II.—*The Geognosy and Mineralogy of Scotland.*—By Professor Heddle.

MAINLAND, Part II.

HILLSWICK NESS.

THIS is a mere fragment of gneissic rocks which is imbedded between the granite of Roeness and the igneous rock which lies to the east: but so different are these entrapped rocks from the ordinary gneiss of Shetland, and so violent a twist do they seem to have received athwart of their normal strike, that the enquiry rises—whence did this fragment come?

A spectator looking west from the top of Ornsfield, gazes seaward upon a mere heap of ruins; while, looking landward, he also sees little else,—so riven and twisted are the rocks by the intrusion of dykes of porphyry, and so shattered and toppling from the invasion of the sea.

The strata lying to the north of this rising ground may be included under the name of hornblendic gneiss, though in many places they more resemble diorite; those lying southward of a line drawn south-eastward from this spot, are chiefly of the nature of chlorite slate.

Every variety of such rocks and endless intermediates, however, occur; they are so convoluted and crushed into one another that dips of all angles, and strikes which appear to radiate from a plurality of centres are not unfrequent.

However distracting to the geologist, such a land of promise to the mineralogist and lithologist is but rarely to be seen.

Despite of the rock turmoil within, or perchance as a result thereof, the ground is so uniformly covered with a firm and close sward, that it is only on the coast line that exploitation can be carried out; and so break-neck is much of the shore that the following record cannot but be incomplete.

At the *Ting of Turness, hornstone* of a brownish-red colour occurs (Hb), it is somewhat earthy, and occasionally porphyritic, the imbedded crystals being bright-red twinned orthoclase. There is here much "claystone porphyry."

At *Staba*, on the north, and at an equal distance from the mouth of the *Nidister* to the south, *hornblende* occurs imbedded in white *albite*

(D. & H.) The former is here of two very different appearances,—in the first, plumes or divergent brushes, a couple of inches in length, of lustrous dark-green crystals, lie bedded in snow-white cleavable masses of albite; in the second, flat, equally lustrous, foliated crystals are impacted singly in the same matrix. Both are striking varieties.

The latter of these spots affords specimens in which pink or flesh coloured *albite* is in foliated crystals, imbedded in the white variety. The specific gravity of this pink variety is 2·615. Its unusual colour induced me to analyse it.

It yielded—

Silica	66·711
Alumina	19·813
Ferrous Oxide	·9
Magnesia	·093
Lime	1·382
Potash	1·264
Soda	9·229
Water	·542
	99·934 (H.)

This albite was minutely striated.

The compound of albite and hornblende is in such quantity as to constitute a rock.

The diorite of Fetlar contains hornblende and *anorthite;* that of Colafirth and Nidister, hornblende and *albite.*

The low rocks and shore south of the mouth of the Nidister ("*the Banks of Nithista*") afford several varieties of *hornblende*, and in large quantities (Hb.); a variety in jet black highly lustrous minute scales, and another in large interlacing crystals of considerable lustre and a dark green colour, are perhaps the finest.

This hornblende sometimes contains cavities filled up by radiating crystals of *epidote* (D. & H.) of the thickness of knitting needles, and an inch or more in length. This epidote was dull, soft looking, and of an olive green colour; its only associates were a fiery-red granular felspar, and a bright red substance which occurred in thin investing layers, and which (or something very similar to which) I have also seen in granite in Rubislaw, as well as elsewhere, with hornblende.* The specific gravity of this epidote was 3·396.

* I believe this to be an undescribed mineral, but I have never been able to get enough for analysis.

It yielded,

Silica	37·866
Alumina	24·722
Ferric Oxide	9·961
Ferrous Oxide	·361
Manganous Oxide	·536
Lime	23·104
Magnesia	·766
Water	2·822
	100·078 (H.)

Although the inclosing hornblende has no appearance of even incipient decomposition, yet it must be said that the epidote has itself some appearance thereof.

The same spot also yields veins (?) consisting of transverse fibres of leek-green *actynolite*, with occasional plates of brilliant *Biotite*. (D and H.)

A nook, just where these banks become cliffy and curve round to the east, is quite a nest of minerals; these occur in beds which strike inland to the north-west, and eastward are seen in a little rocky stack.

First there occurs or rather occurred "a bed of *actynolite* not less than two feet in width, of a fibrous structure, of a splendid leek-green or pistachio-green colour, and of a silky lustre." (Hb.) Hibbert hardly does justice to the beauty of this bed, the few remaining bits of which the writer bore away. The mineral was in parallel crystals half an inch in width, these were separated from each other by films of a soapy *chlorite* (?); the crystals are well-formed six-sided prisms, but are not terminated; they are semi-transparent and green. Their specific gravity is 2·993.

They yielded,

Silica	55·
Alumina	1·512
Ferric Oxide	·994
Ferrous Oxide	3·456
Manganous Oxide	·307
Lime	10·381
Magnesia	23·307
Potash	1·12
Soda	1·097
Water	2·898
	100·072 (H.)

There immediately follows on the south of this wrought out bed of glassy actynolite, a bed of *precious serpentine* of the finest character. (D.

and H.) It is in two layers—one is a rich green to sulphur yellow, the other a rich umber brown. Both are highly translucent; they are very brittle, cut with a knife like slate pencil, but still are softer than the nail. They are very uniform and pure.

The specific gravity of the green is 2·522.

It yielded,

Silica	41·46
Alumina	·01
Ferric Oxide	2·422
Ferrous Oxide	1·163
Manganous Oxide	·23
Lime	trace.
Magnesia	41·763
Water	12·43
	99·478 (H.)

In contact with this serpentine there is found a bed about two feet thick of *anthophyllite* (H.) The outside layers of this bed consist of flat short crystals of the mineral; its inner portion is an interlacing mass of crystals, which are about two inches in length. These lie in all directions, are of a clove-brown colour, and of a vitreous lustre. From the manner in which the crystals are relatively disposed, as well as from their own nature, they form a mass of the most extreme toughness.* Minute specks, which appear to be *molybdenite*, are to be seen among the crystals. (H.)

The specific gravity of this anthophyllite is 3·068; the cleavage angle of the crystals 125° 23′.

They yielded.

Silica	56·861
Alumina	4·495
Ferrous Oxide	8·131
Manganous Oxide	·871
Lime	1·087
Magnesia	25·874
Water	3·355
	100·624 (H.)

* A lump, less than a cubic foot in size, could not be broken by a 28 lb. hammer, and after repeated blows had failed in producing the smallest sign of fracture, it was found that the steel, of 1½ inch in thickness, was rent across the whole face. The baffled quarry man happily characterised the mass as a "bundle of petrified nails."

Two veins or beds were observed in the shingle running seaward from this corner; on sufficient exposure, they were found to consist the one of *Biotite*, the other of *talc-chlorite* of Traversella. (D. and H.)

The Biotite was a mass of soft, friable, scaly crystals, hardly cohering; its colour was brown, it had little lustre, and was soapy to the touch. Its specific gravity was

It yielded,

Silica	39·803
Alumina	14·185
Ferric Oxide	2·594
Ferrous Oxide	11·784
Manganous Oxide	·24
Lime	·097
Magnesia	18·32
Potash	8·43
Soda	2·11
Fluorine	·56
Water	2·52
	100·643 (H.)

The substance which formed the second vein, which was of much larger dimensions, was examined partly on account of a peculiarity in its appearance and partly from its appearing to Professor Roscoe to be very similar to the foliated green vanadiate which had been named after himself. It occcured in such quantity that it could be raised in spadefuls: It was quite pulpy, had a higher and more pearly lustre than chlorite or clinochlores, and in certain positions reflected a light of a golden hue. Its colour was that of a somewhat pale chlorite. As it fell asunder into loose scales in water, its specific gravity could not be ascertained.

It yielded,

	Dry.	Wet.
Silica	39·81	35·461
Alumina	11·432	10·183
Ferrous Oxide	7·974	7·103
Manganous Oxide	·259	·23
Lime	2·804	2·498
Magnesia	25·648	22·846
Potash	1·203	1·072
Soda	3·152	2·808
Water	7·913	17·994
	100·195	100·195 (H.)

It lost at 212° 10·945 of its water. This large content of water at ordinary temperatures was not observed by Marignac, who probably dried the mineral in the bath without previous weighing.

If we except the presence of alkalies in the Shetland mineral, its composition agrees with that from Traversella, and aids in entitling it to be considered a distinct mineral.

Dana conjectures that talc-chlorite may be merely "ripidolite impure from mixture with talc;" but the Shetland mineral in no way bears out such a view. In order to free it thoroughly from saline impregnation it was suspended in water, many times changed, and scales of one size taken for analysis. During the suspension it was carefully examined with a magnifier, and there was no appearance of the smallest admixture of scales of talc.

The small outstanding rock at this corner of the shore contains a small remaining portion of the vein of actynolite; as the finely tinted green crystals are here imbedded in lustrous white scaly *talc* (D and H.), the appearance of the specimens is striking.

Under the impression that this talc was Damourite it was analysed and yielded,

Silica	60·889	
Alumina	4·143	
Ferrous Oxide	1·24	
Magnesia	28·085	
Potash and Soda	traces.	
Water	4·72	
	99·077	(H.)

Its specific gravity was 2·825.

Specimens of actynolite rock here also contain plates of fine lustrous *Biotite*, and equally brilliant ones of *chlorite* (D. and H.)

The pinkish-red variety of *steatite* called "Klebber" is also found here (Hb.) Hibbert adds potstone, but he seems to have confused this, here at least, with precious serpentine.

The great amount of contortion which is to be seen about *Stack Sound* gives countenance to the hope that it might afford minerals; the rocks all around seemed inaccessible, except by landing from a boat. Dr. Gordon succeeded in procuring for me excellent typical specimens of the rock. Careful examination of these leaves no doubt in my mind that the rock is essentially the same as the zoned diorite already described as occurring at Colafirth; the only difference visible to the lens which I could perceive was the presence in the lighter-coloured layers of a considerable amount of quartz. This quartz imparts an unusual endurance to the albitic layers, which stand out in high relief, where the hornblende has been rotted out by the sea spray.

The observation by Dr. Gordon of rocks very similar to those of Colafirth and Hillswick at the head of Roeness Voe, goes far to connect all these rocks with each other.

No finer illustrations of metamorphic rocks of an intermediate type could be pointed out than these schistose diorites of Colafirth and Hillswick. At Colafirth the metamorphism sometimes goes a step further, and the schistose character almost disappears. But here it is, not so. The rock on the large scale is like a plicated gneiss; hand specimens show its components and arrangement of parts to be that of diorite, while in a mass of but a few inches in dimensions we have a condensed delineation of the structure of some 60 yards of the gneiss of Sutherland.

Under the microscope this rock shows the arrangement of the hornblendic ingredient to be somewhat peculiar ; this, in form like grains of corn, is arranged in a somewhat plicated manner, their long diagonals being nearly parallel with the layers of albite ; a red substance, doubtless garnet, is also present.

The first spot south of Cliff Sound where the cliffs can be safely descended is *Quin Geo* ; this, being divided by a projecting point, must be scaled at two places.

In the *North Quin Geo* violet *fluor* occurs in octahedral crystals, imbedded in calcite, in a matrix which carries epidote. (D. and H.)

Epidote occurs here filling a small vein ; it is in rich green crystals of over an inch in length, disposed in a stellate manner over the face of the rock. (D. and H.) The specimens are fine.

Its analysis yielded,

Silica	36·127
Alumina	20·574
Ferric Oxide	14·921
Manganous Oxide	·306
Lime	23·025
Magnesia..	·306
Water	4·568
	99·827 (H.)

Rose quartz occurs here forming a smooth-sided vein (D and H.) The structure is here different from that which it assumes elsewhere in Scotland ; being very massive, calcedonic, and almost hyaline ; it appears to have been originally formed of a granular congeries of crystals little larger than shot, which have been so semifused into each other as almost to obliterate their lines of contact, and to be obscurely saccharoid. The cleavage is thus not rectilinearily continuous, and the mass is diaphanous but not transparent. The colour is pale but fine.

In *South Quin Geo* several veins of a *purplish-pink quartz** occurs (D. and H.); the structure of these is massive fine granular; this quartz is sheathed by foliæ of a mixture of margarodite and chlorite; veins of quartz in a splendent mica slate here carry imbedded dodecahedra of brownish-red *garnet* (Hb.) which imparts a peculiar glandular-like structure to the quartz.

The bight immediately to the south of Quin Geo was named *Carneba* to the author, but as Hibbert mentions a number of minerals as occurring here, none of which were found by the author, while they were all found by him at the spot called Sandy Geo, which is not mentioned by Hibbert at all, there may be some doubt as to the correctness of the name.† At the *Carneba* of the map there were only found some *purple quartz*, and thin veins of a blue-black colour. These, on hasty inspection, appeared to be Lydian stone, on a closer, to be a matted mass of crystals of the variety of tourmaline termed *scorza*; while other portions appear to be a laminated mixture of hyaline quartz with some black mineral unknown. The veins also carry a very red compact felspar in imbedded crystals, with small quantities of radiating epidote identical with that seen in Quin Geo (D. and H.)

Almost at the most southerly point, at a spot called *Baalan*, a vein of crystals of actynolite, identical in appearance with that described as having occurred at Nidister, may be seen on the very brow, and cutting down the face of a beetling cliff. (H.)

Hibbert's statement regarding Carneba is "at a place named Carnebie, is much steatite approaching to the character of potstone, yet of a softer consistence, and of a brownish-purple red colour. Common chlorite is in junction with it, of an earthy foliated character, the colour of which is a brilliant dark green. Interspersed in this mass are numerous small octahedral crystals of magnetic iron ore, of a bluish-black colour."

Descending *Sandy Geo* with the aid of a rope, there are to be found all these substances stated to occur at Carneba. The massive granular *steatite* is of a peculiar reddish-yellow colour; the massive granular *chlorite* is in such intimate association with it, as to prove a close relationship to subsist between the minerals, or in their mode of formation.

That this is the spot to which Hibbert applies the name of Carnebie is shown by his notice of a most interesting and beautiful association of magnetite with ripidolite. Dispersed somewhat sparingly throughout the pinkish steatite are rosette crystallisations of ripidolite, the crystalline plates being disposed around a centre, like an opened out and completely

* Hibbert mentions "much of the substance of a very red compact felspar;" it is possible this compact quartz may have been mistaken for the above.

† Dr. Gordon has ascertained that my naming is correct.

circular fan, and the centre of each of these rosettes is a perfectly formed and brilliant octahedral crystal of blue-black magnetite. As the plates of ripidolite are of perfect transparency and a brilliant dioptase colour; the specimens, though small, are of very considerable beauty.

This, being one of the purest looking ripidolites in Scotland, was analysed, and gave,

Silica	32·549
Alumina	13·95
Ferric Oxide	·972
Ferrous Oxide	5·275
Manganous Oxide	·156
Lime	·79
Magnesia	32·785
Potash	·48
Soda	·062
Water	13·173
	100·192 (H.)

There is here, as also at the adjoining geo, the same chronicling of names cut into the steatite as has been noticed as occurring at Fethaland. The Shetlanders call such places "The Klebber-names."

The cliffs are now intersected by porphyry, and inaccessible until the point denominated *Vanlup* is reached. Here the strata becomes more of the nature of mica schist, or of a mica schist in which the components are segregating apart.

In the quartzose belts of this rock very fine specimens of *kyanite* (Hb.) are found. These are of two varieties; in the one, belts of massive reddish quartz carry isolated bundles of diverging crystals of the mineral, which are very characteristically and beautifully disposed like plumes of feathers—the colour is here red, shading off into bluish or greenish white. In the other variety, masses of interlacing bundles of crystals unite to form large nodules, which lie bedded directly in the micaceous layers of the schists. These bundles are separated from one another at some points by bunches of crystals of *chlorite* and *margarodite*. The kyanite here is pale blue, or red passing into white, sometimes somewhat chocolate coloured.

The latter variety yielded,

Silica	38·153
Alumina	56·979
Ferric Oxide	1·867
Manganous Oxide	·153
Lime	·301
Water	2·646
	100·099 (H.)

The matrix of kyanite at the foreign localities being Damourite, the glistening silvery-lustred plates associated with this kyanite, were analysed, under the impression that they too were that mineral. Their extreme softness during the picking them out, led to their being considered talc; the analysis shewed them to be *Margarodite* (D. and H.)

They yielded,

Silica	45·43
Alumina	29·65
Ferric Oxide	8·33
Manganous Oxide	·02
Lime	·79
Magnesia	1·7
Potash	6·94
Soda	2·27
Water	5·29
	100·42 (H.)

The specific gravity was 2·825.

In Greg and Lettsom's Manual of Mineralogy, under the head of Babingtonite there occurs the sentence—"In this country it has only been found in one of the Shetlands; it occurs in large irregular laminated crystals of a blackish-green colour imbedded in white quartz." This sentence is copied in somewhat briefer terms into many works; and, from the statement being somewhat more full in Allan's Mineralogy and in the above than in these, as well as from the single specimen upon which the statement was founded having been in the old Allan collection, the probability is that it was found by Dr. Hibbert, and presented to Mr. Allan.

The present writer has in vain attempted to find Babingtonite in Shetland; the toil that he has endured in "walking down" distant veins of white quartz has not been little, the white quartz of the islands has itself suffered considerably in consequence, and he has frequently fervently desired that the writer of the above sentence had, from the top of Rona's Hill, viewed the thousand-and-one inlets of these marvellously tortuous shores, and so learned the necessity of writing with precision and point, in indicating localities.

The question as to what the something was, which in Allan's collection had received the name of Babingtonite, possibly may be correctly answered by saying that it was one of two things—either the large laminated crystals of hornblende of a blackish-green colour which occur imbedded in white labradorite in Balta, or large laminated crystals of *chloritoid* of a blackish-green colour, which the present writer found imbedded in white quartz at Vanlup.

The possibility that it was the first of these rests upon the fact that shortly after the Allan-Greg collection became the property of the Nation, the said specimen was found not to be Babingtonite, and was set aside as an ill-defined or inferior specimen of hornblende*; I have already shown that Hibbert mistook white albite for quartz at Colafirth, and he was quite as likely to mistake the labradorite of Balta for quartz.

The possibility that it was the chloritoid of Vanlup lies in the resemblance which that mineral bears to the dark-green laminated form which Babingtonite sometimes assumes, and to its being imbedded in white quartz.

Be this as it may, seeing that Professor Maskelyne discovered that the Allan specimen was not Babingtonite, and that the writer failed during several prolonged visits to Shetland to find that rare mineral when specially sought for, the pen must be drawn through the record of its Shetland occurrence; and, however much we may regret its temporary† exclusion from the list of British minerals, there is no little satisfaction in the knowledge that we are drawing the pen at this same time through a sentence, which should never have found a place in the literature of an exact science.

The *chloritoid* presents two appearances (H.); the first, which attracted attention from its colour, is thus described:—Occurs in quartz veins in the immediate vicinity of the kyanite and margarodite, and in the near vicinity of garnet, ilmenite, and specular iron. Its colour is clove or chocolate-brown. Lustre shining, slightly pearly. Streak greyish. Cleavage basal, perfect but somewhat interrupted; parallel to two lateral planes, imperfect and rough. Structure foliated. In rough lozenge-shaped crystals apparently monoclinic. Hardness 5·5 on the cleavage plane; 6· on the lateral. Brittle. Specific gravity 3·356.

It yielded,

Silica	25·363
Alumina	41·736
Ferric Oxide	3·895
Ferrous Oxide	13·932
Manganous Oxide	·919
Lime	·901
Magnesia	6·82
Water	6·571
	100·137 (H.)

* Professor Maskelyne, who kindly had a search made for this discarded specimen, tells me that, doubtless on account of its having been considered a worthless specimen of a well-known mineral, it has not been preserved.

† It is merely temporary. I have less regret in expunging the Shetland record, seeing that I have found Babingtonite in two localities in Scotland. The first, which I have analysed, is in a granitic mass near Tongue in Sutherland. The second, which shows a single well-defined crystal, is in diorite from the neighbourhood of Portsoy.

An examination of the second variety shewed that the first was partially altered. Except in colour and lustre the description is the same. The colour of the perfectly fresh mineral is blackish-green to dark green; its lustre is more pearly; its streak was pale-greenish grey.

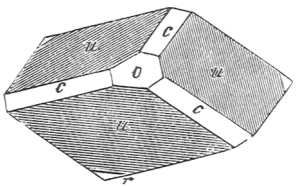
Its gravity ranged from 3·313 to 3·462.

On analysis it yieded.

Silica	24·47
Alumina	41·336
Ferric Oxide	·383
Ferrous Oxide	18·522
Manganous Oxide	·913
Lime	·302
Magnesia	6·80
Water	6·98
	99·706 (H.)

Both varieties invariably occur in imbedded rough crystals, and the green variety contains imbedded *sphene*.

The laminæ of all the rocks in this locality are highly contorted, the convolutions being shewn by extreme plications of the layers which are composed of a mixture of plates of margarodite and chlorite, with minute flakes of specular iron. Among these plates there occur the following minerals;—the two first, being interlaminated therewith obey the plications of their matrix. *Specular Iron* in thin plates, and rarely in crystals of the above (*o u c r*) form. (H.)



SANDY GEO.

The faces *u* are striated by an oscillation with *r*, or an intermediate face.

Ilmenite (H.) in blue-black plates, some inches in size, by about one-eighth in thickness. Its specific gravity is 4·916.

It yielded,

Titanic Acid	20·6
Silica	1·4
Alumina	1·443
Ferric Oxide	63·549
Ferrous Oxide	11·26
Manganous Oxide	·018
Lime	1·792
	100·062 (H).

Rutile (H.) a single brilliant crystal non-terminated, but showing the prismatic faces M h l. *Limonite* pseudo after pyrite, in cubic crystals (H.) *Apatite* (H.) a single hexagonal crystal half-an-inch in width, of a beryl-yellow colour. Fine masses of high-lustred dark-green *chlorite* also occur (H.)

The quartz veins carry in their interior large plumose masses of pale-green *talc* (D and H.); also garnets in *d* crystals (Hb.); their colour is brown, they are much flawed or of a granular structure, and the crystals have rough faces. Granular *chlorite* also occurs in pseudomorphs after the smaller crystals of garnet (H.)

Hibbert writes of this spot—"a little to the north of Vanleep, talcose schist may be found much resembling mica, being of a pearl-grey colour, and remarkably unctuous to the touch. Its plates show a perfect want of elasticity. There is in union with it much *Steatite*. At the same place mica-slate appears of a very splendent lustre, being composed of thin pellicles alternated with plates of very pure white quartz."

The "remarkable unctuosity" and "perfect want of elasticity" indicates that Hibbert regards this as a well-marked sample of the so-called talcose-schist; "pellicles" which answered most completely to his description, and which were both remarkably unctuous and wanted elasticity, were therefore picked for analysis, and yielded,

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

This is *margarodite*, and thus we are accumulating evidence entitling us to hold—as that variety of muscovite was not recognised in Hibbert's time, while he admits that it much resembles mica,—that all Hibbert's talcose schists are margarodite schists.

The following point of distinction between talc and margarodite is direct,—when rubbed in the fingers, however greasy "pellicles" of margarodite may appear, friction merely reduces them to smaller and

thinner pellicles; while talc, when similarly treated, rubs down to an inpalpable coating, the individual particles of which are not recognisable, from their minuteness.

This *margarodite* forms layers upon laminæ of the quartz, and occasionally hexagonal crystals are imbedded in the latter; the lustre is very high, but they have little or no elasticity.

Grariesum. About the divisional point between Vanlup and this, a few pieces of *Kyanite* were found, portions of which had a brilliant *azurite* blue colour, and these also had in small quantity a thin coating resembling *chrysocolla* (D and H.) *Garnets*, but of no beauty, occur here.

The late ardent mineralogist Mr. Copeland, of Blackwood, informed the writer that he found *green-fluor* on the west side of Sandwood bay.

The circles which indicate mineral localities have, in the map of Hillswick, been placed above the cliffs; this was done to prevent their being mistaken for the small stacks, of which so many environ the shore; the spots where the minerals are found, however, are either near the sea level, or on the slopes which descend thereto.

Eastward of Urie Firth there lies the large mass of the rock which Hibbert has called epidotic greenstone. This rock is of a very fine crystalline structure, usually of a dark-grey colour, but reddish where it approaches the rocks of Hillswick. Examined by the microscope it is seen to consist in largest amount of a felspar which is not distinctly striated,—augite,—and irregularly-shaped masses of a garnet-red mineral; this however, has not the fracture of garnet, but is either striated or fissured in a rectilinear manner, the fissures being equidistant.

This rock carries veins of a granite similar to that which forms the veins in the breccia of Colafirth.

PAPA STOUR.

This island is considered in this place, as it is composed of the same rocks as those described as occurring in the south-west of Northmavine; however, we have in addition felsitic rocks and porphyrys which have burst through the bedded rocks.

The interbedding of porphyritic and amygdaloidal traps with Old Red Sandstone strata is well seen on the south shore of the island: the intrusive rocks are mostly confined to the west and north—they are very circumscribed in dimensions. The general dip of the sandstone is to the west in different directions, but almost always at low angles. Beds of volcanic breccia and conglomerate are not infrequent.

The porphyrys are of the soft "Claystone" variety, of red-brown or reddish-purple colours, with ill-defined crystals of red orthoclase and yellowish-white albite (?) sparsely distributed throughout the base.

The volcanic breccias contain in the more recent paste, portions both of the sandstones (often a conglomerate), and of the porphyrys.

The amygdaloid occurs in largest amount in the south-west at the Kirksands, and in the north between Ollas and Culia Voes; it is of a brownish-purple colour, often very vesicular, but the vesicles are small in size. These various strata of argillaceous and arenaceous sandstones, compact felspars, porphyrys, claystones, and amygdaloids, are intercalated in ever-changing order. The best sections are at Bordie and Ungly-braed Head.

The strata of this island being similar in themselves, similarly circumstanced, and acted upon by the same causes as those in operation at Northmavine, we have a similar or even a greater amount of ruin; here most strikingly exhibited in what might be called the cancellated structure of the island,—caves, arches and vaulted passages arresting the eye as it sweeps round the western shores.

The easily disintegrated rocks have, on the Atlantic side of the island, been cut into cliffs of considerable height. As the not infrequent alterations in the matrix of which the rocks are formed present various powers of resistance to the inroads of the sea, there has resulted the formation of a coast-line of striking features; this is always imposing,—it is only on account of a certain weirdness that it falls short of being magnificent.

Professor Jameson has thus in general terms described it:—"The coasts are rugged and precipitous. Frequently the scenes are truly sublime; vast rocks of varying heights, dreadfully rugged and broken, oppose their rude points to all the fury of a tempestuous ocean; which in some places has formed great detached pillars, in others has excavated grand natural arches and caverns, that mock all human magnificence."

It is this *underground scenery*, indeed, which is of the most unique and surpassingly grand character.

A cave near Houseavoe is thus described by Hibbert:—"I entered in a boat a vault involved in gloom, when, after turning an angle, the water began to glitter as if it contained in it different gems, and suddenly a burst of daylight broke in upon us, through an irregular opening at the top of the cave. This perforation, not more than twenty yards in its greatest dimensions, served to light up the entrance to a dark and vaulted den, through which the ripples of the swelling tide were in their passage converted by echo into low and distinct murmurs."

The west coast from Hamna Voe to Culia Voe is shaped by the sea "into a continual recurrence of excavations."

Of these one is pronounced by no mean judge—Dr. Macculloch—to be *facile princeps* of the caves in Britain. It has been thus described—"when surveyed from the summit of the cliff it appears as a cavity of some hundred feet deep, and about 120 feet in length, being situated at a distance of 180 feet from the sea. It can be explored by means of a boat,—a labour that is only to be accomplished in the calmest weather. A large arch first presents itself, and, after rowing through dark vaults, the light of the sun bursts in from the lofty opening above—here the water is several fathoms in depth. The boat then pursues its gloomy course through another extensive perforation, which at length expands into an immense cavern where the light of the sun is wholly excluded. In the innermost recesses there is a steep beach, where the cave ultimately terminates in a number of ramifying dens."

The north-west point of Fuglöe has, however, been sculptured into a form which, for artistic effect, very much transcends anything which does not possess some measure of exposure to the light of day. Projecting in "pillared state" over the ocean, it has entombed in far-reaching recesses, both sea and air and the light of day. Like a many shafted cathedral-crypt, it stands with pediments set in seething foam. The heavings of the ocean, entangled in a labrinthine gloom, lash against each other in self-destructive effort, expending themselves in

sound, which booms from the far-off depths with tympanitic ring, as if the superincumbent mass vibrated to the shock, and each pillar gave back its own metallic note. The swellings of the curling waves, not content with the contrast of their own colours, stream with fleecy foam upon the russet shaftings, exposing in their recoil a verdant mantling—"wrought by the hand which works unseen." The white flash of the sea-bird's wing seems almost to sparkle in the pitchy blackness of this hollow of the land,—whose "far-drawn aisles" present every possible shade in the contrast of light and darkness.

Truly here sea and earth and air, and motion, and colour, and sound seem to have conspired to surfeit all the senses

The exploration of its unknown depths in a boat must be of singularly rare accomplishment:—both tides set right on to it,—it is a place of perpetual motion.

Minerals.

"On the south side of the island and also at Hirdy-geo there are small veins of *hematite,* these are situated in a bed of amygdaloid" (F.)

"At the south end of the Kirksands in an amygdaloidal claystone of a dark-liver colour, druses occur which are filled with *calcareous spar heavy spar, fluor-spar, quartz crystals, chalcedony,* and *green earth.*" (Hb.)

The fluor was first noticed by Jameson.

Veins of red *sinople,*—iron flint—associated with chalcedony and *jasper* (J.)

The exact spot is the third igneous rock to the south-west of the Kirksands.

The *fluor* occurs in pale violet, and dark purple cubes.

The paragenetic minerals, arranged in the order of deposition, are —*chalcedony, quartz, calcite, baryte*—lastly *fluor* (D. and H.)

The green earth of Hibbert—"semi-indurated steatite" of Jameson, is *saponite* (D. and H.)

In separate druses *cockscomb baryte* occurs in fair specimens (D. and H.)

Red Heulandite rarely coats the druses in minute crystals (D. and H.)

A single crystal of white *stilbite* was found (D. and H.)

Psilomelane coated with *wad* occurs in the same rock, at the east end of the same mass which carries the fluor (D. and H.) They form two veins.

Saponite (steatite F.) also occurs at Bordie, Ungly-braed Head, and elsewhere in slaty felspar.

The porphyry near Ollas Voe yields druses of *quartz* (Hb.)

Lying loose on the surface Hibbert observed masses of *glassy actynolite.*

From the same anchorage as that from which Papa Stour is examined two localities on the Mainland may be visited.

These are the banks of the hill of Aithsness where Hibbert observed veins of *Chalybite*; and Dale, where he found *compact felspar.*

There is good anchorage in Housa Voe, but the entrance is difficult. The following directions will, in the absence of a pilot, suffice:—divide the entrance into four parts, take the centre of the second from the north. The mark is—keep a white house at the top of the bay just clear to the south of a chapel, seen a quarter of a mile beyond it.

As a safe harbour from whence to visit all the district, none can equal a bight on the north side of Snarra Voe, on the opposite coast of the Mainland.

VEE SKERRIES.

A piece of rock from these skerries which was brought to the writer could not be distinguished from the peculiar mica-gneiss of Vanlup in Hillswick. It was a contorted mass, consisting of much translucent quartz with foliæ of margarodite, chlorite, and a little ilmenite.

SEELIE VOE.

From this fine anchorage the neighbourhood may be examined.

Within a mile to the west there is a large mass of granite, which extends to Gruting Voe, and also forms the east end of Vaila Island. It is of quite a different nature from the granite of the Roe district, being usually highly porphyritic, and consisting of a melange of crystals, in which a yellow felspar is prevalent. The Brough of Cullswick is built of this granite, as is also that of Burra Voe on the West Coast. So that probably a mass of the same granite may occur in that neighbourhood.

The west shore of the Voe consists of so confused an assemblage of granite, hornblende-rock and porphyry, that it probably might yield minerals similar to those of Hillswick.

On the east shore of the Voe thin veins of pale *pinkish quartz* coated with chloritic-schist are sparingly found (D. and H.) The quartz is massive granular in structure, and opaque.

On the south-eastern shore of Kirkaness large veins of what Hibbert calls *rose quartz* occur; the colour, however, is a purplish-pink, of

by no means a delicate tint. The great size of the masses, however, and the somewhat effective manner in which a chloritic gangue is mingled with the quartz, renders these so far striking. We did not, however, find a single fragment which was in the least hyaline.

A very singular cleavage in two directions, yielding an angle somewhat near to that of hornblende, is a marked feature of this *purple quartz*. On the same shore we found granular *chromite* imbedded in green *serpentine* (D. and H.)

A protruding boss of granite, the components of which are unusually large in size, appears about midway between the Kirkaness shore and the south shore of Bigsetter Voe. From this boss large plates of twinned crystals of *Muscovite* are to be got (D. and H.)

Both in the shore at Kirkaness and on the South shore of Bigsetter Voe a porphyry apparently the same as that described as occurring in the north-east of Unst is to be found. There is perhaps a little more epidote, and the crystals of felspar have a redder and finer colour Hibbert calls this rock epidotic syenite. There can be little doubt that it is the same mass as that which has been described as cutting off the Fitfiel Head schist from that of the Cliff hills,—which forms the islets in the Bay of Scalloway,—and which is probably continued in the islands of Yell Sound. It is at Kirkaness a beautiful rock, admirably adapted for monumental purposes, but so far as the writer could judge, has a tendency to separate into brick-shaped masses of small size.

Chromite, bedded in dark-green *serpentine*, has been wrought in the south shore of Bigsetter Voe: associated with it there occur veins of a brilliantly lustrous white felspar, which breaks with large flat cleavages, these being throughout besprinkled with a graphic lettering of hyaline quartz. No portion could be found sufficiently free from the quartz for such an analysis as would do more than qualitatively determine the felspar. There can be little doubt as to its being albite, and the occurrence of a *graphic albite* is probably new (D. and H.)

In the Burn of Tractagill on the opposite side of the Voe, near the junction of the gneiss with mica slate, on the slopes adjacent to Weesdale Hill, an extraordinary quantity of porcelain-earth lies accumulated, owing to the decomposition of the abundant quantity of felspar which the rock contains. "It is of a very yellowish-white colour, and its particles cohere but slightly to each other. The gneiss from which it is produced, appears to be decomposed in such a manner that the position of the strata is not disturbed by the change; for in the disposition of the layers of porcelain earth, I distinctly traced the line of direction and dip assumed by the undecomposed strata of contiguous rocks." (Hb.)

This "porcelain earth" would from the above description appear to be in all respects similar to that of Lumbhoga in Fetlar.

Hibbert makes the following most interesting observations on the gneiss of Selaness in Aith's Voe :—"In this may be observed a vein of felspar 6 feet in width, consisting of rounded spherical concretions, some of which are no less than 6 or 8 inches in length. They are often composed of felspar alone, but sometimes of quartz and felspar. In a few of them mica is very sparingly disseminated. I have described these portions of rocks under the name of concentrically laminar concretions. Each speroid in the vein is formed by concentric layers, inseparable from their nucleus, and these on account of the firm texture of the rock, are not to be traced without careful observation. In some of these concretions I have remarked that each concentric layer was formed by radiating matter, directed from the circumference of the circle towards the centre. The form of the spheroidal concretions is not always very perfect. Their figure is occasionally impaired by the junction, as if they had been pressed against each other whilst in a soft or yielding state; consequently a tuberculous form is sometimes induced."

This very much corresponds with the structure of the speroidal syenite—the Napoleonite of Elba; and I have seen a very similar structure well marked in two other Scotch rocks. The first is in the rock of the island of Ensay in the Sound of Harris. This rock is very much of the nature of the eklogite of Harris; it contains, however, less garnet, and kyanite is not manifest in it. Dr. Joass, of Golspie, sent me specimen from this island consisting of loose and also of imbedded concretions of radiating actynolite, the structure of which, as developed by zones of colour, is similar to that described. They are not, however, of so frequent occurrence in the rock as to impinge upon one another.

The other instance—a most unique and interesting one—is in the possession of Professor Nicol, of Aberdeen. It was found on the south side of Ben-na-chie in Aberdeenshire; the rock is a fine-grained granite, in the midst of which there lies, firmly imbedded in one-half of the specimen, a "concretion," of which the structure is both a radiating and a concentric arrangement of the constituents of the granite. The other half of the specimen shows the "cast" of the separated concretion.

Clay Slate and Old Red Sandstone Localities.

A stratum of limestone curves round from the north west of Rovie Head forming the dangerous rocks called The Brethren, and the islet of Greenholm; in both *Dolomite* occurs in simple crystals in cavities of the limestone (H.)

Sandlodge.

About a mile to the north of this, the clay-slate contains *serpentine* with *steatite* (Hb.) "Among the strata of micaceous schistus which form the cliffs of Coningsburg crystallised *cyanite*" (J.) (kyanite) " of a white colour tinged with azure. Specific gravity 3·618.

The junction of the clay-slate with the unconformable sandstones may be seen a short distance to the west of the house of Sandlodge. Almost at the junction there is an old mine of *specular iron.*

The clay-slate where last seen at its eastern boundary assumes chloritic features, and consequently the overlying sandstone somewhat largely partakes of the same character. Hibbert goes so far as to speak of it in this locality as being a *magnesian sandstone,* adding that it has a steatitic character.

Many small calcareous veins traverse the sandstone near the junction, and a little way to the east of Sandlodge, a vein which at the surface seems nearly vertical, but which Dr. Fleming says dips to the east at an angle of 45°, has been intermittently wrought for iron and copper.

This vein occurs in " a reddish-coloured argillaceous sandstone" (F.); it strikes from north-east to south-west: near the surface the ores were chiefly those of iron; those of copper were found at a depth of twenty fathoms chiefly.*

*Professors Jameson, Fleming, Traill, and Dr. Hibbert have alike expressed themselves as having formed great expectations of this vein ; Professors Fleming and Traill who minutely inspected the workings, have also alike expressed themselves as having had reason to be utterly dissatisfied with the mode in which it had been on every occasion wrought, and they alike assign the repeated ill-success which has attended the working of this mine to the incapacity and ignorance of the " captain of the mines."

Having examined this mine and its minerals on more than one occasion, having inspected the mode of working during a late attempt, and having had very special opportunities of testing the capacity of the management as regards the two points of following a vein, and recognising mineral species, I have to say that the opinion I had to form agrees with that of the afore-mentioned gentlemen, in at least the two first of the above three particulars. Having also had to come to the conclusion that the Cornish captains of mines who come to Scotland to exercise their function are, with hardly an exception, incapable, and so act a very detrimental part to all judicious mineral-enterpriset I conceive it to be fitting when such an opportunity as the present occurs, to direc, attention to the fact in its double bearings.

I shall therefore quote the opinions of Professors Fleming and Traill, and give my own experience.

Professor Traill, who visited the mine in 1803, during the time it was being wrought, writes :—" The miners had penetrated to a depth of about twenty-two fathoms, and were but little incommoded with water. At that time there were but two Cornish miners, besides a Cornish *Captain of the Mines*, engaged, and these were chiefly occupied in giving directions to the natives employed to work in the mine. The want of men sufficiently

Dr. Fleming mentions the following minerals as having been noticed by him:—*Limonite, native copper, fibrous malachite, pyrite, chalcopyrite, siderite, fahlerz.* Dr. Traill added to this list *micaceous iron ore*; he specifies the limonite as occurring in the varieties of mammillated, stalactitic, and fibrous; also columnar bog-iron-ore and brown iron ochre.

The malachite he says occurs, friable and amorphous, "almost equal to the Siberian specimens, and in capillary radiating crystals;" (G. and L.) the latter occurred in such quantity in the twenty fathom level as "to afford a most beautiful spectacle by the light of our candles."

To this list the author has to make the following additions:—among the specimens brought by Dr. Traill from the mine, he recognised *psilomelane*, and also *lepidocrokite* in highly characteristic scaly, fibrous, and glimmering-lustred specimens. At the mine he, with Mr. Dudgeon, found long opaque crystals of *white quartz* crossing each other in a

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skilled in mining was certainly one cause of their failure. The principal manager was totally ignorant of the art of mining. There was iron in abundance all round. The roads near the mine were all paved with hematites, which the Cornish miners who were there did not seem to regard as of any value, or indeed almost to know. Some of them imagined it was a new kind of copper-ore. Some pieces of bog iron ore which I had collected, were called *copper spume* by one of them; hence it is evident we cannot trust much to the mineralogical opinions of the generality of miners."

Dr. Fleming, who visited the mine in 1808, thus writes:—"The principal vein is said to be nearly fourteen feet broad; none of the shafts have been sunk deeper than fifty fathoms. Brown hematite is found towards the surface in great quantity, and nearly occupies its whole breadth; the sparry ironstone appeared in plenty towards the bottom of the mine, aud constituted the veinstone.

The copper-ore was sent to England, where the best of it, it was stated, was sold for £70 per ton. From the month of June, 1802, to the month of June, 1804, four hundred and seventy tons of this iron-ore were sent from this mine to Swansea. Still it is said that the mining company sustained a very considerable loss. Nor ought this to be a matter of surprise. The persons who have been appointed to conduct the work have frequently been men ignorant of the art of working mines, and of the nature and value of the ores which they met with. Many fruitless attempts have been made to find out new veins in the neighbouring rocks, even where no promising appearances presented themselves, whilst the depth and extent of the principal vein appear only to have been superficially examined. The manager or captain of the mine, who was still at Sandlodge, did not seem to be acquainted either with the composition or value of the sparry ironstone or of the hematite, though by far the most common productions of the vein. The difficulty of working the sparry ironstone or veinstones of the copper-ore was stated to me as the reason for abandoning the mine.

Mining operations under such management must generally terminate in confusion and disappointment."

Doubtless!

"Considerably" more than £33,000 expended in two years on a mine, the deepest galleries of which are but twenty-two fathoms, in which they have no water to raise,—sor an adit level carried it all off—and in which a fourteen foot vein is solidly plugged at furface with fine hematites, below with a "veinstone of sparry iron ore!"

How could they have done it?

singular reticulated manner in cavities of ochry limonite. Powdery *wad* which was examined for cobalt, but found to contain no trace;—this was imbedded in cavities lined with crystals of pyrite. *Orthoclase* crystallised with *siderite*, crystallised *chalcopyrite*, and calcite in small *F.* crystals.

Mr. Dudgeon lately noticed in the Edinburgh Industrial Museum minute crystals of a fine green colour, and of a form somewhat similar to that of Brochantite, upon fibres of malachite from Sandlodge.

A minute quantity of these crystals were examined by the writer, and found to contain neither sulphuric, carbonic, nor phosphoric acids; but contained chlorine, copper, and water; they were fusible. The termination of the crystals was that of atacamite, but the position of one of the prismatic planes was new. Probably the mineral is *atacamite*.

Only in the way in which they did do it; by making roads of the fine hematites, and leaving the "veinstone" in sparry heaps at the pit mouth; for, hear Hibbert, writing in 1822:—"Adjoining to the shore is a pavement strewed over with the produce of the veins. Hematites and bog iron ore have made the road as black as Erebus, and caused it to resemble the vicinity of a smelting furnace. The mineralogist *will find some amusement* in examining the ores which lie in heaps near the old shafts; these have been by Mr. Bruce judiciously preserved; they present satisfactory indications of the contents of the vein, and may afford a criterion of the hopes to be entertained from any future prosecution of *the mining operations of Sandlodge*." This peculiar phraseology is perhaps intended to be explained by his going on to tell us of the loss sustained during the draw ing the £33,000 in two years.

Dr. Hibbert was not given to jokes,—that above is the only one in his book; geology and mineralogy were to him alike full of seriousness; but surely the staid writer inwardly smiled while making that—to him—unusual "find" among the heaps of ores; and we cannot but speculate as to whether the "find" of a new mineral there would, in all respects, have entailed more gratifiaction.

It was certainly not amusement which the writer experienced when he first saw a great heap of that "sparry veinstone"—hand-dressed during the extraction of the chalcopyrite; but it is fitting that he should express his satisfaction in being able to say that the knowledge of Cornish captains of mines has taken a great stride since the day when the hematites and the sparry veinstone were first rejected. Seventy-four years is perhaps a long time for one stride, but it is a beginning; on the second occasion on which he visited Sandlodge, he found that Mr. Bruce's judiciousness had been incontestably proved; the mines were again being worked, and the heaps of "fine hematites" having been sold, as much thereof as could be grubbed up had been removed.

The average Cornish Captain has therefore now attained to a knowledge of Limonite,—but not of Chalybite—not two strides! Chalybite is still above him; and he seems determined to possess himself of it in no way, for he has *buried it*; the tirring and rock from a new shaft having been thrown over it, leaving merely so much exposed as shows the heap still to be there.

When a freshly-broken characteristic specimen from the said heap was submitted to the person locally in charge of the late workings, it was with confidence, but seeming indifference, pronounced to be "a stuff called felspar."

I wish it to be distinctly understood, that in the above, I allude to such miners only as come to Scotland.

Skewsbrough.

This "Brough," or "Pictish tower," stands on a knoll of *serpentine*, the only bit I was able to find in the district. This serpentine is of a rich green colour, with darker almost black markings, which interlace with one another like the cordage of a net. The colour and appearance are hardly to be distinguished from that of the rock of Towanrieff in Aberdeenshire, and they are perfectly indistinguishable from that of the finer varieties of the stone of the Greenhill of Strathdon.

A little to the east of this brough, veins of *iron-mica* of considerable dimensions, occur in the clay slate, they are associated with a belt, some inches thick, of a green nondescript substance—palpably a mixture, and probably one of the soapy allomorphs of hornblende.

The veins of ironstone may be traced first with an eastern trend, they then curve round the foot of the "Wart" (ward), assuming a northerly direction, and keeping near to the junction of the slate with the Old Red Sandstone grit, until they seem to pass into an old mine of limonite on the west shore of Levenwick.

The iron is throughout associated with quartz; at the south end *kyanite* (H.) and *ilmenite* (H.) rarely occur. Here the iron assumes the features of a bed or beds, but towards the north end it gradually crosses the line of junction of the secondary rocks, and in the Old Red Sandstone is evidently continuous with a vein which appears in the north shore of Hoswick, and which vein in its northern outgoing forms one or other of the Sandlodge veins.

The kyanite is greyish-white to pale blue; the ilmenite is in isolated rough thick crystals; both are imbedded in quartz.

The ilmenite yielded—

Titanic acid	21·11
Silica	1·63
Alumina	·364
Ferric oxide	66·321
Ferrous oxide	8·264
Manganous oxide	1·363
Lime	·211
Magnesia	·374
	99·637 (H.)

Its colour was brownish-black, and its lustre dull.

Black *tourmaline* occurs in crystals of half-an-inch in length in gneiss in the cliffs on the west side of *St. Ninians Island.* (H.)

Sphene is found at *Altaness* in *Burray Island*, in porphyritic gneiss. (F.)—*Ed. Phil. Journ. Vol.* 4, *p.* 214. "*Rutile* occurs in small crystals imbedded in gneiss in Burray." (F.)

A vein of pyrite was worked near the junction of the clay slate with the mica slate at Garthsness near Fitfiel Head, for a doubtful trace of chalcopyrite; and in the clay slate at the Girths of Quendal, north of Fitfiel Head, a large vein of *iron mica* was at one time wrought. Its out-goings in the cliff are quite well seen, but it has been lost further inland: on one occasion when we were there, a "Cornish Captain" was engaged in making most successful efforts to prove that he was perfectly incapable of refinding it.

ISLAND OF FOULA.

*"Here no man dies—for all their necks are broke."**

There can be no reasonable doubt that this was the island—the Ultima Thule—seen by Agricola, from Orkney.

From the islands of Westray, Papa Westray, and North Ronaldshay it is, from its over-topping height, and from its also lying more directly to the north,† much more frequently seen than the Fitfiel Head.

Jameson tells us that from the Mainland of Shetland, the island of Foula forms a "tremendous object."

Having well nigh exhausted his vocabulary in describing the cliff scenery of the main group of the Shetlands, this author apparently is in somewhat of a dilemma when he comes to consider those of this outlier. The precipices of the Ord of Bressay are termed "frightful"—those of Noss "tremendous"—the Noup "stupendous"—Fitfiel Head "immense"—the rocks of Æthsting and Sandsting "awfully grand;"—but those of Foula have produced so powerful an impression that they are characterised as "terrific" and "most hideous." This latter expression must, however, have been employed to signify the nervous dread with which they had been contemplated. In its ordinary sense the word certainly most unfittingly expresses the character of the Foula cliffs, which are light and graceful in their contours,—massing with one another in grand combinations, and cutting the upper-air with a skyline in comparison with which the Ord of Bressay and the Fitfiel Head are altogether "hideous."

This island in the altitude, grandeur, and artistic features of its cliffs, very much surpasses everything else of the kind in Shetland.

From whatever side it is viewed, Foula, from the suddenness with which its hills rise from the ocean and the high angle of their slopes, does certainly appear as a startling and "tremendous object." From a base of about a couple of miles in both directions, five hills reaching a height of nearly fourteen hundred feet, spring up with little, and, on one side, no intermediate slope. On their eastern and southern

* From a volume of *original* poems, which will well repay perusal. By James Disher, Stornaway.

† Its distance, some twenty miles from the main group, is the sole difficulty in visiting this island. In Shetland the dangers of *landing* on this island are regarded as nearly insuperable: in the island the dangers to be encountered in *reaching* it are equally dreaded. In average weather these dangers exist only in the imagination.

sides these hills are steep; on their northern they can be scaled, but only by the employment of *all* the limbs; on the west they either drop plumb, or even somewhat overhang the ocean in the first part of the descent; and this they do with most sudden precipitancy, there being in many parts not only no preliminary slope, but not even a resting flat before the fall. From a steep and slippery grass-clad ascent upon the east, the rocks are cleft sheer down upon the west, leaving an edge so narrow that it must in some places be traversed in single file.

Though, from their vastness and from the nature of the rock, deficient in detail, yet for simplicity, chasteness of contour, and the effect of sublimity produced by their stupendous scale, these precipices as a group, stand unrivalled in the British Islands.

With Orkney and Shetland dim-seen in the distance,—with but a small circlet of land set in the midst of a wide expanse of waters at his feet,—with what is seen beneath of birds or crested waves diminished almost to airy nothingness, the spectator feels as if perched in space, and is thankful for that geologic faith which assures him that the perch is abundantly secure.

The five hills of Foula, enumerated from the north, are called Comma Field or Soberly, The Kaim, The Sneug, Lorafield or Hamnafield, and the Noup; it is a fair day's work to ascend all these hills and walk round the island.

Foula in the north and north-east consists of granite and gneiss. Hibbert mentions "slight indications of clay-slate having much the character of sandstone, into which it insensibly passes, so as to deserve little more than the name of argillaceous sandstone."

Also "slight indications of mica slate."

I did not find either of these rocks, but, in the south-east of the the island the sandstone at its junction with the other rocks, is of an ambiguous or ill-defined character.

This ambiguous rock extends from Schoble to a point called Granite-geo. Captain Veitch calls it gneiss. Hibbert classes it as sandstone. I regard it as an argillaceous sandstone much altered, in places converted into a grit or gneissic-schist, and have little doubt that there is here an actual transition from gneissic schists into rock of Old Red Sandstone age.

Starting on the circuit of the island at Ham, the landing place, we find in walking northward, the lower and more gneissic beds of this transition rock, to some of which the name of *millstone grit* might be appropriately applied, so far as expressing its physical structure goes.

The beds dip to the W.S.W. at an angle of 15° to 20°

They are cut off by granite,—or more correctly, there is a geo or fault twenty yards wide between them and the granite; the line of junction of the granite is E ½ S and W ½ N. The dip of the grit is altered to W. by S. with an angle of 30° just before the junction. Veins of the granite run along the strike, sometimes cutting the strata.

The granite is red like that of Roeness Hill, and must be more recent than the grit.

There supervenes a rock, generally a mica-schist, but sometimes a gneiss, through which veins of granite run along the strike of the strata, which, however, they sometimes cut. These veins consist of a pale granite, and, as noticed by Jameson, they are sometimes accompanied by veins of quartz.

At Sheep's Geo there are interstrata of hornblendic schist. The dip here is to the W.S.W., at an angle varying from 20° to 30° or more.

In these rocks there are nests of *green actynolite* (J.), and frequently *garnets*.

It has been stated that granitic veins run along the strike sometimes cutting the beds. The development of granite veins as seen in the low projecting tongue of rock which thrusts itself seaward, is the finest and most striking the writer has seen. The very peculiar form of this protruding mass of rock results from the way in which the rocks have been sea-worn at the junctions. Rectilinear and oft repeated lanes of water intersect the rocks, and, at all states of the tide, have cut off some rocky islets arranged in single file, and these are succeeded by sunken rocks. In these lanes or canals there is depth enough of water for a boat to traverse them, while they are so narrow, and disposed at such a distance from each other, that an active individual can proceed a considerable way seaward by springing from vein to vein,—the granite being generally the more enduring rock.

The junction with the sandstone takes place in a deep cleft called Wirwick. Although there is no granite here—except that of the veins, a very large one of which cuts the sandstone—the sandstone is much altered, having many of the features of quartzite, with a highly vitreous lustre. There is much contortion in the neighbourhood of the large granite vein Unfortunately the cleft, which is floored by deep water, prevents this vein being traced into a connection with any of those which cut the primary rock,—here a mica schist.

Specimens of *red quartz*, disposed in blotches in the yellowish grey sandstone here occur. (H.)

The dip of the arenaceous rocks where in contact with the mica-slate, is to the south-south-west, at an angle of about 72°; and as when

we pass westward we find the dip to be to the north of west at quite low angles, it becomes evident that there has been tilting.

That the tilting is in no way due to the mass of granite which tilted the strata at Granite Geo, is evident from the direction of the dip. There is no visible granite to the north-north-east of the gneiss; the dip of that gneiss at the extreme north point attainable at low water, is about 20°; at its southern extremity, just before its concealment under the turf, it is about 35°. It would therefore appear that the interstitial intrusion of the granite between the laminæ of the strata has *elevated it and the overlying sandstone in increasing amount as they passed southward.**

About the centre of the large open north bay the sandstone becomes very schistose and argillaceous, there are some thin strata of a dense blue impure limestone, and also of a singular micaceous "indurated" clay, with included bands of dense colloidal looking quartz which has filled up shrinkage cracks in the clay. These "cracks" being very much wider towards the centre of the mass than on the outside, a certain amount of septarian appearance is produced; but there is no honey-combing or circularity of arrangement. The structure is unique.

Following this, at the head of a small bight, there is some crushing, fracturing, and wedging, the origin of which is not apparent. There is the usual appearance of "induration," some little plication, and to the west, where the strata are again untroubled, the dip is more to the north.

The shores here commence to rise into cliffs with outlying rocks. One of these is of very singular form. This may be best conveyed to the reader by a comparison with a dog sitting on its haunches with its fore legs stiffened and its head erect; but the pillars representing the legs are much more massive than such a comparison conveys.

It is an insulated rock sloping rapidly towards the land, with its vertical sea face twice perforated by arched openings. One of these has pierced it laterally, while the second breach has, at right angles to the first, cut the prop into two.

As the rock is seemingly nearly two hundred feet in height, and the arches extend almost to the summit, it is a grandly imposing mass, beneath the dome of which an ordinary sized vessel, so far as space required is concerned, might easily pass.

Southward the sandstone is a loose grit. Its strata rise with extreme abruptness both from north and east, but especially from the former, into the ridge of Soberly, which overhangs the Atlantic in a

* The result being similar to what would be effected upon a bound book lying on a table, by the insertion of sheets of cardboard between the leaves.

line of precipices. These looked along in fore-shortening view, present a number of knuckle-like undulations, trending towards the slope of the loftier summit, the Kaim.

The whole of this ridge overhangs; at its northern end the precipice has a height of 671 feet, at its southern of 724.

The ascent of the north side of the Kaim demands (except from a Foula man), the aid of the hands. The summit is a mere pinnacle 1211 feet* above the waters at its base; these are altogether invisible except to one who lies down and extends his body over the verge.†

The manner in which the summit of the Kaim towers, lighthouse-like, above sea and land, surpasses anything the writer has seen, excepting the Myling Head, in Faröe. This much resembles the Kaim, but he found its height to be 2337 feet, while Captain Born made it 2500.

The Sneug, the highest hill in the island, rises steeply in its centre to a height of 1379 feet; it descends with almost inaccessible slopes on the north into two valleys.

Lora Field rises to the east with a height of 1176 feet. Somewhere on the northern slope near the summit of this hill, there is a chasm covered with a flag; this is called the Lum of Snifield. We have Hibbert's and other authority for the statement, that several barrel-fulls of lines have failed to plumb this crevass; but the author and a party of five, two of them being Foulaese, searched for it for some time unavailingly.

The whole mass of these hills consists of loose arenaceous yellow, red, and grey sandstones, very deficient in cement; their upper strata are frequently micaceous, occasionally being rendered flaggy thereby; and they also contain granules of a green powdery matter, in ignorance of the nature of which we might call it *chloritic*, but it has more resemblance to glauconite.

Southward of this line of three hills, the island is cut down to a low level, and nearly divided into two halves by a wide trench called Glen Dahl.

Near the cliffs at the western extremity of this, there is an enormous cleft in the land of about six feet wide at the surface and perhaps thrice that below; it is 100 feet deep, and approximately 300 yards in length. The rent surfaces accord perfectly with each other; this

* Captain Veitch made it 1233 feet.

† By so doing he will to the right observe a lower projecting point called the Little Kaim—say 500 feet high. This the writer was informed is "a terrible place for fools," the English of which is *an unrivalled place for catching birds.*

cleft runs at right angles to the line of coast; it has on the one side the three great hills last named, and on the south the huge towering mass of the Noup. Crevasses similar to this, but running parallel to a cliff line, frequently in Orkney give evidence of a coming fall—the sea having sapped the foundations,—but what has been the force which has operated here with such mighty buttresses on each side?

The precipices being here low, the cliff foot is seen to run out in bluish-black slabs, which dip to the S.W. at an angle of 12°; and, as on the south side of the Noup, the whole hill is seen to overhang to the south at a considerably greater angle, it is probable that this overhang, with a slip, has occasioned the rent.

The Noup rises from the Glen of Dahl—steep, smooth-sided, round topped, and lumpish, to a height of 822 feet. Its domed summit slopes slightly towards a rough-edged precipice of nearly equal height; the hill falls with dangerously steep slope on the south, and terminates in the Ruskie Cliff, 452 feet in height.

The upper portion of this precipice at one spot overhangs to an extraordinary extent, projecting over the waters in a huge protruding mass of jointless rock, which constitutes nearly half the bulk of the precipice.

South of this the shores are lower; they exhibit long projecting shelves of rock all dipping to the S.W., and appearing from above—for they are inaccessible—somewhat like the argillaceous flags of the Old Red.

Returning to the east shore, we come again upon the gritty beds, and find their junction with, or rather transition into dark argillaceous and micaceous schists, to occur at Schoble. There is no unconformability. Here the dip is at first low, but it rapidly rises until at Ham Little there is a dip of 45° to 50°.

Sailing under the tremendous wall of cliffs of Muldi-couse, Wester Hyvda,* and the Kaim, two parallel and synchronously flexured bands of yellow and black striped rock, are to be seen about mid-way up the face of the cliff. These may each be about 80 or 90 feet in thickness—were it not for the abruptness of the flexures, they would have been set down as bedded traps.

* Wester Hyvda has in its centre a sloping bank of tufty grass of treacherous attachment to the rock; it is this sloping bank which is so dreaded by those men who, according to the Stornaway Bard, never die, though all get their necks broke. While standing on the summit of the Noup our party was startled by a sudden report;- turning at the sound in the direction of Wester Hydra a quantity of thin smoke was observed somewhat rapidly disappearing, a mass of fallen rock had by the tremendous blow been largely dissipated into sand

There is no spot where a cross section can be seen, but it is somewhat doubtful if the upper arenaceous beds are conformable with the flaggy layers.

Dr. Fleming mentions *Bituminous shale,* accompanied by thin beds of clay ironstone, as occurring, but does not specify the spot.

FAIR ISLE.

This mid-ocean stepping stone between Orkney and Shetland is, with its outlying stacks, composed solely of sandstones and sandy grits.

As it lies in the line of a continuation of the long strip of sandstone rocks of Shetland, and altogether to the east of a line connecting the two groups of islands, it is to be regarded as belonging geologically to the latter of these groups.

The same conclusion is borne out alike by the bold and bossy character of its shores and hills, the nature of the rock itself, and the occurrence of a copper vein with a north and south strike, which may not improbably be the continuation of that wrought at Sandlodge.

The island is by some considered to derive its name from its being situated in the *fairway* between Orkney and Shetland: by others from its having for the most part cliffy shores unincumbered with rocks; but to the writer it appears that in all probability the name has been a corruption from Far-öe—a Norwegian appellation which we still have both north, south, and east of this.

It has the enviable or unenviable celebrity of having arrested the galley of the Duke of Medina Sidonia, the Admiral of the Spanish Armada in his last desperate attempt to regain his country, after the destruction of his fleet. It has blocked the fair-way from the continent to America with like destructive result to many vessels up to very recent times; and from the thin mists which frequently cling to its heights, it must continue to do so until its claim to be the site of a a lighthouse of the first-class comes to be recognised.

With the exception of a little low ground in the south, the island is altogether of considerable elevation; and it is so girt with cliffs that there are but three landing places on its shore, two on the south, and one on its north-east in a somewhat land-locked bight. No one of these, however, is practicable in rough weather, unless the wind be off-shore.

In the north-easterly bight a small vessel might lie at anchor, with southerly winds.

It has been stated that a vein of copper-ore occurs in this island—it is on its west side. Though this has been lately attempted to be wrought, it was never properly explored; and it doubtless would yield several species besides those which have yet been noticed, if it ever came to be thoroughly opened up.

That most irrepressible naturalist the late Dr. Fleming, thus describes it, at its northern locality :—" it is situated in a mural precipice of sandstone, upwards of 300 feet in height, to the northward of Naversgill, and directly exposed to the western ocean. This vein intersects the strata in a perpendicular direction, and the line of its bearing is from north to south. Both sides of the vein seem to be composed of greenstone, and in the middle of the vein there is a stratum of soft decomposed rock, containing much clay and fragments of compact *heavy spar*. The principal ore is the *copper glance* or *vitreous copper-ore*. There is also a small quantity of *copper green* and *malachite*, disseminated through the copper glance. The vein of ore appeared to be only about six inches in breadth; but as at the time I examined this vein I was necessarily suspended by a rope from the top of the precipice, held by two of the natives, and was furnished with no other instrument than a hammer, I was unable to clear away so much of the decomposed matter as to enable me to get a distinct view of the magnitude of the vein, or the quantity of ore which it contained; and as the surge below prevented me from approaching the vein in a boat, my observations were necessarily confined."

Two specimens were brought to the writer from this spot by a nephew. The first was a massive vitreous ore which had much more the appearance of *fahlerz* than of vitreous copper.

The second was a peculiar fine granular yellowish-white stone of low gravity.

In a hasty and altogether incomplete analysis it yielded 4·97 per cent. of a yellow matter infusible in Fresenius, flux. The portion which dissolved in the flux yielded,—

Silica	51·825
Alumina (with some Fe^2O^3)	31·935
Lime (with some Ba O)	12·1
Magnesia	4·4
	100·26 (H.)

This may be only a gangue; but I have seen a substance indistinguishable from this from one of the Orkneys, where it carried malachite and azurite in cavities.

The same vein appears at the head of a wider geo to the east of Reevor Head, at a more southerly spot on the same western side of the island. Here it is nearly altogether concealed on account of explorations conducted in a quite trifling manner.

The island indeed has never been properly explored.

In the rocky shores of a small bight which is separated by a shingly beach or "ayre" from the little harbour of the east side of the island, *hone-stones* of considerable excellence are obtained.

The vast difference in the force of an Atlantic and of a North Sea billow is well displayed in the inequality in height of the cliffs on the west and on the east of this island. Among the interesting scenes of its intricately cleft shores, subterranean passages to the sea near Reevor Head, and the Screw or north-east point may be specially noted.

Some opinion as to the Geological age of these Islands may be expected before passing from a county which affords such unrivalled facilities in its winding shores for the examination of its rocks, which has supplied so many of the constituents of these rocks in such a state of purity as to be fitted for chemical examination—so many of these in those varying allomorphic conditions which afford every facility for change, and finally not a few localities where change incipient and complete is to be seen.

There are two directions in which correlation may be extended. First, with the rocks of the country in which they occur, or the rocks which the observer has himself examined; and secondly, with such as he draws his acquaintance with from the descriptions and writings of others. On the first of these points the writer is prepared to speak with such an amount of decision as is warranted by a close study of the older rocks of his country during many years; on the second, if he must speak at all, he does so with what he believes to be a very unusual amount of diffidence.

Such questions as these can only be entered upon after a due familiarity with the *literature* of the science; and, apart altogether from our ordinary acceptation of the signification of that word, Geology may be said to have a literature of its own, composed of sentences, words, and letters, as all other literature is.

In this special literature, *elements stand for the letters, minerals for the words, and rocks for the sentences*:—a thorough knowledge of these is as necessary for the proper compilation of the literature of geology, as is a knowledge of sentences, words, and letters to the proper appreciation of the structure of any written language; and yet it may freely be said that in much of the literature of Geology, there has not been over much deference paid to the importance of such knowledge.

Yet when the geologist steps from the fossil-bearing strata, to metamorphic and azoic rocks, such a knowledge is imperatively required.

How are the sentences to be construed and their import unfolded without an adequate knowledge of and acquaintance with their form of construction ?

"The question here arises whether in the absence of organic remains or of stratigraphical evidence, there exists any means of determining approximately the geological age of a given series of crystalline stratified rocks; in other words whether the chemical conditions which have presided over the formation of sedimentary rocks have so far varied in the course of ages as to impress upon these rocks marked chemical and mineralogical differences. In the case of unaltered sediments it would be difficult to arrive at any solution of this question without greatly multiplied analyses; but in the same rocks when altered *the crystalline minerals which are formed, being definite in their composition, and varying with the chemical constitution of the sediments, may perhaps to a certain extent become to the geologist what organic remains are in the unaltered rocks—a guide to the geological age and succession.*"

Geologists who are about to enter upon the study of the older rocks would do well to ponder on these words of Dr. Sterry Hunt; they would also do well to give due weight to the correct chemistry enunciated in the following, from the same author.

"In the case of the permeable or more highly siliceous class of sediments, whose chief elements are silica, alumina, and alkalies, the deposits of different ages will be marked chiefly by a progressive diminution in the amount of potash and more especially of the soda which they contain.

In the oldest rocks the proportion of alkali will be nearly or quite sufficient to form orthoclase or albite with the whole of the alumina present; but as the alkali diminishes, a portion of the alumina will crystallise, on the metamorphism of the sediments, in the form of a potash mica, such as muscovite or margarodite. While the oxygen-ratio between the alumina and the alkali in the felspars just named is 3 : 1, it becomes 6 : 1 in margarodite and 12 : 1 in muscovite. The appearance of these micas in a rock denotes then a diminution in the amount of alkali, until in some strata the felspar almost entirely disappears, and the rock becomes a quartzose mica-schist. In sediments still further deprived of alkali metamorphism gives rise to schists filled with crystals of kyanite or of andulusite, which are simple silicates of alumina, into whose composition alkalies do not enter; or in case the sediments still retain oxide of iron, staurolite and iron-alumina garnet take their place. The matrix of all these minerals is generally a quartzose mica-schist. The last term in this exhaustive process ap-

pears to be represented by the disthene and pyrophyllite rocks, which occur in some regions of crystalline schists."

Being at total dis-accord with Dr. Sterry Hunt as regards the origin of serpentine, it is a source of satisfaction to me to be able to point to the above as forming, in my opinion, correct leading-lines in geological speculation; and I cannot but lay special weight upon the occurrence—if it be a clearly well-marked occurrence of certain mineral species, as being a sure guide in correlation. Such occurrences must go far to prove both a general identity in the composition of rock masses, and a general similarity in the circumstances in which they have been placed, and in the agencies which have affected them.

Making use here of the above leading-lines, the writer in answering the first of the questions propounded, has to say that (excluding the sandstones lying to the east of the Cliff hills, and the sandstones with intercalated igneous rocks of the west coast), the older rocks of Shetland (though some small masses of strata may resemble those of other districts of Scotland), *form a group which occurs nowhere else in the northern division of the kingdom*

The similitudes referred to within the brackets, were pointed out at the time, and dwelt upon with all due, perhaps even an undue amount of force. These were, first, the resemblance of the Blue Mull and Fitfiel rock to that of Glen Rinnies and elsewhere, in Banffshire; and, second, the very startling fact of the almost identity of the serpentines of Colafirth with those of Portsoy, in appearance, bulk, and strike; but as regards the last, here the resemblance ends, for while the dip at Colafirth accords with that at Portsoy, the latter is seen to be the normal dip, while that at Colafirth is not the normal, but hades away from an eruptive rock. Little weight moreover could be laid upon an identity of dip at distances so extreme.

While then the above resemblances exist, they may perhaps be held to be no more than resemblances, when full consideration is given to the following facts.

The schist of Banffshire is rendered typical by the presence of andalusite, chiastolite, staurolite, and kyanite: the Shetland rock never contains these, though two of them occur in the neighbouring gneiss.

The rocks associated with the serpentines of Colafirth and Portsoy, though through the crudeness and bareness of lithological nomenclature bearing names nearly identical, are in their nature altogether dissimilar. The Colafirth rock is a markedly schistose *albitic* rock, the Portsoy one a porphyritic *labradoric* one.

So much for resemblances. The points in regard to which the Shetland group differs from the rocks of the mainland of Scotland, are these—

The general strike is not the same.

The prevailing dip is in the opposite direction.

The gneissic rocks are markedly deficient in felspar, and, when micaceous, invariably carry margarodite or muscovite, and only in one locality, an altogether trifling amount of Haughtonite or Lepidomelane.

The hornblendic beds of gneiss are super-imposed on those which are micaceous—in them the ingredients are usually arranged in markedly separate belts—the quartz almost disappears, and the felspar is *albite*.

The more perfectly schistose rocks are largely composed of allomorphs of hornblende, which ingredient, in its physical properties, then much simulates a magnesian mineral; while it very frequently shows itself as undergoing or having undergone a serpentinous change.

As a group they are signalised by vivid colours, considerable unctuosity, a highly crystalline structure, consequent brilliant lustre, high apparent metamorphism, and great age. They are also locally much disturbed by intrusions of large masses of igneous rocks.

Correlated with the rocks of Scotland, they do not appear quite so ancient as the hornblendic gneiss of the west coast, but markedly more highly metamorphosed than the conglomerates, schists, and gneissic rock which overlie that gneiss; there is therefore no class of rocks in Scotland with which to correlate them,—the Banffshire rocks seeming less old than they.

When we go further afield in our correlation, we have to cross to that New World, which, in geological age, is the Old; and in Dr. Sterry Hunt's description of the Upper Huronian system, with its hornblendic greenstones, with chlorite, steatite, serpentine, and soft margarodite schists, with occasional clayslate and magnesian limestone, I see a system so singularly according with the rocks of Shetland, that I believe that geologist would assign them to that horizon, —members of which he has already recognised in Perth and Argyle Shires.

Should the conjecture of Murchison and Geikie that the gneiss of the west coast is of Laurentian age prove to be correct, (as indeed there can be little doubt,) and should the Shetland rocks with equal correctness be assigned to the Huronian, then in the philite schists of Boharm and Clova, the andalusite schists of Coreen, the staurolitic

and andalusite schists of Kinnairdy, the quartzites and limestones of the Vale of Deskford, Ben Cullen, and away to the south, the serpentines, granular hornblendic rocks, chiastolite, and margarodite schists of Portsoy, we have another series equally accordant with the Taconian of America.

This latter correlation, however, if the gneissoid rocks of the middle and east of Sutherland are truly Silurian—which is open to doubt—would call for an immense upthrow in the line of the boulder-filled valley of the Spey; but it has to be noted that an identity in the gneissic rocks, which lie to the north and the south sides of the great Caledonian Canal rent of Scotland, has never been shewn to be undoubted.

ADDENDUM.

Having directed Mr. Webster's attention to Dr. Fleming's notice of the chromiferous magnetite occurring *in limestone*, near the Loch of Trista, in Fetlar, he kindly made search and found the limestone.

It rises on the north shore of the loch, five or six feet above the level of the water, and crops up for some distance north of the loch. Mr Webster states that it stretches in a line midway between Hamma's Ness and Urister,—the peculiar appearance of the sahlite of which latter place induced the author to suspect the near presence of lime.

The Trista limestone contained the magnetite in minute angular specks. The specimens sent me by Mr. Webster consist of a yellowish, granular, loose-structured limestone, which carries an abundance of Biotite or phlogopite, and the magnetic mineral,—but no sphene.

According to Greg and Lettsom *andalusite* occurs in mica-slate in Unst.