

On the occurrence of Alstonite and Ullmannite (a species new to Britain) in a Barytes-Witherite vein at the New Brancepeth Colliery near Durham.

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THE mining village of New Brancepeth,¹ in the parish of Brandon and Byshottles, is situated in the Durham coalfield at a distance of four miles to the west of the city of Durham. One of the faults which intersect the sandstones, shales, and coal-seams (the Harvey, Busty, and Brockwell seams) of the Coal Measures at this place has, at its eastern end, an east to west direction with a downthrow of 120 feet and a hade of 20° to the south. Along this portion of its course the fault is of the nature of a fissure-vein, with a width varying from a few inches to 16 feet. The material filling the vein consists mainly of barytes. In places, especially where the walls of the vein are of sandstone, the pure white, massive barytes extends throughout from one sharply-defined cheek to the other. Usually, however, the material filling the vein is much brecciated, and fragments of sandstone, coal, and clay are intermixed with the barytes. The barytes is mainly confined to the fissure, but for a distance of a few yards from the vein the beds of sandstone and coal are impregnated with barytes and show it along their joint-planes. The witherite forms irregular patches in the barytes, but at greater depths it forms more or less well-defined selvages on either side of the vein, with the barytes in the centre. The minerals in the vein are, for the most part, massive, but some crystal-lined cavities are found, both in the massive barytes and in the brecciated portions with fragments of sandstone and coal. Metallic minerals are present in very insignificant amount as small strings and pockets.

This barytes vein was discovered in the New Brancepeth Colliery about fifteen years ago, and during the last five years it has yielded

¹ The New Brancepeth Colliery is also known locally as the Sleetburn Colliery, being near to an old farm-house of that name.

about 80,000 tons¹ of barytes. A description of it was given by Mr. Robert Peel² in 1900; but curiously, although finely crystallized minerals have been found, the occurrence has remained unknown to mineralogists.³ In this place I desire to express my thanks to the colliery proprietors, Messrs. Cochrane & Co., Ltd., and in particular to Mr. Brodie Cochrane, one of the directors, who kindly gave me every facility for examining the minerals, and who also presented several fine specimens for the British Museum collection; to the manager, Mr. Robert Peel, for much valuable information and specimens courteously given; and to the underground manager, Mr. Andrew Kerr, for conducting me underground to see the minerals *in situ*.

The finding of the rare minerals alstonite and ullmannite in a coal mine is somewhat unexpected. But the type of vein in which they occur does not appear to differ from those abundantly present at lower horizons of the Carboniferous system in the adjacent portions of the counties of Durham, Northumberland, and Cumberland; the principal difference being that the vein is here met with in the Coal Measures instead of in the Carboniferous Limestone series. This difference is, however, more apparent than real, for in this region the Carboniferous Limestone series consists largely of beds of sandstone and shale with some workable seams of coal. Thirty miles north-west of Durham, at the Fallowfield mine and the Settlingstones mine, near Hexham in Northumberland, there are large veins of barytes and witherite in the Carboniferous Limestone series; and in the Fallowfield mine there is a 5-foot seam of coal. Here also (at Fallowfield) the witherite is not infrequently intimately associated with coal, galena, and alstonite. At the only other locality known for the species alstonite, namely, the Brownley Hill mine, near Alston in Cumberland, there are also seams of coal (here, however, quite thin) with the sandstones, shales, and limestones of the Carboniferous Limestone series.

¹ According to the official (Home Office) statistics, the amount was 10,297 tons in 1907, and 5217 tons in 1908.

² R. Peel, 'Notes upon an occurrence of barytes in a twenty-fathom fault, at New Brancepeth Colliery.' *The Colliery Manager and Journal of Mining Engineering* (The Organ of the National Association of Colliery Managers), London, 1900, vol. xvi, pp. 56-58.

³ In 1907 I selected from the stock of a dealer in the north of England some small specimens of crystallized barytes with witherite, which were labelled 'Rookhope, Weardale, Co. Durham'. Having previously visited Rookhope, I had reason to question this statement of locality, and on making inquiries I learnt that the specimens had come through a miner living at Rookhope, from whom I obtained news of the New Brancepeth occurrence.

A deposit of barytes in a fault at the Lumley Colliery, four miles north of Durham, has been compared by Prof. G. A. Lebour¹ with the New Brancepeth vein; and Prof. H. Louis² has described a fault-vein (containing galena, calcite, and iron-pyrites) in the Wearmouth Colliery. A large body of barytes has also been found in the Felling Colliery, near Newcastle-on-Tyne.³ It is clear that these mineral-veins in the Lower Coal Measures are simply the upward continuations of veins (here also usually fault-veins) which intersect the rocks of the Carboniferous Limestone series lying beneath.

In this connexion it may be remembered that barium has on several occasions been detected in the mine-waters of the Durham and Newcastle districts, and that these waters deposit barium sulphate in the pipes through which they are conveyed from the pits.⁴ Mention may also be here made of the occurrence of barium sulphate as a cementing material in sandstones of later date than the Coal Measures, namely those of the Trias, as recorded from several places in the Midlands of England by Prof. F. Clowes⁵ and others.

In the New Brancepeth vein I have detected the following nine mineral species:—

ALSTONITE.

(Barium and calcium carbonate, $[\text{Ba,Ca}] \text{CO}_3$.)

This species has hitherto been recorded from only two localities, namely the Brownley Hill mine⁶ in the parish of Nenthead, near Alston

¹ G. A. Lebour in the discussion of R. Peel's paper, loc. cit., p. 58.

² H. Louis, 'Note on a mineral vein in the Wearmouth Colliery.' *Trans. Inst. Mining Engineers*, 1903 (Session 1901-2), vol. xxii, pp. 127-129.

³ R. C. Clapham and J. Darglish, 'On minerals and salts found in coal pits.' *Trans. North of England Inst. Mining Engineers*, 1864, vol. xiii, pp. 219-226.

⁴ F. Clowes, 'Deposits of barium sulphate from mine-water.' *Proc. Roy. Soc. London*, 1889, vol. xlv, pp. 368-369.

⁵ F. Clowes, *Proc. Roy. Soc. London*, 1889, vol. xlv, p. 363; 1899, vol. lxi, p. 374.

⁶ This locality is incorrectly given in all the textbooks as 'Bromley Hill', having been given as such in the papers of J. F. W. Johnston and T. Thomson in 1835-7, though in one place (Thomson's description of 'sulphato-carbonate of barytes') it appears correctly as Brownley Hill mine. There is no hill of this name, and it is simply the name of the mine. On the six-inch ordnance map it appears as 'Brownleyhill Dressing floor'. Mr. Jacob Walton, of Alston, writes to me (August, 1909) respecting the history of alstonite: 'This mineral was first obtained at Brownley Hill mine about 1835 [i. e. 1834], when my grandfather, Jacob Walton, was manager. As far as I can recollect, it was found in a small vein or branch leading from a larger vein, called the Jug vein, and

in Cumberland, and the Fallowfield mine in the parish of St. John Lee, near Hexham in Northumberland, at both of which it appears to have been first noticed in the year 1834. These mines were formerly worked for lead (galena), but at the present time the Brownley Hill mine is being worked for zinc (zinc-blende). At both places the alstonite is deposited on either calcite or witherite.

In the New Brancepeth vein, alstonite is associated with corroded barytes and lenticular crystals of witherite in a sandstone breccia with fragments of coal. It seems to be of quite local distribution: I have seen only five specimens, and none down the mine. It occurs as thin platy aggregates of crystals around the barytes, or as groups of crystals scattered over the surface of the witherite. The order of succession is (1) barytes, (2) witherite, and (3) alstonite. The mineral no doubt owes its origin to the action on the barytes of carbonated waters containing calcium in solution, at a period subsequent to the formation of the witherite. Alstonite is the only mineral¹ containing calcium which occurs in the vein, and its local distribution suggests that perhaps there was only one small feeder of water carrying calcium into the vein.

The crystals of the New Brancepeth alstonite are exactly similar to those from the Brownley Hill and Fallowfield mines, though smaller in size, here averaging 2 mm., and not exceeding 4 mm., in length. They have a delicate rose-red tinge of colour, like those from the Fallowfield mine; but on exposure this colour is lost and the crystals become dull white. The form is that of an acute, six-sided pyramid. The faces are deeply striated horizontally, and are each divided into two areas by a suture running from the apex of the crystal to the median horizontal edge, the two areas forming a slight re-entrant angle across the suture-line. On the goniometer this re-entrant angle was measured as $2^{\circ} 26'$. Each compound face gives two bands of reflected images, which are fainter towards the horizontal edge and increasingly brighter towards the apex of the crystal. Further, the two bands show a slight divergence and curvature, being coincident at their fainter ends and showing the greatest separation (of $2^{\circ} 26'$) at their brighter ends. The angles

was obtained in the Great Limestone. No specimen of the mineral has been found at either Brownley Hill or Fallowfield mines for over fifty years.'

The name 'bromlite' (T. Thomson, 1837) for this species is thus based on an error, and, in spite of its priority as urged by Dana, it seems better to give preference to the more expressive name alstonite (A. Breithaupt, 1841).

¹ Calcite I have not found in the New Brancepeth vein; but it was observed in very small amount on the joint-planes of the shales, which are raised from the pit and are ground for making bricks.

between the faces, as measured for the brighter ends of these bands of light, are 50° - 52° over the horizontal median edge, $129\frac{1}{2}^{\circ}$ - $131\frac{1}{2}^{\circ}$ over the apex, and $51\frac{1}{2}^{\circ}$ - $53\frac{1}{2}^{\circ}$ over the polar edge.

Sections of crystals cut perpendicularly to the vertical axis show a six-rayed star of colourless, transparent material, with each ray passing from the centre to a corner of the hexagon; and alternating with these there are wedges of white, cloudy material penetrating from the sides of the hexagon towards the centre. In polarized light the division into sectors is not very evident; the optic axial plane is of variable orientation in different parts of the section, being sometimes parallel to the adjacent edge of the hexagon and sometimes inclined at 30° . The double refraction is negative and strong, and the optic axial angle $2E=10^{\circ}$ about.

The specific gravity is 3.67, this determination being made with the pycnometer on 1.5 gram of selected crystals. The mineral effervesces freely in cold, dilute hydrochloric acid, and the solution imparts to the Bunsen-flame, first a reddish-yellow, and then a yellowish-green coloration; no strontium could be detected with the spectroscope. A drop of the solution on a microscope-slide gives with sulphuric acid an immediate precipitate of barium sulphate, and, on evaporation, an abundant crop of gypsum needles.

Analysis¹ of 1 gram of the material used for the specific gravity determination gave:—

BaO ...	52.3,	corresponding with	BaCO ₃ ...	67.3 per cent. ²
CaO ...	18.0	„	„	CaCO ₃ ... 32.1
MnO ...	0.06	„	„	MnCO ₃ ... 0.1
Insoluble in HCl (particles of barytes)				... 0.2
				99.7

ULLMANNITE.

(Nickel sulph-antimonide, NiSbS.)

In recording this species as new to the British Isles, and its presence in the Coal Measures, it is interesting to recall the occurrence of millerite (NiS) in the Coal Measures of Merthyr-Tydvil in South Wales. By reason of its good cubical cleavage and bright metallic lustre, the mineral

¹ The barium was precipitated with very dilute sulphuric acid (1 in 300) and weighed as sulphate, and the calcium was precipitated as oxalate and weighed as oxide.

² Corresponding with the formula BaCO₃. CaCO₃, the calculated values are BaO 51.56 and CaO 18.86 per cent.

presents, at first sight, a striking resemblance to galena. When, however, the two minerals are compared directly, it is soon evident that in ullmannite the cleavage is less perfect, and that the colour is tin-white to steel-grey rather than a bluish-(lead-)grey; further, ullmannite ($H. = 5\frac{1}{2}$) readily scratches galena ($H. = 2\frac{1}{2}$).

Two distinct types of crystals have been found:—

1. *Cubic habit.* Rough cubes measuring up to 2 cm. along their edges, and parallel groupings of cubes reaching 6 cm. across; one such polysynthetic crystal weighs 624 grams. Bright cleavage areas also frequently measure as much as 6 cm. across. The faces of the cubes are bright, but somewhat uneven, and they are usually roughly striated parallel to alternate edges, as in iron-pyrites. This striation sometimes gives place to narrow faces of the pentagonal-dodecahedron e {210}. Narrow faces of the rhombic-dodecahedron d {110} were also detected with the goniometer.

The crystals of this type occur embedded in clay, together with galena, witherite, barytes, and a little iron-pyrites. A few large lumps, several pounds in weight, were found in a single pocket in the vein.

A feature of special interest is presented by the parallel intergrowth of the ullmannite with the galena, as exhibited by the coincidence of the cleavages in the two minerals. One and the same crystal is seen to consist partly of ullmannite and partly of galena, and frequently the former is surrounded by a shell of the latter. There is no chemical analogy between ullmannite (NiSbS) and galena (PbS), but their molecular volumes are almost identical, being 31.5 and 31.9 respectively. This affords a striking example in support of Mr. T. V. Barker's contention that parallel growths of isostructural substances are conditioned by similarity of molecular volume.¹

A determination of the specific gravity (made with the pycnometer on 2 grams of cleavage fragments of the cubic crystals separated from galena) gave the value 6.70. Analysis of this material showed the presence of sulphur, antimony (over 52 per cent.),² nickel (27.87 per cent.), a trace of iron, and the absence of cobalt and arsenic. The material is thus pure NiSbS . Heated in a bulb-tube, the mineral decrepitates and fuses, giving a faint white sublimate, and near the assay a reddish-yellow sublimate.

¹ T. V. Barker, *Mineralogical Magazine*, 1907, vol. xiv, p. 285; 1908, vol. xv, p. 42.

² The mineral was decomposed with fuming nitric acid, the nickel passing into solution and the antimony remaining as SbO_2 , which was weighed as such (some, however, became reduced and was lost).

2. *Octahedral habit.* Small octahedra measuring about 3 mm. along the octahedral edge. The faces are bright, but rough and rounded. A few crystals are distinctly tetrahedral in their development, with larger and smaller faces in adjacent octants; but no difference could be detected in the surface characters of the larger and smaller faces, nor, indeed, could any definite system of striation be recognized.

Crystals of this type occur, together with zinc-blende, as small veins running through massive barytes; and only a few small specimens were seen.

The material possesses the same tin-white colour and good cubical cleavage as that of the cubic habit. It was tested for antimony and nickel, but was not further examined.

Two types of ullmannite, the pyritohedral and the tetrahedral, have long been known, and Principal H. A. Miers¹ has established that the mineral is really tetartohedral (tetrahedral-pentagonal-dodecahedral class). Hitherto, however, the two types have been found only at separate localities,² so that their association together adds another point of interest to the New Brancepeth occurrence. Although the crystals are of considerable size, they are unfortunately not sufficiently well developed for detailed crystallographic study.

BARYTES.

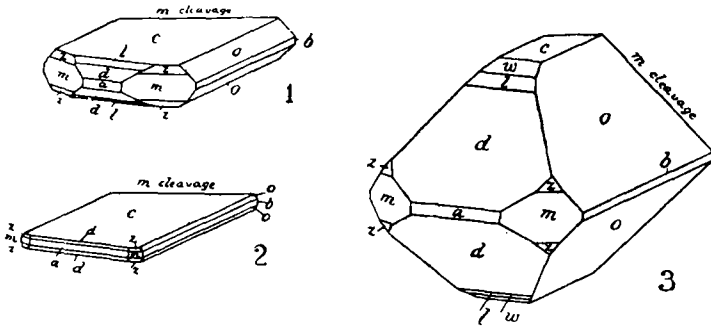
This is the most abundant mineral in the vein and in many places the only one present. It is usually massive, showing large cleavage surfaces, and is pure white and opaque, or sometimes with a yellowish tinge of colour. Small cavities lined with crystals are met with in this massive material; and crystals are also found, together with witherite, in the brecciated portions of the vein. The crystals are perfectly colourless and transparent, and sometimes of considerable size; the largest (fig. 3) I have seen measures 8 to 10 cm. in the directions of the crystallographic axes, and weighs 1027 grams. They are usually tabular in habit, parallel to the basal pinacoid (fig. 1), some of them being quite thin and resembling bevelled plates of glass (fig. 2). Less frequently the habit is prismatic in the direction of the brachy-axis (fig. 3). The common forms are a {100}, b {010}, c {001}, m {110}, o {011}, l {104}, d {102}, and z {111}. In addition to these, the above-mentioned large crystal (fig. 3) shows w {106}, and small faces of y {122}, μ {124}, n {120}, and

¹ H. A. Miers, *Mineralogical Magazine*, 1891, vol. ix, p. 211.

² With the doubtful exception of Lobenstein in Thuringia, where the crystals of octahedral habit are possibly gersdorffite and not ullmannite.

three other prisms between a $\{100\}$ and m $\{110\}$ —a total of fifteen forms.

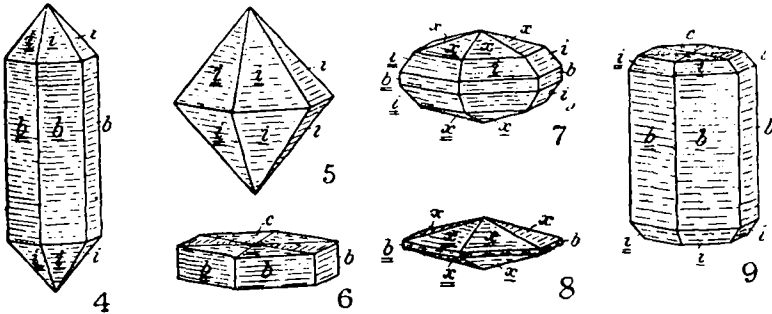
The crystals frequently show beautiful and very sharply defined etch-figures. Where intimately associated with the witherite, they are usually deeply corroded, and are sometimes represented by cellular masses encrusted with minute crystals of witherite.



FIGS. 1-3.—Crystals of barytes from New Brancepeth Colliery.

WITHERITE.

This usually forms nodular masses with a radiated internal structure and a scaly surface; their interior usually consisting of barytes, or occasionally of sandstone or coal. These masses are often of considerable size: one piece which I saw outside the mine measured 50 cm. across.



FIGS. 4-9.—Crystals of witherite from New Brancepeth Colliery.

Crystals are mainly found in cavities in the brecciated portions of the vein. They vary considerably in habit, being lenticular, pyramidal, or prismatic (figs. 4-9). The lenticular habit is the most frequent, and it is this that gives rise to the scaly surface of the nodular masses. The

lenticular form is produced by the rounding of the flat pyramid α with the basal plane, and all gradations from the form shown in fig. 8 to a flat, almost disc-shaped crystal can be traced. Lenticular crystals measuring 4 cm. in diameter have been found. In colour, the crystals are usually white or grey and almost opaque, but small crystals are often colourless and transparent. Some crystals are yellowish, and others quite black, due to the enclosure of particles of coal.

A thin section cut parallel to the base shows a division into six sectors, with twin-lamellae parallel to the diagonals of the hexagon. In each sector the optic axial plane is parallel to the external edge; the double refraction is strong and negative, and the axial angle $2E = 25^\circ$ about. The section is, in fact, exactly as described and figured by Des Cloizeaux.¹ This optic orientation proves that the faces of pseudo-hexagonal pyramids are brachy-domes, and that those of the pseudo-hexagonal prism belong to the brachy-pinacoid. On the goniometer only approximate measurements could be obtained, owing to the deep horizontal striations and the irregularity of the faces. The best angles measured from the pseudo-hexagonal prism $b \{010\}$ to the pseudo-hexagonal pyramids were $34^\circ 24'$, $53^\circ 37'$, $69^\circ 45'$, corresponding with the forms $i \{021\}$, $k \{011\}$, and $x \{012\}$. The basal plane $c \{001\}$ is also sometimes present.

The witherite is clearly of later date than the barytes: small, white, button-like crystals (x i) of witherite are often attached to the water-clear crystals of barytes; small, colourless crystals encrust the cavities of corroded barytes; and the nodular witherite usually occurs as a coating on massive barytes. It is therefore probable that the witherite has been formed from the barytes by the action of carbonated waters.²

GALENA, ZINC-BLENDE, COPPER-PYRITES, AND IRON-PYRITES.

Metallic minerals are present in only small amount, and are of quite local distribution in the barytes vein, usually running as strings through the massive barytes.

Galena, showing large, bright cleavage surfaces, has been mentioned

¹ Des Cloizeaux's figure is copied in Dana's 'System of Mineralogy,' 6th edit., 1892, p. 284, fig. 6.

² In other instances where barytes and witherite are associated together, it has often been assumed that the barytes has been formed from the witherite by the action of waters containing sulphuric acid and ferrous sulphate, the latter having been produced by the weathering of iron-pyrates. This would undoubtedly account for any secondary barytes and for pseudomorphs of barytes after witherite, but probably not for the main mass of barytes in the vein.

above as occurring in parallel intergrowth with the ullmannite. A small group of cubo-octahedra of galena was also obtained.

Zinc-blende and copper-pyrites were detected as specks and minute crystals, usually embedded in the massive barytes, and also, less frequently, in and on the witherite.

Iron-pyrites is rather more common, though not abundant; in one place, however, a large quantity was found in clay between barytes and witherite. It is massive, or has the form of small cubes or cubo-octahedra.

MELANTERITE.

Iron-vitriol is sometimes seen as a green stain on the surface of the massive barytes. A bright green aggregate of fibres, $1\frac{1}{2}$ cm. in length, was found on the surface of shale containing iron-pyrites. This is obviously a secondary mineral derived from the iron-pyrites.
