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On Sartorite and the problem of its crystal-form.

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[Read June 16, 1914, and June 19, 1917.[2]]

TO mineralogists probably few spots in the world surpass in interest the little quarry[3] hollowed out of the dolomite, just where the latter is cut by the Lengenbach, and about half a kilometre above the point where this stream ends its hurried course by joining the Binna at Imfeld, a hamlet lying in the main valley three kilometres above the village of Binn. Here within the compass of a few square metres have

[1] Communicated by permission of the Trustees of the British Museum.

[2] The following were the papers read before the Society: 'On sartorite,' by R. H. Solly, June 16, 1914, and 'On the problem of sartorite,' by G. F. Herbert Smith, June 19, 1917.

[3] An interesting description of the quarry, including an account of its history, is given by Léon Desbuissons in 'La Vallée de Binn (Valais),' Lausanne, 1909, Georges Bridel & Cie, pp. 60-67, some of the particulars being supplied by R. H. Solly.

been found an abundance of well-crystallized mineral-species,[1] not a few of which are peculiar to the quarry, and as yet not known to occur elsewhere. Although of the lead-grey, metallic minerals found here the commonest has been the one considered in this paper, so rare are crystals sufficiently well developed and with sufficiently smooth faces for goniometrical measurement that the precise nature of the crystallization of this species has even up till now been in doubt. The authors have between them had the opportunity of studying a large number of crystals, and among them a few with measurable pyramidal faces. They have therefore been enabled to determine definitely the zonal characters of the crystals, and thereby to arrive at two conclusions:—In the first place, sartorite appears to rank with the telluride of gold—calaverite[2]—in the peculiarity of its atomic arrangement, since in certain at least of its crystals there exist simultaneously two or even three incongruent space-lattices, which may be supposed derivable from one another by a slight shear. In the second place, the mineral represented by the two crystals figured and described by Trechmann[3] is not the same as that defined by vom Rath, although without doubt closely allied to it; it is therefore in this paper for distinction called sartorite-α.

I. Historical.

Careful investigation has established the existence of upwards of ten different species among the lead-grey, metallic minerals occurring in or around the Binn Valley, but so closely do they to a casual, and even, in many instances, to a careful inspection resemble one another that in

[1] Altogether upwards of twenty-five mineral species have been described from the Lengenbach quarry. The most interesting of them are jordanite, tennantite (binnite), and hamlinite (bowmanite), and those peculiar to the quarry, viz. sartorite, seligmannite, baumhauerite, rathite, dufrenoysite, lengenbachite, liveingite, marrite, and hatchite, which are black and opaque, and hyalophane, smithite, hutchinsonite, and trechmannite, which are transparent, the first being colourless and the remainder red.

[2] G. F. Herbert Smith, On the remarkable problem presented by the crystalline development of calaverite. Mineralogical Magazine, 1902, vol. xiii, pp. 122–150.

[3] C. O. Trechmann, Crystallography of sartorite from Binn. Mineralogical Magazine, 1907, vol. xiv, pp. 212-229. It is evident from the concluding paragraphs of his paper that he fully realized the uncertainty of the identity with sartorite of the crystals numbered by him 1 and 2. After pointing out that the character of even the smallest pyramidal faces permitted of exact goniometrical measurement he says—'With less confidence would I wish it to be assumed that the crystals Nos. 1 and 2 are, beyond doubt, to be considered as sartorites.

early days, as it is not surprising to learn, they were all confused together apparently as tetrahedrite, to judge from what appears to be the earliest recorded reference[1] to these minerals. Even a few years later, in 1839, Wiser[2] remarked that the grey, crystalline substance in the dolomite of the Binn Valley was a compound of sulphur-lead with sulphur-antimony, but almost immediately he published a correction,[3] noting that considerable arsenic was present, and little antimony. The following year[4] (1840) he noted the difference in the colour of two examples of these substances. During the succeeding years Swiss collectors had come to use the term binnite to denote the lead-grey minerals from the Binn Valley, differentiating between 'Kugel-Binnit' and 'Stangen-Binnit' according to the spherical or columnar shape of the crystals, and the name found its way into the catalogues of the mineral dealers.[5]

The first considerable investigation of the lead-grey minerals from the Binn Valley was made by Damour.[6] He analysed some poorly crystallized material, and found the composition to correspond to the formula $2PbS.As_2S_3$, and, inasmuch as no mineral with such a composition was at that time known, named it dufrenoysite. He perhaps naturally, but as it turned out wrongly, presumed that a small, brilliant, dodecahedral crystal closely associated with the material analysed was the same species, and accordingly so described the crystal form of his new mineral.

It was not till ten years later, in 1855, that the mistake was pointed out by von Waltershausen,[7] but unhappily in such a way as to leave the confusion almost worse. He remarked that the crystal form of a mineral

[1] C. Lardy, Essai sur la constitution géognostique du St.-Gothard. Denkschriften der allgemeinen Schweizerischen Gesellschaft für die gesammten Naturwissenschaften, 1833, vol. i, pp. 200–280. See p. 244: 'La dolomie de Binden renferme, en outre du Feldspath adulaire, de l'arsenic sulfuré rouge et jaune, du zinc sulfuré jaune en beaux cristaux et une substance métallique d'un gris de plomb qu'on a prétendu être de l'antimoine.'

[2] D. F. Wiser, Beiträge zur mineralogischen Kenntniss des Schweitzerlandes. Neues Jahrbuch Min., 1839, pp. 406–415. See p. 414.

[3] D. F. Wiser, ibid., p. 557.

[4] D. F. Wiser, Neues Jahrbuch Min., 1840, p. 216.

[5] Cf. Annalen der Physik u. Chemie, 1855, vol. xciv, p. 335.

[6] A. Damour, Notice sur le sulfo-arséniure de plomb du Mont Saint-Gothard. Annales de Chimie et de Physique, 1845, 3rd series, vol. xiv, pp. 379–383. Also see l'Inst. 1845, p. 141; Compt. Rend. Acad. Sci. Paris, 1845, vol. xx, p. 421.

[7] W. Sartorius von Waltershausen, Ein Beitrag zur näheren Kenntniss des Dolomits in den Walliser Alpen. Annalen der Physik u. Chemie, 1855, vol. xciv, pp. 115–141. See also Sitzb. Akad. Wien, 1854, vol. xiv, p. 291.

with a composition such as that found by Damour would *a priori* have been expected to have been very similar to that of the analogous antimony mineral, feather-ore, which obviously from its characteristic form did not belong to the cubic system. On examining specimens from the Binn Valley, he came to the conclusion that more than one species was represented among the lead-grey minerals, since some of the crystals were monometric, and others trimetric in symmetry. A chemical analysis of the trimetric material which was made by Uhrlaub did not yield simple ratios between the principal constituent elements; a difficulty which von Waltershausen met by supposing that the mineral was an isomorphous mixture of two hypothetical species, the one, which he named arsenomelane, with the constitution $PbS.As_2S_3$, and the other, which on account of its excessive brittleness he named scleroclase,[1] with the constitution $2PbS.As_2S_3$. The latter species had therefore the composition of Damour's dufrenoysite, but presumably differed from it in its crystalline characters. The name dufrenoysite he proposed to retain for the dodecahedral crystals, which were shown on an analysis by Uhrlaub to be a sulpharsenite, not of lead, but of copper. Von Waltershausen illustrates his paper with drawings of two crystals of the material analysed. On one of them—an iron-black crystal—he was able to make a few angular measurements and thence to deduce the crystal elements. By adopting his setting up of the crystals we have as the observed angles:—(101):($\bar{1}$01) = 64° 44′, (101) : (011) = 45° 1′, and from them obtain:—(100):(101) = 57° 38′; (010):(011) = 56° 49′. These angles do not accord with the accepted values which have been found for any of the principal angles of the known sulpharsenites of lead. The nearest is dufrenoysite, in which (010):(011) = 56° 56′; but the agreement in the second corresponding zone is unsatisfactory, the best angle being (001) : (704) = 59° 9½′. It is worth noting that in hutchinsonite,[2] a red-silver mineral found in the Lengenbach quarry, which crystallizes in the orthorhombic system, (100):(110) = 58 32′, and (001):(021) = 56° 29′. The last substance, however, does not occur in iron-black crystals. It is at any rate quite clear, both from the habit of the crystals as shown by the drawings and from the measurements made on

[1] σκληρός, hard, κλάειν, to break. See loc. cit., p. 126, 'seiner ausserordentlichen Sprödigkeit halber.' The name is not very happily derived; the first of the Greek words has much the same shades of meaning as the Latin *durus*, and the obvious meaning of the word scleroclase would be a substance difficult to break, which is just the opposite to what was intended.

[2] Mineralogical Magazine, 1907, vol. xiv, p. 287.

one of them, that they were not sartorite. The analysis was evidently made on a mixture of the salpharsenites of lead, among which no doubt there was some sartorite.

Heusser,[1] who almost simultaneously with von Waltershausen investigated the lead-grey minerals from the Binn Valley, likewise divided them into two kinds: the one, crystallizing in the regular system, which he also named dufrenoysite, and the other, occurring in the form of heavily furrowed, prismatic crystals, which he proposed to call binnite.[2] He depicts two of the latter crystals, and gives the following measurements in the well-developed dome-zone—58° 6′, 50° 19′, 38° 46′, 21° 56′—which agree with the mean values found for the zone (100):(010) of sartorite (p. 265). He gives a figure also of what he regarded as another crystal of 'binnite', but was unable to measure any of the angles because it was coated with a yellowish-green tarnish. The habit is, however, sufficient to assure us that the crystal was not a sartorite, though we can only conjecture to what species it belonged; it may have been really what we now know as binnite.

In the course of the summer of 1855 Des Cloizeaux and Marignac also visited the Binn Valley, and collected a series of specimens of the minerals occurring there. They collaborated in an investigation of the specimens, and a memoir on the results of their research was published by Des Cloizeaux.[3] Early in it he mentioned that the dodecahedral crystal which had given rise to so much confusion, because Damour had mistakenly supposed that it was identical with the material analysed by him, had by accident been broken, and that on analysis of a fragment thus afforded it turned out to be a sulpharsenite of copper, just as Uhrlaub had found. Remarking that the mistake in the determination of the crystalline form in no way invalidated Damour's discovery of the new mineral, he rightly dissented from the course followed by both von Waltershausen and Heusser of transferring the name dufrenoysite to the copper mineral. When, however, he came to describe the crystalline form of dufrenoysite, Des Cloizeaux was far less happy, because, as was

[1] C. Heusser, Ueber den Dufrenoysit, Binnit und Adular des Binnenthales. Annalen der Physik u. Chemie, 1856, vol. xcvii, pp. 115–129.

[2] C. Heusser, loc. cit. Cf. also ibid., 1855, vol. xciv, pp. 334–335. 'Binnit, ein Name, der in der Schweiz auch bisher statt Dufrenoysit allgemein gebraucht wurde (—man wusste noch Nichts von zwei verschiedenen Schwefelmetallen, sondern glaubte damit den Dufrenoysit des Hrn. Damour zu bezeichnen—) und der ganz passend an den bisher einzigen Fundort erinnert.'

[3] A. L. O. Des Cloizeaux, Sur les formes cristallines de la dufrenoysite. Annales des Mines, 1855, 5th series, vol. viii, pp. 389–398.

apparent with the aid of knowledge obtained later,[1] Marignac's measurements, which were quoted by Des Cloizeaux, had really been made on crystals of sartorite, and the crystals represented by figs. 1 and 2 belonged to that species, while the two small crystals depicted in figs. 3, 3a, and 4 belonged to yet another species—jordanite. As was pointed out by Solly,[2] had Des Cloizeaux tested the specific gravity or at least tried the streak he would at once have seen that his material consisted of at least two distinct species, because jordanite is much denser than sartorite and dufrenoysite, and has a black streak, whereas that of the other two minerals is chocolate-brown in colour.

For a considerable advance in our knowledge of these complexly intergrown metallic minerals from the Binn Valley we have to thank vom Rath. By means of a careful goniometric examination of the non-cubic, metallic material he was enabled to distinguish three distinct species, viz. dufrenoysite, scleroclase, and jordanite, of which the last-named was new. The first and third of them do not concern our present purpose. Under the name scleroclase he described small, needle-shaped, prismatic crystals, which were heavily striated and grooved parallel to their length, and remarked that the mineral was the same as Heusser's binnite and von Waltershausen's scleroclase.[3] He observed the following series of angles measured from the cleavage-face in the prism- and dome-zones,[4] which are mutually at right angles. He regarded the symmetry as orthorhombic. The indices of the faces quoted in the table are vom Rath's, but the angles are the supplements of those given by him, it being the custom in his day to give the obtuse angles between the faces of crystals.

[1] Cf. G. vom Rath, Annalen der Physik u. Chemie, 1864, vol. cxxii, p. 373.

[2] R. H. Solly, Mineralogical Magazine, 1900, vol. xii, p. 283.

[3] As was pointed out above (p. 262) von Waltershausen's hypothetical species had the composition of dufrenoysite; no doubt some of his material was sartorite.

[4] Throughout the present paper the authors use the term 'prism' for the striated zone the edge of which is parallel to the length of the crystal, and the term 'dome' for the, when present, generally broad and well-developed zone running over the end of the crystal. Since, as will be seen below (p. 307), the symmetry is really monoclinic with the plane of symmetry at right angles to the length of the crystals, the terms should, if to accord with the old convention, be interchanged.

Table I. Angular distances from the cleavage-face observed by vom Rath.

Form.[1]	Dome-Zone.	Form.	Prism-Zone.
Be 011	31°45′	5.0.14	22°30′
Bd 043	39 30	5.0.11	28 24
Bx 032	43 28	509	32 30
Bc 021	51 10	101	49 45
Bb 041	67 58	503	62 0
		10.0.1	85 2

One, but only one, of his crystals, viz., that illustrated in his fig. 3, showed the only pyramidal form observed, the one which he selected as (111). Its position was determined by the angle (011) : (111)=44° 19′, whence may be calculated its distance from the cleavage-face, 52° 31½′, and its azimuth from the prism-zone, 28° 19′; it is therefore the form called *Px* below (p. 295).

The name which in this paper we have used for the mineral was proposed in 1868 by Dana,[2] who rejected the name scleroclase for the following reason:—'As the name scleroclase is inapplicable, and the mineral was first announced by Sartorius v. Waltershausen, the species may be appropriately called Sartorite.' It is not clear what was his precise meaning; he may possibly have discarded the name scleroclase on account of its unsuitability on etymological grounds (cf. above p. 262), and because it was originally used by von Waltershausen for a species with the composition of dufrenoysite.

Thirty years passed by before any addition was made to the foundation laid by vom Rath, and it was not till 1895 that Baumhauer[3] published the results of his investigation of the goniometric properties of four crystals of sartorite from the Binn Valley. He, like vom Rath, regarded the symmetry as orthorhombic, and he adopted the latter's elements for the crystals. The first crystal was small, only 1 mm. across at the widest, the second was a mere fragment, the third measured 2 mm. in length by 1 mm. in breadth, and the fourth was 2 mm. in length and 2 by 1 mm. in cross-section; the last was developed at both ends. The most interesting crystal was the third, because it displayed

[1] For convenience of reference the forms are lettered in accordance with the notation adopted in this paper (p. 274).

[2] J. D. Dana, System of Mineralogy, 5th edit., 1868, p. 88.

[3] H. Baumhauer, Über den Skleroklas von Binn, Sitzungsber. k. preuss. Akad. Wiss. Berlin, 1895, pp. 243-252.

several new pyramidal forms. The indices of the forms in the following table are those given by him. The startling irrationality of some of them is noticeable.

Table II. Angular distances from the cleavage-face observed by Baumhauer.

	Form.	Angle.
	Crystal 1.	
	Form.	Angle.
Bf	045	26° 10½′
Bd	043	39 22
Bc	021	50 55
Bb	041	67 58
Ba	010	90 0
	Crystal 2.	
	Form.	Angle.
	106	10° 50′
	207	18 17½
	Crystal 3.	
	Form.	Angle.
	025	18° 38½′
Be	011	31 31½
Bd	043	39 19½
Bc	021	51 6¾
Bb	041	68 1
Px′	441	79 8½
,,	,,	79 5
Pw′	221	69 2
	104	15 35
	3.0.10	18 51
	102	30 22
	102	30 0½
	11.0.4	72 17
Ix′	20.36.15	64 49½
Iz′	65.117.9	84 52
Iz	593	69 42½
Iy	85.153.90	56 45½
Ha	174.377.65	77 59½
Hb′	6.18.1	84 35½
Hc′	18.39.13	68 8
Hd′	102.221.90	54 33½
Hc	18.39.26	50 22½
	Crystal 4.	
	Form.	Angle.
	106	10° 32½′
	104	16 2
	207	18 17
	3.0.10	18 51
	3.0.8	23 35½
	509	32 30½
	405	42 31½
	506	48 39
	17.0.18	47 23
	26.0.27	47 59
	101	48 53
	19.0.18	50 28½
	,,	50 35
	16.0.9	63 41½
	0.4.11	12 42
	025	14 2
	0.9.20	15 29½
	012	17 16
	,,	16 57½
	047	19 30
Bg	023	22 12½
Bf	045	26 20
Bd	043	39 30
	0.41.30	40 15½
	0.47.30	44 18½
	0.17.10	46 32½
	0.26.15	47 6
	0.29.15	50 3
	,,	50 6½
Bc	021	51 8½
Bb	041	67 58½
,,	,,	68 2½
	0.7.15	16 5
Bg	023	22 24½
Bf	056	27 5½
	0.14.15	30 0½
Be	021	51 8½
,,	,,	51 12½
Bb	041	68 6
,,	,,	68 14½

For fixing the azimuths of the pyramidal zones on crystal 3 the following cross-measurements were made:—$(44\bar{1}):(021) = 75^\circ\ 53'$, $(20.36.15):(02\bar{1}) = 77^\circ\ 9\frac{3}{4}'$, $(174.377.65):(021) = 44^\circ\ 45\frac{1}{2}'$. By calculation the corresponding aximuthal angles may be obtained; they are respectively 28° 17′, 43° 59′, 49° 34′, measured from the prism-zone.

R. H. Solly[1] spent the summer of 1898 at the Binn Valley, and succeeded in collecting among other minerals a large number of sartorites. After the crystals had been measured on a goniometer, certain of them were picked out for chemical analysis, which was undertaken by H. Jackson.[2] Altogether he made three analyses, the first on small, brilliant crystals, and the other two on larger crystals: the percentages obtained agree very closely, as will be seen from the Table below, with

[1] R. H. Solly, Sulpharsenites of lead from the Binnenthal. With analyses by H. Jackson. Mineralogical Magazine, 1900, vol. xii, pp. 282–297.

[2] R. H. Solly, loc. cit., pp. 286, 287, 289.

those required by the formula $PbS.As_2S_3$. The density, as determined on the best crystals, was 4·980. Solly announced that the symmetry of sartorite is monoclinic, and not orthorhombic as stated by previous observers, but gave no further particulars of the crystals.[1]

Table III. Chemical Analyses of Sartorite by H. Jackson.

	1.	2.	3.	Calc.
Pb ...	43·24	43·93	43·72	42·68
S ...	25·81	24·60	25·12	26·39
As ..	30·80	30·46	30·12	30·93
	99·85	98·99	98·96	100·00

Four years later, in 1902, Baumhauer[2] mentioned that he had obtained some loose crystals, 3 cm. in length, which were probably sartorite.

At the meeting of the Mineralogical Society on March 24, 1903, Lewis[3] exhibited a large crystal of a sulpharsenite of lead, measuring as much as $4 \times 1 \times \frac{1}{3}$ inches ($10 \times 2·5 \times 0·8$ cm.), which was analysed by H. Jackson, and shown to be sartorite; the figures of the analysis are :—Pb, 42·93; S, 25·32; As, 31·11: total, 99·36.

Again, at the anniversary meeting of the Society in the same year R. H. Solly[4] described specimens of sartorite as well as of other minerals from the Binn Valley.

The following year, 1904, Baumhauer,[5] in the course of a paper dealing with the development of zones rich in faces, gives further measurements made in the prism-zone of sartorite.

In August 1904, C. O. Trechmann visited the Binn Valley, and had

[1] R. H. Solly, loc. cit., p. 297.

[2] H. Baumhauer, Eclogae geol. Helvetiae, 1902, vol. vii, pp. 352-353.

[3] W. J. Lewis, A large crystal of sulpharsenite of lead from the Binnenthal. Mineralogical Magazine, 1903, vol. xiii, p. xxxiv.

[4] R. H. Solly, On sartorite, anatase, galena, and other minerals from the Binnenthal. Mineralogical Magazine, 1904, vol. xiv, p. xx. Abstract in 'Nature', 1903, vol. lxix, p. 142:—'... On fine brilliant crystals of sartorite recently obtained by the author he has been able to confirm the oblique symmetry which he had previously announced, and to determine accurately the elements, $\beta = 88° 31'$, (100) (101) = 54° 45', (010) (111) = 69° 52½' ...' The last two angles appear, however, to have been incorrectly transcribed.

[5] H. Baumhauer, Über die Aufeinanderfolge und die gegenseitigen Beziehungen der Krystallformen in flächenreichen Zonen. Sitzungsber. k. preuss. Akad. Wiss. Berlin, 1904, pp. 543-554. See also Eclogae geol. Helv., 1906, vol. viii, pp. 582-588.

the good fortune to acquire several good crystals of a sulpharsenite of lead, which he subsequently described.[1] He mentioned seven crystals, but devoted nearly the whole of his memoir to those numbered 1 and 2; of these he gave drawings. Their symmetry he found to be monoclinic. The angles measured in the dome-zone agreed closely with those recorded by vom Rath and Baumhauer in the corresponding zone of their crystals, but in other zones there was complete discordance. The principal angles were found to be as follows:—(100):(110) = 51° 16′, (100):(001) = 77° 48′, (100):(101) = 40° 24½′, (100):(10$\bar{1}$) = 53° 25′; while the corresponding angles given by vom Rath were:—(001):(021) = 51° 3½′, (001):(100) = 90° 0′, (001):(101) = 48° 57′. Trechmann's crystals were well developed, and the character of their faces in nearly every instance permitted of a good reading on the goniometer; altogether he observed 87 forms. Crystals 3 and 4 showed the dome-zone well developed and the prism-zone very much striated, but pyramidal faces were entirely absent. The two crystals were joined together 'in an apparently twinned position'.[2] Crystals 5 and 6 were opposite ends of one and the same complete crystal. 'Both of these crystals have a rich development of pyramidal faces, of which forty-five were counted on No. 5 and about thirteen on No. 6. Twin-lamellae were distinctly observable on both crystals, but especially on No. 6, where some of the faces were devoid of them, and others were closely intersected. The zonal relations of these pyramidal faces were, however, so indistinct, and most of them were so small, that it has not been possible so far to identify them. Some measurements made on crystal No. 6 could not be harmonized with Nos. 1 and 2, nor with the pyramids observed by Baumhauer.'[3] As was pointed out early in this paper (p. 260), he clearly did not feel certain that his crystals 1 and 2 were sartorite. Inasmuch as they cannot be brought into harmony with the mineral defined by vom Rath, they must bear another name, and the authors suggest as such sartorite-α.

[1] C. O. Trechmann, Crystallography of sartorite from Binn. Mineralogical Magazine, 1907, vol. xiv, pp. 212–229. The crystals were presented by Dr. Trechmann to the British Museum in 1917, just before his death; those numbered by him 1 and 2 are entered under 390, 3 and 4 under 391, 5 and 6 under 392, and 7 under 393 for the year 1917 in the Register of Accessions in the Mineral Department.

[2] C. O. Trechmann, loc. cit., p. 214. This statement is incorrect. No semi-revolution about any axis will bring the poles of the one crystal into coincidence with those of the other.

[3] C. O. Trechmann, loc. cit., p. 226.

A good summary of what at the time of writing was known of sartorite as well as the other minerals found there was given in 1909 by Desbuissons in his book on the Binn Valley.[1]

The publication of a full description of the crystals of sartorite exhibited at the anniversary meeting of the Mineralogical Society in 1908, which were referred to above, was deferred by Solly in the hopes that additional and better material might be found which would throw light on the puzzling problem presented by this mineral. In 1909, however, the Lengenbach quarry was closed down, and during the years that have since elapsed the disintegrating effect of snow and rain have filled it with huge boulders and tons of drift. The reopening of the quarry would therefore now be such a difficult and costly task that it may be questioned whether any one will be found sufficiently enterprising to undertake it, especially since there were signs that the veins containing the coveted sulpharsenites were fast becoming exhausted. The chance of fresh material coming to light which might be of service in this investigation being thus very remote, Solly, in the course of the years 1913 and 1914, re-measured all the crystals of sartorite that he had obtained before 1908, and in addition measured some good crystals he had acquired since that date. He communicated the results of his investigation to the Mineralogical Society on June 16, 1914.[2] Since some of the crystals showed small pyramidal planes the positions of which could not be determined by means of an ordinary goniometer, Solly brought them to the British Museum for measurement on a three-circle instrument in the Mineral Department. G. F. Herbert Smith undertook the work, and determined the positions of the pyramidal faces on the best crystals. The relations between these faces and the dome-faces were found to be so puzzling and mysterious that it was eventually decided to measure on the three-circle goniometer all the crystals which possessed pyramidal faces, but it was not found possible to prosecute the investigation until the year 1916. Attempts made to bring the observations made on Solly's crystals into harmony with the elements and angles published by Trechmann for his crystals 1 and 2 were entirely without success. It

[1] L. Desbuissons, La Vallée de Binn (Valais). Lausanne, 1909. For sartorite see pp. 104–106.

[2] R. H. Solly, On sartorite. Mineralogical Magazine, 1914, vol. xvii, p. xxxi. Abstract in 'Nature', 1914, vol. xciii, p. 471, 'From a goniometrical examination of 200 crystals it is contended that Dr. Trechmann's crystals, Nos. 1 and 2, belong to a species closely allied to sartorite and smithite. Many new forms for sartorite were found.'

was thought possible that bi-angular measurements of the latter crystals on the three-circle goniometer might suggest a clue to the riddle, and accordingly an appeal was made to Trechmann for the loan of his crystals. With characteristically ready courtesy, which we are glad to have the opportunity of acknowledging, he at once sent all the crystals referred to in his memoir, together with two others which he had acquired since

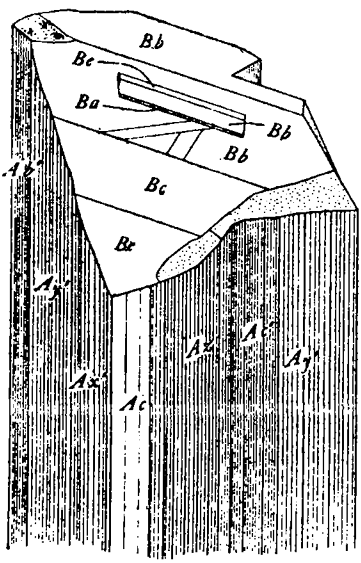

FIG. 1.—Sartorite crystal ; habit No. 1 (B.M. 1918, 408 (2)). See p. 314.

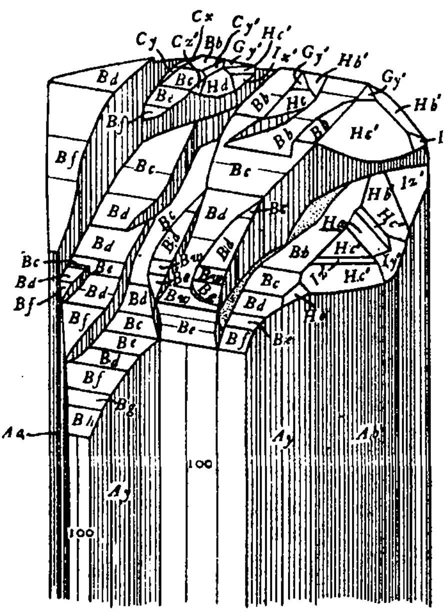

FIG. 2.—Sartorite crystal ; irregular growth (B.M. 1918, 408 (59)).

its publication. All of them were measured, but it was his crystal 5 that was found to be of the first importance; upwards of a hundred faces were observed on the end of the crystal, and a study of the positions of the corresponding poles, when plotted on a gnomonic projection, revealed certain curious zonal relations. With the light thus thrown on the problem by this one crystal the whole of the crystals belonging to both Solly and Trechmann were measured and studied. The conclusions arrived at are discussed below (p. 305).

II. Morphological Characters.

Crystals of sartorite may be classified according to three different kinds of habit:—

(1) Dome-zone (100 : 010) large with bright, smooth planes, and prism-zone (100 : 001) well developed, though deeply grooved (cf. fig. 1). A few crystals show pyramids (cf. figs. 4–9).

(2) Dome-zone (100 : 010) large, but irregularly developed owing to interruptions in the growth of the faces. The crystals sometimes have a tessellated appearance due to repeated twinning, and are sometimes cavernous, the interior of the holes being lined with faces in harmony with the external development (cf. figs. 2 and 3).

(3) Columnar crystals, deeply striated, which have been attached at both ends to the dolomite, and are therefore without faces at the ends. They have been found in masses weighing as much as a hundred grams.

Twinning about (100) appears to be invariable, and it is often repeated so that the crystals are laminated; even in the case of crystals without faces at the ends the re-entrant angles in the prism-zone testify to the presence of twinning. Crystals are occasionally grouped together in parallel or nearly parallel position, and sometimes cross; it is doubtful, however, whether the latter phenomenon is due to twinning (cf. p. 268).

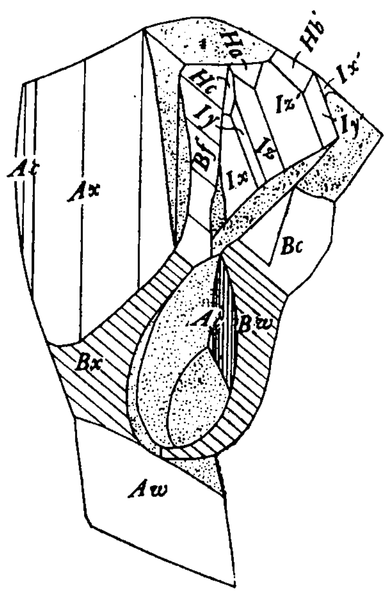

Fig. 3.—Sartorite crystal; cavernous growth (B.M. 1918, 408 (54)).

There is a fair cleavage parallel to (100), and the fracture is of the ordinary conchoidal type. The crystals are extremely brittle, and occasionally break with an audible report, as was noticed by vom Rath. The hardness is about the same as calcite, viz. 3. The colour is lead-grey, the lustre metallic, and the streak chocolate-brown in colour. The crystals are, of course, opaque. The general symmetry is monoclinic, the plane of symmetry being at right angles to the length of the crystals; but, as is explained below, the crystal development is abnormal in character.

III. Observations on Crystals with Pyramidal Faces.

All the crystals discussed below were measured on the smaller three-circle goniometer in the British Museum, viz. the one which was devised by Herbert Smith in 1899,[1] in every instance the striated prism-zone being selected as the zone of reference. All of them were measured from the cleavage-face (100), as origin, and, where the development of the pyramidal faces was sufficient for the determination of the corresponding poles, from (001), (101), and (10$\bar{1}$) also. The pole (100) could generally be accurately fixed because the corresponding face in nearly every instance yielded a well-defined image and, failing it, the faces in the dome-zone gave usually such excellent reflections that the pole could be fixed with very fair accuracy as the intersection of this zone with the prism-zone. The case was, however, far otherwise with the other poles. Seldom was a definite image available in the extended band of reflections to serve as the origin of measurements, and it was necessary to fix them as the intersection of cross-zones with the prism-zones; but, for reasons which will appear below (cf. p. 305), the large smooth dome-faces were in general not available for this purpose and recourse had to be made to the far smaller pyramidal faces. The settings for the three poles (001), (101), (10$\bar{1}$) could not therefore be determined with very great accuracy; but the amounts of the combined error could be gauged by the closeness with which the angles that they subtended with the pole (100) obeyed the usual anharmonic relation.

Many of the pyramidal faces were extremely small; indeed, it was rare for one to measure more than a tenth of a millimetre across in any direction, and they were often of such minute size that the interatomic repulsive forces which manifest themselves in liquids as surface-tension become relatively pronounced and the faces are perceptibly rounded. In such cases it is therefore far from easy to centre the image on the cross-wires in the telescope of the goniometer, since it is necessarily faint on account of the smallness of the reflecting surface, and is rendered diffuse and indistinct on account of the rounding of the face.

[1] G. F. Herbert Smith, Mineralogical Magazine, 1899, vol. xii, pp. 175–182. It may be mentioned that in October 1906, when a convenient opportunity offered itself, the second circle was returned to Messrs. Troughton and Simms, and the vernier made adjustable, with the view of obviating the small zero correction previously necessary in the case of the azimuthal angles.

As source of illumination a 100 watt half-watt electric lamp, yielding about 200 candle-power, was used, the light being passed through a small beaker of water in order to reduce the amount of heat transmitted and at the same time to diffuse the light from the glowing wire over the object-slit of the goniometer; in order to secure greater uniformity of illumination a thin piece of oiled paper was placed just in front of the object-slit. By screening the crystal-holder and wax, and, in fact, all but the crystal, from the light a perfectly dark background was secured in the field of the telescope of the goniometer, against which even an extremely faint and nebulous image could successfully be picked up after the approximate position had been first found by means of the microscope into which the telescope may be converted.

We will now proceed to describe the six crystals which alone boast a sufficient development of the pyramidal faces for the determination of their zonal characters, and to give in full detail the bi-angular measurements made on each face. Strictly speaking, the number of distinct crystals is five, because the first two of them are really opposite ends of one and the same crystal. With this exception none of the crystals was doubly terminated.

It will, however, first be necessary to say a few words in explanation of the tables of co-ordinates. For reasons which are discussed below (p. 305) we have come to the conclusion that the faces appearing on the ends of the crystals can be referred to three distinct and incongruent space-lattices; these are numbered I, II, III respectively in the tables. The first of them has monoclinic symmetry, and, including, as it does, the dome-zone, is the most prominent of them. The other two have triclinic symmetry, but each of them is twinned about the pole (010), so that in such a crystal as No. 1 there are no fewer than five distinct lattices traceable in the crystal. Lattice II is far better developed than lattice III; but it is to the latter that the solitary pyramidal form observed by vom Rath and selected by him as the unit pyramid belongs. The prism-zone is common to all three lattices. As data for computing the elements of the several lattices and the co-ordinates of the faces corresponding to them we selected the angle (100) : (110),[1] either as directly measured or as calculated from a more trustworthy angle in the same zone, and the most concordant set of angles subtended by the poles (001), (101), and $(10\bar{1})$ at (100) as determined by the cross-zonal relations of the pyramidal faces. In the case of the triclinic lattices we have still to select the pole to bear the indices (010). It should be near the

[1] This is the face (041) of vom Rath and Baumhauer.

corresponding pole of lattice I, but which one is determined by the consideration that on the gnomonic projection a slight lateral shift away from the centre should bring the poles of one lattice into coincidence with those of the adjacent one. The azimuthal angles, ϕ_2, ϕ_3, of the zones belonging to the lattices II and III are very simply derived from the corresponding azimuthal angle ϕ_1 of I by the relations $\cot\phi_2 - \cot\phi_1 = c$, and $\cot\phi_3 - \cot\phi_1 = 2c$, where c is a constant for the particular pole of the crystal, but varies for this pole from crystal to crystal (cf. below p. 310).

For designating the forms we have found it convenient to make use of a two-letter notation, the principle of which—viz. the determination of a pole as the intersection of two zones—will be evident from a study of the gnomonic projection shown in fig. 10 (p. 306). Capital letters denote zones passing through (100), and small letters cross-zones passing through (001); but, whereas all poles with the same capital letter lie in the same zone, that is true in the case of poles with the same small letter in general only when they belong to the same space-lattice. Poles lying within dissimilar quadrants are distinguished by a dash; thus *Hb* is (112), *Hb′* ($\bar{1}$12) or (11$\bar{2}$). The prism-zone has been harmonized with the dome-zone, but, of course, the significance of the small letters is no longer the same; thus *Aa* is (001), *Ba* (010), *Ab* (101), *Bb* (110), *Ab′* ($\bar{1}$01), *Bb′* ($\bar{1}$10), and so on.

Crystal No. 1 (*fig.* 4).

This remarkable crystal (Trechmann's No. 5; B.M. 1917, 392), which, before removal from the dolomite matrix, formed part of a slightly larger individual, measures about 1·2 mm. in length, and 0·9 by 0·5 mm. in cross-section. The illustration is a reproduction of an orthogonal drawing projected on to a plane perpendicular to the edge of the prism-zone. The drawing was prepared with the aid of a microscope fitted with a camera lucida, and gives as faithful a picture of the end of the crystal as was found to be practicable. Work of this kind presents considerable difficulty, because, owing to the extremely small size of the crystal; an objective of high power had to be used, and consequently any edge, or even any part of an edge, lying appreciably outside the focal plane was indistinct, if not partly or wholly indiscernible, and the necessary adjustment of the focus invariably upset the coincidence between the drawing and the visual picture. With care it was possible to some extent to overcome this difficulty, but, to assure accuracy, the relative inclinations of the edges on the drawing were determined in the customary manner from a gnomonic projection.

The crystal is twinned about (100), the sector running sideways across the middle being in twinned position with respect to those above and below it, which themselves are therefore in parallel position. The boundaries are very straight and sharp, slight interpenetration taking place only in the case of the lower one on the left-hand side. The large stippled portions represent fractured portions, and the narrow stippled patches, running up and down, indicate clefts, which are lined with faces in harmony with the external development; the narrowness of the

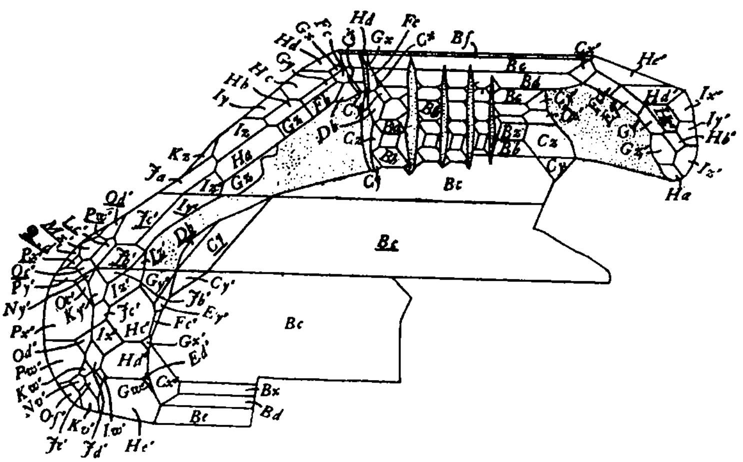

FIG. 4. Sartorite crystal No. 1.

clefts in comparison with their depth prevented observations being made of the faces lying at the bottom. The corresponding faces on the several humps are very nearly parallel to one another, the spreading of the combined reflection being only slight. At the right-hand top-corner of the crystal in the position of the figure occur a number of additional faces, of which some were in the twinned position; they were omitted from the drawing, because otherwise, owing to the lack of perspective, their presence would have led to confusion. Reflections corresponding to isolated crystal-faces occur also on the fractured part of the crystal on the right-hand side as seen in the drawing. An extremely small crystal of pyrites emerges from the prism-zone low down towards the right-hand corner in the position depicted.

Altogether, on the end of the crystal observations were made of no fewer than 123 different faces, representing sixty-seven different forms, and it may be remarked that in arriving at this number we reckoned parallel faces as one. Of these faces fifteen lie in the dome-zone, and therefore 108 are pyramidal. Eighty-five of the faces appear in the figure; the remainder are mostly too minute to be drawn even on that large scale, only a few of them being peculiar to the part of the crystal omitted from the drawing. The left-hand bottom-corner of the crystal is by far the best developed portion of it. As we pass to the upper corner on the same side, we find the faces rapidly diminishing in size, and the growth becoming interrupted and irregular, more so than, owing to the minuteness of the faces, could be indicated on the drawing. The reflections from the large faces in the dome-zone were brilliant and sharp, but from the faces on the farther side they were dispersed and extended in the direction of the zone owing to the rounding that always accompanies narrowness of width in faces. The twin-individuals shown in the figure are combined in such a way that only close observation at a glancing angle will reveal on the large face *Bb* the fine lines indicative of the twin boundaries. Since at the re-entrant angle on the left-hand side of the crystal the prism-zone on both individuals is considerably striated, an overlapping pair of banded reflections was afforded in the field of the telescope of the goniometer, and to determine to which of the two individuals a particular image belonged was a task of some difficulty. The near face (100) was small and considerably stepped, but gave a single distinct reflection; the farther one, on the other hand, was large and divided vertically into two parts which gave readings differing by 21′.

That there is something unusual in the zonal characters of the crystal is suggested by the perceptibly wedge-shaped contour of such faces as *Jc′*, *Fc′*, and *Ey′*, certain opposing edges being nearly, but unmistakably not, parallel to one another as we should expect to find in the case of an ordinary crystal.

There are two faces, viz. *Gw′* and *Gx′*, which are not quite in the position where we should have expected to find them, the azimuthal angle subtended at (100) as origin differing, as will be seen from table below, by about a degree of arc from that of *Gy′*, which is normal in position and which should presumably have been in their zone. Possibly the cause may be their relative smallness of size as compared with the contiguous faces belonging to another lattice.

The elements of the crystal and the co-ordinate angles of the various forms were computed from the following angles :—$(100):(001)=74° 28′$ (the observed value), $100:101 = 36° 6′$ (observed value 36° 4′),

$(100):(10\bar{1}) = 50° 48'$ (observed value $50° 40'$), and $(100):(210) = 51° 7'$ (the observed value).[1] In the prism-zone, owing to its oscillatory character, it was often difficult, if not impossible, to assert with confidence whether a particular reflection corresponded to a positive or a negative face; accordingly, in many instances both sets of indices corresponding to a particular angle were computed, and the simpler of them, if the corresponding angle was in fair agreement, was selected. The question of the development of this zone is discussed more fully below (p. 314).

The shear governing the transition from lattices I to II and II to III was determined thus:—If ϕ_1, ϕ_2, ϕ_3 be the azimuthal angles, measured from the prism-zone, of some particular pole (hkl) in the various lattices subtended at any pole in that zone, then the following relations hold

$$\cot\phi_3 - \cot\phi_2 = \cot\phi_2 - \cot\phi_1 = f.\,A,$$

where A is the cotangent of the azimuth corresponding to the pole (111) in lattice I and f is a fraction. The values of f and A in the case of the four poles (100), (001), (101), (10$\bar{1}$) are—

		f		A
(100)	...	0·3	...	0·36872
(001)	...	0·1	...	0·38845
(101)	...	0·1	...	0·47510
(10$\bar{1}$)	...	0·2	...	0·62488

Elements of the Lattices.

I. $a:b:c = 2·5737:1:2·7118$; $\beta = 105° 22'$.

II. $a:b:c = 2·5769:1:2·7309$;

$(010):(001) = 82° 51'$, $(001):(100) = 74° 28'$, $(100):(010) = 85° 57'$;

$\alpha = 96° 19'$, $\beta = 105° 10'$, $\gamma = 92° 13\tfrac{1}{2}'$.

III. $a:b:c = 2·5820:1:2·7786$;

$(010):(001) = 75° 56'$, $(001):(100) = 74° 28'$, $(100):(010) = 82° 6'$;

$\alpha = 102° 28\tfrac{1}{2}'$, $\beta = 104° 7'$, $\gamma = 94° 26\tfrac{1}{2}'$.

[1] The angles stated to have been observed in the prism-zone were those determined from the cross-zonal relations of the pyramidal faces by means of the third circle of the three-circle goniometer. Wherever possible, three angles were thus measured, of which theoretically only two were necessary; the actual angles taken as data were, however, those considered, having regard to the probable accuracy of the adjustment of the several origins, to accord best with the measured angles. In the case of crystals 3 and 5, a somewhat similar procedure was adopted for the dome-zone, the datum angle being based on more than one angle.

Table IV. Calculated and observed values of the co-ordinate angles.

Face.			Refl.[1]	Observed.		Calculated.	
Lattice.	Symbols.	Indices.		ϕ	ρ	ϕ	ρ
(a) Co-ordinates from (100)—							
	Ad′	30$\bar{1}$	g	0° 0′	18° 35′	0° 0′	18° 25½′
		605	b	,, ,,	44 4	,, ,,	44 2
	Ab′	10$\bar{1}$	b	,, ,,	50 8	,, ,,	50 48
		50$\bar{9}$	s	,, ,,	71 37	,, ,,	71 45
		307	s	,, ,,	79 37	,, ,,	79 12
	Ad	301	b	,, ,,	15 38	,, ,,	15 42
		50$\bar{3}$	b	,, ,,	32 31	,, ,,	32 55
	Az	102	s	,, ,,	49 48	,, ,,	50 29½
		207	s	,, ,,	59 10	,, ,,	59 22
	Aa	001	f	,, ,,	73 50	,, ,,	74 28
		409	b	,, ,,	78 1	,, ,,	78 15
		3.0.$\bar{1}$0	f	,, ,,	87 32	,, ,,	87 8
	Af′	50$\bar{1}$	s	,, ,,	11 39	,, ,,	10 54½
	Ad	301	f	,, ,,	15 35	,, ,,	15 42
		40$\bar{3}$	b	,, ,,	42 25	,, ,,	42 20
	Ab′	10$\bar{1}$	f	,, ,,	50 48	,, ,,	50 48
		104	f	,, ,,	61 52	,, ,,	61 8
		108	b	,, ,,	67 14	,, ,,	67 29
	Az′	10$\bar{2}$	b	,, ,,	75 25	,, ,,	74 57
		10$\bar{4}$	b	,, ,,	85 10	,, ,,	86 27
	Aw′	70$\bar{2}$	f	,, ,,	15 47	,, ,,	15 44
		705	f	,, ,,	29 18	,, ,,	28 56
		405	s	,, ,,	42 41	,, ,,	42 34
		305	s	,, ,,	46 38	,, ,,	46 57½
	Az	102	f	,, ,,	50 23	,, ,,	50 29½
		104	b	,, ,,	61 38	,, ,,	61 8
		105	b	,, ,,	63 38	,, ,,	63 25½
	Aa	001	f	,, ,,	74 25	,, ,,	74 28
		205	f	,, ,,	80 47	,, ,,	80 56
		10$\bar{4}$	b	,, ,,	86 58	,, ,,	86 27
III		21$\bar{7}$	b	19 0	87 30	18 31	88 14
,,	*Qd′*	31$\bar{5}$	b	25 50	76 39	25 50½	76 24
,,	,,	,,	b	26 1	76 19	,, ,,	,, ,,
,,	*Pw′*	72$\bar{9}$	f	28 0	69 26	28 0	69 14
,,	*Px′*	52$\bar{9}$	f	,, ,,	79 27	,, ,,	79 14½
,,	*Py′*	32$\bar{9}$	f	,, ,,	89 52	,, ,,	89 57½
,,	*Pw′*	72$\bar{9}$	b	28 5	69 23	,, ,,	69 14
,,	*Px′*	52$\bar{9}$	b	,, ,,	79 7	,, ,,	79 14½
II	*Mx′*	52$\bar{9}$	b	29 36	76 47	29 28	76 49½
III	*Of′*	51$\bar{4}$	f	30 33	53 38	30 31	53 22½
,,	*Od′*	31$\bar{4}$	b	,, ,,	71 45	,, ,,	71 32
,,	*Oc′*	21$\bar{4}$	f	,, ,,	82 52	,, ,,	82 38
,,	*Od′*	31$\bar{4}$	b	30 34	71 59	,, ,,	71 32

[1] In the column headed 'Reflections' the letters indicate the quality of the reflected image and therefore the trustworthiness of the measured angle, viz. g good, f fair, b bad, s striated.

III	*Oc'*	$21\bar{4}$	b	30° 34'	88° 38'	30° 31'	82° 38'
II	*Lc'*	$21\bar{4}$	b	32 34	80 1	32 15	80 9
,,	*Lx'*	$52\bar{8}$	b	32 35	74 17	,, ,,	74 17
,,	*Lc'*	$21\bar{4}$	b	,, ,,	80 15	,, ,,	80 9
III	*Nv'*	$92\bar{7}$	b	33 16	54 34	33 29	54 4
,,	,,	,,	f	33 25	54 10	,, ,,	,, ,,
,,	*Ny'*	$32\bar{7}$	b	,, ,,	86 45	,, ,,	86 43
II	*Kv'*	$92\bar{7}$	f	35 36	51 22	35 31	51 11
,,	*Kw'*	$72\bar{7}$	b	,, ,,	60 24	,, ,,	60 18½
,,	*Ky'*	$32\bar{7}$	f	,, ,,	84 14	,, ,,	84 11½
,,	*Kw'*	$72\bar{7}$	b	35 42	60 19	,, ,,	60 18½
,,	*Kz*	127	b	35 44	69 41	,, ,,	69 51½
,,	*Je'*	$41\bar{3}$	b	39 19	52 20	39 25	51 55
,,	*Jd'*	$31\bar{3}$	b	,, ,,	62 28	,, ,,	62 11
,,	*Jc'*	$21\bar{3}$	b	,, ,,	74 33	,, ,,	74 48
,,	*Jb'*	$11\bar{3}$	b	,, ,,	89 15	,, ,,	89 6
,,	*Je'*	$41\bar{3}$	f	39 30	51 59	,, ,,	51 55
,,	*Jd'*	$31\bar{3}$	f	,, ,,	62 18	,, ,,	62 11
,,	*Jc'*	$21\bar{3}$	f	,, ,,	74 53	,, ,,	74 48
,,	*Jb'*	$11\bar{3}$	f	,, ,,	89 4	,, ,,	89 6
,,	,,	,,	f	,, ,,	89 11	,, ,,	,, ,,
,,	*Ja*	013	f	39 35	76 26	,, ,,	76 28
,,	*Jc'*	$21\bar{3}$	f	,, ,,	74 52	,, ,,	74 48
,,	*Iv'*	$92\bar{5}$	b	44 2	44 44	44 5	44 1½
,,	*Iw'*	$72\bar{5}$	b	,, ,,	53 14	,, ,,	52 59
,,	*Ix'*	$52\bar{5}$	f	,, ,,	64 48	,, ,,	64 38½
,,	*Iy'*	$32\bar{5}$	f	,, ,,	79 8	,, ,,	79 4
,,	*Iz'*	$12\bar{5}$	f	,, ,,	85 9	,, ,,	85 0
,,	,,	,,	f	44 6	84 51	,, ,,	85 0
,,	*Iw'*	$72\bar{5}$	b	,, ,,	53 4	,, ,,	52 59
,,	*Ix'*	$52\bar{5}$	f	,, ,,	64 48	,, ,,	64 39½
,,	*Iy'*	$32\bar{5}$	f	,, ,,	79 7	,, ,,	79 4
,,	*Iz'*	$12\bar{5}$	b	,, ,,	85 9	,, ,,	85 0
,,	,,	,,	f	,, ,,	84 56	,, ,,	,, ,,
,,	*Iy'*	$32\bar{5}$	b	44 13	79 11	,, ,,	79 4
,,	*Iz*	125	f	,, ,,	69 47	,, ,,	69 48
,,	*Iy*	325	f	,, ,,	57 6	,, ,,	57 2½
,,	*Ic*	7·4·10	b	,, ,,	50 31	,, ,,	51 44½
,,	*He'*	$41\bar{2}$	b	49 28	44 42	49 42	44 27
,,	*Hd'*	$31\bar{2}$	f	,, ,,	54 51	,, ,,	54 33
,,	*Hc'*	$21\bar{2}$	b	,, ,,	68 15	,, ,,	67 58½
,,	*Ha*	012	b	,, ,,	77 20	,, ,,	78 7
,,	*Hb'*	$11\bar{2}$	b	,, ,,	84 49	,, ,,	84 28
,,	*He'*	$41\bar{2}$	f	49 37	44 32	,, ,,	44 27
,,	*Hd'*	$31\bar{2}$	f	,, ,,	54 36	,, ,,	54 33
,,	*Hc'*	$21\bar{2}$	f	,, ,,	68 2	,, ,,	67 58½
,,	*Hd*	312	b	49 40	41 36	,, ,,	41 26
,,	*Hc*	212	b	,, ,,	50 43	,, ,,	50 28
,,	*Hb*	112	b	,, ,,	62 13	,, ,,	62 37
,,	*Ha*	012	f	,, ,,	78 1	,, ,,	78 7
,,	*He'*	$41\bar{2}$	f	49 57	44 18	,, ,,	44 27
,,	*Hc*	212	b	,, ,,	50 30	,, ,,	50 28
,,	*Hd'*	$31\bar{2}$	b	,, ,,	54 28	,, ,,	54 33
,,	*Hb*	112	b	,, ,,	62 21	,, ,,	62 37
,,	*Hc'*	$21\bar{2}$	b	,, ,,	67 30	,, ,,	67 58½
,,	,,	,,	b	,, ,,	68 28	,, ,,	,, ,,
,,	*Ha*	012	f	,, ,,	77 55	,, ,,	78 7
,,	*Gw'*	$72\bar{3}$	b	55 20	45 30	56 26	45 20
,,	*Gx'*	$52\bar{3}$	b	,, ,,	57 10	,, ,,	56 52

II	*Gy′*	$32\bar{3}$	f	56° 13′	72° 19′	56° 26′	72° 26′
,,	*Gx*	523	b	,, ,,	44 15	,, ,,	44 12½
,,	*Gy*	323	f	,, ,,	55 5	,, ,,	55 21
,,	*Gz*	123	b	,, ,,	70 9	,, ,,	70 26½
,,	*Gz′*	$\bar{1}23$	b	,, ,,	88 30	,, ,,	88 54
,,	*Gy′*	$32\bar{3}$	b	56 14	72 42	,, ,,	72 26
,,	*Gx*	523	b	56 32	44 5	,, ,,	44 12½
,,	*Gz*	123	b	,, ,,	70 3	,, ,,	70 26½
,,	*Gy′*	$32\bar{3}$	b	,, ,,	73 48	,, ,,	72 26
I	*Ed′*	$62\bar{3}$	b	60 33	46 51	61 3	47 16
,,	*Ey′*	$32\bar{3}$	b	,, ,,	69 3	,, ,,	68 27½
,,	,,	,,	b	61 2	68 32	,, ,,	,, ,,
II	*Fc′*	$21\bar{1}$	b	64 0	59 58	64 24	60 17
,,	,,	,,	b	64 2	60 34	,, ,,	,, ,,
,,	*Fc*	211	b	64 11	49 11	,, ,,	48 32
,,	*Fb*	111	b	,, ,,	62 13	,, ,,	62 31
I	*Dd*	311	b	68 50	38 52	69 45½	39 5
,,	*Db*	111	b	69 41	65 12	,, ,,	64 37
,,	*Dd*	311	b	70 3	38 20	,, ,,	39 5
,,	*Db*	111	f	,, ,,	64 33	,, ,,	64 37
,,	*Cz*	121	b	78 28	76 6	79 33	76 2
,,	*Cx*	521	b	79 28	43 41	,, ,,	43 50
,,	*Cy*	321	b	,, ,,	57 14	,, ,,	57 10
,,	*Cz*	121	b	,, ,,	75 59	,, ,,	76 2
,,	*Cx′*	$52\bar{1}$	f	79 31	46 52	,, ,,	46 45½
,,	*Cy′*	$32\bar{1}$	b	,, ,,	62 3	,, ,,	61 25½
,,	*Cx′*	$52\bar{1}$	f	79 37	46 42	,, ,,	46 45½
,,	*Cy*	321	f	,, ,,	57 8	,, ,,	57 10
,,	*Cy′*	$32\bar{1}$	b	,, ,,	61 24	,, ,,	61 25½
,,	*Cz′*	$12\bar{1}$	b	,, ,,	81 30	,, ,,	81 35
,,	*Ca*	021	b	79 50	86 35	,, ,,	87 7
,,	*Cx*	521	f	79 59	43 44	,, ,,	43 50
,,	*Cz*	121	b	,, ,,	76 3	,, ,,	76 2
,,	*Cx′*	$52\bar{1}$	b	,, ,,	46 35	,, ,,	46 45½
,,	,,	11·1·0	b	89 25	12 54	90 0	12 42
,,	*Bh*	710	b	,, ,,	19 35	,, ,,	19 31
,,	*Bf*	510	b	,, ,,	26 39	,, ,,	26 23
,,	*Bd*	310	b	,, ,,	39 34	,, ,,	39 35
,,	*Bx*	520	s	,, ,,	45 0	,, ,,	44 46
,,	*Bc*	210	g	,, ,,	51 8	,, ,,	51 7
,,	*Bb*	110	b	,, ,,	68 1	,, ,,	68 2½
,,	*Bz*	120	b	,, ,,	78 24	,, ,,	78 36
,,	*Ba*	010	b	,, ,,	89 41	,, ,,	90 0
,,	*Bf*	510	b	89 55	26 11	,, ,,	26 23
,,	*Be*	410	b	,, ,,	31 50	,, ,,	31 48
,,	*Bd*	310	b	,, ,,	39 25	,, ,,	39 35
,,	*Bc*	210	b	,, ,,	50 26	,, ,,	51 7
,,	*By*	320	b	,, ,,	45 0	,, ,,	44 42½
,,	*Bb*	110	b	,, ,,	68 33	,, ,,	68 2½

(b) Co-ordinates from (001)—

III	*Of′*	$51\bar{4}$	b	28 57	59 33	28 12	59 35
,,	*Nv′*	$92\bar{7}$	b	30 43	60 21	30 54	60 26
II	*Kv′*	$92\bar{7}$	b	,, ,,	63 48	30 20	63 41
,,	*He′*	$41\bar{2}$	f	33 34	75 33	33 26	75 48½
,,	*Je′*	$41\bar{3}$	b	33 58	65 6	,, ,,	65 7
,,	*He′*	$41\bar{2}$	f	,, ,,	75 42	,, ,,	75 48½
,,	*Jd′*	$31\bar{3}$	b	41 34	57 38	41 36	57 46
,,	*Hd′*	$31\bar{2}$	f	,, ,,	69 14	,, ,,	69 22

III	*Od'*	$31\bar{4}$	b	42° 40′	45° 14′	42° 36′	45° 22½′
I	*Cx*	521	b	45 15	79 6	45 50	79 2½
,,	*Cx'*	$52\bar{1}$	f	45 50	86 52	47 0½	86 46
,,	,,	,,	b	46 11	86 52	,, ,,	,, ,,
II	*Gx'*	$52\bar{3}$	b	46 33	71 33	,, ,,	72 33
,,	*Ix'*	$52\bar{5}$	f	47 0	59 10	,, ,,	59 17
,,	,,	,,	b	47 24	58 58	,, ,,	,, ,,
III	*Px'*	$52\bar{9}$	f	48 9	38 3	48 13	38 13
I	*Bc*	210	g	52 7	80 16	52 9	80 19½
II	*Jc'*	$21\bar{3}$	b	53 30	49 30	53 34	49 36
,,	*Hc'*	$21\bar{2}$	f	,, ,,	61 18	,, ,,	61 29½
,,	*Jc'*	$21\bar{3}$	b	53 45	49 30	,, ,,	49 36
,,	*Hc'*	$21\bar{2}$	b	,, ,,	61 15	,, ,,	61 29½
,,	*Fc'*	$21\bar{1}$	b	,, ,,	76 19	,, ,,	76 46
III	*Oc'*	$21\bar{4}$	b	54 51	37 40	55 2	37 55½
I	*Ey'*	$32\bar{3}$	b	59 51	70 19	59 46	70 24
,,	,,	,,	b	60 10	69 31	,, ,,	,, ,,
,,	*Cy'*	$32\bar{1}$	b	60 33	88 6	,, ,,	88 33
II	*Ky'*	$32\bar{7}$	b	61 18	41 5	61 28	41 8
,,	*Iy'*	$32\bar{5}$	f	,, ,,	50 56	,, ,,	51 2½
,,	*Gy'*	$32\bar{3}$	b	,, ,,	64 31	,, ,,	64 43
,,	*Iy'*	$32\bar{5}$	f	61 46	50 50	,, ,,	51 2½
,,	*Gy'*	$32\bar{3}$	b	,, ,,	64 16	,, ,,	64 43
III	*Py'*	$32\bar{9}$	b	63 13	31 33	63 12	31 44
II	*Hb*	112	b	66 30	47 21	66 52	47 25½
,,	*Fb*	111	b	,, ,,	60 1	,, ,,	60 27½
I	*Db*	111	b	68 51	65 23	68 46	65 25
,,	*Bb*	110	b	,, ,,	84 14	,, ,,	84 15
II	*Jb'*	$11\bar{3}$	b	70 28	42 13	70 43	42 16
,,	*Kz*	127	b	76 46	33 58	76 53	34 3½
,,	*Iz*	125	f	,, ,,	41 59	,, ,,	42 6
,,	*Gz*	123	b	,, ,,	53 17	,, ,,	53 43
I	*Cz'*	$12\bar{1}$	b	78 44	84 5	79 0½	82 19
,,	*Bz*	120	b	,, ,,	87 5	,, ,,	86 58
II	*Iz'*	$12\bar{5}$	f	81 6	44 20	81 10	44 32½
,,	*Gz'*	$12\bar{3}$	b	,, ,,	56 43	,, ,,	57 28
,,	*Iz'*	$12\bar{5}$	f	81 34	44 23	,, ,,	44 32½
,,	*Gz'*	$12\bar{3}$	b	,, ,,	56 44	,, ,,	57 28
,,	*Ha*	012	b	87 23	48 2	87 46½	48 19
,,	*Ja*	013	f	87 51	38 0	,, ,,	38 9½
,,	*Ha*	012	f	,, ,,	48 6	,, ,,	48 19

(c) Co-ordinates from (101)—

III	*Of'*	$51\bar{4}$	b	24 18	85 34	24 7½	85 42½
,,	*Nv'*	$92\bar{7}$	b	26 12	85 34	26 37	85 37½
,,	*Oe'*	$41\bar{4}$	b	26 46	85 44	,, ,,	86 21
,,	*Pw'*	$72\bar{9}$	f	,, ,,	78 20	,, ,,	78 28½
,,	*Qd'*	$31\bar{5}$	b	,, ,,	70 48	,, ,,	71 1
II	*Kv'*	$92\bar{7}$	b	27 20	82 17	27 10½	82 22
III	*Px'*	$52\bar{9}$	g	29 48	68 48	29 38	68 53
,,	*Od'*	$31\bar{4}$	b	,, ,,	76 52	,, ,,	76 58
II	*Je'*	$41\bar{3}$	f	30 25	81 48	30 19	81 56
,,	*Kw'*	$72\bar{7}$	b	,, ,,	89 12	,, ,,	89 4
III	*Py'*	$32\bar{9}$	f	33 25	58 31	33 20	58 42
,,	*Oc'*	$21\bar{4}$	f	,, ,,	66 17	,, ,,	66 26
,,	*He'*	$41\bar{2}$	b	34 16	72 11	34 10½	71 56
,,	*Iw'*	$72\bar{5}$	b	,, ,,	81 40	,, ,,	81 27
,,	*Id'*	$31\bar{3}$	b	,, ,,	88 21	,, ,,	88 33
,,	,,	,,	f	34 20	88 29	,, ,,	,, ,,

III	*Gw'*	62$\bar{3}$	b	89° 4′	70° 54′	88° 59½′	70° 20½′
,,	*Hd'*	31$\bar{2}$	f	,, ,,	80 55	,, ,,	80 53½
,,	*Ix'*	52$\bar{5}$	f	,, ,,	87 54	,, ,,	87 54½
,,	*Ky'*	32$\bar{7}$	f	,, ,,	66 45	,, ,,	66 48
,,	*Jc'*	21$\bar{3}$	f	,, ,,	76 50	,, ,,	76 52
,,	*Hd'*	31$\bar{2}$	b	89 10	81 18	,, ,,	80 53½
,,	*Ix'*	52$\bar{5}$	b	,, ,,	87 40	,, ,,	87 54½
,,	*Jc'*	21$\bar{3}$	b	,, ,,	77 0	,, ,,	76 52
,,	*Jb'*	11$\bar{3}$	f	45 8	63 44	45 4	63 45
,,	*Iy'*	32$\bar{5}$	f	,, ,,	74 44	,, ,,	74 48
,,	*Hc'*	21$\bar{2}$	g	,, ,,	87 1	,, ,,	87 7½
,,	,,	,,	b	,, ,,	86 56	,, ,,	,, ,,
,,	*Jb'*	11$\bar{3}$	b	,, ,,	63 45	,, ,,	63 45
,,	*Iy'*	32$\bar{5}$	b	,, ,,	74 40	,, ,,	74 48
,,	*Iz'*	12$\bar{5}$	f	52 48	60 30	52 45½	60 32
,,	*Hb'*	11$\bar{2}$	b	,, ,,	72 17	,, ,,	72 28½
,,	*Fc'*	21$\bar{1}$	b	,, ,,	80 1	,, ,,	79 40
,,	*Gy'*	32$\bar{3}$	b	,, ,,	85 55	,, ,,	86 11
I	*Bd*	310	b	54 27	51 31	54 31½	51 29
,,	*Cx'*	52$\bar{1}$	f	,, ,,	61 30	,, ,,	61 35
,,	,,	,,	b	54 40	61 39	,, ,,	,, ,,
,,	*Ey'*	32$\bar{3}$	b	,, ,,	88 10	,, ,,	88 12
II	*Ha*	012	b	62 20	57 16	62 24½	57 22
,,	*Iz*	125	f	62 26	47 27	,, ,,	47 27
,,	*Ha*	012	f	,, ,,	57 19	,, ,,	57 22
,,	*Gz'*	12$\bar{3}$	b	,, ,,	69 19	,, ,,	70 8
I	*Cx*	521	b	64 33	48 52	64 35	48 56½
,,	*Bc*	210	b	,, ,,	59 19	,, ,,	59 31½
,,	*Cy'*	32$\bar{1}$	b	,, ,,	73 50	,, ,,	72 59½
,,	*Cx*	521	b	64 34	48 45	,, ,,	48 56½
,,	*Bc*	210	g	,, ,,	59 24	,, ,,	59 31½
,,	*Cy'*	32$\bar{1}$	b	,, ,,	72 56	,, ,,	72 59½
,,	,,	,,	b	65 6	73 47	,, ,,	,, ,,
II	*Iy*	325	f	74 6	87 24	74 5½	87 24
,,	*Hb*	112	f	,, ,,	44 30	,, ,,	44 48
,,	*Gz*	123	f	,, ,,	54 18	,, ,,	54 45½
I	*Bz*	120	b	83 15	80 46	83 13½	80 49
,,	*Hc*	212	b	87 16	36 22	87 17	36 4½
,,	*Gy*	323	b	,, ,,	43 15	,, ,,	43 20
,,	*Fb*	111	b	,, ,,	52 50	,, ,,	53 13
(d) Co-ordinates from (10$\bar{1}$)—							
I	*Bf*	510	b	33 0	55 31	32 37½	55 31
II	*Ks*	127	b	36 12	68 9	36 2	68 0
,,	*Iy*	325	b	,, ,,	82 57	,, ,,	82 56
,,	*Hc*	212	b	,, ,,	89 8	,, ,,	89 6
III	*Py'*	32$\bar{9}$	b	39 58	46 51	40 6	46 47½
II	*Ja*	013	f	43 22	64 16	43 16	64 15
,,	*Is*	125	f	,, ,,	72 19	,, ,,	72 17½
,,	*Hb*	112	b	,, ,,	81 28	,, ,,	81 7
,,	*Gy*	323	b	,, ,,	89 25	,, ,,	89 36½
I	*Bd*	310	b	46 49	60 42	46 51	60 51
,,	*Cx*	521	b	,, ,,	68 59	,, ,,	68 59
III	*Qd'*	31$\bar{5}$	b	48 40	34 33	48 49	34 15½
,,	*Px'*	52$\bar{9}$	b	,, ,,	37 54	,, ,,	37 48
,,	*Oc'*	21$\bar{4}$	b	,, ,,	42 4	,, ,,	42 0½
II	*Ky'*	32$\bar{7}$	f	52 46	46 19	53 8	46 15
,,	*Jb'*	11$\bar{3}$	b	,, ,,	52 32	,, ,,	52 31
,,	*Is'*	12$\bar{5}$	f	,, ,,	60 6	,, ,,	

II	*Ha*	012	f	52° 46′	68° 52′	53° 8′	68° 53′
,,	*Gz*	123	f	,, ,,	78 55	,, ,,	78 55
,,	*Fb*	111	b	,, ,,	89 40	,, ,,	89 41
,,	*Ib′*	$11\bar{3}$	b	52 47	52 35	,, ,,	52 31
,,	*Iz′*	$12\bar{5}$	b	,, ,,	60 8	,, ,,	60 2
,,	*Ha*	012	b	,, ,,	68 58	,, ,,	68 53
,,	*Gz*	123	b	,, ,,	79 1	,, ,,	78 55
I	*Bc*	210	b	57 30	66 2	58 0	66 37½
,,	*Cx′*	$52\bar{1}$	f	58 2	57 29	,, ,,	57 37½
,,	*Bc*	210	g	,, ,,	66 36	,, ,,	66 37½
,,	*Db*	111	b	58 4	88 21	,, ,,	88 21½
,,	*Cx′*	$52\bar{1}$	b	58 22	77 28	,, ,,	77 1½
,,	*Cy*	321	b	,, ,,	57 36	,, ,,	57 37½
,,	*Db*	111	b	,, ,,	88 10	,, ,,	88 21½
III	*Pw′*	$72\bar{9}$	f	60 39	30 18	60 39	30 14½
,,	*Od′*	$31\bar{4}$	b	,, ,,	33 40	,, ,,	33 33
II	*He′*	$41\bar{2}$	f	63 48	36 34	63 26	36 40
,,	*Gz′*	$12\bar{3}$	b	65 36	65 19	66 22½	65 24
,,	*Jc′*	$21\bar{3}$	b	65 41	41 50	,, ,,	41 58
,,	*Iy′*	$32\bar{5}$	b	,, ,,	48 21	,, ,,	48 13
,,	*Hb′*	$11\bar{2}$	b	,, ,,	56 7	,, ,,	55 57
,,	*Gz′*	$12\bar{3}$	b	,, ,,	64 45	,, ,,	65 24
,,	*Jc′*	$21\bar{3}$	b	66 30	42 8	,, ,,	41 58
,,	*Iy′*	$32\bar{5}$	b	,, ,,	48 15	,, ,,	48 13
I		$11\bar{2}$	b	72 25	56 30	72 39	56 0
,,	*Ez′*	$12\bar{3}$	b	,, ,,	65 50	,, ,,	65 53½
,,	*Da*	011	?	,, ,,	80 20	,, ,,	78 5
,,	*Cz*	121	b	,, ,,	89 5	,, ,,	89 5
,,	*Cy′*	$32\bar{1}$	b	72 47	64 41	,, ,,	64 48½
,,	*Bb*	110	b	,, ,,	76 8	,, ,,	76 20
,,	*Cz*	121	b	,, ,,	89 5	,, ,,	89 5
II	*Fe′*	$21\bar{1}$	b	79 45	52 29	79 23	52 50
,,	*Kv′*	$92\bar{7}$	b	79 46	27 45	,, ,,	27 25
,,	*Je′*	$41\bar{3}$	f	,, ,,	30 34	,, ,,	30 34
,,	*Iw′*	$72\bar{5}$	b	,, ,,	34 26	,, ,,	34 25
,,	*Hd′*	$31\bar{2}$	f	,, ,,	39 10	,, ,,	39 12
,,	*Gx′*	$52\bar{3}$	b	80 15	44 30	,, ,,	45 14
,,	*Je′*	$41\bar{3}$	b	80 30	30 24	,, ,,	30 34
,,	*Iw′*	$72\bar{5}$	b	,, ,,	34 14	,, ,,	34 25
,,	*Hd′*	$31\bar{2}$	b	,, ,,	39 5	,, ,,	39 12
,,	*Fc′*	$21\bar{1}$	b	,, ,,	52 43	,, ,,	52 50
,,	*Kw′*	$72\bar{7}$	b	82 7	30 33	82 52½	30 34
,,	*Jd′*	$31\bar{3}$	b	,, ,,	34 33	,, ,,	34 28
,,	*Ix′*	$52\bar{5}$	f	,, ,,	39 21	,, ,,	39 19
,,	*Hc′*	$21\bar{2}$	b	,, ,,	45 23	,, ,,	45 26½
,,	*Gy′*	$32\bar{3}$	b	,, ,,	53 3	,, ,,	53 11
,,	*Kw′*	$72\bar{7}$	b	82 58	30 30	,, ,,	30 34
,,	*Jd′*	$31\bar{3}$	f	,, ,,	34 35	,, ,,	34 28
,,	*Ix′*	$52\bar{5}$	f	,, ,,	39 20	,, ,,	39 19
,,	*Hc′*	$21\bar{2}$	f	,, ,,	45 21	,, ,,	45 26½
,,	*Gy′*	$32\bar{3}$	f	,, ,,	52 56	,, ,,	53 11
III	*Of′*	$51\bar{4}$	b	86 33	24 20	86 25½	24 6
,,	*Nv′*	$92\bar{7}$	b	,, ,,	26 33	,, ,,	26 35
I	*Ey′*	$32\bar{3}$	b	89 3	54 30	90 0	54 29
,,	,,	,,	b	89 40	54 24	,, ,,	,, ,,
,,	*Cz′*	$12\bar{1}$	b	89 56	76 54	,, ,,	76 37
,,	*Ba*	010	b	,, ,,	89 48	,, ,,	90 0

Crystal No. 2 (*fig.* 5).

This tiny crystal (Trechmann's No. 6; B.M. 1917, 392), which measures about 1 mm. in length and about 0·2 by 0·2 mm. in cross-section, originally formed, as has been explained, with the preceding crystal opposite ends of a single individual. According to Trechmann[1] the central portion of this individual was overlain by a similar one, almost at right angles to it, and he mentions the suggestion made by Baumhauer[2] that such a conjunction, which has several times been observed, resulted from twinning. That may be true, because, as will be seen from the gnonomic projection (fig. 10), twinning about at least

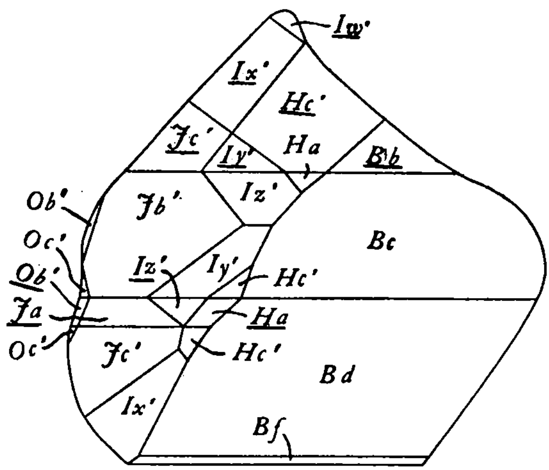

FIG. 5. Sartorite crystal No. 2.

four poles, viz. *Bx*, *Gx'*, *Hc'*, *Iz'*, would result in the prism-zones of the two individuals crossing nearly at right angles. Actual measurement of such a group will, however, be necessary before the existence of twinning of this kind can be accepted; in the case of Trechmann's crystals 3 and 4 the mutual relation is not ordinary twinning (cf. p. 268).

Altogether, 19 pyramidal faces, representing 14 forms, and 7 dome-faces, representing 7 forms, were observed; as is implied by the latter half of the statement, only one half of the dome-zone is developed. Some of the pyramidal faces are striated parallel to the edge of the zone connecting them with (100), the result of repeated twinning about the latter. Except for the faces of the form (100), the prism-zone is much

[1] Loc. cit., p. 226. [2] Loc. cit., p. 251.

striated, and gives bands of reflections extending over wide angles; in the table below the angles given refer to the positions of the brightest portions of these bands. Cross-zonal measurements were not made, because the pyramidal faces were neither sufficiently numerous nor well enough developed for the purpose. The calculated values of the co-ordinate angles were determined from the same elements as in the case of the preceding crystal. It will be noticed that in the case of the zone with azimuthal angle 44° 6′ the oscillation between the faces *Iy′* and *Iz′* of the twin-individuals has led to the formation of intermediate vicinal faces, the polar distances of which are 80° 27′ and 83° 40′. There is a small twinned sector on the right-hand side of the crystal in the position of the drawing; the development here is most oscillatory, but it would only have confused the drawing to have attempted to depict this feature. The pyramidal forms *Ry′* ($3{\cdot}2{\cdot}\bar{1}\bar{1}$) and *Ob′* ($11\bar{4}$) were not observed on the preceding crystal.

Table V. Calculated and observed values of the co-ordinate angles from (100).

Face.			Refl.	Observed.		Calculated.	
Lattice.	Symbols.	Indices.		ϕ	ρ	ϕ	ρ
	Aw′	702	f	0° 0′	16° 9′	0° 0′	15° 44′
	Ab′	101	s	,, ,,	50 9	,, ,,	50 48
		3.0.10	s	,, ,,	87 19	,, ,,	87 8
		16.0.5	b	,, ,,	17 3	,, ,,	17 15
		304	s	,, ,,	42 15	,, ,,	42 20
		105	s	,, ,,	63 6	,, ,,	63 35½
	Aa	001	s	,, ,,	74 18	,, ,,	74 28
	Ad	301	b	,, ,,	15 38	,, ,,	15 42
		207	s	,, ,,	59 31	,, ,,	59 22
		$80\bar{3}$	b	,, ,,	20 29	,, ,,	20 46
		$50\bar{3}$	b	,, ,,	33 33	,, ,,	32 55
	Ab′	$10\bar{1}$	s	,, ,,	51 6	,, ,,	50 48
III	*Ry′*	$3.2.\bar{1}\bar{1}$	b	24 10	87 10	23 58	87 39
,,	*Ob′*	$11\bar{4}$	b	30 22	85 51	30 31	85 41
,,	*Oc′*	$21\bar{4}$	b	30 30	84 13	,, ,,	82 38
II	*Jc′*	$21\bar{3}$	b	39 24	75 3	39 25	74 48
,,	*Ja*	013	b	,, ,,	76 5	,, ,,	76 23
,,	*Jb′*	$11\bar{3}$	f	,, ,,	89 11	,, ,,	89 6
,,	*Jc′*	$21\bar{3}$	f	39 26	74 46	,, ,,	74 48
,,	*Jb′*	$11\bar{3}$	f	,, ,,	89 18	,, ,,	89 6
,,	*Ix′*	$52\bar{5}$	b	44 6	64 51	44 5	64 39½
,,	*Iy′*	$32\bar{5}$	b	,, ,,	80 2	,, ,,	79 4

II	*Iz′*	$12\bar{5}$	b	44° 6′	83° 40′	44° 5′	85° 0′
,,	,,	,,	b	,, ,,	84 45	,, ,,	,, ,,
,,	*Iw′*	$72\bar{5}$	b	,, ,,	53 8	,, ,,	52 59
,,	*Ix′*	$52\bar{5}$	g	,, ,,	64 41	,, ,,	64 38
,,	*Iy′*	$32\bar{5}$	b	,, ,,	78 57	,, ,,	79 4
,,	,,	,,	b	,, ,,	80 29	,, ,,	,, ,,
,,	*Hc′*	$21\bar{2}$	b	49 35	68 38	·49 42	67 58½
,,	*Ha*	012	b	,, ,,	77 15	,, ,,	78 7
,,	*Hc′*	$21\bar{2}$	g	49 38	67 57	,, ,,	67 58½
,,	*Ha*	012	b	,, ,,	77 0	,, ,,	78 7
I	*Cz*	121	b	77 10	76 55	79 33	76 2
,,		910	b	89 59	14 45	90 0	15 24
,,	*Bh*	710	b	,, ,,	19 29	,, ,,	19 31
,,	*Bf*	510	b	,, ,,	26 24	,, ,,	26 28
,,	*Bd*	310	g	,, ,,	39 36	,, ,,	39 35
,,	*Bx*	520	b	,, ,,	44 40	,, ,,	44 46
,,	*Bc*	210	g	,, ,,	51 8	,, ,,	51 7
,,	*Bb*	110	b	,, ,,	68 1	,, ,,	68 2½

Crystal No. 3 (fig. 6).

This crystal (B.M. 1917, 400), which measures about 1 mm. in length and 2 by 1 mm. in cross-section, was acquired by Trechmann subsequent to the publication of his paper; he included it with the other crystals presented by him to the British Museum in 1917. It is noteworthy for the unusual smoothness of the prism-zone and the comparative absence of signs of distortion; on rotation of the crystal about the zone-edge when the zone was in adjustment, practically all the images crossed the field of the telescope of the goniometer accurately bisected by the horizontal wire. The measurements made in the zone are consequently exceptionally trustworthy. A face affording a sharp image of the object-slit was in the position corresponding to $(10\bar{1})$; it rarely happens that the cross-zones meet the prism-zone in faces giving such good reflections. The nearer face of the form (100) as seen in the figure, although it is step-like in character, gives an excellently defined image, the various parts being strictly parallel to one another. On the opposite side, on the other hand, the face is very narrow, being almost linear in character and the reflection is consequently faint and diffuse. The faces in the dome-zone are brilliant and relatively large. The uncommon face (010) occurs in the curious form of a bevelling of only part of the edge common to the two adjacent faces of the form *Bb*. The small triangular face alongside it gives an indistinct reflection corresponding to a face of the form $(\bar{1}23)$ in lattice II; this form has, however, not been observed on any other crystal, and it remains doubtful whether the plane is really a face of the crystal. The pyramidal faces, which, except for the one just referred to, occur only on the bottom right-hand corner of the crystal in the position of the figure, give mostly excellent reflections; all the faces belong to lattice II, not a single face of the third lattice being observed. As customary, the stippled portions of the figure indicate broken or incompletely developed portions of the crystal.

Altogether, on the end of the crystal, observations were made of 12 dome-faces, representing 7 different forms, and of 11 pyramidal faces,

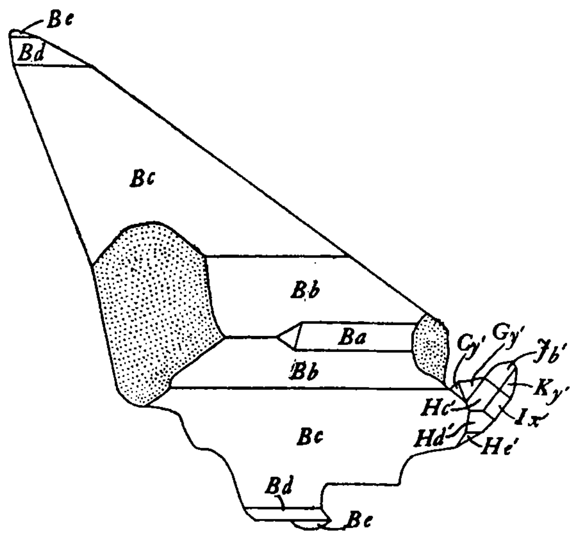

Fig. 6. Sartorite crystal No. 3.

all belonging to different forms. The elements of the crystal and the co-ordinate angles of the various forms were computed from the following angles:—(100) : (001) = 75° 27′ (the observed value), (100) : (101) = 37° 26′ (observed value 37° 42′; no weight was attached to this angle because the setting was far from trustworthy), (100) : (10$\bar{1}$) = 51° 47′ (the observed value), (100) : (110) = 68° 1′ (the value calculated from the measurements obtained for all the faces in the zone). The values of f and A defining the shear are—

	f	A
(100) ...	0·200 ...	0·38560
(001) ...	0·150 ...	0·39074
(101) ...	0·025 ...	0·49076
(10$\bar{1}$) ...	0·175 ...	0·63434

Elements of the Lattices.

I. $a:b:c = 2{\cdot}5583:1:2{\cdot}5938$; $\beta = 104°\ 33'$.

II. $a:b:c = 2{\cdot}6224:1:2{\cdot}6015$;

$(010):(001) = 84°\ 35'$, $(001):(100) = 75°\ 27'$, $(100):(010) = 85°\ 24'$;

$\alpha = 94°\ 25'$, $\beta = 104°\ 13'$, $\gamma = 93°\ 23'$.

No faces belonging to the third lattice were observed.

Table VI. Calculated and observed values of the co-ordinate angles.

Face.			Refl.	Observed.		Calculated.	
Lattice.	Symbol.	Indices.		ϕ	ρ	ϕ	ρ
(a) Co-ordinates from (100)—							
	Af'	$50\bar{1}$	f	0° 0'	11° 24'	0° 0'	11° 22'
	Aw'	$70\bar{2}$	f	,, ,,	16 30	,, ,,	16 22
		$70\bar{3}$	s	,, ,,	24 38	,, ,,	24 36½
	Ay'	$30\bar{2}$	b	,, ,,	37 50	,, ,,	37 20
		$90\bar{7}$	f	,, ,,	42 27	,, ,,	42 37½
	Ab'	$10\bar{1}$	g	,, ,,	51 47	,, ,,	51 47
		$40\bar{7}$	b	,, ,,	71 50	,, ,,	71 17
	Az'	$10\bar{2}$	b	,, ,,	74 43	,, ,,	75 13
		$5{\cdot}0{\cdot}\bar{1}\bar{1}$	b	,, ,,	77 43	,, ,,	77 47½
		$20\bar{5}$	f	,, ,,	80 45	,, ,,	80 57
	Ad	301	f	,, ,,	16 59	,, ,,	16 24
		$80\bar{3}$	f	,, ,,	21 39	,, ,,	21 33
		503	b	,, ,,	26 48	,, ,,	26 31
	Ac'	$20\bar{1}$	f	,, ,,	27 30	,, ,,	28 36
	Az	102	b	,, ,,	51 47	,, ,,	51 56
		107	s	,, ,,	68 0	,, ,,	67 45
		$5{\cdot}0{\cdot}\bar{1}\bar{1}$	g	,, ,,	77 58	,, ,,	77 47½
	Af'	$50\bar{1}$	f	,, ,,	11 32	,, ,,	11 22
		$70\bar{5}$	s	,, ,,	39 16	,, ,,	39 40
	Ab'	$10\bar{1}$	b	,, ,,	52 5	,, ,,	51 47
	Ad	301	f	,, ,,	16 50	,, ,,	16 24
		503	s	,, ,,	27 9	,, ,,	26 31
	Ab	101	s	,, ,,	35 46	,, ,,	37 26
II	*Ky'*	$32\bar{7}$	g	35 8	83 58	35 1½	84 16
,,	*Jb'*	$11\bar{3}$	g	39 4	88 55	39 1	89 10
,,	*Ix'*	$52\bar{5}$	g	43 55	64 44	43 51	64 49½
,,	*Iy'*	$32\bar{5}$	b	,, ,,	78 52	,, ,,	79 13
,,	*He'*	$41\bar{2}$	f	49 44	44 28	49 41½	44 30½
,,	*Hd'*	$31\bar{2}$	g	,, ,,	54 36	,, ,,	54 39
,,	*Hc'*	$21\bar{2}$	g	,, ,,	68 10	,, ,,	68 7
,,	*Hb'*	$11\bar{2}$	b	,, ,,	83 11	,, ,,	84 38½
,,	*Gy'*	$32\bar{3}$	g	56 43	72 42	56 45	72 36
,,		$12\bar{3}$	b	75 30	86 30	74 54	86 4

I	*Cy'*	$32\bar{1}$	b	79° 28'	60° 41'	79° 5'	61° 23½'
,,	*Bf*	510	f	90 0	26 21½	90 0	26 21
,,	*Bv*	920	f	,, ,,	28 44	,, ,,	28 49½
,,	*Be*	410	f	,, ,,	31 50	,, ,,	31 46
,,	*Bd*	310	f	,, ,,	39 37	,, ,,	39 33
,,	*Bc*	210	g	,, ,,	51 5	,, ,,	51 5
,,	*Bb*	110	g	,, ,,	67 59	,, ,,	68 1
,,	*Ba*	010	f	,, ,,	90 0	,, ,,	90 0
,,	*Bf*	510	f	,, ,,	26 27	,, ,,	26 21
,,	*Be*	410	f	,, ,,	31 46	,, ,,	31 46
,,	*Bd*	310	g	,, ,,	39 34	,, ,,	39 33
,,	*Bc*	210	g	,, ,,	51 1	,, ,,	51 5
,,	*Bb*	110	g	,, ,,	68 1	,, ,,	68 1
(b) Co-ordinates from (001)—							
II	*He'*	$41\bar{2}$	f	33 44	74 50	33 37	74 56
,,	*Hd'*	$31\bar{2}$	g	42 4	68 31	41 55	68 34
,,	*Ix'*	$52\bar{5}$	g	47 36	58 22	47 26½	58 20
I	*Bc*	210	g	51 58	80 54	51 59½	80 55
II	*Hc'*	$21\bar{2}$	g	54 27	60 46	54 8	60 50
,,	*Ky'*	$32\bar{7}$	g	62 30	40 23	62 11	40 13
,,	*Iy'*	$32\bar{5}$	b	,, ,,	50 0	,, ,,	50 18
,,	*Gy'*	$32\bar{3}$	g	,, ,,	64 21	,, ,,	64 27
I	*Bb*	110	g	68 40	84 38	68 39	84 36
,,	*Ba*	010	f	89 55	89 54	90 0	90 0
(c) Co-ordinates from (101)—							
II	*Ky'*	$32\bar{7}$	g	38 55	65 31	38 54	65 25
,,	*Ix'*	$52\bar{5}$	g	,, ,,	86 36	,, ,,	86 37
,,	*Hd'*	$31\bar{2}$	g	39 6	82 6	,, ,,	82 1½
I	*Bf*	510	g	,, ,,	44 45	39 11	44 38½
II	*Jb'*	$11\bar{3}$	g	45 12	62 38	45 11	62 34
,,	*Hc'*	$21\bar{2}$	g	,, ,,	85 54	,, ,,	86 2½
I	*Be*	410	b	,, ,,	47 45	45 3	47 32
II	*Hb'*	$11\bar{2}$	b	53 15	71 19	53 11	71 30
,,	*Gy'*	$32\bar{3}$	g	,, ,,	85 10	,, ,,	85 23
I	*Bd*	310	f	53 38	52 22	53 38½	52 15
,,	*Bc*	210	g	63 54	60 10	63 51½	60 5
,,	*Cy'*	$32\bar{1}$	b	,, ,,	73 18	,, ,,	73 47
,,	*Db'*	$11\bar{1}$	b	,, ,,	89 37	,, ,,	89 39
,,	*Bb*	110	g	76 14	72 44	76 13	72 42½
(d) Co-ordinates from ($10\bar{1}$)—							
II	*Ky'*	$32\bar{7}$	b	53 31	45 16	53 18	45 25
,,	*Jb'*	$11\bar{3}$	f	,, ,,	51 39	,, ,,	51 44
I	*Bc*	210	g	57 44	67 2	57 37	67 8
II	*He'*	$41\bar{2}$	f	62 30	37 4	62 22½	37 6½
,,	*Ix'*	$52\bar{5}$	g	84 28	39 2	83 40	39 7
,,	*Hc'*	$21\bar{2}$	g	,, ,,	45 26	,, ,,	45 24
,,	*Gy'*	$32\bar{3}$	g	,, ,,	53 24	,, ,,	53 24½

Crystal No. 4 (*fig.* 7).

This crystal (B.M. 83976), which measures about 1 mm. in length and 1 by 1 mm. in cross-section, was acquired by the Trustees of the British Museum in 1898. The prism-zone is of the customary grooved character and its re-entrant appearance is no doubt due to twinning;

here and there it is comparatively smooth and affords correspondingly distinct reflections. The dome-zone again is large, and the faces are smooth and give brilliant reflections. On the lower corner in the position of the figure appear a number of pyramidal faces. The curious tongue-shape of this corner will be noticed. The face *Jb′* has been bent parallel to the left-hand edge, and gives therefore a double image. This distortion is responsible for the shifting of the face (100) nearly a degree (0° 56′) from the position defined as the intersection of the

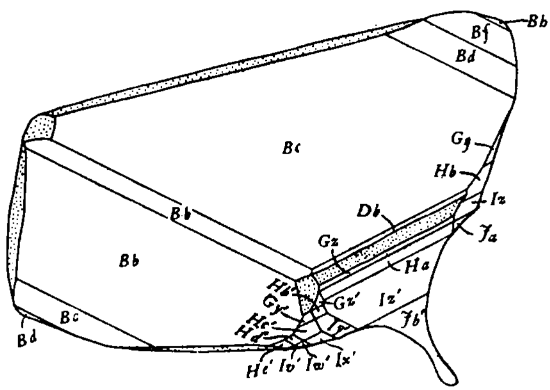

FIG. 7. Sartorite crystal No. 4.

prism- and dome-zones. The stippling indicates as usual imperfectly developed portions of the crystal. A region of this kind separates the dome-zone from the large faces of the second lattice, and may result from the shear giving rise to the latter. No face belonging to the third lattice is present. Reflections corresponding to the forms *Ju′*, *Jx′* were given off the upper rounded edge of the crystal in the position of the drawing; but it is open to question whether they are genuine crystal-faces, since they have not been observed on any other crystal, and, moreover, belong not to the ordinary group—*Jb*, *Jc*, &c.—but to the intermediate one, which has seldom been observed in the case of any zone.

Altogether, on the end of the crystal, observations were made of 10 dome-faces representing 6 different forms, and of 27 pyramidal faces, representing 25 different forms. The elements of the crystal and the co-ordinate angles of the various forms were computed from the following angles:—(100):(101) = 33° 40′ (the observed value),

$(100):(10\bar{1}) = 52° 52'$ (the observed value), $(100):(210) = 51° 2'$ (the better observed value); no trustworthy setting for the pole (001) was obtainable. The values of f and A defining the shear are:—

		f		A
(100)	...	0·375	...	0·35808
(001)	...	0·085	...	0·37876
(101)	...	0·230	...	0·44832
$(10\bar{1})$	...	0·145	...	0·64474

Elements of the Lattices.

I. $a:b:c = 2{\cdot}6395:1:2{\cdot}7929$; $\beta = 110° 25'$.

II. $a:b:c = 2{\cdot}6433:1:2{\cdot}8176$;

$(010):(001) = 82° 31'$, $(001):(100) = 69° 35'$, $(100):(010) = 89° 71'$;

$\alpha = 97° 39'$, $\beta = 110° 29'$, $\gamma = 91° 51'$.

Table VII. Calculated and observed values of the co-ordinate angles.

Face.			Refl.	Observed.		Calculated.	
Lattice.	Symbol.	Indices.		ϕ	ρ	ϕ	ρ
(a) Co-ordinates from (100)—							
	Ad	301	b	0° 0′	14° 10′	0° 0′	14° 54′
	Ac	201	s	,, ,,	21 32	,, ,,	20 49
		$40\bar{5}$	s	,, ,,	61 59	,, ,,	62 1
	Aa	001	s	,, ,,	70 17	,, ,,	69 35½
	Ay′	$30\bar{2}$	g	,, ,,	36 41	,, ,,	37 6½
		$40\bar{3}$	b	,, ,,	40 26	,, ,,	41 25
		$90\bar{7}$	b	,, ,,	42 43	,, ,,	42 48
		$10\bar{1}$	f	,, ,,	53 13	,, ,,	52 52
		$10\bar{5}$	f	,, ,,	81 27	,, ,,	81 45
		304	b	,, ,,	39 39	,, ,,	39 22
		105	b	,, ,,	82 40	,, ,,	81 41
		$10\bar{3}$	f	,, ,,	89 27	,, ,,	89 45
		100	g	,, ,,	0 56	,, ,,	0 0
	Aw′	$70\bar{2}$	s	,, ,,	15 50	,, ,,	15 36
	Ad′	$30\bar{1}$	f	,, ,,	18 37	,, ,,	18 21
		$70\bar{4}$	g	,, ,,	31 25	,, ,,	31 56
	Ab	101	b	,, ,,	34 19	,, ,,	33 40
		$50\bar{4}$	s	,, ,,	42 58	,, ,,	43 53
	Ab′	$10\bar{1}$	b	,, ,,	52 2	,, ,,	52 52
	Av′	$90\bar{2}$	f	,, ,,	83 1	,, ,,	83 6
		$10\bar{4}$	b	,, ,,	85 40	,, ,,	84 52
II	*Kv′*	$92\bar{7}$	b	35 0	52 0	35 47	51 55½
,,	*Ja*	013	b	39 32	75 53	39 36	75 14
,,	*Ju′*	$11.2.\bar{6}$	b	39 35	40 42	,, ,,	40 51

II	*Jd'*	$31\bar{3}$	b	39° 38'	62° 30'	39° 36'	62° 59'
,,	*Jx'*	$52\bar{6}$	b	,, ,,	69 0	,, ,,	69 9
,,	*Jb'*	$11\bar{3}$	f	,, ,,	89 53	,, ,,	89 40
,,	*Iz*	125	b	44 10	69 29	44 10	69 26
,,	*Iv'*	$92\bar{5}$	b	44 16	44 21	,, ,,	44 18
,,	*Iw'*	$72\bar{5}$	b	,, ,,	53 8	,, ,,	53 23
,,	*Ix'*	$52\bar{5}$	b	,, ,,	64 51	,, ,,	65 14
,,	*Iy'*	$32\bar{5}$	f	,, ,,	79 52	,, ,,	79 49
,,	*Iz'*	$12\bar{5}$	f	,, ,,	84 32	,, ,,	84 10
,,	*He'*	$41\bar{2}$	b	49 25	44 15	49 37	44 30
,,	*He'*	$41\bar{2}$	b	49 36	44 35	,, ,,	,, ,,
,,	*Hd'*	$31\bar{2}$	b	,, ,,	54 23	,, ,,	54 39
,,	*Hc'*	$21\bar{2}$	f	,, ,,	67 57	,, ,,	68 8½
,,	*Hb'*	$11\bar{2}$	b	,, ,,	84 14	,, ,,	84 41
,,	*Hb*	112	b	,, ,,	62 32	,, ,,	62 23½
,,	*Ha*	012	b	,, ,,	78 25	,, ,,	77 52
,,	*Gy'*	$32\bar{3}$	b	55 40	71 55	56 6½	72 1
,,	*Gy*	323	b	55 57	56 19	,, ,,	55 41
,,	*Gz*	123	b	,, ,,	71 15	,, ,,	70 52
,,	*Gz'*	$12\bar{3}$	b	,, ,,	89 50	,, ,,	89 22
I	*Db*	111	b	69 58	62 54	70 18	63 9
,,	,,	,,	b	,, ,,	63 42	,, ,,	,, ,,
,,	*Cx'*	$52\bar{1}$	b	79 0	45 50	79 51	47 5
,,	*Cy*	321	b	79 15	56 56	,, ,,	56 28
,,	*Bi*	810	g	89 53	17 4	90 0	17 10½
,,	*Bf*	510	b	,, ,,	26 1	,, ,,	26 19
,,	*Bd*	310	b	,, ,,	39 31	,, ,,	39 30
,,	*Bc*	210	g	,, ,,	51 2	,, ,,	51 2
,,	*Bb*	110	g	,, ,,	67 55	,, ,,	67 59
,,	*Bh*	710	f	90 0	19 35	,, ,,	19 27½
,,	*Bf*	510	f	,, ,,	26 23	,, ,,	26 19
,,	*Bd*	310	f	,, ,,	39 36	,, ,,	39 30
,,	*Bc*	210	g	,, ,,	51 10	,, ,,	51 2
,,	*Bb*	110	f	,, ,,	68 5	,, ,,	67 59

(b) Co-ordinates from (101)—

II	*Jb'*	$\bar{1}1\bar{3}$	b	44 53	64 31	45 1	64 21
,,	*Iy'*	$\bar{3}2\bar{5}$	b	,, ,,	75 37	,, ,,	75 52
,,	*Hc'*	$\bar{2}1\bar{2}$	f	,, ,,	88 34	,, ,,	88 39½
,,	*Ja*	$01\bar{3}$	b	52 5	51 27	52 12	51 15
,,	*Iz'*	$\bar{1}2\bar{5}$	f	,, ,,	61 28	,, ,,	61 18½
,,	*Hb'*	$\bar{1}1\bar{2}$	b	,, ,,	74 3	,, ,,	73 43
,,	*Gy'*	$\bar{3}2\bar{3}$	b	,, ,,	88 7	,, ,,	87 53
,,	*Ha*	012	b	61 0	58 30	61 7½	58 16
I	*Bc*	210	g	65 43	58 45	65 51	58 26½

(c) Co-ordinates from (10$\bar{1}$)—

II	*Jb'*	$11\bar{3}$	f	53 43	51 59	53 34	52 24½
,,	*Iz'*	$12\bar{5}$	f	,, ,,	59 15	,, ,,	59 30
,,	*Ha*	012	b	,, ,,	67 37	,, ,,	67 47
,,	*Gz*	123	b	,, ,,	77 6	,, ,,	77 10
I	*Bd*	310	b	46 16	62 13	45 57½	62 14
,,	*Bc*	210	g	57 28	67 36	57 11	67 41½
II	*Iy'*	$32\bar{5}$	b	67 5	47 23	67 25	47 58
,,	*Hb'*	$11\bar{2}$	b	,, ,,	55 0	,, ,,	55 14
,,	*Gz'*	$12\bar{3}$	b	,, ,,	64 0	,, ,,	64 2½
I	*Bb*	110	g	72 15	76 52	72 8	76 55
II	*Iy'*	$32\bar{3}$	b	84 39	39 15	84 39½	39 27
,,	*Hc'*	$21\bar{2}$	f	,, ,,	45 6	,, ,,	45 14½
I	*Cy'*	$32\bar{3}$	h	,, ,,	52 1	,, ,,	52 28½

Crystal No. 5 (fig. 8).

This crystal (Solly's No. 28; B.M. 1918, 408 (28)), which measures about 1 mm. in length and 0·7 by 0·4 mm. in cross-section, is set in a kind of alcove of sartorite, which is lined with faces very nearly in harmony with the development of the crystal. Observations were on that account rendered difficult, because in the case of many of the faces several images, often overlapping one another, were simultaneously visible in the field of the telescope of the goniometer, and in consequence of the small size of the crystal it was often not easy to determine which of the images belonged to the face under observation. On the left-hand

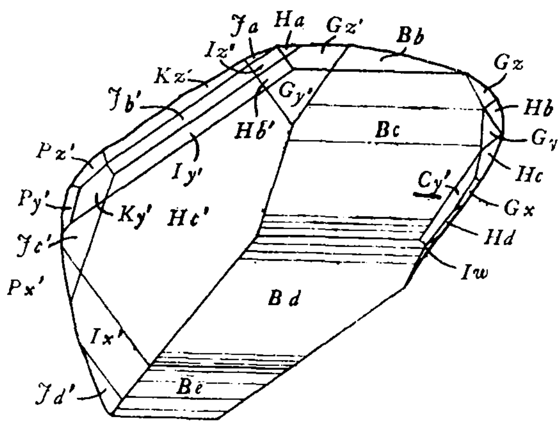

FIG. 8. Sartorite crystal No. 5.

side of the crystal, in the position of the figure, the prism-zone is only partially developed, the growth having been hindered by some foreign substance. Both for this reason and because the intrusion of the sides of the alcove prevented reflections being obtained from the parts lying back, only a limited portion of the zone was available. What reflections were given were indistinct, and some of them were spread out in a direction nearly parallel to the edge of the prism owing to the fact that the crystal is slightly distorted in the direction of the prism-edge. This zone, as usual, was used for setting up the crystal on the goniometer, the images corresponding to the part of the crystal immediately adjoining the terminal faces being selected. The adjustment was, however, not susceptible of great accuracy for the reasons stated, and the want of agreement between the observed and computed values noticeable here and there in the table below is perhaps not surprising. Even the face (100) did not as usual yield a good measurable reflection. The most noteworthy feature of the development of the crystal is the prominence of the faces, *Gy′*, *Hc′*, *Ix′*, and *Jb′*, lying in a zone with (101); they, moreover, yielded brilliant reflections. When the crystal was first set up it was thought that this was the dome-zone, and, since this crystal was measured some time before Trechmann's No. 5, it was not for a while clear whether the crystal was sartorite or not. The dome-zone, on the other hand, is not only itself less prominent, but its faces lack some of their customary smoothness and brilliance, and are, moreover, considerably striated; measurements in this zone are therefore unusually uncertain. A remarkable feature of the crystal is the almost complete absence of twinning about (100); of all the faces observed, only *Cy′* is in the twinned position.

Altogether, on the end of the crystal, observations were made of 53 faces, representing 50 different forms. Owing to the partially concealed position of the crystal, certain of the faces were not observable from (100). The elements and the co-ordinate angles of the various forms were computed from the following angles:—(100):(001) = 72° 0′ (observed value 72° 15′), (100):(101) = 34° 57′ (observed value 34° 47′), (100):(10$\bar{1}$) = 52° 1′ (observed value 52° 11′), and (100):(210) = 51° 7′ (observed value 51° 11′). The values of f and A defining the shears are—

		f		A
(100)	...	$\frac{1}{3}$	...	0·36310
(001)	...	0	...	0·38348
(101)	...	$\frac{1}{6}$	...	0·46004
(10$\bar{1}$)	...	$\frac{1}{6}$	...	0·63560

Elements of the Lattices.

I. $a:b:c = 2{\cdot}6074:1:2{\cdot}7550$; $\beta = 107°\ 0′$.

II. $a:b:c = 2{\cdot}6074:1:2{\cdot}7740$;
(010):(001) = 82° 45′, (001):(100) = 72° 0′, (100):(010) = 87° 46′;
$\alpha = 96°\ 54′$, $\beta = 107°\ 52′$, $\gamma = 90°\ 0′$.

III. $a:b:c = 2{\cdot}6074:1:2{\cdot}8320$;
(010):(001) = 75° 44′, (001):(100) = 72° 0′, (100):(010) = 85° 38′;
$\alpha = 103°\ 36′$, $\beta = 107°\ 29′$, $\gamma = 90°\ 0′$.

Table VIII. Calculated and observed values of the co-ordinate angles.

Face.			Refl.	Observed.		Calculated.	
Lattice.	Symbol.	Indices.		φ	ρ	φ	ρ
(a) Co-ordinates from (100)—							
	Ad	301	b	0° 0′	14° 53′	0° 0′	15° 2′
	Ax	502	b	,, ,,	17 45	,, ,,	17 56
	Ab	101	b	,, ,,	34 17	,, ,,	34 57
	Ay′	$30\bar{2}$	b	,, ,,	35 43	,, ,,	36 52
	Ab′	$10\bar{1}$	s	,, ,,	52 11	,, ,,	52 1
	Az′	$10\bar{2}$	b	,, ,,	75 30	,, ,,	77 9½
		$30\bar{7}$	b	,, ,,	81 25	,, ,,	81 32
		$10\bar{4}$	b	,, ,,	88 27	,, ,,	87 13
	Aa	001	b	,, ,,	72 4	,, ,,	72 0
III	*Px′*	$52\bar{9}$	b	27 35	79 10	28 3½	79 23
,,	*Pz*	129	b	27 45	68 30	,, ,,	69 7
,,	*Pz′*	$12\bar{9}$	b	,, ,,	78 33	,, ,,	79 8
,,	*Pw*	729	f	27 50	46 30	,, ,,	46 27
,,	*Px*	529	b	,, ,,	52 42	,, ,,	52 44
II	*Kx′*	$52\bar{7}$	b	36 1	71 25	35 42	72 2
,,	*Ky′*	$32\bar{7}$	f	,, ,,	84 15	,, ,,	84 55
,,	*Jd′*	$31\bar{3}$	b	39 50	62 42	39 34	62 32
,,	*Jc′*	$21\bar{3}$	f	,, ,,	74 56	,, ,,	75 15½
,,	*Jb′*	$11\bar{3}$	f	,, ,,	89 13	,, ,,	89 38
,,	*Jd*	313	b	39 40	44 35	,, ,,	44 24
,,	*Jb*	113	b	,, ,,	62 25	,, ,,	63 6
,,	*Ix′*	$52\bar{5}$	f	44 19	64 46	44 11	64 51
,,	*Iy′*	$32\bar{5}$	f	,, ,,	79 6	,, ,,	79 19
,,	*Ix*	525	b	44 31	39 0	,, ,,	39 25
,,	*Iy*	325	b	,, ,,	55 54	,, ,,	56 47½
,,	*Iz*	525	b	,, ,,	69 5	,, ,,	69 31
,,	*Hd*	312	f	49 26	41 45	49 44	41 26
,,	*Hc*	212	f	,, ,,	50 57	,, ,,	50 28
,,	*Hb*	112	b	,, ,,	62 42	,, ,,	62 37½
,,	*Ha*	012	b	,, ,,	78 11	,, ,,	78 8
,,	*Hb′*	$11\bar{2}$	b	,, ,,	84 45	,, ,,	84 25½
,,	*He′*	$41\bar{2}$	b	49 41	44 32	,, ,,	44 25
,,	*Hd′*	$31\bar{2}$	f	,, ,,	54 24	,, ,,	54 31
,,	*Hc′*	$21\bar{2}$	g	,, ,,	67 55	,, ,,	67 56
,,	*Hb′*	$11\bar{2}$	b	,, ,,	84 23	,, ,,	84 25½
,,	*Gy′*	$32\bar{3}$	f	55 42	71 46	56 21	72 5
,,	*Gz′*	$12\bar{3}$	b	,, ,,	89 35	,, ,,	89 18
,,	*Gx*	523	b	56 16	44 32	,, ,,	44 41½
,,	*Gy*	323	b	,, ,,	55 17	,, ,,	55 39
,,	*Gz*	123	b	,, ,,	70 34	,, ,,	70 49
,,	*Fc*	211	b	63 15	49 3	64 10	49 4
,,	*Fb*	111	b	,, ,,	63 43	,, ,,	63 14
,,	*Fa*	011	b	,, ,,	82 10	,, ,,	81 56½
I	*Da*	011	b	70 0	83 35	70 3	84 58
,,		144	b	,, ,,	89 35	,, ,,	89 55

I	*Dd*	311	b	70° 6′	38° 15′	70° 3′	38° 43′
,,	*Db*	111	b	,, ,,	63 25	,, ,,	63 54
,,	*Cy′*	$32\bar{1}$	b	79 40	61 52	79 43	61 46
,,	*Cx*	521	b	81 15	44 50	,, ,,	43 36
,,	*Bj*	910	s	89 42	15 25	90 0	15 24
,,	*Bg*	610	s	,, ,,	22 15	,, ,,	22 27½
,,	*Be*	410	b	,, ,,	32 20	,, ,,	31 48
,,	*Bd*	310	b	,, ,,	40 6	,, ,,	39 35
,,	*Bc*	210	g	,, ,,	51 11	,, ,,	51 7
,,	*Bb*	110	b	,, ,,	67 25	,, ,,	68 2½
,,		130	b	,, ,,	74 56	,, ,,	74 57
(b) Co-ordinates from (001)—							
I	*Be*	410	b	32 35	75 18	33 6	74 46½
III	*Pw*	729	b	36 25	35 8	36 41	34 48
II	*Iw*	725	b	,, ,,	48 21	,, ,,	47 48
,,	*Hd*	312	b	41 23	51 7	41 0	50 19
I	*Bd*	310	f	,, ,,	76 0	,, ,,	76 13
III	*Px*	529	b	46 9	31 39	46 12½	31 14
II	*Gx*	523	b	,, ,,	54 15	,, ,,	53 52
III	*Px′*	$52\bar{9}$	b	46 26	40 2	,, ,,	39 46½
II	*Kx′*	$52\bar{7}$	b	,, ,,	51 0	,, ,,	50 10½
,,	*Ix′*	$52\bar{5}$	g	,, ,,	61 1	,, ,,	60 49
,,	*Hc*	212	b	52 33	47 39	52 31	47 52
,,	*Fc*	211	b	,, ,,	58 30	,, ,,	58 58
I	*Bc*	210	g	,, ,,	78 34	,, ,,	78 49
II	*Jc′*	$21\bar{3}$	f	52 40	51 17	,, ,,	50 51
,,	*Hc′*	$21\bar{2}$	g	,, ,,	63 0	,, ,,	62 56
,,	*Ky′*	$32\bar{7}$	b	59 23	42 11	60 5½	42 4
,,	*Iy′*	$32\bar{5}$	f	,, ,,	51 52	,, ,,	52 9
,,	*Gy′*	$32\bar{3}$	g	,, ,,	65 29	,, ,,	65 57½
,,	*Jb*	113	b	67 53	38 20	69 1	37 28½
,,	*Hb*	112	b	,, ,,	47 0	,, ,,	46 32
,,	*Fb*	111	b	,, ,,	60 0	,, ,,	59 23½
I	*Db*	111	b	,, ,,	65 23	,, ,,	64 42
,,	*Bb*	110	f	,, ,,	83 23	,, ,,	83 22
II	*Jb′*	$11\bar{3}$	f	68 31	42 55	,, ,,	43 0
,,	*Hb′*	$11\bar{2}$	f	,, ,,	53 54	,, ,,	54 24
III	*Pz′*	$12\bar{9}$	f	78 42	27 41	79 9	28 3½
II	*Iz′*	$12\bar{5}$	b	,, ,,	44 55	,, ,,	44 58
,,	*Gz′*	$12\bar{3}$	b	,, ,,	56 30	,, ,,	57 56½
,,	*Gz*	123	b	80 15	54 15	,, ,,	53 11
I	*Cz*	121	b	,, ,,	75 50	,, ,,	76 2
II	*Ha*	012	f	89 32	47 52	90 0	48 16
,,	*Fa*	011	b	,, ,,	68 50	,, ,,	69 6
(c) Co-ordinates from (101)—							
III	*Pz′*	$12\bar{9}$	f	36 38	49 47	37 30	50 26
II	*Hd′*	$31\bar{2}$	b	38 45	79 35	39 11	80 4
,,	*Ix′*	$52\bar{5}$	f	,, ,,	88 55	,, ,,	88 31
,,	*Ky′*	$32\bar{7}$	f	39 14	68 9	,, ,,	66 49½
,,	*Jc′*	$21\bar{3}$	f	,, ,,	78 13	,, ,,	77 13
III	*Pz*	129	b	42 1	40 26	42 58	41 0
II	*Jb′*	$11\bar{3}$	f	45 3	65 4	45 5½	63 58
,,	*Iy′*	$32\bar{5}$	f	,, ,,	76 6	,, ,,	75 15½
,,	*Hc′*	$21\bar{2}$	g	,, ,,	88 24	,, ,,	87 50½
I	*Be*	310	b	47 31	45 45	47 23	45 47½
II	*Iz′*	$12\bar{5}$	b	52 27	61 27	52 31	60 53
,,	*Hb′*	$11\bar{2}$	b	,, ,,	73 58	,, ,,	73 4

II	*Gy'*	32$\bar{3}$	f	52° 27'	87° 38'	52° 31'	87° 3½'
I	*Bd*	310	b	55 35	50 29	55 23½	50 47
III	*Px*	529	b	57 30	25 56	58 28½	25 59
I	*Bc*	210	g	65 30	58 31	65 18	59 1
III	*Pw*	729	b	68 15	21 30	69 1	21 26½
II	*Iy*	325	b	72 13	37 35	72 27	37 35
,,	*Hb*	112	b	,, ,,	45 10	,, ,,	45 7
,,	*Gz*	123	b	,, ,,	55 17	,, ,,	55 18
,,	*Fa*	011	b	,, ,,	68 40	,, ,,	68 44½
,,	*Iw*	725	b	81 15	26 35	81 16	26 33½
,,	*Hd*	312	f	,, ,,	30 46	,, ,,	30 41
,,	*Gx*	523	b	,, ,,	36 12	,, ,,	36 6
,,	*Fc*	211	b	,, ,,	43 22	,, ,,	43 26
,,	*Hc*	212	b	85 0	35 58	85 36	36 6
,,	*Gy*	323	b	,, ,,	43 25	,, ,,	43 30
,,	*Fb*	111	b	,, ,,	53 42	,, ,,	53 38
I	*Db*	111	b	90 0	57 20	90 0	57 32

(d) Co-ordinates from (10$\bar{1}$)—

III	*Pw*	729	b	20 11	85 38	19 53	85 22
,,	*Px*	529	b	22 30	80 0	22 14	79 36
,,	*Pz*	129	b	28 47	64 8	28 53	64 39
II	*Hd*	312	b	30 30	82 20	30 23½	82 59
III	*Pz'*	52$\bar{9}$	b	33 48	55 1	33 49	55 41
II	*Jb*	113	b	35 50	75 0	35 47	74 48
,,	*Iy*	325	b	,, ,,	82 35	,, ,,	82 12
,,	*Gx*	523	b	36 7	82 0	,, ,,	82 27
,,	*Hc*	212	b	,, ,,	89 37	,, ,,	89 52
,,	*Iz*	125	b	43 30	71 15	43 55	71 22
,,	*Hb*	112	b	,, ,,	78 30	,, ,,	80 7½
,,	*Iz*	125	b	43 50	72 0	,, ,,	71 32
,,	*Hb*	112	b	,, ,,	80 45	,, ,,	80 7½
,,	*Gy*	323	b	,, ,,	89 35	,, ,,	89 11
I	*Bd*	310	g	46 6	61 31	46 22	61 41
II	*Ha*	012	b	53 55	67 50	53 26½	68 11½
,,	*Gz*	123	b	,, ,,	77 51	,, ,,	77 51½
,,	*Fb*	111	b	,, ,,	88 10	,, ,,	88 16½
,,	*Lc'*	21$\bar{4}$	b	54 44	36 55	,, ,,	37 2
,,	*Ky'*	32$\bar{7}$	b	,, ,,	45 51	,, ,,	46 19
,,	*Jb'*	11$\bar{3}$	f	,, ,,	52 3	,, ,,	52 24
,,	*Iz'*	12$\bar{5}$	b	,, ,,	59 10	,, ,,	59 40
,,	*Ha*	012	b	,, ,,	67 25	,, ,,	68 11½
,,	*Gz*	123	b	,, ,,	77 45	,, ,,	77 51½
I	*Bc*	210	f	57 15	67 40	57 33½	67 21
,,	*Db*	111	b	57 30	87 25	,, ,,	88 22
II	*Kx'*	52$\bar{7}$	b	67 41	36 7	67 2	37 5½
,,	*Jc'*	21$\bar{3}$	b	,, ,,	41 59	,, ,,	42 0
,,	*Iy'*	32$\bar{5}$	f	,, ,,	48 1	,, ,,	48 4
,,	*Hb'*	11$\bar{2}$	b	,, ,,	55 30	,, ,,	55 32
,,	*Gz'*	12$\bar{3}$	b	,, ,,	64 45	,, ,,	64 38
,,	*Fa*	011	b	,, ,,	86 50	,, ,,	87 8
I	*Bb*	110	b	71 36	75 39	72 19	76 45
II	*Hd'*	31$\bar{2}$	b	77 39	38 44	78 2	39 30½
,,	*Jd'*	31$\bar{3}$	b	84 16	34 50	83 57	34 48
,,	*Ix'*	52$\bar{5}$	g	,, ,,	39 31	,, ,,	39 26
,,	*Hc'*	21$\bar{2}$	g	,, ,,	45 24	,, ,,	45 22½
,,	*Gy'*	32$\bar{3}$	f	,, ,,	52 51	,, ,,	52 50
,,	*Fb'*	11$\bar{1}$	b	,, ,,	73 11	,, ,,	73 18½

Crystal No. 6 (fig. 9).

This crystal (Solly's No. 24; B.M. 1918, 408 (24)), measures 2·6 mm. in length and 1·7 by 1·2 mm. in section. The dome-zone is of unusually large relative size, and the faces are conspicuously bright and smooth. Into the large face *Bc* runs a cleft which is bounded on the farther side in the position of the figure by the face *Bd* and at the sides by some irregular growth. The same sort of hump-like growth occurs on the

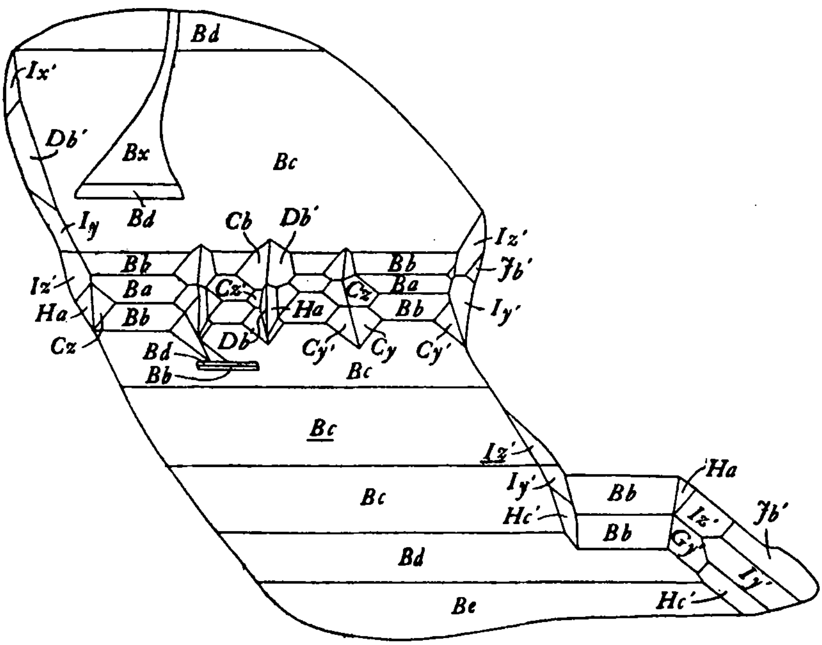

FIG. 9.—Sartorite crystal No. 6.

top as was noted in the case of Trechmann's crystal No. 5 (p. 274). As usual, the crystal is twinned, a small twin section running from side to side just below the hump-like growth referred to. As is often the case, the growth of the prism-zone has been interfered with and the edges bounding the various little faces are slightly tilted towards one another on opposite sides of the crystal; in consequence it is not possible to adjust the crystal so that all the reflected images given by this zone on rotation of the crystal traverse centrally the horizontal wire in the eye-piece of the telescope of the goniometer, and the positions of the poles determined by the intersections of cross-zones must necessarily be a little uncertain. Of the faces of the form (100) the near one in the figure gives a distinct reflection despite the oscillatory and step-like character; the parallel one on the other side of the crystal affords a far less satisfactory reflection.

Altogether, on the end of the crystal, were observed the pinacoid of symmetry, 9 dome-faces representing 6 different forms, and 28 pyramidal faces representing 17 different forms. The elements and co-ordinate angles of the various forms were computed from the following angles:— (100):(001) = 75° 1′ (the observed value), (100):(101) = 36° 39′ (observed value 36° 40′), (100):(10$\bar{1}$) = 51° 2′ (the observed value), and (100):(210) = 50° 55′ (the most trustworthy observed value). The values of f and A defining the shear are:—

		f		A
(100)	...	0·24	...	0·37724
(001)	...	0·16	...	0·39225
(101)	...	0·04	...	0·48478
(10$\bar{1}$)	...	0·20	...	0·63144

None of the faces referable to the third lattice were observed. It will be noticed that the corresponding faces on different lattices are on this crystal very nearly in the same zone with the pole (101).

Elements of the Lattices.

I. $a:b:c = 2·5495:1:2·6511$; $\beta = 104°\ 59'$.

II. $a:b:c = 2·5544:1:2·6624$;

(010):(001) = 88° 42½′, (001):(100) = 75° 1′, (100):(010) = 84° 55½′;

$\alpha = 95°\ 10\tfrac{1}{2}'$, $\beta = 104°\ 34'$, $\gamma = 93°\ 35\tfrac{1}{2}'$.

Table IX. Calculated and observed values of the co-ordinate angles.

Face.			Refl.	Observed.		Calculated.	
Lattice.	Symbol.	Indices.		φ	ρ	φ	ρ
(a) Co-ordinates from (100)—							
	Ad	301	b	0° 0′	16° 35′	0° 0′	15° 57½′
		503	b	,, ,,	25 55	,, ,,	25 52½
		705	b	,, ,,	29 23	,, ,,	29 24
		708	b	,, ,,	39 40	,, ,,	39 35
		103	s	,, ,,	57 0	,, ,,	57 56
	Af	501	b	,, ,,	9 32	,, ,,	10 2
		703	b	,, ,,	19 38	,, ,,	19 47
		103	b	,, ,,	58 7	,, ,,	57 56
		105	b	,, ,,	64 10	,, ,,	64 13
		$40\bar{7}$	f	,, ,,	71 49	,, ,,	70 50
		$10\bar{3}$	s	,, ,,	84 0	,, ,,	84 47½
		705	b	,, ,,	29 45	,, ,,	29 24
		708	b	,, ,,	39 7	,, ,,	39 35
		3·0·11	b	,, ,,	60 38	,, ,,	60 42
		$40\bar{7}$	b	,, ,,	71 11	,, ,,	70 50
	Ae	401	b	,, ,,	11 46	,, ,,	12 20
		10·0·3	b	,, ,,	16 46	,, ,,	16 46
		703	b	,, ,,	19 39	,, ,,	19 47
		704	b	,, ,,	24 47	,, ,,	24 56
	Ay′	$30\bar{2}$	b	,, ,,	37 10	,, ,,	36 35
		203	b	,, ,,	44 45	,, ,,	45 25½
	Ab′	$10\bar{1}$	b	,, ,,	51 37	,, ,,	51 2
II	*Jb′*	$11\bar{3}$	f	39 24	89 7	39 17	89 29½
,,	*Ix′*	$52\bar{5}$	f	43 55	65 0	44 3	64 54
,,	*Iy′*	$32\bar{5}$	f	,, ,,	79 25	,, ,,	79 28
,,	*Iz′*	$12\bar{5}$	f	,, ,,	84 50	,, ,,	84 30
,,	,,	,,	b	44 0	84 54	,, ,,	,, ,,
,,	*Iy′*	$32\bar{5}$	f	44 10	79 10	,, ,,	79 28
,,	*Iz′*	$12\bar{5}$	b	,, ,,	85 35	,, ,,	84 30
,,	*Hc′*	$21\bar{2}$	f	49 45	68 19	49 48	68 18
,,	*Hb′*	$11\bar{2}$	b	,, ,,	84 15	,, ,,	84 59
,,	*Ha*	012	b	,, ,,	77 52	,, ,,	77 28
,,	*Hb′*	$11\bar{2}$	b	,, ,,	84 35	,, ,,	84 59
,,	*Hc′*	$21\bar{2}$	b	49 49	68 19	,, ,,	68 18
,,	*Hb′*	$11\bar{2}$	b	,, ,,	84 38	,, ,,	84 59
,,	*Hc′*	$21\bar{2}$	b	49 50	68 38	,, ,,	68 18
,,	*Ha*	012	b	,, ,,	77 50	,, ,,	77 28
,,	*Hb′*	$11\bar{2}$	b	,, ,,	84 53	,, ,,	84 59
,,	*Gz′*	$12\bar{3}$	b	56 46	88 36	56 43	88 12
,,	*Gy′*	$32\bar{3}$	b	56 47	72 40	,, ,,	72 53
,,	*Fb′*	$11\bar{1}$	b	65 40	79 0	64 56	78 56
I	*Lb′*	$11\bar{1}$	b	68 37	74 16	69 20	74 4
,,	*Da*	011	b	68 42	84 50	,, ,,	84 36
,,	*Db′*	$11\bar{1}$	b	68 44	74 8	,, ,,	74 4
,,	*Cz′*	$12\bar{1}$	b	78 52	81 4	79 19	81 28

I	*Cy*	321	b	79° 9′	57° 7′	79° 19′	57° 3′
,,	*Cz*	121	f	,, ,,	76 8	,, ,,	76 1
,,	*Cx*	$52\bar{1}$	b	,, ,,	46 40	,, ,,	46 32
,,	*Cy*	321	b	79 14	57 15	,, ,,	57 3
,,	*Cy′*	$32\bar{1}$	b	,, ,,	61 24	,, ,,	61 14
,,	*Cz*	121	f	79 15	76 15	,, ,,	76 1
,,	*Be*	410	f	90 0	31 40	90 0	31 37
,,	*Bd*	310	f	,, ,,	39 26	,, ,,	39 23
,,	*Bc*	210	g	,, ,,	50 55	,, ,,	50 55
,,	,,	,,	f	,, ,,	50 57	,, ,,	,, ,,
,,	*Bb*	110	f	,, ,,	67 50	,, ,,	67 54
,,	*Bd*	310	b	,, ,,	39 15	,, ,,	39 23
,,	*Bx*	520	f	,, ,,	44 35	,, ,,	44 34
,,	*Bc*	210	g	,, ,,	50 53	,, ,,	50 55
,,	*Bb*	110	f	,, ,,	67 50	,, ,,	67 54
,,	*Ba*	010	b	,, ,,	90 0	,, ,,	90 0

(b) Co-ordinates from (001)—

I	*Be*	410	g	32 30	77 19	32 31	77 17
,,	,,	,,	g	,, ,,	77 28	,, ,,	,, ,,
,,	*Bd*	310	g	40 25	78 32	40 21½	78 28
,,	,,	,,	g	,, ,,	78 40	,, ,,	,, ,,
,,	*Bx*	520	g	45 54	79 39	45 34	79 23
,,	*Bc*	210	g	51 57	80 47	51 53	80 37
,,	,,	,,	g	52 15	80 48	,, ,,	,, ,,
II	*Hc′*	$21\bar{2}$	b	54 5	60 47	54 11	61 4½
,,	,,	,,	f	54 26	60 56	,, ,,	,, ,,
,,	*Iy′*	$32\bar{5}$	f	62 2	50 37	62 16	50 34
,,	*Gy′*	$32\bar{3}$	b	,, ,,	64 26	,, ,,	64 30
,,	*Iy′*	$32\bar{5}$	b	62 27	50 25	,, ,,	50 34
I	*Bb*	110	f	68 33	84 31	68 35	84 25
,,	,,	,,	b	68 36	84 25	,, ,,	,, ,,
,,	*Db′*	$11\bar{1}$	g	68 45	74 45	,, ,,	75 7
,,	*Bb*	110	f	,, ,,	84 24	,, ,,	84 25
,,	,,	,,	f	68 36	84 29	,, ,,	,, ,,
,,	*Cz*	121	f	79 8	76 10	78 54	76 20
,,	,,	,,	f	79 26	76 9	,, ,,	,, ,,
II	*Iz′*	$12\bar{5}$	f	82 2	44 17	82 24	44 17
,,	*Ha*	012	b	87 0	48 22	86 24	48 20
,,	,,	,,	f	87 10	48 17	,, ,,	,, ,,

(c) Co-ordinates from (101)—

II	*Ix′*	$52\bar{5}$	b	39 6	86 52½	39 5	87 14
,,	*Jb′*	$11\bar{3}$	f	45 19	63 15	45 19	62 57
,,	*Iy′*	$32\bar{5}$	b	,, ,,	74 13	,, ,,	74 2
,,	*Hc′*	$21\bar{2}$	b	,, ,,	86 20	,, ,,	86 29
,,	*Jb′*	$11\bar{3}$	b	45 25	62 26	,, ,,	62 57
,,	*Iy′*	$32\bar{5}$	f	,, ,,	73 53	,, ,,	74 2
,,	*Hc′*	$21\bar{2}$	f	,, ,,	86 19	,, ,,	86 29
I	*Be*	410	g	45 47	47 3	45 53	46 54½
II	*Iz′*	$12\bar{5}$	b	53 17	59 54	53 15	59 44½
,,	*Gy′*	$32\bar{3}$	b	,, ,,	85 37	,, ,,	85 35½
,,	*Iz′*	$12\bar{5}$	b	,, ,,	60 1	,, ,,	59 44½
,,	*Hb′*	$11\bar{2}$	b	,, ,,	71 50	,, ,,	71 43½
,,	*Gy′*	$32\bar{3}$	b	,, ,,	84 57	,, ,,	85 35½
I	*Bd*	310	g	53 54	51 56	53 59	51 40
,,	,,	,,	g	53 59	51 50	,, ,,	,, ,,
II	*Ha*	012	b	63 10	56 51	63 15	56 37
,,	,,	,,	f	63 15	56 55	,, ,,	,, ,,

I	*Db′*	$11\bar{1}$	b	63° 42′	89° 25′	64° 8′	88° 59′
,,	,,	,,	f	64 9	89 21	,, ,,	,, ,,
,,	*Bc*	210	g	64 11	59 45	,, ,,	59 37
,,	*Cy′*	$32\bar{1}$	f	,, ,,	73 27	,, ,,	73 12
,,	*Bc*	210	g	64 17	60 0	,, ,,	59 37
,,	*Da*	011	b	76 8	73 23	76 22½	73 26
,,	*Bb*	110	b	76 18	72 15	,, ,,	72 26
,,	,,	,,	f	76 31	72 24	,, ,,	,, ,,
,,	*Cx*	521	f	89 35	72 19	90 0	72 28
,,	,,	,,	f	89 56	72 40	,, ,,	,, ,,
(d) Co-ordinates from $(10\bar{1})$—							
I	*Be*	410	g	38 55	57 35	38 22½	57 37
,,	,,	,,	g	,, ,,	57 46	,, ,,	,, ,,
,,	*Bd*	310	f	46 47	60 59	46 33	60 55
,,	,,	,,	f	47 1	61 4	,, ,,	,, ,,
,,	,,	,,	f	,, ,,	61 12	,, ,,	,, ,,
II	*Ha*	012	f	53 10	52 58	52 51	52 36
,,	*Iz′*	$12\bar{5}$	b	,, ,,	60 39	,, ,,	60 16
,,	*Jb′*	$11\bar{3}$	f	,, ,,	69 43	,, ,,	69 18
,,	*Ix′*	$52\bar{5}$	b	53 14	60 17	,, ,,	60 16
,,	*Jb′*	$11\bar{3}$	b	,, ,,	69 15	,, ,,	69 18
I	*Bc*	210	f	58 4	66 58	57 44	66 38½
,,	,,	,,	g	58 5	66 51	,, ,,	,, ,,
II	*Iy′*	$32\bar{5}$	b	66 6	48 25	66 9	48 22
,,	,,	,,	b	66 29	48 48	,, ,,	,, ,,
,,	*Hb′*	$11\bar{2}$	b	,, ,,	56 46	,, ,,	56 18
I	*Bb*	110	b	72 34	76 23	72 29	76 19
,,	*Cz*	121	f	,, ,,	89 47	,, ,,	89 21
,,	,,	,,	f	72 40	89 21	,, ,,	,, ,,
,,	*Bb*	110	f	72 42	76 5	,, ,,	76 19
,,	*Cy′*	$32\bar{1}$	f	72 56	64 52	,, ,,	64 36
II	*Hc′*	$11\bar{3}$	b	82 35	39 23	82 48	39 24
,,	*Ix′*	$52\bar{5}$	b	,, ,,	45 48	,, ,,	45 50
,,	,,	,,	b	82 54	46 8	,, ,,	,, ,,
,,	*Gy′*	$32\bar{3}$	b	,, ,,	54 1	,, ,,	53 58

Other Crystals.

Nineteen of the remaining measured crystals showed pyramidal faces, though neither sufficiently numerous nor well enough developed for the cross-zonal relations to be determined. These crystals comprised fourteen in R. H. Solly's collection (B.M. 1918, 408), namely, those numbered 11 (a), 11 (b), 14, 15, 20, 21, 23, 25, 28 (b), 44, 54, 58, 59, 60; and five formerly in C. O. Trechmann's collection, namely, the one numbered 7 in his memoir,[1] and four others, the several pairs being numbered 1917, 395, and 1917, 399, in the British Museum Register of Accessions. A few additional forms on the end of the crystals were noted, namely, two pyramidal forms *Iu* (11·2·5) and *Jz* (126) each of which was represented by a single tiny face giving a faint and ill-defined

[1] Loc. cit., pp. 214, 225, 226.

reflection and is rather doubtful, and fifteen dome-forms—(23.1.0), (16.1.0), *Bl* (11.1.0), *Bk* (10.1.0), *Br* (17.2.0), *Bg* (610), (16.3.0), (31.6.0), *Bw* (720), (830), (13.6.0), (11.7.0), (760), (570), (15.8.0). Owing to the striated character of the prism-zone and the consequent banded nature of the reflections, readings in this zone were very uncertain. It will be noticed from the table that reflections were met with almost continuously through a right angle from the origin of measurement, or, in other words, through the whole of the zone. The grouping of the angles as given in the table was therefore to some extent arbitrary, but as far as possible thick clusters of readings were brought together. The values given in the column of calculated angles are those computed on the data found for Crystal No. 1 above (p. 278); the nearest concordant pole with simple indices, whether positive or negative, was entered in the column.

Table X. List of forms observed on 19 *other crystals and the corresponding co-ordinate angles from* (100).

Face.		Observed Means.		Limits of Observations.		No.	Calculated.	
Symbol.	Indices.	ϕ	ρ	ϕ	ρ		ϕ	ρ
Aj'	$90\bar{1}$	0° 0'	5° 48'			1	0° 0'	5° 58'
Ah'	$70\bar{1}$	,, ,,	7 32			1	,, ,,	7 43
Ag'	$60\bar{1}$	,, ,,	9 17			1	,, ,,	9 3
Av	902						,, ,,	10 53
Af'	$50\bar{1}$						,, ,,	10 54½
Ae	401	,, ,,	11 44		10 28 - 13 37	14	,, ,,	12 8
Av'	$90\bar{2}$						,, ,,	12 9
Aw	702						,, ,,	13 41½
Ae'	$40\bar{1}$						,, ,,	13 43
Ad	301	,, ,,	15 50		14 7 - 17 5	20	,, ,,	15 42
Aw'	$70\bar{2}$						,, ,,	15 44
Ax	502	,, ,,	18 26		17 46 - 19 12	16	,, ,,	18 22
Ad'	$30\bar{1}$						,, ,,	18 25½
	$80\bar{3}$	,, ,,	20 25		19 56 - 21 23	6	,, ,,	20 45½
Ac	201	,, ,,	22 22		22 0 - 22 33	5	,, ,,	22 5
Ax'	$50\bar{2}$						,, ,,	22 9½
	905						,, ,,	24 0
	704	,, ,,	24 33		23 6 - 25 51	13	,, ,,	24 32
	503						,, ,,	25 27½
	805						,, ,,	26 15
Ay	302	,, ,,	27 7		26 39 - 27 40	3	,, ,,	27 32
Ac'	$20\bar{1}$						,, ,,	27 39
	$90\bar{5}$	,, ,,	30 28		29 40 - 31 18	7	,, ,,	30 36

	$70\bar{4}$						0° 0′	31°27′
	605	0° 0′	32°33′		31 53 – 32 55	10	,, ,,	32 10
	$50\bar{3}$						,, ,,	32 55
Ab	101	,, ,,	36 7		35 34 – 38 15	8	,, ,,	36 6
Ay′	$30\bar{2}$						,, ,,	36 17
	506	,, ,,	40 0			1	,, ,,	40 0
	405	,, ,,	40 50			1	,, ,,	40 57
	304	,, ,,	42 21		41 43 – 42 50	15	,, ,,	42 20
	$50\bar{4}$						,, ,,	42 34
	$60\bar{5}$	,, ,,	44 14		44 10 – 44 18	2	,, ,,	44 2
	203	,, ,,	44 48			1	,, ,,	44 43
	$90\bar{8}$	,, ,,	46 30			1	,, ,,	46 24
	407	,, ,,	47 38		47 13 – 48 7	3	,, ,,	47 55½
Az	102						,, ,,	50 29½
Ab′	$10\bar{1}$	,, ,,	50 41		48 43 – 52 9	23	,, ,,	50 48
	307	,, ,,	53 49		53 0 – 54 31	7	,, ,,	53 15½
	$70\bar{8}$	,, ,,	55 49		55 41 – 55 57	2	,, ,,	55 49½
	$40\bar{5}$	,, ,,	59 6		58 19 – 59 55	9	,, ,,	59 10
	104	,, ,,	61 17			1	,, ,,	61 8
	$30\bar{4}$	,, ,,	61 35			1	,, ,,	61 32
	209	,, ,,	62 21				,, ,,	62 29
	$50\bar{7}$	,, ,,	63 19		63 2 – 63 49	3	,, ,,	63 17½
	106	,, ,,	65 8			1	,, ,,	65 17½
	$30\bar{5}$	,, ,,	68 17		68 33 – 68 57	3	,, ,,	68 17
	$40\bar{7}$	,, ,,	71 6		70 14 – 72 52	5	,, ,,	70 52
Aa	001	,, ,,	75 33		74 45 – 76 16	3	,, ,,	74 28
Az′	$10\bar{2}$						,, ,,	74 57
	$20\bar{5}$	,, ,,	80 40		77 57 – 82 16	11	,, ,,	80 56
	$10\bar{3}$	,, ,,	85 41		83 0 – 87 14	15	,, ,,	85 28
	$\bar{1}04$	,, ,,	89 16		89 8 – 89 24	2	,, ,,	89 44½
Pw′	$72\bar{9}$	28 2	69 34	27 48 – 28 13	69 28 – 69 40	2	28 0	69 14
Px′	$52\bar{9}$	,, ,,	79 27		79 12 – 79 42	2	,, ,,	79 14½
Od′	$31\bar{4}$	30 29	72 35			1	30 31	71 32
Oc′	$21\bar{4}$	,, ,,	84 49			1	,, ,,	82 38
Jz	126	39 39	71 10	39 18 – 40 17		1	39 25	69 41
Ja	013	,, ,,	75 57		75 30 – 76 15	3	,, ,,	76 23
Jb′	$11\bar{3}$	,, ,,	89 12		88 5 – 90 0	8		89 6
Iu	11.2.5	44 6	28 22	43 12 – 45 29		1	44 5	29 28
Iw	725	,, ,,	39 30			1	,, ,,	39 35
Iv′	$92\bar{5}$	,, ,,	44 35			1	,, ,,	44 1½
Ix	525	,, ,,	46 58			1	,, ,,	47 7
Iy	325	,, ,,	57 3			1	,, ,,	57 2½
Ix′	$52\bar{5}$	,, ,,	64 42		64 4 – 65 10	10	,, ,,	64 39½
Iz	125	,, ,,	69 40		69 10 – 69 59	11	,, ,,	69 48
Iy′	$32\bar{5}$	,, ,,	79 25		78 52 – 80 5	11	,, ,,	79 4
Iz′	$12\bar{5}$	,, ,,	84 49		84 10 – 85 32	17	,, ,,	85 0
Hd	312	49 45½	41 30	48 54 – 51 15		2	49 42	41 26
He′	$41\bar{2}$	,, ,,	44 40		43 36 – 45 49	9	,, ,,	44 27
Hc	212	,, ,,	50 29		50 11 – 50 47	2	,, ,,	50 28
Hd′	$31\bar{2}$	,, ,,	54 36		54 15 – 55 18	9	,, ,,	54 33
Hb	112	,, ,,	62 45		62 33 – 62 57	2	,, ,,	62 37
Hc′	$21\bar{2}$	,, ,,	68 4		67 29 – 68 58	26	,, ,,	67 58½
Ha	012	,, ,,	77 52½		77 10 – 78 30	10	,, ,,	78 7
Hb′	$11\bar{2}$	,, ,,	84 34		84 9 – 85 30	7	,, ,,	84 28
Gw′	$72\bar{3}$	56 24	47 59	56 3 – 57 30		1	56 26	45 20
Gz	123	,, ,,	69 29			1	,, ,,	70 26½
Gy′	$32\bar{3}$	,, ,,	72 24½		71 52 – 73 8	4	,, ,,	72 26
Gz′	$\bar{1}23$	,, ,,	89 41		89 30 – 89 52	2	,, ,,	88 54
Fc	211	63 58	50 7	63 30 – 64 40		1	64 24	48 32

Fc'	$21\bar{1}$	68°58'	60° 5'		59 5 - 61 5	2	64°24'	60°17'
Db'	$11\bar{1}$	70 27	74 37	69 40 - 71 15	73 32 - 75 42	2	69 45½	74 14½
	$\bar{1}44$	,, ,,	89 55			1	,, ,,	89 55
Cx	521	79 19	43 48	78 38 - 80 12		1	79 33	43 50
Cx'	$52\bar{1}$	,, ,,	46 44		46 39 - 47 1	3	,, ,,	46 45½
Cy	321	,, ,,	56 55		56 37 - 57 23	5	,, ,,	57 10
Cy'	$32\bar{1}$	,, ,,	61 30		60 15 - 62 6	7	,, ,,	61 25½
Cz	121	,, ,,	76 8		75 50 - 76 26	2	,, ,,	76 2
Cz'	$12\bar{1}$	,, ,,	82 2			1	,, ,,	81 35
	23.1.0	90 0	6 7	89 22		1	90 0	6 9
	16.1.0	,, ,,	8 58			1	,, ,,	8 49
Bl	11.1.0	,, ,,	12 34		12 28 - 12 44	5	,, ,,	12 42
Bk	10.1.0	,, ,,	13 52		13 44 - 13 58	5	,, ,,	13 56
Bj	9.1.0	,, ,,	15 21½		15 14 - 15 30	6	,, ,,	15 24
Br	17.2.0	,, ,,	16 29		16 26 - 16 32	2	,, ,,	16 16
Bi	810	,, ,,	17 14		17 6 - 17 21	5	,, ,,	17 18½
Bh	710	,, ,,	19 32		19 21 - 19 45	8	,, ,,	19 30½
Bt	13.2.0	,, ,,	21 12			1	,, ,,	20 53
Bg	610	,, ,,	22 26		22 20 - 22 30	7	,, ,,	22 27½
	16.3.0	,, ,,	24 50		24 46 - 24 56	8	,, ,,	24 56½
	31.6.0	,, ,,	25 43		25 20 - 25 56	4	,, ,,	25 38½
Bf	510	,, ,,	26 28		26 14 - 27 4	17	,, ,,	26 28
Bv	920	,, ,,	28 56			1	,, ,,	28 52
Be	410	,, ,,	31 45		31 14 - 32 4	15	,, ,,	31 48
Bw	720	,, ,,	35 34		35 23 - 35 45	2	,, ,,	35 32
Bd	310	,, ,,	39 37		39 2 - 39 56	20	,, ,,	39 35
	830	,, ,,	42 34		42 27 - 42 41	2	,, ,,	42 55½
Bx	520	,, ,,	44 31		43 42 - 45 0	8	,, ,,	44 42½
	13.6.0	,, ,,	48 58			1	,, ,,	48 51
Bc	210	,, ,,	51 7		50 52 - 51 29	30	,, ,,	51 7
	11.7.0	,, ,,	57 44		57 30 - 57 58	2	,, ,,	57 38
	760	,, ,,	64 45			1	,, ,,	64 48½
Bb	110	,, ,,	68 3		67 15 - 68 32	28	,, ,,	68 2½
	570	,, ,,	74 8			1	,, ,,	73 56
	580	,, ,,	75 43		75 31 - 75 56	3	,, ,,	75 51
Bz	120	,, ,,	78 44		78 25 - 79 19	11	,, ,,	78 36
Ba	010	,, ,,	90 0		89 39	8	,, ,,	90 0

IV. The Lattice Arrangements.

The advantages of the use of the gnomonic form of projection in the determination of the zonal properties of a crystal is well known. Owing to the fact that all great circles on the sphere, and therefore zones on the crystal, appear as straight lines on the projection, it follows that, if the projection be made on a plane perpendicular to the axis of some zone—usually the, or one of the, principal zones of symmetry on the crystal—all the zones passing through a pole in this zone are projected as straight lines intersecting one another at infinity, or, in other words, as parallel straight lines. In the case, therefore, of a simple crystal of the usual kind a gnomonic projection prepared in the foregoing manner takes the form of a continuous network, the nodes of which represent the principal observed faces. If, however, we prepare a gnomonic projection of sartorite on a plane perpendicular to the edge of the prism-zone (fig. 10), we see at once that we obtain a patchy network which

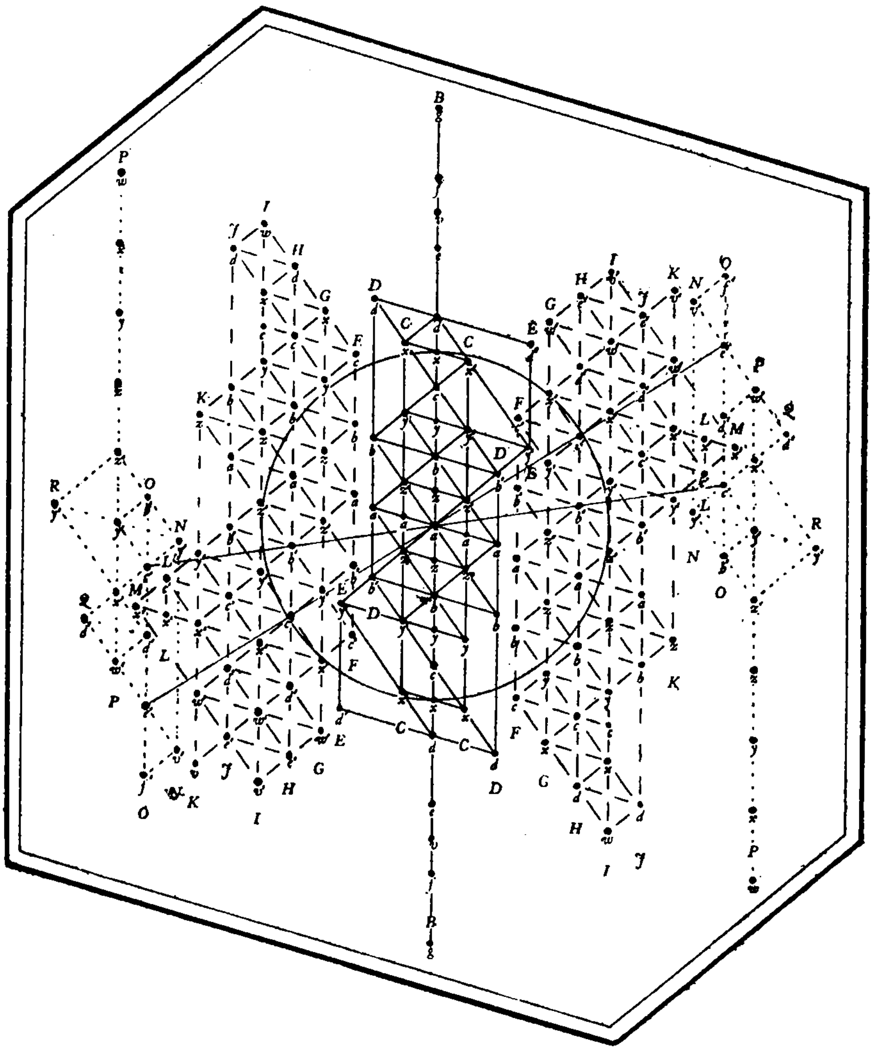

Fig. 10.—Gnomonic projection of sartorite.

is not continuous over the whole of the projection. A brief study of the projection shows that the discontinuity cannot be set down as due to twinning or repeated twinning about (100), which is the ordinary twin-plane, or about any other face or axis. Zones passing through the pole (100) are continuous right across the diagram, and are, indeed, individually quite normal. It is, however, otherwise with zones passing through other poles in the prism-zone. The spacing in all straight lines parallel to a particular direction remains the same—that is to say, the linear distances between the points representing crystal-faces are simple multiples of the same unit; but these straight lines, if extended over the diagram, do not in general cross at nodal points the series of parallel straight lines representing the zones radiating from the pole (100).

There are in fact five different networks corresponding to as many lattices. Lattice I, which includes the, if present, usually conspicuous dome-zone, is monoclinic in symmetry. Close to it on either side of the vertical straight line (in the position of the drawing) which corresponds to the dome-zone lie a pair of similar networks, which are related to one another by twinning about the axis of symmetry; this lattice II is triclinic in symmetry. Farther away from the central straight line, and close to the sides of the diagram, we find another pair of similarly related networks; this lattice III is likewise triclinic in symmetry. Lattice III is far less conspicuous than lattice II, crystal No. 1 alone possessing many faces belonging to the former; but, strange to say, the unit pyramidal form selected by vom Rath belongs to lattice III.

Besides the identity of spacing in parallel straight lines on the diagram to which we have already alluded, there is another relation between the several lattices. If we extend the networks until they overlap, we obtain for the five crystals whose cross-zonal relations we were able to determine, the lattice arrangements depicted in fig. 11. The underlying feature of all of them, despite certain noticeable differences, is that the three adjacent nodes, each belonging to a different network, are co-linear, and the node belonging to lattice II bisects the distance between the nodes belonging to lattices I and III. This property was determined from the observations made on crystal No. 1, and was confirmed by observations made on its companion crystal No. 2 and on crystal No. 5; the three crystals Nos. 3, 4, and 6 were entirely lacking in faces of lattice III. From this property it follows, as is shown on the gnomonic projection (fig. 10), that the faces *Hb′* and *Oc′*, belonging to lattices II and III, lie in a zone with *Ba* and therefore with the same faces *Hb′* and *Oc′* belonging to the companion lattices. The diagrams in fig. 11 show that crystals Nos. 1 and 5 are of the one, and crystals

Nos. 3, 4, and 6 are of the other kind, a distinction indicative of the end of the crystal represented; none of the crystals is double-ended, but, as has been mentioned, Nos. 1 and 2 were at one time opposite ends of a single crystal.

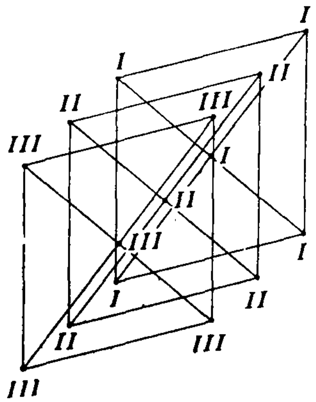

FIG. 11 a.—Lattice of crystal No. 6 (p. 298). [The lattice of crystal No. 3 is practically identical with this.]

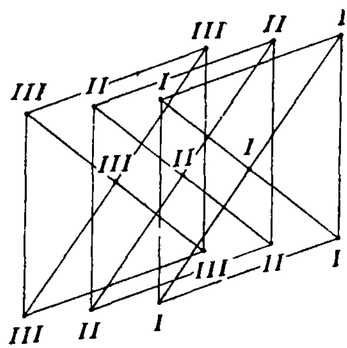

FIG. 11 b.—Lattice of Crystal No. 4 (p. 289).

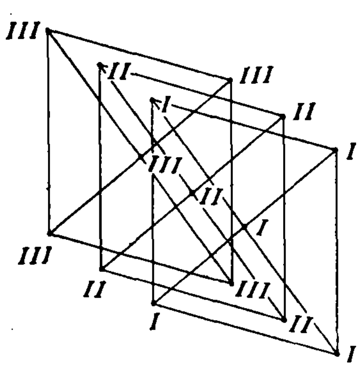

FIG. 11 c.—Lattice of crystal No. 1 (p. 274).

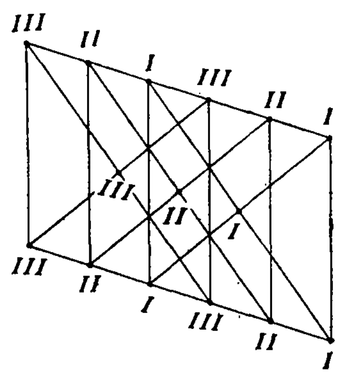

FIG. 11 d.—Lattice of crystal No. 5 (p. 298).

It may fairly be asked—do the differences in the arrangements shown in fig. 11 as characterizing the five crystals really exist, or may they not be due to errors of observation? We have admitted that the determination of the origin of measurements as the intersection of zones is necessarily liable to error when the reflections used for the purpose are neither very bright nor very distinct, and further that the faces belonging to lattices II and III, especially the latter, often afford faint and nebulous reflections, the concordance between the observed and the computed values of the co-ordinate angles being, as may be seen from the tables above, far from exact. Were it not for actual tests of the zonal characters made on the three-circle goniometer—one of the great advantages of this type of goniometer—we should have hesitated to believe in the reality of the differences in the lattice arrangements, or even have overlooked them altogether. In the case of crystal No. 6, which was the first one to be measured on the three-circle goniometer, the zonality with respect to the pole (101) between faces belonging to different lattices is so close that any slight divergence might readily be attributed to the small departures from the theoretical positions which are common in the faces of all crystals. In the case of crystal No. 5, which was the next one measured on that instrument, on the contrary, while there was almost perfect zonality with respect to the pole (001), there was none with respect to (101), as in the previous instance. No further light was thrown on the problem until crystal No. 1 was investigated, when it was clear that in this case there was no zonality with respect to either of the poles mentioned, or, indeed, to any other pole in the prism-zone except (100). The want of zonality was not large in the case of the pole (101); but even in this instance it was found impossible to adjust the crystal in such a way that the reflections given by the faces of different lattices crossed the field of the telescope of the goniometer along the horizontal wire on rotation of the crystal about the axis of the first circle. Crystal No. 8 is very similar to crystal No. 6, while the want of zonality in crystal No. 4 is even more marked than in crystal No. 1, but the arrangement is less certain owing to the inferior development of this crystal. It is, of course, precisely to this want of zonality in the cross-zones that the abnormal character of the indices given by Baumhauer for the faces observed by him is due (cf. p. 266).

It may be noticed from the gnomonic projection (fig. 10) that the several networks overlap but slightly. Further, a reference to the drawings of the crystals, especially fig. 4, shows that the faces are arranged with respect to one another exactly according to the positions of the poles corresponding to them, and that all the interfacial angles are salient, except possibly the angles between contiguous faces of different individuals of the same twinned crystal, a phenomenon that is in no way connected with the problem under consideration. In the following table we have tabulated the amount and direction of the shear which defines the transition of one lattice to that adjacent to it, the amount and the azimuthal angle being measured from the pole of monoclinic symmetry and from the plane at right angles to the common edge of the faces in the dome-zone respectively.

Table XI. Amount and direction of the inter-lattice shear.

Crystal.	Amount.	Azimuth.
No. 1 (fig. 11 c) ...	7°29′ ...	57°27′
No. 3 (cf. fig. 11 a)...	6 21 ...	43 47
No. 4 (fig. 11 b) ...	8 15 ...	83 54
No. 5 (fig. 11 d) ...	7 11 ...	72 0
No. 6 (fig. 11 a) ...	7 14 ...	45 33

The amount of the shear is constant for three of the crystals in spite of considerable variation in the azimuthal angle; it lies about a degree (57′) above or below this mean value in the case of the remaining two crystals, but this deviation may partly at least be explainable by errors of observation. Evidently the azimuthal angle may vary considerably, and to this variation is due the difference in zonal characters of the crystals to which we have drawn attention above.

For a plausible solution of the problem presented by the morphological characters of sartorite we may look to the changed physical conditions in which the crystals now find themselves. Undoubtedly they were formed at very much higher than ordinary pressures and temperatures. That many of the crystals are still in a state of strain is shown by their extreme brittleness; it is by no means uncommon for one spontaneously to break in two with an audible report. In the case of a well-developed crystal such as No. 1 we find five distinct sections running vertically from front to back in the position of the drawing (fig. 4). The central layer has apparently suffered no deformation. In the adjoining sections on either side the vertical layers of atoms appear to have successively slipped downwards in such a way that planes which were horizontal became inclined thereto at an angle of 7° 18′ (the mean value). On the outside of the crystal, right and left, we find another pair of sections, in which a similar amount of slipping of the vertical layers of atoms has occurred with respect to the positions of the atoms in the adjoining sections. The rigidity of sartorite is therefore relatively weak in certain directions. From the variability of the azimuthal angle of the shear we may argue that slipping of the atoms has taken place parallel to two different planes in relatively varying amounts. Since there is a cleavage parallel to (100), the simplest explanation is to suppose that slipping of the kind in question has occurred parallel to that plane both in a downward direction, i.e. parallel to the axis of symmetry, and at right angles thereto, the relative amount of slip being probably constant vertically, but variable in the other direction. It will be noticed that the variability in shear is accompanied by a perceptible difference in the constants defining the constituent lattices of the several crystals. We have, in fact, in sartorite a deformation similar to that long known in the case of crystals showing the so-called optical anomalies; but in this instance, as also in the case of calaverite, it is so comparatively large as to be measurable on a goniometer.

The extremely striated character of the prism-zone and the variability from crystal to crystal of the observed angles in this zone is suggestive not only of the oscillatory effect of repeated twinning about (100), which undoubtedly often occurs, but also of some interruption of the homogeneity of the internal structure. In a many-faced zone on a normal crystal we find the whole gamut of simple indices represented, but such is not the case with sartorite, as a reference to the tables of measured angles will show; not only are many simple ratios not found, but, in order to obtain even fair approximation with the observed angles, it was necessary to select unusual indices. It is possible that certain of the prism-faces are determined as the intersection with zones connecting faces each of which belongs to a different lattice. Thus the zone *Ba Hb′ Oc′* intersects the prism-zone in a face which subtends with (100) an angle of 81° 28′ calculated on the data for crystal No. 1. A reflection giving an angle of about this amount has not infrequently been observed. A few further points connected with the crystalline development are worth noting. The angle subtended between the poles (101) and (10$\bar{1}$) is in all cases very nearly a right angle, the following respectively being the values determined for the crystals Nos. 1, 3, 4, 5, and 6:—86° 44′, 89° 29′, 86° 32′, 86° 58′, and 87° 42′. Other angles of nearly a right angle are met with. For instance, the distance angle of the face *Py′* differs only a few minutes of arc from a right angle, the observed value in the case of crystal No. 1 being 89° 52′. The distance angles for two other faces approximate to a right angle, although not so closely as in the previous instance. Thus we have for *Jb′* on crystal No. 1 89° 4′, 89° 11′, 89° 15′, crystal No. 4 89° 58′, crystal No. 5 89° 18′, and crystal No. 6 89° 7′: and for *Gz′* on crystal No. 1 88° 30′, crystal No. 4 89° 50′, crystal No. 5 89° 35′, and crystal No. 6 88° 36′.

V. Sartorite-α.

The two crystals (B.M. 1917, 390) which were numbered by Trechmann 1 and 2 and formed the principal subject of his memoir were measured on the three-circle goniometer with the view of ascertaining whether any way of bringing them into crystallographical harmony with the ordinary sartorite of vom Rath would suggest itself, but without success; although the angles in the dome-zones were almost identical with those found for sartorite, the dissimilarity in the case of any other zone can only mean that these two crystals belong to a different, though no doubt closely related, species, which for distinction we have named sartorite-α. Besides the close relation in the dome-zone there is a certain similarity in the azimuthal a gles at (100), as may be seen in the following table, in which we compare the calculated values for sartorite-α with those given in Table IV for crystal No. 1 (p. 278).

Table XII. Azimuths of zones passing through (100).

Zone with		Sartorite.	Zone with	Sartorite-α.
I	021	79°33′	041	78°11′
,,	001	69 45½	021	67 17½
II	012	49 42	011	50 4½
,,	025	44 5	045	43 42
,,	013	39 25	023	38 32

The additional facilities provided in the form of goniometer used enabled us to note a few faces not recorded by Trechmann; the measurements determining them are given below. The calculated values are based on the data recorded by him.

Table XIII. Additional faces of Trechmann's Crystals Nos. 1 *and* 2 (*Sartorite-α*).

Crystal.	Face.	Refl.	Observed.		Calculated.	
			φ	ρ	φ	ρ
1	344	b	50° 8′	58° 27′	50° 4½′	58° 54′
,,	1̄33	b	,, ,,	86 0	,, ,,	86 23½
2	704	b	0 0	34 47	0 0	34 23
,,	503	b	,, ,,	35 45	,, ,,	35 54
,,	304	b	,, ,,	63 2	,, ,,	63 19
,,	305	b	,, ,,	70 15	,, ,,	70 15½
,,	645	b	43 45	55 45	43 42	56 7½
,,	245	b	43 41	66 49	,, ,,	66 24

In addition to these two crystals, a tiny crystal (B.M. 1917, 401) of sartorite, measuring only 1 by 0·5 by 0·2 mm., was met with on one of Trechmann's specimens and the measurements given in Table XIV were made on it. The forms (140) and ($\bar{3}$.12.3), the latter being somewhat doubtful, are new. The crystal showed also faces at the other end, but unfortunately it fell off the wax of the crystal-holder and was lost before that end was measured.

Table XIV. Observed and calculated values of the co-ordinate angles from (100) of Crystal No. 7 (Sartorite-a).

Face.	Refl.	Observed.		Calculated.	
		ϕ	ρ	ϕ	ρ
$40\bar{1}$	g	0° 0′	14° 41′	0° 0′	15° 27′
$20\bar{1}$	f	,, ,,	29 34	,, ,,	30 28
$40\bar{3}$	b	,, ,,	42 26	,, ,,	43 17
$10\bar{1}$	b	,, ,,	52 31	,, ,,	53 25
$70\bar{8}$	b	,, ,,	58 20	,, ,,	58 6
$90\bar{1}$	b	,, ,,	6 54	,, ,,	6 47
$40\bar{1}$	f	,, ,,	15 10	,, ,,	15 27
$80\bar{3}$	b	,, ,,	22 47	,, ,,	23 9
$20\bar{1}$	b	,, ,,	29 58	,, ,,	30 28
403	f	,, ,,	43 5	,, ,,	43 17
$10\bar{1}$	f	,, ,,	52 42	,, ,,	53 25
$40\bar{1}$	b	,, ,,	14 25	,, ,,	15 27
$50\bar{2}$	b	,, ,,	25 17	,, ,,	24 39
$70\bar{4}$	f	,, ,,	34 11	,, ,,	34 23
$30\bar{2}$	b	,, ,,	40 40	,, ,,	39 18½
$40\bar{3}$	b	,, ,,	43 36	,, ,,	43 17
001	b	,, ,,	77 56	,, ,,	77 48
$40\bar{1}$	b	,, ,,	15 31	,, ,,	15 27
$70\bar{3}$	b	,, ,,	25 59	,, ,,	26 20
$70\bar{4}$	g	,, ,,	34 27	,, ,,	34 23
$70\bar{5}$	b	,, ,,	41 41	,, ,,	41 37
221	b	67 12	50 32	66 50	50 28
$\bar{1}21$	f	67 38	73 56	,, ,,	74 7
$\bar{2}41$	f	78 8	70 41	78 11	70 51
041	b	,, ,,	86 29	,, ,,	87 24
441	b	78 15	50 24	,, ,,	50 17½
241	f	,, ,,	66 20	,, ,,	66 21
041	b	,, ,,	87 19	,, ,,	87 24
441	f	78 19	50 18	,, ,,	50 17½
$\bar{3}$.12.3	b	,, ,,	64 16	,, ,,	64 27
$\bar{2}41$	g	,, ,,	70 45	,, ,,	70 51
041	b	,, ,,	87 40	,, ,,	87 24
410	b	89 58	18 30	90 0	17 19
210	b	,, ,,	31 55	,, ,,	31 56
320	g	,, ,,	39 44	,, ,,	39 44
430	b	,, ,,	43 39	,, ,,	43 5
110	g	,, ,,	51 17	,, ,,	51 16
120	f	,, ,,	68 14	,, ,,	68 9
140	g	,, ,,	78 44	,, ,,	78 40
320	b	89 56	39 31	,, ,,	39 44
110	f	,, ,,	51 10	,, ,,	51 16
120	f	,, ,,	68 2	,, ,,	68 9

Although no attempt to determine the chemical composition of sartorite-*a* has been possible, it is not a very hazardous conjecture to suppose that in this respect both species, sartorite and sartorite-*a*, are alike, the relation between them resembling that between calaverite and krennerite. In the case of the latter pair, it will be remembered, the chemical composition is the same, but the crystalline form very different, although certain angles are very similar;[1] krennerite is normal in its crystallization, but calaverite shows the same type of arrangement of lattices as we have found in sartorite.

VI. Doubtful Crystals without pyramidal faces.

Since the prism-zone of sartorite-*a* is little striated and the reflections yielded by it correspond to the positions required for poles with normal simple indices, it is probable that the remaining measured crystals which showed dome-, but not pyramidal, faces are, because of the striated nature of the prism-zone and the uncertainty of the readings afforded by it, sartorite and not sartorite-*a*. To illustrate the variable nature of the measurements in the prism-zone, we may take two well-formed crystals, 8 and 9 (B.M. 1918, 408 (2), and B.M. 1918, 408 (9)), which are numbered respectively 2 and 9 in Solly's collection, the former (fig. 1, p. 270) measuring about 6 mm. and the latter 15 mm. in length. It will be seen from the table below that whereas the agreement in the dome-zone is close, very few, if any, of the angles in the prism-zone appear to correspond. The angles in every case have been measured from (100) and the calculated angles are based on the data found for crystal No. 1.

[1] See Mineralogical Magazine, 1902, vol. xiii, p. 142.

Table XV. Measurements made on Crystals Nos. 8 and 9.

Crystal No. 8.

Face.	Refl.	Observed.	Calculated.
310	g	39°24′	39°35′
210	g	51 6	51 7
110	g	68 2	68 2½
130	b	82 20	82 21
010	b	90 0	90 0
210	g	50 58	51 7
110	g	67 55	68 2½
120	b	78 53	78 36
704	b	24 56	24 32
101	s	34 39	36 6
$30\bar{2}$	s	38 9	36 17
$30\bar{7}$	b	53 9	53 15½
$10\bar{1}$	s	51 10	50 48
103	s	57 26	57 17
$50\bar{9}$	b′	72 25	71 45½
101	s	36 40	36 6
$10\bar{1}$	s	48 15	50 48
$20\bar{5}$	s	80 30	80 56
201	f	21 48	22 5
704	f	24 47	24 32
305	f	26 25	26 15
403	b	29 45	29 57
101	f	37 30	36 6
304	b	42 14	42 20
203	b	44 21	44 48
307	s	53 21	53 15½
001	b	74 41	74 28
$20\bar{5}$	b	81 26	80 56

Crystal No. 9.

Face.	Refl.	Observed.	Calculated.
310	g	39°33′	39°35′
520	f	44 15	44 42½
210	f	50 45 }	51 7
	f	51 15 }	
110	b	67 58	68 2½
210	b	51 18	51 7
110	g	67 59	68 2½
509	s	48 42	48 29
405	b	58 30	59 10
301	b	15 25	15 42
509	s	48 10	48 29
$10\bar{1}$	b	51 45	50 48
$40\bar{5}$	b	59 10	59 10
105	b	63 36	63 35½
$70\bar{2}$	b	15 20	15 44
$50\bar{3}$	f	32 49	32 55
$70\bar{5}$	b	37 57	38 35½
405	f	40 41	40 57
$10\bar{1}$	f	50 24	50 48
13.0.1	b	3 59	3 57
601	b	8 28	8 19
301	b	16 5	15 42
102	s	49 56	50 29½

The striations on the face *Bb* (110) of crystal 8 (fig. 1) are parallel respectively to the edges with (001) and (403). The bracketed angles in the column of observed angles correspond to the ends of a nearly continuous band of reflections.

VII. Summary.

As the result of the investigation forming the subject of this paper the following conclusions have been drawn :—

1. The six crystals, the measurements of which are given in complete detail above, belong to the same species (sartorite) as that described by vom Rath and Baumhauer. The faces observed on the ends of the crystals are referable to three distinct and non-congruent lattices, of which one is monoclinic and the other two are triclinic in symmetry.

The latter two are, however, twinned about the axis of symmetry so that in the case of a fully-developed crystal there are altogether five distinct lattices. The shear by means of which each lattice may be imagined to be transformed into the one adjoining it is constant in amount, but variable in direction. At the same time there is a perceptible difference in the constants defining the constituent lattices of the several lattices.

2. The two crystals figured and described by C. O. Trechmann, together with a third described in this paper, belong to a distinct, though no doubt closely allied, species, which for convenience we have named sartorite-α.

3. Sartorite and sartorite-α have probably the same chemical composition, and the relation between their morphological characters is parallel to that existing in the case of calaverite and krennerite.