

## ON THE OCCURRENCE OF COBALT ORE IN FLINTSHIRE.

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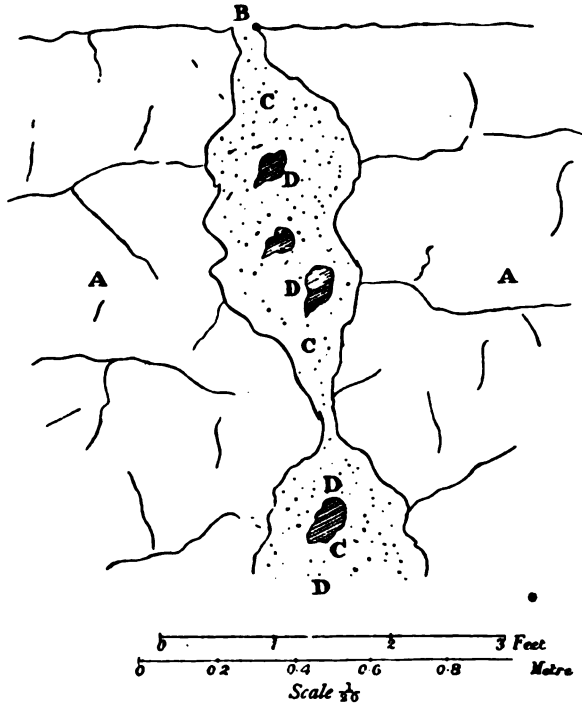
DURING the last few years cobalt ore has been obtained from Foel Hiraddug Mine, in the parish of Cwm, near Rhyl.

The ore occurs in the Carboniferous Limestone, which seems to have furnished a good deal of iron ore from shallow pockets, if one may judge by the numerous pits scattered about near the mine.

It was in working one of these pockets that Mr. Gage made the discovery of the cobalt. He happened to notice some black strings in the limestone, and on testing them with the blowpipe he ascertained that the black colour was due to oxide of manganese in some cases, and to oxide of cobalt in others. On further examination of the pit, Mr. Gage discovered a vein of cobalt ore, which has now been worked continuously on a small scale for several years.

The vein runs in a general N.N.E. direction, and has a varying dip, sometimes to the east, and sometimes to the west, whilst very often it is nearly perpendicular. On the whole it is extremely irregular. The accompanying sketch will give a better idea

of its general character than a mere verbal description.



AA, grey crystalline limestone; BB, vein of cobalt ore, composed of red clay, CC, and loose fragments of limestone, DD. The clay contains small lumps of brown hæmatite, and black grains of wad and asbolane, or earthy cobalt ore. Occasionally lumps of asbolane, as big as walnuts, or even hen's eggs, are met with. These pieces of ore often exhibit a reniform or botryoidal structure; they are black in colour, soft enough to mark paper, and give a shining black streak upon porcelain. Their chemical composition is by no means uniform, as will be seen from the ac-

comparing analysis, made by Mr. Gage. The pieces of ore were carefully cleaned from all adhering clay, and then dried at 212° F. before being analysed.

	1	2	3
Cobalt sesquioxide, $\text{Co}_2\text{O}_3$ . . . . .	37·40	20·63	26·20
Nickel sesquioxide, $\text{Ni}_2\text{O}_3$ . . . . .	8·58	6·85	10·35
Manganese binoxide, $\text{MnO}_2$ . . . . .	23·12	39·50	25·58
Iron sesquioxide, $\text{Fe}_2\text{O}_3$ . . . . .	13·85	15·10	21·10
Copper oxide . . . . .	traces	traces	0·25
Silica . . . . .	0·45	2·00	0·60
Alumina . . . . .	0·10	0·50	0·18
Water . . . . .	16·00	15·00	15·00
	99·50	99·58	99·26

The Flintshire asbolane is remarkable for the large amount of nickel it contains.

The width of the vein varies from nothing to 8 or 10 feet, and it widens out and becomes pinched up very suddenly. The ordinary width does not exceed a foot. The walls are extremely irregular, as shown in the figure, and the cavity containing the ore has all the appearance of having been eaten out by water.

The mine has been worked to a depth of about 240 feet, the shoot of ore being followed by a series of *winzes* and irregular passages. The whole of the vein is not necessarily cobaltiferous; in fact, where it reached a width of 10 feet there was nothing but red clay without any cobalt. The only guide for the

miner is the streak upon porcelain. A little of the clay is taken and drawn over a piece of unglazed porcelain with the flat side of the blade of a knife; if a series of black shining streaks are formed, the miner concludes that cobalt is present, and the ore is saved; but as the streaks may be caused by particles of non-cobaltiferous wad, the value of the ore can only be definitely determined by chemical analysis.

On the whole the shoot, or ore-bearing part of the vein, dips to the North, and its horizontal length is about 20 or 30 yards. A second vein also has been discovered by Mr. Gage, and a trial has been made upon it to a depth of 90 or 100 feet.

The only preparation of the ore at the surface consists in picking out the numerous lumps of brown iron ore, and occasional fragments of limestone.

The ore sent to the smelters in Swansea contains but a small percentage of metal, as will be evident from the accompanying assays of five parcels.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Metallic cobalt . . .	1·0	1·1	1·2	1·6	1·8
Metallic nickel . . .	0·4	1·1	1·0	0·7	0·8
Total cobalt and nickel .	1·4	2·2	2·2	2·3	2·6

Strong traces of titanium have been found by Mr. Gage in some of the parcels of ore.

The amounts of ore sold have been as follows :

Year.	Tons.	Cwt.	Value.		
			£	s.	d.
1878	98	18	616	17	0
1879	116	11	833	2	5
1880	49	3	297	6	4
Total	264	12	£1747	5	9

The value of the ore per ton has therefore been on an average about £6 12s.

The mode of formation of the cobalt vein is a matter concerning which I have not been able to make up my mind. I have already said that the cavity between the two walls shows evidence of watery action, and it is probably merely a joint widened out by the long continued action of water charged with carbonic acid. The source of the cobalt is uncertain. Mr. Gage considers that it has been derived from the decomposition of cobaltiferous iron pyrites, and in confirmation of this view he showed me a large lump of brown iron ore which still contains a core of undecomposed pyrites. This lump was found in the lode at a depth of 30 feet from the surface; the pyrites has been analysed, and shows traces of cobalt and copper. Brown iron ore pseudomorphous after iron pyrites has also been found in the lode, and a very perfect little specimen has been presented to the Society by Mr. Gage. I noticed many such pseudomorphs among pieces of brown iron ore lying at the surface. These are reasons, therefore, for supposing that the present vein is the

*gossan*, or decomposed upper part of a lode of cobaltiferous iron pyrites. It is possible that the manganese may have been derived from the limestone; for on making an analysis of the *country*, Mr. Gage discovered that it contained about  $\frac{1}{30}$  per cent, or 2 parts in 10,000, of oxide of manganese. Of course it might be objected that the manganese had found its way from the lode into the adjacent rock; but, on the other hand, it is well known that small quantities of manganese do occur in limestone occasionally; and I may here remark that the blowpipe reveals the presence of that metal in some of the limestone of the Great Orme's Head.

In conclusion, I desire to express my best thanks to Mr. Gage for the large amount of valuable information which he has placed at my disposal; and, as an incentive to the study of blowpipe analysis, I wish to place the fact upon record that Foel Hiraddug Mine, the only cobalt mine now worked in the British Isles, owes its existence as such entirely to his knowledge of this useful art.