II.—MINERALS FROM THE NEIGHBORHOOD OF PIKE'S PEAK.

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GENERAL.

The name of Pike's Peak has become well known the world over in connection with the large and perfect crystals of Amazon stone (microcline) which have found their way into almost every mineral collection of importance, and yet the stranger who ascends the mountain from Manitou may see no sign of that or of any other of the numerous species accredited in a general way to the region. It may be well, therefore, to preface this description with a few remarks concerning the mode of occurrence and the distribution of the Pike's Peak minerals.

The mountain proper rises to a height of 14,147 feet, and is surrounded by many lesser peaks which reach 10,000 feet. The same coarse reddish granite which forms the greater part of all these points extends in a northerly direction for at least 35 miles. Owing to a lack of gold and silver bearing ores the granitic formation has not been thoroughly explored, the region is uninhabited, excepting on certain routes of travel, and the great majority of the mountains and streams are unnamed. Hence it is that minerals found in many remote spots are afterwards labelled simply as from Pike's Peak. For many of the species the inaccuracy is unimportant, as throughout the entire granitic area some of them are surely to be found upon search.

List of Species Known.—Up to the year 1882 the following minerals had been identified with certainty, viz.: Microcline, albite, biotite, muscovite, quartz (smoky and clear), fluorite, columbite, göthite, hematite and limonite (pseudomorph after siderite), arfvedsonite, astrophyllite, zircon, bastnäsite, and tysonite. The species described in this article have been identified by us since that time, viz: topaz, phenacite, kaolinite, cryolite, pachnolite, thomsenolite, gearksutite, ralstonite (?), prosopite, and elpasolite.

Another series of minerals now in the course of investigation embraces several salts of cerium, yttrium, etc., belonging to species not as yet fully determined, although xenotime and yttrotantalite are probably present. Cassiterite also occurs in small quantity. (See p. 74.)

Mode of Occurrence.—The reddish granite of the region belongs to a type common in the Colorado range of the Rocky Mountains, and is supposed to be a part of the Archæan formation. It consists of a largely predominant reddish feldspar, to which are added brilliant black biotite and quartz, the latter subordinate, and occurring in small grains. The feldspar consists largely of an intergrowth of orthoclase and albite, somewhat after the manner of perthite.

Throughout the granite body, though much more abundant in some places than in others, are drusy cavities or "pockets" of very variable size, and often distorted by movements of the rock mass. Lining these druses, or entirely filling them in some cases, are crystals of feldspar and smoky quartz, in the first degree, with fluorite, topaz, phenacite, zircon, göthite, hematite, and limonite, as more or less constant companions.

The granite disintegrates rapidly through the action of the weather into a coarse, gravel-like mass, and many of the mountain slopes are covered by such material, with solid rock appearing here and there. On finding fragments of crystal in the *débris* the prospector for minerals, with pick and shovel in hand, endeavors to find the original cavity from which the fragments came. One of these druses has been known to yield more than a ton of crystallized specimens of Amazon stone, smoky quartz, etc.

Vein-like masses, composed chiefly of white quartz and reddish microcline, are also locally abundant, and in these are sometimes found small masses of cryolite and its alteration products, with zircon, astrophyllite, and columbite as observed associates.

CRYOLITE.

Locality.—The point at which cryolite and its alteration products have been found is at the northeastern base of Saint Peter's Dome, a minor peak due west of Cheyenne Mountain and near the toll-road from Colorado Springs to the Seven Lakes, at the southern base of Pike's Peak. The spot lies nearly on the southeastern border of the extensive region within which Amazon stone and its associates occur, and may be thus considered within the "Pike's Peak region," although several miles distant from the mountain proper. The fluorides were first shown in a prospect shaft and in a neighboring tunnel, but visits made to the locality since the first publication have proven the presence of cryolite masses in several of the small irregular veins north and west of Saint Peter's Dome.

Occurrence and Association.—The manner of occurrence and the relationship of the fluoride masses can now be stated much more clearly than was possible in our first notice. Cryolite, in the massive form to be described, was deposited in the veins of secretion which are so abundant in the granite country rock, in small but pure and homogeneous masses. Some of these veins have certainly had two periods of secretion, as is shown in the Eureka tunnel, Saint Peter's Dome. This tunnel penetrates for about 200 feet an irregular mass, consisting largely of white quartz and reddish microcline. The greater part of the quartz is the common white vein material containing no included minerals, but a portion of it, appearing in sharply defined angular blocks, is full of the transparent zircon to be hereafter described. Small particles of microcline are also disseminated through this quartz, while in the body of the vein it presents huge individuals, sometimes several feet in diameter. An examination of the tunnel walls shows here and there faces of pure massive fluorides 5 or 6 feet across and sharply defined against both pure and zircon-bearing quartz, the spaces filled being very irregular and angular. No contemporaneous minerals of importance accompany the zircon and cryolite in this vein.

The purity or homogeneity of the white quartz, zircon-bearing quartz, and fluoride masses, together with their irregular forms, seems to indicate different periods of development, and it seems further probable that a time of disturbance, in which the original quartz and feldspar vein was much fractured, produced the irregular spaces subsequently filled by different deposition. The cryolite may have been formed here during the time in which fluorite and topaz were deposited in the cavities of the region to the northwest.

The only mineral observed to be undoubtedly contemporaneous with the cryolite is columbite, which has been seen in small crystals embedded directly in fresh cryolite. At one place astrophyllite blades penetrate cryolite, but these are implanted directly upon the granite wall, and are probably an earlier formation, as are the zircon crystals at their base, and impregnating the granite itself. In the immediate neighborhood arfvedsonite and astrophyllite are quite abundant, both occurring most frequently embedded in white massive quartz. The original locality of tysonite and bastnäsite is not far from Saint Peter's Dome, but little is known to us concerning the manner of occurrence of these minerals.

Purely Scientific Value of the Discovery.—As numerous inquiries concerning the probable commercial value of this new cryolite locality have been received since the published description, it may be well to emphasize the conclusion which is clearly suggested by the description of the occurrence of the mineral. All the cryolite as yet known occurs in the form of subordinate masses in the veins of secretion which appear here and there throughout the granitic formation, and there is no reason to suppose that masses of economic importance can occur in the region.

Recent Literature of Cryolite and its Alteration Products.—The minerals of this group, of which so little was known a few years ago, are now among the best known. As most of the recent publications are of direct interest to us in describing the material of the new find, a brief mention of the leading articles is in place.

The earliest contribution to be mentioned is that of Prof. P. Groth, then in Strassburg, who instituted a careful investigation of cryolite and its alteration products, several of which had received names without satisfactory proof of their homogeneity, while more or less doubt was justifiable in regard to the chemical composition of all of them. Similar rare minerals of other occurrence were also studied. The purely mineralogical part of this investigation was conducted by Professor Groth personally, while material selected by him was subjected to chemical analysis by Dr. J. Brandl, in Munich. To the papers by Messrs. Groth[16] and Brandl[17] we shall refer frequently in the course of the following description. Owing to better material we are able to supplement in some particulars the results of these gentlemen, and in but a single case, namely, in regard to the composition of pachnolite, is there any discrepancy between our conclusions and theirs.

Concerning the crystallography of the group, Krenner[18] and Des Cloizeaux[19] have made important contributions while the laws of twining in massive cryolite have been investigated by Mügge.[20]

General Description.—The pure cryolite appears in massive aggregates of large individuals, quite like that from Greenland. The three prominent cleavage surfaces are often continuous for two or three inches, indicating the size of the individuals present. A delicate pink or even decidedly rosy hue is characteristic of the freshest substance found, but the greater part is either of a faint greenish tinge or dull white, and none so far obtained has the snowy whiteness or the clearness of the Greenland mineral. The color disappears on heating, leaving the cryolite pure white.

The three marked cleavage directions are situated nearly at right angles to each other and one seems slightly more perfect than the other. A parting parallel to these planes is by no means so easily effected as one would expect from the distinctness with which they are seen, a fact explained by the complicated polysynthetic structure to be described.

Twin Structure.—As no crystals of cryolite have been found in this locality, the study of the complicated twin structure exhibited by the massive material is no easy matter. The recent investigations of

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[16] P. Groth. "Beiträge zur Kenntniss der natürlichen Fluorverbindungen," Zeitschrift für Krystallographie, VII, pp. 375–388 and 457–493, 1883.

[17] J. Brandl. Sitzungsbericht der königl-bayr. Akademie der Wissenschaften zu München, 1882, p. 118, and Annalen der Chemie, CCXIII, p. 1.

[18] J. A. Krenner. "Die grönländischen Minerale der Kryolith Gruppe." Budapest, 1883.

[19] A. Des Cloizeaux. "Nouvelles observations sur le type cristallin auquel doit être rapportée la cryolite." Bull. Soc. Min. d. Fr., 1883.

[20] O. Mügge. "Über die Zwillingsbildung des Kryoliths." Jahrbuch d. wiss. Anstalten zu Hamburg, 1883, p. 67.

Krenner, and especially those of Mügge upon the massive mineral from Greenland, have, however, done much to make the relations clear.

Dana[21] mentions ∞ P, Websky[22] 0 P and ∞ P ∞, and Krenner[23] ∞ P and $\frac{1}{2}$ P as twinning planes identified upon crystals of cryolite. Mügge[24] seems to have identified $\pm\frac{1}{2}$ P as a twinning plane in the massive material, independently of Krenner's determination. In all the above-mentioned laws the axis of revolution is the normal to the twinning plane, which is usually the composition face. The polysynthetic development of various laws was briefly alluded to in the first notice of the Colorado cryolite, and the descriptions of Mügge show that a similar, although by no means equally complicated, structure exists in the Greenland mineral.

The well known pseudo-symmetry of cryolite is illustrated by the following values, taken from Krenner: $\beta = 89^\circ\ 49'$; the prism angles are 88° 2′ and 91° 58′, the angles between 0 P and opposite prism faces are 90° 8′ and 89° 52′. The axes of elasticity are also situated in peculiar agreement with this symmetry, the bisectrix lying in the clinodiagonal section, inclined 43° 54′ to the vertical axis and 45° 55′ to the clino axis. It is to be noticed that by all the above-mentioned laws of twinning the planes of 0 P and ∞ P are brought in so nearly coincident positions that the deviations are unnoticeable upon the cleavage surfaces of the massive substance.

The examinations of Mügge were conducted upon thin sections lying in water, the index of refraction of the liquid being almost equal to that of cryolite. Our observations were made upon sections prepared in the usual manner. As none of them exhibit anything corresponding to the results obtained by Mügge on heating to a temperature of over 400° C., it is assumed that no change in the optical properties was produced by the temperature necessary in mounting these sections in balsam.

Although we cannot in the cleavage material distinguish with certainty between ∞ P and 0 P, or between the positive and negative quadrants, still, if from a given cube, sections be prepared parallel to each of the three cleavage faces, we should be able to observe the relations of all twinning laws seen to each other and to a ground form which can be assumed. For a clear distinction of all the individual parts it is necessary to examine the thin sections between crossed nicols and with an inserted gypsum plate giving the field of vision a red color of the higher order. As nearly all the twinned parts are symmetrically related to ∞ P or 0 P, the first position in which their relations can be seen to advantage is secured by placing the cleavage lines in each section ± to the principal sections of the crossed nicols. This position is hereafter designated as position I. It is evident that the extinction in the basal section takes place parallel to the diagonals of the prism, as indicated by the cleavage lines, *i. e.*, about 45° from each. The theoretical extinction parallel to a face of ∞ P is 31° 15′ from the vertical axis (Groth), which direction lies parallel to one set of cleavage lines.

The various laws of twinning observed will now be taken up and the resulting structure parallel to each of the cleavage faces described.

Law a.—Twinning plane and composition face ∞ P, axis the normal upon it.

One of the three sections shows a fine banded structure parallel to one set of cleavage lines; this resembles plagioclase twinned according to the albite law, but the boundaries are less clearly defined. In position I alternate bands are blue, the remainder yellow; reversed colors are produced by a revolution of 90°; extinction occurs at about 31° from the twinning plane, right or left according to color. The second section shows no such banded structure, but extinction takes place at 31° from either cleavage system. The third section exhibits a banded structure with blue and yellow colors, but with nearly coincident extinction at 45° from the twinning line, which is parallel to one cleavage direction.

As experience shows this twinning to be always parallel to one pair of prism faces and there is evidently a definite relation between the other laws and the present, we will assume the left-hand front prism-face as the twinning plane, ∞ P (*l*). The first section was therefore parallel to ∞ P (*r*), the second to ∞ P (*l*), and the third to 0 P. This assumption is made in all subsequent discussion, so that the relations of the different laws may be correctly expressed.

The laminæ are sometimes broad, but more frequently narrow, measuring 0.01 to 0.10^{mm} in thickness. It is therefore difficult to prepare a section so nearly parallel to ∞ P (*l*) that it shall not cut obliquely several of the laminæ, producing a broad irregular banding, as represented in Fig. 7. The four vertical bands with irregular boundaries are alternately blue or yellow in position I, and extinguish at 31° right or left.

Law b.—Twinning plane and composition face $\frac{1}{2}$ P (*r*), axis the normal upon it.

Sections parallel to ∞ P (*r*) usually show in each lamina produced by the first law a structure illustrated by the lower left-hand portion of Fig. 8. The parts of new orientation are represented by the small rectangular or graphic forms lying parallel to the diagonals of the square, right or left as the case may be, and however zigzag the shape the bounding lines are almost always parallel to the diagonals mentioned. These forms are apparently identical with those described by Mügge as twinned parallel to $\pm\frac{1}{2}$ P, and they appear in the other two sections in a manner agreeing with this supposition. In Fig. 7 they are represented by the smaller horizontal lamellæ which do not cross the boundaries of the broad bands, and in Fig. 9 by the vertical lamellæ included in the larger ones. They are therefore cut by the plane ∞ P (*r*) nearly or

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[21] System of Mineralogy, 5th ed., p. 127.

[22] Neues Jahrbuch für Mineralogie, etc., 1867, p. 810.

[23] *Loc. cit.*

[24] *Loc. cit.*

quite at right angles, and their inclination is that of the plane $\pm\frac{1}{2}$ P, according to which they are intergrown.

The explanation above given is, however, insufficient, as there are particles of three distinct optical orientations among these formally indistinguishable portions. If a lamina cut parallel to ∞ P (*r*) be placed in position I, and then shows a blue color, the visible included parts of the form in question will appear yellow. On revolving the lamina 31°, to its position of extinction, it is found that some of those diagonally-situated particles have the same extinction as the lamina containing them, while the others become still brighter yellow and are found to extinguish simultaneously with the adjacent yellow lamina. On moving the section out of position I diagonal parts of the third orientation appear. These were blue in position I, but do not extinguish with the substance surrounding them; on the contrary, they correspond in this particular with the neighboring yellow lamina. It is impossible to definitely determine the laws according to which the substances are twinned, but in Fig. 10 the observed relations are explained in one way. The larger arrows indicate the normal directions of extinction parallel to ∞ P (*r*), with reference to the vertical axis. The area *x* represents the position of the corresponding directions of extinction in a lamella twinned parallel to the upper right-hand face of the positive hemipyramid, $\frac{1}{2}$ P (*r*). This will extinguish at 31° to the right from the vertical axis, while corresponding very nearly in color with the inclosing substance in position I. This is considered the equivalent of the law identified by Krenner. The lamella *y* is related to *x* as if twinned according to law *a*, and thus will exhibit parallel extinction with the inclosing substance but the opposite color in position I. The part *z* corresponds in color and extinction to the adjacent lamina, twinned after law *a*, and intergrown parallel to $\frac{1}{2}$ P (*r*) or $-\frac{1}{2}$ P (*l*).

Careful study of a number of sections has failed to show any method of distinguishing between these various parts aside from their optical orientation. Now one, now another, seems to predominate, and often all three are to be seen in a single lamina.

The sections parallel to ∞ P (*l*) and 0 P cut these thin particles at an oblique angle, and their proper optical action is thus so obscured that they cannot be used to test the accuracy of the relation represented by Fig. 10.

Law c.—Twinning plane ∞ P $\breve{\infty}$, axis the normal upon it, composition face ∞ P, or an irregular surface near it.

Sections parallel to 0 P never show a twinning plane running parallel to either pinacoid, and yet substance is found whose orientation corresponds to the requirements of the above law. This is shown upon 0 P by polysynthetic twin structure parallel to the second prism plane, ∞ P (*r*), the laminæ extinguishing at 45° and hence presenting 0 P. (See Fig. 9.) This might be considered as twinning after the prism plane ∞ P (*r*) except that a corresponding structure upon ∞ P (*l*) does not appear. There is, it is true, a vertical lamellar twinning sometimes seen, but accompanied by the substances intergrown as described under law *b*. This is represented in Fig. 7, and is the natural result of law *c*, which brings ∞ P (*r*) with its twinning after laws *a* and *b* into parallel position with ∞ P (*l*), produces a crossing of the laminæ upon 0 P, and, lastly, brings ∞ P (*l*) parallel to ∞ P (*r*). This latter position is naturally seldom seen in sections, as the part thus twinned is usually a rather thin plate parallel to ∞ P (*r*), of the chief individual. In one case, however, a section parallel to ∞ P (*r*) which exhibits the usual complicated structure over the greater part, passes by an irregular indistinct line into substance of more simple action, like that represented for ∞ P (*l*) in Fig. 7, as if the slightly oblique section plane had cut into the plate twinned after this law *c*. Websky describes the composition face, in the case noticed by him, as irregular, although lying approximately parallel to ∞ P ∞.

Law d.—Twinning plane $\frac{1}{2}$ P (*l*), axis the normal upon it, composition face ∞ P (*l*), or an irregular surface near it.

By this law ∞ P (*r*) and 0 P are interchanged. It seems required to explain the appearance in the section parallel to ∞ P (*r*) of laminæ parallel to those of *a*, but with extinction of 45° (see Fig. 8), and the similar laminæ on 0 P with extinction of 31°, and including parts twinned after the law *b*. Upon ∞ P (*l*), the composition face, this law cannot be identified.

Law e.—Twinning plane $-\frac{1}{2}$ P (*l*), axis the normal upon it, composition face irregular.

This law seems required to account for certain relations frequently seen upon ∞ P (*r*) and ∞ P (*l*). Upon the former the usual structure of this face appears at right angles to its proper position, while upon ∞ P (*l*) horizontal bands may be seen which are polysynthetic, and give extinction at 45° from position I. This would be explained by the law above given, and is illustrated by Figs. 7 and 8.

Of the above laws the first seems to be identifiable in all portions not parallel to the twinning plane, and the second is nearly as persistent. Law *d* affects substance already twinned after laws *a* and *b*, while *c* and *e* produce a twinning of matter showing *a*, *b*, and *d*. Laws *c*, *d*, and *e* are thought to be justified, for however irregular their composition face, the position of the parts twinned after *a* and *b* is always a very definite and regular one with reference to corresponding parts in the primary individual.

Whether the prismatic twinning plane is right or left, it is clear that the planes of laws *b* and *e* and the composition face of *c* lie in the zone between the prismatic twinning plane and 0P, and that the plane of *d* is in the zone of 0P to the other prism plane.

No twinning parallel to 0P was noticed, unless a horizontal division of a few laminæ twinned after *a* be thus interpreted (Fig. 8).

CHEMICAL COMPOSITION.—For all analyses of this and the following minerals the greatest care was taken to have the purest of reagents. The fluorine was in all cases determined by the Wöhler-Fresenius method, with the slight modifications introduced by Brandl,[25] except that the iron plate instead of the oil-bath was used for heating. The sulphuric acid was obtained of the highest degree of concentration and purity by distillation from a platinum retort. The water was determined by absorption in a chloride of calcium tube, the mineral having been heated in a tube with either oxide of lead or carbonate of sodium, the results being the same whether one or the other was used.

The cryolite, of which the analysis is here given, possessed the specific gravity 2.972 at 24° C., was faintly pink in color, and contained as a visible impurity the oxide of iron represented in the analysis:

	XXV.
Fe_2O_3	0.40
Al	[26]12.81
Ca	0.28
Na	32.40
H_2O	0.30
F	*53.55
	99.74
(W. F. Hillebrand.)	

* As the mean of 53.35, 53.46, 53.55, and 53.85.

The presence of a slight amount of water indicates incipient alteration, but although purer and fresher material was subsequently obtained, a second analysis seems unnecessary.

ALTERATION OF CRYOLITE.—Although pure and fresh cryolite is common, the greater part of masses so near the surface is naturally changed. In the Eureka tunnel the surfaces seen upon the walls exhibit plainly the three cleavage directions of cryolite, especially when moistened. The material is chiefly massive pachnolite, however, as can be distinctly seen in thin sections, while fresh cryolite is still visible in small patches. Alteration of the cryolite proceeds in two ways, producing the same minerals in the end. By one process the principal cleavage fissures are utilized by the solutions which effect the change, and thin walls are formed of a white crystalline substance. The next step seems to be the bodily removal of the cryolite matter between these walls, leaving a network of partitions in the three directions of the chief cleavages of the original cryolite. These partitions or walls are lined by minute crystals. The second mode of alteration proceeds from the neighboring quartz and from the boundaries of the different crystalline individuals of the cryolite, the result being a compact crystalline mass of a faint bluish tinge. The material at hand illustrates the two processes and their products about equally well, and they are often combined.

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[25] Annalen der Chemie und Pharmacie, CCXIII, p. 1.

[26] If Al=27. In this and all subsequent analyses, percentages of aluminium are calculated with the assumption of 27 as its atomic weight.

A large part of the material in the Eureka tunnel is a massive mixture of indistinguishable compounds, probably derived from the alteration of pachnolite. Fluorite is one of the further products, but never appears prominently.

The small mass of fluorides struck in the incline near the Eureka tunnel is remarkable for the purity of a number of further products. Near the quartz and granite walls decomposition has progressed until a pure white substance has been formed, which, when dry, is a kaolin-like powder of extreme fineness. It resembles plaster of Paris when wet, as it invariably is in the vein. This is the gearksutite to be described further on. From this same small mass were obtained most of the specimens utilized in the determinations of the species whose consideration follows.

PACHNOLITE.

FROM THE THIN WALLS.—The microscopical examination of the walls and membranes produced by the first mode of alteration of the cryolite, shows them to be coated by many minute but perfect, colorless, and transparent prismatic crystals, which are usually placed at right angles to the central plane of the wall, though sometimes in an irregular manner. They reach a maximum length of 2^{mm} by a thickness of 0.2 to 0.4^{mm}. The crystals are occasionally yellow in color while retaining their transparency, the color being doubtless owing to some matter derived from the alteration of the astrophyllite which penetrates all such specimens. The crystallographical identification of these crystals with pachnolite is quite certain, for upon placing them in vertical position under the microscope the prism angles can readily be measured, and correspond closely to 81° 24′ and 98° 36′, the theoretical angles of pachnolite (see Groth, l. c., p. 463). The prism ∞P and base $0P$ are in all cases the chief faces, accompanied frequently by a hemi orthodome and very rarely by a clinodome, both very slightly developed. The former is considered to be $-P\bar{\infty}$, from data given below. Pyramid faces have not been seen upon crystals of this growth. Although all detached crystals show, when examined in polarized light as lying upon a prism face, an oblique twinning plane in the prismatic zone,[27] still a projecting angle upon the base can but rarely be seen. The reflecting surfaces of the thinnest walls are composed of innumerable small facets of rhombic outline,—the basal planes of the very low prisms. In fragments from some of the thinnest walls, placed horizontally under the microscope and observed in polarized light, twinning parallel to the shorter (ortho-) diagonal can easily be seen. The crystals are usually quite equally bisected by the twinning line. The central portion of these walls is rather dull white, and probably represents the alteration product on cleavage planes of the original cryolite, while the crystals

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[27] Groth, *l. c.*, p. 464.

themselves were formed during or after the removal of the intermediate cryolite substance. Material from a network of thin walls covered by pachnolite crystals was subjected to chemical analysis, yielding the result under XXVII, p. 54.

FROM THE BLUISH MASSIVE ALTERATION PRODUCT.—The pale bluish mass formed by the second mode of decomposition has, in great part, a regular crystalline structure produced by a more or less perfect intergrowth of pachnolite individuals in three directions approximately at right angles to each other. Nearly simultaneous reflection over the greater part of certain irregular surfaces make this relation plain. By the examination of such a surface with a lens one can usually identify a number of rhombic facets which are nearly or quite coincident in position with striated planes, the two corresponding to $0P$ and ∞P of different individuals. Such a structure is also illustrated by the crystals in the numerous small cavities occurring in the massive material.

These cavities are wholly of irregular shape and reach a maximum observed diameter of 3 to 4^{cm}. The crystals lining them are often very perfect, and are occasionally 2 to 3^{mm} in length, with a thickness of 1^{mm} or less. The study of these crystals proves that, as in the preceding case, most of them must be referred to pachnolite, although thomsenolite is sparingly present. These pachnolite crystals differ in habit from those already described in that the pyramid is usually prominent, being, however, in nearly every case truncated by the basal plane; in fact, crystals without $0P$ are very rare. The rhombic section of the prism is everywhere plain. Although every prism on being optically tested shows a twinning plane in the prismatic zone, the low projecting angle of 179° 20′ upon $0P$ can seldom be distinctly seen. Many crystals are somewhat extended parallel to one pair of prism faces. A hemi-orthodome of the same order as the pyramid is sometimes developed, and probably corresponds to that noticed upon the crystals of the foregoing type. Most of the crystals of these cavities, while very perfect and distinctly recognizable as pachnolite, are too small and their surfaces are too frequently covered by minute crystals of a later growth to be available for measurements with the goniometer. Two specimens, however, of the bluish massive material, when carefully examined, proved to contain pachnolite in a form allowing of more exact crystallographical, optical, and chemical investigation.

CRYSTALLOGRAPHICAL DETERMINATIONS.—The first of the specimens above mentioned, which we will designate specimen A, is about $8 \times 5 \times 2^{cm}$ in size, is somewhat more coarsely granular than the variety just described, and possesses in an eminent degree the regular structure there observed. While compact in the greater part of the specimen, there are portions in which the grains are more loosely aggregated together, and parts of individuals have perfectly developed crystal faces. In some minute cavities a few crystals with quite perfect terminations were found, and upon these some faces were sufficiently large and polished to admit of measurements with a Fuess reflection goniometer. These crystals are about 1^{mm} long and nearly the same in thickness. They show ∞P, $0P$, with subordinate $-P$, and a negative pyramid determined, as $-3P\bar{3}$. They are all twinned parallel to $\infty P \infty$, and the low projecting angle upon $0P$ is sometimes distinctly visible.

The angles given in the following table are all means of numerous closely agreeing measurements and demonstrate the crystallographical identity of the mineral under discussion with pachnolite:

Angle.	Crystal *a*.	Crystal *b*.	Other crystals.	Calculated.
	° ′	° ′	° ′	° ′ ″
$\infty P \wedge \infty P$	81 19	81 22	81 18	81 24
$\infty P \wedge 0P$	....	90 21	90 21	90 20
$-P \wedge 0P$	....	116 39	116 30	116 30
$-3P\bar{3} \wedge -3P\bar{3}$	138 45	....	138 45	138 52 14
$-3P\bar{3} \wedge \infty P$	149 03	....	....	149 07 19
$0P \wedge 0P$ (twin)	....	179 21	....	179 20

The face $-3P\bar{3}$ was observed on a number of distinct twin crystals, with projecting angle on $0P$, and in several cases on both of the negative angles.

Upon one side of specimen A are a few thomsenolite crystals, distinguishable by their prism angle of nearly 90°. They lie irregularly, and seem to be later in formation than the pachnolite. Upon them are deposited minute prosopite crystals and indistinct alteration products. In the mass of this specimen no thomsenolite can be detected, while all individuals with partially free development are plainly pachnolite. Analysis XXVIII of the table (p. 54) was made upon material obtained from the clear loosely granular portions of specimen A, and although it was necessary to include many transparent grains of irregular shape in order to obtain a desirable amount of substance, there is no doubt in our own minds that thomsenolite was wholly absent from the material analyzed.

The second specimen, B, from which especially good material was obtained, had a seam 2^{cm} thick of coarse granular structure running through it, and upon splitting it open along this seam two surfaces of water-clear loosely adhering crystalline grains of pachnolite were exposed with the regular arrangement described. Actual development of crystal faces other than the prism is rarer than in specimen A, but the size of the grains, reaching 5^{mm} in length by 1—3^{mm} in thickness, is such as to admit of the preparation of thin sections for optical examination, and also gave absolutely pure material for chemical analysis. None of the crystals upon which the faces were well formed were superior to those of specimen A, and only measurements of the prism angles were made. The face $-3P\bar{3}$ was not observed at all.

The optical properties of these pachnolite crystals are such as to leave no doubt concerning their crystallographical identity with the mineral described by Professor Groth as pachnolite. Several sections were prepared as nearly parallel to the clinopinacoid as possible. These exhibit in all cases a twin structure, and this is frequently polysynthetic. The twinning lines are straight and lie parallel to the vertical axis. Extinction takes place at 21° 30′ to 22°, or 68° to 68° 30′ from the twinning line, in opposed directions in alternate laminæ. According to Groth the bisectrix is in the plane of symmetry, and inclined 68° 5′ forward from the vertical axis. Sections parallel to the base also show the twinning structure, the line lying parallel to the orthodiagonal.

A large part of the purest crystals and fragments from this specimen were used for chemical analysis and repeated water determinations, the results of which are given below (XXIX, p. 54).

CHEMICAL INVESTIGATION.—Previous to the analysis by Brandl[28] of pachnolite carefully selected by Groth, pachnolite and thomsenolite were considered to possess the same chemical composition. The results of all earlier analyses, excluding such as referred to manifestly very impure material, while frequently deviating materially from the figures required by theory for the formula NaF, CaF_2, AlF_3. H_2O. still agree on the whole very well, as shown in the accompanying table, and fully justified the belief in the chemical identity of the two species.

	Thomsenolite.		Pachnolite.					
	Wöhler.[29]	König.[30]	Knop.[31]	König.[30]	Vom Rath [32]		Hagemann.[33]	Calculated for NaF, CaF_2, AlF_3, H_2O.
Al	13.43	13.74	13.14	12.50	13.46	12.93	10.37	12.32
Ca	17.81	16.79	17.25	18.17	18.10	17.99	17.44	17.98
Na	10.75	10.10	*12.16	10.23	10.63	12.06	12.04	10.34
H_2O	8.20	9.00	9.60	8.19	......	......	8.63	8.10
F	49.78	50.37	50.79	51.51	......	......	51.15	51.26
	100.00	100.00	102.94	100.63	......	......	99.63	100.00

* Also, 10.80 and 10.81.

Wöhler's analysis was entirely confirmed some years subsequently by Jannasch,[34] in Göttingen, who analyzed pure thomsenolite selected by Klein.

In view of the above, the analysis of pachnolite by Brandl, showing results agreeing well with those required by the formula NaF, CaF_2, AlF_3, was calculated to cause no little surprise. Groth accepts without question the anhydrous nature of pachnolite, and endeavors to explain away the opposing evidence, shown in the foregoing table, by assuming that the supposed homogeneous material analyzed was contaminated largely with thomsenolite. As in no published analysis does the percentage of water fall below 7 per cent., this assumption necessitates a most improbable admixture of thomsenolite. In those cases where the percentage of water equals or exceeds that required for thomsenolite the presence of gearksutite is suggested by Groth as a possible explanation. Even on this supposition the percentage of foreign admixture could not fall below 50 per cent., in which extreme case the whole of the impurity must be gearksutite, an amount which it is difficult to conceive should have escaped the notice of such observers as König, vom Rath, and Knop, the latter of whom expressly says that his analysis was made upon material identified as pachnolite.[35] Notwithstanding the difficulty of explaining the agreement between the previous analyses of pachnolite and thomsenolite, on the assumption of the anhydrous nature of the former, the correctness of Brandl's analysis was not at first questioned by us.

In the course of the present investigation the compact bluish material (see page 50), having the specific gravity 2.980 at 22° C., was first analyzed, the crystalline pachnolite not having yet been observed. The results of analysis as given under XXVI, below, agree in the main so well with the figures required for the formula NaF, CaF_2, AlF_3. H_2O. that no hesitation was felt in considering the mineral to be thomsenolite, probably slightly contaminated with fluorite. Later, the crystalline coating on the thin walls produced by the first mode of alteration of the cryolite, the crystals forming which had not yet been identified crystallographically as pachnolite, were subjected to analysis with the results given under XXVII. Here again the identity with thomsenolite seemed clear. It was not until the analysis of perfectly transparent fresh crystals and crystal fragments, all taken from specimen A, above described, gave the results shown under XXVIII, that the possibility of the first analyses having been also made upon pachnolite was suggested. That this was, however, so in the case of No. XXVII, subsequent careful examination fully revealed, though the crystals analyzed were not entirely free from foreign admixture. It seems certain, also, that the compact bluish portions (XXVI) consist almost entirely of pachnolite, although it cannot be positively asserted that some thomsenolite may not be intergrown with it. That no possible doubt might exist in the mind of any one as to the homogeneity of the material used for analysis XXVIII, a further analysis was made upon crystals from specimen B, above described, particular care being taken to identify each as pachnolite by the rhombic section. The results of this analysis appear under XXIX.

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[28] Annalen der Chemie und Pharmacie, CCXIII, p 6.

[29] Neues Jahrbuch für Mineralogie, etc., 1876, p. 851.

[30] Proceedings Acad. Sci. of Phila., 1876, p. 42.

[31] Annalen der Chemie und Pharmacie, CXXVII, p. 61.

[32] Sitzungsbericht d. niederrhein. Ges. für Natur.- und Heilkunde, 1860, XX, p. 141.

[33] Am. Jour. Sci., 1866, II, XLI, p. 119.

[34] Neues Jahrbuch für Mineralogie, etc., 1877, p. 808.

[35] Neues Jahrbuch für Mineralogie, etc., 1876, p. 850.

	Hillebrand.							Brandl.[36]	Calculated for NaF, CaF_2, AlF_3, H_2O.
	XXVI.		XXVII.		XXVIII.		XXIX.		
Al	11.94	......	12.93	12.92	12.14	....	12.27	13.51	12.16
Ca	19.32	....	15.27	15.17	18.06	....	18.04	18.83	18.02
Mg	0.13	....	1.53	....	....	....	....	....	....
Na	10.43	.....	10.28	....	10.23	....	10.25	11.73	10.36
K	....	....	0.13	....	....	....	....	....	....
H_2O	7.87	7.95	8.64	8.79	8.10	8.11	8.05	.....	8.11
F	....	....	....	......	51.33	51.28	*51.39	55.69	51.35
	....	....	....	....	99.88	....	100.00	99.76	100.00

*By difference.

Further determinations of water, on material from specimen B, gave 7.95, 7.99, 8.14, and 8.15 per cent. Still other determinations, some on material every fragment of which showed the rhombic section, others on material taken at random from the crystalline mass, gave results between 7.90 and 8.20 per cent. The specific gravity at 17°C. of the perfectly pure material, as the mean of four determinations varying between 2.963 and 2.968, was 2.965. A single determination on another portion, equally pure, at 22°C. gave 2.962. The transparent crystals, as well as all the other portions analyzed decrepitated violently on heating in a test tube, the walls became lined with the white deposit so characteristic of thomsenolite and pachnolite, and much water was given off. Hence it appears that the pachnolite from Pike's Peak and thomsenolite are identical in composition, unless the fact of all analyses of thomsenolite showing slightly more water than required for the formula NaF, CaF_2, AlF_3, H_2O may indicate, as suggested by Groth, a partial replacement of fluorine by hydroxyl in that mineral. Should this prove to be the case, a plausible explanation of the difference in crystallization of the two minerals is offered without recourse to the theory of dimorphism.

A satisfactory explanation of Brandl's results, so opposed to those presented by all earlier analyses and the ones above given, is impossible, but it may be well to call attention to the fact that Brandl was obliged to make his determinations of fluorine and the metals upon quantities of 0.1106 gr. and 0.1430 gr. weight respectively, whereas material was not wanting for the present analyses, the determinations having been made upon weights of from 0.3 gr. to 0.75 gr. It nowhere appears that a direct test for water was made upon the material furnished by Groth. The latter, it is true, remarks (*l. c.* p. 461): "*Ausserdem bildet sich bei letzterem* (Thomsenolite) *in den kälteren Theilen des Rohres ein Wasserbeschlag, welcher beim Erhitzen reinen Pachnolithes natürlich ausbleibt.*" The absence of water does not, however, seem to be hereby proven, but simply to be assumed from the close approximation to 100 of Brandl's results, exclusive of water. Brandl himself says water is wanting, but does not mention whether this was ascertained by direct experiment. The small amount of material at his disposal renders it not improbable that no direct test was made.

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[36] Annalen der Chemie und Pharmacie, CCXIII, p. 6. The percentage of Al is calculated to correspond with the other analyses (Al=27).

Since the conclusion of the above investigations, through the kindness of Mr. Albert F. Damon, president of the Pennsylvania Salt Manufacturing Company, we have obtained specimens of Greenland cryolite and its alteration products. From one of these specimens was removed a large number of small, needle-like, pyramidally terminated, twinned crystals with a rhombic prismatic section, showing in fact precisely the common occurrence[37] and ordinary habit of pachnolite[38] as described by Groth. These crystals, slightly yellowish in color, but quite transparent, were individually examined under the microscope, all such as did not show beyond a doubt the above described habit being excluded. They were then tested in a small glass tube for water. Decrepitation ensued on heating and the walls of the tube became lined with a white powder, and also with a deposit of water, in such quantity as to preclude the possibility of its having been derived from but a small portion of the material experimented upon.

OTHER FORMS OF PACHNOLITE.—In some very cellular specimens, whose walls run irregularly and seemingly without reference to the cleavage of the original cryolite, are crystals of pachnolite of different habit from that so far described.

One or two of these cavities show crystals corresponding in size to those upon the thin walls, but exhibiting each and every one a re-entering angle on the free termination. In such little crystals the basal planes are prominent, and they are bounded on the inside by a pyramid and dome, doubtless $-P$ and $-P\breve{\infty}$. Outward there sometimes appears another pyramid ($+P$?), though the prismatic faces themselves usually form a sharp edge with $0P$. All these crystals are too small for measurement, but as the appearance described is such as would be normal for the termination by which the twin crystals are commonly attached, it seems admissible to consider the faces as $0P$, $-P$, $-P\breve{\infty}$ and probably $+P$. On many twins of this kind the outer or positive angles between ∞P and $0P$ are replaced by two faces greatly resembling those of $-3P3$, and although entirely too minute for measurement it is probable that this form $-3P\breve{3}$ is here represented. The crystals of Greenland pachnolite are always attached by the end with the re-entering angle, according to Groth.

THOMSENOLITE.

OCCURRENCE AND DESCRIPTION.—While it is quite certain that thomsenolite is present in small quantity with the pachnolite, it has been impossible to obtain any quantity of it for examination. The microscopical study of the minute crystals lining the thin walls described, shows a few of nearly square section with sharp pyramidal form and destitute

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[37] P. Groth, *l. c.*, p. 461.

[38] P. Groth, *l. c.*, p. 462.

of a twin structure. These are usually deposited with corresponding ones of pachnolite in a wholly irregular manner upon the low crystals of pachnolite forming the main portion of the walls. The reflecting surfaces of the massive product show under the lens distinctly rhombic facets or striated planes; and thin sections, which reveal the characteristic twinning of pachnolite, afford no reason for suspecting the presence of thomsenolite here in any considerable quantity.

The statement already made for a single case (p. 51) is probably true for all cases where thomsenolite has been noticed, viz., that it is later in formation than the greater part of the pachnolite, although the latter mineral is usually present in a second generation, as contemporary with the thomsenolite. No chemical identification has been possible, but the nearly square section, perfect basal cleavage, and absence of twinning are under the circumstances quite sufficient proofs.

In many cavities, arising from both modes of decomposition of the cryolite, a second series of minerals has been deposited, chiefly as a whitish, easily crumbling aggregate of minute crystalline grains, which are recognizable under the microscope as thomsenolite, pachnolite, and a mineral of the isometric system. The difference in habit of the former two species is here quite plain, for some of the little crystals of thomsenolite are doubly terminated and show distinct monoclinic symmetry in spite of the square section, through the more prominent development of the negative pyramid, while pachnolite seems perfectly rhombic in form, through its twinning.

RALSTONITE.

PROBABLE IDENTIFICATION.—This rare species, originally described by Brush,[39] from microscopic crystals, has been more definitely determined by Groth and Brandl. Its chemical composition is, according to Brandl, expressed by the formula $3NaF, 4AlF_3, H_2O$, a small part of the sodium being replaced by calcium. The crystals are of the isometric system, and represent the cube modified by the octahedron.

Groth's description of the occurrence of the mineral agrees very closely with that of the isometric mineral mentioned above as appearing with a recent generation of thomsenolite and pachnolite. The crystals here found are transparent cubes whose corners are replaced by small octahedron faces and seldom reach a diameter of 1^{mm}, while sinking to microscopic size. Some crystals of pachnolite seem by a low magnifying power to be coated by a crystalline dust whose particles are found, by applying a high power, to be most perfect little crystals of the form just mentioned. These sometimes unite to form a crust. No material for a chemical test could be secured, but the analogy in form and occurrence is so complete that scarcely a doubt can exist of the identity of these beautiful little crystals with the species ralstonite, although another mineral of the same crystal system is now to be described.

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[39] G. J. Brush, Am. Jour. Sci., III, II, 30, 1871.

ELPASOLITE, A NEW MINERAL.

Just at the close of our investigations a mineral was found, occurring sparingly in a few specimens, which seems to be very different from any known species. It was found in small cavities in the massive pachnolite as a compact irregular mass, colorless but not perfectly clear, and exhibiting but seldom traces of crystalline form. In one specimen, however, the mass of the mineral was covered by small rounded crystal-like projections, which seemed like crystals of the isometric system. An examination with a loupe showed the absence of recognizable faces, but such particles when broken off and tested under the microscope proved to be fully isotropic. A few faces found on one crystal seemed to belong to cube and octahedron, and particles detached from the same are isotropic in action in polarized light. Supposing that this substance must be ralstonite in exceptional development, enough material for the following partial chemical analysis was selected, being carefully freed from attached particles of pachnolite and other anisotropic minerals by microscopical examination. The Al, Ca, and Mg were accurately determined, the K and Na, owing to an unfortunate mishap, only approximately. No water could be detected by direct test upon a small portion. Fluorine was present in quantity, and the percentage given below is calculated on the assumption that the metals are fully combined with it:

	XXX.
Al	11.32
Ca	0.72
Mg	0.22
K	28.94
Na	9.90
F	46.98
	98.08
(W. F. Hillebrand.)	

From this analysis may be derived a formula analogous to that of cryolite, in which about two-thirds of the sodium is replaced by potassium.

The imperfections of the above analysis do not allow of definite conclusions as to the composition of the mineral, but it is nevertheless widely different from any known mineral species, while the purity of the substance is shown by its isotropic action in polarized light. Since the original description of the mineral[40] the locality has been revisited in the hope of obtaining more material, but the spot was at the time inaccessible, so that we can offer no further data concerning this interesting new species. We wish to propose the name *elpasolite* for it, from the county El Paso, which embraces the greater part of the Pike's Peak region. Further investigations as to the properties of the mineral will be made as soon as material can be procured.

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[40] Am. Jour. Sci., III, XXVI, 283, 1883.

GEARKSUTITE.

General Description.—This mineral, first observed by Hageman[41] on compact thomsenolite, and described as earthy and kaolin-like in aspect, dull white, opaque, and of hardness 2, seems to be so rare in connection with the Greenland fluorides that no one has had material for further examination. Groth[42] found it in very small quantity among the minerals at his disposal, but could not obtain enough for analysis. He found, however, that it consisted of very minute microscopic needles, with oblique extinction, and considers it as undoubtedly a definite species.

Among the minerals from St. Peter's Dome gearksutite is quite abundant. It is not formed from other minerals by molecular replacement, but is deposited from solution in cavities upon fresh crystals of pachnolite, etc. The smaller cavities are sometimes filled by it, and on the contact with the quartz it is specially developed.

In appearance it corresponds closely to the description of the Greenland mineral as given by Dana, the resemblance to the purest, finest kaolin being especially remarkable. Examined microscopically, gearksutite is seen to consist, as stated by Groth, of exceedingly minute colorless needles, the average length of which is less than 0.02^{mm} and the thickness less than 0.002^{mm}, and apparently possessing oblique extinction.

Chemical Investigation.—Gearksutite was found by Hagemann (*l. c.*) to possess the following composition:

Al	15. 52
Ca	19. 25
Na	2. 46
H_2O	20. 22
F	41. 18
	98. 63

An examination of the above results shows that the atomic ratio of Al : Ca+Na_2 : F is 1:1:4, instead of 1:1:5, which would represent complete saturation and require about 12 per cent. more fluorine than was found. On the assumption that the missing fluorine is replaced in the mineral by oxygen or hydroxyl, there should appear a much greater loss than the analysis indicates. An error is therefore evident, probably in connection with the determination of the fluorine or of the water, or both, in consequence of which the construction of a satisfactory formula has heretofore been impossible.

The material for the following analyses was first partially crushed, then freed from admixed heavier particles of foreign matter by triturating in a beaker with water, the impurities falling to the bottom of the vessel, while the light gearksutite remained suspended in the liquid and was removed by decantation. By repeating this operation a great many times a product was finally obtained entirely free from all foreign admixture. It was allowed to settle completely, the supernatant liquid poured off and the residue dried first on the water bath, then at 100° C. Thorough pulverization of this residue is a difficult matter, as it flattens out under the pestle, forming flakes which strongly resist the pulverizing action. This is of little moment, however, since the flakes are so spongy as to offer no hindrance to attack by sulphuric acid. Two analyses were made from the same sample, with the results tabulated below. In *b* sodium and potassium were not determined:

	XXXI.		
	a.	*b.*	Mean.
Al	15. 22	15. 19	15. 20
Ca	22. 29	22. 32	22. 30
Na	0. 10	......	0. 10
K	0. 04	.....	0. 04
H_2O	15. 54	15. 39	15. 46
F	42. 14	42. 01	42. 07
	95. 33	......	95. 17
Loss as 0	4. 67	......	4. 83
	100. 00	......	100. 00
(W. F. Hillebrand.)			

Taking the figures in the third column and combining the fluorine with the calcium, sodium, potassium, and, as far as possible, with the aluminium, there remains of the latter 5.35 per cent., requiring 4.76 per cent. of oxygen, an amount agreeing very well with that obtained above by difference and making the sum total almost exactly 100:

22. 30 Ca	requires	21. 18 F.
0. 10 Na	requires	0. 08 F.
0. 04 K	requires	0. 02 F.
9. 85 Al	requires	20. 79 F.
10. 11 Al_2O_3		
15. 46 H_2O		42. 07
42. 07 F		
99. 93		

The agreement of the above analysis with that of Hagemann, after substituting in the latter for the sodium its equivalent in calcium, is very close, with the single exception of the water. As his analysis was manifestly erroneous in some particular, the assumption of the identity of gearksutite with the mineral here discussed is fully justified, supported as it is by the similarity in occurrence, appearance, and physical characteristics. His error would then consist in having obtained from 4 to 5 per cent. too much water, a result not difficult of explanation in

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[41] Dana, System of Mineralogy, 5th ed., p. 130.

[42] Groth, *l. c.*, pp. 460, 481.

the case of a hydrated fluoride, if no precaution was taken to prevent the escape of fluorine.

Substituting in the mean of analyses *a* and *b* for sodium and potassium their equivalent of calcium, and dividing the percentages by the atomic weights, the atomic ratio is found to be as given below:

Al ......15.20÷27=0.563
Ca ..... 22.41÷40=0.560
H_2O ...15.46÷18=0.859
O....... 4.76÷16=0.297
F.... ..42.07÷19=2.214

The ratio of Al : Ca : F is here nearly as 1 : 1 : 4, the same as found by Hagemann. Subtracting from the atomic value for water an amount 0.297 equal to that for oxygen, in order to form with the latter hydroxyl, the result is as given in the first column below, while in the second appears the ratio referred to calcium as unity.

Al........	0.563	1.005	
Ca........	0.560	1.000	
H_2O	0.562	1.004	
HO.......	0.594	1.061	5.015
F.........	2.214	3.954	

It will be seen that by combining hydroxyl and fluorine the ratio Al:Ca:H_2O:(F,OH) is 1:1:1:5, and the formula for the mineral becomes CaF_2, $Al(F, OH)_3$, H_2O, in which the fluorine and hydroxyl combined with the aluminium, stand nearly as 2:1. Were the latter proportion exactly fulfilled, the formula might be written $3CaF_2$, $2AlF_3$, $Al(OH)_3$, $3H_2O$, requiring the percentages: Al 15.17, Ca 22.47, F 42.69, O 4.50, H_2O 15.17=100.00.

Of the 15.46 per cent. of water found by analysis, 5.35 per cent. has been considered in the foregoing as basic. While this amount may, on theoretical grounds alone, enter into the inner constitution of the mineral as basic water, the remainder cannot, but must be water of crystallization. That a portion of the water is basic is rendered more than probable by the fact that at 300° C. some is still retained. In this connection the following experiments were made: 0.5677 gram of the mineral, not, however, from the same sample as that used for analysis, dried first at 100° C. and contained in a platinum crucible, was exposed in an air bath during 145 hours to temperatures ranging from 100° C. to 300° C., the weight being taken at intervals averaging 10 hours each. The results in brief showed that at 145° C. the loss was but 0.35 per cent., at 230° C. only 0.92 per cent., at 250° C. 7.02 per cent., after prolonged heating at 265°–270° C. 9.49 per cent., and at 295° C. 13.92 per cent. As no further loss occurred after six hours heating at 295°–300° C., a portion of the residue which still retained its original appearance was subjected to a quantitative test for water, of which 1.76 per cent. was found. This added to the 13.92 per cent. driven off below 300° C. made the total 15.68 per cent. Since this is slightly higher than the mean of the previous results, it seemed possible that some fluorine might have escaped. The remainder of the residue was therefore tested quantitatively for fluorine, of which was found 40.60 per cent., thus apparently proving the correctness of the surmise. A similar experiment with the same general results was made upon a smaller portion of another sample. A comparison of the full results of both experiments showed that by sufficiently prolonged heating at approximately 270° C. all the water of crystallization could be driven off; also that by still further heating at little if any higher temperature the basic water began to escape, but was not entirely expelled even after many hours exposure to a temperature of 295°–300° C.

While these experiments cannot be considered as affording any conclusive proof that the water in this mineral is to be reckoned as water of crystallization and basic water in the above given proportions, since at the point when the last of the former is driven off by heat some of the latter appears also to escape, still the belief that this should be done is a natural one and is supported by the fact (which may possibly, however, be merely the result of accident) that by so doing the ratio of calcium to water of crystallization is exactly 1:1, while if all the water is assumed to be water of crystallization the ratio is 1:1.534 or 2:3.068.

EVIGTOKITE.—In the Journal of the Chemical Society for 1883, p. 140, Walter Flight describes a mineral obtained from the cryolite bed of Greenland. "It is made up of a congeries of minute white transparent crystals, mostly broken up and lying entangled among each other in every sort of direction, which gives the mass an appearance of opacity much resembling that of kaolin or chalk."

Chemical analysis showed it to consist of—

		Equivalents.
Al.......16.23 with F 33.64=	49.87	0.59
Ca.......22.39 with F 21.27=	43.66	1.12
Na....... 0.43 with F 0.33=	0.76	
	94.29	
Water..................	5.71	0.63
	100.00	

The fluorine seems to have been calculated for the metals, and the water was found by difference.

From the above data the author obtains the formula $2CaF_2$, Al_2F_6, $2H_2O$,[43] and, considering the mineral new, names it evigtokite.

Mr. Flight seems to have overlooked the description of gearksutite in Dana's System of Mineralogy and Professor Groth's remarks upon the same (l. c., pp. 481 and 493), else the very fair agreement of his analytical data for the metals with those of Hagemann, and the similarity of oc-

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[43] Probably a printer's error. It should read $2CaF_2$, Al_2F_6, H_2O.

currence, appearance, and physical characteristics of the two minerals, must have led to at least a suspicion of their identity. There can hardly exist a doubt that Flight has analyzed gearksutite and that the name evigtokite is therefore to be dropped.

PROSOPITE.

OCCURRENCE.—This rare species, hitherto unobserved in association with the cryolite minerals and known only in connection with the tin-bearing veins of Altenberg in Saxony, has been identified at St. Peter's Dome.

Both of the coarsely crystalline specimens of pachnolite, above described as A and B, have prosopite upon them. Specimen B is in parts in process of alteration to a dull white substance with little cavities in which are minute crystals of prosopite. These are colorless, transparent, tabular in shape, agreeing exactly in form and optical behavior with those determined as prosopite by chemical analysis. In two other specimens of pachnolite prosopite tablets may be seen upon certain granular surfaces when decomposition of the pachnolite has already begun. The crystals are usually attached by the prismatic edges, although free and perfect terminations are to be found. Gearksutite was noticed upon them in one specimen and the position of prosopite in the series of hydrous fluorides is doubtless between thomsenolite and gearksutite. No material for chemical tests could be procured from the specimens described.

The penetration of the fluoride mass by astrophyllite blades springing from the side of the vein has been mentioned (p. 42). Here the cryolite has been altered to cellular pachnolite, according to the first mode described, and this has for the greater part given way to other products and been dissolved and carried away, leaving the astrophyllite blades more or less free or imbedded in gearksutite and other soft, crumbling material. The free blades usually have a coating composed of a little purplish fluorite, and over this a nearly colorless or slightly yellowish substance. At and toward the base of the astrophyllite blades the latter is present in roundish aggregates made up, as shown by the lens, of clear tablets, in more or less radiate arrangement The crystal form is here quite obscure, but the general appearance was so suggestive of prosopite that by sacrificing the best specimen enough material was obtained for determination of the bases and of fluorine, with the result given below, XXXVI, p. 64.

Adjoining the quartz in the Eureka mine is usually an irregular zone of purplish or greenish fluorite, and next to this a rather coarsely granular mass of a colorless mineral, with two distinct cleavage planes, which passes gradually into the compact white substance beyond. This zonal arrangement is not without exceptions, for both granular and compact masses come directly in contact with the quartz in some specimens, and fluorite is more or less abundantly sprinkled through the other substances; in fact, the relation of the minerals to each other is such as to indicate that they are but different phases of alteration from a common source. The granular mineral occurs in sufficient purity to afford material for chemical analysis, and its individuals are large enough to admit of the preparation of thin sections, with definite relations to the cleavage planes. The analysis first proved the identity of this mineral with prosopite, the optical properties shown by the thin section confirmed this determination, and a few minute crystals were found in one specimen, which agree with the published data on the Saxon mineral. As the identification of this rare species, particularly in its present association, is a matter of considerable interest, we will describe it somewhat in detail.

CRYSTALLINE FORM AND PHYSICAL PROPERTIES.—The minute crystals observed are all of the habit shown in Fig. 11 of the plate. This is from a camera lucida drawing of a crystal measuring 0.5^{mm} normal to the edge of the prism, and can therefore make no pretensions to crystallographic accuracy. The crystals are colorless and transparent, have uniformly a tabular form through the development of $\infty P \bar{\infty}$, and show plainly the prism and two pyramids, which may be considered as P and $-2 P \bar{2}$, for extinction takes place nearly or quite parallel to the edge of $-2 P \bar{2}$, which is, according to Des Cloizeaux[44] and Groth,[45] the position of the bisectrix.

Thin sections prepared as nearly as possible perpendicular to the edge of the two cleavage faces in the irregular granular individuals, show that the angle of the cleavage planes is very nearly 135°, and that extinction takes place parallel to the direction bisecting that angle. This behavior agrees perfectly with the statements concerning prosopite, according to which the chief cleavage is parallel to $-2 P \bar{2}$, the angle of which is about 134°. The present material does not allow of a definite settlement of the question of the crystalline form of prosopite, but nothing observed is in conflict with the reference to the monoclinic system.

CHEMICAL INVESTIGATION.—The formula deduced by Brandl[46] for prosopite, from the results of his analysis as here given—

		Atomic values.
F	35.01	1.842
Al	23.37	0.853
Ca	16.19	0.405
Mg	0.11	0.004
Na	0.33	0.014
H_2O	12.41	0.689
Loss as oxygen	12.58	0.786
	100.00	

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[44] Bull. Soc. Min. de Fr., V, 317.

[45] *l. c.*, p. 290.

[46] Annalen der Chemie und Pharmacie, CCXIII, p. 13.

is $Ca F_2, 2Al (F,OH)_3$. The whole of the water is assumed to be basic, entering with oxygen into the constitution of the mineral as hydroxyl, the latter replacing an equivalent amount of fluorine. In support of this assumption Brandl mentions that no loss is perceptible below 260° C.

In an earlier partial analysis Scheerer (Pogg. Ann., CI, p. 361) found Al 22.77, Ca 16.41, H_2O 15.50.

Of the analyses tabulated below, those under XXXII, XXXIII, XXXIV, and XXXV were made upon material from vein B. That analyzed under XXXII, *a* and *b*, was composed of comparatively large irregular crystalline pieces showing no visible impurity whatever, having a specific gravity at 23° C. of 2.880 and a hardness of about 4.5. As the ratio Al : Ca differed materially from that of 2:1, required by Brandl's formula, it appeared that some foreign matter must be present, consequently no further determinations were made, as it was hoped better material might be obtained.

Analysis XXXIII was made upon material separated from quartz, zircon, fluorite, and other accompanying minerals, by a solution of iodide of mercury in iodide of potassium. The result was a slight improvement, and the analysis was completed. The material for XXXIV was picked out carefully by hand with the aid of a lens, but as the result was still unsatisfactory, a further portion (XXXV), aggregating, however, only 0.1022 gram, was selected with the greatest possible care, every particle being distinctly crystalline, and showing under the microscope no trace of impurity. Here a slight improvement becomes evident in the ratio, but as the amount taken for analysis was so extremely small, it cannot be asserted that the better results may not be due to unavoidable errors of analysis. The material for analysis XXXVI was derived from the crystals occurring on astrophyllite. This material was, however, evidently not quite pure, being opaque and very slightly colored in part by oxide of iron. The analysis was made merely to prove its identity with the prosopite of the other occurrence.

	XXXII.		XXXIII.	XXXIV.	XXXV.	XXXVI.
	a.	*b.*				
Al	21.94	21.68	21.88	22.13	22.49	21.64
Ca	17.67	17.87	16.92	17.14	16.80	16.84
Mg			0.20		0.15	0.35
Na			0.48		0.48	0.79
K						0.11
H_2O			*13.54			
F			33.14	33.22		32.30
			86.16			
Loss as oxygen			13.84			
(W. F. Hillebrand.)			100.00			

* And 13.37.

The mean of analyses XXXII–XXXV is as follows:

Al	22.02
Ca	17.28
Mg	0.17
Na	0.48
H_2O	13.46
F	33.18
	86.59
Loss as oxygen	13.41
	100.00

After subtracting from the fluorine an equivalent for the calcium, magnesium, and sodium, and combining the remainder with aluminium, there remains of the latter 14.39 per cent., requiring 12.79 per cent. of oxygen, instead of 13.41 per cent. found by difference. The atomic values appear as follows, after substituting for magnesium and sodium an equivalent of calcium:

$$\begin{array}{l}
\text{Al}\ldots\ldots 22.02\div27=0.815\\
\text{Ca}\ldots\ldots 17.98\div40=0.449\\
\left.\begin{array}{l}\text{F}\ldots\ldots\ldots 33.18\div19=1.746\\ \left.\begin{array}{l}\text{H}_2\text{O}\ldots\ldots 13.46\div18=0.748\\ \text{O}\ldots\ldots\ldots 12.79\div16=0.799\end{array}\right\}1.547\end{array}\right\}3.293
\end{array}$$

The result is unsatisfactory, the ratio of Ca : Al being 1 : 1.81 instead of 1 : 2. In none of the material analyzed was the slightest trace of kaolinization to be observed, nor any other foreign matter. It therefore becomes impossible to explain with any degree of certainty the above abnormal results.

The general agreement of all the analyses, the aluminium being found too low and the calcium too high in each case, shows pretty conclusively that an explanation cannot be sought for in analytical errors.

As fluorite occurs here always in most intimate association with prosopite, and the possibility suggested itself that some of this might be so intergrown with the latter as to escape the closest scrutiny, it became desirable to ascertain what change would be effected in the ratio above given by subtracting enough calcium to make the ratio Ca : Al as 1 : 2, and an equivalent amount of fluorine. The atomic values then become:

$$\begin{array}{ll}
\text{Al}\ldots\ldots 0.815 & 2.00\\
\text{Ca}\ldots\ldots 0.408 & 1.00\\
\left.\begin{array}{l}\text{F}\ldots\ldots\ldots 1.664\\ \text{HO}\ldots\ldots 1.547\end{array}\right\}3.211 & 7.87
\end{array}$$

which agree nearly as well for the formula $Ca, Al_2 (F, OH)_8$ as those obtained by Brandl.

If, instead of the mean of all the analyses, the figures of XXXIII alone are taken for calculations similar to the above, the result is the same, even a little more closely approximating to the ratio 2 : 1 : 8.

The prosopite is much less readily attacked by sulphuric acid than the other fluorides described, and unless the pulverization is very thorough a small portion is generally left undecomposed even by boiling acid. To this fact may possibly be due the deficit of nearly 2 per cent. in fluorine, as compared with Brandl's results. On the assumption that 35 represents more nearly than 33.18 the true percentage of fluorine in the mineral analyzed, the ratio of water to required oxygen after combining all fluorine is 1 : 1.005, instead of 1.068. Allowing, then, for possible admixture of fluorite as above, the ratio Al : Ca : F+OH is 2.00 : 1.00 : 7.99, almost exactly 2 : 1 : 8.

The observation made by Brandl that below 260° C. no loss in weight occurs, was found to apply here, provided the exposure to this degree of temperature is short. If continued for many hours a slight but sensible loss is observed.

ZIRCON.

General Occurrence.—Zircon is one of the most widely distributed minerals of the region, occurring as an associate of nearly all other species in veins and druses and also impregnating the granite itself. König[47] has described it as an associate of astrophyllite and as intergrown with microcline. In its usual form it is brown or nearly black in color, and has only the ground pyramid and corresponding prism, the latter quite subordinate. König identified the basal plane 0P, and it seems to appear in very minute form upon crystals of all modes of occurrence though on comparatively few from each place. Sometimes the zircon crystals are more than an inch in diameter, sacrificing perfection to size, as there is commonly more or less distortion of angles and unevenness of surfaces in such individuals.

Zircon from the Eureka tunnel.—Reference has already been made in describing the occurrence of cryolite to the mutual relations of the different parts of the irregular vein into which the Eureka tunnel has been driven. The part containing zircon is but small, comparatively, and is sharply defined. It evidently represents a contemporaneous formation of quartz, zircon, and microcline. Zircon crystals varying in size from less than 1^{mm} to 1^{cm} are very plentifully and uniformly scattered throughout, while small patches of reddish microcline were also included in the more abundant quartz and themselves inclosed numer- small zircons. The occurrence is noteworthy from the perfection in form and the transparency of the zircon.

The zircon crystals imbedded in quartz are sometimes perfect, but in most cases the formal development has been hindered by the surrounding mineral, producing striated or distorted faces. These crystals, too, are much shattered by the jars of the blasting and the blows necessary in breaking up the larger pieces. Those smaller crystals deposited in the microcline were able to develop freely and they are now found imbedded in pure white kaolinite or a compact yellowish mica—the alteration products of the original microcline, some of which is yet visible. The nature of the surrounding material has protected these crystals from jars and also makes it possible to isolate single ones, absolutely unharmed, for examination. The color varies from a rich reddish-brown to a light wine or honey yellow shade. A few minute crystals are of a deep emerald green and spots of similar color were noticed in some pinkish crystals. While a few are really gems in clearness and color, they are usually of the smallest size, and are those found in the kaolinite or mica.

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[47] G. A. König, Zeitschrift für Krystallographie, I, 423, 1877.

The common habit of all crystals is pyramidal, the prisms being always subordinate when they appear. The forms determined with certainty are P, 3P, 0P, 3P3, ∞P and ∞P∞. The rare face 0P is much less frequently developed than any of the others, but it was observed distinctly on at least twenty-five crystals. Repeated measurements on different crystals of the angle 0P $\wedge$ P give results varying less than 3′ from the calculated value (137°50′). Between 0P and P is a low pyramid appearing quite constantly with 0P, which forms an angle of 164° 46′ with P. This corresponds very nearly to $\frac{14}{25}$P. The angle between this form and P is replaced by a curved surface giving an almost continuous reflection, but the angle with 0P is distinct. 0P is often visible on but one termination, but it is by no means rare to find it upon both.

Chemical analysis shows this zircon to be exceedingly pure and the specific gravity of transparent crystals is 4.709 at 21° C.

KAOLINITE.

The chief alteration product of microcline in the Eureka vein proves to be a very pure kaolinite. Some of the large individuals are changed into a compact white foliate kaolinite in the mass of which the cleavage planes of the microcline are still indicated. In other cases a more coarsely foliate aggregate is formed, the single leaves of which are beautiful transparent crystals.

The smaller patches of microcline deposited in the zircon-bearing quartz are also changed into kaolinite or a yellow micaceous mineral whose analysis accompanies that of the kaolinite below. Sometimes small cavities in the quartz contain single projecting crystals. These are exceedingly thin, colorless, transparent, rhombic leaves, the acute angle being usually evenly truncated, producing sometimes an almost perfect hexagon. The result of many measurements under the microscope seems to indicate that the obtuse angle of the rhomb is slightly less than

120°, the best results varying from 118° 30′ to 119° 30′. The thinnest leaves show distinct action on polarized light and extinguish parallel to the diagonals of the rhomb. The thicker crystals are made up of many tablets which are usually not perfectly coincident in position and sometimes form more or less perfect rosettes. The kaolinite possesses the composition XXXVII, and the mica XXXVIII, as given below. The kaolinite contained a small amount of fluorite in almost microscopic crystals, the quantity being calculated from the Ca found.

	XXXVII.		
	a.	b.	Mean.
SiO_2	45.91	46.22	46.06
Al_2O_3	39.65	39.62	39.63
H_2O	13 77	......	13.77
CaF_2	0.68	....	0.68
	100.01		100.14
(W. F. Hillebrand.)			

	XXXVIII.
SiO_2	52.59
Al_2O_3	29.72
Fe_2O_3	1.40
CaO	0.26
MgO	2.12
K_2O	8.33
Na_2O	0.50
H_2O	4.39
	*99.31
(W. F. Hillebrand)	

* The presence or absence of fluorine was not ascertained.

Oxygen ratio of XXXVII:

$$Al_2O_3 : SiO_2 : H_2O.$$
$$3.05 : 4.01 : 2.02.$$

The kaolinite has nearly the theoretical composition, while the mica is probably a variety of muscovite.

PHENACITE.

FROM CRYSTAL PARK.—This mineral was first identified from two crystals found in association with topaz in Crystal Park, near Manitou. Subsequent search revealed a number of others at the same place, but as they are inferior to those originally described[48] no new data can be given of this occurrence. The crystals found are but fragments, representing in each case somewhat less than half of the complete crystal. Fig. 12 of the plate represents one crystal in about the natural size; another measures nearly 7^{cm} in longest diameter, and has the same faces developed in similar manner. In no crystal do any faces of the vertical zone appear, thus producing a flat lenticular habitus. The forms appearing have been identified as $R, -\frac{1}{2}R, -R$ and $\frac{2}{3}P2$, and although the faces are too rough to admit of exact measurements with the reflection-goniometer, the size of the faces and their simple development render sufficiently accurate results with the hand instrument possible. The angles obtained as means of several measurements are:

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[48] Am. Jour. Sci., III, XXIV, p. 282, October, 1882.

	Crystal *a* (Fig.)	Crystal *b*.	Authorities.
	° ′	° ′	° ′ ″
$R \wedge R$ (terminal)		116 20	116 36 (D)
$R \wedge R$ (lateral)		63 00	63 24 (S)
$R \wedge -\frac{1}{2}R$ (over $\frac{2}{3}P2$)	148 30	148 50	148 18 (D)
$R \wedge \frac{2}{3}P2$	159 45	159 58	159 56 (D&S)
$R \wedge -R$	74 30	74 40	74 42 45 (S)
$-\frac{1}{2}R \wedge -\frac{1}{2}R$	143–144 00		144 1 26
$-\frac{1}{2}R \wedge -R$		163 43	163 32 2
$\frac{2}{3}P2 \wedge -\frac{1}{2}R$	168 11	168 50	168 22 (S)
$\frac{2}{3}P2 \wedge \frac{2}{3}P2$	156 40	156 00	156 44 (D&S)

The figures of the third column are the calculated angles given for phenacite by Dana[49] or Seligmann,[50] or else our own calculations based on the theoretical values given by them. The agreement between the angles measured on these crystals and the theoretical ones is sufficiently close to justify the signs given to the faces of the figures. In the development of the different forms R and $-\frac{1}{2}R$ are always prominent, while the faces of $\frac{2}{3}$ P2 are variable. One face of $\frac{2}{3}$ P2 on crystal *b* is 2.5^{cm} broad, although usually each face of $-\frac{1}{2}R$ is broader than both adjoining faces of $\frac{2}{3}$ P2; —R is subordinate and the faces are quite rough; $\frac{2}{3}$ P 2 appears with its full complement of faces. The roughness of the faces is in part caused by striæ, which on $-\frac{1}{2}$ R and $\frac{2}{3}$ P2 run parallel to the terminal edge of R replaced by those faces. On R the markings are less distinct. These striæ and partially regular depressions seem like natural etching figures, and bring out the rhombohedral symmetry of the mineral very plainly.

The crystallographical determination of these minerals as phenacite is confirmed by all the physical characteristics as far as observed and by the chemical composition. There is an imperfect cleavage parallel to ∞ P2. Both crystals are clear and colorless, resembling quartz, and the hardness is nearly or quite 8. The specific gravity of the crystal figured, though containing some impurities, is 2.967 at 23° C.

PHENACITE FROM NEAR FLORISSANT.—Another occurrence of phenacite was discovered during the summer of 1884, near Florissant, in association with the topaz crystals described later on. The crystals here are small, colorless, of lenticular form, and are deposited upon or slightly embedded in amazon stone crystals, in the same manner as the topaz, which is often present side by side with the phenacite. None seen exceed 5^{mm} in diameter, and crystals of this size in one case form an almost continuous crust upon the surface of a feldspar crystal. More commonly they are attached by an edge, although occasionally in all other positions.

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[49] Dana, System of Mineralogy, 5th ed., p. 263.

[50] G. Seligmann, in Neues Jahrbuch für Mineralogie, etc., 1880, I, 129.

These small crystals, while preserving the lenticular form of those from the first locality, exhibit a development of several new faces. These can be determined with considerable certainty by a reference to the article by Seligmann, reviewing the crystallography of the species.[51] All the present forms are mentioned by him as occurring with very nearly the same relative development upon the phenacite from the Ilmen Mountains, in the Urals. The zonal relations are almost sufficient to determine the new faces, although measurements were made to insure accuracy.

The new forms observed are: $-2R$, seen in a few crystals in good development; $-\frac{1}{2}R3$, which appears prominently with six nearly equal faces; $R3$, of which only three faces were found on any crystal, and which is often not developed at all; ∞R and $\infty P2$, appearing as very narrow faces, which do not produce a prismatic habit in any case and are often wanting. A narrow face sometimes seen between R and $-\frac{1}{2}R3$ is probably $\frac{1}{3}P2$ [52]

TOPAZ.

Within the past two years topaz has been found in several places within the Pike's Peak region, and we can supplement our original notice[53] of the mineral quite materially.

Topaz has been found in Crystal Park, south of Manitou, in a cavity containing feldspars, smoky quartz, zircon, and phenacite; at the main amazon stone locality near Florissant, about 12 miles northwest from Pike's Peak; and, more plentifully and in better form than elsewhere, on Devil's Head Mountain (Platte Mountain), north of Pike's Peak about 30 miles.

CRYSTAL PARK.—Of the few crystals found in this locality the most perfect one measures 2.5$^{\text{cm}}$. parallel to the vertical axis, 3.3$^{\text{cm}}$. parallel to the brachy axis, and 2.8$^{\text{cm}}$. parallel to the macro axis. It is colorless and some parts of the crystal are very clear. The prisms ∞P and $\infty\breve{P}2$ are well developed. The terminations are drusy, although many of the prominences are large enough to admit of the determination of some of the faces which bound them. The pyramid $2P$ has been recognized with certainty, while a form between $\frac{2}{3}P$ and P, which is probably $\frac{4}{5}P$, and another pyramid near $2\breve{P}4$ are also present. Measurements of sufficient accuracy for the calculation of these latter forms could not be obtained. The lateral edges of these pyramidal prominences lie in a plane corresponding to the brachydome $2\breve{P}\infty$, and although that form does not actually appear, the crystal has a domatic habit. A rough face of $4\breve{P}\infty$ is present quite distinctly. While one termination is more perfect than the other, both are alike. Not more than a dozen crystals have been found in this locality.

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[51] G. Seligmann. "Krystallographische Notizen, I," Neues Jahrbuch für Mineralogie, etc., 1880, I, 129.

[52] An announcement of this locality was made by W. E. Hidden, Am. Jour. Sci., March, 1885, received after this article was written.

[53] Am. Jour. Sci., III, XXIV, p. 282, 1882.

FLORISSANT.—The first specimen identified from Florissant is mainly noteworthy on account of the enormous size of the original crystal from which it came. This specimen is but a corner of a large crystal, the forms appearing being two faces of $\infty\breve{P}2$, one of ∞P, and one each of $2\breve{P}\infty$ and $4\breve{P}\infty$. The fragment is about 9$^{\text{cm}}$ ($3\frac{1}{2}$ in.) in its longest diameter, and if the other faces were developed to correspond to those here seen, the complete crystal must have been nearly or quite one foot in diameter parallel to the brachy diagonal. It is clear in parts and has a decided greenish tinge. It was supposed to be fluor spar by the original collectors, and the other pieces of the crystal are undoubtedly lost.

The specific gravity of this fragment is 3.578 at 22° C. and it has the following composition:

	XXXIX.
SiO_2	33.15
Al_2O_3	57.01
F	16.04
	106.20
O for F	6.75
	99.45
(W. F. Hillebrand.)	

Atomic ratio:

$$\begin{array}{c} Si : Al_2. \\ 1.025 : 1.000. \end{array}$$

Within a few months a further discovery of topaz has been made near Florissant. In this case the crystals were found deposited upon or partially imbedded in amazon stone, albite, or limonite (pseudomorph after siderite). The crystals seen by us are deposited upon different faces of the microcline and so seldom with any parallelism in position that any such coincidence must be considered accidental. In size the crystals vary from a length of nearly two inches to those which are almost microscopic. They are deposited singly or in groups and are attached in all positions, so that many of them are quite well terminated at both ends. The forms observed are as follows: ∞P and $\infty\breve{P}2$, both polished and striated; $4\breve{P}\infty$, $2\breve{P}\infty$, and $\frac{4}{3}\breve{P}\infty$; $0P$; $2\bar{P}\infty$; P and $\frac{2}{3}P$; $\infty\breve{P}\infty$.

Quite characteristic is the prominent development of the brachydomes $4\breve{P}\infty$ and $2\breve{P}\infty$, the former in particular, the faces of opposite terminations often meeting. $4\breve{P}\infty$ is almost uniformly dull, like ground glass, while $2\breve{P}\infty$ is smooth and brilliant, passing into $\frac{4}{3}\breve{P}\infty$ or $0P$ by a roughened line. $\frac{4}{3}\breve{P}\infty$ and $0P$ are usually rough through minute irregularities bounded by crystal planes. The base is usually very narrow through the predominance of the brachydomes, the pyramidal planes and the macrodome are quite insignificant when present at all, and $\infty\breve{P}\infty$ is occasionally present as a small, smooth face. No indications of hemimorphism are noticeable, although the faces of opposite ends are seldom symmetrically developed.

Some of the crystals have a decided greenish tinge, although many are colorless.

TOPAZ FROM DEVIL'S HEAD MOUNTAIN.—The country embracing Devil's Head Mountain is composed chiefly of the same granite which has been described in its occurrence near Pike's Peak, and it contains similar druses of microcline, smoky quartz, and other minerals. The topaz found here is the most noteworthy crystallized species, some of the specimens found being probably the best yet discovered in the United States. The discoverer, Mr. W. B. Smith, now assistant in the Rocky Mountain division of the Survey, has given us a few notes on the manner of occurrence and associations of the topaz, which are appended to this description, p. 73.

In the American Journal of Science for December, 1883, Rev. R. T. Cross, of Denver, published a note announcing the discovery of this locality by Mr. Smith. The specimens obtained since that time are much superior to those first found, though comparatively few in number.

Specimens from Devil's Head have found their way into various mineral collections of the country, and as the most noteworthy crystals passed through our hands we are able to give some details. All are colorless or faintly wine-colored and very clear within, though marred by more or less roughened surfaces, often stained by oxide of iron which penetrates fissures. Many fragments are sufficiently clear for cutting.

Three especially fine crystals have been obtained. Of these the one with the most polished surfaces, and hence the clearest, weighs 3.5 ounces, measuring $\breve{a}:\bar{b}:\dot{c}=4.4:4.9:3^{cm}$. The faces ∞P, $\infty \breve{P}2$, $4\breve{P}\infty$, $\frac{4}{3}\breve{P}\infty$, $0P$, $\frac{2}{3}\bar{P}\infty$, P, and $2P$ are quite well developed, while $\propto \breve{P}3$, $\infty \breve{P}\infty$, $2\bar{P}\infty$, and $\frac{2}{3}P$ are less prominent or not present in full quota. But one termination has definite faces.

The second crystal weighs 5.5 ounces, and measures $\breve{a}:\bar{b}:\dot{c}=3.7:5.5:4.6^{cm}$. Clear with dull surfaces. One termination has large $0P$, with a very symetrical development of the faces mentioned above and $2\breve{P}\infty$. A second termination is formed by one large undulating face, corresponding to $\frac{2}{3}P$, with $0P$ and single faces of $4\breve{P}\propto$ and $2P$.

A third crystal weighs $6\frac{3}{4}$ ounces and measures $\breve{a}:\bar{b}:\dot{c} = 4.2:5.3:4.5^{cm}$. It has rather dull surfaces but is clear within, and has a distinct wine color. One termination is quite symmetrical, showing the planes named.

A number of the smaller crystals are very clear and transparent, with beautifully polished surfaces, although it is seldom that all are smooth.

Nearly all crystals from Devil's Head, Crystal Park, and many from Florissant, have been found detached, some being badly broken. The same is true of a large portion of the crystals of the accompanying minerals. Movements of the whole mountain mass, as in folding or faulting, have probably caused this detachment and fracture of the crystals. Particularly noticeable with the topaz, though also observed on smoky quartz, is the fact that all these old fracture planes are healed over, so to speak, and are now covered by drusy surfaces caused by little prominences which are bounded by glistening crystal faces. An examination shows that pyramidal planes of both orders are the most common, the little elevations resembling those upon $2\breve{P}\infty$ above described. When the fractured plane is parallel $0P$ there are usually a great number of the pits or etching figures also previously noticed.

APPENDIX.

NOTES UPON THE OCCURRENCE OF TOPAZ AT DEVIL'S HEAD MOUNTAIN, BY W. B. SMITH.

The name "Devil's Head" was applied many years since to a jagged and precipitous mass of granite, rising to a height of 9,348 feet, in the Colorado range, some 30 miles north of Pike's Peak. This is the name by which it is still known locally, though upon Hayden's Atlas it is called "Platte Mountain."

The granite forming the mountain is similar to that near Pike's Peak, and the minerals found occur in cavities or pockets as in the latter region. No extensive pockets of amazon stone, smoky quartz, etc., have been found, but a few smaller ones contain a noteworthy association of species.

TOPAZ.—The pocket in which the topaz was found is of irregular shape, being about 50 feet long, from 2 to 15 feet wide, and averaging 4 feet in depth. Owing to the disintegration of the rock at the surface many of the crystals had been carried in the *débris* to a considerable distance down the mountain side, and were badly worn and broken.

The topaz occurs in isolated and usually loose crystals, surrounded by distorted quartz crystals, of smoky and reddish shades—frequently the exact color of the topaz—light green microcline, mamellary radiations of albite, cleavage masses and compact nodules of mica—probably muscovite, although sometimes much altered from the original substance. Also, more rarely, cassiterite, goethite, orthite?, fluorite and kaolinite occur. Much of the topaz is reddish, though wine-yellow, milky blue, and colorless crystals were found.

All the crystals attached to the gangue were more or less decomposed, a kaolin-like substance being the result. Frequently the terminal planes and a part of the prism would be found protruding from the rock unaltered, while the remainder of the crystal, running into the albite, would be composed of alternate layers of topaz and kaolin. More frequently, however, the kaolin, instead of being parallel to the cleavage planes, occupied curved fissures running irregularly through the topaz.

MICROCLINE.—This mineral in simple crystals was the common species in the pocket. Some were very large, measuring 18 inches across. They were usually badly fractured and fell in pieces on being removed. The base, 0 P, of each crystal has a curious appearance, owing to the angular elevations and depressions that compose the surface, looking not unlike oriental characters cut in relief.

CASSITERITE.—Twenty-five or thirty small, irregularly-shaped masses of this mineral were found embedded in massive albite or quartz. A few rude crystals were obtained, one being a little less than an inch in diameter. Only the pyramid is developed. No cassiterite was found outside of the topaz-bearing cavity.

FLUORITE.—In the adjacent region a number of interesting crystals of the chlorophane variety of fluorite were found in a small pocket of microcline and smoky quartz. The most perfect crystal is a cubo-octahedron, with every face well developed. It was found lying loose in the cavity and the surface is rough. The color is of a greenish tinge outwardly, with an included cube of dark purple.

III.—ON THE LUSTRE EXHIBITED BY SANIDINE IN CERTAIN RHYOLITES.

By WHITMAN CROSS.

The sanidines of two rhyolites in Colorado, examined by the writer, possess a remarkable lustre which is, as far as he can ascertain, unlike anything previously described by any other observer. One of these cases has already been briefly noticed in the American Journal of Science for February, 1884. The discovery of a second instance of this same lustre, and the results of a comparison with earlier descriptions of lustre and color in feldspar, render a fuller treatment in this place desirable.

SANIDINE IN RHYOLITE FROM CHALK MOUNTAIN.—The rhyolite containing the lustrous sanidine occurs in a massive body forming the greater part of Chalk Mountain, situated upon the continental divide at the headwaters of the Arkansas, Ten Mile, and Eagle Rivers, in central Colorado. It is of the type recently defined as nevadite by Messrs. Hague and Iddings,[54] and may be characterized as a porphyritic rock, showing large glassy sanidine and many smoky quartz crystals embedded in a grayish ground mass, which appears under the lens to be evenly granular, and is really so, with the exception of isolated glass particles revealed by the microscope. Biotite is but sparingly present. This nevadite is one of the most beautiful of rocks, owing to its abundant smoky quartz crystals and to the lustrous sanidines about to be described. Chalk Mountain lies upon the boundary between the geological maps of the Mosquito range and of the Ten-Mile mining district, which are soon to be published, with monographic reports, by the U. S. Geological Survey. In both of these works the manner of occurrence and the characteristics of the rock will be fully given.

Many crystals of sanidine in the nevadite exhibit in certain positions a delicate or brilliant satin-like lustre. If examined with the aid of a lens a faint play of very delicate colors is seen, while the crystal seems white and opaque when looking down upon the lustrous surface in such a direction that the lustre itself does not appear. The position of the lustrous plane is readily seen to be near that of the orthopinacoid, and the extent of the deviation from it is plain when a crystal twinned ac-

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[54] Am. Jour. Sci., III, XXVII, 461, 1884.