On some New Localities for the Mineral Diatomite, with Notes on the Chemical Composition of the Specimens exhibited.

By W. Ivison Macadam, F.C.S., F.I.C., Professor of Chemistry, New Veterinary College, Edinburgh, &c.

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IN my previous papers on this subject* I have detailed various localities in which the mineral Diatomite has been found. Since the dates on which my papers were read various other localities have been discovered for the mineral, and I now beg to lay the details before the Society. The new samples are four in number, and are from—

1.—Golspie, Sutherlandshire.
2.—Loch Osabhat, Tolsta, Lewes.
3.—Auchnerran, Aberdeenshire.
4.—Presswhin, Aberdeenshire.

A fifth sample of a nodular mass from the Diatomite of Loch Kinnord, Aberdeenshire, has been analysed, and the results are included in this paper.

No. 1 Sample, from Golspie, was obtained by the Rev. J. M. Joass. The mineral is of a light yellow colour and encloses the ordinary plant remains common to these deposits.

No. 2 Sample, from Loch Osabhat, Lewes, was obtained from Mr. William Morrison, of Dingwall, who brought it from the deposit. The locality is described as covering the bottom of a drained loch (Loch Osabhat), and to be about 1½ acres in extent. The depth of the deposit is about 11½ feet, and after deducting about 4 feet of dark peaty stuff, we have about 7½ feet of the pure deposit. At the edges of the basin the deposit thins out to 1½ feet. When freshly cut the material gives off a disagreeable fœtid odour, but on drying the smell disappears and the colour changes from a dark brown to a light drab. Mr. Morrison calculates the bulk of the material at 7,500 square yards, which will be equivalent to about 10,000 tons weight. One cubic foot weighs about 54 lbs., which is equal to 13 cwts. per cubic yard. The loch was drained in 1874.

* *Trans. E. Geo. Soc.* Vol. IV. Pt. 3, and Vol. VI. Pt. 1.

No. 3 Sample is from Auchnerran, in the parish of Logie-Coldstone, Aberdeenshire; and

No. 4 Sample from Presswhin, Logie-Coldstone.

This latter deposit is at an altitude of 2,100 feet.

The *fifth sample* is of a dark brown, almost black, colour, very compact, and difficult to cut with the knife. It, however, contains a considerable proportion of organic matter; and, beyond the colour and the large proportion of iron present, it does not differ much from the other samples.

These compact masses give rise to considerable difficulty when the Diatomite is to be employed for dynamite manufacture; for during the preliminary process of roasting, to get rid of the organic constituents and water, these masses fuse and cause both loss of time and material. The large proportion of iron would not in itself be objectionable; for, as I have previously stated, the higher coloured dynamites are preferred by the miners—the colour being supposed to indicate strength,—but the fusibility of the mass renders the calcined residue worthless on account of its compact nature and small absorbing power. Kilns are now erected in Aberdeenshire, on the sites of these deposits; the iron nodules will be thrown aside, and a consequent saving of carriage effected. The market value of the Diatomite is about £4 per ton in the crude condition on truck at the nearest railway station. Kieselguhr fetches about £3 6s. per ton at the works.

The analyses of the samples are given in Tables A, B and C.

The Golspie sample contains a small proportion of organic constituents and corresponding increase of siliceous matter. It is, however, somewhat compact and not quite so absorbent as some of the other samples. Sand particles are also present, and although not in great quantity, would cause extra trouble and expense in purification preliminary to the use of the material either for dynamite or ultramarine.

The Loch Osabhat sample has a somewhat similar composition but is more open and porous, which, taken along with greater freedom from sand particles, renders the deposit of greater commercial value for an absorbent.

The Auchnerran sample is more of the character of the Black Moss and Kinnord samples described in my previous papers, having a considerable proportion of fibrous stems of reeds and water-plants embedded in the mass, which give binding power sufficient to allow of the body being "cast" like peats and regularly stacked to dry. These advantages in handling make this locality a valuable one, and, provided roads are available or the hill sides are sufficiently smooth for the peat sledge, then the material should be put in the market at a small cost. Moreover, the large proportion of

organic matter means that on calcination a more open and porous mass will be obtained, and a higher class absorbent. I look upon this Auchnerran deposit as one of the most valuable yet discovered. Even better, however, is the Presswhin sample, which, with fully ten per cent. less organic matter, is more open and porous than the Auchnerran material. It is also of a light drab colour, and has all the other characteristics of those Aberdeenshire deposits.

All of the above four samples yield to ether more or less chlorophyll, the green colouring matter of growing plants.

The last sample—the nodule from Kinnord—gives, on calcination, a bright red highly ferruginous ash, and, from the proportion of iron present, is very much more dense than any of the other samples and quite unfit to be used for either dynamite or ultramarine.

The proportion of diatomaceous matter is large in all the samples with the exception of that from Sutherland. This is a rather curious point, for this sample is one of the lightest in colour we have as yet had in our hands. On examination of the sample, however, it will be readily noticed that the iron, although not mixed throughout the mass, is concentrated in little particles, and has evidently been formed by the oxidation of spathic ore or from the decomposition of pyrites by means of organic matter. The Loch Osabhat sample is very similar in composition, and the remarks made as to the previous sample will be equally applicable to this deposit.

The agglomeration of iron as shown in the Kinnord nodule is interesting, and may point to a possible means of the formation of bog iron ore. It will be noticed that the other constituents of mineral origin are not in excess, and that even the allied alumina is small in quantity.

I have laid these few remarks before the Society in the endeavour to keep abreast of the age, and as proof of the statement made by me in my last paper that these deposits, although now of limited number and limited extent, only required the impetus of commercial value to lead to the discovery of fresh beds, and that from the various notices of diatomaceæ in the microscopical and other journals the localities would be neither few nor of small extent.

A.—Analysis of Samples as received.

		Lewes.		Aberdeenshire.		Ball from Kinnord Deposit, Aberdeenshire.
	Sutherland.	*Grest.*		Auchnerran.	Presswhin.	
Moisture	7·92		10·64	12·60	10·61	12·48
Organic Matter (Soluble in Ether) Chlorophyll	12·04	13·875	1·32	0·61	0·32	0·07
Organic Matter (Cellulose, &c.)			11·04	37·67	27·92	51·04
Inorganic Constituents	80·04	86·125	77·02	49·08	61·16	36·21
	100·00	100·000	100·02	99·96	100·01	99·80

B.—Analyses calculated free from Moisture.

Organic Matter Soluble in Ether, Chlorophyll, &c.	13·08	13·874	1·47	0·70	0·35	0·08
Organic Matter Cellulose, &c.			12·35	43·12	31·23	58·31
Inorganic Constituents	86·92	86·125	86·17	56·18	68·29	41·37
	100·00	99·999	99·99	100·00	99·87	99·76

C.—Analyses of Inorganic Portion.

	Sutherland.		*Grest.*	Auchnerran.		Presswhin.	Kinnord Ball.
I. *Soluble in Water.*							
Calcic Oxide	0·706						
Magnesic ,, ...	0·362						
Potassic ,, }	0·113						
Sodic ,, }							
Sulphuric Anhydride ...	0·011						
		1·192					
II. *Soluble in Hydric Chloride.*							
Ferric Oxide	8·841		1·326	6·323	1·047	0·889	16·726
Aluminic ,, ...	1·120		0·753				
Calcic ,, ...	2·379			0·325	0·443	0·206	0·963
Magnesic ,, ...	0·935						
Alkalies, &c.	0·226						
Soluble Silica	0·623						
		14·124					
III. *Silicates decomposed by Hydric Fluoride.*							
Ferric Oxide	0·442						
Aluminic ,, ...	0·516						
Calcic ,, ...	0·187						
Magnesic ,, &c. ...	0·098						
		1·243					
Silica, mostly Diatoms ...		82·638	94·495	90·367	96·574	95·725	37·321
		99·197					

Diatomaceous Deposits in Skye.

PART I.—DESCRIPTIVE. By J. S. GRANT WILSON, H.M. Geological Survey.

PART II.—CHEMICAL. By W. IVISON MACADAM, F.I.C., F.C.S., Professor of Chemistry, New Veterinary College, and Lecturer on Chemistry, School of Medicine, Edinburgh.

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PART I.—DESCRIPTIVE.

CONTENTS.

INTRODUCTION.

IN the following pages we propose to give a short description of the recent discovery of diatomite in Skye. The portion of ground that has been explored for the deposit lies at the north end of the Island, and forms the estate of Colonel Fraser, of Kilmuir. The area is about 58 square miles, and within these limits the diatomite has been found in large quantities at two localities. As the situation of these and the conditions under which the deposition took place are in both cases very different, they will be described separately.

I. LOCH CUITHIR (QUIRE).

1. Topography.—The north end of Skye is divided into two nearly equal portions by a well-marked range of hills which trend north and south. The Sgurr Moor terminates this ridge on the north, while southwards from this point it presents a very bold escarpment to the east, and includes, among

numerous picturesque rock masses, the famous Quirang. This escarpment is almost entirely composed of beds of basalt and volcanic ash dipping gently to the west. On the north-east side of Creag-a-Lain the basaltic cliffs have succumbed more rapidly to the various denuding agencies that have been at work, and the result has been the production of a magnificent "corrie" almost circular in form. This depression is flanked by projecting masses of rock that have yielded more slowly to the agents that formed the rest of the escarpment. The centre of the corrie of Cuithir is occupied by a small loch of the same name. This sheet of water is small and shallow, and lies at the north-east edge of a well-marked circular depression, the remaining portion of which is a soft marsh. Below this marsh has been found the largest deposit of diatomite as yet discovered in Skye. The sides of this rock basin are from 15 to 20 feet above the level of the water, and every where the slope is steep and appears to be entirely composed of basalt. The various small streams that drain off the sides of the "corrie" enter the basin at the south-west corner, and the marsh in this direction continues for some distance between two of the burns.

2. Area of Diatomite Deposits.—The total area of the swamp and tarn, calculated from the ordnance 6 inch scale, is about 24 acres.

3. Depth of Diatomite.—In order to form an approximate idea of the thickness of the diatomite over the area, a borer 12 feet in length was used, and at the bottom of several of the bores an 18 foot iron rod was inserted, and in one case only did it touch the bottom; over portion of the marsh ground; it was impossible to put down any bores on account of the boggy nature of the surface. To the south-west of the lake 19 bores were put down with the following general results:— These bores proved the average thickness of the turf and peat lying above the diatomite to be 3 feet 8 inches. No intervening beds of sand or silt were met with, but the borer passed directly into diatomite and showed an average thickness of at least 8 feet 4 inches of that substance over the whole area bored. Further, the iron rod above-mentioned as 18 feet long was used to probe these bores, and in only one case, and that close to the edge of the basin, did it touch the bottom. Assuming, then, that the total depth is only 18 feet, this leaves a thickness of 14 feet 4 inches of diatomite. Future bores will no doubt show that the diatomite has a greater thickness than 18 feet, and this is rendered very probable by the uniform steepness of the sides of this basin. The flat ground beyond the circular basin and between the two burns was only bored to the depth of 12 feet, and nowhere was the bottom reached. The average thickness of peat cover was found to be 3 feet 10 inches, leaving 8 feet 2 inches of diatomite.

4. Calculated Number of Tons.—In working a similar deposit on Lord Aberdeen's estate at Tarland, it was found in practice that it took 6 cubic yards of the raw material to form a kiln-dried ton.* Calculated on this basis, and with a necessary allowance for shrinkage when the ground is drained, there are at least 72,000 tons of diatomite lying in this portion of the ground.

5. Diatomite found in Ground above the Swamp.—The flat between the burns is surrounded on the south and west sides by rough, hillocky ground, covered with heather, where diatomite has also been found. This portion of the deposit may be due to the small streams which empty themselves at this point into the swamp; or, on the other hand, the water of the loch may have stood at a higher level than it does at present. That this change of level has taken place is proved by the fact that a small patch of diatomite lies to the south of the large circular depression, and rests on the sharp rock slope that forms the side of the basin. The present outlet of the loch has a very artificial appearance, and if it were closed the surface of the water would be 15 feet higher than it now is, quite sufficient to submerge the greater portion of the rough ground.

6. Quality of Deposit.—The wet samples brought up by the borer showed that the top portion of the deposit had a bright green tint. This colour is due to chlorophyll and can be extracted by ether. A few feet down from the surface this colour usually changed to a light grey, or brown. When dried for some hours in an oven these different colours all disappeared, the samples either becoming chalk-coloured or creamy-white. The purity of this diatomite at Cuithir is very remarkable, as none of the bores show any intercalated bands of sand or silt, and the material itself contained no trace of grit. This freedom from any admixture of foreign matter is doubtless due to the position it occupies. The small streams that drain into the swamp are fed by springs which rise at the foot of the basaltic cliffs that form the walls of the "corrie." None of these streams run over peaty ground, so that the water during the period of deposition must have reached the lake in a state of great purity. The climatic conditions that prevailed during the time when the diatom forming plants flourished must have been peculiarly favourable to their growth, and in addition to the situation of the lake, sheltered on every side, must have contributed in no small degree to the accumulation of so large a deposit.

The streams all originating in springs, a constant amount of water would flow along them, and they would not be liable to sudden floods.

* *Trans. Geol. Soc. of Edin.* Vol. IV. p. 210.

The best gathering places for living diatoms are usually to be met with where springs issue from the ground. It is probable, therefore, that a large proportion of the diatoms did not live in the loch, but existed in the springs and burns, and were only swept into the loch afterwards. The "corrie" being almost destitute of any drift-deposit, the only foreign matter carried down by the burns consists of rock detritus, and this has been precipitated at once in the form of cones when they entered the basin before the present partial drainage of the loch. The diatoms, from their minute size and consequent lightness, would be much longer held in suspension, and thus distributed equally over the rock basin. The diatomite of Loch Cuithir was also found to contain fewer species of diatoms than similar deposits in Skye, where there is a considerable admixture of foreign matter. The fewer number of species obtained from Cuithir is doubtless due to the more equable conditions kept up by the springs which fed the loch.

The covering of peat that now lies above the diatomite has grown since the lowering of the surface of the water. When this took place there would only remain a few feet of water above the diatomite, and the various peat-forming plants and mosses with their rapid growth would soon convert the crystal clear lake into its present condition of swamp and tarn.

II. Loch Monkstadt.

1. Topography.—To the north-west of Cuithir and in close proximity to the western seaboard lies the site of what was once the Loch of Monkstadt. A good many years ago the loch was drained by a large ditch which was cut from sea level at Camas More to the northern edge of the loch, a distance very little short of a mile. The former site of the loch, about 70 feet above sea level, is now a large flat of fairly well drained ground, all under pasture, and about half a square mile in extent. In outline it forms a rough triangle, with its apex pointing to the south-east and its base facing the north-west. Through the centre of this meadow land runs the main drainage level, and alongside this a series of bores were put down.

Thickness.—These showed that the deposit of diatomite occurred in a very irregular manner. At the south end of the flat it was almost entirely wanting, and when present was very much mixed with sand and mud. In a drain to the north of the old ruins of the monastery, about 1 foot 6 inches is seen immediately below the surface, and from this point to the north-west corner of the loch its position was proved by boring. The cover of mud, turf and peat varies in thickness from 1 to

5 feet, with a corresponding range in the thickness of the diatomite. The deposit is sometimes mixed with fine mud and silt, and in one instance a bed of sand occurs in the centre of 3 feet of diatomite.

Conditions prevailing during the Deposition of the Diatomite.—The water that drains into the loch enters at the south-east corner by several burns. These all flow off or through peat, and this is evidently the reason why the diatomite, when present over the upper portion of the basin, is always mixed with fine silt or mud. The area between the old monastery and the north-west corner would be the part farthest removed from the disturbing influences, and it is here that the diatomite is found in its greatest thickness and purity. As compared with Cuithir, the quality of the Monkstadt deposit is inferior, but it is quite equal to the German supply from the "Kieselguhr." Samples from the various bores all contained a little grit and particles of mica. When these were dried they had a darkish grey colour, and in proportion were much heavier than similar specimens from Cuithir.

III. Other Localities where Diatomite has been found.

Loch Mealt.—Very good diatomite has been found under the marsh ground that fringes the western margin of the loch. It is covered with 10 feet of peat close to the edge of the water, and between this point and the landward side of the marsh a thin covering is spread over the rocky bottom as it rises shorewards.

Sartil.—The locality is situated two miles to the west of Staffin, on the Uig Road, and the deposit is a very irregular one. The diatomite is found in rough, hillocky ground, very similar to that surrounding a portion of the swamp at Loch Cuithir.

Loch Cleat is a small loch lying to the east of Duntulm Bay. Diatomite of very good quality has been got below the swamp that borders the lake.

Loch Snuisdale.—This loch lies midway between Monkstadt and Cuithir, and diatomite has been found below a peat-moss a little to the west of the loch, and about 500 feet above sea-level.

Glen Uig.—A small deposit on the right hand of the glen. The diatomite lies on a slope and is of no extent.

Part II.—Chemical.

The annexed table of analyses shows the chemical composition and absorptive value of the samples obtained from the various deposits.

With the single exception of the No. 1 Monkstadt sample, the proportion of organic matter is small, being only 4½ per cent. of the dried

Diatomite—Skye.

I. *Analysis of Sample as received:—*

	"Quire." *No. 1.*	"Quire." *Edge.*	"Quire." *Centre.*	"Sartil." ——	"Loch-snuisdale." ——	"Monk-stadt." No. 1.	"Monk-stadt." No. 2.	"Uig." ——
Moisture	6·921	8·240	6·405	8·466	7·417	10·106	8·602	8·164
Organic Matter... ...	4·246	9·690	4·149	7·134	4·291	20·685	10·402	10·463
Ferric Oxide	2·679	1·271	0·673	3·079	7·189	8·211	4·367	3·511
Lime, &c.	0·521	0·805	0·041	0·685	3·525	3·746	0·854	0·501
Silica (diatoms) ...	85·633	79·994	88·732	80·636	77·578	57·252	75·775	77·361
	100·000	100·000	100·000	100·000	100·000	100·000	100·000	100·000

II. *Calculated free from Moisture:—*

Organic Matter ...	4·561	10·560	4·432	7·794	4·634	23·010	11·381	11·393
Ferric Oxide	2·878	1·385	0·719	3·363	7·753	9·134	4·778	3·823
Lime, &c.	0·559	0·877	0·043	0·748	3·807	4·167	0·934	0·545
Silica (diatoms) ...	92·000	87·177	94·804	88·094	83·792	63·686	82·906	84·238
	99·998	99·999	99·998	99·999	99·986	99·997	99·999	99·999

III. *Results after Calcination:—*

Ferric Oxide	3·015	1·548	0·752	3·647	8·142	11·864	5·391	4·314
Lime, &c.	0·585	0·980	0·045	0·811	3·992	5·412	1·054	0·615
Silica (diatoms) ...	96·397	97·469	99·200	95·540	87·865	82·723	93·554	95·069
	99·997	99·997	99·997	99·998	99·999	99·999	99·999	99·998

IV. *Absorptive Value:—*

100 parts of Calcined Material become when saturated with water ...	369	356	397	284	327	359	266	301

material, as obtained from Quire and Lochsuisdale, 7¼ per cent. in Sartil, and from 10 to 11 per cent. in the Monkstadt No. 2, in Uig, and at the side of Quire deposit.

Ferruginous impurity is practically absent in the central part of the Quire deposit (0·71 per cent.), but at other parts of the same basin the quantity was found to be from 1·3 to 2·8 per cent. In the remaining deposits we find 3·3 per cent. in Sartil, 3·8 per cent. in Uig, 7·7 per cent. in Lochsnuisdale, and from 4·7 to 9·1 per cent. in Monkstadt.

The value of the material for absorbing fluids such as nitro-glycerine is also high. 100 parts of the calcined substance take up of water from 166 parts to 297 parts, or from 1½ to 3 times its weight.

The Quire central zone will be found to be very valuable for the manufacture of ultramarine, and other uses where iron is objectionable, whilst the freedom from sharp sand renders the remaining deposits valuable for the various manufactures where a small proportion of iron is not objectionable.