

*On Fermorite, a new arsenate and phosphate of lime and strontia, and Tilasite, from the manganese-ore deposits of India.*¹

By G. F. HERBERT SMITH, M.A., D.Sc., F.G.S.
 Assistant in the Mineral Department of the British Museum,
 and G. T. PRIOR, M.A., D.Sc., F.G.S.
 Keeper of Minerals in the British Museum.

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ANALYSES of Indian manganese-ores generally show the presence of small amounts of arsenic. The form in which this constituent occurs was discovered by Dr. L. Leigh Fermor in the course of his investigations of these well-known deposits.² At two different localities crystalline arsenates were found. One of these occurrences is at the Sitapar deposit in the Chhindwara district, Central Provinces. The pinkish-white to white arsenate found there is the new mineral to which we have given the name fermorite. The other locality at which an arsenate was found is Kajlidongri, Jhabua State, Central India. The pale-green arsenate, somewhat resembling apatite in appearance, which occurs at this locality has been found by us to be identical with the tilasite from Sweden described by Sjögren.

Specimens of the arsenates from both localities were presented to the British Museum and constitute for the most part the material used for the investigations, the results of which are given in the present communication.

FERMORITE.

The arsenate from the Sitapar manganese-ore deposit is a pale pinkish-white to white mineral occurring in veins in the manganese-ore, which here consists of a mixture of braunite, hollandite, pyrolusite, and the new mineral sitaparite.

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² L. L. Fermor, 'The manganese-ore deposits of India,' *Memoirs of the Geological Survey of India*, 1909, vol. xxxvii.

The physical characters of the mineral have been already partially described by Dr. Fermor, in his elaborate report on the manganese-ore deposits to which reference has already been made. It is translucent with a greasy lustre, and has a rather even fracture and a white streak. No well-crystallized specimens of the mineral were found, but one piece showed three sides of what appeared to be a hexagonal prism.

From this observation and the result of a qualitative analysis showing that the mineral consisted essentially of a phosphate and arsenate of lime, Dr. Fermor was led to suggest that it was isomorphous with apatite. The optical and chemical investigation of the mineral which we have made tend to support this idea.

Physical Characters.

The mineral has a hardness of 5, and a specific gravity of 3.518 (as determined with the pycnometer on 1.1968 grams of material). It is infusible in the Bunsen-flame. Optical examination (G.F.H.S.) showed that it is uniaxial and negative, has a low double refraction, and has a mean refraction very slightly above that of monobromonaphthalene, i.e. about 1.660. One specimen showed three prism-faces which provided rough measurements of 60°.

Chemical Composition. (G. T. P.)

The mineral is readily soluble in hydrochloric acid and in nitric acid. The result of the quantitative analysis is as follows:—

| | | | | | Molecular ratios. |
|--------------------------------|-----|-----|--------|-----|-------------------|
| CaO | ... | ... | 44.34 | ... | 0.792 |
| SrO | ... | ... | 9.93 | ... | 0.096 |
| As ₂ O ₅ | ... | ... | 25.23 | ... | 0.110 |
| P ₂ O ₅ | ... | ... | 20.11 | ... | 0.142 |
| F | ... | ... | 0.83 | ... | 0.044 |
| H ₂ O | ... | ... | trace | | |
| Insoluble | ... | ... | 0.08 | | |
| | | | <hr/> | | |
| | | | 100.52 | | |
| Less O for F | ... | ... | 0.35 | | |
| | | | <hr/> | | |
| | | | 100.17 | | |

Weight of material used in analysis, 0.9138 gram.

In the analysis the mineral was dissolved in hydrochloric acid, and

the arsenic was precipitated as sulphide, and finally determined as arsenate of magnesia, after oxidation of the sulphide with hydroxyl. The phosphoric acid was determined in the precipitate obtained with ammonia in the filtrate from the sulphide of arsenic. This precipitate was fused with sodium carbonate and silica, and the phosphoric acid in the water extract was determined in the usual way with molybdate, and the lime and strontia in the residue by precipitating as oxalates and separating by treatment of the nitrates with a mixture of alcohol and ether. The fluorine was determined by the Berzelius method as modified by Hillebrand, and is probably too low. No chlorine was detected in the mineral.

The numbers obtained in the analysis correspond fairly closely to the formula $3[(\text{Ca}, \text{Sr})_3(\text{P}, \text{As})_2\text{O}_8] \cdot \text{Ca}(\text{OH}, \text{F})_2$, thus confirming Dr. Fermor's suggestion that the mineral consists to a large extent of the arsenic analogue of apatite.

We have named the mineral fermorite in honour of Dr. L. Leigh Fermor, of the Geological Survey of India, who has contributed so much to our knowledge of the Indian manganese-ore deposits.

TILASITE.

1. *Mode of Occurrence.*

Two occurrences of the pale-green arsenate at Kajlidongri in the Jhabua State are described by Dr. Fermor. One of these is in a vein of quartz and barytes traversing the manganese-ore body, where the mineral is found in rounded crystals up to half an inch in length. The other occurrence is in the north-west spur workings, where the mineral forms the chief constituent of a rock in which it is associated with quartz, spessartite, and braunite.

Specimens of the mineral from these two occurrences, as well as better crystallized specimens which were collected by Mr. E. J. Beer and by Mr. H. J. Winch, the manager of the mine at Kajlidongri, were sent to the British Museum for examination. The result of optical examination and measurements of crystals left no doubt that the green mineral from all these sources was the same.

2. *The Morphological Characters.* (G. F. H. S.)

Although the crystals were fairly distinct in form, yet the determination of the crystallographic characters was for several reasons attended with some difficulty. The crystals were in the first place too large to

admit of convenient manipulation on the goniometer, and it was therefore generally impossible to complete the observations in a zone without at least once re-centring the crystal so as to bring the reflections within the field of view. Again, the faces, as often happens with large crystals, were far from plane, and the reflections of the object-slit took the form of a blur of light extending over several degrees of arc in the field of view of the telescope. Moreover, all the crystals were incompletely developed—omitting the cleavage and parting planes—and it was not always obvious how the observations made on different crystals should be collated.

Altogether twelve crystals and fragments were used in the crystallographic investigation, but the values given in the table below were obtained on only five, the best of them. The whole of them were measured upon a goniometer of the ordinary type with a single, horizontal circle; a few were also measured upon a goniometer with three circles, but little reliance could be placed upon the values found for the azimuthal angles.

The crystals belong to the monoclinic system, and reasons will presently be given for believing that they may be assigned to the clinohedral class of that system, which is characterized by a plane of symmetry, but no axis of symmetry; this class has as yet only a single indisputable representative among minerals, viz. the calcium-zinc silicate, clinohedrite,¹ described by S. L. Penfield and H. W. Foote.

Excluding the complementary forms, altogether twelve forms were observed on the crystals:—

- b* (010), rather dull, not common.
 - a* ($\bar{1}00$), comparatively bright, not common.
 - m* (110), *m*₁ ($\bar{1}10$), bright and common; a plane of parting as revealed by striations.
 - e* ($\bar{1}01$), present only as a cleavage-face.
 - g* (021), very dull; only once observed (fig. 5).
 - p* (111), *p*₁ ($\bar{1}\bar{1}\bar{1}$), bright and common.
 - x* ($1\bar{1}\bar{1}$), dull; only once observed (fig. 3).
 - r* ($3\bar{3}1$), *r*₁ (331), bright and common; a plane of parting as shown by striations.
 - o* ($\bar{1}31$), rare; conspicuous on only one crystal (fig. 7).
 - y* (112),
 - z* (152),
 - δ* ($1\bar{6}5$),
- } all three dull and rare.

¹ S. L. Penfield and H. W. Foote, Amer. Journ. Sci., 1898, ser. 4, vol. v, p. 289.

The morphological constants were calculated from the angles given in the following table, and were found to be

$$a : b : c = 0.7503 : 1 : 0.8391 ; \beta = 120^\circ 59\frac{1}{2}'.$$

Table I. *Angles used as basis of calculations.*

| Form. | | Mean Values. | Limits of Observed Values. | No. |
|------------|-----------|--------------|----------------------------|-----|
| <i>mm'</i> | 110 : 110 | 65° 30' | 65° 31'—65° 51' | 6 |
| <i>me</i> | 110 : 101 | 61 4 | 61 0—61 10 | 3 |
| <i>mp</i> | 110 : 111 | 27 5 | 26 56—27 18 | 4 |
| <i>mp'</i> | 110 : 111 | 60 11 | 59 30—60 53 | 3 |

The indices given above having been severally selected for the forms *m*, *e*, and *p*, those of the remaining forms followed from the measurements, particulars of which will now be given.

g (021). This form appeared only once as a rough face on the crystal represented in fig. 5, and no measurable reflections were obtainable. From the parallelism of the corresponding edges it evidently lies in the zone connecting the faces *p* (111) and *m*₁ (110). By adjusting the edges common to *b* and *m*, and to *b* and *g* successively parallel to the vertical spider-line of the telescope of the goniometer when converted into a microscope by the insertion of the auxiliary lens, an approximate value, 59°, was obtained for the acute angle between these edges; the calculated value of the supplement of β is 59° 0½'. The face *g* is defined therefore as the intersection of the zones [111 : 110] and [010 : 001], and has accordingly the indices (021).

r (331). Three different angles were available for fixing the position of this form:—*re* (331 : 101) observed 69° 50', 69° 54', these being the best values, calculated 70° 15'; *rr'* (331 : 331) observed 57° 30', 58° 12', calculated 58° 35'; *rm*₁ (331 : 110), observed 10° 40', 10° 56', 11° 0', 11° 25', 12° 26', calculated 11° 31'. Since a plane of parting exists parallel to this form, the complementary form was also observed.

o (131). The distance angle measured from the nearest face of the form *m*₁, and the azimuthal angle with regard to the equatorial plane were available:—observed ρ 45° 35', ϕ 31° 50', and ρ 46° 37', ϕ 30° 5'; calculated ρ 45° 44', ϕ 29° 56'.

y (112). This form lies in the zone connecting *m*₁ (110) and *e* (101), and the angle *m*₁*y* (110 : 112) was measured as 80° 33', the calculated value being 80° 15'.

z (152). The position of this form was determined by its distance from the nearest face of the form m (110) and the azimuthal angle with respect to the zone me [$110 : \bar{1}01$], the values in the two cases being:— ρ observed $62^\circ 30'$, calculated $60^\circ 47'$, and ϕ observed $42^\circ 0'$, calculated $42^\circ 25'$. The measurements were only approximate, and in the case of the second face of the form no observations were found possible.

x ($1\bar{1}\bar{1}$). The solitary face that was observed of this form (fig. 3) lay in the zone connecting m (110) and y ($11\bar{2}$). A very rough measurement gave 40° as the value of the angle $m\alpha$; the calculated value is $45^\circ 10'$.

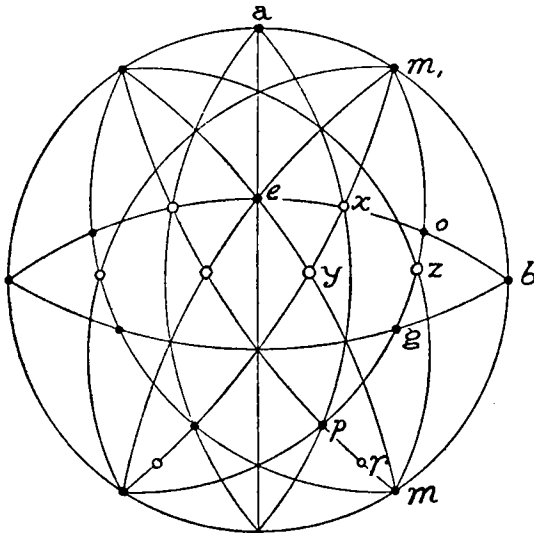


FIG. 1.—Stereographic projection of the crystal-forms of Tilasite. (The circlets represent the positions of faces beneath the plane of projection but on the opposite side of the centre, i.e. the points where the normals to the faces intersect the upper half of the sphere of projection. Compare J. W. Evans, this Magazine, 1910, vol. xv, p. 401.)

δ (165). The single face that was observed of this form was measured from the nearest face of the form m (110), and a measurement was also made of the azimuthal angle with regard to the equatorial plane, but the values can only be regarded as approximate:— ρ observed $54^\circ 50'$, calculated $55^\circ 18'$; ϕ observed $57^\circ 0'$, calculated $56^\circ 28'$.

In the table below are given the distance and azimuth calculated for the principal forms referred to the face of symmetry b (010) as origin.

Table II. *Calculated coordinates of the principal forms.*

| Form. | Azimuth. | Distance. |
|-----------|----------|-----------|
| b (010) | 0° 0' | 0° 0' |
| a (100) | 0 0 | -90 0 |
| m (110) | 0 0 | 57 15 |
| r (331) | 13 16 | -60 42½ |
| p (111) | 27 43 | 68 41½ |
| y (112) | -87 0 | -67 16 |
| z (152) | -87 0 | -25 31 |
| e (101) | -54 53 | 90 0 |
| o (131) | -54 53 | 25 54 |

a (100) is a plane of twinning. Parallel to e (101) is a good cleavage, while planes of parting run parallel to r (331) and m (110), the former being by far the more prominent, and having the peculiarity that often the planes parallel to one face alone of the form are noticeable.

The crystals are sage- to olive- or apple-green in colour, and translucent to opaque; the lustre is vitreous on the cleavage-face, but otherwise resinous. The hardness is about 5, being somewhat greater than was stated by Dr. Fermor, the massive mineral owing to its readiness to split appearing softer than the crystals.

3. *Description of the Crystals.* (G. F. H. S.)

1. Combination a , m , e , r (fig. 2), the last two being the result of splitting.

This fragment was obtained by fracture from a large crystal. To illustrate its unsymmetrical appearance the back of the fragment has been indicated by dotted lines in the figure. The planes of parting parallel to r are clearly shown.

2. Combination a , m , r , e , x , y , z (fig. 3). Greatest diameter 12 mm.

This crystal is interesting on account of the large number of forms represented. To show its curious shape the faces lying at the back in the figure are indicated by dotted lines. The planes of parting parallel to r are conspicuous, and this face is striated parallel to its intersection with m .

3. Combination b , m , m_1 , e , p , p_1 , o (fig. 4). Greatest diameter 15 mm.

This crystal is interesting because of the presence of *b* and the absence of any noticeable planes of parting parallel to *r*. The back is very rough.

4. Combination *b*, *m*, *m*₁, *p*, *p*₁, *o*, *g*, *δ* (fig. 5). Greatest diameter 23 mm.

A second individual in parallel position penetrates through that drawn, and appears at the left-hand top corner and at the back in the

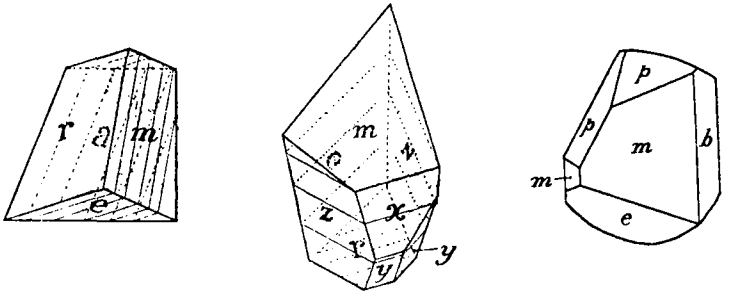


FIG. 2.

FIG. 3.

FIG. 4.

Crystals of Tilasite from Kajlidongri, India.

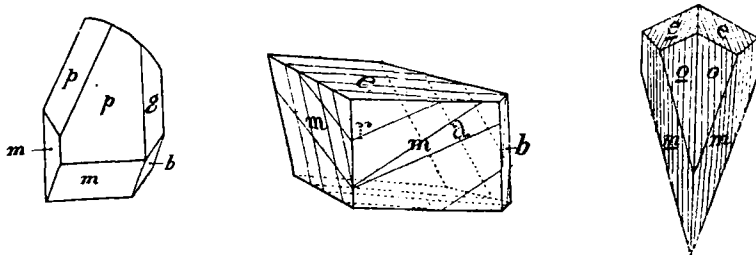


FIG. 5.

FIG. 6.

FIG. 7.

Crystals of Tilasite from Kajlidongri, India.

position of the figure; the faces *o* and *δ* were observed on this individual. The latter and the form *g* were observed only on this specimen.

5. Combination *a*, *b*, *m*, *e*, *r* (fig. 6), the last two being given by fracture. Greatest diameter 20 mm.

The fact that the form *a* is opposed to the form *m* is clearly brought out by this crystal. The planes of parting parallel to *r* are again conspicuous. The other striations on the faces *m* are in zone with (001), which has not been observed as a face.

6. Combination m, o, e, r (fig. 7), the last two being the result of splitting. Greatest diameter 25 mm.

This crystal is twinned about a , and very symmetrically developed, and is remarkable for the exceptional prominence of the form o . The striations are parallel to the corresponding face of the form r .

7. Combination e, r . Dimensions, 6 cm. in length, and 4 by 3 cm. in cross-section.

This, which is by far the largest crystal as yet found, is a twin, one individual being much better developed than the other. The plane of composition runs from a re-entrant angle at the top of the crystal on the right hand, down the centre, and inclined to the left at the bottom, reappearing at the back towards the right, and running across to the cleft at the top. The large face e is traversed by planes of parting parallel to r , which forms one side of the cleft referred to. The remainder of the crystal is rough, and only indications of faces are given; braunite occurs in cracks, and gypsum adheres to the surface. This crystal is now in the British Museum.

8. Combination b, m, o, e . Dimensions 5 cm. in length, and 2 cm. in cross-section.

This fine crystal, which is embedded in quartz, is twinned. Both individuals are prismaticly developed, the faces of the form m being large, and the plane of composition is approximately perpendicular to the prism zone. The faces b and o are small, and e is, as usual, developed by cleavage. A small simple crystal, 25 mm. in length, also prismaticly developed, and showing the faces m and e , the latter by cleavage, is on the same specimen. This specimen belonged to Mr. H. J. Winch.

4. *Optical Characters.* (G. F. H. S.)

If a section parallel to the cleavage-face e ($I01$) be examined in convergent polarized light a biaxial interference-figure with large axial angle is visible, the 'eyes' being outside the field of view. Owing, however, to the imperfect transparency of the crystals no figure is to be discerned, unless the section is ground very thin. The acute bisectrix is perpendicular to the cleavage-face, the double refraction being negative in character, and the plane of the optic axes runs at right angles to the plane of symmetry; $\rho < v$, but the colour-dispersion is very small. The following values were obtained by means of an axial-angle instrument for the angle between the optic axes of a small fragment which was ground parallel to e ($I01$), when immersed in methylene iodide at 20° C.:—Li 78° 57', Na 78° 16', Tl 76° 10'. Observations were made

on a crystal-face with a small refractometer, and approximate measurements obtained of the principal indices of refraction:— $\alpha = 1.640$, $\beta = 1.660$, $\gamma = 1.675$. The value of $2V$, the angle between the optic axes, calculated from the refractive indices is $83^\circ 24'$; while the observed value given above, viz. $78^\circ 16'$, corresponds to a value of $2V$ of $82^\circ 44'$, the refractive index of methylene iodide being taken as 1.7381. Considering the rough nature of the observations, the agreement is very satisfactory. The type of symmetry determined from the morphology of the crystals would lead us to expect an interference-figure characterized by horizontal dispersion, but none was observed; in an interference-figure with such a large angle between the optic axes, however, it would need to be very pronounced to be noticeable.

Dr. Fermor says in his report, 'One of these brushes indicated in a section in which the angle between the two sets of cleavage was 60° , that the optic axial plane lies from acute angle to acute angle of the cleavage rhombs.'¹ The two sets of cleavage referred to are the planes of parting parallel to the two faces of the form r (331), the calculated value of the angle between the edges in which these faces intersect the cleavage plane e (101) being $61^\circ 45'$, and the optic axial plane meeting the cleavage-face in a direction which is parallel to the bisectrix of the acute angle between the edges mentioned.

5. *Polar Characters, and Crystalline Symmetry.* (G. F. H. S.)

That the face a , when it occurs, is always found on the side of the crystal remote from the faces of the form m , and that while m is a prominent form, r (331) is no less conspicuous on account of the well-marked planes of parting parallel to the faces composing it, point to the conclusion that the mineral has not the full symmetry of the monoclinic system, but should probably be assigned to the clinohedral sub-class. Since this class has no centre of symmetry, the crystals should, if this view be correct, display signs of polarity.

Tests were, therefore, made for electrical polarity by means of Kundt's well-known apparatus. Several crystals were carefully heated, and while cooling were dusted with a mixture of red lead and sulphur blown through a sieve. In every instance there was a distinct difference between the appearance of the side of the crystal on which a occurred and that opposite to it, the former being positively electrified, and therefore yellow in colour, and the latter negatively electrified, and therefore red in colour.

With the solitary exception of the form b (010), parallel faces on a

¹ L. L. Fermor, loc. cit., p. 220.

crystal possessing the symmetry of the clinohedral sub-class of the monoclinic system belong to different forms, but granted that the forms *a* and *m* are opposed to one another no difficulty was experienced in deciding from a study of the habits of the crystals examined to which of the pair of complementary forms any particular face should be assigned, and the proper signs have accordingly been allotted to the indices in the list of forms compiled above (p. 87).

6. Chemical Composition. (G. T. P.)

The mineral is easily fusible in the blowpipe-flame; and is readily soluble in hydrochloric acid and in nitric acid. Heated in a glass tube with sulphuric acid or with potassium-hydrogen sulphate it gives off hydrofluoric acid which etches the tube. The material used in the analysis was taken from a mass in quartz, and, as it was unaccompanied by any other mineral, it was exceptionally pure. It was dissolved in hydrochloric acid and the arsenic was precipitated by sulphuretted hydrogen; and finally determined as magnesium arsenate. The phosphoric acid in one analysis was determined in the slight precipitate obtained with ammonia, which was fused with sodium carbonate and silica; in the second analysis it was determined in a measured portion of the filtrate from the sulphide of arsenic, the lime and magnesia being determined in the remainder after removal of the phosphoric acid by means of tin. The fluorine was determined by fusing with sodium carbonate and silica, according to the method of Berzelius as modified by Hillebrand.

The numbers obtained in the analyses are given under I and II, and under III for comparison are given the results of Mauzelius's analysis of tilasite (fluor-adelite) from Sweden:—

| | I (India). | II (India). | Mean. | Molecular ratios. | III (Sweden). |
|------------------------------------|---------------|----------------|-------------------|----------------------|------------------------|
| As ₂ O ₅ ... | 50.45 ... | 50.25 ... | 50.35 ... | 0.219 ... | 50.91 |
| P ₂ O ₅ ... | 0.32 ... | 0.54 ... | 0.43 ... | 0.008 ... | trace |
| FeO ... | 0.55 ... | — ... | 0.55 ... | 0.008 ... | 0.14 |
| MnO ... | — ... | — ... | — ... | — ... | 0.16 |
| CaO ... | 25.62 { | 25.75 ... | 25.68 ... | 0.459 ... | 25.82 |
| SrO ... | | 0.06 ... | 0.06 ... | — ... | — |
| MgO ... | 18.30 ... | 18.38 ... | 18.34 ... | 0.458 ... | 18.22 |
| F ... | 7.18 ... | — ... | 7.18 ... | 0.879 ... | 8.24 |
| H ₂ O ... | 0.73 ... | — ... | 0.73 ... | 0.040 ... | 0.28 |
| Insoluble ... | 0.11 ... | — ... | 0.05 ... | — ... | Cl 0.02 |
| | | | | | Na ₂ O 0.29 |
| | | | 103.37 | | 103.58 |
| | | | Less O for F 3.02 | | 3.47 |
| | | | 100.35 | | 100.11 |
| Specific gravity | | | 3.77 | | 3.28 |

The weight of material used in analysis I was 1.0367 grams, and in analysis II 0.9502 gram. The specific gravity (3.77) was determined with a pycnometer on 1.2048 grams of material.

7. Identity with Tilasite.

A fluo-arsenate of magnesium and calcium with very similar composition has been described under the name tilasite by H. Sjögren;¹ it occurs with berzeliite and calcite in the manganeseiferous dolomite at Långban, Sweden. If the results of the analysis made of tilasite by R. Mauzelius (under III) be compared with those of the mineral considered in this paper (I and II), the similarity of the two will be obvious.

The numbers obtained in the analyses correspond to the formula $(MgF)CaAsO_4$, the close agreement in the numbers for lime and magnesia in the material from the two widely distant localities indicating that in this mineral these earths are not isomorphously replaceable, but occur in definite proportions.

The tilasite from Sweden was found massive and granular, and showed no signs of crystal form; this character may conceal a slight want of homogeneity, which would account for the perceptibly lower specific gravity. It displayed one distinct cleavage, which Sjögren calls *A*, and at least three others less distinct, which he calls *B*, *C*, *D*. The colour is grey, tinged with violet, and the lustre resinous, but vitreous on the cleavage-surfaces. The colour differs from that of the Indian mineral; the tinge of violet is no doubt due to the presence of manganese.

It would be anticipated that the cleavage plane *A* would correspond to the cleavage e (101) found in the Indian mineral, and this supposition is confirmed by the optical characters. Sjögren states that a thin section parallel to the plane *A* displays in convergent light a biaxial interference figure with wide axial angle, the optic axes lying outside the field of view of the microscope, and that the acute bisectrix is nearly perpendicular to this plane, and the double refraction is negative. Sections of the Swedish mineral were cut at right angles to both the acute and the obtuse bisectrices, and the axial angles $2H$ (acute) = $99^\circ 50'$ and $2H$ (obtuse) = $111^\circ 40'$ were measured by Sjögren in poppy-oil of refractive index 1.4789. From these observed angles for yellow light the actual angle between the optic axes, $2V$, and the mean refractive index, β , may be calculated; they are $85^\circ 31'$, and 1.667 respectively. Con-

¹ H. Sjögren, Geol. För. Förhandl., Stockholm, 1895, vol. xvii, p. 291.

sidering the necessarily approximate nature of the observations, the agreement is satisfactory with those found for the Indian mineral.

Sjögren found that the cleavage plane *B* intersected the plane *A* in an edge which made an angle of 30° with the trace of the plane of the optic axes, and met the plane perpendicular to the obtuse bisectrix in an edge which made an angle of 19° with the trace of the plane of the optic axes. The corresponding angles calculated for *r* (331) are $30^\circ 52\frac{1}{2}'$, and $21^\circ 51'$. The plane *B* is therefore the plane of parting *r*.

Again, he found the corresponding angles for the plane *C* to be 34° and 28° . These angles calculated for *m* (110) are $38^\circ 11'$, and $35^\circ 7'$. The differences, though larger, are still within the range covered by errors of observation.

According to Sjögren the cleavage-plane *D* intersected the plane *A* in an edge which was nearly at right angles to the trace of the optic axial plane, and was not observed at all in the section cut perpendicular to the obtuse bisectrix. It would appear, therefore, to correspond to the face *b* (010), but no such cleavage or plane of parting was noticed on the Indian arsenate. There was, however, on a rough part of the crystal represented in fig. 3 a suspicion of a cleavage parallel to *x* (111). This would intersect *e* (101) in an edge at right angles to the trace of the plane of the optic axes; but on this assumption we must suppose that it was not noticeable in the section at right angles to the obtuse bisectrix which Sjögren examined.

The concordance in physical and chemical characters, as far as the former were developed, clearly indicate the identity of the fluo-arsenate described in this paper with the tilasite from Sweden.

A similar arsenate (adelite), with hydroxyl in place of fluorine, has also been described by Sjögren; it occurs at Långban, and also at Nordmark and Jakobsberg, but its physical characters are quite distinct from those found for either tilasite from Långban or the present mineral.
