
Ferrous Oxide	4·393	6·087	
Manganous Oxide	·007	·23	
Lime	5·067	·86	
Magnesia	29·226	31·566	
Soda	·743	·341	
Water	8·5	9·302	
	100·228	100·342	(H.)

The mode of the change of *asbestus* into *serpentine* here shown is, a gradual increment of water,—a gradual decrement of lime, and partially of the other bases,—but as yet no decrement of silica.

There is, as the result of the above, the *apparent* increment of magnesia; but this is, in reality, merely a *proportional* increment, not an actual insertion. This change is probably the result of the direct action of carbonated waters.

At the Cleft-geo, to the south of the last, diallage, similar to that of Brough geo, but in still larger specimens, is to be found (D. and H.); they are perhaps the finest to be obtained in Scotland; their matrix is again the white labradorite.

The Great-geo affords a fast disappearing vein (?) and numerous loose blocks of granular and translucent quartz, carrying imbedded crystals of *epidote* of half an inch or more in size, and of a fine green colour (D. and H.) This occurrence is doubly anomalous:—first as regards the presence of quartz in gabbro; and secondly, as regards the occurrence of epidote without hornblende,—of which mineral it is commonly regarded as an alteration product. So far as Scotland is concerned, I am prepared to combat such a view, and this very case aids me in the so doing. There is no hornblende in the vicinity; and the perfectly fresh epidote is in fairly well-developed crystals, which impress their form on the inclosing quartz. They are isolated crystals, and must have crystallized out of a paste of the quartz. It is more than difficult to conceive any formation from hornblende in such circumstances.

This epidote contains,

Silica	38·753
Alumina	26·986
Ferric Oxide	7·898
Ferrous Oxide	1·806
Manganous Oxide	·501
Lime	20·378
Magnesia,	·786
Potash	·25
Soda	·21
Water	2·376
	99·944 (H.)

By turning the point of a tongue of land, or rather cliff in the Muckle Head Geo, a vein of *amianthus* of considerable bulk, lying at the very foot of the first step of the cliff, may be seen (H.) It is of much the same nature, but inferior in colour to that noticed from Doos' Geo. Amianthus

is also found in small quantities at a point marked on the chart, on the east side of the island.

A small indentation in the shore cliffs at the south end of the island, is, at its termination, blocked up by what appears to be a decomposing vein of yellowish-white clay,—perhaps kaolin, from felspar; if so, it may be worth looking after, as the quantity is large. In this, the writer got a single finely formed crystal of *Muscovite*, of a very brilliant yellow colour.

In several points of the east shore of the island of Hunie, diallage and labradorite, similar to that of Balta, are to be found. It is generally the case that any substances which occur in minute proportions throughout the general mass of a rock, crystallize in readily determinable forms in the exfiltration veins or belts of giant crystals, should such occur; but in neither Balta nor Hunie have I found, along with the larger masses of diallage, any other substance imbedded in the felspar;—except a very occasional trace of *Chlorite*.

A small creek between the harbour of Muness and the bay of Sandwick, lies in a Chlorite slate, which is so impregnated with granular pyrites (Hb.) as to give to the locality the name of the Golden Geo.