

Pisanite from Parys Mountain, Anglesey.

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DURING the Manchester University's 1946 geological excursion to Anglesey, a visit was made to Parys Mountain. At this locality small quantities of an attractive light blue mineral were found capping pyrite veins and in clefts in the rock. Larger finds were obtained in an artificial cavern which extended for fifty or sixty feet into the south-east side of the excavated pit. A specimen weighing $2\frac{1}{2}$ pounds and consisting of silicified shale veneered with the pale blue mineral was collected by the author and examined in the geological research laboratory at Manchester University during the session 1948-1949. The blue mineral was identified as pisanite, and this is the first record of pisanite as a British mineral.

Parys Mountain is situated in the north-west of Anglesey close to Amlwch. Copper and to a smaller extent lead were mined throughout a period exceeding one hundred and fifty years, but operations have completely ceased since the first world war. The geological structure of the district need only be briefly outlined for the purpose of this study. Upper Ordovician shales (Parys Green Shales) are separated by a thick felsite sill from Lower Silurian shales (Llandoverly), all the beds being folded isoclinally so that the limbs dip steeply north-north-west. The shales are finely cleaved and the area is cut by several major faults, one of which (Rhwms thrust plane) underlies much of Parys Mountain. Post-Silurian metasomatism gave rise to the rich and varied assortment of minerals to be found in this locality, and Greenly¹ envisages three distinct phases of metasomatism. At first the fine-grained shales and the felsite dike were silicified to such a degree that, commonly, the silicified shales comprise nothing but minute interlocking quartz grains. The latter show no sign of stresses or straining and are indicative of the younger age of silification with respect to Silurian earth movements. A second period of metasomatism saw the introduction of micaceous material, whilst the third period witnessed the incoming of pyrite and associated metallic ores.

¹ E. Greenly, *The geology of Anglesey*. Mem. Geol. Surv., 1919, vol. 2, pp. 561 and 823. [M.A. 1-328.]

Among the twenty-six minerals listed by Greenly as occurring at Parys Mountain mention is made of melanterite and hydro-glockerite, but data for these minerals were not published. There is no reference to pisanite in his memoir. The mineral described here is not likely to have been Greenly's melanterite, because it had obviously grown within recent years and, in addition, no search was made to prove or disprove the presence of true melanterite.

The mineral here described was found as a fungus-like growth in clefts and artificial cavities. Blasting of the rocks had left several large caverns in which percolating water had given rise to the recent development of pisanite capping pyrite veins and forming stalactites from overhanging ledges. The country-rock is a completely silicified shale which, under the microscope, reveals a mass of closely interlocking quartz grains cut by many quartz veins. The quartz veins carry innumerable cubes of pyrite and grains of chalcopyrite, many of which are surrounded by a halo of sericite crystals.

In the hand-specimen the pisanite is seen to be a pale blue mineral of crystalline nature but indeterminate crystal morphology. Closest to the flinty country-rock the pisanite is blue in colour, but farther away from the contact it becomes dirty green and is generally coated with a sulphur-yellow, dust-like mineral. The yellow mineral is found as tiny amorphous flecks and, rarely, as small glassy nodules. Although an accurate determination of the crystal morphology of this pisanite is impossible, due to the small and poorly developed crystals, the general crystal form can be made out. The most characteristic feature is the acicular nature of crystals with elongation parallel to the *c*-axis and flattening on the (010) face. A good cleavage parallel to (001) can also be observed in the hand-specimen. The acicular crystals are sometimes a quarter of an inch long but no thicker than a needle, and where packed closely together the pisanite has a decidedly fibrous appearance.

So far as was possible, pisanite was separated from yellow mineral, but as is inevitable when minerals are very closely intergrown, a small proportion of the yellow mineral was analysed along with the pisanite and presumably gives rise to the presence of some of the ferric iron. Water of crystallization was determined by heating at about 380° C. for 10 hours. This sufficed to obtain a constant weight. Less water of crystallization is present than a theoretical consideration demands (only 93.95 % theoretical water—due to partial dehydration during storage in a warm, dry room). The chemical composition of Parys Mountain

pisanite is summarized in table I. Insoluble matter was determined separately for each sample used and the analyses were corrected accordingly.

TABLE I. Chemical analysis of pisanite from Parys Mountain.

	%	Mol.% × 1000.	FeSO ₄ ·7H ₂ O.	CuSO ₄ ·7H ₂ O.	Diff.
SO ₃ ...	28.89	361	233	122	+6
FeO ...	16.83	233	233	—	—
Fe ₂ O ₃ ...	2.05	13	—	—	+13
CuO ...	9.72	122	—	122	—
H ₂ O ...	42.69	2360	1631	854	-125
	100.18		64.4 %	34.7 %	
Sp. gr.	1.90				

For purposes of comparison the chemical analyses of some other pisanites are reproduced in table II.

TABLE II. Selection of previous analyses of pisanite.

	1.	2.	3.	4.	5.	6.	7.	8.
SO ₃ ...	29.90	28.8	29.18	29.25	27.33	28.18	28.98	28.66
FeO ...	10.98	8.5	16.47	5.46	17.23	13.43	19.67	15.08
CuO ...	15.56	19.2	9.22	17.95	8.21	11.67	4.82	11.51
H ₂ O ...	43.56	44.9	45.74	45.21	46.96	46.72	44.76	44.70
	100.00	101.4	100.61	100.69	100.00	100.00	99.77	100.30

1. The original pisanite from Turkey. F. Pisani, *Compt. Rend. Acad. Sci. Paris*, 1859, vol. 48, p. 807.

2. Sain-Bel, Rhône, France. A. Lacroix, *Min. France*, 1910, vol. 4, p. 229.

3, 4. Leona Heights, Alamada Co., California. W. T. Schaller, *Bull. Dept. Geol. Univ. California*, 1903, vol. 3, p. 199. Extreme values of three analyses. Insoluble residue deducted. In analysis 4 also MgO 2.82 %.

5, 6. Lading, Carinthia. H. Leitmeier, *Centralblatt Min.*, 1917, p. 231. In analysis 5 also NiO 0.27 %. [M.A. 1-347.]

7, 8. Rio Tinto, Spain. H. F. Collins, *Min. Mag.*, 1923, vol. 20, p. 32. Extreme values of four analyses, a fifth partial analysis shows CuO 17.54 %. In analysis 7 also MnO 0.31 %, ZnO 1.13 %, (Ni,Co)O 0.10 %. In analysis 8 also ZnO 0.35 %.

Standard works give the optical properties of melanterite (FeSO₄·7H₂O), pisanite ((Fe,Cu)SO₄·7H₂O), and boothite (CuSO₄·7H₂O), and table III tabulates the properties of these minerals as recorded by Dana¹ and Winchell². The last column shows the optical properties of Parys Mountain pisanite as determined by the writer.

¹ E. S. Dana, *A textbook of mineralogy*. 4th edition, 1932, pp. 761-762. [M.A. 5-193.]

² A. N. Winchell, *The microscopic characters of artificial inorganic solid substances or artificial minerals*. 2nd edition, 1931, pp. 231-232. [M.A. 5-2.]

TABLE III. Optical and physical data.

	Melanterite, FeSO ₄ .7H ₂ O.	Pisanite, (Fe,Cu)SO ₄ .7H ₂ O.	Boothite, CuSO ₄ .7H ₂ O.	Pisanite, Parys Mtn.
Angle β ...	75° 45'	74° 38'	74° 24'	75° 12'
Refr. indices $\left\{ \begin{array}{l} \alpha \\ \beta \\ \gamma \end{array} \right.$	1.471 1.478 1.486	1.472 1.479 1.487	near those of pisanite	1.471 — 1.487
Optic sign	+	+	+ or —	+
2V ...	85° 27'—86°	very large	90°	87°
Opt. ax. pl.	(010)	(010)	(010)	(010)
$\alpha : c$...	29°	22°	about 15°	26°
Cleavage	{(001) perfect {(110) less so	(001) perfect	(001)	(001)
Sp. gr. ...	1.89-1.90	1.9	2.1	1.90
Colour ...	green	pale blue	blue	pale blue

As the optical properties of pisanite and melanterite are almost identical it is difficult to name the Parys Mountain pisanite without reference to a chemical analysis. Microscopical examination of the pisanite indicates that the green colour of exposed mineral is largely due to the included fragments of yellow alteration mineral which occurs only on the outer exposed edge of the crystalline pisanite mass. The pisanite itself is derived by hydration and oxidation from pyrite; further weathering produced the yellow alteration mineral.

Under the microscope, the yellow mineral is seen to be an amorphous material with some measure of birefringence or a cryptocrystalline mineral of very low birefringence. It is pale yellowish-green in colour, honey-yellow in reflected light, and has a refractive index in the vicinity of 1.732. It is soluble both in water and carbon bisulphide. A yellow ferric sulphate from Parys Mountain was analysed by A. H. Church¹ who gave it the formula $2\text{Fe}_2\text{O}_3 \cdot \text{SO}_3 \cdot 8\text{H}_2\text{O}$. This formula is similar to that of glockerite but with more water, and E. Greenly (loc. cit.) applied to it the name hydro-glockerite. Church stated that the mineral was crystalline and seemed to be isotropic. Whether this is identical with the yellow mineral now described is uncertain. As insufficient yellow mineral was available for chemical analysis its true nature must remain unknown.

A few minute crystals of a chestnut-brown alteration mineral have also been noticed, but not identified. These crystals may possibly be r merite $\text{FeSO}_4 \cdot \text{Fe}_2(\text{SO}_4)_3 \cdot 14\text{H}_2\text{O}$.

Some thirty compounds having the general formula $x\text{Fe}_2\text{O}_3 \cdot y\text{SO}_3 \cdot z\text{H}_2\text{O}$ have been listed² and the system $\text{Fe}_2\text{O}_3 - \text{SO}_3 - \text{H}_2\text{O}$ has been studied

¹ A. H. Church, *Min. Mag.*, 1895, vol. 11, p. 13.

² F. K. Cameron and W. O. Robinson, *Journ. Phys. Chem.*, 1907, vol. 11, p. 641.

in detail¹. These researches indicate that a high degree of solid solution occurs between the three primary components and most of the binary and ternary compounds, so that the existence of phases is possible, the physical properties of which differ from those of definitely fixed compounds.

¹ E. Posnjak and H. E. Mervin, Journ. Amer. Chem. Soc., 1922, vol. 44, p. 1965. [M.A. 2-21.]
