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A CONTRIBUTION TO THE MINERALOGY OF WISCONSIN.

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BY WILLIAM HERBERT HOBBS,
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INTRODUCTION.

So far as I am able to determine, nothing has been published descriptive of the crystallography of Wisconsin minerals. The minerals of economic importance have re-

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¹Read before the Wisconsin Academy of Sciences, Arts, and Letters, June 8th, 1895.

ceived attention, and the minerals in association with them have been mentioned in the several reports of the Wisconsin Geological Survey as well as in other publications. The present investigation has been devoted chiefly to the crystallographical development of Wisconsin minerals, and it has shown that from a purely scientific standpoint they possess considerable interest. Most of the species described have been before reported from the localities, and some, such as the calcites and smithsonites from the Galena Limestone, are quite widely distributed in cabinets. A few of the occurrences are quite new. The list of species considered includes with but few exceptions, it is believed, all that have been reported as occurring in definite megascopic crystals within the boundaries of the state.

The material on which this study has been made is chiefly from the Mineral Collection of the University of Wisconsin, in which is included the W. T. Henry collection, with little doubt the most complete collection of minerals that has been made from the mining region of southern Wisconsin. The writer is under obligations to Professor Edward Kremers of the University, for specimens of crystallized minerals collected from the Hamilton Cement Rock at Milwaukee, and to Mr. L. S. Cheney, also of the faculty of the University, for specimens from the vicinity of Platteville.

Below is given a partial list of the papers which treat of Wisconsin minerals. I have not included in this list the voluminous literature by Irving, Van Hise, Pumpelly, Brooks, and others, on the crystalline rocks of northern Wisconsin, in which descriptions of microscopic rock constituents are given.

Moses Strong, *Geology and Topography of the Lead Region. Geology of Wisconsin, Vol. II*, pp. 689-752. (1878.)

R. D. Irving, *The Mineral Resources of Wisconsin. Trans. Am. Inst. Min. Eng., New York Meeting, 1880*, pp. 1-31. (1880.)

T. C. Chamberlin, The Ore Deposits of Southwestern Wisconsin. *Geology of Wisconsin*, Vol. IV, pp. 377-398. (1882.)

R. D. Irving, Minerals of Wisconsin. *Ibidem*, Vol. I, pp. 309-339. (1883.)

George F. Kunz, (Note on finding of Eagle Diamond). Mineral Resources of the United States for 1883 and 1884, p. 732. (1885.)

George F. Kunz, On the Occurrence of Diamonds in Wisconsin. *Bull. Geol. Soc. Am.*, Vol. 2, pp. 638, 639. (1891.)

E. S. Dana, Catalogue of American Localities of Minerals. *System of Mineralogy*, 6th Ed., p. 1087. (1892.)

Wm. P. Blake, The Mineral Deposits of Southwest Wisconsin. *Trans. Am. Inst. Min. Eng.*, Chicago Meeting, pp. 1-11. (1893.)

Wm. H. Hobbs, On a recent Diamond Find in Wisconsin and on the Probable Source of this and other Wisconsin Diamonds. *American Geologist*, Vol. XIV, pp. 31-35. (1894.)

THE CRYSTALLIZED MINERALS FROM THE PRE-SILURIAN FORMATIONS OF SOUTHERN WISCONSIN.

Quartz Crystals from Devil's Lake.—The fissures in the Upper Huronian Quartzite of Devil's Lake, near Baraboo, are frequently found to be lined with crystals of quartz, which though quite small are very clear and have faces well fitted for measurement. The occurrence of crystallized quartz in the vicinity of Devil's Lake has been mentioned by Irving in a paper entitled "Minerals of Wisconsin."¹ These crystals are fully as limpid as the well known quartzes from Herkimer county, New York. A crystallographic study has been made of them on material recently collected at Devil's Lake by Professor Van Hise. The crystals have an average length of 3-6^{mm}. and a thickness of 1-2^{mm}. They have generally a marked trigonal habit occasioned by the unequal development of alternate faces of the prism, and by the subordination of the form *z* to *r*.² Besides the

¹ *Geology of Wisconsin*, Vol. I, p. 318, 1883.

² Throughout this paper the lettering of known planes agrees with that used by Dana in the 6th edition of the *System of Mineralogy*. In one or two cases the lettering used by

usual forms m , r , and z , the crystals are modified by the trigonal pyramids s and s' , the right and left forms being often observed together on the crystal. Examination with a lens reveals the fact that some crystals are further modified by the occurrence of a positive right trapezohedron between s and z . Measurement with the goniometer shows this plane to be the form τ_4 , $+\frac{8}{7}P\frac{2}{3}r$, (71 $\bar{8}$ 7), which I think has not before been observed, though the complementary negative left form τ_4 , $-\frac{8}{7}P\frac{2}{3}l$, (17 $\bar{8}$ 7) is given in the lists of Dana and Goldschmidt. In the zone of mr on another crystal a faint but distinct reflection was also obtained from a plane which has the symbol $\frac{4}{3}R$, (47. 0. 47. 30) and which has not before been described on quartz. The habit and development of the crystals is represented in figure 1.

FIG. 1.—QUARTZ CRYSTALS FROM DEVIL'S LAKE.

The following list gives the forms observed in the order of their amounts of development:

$$m, \infty R, (10\bar{1}0).$$

$$r, R, (10\bar{1}1).$$

$$z, -R, (01\bar{1}1).$$

$$s, \frac{2P2}{4} r, (11\bar{2}1).$$

$$s', \frac{2P2}{4} l, (2\bar{1}11).$$

$$\tau_4, +\frac{8}{7}P\frac{2}{3} r, (71\bar{8}7).*$$

$$\alpha, \frac{4}{3}R, (47. 0. 47. 30).*$$

Irby and Goldschmidt has been adopted. For new planes discovered German letters have been used wherever this is possible.

The angles were measured on two crystals with the following results:

	Measured.	Calculated.
$m : s, 10\bar{1}0 : 11\bar{2}1$	$38^{\circ} \frac{1}{2}'$	$37^{\circ} 58'$
$s : \tau'_4, 11\bar{2}1 : 71\bar{8}7$	23 12	23 15
$\tau'_4 : z, 71\bar{8}7 : 01\bar{1}1$	5 31	5 39
$\tau'_4 : m, 71\bar{8}7 : 10\bar{1}0$	61 $12\frac{1}{2}$	61 13
$r : z, 10\bar{1}1 : 1\bar{1}01$	46 34	46 16
$r : s, 10\bar{1}1 : 11\bar{2}1$	28 55	28 54
$m : r, 10\bar{1}0 : 10\bar{1}1$	38 11	38 13
$m : \alpha, 10\bar{1}0 : 47.0. \bar{4}7.30$	28 56	28 57
$m : m, 10\bar{1}0 : 1\bar{1}00$	60 0	60 0

The considerable variation from the theory in the measurement for the angle rz is due to the vicinal character of the face z . With this exception the faces gave excellent images of the signal.

Arsenopyrite in dike rock at Marquette, Green Lake County.—This mineral is found as an accessory constituent in a diabasic rock which occurs in a small dike in Marquette, Green Lake county. The locality is on the south side of the hill south of Mr. Ingalls's house and about one and one-fourth miles south-southwest of the village of Marquette.

FIG. 2.—ARSENOPYRITE FROM MARQUETTE.

The mineral occurs in crystals three to four millimetres across and bounded by the forms $u, \frac{1}{2}\bar{P}\infty (014)$ and $m, \infty P, (110)$ (See Fig. 2). The u faces are as usual striated parallel to their intersection. The faces are all bright and reflect well, but are too much rounded to admit of measurement. Heated on charcoal in the oxidizing and reducing flames of the blowpipe, arsenic and sulphur fumes are

evolved and the iron is oxidized. The mineral is locally supposed to be silver and the locality is referred to as the "silver mine."

Crystallized Calcite from Madison.—In the extensive quarries in calcareous sandstone which are located just west of the city of Madison and which belong to the Lower Magnesian formation, are occasionally found druse crystals of calcite. A specimen collected from this locality exhibits crystals of three to four millimetres diameter lining a small cavity.

FIG. 3.—CALCITE FROM MADISON.

These crystals have a yellowish tint and are somewhat translucent. The faces are considerably rounded, so as to be unfit for measurement, but the forms can be easily determined to be $-\frac{1}{2}R$ (01 $\bar{1}$ 2) and R (10 $\bar{1}$ 0), the latter very small. Another specimen is made up of crystals varying from 1-2 cm. in diameter bounded by the form $-\frac{1}{2}R$. Still another is bounded by R , ∞R and a scalenohedron. Still another specimen, apparently dropped on the University Drive by the quarry teams, is bounded by $0P$, R , $-\frac{1}{2}R$, and $-2R$.

THE CRYSTALLIZED MINERALS FROM THE CAVITIES IN THE GALENA LIMESTONE OF SOUTHERN WISCONSIN.

The lead and zinc ore region of the Upper Mississippi valley includes portions of Wisconsin, Illinois, Iowa, and Missouri. In Wisconsin the mines are now worked chiefly for zinc, which is obtained very largely from a porous variety of smithsonite colored brown by limonite, and known locally as *dry bone* or *dry bone ore*. This material is mainly utilized for the manufacture of zinc paint. At Shullsburg, where there is at present the greatest activity, black jack is the principal ore and is mined for *spelter*. The minerals

associated in the deposits in the Wisconsin area are calcite, smithsonite, galena, cerussite, sphalerite, gypsum, barite, marcasite, pyrite, chalcopyrite, azurite, malachite, and limonite. Hematite, siderite, pyrolusite, hydrozincite, and anglesite have also been reported. As will be shown below it is probable that what has been reported as anglesite is a well crystallized variety of gypsum, or selenite. Some additional minerals, notably amethystine quartz and calamine, are found in the areas of adjoining states, the so-called "calamine" of the Wisconsin mines is, however, not calamine but smithsonite.

Wisconsin calcites, smithsonite pseudomorphs, and azurites, are somewhat widely distributed in cabinets, as are also the galenas from Galena, Ill., but I am not aware that any crystallographical study has heretofore been made on any of these minerals.

CALCITE FROM MINERAL POINT, LINDEN MINE, MIFFLIN,
AND GALENA.

Southern Wisconsin has long been known as a locality for crystallized calcite, and specimens from the region are, therefore, somewhat widely distributed in collections. The best crystals come from the Linden Mine, Mineral Point, Galena, and Mifflin. They are frequently found to be modified, and they show considerable variety in their habits. Without regarding the less important variations, seven distinct types of crystal are observed, four of which are frequently met with and stand in an interesting relationship to one another as regards their periods of formation. These types may be distinguished as follows: .

Type 1. Habit, common scalenohedron R_s ($21\bar{1}1$) very much rounded; modified by R and by other undeterminable faces; color, milk white, brown, or pink, often variegated; opaque; crystals seldom over two inches in length, though larger cleavage pieces are found. Linden Mine and Galena. (See plate 4, fig. 1.)

Type 2a. Habit, scalenohedron R_s ($21\bar{3}1$) quite alone; color, light wine yellow; translucent to transparent; crystals almost always formed about a nucleal crystal of type 1; uniformly from three to six inches long; faces covered by *Aetzhügel* due to much corrosion by solvents. Mineral Point. (See plate 4, fig. 2a.)

Type 2b. Habit, flat rhombohedron $-\frac{1}{2}R$ ($01\bar{1}2$) either quite alone or with small face of R ($10\bar{1}1$); color like type 2a; translucent to transparent; faces quite free from etching phenomena; crystals from three to five inches broad; found generally in geodes which have a diameter of a foot or less. (These crystals were probably formed by the same solutions as those of type 2a, the difference in habit being explained by local conditions.) Mineral Point. (See plate 4, fig. 2b.)

Type 3. "Dog tooth spar." Habit, common scalenohedron R_s ($21\bar{3}1$) with moderate truncation by the fundamental rhombohedron R ($10\bar{1}1$) and much modified; color, grayish white; poorly translucent; faces marked by *Aetzfiguren* and *Aetzkanäle* but generally without *Aetzhügel*, hence less corroded than crystals of type 2a; usually has a core of type 2a within which is a core of type 1; two sizes of crystals, about two inches and four to seven inches long respectively. Linden Mine and Galena. (See plate 4, fig. 3.)

Type 4. "Nail head spar." Habit, fundamental rhombohedron R ($10\bar{1}1$) moderately beveled by the common scalenohedron R_s ($21\bar{3}1$) and much modified, the forms being the same as on crystals of type 3; color, like type 3 but considerably more translucent, being in this respect intermediate between types 2a and 3; less marked by etchings than type 3; occurs either alone or as parallel growths on surface of crystals of type 3, forming knobby projections if attached to the lateral faces, and scepter calcite resembling "scepter quartz" if attached to the apex of the crystals; when large numbers of these crystals are attached to the faces of crystals of type 3 they may unite as sub-indi-

viduals to form apparent secondary enlargements to that type; usually one to two inches in diameter; Galena, Linden Mine, Mineral Point, and Mifflin. (See plate 4, fig. 4; also plate 5, fig. 1.)

Type 5. Habit, a combination of the common rhombohedron R ($10\bar{1}1$), with the basal pinacoid, $0P$ (0001), and with small development of R_3 ($21\bar{3}1$). The only representative specimens of this type are large twinned crystals which will be fully described below. Linden Mine. (See plate 4, fig. 5.)

Type 6. Habit, prismatic from development of steep rhombohedron $24R$. ($24.0.\bar{2}4.1$); terminal planes e , v , and subordinate k ; white and opaque; Diamond Grove. Only one crystal of this type has been observed. (See plate 4, fig. 6.)

Crystallographically the most interest attaches to the types 3 and 4, since the crystals of type 1 are too much rounded to permit of any determination of their forms, and both varieties of type 2 are very simple, 2a exhibiting only the form R_3 ($21\bar{3}1$) and 2b the forms $-\frac{1}{2}R$ ($01\bar{1}2$) and R ($10\bar{1}1$). Although the crystals of types 3 and 4 are markedly different in their habits, between which no transitional forms have been observed, they are identical in their modification. The crystals of the latter type being less corroded, are best suited to measurement, but even on the best of these crystals the rounding of some of the faces renders very accurate measurements impossible. They are also too large for convenience of measuring with the reflecting goniometer. The following forms have been determined, those marked with an asterisk being so far as I know new to the species. They are not included in the lists of forms compiled by Irby,¹ Goldschmidt,² and Dana.³

¹ Irby, On the crystallography of calcite. Inaug. Diss. Göttingen, 1878.

² Goldschmidt, Index der Krystallformen, I. Berlin, 1886.

³ Dana, E. S., System of Mineralogy, 6th Ed., New York, 1892.

- r , R ($10\bar{1}1$).
 e , $-\frac{1}{2}R$ ($01\bar{1}2$).
 v , R_s ($21\bar{3}1$).
 a , $-\frac{1}{10}R$ ($0.11.\bar{1}1.20$).*
 b , $-\frac{1}{18}R$ ($0.18.\bar{1}8.25$).*
 f , $-2R$ ($02\bar{2}1$).
 c , $24R$ ($24.0.\bar{2}4.1$).*
 δ , $10R$ ($10.0.\bar{1}0.1$).
 k , $\frac{5}{8}R$ ($50\bar{5}2$).
 53 ,¹ $\frac{3}{8}R2$ ($11\bar{2}3$).
 t , $\frac{1}{4}R3$ ($21\bar{3}4$).
 57 ,¹ $\frac{1}{8}R\frac{7}{8}$ ($52\bar{7}9$).
 E , $\frac{1}{8}R\frac{5}{8}$ ($41\bar{5}6$).

These forms have been determined by the following measurements which are for the most part averages of several readings made on corresponding angles²:

Zone of e and m.

	Measured.	Calculated.
$e : a$, $01\bar{1}2 : 0.11.\bar{1}1.20$	$2^\circ 2'$	$2^\circ 14'$
$e : b$, $01\bar{1}2 : 0.18.\bar{1}8.25$	$9 \ 20$	$9 \ 8$
$e : f$, $01\bar{1}2 : 02\bar{2}1$	$36 \ 30$	$36 \ 52$
$e : c$, $01\bar{1}2 : 24.0.\bar{2}4.1$	$66 \ 10$	$66 \ 10$
$e : \delta$, $01\bar{1}2 : 10.0.\bar{1}0.1$	$69 \ 30$	$69 \ 32$

Zone of e and r.

$e : 53$, $01\bar{1}2 : 11\bar{2}3$	$14^\circ 13'$	$14^\circ 20'$
$e : t$, $01\bar{1}2 : 21\bar{3}4$	$20 \ 30$	$20 \ 58$
$e : 57$, $01\bar{1}2 : 52\bar{7}9$	$22 \ 50$	$23 \ 4$
$e : E$, $01\bar{1}2 : 41\bar{5}6$	$27 \ 15$	$27 \ 4$
$v : v$ (Edge X), $21\bar{3}1 : \bar{2}3\bar{1}1$	$75 \ 22$	$75 \ 22$
$v : v$ (Edge Z), $21\bar{3}1 : 12\bar{3}\bar{1}$	$46 \ 55$	$47 \ 1$

¹ Numbers used by Irby.

² The vicinal character of r prevented measurement, but the plane is easily identified by the cleavage. The face k is determined by its zones.

The different forms show considerable difference in the character of their markings. The planes of R_3 are striated parallel to their combination edge with R . Both R_3 and R are often marked by *Aetzkanäle* which incline to follow the direction of cleavage. On R the etched figures have the symmetry and approximately the shape of the artificial figures produced by the action of hydrochloric acid. This face is very frequently vicinal, the facets representing two scalenohedrons of large indices. Between R and R_3 a small and undeterminable face occurs which is probably the result of corrosion—*Prärosionsfläche* of Hamberg. The new form α , $-\frac{1}{2}R$ (0.18. $\overline{18}$. 25) may possibly also be of this character.

The parallel growths of four of the different types of crystals with one another demonstrate the fact that they represent successive separations from the solutions from which they were formed, their order of age being that represented by the numerals assigned to the types, viz.: 1, 2a, 3, 4, type 1 being the oldest. The crystals of type 2b were probably formed at the same time as those of type 2a, but in a different situation. Crystals of type 1, though common as a core of the later types, are most rarely found alone. The crystals of type 2a were most easily corroded by solutions, for specimens of parallel growths with the two later types are found in which the core of type 2 has been entirely removed, whereas the enclosing zone of type 3 has only been rendered porous and that of type 4 has been comparatively little affected. In one instance the cavity left by the removal of type 2 has been filled with sphalerite, thus forming a mechanical infiltration pseudomorph. Numerous specimens in the University Collection are parallel growths of the four types in isomorphous layers, and when broken across these types are seen to be sharply separated from one another by the differences in color and transparency. A few parallel growths include less than the full series of types, but no one of the types has been

observed out of the order stated. The character of one of these interesting parallel growths is represented in plate 5, fig. 1.

The only representative specimens of type 5 are two large twinned crystals from the Linden Mine. They are interesting both because they are the only specimens in the collection on which I have observed the basal pinacoid, and because they furnish the only observed illustration of twinning in the calcites of the region. The specimens are very large (the largest about 7 x 6 x 5 inches), and have a gray color and a much corroded surface. The individuals of both specimens exhibit the combination of the fundamental rhombohedron, R ($10\bar{1}1$), with the basal pinacoid, $0P$ (0001) and the common scalenohedron, R_s ($21\bar{3}1$). On one of the individuals of the larger specimen the basal plane has a very large development influencing the habit of the crystal, while on the other individual it is quite small. The two individuals have parallel axes, and the twinning plane may be considered either a face of the fundamental prism, ∞P ($10\bar{1}0$), or the basal pinacoid, $0P$ (0001). The large triangular area of the basal pinacoid on one individual is divided very accurately into two smaller and perfectly equilateral triangles by the projection above it of the rhombohedral faces of the other individual. On the largest of these triangular areas has formed a deep green yellow calcite enlargement. This addition of calcite material has extended the rhombohedral planes which outline two sides of the triangle, and on the third side opposite the rhombohedral face of the other individual it has developed a new rhombohedral face, so that the apparent lack of symmetry between the two individuals caused by the greater development of c on one of them, is in part removed. The other triangular section of the pinacoid has received no addition of calcite material. To one side of the specimen are attached small crystals of barite which will be described below.

The smaller specimen of this type is very similar to the one just described, but the basal plane has a smaller development, and on one individual it hardly appears at all. It is interesting, however, to note that there has been an addition of the yellow green calcite to this plane, so as to extend the surrounding rhombohedral faces and replace the pinacoid in the manner described for the first specimen.

The stereographic projection (plate 5, fig. 2) represents all the forms observed on the calcites of this region and exhibits their zonal relationships.

SMITHSONITE FROM MINERAL POINT.

The mineral smithsonite occurs at Mineral Point in two forms, one a massive, semi-vitreous, white to gray variety, locally called "calamine," which incrusts much of the calcite and blende of the locality, and the other a porous gray to brown variety known as "dry bone," apparently in all cases a replacement pseudomorph after either calcite or blende. The "dry bone" variety is much the more abundant. The more perfect pseudomorphs after calcite are very beautiful and represent the types 3 and 4 described under calcite. As these pseudomorphs are well known and are somewhat widely distributed in cabinets, a full description of them here is unnecessary. They have evidently been produced through the action of solutions by a metasomatic process of alteration, the lime of the calcite being replaced molecule by molecule by zinc. An examination of the wide range of specimens in the University Collection shows, however, that there have generally been several stages in the process. In most cases the first change was an incrusting of the calcite crystals by the compact "calamine" variety of smithsonite. As a result of this nearly all the pseudomorphs have an outer shell of compact material. The second stage of the process consisted in a partial, and in some cases even a complete, solution of the included calcite crystal. This solution if partial, as was

generally the case, took place along the cleavage cracks parallel to the rhombohedron, thus separating the crystal into partially detached rhombic blocks. Along the channels thus opened the solutions which effected the change found their way and replaced molecule by molecule the residual blocks, the channels remaining unfilled in the completed pseudomorph.

Numerous specimens in the University Collection indicate that the process above described was in some cases varied by the complete solution of the calcite and the failure to refill the cavity. Very beautiful incrustation pseudomorphs have resulted in this way. The majority of the specimens, however, contain residual portions of unaltered calcite, and clearly indicate that in most cases all stages of the process went on simultaneously in different parts of the crystal, the action beginning at the surface immediately under the incrustation of the "calamine" variety.

FIG. 4.—SMITHSONITE PSEUDOMORPH AFTER CALCITE, FROM MINERAL POINT.

Such specimens have immediately beneath the incrustation, a layer of the porous "dry bone" retaining the cleavage channels of the calcite. This layer is sharply delimited from the incrustation, but passes insensibly into the layer of porous corroded calcite immediately beneath, which likewise passes by all intermediate phases into the unaffected calcite nearer the center of the crystal. (See figure 4).

The dry bone material of these pseudomorphs is invari-

ably colored ochre yellow by limonite in the pulverulent form, and this material is sometimes found quite pure. Its fine state of subdivision as well as its uniform distribution in the pseudomorphs, makes it probable that its source is the iron of the "black jack" which supplied the zinc to the solutions, as has already been pointed out by Chamberlin.¹ The pseudomorphs of smithsonite after sphalerite which are in the collection are of much less interest, since they have the form simply of plates and spheroidal masses and not of definite crystals of blende.²

GALENA FROM YELLOWSTONE, MINERAL POINT, HIGHLAND,
GALENA, ETC.

The crystals of Galena from this region are invariably either cubes or a combination of the octahedron and cube. On some specimens from Galena the rhombic dodecahedron occurs as a small truncation of either the cubic or the octahedral edge. The largest crystals come from the Yellowstone Diggings. The Yellowstone crystals are always elongated, either in the direction of a principal axis, which produces an apparently tetragonal combination (see plate 6, fig. 2), or in the direction of a digonal axis, which results in an apparently hexagonal combination (plate 6, fig. 1). The length of these apparently prismatic crystals may be several times their breadth. A crystal of tetragonal habit in the University Collection has a length of over a foot and a breadth and thickness of about four inches. Another crystal with hexagonal habit is about nine inches in length with transverse dimensions of about four inches. The faces of these crystals are considerably rounded from corrosion. The specimens which come from Highland are quite symmetrical cubes with the cubic edge

¹ T. C. Chamberlin. The ore deposits of southwestern Wisconsin. Geology of Wisconsin, Vol. IV, p. 396. (1882.)

² Dana states in his system (8th ed.) that pseudomorphs after crystals three inches or so in diameter are found at Mineral Point. None are, however, contained in the University Collection.

often as much as three inches in length. A specimen from Benton presents interesting skeleton growths, which outline the half of an octahedron truncated by a cube. This probably represents one phase of the Galena referred to as *reticulated galena* in the report of the state geologist.¹ The more beautiful feather-like skeleton growths have been figured in that report.

FIG. 5.—AGGREGATE OF GALENA FROM MINERAL POINT.

At Mineral Point have been found large quite symmetrical cubes resembling those found at Highland. On some specimens the faces of the galenas are studded with octahedrons of pyrite which are superficially altered to limonite. On the crystals of other specimens are found gray cerussite crystals from 5-7 mm. in diameter. Still another series of specimens from Mineral Point presents very beautiful aggregations of sub-individuals on which the octahedron has a large development, forming hopper-faced aggregate individuals of the same habit (see figure 5). The average size of the component individuals is only a few millimeters and they are nearly perfect carbo-octahedrons, but at the ends of each of the principal axes of the aggregate crystal are large crystals with cubic habit, whose cubic face determines the size of the cube face on the aggregate crystal. The aggregate crystals have quite uniformly a diameter of about three to six centimeters and

¹ Chamberlin, Geol. of Wis., Vol. IV. p. 385. (1882.)

the component individuals at the ends of the principal axes a diameter of about one to two centimeters.

On specimens from Highland are found interesting arborescent forms not unlike the forms assumed by native copper (see figure 6). The individual cubes are much elongated in the direction of a principal axis and otherwise distorted, and the arborescent groups of crystals are often attached by the end of a single crystal, so that their resemblance to trees is very striking.

FIG. 6.—ARBORESCENT FORM OF GALENA FROM HIGHLAND.

Polysynthetic twin lamellæ like those described by Cross¹ have been observed on crystals from several of these localities. On crystals from Highland the twinning plane of the lamellæ is the octahedron, which corresponds to the second law mentioned by Cross. The crystals on which the lamellæ are observed, are cubes with small truncation by the octahedron. The faces of the cube are divided along lines parallel to their own edges into four sectors, in each of which pronounced striations run parallel to the adjacent octahedral face. All the cubic faces are affected in the same manner, but the octahedral faces are quite plane. This structure is indicated in plate 6, fig. 7.

Lamellar twinning according to the other law determined by Cross, where the twinning plane is a plane of the dodecahedron, is well shown by crystals from Mineral Point. The appearance of these crystals is shown in plate

¹ Whitman Cross, Note on Slipping Planes and Lamellar Twinning in Galena. Proc. Col. Sci. Soc., 2, p. 171-174. (1887).

6, fig. 6, which has been drawn from one of the crystals examined. The top cubic face of this individual is striated in the same manner as the crystals from Highland, but the structure is different on the adjacent faces. Here the course of the lamellæ is parallel to the cleavage lines, showing clearly that the twinning plane is the dodecahedron. On one of these faces a division of the face into sectors is noticed, but in this case the lines of division run parallel to the diagonals of the face. A few of the striations take their course across the direction of the prevailing ones at such an angle as to suggest that they represent a third law of twinning for the mineral such as has been described by Sadebeck,² in which the twinning plane is a trisoctahedron. In all cases the sectors into which the striations divide the faces constitute vicinal planes, all of which slope away from the center of the face.*

An exceptionally beautiful instance of the dodecahedral twinning above described is afforded by a large crystal from Yellowstone. This specimen is the broken end of what was apparently one of the elongated crystals with tetragonal habit which are common from this locality. The crystal had a breadth of about five and a thickness of some four centimeters. Figures 3, 4, and 5 of plate 6, represent three parallel sections of this crystal along the cleavage planes, those of figures 4 and 5 being separated by about three centimeters and those of figures 3 and 4 by about a centimeter and a half. The central portion of the

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² Zeitsch. d. D. geol. Gesellsch., Vol. XXVI, p. 631 (1874).

*NOTE.—That these twin lamellæ have been noticed before on Galena from the upper Mississippi valley, is evident from the following extract from a paper by James T. Hodge entitled, "On the Wisconsin and Missouri Lead Region," which was published in Silliman's Journal in 1842 (Vol. 43, p. 38):

"The smelters think they can distinguish the ores that are found in different fissures—that from an east and west fissure being perfectly crystallized, of a smooth surface, striæ indistinct; that from a north and south fissure, of crystalline structure, with two sets of striæ very distinct, crossing each other at right angles; and the ore from a quartering fissure crystalline, with many sets of striæ crossing each other obliquely; and to some extent I had opportunity of proving their observations correct."

Supposing this idea of the smelters to be correct, it is difficult to account for this difference unless the crystals of galena have a uniform orientation with reference to the walls of the fissure.

crystal is an unstriated nucleus whose former crystal boundaries are indicated by a line of tarnished mineral. The nucleus contains irregular-shaped cavities in which cerussite has crystallized. The striations in the outer portion of the crystal are high ridges near the periphery, but these diminish in prominence as they take their course toward the nucleus, dying out completely before they reach it, and as they do so often taking a sharp curve to a direction which suggests a sudden change to the law of Sadebeck. It is evident that this structure has not been produced by any stress to which the crystal has been subjected since its formation, but it is in some way to be connected with the strains induced in the outer portion of the crystal, as it accommodated itself to the nucleal crystal in growing about this and being oriented by it. Lamellæ have also been observed on crystals from Platteville, Wis.

Some very interesting forms of galena come from Galena, Ill. Many specimens indicate that there have been for the limestone cavities at least two periods in which galena crystallized out, separated by a period when crystallized marcasite was deposited. Cubes of galena, having an edge of three to five centimeters, are found coated with marcasite and studded with numerous nearly perfect octahedrons of galena, having a diameter of about two millimeters. The octahedron is usually absent from the crystals of the first separation of galena though it sometimes appears as a very minute truncation of the solid angles; while the cube, though always very small, is usually present on the octahedral crystals of the later generation.

One crystal in the collection has some interest from its twisted form. It is a simple cube elongated in the direction of a principal axis so that its length is about six inches and its breadth and thickness only about two inches. One end of the crystal is nearly or quite parallel to the other but occupies the position it would have if it had been rotated thirty degrees from its normal position about the long

axis of the crystal. The long faces of the crystal present a nearly perfect warped surface with only a single important interruption near one end.

On closer examination very slight interruptions are noticed at intervals of three or four centimeters, which indicate that the apparent individual is an aggregate of several individuals nearly, though not quite, parallel. Each individual is rotated through a small angle from its nearest neighbors about the axis of the aggregate, the rotation being always in the same direction. But this is not the only attempt which the crystal has made to assume a spiral form, for the faces of the sub-individuals are warped, and though the greater part of the aggregate is coated with marcasite, a cleavage surface is exposed at one point and exhibits the polysynthetic twin lamellæ. It is thus probable that the crystal has been subjected to some force from without which has inclined it to the direction it has taken.

CERUSSITE FROM HIGHLAND, MINERAL POINT, AND GALENA.

This mineral always appears on the surface of Galena crystals where it has doubtless been formed through the action of carbonated waters. The best specimens in the University Collection were found at Highland and Mineral Point. Larger but less perfect crystals are common on specimens from Mineral Point and from Galena, Ill., the latter place being located but a few miles from the state boundary. The Galena to which the Highland cerussite is attached occurs on the hopper-faced octahedrons composed of a great number of sub-individuals, which have been described under Galena (Fig. 5). Two strikingly different types of Cerussite crystals are found upon the same specimens, the one being long columnar in the direction of the brachydiagonal axis, and the other pseudo-hexagonal in habit, from the nearly equal development of pyramid and brachydome. Both types are to be found in

twins according to the common law, the twinning plane a face of the fundamental prism. Stellate forms of the second type are frequently only to be distinguished from the individual crystals by a search for the twinning lines, or by measurement of the angles on the goniometer.

Type 1. Crystals columnar in the direction of the brachy-diagonal axis: Crystals of this type usually have a length several times their breadth, and have their habit conditioned by the brachydomes i (021) and x (012), and the pyramid p (111) (see plate 7, fig. 1). They vary from four to eight millimetres in length. The forms observed upon them are the following, r being new to the species:

$$i, 2\bar{P}\infty (021).$$

$$x, \frac{1}{2}\bar{P}\infty (012).$$

$$r, \frac{2}{3}\bar{P}\infty (0.25.4).*$$

$$p, P (111).$$

$$b, \infty\bar{P}\infty (010).$$

$$m, \infty P (110).$$

$$r, \infty\bar{P}3 (130).$$

The above enumerated forms were determined by means of the following measurements:

	Measured.	Calculated.
$m : m', 110 : \bar{1}\bar{1}0$	62° 46'	62° 46'
$r : r', 130 : \bar{1}\bar{3}0$	57 35	57 19
$m : b, \bar{1}\bar{1}0 : 0\bar{1}0$	58 37	58 42
$m : p, 110 : 111$	35 46	35 46
$i : i', 021 : 0\bar{2}1$	69 13	69 20
$x : x', 012 : 0\bar{1}2$	39 51	39 45
$b : i', 0\bar{1}0 : 0\bar{2}1$	34 31	34 40
$b : r, 0\bar{1}0 : 0.25.4$	12 30½	12 29

The face r is certainly (0.25.4) and not the known form (061), as the face is a large one and quite perfect. Both r and b reflect finely, giving single sharp images of the signal. The calculated angle $b : t$ (010 : 061), is $12^\circ 59'$, which differs from the value obtained by over $18'$, whereas it is impossible that an error of more than a very few minutes should be made in the reading. With the exception of r , which is small and gives only a faint reflection of the signal, all the faces afford excellent readings.

Type 2. Crystals with pseudo-hexagonal habit due to the nearly equal development of the pyramid and brachydome: The individuals of this type (plate 7, fig. 2) are generally larger than the crystals of the first type and have the habit of the crystals from Bereзов figured by Dana,¹ but they are more modified. Their habit is conditioned chiefly by the forms p , i , and b . They may be easily confused with stellate twins, which occur with them and from which they can often only be distinguished by a measurement of the angles in the prismatic zone, the angle $m : \bar{m}$ being either $54^\circ 28'$ or $62^\circ 46'$, while that of $m : b$ is $58^\circ 37'$. Most of the crystals are twinned at least once, the twinning line taking usually a somewhat irregular course over the faces and frequently bringing p and i nearly into coincidence. On single individuals the faces are all remarkably perfect and give each a single sharp bright image of the signal. The forms are as follows:

p , P (111).

m , ∞P (110).

a , $\infty \bar{P} \infty$ (100).

b , $\infty \bar{P} \infty$ (010).

i , $2\bar{P} \infty$ (021).

k , $\bar{P} \infty$ (011).

x , $\frac{1}{2}\bar{P} \infty$ (012).

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¹ System, 6th ed., p. 287, fig. 8.

The following measurements were made to identify the above forms:

	Measured.	Calculated.
$m : m', 110 : \bar{1}\bar{1}0$	62° 47'	62° 46'
$m : b, 110 : 010$	58 36	58 37
$m : a, 110 : 100$	31 24½	31 23
$m' : a, 110 : 100$	31 22½	31 23
$m : p, 110 : 111$	35 48	35 46
$i : k, 021 : 011$	19 29	19 28
$i : x, 021 : 012$	35 28	35 28

On twinned individuals:

$m : \underline{m}, 110 : \underline{110}$	54 23	54 28

Many of the crystals have their faces studded with numerous small lenticular yellow crystals with much rounded faces, which are probably siderite.

The best cerussites which I have examined from Mineral Point are found, like the Highland crystals, on skeleton octahedrons of galena. Some of the smaller crystals have very sharp faces, and so far as examined they appear to have the same forms and habits as the Highland crystals.

Type 3. Crystals with domal habit. The large gray cerussites which come from Galena and Mineral Point, are less perfect and less highly modified than the types just described. The faces reflect poorly, but the following goniometer readings were made on crystals bounded by the forms i , x , m , and subordinate p , this being apparently the usual habit. (See plate 7, figure 3.)

	Measured.	Calculated.
$i : i', 021 : 0\bar{2}1$	111° 2'	110° 40'
$x : x', 012 : 0\bar{1}2$	40 6	39 51
$m : m', 110 : \bar{1}\bar{1}0$	62 35	62 46
$p : p, \text{(with front lens)}$	50	50 30

These crystals are as frequently simply twinned as the Highland crystals. Their form is represented in plate 7,

fig. 3. An analysis of such crystals on selected material from Galena yielded Mr. R. B. Green the following results:

		Calculated.
PbO.....	83.42	83.52
CO ₂	16.45	16.48
	99.87	100.00

The material was specially examined for zinc with negative results.

SPHALERITE FROM SHULLSBURG, MINERAL POINT, AND GALENA.

Although sphalerite is one of the most common minerals in the crevices of the Galena Limestone, it is usually found in the massive form or in small and imperfect crystals. It usually contains a small amount of iron sulphide, as is indicated by its dark color. I recently collected at the Wisconsin Zinc and Lead Company's mine at Shullsburg, some specimens of this mineral on which the crystal forms can be made out. These sphalerite crystals occur in an elongated roughly cylindrical cavity, which has been formed by the solution and removal of a fossil, probably an orthoceras. The largest crystal is over a centimeter in diameter and is a much distorted simple individual on which are found the following forms:

$$o, + \frac{O}{2} \quad (111).$$

$$o_1, - \frac{O}{2} \quad (1\bar{1}1).$$

$$d, \infty O \quad (110).$$

$$m, + \frac{3O3}{2} \quad (311).$$

$$+ \frac{mOn}{2} (hkl).$$

All the faces with the exception of *m* are dull and consequently give no image of the signal. The face *m* is very bright but is rounded through bevelment by a considerable number of hexoctahedrons having large indices. The angle *m* : *m* (over *a*), was measured by reflection and found to be $50^{\circ} 53'$, the theoretical value being $50^{\circ} 28'$. The angle *d* : *d*, (101 : 011) was roughly measured with a hand goniometer as 61° , the calculated angle being 60° . A hexoctahedron which has a development about equal to *m*, and whose faces occur on either side of the *m* face, could not be determined owing to the lustreless character of its faces.

A smaller crystal from the same specimen is bounded by the forms *o* (111) and *d* (110) and is twinned according to the common law for this mineral, the twinning plane a face of *o*. Other specimens from Shullsburg are light wine yellow in color to nearly colorless and transparent.

An analysis by Mr. E. B. Skinner of the darker crystals first described gave the following:

Zn	66.67
S	32.48
Fe.....	.37
	99.52

Sphalerite also occurs in crystals at Platteville and at Mineral Point, the individuals obtained from the former locality being a centimeter or more in diameter, while those from the latter locality are small though often with tolerably bright faces. The forms *d*, *o*, and *m* were observed upon both. Frequently, however, those found at Mineral Point are coated with a layer of white mineral which is probably smithsonite. Dana¹ states that crystals of this mineral three inches or more in diameter are found altered to smithsonite at Mineral Point. No such specimens are included in the University collection, though spheroidal aggregates of crystals as large as that are not uncommon, and these are sometimes altered to smithsonite. No crystals

¹ System, 6th Ed., p. 62.

of sphalerite much over a centimeter in diameter have been observed by the writer on Wisconsin specimens.

Sphalerite is found in exactly the same association at Galena. These crystals have much the same form, but some have been found on which the faces are much more perfect. They nearly always exhibit one form in addition to those observed on crystals from the other localities.

FIG. 7.—SPHALERITE FROM GALENA, ILL.

This is the tetragonal tristetrahedron or hemi-trisioctahedron A , $\frac{1}{2}O$ (775) which has not, I believe, been before observed on this mineral. On one crystal in particular the faces d , o , and A are very perfect and give excellent reflections of the signal (Fig. 7). On this crystal the following measurements were made:

	Measured.	Calculated.
$o : d$, 111 : 110	$35^{\circ} 18'$	$35^{\circ} 16'$
$d : A$, 110 : 775	26 49	26 48

On the same crystal the faces of the icositetrahedron (probably m) and the hexoctahedron are too much rounded to admit of measurement. On less perfect crystals the face A was measured with results varying $11'$ to $12'$ from those obtained on the most perfect crystal.

GYPSUM FROM MINERAL POINT.

The specimen about to be described was presented to the University Mineral Collection by a friend, who obtained it from a local collector at Mineral Point. It was supposed to be anglesite by the person who collected it, possibly because it occurs on crystals of galena. The crystals referred to are long columnar in habit, colorless, and perfectly transparent. Their greatest length is 10^{mm}. and their greatest breadth about 2^{mm}. They are attached to small cubes of galena which are covered by a layer of red cryptocrystalline smithsonite. As this is an unusual appearance for the local smithsonite, it was determined to be that mineral by its reacting for zinc on charcoal and being completely soluble with effervescence in hydrochloric acid. The red color of the mineral is superficial, the under portions having the usual gray color.

FIG. 8.—SELENITE FROM MINERAL POINT.

The transparent colorless crystals which are attached to the smithsonite and galena, are not anglesite as supposed, but gypsum or selenite. They have the usual habit of gypsum crystals, being bounded by the prism and clinopinacoid and the rounded terminal planes, l , (111) and occasionally e , ($\bar{1}03$) (see fig. 8). The following measurements

are the average of a number which were made with the reflecting goniometer on several crystals, the rounded character of the faces sometimes introducing errors of as much as 30':

		Measured.	Calculated.
$m : m$ (front)	$110 : \bar{1}\bar{1}0$	$68^{\circ} 49'$	$68^{\circ} 30'$
$m : m$ (back)	$\bar{1}10 : \bar{1}\bar{1}0$	68 41	68 30
$m : b$ (front)	$\left\{ \begin{array}{l} 110 : 010 \\ \bar{1}\bar{1}0 : 0\bar{1}0 \end{array} \right\}$	55 40	55 45
$m : b$ (back)	$\left\{ \begin{array}{l} \bar{1}10 : 010 \\ \bar{1}\bar{1}0 : 0\bar{1}0 \end{array} \right\}$	55 50	55 45

The terminal faces were too much rounded to permit of measurement. The clino-pinacoidal cleavage is almost micaceous in perfection and the pyramidal cleavage (n) is well developed. There was no case of twinning observed. The hardness is 2. Ignited on charcoal in RF the powder of the mineral glows and yields an alkaline residue. Moistened with hydrochloric acid and introduced into the flame of the Bunsen burner it shows the calcium flame. The optical orientation of the mineral was found to agree in every respect with that of gypsum. Since the examination of this mineral was made, Prof. Kremers of this university has shown me a very similar specimen from Mineral Point which was brought to him labelled "anglesite." It is therefore almost certain that the mineral which has been referred to as "anglesite" from Mineral Point in the state reports is really gypsum. These references are always very indefinite, and usually state that the mineral is "reported" or is "said to occur" at the locality. No determination of the supposed anglesite seems to have been made.

BARITE FROM THE LINDEN MINE.

Barite or barytes, as it is called at the mines, has been found massive in considerable abundance at a number of localities in the eastern portion of the mining region. Specimens from Mineral Point, Crow Branch Mine, the Welsh Settlement in Iowa county, and the Linden Mine, are included in the University Collection. The mineral is almost invariably crystalline, as is shown by its cleavage and by the projection of indeterminable crystal edges from its knobby surfaces. Crystals have been reported from Scale's Mound just over the interstate boundary in Illinois. I have not been able to examine any specimens from this locality. A few crystals of the mineral were, however, found attached to one of the faces of the larger twinned crystal of calcite from the Linden Mine, which has already been referred to in this paper. These crystals of barite are represented in plate 7, figure 4. They have a maximum length of about a centimeter and a half, are of a light gray or brown color, and possess a rather unusual habit. They are lath-shaped, approaching acicular, with the direction of principal development the macro-diagonal axis. This fact is easily determined, since the acute angle of the perfect prismatic cleavage is found at the extremities of the crystals. The narrow tabular plane which forms the top of the laths is the basal pinacoid, since it is parallel to the best cleavage. The other planes present are m , ∞P (110) and d , $\frac{1}{2}\bar{P}\infty$ (102). The former can be seen to be parallel to the second cleavage, and the latter has been determined with sufficient accuracy by the following measurement made upon the reflecting goniometer, the face c affording a fair and d a much blurred image of the signal:

	Measured.	Calculated.
$c : d, 001 : 101$	$37^{\circ} 45'$	$38^{\circ} 51'$

Most of the faces are dull and reflect poorly, but poor as the measurements are they are the best that were pos-

sible under the circumstances. Some very imperfect crystals of barite, in part colored brown by oxide of iron, have been collected by Mr. L. S. Cheney from Belmont, Wisconsin.

MARCASITE FROM LINDEN MINE, CROW BRANCH MINE,
MINERAL POINT, DIAMOND GROVE, HAZEL
GREEN, AND GALENA.

The mineral marcasite is found at many localities in the Galena limestone, and seems to be of much more common occurrence there than pyrite. It appears under a variety of forms. It is sometimes found as a cryptocrystalline to crystalline coating on the surface of galena or blende, and it also occurs in well formed crystals, the University Collection including a good suite of specimens from the several localities. These crystals of marcasite show as great variety in habit and combination as the massive and cryptocrystalline varieties show in their shapes. At least seven different types of crystals have been observed on the specimens in the University Collection. These will be described in detail below. Their distribution is indicated in the following list:

- Type 1.* Linden Mine, Crow Branch Mine, and Mineral Point.
- Type 2.* Linden Mine.
- Type 3.* Diamond Grove.
- Type 4.* Hazel Green.
- Type 5.* Hazel Green.
- Type 6.* Galena.
- Type 7.* Galena.

Type 1. Crystals of this type have a thin tabular habit and are bounded by the forms c , $0P$ (001); m , ∞P (110); l , $\bar{P}\infty$ (011), and v , $\frac{1}{3}\bar{P}\infty$ (013). (See plate 8, fig. 1.) The base is as usual the plane of tabular development, and the edge $l:l$ at the extremity of the $\bar{b}$ axis is about as long as the

face m , so that crystals have a hexagonal appearance when observed in the direction of the c axis. The specimen which shows the most perfect crystals of this type is without a label, but it was obtained from the W. T. Henry Collection with material from the Linden Mine, and was probably found at that locality. These crystals have a diameter of 5-8^{mm}. The following measurements were made upon them:

	Measured.	Calculated.
$m : m, 110 : \bar{1}\bar{1}0,$	75° 22'	74° 55'
$l : l, 011 : 0\bar{1}1,$	100 5	101 58

The prism m is sometimes beveled for a short distance by a prism which gives a reading of 78° 1', the reflection of the signal being as sharp and bright as that from m . In one instance also a brachyprism gave a reading of 99° 52'. These two forms would correspond to the symbols of the brachyprisms $\frac{1}{2}\bar{1}\bar{1}P\infty$ and $\frac{1}{2}\bar{1}\bar{1}P\infty$, but in view of the wide variations of the angles exhibited by crystals of marcasite, the correctness of these symbols can not be relied upon. The face l furnishes but poor images of the signal and c and v are altogether unsuited to measurement. The greater number of specimens of this type are parallel growths, each individual varying slightly from perfect parallelism with the individuals adjacent. This produces the usual "cockscomb" forms. Twins, with the twinning plane the prism m are quite common, but so far as observed they are composed of but two individuals (plate 8, fig. 1a). On one such twin the angle between adjacent prism faces lying on either side of the twinning plane was measured with the following result:

	Measured.	Calculated.
$m : \underline{m}, 110 : \underline{110},$	30° 1'	30° 10'

Pseudomorphs of limonite after marcasite have been found at Mineral Point as well as at other localities. Ex-

cellent specimens from Mineral Point are included in the University Collection.

Type 2. On some specimens from the Linden Mine the marcasite crystals have a lath-shaped habit due to their unusual development in the direction of the $\bar{b}$ axis, the macropinacoid forming the edge of the lath, c the fairly broad top, while the brachydomes at the top and bottom and m from the vertical faces, produce a slight sharpening of the laths at the ends (plate 8, fig. 2). All the faces are very much curved and can not be measured. It is noticeable that the prism is connected to the macropinacoid by a uniformly curved surface.

Type 3. This type of crystals is common on specimens from Diamond Grove. The crystals are invariably stellate twins, the individuals composing which have a thick tabular habit with c small and l large, and are but little striated or rounded (plate 8, fig. 3). No simple twins were observed, the groups being apparently cyclic fivelings though the fifth individual is not made out owing to the broad attachment of the twin by one of its edges. The reentrant angles formed by m appear between individuals, but they are very small. The face c is striated by oscillatory combination with either l or v . Unlike the crystals of type 1, which have a brassy lustre, or those of type 2, which have a greenish color, the surface of these individuals has a reddish brown color and an iridescence which is ascribed to incipient alteration to the hydrated oxide. The stellate groups have a diameter of 3-4 mm. and are attached to greenish marcasite which forms a surface layer over blende, its tabular crystals being oriented normal to the surface of the blende and crowded so closely that only the edges of l can be seen.

Type 4. This type represents the simplest combination, the only forms developed being c and m (plate 8, fig. 4.). The individuals are quite thick so that they have rather the appearance of short prisms with diamond cross sec-

tion, than of tabular plates. Simple twins with twinning plane the prism are common on these specimens. The prism was determined as m by the following measurements:

	Measured.	Calculated.
$m : m, 1\bar{1}0 : 110,$	$105^{\circ} 2'$	$105^{\circ} 5'$
On twinned crystals,		
$m : \underline{m}, 1\bar{1}0 : \underline{110},$	$30^{\circ} 34'$	$30^{\circ} 10'$

The face c is striated parallel to the brachydiagonal axis, which causes a slight rounding of the face near the edge $110 : \bar{1}10$. The color of this type of crystals is brown. Parallel growths of a simple character produce the "cockscomb" aggregates.

Type 5. The second type of crystals from Hazel Green (plate 8, fig. 5) is quite different from the first, but almost identical with a marcasite from Schemnitz which is figured by Dana.¹ These crystals have a diameter of 4–5 mm. and are quite symmetrically developed. They are bounded by the following forms:

$$m, \infty P \quad (110).$$

$$l, \bar{P}\infty \quad (011).$$

$$e, \bar{P}\infty \quad (101).$$

$$s, P \quad (111).$$

$$x, m\bar{P}\infty \quad (01h).$$

The faces are bright with a brassy lustre and in most cases reflect but a single image of the signal, so that the probable error of reading is very small. Notwithstanding this fact the measurements of corresponding angles not only vary much from the values determined by Sadebeck for this mineral but they vary much from one another. This variation must therefore be explained by actual variations in the angles themselves, though the faces do not

¹ System, 6th Ed., p. 95, fig. 2.

show vicinal planes, and with the exception of l and x are not striated. The variation in the angles of marcasite is well known and the values obtained by Sadebeck are not supposed to be very accurate. The measurements made on the crystals from Hazel Green are as follows, the general correctness of the average determination being confirmed by the zone relations:

		Measured.		Calculated.
$s : s$ (over l)	$111 : \bar{1}11$	$88^{\circ} 57'$		$90^{\circ} 48'$
$s : s$ (over e)	$111 : \bar{1}\bar{1}1$	$65 \quad 35$		$66 \quad 7$
$s : s$ (over m)	$111 : 11\bar{1}$	$56 \quad 7$		$52 \quad 28$
$l : l,$	$011 : 0\bar{1}1$	$99 \quad 56$	$\left. \begin{array}{l} \\ \\ \end{array} \right\} 100^{\circ} 26'$	$101 \quad 58$
		$99 \quad 13$		
		$102 \quad 9$		
$e : e,$	$101 : \bar{1}01$	$113 \quad 48$	$\left. \begin{array}{l} \\ \\ \end{array} \right\} 112 \quad 47$	$116 \quad 20$
		$112 \quad 30$		
		$112 \quad 3$		
$l : x,$	$011 : 0\bar{1}h$	$54 \quad 16$		
		$54 \quad 25$		
$x : l',$	$0\bar{1}h : 0\bar{1}1$	$44 \quad 38$		
		$44 \quad 48$		

Beside the form x , which occurs with only half its planes on these crystals, the edge ll' is occupied by a large number of indeterminate brachydomes, so that the edges lx and xl' are well rounded. If the readings lx and $l'x$ could be relied upon the form x would have the symbol $\frac{1}{2}P\infty$, and it is in any case a very flat dome. That it is not the basal pinacoid, which occurs on the Schemnitz crystals, is apparent even by examination with the naked eye. A number of simple twins and several polysynthetic trillings were observed on these specimens (plate 8, fig. 5a). The twinning plane is shown to be m , the unit prism, by the twinning line following the edge le and then traversing the face m parallel to the edge mm . Trillings are easily determined from the zigzag forms assumed by the x plane.

Type 6. The crystals of marcasite from Galena which are in the University Collection bear most resemblance to the crystals of type 5 from Hazel Green. One variety has a distinctly prismatic habit conditioned by the large development of the prism m , the nearly equal development of the domes l and e , and the absence of the base c , the dome x , and the pyramid s . Crystals of this type are built up of a large number of sub-individuals and are nearly always twinned with a face of m the twinning plane (plate 8, fig. 6.). Such twins are either simple twins or polysynthetic trillings, in which latter case the middle individual is quite thin. A trilling is easily distinguished from a simple twin by the striations on the l faces. In a simple twin the larger striated l faces are adjacent, and opposite to a pair of adjacent and glistening e faces (plate 8, fig. 6b.). In a trilling two e faces appear opposite one another as in a simple individual (plate 8, fig. 6a), and the only evidence that the crystal is twinned may be the re-entrant angle along the edge le and on the face m . Although a majority of the crystals are composed of small sub-individuals which appear as projections on the faces of the aggregate crystal, many of the composite individuals are terminated by one large simply twinned crystal. On such a twinned individual the following measurements were made:

	Measured.	Calculated.
$l : e, 011 : 101$	$68^{\circ} 18'$	$70^{\circ} 49'$
$e : e, 101 : \underline{101}$	54 57	56 34
$l : \underline{l}, 011 : \underline{011}$	84 36	85 4

A specimen of marcasite collected at Galena by Mr. L. S. Cheney has a somewhat different development. The fundamental prism is large, giving the crystals their columnar form, while $v, \frac{1}{2}\bar{P}\infty$ and subordinate $l, \bar{P}\infty$ serve as terminal planes. These crystals are in part attached to larger octahedrons of pyrite.*

* NOTE.—Some quite interesting arborescent aggregates of marcasite crystals were collected by Mr. Cheney at Cuba City, Wis. These were received too late for study in connection with the other specimens of this mineral which are here described.

Type 7. Another variety of the Galena marcasite crystals resembles type 5 more closely, though *s* and *m* are both very small. They are frequently attached by one of the dome faces so that an opportunity is given for the development of dome faces at both ends of the crystals. The result is a mimicry of the octahedron, so that these crystals might be taken for octahedral pyrite having small truncations by the cube (plate 8, fig. 7). On some specimens radial groupings of such crystals produce aggregates having a diameter of about two centimeters, on which particularly large crystals or groups of crystals project at points corresponding to the ends of the crystallographic axes, and make the groups somewhat resemble hollow-faced octahedrons.

Dana¹ has figured a crystal from Galena which has a tabular habit, is bounded by the forms *l*, *v*, *c*, *b*, *m*, *e*, and *s*, and is twinned according to *m*.

PYRITE FROM SHULLSBURG AND MINERAL POINT.

Pyrite, like marcasite, is a common mineral in the crevices of the Galena Limestone. Well crystallized specimens would not, however, seem to be very common. During a recent visit to the Wisconsin Zinc and Lead Company's mine at Shullsburg, I picked up a specimen of limestone having a small cavity lined with pyrite crystals. Some of the individuals have a diameter of two to three millimeters, but the better crystals are seldom much over a millimeter in diameter. They are usually combinations of the common pentagonal dodecahedron (210) with the cube and octahedron, and are but little distorted. Their habit is generally conditioned by the pyritohedron, which is generously truncated by the cube and octahedron (plate 8, fig. 8). In a few cases the pyritohedron is but little developed, the form of the crystals being given by the cube. The faces

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¹ System, 6th Ed., p. 95, fig. 4.

are bright but have a purplish iridescence due to incipient alteration. The pyritohedron was determined with sufficient accuracy as the common form e , $\frac{\infty O2}{2}$ (210) by measuring the edge A on the reflecting goniometer, the result obtained being $52^{\circ} 32'$, and the calculated value $53^{\circ} 8'$.

Pyrite occurs at Mineral Point in cubes apparently unmodified and as much as three-quarters of a centimeter on an edge. Associated with these symmetrically developed cubes are interesting groups composed of long columnar individuals arranged radially about a centre located a little below the point of attachment (plate 8, fig. 9.). These crystals have a length of a centimeter or a little less, and a thickness of a little more than a millimeter. They are cubes developed in the direction of one of the principal axes. The individuals composing the group do not come in contact, except perhaps at the point of attachment. Other specimens from this locality are similar in character but of much larger dimensions, the pyrite needles having a length of several inches and a diameter of only a few millimeters. The space between the pyrite needles is occupied by crystallized sphalerite, which is in part coated with smithsonite. The large radial sheaves of iron sulphide which occur at Galena are for the most part pyrite.

A perfect unmodified octahedron of pyrite a half centimeter along the axes was collected by Mr. Cheney at Democrat, near Etna, Wis.

AZURITE FROM MINERAL POINT.

Both the carbonates of copper are found at Mineral Point attached to massive chalcopyrite, where they have doubtless been formed through the action of carbonated waters. The azurite is quite well crystallized, but the individuals are rarely over 2^{mm} long. In a few specimens they attain dimensions of $3\text{--}4^{\text{mm}}$. The crystals have either a domal habit with the ortho-diagonal the axis of great-

est development, or a thick tabular habit with the basal pinacoid the tabular face. Crystals of the first mentioned variety possess about the proportions given by Farrington for the crystals of lath-like habit from Arizona.¹ Different crystals show considerable variation in the occurrence of forms as well as in the relative development of those which occur.

Three crystals have been completely measured, the first two being lath-shaped, but representing different combinations, and the third tabular. In all, ten forms have been determined, four of which are new to the species.

On crystal I the prominent faces in the zone of the axis $\bar{b}$ are the basal pinacoid, the negative unit orthodome (σ), and the new form $\frac{1}{2}\bar{P}\infty$ (205); and the crystal is terminated by a single plane of e , $\frac{1}{2}P2$ ($\bar{2}45$). (See plate 7, fig. 6.) The habit of crystal II is conditioned chiefly by the same forms as crystal I, with the addition of the new form $\frac{1}{2}\bar{P}\infty$ ($\bar{2}03$) in the zone of $\bar{b}$; and though both e and the new form b , $-\frac{1}{2}P\frac{1}{2}$ (9.12.8), are represented as terminal planes, the former is much the larger, and one of its faces is large and the other comparatively small (plate 7, fig. 7.).

On crystal III the terminal forms occur with their full complement of faces, which have nearly equal development (plate 7, fig. 8.). In addition there occurs on this crystal a small positive hemi-brachypyramid, which has larger parameters on both c and a than has the form e . This pyramid is not far removed from the zone of $\bar{2}45$ and $24\bar{5}$, but it could not be accurately determined. An indeterminate negative pyramid with much rounded faces and quite small development, is also found on the crystal. This crystal has as the largest faces in the principal zone, the tabular basal pinacoid, the form σ , $\bar{P}\infty$ ($\bar{1}01$) and the new form c , $-\frac{1}{2}\bar{P}\infty$ (307). The only forms which are found

¹ O. C. Farrington, On Crystallized Azurite from Arizona. Amer. Jour. Sci. (3) XLI, p. 300. (1891).

on all of the three crystals are c , σ , e , and a . The new forms lying in the principal zone were easily determined from their angles with the basal pinacoid. The forms e and b were determined, the former from its angle with c and with 010 (one-half the angle $e : e$ over the end of the $\bar{b}$ axis), the latter from its angle with c and with both e and b .

The forms observed on the three crystals are given below, those that are new to the species being marked by an asterisk:

<i>Forms.</i>		<i>Crystals.</i>		
c , 0P	(001)	I	II	III
a , $\infty \bar{P}\infty$	(100)	I	II	III
σ , $-\bar{P}\infty$	(101)	I	II	III
c , $-\frac{2}{3}\bar{P}\infty$	(307)*			III
θ , $\bar{P}\infty$	($\bar{1}01$)	I		III
b , $\frac{2}{3}\bar{P}\infty$	($\bar{2}03$)*		II	
n , $\frac{1}{2}\bar{P}\infty$	($\bar{1}02$)		II	
a , $\frac{2}{3}\bar{P}\infty$	($\bar{2}05$)*	I	II	
e , $\frac{1}{2}P\bar{2}$	(245)	I	II	III
b , $-\frac{2}{3}P\bar{2}$	(9.12.8)*		II	III

The average of several measurements of the interfacial angles of the planes of the above forms are given below. The reflections from the pyramid faces are fairly good, but in the principal zone the measurement is made difficult by striation, particularly on the faces θ , a , and n , and by a curvature, or better warping, apparently caused by the intergrowth of nearly parallel individuals. This explains the considerable variation between the readings of angles and their calculated values, as indicated in the parallel columns of the following table.

		Measured.	Calculated.
$c : \theta,$	$001 : \bar{1}01$	$46^{\circ} 12'$	$47^{\circ} 12'$
$c : a,$	$001 : 100$	88 5	87 37
$c : \sigma,$	$001 : 101$	44 23	44 44
$c : c,$	$001 : 307$	22 44	22 49
$c : a,$	$001 : 205$	22 21	22 53
$c : b,$	$001 : 203$	35 45	35 21
$c : n,$	$001 : \bar{1}02$	26 42	27 52
$a : \sigma,$	$100 : 101$	43 15	42 50
$b : b,$	$9.12.8 : 9.12.\bar{8}$	98 3	99 48
$b : e,$	$9.12.8 : 24\bar{5}$	53 21	53 6
$b : c,$	$9.12.8 : 001$	58 4	59 12
$b : \sigma,$	$9.12.8 : 101$	40 35	
$e : e,$	$\bar{2}45 : 24\bar{5}$	113 30	113 6

The crystals are translucent with the beautiful azure blue color characteristic of this mineral. They are sometimes coated with a thin film of green malachite.

MALACHITE FROM MINERAL POINT.

This mineral is found as a superficial alteration product of chalcopyrite. Some very beautiful radial and sheaf-like forms are to be seen in specimens in the University Collection. Some very minute crystals having a maximum length of only about three-tenths of a millimeter, when examined under low powers of the microscope appear as columnar crystals much flattened in the plane of the ortho-pinacoid (plate 7, fig. 5). This face is so much broader than the others that the crystals invariably rest upon it and consequently always exhibit parallel extinction. They are in all cases bounded very sharply by the forms a , $\infty P\infty$ (100); m , ∞P (110); c , $0P$ (001); and b , $\infty P\infty$ (010); the latter plane being very small and recognized only when the crystal is

adjusted on the goniometer. Owing to the minute size of the crystals, the face *a* is the only one which furnishes even a fair image of the signal. The angle *a* : *m* was roughly measured twice, using the front lens of the telescope, and found to be about 39° , the usual value given being $37^\circ 50'$.

THE DRUSE MINERALS OF THE HAMILTON CEMENT ROCK AT MILWAUKEE.

Calcite.—The Hamilton cement rock which occurs at Milwaukee carries cavities in which good crystals of calcite¹ may be found. A number of specimens have been collected by Professor Edward Kremers, the head of the School of Pharmacy of the University, and generously presented to the University Mineral Collection. I am therefore largely indebted to him for the material which is here described. The crystals are translucent and either colorless or yellowish.

FIG. 9.—CALCITE FROM MILWAUKEE.

They vary in length from 8–12^{mm}, and in diameter from 3–5^{mm}. Their habit is short columnar, conditioned by the combination of a steep positive rhombohedron and $-\frac{1}{2}R$ (01 $\bar{1}2$) (see figure 9). The former is much rounded but can be approximately determined to be 18 R by measurement of the convergence of the long sides of its faces. One crystal in the collection was attached by this face and is doubly

¹ The occurrence of calcite, pyrite, and rarely also sphalerite in the cavities of the cement rock has been mentioned by Chamberlin (Geology of Wisconsin, Vol. II, p. 393, 1878).

terminated. The common scalenohedron R_3 , $(21\bar{3}1)$ sometimes appears as a replacement of the solid angle formed by two faces of $-\frac{1}{2}R$ and one of $18R$. The forms observed are therefore

$$\rho, 18R \quad (18.0.\bar{1}8.1)$$

$$e, -\frac{1}{2}R \quad (01\bar{1}2)$$

$$v, R_3 \quad (21\bar{3}1)$$

the two latter having been determined by the following measurements:

		Measured.	Calculated.
$e : e,$	$01\bar{1}2 : 1\bar{1}02$	$44^\circ 35'$	$45^\circ 3'$
$v : v, (Y),$	$3\bar{1}\bar{2}1 : 21\bar{3}1$	$36 \quad 29$	$35 \quad 36$

The faces are all somewhat rounded, particularly the faces ρ and v . One specimen in the collection shows a larger wine yellow calcite which is a parallel growth of several simple rhombohedrons, about which and on which the colorless crystals with habit ρe have formed. This larger crystal is thus shown to belong to an older generation.

FIG. 10.—PYRITE FROM MILWAUKEE.

Pyrite.—The cavities in the Milwaukee Cement Rock which contain the calcite crystals just described, are often coated with pyrite, so that the calcite is formed on the pyrite. The pyrite appears in good crystals having a diameter of 1-2^{mm}. and is bounded by the octahedron and cube. The habit is octahedral, the cube usually having a small though a quite constant development (Fig. 10.).

Sphalerite.—This mineral would seem to be much less abundant in the cavities of the cement rock than either calcite or pyrite. Only one specimen out of quite a num-

ber supplied the writer by Dr. Kremers included any crystals of sphalerite, and these were few and small. These crystals were twinned according to the common law, as a result of which they were flattened parallel to a face of the tetrahedon. The faces are not bright enough for measurement, but the forms $\frac{O}{2}$ (111), αO (101), an icositetrahedron, and a hexoctahedron, can be made out upon them.

As is frequently observed on this mineral, the faces of the tetrahedron show triangular markings. The faces of the icositetrahedron truncate the edges of the hexoctahedron, so that it is very probable that the icositetrahedron is $2O_2$ and the hexoctahedron $3O_{\frac{3}{2}}$. In order to determine with certainty, however, it would be necessary to secure much better material.

Marcasite.—While this paper was in the printer's hands, I had an opportunity to visit the Milwaukee cement quarries and collect there specimens of marcasite and celestite. I also had an opportunity to make a hasty examination of the valuable mineral collection owned by Howard Green, Esq., in which are contained very beautiful millerite crystals from the cement works. So far as I know, none of these minerals have been reported from the locality.

The marcasite is found in very well formed, brightly iridescent crystals of lath-like habit, with the axis of development the brachy-diagonal. The largest crystals found had a length of only a few millimetres. The forms developed are apparently *c*, *v*, and *m*, with other smaller faces. They have not yet been carefully studied.

Celestite.—This mineral occurs in masses as large as a man's head composed of inter-grown crystals, the individuals of which are sometimes several inches in length. These masses are found in the layer of rock immediately underlying the one quarried for cement. The crystals seem quite pure and have a white color with irregular areas of pale celestial blue. A qualitative determination

was made to identify the mineral. The powder of the mineral moistened with hydrochloric acid yields in the Bunsen flame the intense red color of strontium. Heated on charcoal in the reducing flame of the blowpipe the mineral glows, and if fused with soda and placed upon moistened silver, gives a deep stain of silver sulphide.

Millerite.—Very beautiful specimens of millerite from the cement quarries are contained in the collection of Mr. Howard Green of Milwaukee. I have not yet found an opportunity to carefully examine them.

DIAMONDS FROM THE DRIFT.

Three large diamonds and a number of smaller ones have been found in the glacial drift of Wisconsin. There is also a report of three other diamonds, one of them as large as a robin's egg, which were found and subsequently lost, their real character not being known. It is not improbable that the report is correct, but there is not sufficient evidence to prove it. The large diamonds have all been found in the "kettle moraine" outlining the Green Bay lobe of the ice sheet, though the localities at which the finds were made are somewhat widely separated. Several small diamonds have been found in the bed of Plum Creek, Rock Elm township, in Pierce county. The report on the Pierce county diamonds has been made by Mr. George F. Kunz.¹ The writer has elsewhere² described the latest find at Oregon in Dane county, and recorded facts furnished by Col. S. B. Boynton of Chicago, concerning the finding of the Eagle and Kohlsville diamonds. In the paper referred to, the writer has also shown that the probable source of the diamonds found in the Green Bay lobe of the "kettle

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¹ On the Occurrence of Diamonds in Wisconsin. Bull. Geol. Soc. Am., Vol. 2, p. 638. (1891.)

Cf. also Min. Res. of U. S., 1889-90, p. 446. (1892.)

² On a recent Diamond Find in Wisconsin and on the Probable Source of this and other Wisconsin Diamonds. Am. Geol., Vol. XIV, p. 31-35. (1894.)

moraine, is the region about the Menominee river in the northeast portion of the state. At the time that paper was written the Kohlsville stone had not been given an examination, but the writer has since had an opportunity to examine it and has found it to very closely resemble the other large diamonds found at Eagle and Oregon, so that the theory that the diamonds found in the kettle moraine have a common source, is thereby supported.

Below are given in tabular form the most important facts concerning the recorded diamonds from Wisconsin.

Where and how found and by whom owned.	Date of Finding.	Date of Determination.	Weight in Carats.	Crystal Form.	Color.
<i>Eagle Diamond.</i>					
Found by a laborer employed by Mrs. Clarissa Wood, on farm owned (1876) by Dr. Tucker and located in the town of Eagle, Waukesha county. Owned by Tiffany & Co.	1876	1883	16	Dodecahedron.	Wine Yellow.
<i>Oregon Diamond.</i>					
Found by a small son of Charles Devine on farm of Judson Devine in the town of Oregon, Dane county. Owned by Tiffany & Co.	1893	1893	$32\frac{7}{8}$	"	Nearly White.
<i>Kohlsville Diamond.</i>					
Found by a farmer, Louis Endlich, while rolling a field on his farm at Kohlsville, Washington county. Owned by his widow, who now resides at Kewaskum, Washington county.	1886	1894	$21\frac{1}{4}$	"	Wine Yellow.
<i>Pierce County Diamonds.</i>					
Found by G. H. Nichols and party while prospecting for gold in the bed of Plum creek, Rock Elm township, Pierce county. Several of the stones owned by Tiffany & Co.	1887, 1888 and 1889	1891	Several stones, the largest $\frac{25}{32}$, $\frac{7}{16}$, $\frac{3}{8}$	Hexoctahedron.	White or Yellow.

It seems at first a little surprising that the Eagle and Kohlsville diamonds should not have been earlier identified, but it must be borne in mind that simple as is the determination of this gem, it is rare to find anyone not a professional mineralogist who would think to apply the

test of hardness. Experience seems to show that the average jeweler is as ignorant of the properties of the common gems as is the farmer. Most people can with little trouble have the use of either an emery wheel or a little coarse emery, and since diamond is the only natural mineral which can not be scratched by emery, no one need be without the means of determining at once whether a rough stone is diamond.

EXPLANATION OF PLATES.

PLATE 4.

Crystals of calcite from southern Wisconsin,

Fig. 1. Crystal of type 1 bounded by R_s and R and having much rounded angles. *Fig. 2a.* Crystal of type 2a bounded by R_s alone. *Fig. 2b.* Crystal of type 2b bounded by $-\frac{1}{2}R$ and R. *Fig. 3.* Crystal of the somewhat modified type 3. Excluding the small scalenohedrons which bevel the edge *re* this crystal exhibits the following forms: r, R; e, $-\frac{1}{2}R$; v, R_s ; a, $-\frac{1}{10}R$; d, $-\frac{1}{10}R$; f, $-2R$; c, $24R$; δ , $10R$; k, $\frac{5}{2}R$. *Fig. 4.* Crystal of type 4 which has the same modification as type 3 but has rhombohedral instead of scalenohedral habit. *Fig. 5.* Twinned crystal from the Linden mine with twinning plane the basal pinacoid. The forms developed are R, R_s , $-\frac{1}{2}R$, and 0P. One of the individuals has received a secondary growth of darker and yellow green calcite, which tends to give symmetry of development to the twin. *Fig. 6.* Crystal of type 6 bounded by the forms $24R$, R_s , $-\frac{1}{2}R$, and $\frac{5}{2}R$.

PLATE 5.

Calcite from southern Wisconsin.

Fig. 1. Parallel growth of calcites of types 1, 2a, 3, and 4.

Fig. 2. Stereographic projection of forms observed on calcites from southern Wisconsin.

PLATE 6.

Galena from southern Wisconsin.

Fig. 1. Large crystal from Yellowstone having an apparently hexagonal symmetry from development in the direction of a digonal axis.

Fig. 5. Crystal from Yellowstone having apparently tetragonal symmetry from development in the direction of a principal axis. *Figs. 3, 4, 5.* Sections across a crystal of Galena from Yellowstone in the direction of the cleavage. These sections show an interior core which is outlined by a line of tarnish and includes irregularly shaped cavities. This core is surrounded by a later growth which is polysynthetically twinned with the twinning plane the rhombic dodecahedron. *Fig. 6.* Crystal of Galena from Mineral Point showing polysynthetic twin lamellæ with the twinning plane the rhombic dodecahedron. *Fig. 7.* Crystal of Galena from Highland showing polysynthetic twin lamellæ with the twinning plane the octahedron.

PLATE 7.

Crystals of cerussite, barite, malachite, and azurite from southern Wisconsin.

Fig. 1. Crystal of cerussite of type 1 from Highland. The forms present are: i , $2\bar{P}\infty$; x , $\frac{1}{2}\bar{P}\infty$; γ , $\frac{2}{3}\bar{P}\infty^*$; p , P ; b , $\infty\bar{P}\infty$; m , ∞P ; and r , $\infty\bar{P}3$. *Fig. 2.* Crystal of cerussite of type 2 from Highland. The forms present are: p , P ; m , ∞P ; a , $\infty\bar{P}\infty$; b , $\infty\bar{P}\infty$; i , $2\bar{P}\infty$; k , $\bar{P}\infty$; and x , $\frac{1}{2}\bar{P}\infty$. *Fig. 3.* Twinned crystal of cerussite of type 3 with the twinning plane the fundamental prism. The types present are: i , $2\bar{P}\infty$; x , $\frac{1}{2}\bar{P}\infty$; m , ∞P ; and p , P . *Fig. 4.* Crystal of barite from the Linden mine, bounded by the forms c , $0P$; m , ∞P ; and d , $\frac{1}{2}\bar{P}\infty$. *Fig. 5.* Crystal of Malachite from Mineral Point. *Figs. 6 and 7.* Crystals of Azurite of domal habit. *Fig. 8.* Crystal of azurite of thick tabular habit. The forms present on these azurite crystals are: c , $0P$; a , $\infty\bar{P}\infty$; σ , $-\bar{P}\infty$; ϵ , $-\frac{2}{3}\bar{P}\infty^*$; θ , $\bar{P}\infty$; b , $\frac{2}{3}\bar{P}\infty^*$; n , $\frac{1}{2}\bar{P}\infty$; α , $\frac{2}{3}\bar{P}\infty^*$, e , $\frac{4}{3}P2$; and δ , $-\frac{2}{3}\bar{P}\frac{1}{2}\infty^*$.

PLATE 8.

Crystals of marcasite and pyrite from southern Wisconsin and Galena, Illinois.

Fig. 1. Crystals of marcasite of type 1 which has thin tabular habit and is bounded by the planes; $0P$, ∞P , and $\bar{P}\infty$. *Fig. 1a.* Orthographic projection on basal pinacoid of twinned crystal of type 1. *Fig. 2.* Lath-shaped crystal of marcasite of type 2 bounded by the forms $0P$, $\infty\bar{P}\infty$, $\bar{P}\infty$, and ∞P . *Fig. 3.* Stellate twin (cyclic fiveling) of marcasite, constituting type 3. *Fig. 4.* Crystal of marcasite of type 4, bounded only by ∞P and $0P$. *Fig. 5.* Crystal of marcasite of type 5 possessing pseudo-

isometric habit, bounded by the forms $\check{P}\infty$, $\bar{P}\infty$, ∞P , P , and $m\check{P}\infty$. *Fig. 5a.* Orthographic projection of a polysynthetic trilling of marcasite of type 5 on the basal pinacoid. *Fig. 6.* Twinned parallel growth of marcasite of type 6 bounded by the forms ∞P , $\check{P}\infty$, and $\bar{P}\infty$. *Fig. 6a.* Orthographic projection of marcasite trilling of type 6 on the basal pinacoid. *Fig. 6b.* Similar projection of simple twin of same type of marcasite. *Fig. 7.* Crystal of marcasite of pseudo-octahedral habit (type 7) bounded by the forms $\check{P}\infty$, $\bar{P}\infty$, $0P$, ∞P , and P . *Fig. 8.* Crystal of pyrite from Shullsburg. *Fig. 9.* Pyrite aggregate from Mineral Point.

Mineralogical Petrographical Laboratory,
University of Wisconsin.

FIG 1

FIG 2a

FIG 2b

FIG 3

FIG 4

FIG 5

FIG 6

fig 1

fig 2

FIG. 1.

FIG. 2.

FIG. 3.

FIG. 5.

FIG. 4.

FIG. 6.

FIG. 7.

FIG. 8.

FIG 1

FIG 1 a

FIG 2

FIG 3

FIG 4

FIG 5

FIG 5 a

FIG 6

FIG 7

FIG 8

FIG 6 a

FIG 6 b

FIG 9

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