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1890

UNITED STATES GEOLOGICAL SURVEY

J. W. POWELL, DIRECTOR

CONTRIBUTIONS

TO THE

MINERALOGY OF THE PACIFIC COAST

BY

WILLIAM HARLOW MELVILLE

AND

WALDEMAR LINDGREN

29858

WASHINGTON

GOVERNMENT PRINTING OFFICE

1890

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3. Cinnabar crystal.
4. Cinnabar crystal, with reentrant angle.
5. Crystal with gas inclusions.
6. Cinnabar crystal.

II. Fig. 7. Cinnabar crystal, analogue pole.
8. Cinnabar crystal with reentrant angle, antilogue pole.
9. Cinnabar crystals, with inclusion.
10. Cinnabar crystal, analogue pole.
11. Cinnabar crystal, antilogue pole.

III. Fig. 12. Subindividual on tectonic face.
13. Illustration of derivation of tetartohedral forms.
14. Section lines of tetartohedral forms of crystals 1 and 2 with basal plane.

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF THE PACIFIC,
San Francisco, February 1, 1889.

SIR: We have the honor to transmit herewith through Mr. G. F. Becker, geologist in charge, Division of the Pacific, a paper on mineralogical studies of certain specimens which were collected during the recent examination of the quicksilver deposits of California.

In this material we are able to add somewhat to the previous knowledge of the habits of cinnabar crystals, and to give measurements which identify those crystal forms to which are ascribed the phenomena of right and left rotation. Two new mineral species, into the composition of which chromium enters largely, are described and named, while the remaining matter is mostly confirmatory of previous observations to be found in the literature of mineralogy.

Very respectfully,

W. H. MELVILLE,
Chemist.

WALDEMAR LINDGREN,
Assistant Geologist.

Hon. J. W. POWELL,
Director U. S. Geological Survey.

CONTRIBUTIONS TO THE MINERALOGY OF THE PACIFIC COAST.

By W. H. Melville and W. Lindgren.

CINNABAR CRYSTALS FROM NEW IDRIA, CALIFORNIA.

While examining the collection made by the U. S. Geological Survey at the New Idria quicksilver mines, our attention was drawn to a number of very minute cinnabar crystals having a somewhat uncommon habit. They were obtained from Superintendent J. W. C. Maxwell, who had washed them out from a soft ore occurring in the upper workings of the mine. The ore was in all probability a soft gray arkose sandstone impregnated with cinnabar. Examination showed that the apparently simple crystals have generally a thin tabular habit and present the forms $0R$, $-\frac{2}{3}R$, $-\frac{1}{2}R$, combined with tetartohedral faces of more or less complicated nature mostly in the zone of the terminal edge of $-\frac{2}{3}R$. The crystals are collective individuals built up of alternating layers of substance with opposite rotary power, dextro-gyre and levo-gyre, arranged with approximately parallel axes, the resulting structure being in many cases quite complex.

Long ago Des Cloizeaux[1] discovered that cinnabar belonged to the small class of substances which exhibit circular polarization, and that it rotates the plane of polarization more strongly than any other known substance. He also found that almost all of his sections cut perpendicularly to the axis did not belong to simple crystals, but showed a combination of right and left turning parts analogous to the well-known phenomena observed in quartz and its variety amethyst.[2]

In 1871 A. D'Achiardi[3] discovered tetartohedral faces of

$$\frac{\infty P}{4} \text{ and } \frac{mP}{4}$$

but we are not aware that he determined their position. Dana[4] records one scalenohedron, $\frac{1}{3}R3$.

[1] Comptes Rendus, vol. 44, p. 876.

[2] Rammelsberg, in Handbuch der krystall. Chemie, Berlin, p. 81, states erroneously that only left turning crystals have been noted.

[3] Boll. Com. Geol. Ital., vol. 2, 1871, p. 163. The monograph of Schabus (Ber. Wien. Acad., vol. 6) is unfortunately not accessible to us.

[4] A System of Mineralogy, by J. D. Dana, fifth edition, 1884, p. 55.

The crystals hitherto found in the California quicksilver mines have either a prismatic or a rhombohedral habit and present no uncommon forms.[1] In the thin sections made by the Survey for the petrographical study of the quicksilver mines of the Pacific coast, the cinnabar whenever crystallized has a prismatic habit. The tabular crystals now under consideration are very small, almost microscopic, the diameters of which range from 0.05 mm to 0.6mm, and the thicknesses from 0.02mm to 0.2mm. The trapezohedral faces which replace the terminal edges of the rhombohedrons are much broken and curved in the larger crystals, while in the smaller they are sometimes quite well developed and so large as to influence the general triangular habit of the tables. The individuals are often grouped in more or less complex bunches and irregularly interpenetrate one another; two crystals may be frequently seen connected in such a way that one has grown either perpendicularly or obliquely into the basal plane of the other. There does not appear to be any general law governing these groupings.

On account of the tabular habit and their minute dimensions these crystals are admirably adapted for optical examination. They are translucent and deep red in color, the tint, however, being so dark that the phenomena can only be properly observed with low objectives. The apparently simple crystals present, when examined in parallel polarized light, considerable tectonic complications. On account of the feeble gyroid power of quartz this phenomenon can not be well observed in very thin sections of that mineral with common light. Cinnabar, on the other hand, rotating the plane of polarization more than quartz, according to Des Cloizeaux's measurements, fifteen to seventeen times as strongly, shows this property very well in the tabular crystals. The exact value of the angle is difficult to determine on account of the dark color in transmitted light. The crystal in Fig. 10 is drawn with the analyzer 26° to the right, its thickness is 0.09mm. This gives a rotation of 289° for 1mm, or 16.8 times as large as that of quartz, which for the red line C is 17.2. The arrangement of the dextro-gyre and levo-gyre parts is evidently governed by the law of regular grouping with parallel positive rhombohedrons, as in quartz, although there is reason to believe that the law is not strictly but only approximately true. The deviations at all events are small.

Generally speaking a composite crystal is formed of six sectors of 60° angle, whose directions of rotation are different, as illustrated in Figs. 7 and 8. The numbers of right or of left turning sectors are not constant, but may alternate regularly, or several adjacent sextants may be composed of the same substance. In the latter case they are usually separated by a narrow band of opposite rotary power and marked by a reentering angle between rhombohedral and trapezohedral planes (Figs. 4 and 7). With crossed nicols the sectors have a dark intermediate tint traversed by black radiating lines, indicating overlapping of

[1] E. Bertrand, Neues Jahrbuch, 1878, p. 657. (Redington mine, $\infty R, \frac{4}{5}R$).

the different parts. These black bars move a short distance when the analyzer is turned. Deducted from the amplitude of the movement and the thickness of the crystal the dividing plane was found in some instances to have an inclination of 110° to 120° to the basal plane. Very frequently, however, the dividing surface is altogether irregular, and often only shadows moving indistinctly can be observed on turning the analyzer, as in Figs. 5 and 6. There are not uncommonly found alternating parallel layers within one sector, appearing with crossed nicols as a system of black equilateral triangles. Thin cuneiform pieces of different rotary directions are inserted in larger areas which are uniform in rotation. When the crystals rest on the basal plane they remain perfectly isotrope on turning the table of the microscope. Exceptionally a faint change in the intensity may be observed in isolated places, as in Fig. 9 at the point marked A in the dextro-gyre section. The cause is probably a local state of tension.

Gas and fluid inclusions have been recognized. The latter are small and have sometimes a movable bubble which does not change in volume on heating. The gas inclusions often take the form of negative crystals. In Fig. 8 a series of beautiful inclusions are represented. They surround a hexagonal figure in the interior of the crystal, the sides of which are parallel to the rhombohedral planes, and appear in transmitted light deep black on the red background of the crystal. A small red spot is to be seen in the center. This phenomenon is easily explained by the very high refracting power of cinnabar $\varepsilon=3.20$, considerably higher than that of the diamond. The angle of total reflection is consequently about $20\frac{1}{2}°$. In reflected light the inclusions appear brilliantly red on the now black background.

Crystal forms.—Rhombohedrons: In order to determine the symbols of the crystal faces an attempt was made to measure them under the microscope with micrometer screw and eye-piece. It was found, however, that the error in the very small vertical measurement was so large as to seriously impair the results. The next resort was the determination of the rhombohedral faces and the calculation of other forms, as far as possible, by means of their zone relations and horizontal measurements on the stage of the microscope. The rhombohedral faces and basal plane, in spite of the minute size of the crystals, gave tolerably good signals in a Fuess goniometer, and in a series of the larger crystals the zone $[0R, R]$ was closely measured, as shown in the following table:

Interfacial angles $0R \wedge mR$.

Crystal.	$0 \wedge r (r = -R)$.	$0 \wedge r_{//} (r_{//} = -\frac{2}{3}R)$.	$0 \wedge r_{///} (r_{///} = -\frac{1}{2}R)$.	Remarks.
	° ′	° ′	° ′	
	127 6	138 36	146 32	Calculated angles.
a		138 59	147	Reflex $r_{///}$ elongated.
b		138 4		
c		138 56	147*	Reflex $r_{///}$ elongated.
d	127 15	139 4		Reflex 0 duplicated.
e		138 28	147†	$r_{///}$ indistinct.
f		138 42		
g		138 53		$\pm \infty R$ observed.
h	127 38	138 58	147 11	$r = +R : r_{///}$ duplicated.
k		138 55	146 13	$+R$ observed.

* Closely. † Approximate.

Crystal *f* was subjected to a revolution of 360°, and measurements were taken, as follows:

	Between normals.	Interfacial.
	° ′	° ′
$0R \wedge -\frac{2}{3}R$	41 18½	138 41½
$-\frac{2}{3}R \wedge 0R'$	138 42	41 18
$0R' \wedge -\frac{2}{3}R$	41 1	138 59
$-\frac{2}{3}R \wedge 0R$	138 58½	41 1½
	360	360

Reflected light, but no signal, was obtained from planes $-\frac{1}{2}R, -\infty R$ and possibly $+mR$ in this same zone.

Crystal *g* contained the prism face $-\infty R$ as shown by measurements in zone $[0R, -\frac{2}{3}R]$:

	Between normals.	Interfacial.
	° ′	° ′
$0R \wedge -\frac{2}{3}R$	41 7	138 53
$-\frac{2}{3}R \wedge -\infty R$	48 57	89 56

On crystal *h* the following measurements were recorded:

	Between normals.		Interfacial.
	° ′		° ′
$-\frac{2}{3}R \wedge -\frac{1}{3}R$	8 13	$-\frac{2}{3}R \wedge 0R$	138 58
$-\frac{1}{2}R \wedge 0R$	32 49	$-\frac{1}{2}R \wedge 0R$	147 11
$0R \wedge 0R'$	180	$+R \wedge 0R$	52 22
$0R' \wedge +R$	52 22	$+R \wedge 0R'$	127 38

Also in the same zone reflected light from prism planes was observed. These latter planes are very narrow, occur along the lateral edges of the tabular cinnabar crystals, and are quite common, but in rare cases only can good signals on the goniometer be seen.

The rhombohedral face, $-\frac{2}{3}R$, is invariably perfect, and the basal plane, $0R$, is usually so; but the latter is oftentimes broken, the angle between its parts sometimes amounting to 1°. In some crystals the irregularities may be seen to follow the line between dextro-gyre and levo-gyre substance, indicating that the positions of the different parts are not strictly parallel. Planes of the rhombohedron, $-\frac{1}{2}R$, on the other hand, never give good reflections and are always striated. These striations are parallel to the combination edges of the rhombohedral face and the trapezohedral faces on either side. They are interesting and will be subsequently considered. Positive rhombohedral forms, $+mR$, are seldom present. In Fig. 9 one small face of $+\frac{2}{3}R$ (r_2) and one of $+\frac{1}{2}R$ (r_3) are noted.

In giving the negative sign to the dominant rhombohedron, we were led by considerations based on the nature of the trapezohedral faces, as well as by previous descriptions of the habit of cinnabar crystals.

The simple forms observed are tabulated thus:

Naumann.	Bravais-Miller (*hkli*).
$0R$	(0001)
$-\frac{4}{3}R$	$\kappa(02\bar{2}3)$
$-\frac{1}{2}R$	$\kappa(01\bar{1}2)$
$-R$	$\kappa(01\bar{1}1)$
$+R$	$\kappa(10\bar{1}1)$
$+\frac{3}{4}R$	$\kappa(20\bar{2}3)$
$+\frac{1}{2}R$	$\kappa(10\bar{1}2)$
∞R	$\kappa(10\bar{1}0)$

Of these forms $0R$ and $-\frac{2}{3}R$ are by far the most prominent.

Some typical crystals were selected, mounted in balsam and drawn under the camera-lucida. The greatest care was taken to reproduce a perfect image in the drawing, and this position of the crystals seemed best adapted to illustrate their irregularities and the relations of the trapezohedral planes to the other forms. The drawings could be made conveniently only with strong reflected light. Whenever special measurements of angles in a horizontal section were necessary, they were made by cross-hair and graduated table and were not taken from the drawings.

Tetarto-trapezohedrons.—Obliquely replacing the terminal edges of $-\frac{2}{3}R$ and $-\frac{1}{2}R$ (Figs. 1 and 3), there appeared a series of faces often broken and irregular, which from their position and connection with the dextro-gyre and levo-gyre substance of the cinnabar could only be regarded as tetartohedral forms of a dihexagonal pyramid. The interest

arose from the fact that in many individuals these forms were more largely developed, than in any cinnabar crystals heretofore described. Trapezohedral faces lying in the terminal zone of R have been observed on quartz crystals[1] and on hypoiodate of sodium[2] but there seems to be no record of such faces in a zone of more obtuse forms.

The relation between the sectors of different rotating power and the trapezohedral faces must now be considered. Applying the law of rhombohedral hemihedrism to the dihexagonal pyramid mPn, two scalenohedrons, $\pm\frac{mPn}{2}$ or $\pm\ m'Rn'$, are derived, which differ in position by 60°. Again applying the law of trapezohedral tetartohedrism to $\pm\frac{mPn}{2}$ we obtain four enantiomorph forms, $\pm r\frac{mPn}{4}$ and $\pm l\frac{mPn}{4}$ right and left trigonal trapezohedrons. Furthermore, the hexagonal pyramid of the second order, mP2, when subjected to trapezohedral tetartohedrism, yields two trigonal pyramids $r\frac{mP2}{4}$ and $l\frac{mP2}{4}$ which can be regarded as the limits between positive and negative trigonal trapezohedrons (Fig. 13).

The connection between the trapezohedral forms and the rotating direction in the case of quartz[3] is as well known as that dextro-gyre crystals are modified by planes of

$$r\frac{mP2}{4}, +r\frac{mPn}{4}, -l\frac{mPn}{4}$$

and levo-gyre crystals by planes of

$$l\frac{mP2}{4}, +l\frac{mPn}{4}, -r\frac{mPn}{4}.$$

If the positive rhombohedron should be taken as negative, the first of the two divisions above would correspond to levo-gyre, and the second to dextro-gyre crystals.

In combination with a positive rhombohedron in right turning crystals[4] (the face of +R being held in front of the observer), $r\frac{mP2}{4}$ is placed on the right terminal edge obliquely towards the observer; $-l\frac{mPn}{4}$ lies between $r\frac{mP2}{4}$ and $-\frac{1}{2}R$, and $+r\frac{mPn}{4}$ replaces the combination edge of $+R$ and $r\frac{mP2}{4}$.

In levo-gyre crystals the planes $+l\frac{mPn}{4}$ and $-r\frac{mPn}{4}$ are placed on the other side of this terminal edge. In combination with a negative rhombohedron the relations are reversed, so that the dextro-gyre forms

[1] Websky on quartz crystals. Neues Jahrbuch, 1871, p. 732.
[2] Groth: Physik. Krystall, 1876, p. 302.
[3] Groth: Physik. Krystall., 1876, p. 301.
[4] P. Groth: Monatsbericht d. Berlin Akad., 1869.

here correspond in relative positions to the levo-gyre forms in the case of the positive rhombohedron.

In order to determine the nature of these trapezohedral faces and the form to which they belonged, measurements in the horizontal section were taken of the angles which the combination edges of $(-mR \wedge 0R)$ made with those of the trapezohedral planes over the same basal plane. The crystal in Fig. 1 was chosen for this purpose and the angles on both the analogue and the antilogue poles were ascertained by means of cross-hair and stage of the microscope. The angles in Fig. 1 are designated α, β, etc.,[1] lettered in order; those in Fig. 2 are self-evident. In the first series of measurements low magnifying power was employed, and in the second, higher power for the determination of the angles where two trapezohedral faces formed re-entering angles. The latter should be accurate within one degree.

First series.		Second series.
Fig. 1.	Fig. 2.	Fig. 1.
°	°	°
$\alpha = 141$	Above $d = 140$	$\alpha = 138\frac{1}{2}$
$\beta = 100$	Above $c = 99$	$\beta = 99$
$\gamma = 137$	Above $b = 137$	$\gamma^1 = 139$
$\delta = 103$	Above $a = 104$	$\gamma^2 = 183$
$\eta = 135\frac{1}{4}$	Above $f = 136$	$\delta = 100$
$\theta = 104$	Above $e = 104\frac{1}{2}$	$\eta^1 = 130$
		$\eta^2 = 185\frac{3}{4}$
		$\theta = 103\frac{3}{4}$

The angles lettered γ^2 and η^2 are re-entering and are formed by two trapezohedral planes. Those edges forming γ^2 make with the combination edge $(-mR \wedge 0R)$ on the right angles of 139° and 142°, respectively, and those forming η^2 make in the same way angles of 130° and $135\frac{3}{4}$°, respectively. That these trapezohedral planes belong to the same class of derivatives from the scalenohedron and possess the same general symbol, is evident from Fig. 14, in which is shown the projection of the combination edges of the negative rhombohedron, $-m$R, and of the trapezohedral planes with the basal plane. The heavy lines represent the positions of these edges as they appear in Fig. 1, and the dotted lines the corresponding edges of Fig. 2 in their true relation to the crystal and Fig. 1. Figs. 13 and 14 show further that the trapezohedral planes in relation to $-mR$ have the general symbol $+r\frac{mPn}{4}$ and that the angles may vary in the basal section of (1) $+r\frac{mPn}{4}$ for α[2] from 120° to 150°, and for β from 90° to 120°; β on left hand (2) $-l\frac{mPn}{4}$ for α from 150° to 180°, and for β from 60° to 90°; β on left

[1] Compare Fig. 11.

[2] β=the less obtuse angle.

hand (3) $+l\frac{mPn}{4}$ for α from 120° to 150° and for β from 90° to 120°; β on right hand (4) $-r\frac{mPn}{4}$ for α from 150° to 180°, and for β from 60° to 90°; β on right hand. From the discussion above, the tetartohedral planes must belong to the form trigonal trapezohedron, and in this special case, Figs. 1 and 2, to $+r\frac{mPn}{4}$. Notwithstanding the large deviation in the angular measurements of the basal section, as in α, γ^1, η and in β, δ, θ, the trapezohedral planes, three above and three below, must constitute a complete form, and we are obliged to seek explanation of these discrepancies in the errors of measurements, in the distortions of the crystals, and in the fact that narrow planes, almost mere lines, which are present, may correspond to missing trapezohedral faces. Unfortunately, these narrow planes scarcely admit of a representation on the scale of the drawings, and much less of even an approximate measurement.

On studying the relations of the angles α and β to the other parts in many crystals, it was discovered that in the dextro-gyre sectors the angle β is always on the left side when the trapezohedral face is held towards the observer, and in levo-gyre sectors on the right. This, considered in connection with what has been said before concerning the positions of trapezohedral faces, can only be true if we consider the dominant rhombohedron negative, always of course under the supposition that the relation between differently rotating substance and the trapezohedrons (see p. 16) is the same as in quartz. If we reverse this, the rhombohedron must be considered positive. The most common face is that of $+l\frac{mPn}{4}$ in the left turning sectors and of $+r\frac{mPn}{4}$ in the right turning; negative trapezohedrons, where the angle $\beta<90°$ are quite rare; twice β was measured to 90°, corresponding to a section line of a trigonal pyramid.

The larger and more regular planes replacing the terminal edges of the rhombohedrons appear to be exactly in the zone of $[-\frac{2}{3}R, +\frac{1}{3}R]$, since under the microscope the combination edges of the trapezohedral face with the adjoining rhombohedral faces $-\frac{2}{3}R$ are parallel and make with the combination edge $(-\frac{2}{3}R \wedge 0R)$ on the right and left respectively equal angles of 150° in the horizontal projection. On the goniometer a faint, elongated flash of light, scarcely to be called a signal, was reflected from each of these planes in the zone $[-\frac{2}{3}R, -\frac{2}{3}R]$. Calculated from the observed values of β and the zone equation complex symbols of the trapezohedral forms are obtained. It was found by comparison of the different values that the position of the planes oscillates about the simpler forms $+r\frac{\frac{2}{5}P\frac{3}{2}}{4}$ and $+l\frac{\frac{2}{5}P\frac{3}{2}}{4}$, $\varkappa\varkappa''$ $[2.4.\overline{6}.15]$ corresponding to a value of $\beta=100°\,53'+$, but only once actually measured. The following

table shows the angles β, measured on several crystals, and the more obtuse angles α corresponding to these. The third column contains the measured angles α, and the fourth the symbols calculated from the angle β.

β measured.	$\alpha = 240° - \beta$.	α measured.	Symbols, $+r\frac{mPn}{4}$
° ′	° ′	°	
When $\beta =$ 93	$\alpha = 147$	.....	$\frac{1}{6}a : a' : \frac{1}{6}a'' : \frac{3}{7}c$
95	145	.....	$\frac{1}{8}a : a' : \frac{1}{11}a'' : \frac{5}{15}c$
99	141	.....	$\frac{1}{4}a : a' : \frac{1}{5}a'' : \frac{1}{3}\frac{5}{7}c$
100	140	139	$\frac{2}{6}a : a' : \frac{2}{11}a'' : \frac{2}{5}c$ $2.889a : a' : 1.532a'' : 0.407c$
100 53	139 7	(*)	$3a : a' : \frac{3}{2}a'' : \frac{3}{5}c$ $2.999a : a' : 1.5a'' : 0.4c$
101	139	$139\frac{1}{2}$	$3a : a' : \frac{3}{5}a'' : \frac{3}{8}c$ $3.015a : a' : 1.496a'' : 0.3996c$
102	138	.....	$\frac{1}{6}a : a' : \frac{1}{13}a'' : \frac{3}{8}c$ $3.165a : a' : 1.462a'' : 0.396c$
103	137	137	$\frac{1}{3}a : a' : \frac{1}{7}a'' : \frac{1}{2}\frac{5}{3}c$
104	136	136	$\frac{2}{3}a : a' : \frac{2}{5}a'' : \frac{7}{1}\frac{5}{8}c$
105	135	$134\frac{1}{2}$	$\frac{1}{3}a : a' : \frac{1}{3}a'' : \frac{1}{7}\frac{5}{3}c$
107	133	.....	$\frac{1}{4}a : a' : \frac{1}{13}a'' : \frac{1}{3}c$

* Not measured.

The frequent occurrence of trapezohedrons on quartz with complex symbols has often been commented on. Websky[1] has attempted to explain these by the theory of the induced faces, supposing the crystal to be built up of alternating layers of substance turned 180° around the vertical axis so that in this twin position $+R$ of one individual covers $-R$ of another. The trapezohedral forms in the upper layer are consequently influenced by those belonging to a different series in the lower layer, and, not being able to develop in their proper places, they take positions intermediate between these and those of the inducing face. This view seems not improbable in the present case under discussion.

Even in the more regular crystals, Figs. 1, 3, 7, the trapezohedral faces are seldom perfectly smooth, but generally slightly broken and curved. Figs. 7 and 10 show this tendency increased (t and d', Fig. 6; u', u, x, Fig. 10). Finally, in Figs. 5, 6, and 9 the faces are exceedingly rough, and broken into a number of irregular planes. Such phenomena have also been observed on the tetartohedral faces of quartz crystals.[2] Partially, at least, these irregularities may be explained by the hypoparallel position of the differently rotating parts composing the whole crystal.[3]

The fact that the basal plane is frequently broken, confirms the explanation just given. It appears peculiar, however, that the rhombo-

[1] See paper regarding Quartz Crystals from Strigau in Neues Jahrbuch, 1871, pp. 132, 785.

[2] Websky. Uber Deformitäten an Quarz-krystallen. Neues Jahrbuch, 1870, p. 353.

[3] Sadebeck. Krystallotektonik, p. 184.

hedral faces,—$\frac{2}{3}R$, do not show more markedly the effects of this hypoparallelism if it is really the cause of all the disturbances. On the goniometer the reflected signals from $-\frac{2}{3}R$ are frequently duplicated, but striations are wanting.

The tectonic face of $-\frac{1}{2}R$ has been alluded to. This face presents irregularities which under strong objectives appear as distinct figures formed by trapezohedrons and rhombohedrons, Fig. 12. Sometimes the whole face is covered by these protruding "subindividuals," bordered by vicinal planes,[1] causing either a rough (Drusigkeit) or a striated appearance, Fig. 12 *a*, *b*, Fig. 5. The tendency of $-\frac{1}{2}R$ to form vicinal faces is well shown in Fig. 8, and is illustrated by the irregularly running edge ($-\frac{2}{3}R \wedge -\frac{1}{2}R$). When re-entering angles are formed, which is very often the case, then the edge ($-\frac{1}{2}R \wedge 0R$) becomes broken and irregular, thus accounting in great measure for the large variation of β in the table on page 19. In Fig. 4 at the point marked st''' there is a coarse striation, which under strong objectives can be seen to be due to the combination of $-\frac{1}{2}R$ with a trapezohedron, the same which lies in zone $[-\frac{2}{3}R, -\frac{2}{3}R]$.

Description of crystals.—Crystal 1, Figs. 1 and 2. Rather uniformly built and principally of dextro-gyre substance. Angle β_d measured 99°, angle β_b $103\frac{3}{4}$°. Both trapezohedral planes have the general symbol $+r\frac{mPn}{4}$ and lie on either side of $+r\frac{\frac{2}{5}P\frac{3}{2}}{4}$. The symbols corresponding to the measured angles are, as shown on page 19, $+r\frac{\frac{15}{7}P\frac{11}{7}}{4}$ and $+r\frac{\frac{7}{18}P\frac{7}{5}}{4}$ respectively. There are other triangular trapezohedral planes, *m*, *n*, *p*, *q*, which belong to a more acute form than those determined. The symbols of these could not be ascertained either by measurement or by zone relations.

Crystal 2, Fig. 3, has two well-developed trapezohedral planes, and angle β_u measured 103°, and β_c 103°. Corresponding to this angle $c=+l\frac{\frac{9}{23}P\frac{10}{7}}{4}$ and $u=+r\frac{\frac{9}{23}P\frac{10}{7}}{4}$

The upper edges show some irregular trapezohedral faces.

Crystal 3, Fig. 4. A re-entering angle is formed by $r_{//}$ and a broken trapezohedral face *k*. A narrow plane lying in the zone $[r_{///}, r_{//}]$ belongs probably to the trapezohedron of which *b* forms a part. There are present one right-handed and one left-handed trapezohedron,

$$b=+r\frac{\frac{5}{13}P\frac{11}{8}}{4} \text{ and } t=+l\frac{\frac{5}{13}P\frac{11}{8}}{4}, \text{ where } \beta_b \text{ and } \beta_t=105°.$$

Crystals 4 and 5, Figs. 5, 6. These crystals show how the irregularities of the trapezohedral faces increase as the complexity of the arrangement of dextro-gyre and levo-gyre parts increases. It does not seem improbable that most of the deviations from the correct positions of the

[1] Websky. Zeitsch. Deutsch. geol. Gesell., vol. 15, p. 677, Berlin. Sadebeck, Krystallotektonik, p. 195.

faces are caused by a conflict between series of forms of different rotating power belonging to cinnabar. $r_{///}(-\frac{1}{2}R)$, as well as $r_{//}(-\frac{2}{3}R)$ becomes very prominent and is characterized by striations and grooves.

Crystal 6, Fig. 7 and Fig. 8 opposite poles. Built of alternating sectors with smooth trapezohedral faces.

Angle measured.	Fig. 6*a*.	Fig. 6*b*.	Symbol.
	°	°	
β_b	105	.....	$+r^{\frac{5}{13}}\frac{P^{11}_{8}}{4}$
β_t	105	.....	$+l^{\frac{5}{13}}\frac{P^{11}_{8}}{4}$
$\beta_{b'}$	.....	104	$+r^{\frac{7}{18}}\frac{P^{7}_{5}}{4}$
$\beta_{t''}$	.....	102	$+l^{\frac{2}{5}}\frac{P^{19}_{13}}{4}$
$\beta_{t'''}$	.....	97	$+r^{\frac{2}{5}}\frac{P^{5}_{3}}{4}$

In Fig. 7, at the lower right-hand of the drawing a re-entering angle appears, causing a thin wedge of dextro-gyre substance to occur in a levo-gyre sector. At this part of the crystal there are three planes, t^2, t^3, t^4, the special symbols of which could not be determined. The plane t^2 belongs to the form $+l\frac{mPn}{4}$, and t^3 to $-r\frac{mPn}{4}$. The triangular planes o, o', p are probably more acute trigonal trapezohedrons. The re-entering angle at d was so irregular and the combination edges with $0R$ so broken that no reliable information could be obtained concerning the planes. The opposite pole, Fig. 8, does not present such complex combinations of forms.

Crystal 7, Fig. 10, is very similar to crystal 7, but almost wholly levo-gyre. Measured, $\beta u=103°$, $\beta x=95°$. Therefore

$$u=+l^{\frac{9}{23}}\frac{P^{10}_{7}}{4}, \text{ and } x=+l^{\frac{8}{19}}\frac{P^{19}_{11}}{4}$$

The remaining planes were not determinable. Fig. 11 represents the antilogue pole. β, β', β'' measured 106°, 107°, 103°, respectively.

Crystal 8, Fig. 9, is levo-gyre for the most part, and exhibits beautiful gas inclusions. The usual trapezohedrons are here present with combination edges very much broken. Plane g is probably a trigonal pyramid, for angle $\beta=90°$, while the measured angle $\alpha=150°$ ($g : r_{///}$ on the right). The form is then $r\frac{mP2}{4}$; $r_2=+\frac{2}{3}R$ and $r_3=+\frac{1}{2}R$.

CINNABAR CRYSTALS FROM SULPHUR BANK, LAKE COUNTY, CAL.

In the collection of the Survey appears a coating of cinnabar crystals upon an argillaceous rock, which has resulted from the decomposed and disintegrated basalt abounding in the quicksilver workings at Sulphur Bank. Throughout this rock run seams of persulphide of iron, probably marcasite, and patches of this mineral form the lining of cavities

upon which have grown calcite crystals. Cinnabar is also very abundant in the mass of the rock, and in many places has crystallized contemporaneously with the calcite. The crystals in the coating are brick-red, possessing a rather metallic luster, by no means so highly adamantine as the tabular crystals from New Idria, while the powder yields a brilliant vermillion. The crystals, varying in diameter from 0.5 to 0.75^{mm}, were found to be simple rhombohedrons with no other hexagonal modification. The rhombohedral faces are curved much as they often are in mineral dolomite, and, owing to this fact, as well as to the dull luster, great difficulty was experienced in obtaining close measurements. The most reliable angular measurements were those taken over the terminal edge of the rhombohedron. This angle is 74° 40′ between normals, the mean of over a dozen determinations, from which is deduced the symbol $\pm\frac{3}{4}R$. The calculated angle for $\pm\frac{3}{4}R$ is 75° 8½′ between normals, or 104° 51½′ interfacial.

CINNABAR CRYSTALS FROM KNOXVILLE, NAPA COUNTY, CAL.

Large masses of marcasite, which is often vesicular and carries fragments of quartz and opal, occur in the quicksilver deposits at Knoxville. The marcasite is frequently crystallized in the cavities. Metacinnabarite forms the greatest part of the sulphide of mercury which these specimens contain, while upon its surface brilliant needles of cinnabar have crystallized sometimes in tufts and again in irregular network. The needles vary in length from 0.5 to 2^{mm} and their diameter is rarely greater than 0.1^{mm}. Excellent measurements were obtained which resulted in the identification of the crystal forms $-\frac{4}{5}R$ (or $+\frac{4}{5}R$) and the hexagonal prism ∞P (or $\pm\infty R$). The angle between normals $-\frac{4}{5}R \wedge -\infty R = 43°\,26'$, interfacial 136° 34′. The calculated angle for $(-\frac{4}{5}R \wedge 0R) = 46°\,34'$ between normals, 133° 26′ interfacial (133° 24′ Dana) This habit of cinnabar has been observed also by E. Bertrand. (See note p. 12.)

CINNABAR CRYSTALS FROM NEW ALMADEN, CAL.

Many crystals were examined which were found on specimens from New Almaden mines. These stout and brilliant crystals usually exhibited the forms $0R, -\frac{1}{2}R, -\frac{2}{3}R, -2R, \pm\infty R$; one had the form $+mR$. An angular measurement was obtained, $-mR \wedge 0R = 75°\,7'$ (normals), which corresponds to the form $-\frac{14}{5}R$. This form has not been given by Dana, and by us was observed only once.

METACINNABARITE FROM KNOXVILLE, CAL.

The metacinnabarite associated with the needles of cinnabar previously described occurs in seams from 2 to 4^{mm} wide, is easily detached and but slightly contaminated with quartz and possibly marcasite. Occasionally small nodules of metacinnabarite are seen on the specimens and appear to be formed of crystals which present dull and curved

faces baffling all attempts at recognition and identification. In the following analysis the mercury, iron, and silica were determined, and the amount of sulphur was calculated for the metals, analysis (I) on the assumption that iron is combined as FeS; (II), that FeS_2 is the combination:

	I.		II.
	Per cent.		*Per cent.*
HgS	98.48	HgS	98.48
FeS	0.691	FeS_2	0.942
SiO_2	0.707	SiO_2	0.707
	99.878		100.129

In order to ascertain if possible in which state of combination the iron existed in the sample, two experiments were made. Crystals of marcasite were taken from the same specimen which furnished the sample for analysis, and the fine powder was boiled with dilute hydrochloric acid (1HCl : 10Aq). Appropriate tests gave barely a trace of sulphureted hydrogen. On the other hand a portion of the sample employed for analysis yielded an abundance of this gas when slightly heated with the dilute acid. In the absence of other sulphides the conclusion must follow that the iron exists wholly or in part in the form of protosulphide.

METACINNABARITE FROM CERRO GORDO MINE, CAL.

At the Cerro Gordo Mine, 11 miles west of Panoche, Fresno County, was found a specimen of metacinnabarite associated with chalcedony and crystallized quartz. The quantity collected for analysis amounted only to 0.0159 grams, and this sample contained a small percentage of cinnabar. 95.62 per cent. HgS was obtained on analysis, the residue, 4.38 per cent., consisted of quartz and a little iron which was undetermined.

SULPHATES FROM THE REDINGTON QUICKSILVER MINE, KNOXVILLE, CAL.

The mass of the rock specimen is a black opal which is much fractured. The seams contain three distinct salts.

(1) Small black crystals belonging to the isometric system and presenting the forms 0 and ∞ 0. The substance is a double sulphate of iron and potassium, an alum in which both the ferrous and the ferric states of iron occur.

(2) The mass is fibrous, often so fine that the fibers can hardly be distinguished under the microscope; seldom are seen massive portions with crystalline structure. The color is pale purple. The parallel-fibrous aggregates are sometimes white with silky luster and only purple on the surface perpendicular to the fibers. Under the micro-

scope they are colorless with no visible crystalline form. The system of crystallization is probably triclinic, as extinctions parallel to the fibers are never obtained. Extinction 13° to 38°. Double refraction feeble. Specific gravity=1.761. Soluble in water.

Analysis.

H_2O at 100° C	27.093
H_2O above 100° C	14.340
SO_3	35.352
Al_2O_3	5.136
Cr_2O_3	7.512
Fe_2O_3	0.186
FeO	4.579
NiO	1.001
MnO	trace.
MgO	1.850
Residue	3.457
	100.506

The atomic ratio is therefore $R'' : R^{vi} : S^{vi} : H_2 = \frac{1}{4} : \frac{2}{3} : 2\frac{3}{4} : 4\frac{3}{4}$, and the simplest symbol $9RO.\ 8R_2O_3.\ 33SO_3.\ 171H_2O$. A portion of this large amount of water can be accounted for in the moisture of the sample. There seems to be a possibility of an isomorphous mixture of different sulphates in this substance, but a mechanical separation of the massive from the fibrous portions was quite out of question. We propose for this mineral the name Redingtonite.

(3) This sulphate coats the purple salt in small quantities. Under the microscope it is found to consist of rhombic tables with angles of 78° and 102°. The system is rhombic. The cleavage is excellent, parallel to $0P$. and good parallel to ∞P and $\infty P\bar{\infty}$. The color is greenish yellow; the mineral is somewhat dichroic; the color being most intense when the short diagonal of the tables is parallel to the principal section of the nicols. It is doubly refracting. The tables are too small to show the emergence of the optic axis. Tests with mica plates show, however, that of the two axes of elasticity lying in the basal plane the one parallel to the brachydiagonal is the larger. This also agrees with copiapite, which is negative.

The following analysis was made with 0.1482 grams material which was separated from associated substances as well as possible. The water above 100° C. was determined by difference.

H_2O at 100° C	9.296
H_2O above 100° C	17.596
SO_3	35.905
Cr_2O_3	7.409
Al_2O_3	4.835
Fe_2O_3	15.360
FeO	3.813
NiO	0.835
MgO	3.216
Residue	1.735
	100.00

The atomic ratio is R^{ii}: R^{vi}: S^{vi}: $H_2 = \frac{3}{10}$: $\frac{7}{6}$: $\frac{11}{4}$: 3. From its optical and some of its chemical characters there are evidences of its isomorphism with copiapite from Knoxville, a mineral hereafter described, and a comparison of the atomic ratio with that obtained by analysis of the latter mineral shows rather close analogy. This sulphate is more basic than that, and its composition indicates a derivation from other sources than persulphide of iron. We propose for this mineral the name Knoxvillite.

COPIAPITE FROM REDINGTON MINE, KNOXVILLE.

The specimem of copiapite consists of a soft mass composed of microscopic scales and crystalline particles, the color of which is sulphur-yellow. The optical properties of the mineral species have been described by E. Bertrand[1] and this specimen confirms his description in all important points.

The mineral is rhombic, and the microscopic fragments are mainly cleavage pieces from 0.04 to 0.2^{mm} in diameter. The cleavage is perfect parallel to $0P$, and fairly good parallel to ∞P. The angles of the prism are 78° and 102°. The plane of the optic axes is $\infty P\breve{\infty}$. The second median line is perpendicular to $0P$. The double refraction is negative. The pleochroism is quite distinct, especially on $0P$; a slightly greenish-yellow, b nearly colorless, c yellowish.

Analysis.

H_2O	30.43
SO_3	39.97
Fe_2O_3	26.54
FeO	0.46
MnO	0.21
MgO	3.06
	100.67

Atomic ratio $R^{ii} : R^{vi} : S^{vi} : H_2 = 1 : 6 : 18 : 20$, corresponding to the formula

$$RO . 2R_2O_3 . 6SO_3 . 20H_2O.$$

COPIAPITE FROM SULPHUR BANK, LAKE COUNTY, CALIFORNIA.

In the surface mines of the quicksilver deposits at Sulphur Bank bright red cinnabar is associated with the products of the decomposition of marcasite. Among these are ferrous sulphate, a white silky sulphate of iron and alumina, and a yellow ferric sulphate. The latter salt was studied in order to ascertain how closely it approached the

[1] Groth's Zeitschr. für Krystall. u. Min., vol. vi, 1882, p. 296.

copiapite from Knoxville in its characters. Under the microscope it entirely resembled this mineral, and the description above given for copiapite answers for this ferric sulphate. The following analysis was made, in which the water above 100° C. was determined by difference:

H_2O	29.575
SO_3	38.820
Al_2O_3	0.371
Fe_2O_3	26.792
FeO	3.277
MnO	trace.
CaO	0.255
MgO	0.156
Residue	0.754
	100.000

The atomic ratio is $R^{ii} : R^{vi} : S : H_2 = 1 : 10 : 30 : 33\frac{1}{3}$, corresponding to the formula $\frac{3}{2}RO . 5R_2O_3 . 15SO_3 : 50H_2O$.

Since all these sulphates, with the exception of redingtonite, were yet damp when taken for analysis, the moisture which was thus mechanically occluded by the salts can not be considered in the discussion of their formulæ. The atomic ratios calculated for the anhydrous salts on the basis of 100 per cent. are tabulated as follows:

Purple sulphate, Redingtonite, anhydrous	$R^{ii} : R^{vi} : S^{vi} = 0.44 : 0.98 : 4.77$
Green sulphate, Knoxvillite, anhydrous	$R^{ii} : R^{vi} : S^{vi} = 0.40 : 1.61 : 3.77$
Copiapite, anhydrous	$R^{ii} : R^{vi} : S^{vi} = 0.24 : 1.42 : 4.27$
Yellow salt, Sulphur Bank, anhydrous	$R^{ii} : R^{vi} : S^{vi} = 0.16 : 1.47 : 4.18$

	Purple sulphate.	Green sulphate.	Copiapite.	Yellow sulphate.
Atomic ratio	2 : 4 : 19	12 : 36 : 90	6 : 36 : 102	6 : 54 : 150
Formulæ	$6RO . 4R_2O_3 . 19SO_3$	$6RO . 6R_2O_3 . 15SO_3$	$3RO . 6R_2O_3 . 17SO_3$	$3RO . 9R_2O_3 . 25SO_3$

It is evident that the yellow ferric sulphate is identical with the copiapite from Knoxville, because the ratio of the atomicities of the total base to SO_3 is practically the same; i. e., in copiapite, 21 : 17; in the yellow salt, 20 : $16\frac{1}{3}$. The purple salt scarcely belongs to this scheme, because it proves to be a neutral sulphate according to its properties as well as by the atomic ratio first given in the description of the mineral species. Its rather compact state does not admit of the occlusion of much moisture. The other sulphates are loose in texture, and a fair comparison of their composition can be attained only through the above scheme. These sulphates are then basic sulphates, and in the anhydrous state are closely represented by the formulæ in the above table.

STROMEYERITE FROM CALICO, SAN BERNARDINO COUNTY, CALIFORNIA.

On the lower levels of the Silver King Mine in Calico, a sulphide of copper and silver was found, which by the following analysis proved to be stromeyerite:

Ag	53.964	which requires 8.018 S as Ag_2S	
Cu	28.575	which requires 7.223 S as Cu_2S	
Fe	0.264		
S	15.512	15.241 theoretical S.	
Residue	1.552		
	99.867		

Theory requires for $Ag_2S \cdot Cu_2S$... Ag = 53.084, Cu = 31.148, S = 15.768, 100.000

The residue was mostly barite with a very little quartz. Comparison with the analyses of this mineral species which Dana[1] has tabulated, shows that the specimen under examination differs greatly, in composition, from those from Arizona, while it more nearly approaches specimens from localities in Siberia and Silesia. The analyses of stromeyerite from Arizona show a variation in silver from 7.42 to 14.05 per cent; in copper from 72.73 to 64.02 per cent.

The specific gravity of our specimen, 6.28, was found to be the same as that given by Dana for the mineral species. The mineral is dark-steel gray on fresh fracture, but tarnishes somewhat on exposure. It is associated with barite, malachite, and contains widely separated and minute areas of a brown oxide of manganese.[2] Other minerals found in the same mining region are as follows:

Cerargyrite (horn-silver) as brown coatings; embolite (chloro-bromide of silver) greenish-yellow coatings, and crystalline aggregates, combinations of 0, $\infty 0 \infty$, and $\infty 0$; chalcopyrite; chrysocolla, usually microscopic; malachite; cerussite; pyrolusite; barite, massive and tabular crystals; calcite.

CHROMIFEROUS CHLORITE—KOTSCHUBEITE.[3]

The great serpentine belt crossing the North Fork of the American River above Dutch Flat contains several deposits of chromite, some of which are worked on a small scale. While examining the ore from one of these occurrences—Green Valley, in the cañon of the American River, below Towle's on the Central Pacific Railroad—coatings of a micaceous

[1] A System of Mineralogy, by J. D. Dana, ed. of 1883, p. 54.

[2] W. Lindgren: Trans. Am. Inst. Min. Engineers, Feb., 1887.

[3] This article and those following have already appeared in print, having been published in the Proceedings of the California Academy of Sciences, Dec. 20, 1887, under the title, "Contributions to the Mineralogy of the Pacific Coast," by Waldemar Lindgren, U. S. Geol. Survey.

mineral of a beautiful peach-blossom color, together with smaller pieces of the same mineral, were found in the massive state. The substance proved to be a chlorite, and is most closely allied to that variety of clinochlore to which Kokscharow[1] gave the name kotschubeite. With a magnifying glass the micaceous coatings are seen to be composed of thin hexagonal tables from 0.2mm diameter down to the smallest dimensions, often roughly arranged in rosette form and in smaller fibrous masses, the latter being mixed with minute grains of uwarowite and chromite. The crystals cleave perfectly parallel to the hexagonal section, and appear to consist of a basal plane and rhombohedrons, one of which presents small striated faces. No accurate measurements could be obtained by means of the goniometer, or the micrometer and micrometer screw.

Under the microscope the tables, when resting on their bases, are pale purple and transparent, and between crossed nicols the crystals prove to be double-refracting and biaxial. The tables, apparently strictly hexagonal, are twinned monoclinic crystals, the most regular forms being usually divided into six sectors with a common apex in the center and with their axes of elasticity in different position. The colors of interference are low on the base, not exceeding the grays of the first order; those of the fibrous aggregates are more vivid, more so in fact than is usual with the chlorites.

In convergent light the plane of the optic axes is found in each sector to be parallel to its base; angle of the optic axes quite large, probably about 30°. Double refraction positive. The character of the dispersion can not be well observed on account of the small size of the crystals.

The acute bisectrix stands nearly normal to the base $0P$, and the extinction of the fibers is consequently quite small. Pleochroism distinct: a and b purplish, c (vibrating perpendicularly to $0P$) yellowish red.

Streak of the mineral, white; luster of cleavage face, somewhat pearly. $H=2$. G (massive variety)$=2.69$.

Before the blow-pipe the mineral becomes greenish white, and is fusible on the edges with great difficulty. With fluxes strong chromium reactions.

In the following analysis the sample was quite free from associated chromite and uwarowite. In order to facilitate comparison two analyses follow, one from Dana's Mineralogy, an analysis of kämmererite; the other an analysis of kotschubeite by von Leuchtenberg.

[1] Bull. Acad., St. Petersburg, 1861, p. 369.

			Kämmererite, Texas, Pa.	Kotschubeite, Ural.
Loss at 105° C.	0.365	13.043	13.20	12.63
Loss above 105° C.	12.678			
SiO_2	31.740		31.31	32.67
Cr_2O_3	11.392		2.98	4.09
Al_2O_3	6.741		12.84	13.18
Fe_2O_3	.....		.....	2.22
FeO	1.231		2.46	.....
NiO	0.487		0.45	.....
CaO	0.183		0.82	.....
MgO	35.178		35.02	35.65
	99.995		99.08	100.44

The two forms of chlorite, penninite and clinochlore (ripidolite), have, according to Rammelsberg, substantially the same composition, and differ only in their crystallization, penninite being hexagonal, and clinochlore, monoclinic. Both have varieties rich in chromium, that corresponding to penninite being kämmererite from the Urals and the well-known locality, Texas, Pa. It has been proved to be uniaxial by Des Cloizeaux[1] and J. P. Cooke.[2] Various authors have also designated it as rhodophyllite, chromchlorite, rhodochrom. The chromiferous variety of clinochlore, kotschubeite, from the Urals, has been described by Nicholas von Leuchtenberg,[3] but has not been noticed from any other locality, and its occurrence in California is therefore not without interest.

Von Leuchtenberg arrives at the conclusion that kotschubeite is a variety of clinochlore, but differs from it in the inclination of the acute bisectrix to the normal of the base; while this value amounts to 12° to 16° in clinochlore, it has been measured to 1° to 2° in kotschubeite. The same writer's description applies equally to the California specimen as to the optical characters, but the crystal form differs. The mineral from the Ural had the form of hexagonal pyramids, and was apparently composed of simple crystals, while that here described occurs in thin tables composed of three individuals, and twinned according to the well known law of clinochlore, so as to appear as hexagonal crystals. In the position of the optical axis the crystals most resemble those of clinochlore from Texas, Pa., described by Cooke.

A further and notable difference from Koksćharow's kotschubeite, and, indeed, from any known chromiferous chlorite, is in the very high percentage of Cr_2O_3; v. Leuchtenberg found 4.09 per cent, while the highest amount of Cr_2O_3 in kämmererite is 5.50 per cent. The analysis of the California mineral shows more than twice that amount, viz: 11.392 per cent Cr_2O_3, replacing Al_2O_3, but in other respects it agrees well with those of kämmererite and kotschubeite above.

[1] Mineralogie, vol. 1.

[2] Am. Jour. Sci., 2d series, vol. 44, p. 201.

[3] Bull. Acad. Imp. Sci., St. Petersburg, vol. 13, 1869, p. 34.

In the collection of the California State Mineralogical Museum there is one specimen of chromite from a locality near Jackson, Amador County, covered with a thin coat of massive, peach blossom colored chlorite. Whether it is kämmererite or kotschubeite is difficult to decide.

UWAROWITE.

Together with the kotschubeite, mixed with it as small grains or lining small fissures in chromite as almost microscopic crystals with brilliant faces, there occurs a deep emerald-green garnet. Under the microscope the crystals prove to be almost perfect dodecahedrons; with fluxes, strong chromium reaction. H. above 6. Refraction very strong. Between crossed nicols some grains are isotropic, but the largest number are faintly double-refracting, some of these showing an approximate division into sectors. Garnets, as well known, often present abnormal phenomena of double refraction, and, according to Rosenbusch,[1] uwarowite always shows these optical anomalies. Uwarowite is known to occur on chromite from New Idria, California.

A green chromium mineral, also on chromite, from the vicinity of Livermore, California, proved to be uwarowite in microcrystalline form, and not trautwinite as supposed.

Trautwinite[2] is associated with chromite from Monterey County. In chemical composition it approaches uwarowite, but differs, according to Goldsmith, in crystal form, since it is hexagonal; it is, moreover, very soft, while uwarowite has a hardness approaching 7.

SCORODITE.

At Steamboat Springs, Nevada, metalliferous veins occur with arsenopyrite among other minerals in the metamorphic series. In cavities and cracks of this mineral coatings of a leek-green scorodite are found, which under the microscope often show perfect crystals with the usual combination of pyramid and pinacoids {111}, {010}, {100}. Refraction and double refraction very strong. This mineral has recently been found by A. H. Chester at the Hornsilver Mine, Utah,[3] and as deposit from arsenical thermal waters in the Yellowstone Park by Mr. A. Hague,[4] of the U. S. Geological Survey.

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[1] Microskopische Physiographie der Mineralien, 2d ed., 1885, p. 269.

[2] E. Goldsmith: Proc. Acad. Sci., Phila., 1873, pp. 9, 348, 365.

[3] Am. Jour. Sci., vol. 33, 1887, p. 290.

[4] Ibid., vol. 34, 1887, p. 171.

NOTE.

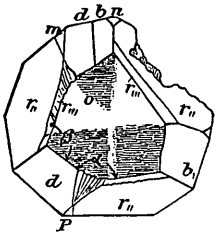
Since the foregoing was written, cinnabar crystals from the Avala Mountains, Servia, have been described by A. Schmidt, in Földtani Közlöny, XVII, 551–555, 1887, and in Zeitschr. f. Kryst. Bd. XIII, 433–449, 1888, and an extract from the paper appeared in Neues Jahrb. f. Mineralogie, Bd. 1, 45, 1889. This admirable treatise contains an exhaustive description of complex crystals, upon which trapezohedral planes were observed, much like those on the crystals from New Idria. The Servian material was much more perfect, with larger individual forms than ours, thus admitting of angular measurements which we found impossible to make. The dominant forms, viz, the basal plane and rhombohedrons, are the same from the two localities, while among the trapezohedrons only one which we observed, $+r\frac{\frac{5}{13}P\frac{11}{8}}{4}$, approximates one of Schmidt's, $+r\frac{\frac{4}{13}P\frac{3}{2}}{4}$. As a rule we found far more complex forms, and, as the table on page 19 indicates, a slight deviation of angle makes considerable difference in the symbol. The reentering angles and tectonic faces apparently suggested many more trapezohedron planes than are recorded, but with objectives of very high power these planes were proved to be parallel to others whose symbols were established. In all about twelve different trapezohedrons were fully identified. In general, then, the habits of the cinnabar crystals from New Idria and Servia should be considered identical.

PLATES.

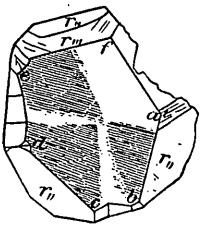
PLATE I.

PLATE I.

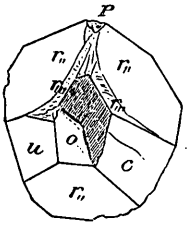
FIG. 1. Cinnabar crystal, analogue pole.
2. Cinnabar crystal, antilogue pole.
3. Cinnabar crystal.
4. Cinnabar crystal with reentrant angle.
5. Crystal with gas inclusions.
6. Cinnabar crystal.


d b n
m
r_{II}
r_{III}
o
r_{III}
r_{II}
b_1
d
r_{II}
P

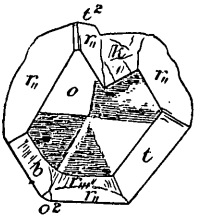
1


r_{II}
r_{III}
t
d^2
r_{II}
r_{II}
b_1

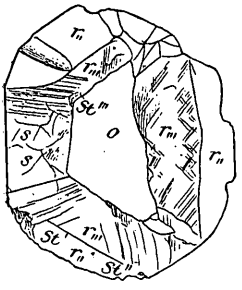
2


P
r_{II}
r_{II}
r_{III}
r_{III}
u
o
c
r_{II}

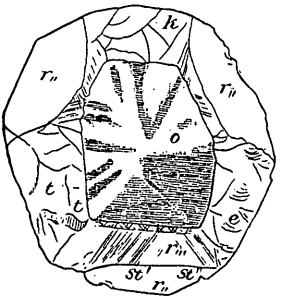
3


l^2
r_{II}
r_{II}
r_{II}
o
t
b
r_{III}
o^2

4


r_{II}
r_{III}
St^{III}
o
r_{III}
r_{II}
s
s
St
r_{III}
r_{II}
St

5

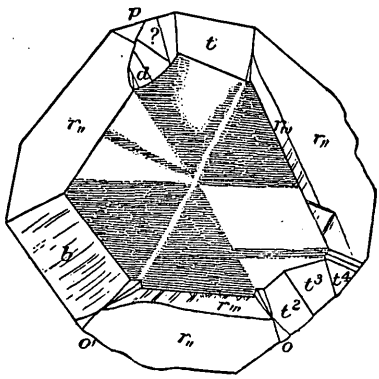

k
r_{II}
r_{II}
o
t
t
r_{III}
St
r_{II}
St

6

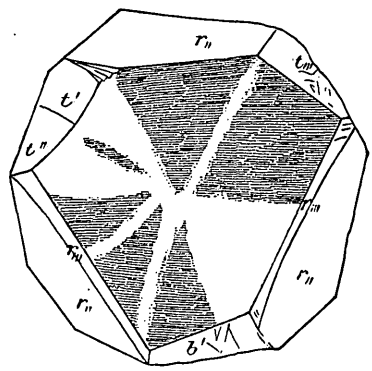
PLATE II.

PLATE II.

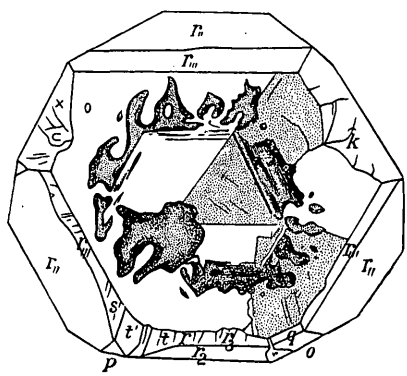
FIG. 7. Cinnabar crystal, analogue pole.
8. Cinnabar crystal with reentrant angle, antilogue pole.
9. Cinnabar crystals, with inclusion.
10. Cinnabar crystal, analogue pole.
11. Cinnabar crystal, antilogue pole.


p
?
t
d
r''
r'''
r''
b
t³
t⁴
t²
r'''
o'
r''
o

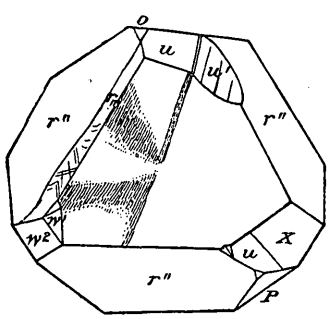
7


r''
t'''
t'
t''
r'''
r''
r''
b'

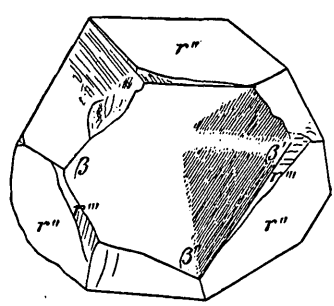
8


r''
r'''
o
c
k
r'''
r''
s'
t'
t
r
r₂
q
p
o

9


o
u
u'
r''
r''
w²
X
u
r''
P

10


r''
β
β'
r'''
r''
r''
β'

11

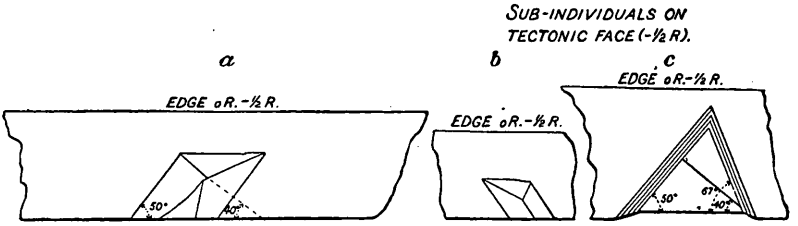
PLATE III.

PLATE III.

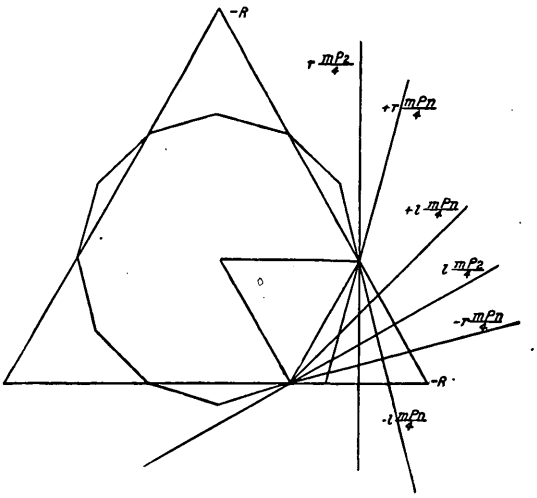
FIG. 12. Subindividual on tectonic face.

13. Illustration of derivation of tetartohedral forms.

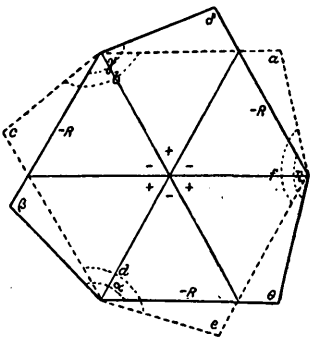
14. Section lines of tetartohedral forms of crystals 1 and 2, Plate I, with basal plane.


SUB-INDIVIDUALS ON
TECTONIC FACE (-½ R).
a
b
c
EDGE oR.-½ R.
EDGE oR.-½ R.
EDGE oR.-½ R.
50°
40°
50°
67°
40°

12


-R
r mP2/4
+r mPn/4
+l mPn/4
l mP2/4
-r mPn/4
-R
-l mPn/4

13


δ
a
-R
c
-R
+
-
-
+
+
-
f
β
d
-R
θ
e

14