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XXI.—*The Geognosy and Mineralogy of Scotland.*

By Professor Heddle.

THE ORKNEY ISLANDS.

Part II.

Pomona or Mainland.

THE localities of geognostic interest in this large island have been referred to in the general description of the islands, and its mineralogy alone now remains to be considered.

It has been remarked above, that the muddy silts which, impregnated with the putrescent pitch of fermenting organisms, form the great mass of the flags of the "Old Red," are exceptionally barren in minerals of interest. The cause of this is not far to seek:—the components of such silts are not themselves those which go to the formation of many mineral bodies;—nor have they been subjected to the metamorphic stimulus which excites to a chemical union of ingredients and elements which lie merely in the contact of granular apposition.

Formed as they are of the triturated and granulated debris of older formations, there are to be found in them the two minerals which may be regarded as the most universally occurring in *all* rock masses,—*baryte* and *pyrite*. These are here found for the most part in veins which fill transverse rents;—and perhaps no better illustration could be given of one of

the essential attributes of the crystallipolar force—its *selective cohesion*—than is here to be seen; namely, the manner in which it can from far distances draw to sparsely occurring centres, so as to link together in a crystalline structure the minute quantities of these two chemical compounds which occur in the comminuted paste of the older or parent rock.

Small veins of these minerals are not infrequent, but they seldom show anything more than imperfect crystals.

Almost equally frequent are veins of *galena*, these also being trifling in bulk.

The first mineral to which special interest attaches is *avanturine*.

This was found by Mr. G. W. Traill* upon the shore and beneath a cliff of, I believe, the lower bed of the fiery-red freestone, noticed as forming the trough which runs through the islands.

This cliff forms the north-west corner of the Bay of Birstane, a branch of Inganess bay. The avanturine was found in small rolled pebbles. Occurring only at this spot, they doubtless were either loosened out of the cliff, or were formed by the trituration of the fragments of a band in the cliff,—but Mr. Traill could not find them *in situ*.

These pebbles were none of them of the size of a bean;—in other respects they are finer than any avanturine I have seen from Scotland. They are of that variety of the mineral in which the internal sparkle is due to flakes of mica; indeed, minute regular crystals of it are to be seen. Mr. Traill writes—"The mica is in most of the specimens arranged in layers, as it would naturally settle in a fluid, and it thus determines the cleavage of the quartz; in other cases there is no such regularity, and the mica is sprinkled about, as in artificial avanturine."

The colour of the quartz being high, the spangles approach somewhat to a golden flash, and as the quartz is not at all shivery or loose in structure, the pebbles polish fairly well,—some small ornaments made from them being not markedly inferior to the foreign stone.

Associated with the avanturine, Mr. Traill found interesting specimens of a sandstone of which the appearance is striking, and which discloses in an unmistakable manner that certain of the changes in rocks result from the action of percolating oxygenated waters.

In this sandstone a uniformly-tinted band overlies one which is profusely sprinkled with elongated spottings of a deep brown-black colour. These spottings, however, are not promiscuously disposed, nor are they in any degree uniform in size. At the line of the junction of the two bands of the stone, a multitude of minute dark specks almost eclipse the ordinary

* Author of a meritorious monograph of Quartz and Opal.

red tint;—from this line downward these specks diminish in number, but increase in size in an almost equal ratio, and by an almost regular progression. The long diagonal of the ovoid stain is invariably at right angles to the line of demarkation of the bands of the stone. The black markings are ovoidal in two directions at right angles to one another, and circular in cross-section.

The structure, as a whole, conveys the impression that granules of an alterable mineral were sprinkled throughout the sedimenting sand,—at first few in number, but comparatively ample in bulk; and that, as the deposition progressed, the relationship of this mineral to the arenaceous matrix, while it remained much the same in amount, altered in this respect, that the granules become smaller in size but greater in number. The ovoid stains appear to have resulted from oxidation by air-charged water soaking from the atmosphere, which carried a darkening stain downward from the changed mineral,—larger or smaller according to its bulk.

The stained portions have a manganesian or cobaltic tinge; but I have had no specimen whereon I could determine their nature. A drawing is given of the single specimen I possess. (Plate XII).

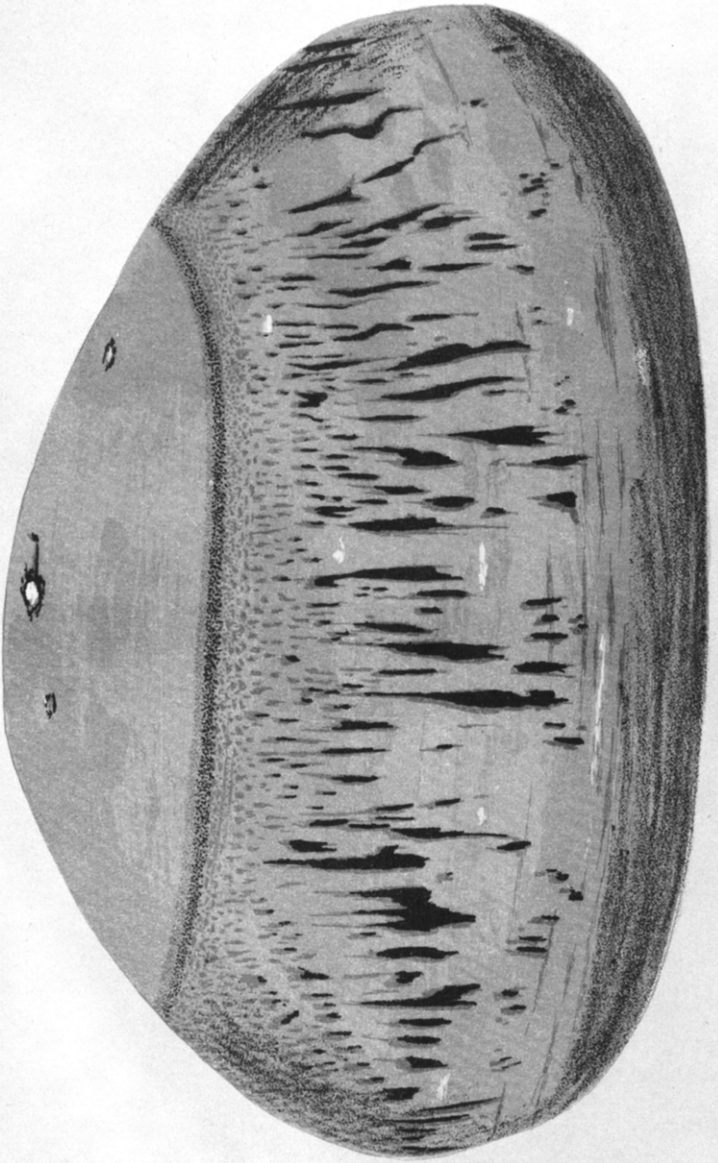
The Rev. Dr. Clouston in his excellent sketch of the geology and mineralogy of Orkney, drawn up in 1839 for the Statistical Account of Scotland, remarks—"In some places the strata have a bituminous appearance on the surface, or contain little cavities which are filled up with a soft *bitumen* or *petrolium*, occasionaly glance coal?" From the context I am led to believe that one of the localities which Dr. Clouston referred to as affording occasionally a mineral much resembling (for so I read his mark of interrogation) *glance coal*, lies about a mile north of the termination of the granitic-gneiss of Inganess. Here, at least, I found the substance now described.

It occurs in patches, generally imbedded in an inferior blue limestone, but sometimes filling thin cross-rents in the blue-flags. It is of a jet-black colour, and a high obsidian lustre. It is very much rent, so as to spring loose from the matrix in "dressing" the specimens. The fragments thus detached are smaller than peas, and have rhomboidal angles.

It sinks rapidly in water, but I had no fragment large enough to determine its specific gravity on. Its hardness is about 3. *It is soluble in benzole.*

It yielded when burnt at a red heat—

Volatile below 210°	·1	
Gas (highly illuminating)	47·82	
Carbon	51·84	
Ash	·24	H.



STAINED SANDSTONE.— BIRSTANE BAY.

Copied from original partly coloured plates.

The carbon or coke was very light and blebby. Unfortunately I had not a sufficiency for an organic analysis. As, however, no known mineral gives anything like the above numbers, there can be little doubt of this being a new bituminous mineral; and to it I give the appropriate name of *Cloustonite*, after its discoverer,—a gentleman whose life-long devotion to this and other branches of science, calls for—and has indeed already won for him—an honourable distinction.

Dr. Clouston notes the occurrence in the flagstone quarry at Yesknaby, of fine specimens of *dendritic pyrites*; and from Dr. Traill of Woodwick, I got specimens of the same mineral, of some size, which bore much resemblance to pseudomorphs after large radiating crystals of arragonite.

Lydian stone and *chert* also occur in association with the limestone of Yesknaby (Clouston.)

Dr. Clouston remarks upon the frequent occurrence of veins of *felspar* in the gneiss; from only two localities was I able to procure it in quantity and quality sufficient for analysis.

The first of these was from the northern extremity of the granite at Inganess. Here it occurs in exfiltrative *nodules* rather than veins, imbedded in the gneiss of the shore, immediately north of, and sometimes in close proximity to the white-trap dyke which cuts through the gneiss.

This *orthoclase* is cream-coloured; its specific gravity is 2·549.

It yielded—

Silica	63·671
Alumina	18·515
Ferric Oxide	·878
Manganous Oxide	trace.
Lime	·731
Magnesia	·307
Potash	13·536
Soda	1·798
Water	·875
	100·311 (H.)

It showed the "corded structure," described by me in the Transactions of the Royal Society of Edinburgh, and therefore probably is *microcline*.

The second of the localities alluded to, is the shore immediately west of the Point of Ness near Stromness.

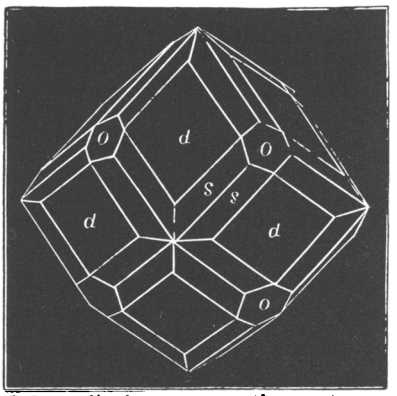
Here the gneiss is cut by many small granitic bands; but it was with difficulty that I obtained enough of the felspar for analysis. Here also it was of a pale flesh or cream colour. It yielded

Silica	60·769
Alumina	18·874
Ferric Oxide	1·318
Lime	3·747
Magnesia	·23
Potash	12·692
Soda	1·95
Water	·862
	100·442 (H.)

This felspar did not show the corded structure. It is altogether singular in composition. While it must be called *orthoclase*, yet it contains a marked deficiency in the amount of silica, and a very large quantity of lime; but as it does not in composition as a whole shade off to any of the other felspars, we cannot but regard it as a variety of orthoclase.

The granite here, but more markedly on its eastern slopes, contains *Haughtonite* (H) in very small flakes; its quartz is milky or even somewhat fatty in lustre; it does not, to the lens at least, show any oligoclase. Lithologically it differs from all neighbouring granites: it differs markedly from any in Shetland; even where most syenitic it bears no resemblance to that of Ben Loyal, and is in no way like either the Ord or the Abriachan rocks; it has, however, some resemblance to some granites of intermediate character, which occur in Aberdeen and Banff.

It passes by almost insensible gradation into gneiss.



Jameson found *garnets* in those parts of the rock which passed to mica-slate. These garnets are very small, but the form figured can be made out.

Clouston registers *rock-crystal.* He also notes the occurrence in it of small veins of *galena*; and I have myself found in the gneiss at the Point of Ness small veins of Traill's *stromnite.*

In one of the letters quoted in the preface of Low's "Tour through Orkney" there occurs the sentence:—"I beg to know what the white

stuff was I sent. It is found *in vein* through the rocks of the Mainland.' There is much probability that this was the first observation of the stromnite.

Dr. Traill gives as the composition of this mineral.

Carbonate of Strontia	68·6
Carbonate of Lime	2·6
Sulphate of Baryta	27·5
Ferric Oxide	·1
	98·8

The locality at which Dr. Traill found the mineral was a vein which cut the flags, with about a N.N.W. and S.S.E. strike, about 50 yards westward of the Point of Ness. A breakwater now covers the spot, but at dead low-water of spring tides, specimens may still be got from the southern end of this vein.

Here the writer has obtained it, showing minute elongated acicular crystals,—the general mass having in its fracture a laminated appearance. This, taken along with the fact that weak acid dissolves out strontium carbonate, leaving sometimes a powder, sometimes a foliaceous loose mass of crystals, tends to the conclusion that this is a mere mixture of *strontianite* with baryte. Some specimens I also find to consist almost solely of strontianite.

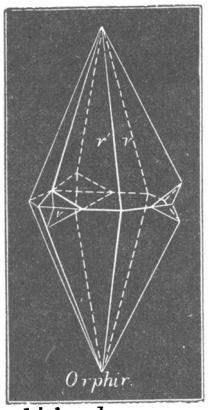
Some minute veins of this substance may be found in the flags westward of this; and Clouston states that it also occurs in an old lead-mine, about a mile still further west.

This mine, which was worked for some time, contains cubes of *galena*. *Blende* (H.) also occurs here in double veins of about half-an-inch in thickness, and there are traces of *calamine* and *cerussite*.

Lydian Stone cuts the flags in numerous veins. *Marcasite*, (H) in cockscomb forms converted into limonite, coats the rocks occasionally.

The numerous ichthyolytes, which blacken the flags in the vicinity of the old mine, have been converted into a jetty-black brittle substance, which was pronounced to be coal by Dr. Fleming; as this substance, though of no constant composition, invariably contains a considerable quantity of phosphate of lime, such an appellation is altogether unsuitable.

A point of very considerable interest connected with this locality is the fact noted above of both the granitic rock and the recent flags being alike cut by veins not only of galena but also of stromnite;—this almost induces the conclusion that the rents had been filled from above.



The shore cliffs which bound the north side of Scalpa Flow are rarely cut by veins of *calcite* (H); from one of these in the parish of Orphir, about half a mile west of Walkmill Bay, the writer obtained twin crystals of the form figured, of about three inches in length.

The freestone cliffs on both sides of the head of the Bay of Scalpa contains veins of lamellar *baryte*, and of *pyrite*; a vein of the latter nearly two inches in width also occurs among the rocks facing Enhallow in the west of the parish of Evie.

In this account of the mineralogy of these islands no attempt is made to enumerate the localities in which *galena* occurs, as it is, so far as I know, always trifling in amount.

As bearing on the question of the elevation of the land, it has to be noted that at Houton Head there is a small cave in the face of the rock, the mouth of which is about 90 feet above flood mark, narrow at the entrance, but widening and becoming higher towards the inner extremity, which extends to a distance of about 14 feet.

ISLAND OF BURRAY.

In Low's Tour through Orkney there occurs the following.

"Minerals and indications of mines are frequent in it (Burra); at the south side of the island was shown a sort of mineral, which Mr. Sangster told me produced lead and some small proportion of silver; but it should seem not so much as to encourage the working of it, and indeed it seems to be fuller of sulphur than of silver. At the west end of the island are plain indications of copper, and this also so easily procured as encouraged Sir Lawrance Dundas to send down a set of miners to work it; however it proved but a poor ore, and was given over. I saw some of the ore; it was but light, sprinkled over with a green matter like verdigrease. and on some of the pieces fine blue crystals of copper or vitriol. Mr. Sangster showed me some of the finer ore which was heavy and good, as also a piece of the smelted metal, which is very good and well coloured. He told me that in breaking through a crumbling sort of rock in working it they found the purest virgin copper in the appearance of leaves and sprigs of trees, according as it had wrought itself through the fissures of the stone. Where the miners dug it has all the appearance of a large vein, confined on each side by a pretty thick partition of a sort of fuller's earth which entirely separates it from the rocks on each side."

Here we have evidence of the occurrence of *native copper*, *malachite*, *azurite* and either *chalcopyrite* or *vitreous copper*.

The description of the vein indicates one very similar to that of Rousay.

In the same work we read of the Cornholm of Copinsha:—"In the southermost point S.S.W. a quarry of a greyslate much worn through and chinks filled up with spar, but curious on account of the many beautiful figures of seaweeds found between the plates. These figures are most elegantly drawn, and represent a vast variety of weeds, few like them are to be found; they are painted of a brassy color, and many of them very clear, even to the smallest fibres."

In Wallace's account of the Orkney Islands there occurs the following description of the fall of a meteoric stone.

"The air and clouds here, by the operation of the sun, do sometimes generate several things; as some years since, some fishermen fishing half a league from land over against Copinsha in a fair day, there fell down from the air a stone about the bigness of a foot-ball, which fell in the middle of the boat and sprung a leake, to the great danger of the lives of the men that were in it, which could be no other than some substance generated in the clouds.

The stone was like condensed or petrified clay, and was a long time in the custody of Captain *Andrew Dick*, at that time Steward of this country; and Captain *Dick*, who is yet alive, told me he gave it to the late Earl of Glencairn."

ISLAND OF GRÆMSAY.

This island shows on its northern shore between the lighthouses, a section similar to that on the north side of Hoy Sound:—a granitic nucleus with gneissic belts in each side,—these being flanked in turn by the schists, dipping on either hand away therefrom.

The only other notice I have to make of it, concerns what I took to be a dense variety of peat. This I found compacted, doubtless merely by the superincumbent pressure, in a washed out trap-dyke or deep cleft in the rock, near the summit level of the island, and towards its west side.

It seemed to me to bear a resemblance both to a dense peat which I had dug from under about 450 feet of superincumbent strata of alternating trap and peat, in the island of Tintholm in Faröe; and also to an artificially-condensed peat which is sold in London.

The analyses of the three are as follows—

	Græmsay	Tintholm	London	
Specific Gravity ..	1·31 ..	1·27 ..	1·2	
Water	6·06 ..	9·44 ..	3·94	
Volatile at 240° ..	6·88 ..	4.16 ..	6·29	
Gas	15·52 ..	49·40 ..	56·05	
Carbon	·62 ..	20·50 ..	28·08	
Ash	70·92 ..	16·50 ..	5·64	(H)

The Græmsay substance therefore evidently consists largely of earth, and would be useless as fuel.

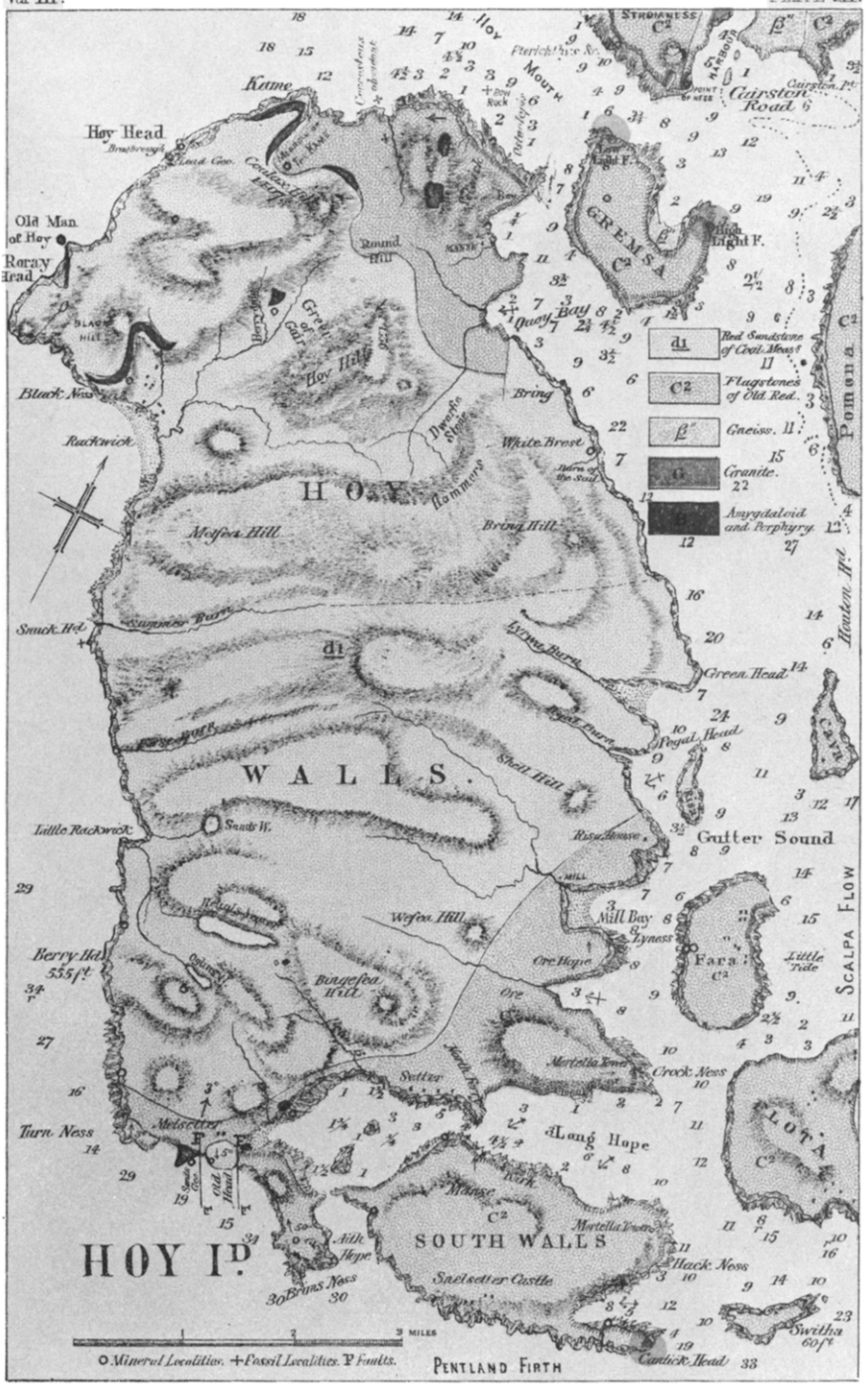
ISLAND OF HOY.

In a book descriptive of the scenery of Orkney* we read—"Opposite, on the southern side, across the Sound, with its swift-rushing tides, rise the dark and precipitous hills of Hoy, which hold, as with some weird attraction, the spectator's eye. Seamed and scarred by the storms of centuries, they have an aspect of wild loveliness and desolate grandeur. The sea smiles in the sunlight, but they never lose their look of dark sublimity. In the great hollow between the heights the shadows condense into a gloom that might be felt. The effects of light and shade are profoundly touching in their almost unearthly beauty. Here and there on the lower grounds, patches of green come out vividly in sudden gleams of light, forming a striking contrast to the overhanging gloom of the weird and withered hills. The low emerald isle of Graemsay, with cattle grazing amid its pleasant pastures, lying along the waters beneath the lowering brows of the giant heights, enhances still more the wonderful effects of contrasted beauty and gloom. Wreaths of misty vapour, wafted from the wide Atlantic, seem ascending and descending the precipitous sides. No sooner has one mist-cloud drawn up its thin skirts to the topmost pinnacle and melted into thinner air, than another descends, and again the white wreaths rise seething and curling out of the gloom below. The entire view, in its fine combination of sea and land scenery, stimulates the fancy and exhilarates the heart. Seated on the Stromness side of the Sound at sunset, nothing can surpass the mingled beauty and sublimity of the spectacle when the weather-worn hills of Haa-öe loom greenly above the waters, while over their dark summits and through the great gorge between streams a silent flood of yellow light, gilding the swift currents as they glimpse out of the dark-purple shadows."

The scenery of a country is ever dependent upon its geology;—this description of towering hills with sides so steep as to throw sombre shadows over the emerald sward of one of the islands whose geognosy and rocks we have been considering, points unmistakably to an overlying series of rocks; while the contrasted appearance presented by these hills with that of the general aspect of the lower lands indicates, at least, an altogether different formation.

This upper rock consists of a series of beds, which attain a thickness of about 1300 feet. Throughout the whole of this thickness they are of the

* "Summers and winters in the Orkneys."—Gorrie.



Copied from original partly coloured plates.

nature of freestone; in the lower beds micaceous, and with included masses of decomposing shale, flag, or perhaps mica slate; in the upper showing little else than feebly agglutinated grains of sand:—indeed, a deficiency of cement is the marked feature of the rock throughout.

Yellow colours with an occasional tendency to red tints prevail.

It was probably their colour and soft or loose structure, as much as their superior position, which for long led to their being considered to belong to the New Red Sandstone: Jameson, however, was not so far astray as was at first imagined, when he indicated that he did not think that they were far off from the Coal Measures.

These thick-bedded and coarse-grained rocks are in no part of the island of Hoy conformable with the flags of the Old Red. A fringe of the latter occurs both in the north-east, and in the eastern and southern shores of the island, and there are several points where the relationship of the one to the other is disclosed. At one or more localities, moreover, an igneous rock is interstitialised between them. The occurrence of this igneous rock had been noticed by Wallace and by Jameson;—the latter says, "in many places I observed a rock of wacken,"—but its position and relation to the other rocks was first pointed out by George Anderson, and by Dr. Clouston.

Anderson, in the first editions of his "Guide to the Highlands," writes: "All the deposits now enumerated are traversed by numerous dykes, veins, and beds of trap-rocks. The base of the "Old Man of Hoy" consists of an irruptive porphyry rock, supporting an isolated crown of sandstone on its top; in the south-east side of the same island, at Walls, a mass of amygdaloidal trap extends nearly 600 yards along the coast."

Dr. Clouston writing in 1839 (Statistical account of Scotland) says,—"These secondary strata (the slates) may be found at all inclinations, from horizontal to perpendicular, but in general they dip to the west, at an angle of about 20°. III. *Sandstone.*—To understand the position of these rocks, it is necessary to trace them to Hoy, where the sandstone rests upon the slates. This sandstone is easily decomposed by the action of the sea, and forms numerous caves and fantastic forms along the precipices where it occurs, of which the insulated rock called the Old Man of Hoy may be given as an instance. This singular rock is formed of the same strata as the precipice from which it is disjoined; and as this is nearly 1000 feet perpendicular, it affords a magnificent exhibition of the strata. The top is red sandstone and the base on which it rests amygdaloid. The only place where I know of trap overflowing the secondary rocks is one which I discovered about twelve years ago, in the west side of Hoy, where there is a bed of it fully 100 feet thick, and, I believe, several miles in extent. Near the same bed, on the sea shore near Rackwick, I also found a fine vein of fibrous gypsum."

A nephew of the writer's found this bed high up in an almost inaccessible portion of the precipice of the Kame, immediately above a spot where the unconformability of the yellow beds to the underlying flags is admirably disclosed,—thus proving its extent to be, as stated by Dr. Clouston, "several miles."

Lastly, Professor Geikie has, in his classical paper upon the Old Red Sandstone, founded strongly both upon the unconformability of the upper rock, and upon the intervening igneous platform, in insisting upon a separation of the two sets of beds,—a separation which he makes more absolute in his Geological Map of Scotland, by removing these upper beds altogether from an association with the Old Red, and placing them in line with and at the bottom of the Coal Measures.

In so doing, Professor Geikie has retained the Old Red colouration;—but, following in his track, the writer has, for the sake of consistence, adopted in his map of the island Geikie's Coal Measure tint.

These upper beds of sandstone, then, have nothing in common with the flaggy silts upon which they lie. They differ from them in composition, and in included minerals,—they are altogether discordant with them in dip, and a great igneous sheet, indeed, (as Geikie shows,) two sheets, had been poured out over the flags, and had been solidified, before the sand-grains of the upper rock settled to their place. An enormous period of time, indeed, had intervened between the cessation of the deposition of the true "Old Red" and the commencement of the formation of these rocks. Though it is probably the upper beds of the lower formation upon which they rest, still these beds had been solidified, raised above the waters, and denuded to a great extent, ere ever the volcanic fires had poured that massive sheet over their abraded edges; and what period had elapsed before the dry land had again been submerged and the first grains of sand, borne from the waste of an altogether diverse parent-rock had settled upon the bottom of the new oceanic lake, we have no means of judging. The organisms of the past had, for the most part, ceased to exist; another day in the creative progress had dawned, and almost all things had become new.

The want of cement in these upper sandstones has been noticed:—this, their most marked feature, renders them exceedingly friable, prone to disintegration, and readily subject to aerial waste; streams cut their channels here with ease; the ocean waves cut and carve at them at will; and the old glacial mantle has scalped their summits into rounded contour.

A single central bed of about 60 feet in thickness has somewhat greater closeness and compactness of structure; it shews itself in the

three northmost hills; and, from its cleaving by cross-joints into rude parallelograms resembling somewhat the head of a hammer, it has given to the most southerly of these hills the quaint name of The Hammers.*

The general dip of these beds is to the S.S.W.

The amount of waste of this rock along the ocean verge is enormous,—Five of the hill ranges,—the Coolax, (? *Coolacks*) the Black hill, Melfea, the Snuke, and the Bery—have been cleft sheer off; forming precipices which are nearly mural, and from 600 to over 1100 feet of perpendicular height. Nor, indeed, are the rock-shores which intervene between these ranges of so greatly smaller altitude as to prevent the coast as a whole from presenting the appearance of an almost unbroken wall,—a rampart of towering stone of almost unrivalled grandeur. No one of the individual cliffs, however, can compare in lightness and in elegance with those either of Foula or St. Kilda; the heavy beetling mass of the somewhat higher hill-ground in the back, giving to all except perhaps the Bery and the Snuke, somewhat of the aspect of *a bluff*; and much diminishing the apparent altitude.

One of the detached stacks, however, the far seen and further famed "Old Man of Hoy," stands pre-eminent—*facile princeps* of all in Britain.†

From the abruptness of the truncation of the strata of this upper sandstone, and from its altitude, the view to be obtained from its summit is both panoramic and almost overhanging.

Gorrie, whose power of scenic description is far in advance of his geology, says of the view from Hoy Hill—"Now we stand upon the bald crown, and lo! the whole Orcadian Archipelago, with its islands, holms, stacks, and skerries, lies at our feet like the scattered fragments of some parti-coloured toy-map. It would be difficult to match the spectacle in unexpectedness of scenic effect. There is in it something dreamy, aërial, mystical, unreal. We seem to be looking down upon isle and islet, cape and bay, from the car of a balloon, or the balcony of a lofty tower."‡ This

* Two of these hammer heads have become dislodged, and have fallen into a glen;—one of these having been hollowed out into small chambers, probably by idle hands, is now known as the Dwarfie Stone.

† Gorrie says: "This rock is a huge primeval pillar, standing out from the line of cliffs;—heedless alike of calm and storm, the Old Man of the Sea, like a grim and veteran sentinel at his post, keeps silent watch and ward amid the lonely waters."

So far from being a *primeval* pillar, however, it is formed of much the *youngest* rock in the islands; and so far from being heedless of the storm, one of his limbs lately gave way during a storm, and the "grim sentinel" is now on his last leg.

‡ The sunset view from the summit of Hoy Hill has lately been described in the following lines:—

"Stretched like a map the prospect lies
In varied beauty far and wide;
There, Orphir's green acclivities,
There, Pentland with its raging tide.

description is happy, markedly so in the last line:—but this line shows that Mr. Gorrie had never stood upon the pinnacle of steep Suilven, or he would have reserved his last comparison for that lighthouse-like hill.

Dr. Clouston conceives that this upper sandstone is cut by dykes, and instances the cleft of the Green of Gair as having originated in a washed out dyke. This is nearly opposite to the amygdaloid of the Burn of Berridale; and the occurrence of loose agates on the hill-tops is also strongly confirmatory of the supposition.

The flags in the north end of the island dip persistently directly from the primitive rocks of Græmsay, and maintain this dip till they are encased by the huge enveloping masses of The Hammers, Hoy Hill, and The Coolax. Where overlaid, however, by the towering rocks of the Kame, the dip is to the south west; and as, where they are exposed by sea-scalping in the indentation near the Old Man, they are dipping to the east and south east, there must be a fold under the sandstone of Hoy Head.

In the south end of the island there are many folds; along the east shore these and the dips are inconsiderable; but in South Wales the dip is persistently to the west of north. In the peninsula of Brims, which is probably faulted on both sides, the dip is high; the beds are pronouncedly separated from one another, and a rugged and uncouth line of serrated precipices is the result.

Immediately to the westward of this, there is a great fault, which probably runs continuously northward to the eastern foot of the hill of Melsetter. West of this fault the upper sandstones come in, in the detached mass of the Old Head,—a bold promontory of 150 feet in height, which, faulted on both sides, has its basement strata thrown down below the level of the flags. A dyke succeeds to the fault upon the west; fault and dyke together forming the artificial looking boat-harbour of Sandsgeo. To this a large mass of purple-coloured amygdaloid succeeds.

There is again faulting, succeeded by slabby and micaceous beds of the sandstone, which form the coast-line till they are overlaid by the

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Ben Hope's huge dome of mystic blue
Looms from afar in form sublime,
Ben Loyal and coned Morven too
Eke out the splendours of the line.

The distant Klibrick rears its peak
In azure tints which melt to sky,
And the grim Griams' contours seek
With varied form to charm the eye.

And Rath's grand capes, mid skies of gold,—
Fit setting for that sapphire crest,—
Their splintered pinnacles unfold
To spangle in the blazing west."

towering and steep-sloped mass of the Bery Head; this, with the much lower Dunnet Head on the Caithness coast, forms the jaws of the Pentland Firth.

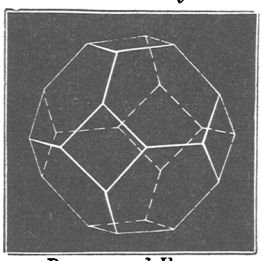
Geikie discovered in Hoy two of the throats of the igneous out-flow; and in South Walls another apparently occurs at the Burn of Simmary; while there are several veins or masses of tufaceous mud, now very serpentinous and decomposed, at the south-west end of the Bay of Melsetter.

A mound, grass clad throughout, which stretches across the mouth of the meadow of the Kame, has much the appearance of a terminal moraine. The hills, both of the lower and of the upper formation, exhibit well marked glacial contours.

We have in this island to consider the minerals of the flag formation, of the sandstone, and of the igneous rocks.

Minerals of the Flags.

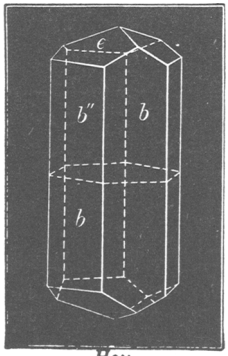
Hoy.—At Selwick there is an old lead mine; it would appear to be the continuation of the vein on the opposite shore of the Mainland. The *Galena* from this vein was said to contain 46 ozs. of silver to the ton. It is rarely in cubo-octahedral crystals.



Rousay and Hoy.

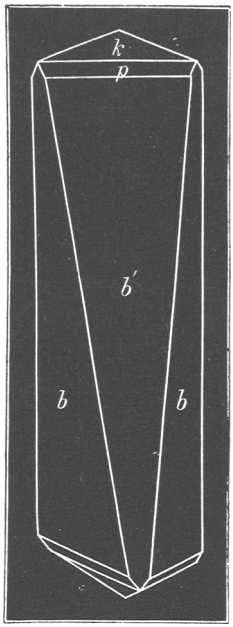
A little north of this, the smooth face of a cliff which faces about due north, is covered with crystals of about an inch in length of *calcite* in the twin-form figured. There are also rarely veins, with crystals of the second form drawn, *b*, *p*, *k*.

A little north of the Manse of Hoy, two veins of *limonite* were worked for some time. These veins run nearly north-west and south-east. The ore is in the botryoidal form, and so dense that the fibrous structure is obscure; it is dark-brown in colour; and is apparently somewhat stained with *reddle*, which occurs in the rock matrix.



Hoy.

Walls.—The flags of this southern part of the island, though they do not contain so many fossils as those at its northern extremity, are in certain localities highly charged with bituminous matters; and those flags which are so charged invariably show upon their surfaces slickenside or friction polishing, of a contorted and grooved nature; as if there had been frequent twistings and rubbings going on among them.



Localities where such dark flags abound, are the little Bay of Osmondwall, and a little west of the South Ness, in South Wales. At both of these localities the dip is to the N.N.W. at low angles.

A specimen of the Osmondwall flag yielded—

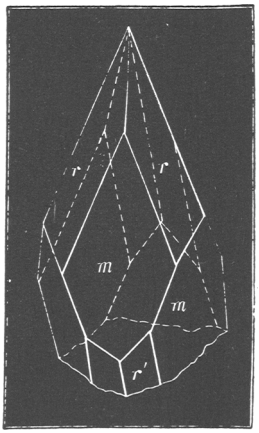
Water	3·11
Gas..	17·61
Carbon	5·936
Ash	73·044 (H.)

Mr. Low states that out of the "burrows" there used to be got "beads made of a sort of Lithandax or Parrot Coal, which burn in a candle leaving white ashes, after a very bright white flame."

These beads probably were made from the above flags.

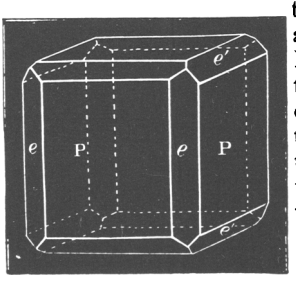
We here see that the term "Parrot Coal" was in use in 1774.

Probably it was the occurrence of these bituminoid flags which led Jameson and others to entertain the hope that coal would be found in this part of the island. There can be little doubt, however, that the hydro-carbon which impregnates the stone has had its source in animal organisms.

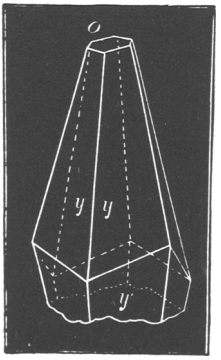


On the east shore of Aith Hope there is a vein which yields specimens of *red hematite*—this occurs in stalactites which have a hollow core.

At about the centre of the Peninsula of Brims there is a small drained lake, the bed of which is composed of marl; the cracks of the rocks which intervene between this and the sea are filled with calcite. From one of these veins *calcite* in small crystals of the form *m r* that of the figure may occasionally be got.



The flags which are in the immediate vicinity of a "neck" of tufa which has penetrated them at the Burn of Simmary, contain vesicles filled with tarry *bitumen*. Other cavities and veins in the vicinity contain *pyrite* in the form *Pe*; crystallised *calcite* also occurs in the form *y o*.



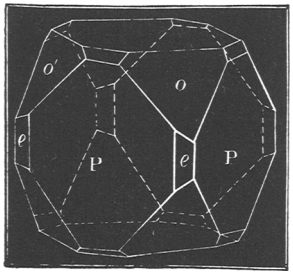
Minerals of the Sandstone.

At this south west extremity of the *cul de sac* called the Meadow of the Kame there are two clefts in the rock, by means of which the cliffs may be scaled. Lining the sandstone of the southern of these, *psilomelane* is rarely to be found.—(H).

Lumps of *reddle* are here also to be met with.

A little west of the highest point of Hoy Head, there is a turret-like projection called Braebrough; this, which is the most mural point of the whole cliff, is almost isolated; indeed it is attached to the main line of cliff by merely a narrow neck of lower altitude.

Here Dr. Clouston found a vein of *psilomelane*.



The face of the main cliff upon the right hand of the neck where it faces Braebrough, is covered with crystals of *limonite*, pseudo. after pyrite; it is in the interesting form drawn.—(H).

About three hundred yards further south, a locality called Lead Geo is reached.

George Low, writing in 1774, says,—"The ores of iron in Hoy are of two kinds, and found in great plenty in two different places. That dug near the Kirk is Hematites. * * * Another kind may be had in vast quantities from Hoy Head, where it runs in many regular veins in the very brink of the sea rocks. This is blacker than the former to appearance, it is much more solid, and weightier, looks as if it had been once in fusion, and had settled in a number of bubbles, which I dare say had not been the case: its first formation is from an infinite number of small particles or drops adhering very firmly together, and growing still more solid as they imbibe more of the iron, till at length it becomes a flint-like mass of the colour above described. Some years ago a company of adventurers from London dug several tons of this last, which they imagined was an ore of Cobalt, but without foundation. They sent several specimens to London, but how it turned out I could never learn. The work, however, was given up. When Mr. Banks was in Orkney on his way from Iceland, he took a step to this mine and smelted a piece of the ore, and assured me of its being iron."

As the ruins of a turf hut are to be seen here, and as the writer found a buried deposit of about four hundred-weight of the ore, near to where there were evident signs of working, there can be no question

that this is the locality alluded to by Low; and, as no galena is now at least to be seen here, the following extract of a letter of Mr. Low may probably explain the name of *Lead* Geo. "Has not your friend* perhaps something mistaken the words of the historian with respect to the black and white lead (*Plumbum album et nigrum*) Buch. History? I have never heard of black lead or "Wad" to be found here, but common lead in many places."

Tne common confusion between *wad* and *graphite*, taken along with the manner in which the hands are soiled in working among the ores which occur at this spot, doubtless led to the adoption of the incorrect name.

The ore described by Low is however not one of iron, but is for the most part *psilomelane*; his "flint-like mass" is a very dense *wad*. There is it is true a small quantity of *limonite*, but not enough to explain the extraordinary statement as to iron having been smelted *upon the spot* apparently,—for so the language used would imply.

Low's description of the ore is most accurate, and, as it will be seen, most suggestive and shrewd.

The veins are situated about 200 feet below the summit of the cliff, here called 1130 feet in height.

There are three or four veins still to be with difficulty seen, for the working has, from the precarious footing and the danger of the position, been of a rough and destructive description.

The appearance of the *psilomelane* varies in each of the veins; it occurs in finer masses here than at probably any other known locality.

In its commonest and least interesting appearance it presents itself in mammilated masses with an obscure fibrous structure and a dull lustre. Of this variety the specimens merely as such are the finest. Such masses sheath the sides of the vein and any loose or projecting processes which may occur in its vacuous centre. Though the surfaces of these mammilations are dull, and so soft as to soil the hands, they may when dry be polished by friction; but, when wet, the mineral may by brushing be diffused through water to a large extent.

There is therefore in these specimens a certain approach to *wad*.

Another appearance, though a rare one, is in large flat sheets which possess a mirror-like lustre, and have little trace of fibrous structure.

* *Pennant*. Mr. Anderson, in his introduction to Low's work, very clearly shews the *vampire character* of Pennant's friendship for Low.

In another vein it is of an exceedingly peculiar appearance, resembling a quantity of wires, of the thickness of needles, laid longitudinally together. The wires can be separated from one another with perfect ease—they pass transversely from side to side of the vein, which is about eight inches in width.

Another vein is of the nature of a dense *wad:* it is about two inches in width, is devoid of structure, if it be not of a granular description, and it breaks with a well-marked conchoidal fracture. This therefore is probably Low's "flint-like mass."

There is one marked fact which is to be observed of all these veins, it is that at their sides, the yellow, loose-grained sandstone-rock is stained by the manganese in a manner which forcibly conveys the impression that the ore did not *exude* from the rock into the vein-rent; but was *poured into* the rent, and soaked to a small extent into the porous stone: the limit of the stain is a sharp line of demarkation, it does not shade off with a fainter tinge, to the smallest extent.

I have said that *limonite* is associated with the psilomelane,—it is so associated in two of the veins only, and its appearance in them is very dissimilar.

In both it is superimposed upon the manganese, but in the one it assumes, or rather attempts to assume a minute stalactitic structure, sometimes passing into a pseudo-fibrous or knitted appearance. The coating of limonite however, which does this, has in itself the usual divergent-fibrous growth; the fibrous surface is of a purplish-brown colour, and it has a certain amount of the tremulous half-scaly appearance of lepidocrokite. But the chief feature of this variety of limonite is that its surface, which is dull, has invariably a greenish to an ochery tint.

This variety had a specific gravity 3·684, and yielded—

Ferric Oxide	78·787
Ferrous Oxide	3·236
Manganous Oxide	·153
Alumina	·56
Lime	·472
Silica	3·067
Water	14·314
	100·589 (H)

When dissolved in cold hydrochloric acid, a small quantity of light flocculent silica separates; upon applying heat this went entirely into solution.

The silica therefore is in combination.

The second variety of limonite I found directly coating the sandstone, in one or two specimens; usually it coats the botryoidal psilomelane, and, being a coating of uniform thickness, it assumes the botryoidal form of the under-lying mineral.

The surface of this variety is highly polished—jet black, and splendidly lustrous. Its internal structure is divergent-fibrous but it is tough. The internal colour is purplish-brown, and the lustre satin-like to vitreous. Its powder, however, is of a very rich ochre-yellow.

It yielded—

Ferric Oxide	82·135
Manganous Oxide	·343
Lime	·571
Magnesia	·214
Silica	3·315
Water	13·87
	100·468 (H)

Here also the silica was in combination.

The thickness of the coatings of this variety of limonite vary from about the fourth of an inch, to films of extreme thinness—these can always be recognised by their brilliant lustre, and of course by their ochre streak.

Of the *psilomelane* I analysed the massive sub-fibrous variety.

Its specific gravity is 4·607. It yielded—

Manganous Oxide	66·995=MnO, Mn_2O_3 71·868
Cobalt Oxide	1·478
Magnesia	·098
Baryta	14·876
Potash	·5
Soda	·003
Oxygen	6·658
Water	6·051
	101·484 (H.)

The vein which I have considered to be a dense *wad*, had a blue-black colour, and a brown streak.

Its specific gravity is 4·4. It yielded—

Manganous Oxide	64·87=MnO, Mn_2O_3 69·58
Cobalt Oxide	1·995
Magnesia	·199
Baryta	14.97
Potash	·247
Soda	·259
Alumina	1·097
Silica	·898
Oxygen	5·521
Water	5·688
	100·454 (H.)

When this variety is steeped in water and then left to dry, a saline efflorescence exudes from it, which is chiefly a salt of potash; as the specimens had been washed, and also had been buried in wet earth for a century, probably most of the alkalies must have been lost before analysis.

These analyses show that the "London adventurers" were not altogether wrong in conceiving the mineral to be an ore of cobalt.

They also show a most peculiar antagonism to exist between the two closely chemically-allied metals—iron and manganese. Though here occurring together, formed to some extent possibly by similar processes, and superimposed in layers over each other, the iron-ore has almost absolutely repelled the manganese; while no specimen of the psilomelane which I have examined contained a trace of iron. I do not remember ever having examined a mineral which was so absolutely free from the minutest trace of iron.

Cavities in the psilomelane are rarely covered with a velvet-like coating of "*mangan-sammat-erz*."

Low, in his remarks upon this ore, says that it "looks as if it had been once in fusion, and had settled in a number of bubbles." Though its usual occurrence, in fibrous-mammillations after the manner of the hematites, by no means indicates such a mode of deposition, yet I have already had to allude to indications of its having been *intruded* into the veins from without; and there are certain modes of its occurrence now to be described, which go a very long way indeed to show that some portion of it at least had been in a state of liquidity from heat.

To aid in the description of these, diagrammatic figures of actual specimens have been given; these will be referred to by number.

They group themselves into four varieties.

1. Drops which seem to have been sprinkled over a surface.

2. Drops which seem to have fallen into narrow spaces, and to have moulded themselves to the bounding walls of those spaces.

3. Pendulous masses, which seem to have run down the surfaces of the sustaining substance.

4. Drops which exhibit shrinkage markings, and which, having fallen one upon another, have taken an impression or cast of these shrinkage markings; but which drops are free from all attachments.

In the case of the first three varieties the so-called drops invariably lie upon the surface of the glossy limonite: in the case of the last they do not do so, but upon either the mammilated psilomelane, or upon other drops.

In the first two cases the drops are perfectly spherical, except where in contact with their support, or where by juxta position they impinge upon each other: they vary in size from the smallest sparrow-hail, to bullets which would be about four to the pound.

Their internal structure is obscurely fibrous

The pendulous masses have also an obscurely fibrous structure; but the drops which came under head No. 4, do not show any structure—being like flint when broken.

Fig. 1, plate X, shows a slab of the rock partially coated with a thin layer of the glossy limonite.

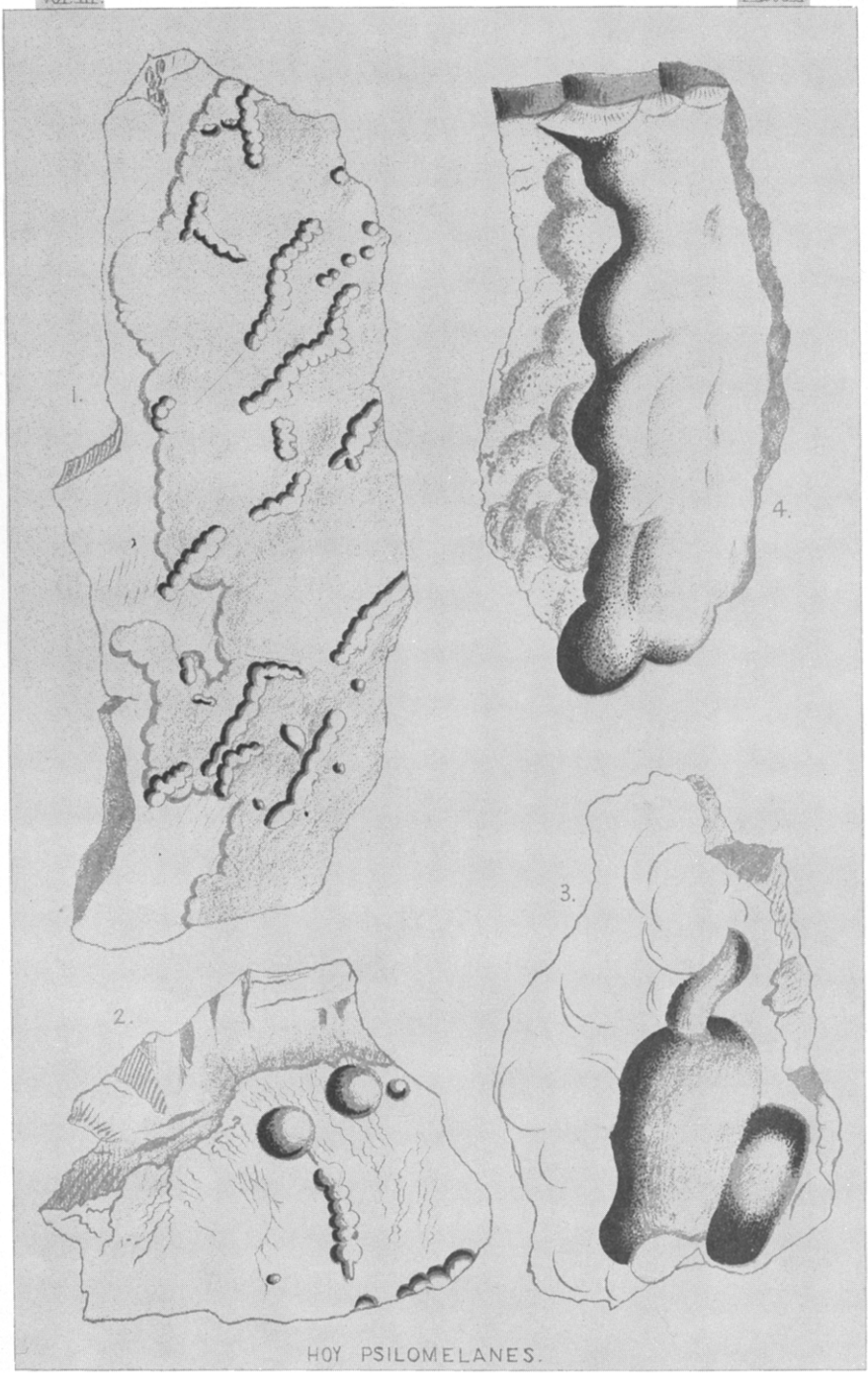
The rock has a very vitrified appearance, and the absence of the iron compound from *part* of its surface, considered along with the reniform margin of the portion of limonite which does sheathe it, is of difficult explanation under any supposition of its having been deposited from water.

Over the smooth and glossy surface of this limonite, and occasionally also over the sandstone itself, there are sprinkled vermiform aggregates of minute spheres of coalescent psilomelane.

The limonite layer is here about the sixteenth of an inch in thickness.

In figure 2 it is about the fourth of an inch, and the surface though glossy is stalactitically fibrous and rough; globules larger than swan-shot are singly or confluently sprinkled over this.

In the specimen figure 3, the glossy limonite (which is sheathing botryoidal psilomelane) has a thickness not much exceeding that of a coat of varnish, and upon this two large rounded masses lie; and a



Copied from original partly coloured plates.

narrow, tortuous, and more recent drop overlies both the limonite and these drops of psilomelane.

Of these three specimens it may be argued that they are not cases of droppings at all, but merely of local segregations of matter which had not deposited itself in a uniform layer over the surface of the limonite; and that it had not done so on account of the smoothness of the latter not only affording but few points or centres for radiant growth, but on account of its oil-like surface acting repellantly to the exercise of ordinary adhesion; and that once that crystalline shoots emanated from the few rough centres which did exist, the succeeding growths were localised at these,—as is so frequently seen in zeolites of a radiating character.

While giving all due weight to this argument, it has to be replied that the manner in which the limonite ordinarily coats the psilomelane, negatives the idea that there had been any repulsion between the two minerals, and that the above argument in no way meets the fact of some of the drops reposing upon the comparatively rough sandstone.

Specimen fig. 4 shows an apparent flow of molten matter over the limonite; it is figured in the position in which it was found in the vein.

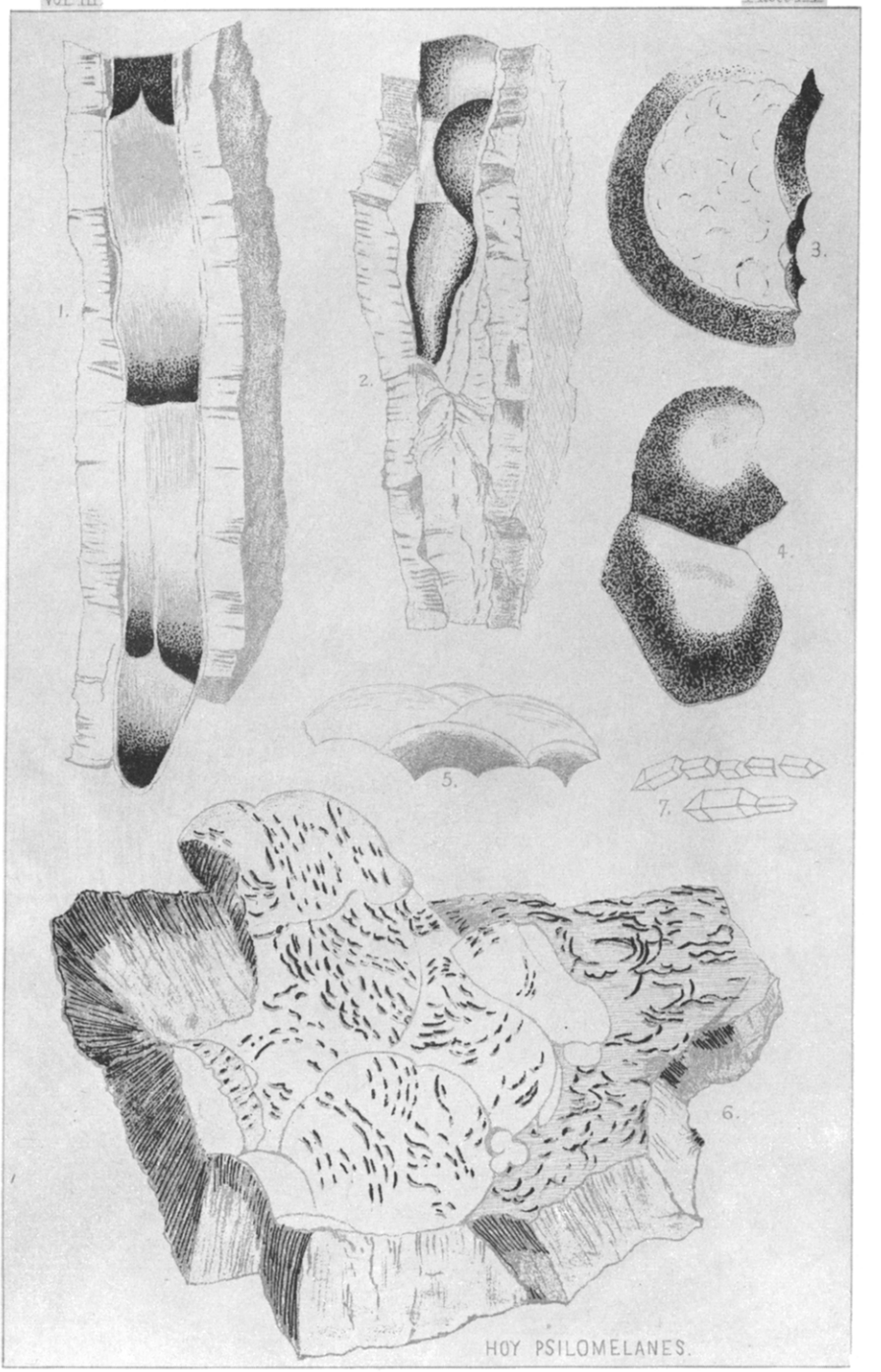
So also for figures 1, 2, and 3 of the plate XI. These seem to point to a large drop or drops of a plastic substance which has taken a cast of the narrow crevice which received them. None such were found adherent to the *upper* part of any drusic cavity.

In figure 1 the specimen is looked at from above; figure 2 is the eame specimen looked at horizontally,to shew the manner in which the drops have fitted themselves in between the two coats of the psilomelane, which had sheathed the surfaces of the rock-rents.

Figure 3 is a single loose "drop" which has fallen upon others in a narrow vein,—and has a thin adhering layer of *limonite* attached to it upon both of its lateral surfaces.

The specimens which fall to be considered under the 4th head, however, seem to be inexplicable upon any view save that of a succession of molten masses alighting upon one another, after the lapse of definite periods of time,—each period having been of such a duration as sufficed for the solidification of each drop.

In these, a number, sometimes a large number, of *loose* drops are superimposed upon one another, without even so much adhesion as to allow the specimen to be removed from the rock without their falling apart.



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There is here no limonite—drop lies upon drop in immediate contact.

The surface of each drop is highly polished; but it is marked throughout with a number of projecting ridges, which bear the most perfect resemblance to a solidified crust that has been rent and roughened by the contraction of a shrinking and still-liquid centre.

Each drop has taken *the most perfect cast* of that which it has fallen upon (or at least of what it lies upon), both as regards the converging curvitures thereof, and the above-mentioned linear rugosities: and each drop is on *its upper surface* lined and roughened in a perfectly similar way.

If it be a large drop, it envelopes several of those which are smaller and inferior, filling up every interstice between them; and the rugosities upon the upper surface of a large drop are ever larger and more boldly marked than those upon a small one; as might be expected from the contraction of a more ample mass.

While such a structure as this is in every way accordant with igneous liquidity, it appears to be altogether inexplicable upon the theory of watery solution, or of deposition of particles which had been in suspension in a liquid; and the observant Mr. Low was fully justified in saying that it "looks as if it had been once in fusion, and had settled in a number of bubbles."

Figures 4, 5, 6, and 7 illustrate this fourth variety.

4 and 5 represent two confluent "drops;" in 4 they are seen from above, and in 5 in perspective.

Figure 6 shews the shrinkage crust-cracks; 7 is the magnified appearance of one of these, showing an approach to a crystalline structure.

I may here state that I possess from another locality a specimen of perfectly amorphous psilomelane, which fills up all the interstices between a number of "stalactites" of hematite—and these stalactites have a markedly-scorified appearance.

But the question of the liquifiability of the mineral may be, to some extent, determined by actual experiment.

In ascertaining the amount of the water in the two minerals it was found that after the application of the heat—nearly a white heat—obtainable from a three-jet Griffin blast furnace, the crushed powder of the psilomelane had agglutinated throughout; while the portion thereof which was in contact with the sides and bottom of the crucible

had fused so far as to be firmly adherent thereto, and to have become glistening in lustre.

The fine powder of the wad again—(which differed from that of the psilomelane in its comportment under heat in this, that it became brown at a red heat, while the colour of the psilomelane was unchanged)—was not only fused to the crucible in its lower portions, under the influence of the white heat, but had collected into distinct drops which were more or less rounded.

It has to be kept in view that, under the concentrated energy obtainable in close cavities, and with the larger amount of alkalies which the *unaltered* mineral would contain, the amount and the ease of the liquifacion must have been more complete.

Upon the surface, about a mile south-west of the Lead Geo, pieces of *limonite* are found lying loose. The length of the fibres of these specimens show that the vein from whence they came must have been of considerable thickness. These specimens have naturally been affected by the weather, and sometimes show alternate bands of *yellow ochre* and *red hematite*,—forming strong contrasts.

Among the cliffs of a rocky gorge at the mouth of the stream or cateract called the Burn of the Sail, *Göthite* occurs in veins, in fine specimens. (H) Minute lustrous crystals of it spangle in the druses of a massive granular hematite; and acicularly-fibrous mammilated masses also occur, the fibres being one-and-a-half inches in length.

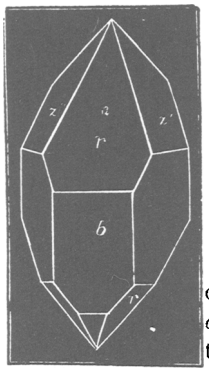
Its colour is chocolate-brown, sometimes banded with ochrey belts; the fibres are very minute.

Its specific gravity is 4·13. It yielded—

Ferric Oxide	84·395
Ferrous Oxide	·054
Manganous Oxide..	·1
Alumina..	1·295
Lime	1·324
Water	10·863
Silica	2·
	100·031 (H)

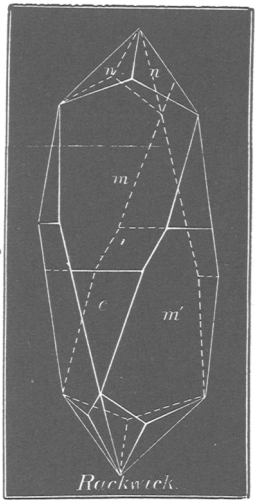
The greater part of the Silica was insoluble in acid.

It was quite similar in appearance, and in the colour of its powder to limonite.



The druses of this Göthite sometimes carry small doubly terminated and symmetrically distorted *rock crystals*, disposed in isolated individuals upon the surface of the göthite fibres; these form specimens of great beauty.

At Rackwick veins of *satin-spar* were found by Clouston: these veins are narrow, and the fibres are too coarse for beauty.



In veins on the north side of this bay, the writer obtained *calcite* in the rare form figured, the crystals are almost an inch in length.

The terminal planes sometimes truncate more deeply so as to cut in upon the faces *e*.

Tremolite is stated to have been found at the Snuke; it probably had been satin-spar which had been mistaken for it.

In the south-west end of the island about half-a-mile north of Turnness, there stands a many-arched stack called the Perforated Rock. The sides of the geos in the neighbourhood yield occasionally reniform *psilomelane*; which indeed occurs in the upper sandstone of the island not unfrequently, though it is generally in thin coatings, and in inferior specimens.

The sandstone here is somewhat more flaggy and micaceous than common, and it carries numerous imbedded fragments of *reddle*, and of a greasy schistose substance which from their round edges and angles would appear to be the worn and altered fragments of an older rock.

At this locality they are usually of a pale brownish-red colour, often passing in part of the fragment to a greenish-yellow. They are very soft, and show occasionally numerous minute scales of mica. They soil the hands.

A specimen which was chosen as being apparently less altered than most, was taken for analysis; it was not one of the most *reddle* or clay-like masses, but rather liker to a shale.

Its specific gravity was 3·43. It yielded—

Silica	62·555
Alumina	17·252
Ferric Oxide	3·458
Ferrous Oxide	2·21
Manganous Oxide	tr.
Lime	·478
Magnesia	1·619
Potash	4·68
Soda	·598
Water	6·72
	99·565

The large quantity of alumina and alkalies in the above do not point to this being a portion of any of the underlying flags—but do point to its being a portion of a highly micacious rock, either a flaggy gneiss, or most probably a mica schist.

It has been mentioned above, that it is probable that the upper sandstone is cut by dykes,—this is rendered probable by the occurrence of frequent specimens of *chalcedony*, which lie loose upon the surface of the hills,—and also, though sparingly, of *agates*. The latter I have even found upon the shores of Hoy.

The specimens of chalcedony are all of one appearance; they are of a pale blue colour, and invariably show casts of curved dolomite or pearl-spar crystals; and from the freshness and sharpness of these pseudomorphic casts, it would seem as if no great length of time had elapsed since the specimens had been dislodged from their matrix.

The agates are pale blue, banded with white in one arrangement, and occasionally containing imbedded chips? of dense dull-red massive jasper. Still more rarely do they show small *amethystine* crystals.

Small rolled masses of a massive yellow *iron-flint* are also found in similar circumstances.

In the cliff face, about a mile north of the precipice of the Bery Head, a long deep crevice or cave runs landward at right angles to the line of the coast. As this is the strike of the trap dykes, and as it has a width of only about three feet, it has possibly been formed by the washing out or disintegration of one of these. It is now studded with numberless *stalactites* of great purity of colour, and considerable lustre. The floor of the recess is a flat sheet of stalagmite, which sometimes is spread over pools of water, and which, breaking with the

weight of the body, allows the leg to plunge into a depth which not improbably may be profound.

Near a wide geo at the western end of the Old Head in Walls, the clefts in the rock are filled with small veins of *Albertite* (H); these veins are not above one-third of an inch in width, and it is singular that it is both the vertical and horizontal rents which are filled with the mineral, which sheathes, and, as it were, cements loose fragments of the rock.

Its specific gravity of this Albertite is 1·076. It yielded—

Volatile below 212°	·54	
Gas	65·72	
Carbon	32·83	
Ash (sand)	·91	(H)

Minerals of the Igneous Rocks.

From among the sands of the shore immediately north of the mouth of the Mill burn near the Manse of Hoy, *iserine* (H) may be collected in some little quantity.

The source of this was somewhat of a puzzle, till Geikie found two masses of tufa a short distance westward; from these the black sand may have been brought down by the stream.

These knolls of trap Geikie regards as two of the throats through which the matter of the platform, which may be said to underlie the whole of the north Hill, from the Coolax and the Kame to Rackwick and Rora Head, was ejected.

Of the black sand here found, very little is *iserine*, or indeed magnetic. The iserine yielded—

Titanic Acid	18·4	
Ferric Oxide	54·979	
Ferrous Oxide	14·422	
Alumina	·6	
Lime	5·6	
Magnesia	·2	
Silica	6·1	
	100·301	(H)

It was in very minute black magnetic grains; these differed considerably in appearance from ordinary granular iserine. When examined with the microscope they were found to consist almost entirely of oval grains with rounded outline. They shine like little

bits of graphite—had few fractures, these were highly lustrous. There was very rarely a doubtful outline of a worn octahedron.

The rocky cliff, immediately above the spot where this iserine is found, forms one of the best flagstone quarries in the island;—and this chiefly on account of the extreme ease with which the flags can be raised. This facility of working is due to the regularly disposed distances of a system of rhomboidal cross-rents.

These resemble, on a large scale, the diamond pavement described near Yesknaby, ; the rents of which, it was stated, had been referred to the action of the weather by Dr. Fleming, but which the writer considered were more probably a part of the structure of the rock itself.

The fact that, in the locality at present under notice, this system of rents is found to continue as far back as the rock has been opened, and where it is perfectly sheathed from, and absolutely unaltered by any atmospheric influence, at once negatives the assumption that atmospheric agents have in any way effected it.

Such rents are usually assigned to shrinkage. There are certain facts, however, which are difficult to reconcile with such an assumed cause. These are, first, that the development of the cracks is very much more pronounced and determinate in some situations than they are in others. Second, that it is difficult to understand how the rents should have taken place *in that inequality of distance*, as regards the individual particles, which is the character of a *rhomboidal* structure; and not in the *equality* which the *hexagonal* structure presents,—(as seen in basaltic columns, starch, furnace hearth-stones, and in an inferior degree in sun-cracks)

The third of these facts is that the rents are not at right angles either to the bedding of the rock,—or vertical to the horizon; as we should expect the rents of such a shrinkage to be, as has to be assigned either to *contact* or *radiant* abstraction of *caloric*, or to the removal of water, either by surface drying, or subjacent heat. The system of joints under consideration. at least such as are part of the *physical structure* of the rock., forms an oblique angle with the bedding. This points directly to the operation of mechanical causes, in all likelihood to pressure or *lateral thrust.*

It would be probably going too far to assign the compression, in the case of the Yesknaby pavement, to the closely adjacent dykes between which that pavement lies; because it may reasonably be held that these dykes merely filled up pre-existing giant-rents in the rock.

It may also be brought forward as a difficulty, that the rents occur where there is no curvature, or crumpling of the strata. But it has to

be maintained that it is just where there are *no* plications of the strata, that compression, perchance obliquely directed upon a substance retained in place by great superincumbent weight, would effect such a result; and there is every probability that the system will be found to be best developed where there are numerous faults.

The chief points to be noted as regards the jointing of the Orkney flag-rocks are, that it occurs in an equally well-marked degree where the strata are horizontal, as where they dip;—that the fossils, though frequently rent and having the rents filled with calcite, are not usually much compressed, and seldom distorted; that it cuts thick beds and thin almost alike; and that it occurs in a highly aluminous and frequently bituminous rock,—one in which there is no such approach to uniformity of composition as would warrant the assumption that a segregatory process or the force of crystallization had any share either in producing the jointing or even in influencing its direction.

The tufacious rock of the Burn of Berridale has much the appearance of being *in* the sandstone, as it passes for some distance up the rocky sides of the burn. I found nothing in it but masses of *calcite*.

The "neck," if it be one, at the Burn of Simmary contains *asphalt* and *calcite*.

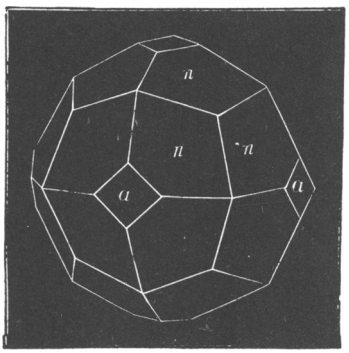
The amygdaloid which occurs at the "Links of Walls" contains innumerable druses.

These at its western extremity are of small size; the "rock-kernels" here consist chiefly of *calcite*, which is coated with light green *celadonite* (H) of a fine colour.

Frequently, however, they are filled with granular *saponite* (H); the specimens are fine; the colour is sap-green.

The druses increase in size towards the east end of the mass, at Sandsgeo.

Here they are frequently coated with a film of minute crystals of *Heulandite*, (H); disposed upon this are crystals of *analcime*—form *Pr*, (H). The centre of the druse is filled up with *pearl-spar* (H), which carries large imbedded lamellar crystals of white *baryte* (H.)



The druses which yield the finest crystals of analcime are found towards the centre of the mass near the sea edge; they are of the form drawn.

They are from half-an-inch up to nearly three inches in size, are translucent and colourless, or with a slight

pinkish tint, and they show the face P better than the crystals of any other locality in Scotland.

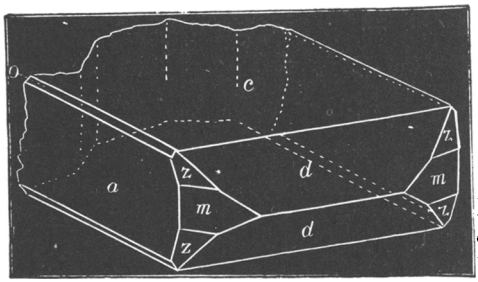
Their specific gravity is 2·244. Their analysis yielded—

Silica	57·624
Alumina	18·724
Ferric Oxide	·193
Ferrous Oxide	·74
Manganous Oxide	tr
Lime	1·888
Magnesia	·459
Potash	1·389
Soda	10·28
Water	8·452
	99·749 (H)

The pearl-spar is occasionally in curved primary crystals. Its specific gravity is 2·78. Its analysis yielded—

Carbonate of Lime	62·4
Carbonate of Magnesia	32·056
Carbonate of Iron	1·74
Carbonate of Manganese	4·276
Insoluble (Quartz)	·16
	100·632 (H)

Chalcedony in thin coatings rarely covers pearl-spar.



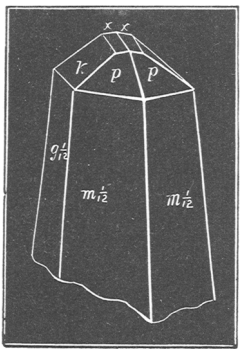
The baryte is rarely in small crystals of the form *c a o d m* z, as drawn.

Imbedded in the pearl-spar I obtained a single specimen of *Babel-quartz*. It was of the fine tint of colour which pertains to the Ben Lawers and Craig Cail-leach quartz,—a mixture of brown and amethystine.

Rarely there occur in this amygdaloid druses filled with a mixture of pearl-spar and small foliæ of *rubin-glimmer*; layers of the latter being deposited in bands which accord with the shape of the druse.

The above paragenesis of analcime, pearl-spar, and baryte, I have found to occur in other localities.

ISLAND OF FARAY.



On the west shore of this island some attempts were made to work *galena*. It occurs rarely in cubo-octohedral crystals.

Dr. Fleming found at this spot a vein of *satin spar* about two inches in width; it is of somewhat a grey colour, but is fairly firm in the fibre, and hard.

Arragonite rarely occurred in crystals; the form in the margin is that of the *Unst* crystals.

STACK AND SKERRY.

Though these two rocks are somewhat nearer to Hoy than to the Sutherland coast, geologically they belong to the latter county; for they are formed of a syenite which contains *sphene*, and which is identical in appearance with the syenite of Ben Loyal.

The two would thus appear to be the summits of two hills, much resembling Ben Loyal and Ben Stomino;—a craggy peak, and a flattish dome.

Recent depression of the land. This is considered by many as having, without doubt, taken place. The conclusion is arrived at from the two circumstances of the sea now standing where once there was land,—and from trunks of trees, hazel nuts, and leaves having been dug from beneath sand, at low water-mark, or from their having been thrown up by the waves.

The two may be but one piece of evidence; and that may be shown to be capable of explanation, without calling for any even local movement of the earth's crust,— although such movement is a perfectly recognised, as it has been indeed an oft-repeated fact.

It is probably the case that the fact that the great Bay of Otterswick, in Sanday, was formerly land, is regarded by many as having been more of the nature of an *invasion of the sea*; and it may be that the very fact of its having been said to have occurred in *one night*, may lead to a proper understanding of what had taken place.

Many trunks of trees are said to have been found beneath the sand all round this bay. The locality in which the writer had the best

opportunities of observing the circumstances and surroundings, was a small bay upon the coast of Rousay, nearly opposite to the little island of Enhallow.

From beneath the sand of this semi-circular bay, tricklings of a logwood-red water may, generally during any unusually low tide, be observed to issue; and the sorely decayed stems of brown-red trees may be seen to project. Upon making the circuit of the bay, it will be observed that these stems slope everywhere, with a very decided dip, inwards to the centre of the bay, or rather to the centre of a circle, of which the shores of the bay would form about a fourth part.

The trees had evidently grown where they fell;—had grown around the circumference of a fresh-water lake,—had fallen upon its banks, or into its waters, to be buried beneath its silts and sands.

Many lakes may at the present time be pointed to in Orkney scarce above the limit of the saline waters;—in the largest of them all indeed, through a very unusual and altogether lunatic arrangement,—fresh and salt maintain a rhythmical possession, for one-half of each day.

There is present evidence, in more than one part of the semi-submerged islands, that through the constant shore nibblings of the sea, the last barrier between it and these littoral lakes, had been one of those boulder-breaches of stones, locally termed "ayres."

Through the open crevices of these ayres the soaking waters commenced their sap; carrying out grain by grain during every tide, the ooze and muddy silts which underlay the peaty and vegetal bottoms of the fresh-water pools;—lowering, through long continued and incessant action, the lake-floors, till the inner prop to the boulder-breach was gone, and, in some time of heavier breaker assault, itself succumbed.

There thus came to be a "little sea" within the land, imperfectly cinctured by a projecting tongue of stones. Rapidly now would the daily sweep and drain of waters suck out its pulpy bed, till the sides "caved in"; its already buried trees would be buried afresh by layer after layer of the sea-shore sand, up to the time when the biting tooth of the ocean made a bay of what had been a lagoon; and, with purpose constant and yet inconstant as its own ebb and flow, to-day would swaddle up what to-morrow it would again lay bare.