

*On stilpnomelane from North Wales.*¹

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PISOLITIC ironstones occur at various localities in North Wales,² at about the horizon of *Nemagraptus gracilis*.³ The rocks have undergone considerable folding and the hard ironstones are often faulted and in many cases deformed. Greenstone dikes frequently intersect the beds, usually with little visible alteration of the ore, though the ironstones are generally hardened, with incipient re-crystallization of the chamosite. At Pen-y-rallt iron mine, situated half a mile east of Llanfrothen church near Penrhynreudraeth in Merionethshire, a steeply inclined pisolitic ironstone bed rests upon a mass of igneous rock; and here the alteration of the ore is in a more advanced stage, for the ironstone is in places seamed with roughly parallel asbestiform veins (up to 1 inch) which contain a brittle dark-brown mineral strongly resembling biotite;⁴ the centre of the vein is sometimes filled with chalybite.

In micro-sections the ore is seen to be an oolitic chamosite mudstone, very poor in carbonates, and containing disseminated specks of magnetite, mainly in zones in the ooliths. The veins are simple fissures, lined with elongated flakes of a rather strongly birefringent chlorite, roughly normal to the walls. The chlorite is pleochroic, green for vibrations parallel to the base, pale greenish-yellow for those at right

¹ Communicated by permission of the Director, H.M. Geological Survey.

² See Mem. Geol. Survey, Special Reports on Mineral Resources, 1920, vol. 13.

³ Discussion on paper by R. L. Sherlock, Quart. Journ. Geol. Soc., 1919, vol. 74, pp. 106-115.

⁴ The occurrence of this mineral had been observed by Mr. G. J. Williams, of Bangor, and by Mr. Arthur Russell; the latter very kindly put at the author's disposal a specimen of similar material in a vein about half an inch thick, between white vein dolomite and oolitic ironstone, from Cross Foxes mine, near Dolgelly, Merionethshire. The colour is not quite so dark as in the material now described; ω 1.66, ϵ 1.56 approx. Feathery growths of the same mineral appear in the oolitic ore itself.

angles; the basal cleavage is well marked.¹ In the wider veins these flakes are mingled with, and finally give place to, similar flakes of a brown mineral with intense pleochroism. This was at first thought to be biotite, but proves on analysis to contain practically no alkalis and to be closely similar to some chlorites described under the names stilpnomelane and chalcodite.

Physical Properties.

The mineral is brittle, with an eminent basal cleavage and also well-marked prismatic cleavage, yielding numerous pleochroic chips. The specific gravity is 2.85, and the hardness $3\frac{1}{2}$. Extinction sensibly parallel with the basal cleavage. Apparently uniaxial, though the interference-figure cannot be seen on account of the dense brown colour. Optically negative, refractive indices by immersion in liquids, ω 1.685, ϵ 1.595. Pleochroic, dark olive-brown for vibrations parallel to the base, pale-yellow for those at right angles.²

Chemical Composition.

The following analysis (I) was made by Mr. F. R. Ennos in the Geological Survey Laboratory. The mineral was picked out and powdered to 90 mesh (to the inch). It proved to be insoluble when boiled for 10 minutes with N/2 hydrochloric acid. The whole sample was therefore treated in this way, to destroy any chamosite or carbonate that might be present. The second analysis is that of moravite, and the remainder are of minerals variously described as stilpnomelane and chalcodite.

Stilpnomelane Group.

	SiO ₂ .	Al ₂ O ₃ .	Fe ₂ O ₃ .	FeO.	MnO.	CaO.	MgO.	K ₂ O.	H ₂ O—.	H ₂ O+
I.	43.74	6.36	22.47	15.74	0.50	0.53	1.42	0.75	2.59	6.36
II.	47.30	22.71	5.04	13.99	nil	trace	1.82	1.10	—	4.95
III.	45.29	3.62	20.47	16.47	—	0.28	4.56	—	—	9.22
IV.	44.64	6.75	23.59	nil	—	—	9.86	—	—	6.21 7.14.
V.	45.12	6.29	23.67	5.93	—	trace	9.36	trace	—	9.12
VI.	40.24	10.34	24.57	5.21	—	—	6.78	2.20	3.03	7.63
(a)	44.75	4.36	4.99	30.34	—	—	5.47	—	—	9.18
(b)	44.08	4.74	5.27	23.31	0.87	trace	8.36	—	2.21	10.28

¹ This is possibly thuringite or an aluminous variety of stilpnomelane, but could not be isolated for analysis.

² E. S. Larsen (Bull. U.S. Geol. Survey, 1921, no. 679) records: 'Stilpnomelane', Nassau, ω 1.69 dark brown, ϵ 1.60 yellowish. 'Chalcodite', Antwerp, N.Y., ω 1.76 dark red-brown, ϵ 1.63 pale yellowish. 'Chalcodite', North Carolina, α 1.65 pale yellowish, β and γ 1.78 deep red-brown.

- I. 'Stilpnomelane': Pen-y-rallt, North Wales. Also (Co,Ni)O and Na₂O traces, TiO₂ nil. (F. R. Ennos.)
- II. 'Moravite': Gobitschau, Moravia. (F. Kretschmer, Centralblatt Min. 1906, p. 294.)
- III. 'Chalcodite': Sterling mine, New York. Sp. gr. 2.76, H. 1. (G. J. Brush, Amer. Journ. Sci., 1858, ser. 2, vol. 25, p. 198.)
- IV. 'Chalcodite': Westfield, Massachusetts. *n* 1.64. (E. V. Shannon, Proc. U.S. Nat. Mus., 1920, vol. 57, p. 402; Min. Abstr., vol. 1, p. 171.)
- V. 'Chalcodite': Lambertville, New Jersey. *n* 1.63. (E. V. Shannon, *ibid.* 1920, vol. 58, p. 453; Min. Abstr., vol. 1, p. 213.)
- VI. 'Hydromica': Rocky Hill, New Jersey. (F. W. Clarke and N. H. Darton, Amer. Journ. Sci., 1899, ser. 4, vol. 7, p. 365.)
- (a) 'Chalcodite': Sterling mine, New York. Sp. gr. 2.957. (F. A. Genth, Proc. Amer. Phil. Soc., 1885, vol. 23, p. 44.)
- (b) 'Stilpnomelane': Westfield, Massachusetts. Refr. indices 1.560 and 1.575. (E. V. Shannon, Proc. U.S. Nat. Mus., 1920, vol. 57, p. 400; Min. Abstr., vol. 1, p. 171.)

The above analyses obviously fall into two groups, the last two being deficient in R₂O₃; these groups, however, bear no relation to the names used. It has been thought that 'chalcodite' was a scaly mineral resulting from the oxidation of 'stilpnomelane', and Shannon adopted this view in naming minerals IV, V, and (b) in the above table. Examination of a typical specimen of 'stilpnomelane' from Moravia, in the British Museum collection, proves that this dark scaly vein-mineral corresponds very closely in refractive index and birefringence with the mineral now described. There can, indeed, be little doubt that the name was originally designed to indicate minerals of this type, which were early recognized in Silesia, and not the mineral of peculiar composition represented by analyses (a) and (b), to which the name was transferred by Shannon.

It will be seen from the table that the application of the names has fallen into hopeless confusion, though the analyses seem fairly consistent. Nevertheless, since there would seem to be no doubt about the identity of the original 'stilpnomelane', it appears best to retain that name for the species represented by analyses I, III, IV, and V, in the table. Moravite (anal. II) apparently represents the corresponding alumina compound, but the material requires further investigation. The identity of the substance represented by analyses (a) and (b) need not be discussed here. The 'hydromica' (no. VI) has been included on account of the general similarity of the analysis; it may be mixed with biotite.

Constitution.

Molecular ratios calculated from the above analyses are given in the following table :

	<i>Approximate Molecular Ratios.</i>				
	SiO ₂ .	R ₂ O ₃ .	RO.	R ₂ O ₃ + RO + K ₂ O.	H ₂ O.
I.	600	169	217	393	294
II.	600	188	183	380	201
III.	600	180	273	403	414
IV.	600	172	198	370	310
V.	600	168	252	420	403
VI.	600	227	235	462	378
(a)	600	60	450	510	408
(b)	600	64	444	508	465

The values for R₂O₃ and RO, taken separately, are only moderately consistent, but the sum of the two groups is much more constant, and is in satisfactory agreement with the simple value 400 (K₂O is treated as belonging to molecules of muscovite type). This corresponds with a similar behaviour of the muscovite analyses; the present minerals can in fact be represented by the formula 4(R₂O₃, RO).6SiO₂ + aq., which corresponds with that of phengite, K₂O.3(R₂O₃, RO).6SiO₂ + aq., the potash being replaced by Al₂O₃. The degree of hydration is variable, as in muscovite.

The view that this mineral is chemically analogous with the micas accords with its physical properties, for it is harder than the chlorites and has very high birefringence, with a negative optical sign like the micas.

Although stilpnomelane has hitherto been regarded as an unimportant chlorite, it is probable that these minerals play an essential part in many metamorphic and even in igneous rocks. Many sediments, though too impure to be regarded as workable ironstones, contain a high proportion of the ferruginous chlorites, while glauconite and the potassic clay-minerals are subordinate or absent, the rest of the rock being composed of fine elastic silica and ordinary clay. On reconstitution by regional metamorphosis, such rocks cannot yield potassic micas, but it would seem probable that they will pass over into stilpnomelane-schists characterized by minerals of the present group. Under the microscope such rocks would be almost indistinguishable from the mica-schists. So far as they contained potash, they would yield also biotite, and might therefore be described as containing two dark micas. The minerals could probably be separated by their densities, for that of the stilpnomelanes is generally 0.1 or 0.2 unit lower than that of biotites of similar composition.

Moravite.

The original moravite¹ from Gobitschau in Moravia is described as a fine crystalline aggregate which apparently reaches a maximum thickness of 78 metres, between Middle Devonian clay-slates and a thick mass of diabase. The bed passed laterally into a seam of thuringite-ore, with scattered ooliths, the proportion of thuringite increasing when the hanging-wall became a schalstein in place of the diabase. The proportion of silica in the moravite is much higher than in the thuringite-ore, so that its formation is attributed to silicification by the diabase. The thuringite is itself cryptocrystalline, and may not be the original material, but the ore is considered to have been a bedded deposit, probably much distorted and altered in the region of contact with the diabase.

When the potash content is taken into account, the formula here given is at least as satisfactory as that proposed by Kretschmer ($7\text{SiO}_2 \cdot 2\text{Al}_2\text{O}_3 \cdot 2\text{FeO} \cdot 2\text{H}_2\text{O}$). The birefringence (0.005) and density (2.38) assigned to moravite seem unusually low for a member of the present group. Slavíková and Slavík give the refractive index 1.615 for moravite from Chabičov.² Kretschmer, on the other hand, gives the low value 1.56. Micro-sections of three specimens in the British Museum of moravite from Gobitschau show a rock containing many sharply angular patches filled with greenish birefringent minerals; the ground mass has curious dark, parallel wavy lines, resembling flow-lines, and consists of an aggregate of minute flakes with a birefringence apparently somewhat greater than that of quartz. The material has the appearance of being an altered ferruginous tuff. It is extremely doubtful whether the groundmass is a single mineral and a re-examination of the whole occurrence and material seems desirable.

¹ F. Kretschmer, Neues Jahrb. Min., 1918, pp. 19-42 [Min. Abstr., vol. 1, p. 254]; Centralblatt Min., 1905, pp. 195-204, 1906, pp. 293-311.

² See Min. Abstr., 1922, vol. 1, p. 264.