


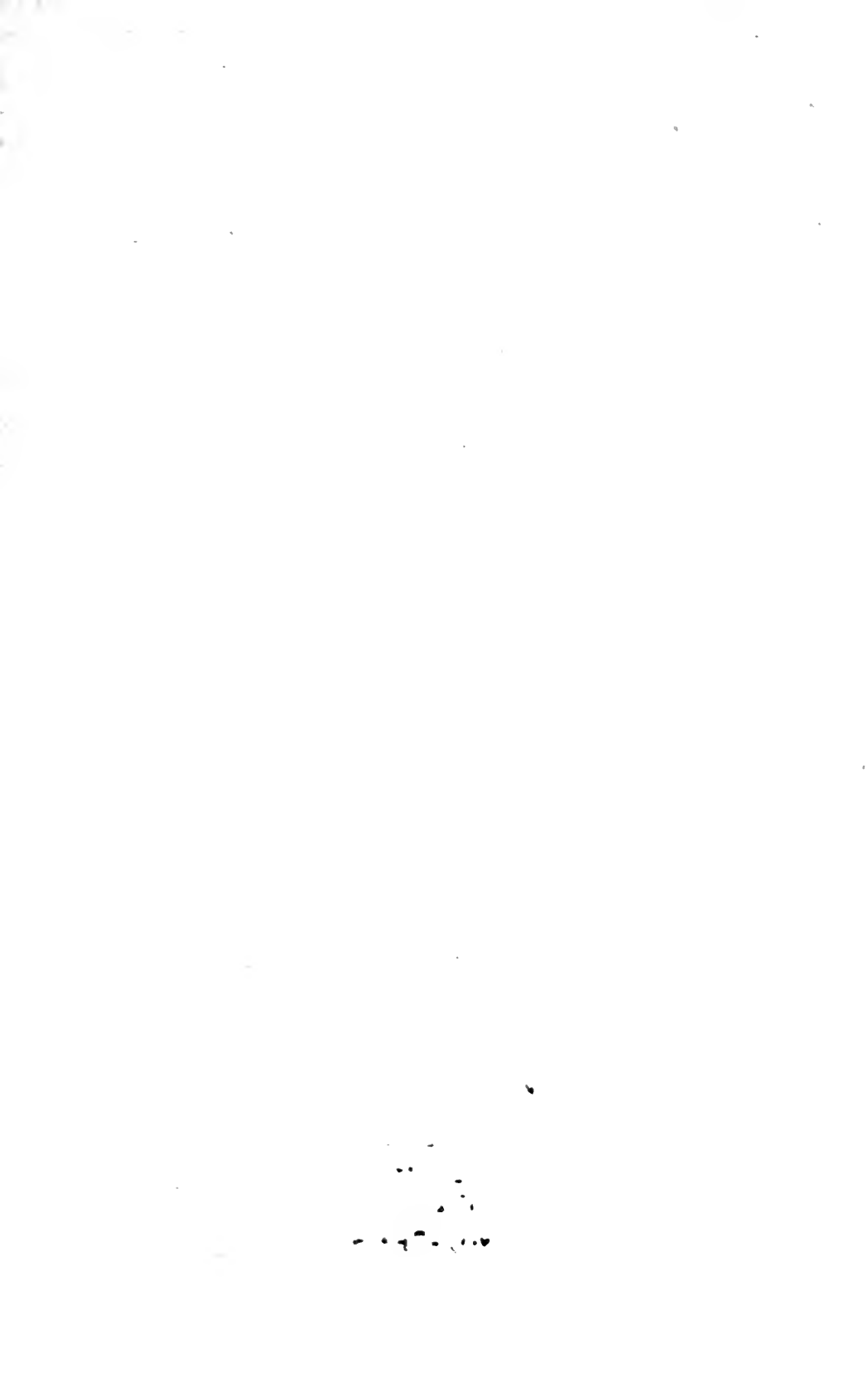
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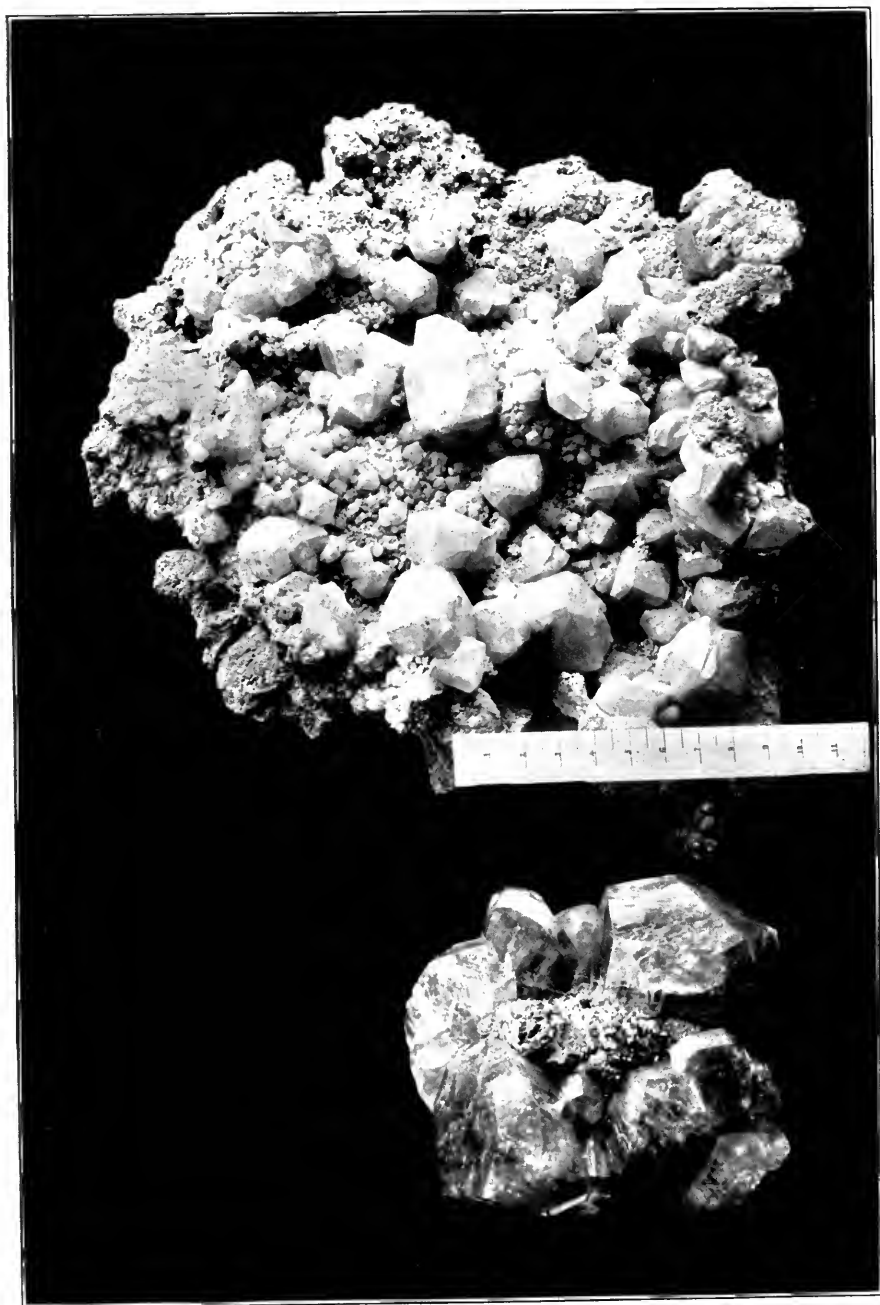


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GROUPS OF CALCITE FROM JOPLIN, MISSOURI.
The crystals of the smaller specimen are of Type 1, those of the larger of Type 3.

FIELD COLUMBIAN MUSEUM

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GEOLOGICAL SERIES.

VOL. I, No. 7.

I.

NEW MINERAL OCCURRENCES.

II.

CRYSTAL FORMS OF CALCITE
FROM JOPLIN, MISSOURI.

BY

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CHICAGO, U. S. A.

February, 1900.



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NEW MINERAL OCCURRENCES.

INESITE.

SAN CAYETANO MINE NEAR VILLA CORONA, STATE OF DURANGO, MEXICO.
MUSEUM No. M 5889.

A specimen of inesite from the above locality was first secured by the writer in the spring of 1896 while at Villa Corona. Having later determined the mineral by its blowpipe characters as inesite, a request was sent to Mr. John D. Almy, one of the proprietors of the mine, to procure more specimens if possible. Through his kindness, and that of Mr. W. H. Schlemm, a few more specimens were obtained, and were generously placed at the writer's disposal for study. The rarity of the mineral makes the find of interest, as it is known at only three other localities in the world, viz.: The manganese mines at Nanzenbach, northeast of Dillenburg, Germany; the Harstig mine, Pajsberg, Wermland, Sweden,* and Jakobsberg, Nordmark, Sweden.† In the specimens from the San Cayetano mine the mineral occurs partly in cavities and partly intergrown with calcite and a flesh-colored manganesian calcite. These fill narrow veins in what is probably an altered andesite. The inesite occurs in tufts of radiating crystals which are of the characteristic flesh-red color. The most characteristic pyrognostic reaction of the mineral, noted by the writer, is, that when heated in the closed tube it becomes opaque, gives off water, and falls to powder. The crystals are of slender, prismatic habit, averaging about 5 mm. in length. None were found doubly terminated, the attachment at one end preventing the development of faces there. A total of seven forms was identified, as follows:

a (100), b (010), c (001), g (201), d (011),
 k (11.0.12), and s (946).

Of these the forms k (11.0.12) and s (946) are new. The form k occurred on several crystals, the form s was found on but one. The

*Dana's Mineralogy, Sixth Edition, p. 564.

†First Appendix to Dana's Mineralogy, 1899.

table following gives the measurements by which these forms were identified, together with measurements of the other forms noted. The calculated values given with them are deduced from Scheieb's ratios as quoted by Dana.*

	No. of Measurements.	Limits.	Observed.	Calculated.
$c : s = 001 : 946$	1		34°	34° 10'
$g : s = 201 : 946$	1		13° 23'	13° 30'
$a : s = 100 : 946$	1		19° 47'	19° 48'
$d : s = 011 : 946$	1		45° 20'	45° 21'
$b' : s = 010 : 946$	1		84° 30'	84° 33'
$c : k = 001 : \bar{1}1.0.12$	3	79° 48'—80° 42'	80° 26'	80° 9'
$k : a' = \bar{1}1.0.12 : 100$	3	52° 36'—55° 34'	52° 25'	53° 9½'
$a : g = 100 : 201$	6	11° 47'—12° 27'	12°	12° 5'
$g : c = 201 : 001$	6	34° 36'—35° 9'	34° 36'	34° 36½'
$b' : d = 010 : 011$	4	48° 27'—50° 40'	48° 34'	49° 23'
$d : c = 011 : 001$	4	46° 25'—46° 30'	46° 30'	47° 22'
$c : b = 001 : 010$	4	82° 48'—84° 35'	82° 50'	83° 15'
$a : b = 100 : 010$	4	80° —86° 33'	82° 30'	82° 35'
$b : a' = 010 : \bar{1}00$	4	97° 25'—100°	97° 25'	97° 25'

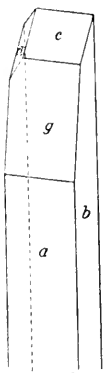


FIG. 1—Inesite.

The crystal faces were found in general to be fairly flat and bright, except the clinopinacoids, which were always vertically striated, so that no very satisfactory measurements could be made from them. The usual habit and development of the crystals is illustrated in Fig. 1. Fig. 2 shows a completed crystal giving the new forms, k ($\bar{1}1.0.12$) and s (946) in their relative development.

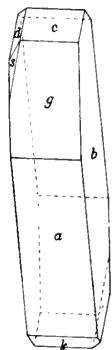


FIG. 2—Inesite.

An analysis of the mineral was made by the writer. For this purpose about two grams were laboriously separated from the calcite in which it was largely embedded. Experiments were first made upon the temperature at which water was driven off in order to determine, if possible, the nature of its existence in the mineral. About a gram of the finely powdered mineral was heated at successively increasing temperatures until practically constant weight was

*Dana's Mineralogy, p. 565.

obtained at each. The following are the percentages of loss obtained: At 110°, 3.88%; at 240°, 1.94%; at 310°, 0.10%; at faint redness, 1.00%; total, 6.92%. Of the above amount, 5.99% was taken up again by the mineral on exposure to ordinary air. This amount may, therefore, be regarded as water of crystallization. On continuous heating at faint redness, the mineral turned dark and showed a gain in weight doubtless from oxidation of manganous compounds. It was evident, therefore, that water could not be correctly determined by loss upon ignition.

A direct determination was made, therefore, upon a separate portion by Penfield's method,* a blast lamp being used for the final heating. This determination gave 8.20% of water. It could be distinctly seen on application of the higher heat of the blast lamp that more water was given off at the high temperature, showing beyond question that some of the water was present as water of constitution. If the percentage of water taken upon exposure to air, 5.99%, be regarded as water of crystallization, then the remainder, 2.21%, may be considered to denote the percentage of combined water. This agrees well likewise with Bärwald's observations, he having found 1.97% of water given off above 300°. It is evident from the above experiments also that determination of water as loss upon ignition would certainly give too low a result. This may account for the low percentage, 7.17%, obtained by Flink.

The remainder of the analysis was performed by the methods commonly employed for the analysis of silicates. A sodium carbonate fusion was made, the bases separated from silica by solution with hydrochloric acid, iron precipitated by ammonia, manganese by bromine and calcium by ammonium oxalate. Results of the analysis with ratios are as follows:

		Ratio		
Si O ₂	44.89	748	748	1.64
Mn O.....	36.53	517	} 699	1.53
Fe O.....	2.48	034		
Ca O.....	8.24	148		
Mg O.....	tr.			
H ₂ O cryst.....	5.99	336	} 456	1.
H ₂ O const.....	2.21	120		
	100.34			

Sp. Gr. (det. by Thoulet's solution)=2.965.

The ratio of Si O₂ : R O : H₂O is thus nearly 1.5 : 1.5 : 1. Considering the ratio of water of crystallization to water of constitution = 3 : 1, and of Mn : Ca = 4 : 1, the formula can be expressed as

*Amer. Jour. Sci., 3rd Ser., Vol. 48, p. 30.

$4 \text{ H}_2\text{O}$, $6 (\text{Mn, Ca}) \text{O}$, 6 Si O_2 , or $\text{H}_2 (\text{Mn, Ca})_6 \text{ Si}_6 \text{ O}_{19} + 3 \text{ H}_2 \text{O}$. Comparing the percentages called for by the formula, with the writer's analysis calculated to 100% (reckoning Fe O as Mn O), the results are as follows :

	Theory.	Analysis Calculated to 100.
6 Si O_2	42.91	44.76
$\frac{1}{2} (6 \text{ Mn O})$	40.51	38.86
$\frac{1}{2} (6 \text{ Ca O})$	8.00	8.21
$4 \text{ H}_2 \text{O}$	8.58	8.17
	100.	100.

Here the greatest discrepancy to be noted is in the percentage of Si O_2 , which is noticeably higher in the analysis than the theory calls for. Mn O is also a little lower. Yet it is believed that this formula better agrees in general with analyses of the mineral and better expresses its constitution than any hitherto proposed. Flink's formula, $2 (\text{Mn, Ca}) \text{ Si O}_3 + \text{H}_2 \text{O}$, reckons all the water as water of crystallization, which is clearly incorrect. Moreover, the percentage of Mn O called for by his formula, 41.4%, is larger than has ever been obtained. Bärwald's formula, $\text{R} (\text{R OH})_2 \text{ Si}_3 \text{ O}_8 + \text{aq.}$, gives percentages nearly like that proposed by the writer, but the compound represented by such a formula would less resemble other zeolites in manner of constitution than does that of the writer's formula. Moreover, one would expect a darker color if the molecule Mn OH were present in the mineral.

CALEDONITE.

STEVENSON-BENNETT MINE, ORGAN MTS., NEAR LAS CRUCES, NEW MEXICO.
MUSEUM No. M 5486.

A single specimen of this mineral was picked up by the writer on the dump of the Stevenson-Bennett mine in the spring of 1896. It is the only specimen ever found there, so far as I am aware. It is also the second or possibly the third occurrence of the mineral reported in America. It is known to occur* at the Cerro Gordo mines in California, and has been reported from Mine la Motte, Missouri, but the report needs confirmation. In the specimen secured by the writer the mineral is in the form of several distinct

*Dana's Mineralogy, p. 925.

crystals which occur on a piece of the quartz gangue common at the mine. With the caledonite crystals are associated crystallized cerrusite, massive galena, linarite, and wulfenite. One of the crystals of caledonite is of good size, being 5 mm. in length in the direction of the vertical axis, and 3 mm. in length in the direction of the macrodiagonal axis. The other crystals are smaller. All are developed prismatically in the direction of the brachydiagonal axis, and are attached by its extremity. The crystals are of a deep bluish-green color and transparent. They are penetrated to some extent by cerrusite, which shows as darker spots when seen under a lens. These portions also turn brown when fragments of the mineral are heated in the closed tube. Other pyrognostic characters of the mineral, noted by the writer, which may be added to those given by Dana, are: In the closed tube it decrepitates, becomes black and opaque, and gives off water. Fuses easily B. B. with intumescence to a black globule.

The crystals were fairly well suited for goniometric measurement, and the following forms were found, the position and lettering being that given by Dana:

<i>b</i> (010)	<i>x</i> (201)	<i>s</i> (223)
<i>c</i> (001)	<i>f</i> (012)	<i>t</i> (221)
<i>m</i> (110)	<i>e</i> (011)	

The development of the different crystals was found to be quite constant, the prominent forms being *c*, *b*, *m* and *s*. The most perfect crystal was considerably striated parallel with the direction of the brachydomes, also in the direction of the zone of the pyramids and prism. Owing to these striations but few really accurate measurements could be obtained, but a few were secured which are of interest as supporting the correctness of the ratios obtained by Busz* from a study of the caledonite of Leadhills. The following are the measurements which it was possible to make with accuracy, and for comparison are given the values as calculated by Busz:

	Measured.	Calculated.
<i>b</i> : <i>m</i> = (010) : (110).....	47° 26'	47° 25' 30"
<i>m</i> : <i>m'''</i> = (110) : (110).....	85° 12'	85° 9'
<i>s</i> : <i>s'''</i> = (223) : (223).....	66° 35'	66° 30' 34"
<i>c</i> : <i>x</i> = (001) : (201).....	71° 52'	71° 53'
<i>x</i> : <i>x'</i> = (201) : (201).....	36° 15'	36° 14'

The crystals were carefully studied also in the hope that some measurements might be found which would throw some light on the

**Neues Jahrbuch fur Min. Geol. u. Pal.* 1805, *Band I*, p. 111.

disputed question as to whether the mineral crystallizes in the orthorhombic or monoclinic system. Owing, however, to the incompleteness of the crystals on account of their attachment, or to the striations on the faces, only one reliable set of measurements bearing upon this point could be obtained. These were measurements of the zone $c:x:x':c'=(001):(201):(2\bar{0}1):(0\bar{0}1)$, as already quoted. Completing this zone by difference, the angles are:

$$c:x=(001):(201)=71^{\circ} 52'.$$

$$x:x'=(201):(2\bar{0}1)=36^{\circ} 15'.$$

$$x:c'=(2\bar{0}1):(0\bar{0}1)=71^{\circ} 53'.$$

Thus the brachydiagonal is an axis of binary symmetry and the mineral must be regarded orthorhombic. As noted by Busz also, the habit of the crystals gives the impression of orthorhombic symmetry.

The usual development of the crystals is shown in Fig. 3. That shown in the direction of the brachydiagonal is necessarily estimated, as no crystals doubly terminated in the direction of this axis were found. The general resemblance in habit to that of cerussite from Rezbanya* figured by Schrauf will be noted.

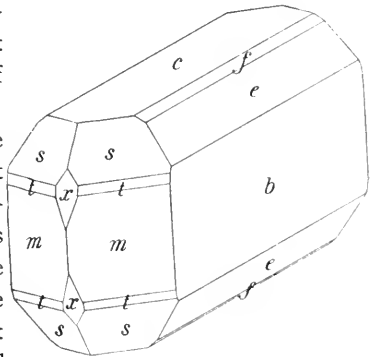


FIG. 3—Caledonite.

GAY-LUSSITE.

SWEETWATER VALLEY NEAR INDEPENDENCE ROCK, WYOMING.
MUSEUM No. E 9695.

On dissolving in water the native carbonate of soda found in the Sweetwater Valley, Wyoming, a residue of clay and minute crystals is left. Some of the latter were kindly forwarded to the writer by Prof. W. C. Knight of the University of Wyoming, who was the first to notice the crystals, so far as I am aware. A test of the pyrognostic and crystallographic characters showed the crystals to be undoubtedly gay-lussite. They are microscopic in size, none that I found being as large as the head of an ordinary pin. More exactly, none

*Dana's Mineralogy. p. 287.

exceed one millimeter in the direction of greatest length. They are colorless and transparent and remain so with the exception of a slight deliquescence on exposure to air. In distilled water, however, they turn white and in a short time become pulverulent from solution of sodium carbonate. The crystal forms are well developed and the faces fairly sharp and bright. In habit the crystals are somewhat different from any heretofore described on account of the relative subordination of e (011) and the relative greater prominence of r ($\bar{1}12$) and c (001).

The following forms were found :

c (001), m (110), e (011), r ($\bar{1}12$).

They were identified by the following measurements :

	No. of Measurements.	Limits.	Observed.	Calculated.
$m : m''' = 110 : 110 \dots\dots\dots$	5	$110^\circ 41' - 111^\circ 11'$	$110^\circ 59'$	$111^\circ 10'$
$c : m = 001 : 110 \dots\dots\dots$	2	$83^\circ 25' - 83^\circ 30'$	$83^\circ 30'$	$83^\circ 30'$
$c : r = 100 : 112 \dots\dots\dots$	2	$43^\circ 13' - 43^\circ 20'$	$43^\circ 20'$	$43^\circ 20'$
$e : e = 001 : 011 \dots\dots\dots$	7	$54^\circ 10' - 54^\circ 52'$	$54^\circ 45'$	$54^\circ 45'$
$e : e' = 011 : 011 \dots\dots\dots$	5	$108^\circ 59' - 109^\circ 23'$	$109^\circ 23'$	$109^\circ 30'$
$r : r' = \bar{1}12 : 112 \dots\dots\dots$	2	$69^\circ 34'$	$69^\circ 34'$	$69^\circ 29'$
$m : e = 110 : 011 \dots\dots\dots$	4	$42^\circ 17' - 42^\circ 25'$	$42^\circ 25'$	$42^\circ 21'$
$e : r = 011 : \bar{1}12 \dots\dots\dots$	4	$27^\circ 22' - 27^\circ 29'$	$27^\circ 25'$	$27^\circ 44'$
$m : r = 110 : 11\bar{2} \dots\dots\dots$	2	$53^\circ 10' - 53^\circ 22'$	$53^\circ 10'$	$53^\circ 10'$

The accompanying figure (Fig. 4) shows the usual development of the crystals. This development was quite constant for all that

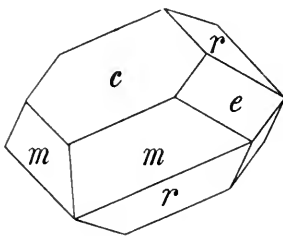


FIG. 4—Gay-lussite.

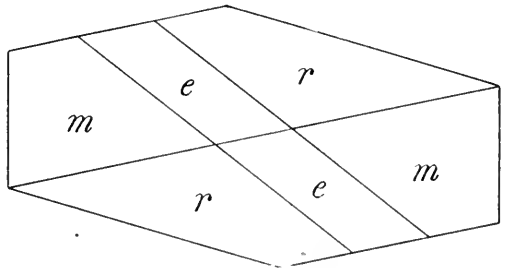


FIG. 5—Gay-lussite.

were examined. Fig. 5 shows the same forms in horizontal projection on the plane of the clinopinacoid. Here is better shown, too, the relative greater length of the crystals in the direction of the clinodagonal axis. The faces of the prism m (110) are usually duller in lustre than the others, and the basal plane c (001) is often striated parallel to the edge $c r$.

EPSOMITE.

NEAR WILCOX STATION, 65 MILES NORTH OF LARAMIE, WYOMING.
MUSEUM No. M 6126.

An account of the above occurrence of epsomite was given the writer by Prof. W. C. Knight of the University of Wyoming, in a recent letter. He writes: "A deposit of epsomite, which is of variable depth, covers an area of 90 acres near Wilcox Station, Albany County, Wyoming. In the spring the area is covered with water to the depth of a foot or more, forming a small lake, but on the advent of summer the water evaporates rapidly and an abundant deposit of beautifully crystallized epsomite is left."

A few of these crystals were received from Prof. Knight at the same time by the writer, but not being able to study them immediately, they became, through deliquescence, unfit for thorough crystallographic investigation. I have thought it desirable, however, to publish an account of the occurrence so that any who may visit the locality may improve the opportunity to secure material whose forms may admit of exact determination. The crystals received by the writer are from 8 to 15 mm. in length and are of elongated prismatic habit. Many are doubly terminated and have pyramidal planes which plainly show sphenoidal symmetry. The habit of the crystals and the fundamental

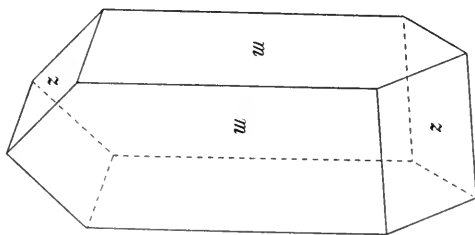


FIG. 6—Epsomite.

forms are shown by Fig. 6. The determination of the pyramid $z(111)$ depends on a measurement secured as follows:

	Measured.	Calculated.
$m : z = 110 : 111$	= $50^{\circ} 30'$	$50^{\circ} 55'$

While some of the crystals have only the simple development represented in the figure, others are evidently more highly modified, but owing to the deliquescence previously referred to, it was found impossible to determine the forms.

GOLDEN CALCITE.

BAD LANDS, SOUTH DAKOTA. MUSEUM No. M 5904.

On breaking open the concretions found in beds of Fort Pierre shale in the region of the Bad Lands, South Dakota, the internal cavities are often found to be studded with crystals of calcite of a more or less golden yellow color. While this occurrence of calcite has been known for some time, the form of the crystals has not heretofore received description. A large quantity of the crystals having been collected by the Museum Expedition to the Bad Lands of 1898, I have examined them with the following results: In form the crystals are all simple rhombohedrons having the symbol $f, -2R$. This symbol is sufficiently established by the relation of the cleavage rhombohedron to the crystal form and by several measurements ranging from $101^{\circ} 25'$ to $101^{\circ} 35'$ for $f: f = 02\bar{2}1 \wedge \bar{2}021$. The calculated value is $101^{\circ} 9'$. No planes could be found which were suited to accurate measurement, even the most favorable giving only dim and elongated reflections. The most interesting feature of the crystal form is the distortion which it exhibits. Although some of the crystals show a normal development of the rhombohedron, the greater number are lengthened out along an axis normal to one of the rhombohedral planes. The appearance is therefore that of a monoclinic crystal made up of a prism and basal planes. This apparent prismatic form is made more striking from the fact that the crystal usually rises more or less perpendicularly from its plane of attachment. The apparent basal plane is usually more or less

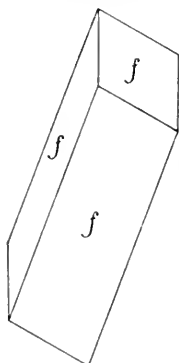


FIG. 7.—Golden Calcite.

curved, and has a somewhat pearly lustre. The prismatic planes are often curved as well. The length of the apparent prisms varies from a few millimeters to about 2 centimeters. The form of these crystals is represented in Fig. 7. Another form of distortion is shown in Fig. 8. Here the lengthening out has taken place in two directions, so that an apparently flattened rhombohedron results. The planes of such crystals show a curving

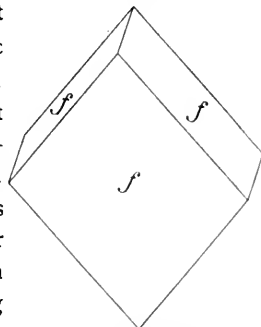


FIG. 8.—Golden Calcite.

similar to those previously described. The color of the crystals of all types varies from a pale yellow to a deep orange. Some are perfectly transparent, but the majority are translucent to opaque. The yellow color is probably due to the presence of iron, as on heating the crystals turn black and become slightly magnetic. Other qualitative tests likewise indicate the presence of considerable iron.

DOLOMITE USED AS INDIAN MONEY.

NEAR LAKEPORT, LAKE COUNTY, CALIFORNIA. MUSEUM No. M 6387.

Specimens of dolomite from the above locality, and of the "money" made from it, were collected by Dr. G. A. Dorsey, Curator of Anthropology of the Museum, during a visit made in 1889 to the Pomo Indians, a tribe of the Kulanapan stock who inhabit the region. The material has long been used as a medium of exchange among these Indians, but I cannot learn that it has been hitherto described.

The mineral occurs in the form of nodules, or boulders, roughly oval in shape, and from four to eight inches in diameter. They are of a rusty yellow color upon the surface and the local Indian name for them, *Pol'-ka-be*, means rusty color. A freshly fractured surface shows a pure white color, except for occasional rusty seams, and lustre like that of unglazed porcelain. The texture is compact and fracture flat conchoidal. A determination of the specific gravity of a pure white fragment gave $G. = 2.878$. Dr. Dorsey did not visit the mine whence the dolomite is obtained, but was informed that it was situated on the east shore of Clear Lake, a few miles southeast of Lakeport.

While the mode of occurrence cannot be stated with certainty, it is probable that it is as residual boulders in a reddish clay.

A partial analysis by the writer gave Ca O, 28.27%, Mg O, 22.46%, and Fe O, 1.18%. These percentages are nearly those of a typical dolomite.

The use of the mineral by the Indians as a medium of exchange is a long established custom, and the value at which they esteem a well worked piece is nearly equal to its weight in gold. In order to make the money, symmetrically shaped cylindrical pieces are cut out from the crude boulders. These are burned and the burning brings out reddish streaks of color doubtless from oxidation of the iron,

which adds to the beauty of the pieces in the eye of the Indian. The pieces are then polished and perforated and pass as money, the local Indian name for them being *Po*. Many of the small pieces are also used as beads for necklaces and other ornaments. Fig. 9 shows the appearance of two typical pieces of *Po*.



FIG. 9.

CRYSTAL FORMS OF CALCITE FROM JOPLIN, MISSOURI.

Large crystals of calcite from Joplin, Missouri, have been known for some years to collectors, and have become widely distributed in collections. The crystals are remarkable, not only for their size, but for their transparency, varied color and the perfection of their crystal form. So far as I can learn no crystallographic study of these calcites has ever been published. Photographs of some of the crystals, together with some general statements as to the occurrence of calcite in Missouri, are to be found on pp. 457-9 of Vol. VII, of the Reports of the Missouri Geological Survey. There is also mention, on p. 567 of the same volume, of calcite crystals of large size occurring in Crystal Cave, Joplin, and some description of the cave is given. No crystallographic details are given in this account, however, the crystals being simply described as scalenohedral or rhombohedral. The present study of some of the crystal forms can in no sense be considered a complete one, since the only material undertaken to be described is that comprised in the Museum collections, and some crystals that were kindly loaned for examination, through Prof. J. P. Iddings, by the University of Chicago. Having, however, cursorily examined a large number of crystals from this locality as exhibited in collections, both in this country and in Europe, I may say that I have found them to be remarkably uniform in character, and hence believe the characteristic forms to be largely comprised in the types here described. The specimens in the Museum collection have been obtained from various sources, chiefly by purchase or exchange, but some were collected at the mines in Joplin during the spring of 1898 by Mr. H. W. Nichols, Assistant Curator of Geology.

LOCALITIES OF LARGE CRYSTALS.

The large crystals known to collectors are chiefly of two types, differing in color and form. Those of the type which I may designate as Type No. 1 are characterized by a delicate violet to wine yellow color, often showing within a deeper yellow or violet light.

These came from the Blakie No. 2 mine. The crystals which may be designated as Type No. 2 are characterized by a deep amber yellow color ranging to colorless. They come from the Crystal Cave, Ino mine. These two mines are quite near one another, and are both located in Leadville Hollow, within the city limits of Joplin.

FORMS OF LARGE CRYSTALS.

TYPE 1.—Crystals of this type are very simple in form. They are made up of the common scalenohedron v , $+R_3$,* truncated by the flatter scalenohedron t , $+1/4R_3$. The average development of the forms is illustrated in Fig. 1, Pl. xxviii, it being drawn one-half size from one of the crystals in the Museum collection. Such a size is usual to crystals of this type. The following are averages of measurements of several angles on crystals of this type, as made with a contact goniometer:

		Measured.	Calculated.
$t : t'$	$= 2\bar{1}34 : \bar{2}3\bar{1}4 = \dots\dots\dots$	42°	$41^\circ 55'$
$t : t''$	$= 2\bar{1}34 : \bar{3}\bar{1}24 = \dots\dots\dots$	22°	$20^\circ 36\frac{1}{2}'$
$t : v$	$= 2\bar{1}34 : 2\bar{1}3\bar{1} = \dots\dots\dots$	36°	$35^\circ 56'$
$t : \text{cleavage}$	$= 2\bar{1}34 : 10\bar{1}\bar{1} = \dots\dots\dots$	16°	$16^\circ 29'$
$v : v'$	$= 2\bar{1}3\bar{1} : \bar{3}\bar{1}2\bar{1} = \dots\dots\dots$	74°	$75^\circ 22'$
$v : v''$	$= 2\bar{1}3\bar{1} : \bar{2}3\bar{1}\bar{1} = \dots\dots\dots$	35°	$35^\circ 36'$
$v : \text{cleavage}$	$= 2\bar{1}3\bar{1} : 10\bar{1}\bar{1} = \dots\dots\dots$	30°	$29^\circ 2'$

The surfaces of the crystal planes on these crystals are, in general, flat and bright and of uniform lustre. They are, however, more or less irregularly marked similar to the planes shown in Fig. 2, Pl. xxviii, and reentrant angles resulting from abortive terminations often occur. While the crystals are often doubly terminated, as illustrated in the figure, more commonly only about half of the complete crystal form is present, the plane of attachment being a rhombohedral or a basal plane. Numerous planes of rhombohedral cleavage pass through the crystals, and the light reflected from them often brilliantly illuminates the interior. Many crystals are also often iridescent from interference colors produced by parting along cleavage planes. Irregularly shaped grains of marcasite from one to two millimeters in diameter often occur scattered through the outer layers of the crystals. Other associated minerals, often well crystallized and found more or less in contact, are galena, dolomite and chalcopyrite. A group of this character, now in the Museum collection, is shown in the frontispiece.

*The letters used are Dana's.

TYPE 2.—Crystals of this type are characterized, as has been said, by an amber yellow color. This may be deeper or paler. The size of the crystals is also remarkable. Some are known $2\frac{1}{2}$ feet (.76 meters) in length, and the average size of those seen in collections is from 6 inches (.15 meters) to 1 foot (.30 meters) in length. Those seen in collections are rarely, if ever, doubly terminated, only about half of the complete crystal being present. Some account of the mode of occurrence of these crystals in a cave as well as a plan of the cave is given, as already mentioned, on p. 567 of Vol. vii, Reports of the Missouri Geological Survey. For the following further information I am indebted to Mr. Henry Weyman, the present owner of the cave: "The cave is from 250 to 300 feet long, from 40 to 60 feet wide and of an unknown depth in places, *i. e.*, we have never been able to measure the bottom, as only a part of it is above water. The whole opening is covered with crystals of various sizes, leaving no place on any of the roof or wall exposed and going down as far as can be seen in the water. At one place a slab covered with large crystals has fallen from the roof at some time, and since then new crystals have formed on the roof where the slab has been broken away; also new crystals have formed on the broken side of the slab after it had fallen down. The largest crystals, I should think, would measure 2 to $2\frac{1}{2}$ feet long. The greater part of the crystals are doubly terminated, ending in very sharp points. The cave was discovered by mining after lead and zinc ore, when a shot put in the bottom of the drift broke through the roof of the cave and so exposed the mass of beautiful crystals. This is so far the only opening allowing admittance to the cave. It is our intention to preserve the cave in its present state and make access to it more convenient to visitors." It is also stated in the account previously mentioned* that the cave is remarkable for the entire absence of stalactites of the usual type. Since these are absent it is probable that the cave at the time of formation of the crystals was filled with water holding carbonate of lime in solution, from which crystallization took place. Had the cave been only in part filled with water, the dripping waters would doubtless have formed stalactites of the usual type.

The form of the crystals of Type 2 is primarily determined by the common scalenohedron v , + R3. This may alone constitute the crystal or its form may be slightly or highly modified. A common modification is the truncation of the apex of the scalenohedron by the rhombohedron e , $-\frac{1}{2}$ R. Fig. 2, Pl. xxviii, represents a combination

*Report of the Missouri Survey *loc. cit.*

EXPLANATION OF PLATE XXVIII.

FIG. 1. Crystal of Type 1.
Joplin Calcite.
One-half natural size.
Mus. No. M5513.

FIG. 2. Crystal of Type 2.
Joplin Calcite.
One-half natural size.
Mus. No. M5621.

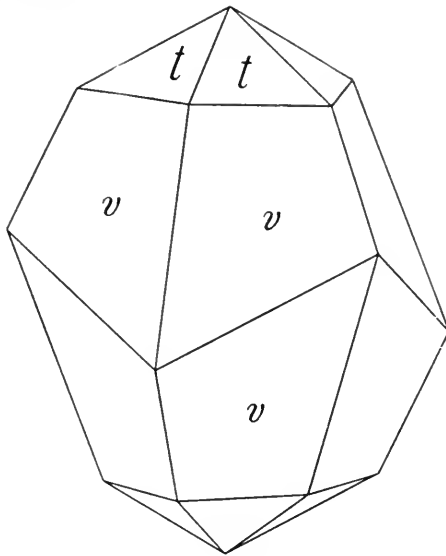


FIG. 1

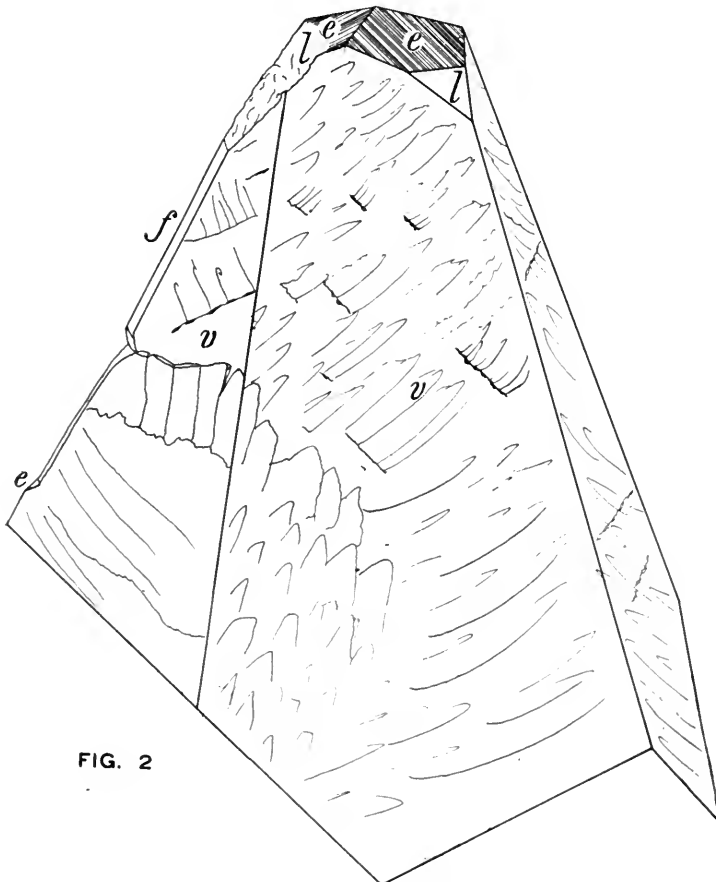


FIG. 2

CALCITE, JOPLIN, Mo.

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of these forms together with the rhombohedron $l, -\frac{1}{3}R$, as seen on a crystal in the Museum collection. There is also present one plane of the negative rhombohedron $f, -2R$.

Some measurements made on this crystal with the contact goniometer are as follows :

	Measured.	Calculated.
$v : l = 21\bar{3}1 : 04\bar{4}5 = \dots\dots\dots$	43°-44'	44° 6'
$v : f = 21\bar{3}1 : 0221 = \dots\dots\dots$	35°-38'	37° 41'
$e : l = 01\bar{1}2 : 04\bar{4}5 = \dots\dots\dots$	11°-12°	12° 2'
$e : v = 0112 : 21\bar{3}1 = \dots\dots\dots$	45°-52°	50° 36'

As has often been observed on calcites from other localities, the planes of the rhombohedron $e, -\frac{1}{2}R$ are, in this crystal, striated parallel to the edge r/r' . They are also somewhat rounded. The curious sporadic occurrence of the plane f and the accompanying imperfect growth of planes seems to be quite common for Joplin crystals showing the above combinations. At least the writer has noticed the same appearance on several other similar but smaller crystals. It would be interesting to know the nature of the molecular forces which would uniformly produce degradation of this sort. The planes of the scalenohedron v on the crystal are in general flat and bright, but show peculiar markings suggesting stages of growth. These markings are quite irregular in form and seem to have no angular values whatever. They follow, however, so far as they have any arrangement, the lines of the cleavage rhombohedron. Partings along planes of this rhombohedron are to be seen through the crystal and the surface of attachment is usually characterized by cleavage planes.

Other crystals of Type 2 are more highly modified than the one just described. Fig. 1, Pl. xxix, represents one such crystal now in the Museum collection. Here the primary scalenohedron $v, +R_3$ is modified by the scalenohedrons $n, +R_{\frac{5}{3}}$ and $w, +\frac{2}{3}R_2$, also by the positive rhombohedrons $r, +R$ and $M, +\frac{1}{4}R$, and by the negative rhombohedron $l, -\frac{1}{3}R$. Only about half the complete form is present in the specimen. In Fig. 2, Pl. xxix, is shown the completed ideal form which would be produced by these combinations. Some of the measurements made on this crystal with the contact goniometer are as follows :

	Measured.	Calculated.
$v : r = 21\bar{3}1 : 10\bar{1}1 = \dots\dots\dots$	30°	29° 2'
$v : M = 21\bar{3}1 : 40\bar{4}1 = \dots\dots\dots$	18°	19° 24'
$r : M = 10\bar{1}1 : 40\bar{4}1 = \dots\dots\dots$	31°	31° 10½'
$v : l = 21\bar{3}1 : 04\bar{4}5 = \dots\dots\dots$	44°	44° 6'

	Measured.	Calculated.
$r : l = 10\bar{1}1 : 04\bar{4}5 = \dots\dots\dots$	40°	39° 4'
$l : l' = 04\bar{4}5 : 40\bar{4}5 = \dots\dots\dots$	65°	64° 53½'
$v : n = 2\bar{1}31 : 41\bar{5}3 = \dots\dots\dots$	17°	14° 28½'
$n : n' = 41\bar{5}3 : 45\bar{1}3 = \dots\dots\dots$	78°	78° 5'
$n : n^v = 41\bar{5}3 : 5\bar{1}43 = \dots\dots\dots$	19°	18° 7'
$v : w = 2\bar{1}31 : 31\bar{4}5 = \dots\dots\dots$	33°	33° 50'
$w : w' = 31\bar{4}5 : 41\bar{3}5 = \dots\dots\dots$	50°	49° 23'
$w : w^v = 31\bar{4}5 : 5\bar{1}43 = \dots\dots\dots$	16°	16°

The planes of r are further identified by their evident parallelism to the cleavage planes.

An interesting peculiarity of the specimen is the surface differentiation of the planes. Thus the planes of the scalenohedron v and the negative rhombohedron l are flat and bright; those of the scalenohedrons n and w are striated parallel to the adjoining edges of the unit rhombohedron, and the planes of the unit rhombohedron and the rhombohedron M are rough. The differentiation closely follows and beautifully illustrates the law that crystallographically equivalent planes are similarly affected. An examination of the rough planes reveals but little in the way of symmetrical etching figures. The roughness is caused chiefly by delicate pitting, which is also wholly irregular. There are to be seen occasional pits, however, which are larger than the others and which have a definite pyramidal shape. They are different in form from the etching figures usually produced artificially on calcite by hydrochloric acid. The boundaries of the pits lie parallel to the bounding planes of the unit rhombohedron. Their character is illustrated in the accompanying figure (Fig. 10).

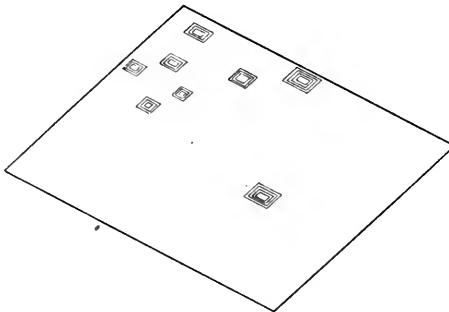


FIG. 10.—Growth figures on plane of +R. Calcite, Joplin, Mo.

EXPLANATION OF PLATE XXIX.

FIG. 1. Crystal of Type 2.
Joplin Calcite.
One-half natural size.
Mus. No. M5515.

FIG. 2. Completed ideal form of crystal
shown in Fig. 1.

FIG. 3. Crystal of Type 3.
Joplin Calcite.
Mus. No. M5511.

FIG. 4. Crystal of Type 5.
Joplin Calcite.
Mus. No. M5824.

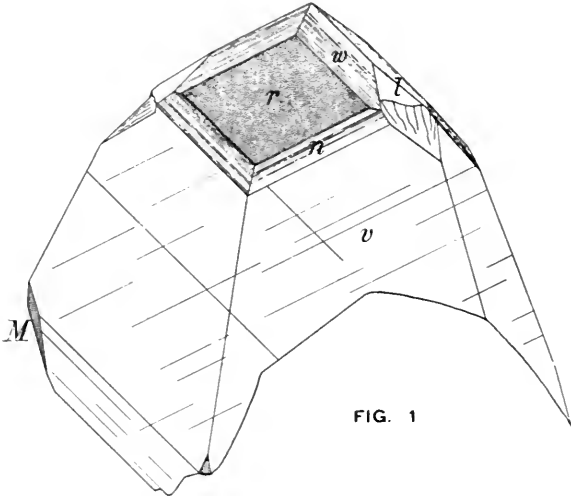


FIG. 1

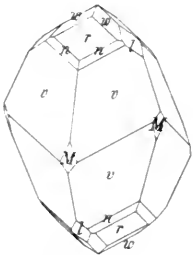


FIG. 2

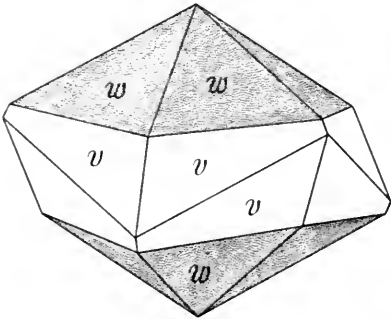


FIG. 3

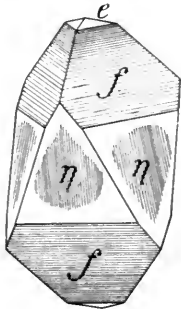


FIG. 4

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FORMS OF SMALLER CRYSTALS.

None of the following crystals have the large size of those of the types above described. They show, however, characteristic combinations which warrant their description as types.

TYPE 3.—Crystals of this type are illustrated in Fig. 3, Pl. xxix. As is usual with the Joplin crystals they are not highly modified, being made up solely of the scalenohedrons v , + R_3 and w , $\frac{2}{3}$ R_2 . The specimens of these crystals in the Museum collection come from the Pelican mine in Joplin, occurring with sphalerite on the characteristic chert breccia of the region. A large group is shown in the frontispiece. The largest single crystal is not over 4 inches (10 cm.) in length, and from this the crystals grade to a very small size. Measurements of the planes made with the reflecting goniometer are as follows:

	Measured.	Calculated.
$v : v' = 21\bar{3}1 : 2\bar{3}11 = \dots\dots\dots$	$75^\circ 25'$	$75^\circ 22'$
$v : v^v = 21\bar{3}1 : 3\bar{1}21 = \dots\dots\dots$	$35^\circ 36'$	$35^\circ 36'$
$v : v^{vi} = 3\bar{1}21 : 3\bar{2}1\bar{1} = \dots\dots\dots$	$46^\circ 53'$	$47^\circ 1\frac{1}{2}'$
$w : w' = 31\bar{4}5 : 3415 = \dots\dots\dots$	$50^\circ 58'$	$49^\circ 23'$
$w : w^v = 31\bar{4}5 : 4\bar{1}35 = \dots\dots\dots$	$15^\circ 59'$	16°

The most striking characteristic of these crystals is the fact, represented in the figure, that the planes of scalenohedron v are smooth and brilliant, while those of w are rough. This differentiation of planes is constant for all the crystals which have come under the writer's observation. The rough planes do not show definite etching figures, but rather under a lens series of troughs crossing one another and following the lines of the cleavage rhombohedron. In the writer's opinion the roughness is due to irregularities of growth of the crystals rather than to etching. The reasons for this opinion are: First, it is difficult to conceive of any etching agent which could leave the planes of one scalenohedron so entirely untouched while those of the other were so deeply corroded. Second, on submitting the crystal to the action of weak vinegar as an etching agent the planes of the scalenohedron v were affected much more rapidly and noticeably than those of w . The etching produced by the vinegar on the planes of v was in the forms of troughs or striæ following the lines of cleavage, on w there occurred only a slight additional roughening of the planes. It is, therefore, in the writer's opinion, not always correct to speak, as is usually done, of the rough planes as *etched* planes. They will often be more correctly described by the term *imperfect* or *incomplete* planes.

TYPE 4.—The only crystals of this type in the Museum collection come from Leddy's Lease, Central City, about 5 miles from Joplin. They are, however, a characteristic type for the Joplin district. They are scalenohedral in character, often doubly terminated, colorless, and frequently reach a length of from 2 to 3 inches (5-7.5 cm.). The forms characterizing the type are v , $+R_3$ dominant with e , $-\frac{1}{2}R$, f , $-2R$ and Σ , $-11R$, subordinate. A characteristic feature is the habitually rounded and cross striated character of the planes of f . In fact this form often grades into a scalenohedron of large indices, the symbols of which it is impossible to determine. The planes of f likewise usually widen toward the apices of the crystal, so as to crowd out the planes of v , and themselves define the termination of the crystal. Fig. 1, Pl. xxx, sufficiently illustrates the average development of planes on crystals of this type, although the one figured is a twin crystal and larger than the average of the type.

TYPE 5.—Crystals of this type are of rhombohedral development. Type specimens in the Museum collection come from the Meadowcroft mine, Joplin. They are colorless, and not over 1 inch (2.5 cm.) in length. They are made up of the negative rhombohedrons γ , $-4R$ and f , $-2R$ dominant, with the latter truncated by e , $-\frac{1}{2}R$. A typical crystal is shown in Fig. 4, Pl. xxix. The planes of f and γ are considerably curved, and admit of only approximate measurement. The symbol of f was, however, sufficiently determined by its relation to the cleavage rhombohedron, and that of γ was determined from the mean of measurements of ten crystals, which gave $e : \gamma = 02\bar{2}1 : 04\bar{4}1 = 49^\circ$. The calculated value is $49^\circ 32'$. The planes of e are usually smooth and bright, those of f are deeply striated parallel to the edge $f\gamma$, and those of γ parallel to the longest diagonal of the rhomb. Rounding of the planes of the three rhombohedrons e , f and γ into one another is common. One crystal showed an intermediate rhombohedron between e and f , but it was impossible to obtain a measurement sufficiently satisfactory to determine its symbol. In some crystals again the rhombohedron f is absent and the crystal is made up of only the forms γ , $-4R$ and e , $-\frac{1}{2}R$.

FORMS OF TWINNED CRYSTALS.

Only a few twinned crystals were noted among those examined. The larger number of those noted are twinned upon the basal plane. These occur of both Types 3 and 4. The crystal chosen for special study was of Type 4, and is from the collection of the University of

EXPLANATION OF PLATE XXX.

- FIG. 1. Basal twin of Joplin Calcite. FIG. 2. Ideal form of twin shown in
One-half natural size. Fig. 1.
University of Chicago collection.

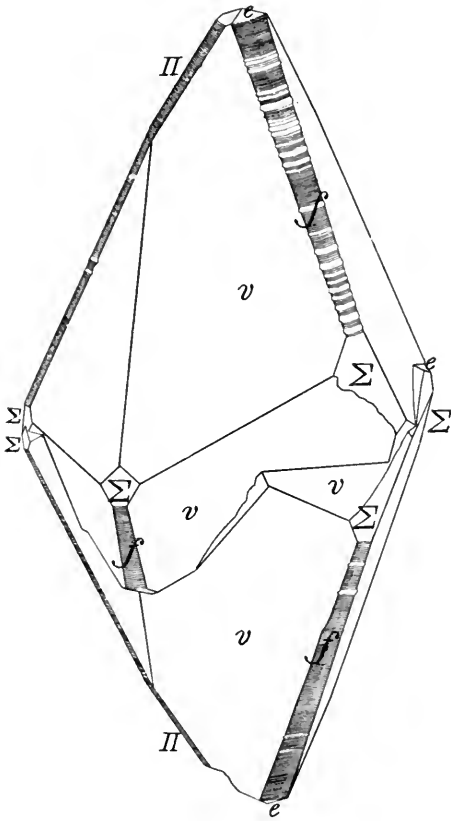


FIG. 1

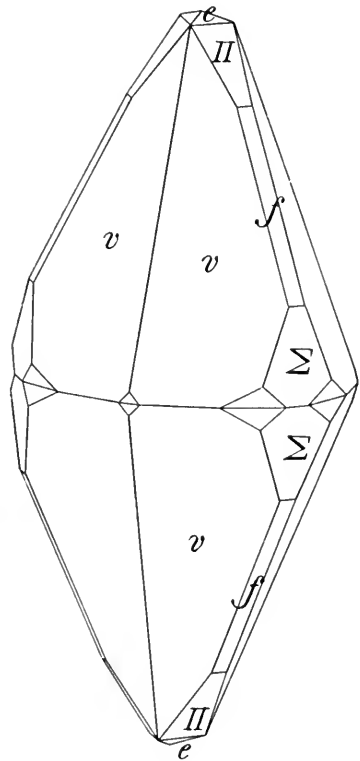


FIG. 2

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Chicago. The crystal is shown in Fig. 1, Pl. xxx. Measurements made in the zone of the negative rhombohedrons on this crystal with the contact goniometer are as follows:

	Measured.	Calculated.
$e : H = 0112 : 0775 = \dots\dots\dots$	28°	$27^\circ 51'$
$H : f = 0775 : 0221 = \dots\dots\dots$	9°	$9^\circ 1'$
$e : f = 0112 : 0221 = \dots\dots\dots$	36°	$36^\circ 52'$
$e : \Sigma = 0112 : 0.11.11.1 = \dots\dots\dots$	$59\frac{1}{2}^\circ$	$58^\circ 29'$

The determination of Σ rests rather on its occurrence on other crystals of this type which could be measured with a reflecting goniometer, than on the value obtained on this crystal, it being presumed that the same plane was most likely to occur again.

The peculiar distortions and striations exhibited in this crystal are illustrated in the figure. How far these have caused it to depart from the normal form may be seen by comparing Figs. 1 and 2, Pl. xxx. The tendency shown in this crystal for the two individuals of the twin to grow by one another and partially complete themselves, is quite common among the Joplin twins. Further struggles of the molecular forces are illustrated by the number of abortive planes of e , $-\frac{1}{2}R$, these being so numerous as to produce cross striations on f , $-2R$. The latter planes are further rounded from the tendency to produce scalenohedral forms.

Another and the only other type of twin crystal noted has e , $-\frac{1}{2}R$ as the twinning plane. Such twins occur among a group of calcite crystals formed together on a specimen in the collection of the University of Chicago. The crystals of this group are in general scalenohedral in form, colorless to amber in color, and vary from 1 to 2 inches (.3 to .6 cm.) in length. Many are simple crystals made up of r , $+R3$ dominant, modified by e , $-\frac{1}{2}R$, f , $-2R$, and a form new to calcite, Ω , $-20R$.* Others are intermediate in character, and are the result, doubtless, of one individual pushing by the other, as twins on the base have already been shown to do. Such a crystal is represented in Fig. 1, Pl. xxxi, the crystal being drawn in the position of the negative scalenohedron in order better to show the elongation in one direction. This elongation characterizes the true twins as well. In this crystal on the side toward the observer,

*The letter given to this form was chosen in accordance with Goldschmidt's system, Dr. Charles Palache having kindly indicated to me what the appropriate letter, according to this system, would be. I do not feel called upon to apologize for thus combining Dana's and Goldschmidt's lettering. I deem it essential that new forms should be lettered in accordance with Goldschmidt's system in order to avoid conflict of letters, but the common forms are, and are long likely to be, better known by Dana's letters.

although the lower part of the crystal is quite incomplete, the boundary planes are evidently those of a twin crystal. On the reverse side, however, the development is that of a simple crystal.

The completely formed twins resemble in many respects those from Guanajuato, described by Pirsson.* The twinning plane is the same, the lengthening out in one direction is similar, though not to the extent of the Guanajuato crystals, and the proportional development of the faces is analogous. The Joplin twins, however, differ notably from those of Guanajuato in their development at the apex of the salient angle. In the Guanajuato twins the scalenohedral planes of the two individuals of the twin are prolonged at the apex of the salient angle until they meet in a point. In the Joplin twins, however, the scalenohedral planes of each individual have only a normal development, and there is no prolongation to an apex. Some crystals occur in which one individual has grown by the other at the salient angle in the direction of the vertical axis of the individual, this being but another illustration of the curious tendency which has been previously noted. There is, however, no prolongation at the end of the twinning plane. The Guanajuato twins are usually attached at the salient angle, while the reverse is true of the Joplin twins. The attachment of the Joplin twins by the reëntrant angle often takes place at the end of a projecting process of calcite, usually more or less bounded by crystal planes, and seeming to serve as a sort of stem of crystal growth.

As regards the size of the twin crystals, it may be said that the longest noted measures 3 inches (.75 cm.) from end to end of the vertical axes. The lengthening out of the same crystal makes it about 1 inch (.25 cm.) long in the same direction. The combination of forms which make up these crystals has already been indicated. The determination of the new form O' , $-20R$, rests upon its evident location in the two zones $v v'$ and $e m$ and upon a very accurate measurement with the contact goniometer of the angle $e : O' = 0221 : 0.20.20.1 = 24^\circ$. The calculated value is $23^\circ 59'$. The form usually has rounded planes. The determination of the other forms likewise rests upon measurements made with the contact goniometer, but these correspond so closely with calculated values, and the analogy of the occurrence of the forms is so similar to that of the other Joplin calcites that there can be little doubt of their being correctly identified. The form O , $-\frac{2}{3}R$, is quite sporadic in its occur-

*Amer. Jour. Sci. 3d Ser., Vol. 41, p. 61.

EXPLANATION OF PLATE XXXI.

- FIG. 1. Partially twinned crystal of Joplin Calcite.
University of Chicago collection.
- FIG. 2. Twin crystal of Joplin Calcite.
Twinning plane $e, -\frac{1}{2} R$.
University of Chicago collection.
- FIG. 3. Same crystal as Fig. 2, drawn in the position of the negative scale-nohedron.

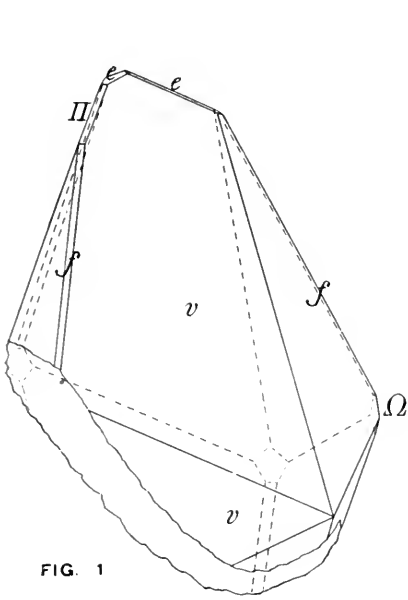


FIG. 1

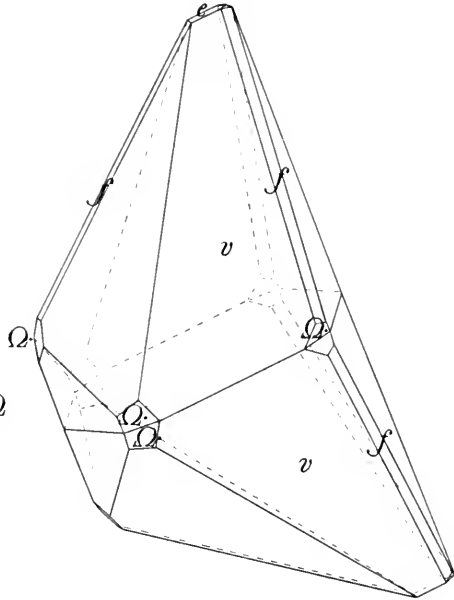


FIG. 2

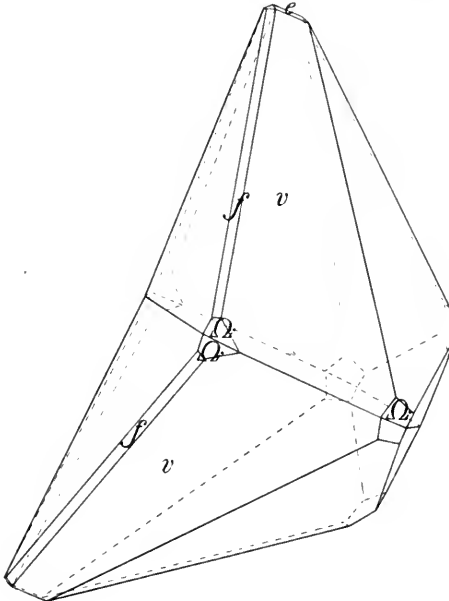


FIG. 3
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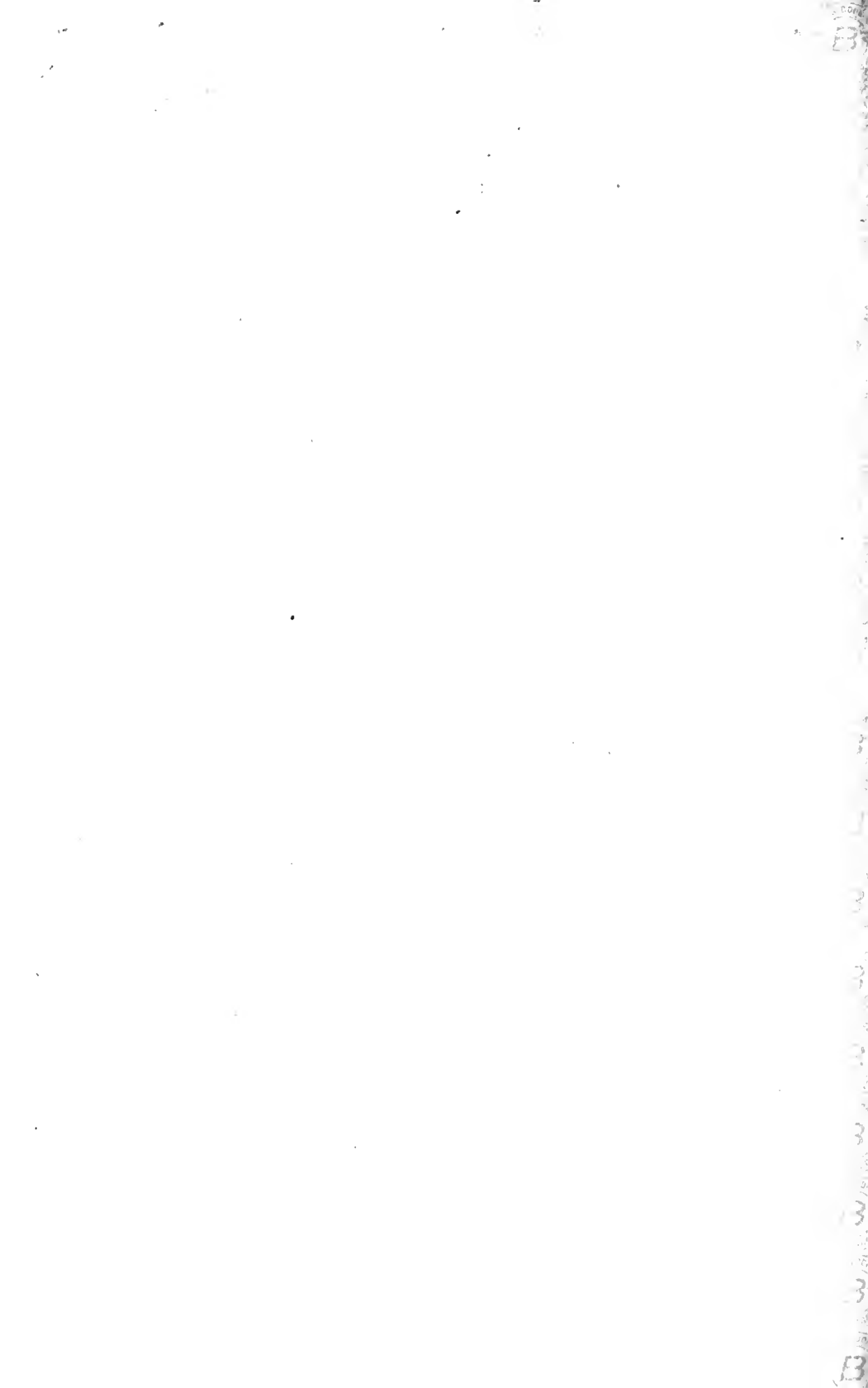
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rence, appearing sometimes as a single plane, more often as two, and only once in its full number of three planes.

In conclusion, the following list includes the forms noted on the Joplin calcites by the writer :

$r, 10\bar{1}1, +R$	$n, 41\bar{5}3, 1\frac{1}{2}$	$+R\frac{1}{2}$
$M, 4041, +4R$	$v, 21\bar{3}1, 1^s$	$+R_3$
	$w, 31\bar{4}5, \frac{2}{3}$	
$e, 01\bar{1}2, -\frac{1}{2}R$	$t, 21\bar{3}4, \frac{1}{4}$	$+\frac{1}{4}R_2$
$l, 04\bar{4}5, -\frac{1}{4}R$		
$\Pi, 0775, -\frac{1}{3}R$		$+4R_3$
$f, 0221, -2R$		
$\eta, 0441, 4R$		
$\Sigma, 0.11.\bar{1}1.1, -11R$		
$\Omega, 1.20.\bar{2}0.1, -20R$		

It is evident that the largest variety of forms occurs in the zone of negative rhombohedrons. Indeed, it is hardly likely that the above list includes all the negative rhombohedrons which occur, as several measurements made by the writer indicated others, although they could not positively be identified. The positive rhombohedrons are of rare occurrence and have little to do with determining the forms of the crystals. Among the scalenohedrons, $v, +R_3$, is almost universally present and is usually the dominating form. This scalenohedron in connection with $e, -\frac{1}{2}R$, and $f, -2R$, determines the habit of most of the Joplin crystals.





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