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HELVITE AND DANALITE FROM NEW MEXICO AND THE HELVITE GROUP*

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ABSTRACT

Helvite and danalite occur at Iron Mountain in Sierra and Socorro Counties, southwestern New Mexico, in a metamorphic contact zone between Paleozoic limestone and Tertiary rhyolites and granites. The host rock is a dark, banded tactite composed chiefly of magnetite, fluorite, chlorite, and diopside. The most coarsely crystallized helvite at Iron Mountain is amber to mahogany colored. $G=3.334$, $n=1.746$.

Danalite and some of the finely disseminated helvite occur in a conspicuously banded, light grayish-green tactite that has been termed "ribbon rock." Danalite is pale honey-yellow and resembles a beryllium-bearing grossularite with which it is in places intergrown. The index of refraction ranges from 1.750 to 1.759. Associated beryllium-bearing minerals are grossularite, idocrase, pink epidotes, tilleyite, and thuringite.

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** Mineralogical work by Glass; geology by Jahns; analytical chemical work by Stevens.

A staining method for distinguishing the members of the helvite group from the garnets is given.

The helvite group consists of three isomorphous species: helvite, $Mn_4Be_3Si_3O_{12}S$; danalite $Fe_4Be_3Si_3O_{12}S$; and genthelvite, $Zn_4Be_3Si_3O_{12}S$. The name genthelvite is here given to the zinc member in honor of the memory of Frederick A. Genth who first described this species in 1892. The only known occurrence is West Cheyenne Cañon, El Paso County, Colorado. Genthelvite is isometric, tetrahedral. Pale rose-red. $G=3.66$, $n=1.744$.

Analyses of members of the helvite group are assembled, together with determined indices of refraction for all available material. Correlation of variations in specific gravities and indices of refraction with chemical composition is shown on a three component diagram. Measured values of a_0 are given.

The properties of the three end members are:

		G	n	a_0
Helvite	$Mn_4Be_3Si_3O_{12}S$	3.20	1.728	8.27
Danalite	$Fe_4Be_3Si_3O_{12}S$	3.35	1.771	8.18
Genthelvite	$Zn_4Be_3Si_3O_{12}S$	3.70	1.740	8.10

INTRODUCTION

The contact deposits of iron and other metals on Iron Mountain in the northern Sierra Cuchillo, southwestern New Mexico, have been known and repeatedly examined by prospectors for many years. The presence there of several unusual minerals was first noted in 1926 by T. C. Parker, at that time principal claim owner in the area, but it was not until November 1941, when L. W. Strock (30) announced his discovery of beryllium in certain of the ores, and his identification of the chief beryllium-bearing mineral as helvite, that the attention of the geologists was focused upon these deposits. A detailed examination of the district was made by the Geological Survey during the summer and fall of 1942, and the more significant minerals have been studied in the laboratory.

OCCURRENCE

Iron Mountain is a high ridge that forms the north end of the Sierra Cuchillo in Sierra and Socorro Counties, New Mexico (Fig. 1). It is located nine miles north of Winston (Fairview), the nearest town, and 33 miles northwest of Hot Springs, from which it can be reached over a fair gravel road (State Route 52).

The mountain, which is elongate north and south, is a narrow, tilted fault block, and the faceted spurs along its western base are conspicuous features. It consists of Paleozoic limestone and associated minor sandy and shaly beds that dip rather uniformly east at moderate angles. These sedimentary rocks have been cut by many dikes and irregular plugs of rhyolite and coarsely porphyritic rhyolite, and by younger sills and dikes of aplite and fine-grained granite, all of which are believed to be of

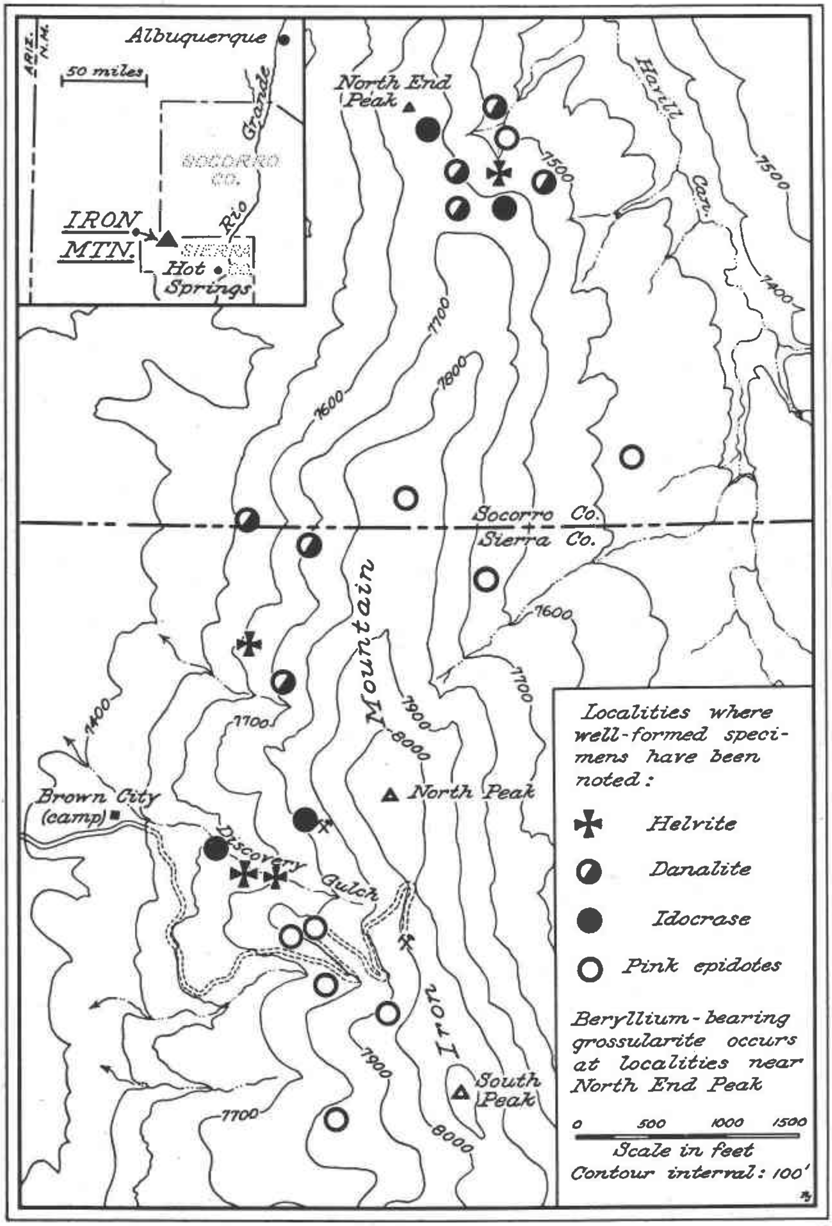

FIG. 1. Topographic map of Iron Mountain, showing localities from which well-formed specimens of helvite, danalite, idocrase, and pink epidotes have been obtained. Inset shows location of Iron Mountain in Sierra and Socorro Counties, southwestern New Mexico.

Tertiary age. As a result of this igneous activity the more susceptible strata were recrystallized, as well as locally reconstituted, to form iron-poor and iron-rich silicate rocks. Chief among the iron-poor contact rocks, which occur in the "zone of the light-colored silicates" of Hess and Larsen (14), are dense, homogeneous, fine-grained granulites that contain varying proportions of quartz, diopside, clinozoisite, wollastonite, and plagioclase of bytownite-anorthite composition. The iron-rich silicate rock, or tactite, locally contains appreciable amounts of beryllium and tungsten and is, therefore, of economic as well as scientific interest.

The more common variety of tactite is a black to greenish, massively bedded magnetite-andradite rock which was formed through the replacement of limestone. It represents an early-stage product of pyrometasomatism. Bodies of massive tactite range from a few inches to a hundred feet or more in width; the largest of these lie along the crest and high on the slopes of Iron Mountain.

A second variety of tactite is a conspicuously banded rock, to which the name "ribbon rock" has been given (17). Ribbon rock is a garnet-poor, magnetite-fluorite tactite in which layers of magnetite alternate with layers composed of fluorite and silicate minerals. Two distinct varieties of ribbon rock occur at Iron Mountain. (1) A dark, beryllium-rich variety containing 15 to 20 per cent helvite (30) (Fig. 2) forms small bodies in Discovery Gulch, a narrow canyon east of Brown City (a temporary mining camp), as well as on the west slope of the mountain about three-tenths of a mile north of Brown City. (2) A lighter-colored tapestry variety (Fig. 3) that contains a small amount of beryllium-bearing minerals, including an average of less than one-half of one per cent helvite and danalite, is widely distributed in the North End area; the largest bodies are exposed on the west side of the mountain and on the ridge crest about one mile northeast of Brown City. The ribbon rock bodies are roughly lense-shaped or finger-like, trend about parallel with the strike of the original beds and dip eastward in crude conformity with the beds. A distinct boundary can be seen between the ribbon rock and the massive tactite and granulite, but the ribbon rock grades into recrystallized limestone through contact zones several inches wide. Where ribbon rock and massive tactite are both present, the massive tactite tends to occur between the ribbon rock and the nearest intrusive contact, thus the ribbon rock lies between earlier-formed massive tactite and recrystallized limestone. It appears to be a product of late-stage hydrothermal action.

Immediately following, and perhaps in part contemporaneous with the action of ordinary silication, hydrothermal solutions penetrating along fractures introduced abundant fluorine and appreciable amounts of manganese, iron, zinc, beryllium, boron, and other elements. Most of the helvite and danalite, beryllium-bearing grossularite and idocrase, and members of the pink epidote group appear to have been formed during this relatively late stage. During a still later stage, other minerals such as chalcedony and zeolites were formed.

HELVITE

General Statement

The helvite at Iron Mountain has been described by Strock (30), but additional information has been obtained by the Geological Survey from a recent field study of the district and from detailed laboratory study of the mineral and its associates. The rapidly increasing interest in helvite and its possibilities as a source of beryllium make it advisable to present the new geologic, mineralogic, and chemical data secured during the course of studies by the United States Geological Survey.

The chemical composition of the helvite group of minerals is expressed by the general formula $R_4Be_3Si_3O_{12}S$. The group is a three component one, the composition of whose members can be interpreted as varying mixtures of the three theoretical end-members or components

$$Mn_4Be_3Si_3O_{12}S$$
$$Fe_4Be_3Si_3O_{12}S$$
$$Zn_4Be_3Si_3O_{12}S$$

None of these three end members is known to occur in nature in a pure state. All the known members contain both manganese and iron in varying quantities and in half of them zinc also is present. It is possible that many of the helvites for which no zinc is reported in the analyses may actually contain small quantities of zinc.

The atomic ratio of beryllium remains fixed, as indicated in the three formulas given, and the percentages of BeO in any mixture of these three components should lie within the very narrow range from 12.58 to 13.52. That the actual analytical figures transgress these theoretical limiting values may be due either to impurities in the sample analyzed or to slight analytical errors. Bowley (2) comments that the numerous complex formulas suggested for this series "are based on incorrect analytical figures, due, in many cases, to incomplete separation of beryllium from manganese, iron, and zinc."

In consequence of the varying quantities of Mn, Fe, and Zn, the physical properties of members of the group vary with the chemical composition. The determined specific gravities of members of the helvite group range from 3.16 to 3.66 and the determined indices of refraction from

FIG. 2. Dark, beryllium-bearing ribbon rock tactite from Discovery Gulch, Iron Mountain, New Mexico. Black areas are fine-grained silicates stained with manganese oxide; gray areas are magnetite; grayish, irregular pod-like areas are helvite; and the white patches and thin veinlets are fluorite. (Natural size.)

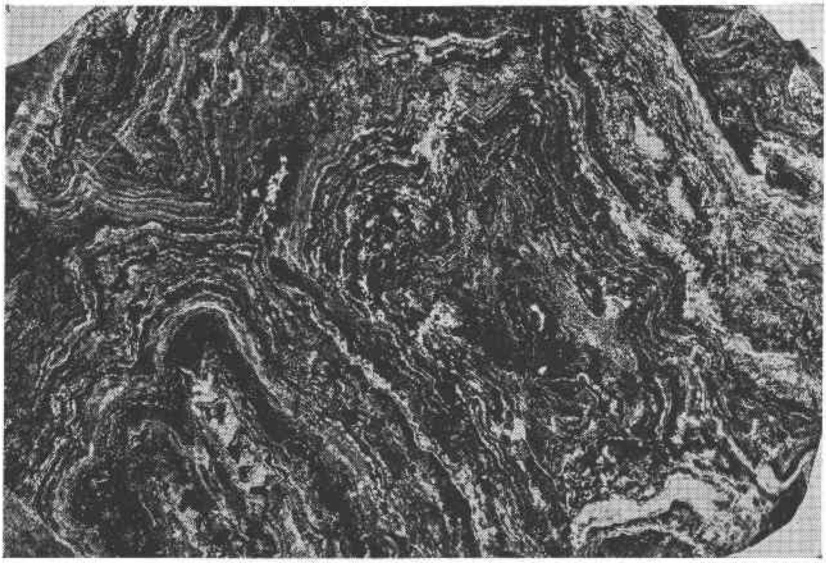

FIG. 3. Ribbon rock tactite from North End area, Iron Mountain, New Mexico. White veinlets and vug fillings are fluorite in which is embedded small crystals of helvite and beryllium-bearing grossularite. Gray ground-mass is an intimate intergrowth of magnetite, fluorite and silicates. (Natural size.)

1.728 to 1.765, a value probably too high. In the last part of this paper an attempt is made to correlate the varying specific gravities and indices of refraction with chemical composition for all known members of the helvite group.

Discovery Gulch Deposits

Most of the known coarsely crystalline helvite (Fig. 2) occurs at Discovery Gulch in small bodies of tactite along a contact between recrystallized limestone and a plug of coarsely porphyritic rhyolite. Smaller amounts have been found in tactite lenses that lie in recrystallized limestone at and near contacts with masses of aplite and fine-grained granite. The iron-rich host rock for the helvite (Fig. 2) is composed rather uniformly of magnetite and fluorite, with minor amounts of biotite, chlorite, and diopside. Garnet is rare to absent. The tactite is characteristically layered, with crenulated parallel laminae that locally are concentric about aggregates of solid magnetite or more commonly crystalline fluorite. These bands range in width from 0.05 mm. to 10 mm., with a prevailing average of about 0.2 mm. Some consist of solid helvite, but most helvite-bearing layers are aggregates of fluorite and helvite; the intervening layers are solid magnetite or biotite-chlorite aggregates 3 to 10 mm. thick. Irregular pods of coarsely crystallized helvite, with maximum dimensions of 1 inch by 3 inches by 4 inches, are present but are not common. Although helvite locally constitutes as much as half the rock, it is generally present in much smaller quantities, even in the richest ore shoots.

North End Deposits

A small quantity of helvite from the Lower Star body, North End area, has an index of refraction (1.737) lower than that of the more typical and more abundant helvite from Discovery Gulch, and indicates a higher manganese and lower iron-plus-zinc content. These lower index grains were found in crushed material and their association is not known.

Properties

The helvite from Discovery Gulch is amber-brown to mahogany-red (Ridgway's Color Standard) with a vitreous to resinous luster. Much of it is stained dark brown or nearly black by iron and manganese oxides. Most of the helvite is massive, but well-formed crystals occur in vugs, commonly associated with comb quartz and fluorite. Simple tetrahedra though not rare are less common than the combination of positive and negative tetrahedra. On many crystals the positive and negative faces are so equally developed that perfect octahedra have resulted. Although most of the crystals are less than 4 mm. in diameter, some reach dimensions as great as 12 mm. ($\frac{1}{2}$ inch) on an edge. Fine and evenly spaced striations appear on some of the crystal faces. The mineral has a hardness of about 6, but because of its brittleness it appears to be much softer. Cleavage is absent or at most very poorly developed. The helvite from Discovery Gulch deposit seems to be uniform and constant in composition and properties. The specific gravity of the analyzed sample is 3.334, and its index of refraction is 1.746 for sodium light. By contrast the minerals of the helvite group from the North End deposits vary considerably in their indices.

Helvite resembles garnet, and it is possible that this beryllium-bearing mineral has been overlooked or mistaken for garnet in other contact metamorphic deposits. The chief properties that distinguish helvite from the typical andradite garnet of the Iron Mountain area are its tetrahedral habit, hardness of only 6, and lower specific gravity. The associated andradite is liver-brown to greenish-yellow or pale canary-yellow, shows

TABLE 1. ANALYSIS OF HELVITE FROM DISCOVERY GULCH, IRON MOUNTAIN, SOCORRO AND SIERRA COUNTIES, NEW MEXICO
Rollin E. Stevens, analyst

	Analysis	Atomic Ratios		
SiO_2	31.54	.5251		
Al_2O_3	.37	.0073		
		.5324	3.00	Si_3
BeO	13.60	.5436	3.06	Be_3
MnO	26.51	.3738		
FeO	18.02	.2508		
ZnO	5.61	.0689		
CaO	1.62[1]	.0289		
MgO	None			
		.7224	4.07	$(Mn, Fe, Zn)_4$
S	5.34	.1665	.94	S
TiO_2	.01			
H_2O	.06			
	102.68			
Less O=S	2.67			
	100.01			

Formula: $(Mn, Fe, Zn)_4Be_3Si_3O_{12}S$

[1] The unusually high calcium content is due partly to the presence of a few fragments of fluorite.

abnormal double refraction, and has an index of refraction ranging from 1.865 to 1.885. Helvite dissolves slowly in boiling hydrochloric acid (1:1), forming a silica gel and hydrogen sulfide, whereas garnet is very difficultly soluble in acid and neither gelatinizes nor yields hydrogen sulfide.

The most coarsely crystallized and most highly concentrated mahogany red type of helvite from an exploration pit in Discovery Gulch was analyzed. The rock from which the mineral was taken is a magnetite-rich tactite composed of 68½% magnetite, 18% fluorite, and 13½% helvite.

The sample was carefully prepared, first by crushing and screening to remove the fine powder, then by removing the magnetite with a magnet and the fluorite with heavy solutions, and last by carefully hand picking only the grains with bright luster.

DANALITE

North End Deposits

The danalite from the North End Deposits occurs chiefly in the ribbon rock (Fig. 3) that lies relatively low on the west slope (Fig. 1) of the north end of Iron Mountain. This ribbon rock, composed essentially of magnetite, fluorite, biotite, and chlorite, has a reddish or a dark green groundmass with white to pale yellow bands 0.1 mm. to 3 or 4 mm. wide, which are either straight or curved but generally arranged concentrically about cores filled with aggregates of fluorite crystals. The banding may be ascribed to a diffusion effect, involving solutions that worked outward from fractures and "open" bedding planes. In places the thicker layers and fluorite-filled vugs contain scattered crystals of danalite. The ribbon rock bears a remarkable resemblance in structure and in composition to the orbicular contact rock of Brooks Mountain, Seward Peninsula, Alaska, described by Knopf (18).

Properties

The danalite is pale creamy yellow to honey-yellow. The crystals show rounded dodecahedral form and are embedded in fluorite aggregates, commonly in intimate association with grossularite from which it is not readily distinguishable. Under the microscope both danalite and the associated grossularite show optical anomalies. The index of refraction of the danalite is variable, ranging from 1.750 to 1.759, a little lower than that for the grossularite, which also has variable index, 1.765 to 1.775.

It was not possible to obtain enough of this danalite for chemical analysis but its relatively high index of refraction shows that it must be high in iron and close to the iron end component, as spectrographic tests show that zinc is absent.

The relations between the danalite and grossularite in the North End ribbon rock seriously complicate field identification, because these two minerals not only look alike, but, unlike the widely separated andradite and helvite at Discovery Gulch, they commonly occur together. The dodecahedral habit of the crystals is the same for both minerals, with occasionally less distinct faces on the danalite. Both minerals have the same color. Some of the crystals of grossularite have a brilliant luster, but not all of it is transparent and glossy; much of it is translucent and brittle like the danalite.

Distinctions between the two minerals may be made with a petrographic microscope by immersing the grains in a liquid of index 1.760; grains of lower index are danalite and grains of higher index are grossularite. The distinction may also be made by means of a staining method. A lump of the rock or a polished surface cut parallel to the vein where flat aggregates of crystals are exposed may be used. Staining of the smoothly polished surfaces of specimens will clearly show the relation of the danalite to the grossularite. Examples of what appeared to be complete or nearly complete replacement of grossularite by danalite have been noted in several specimens. If replacement has actually taken place the dodecahedral form of the grossularite may have been inherited by the danalite.

STAINING METHOD FOR DISTINGUISHING MEMBERS OF THE HELVITE GROUP FROM THE GARNETS

A successful staining method for the identification of the helvite group has been developed by John W. Gruner at the laboratories of the University of Minnesota for Continental Machines, Inc., Minneapolis, Minnesota, who own claims at Iron Mountain, New Mexico. We quote from their report:

> "The mineral resembles garnet in several respects and can be easily confused with it especially in small grains and in those of microscopic size. Since garnet is a very common constituent in the rocks of this area (Iron Mountain, New Mexico), it becomes quite difficult to judge a sample of ore as to its possible or probable content of beryllium. The difficulty is increased by the fact that chemical analyses for beryllium are long and tedious if any accuracy is desired.
>
> "For practical purposes of finding ore, it should not be necessary to analyze for beryllium chemically, except for checking results. If the grains of helvite can be made visible easily, either to the naked eye or under the microscope, they can be counted and their ratio to the number of grains of the gangue determined.
>
> "Such a method has been developed and checked by literally hundreds of tests and many chemical analyses. It is quick and simple and absolutely foolproof. A very small

representative sample of the powdered or crushed rock is put in a small 50 cc. glass beaker and enough dilute H_2SO_4 (one acid to five water) is added to cover the sample. A pinch of arsenic trioxide (As_2O_3) is added, and the solution is boiled for about one to two minutes. The acid is then decanted and the powder is washed with water a couple of times by decanting. The contents of the beaker still covered by a little water are examined under the binocular microscope. Any helvite present will be stained a brilliant canary yellow. This stain is arsenic sulfide (As_2S_3). This test is so sensitive that one grain of helvite can be found among thousands of gangue minerals. Should it happen that the gangue were all yellow garnet, the canary yellow could still be spotted. If there were any doubt, *metallic* antimony could be *substituted* for the arsenic trioxide in test above. A brilliant red would stain the helvite then. This stain is antimony sulfide (Sb_2S_3)."

Associated Minerals

The tactite zones at Iron Mountain have yielded more than fifty mineral species. Only those minerals that show beryllium in traces or more and that have been found associated with helvite and danalite are considered in this paper. A paper that contains a summary of all minerals recognized in the Iron Mountain deposits is in preparation.

Garnets

The associated garnets, andradite and grossularite, have already been mentioned. The variable index of refraction of the grossularite from the North End area is too high for normal grossularite and too low for normal spessartite or andradite. Although qualitative analysis shows that it contains manganese and iron, the iron-rich environment might well favor the predominance of the andradite molecule. Three different samples of isolated well-formed crystals of the grossularite, according to spectrographic examination by L. W. Strock, showed 0.08%, 0.13%, and 0.19% BeO. These samples were taken from the helvite-grossularite zone, but not from immediate association with helvite-bearing veinlets. These results suggest that the grossularite in the North End area is beryllium-bearing. Further investigation of this garnet is in progress at present.

Idocrase (vesuvianite)

Fibrous, beryllium-bearing idocrase is widely but sparingly distributed throughout the ribbon rock tactite, and occurs in larger concentrations in a heavily mineralized garnetiferous tactite high on the west slope of the North Peak (Fig. 1). It occurs also in fluorite-rich tactite in the lower part of Discovery Gulch.

The idocrase forms small, colorless to pale green or very pale yellow radiating aggregates of slender prismatic crystals in clusters ranging from 3 to 10 mm. in length.

Table 2 shows the optical properties of specimens from two widely separated localities (Fig. 1).

Table 2. Optical Properties of Beryllium-Bearing Idocrase from Iron Mountain, New Mexico

Locality	North Peak (West Side)		Pit near North End Peak	
	1	2	1	2
	Tetrag.	Tetrag.	Tetrag.	Tetrag.
ϵ	1.711	1.712	1.703	1.705
ω	1.718	1.722	1.709	1.710
B	.007	.010	.006	.005
Sign	—	—	—	—
2V (abnormal)	0° to 7°	5° to 6°		

The optical data agree with those for beryllium-bearing idocrase from Franklin, New Jersey (24) ($\epsilon=1.700$, $\omega=1.712$), the redetermined beryllium content of which has not as yet been published.

Table 3. Chemical Analysis of Beryllium-Bearing Idocrase from Iron Mountain, Sierra and Socorro Counties, New Mexico

Rollin E. Stevens, analyst

SiO_2	36.19
Al_2O_3	13.36
Fe_2O_3	4.15
FeO	2.15
BeO	1.09*
MgO	2.42
CaO	32.02
Na_2O	.22
K_2O	.05
H_2O-	.43
H_2O+	.60
TiO_2	Trace
F	3.22
MnO	4.48
ZnO	.43
B_2O_3	.11
	100.92
$-O=F$	1.36
	99.56

* Average of two determinations, 1.07% and 1.10%.

Specific gravity slightly greater than 3.3. $\epsilon=1.711$, $\omega=1.718$.

A chemical analysis was made on carefully selected and purified material from North Peak. First the magnetite was removed from the crushed sample by use of an alnico hand magnet; then the minerals lighter than idocrase were floated off by heavy solutions; the concentrate, consisting of idocrase, garnet, and a few grains of fluorite, was separated by use of the Frantz isodynamic electro-magnet; and the final concentrate was then hand-picked. The results of the analysis are given in Table 3:

Spectrographic examination shows the Be, B, and Zn lines to be slightly stronger for the idocrase from near the North Peak, than for that near the North End Peak (Fig. 1). X-ray diffraction patterns are identical, and, though these patterns do not agree entirely with patterns of known specimens of idocrase, it is believed that the difference may be due to minute inclusions of extraneous material, or to slight alteration of the mineral itself.

The minerals associated with the North Peak idocrase, which in places forms about 2 to 3% of the rock mass, are magnetite, approximately 60%; fluorite, 34%; chlorite, garnet, iron oxides, etc., 3%; and tilleyite and rhodochrosite, 1%. The material examined represents selected specimens. Random samples from the same area would show a higher percentage of magnetite and a lower percentage of fluorite; garnet would equal or exceed the amount of fluorite.

Selected hand specimens from the North End Peak locality contain magnetite and fluorite in almost equal proportions. Chlorite is more abundant than it is in the North Peak deposit, and garnet is less abundant. No other minerals have been observed with the idocrase. At the North End Peak locality the material is apparently fresher and more coarsely crystallized.

Pink Epidotes

Pink to red members of the epidote group, ranging from pink zoisite (thulite) to piedmontite, are widely distributed throughout the iron-poor silicate rocks of Iron Mountain (Fig. 1). Thin blades of yellowish-green epidote and pale brown to colorless zoisite are commonly associated with the pink minerals. These pink minerals occur as incrustations on fracture faces in a fine-grained greenish-gray quartz-pyroxene-clinozoisite granulite, forming typical radiating sheaf-like aggregates. Some of the crystals of the piedmontite variety show a regular succession of growth ridges along their length that correspond in position and in outline to traces of repeated terminations. In some crystals the characteristic deep rhodonite-pink color fades to pinkish-brown toward the end farthest from the center of the cluster.

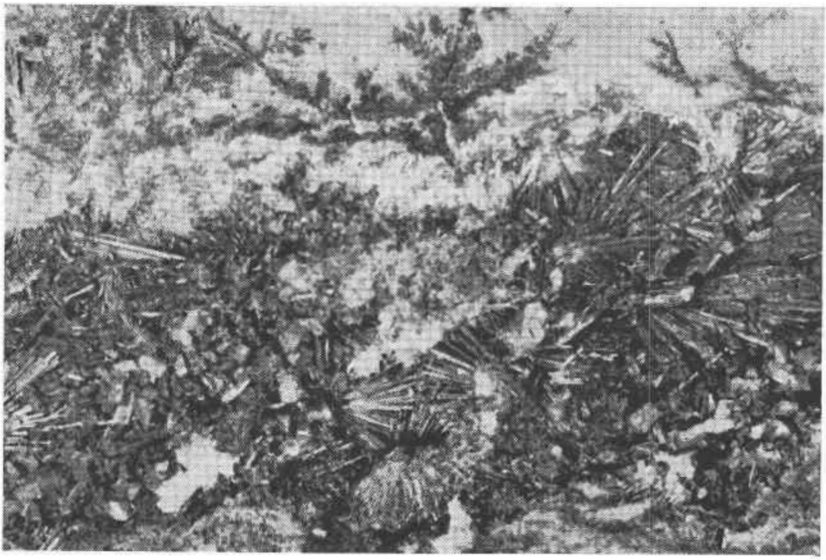

FIG. 4. Radial growth of pink zoisite (thulite) and clinozoisite with zeolites on surface of fine-grained clinozoisite-diopside granulite. Many of the needles of pale green clinozoisite change toward their outer ends into thulite (×3).

The optical data (Table 4) show a gradation from pink zoisite through pink clinozoisite to piedmontite. The variation in optical data shown in the study made by Schaller and Glass (27) based on samples that represent 14 localities from 12 states shows a continuous gradation from low-index pink zoisite to pink clinozoisite.

Table 4 shows the optical properties of two examples each of the low-index pink zoisite, the intermediate clinozoisite, and the highest-index piedmontite. Additional laboratory data show a continuous progression in optical variation from the lowest to the highest readings shown in the table below. The map (Fig. 1) indicates the distribution of some of the pink epidotes in the Iron Mountain area.

Most of the pink zoisite (thulite) occurs on the ridge south of Discovery Gulch (Fig. 1), where it is found encrusted on greenish-gray, iron-poor granulite and is associated with pink clinozoisite and colorless to brown zoisite. Pink clinozoisite is more widely distributed and occurs everywhere with the other varieties. Piedmontite is found most abundantly in the North Peak area. Although it is the richest in manganese and iron, this mineral falls in the lower end of the piedmontite range of indices of refraction.

Table 4. Optical Properties of Pink Zoisite, Clinozoisite, and Piedmontite from Iron Mountain, New Mexico

	Zoisite Ridge South of Discovery Gulch		Clinozoisite All localities		Piedmontite Canyon near North End Peak	
α	1.698	1.707	1.716	1.725	1.725	1.727
β	1.700	1.711	1.722	1.730	1.730	1.738
γ	1.705	1.718	1.726	1.740	1.750	1.755
B	0.007	0.011	0.010	0.015	0.030	0.028
Sign	+	+	+	+	+	+
2V	30°	55°	75°	80°	70°	75°
Disp.	Strong	$r<v$	mod.	variable	$r>v$	$r>v$
Pleoc.	X=Pink; Y=Cs.; Z=Yel.		X=Yel; Y=Cs.; Z=Pink		X=Yel; Y=Pink; Z=Red (strong)	

Note: Cs.=colorless; Yel.=yellow.

A spectrographic examination of the pink epidotes showed a trace of beryllium.

Tilleyite

Patches of a white mineral that resemble drusy quartz but about as hard as calcite were found in cracks and cavities in a sample of greenish tactite from the west slope of North Peak. The sample was collected because it contained an unusually large amount of pale green idocrase. The harder part of the sample is composed of yellowish-green andradite and magnetite, with a small patch of glassy clear fluorite. The white mineral has the optical properties of tilleyite. It is biaxial with large positive axial angle, and shows weak dispersion, $r<v$. Indices of refraction: $\alpha=1.616$, $\beta=1.635$, $\gamma=1.651$. The mineral effervesces in hydrochloric acid like calcite and forms a silica gel. Spectrographic examination showed a trace of beryllium. Because of the small amount of material, no further study was made.

Thuringite (Chlorite)

A pale green to dark green brittle chlorite with pearly luster is found closely associated with coarsely crystallized fluorite in pods in the ribbon rock and in places with the grossularite. Spectrographic examination of the chlorite showed distinct beryllium lines. Other observed data correspond to normal thuringite.

THE HELVITE GROUP

The helvite group consists of three isomorphous species whose chemical composition is expressed by the general formula, $R_4Be_3Si_3O_{12}S$, with

R = Mn in helvite, Fe in danalite, and Zn in genthelvite; that is, the end members of the group are

Helvite	$Mn_4Be_3Si_3O_{12}S$
Danalite	$Fe_4Be_3Si_3O_{12}S$
Genthelvite	$Zn_4Be_3Si_3O_{12}S$

The last name, genthelvite, is here given to the essentially zinc member of the helvite group, found in Colorado many years ago and described by Genth (8) in 1892. It is fitting that this mineral species bear the name of Genth. The name genthite has already been used to refer to a nickel-bearing deweylite. Therefore, we take pleasure in naming the zinc member of the helvite group *genthelvite*, and in this way honoring the memory of Frederick A. Genth, who first described the species.

The helvite group is generally recognized as a three-component system, although later writers seem to have overlooked the published (1892) analysis of a "danalite" that contained a high percentage of zinc. The zinc component has been mentioned by Goldschmidt (9), Bowley (2), and others, but particularly by Pauling (25) who explains the higher specific gravity (3.427) of the danalite from Rockport, Mass., over that of helvite (3.23 calculated) as due to the presence of about 40 per cent of the zinc end member. The only known occurrence of genthelvite is West Cheyenne Cañon, near St. Peter's Dome, El Paso County, Colorado, and the only known existing specimen is in the Genth Collection at Pennsylvania State College, State College, Pennsylvania. A brief summary of the essential properties of this mineral, taken in part from Genth's description, is as follows:

Genthelvite, $Zn_4Be_3Si_3O_{12}S$. Isometric, tetrahedral.
Forms: $d\{110\}$, $o\{111\}$, $o'\{1\bar{1}1\}$. No cleavage observed.
Pale rose-red to brownish owing to slight oxidation.
Isotropic, $n = 1.744$. G. = 3.66. Transparent and nearly colorless in thin fragments.
Decomposed by acid, and in general resembles danalite.

None of the three minerals of the helvite group is known to occur in nature in the pure state; all contain both manganese and iron, and half of them also contain zinc. The helvite (analyses 1 and 2, Table 5) from Amelia, Virginia, contains the greatest quantity (96 per cent) of the manganese component; the danalite from Cornwall, the greatest quantity (70 per cent) of the iron component; and the genthelvite from Colorado the greatest quantity (85 per cent) of the zinc component. As the name helvite refers to members of the helvite group that consist dominantly of the manganese component $Mn_4Be_3Si_3O_{12}S$, the name danalite should be restricted to those members of the helvite group which consist dominantly of the iron component, $Fe_4Be_3Si_3O_{12}S$, and genthelvite should refer to members which consist dominantly of the zinc component, $Zn_4Be_3Si_3O_{12}S$.

Cooke's (5) analyses of danalite from Rockport and Gloucester, Mass., yield only 55 per cent of the iron component together with 32 per cent and 34 per cent, respectively, of the zinc component. It is interesting to recall Cooke's reason for giving the then (1866) new name danalite to this mineral. He says: "In its peculiar constitution the new mineral is allied to Helvin, although the two species have no outward resemblance. The holohedral character of its crystallization, the very large amount of iron and zinc entering into its composition, its color, luster, hardness, and other physical as well as chemical properties, all distinguish it from helvin and prove the mineral to be a new species." Most of these criteria would hardly suffice to establish a new species today.

Members of the helvite group may show considerable variation in properties and composition, due to the isomorphism of manganese, iron, and zinc, as is demonstrated by the helvite and danalite from the Lower Star body and the North End Peak areas of Iron Mountain, New Mexico, where the index ranges from 1.737 to 1.759. Similarly a range of from 1.742 (yellow material) to 1.754 (raspberry-red material) was found for the mineral from Bartlett, New Hampshire. One fragment from the Bartlett locality showed a rim of red enclosing the yellow variety.

The large, rude, reddish crystals of danalite from Cornwall contain in their crevices and cavities minute tetrahedra of both reddish-brown and yellow color, as described by Miers and Prior (23). These minute crystals "are mostly of the same colour [columbine-red to brick-red] as the main mass of the material, but some are yellowish, and one was found, which, while red at one end, was clear grayish-yellow at the other." The index of refraction of the red danalite (sample obtained from the British Museum) ranges from 1.756 to 1.759 with most of the grains 1.758. The palest colored danalite (pale pink) has an index of 1.753. The red danalite is clearer and more transparent than the paler colored variety and evidently represents the variety analyzed by Miers and Prior who state that in the preparation of the sample for analysis, "the most transparent pieces were picked out under the lenses."

Some members of the helvite group, however, are homogeneous for some localities. The helvite from Discovery Gulch shows consistently the same index of refraction (1.746) in all parts of the deposit, as does the danalite at Rockport (1.755). The helvite from Saxony shows only slight variation (1.728–1.733).

All available analyses of the members of the helvite group are given in Table 5, and are arranged in order of decreasing percentages of the manganese component, $Mn_4Be_3Si_3O_{12}S$.

TABLE 5. ANALYSES OF MINERALS OF THE HELVITE GROUP

	SiO_2	BeO	MnO	FeO	ZnO	MgO	S	X*		Less O=S	
HELVITE:											
1. Amelia, Va.	25.48	12.63	50.24[a]	2.03[b]	—	—	4.96	5.10	100.44	2.48	97.96
2. Amelia, Va.	31.42	10.97	51.64[c]	2.99	—	—	4.90	.36	102.28	2.45	99.83
3. Norway	33.13	11.46	49.10[d]	4.00	—	—	5.71	—	103.40	2.85	100.55
4. Schwarzenberg	33.33	14.92	44.43	4.45	—	—	5.03	.77	102.93	2.51	100.42
5. Schwarzenberg	33.26	12.03	41.76[e]	8.00	—	—	5.05	1.15	101.25	2.52	98.73
6. Lupikko	30.34	10.46	37.88	10.37	—	0.68	5.95	4.92	100.60	2.97	97.63
7. Sigtesö	32.85	11.19	39.68	13.02	—	—	5.71	1.40	103.85	2.85	101.00
8. Ilmen Mts.	32.49	13.52	35.41	15.12	—	—	5.77	.77	103.08	2.88	100.20
9. Argentina	32.65	12.20	30.79	14.75	4.89	2.24	6.01	—	103.53	3.00	100.53
10. Hörtekollen (Christiana Dist.)	31.95	13.17	28.46	15.55	7.65	—	5.86	—	102.64	2.93	99.71
11. Australia	31.82	13.90	28.00	15.80	7.76	—	5.75	—	103.03	2.87	100.16
12. Iron Mt., N. Mex.	31.54	13.60	26.51	18.02	5.61	—	5.34	2.06	102.68	2.67	100.01
DANALITE:											
13. Redruth, Cornwall	29.48	14.17	11.53	37.53	4.87	—	5.04	—	102.62	2.52	100.10
14. Rockport, Mass.	31.73	13.83	6.28	27.40	17.52	—	5.48	—	102.24	2.74	99.50
15. Gloucester, Mass.	29.88	14.72[f]	5.71	28.13	18.15	—	4.82	.83	102.24	2.41	99.83
GENTHELVITE:											
16*a*. W. Cheyenne Cañon, Colorado	30.26	12.70	1.22	6.81	46.20	—	5.49	.51	103.19	2.74	100.45
16*b*. W. Cheyenne Cañon, Colorado[g]	—	—	1.5	6.1	46.0	—	—	—	—	—	—

* CaO, Al_2O_3, Na_2O, K_2O, TiO_2, H_2O.

HELVITE

1. R. A. Haines, *Acad. Nat. Sci. Phila. Proc.*, **101** (1882).
2. B. E. Sloan, *Chem. News.*, **46,** 195 (1882).
3. C. F. Rammelsberg, *Annalen d. Physik u. Chemie* (Pogg.), **93,** 453 (1854).
4. Miers and Prior, *Mineral. Mag.*, **10,** 10 (1892). (Recalculated after deducting 4.6% fluorite.)
5. J. F. Gmelin, *Annalen d. Physik u. Chemie* (Pogg.), **3,** 53 (1825), corrected by C. F. Rammelsberg, *Handb. d. Mineralchemie*, 701 (**1860**).

6, 8. Teich, *Mineral. Russlands*, **7,** 322, 323 (1866).

7. Bäckström, *Zeits. Krist.*, **16,** 176 (1890).

9. W. Fischer, *Centralbl. Mineral.* (**1926**), A, p. 33.

10. V. M. Goldschmidt (*Videnskap. Skrifter*, No. 1, 396, **1911**). *Zeits. Krist.*, **55,** 95 (1915).

11. H. Bowley, *Jour. Roy. Soc. W. Australia*, **18,** 83 (1932).

12. R. E. Stevens, *Am. Mineral.*, this issue.

DANALITE

13. Miers and Prior, *Mineral. Mag.*, **10,** 10 (1892).

*14, 15. J. P. Cooke, *Am. Jour. Sci.*, Ser. 2, **42,** 73–79 (1866),

GENTHELVITE

16*a*. F. A. Genth, *Am. Jour. Sci.*, Ser. 3, 44, 385, 1892.

16*b*. R. E. Stevens, *Am. Mineral.*, this issue.

[a] Includes 8.66% Mn calculated as MnO.

[b] Fe_2O_3, 2.26% calculated as FeO.

[c] Includes 8.59% Mn calculated as MnO.

[d] Includes 9.77% Mn calculated as MnO.

[e] Includes 8.67% Mn calculated as MnO.

[f] With Al_2O_3.

[g] Partial analysis made on a minute quantity of material.

* Cooke's analysis on Rockport material was checked by Stevens.

On the basis of interpretation that the members of the helvite group may be considered as a three component system, the percentages of these three components, or end members, with the determined specific gravity (G) and index of refraction (n) of the minerals are shown in Table 7 below. The placement of these 16 members of the helvite group on a compositional basis is shown in Fig. 5. In this figure, the 2 per cent of the magnesium component in No. 6 and the 6 per cent of the magnesium component in No. 9, are added to the percentages of the manganese component.

TABLE 7. PERCENTAGES OF COMPONENTS CALCULATED FROM ANALYSES OF MEMBERS OF THE HELVITE GROUP, WITH DETERMINED SPECIFIC GRAVITY (G) AND INDEX OF REFRACTION (*n*)

No	Locality	Mn Comp.	Fe Comp.	Zn Comp.	G[a]	*n*	Mineral
1	Amelia	96	4	0	—	—	Helvite
2	Amelia	95	5	0	3.25	—	
3	Norway	92	8	0	3.17	—	
4	Schwarzenberg	91	9	0	3.20	—	
5	Schwarzenberg	84	16	0	3.17	—	
6	Lupikko[c]	79	21	0	3.30[b]	—	
7	Sigtesö	75	25	0	—	—	
8	Ilmen Mts.	70	30	0	3.33	—	
9	Argentina[d]	64	28	8	3.29	1.74[e]	
10	Hörtekollen	56	30	14	3.32	1.747	
11	Australia	55	31	14	3.31	1.765[f]	
12	Iron Mountain	53	36	11	3.33	1.746[g]	
13	Cornwall	22	70	8	3.35	1.758[g]	Danalite
14	Rockport[h]	13	55	32	3.43	1.755[g]	
15	Gloucester	11	55	34	—	—	
16	Colorado	2	13	85	3.66	1.744[g]	Genthelvite

[a] Rounded off to two decimals.

[b] Average of range 3.23–3.37.

[c] Includes two per cent of the magnesium component.

[d] Includes six per cent of the magnesium component.

[e] Given as slightly under 1.74.

[f] Probably too high. See text.

[g] By J. J. Glass.

[h] Given as 1.754 in Dana-Ford *Textbook of Mineralogy*.

TABLE 8. THEORETICAL COMPOSITIONS OF THE THREE COMPONENTS OF THE HELVITE GROUP

	Mn Component	Fe Component	Zn Component
MnO	51.12	—	—
FeO	—	51.44	—
ZnO	—	—	54.54
BeO	13.52	13.43	12.58
SiO_2	32.46	32.25	30.19
S	5.78	5.74	5.37
	102.88	102.86	102.68
Less O=S	2.88	2.86	2.68
	100.00	100.00	100.00

The calculated percentages of the components given in Table 7 are based on the theoretical compositions of the three end-member components, as given in Table 8.

The determined specific gravities, as listed in Table 7, range from 3.17 to 3.66. From a study of these figures, the specific gravities are probably close to 3.20, 3.35, and 3.70 for the manganese, iron, and zinc components respectively.

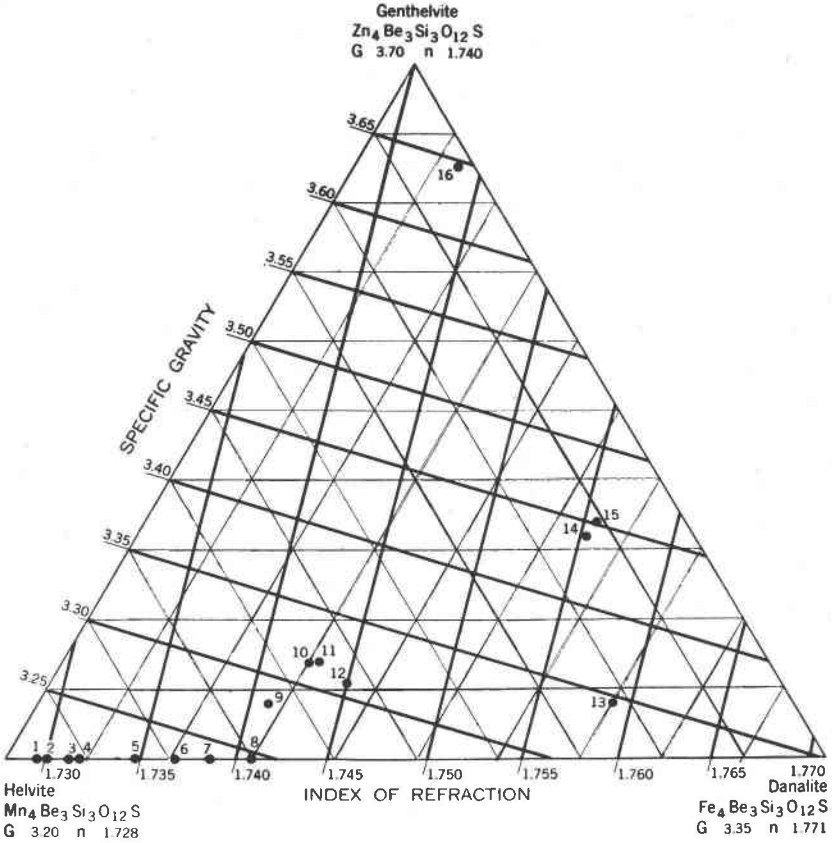

FIG. 5. Diagram showing the correlation of the variations in specific gravities and indices of refraction with the chemical composition of members of the helvite group.

The specific gravity variation lines (heavy, solid) shown in Fig. 5 are based on these values. The following comparison of calculated and determined values confirms the approximate correctness of these figures.

The agreement between the calculated and determined specific gravities is close and indicates that the values given for the end member components are very nearly correct.

TABLE 9. COMPARISON OF CALCULATED AND DETERMINED SPECIFIC GRAVITIES (G) FOR THE HELVITE GROUP

Number	G Calculated	G Determined	Difference
1.	3.21	—	—
2.	3.21	3.25	−.04
3.	3.21	3.17	+.04
4.	3.21[a]	3.20	+.01
5.	3.22[a]	3.17	+.05
6.	3.23	3.30[b]	−.07
7.	3.24	—	—
8.	3.25	3.33	−.08
9.	3.29	3.29	0
10.	3.32	3.32	0
11.	3.32	3.31	+.01
12.	3.31	3.33	−.02
13.	3.35	3.35	0
14.	3.44	3.43	+.01
15.	3.45	—	—
16.	3.65	3.66[c]	−.01

[a] Pauling (25) calculated 3.23 from x-ray data.

[b] Given as 3.23–3.37.

[c] G=2.626–2.661 given in *Dana*, Sixth Edition, Supplement, p. 1032, is a typographical error for 3.626 to 3.661.

Barth (1) calculated 3.24, 3.34, and 3.57 for the three components. The last value obviously is too low as Genth found 3.66 for the genthelvite (85 per cent Zn component) from Colorado.

In an attempt to correlate the indices of refraction with other recorded data for the helvite group, indices of refraction have been determined on as many samples as could be obtained for this purpose. Data in the literature are very incomplete. Determinations of indices of refraction have been made for only a few of the analyzed members of the helvite group. Of seven determinations in the literature only three are for analyzed material; one of these (No. 9) is approximate, one (No. 11) is obviously in error, and one (No. F in Table 10) is probably a misprint. Four new determinations on analyzed material, including the helvite from Discovery Gulch, Iron Mountain, New Mexico, have been made. Unfortunately, material from New Mexico with the highest and lowest indices is not available in quantity sufficient for chemical analysis. Nine additional determinations of indices were also made on unanalyzed samples (Table 10). Published indices have been included in the tabulation.

The index (1.765) given by Bowley (2) for helvite from West Australia (No. 11) is believed to be too high. He used measured proportions of iodides and piperine which when heated may or may not have formed a melt of the calculated index of refraction. That his melt probably did not have this high index is suggested by his statement that he obtained the same high value for the danalite from Rockport, whereas we found the lower value of 1.755. The helvite from West Australia has a calculated index of 1.743. Confirmation of the suggestion that Bowley's index value is too high lies in the very close equality of component composition of his helvite (No. 11) with Nos. 10 and 12 whose measured indices are 1.747 and 1.746, respectively. The specific gravities of Nos. 10, 11, and 12 are likewise almost identical.

The index of refraction, 1.737 ± .003 (Table 10 "F") given for danalite from Rockport, Mass., by Larsen (19) (1st edition) is probably a misprint for 1.757 ± .003, as we obtained 1.755 for the identical material (U.S.N.M. 45943) on which Larsen made his determination.

TABLE 10. INDICES OF REFRACTION ON UNANALYZED MEMBERS OF THE HELVITE GROUP
(Indices for members marked with a star (*) were determined for this paper)

	Locality	Index of Refraction	Remarks	
HELVITE:				
*A.	Schwarzenberg, Saxony	1.728–1.730	Variable	Specimens loaned by the U. S. National Museum, No. R-3395; and by Columbia University.
*B.	Silverton, Colorado	1.728–1.734	Variable	Sample contributed by Ward C. Smith.
*C.	Breitenbrunn, Saxony	1.733	—	Sample loaned by Columbia University.
D.	Butte District, Montana	1.734	Doubtful trace of zinc	D. F. Hewett (15).
*E.	Iron Mountain, New Mexico	1.737	—	Lower Star body.
F.	Rockport, Massachusetts	1.737	Probably a misprint for 1.757.	E. S. Larsen (19).
G.	Langesundfiord, Norway	1.739	—	Levy and Lacroix (21).
H.	Eureka Gulch, Colorado	1.74	No zinc	W. S. Burbank (4).
*I.	Bartlett, New Hampshire	1.742	Yellow variety	Sample contributed by Prof. Charles Palache, Harvard University, and similar material contributed by Lester W. Strock.
*J.	Amelia, Virginia	1.743	—	U. S. National Museum, No. R-3397.
DANALITE:				
*K.	Bartlett, New Hampshire	1.754	Red variety	See "I".
*L.	Rockport, Massachusetts	1.755	—	U. S. National Museum, No. C-2684.
*M.	Iron Mountain, New Mexico	1.750–1.759	Variable, no zinc	Collected at North End Peak.

A large number of calculations based on the indices of refraction recorded in Table 7 and Table 10 indicate that the indices for the end member components are probably close to the values: $n=1.728$ for the Mn-component, 1.771 for the Fe-component, and 1.740 for the Zn-component.

From these established values for the end member components, a comparison of the calculated and the determined indices for members of the helvite group, omitting the probably too high value given for the helvite from Australia (No. 11), is shown in the table below.

TABLE 11. COMPARISON OF CALCULATED AND DETERMINED INDICES OF REFRACTION (n) FOR THE ANALYZED MEMBERS OF THE HELVITE GROUP

Number	Locality	n Calculated	n Determined	Difference
4	Schwarzenberg	1.732	1.730[a]	+.002
9	Argentina	1.739	1.74	—
10	Hörtekollen (Christiana District)	1.743	1.747	−.004
12	New Mexico	1.745	1.746	−.001
13	Cornwall	1.759	1.758	+.001
14	Rockport	1.755	1.755	.000
16	Colorado	1.744	1.744	.000

[a] Not on analyzed material. Average value for four samples ranging from 1.728 to 1.733.

Two samples of analyzed helvites have the same index (1.728) as the Mn-component. These low values may be due to the presence of a small amount of magnesium which would lower the index of refraction appreciably. Only two of the sixteen analyses listed in Table 5 report any MgO, one (No. 9) showing 2.24 per cent MgO.

TABLE 12. CHARACTERISTICS, OCCURRENCES, AND ASSOCIATIONS OF ANALYZED MEMBERS OF THE HELVITE GROUP

	Locality	Color	Spec. Characteristics	Occurrence	Associated Minerals
HELVITE:					
1, 2.	Amelia, Virginia	Sulphur yellow	Translucent, waxy, crystalline masses	Mica and feldspar pegmatite	Spessartite, amazonstone, microlite, monazite, etc.
3.	Norway (southern)	Sulphur yellow	Translucent crystals	Zircon syenite	Zircon, feldspars, etc.
4, 5.	Schwartzenberg, Saxony	Sulphur yellow	Translucent, waxy, tetrahedral crystals	In gneiss	Garnet, scheelite, quartz, fluorite, calcite.
6.	Lupikko, Finland	Reddish-brown	Translucent crystals 1½ inches through	Data not availble	Magnetite and fluorite.
7.	Sigtesö (Island)	Sulphur yellow to brown	Translucent to transparent crystals	Augite-syenite	Aegirite, nephelite, feldspar, etc.
8.	Ilmen Mountains, near Miask	Yellow	Vitreous, translucent, large spherical masses	In pegmatite	Topaz, phenakite, monazite, pyrochlore, etc.
9.	Sierra de Cordoba, Argentina	Dark brown (stained)	Tetrahedral crystals, greasy luster	Contact metamorphic zone	Garnet, epidote, calcite, fluorite, chlorite, etc.
10.	Hörtekollen, Christiana District, Norway	Yellow to reddish	Tetrahedral crystals, vitreous	Contact metamorphic zone	Magnetite, fluorite, feldspar, etc.
11.	Mt. Francisco, West Australia	Carob brown	Oxidized angular masses up to 2 inches across	Not given	None given.
12.	Iron Mountain, Discovery Gulch, New Mexico	Amber to mahogany	Tetrahedral crystals, vitreous to resinous	Contact metamorphic zone, magnetite-tactite	Magnetite, fluorite, chlorite, etc.
DANALITE:					
13.	Redruth, Cornwall	Columbine red	Large, rough tetrahedral crystals, vitreous	Not given. Specimen purchased	Quartz, arsenopyrite, chlorite.
14.	Rockport, Massachusetts	Flesh-red to gray	Crystal masses, octahedral, and grains, vitreous to dull	In granite	Lepidolite, fluorite, amazonstone, etc.
15.	Gloucester, Massachusetts	Rhodonite red	Translucent, vitreous	In granite	(Same).
GENTHELVITE:					
16.	West Cheyenne Cañon, Colorado	Rose-red to brown	Crystal 15×17 mm. vitreous	Not given	Quartz and astrophyllite.

TABLE 13. CHARACTERISTICS, OCCURRENCES, AND ASSOCIATIONS OF UNANALYZED MEMBERS OF THE HELVITE GROUP[a]

	Locality	Color	Spec. Characteristics	Occurrence	Associated Minerals
HELVITE:					
A.	Schwarzenberg, Saxony	Sulphur yellow	Translucent, waxy.	In gneiss	Garnet, scheelite, quartz, fluorite.
B.	Silverton, Colorado	Yellow to greenish yellow	Waxy, translucent, zoned	In veins of manganese silicates and carbonates	Rhodonite and rhodochrosite.
C.	Breitenbrunn, Saxony	Sulphur yellow	Vitreous, translucent	—	—
D.	Butte District, Montana	Lemon yellow	Waxy luster, grains	In veins of manganese silicates and carbonates	Rhodonite, rhodochrosite, quartz, sulfides.
E.	Lower Star, Iron Mtn., New Mexico	Pale yellow	Vitreous luster	In ribbon rock tactite, contact metamorphic zone	Fluorite, magnetite, chlorite.
F.	Rockport, Massachusetts	Flesh red	Vitreous crystalline mass	In granite	Lepidolite, fluorite, feldspar.
G.	Langesundfiord, Norway	Yellow	Translucent	In pegmatite in augite-syenite	Aegirite and nephelite.
H.	Eureka Gulch, Colorado	(Same as "B" above)			
I.	Bartlett, New Hampshire	Honey yellow	Translucent to transparent	In iron mines	Fluorite, magnetite, sphalerite, galena, etc.
J.	Amelia, Virginia	Sulphur yellow	Translucent, waxy luster	In feldspar and mica pegmatite	Spessartite, monazite, microlite, amazonstone.
DANALITE:					
K.	Bartlett, Hew Hampshire	Flesh red	Translucent	In iron mines	Magnetite fluorite, galena, sphalerite.
L.	Rockport, Mass.	Same as No. 14 (Table 12), and same as "F" above.			
M.	North End Peak, Iron Mtn., New Mexico	Creamy to honey yellow	Translucent	Contact metamorphic zone, ribbon rock tactite	Fluorite, grossularite, magnetite, chlorite, etc.

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[a] Refer to Table 12.

Values of a_0 were measured by Joseph M. Axelrod of the Geological Survey for the several available members of the helvite group with the results shown in Table 14. The data of Barth (1) and Pauling (25) are included.

TABLE 14. MEASURED VALUES OF a_0 FOR MEMBERS OF THE HELVITE GROUP

Mineral	Locality	Composition			a_0
		Mn	Fe	Zn	
Helvite	Saxony[a]	90	10	0	8.273 ± .005. Axelrod.
Helvite	Saxony	90	10	0	8.25. Pauling.
Helvite	Hörtekollen	56	30	14	8.19. Barth.
Helvite	New Mexico	53	36	11	8.21 ± .02. Axelrod.
Danalite	Cornwall	22	70	8	8.199 ± .005. Axelrod.
Danalite	Rockport	13	55	32	8.155 ± .005. Axelrod.
Genthelvite	Colorado	2	13	85	8.115 ± .005. Axelrod.

[a] Composition given by Pauling.

The values of a_0 determined by Barth and Pauling fall within the range of the values measured by Axelrod, but Gottfreid's (10) value of 8.52 for a helvite of unstated origin must be considerably in error.

Based on the measurements made by Axelrod, as given above, the extrapolated values of a_0 for the end member components are 8.27, 8.18, and 8.10 for the Mn, Fe, and Zn members, respectively.

Calculated values of a_0 based on the values just given, agree closely with the measured values (Table 15).

TABLE 15. COMPARISON OF CALCULATED AND MEASURED VALUES OF a_0.

Mineral	Locality	Calculated a_0	Measured a_0
Helvite	Saxony	8.261	8.273
Helvite	Saxony	8.261	8.25
Helvite	Hörtekollen	8.219	8.19
Helvite	New Mexico	8.219	8.21
Danalite	Cornwall	8.193	8.199
Danalite	Rockport	8.166	8.155
Genthelvite	Colorado	8.114	8.115

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