On the Crystalline Form of Meneghinite.

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A complete description of this mineral was given in Poggendorf's *Annalen*, vol. 132 (1867), p. 372, by Prof. vom Rath, who ascribed it to the oblique system with the elements, $a : b : c = \cdot 361639 : 1 : \cdot 116825$; $\beta = 87°40'18''$.

This paper gives a full account of the appearance and properties of the Meneghinite from Serravezza, and of its association with Quartz, Galena, Blende, Chalybite, Copper Pyrites, Iron Pyrites, Calcite, and Albite; the results of the analysis also accord fairly with the previous determinations of Bechi and Hofmann, which give for the formula $Pb_4\ Sb_2\ S_7$ or $4Pb\ S + Sb_2\ S_3$.

The determination of the crystallographic elements is attended with some difficulty in consequence of the minute size of the end faces which are seldom found; in fact the values given by Prof. vom Rath appear to be mainly derived from a single crystal (fig. 2. *loc. cit.*), the measurement of which was repeated by Hessenberg. The original observations of Sella (*Gazz. Uffic. d. R. d' Italia*, 1862) as quoted by vom Rath, placed the mineral in the Rhombic system; but the only two measurements which his crystals yielded were the prism angle of 46°33′ ($=b\ T$) and the angle from the basal plane on to a dome 18°59′ ($=cd$). The apparently Rhombic symmetry of the crystals was explained by vom Rath as a result of twinning on the face 100.

Three specimens in the British Museum afforded twelve small needles with terminal faces, from which were obtained the results given below; these results were confirmed, and two forms added, by two crystals from a specimen in the Ludlam collection which I was enabled to examine through the kindness of Mr. Rudler.

These specimens are all from the Bottino mine near Serravezza, in Tuscany, where Meneghinite occurs as striated needles and slender prisms of bright metallic lustre associated with the above-mentioned minerals, and also Jamesonite, Boulangerite, and Mispickel. (*Achiardi, Mineralogia della Toscana*, ii. 350.)

The crystals generally betray a tendency to grouping in parallel aggregations, and to this is perhaps to be ascribed the deep channeling of the prisms, and the frequent unevenness and broken nature of the terminal faces. The following are the results of the measurements made with a Fuess goniometer :—

Rhombic. $a : b : c = 1{\cdot}89046 : 1 : {\cdot}68664$.

100 : 110 = 62°7′21″. 010 : 011 = 55°31′30″. 001 : 101 = 19°57′32″.

$a = 100$	$t = 212$	$e = 230$	$U = 410$	$x = 24, 18, 13$
$b = 010$	$u = 414$	$S = 430$	$h = 10, 1, 0$	$q = 24, 0, 11$
$c = 001$	$n = 101$	$l = 320$	$k = 12, 1, 0$	$\delta = 0, 6, 13$
$r = 111$	$m = 110$	$f = 530$	$\psi = 24, 12, 13$	$o = 023$
$v = 011$	$\mu = 814$	$T = 210$	$\pi = 24, 24, 13$	$y = 038$
$d = 012$	$\lambda = 24, 6, 13$	$g = 310$	$\rho = 24, 12, 11$	$\theta = 045$ (vom Rath).
$s = 434$	$\beta = 412$	$i = 720$	$\sigma = 24, 6, 11$	$w = 051$ (vom Rath).

	Calculated.	Observed.	No. of edges.		Calculated.	Observed.	No. of edges.		Calculated.	Observed.	No. of edges.
bv		55°31½′	18	bU	64°42¼′	64°35′	3	dr	22°38′	22°35′	2
bs		64°10¼′	10	bh	79°17¾′	79°4′	2	ds	19°40′	19°38′	2
br	57°9¾′	57°8′	10	bk	81°2⅔′	80°59′	3	dt	18°57½′	19°4′	7
bt	72°7′	72°4′	14	bn	90°0′	90°0′	8	du	21°40′		
bu	80°50′	80°50′	14	aq	51°36½′	51°53′	1	dn	27°15′	27°9′	1
an	70°2½′	70°2′	2	$b\mu$	82°5½′	82°14′	7	$d\mu$	36°37′	36°38′	3
bd	71°3′	71°3½′	2	$a\mu$	54°24′	54°30′	3	$d\lambda$	32°36¾′	32°37′	3
ar	73°20′	73°18′	2	$b\lambda$	75°15¼′	75°9′	10	$d\beta$	34°29½′	34°34′	1
as	72°6⅓′	72°12′	1	$a\lambda$	57°25′	57°26′	2	vr	16°40′		
at	71°2½′	71°1′	3	$b\sigma$	73°38½′	73°46½′	2	vs	19°15½′		
au	70°17⅔′	70°18′	4	$a\sigma$	53°25½′	53°22′	1	vt	24°19½′		
bo	65°24¼′	65°41′	2	$b\psi$	62°14′	62°9′	3	vu	31°13⅔′	31°14′	1
by	75°33⅔′	75°43′	2	bx	51°42′	51°29′	1	vn	39°12½′		
$b\theta$	61°13¼′			$b\pi$	43°31½′	43°22′	1	$v\mu$	39°37′		
$b\delta$	72°25′			$b\rho$	59°35′	59°38½′	1	$v\lambda$	36°16¼′		
bw	16°14⅓′			$a\psi$	60°28⅔′	59°50′	1	$v\beta$	37°25⅔′		
bm	27°52⅔′	27°49′	1	$a\rho$	57°37′			$r\beta$	22°36′	22°49′	1
be	19°25½′	19°34′	4	$T\rho$	42°31¼′	42°26′	1				
bS	35°11¾′	35°26′	9	$T\psi$	47°18′	47°9′	1				
bl	38°25¾′	38°0′	1	$U\lambda$	53°26′	53°19′	1				
bf	41°24′	41°35′	1	$U\sigma$	48°45¾′	48°46′	1				
bT	46°36¾′	46°35′	7	Tt	63°26⅔′	63°25′	1				
bg	57°47′	56°45′	3	$b\beta$	74°28′	74°28½′	1				
bi	61°37½′	61°47′	3	$a\beta$	55°30½′						

Fig. I. gives a general view of the most important forms and their relative development; but the crystals are, as a rule, very unsymmetrical in appearance.

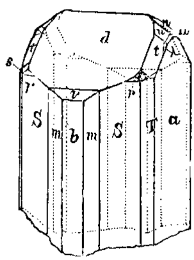

Fig. I.

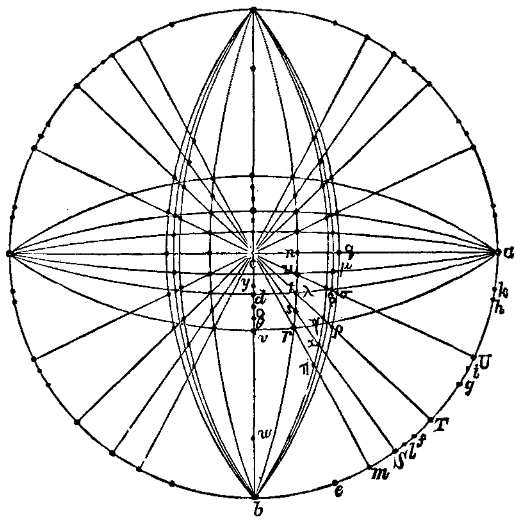

Fig. IA.

The zone *b v d*, which contains the largest faces, was found on almost all the crystals, and was determined, wherever measurements on to the prism zone were possible, to be perpendicular to that zone. In the prism zone itself measurements were extremely difficult in consequence of the deep striations which generally give rise to a continuous series of banded images as the crystal is turned round; the angles given for this zone in the above table are therefore chosen only from faces which gave a single though in many cases a broad image. Of these, *b* is always smooth and bright; the faces *f T U K a S e* were also observed as broad bright planes giving good images in isolated cases, but *a* is rarely present. The end faces with the exception of *v* and *d*, though very bright, are almost always very minute, and are sometimes barely recognisable under the lens. Observations from them could be only in general made with the δ eyepiece of Fuess's goniometer.

It is fortunate therefore that the positions assigned to these faces were fully confirmed by a very well-developed crystal, represented in Fig. II., which is somewhat larger than the others, and on which even the smaller faces can be recognised without difficulty. The values of the angles *bv* and *bs*, used above as parametral angles, are identical with those derived from this crystal, on which scarcely a single

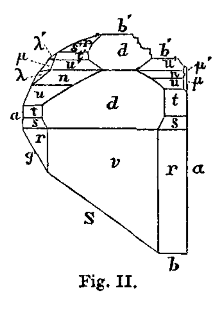

Fig. II.

measurement differed as much as ten minutes from the calculated value; the majority not more than three or four minutes. (In comparison with this, the measurements upon the other crystals must be regarded as more doubtful.)

It may be mentioned, however, that the best value of *ab* is 89°36, while opposite faces of *a* and *b* are not strictly parallel.

The positions of the faces λ and μ were determined with considerable accuracy as follows :—

	Observed.	Calculated.
$b\mu = 010 : 814$	$=82\cdot°10'$	
$b\mu = 0\bar{1}0 : \bar{8}\bar{1}4$	$=82\cdot°0'$	82°5½′
$b\mu = 0\bar{1}0 : 8\bar{1}4$	$=82\cdot°8'$	
$b\lambda = 010 : \overline{24},6,13$	$=75\cdot°10'$	
		75·°15¼′
$b\mu = 0\bar{1}0 : \overline{24},\bar{6},13$	$=75\cdot°15'$	
$d\mu = 012 : 8\bar{1}4$	$=44\cdot°24'$	
		44°30½′
$d\mu = 012 : \overline{81}4$	$=44\cdot°25'$	
$d\mu = 012 : 814$	$=36\cdot°42'$	36·°37′
$d\lambda = 012 : \overline{24},6,13$	$=32°34'$	32·°36¾′

In addition to its superiority in size and development, this crystal is distinguished from the others by the perfect symmetry of the plane *d*, both angles *bd* being 71°3½′.

In all other cases considerable variations were found in the angle *bd*, which extends from 69°30′ to 72°18′, having generally a value between 70°40′ and 70°50′, but rarely the same on both sides of *c*; *bv* also varies between 55°26′ and 55°36′; generally about 55°30.′

It is in consequence of the variations in this zone that Prof. vom Rath has ascribed the mineral to the oblique system, taking as parametral crystal that represented in fig. II. *loc. cit.*, in which on one side of *c* are two faces distant respectively 70°0′ and 71°47′ from the cleavage face; and on the other side one distant 70°1′ from the opposite cleavage face.

Of these angles 71°47′ I have not observed in any case; 70°5½′ was found upon one crystal; but *bd* seems to have generally a value about 70°40′, sometimes about 69°40′, and sometimes about 72°.

The angle *dd′* ($=012 : 0\bar{1}2$) is given below for a number of cases in which the measurements can be relied upon to five or six minutes; with *bd*, *b′d′*, *bv*, *b′v′*.

	dd′	*bd*	*b′d′*	*bv*	*b′v′*	
1.	38°45′	70·°15½′	70°59½′	55°31½′	55°34′.	
or	38°19′	70°41½′	70·°59½′			
2.	37°53′	71°3½′	71°3½′	55°31½′		(Fig. II.)
3.	38°11½′	69°30½′	72°18		55°33′½.	
or	40°47½′	69°30½′	69°42′			

4.	36°55½′	71°2′	72°2½′	55°26′	55°29′.
5.	38°20′	70°32′	70°46′	55°32′	55°29′.
6.	38°17½′	70°49′	70°53½′	55°31½′	

Besides the above, the following very definite values were obtained for the angle between *b* and the largest and brightest of the faces in this zone :—65°40′; 69°41′; 70°5½′; 70°44′; 75°26′.

It seems probable, therefore, that the position of the face *d* is subject to very considerable and irregular variations; and in some cases it appears necessary to ascribe it to the forms (0,6,13,) or (038). The above table discloses no regularity in this variation, and suggests no further explanation of the crystal measured by Prof. vom Rath and Hessenberg, which gives such definite results, and yet differs widely from the crystal represented here in Fig. II.

The zone [*brstun*], faces of which were observed well-developed on eight crystals, offers a much greater constancy. In five crystals the angle between the zones [*br*] and [*bd*] was determined to be 19°58′; 20°0′; 19°57′; 20°0′; 19°59′; 20°34′; 19°2′; 19°44′; the first four of these being probably the best values; while *br*, *bs*, *bt*, *bu*, rarely differ more than 5 or 6 minutes from the calculated angles. Faces of the form μ were found on five, faces of λ on six crystals. The positions on Fig. IV. of π ρ σ and the angles Uλ, 1ψ, *Tt*, will be found in the first table given above. The other most important observations on this crystal are $b\psi=$ 62°12′; $b\lambda=$75°14′.

The face β was observed on one crystal in conjunction with *bvdre*μ*tu*, and was determined by the measurements.

		Observed.	Calculated.
	$b\beta$	74°28′	74°28½.′
$\bar{2}30$: 412=	$e\beta$	86°19½′	86°19¾′.
	be	19°25½	19°25½.′

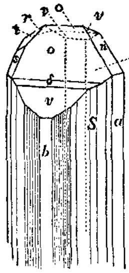

Fig. III.

It might appear from the stereographic projection that the zones [$b\ x\ \psi\ \lambda$] and [$b\ \rho\ \sigma\ q$] are merely distortions of the zone [$b\ \mu$] to which they are inclined at angles of 2°9′ and 2°24′ respectively. But the faces ρ σ were found in conjunction with π ψ λ on a crystal from the Ludlam specimen (Fig. IV.), and q x ψ λ with μ and σ on a crystal from one of the British Museum specimens.

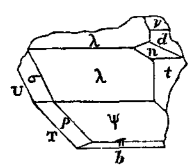

Fig. IV.

That neither λ nor σ are to be confused with (412), nor ψ nor ρ with (211), will be seen from the calculated angles :—

100,412=55°30¾.' 100,211=59°5¼'.
010.412=74°28½.' 010,211=60°56¾.'

The following table gives the greatest variations in the principal observed angles where fairly definite images were obtained :—

bv 55°22′ to 55°36′	*b*λ 75°0′ to 75°47.′
br 56°41′ ,, 57°20′	*a*λ 57°21′ ,, 57°31′.
bs 63°47′ ,, 64°17′	*b*ψ 62°5′ ,, 62°12′.
bt 74°4′4 ,, 72°16′	*bn* 89°56′ ,, 90°10′.
bu 80°′44 ,, 81°3′	*an* 70°2½′ ,, 70°1½.′
ar 73°6′ ,, 73°30′	
at 70°54′ ,, 71°9′	
au 70°11' ,, 70°20′	
*b*μ 82°8′ ,, 82°34′	
*a*μ 54°21′ ,, 54°36′	

It may be mentioned that one crystal presented the appearance of Fig. III., in which *bv*=55°34′ ; *bo*=65°41′ ; *b*δ=72°18′ ; *bv′*=124°26′ ; so that δ*o* is a re-entrant angle. The faces *f* and *U* also occurred as large bright planes in two other cases, having a second individual upon them apparently in parallel position.

Any external appearance however of a twin structure is generally confined to the zone [*bvd*] ; the faces *rstu* being constant in position and fairly symmetrical. The basal plane *c* has been observed as the only terminal face (somewhat dull) in at least one case.

As regards the physical characters of these specimens, there is a perfect but occasionally uneven cleavage parallel to *b* ; also a smooth basal cleavage, which is not however always easy to obtain. On the Ludlam specimen the needles are mostly arranged in roughly parallel positions, frequently show a bright and perfect basal cleavage, and are partly covered with a thick black or deep brown incrustation.

Fracture conchoidal. Specific gravity of a bright crystallised mass weighing ·9138 of a gramme, and apparently consisting of pure Meneghinite 6·399. From this mass was taken the crystal mentioned above as exhibiting the form β.*

The formula given for Meneghinite corresponds to that of Jordanite $4PbS + As_2S_3$, and Prof. Groth has in consequence (*Tabellarische Uebersicht*, 1882, p. 29) endeavoured to explain the measurements of vom Rath as leading to the Rhombic system, and to the parameters of Jordanite. But it may be observed that (using vom Rath's notation) this makes the small bright face 2*x*, and the cleavage face a pair of prism-planes, while the new plane of symmetry *t* (302) was only once observed

* Two subsequent analyses of this specimen showed that it was far from homogeneous, the analyses differing widely.

by vom Rath, and gave $at = 61°55'$ instead of $62°45'$ as it should be on this assumption.

Using the axes and parameters here adopted, it is difficult to refer Jordanite to the same, while preserving the cleavage face as (010). The nearest comparisons that can be made between the two minerals are

$$\text{Jordanite } c : b : \tfrac{5}{4}\, a = 2{\cdot}0308 : 1 : {\cdot}6719.$$
$$\text{Meneghinite } a : b : c = 1{\cdot}8904 : 1 : {\cdot}6866.$$
$$\text{or Jordanite } \tfrac{7}{2}\, a : b : \tfrac{1}{3}\, c = 1{\cdot}8812 : 1 : {\cdot}6769.$$

In the first case Jordanite $010,011 = 26°13'$. $010,450 = 56°6\tfrac{1}{4}'$.
Meneghinite $010,110 = 27°{\cdot}52\tfrac{2}{3}'$. $010,011 = 55°{\cdot}31\tfrac{1}{2}'$.
In the second case Jordanite $010,110 = 61°{\cdot}44\tfrac{1}{2}'$. $010,013 = 55°{\cdot}54\tfrac{1}{2}'$.
Meneghinite $010,720 = 61°{\cdot}37\tfrac{1}{2}'$. $010,011 = 55°{\cdot}31\tfrac{1}{2}'$.

It will be observed that two of the axes to which Meneghinite is here referred are equal to two of those of Stephanite, while the third is three times as great.

$$\text{Stephanite } 3b : a : c = 1{\cdot}8873 : 1 : {\cdot}6853.$$
$$\text{Meneghinite } a : b : c = 1{\cdot}8904 : 1 : {\cdot}6866.$$

Note.—Immediately before the publication of the above, a paper on the same subject by Prof. Krenner has reached me. (*Zeitschrift der Ungarischen Geologischen Gesellschaft*, 1883.)

Prof. Krenner has come to the same conclusions respecting the system and parameters of the mineral, but has not observed the curious group of faces λ, ψ, π, ρ, σ.

The following is an identification of the forms observed by Profs. vom Rath and Krenner with those mentioned above :—

Vom Rath.	Krenner.		Vom Rath.	Krenner.	
b	*a*	*a.*	*m*	*n*	*e.*
a	*b*	*b.*	$\tfrac{1}{3}m$	*g*	*S.*
$2p$, $2x$	*y*	*v.*		*k*	*U.*
p, *x*	*x*	*d.*		*u*	
n, *o*	*o*	*t.*		*w*	
s	*s*	*β.*		*v*	*n.*
e	*e*	*u.*		*p*	
d	*d*	*s.*		*z*	*μ.*
$\tfrac{1}{3}m$	*m*	*T.*		*q*	*r.*
$\tfrac{2}{3}m$	*l*	*m.*			