THE GEOLOGY, PETROGRAPHY, AND MINERALOGY OF THE VICINITY OF ITALIAN MOUNTAIN, GUNNISON COUNTY, COLORADO

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INTRODUCTION

By Whitman Cross

The minerals described by Mr. Shannon in the second part of this paper were collected in 1885 and 1887 during the geological survey of the Crested Butte quadrangle, which is on the southern slope of the Elk Mountains in central Colorado. I was at that time assistant to the late S. F. Emmons, specially charged with examination of the igneous rocks, while the stratigraphic and structural geology was the particular field of my colleague, the late George H. Eldridge.

These minerals occur mainly in much altered sediments adjacent to certain large intrusive masses. It was recognized that the occurrence was of unusual interest and deserved much more extended examination than could be given to it at the time of discovery. It was hoped that opportunity might be found at some later date to return to the area for a more thorough study of the minerals and the problem of their origin. But the exigencies of other work have not permitted the carrying out of this plan.

In the Anthracite-Crested Butte folio of the United States Geological Survey, issued in 1894, there is brief reference to the occurrence of these minerals, but all details, including the chemical analyses by L. G. Eakins, here given in Mr. Shannon's description, were left for some later publication.

GEOLOGY OF THE MINERAL DISTRICT

Figure 1 presents the principal geographical and geological features of the area from which most of the minerals to be described were obtained. It represents the geology as shown on the areal sheet of the Anthracite-Crested Butte folio except that the several Paleozoic formations are combined in one unit. Cement Creek and Brush Creek are tributaries of Slate River, which enters the Gunnison near Gunnison City. Taylor River is the principal northern branch of the Gunnison, and the basin under the Sawtooth Range is its extreme head.

The Archean gneisses and schists of the northeastern corner of the figured district are on the western border of a large area, the dominant feature of which is the Sawatch Range, whose crest is some 10 miles to the eastward.

Upturned against the pre-Cambrian mass is a series of five Paleozoic formations. These are, in order of succession: 1, Sawatch quartzite (Cambrian); 2, Yule limestone (Silurian); 3, Leadville limestone (Carboniferous); 4, Weber formation (Carboniferous); and 5, the Maroon conglomerate (Carboniferous). The four lower formations are relatively thin, none exceeding 500 feet in thickness, except locally. In contrast the Maroon conglomerate attains a maximum thickness of about 2,500 feet, but only its lower part is present in the area of the figure. A remnant of Jurassic and Cretaceous (Dakota) beds is represented as dipping northeasterly into the mass of Hunters Hill. This was interpreted by Eldridge as due to deposition against a bluff of Carboniferous sediments, but in view of the complex structure referred to later an overthrust fault seems a more probable explanation.

The sedimentary rocks of the area of Figure 1 are penetrated by three large intrusive bodies, one notable dike and several minor ones, which are no doubt but arms of the large masses. The principal body extends westward for 10 miles, and then turns north for several miles into the heart of the Elk Mountains. A similar branch runs north from the Sawtooth Range. This is the southeastern extremity of the mass, originally mapped by the Hayden survey, the relations of which to the great fault-fold of the Elk Mountains have long excited the interest of geologists. The other two main intrusives occur in contact in the Italian Peak group. They may all be connected at some depth.

In the Anthracite-Crested Butte folio I called the mass in South Italian Mountain granite and the other two bodies diorite. Unhappily, both names fail to indicate the characteristic association of plagioclase and orthoclase; each present in important amount in both rocks. They belong to the group intermediate as regards the dominant feldspathic constituent between granite and quartz diorite for which I have long used the term quartz monzonite. The "granite" of South Italian Mountain probably has nearly as much plagioclase as the "diorite," though orthoclase is the more conspicuous in the former rock.

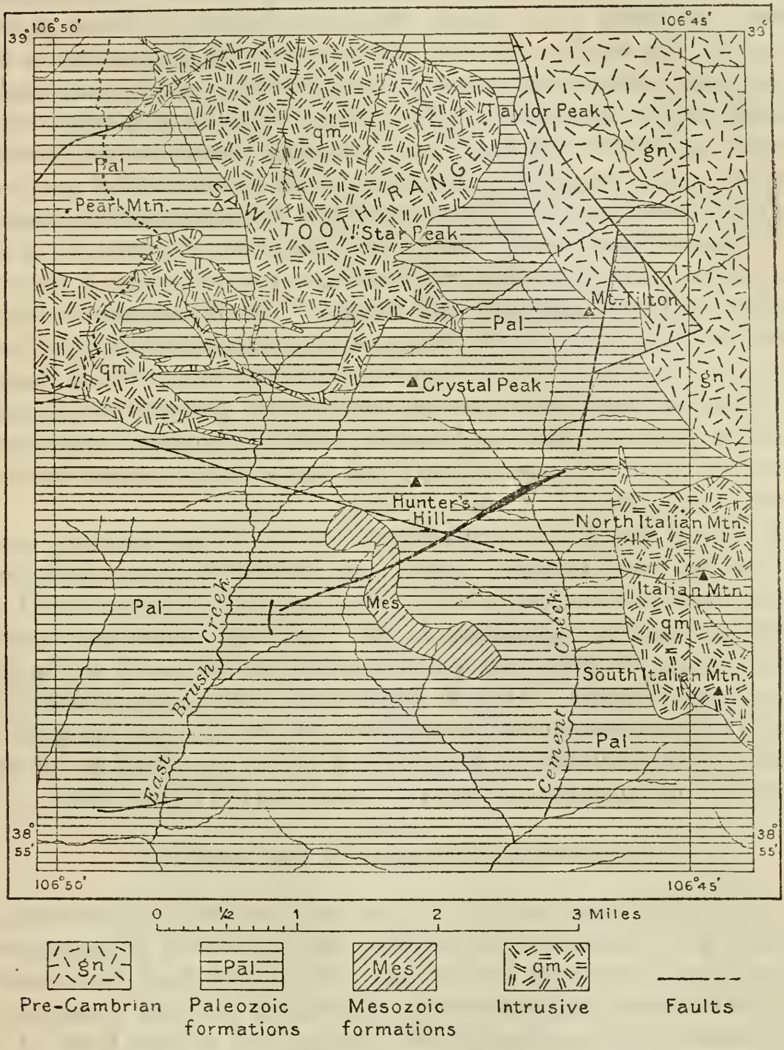


FIG. 1.—GEOLOGIC MAP OF VICINITY OF ITALIAN MOUNTAIN

The Paleozoic bed lying between the intrusive masses and the pre-Cambrian complex are not only highly metamorphosed but are folded and faulted in most intricate manners. On the folio structure section sheet of the Crested Butte quadrangle Mr. Eldridge has indicated by symbols a great variety of dips, both anticlinal and synclinal axes and others of complex folding. But he could not work out all details of structure in the time at his disposal.

It is natural to inquire how nearly contemporaneous the periods of faulting and folding, intrusion and metamorphism, may have been. The zone of intense folding along an axis approximately parallel to the basal contact zone crossing Mount Tilton extends north and south from Italian Peak for 10 miles or more in each direction, far beyond the limit of metamorphism and intrusion, and it appears certain that the major structural feature is independent of and earlier than the intrusive action while the metamorphism is clearly associated with the latter. It seems inconceivable, however, that the large intrusions can have occurred in such folded and fractured rocks without adding materially to the structural complexity.

It appears that the Elk Mountains fold is one element in the system of orogenic movements which occurred at the close of the Cretaceous and continued into the Eocene. The intrusions of Italian Mountain and the Sawtooth Range are considered as belonging with the large number of stock, dike, and laccolith intrusions of similar petrographic character occurring over a wide area in Colorado and adjacent parts of Utah and Arizona. There is, however, no evidence thus far noted to suggest that they are much younger than the structural features.

The great San Juan mountain area of volcanic and intrusive rocks lies south of the Gunnison Valley. Its lower volcanics extend down to the Gunnison Canyon in some places and there meet similar if not identical materials belonging to the West Elk Mountains breccia, which forms an important mass extending as far north as the Anthracite quadrangle. Thus it appears that the igneous history of the Elk Mountains should be considered as but one local phase of the great volcanic activity in southwestern Colorado, which in the San Juan region continued at intervals through all Tertiary time.

PETROGRAPHIC CHARACTER OF THE INTRUSIVES

The petrographic character of the intrusive rocks in the area of Figure 1 is simple and, in general, similar to that characterizing many other occurrences in Colorado. The largest body has a nearly uniform composition and texture wherever it has been examined in the Crested Butte quadrangle for 10 miles west of Star Peak. It is of varying shades of gray in color, evenly fine-grained, most mineral particles ranging between 0.5 and 2 mm. in diameter. Plagioclase, orthoclase, quartz, biotite, hornblende, with occasional green augite, are the principal minerals. The lighter colored minerals predominate. Biotite and hornblende occur rather in grains than in leaves or prisms and their even distribution is a marked feature. Magnetite, apatite, titanite, zircon, pyrite, and allanite are the accessories in decreasing order of abundance. Honey-yellow titanite grains or crystals are characteristic but allanite is very rare.

Plagioclase is the most abundant constituent, occurring in stout little prisms often with an irregular fringe of oriented orthoclase. Zonal variation is usual, the center being $Ab_3\ An_4$ is some crystals determined and the outer zones ranging to oligoclase. Orthoclase and quartz play similar rôles, each occuring commonly in anhedral grains but not infrequently serving as matrix for other mineral particles in irregular patches of microscopic size.

Biotite and hornblende, of usual characters, are nearly always fresh, chlorite and epidote being the more frequent alteration products.

In the following table is given a chemical analysis of this rock by L. G. Eakins, together with others of nearly allied intrusives of other localities. The corresponding norms are shown in another table. Both analyses and norms have been taken from Washington's Tables.[1] All analyses were made in the laboratory of the United States Geological Survey.

Table of analyses

	I	II	III	IV	V	VI	VII	VIII
SiO_2	62.71	62.85	61.42	63.91	64.85	62.10	58.74	63.39
Al_2O_3	17.06	16.21	17.69	17.07	16.57	15.47	16.02	16.58
Fe_2O_3	3.79	3.08	4.24	4.39	2.10	2.64	4.16	1.41
FeO	2.74	1.46	1.74	1.51	2.15	3.15	3.50	3.08
MgO	1.78	1.47	1.81	.81	2.14	2.57	2.18	2.15
CaO	5.51	4.72	5.29	4.47	4.01	5.31	5.12	4.76
Na_2O	3.54	3.49	3.14	3.48	3.71	3.56	3.26	3.47
K_2O	2.96	3.10	3.19	3.74	3.10	3.15	2.39	2.79
H_2O+	} .24	2.03	} .97	.33	.35	.72	1.60	1.87
H_2O-		.29				.14	.83	.22
TiO_2	----------	.41	.37	----------	.91	.81	1.29	.44
P_2O_5	----------	.48	.14	.21	.14	.27	.56	.14
MnO	Trace.	.15	.19	----------	----------	----------	.22	----------
BaO	----------	.11	.09	----------	----------	----------	.10	.11
FeS_2	----------	----------	----------	----------	----------	----------	.11	----------
ZrO_2	----------	----------	----------	----------	----------	----------	.05	----------
	100.33	99.85	100.28	99.92	100.03	99.89	100.13	100.41
Analyst	Eakins.	Chatard.	Eakins.	Eakins.	Whitfield.	Steiger.	Hillebrand.	Stokes.

[1] Washington, H. S., Chemical Analyses of Igneous Rocks, U. S. Geol. Survey Prof. Paper 99, 1917.

Table of norms

	I	II	III	IV	V	VI	VII	VIII
Q	16.44	19.98	17.64	19.74	19.50	15.48	17.04	18.06
Or	17.79	18.35	18.90	21.68	18.35	18.90	14.46	16.68
Ab	29.87	29.34	26.20	29.34	31.44	29.87	27.77	29.34
An	22.24	19.46	24.74	20.29	19.18	16.96	21.68	21.13
di	4.02	.86	.65			6.02		1.33
hy	4.44	3.30	4.20	2.00	16.19	5.88	6.82	8.43
mt	5.57	3.94	5.34	4.87	3.02	3.71	6.03	2.09
il		.76	.76		1.67	1.52	2.43	.91
hm		.32	.64	1.12				
ap		1.01	.34	.67	.34	.67	1.34	.34
	(1)II.4.3(3)4 Tonalose.	I(II)4.3(3)4 Yellowstonose.	I(II)4.33″ Amiatose.	1″.4″.3.3″ Amiatose.	I(II)4″.3(3)4 Yellowstonose.	″II.4.3″.4 Tonalose.	″II.4.3″.4 Tonalose.	(1)II.4.3.(3)4 Tonalose.

I. Quartz monzonite. West Brush Creek, Crested Butte quadrangle, Colo. Nearly identical with the mass in the Sawtooth Range. Washington's Tables, p. 374.

II. Quartz monzonite. From a large asymmetrical laccolith, Mount Marcellina, Anthracite quadrangle, Colo. Washington's Tables, p. 254.

III. Quartz monzonite porphyry. Storm Ridge. Anthracite quadrangle, Colo. Washington's Tables, p. 246.

IV. Quartz monzonite. Sultan Mountain, near Silverton, San Juan region, Colo. Washington's Tables, p. 246.

V. Quartz monzonite. Electric Peak, Yellowstone National Park. Washington's Tables, p. 254.

VI. Quartz monzonite. Frisco district, Utah. Washington's Tables, p. 374.

VII. Quartz monzonite, near Pinal Peak, Globe district, Arizona. Washington's Tables, p. 376.

VIII. Quartz monzonite porphyry. Grass Valley, Nevada County, Calif. Washington's Tables, p. 382.

The intrusive mass which extends from North Italian Mountain to the summit of Italian Peak proper is very much like the fine-grained quartz monzonite of which a description and analysis have been given. It is, however, more variable in texture and composition than the larger body. The common facies is a quartz-biotite-hornblende rock, but augite appears in some places, and near the contacts hornblende is apt to be more abundant than elsewhere. A crude prophyritic texture appears here and there, though a development of orthoclase in a few phenocrysts 1 to 2 cm. in diameter and locally plagioclase and hornblende are conspicuous.

The rock of South Italian Mountain differs but little in any essential respect from that of the northern summit. It is the older intrusive and, due to incipient alteration of the orthoclase by dissemination of ferric hydroxide particles all through most grains, there is a dull pinkish tinge to this feldspar, causing the appearance of more potash feldspar than is actually present. The same impregnation is also exhibited to a lesser extent in the plagioclase. Reexamination of this rock makes it probable that the plagioclase (oligoclase-andesine) is probably as abundant as orthoclase, if not more so, and the name quartz-monzonite applies to that rock of both intrusives.

As shown by the Hayden map, the intrusive of South Italian Mountain extends about 3 miles to the southeast, forming a nearly straight ridge. The great amount of talus and slide rock about both intrusives effectually conceals contacts with the sedimentary beds except in a few localities. At observed contact exposures the intrusive was obviously crosscutting.

The long dike crossing Hunters Hill is presumably an offshoot from the conduit of the North Italian Mountain body, for its central portion is very similar to the hornblendic contact zone facies of the large mass. At its maximum width of 250 feet in Cement Creek Valley there are dark lamprophyric contact zones 20 feet or more wide on either side of this dike, bu they are inconspicuous in narrower portions.

OCCURRENCE OF THE MINERALS

The minerals to be described by Mr. Shannon occur very abundantly in a contact zone, of very variable width from place to place, about the quartz monzonite intrusive masses above considered. Most of them also occur in crystalline coatings on the walls of narrow fissures in the intrusive rocks or perhaps filling such cracks completely.

The most highly altered sediments, in which the minerals are most perfectly and freely developed, are in the wedge-shaped area caught between the two intrusive masses of the Italian Mountain group. At and about the summit of the central peak where several small dike offshoots penetrate the sediments the secondary minerals are abundant and the original character of the strata entirely obliterated. The yellowish-green fluoriferous epidote and chlorine-bearing mizzonite, of which Mr. Shannon quotes analyses by Eakins, were found on the central peak of the group.

Another exceptionally fine spot for collecting the minerals is near the summit of North Italian Mountain on the west and north. It was here that a carbonaceous shale of the Weber formation was changed to a graphitic mass with garnet crystals, black from included particles.

The extensive alteration of strata about the larger and very irregular intrusive body results in the formation of secondary minerals of good crystal habit in many places but far less commonly than in Italian Mountain. But the presence of garnet, epidote, and pyroxene in crystals attracting attention was noted in many places a mile or more from the surface contact of the intrusive body. For most of the contact zone in the Crested Butte quadrangle the Maroon conglomerate is the formation adjacent to the igneous rock. The striking red color of the beds, normal where they are distant from intrusive masses, gives way in the contact zone to somber purple or mottled red and green and other tones. Induration by hornfels formation causes the sediments to resist erosion almost as much as does the quartz monzonite, and where the former have been somewhat bleached it is often no easy matter to detect the actual contact except by close examination. Teocalli Mountain (13,220 feet) exhibits a striking example of the change in color of beds in the contact zone.

One commonly observable feature of the alteration of the limestone pebbles which are abundant in the Maroon conglomerate is the change of the mass of the pebble into white granular marble, while the impurities have been concentrated in one or at least only a few good-sized crystals of garnet.

In some parts of the great intrusive body of quartz monzonite there are many huge xenoliths of sedimentary beds torn loose from the irregular walls. Some 16 of these were large enough to indicate on the Crested Butte map. Such bodies are naturally very greatly altered, much like the contact zone rocks. Few of them were accessible for close examination.

The quartz monzonite intrusives have suffered very little from alteration of any kind. But they were considerably and irregularly fissured at an early date, and in these fissures, seldom more than an inch or two in diameter, there was deposited a more or less complete filling of one or more of the secondary minerals characteristic of the contact zone. In some places an aplitic or pegmatitic filling is complete. Mr. Shannon has examined the specimens collected and finds the species described in the following pages generally occurring in the wall linings where cracks have been but partially filled.

In conclusion, there are several special points of interest attaching to this district of contact zone mineralization which may be summarized. The minerals are mainly silicates such as are commonly produced in contact zones where a sedimentary section of various rocks, largely carbonates, is penetrated by extensive igneous bodies. The reactions resulting in the new compounds arise from the permeation of the sediments under a condition of high heat, long sustained, by hot aqueous solutions carrying absorbed gases and other "mineralizing agents."

The particular interest of this occurrence lies partly in the unusual perfection of development of some species, as vesuvianite, garnets, pyroxenes, and amphiboles. The specimens obtained were secured in a short time in the course of geological field work. It is evident that when carefully explored as a mineral locality a much more extensive collection and doubtless of finer quality can be made.

Another feature of note is that while the intrusive masses are very similar petrographically to many others known in the adjacent country to the south or west there is no corresponding contact zone alteration of the sediments in any other locality. The presence of chlorine and fluorine in mizzonite and epidote, respectively, on Italian Peak shows that unusual mineralizers accompanied the quartz monzonite magma in that particular intrusion, but it seems unwarranted to assume that any large part of the extensive mineral formation was due to the activity of these agents.

The greatly folded and faulted or crushed condition of the sediments in the mineralized area has been emphasized. It seems probable that the high permeability of the intruded rock complex by solutions or gases was the most important factor in the case.

DESCRIPTION OF THE MINERALS

By Earl V. Shannon

In the collection of some 200 specimens from the Italian Mountain locality 28 minerals were observed. These are described in some detail in the following pages in the order listed below.

1. Garnet.
2. Diopside.
3. Sahlite.
4. Vesuvianite.
5. Epidote.
6. Albite.
7. Anorthite.
8. Orthoclase.
9. Titanite.
10. Talc.
11. Chlorites.
12. Mizzonite.
13. Quartz.
14. Scolecite.
15. Thomsonite.
16. Stilbite.
17. Heulandite.
18. Chabazite.
19. Graphite.
20. Magnetite.
21. Hematite.
22. Chalcedony.
23. Siderite.
24. Ankerite.
25. Calcite.
26. Pyrite.
27. Apatite.
28. Barite.

GARNET

Garnet is the most abundant mineral in the collection and occurs in a variety of forms, habits, and colors, and exhibits considerable variation in composition and associations.

The most abundant garnet is pale buff in color, varying to almost colorless in some specimens. This forms more or less well-developed crystals varying from 1 mm. to nearly 4 cm. in diameter. The average color is light buff but varies from practically colorless through various shades of light brown to greenish buff or green. This garnet occurs lining open spaces in massive garnet or garnet-diopside hornfels as loosely assembled aggregates of large garnets or as druses along the open centers of seams. Some of the crystals are transparent, most of them from translucent to opaque in the specimen. The smaller crystals are the most perfectly developed. All of them have the same habit, the dodecahedron *d*(110) modified by narrow faces of the hexoctadedron *s*(321). Rarely the dodecahedron alone is present, and in a few specimens the hexoctahedron forms the dominant faces, reducing the faces of the dodecahedron to minute size.

Minerals associated with this garnet in the 30 crystallized specimens included in the collection include diopside, vesuvianite, epidote, pyrite, and the zeolites, chabazite, stilbite, heulandite, and scolecite. While the diopside is probably contemporaneous with the garnet in part, all the others rest upon the garnet crystals or occupy the interstices between them and seem later.

This buff garnet was analyzed by Eakins, but the exact specimen used for the analysis is not indicated, 24 having the same number. The analysis is given below.

Analysis of buff garnet

[L. G. Eakins, analyst]

Constituent	Per cent	Ratios		
SiO_2	39. 26	0.655	0.655	1.00 × 3
Al_2O_3	19. 63	.192	.220	1.01 × 1
Fe_2O_3	4. 48	.028		
MnO	Trace.			
CaO	36. 61	.653	.653	.00 × 3
MgO	Trace.			
H_2O	. 08			
Total	100. 06			

The ratios obtained from this analysis indicate very exactly the garnet formula, $3R''O. R'''_2O_3. 3SiO_2$, and the absence of ferrous iron, magnesia, and manganese indicate that it is a simple two-component isomorphous mixture of the lime-alumina garnet grossularite, $Ca_3Al_2Si_3O_{12}$, and the lime-ferric iron garnet andradite, $Ca_3Fe'''_2Si_3O_{12}$. The above garnet analysis indicates these two compounds to be present in the proportions of 86 per cent of grossularite to 14 per cent of andradite. The specific gravity of the analyzed sample was determined by Eakins to be 3.629 at 23° C. The calculated specific gravity for a garnet of this composition from Ford's data for the end members is 3.561, the difference 0.068 probably indicating an error in the determination.

Unfortunately, the refractive index of the analyzed sample was not determined. The calculated refractive index for the above composition is 1.747. Several specimens from the same lot were examined optically. One specimen of small transparent very pale brownish crystals overlain by chabazite and a little scolecite was found to be colorless and transparent and completely isotropic with a homogeneous index of 1.745. Another of transparent pale amber crystals was 1.752. Nearly colorless crystals 5 mm. in diameter had an index of 1.746. An aggregate of fairly large crystals of a brown color, translucent in the hand specimen, showed distinct birefringence, and, although the index of the bulk of the material was about 1.75, the crystals are evidently zoned and vary in index from 1.752 to about 1.780. Another specimen showing very large crystals—up to 4 cm. in diameter—appears slightly zoned in color in the hand specimen and ranges in index from 1.753 to 1.756. Most of the nearly transparent crystals seem to approximate closely the calculated refractive index.

This brown grossularite occurs not only as the crystals described above but also makes up large masses of dense garnet rock, sometimes almost pure but usually containing considerable amounts of diopside, even when no green color due to the diopside can be detected. Such garnet-diopside hornfels forms the matrix of the crystallized grossularite specimens and also of the numerous specimens which bear vesuvianite in the cavities. One dense lustreless hornfels of pale brown color, the cavities of which were lined with nearly colorless grossularite, was found to consist of approximately equal parts of fine-grained colorless diopside and colorless isotropic garnet with an index of refraction of 1.745 (No. 84553). The matrix of one of the best specimens of vesuvianite (No. 84548), a typical hornfels of this lot of specimens, likewise shows a large proportion of colorless isotropic garnet the index of which ranges from 1.745 to 1.748.

A second lot of garnet decidedly different from the last (No. 84556) is labeled as from North Italian Mountain and contains 10 specimens. This consists of brilliant sulphur-yellow to greenish sulphur-yellow crystals of perfect dodecahedral form averaging only about 3 mm. in diameter. These little garnet crystals appear disseminated through coarse granular calcite, sometimes sparsely and sometimes so thickly as to make up solid masses of granular garnet rock. Usually the garnet is alone, but in a few specimens it is accompanied by vesuvianite in perfect little embedded crystals of a brown color. This garnet was also analyzed by Eakins, the results being given, with ratios, below.

Analysis of yellow garnet

[L. G. Eakins, analyst]

	Per cent	Ratios		
SiO_2	37. 89	0.631	0.631	1.02 × 3
Al_2O_3	7. 90	.077 }	.180	.87 × 1
Fe_2O_3	16. 43	.103 }		
CaO	35. 43	.632	.632	1.02 × 3
MgO	. 59			
Na_2O	1. 10			
H_2O	. 36			
Total	99. 70			

The ratios of this analysis do not approach so nearly to the ideal garnet proportions, the high bases and silica as well as the presence of magnesia and soda suggesting contamination of the sample by some foreign constituent which seems surprising, as the material of the specimens appears ideal. This also is essentially a simple member of the andradite-grossularite series, but here andradite makes up a greater proportion, the analysis indicating approximately 60 per cent of andradite to 40 per cent of grossularite. The specific gravity of a garnet of this composition should be 3.662, while the specific gravity of the analyzed sample is recorded as 3.72 at 16° C. The refractive index should be 1.831. It was found to be well above 1.80, the highest immersion oil at hand.

One other garnet analysis made on material from this locality is recorded by Eakins. This gives the following results:

Analysis of garnet

[L. G. Eakins, analyst]

	Per cent	Ratios		
SiO_2	36. 88	0.615	0.615	1.01 × 3
Al_2O_3	10. 34	.101 }	.210	1.02 × 1
Fe_2O_3	17. 51	.109 }		
CaO	34. 85	.623	.623	1.00 × 3
MgO	. 43			
Na_2O	Trace.			
H_2O	. 21			
Total	100. 22			

This appears to be a much better garnet analysis than the last, but there is nothing to indicate the type of material or the specimen on which it was made. It evidently is also a member of the andradite-grossularite series, containing 55 per cent andradiate and 45 per cent grossularite. Such a garnet has a calculated gravity of 3.651, while the measured specific gravity is given as 3.721 at 17.2° C.

A third lot of garnet (No. 84550) from the north side of the gulch leading north of North Italian Mountain contains four specimens. The garnet is in brown, more or less globular masses, ranging from 1 to 6 mm. in diameter. These are scattered sparsely through dirty white granular marble and are conspicuous on weathered surfaces. When closely examined the globules are found to be made up of innumerable very minute dodecahedral units in parallel position. The powder of these garnets is pale brown, and under the microscope they exhibit a peculiarly wavy appearance and comparatively strong birefringence. They are probably andradite, since the refractive index is much higher than 1.80.

Distinctly green garnets were seen in several specimens. Beautifully sharp little green dodecahedral garnets 2 mm. in diameter, lining a cavity of garnetiferous hornfels of one specimen (No. 84551) from Italian Mountain, have a beautifully iridescent metallic sheen or luster. A few stilbites were deposited on them, followed by a layer of chabazite, and then the cavity was filled with calcite. They are now exposed where the calcite has dissolved away. Another specimen (No. 84576) has a druse of 1 to 2 mm. green dodecahedral garnets crusting garnet hornfels and overlain by little crystals of adularia and pyrite.

One specimen (No. 84551) consists of small opaque-appearing sharp dodecahedral brown garnet crystals up to 2 mm. in diameter, thickly scattered in white calcite and making up a granular rock.

Two specimens show garnet crystals which display an unusually sharp color zoning (No. 84558). These occur in veins up to 2 cm. wide in fine-grained green diopside rock. The garnet crystals overlie diopside prisms and are themselves overlain by epidote and calcite. The garnet crystals are dodecahedrons narrowly truncated by the trapezohedron and reach 1 cm. in diameter. The cores of the garnets are deep red-like almandite with an outer border about 1 mm. thick of pale buff material and a very thin outside brown shell. The indices of all parts of the crystals are well above 1.80, so that the material is doubtless andradite with varying amounts of the grossularite molecule.

A specimen of highly graphitic schist from North Italian Mountain (No. 84552) contains numerous black dodecahedral garnets averaging 5 mm. in diameter. When powdered this garnet is black and white, and under the microscope it is seen to owe its black color to black opaque inclusions, doubtless of graphite. The garnet itself is colorless in section and isotropic with an index of refraction of 1.742 to 1.744.

Another single specimen (No. 84549) is labeled "garnet on limonite" and consists of a heavy iron-stained mass mainly made up of blackish garnets of dodecahedral form narrowly truncated by the octahedron. Under the microscope the garnet is colorless, but contains opaque brownish material. Its index is, for the most part, 1.736, but varies to 1.745. It is probably grossularite.

DIOPSIDE

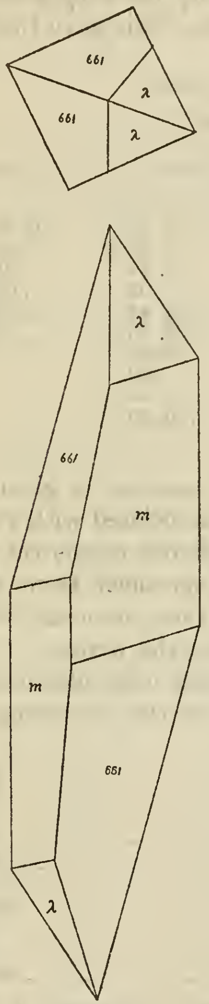
Diopside is a common mineral and occurs in many specimens, in some as almost ideally perfect twinned prisms, in others as both small twinned prisms and simple crystals of small size but perfect form. Moreover, this mineral occurs in massive form, making up a solid green diopside rock, and also mixed with more or less garnet in a hornfels which is the base of most of the fine specimens of vesuvianite and grossularite.

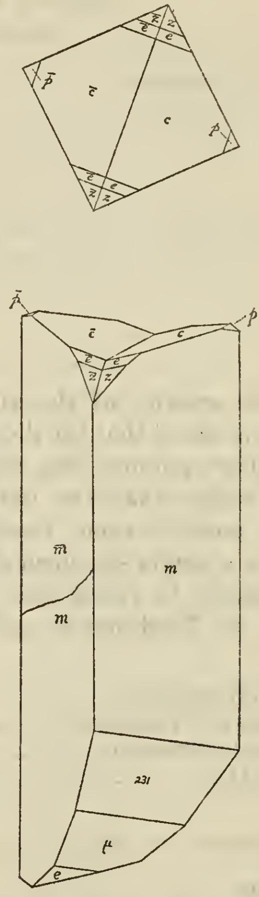
Most noteworthy are the twinned diopside crystals which attain a size of 8 by 10 mm. or more. These are gray-green or olive gray-green in color and rest upon the walls of cavities in massive diopside rock. Practically all of the crystals are contact twins on (100) and the larger ones are rather highly modified. The interstices between the diopside crystals may contain later epidote, andradite garnet, or calcite. A crystal typical of the best and larger twins is shown in Figure 4. This gave the following measurements:

Measurements of diopside, Figure 4

Form		Symbol		Quality description	Measured				Calculated			
No.	Letter	Gdt.	Miller		φ		ρ		φ		ρ	
					°	′	°	′	°	′	°	′
1	*c*	0	001	Medium	89	14	15	38	90	00	15	51
2	*a*	∞0	100	Poor, narrow	89	14	90	00	90	00	90	00
3	*b*	0∞	010	Excellent	0	00	90	00	0	00	90	00
4	*e*	01	011	do	25	39	33	24	25	43	33	00
5	*p*	−10	$\bar{1}01$	do	90	00	15	55	90	00	15	27
6	*m*	∞	110	do	43	35	90	00	43	33	90	00
7	*ε*	+12	121	Good	35	18	55	00	35	36	55	24
8	*μ*	−12	$\bar{1}21$	Excellent	13	25	50	36	$\bar{1}3$	12	50	27

This figure is drawn with the position of the clinopinacoid, *b* (010) in front. When one of these larger twinned crystals is crushed and examined under the microscope as a powder of 80 mesh or under it is found to be pure and practically colorless. The indices are subject to a slight variation from grain to grain but the material is fairly homogeneous. The optical properties, mean, as measured are: Biaxial negative with 2V medium, dispersion, $r < v$, pronounced. The average indices of refraction are, $\alpha=1.676$, $\beta=1.683$, $\gamma=1.702$. The extinction, $Z \wedge c$, is 36° average of a number of measurements on grains which are possibly cleavage fragments lying on a face of the (110) cleavage. The maximum extinction measured on such a grain was 43° and the minimum 30°. Scattered grains show, in addition to the contact twinning on 100 which is not observed in crushed fragments, the insertion of thinner lamellæ in twinned position.





2 3

FIGS. 2–3.—2, DIOPSIDE CRYSTAL OF STEEP PYRAMIDAL HABIT. PROJECTED ON (010). 3, DIOPSIDE CRYSTAL TWINNED ON (100). PROJECTED ON (010)

Grains showing this twinning were found to be parallel to the optic axial plane or perpendicular to the optic normal, and since they give symmetric extinction of approximately 22° on either side of the twinning plane it is probable that the twinning is on the basal pinacoid *c* (001).

The matrix of these larger gray-green twinned pyroxenes is in all cases a pale gray-green rock of fine sugary texture which consists of almost pure diopside. Examined under the microscope this diopside is found to be essentially the same in optical properties and hence probably in composition, as the foregoing crystals.

An analysis of diopside from this locality made by Eakins doubtless represents the larger twinned crystals. This gave the following results:

Analysis of diopside crystals

[L. G. Eakins, analyst]

Constituent	Per cent	Ratios	
SiO_2	47.53	0.791	0.791
Al_2O_3	9.88	.097	.108
Fe_2O_3	1.79	.011	
FeO	.91	.013	.829
MgO	14.43	.361	
CaO	25.46	.455	
Na_2O	trace		
H_2O	.30		
Total	100.30		

The specific gravity of the analyzed material is given as 3.312 at 16.7°. It is stated that the diopside is associated with vesuvianite, scapolite, garnet, epidote, etc., which probably means the collection as a whole rather than the individual specimen from which the material for analysis came, since all of these minerals were in no case found in a single specimen studied by the writer.

If this analysis be recast into constituent molecules according to the method of Washington and Merwin the following table is obtained:

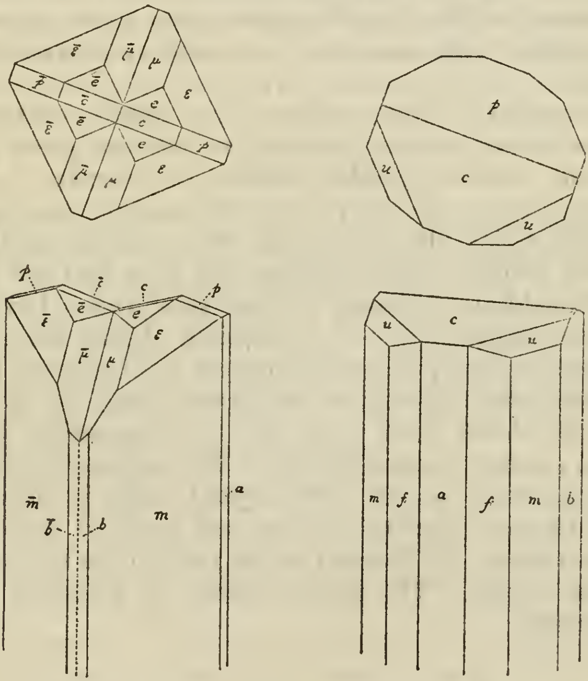
Diopside ($CaMgSi_2O_6$)	83.75
Hedenbergite ($CaFeSi_2O_6$)	3.23
Wollastonite ($CaSiO_3$)	3.62
$Fe_2O_3+Al_2O_3$	11.67
	102.27
Deficiency in SiO_2	2.27
Sum	100.00

Another and but slightly different type of diopside is found in certain greenish-gray masses of massive pyroxene of very porous texture, the cavities of which are occupied by small crystals, some of them, like the last, twinned on (100) and others simple, of an acute pyramidal habit. The crystals reach a length of only 3 or 4 mm. Some of the twins show terminal faces of several forms and others are very simply truncated by only *c* (001). One twinned crystal from a specimen of this kind is illustrated in Figure 3. This is the only doubly terminated crystal seen in this specimen, and the lower end is not twinned and, as shown in the drawing, has a distinctly different habit from the twinned end. The angles measured in two settings of both ends of this crystal are given in the following table:

Angles of diopside crystal, Figure 3

Form		Symbol		Quality description	Measured		Calculated	
No.	Letter	Gdt.	Miller		φ	ρ	φ	ρ
					° ′	° ′	° ′	° ′
1	c	0	001	Medium	89 14	16 17	90 00	15 51
2	m_2	∞	110	Good	43 35	90 00	43 33	90 00
3	e	01	011	Medium	25 30	33 48	25 43	33 11
4	z	02	021	Excellent	13 15	51 06	13 32	50 29
5	p	−10	$\bar{1}01$	Good	89 49	15 59	90 00	15 27
6	μ	12	121	do	35 47	55 27	35 36	55 24
7	s	23	231	do	38 30	66 16	n. c.	n. c.

Many of the crystals of specimens of this type are simple in habit and, in a few measured, these are very poor in forms. A typical



FIGS. 4–5.—4, DIOPSIDE CRYSTAL. TWINNED ON (100). 5, SAHLITE CRYSTAL

one showing as a prominent form a new positive pyramid (661) is shown in the drawing, Figure 2. This crystal gave the angles as illustrated above.

Angles of diopside crystal, Figure 2

Form		Symbol		Quality description	Measured				Calculated			
No.	Letter	Gdt.	Miller		φ		ϵ		φ		ϵ	
					°	′	°	′	°	′	°	′
1	*b*	0∞	010	Poor	1	22	90	00	0	00	90	00
2	*m*	∞	110	Medium	44	06	90	00	43	33	90	00
3	new	*6	661	Good	46	36	79	10	N. C.		N. C.	
4	λ	−3	$\bar{3}31$	Excellent	37	52	66	47	38	19	66	04

Although no optical properties were measured or no analyses made upon material of the last-described specimens, they are probably very similar in composition to the foregoing.

SAHLITE

While most of the pyroxene of this locality consist of nearly pure diopside, there are several specimens which are largely made up of another member of the diopside-hedenbergite series shown by its optical properties to be somewhere near midway between these two end members.

The principal lot of these specimens (No. 84565) contains several large masses almost entirely composed of blackish green pyroxene varying from massive granular material to prismatic crystals of simple habit up to 4 by 10 mm. in size, which project into open spaces or into calcite which fills part of the vugs. In the empty vugs a few scattered whitish apatite crystals rest upon and are evidently later than the sahlite. Optically this pyroxene is biaxial and positive with 2V large, dispersion $r > v$, perceptible. Under the microscope it varies slightly from pale brownish-green to blue-green, the latter probably being the original tint, the brown being due to incipient oxidation. It shows good cleavage. The maximum extinction measured on crushed fragments is 44°. The refractive indices measured are $\beta=1.690$, $\gamma=1.715$. The crystal habit is illustrated in Figure 5. In some cases the crystals are sheathed with an outer coating of actinolite, the fibers of which parallel the vertical axis of the pyroxene crystal. The crystal which was measured gave the following angles:

Measurements of sahlite crystal, Figure 5

Form		Symbol		Quality description	Measured				Calculated			
No.	Letter	Gdt.	Miller		φ		ρ		φ		ρ	
					°	′	°	′	°	′	°	′
1	*c*	0	001	Very poor	90	00	17	19	90	00	15	51
2	*a*	∞0	100	Excellent	90	00	90	00	90	00	90	00
3	*m*	∞	110	Very good	43	34	90	00	43	33	90	00
4	*f*	3∞	310	Poor	70	57	90	00	70	41	90	00
5	*u*	+1	111	Very poor	54	12	45	54	55	04	45	50
6	*p*	−10	$\bar{1}01$	do	$\overline{90}$	00	16	10	$\overline{90}$	00	15	27

Another single specimen (No. 84580) from Taylor Peak has what apparently is altered diorite for a base with euhedral crystals of vitreous blackish-green pyroxene projecting into a mass of stilbite and scolecite. The pyroxene crystals are all broken and show no terminations remaining. The remnants of crystals reach 15 by 40 mm. in size. Under the microscope the crushed pyroxene is fresh, pale blue-green and nonpleochroic. It is biaxial positive with 2V medium large, dispersion r < v weak to marked. The extinction is Z Λ c=41° maximum measured on cleavage fragments. The refractive indices measured are: $\alpha=1.682$, $\beta=1.697$, $\gamma=1.713$.

VESUVIANITE

Vesuvianite is one of the most interesting and attractive of the minerals occurring at Italian Mountain and constitutes very excellent mineralogical specimens containing well developed crystals, some of which reach fairly large size. With the possible exception of Crestmore, California, and one or two Maine localities, no place in America has heretofore furnished such fine specimens of this mineral and the specimens from the other localities mentioned are distinctly different in habit, color, and associations.

The most abundant type of vesuvianite represented in the collection occurs in crystals of transparent yellowish olive-green color varying gradually in habit from bipyramidal to short prismatic. These are found either singly or in groups or crusts implanted on the walls of open spaces in a dense garnet-diopside hornfels. The limits of variation in crystal dimensions are illustrated in Figures 6 and 7. Figure 6 exposes the commonest habit—bipyramidal with the dominant form the unit pyramid *p*(111), the prismatic faces being greatly suppressed. A small crystal of this habit gave the following measurements:

Measurement of vesuvianite, Figure 6

Form		Symbol		Quality description	Measured		Calculated	
No	Letter	Gdt.	Miller		φ	ρ	φ	ρ
					° ′	° ′	° ′	° ′
1	*a*	0∞	010	Very good----	0 00	90 00	0 00	90 00
2	*m*	∞	110	Excellent-----	45 46	90 00	45 00	90 00
3	*f*	∞2	120	Good---------	26 37	90 00	26 34	90 00
4	*p*	1	111	Excellent-----	45 31	37 19	45 00	37 14
5	*c*	0	001	Good---------	--------	0 00	--------	0 00

The crystals vary gradually through elongation of the prismatic direction to the proportions of Figure 7. Many crystals of such proportions are very simple and the one illustrated is about the most highly modified seen. This, upon measurement on the 2-circle goniometer gave the following angles:

Measurements of vesuvianite, Figure 7

Form		Symbol		Quality description	Measured		Calculated	
No.	Letter	Gdt.	Miller		φ	ρ	φ	ρ
					° ′	° ′	° ′	° ′
1	*c*	0	001	Medium------	-- --	0 00	-- --	0 00
2	*a*	0 ∞	010	Fair----------	0 20	90 00	0 00	90 00
3	*m*	∞	110	-----do-------	45 24	90 00	45 00	90 00
4	*φ*	$\infty\frac{5}{3}$	350	v. poor-------	30 53	90 00	30 58	90 00
5	*p*	1	111	Excellent-----	45 16	37 16	45 00	37 14
6	*o*	01	011	Fair----------	0 46	27 37	0 00	28 15
7	*t*	3	331	v. good-------	45 16	66 12	45 00	66 19
8	*s*	13	131	Fair----------	14 07	57 59	18 36	59 32

Other specimens show crystals, differing from the last chiefly in greater opacity and darker green color, forming solid crusts so that no individual is completely developed. These show some forms not present on the more perfect crystals as illustrated in the drawing, Figure 9. This crystal gave the following angles:

Measurements of vesuvianite, Figure 9

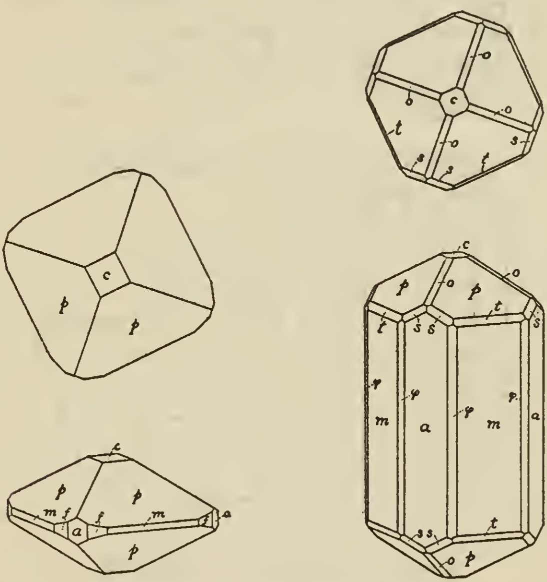
Form		Symbol		Quality description	Measured		Calculated	
No.	Letter	Gdt.	Miller		φ	ε	φ	ε
					° ′	° ′	° ′	° ′
1	*a*	0 ∞	010	Excellent-----	0 00	90 00	0 00	90 00
2	*h*	∞3	130	v. p. narrow--	18 20	90 00	18 26	90 00
3	*o*	01	011	-----do-------	0 00	27 09	0 00	28 15
4	*u*	02	021	-----do-------	0 00	46 02	0 00	47 04
5	*π*	03	031	-----do-------	0 00	58 00	0 00	58 12

The better crystals of vesuvianite are all about alike optically. Under the microscope the mineral exhibits low birefringence and the larger crystals are homogeneous, have uniform extinction and show faint zoning in birefringence in basal sections. Different zones vary very slightly in refractive indices and from uniaxial to biaxial with 2V very small. The average refractive indices are

$$\epsilon=1.713,\ \varpi=1.715.$$

The thicker grains show pleochroism with ϖ=pale yellow-green, ϵ= colorless. No cleavages were noted.

The crystals vary in size from a few which are minute to an observed maximum of 2.5 cm. thick by 5 cm. long. The most frequent and best developed ones are around 1 cm. in size.



6 7

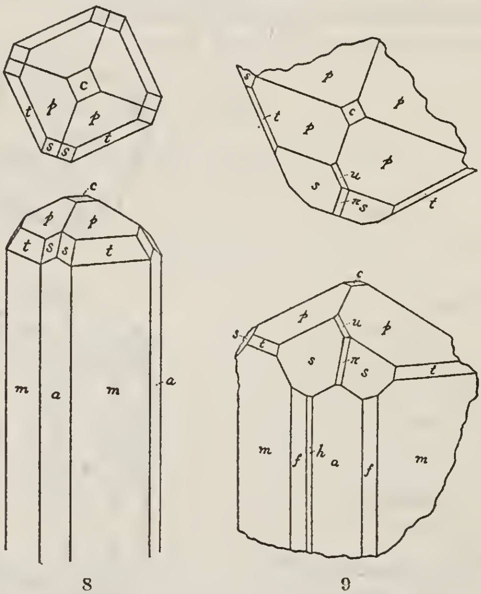
FIGS. 6–7.—CRYSTALS OF VESUVIANITE

Some 60 specimens of this yellow-green vesuvianite, all from Italian Mountain, proper, are included in the collection. The matrix is in all cases a dense hornfels composed sometimes almost entirely of massive pale brown garnet, more frequently of a mixture of garnet and diopside, usually with a little interstitial calcite and a fibrous zeolite referred to scolecite. The vesuvianite does not appear as a constituent of the massive matrix but appears always to be a late introduction into the cavities. This mineral rests upon and is clearly later than crusts of pale buff grossularite garnet. Later minerals associated with and resting upon the vesuvianite are epidote, chabazite, and stilbite.

Selected clear green crystals of this type were analyzed in the Geological Survey laboratory by L. G. Eakins with the following results:

Analysis of vesuvianite

SiO_2	37.11
Al_2O_3	19.30
Fe_2O_3	3.31
MgO	3.89
CaO	36.24
H_2O	.06
F	.58
Total	100.49



FIGS. 8–9.—CRYSTALS OF VESUVIANITE

The specific gravity of the analyzed sample was 3.394 at 20°.

Another type of vesuvianite of quite different appearance forms a number of specimens, also from Italian Mountain. This is essentially a vesuvianite rock made up of greenish yellow acicular prisms of vesuvianite with interstitial calcite. The habit of one of the prisms which was terminated is shown in figure 8. This rock grades into patches of calcite in which small model-perfect brown short prismatic vesuvianite crystals averaging 2 mm. in length occur with small dodecahedral crystals of sulphur-yellow to greenish-yellow garnets.

A third and very unusual type of vesuvianite remains to be mentioned. Certain specimens showing large imperfect and somewhat corroded crystals of the first type contain silky white fibrous material having the appearance of a zeolite. This is grown upon the vesuvianite crystal parallel to the vertical axis and apprently is replacing it. About 5 specimens show this material. When examined under the microscope the fibers are thin and of such extremely low birefringence that only very thick bundles are visible under crossed nicols. They have parallel extinction, positive elongation and a refractive index, approximately, of 1.717. The material of the fibers is evidently also vesuviante.

EPIDOTE

Epidote forms well terminated crystals varying somewhat in size, in cavities in anorthite, imperfect green or greenish-yellow columnar or acicular masses resting upon vesuvianite or on well developed diopside crystals and in cavities in massive diopside rock, between large grossularite garnets or in calcite veinlets cutting hornfels and altered shale.

The largest group of epidote-bearing specimens is that which has been mentioned beyond as consisting of anorthite cores partially replaced by adularia and containing numerous cavities in which the epidote occurs in crystals associated with titanite crystals, limonite pseudomorphs after pyrite, and scaly aggregates of chlorite. Many of the cavities are molds of a prismatic mineral of unknown identity which was removed before the later minerals were deposited. (No. 84560.) The epidote crystals vary in size from minute and comparatively perfect prisms with good terminations to a maximum observed size of 1 by 2 centimeters and the color varies from greenish-yellow to greenish-black. The mineral of one specimen of this lot was found to be biaxial and negative with 2V medium large, dispersion, $r > v$, strong. The refractive indices were roughly $\alpha=1.722$, $\beta=1.730$, $\delta=1.755$.

Another specimen shows an almost solid mass of epidote resting upon coarse vesuvianite. Cavities in this contain epidote crystals, which are rude prisms, deep yellow-green inside and light greenish-yellow outside. The suggestion of zoning in composition, obtained from the color distribution in these imperfect crystals is confirmed by their optical properties. When a whole crystal is crushed the grains are found to be biaxial negative, (−), with 2V varying from medium to large. The dispersion, $r < v$, varies from perceptible to strong, and the β index ranges from about 1.720 to 1.740. The grains show some twin lamellae. This powder gave no fluorine reaction in a closed tube with potassium bisulphate.

Aside from the most typical mode of occurrence of epidote in the anorthite-bearing masses, this mineral was found in several other associations. Not infrequently a small mass of columnar yellow-green material or a group of imperfect prisms is observed resting on good vesuvianite crystals in garnet-diopside hornfels. In a few specimens similar epidote is interstitial with relation to large poorly formed grossularite garnets. In several other cases radiated acicular greenish yellow epidote fills small seams and cavities in fine-grained massive diopside rock. In 2 specimens similar epidote rests on twinned diopside crystals and zoned garnets, and is overlain by calcite. One specimen contains deep yellowish green epidote in ill-defined crystals along the sides of a 1-centimeter calcite veinlet in altered shale.

Two analyses of epidote from this locality were made by Eakins. There is no record as to which specimens in the collection furnished the material for those analyses. The results obtained are as follows:

Analyses of epidote

[L. G. Eakins, analyst]

Constituent	1	2
	Per cent	*Per cent*
SiO_2	38. 21	37. 22
Al_2O_3	28. 70	24. 09
Fe_2O_3	8. 16	12. 80
FeO	----------	. 79
MnO	----------	. 11
MgO	----------	Trace.
CaO	24. 30	23. 36
Na_2O	. 21	. 06
H_2O	. 10	1. 61
F	. 35	. 06
	100. 03	100. 10
Less O=F	. 15	. 02
Total	99. 88	100. 08

The most noteworthy feature of the analyses is the presence of fluorine, these being the first analyses to record fluorine in this mineral. The specific gravities recorded for the analyzed samples are 3.448 at 25° C. for the material of analysis 1 and 3.452 at 17° C. for the material of analysis 2.

ALBITE

Soda feldspar has been identified as a constituent of a number of specimens. In a mass of loosely aggregated large brown grossularite garnets small scattered imperfectly prismatic white crystals occur in a number of open spaces. This mineral is biaxial with 2V near

90° and varies from positive with dispersion r < v to negative with r > v. The β index of refraction similarly varies from about 1.530 to 1.540. The crystals are zoned in composition and show polysynthetic twin lamellae. The material is evidently feldspar varying from nearly pure albite to oligoclase. Many of the crystals are partly covered with drusy crusts of minute crystals of heulandite. The feldspar is younger than the garnet and older than the heulandite.

Small and rather perfectly formed lutrous white albite crystals, not exceeding 2 mm. in diameter, occur sparsely scattered over the interior of a cavity in a single greatly altered specimen of garnet diopside rock (No. 84583).

The largest group of albite specimens is numbered 84583 and consists of pale pink crusts of drusy crystals averaging about 2 mm. broad by ½ mm. in thickness. The druses occur along open cracks in the centers of feldspar-filled seams in fine-grained altered diorite and the specimens show a layer of granular massive pink feldspar up to 1 cm. thick between the druse and the diorite. Under the microscope this albite is somewhat muddy from incipient kaolinization. It is biaxial positive (+) with 2V large, dispersion r < v weak, refractive indices α=1.525, β=1.530.

The crystals have a peculiar flat habit as is illustrated in the drawing, Figure 10, in which the notation follows the table of Brezina's elements in Goldschmidt's Winkeltabellen. The measurements are as follows:

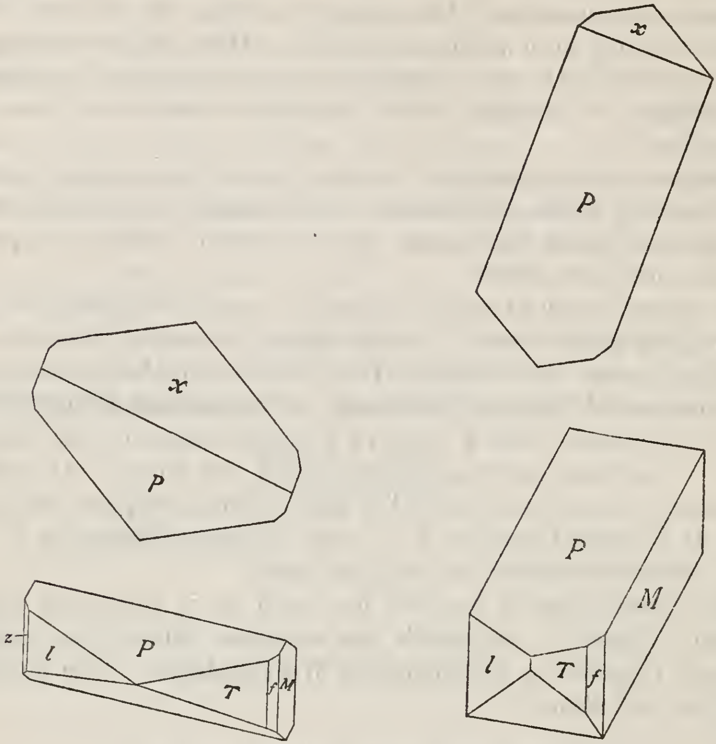
Crystal measurements of albite, Figure 10

Form		Symbol		Quality description	Measured				Calculated			
No.	Letter	Gdt.	Miller		φ		ρ		φ		ρ	
					°	′	°	′	°	′	°	′
1	*P*	0	001	Fair, pearly	81	51	25	51	81	51	27	01
2	*M*	0∞	010	Poor	0	00	90	00	0	00	90	00
3	*T*	∞	110	Poor, blurred	57	19	91	53	60	30	90	00
4	*f*	∞3	130	Dim, poor	27	50	90	00	30	23	90	00
5	*l*	$\infty\bar{\infty}$	$1\bar{1}0$	Good	119	15	90	00	119	52	90	00
6	*z*	$\infty\bar{3}$	$1\bar{3}0$	do	149	07	90	00	149	44	90	00
7	*x*	−10	$\bar{1}01$	v. p. dull	n. s.		n. s.		80	54	24	12

Associated with or overlying the pink crusts of albite are chabazite in simple rhombohedrons or penetration twins up to 1½ mm. in diameter, minute rare quartz crystals of normal habit, and tiny honey-yellow crystals of titanite.

White albite ocurs in opaque crystals up to 1 mm. in size coating a banded rock which is probably a metamorphosed shale (84584).

This albite is overlain by the quartz crystals which resemble topaz, described below. The albite has the habit shown in the drawing, Figure 11.



10 11

FIGS. 10–11.—CRYSTALS OF ALBITE

ANORTHITE

Plagioclase feldspar very near the anorthite end of the series makes up an important part of a number of specimens although in none of these does it form good or attractive specimens worthy of inclusion in collections as anorthite. One group of specimens containing the measured crystals of titanite and the best epidote crystals consists largely of a translucent white mineral which is the earliest material and makes up the cores of the specimens. Optically this mineral is found to biaxial and negative (−) with 2V large, dispersion $r < v$ strong, extinction highly inclined against the cleavage. The birefringence is fairly low and the intermediate index of refraction, β, is 1.582±.002. This mineral is doubtless anorthite. It preserves hollow molds up to 2 cm., on an edge of their rhombic cross section, of a prismatic mineral which preceded the anorthite but was subsequently removed. Later the anorthite was to a considerable degree replaced by a fine-grained chalky-appearing white mineral shown by its optical properties to be the adularia variety of orthoclase. Epidote, pyrite, titanite, and fine globular grayish chlorite were also deposited in the cavities. (No. 84560.)

Another lot (No. 84562) consists largely of whitish feldspar mixed with more or less pyrite, calcite, epidote, and an undetermined greenish silicate. The massive feldspar has the following optical properties which identify it as anorthite: Biaxial negative (—), 2V near 90°, dispersion $r < v$, weak. Refractive indices $\alpha=1.572$, $\beta=1.580$, $\gamma=1.585$. It shows a few narrow twin lamellae. Specimens Nos. 84560 and 84561 are similar. In a cavity in one specimen of this material are a few simple rhombohedral-appearing crystals up to 5 or 6 mm. in size. These are biaxial negative with 2V large, dispersion $r < v$, marked $\beta=1.582$. These show no twinning and resemble adularia crystals but are shown by their optical properties to also be anorthite.

ORTHOCLASE

Small white crystals of rhombohedral appearance and granular masses resting on and apparently replacing anorthite (No. 84560) and associated with epidote, titanite, pyrite—altered to limonite—and a globular gray chlorite are apparently the adularia variety of orthoclase. The adularia is probably older than the epidote and is definitely older than the titanite and chlorite. It is identified by its insolubility in acid and optical properties which are: Biaxial negative (—), dispersion $r < v$ strong, β about 1,520, λ=slightly above 1.53. Another specimen of the same number is a mass principally made up of whitish chalky-looking mineral showing indistinct lusterless crystals of rhombohedral appearance with epidote. The white mineral is biaxial and negative with 2V estimated at 60°. The dispersion, $r < v$, is perceptible and the indices measured are $\beta=1.531$, $\lambda=1,538$. This is probably albite.

Scattered white crystals with the rhombic appearing habit of adularia rest, in one specimen, upon a crust of little green garnets surfacing garnet hornfels. The white crystals, which vary up to 3 millimeters in diameter, are optically biaxial negative (—) with 2V medium, dispersion $r < v$ marked, indices well below 1.55. This mineral is doubtless orthoclase. It is later than the garnet and earlier than the associated pyrite, which is now altered to limonite pseudomorphs.

TITANITE

Titanite is a common mineral though in small crystals not readily seen without the aid of a lens. It occurs in a variety of situations and varies somewhat in habit.

The best crystals of titanite occur closely associated with the yellowish-green epidote, pyrite and fine-scaly grayish chlorite in vugs and cavities in whitish feldspar specimens the base of which consists of anorthite, to some extent replaced by orthoclase (No. 84561). The titanite crystals are small, most of them averaging only about 1 mm. and the largest not exceeding 3 mm. Many of them are pale yellow in color and from this they grade into a greenish yellow approaching that of the associated epidote. The crystals of this lot of specimens consist of both simple individuals and twins. One of the simple crystals of typical development is illustrated in Figure 12. As is shown these crystals are prismatic by elongation of the positive hemipyramid *n*(111), a not uncommon habit for this mineral. The crystals of this habit were measured in several positions and that adopted in the drawing was finally found to be correct. The angles measured were as follows:

Measurements of titanite, Figure 12

Form		Symbol		Quality, description	Measured		Calculated	
No.	Letter	Gdt.	Miller		φ	ρ	φ	ρ
					° ′	° ′	° ′	° ′
1	*y*	0	001	Excellent	89 55	29 54	90 00	--------
2	*P*	∞0	100	Minute, poor	90 13	90 00	90 00	90 00
3	*r*	∞	110	Good	56 30	90 00	56 45	90 00
4	*n*	+1	111	Very good	65 39	63 53	65 30	64 06
5	*t*	−1	$\bar{1}11$	Poor	$\overline{40}$ 15	48 28	$\overline{40}$ 36	48 22

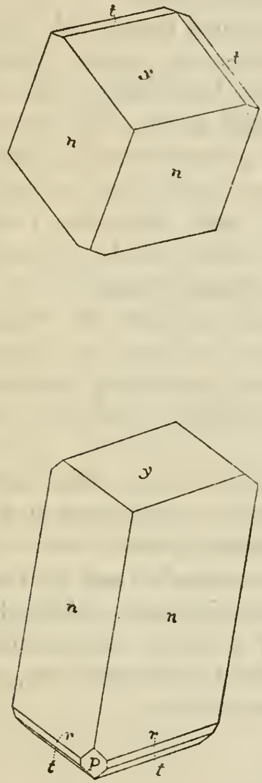
The twinned crystals occur with the untwinned ones and appear, except for the twinning, to have the same habit; but measurement of several twins in several positions showed that, while the direction of elongation of the simple crystals is parallel to *n*(111), the twins are elongated parallel to the vertical axis, the twinning plane being *P*(100), the commonest twinning plane for this species. A typical twin is illustrated in Figure 13. This gave the following angles:

Measurements of titanite (twin) Figure 13

Form		Symbol		Quality description	Measured		Calculated	
No.	Letter	Gdt.	Miller		φ	ρ	φ	ρ
					° ′	° ′	° ′	° ′
1	*y*	0	001	Excellent	90 05	29 25	90 00	--------
2	*P*	∞0	100	Very good	90 00	90 00	90 00	90 00
3	*r*	∞	110	Excellent	56 49	90 00	56 45	90 00
4	*l*	−½	$\bar{1}12$	Very poor	$\overline{11}$ 06	23 38	$\overline{10}$ 42	23 29
5	*t*	−1	$\bar{1}11$	Excellent	$\overline{40}$ 29	48 13	$\overline{40}$ 36	48 22
6	*w*	−2	$\bar{2}21$	do	$\overline{50}$ 09	69 30	$\overline{49}$ 59	69 22

The twinned crystal figure is drawn with (010) in front.

Very numerous minute honey-yellow titanite crystals of the common "envelope" habit occur impaled upon needles of byssolite hornblende or embedded in wool-like byssolite in a number of specimens consisting principally of byssolite, mizzonite, and scolecite (No. 84566) from Italian Mountain. A few little etched and



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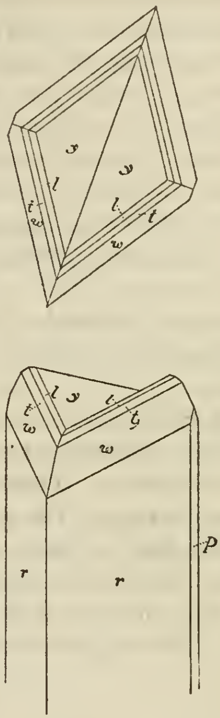


13

FIGS. 12–13.—CRYSTALS OF TITANITE

abraded titanite crystals 1 mm. or less in diameter rest upon a crust of albite (No. 84583) associated with a few distorted quartz crystals.

A few small (2 mm.) honey yellow perfect titanite crystals occur sparsely disseminated in apparently fresh diorite from the southeast slope of Cinnamon Mountain (No. 84563).

TALC

Small aggregates of pearly folia of greenish talc were noted in little cavities in granular magnetite (No. 84557) from North Italian Mountain. Other cavities in the magnetite contain minute greenish-yellow garnets.

CHLORITES

Several varieties of chlorite were seen in different specimens in this collection. Minute globules and aggregates of globules of a smoky-gray chloritic mineral occur on epidote, adularia, and titanite in the andradite specimens (No. 84560). The chlorite appears to be the youngest mineral of the specimens except pyrite.

A single flat specimen (No. 84570) consists largely of ill-defined inelastic blackish-green scales up to 3 millimeters across. Under the microscope these are mostly blue-green in basal plates but in considerable part they are oxidized to brownish-green. The few grains which could be turned on edge did not seem markedly pleochroic. The mineral is uniaxial and negative with the ω refractive index=1.60. This may be biotite but it looks more like a chlorite.

A single specimen shows numerous plates up to 1 centimeter across (No. 84570) of pale apple-green chlorite embedded in coarse calcite. These show repeated twinning on the same law which produces the common "A" or feather structure in mica. Under the microscope the material of these crystals is practically uniaxial and optically positive with an index of $\omega=1.578$. This is probably penninite.

A piece of banded rock, probably altered shale (No. 84571) is coated on one side with a druse of micaceous crystals up to 1 millimeter in diameter. These are hexagonal-prismatic with perfect micaceous cleavage. The prism faces are corroded and dull but the luster on the base is pearly and somewhat iridescent. Optically this mineral is biaxial and negative with 2V small to very-small, acute bisectrix (X) inclined slightly to the normal to the cleavage, indices, $\beta=1.570$. This is probably an iron-free chlorite.

MIZZONITE

Scapolite, all apparently of the variety mizzonite, makes up the bulk of a large number of specimens. The most striking lot of these (No. 84567—6 specimens) consists of large variously oriented prismatic masses or sheaves up to 4 by 10 cm. of ill-defined slightly divergent fibrous structure. This material varies from slightly purple to cream color where not stained by iron. The interstices between the masses of scapolite are filled with white calcite. Under the microscope the material of the scapolite masses, which under a lens appears pure, is found to consist of 3 minerals. The scapolite itself is in part clear and glassy, uniaxial and negative (—) with indices of refraction approximately $\epsilon=1.535$, $\omega=1.551-1.555$, indicating mizzonite. This mizzonite exhibits alteration or replacement to a greater or less degree by a fine fibrous mineral which has developed parallel to the vertical axis. This mineral has negative elongation and an index of refraction of about 1.515 and is probably scolecite. Scattered clear grains which also occur in the powder are colorless and isotropic or with very feeble birefringence and an index of 1.485. This mineral is probably analcite. In a few cavities in these specimens considerable areas are covered with drusy terminations of perfect little heulandite crystals.

The second large lot of scapolite specimens (No. 84568—9 specimens) is labeled "scapolite in diorite, south slope of Sawtooth Range, Taylor R. Gunnison County." These contain veins of solid grayish-white compact scapolite up to 6 cm. wide with borders ⅔ cm. wide on each side of a mixture of scapolite and a green mineral, probably diopside. These cut fine grained diorite. The scapolite shows cleavage blades up to 1 by 6 cm. Under the microscope this scapolite is comparatively fresh and free from alteration. It is uniaxial negative (—). The refractive indices are, ϵ=1.542, ω=1.558, birefringence, $\omega-\epsilon$=.016.

The third group of specimens (84566), labeled "scapolite with byssolite, Italian Mountain," consist of loose textured masses of rude dirty white prisms up to 1 by 3 cm. forming a network, the interstices of which are filled with byssolitic hornblende. These prismoidal masses are to a large extent corroded and replaced by a dull fine-fibrous zeolite which has the properties of scolecite. Where they contain cores of unaltered material this is uniaxial negative with negative elongation; indices, ϵ=1.542, ω=1.550. The scolecite and byssolite, as well as the heulandite and titanite which occur in the cavities, are described elsewhere.

A single specimen (No. 84567) is largely composed of radiating fine columnar bundles of prismatic scapolite, white in color and slightly pearly in luster. The bundles average 1 cm. broad by 4 cm. in length. In vuggy parts of the specimen the scapolite forms rude crystals up to 3 by 15 mm. Pyrite, altered to lustrous limonite pseudomorphs, occurs in thickly scattered crystals up to 5 mm. in diameter, resting on the scapolite. Optically this scapolite is uniaxial negative with refractive indices of approximately ϵ=1.539, ϖ=1.549, which indices indicate that it is mizzonite. Some alteration to scolecite gives parts of the scapolite lower indices and birefringence and a fibrous structure.

Another single specimen (No. 84567) shows rude white prismatic masses up to 8 by 20 mm. coating the face of a sheeted rock which is itself largely scapolite. This material has the refractive indices ϖ=1.553, ϵ=1.541.

A sample of scapolite from Italian Mountain was analyzed by Eakins with the following results:

Analysis of mizzonite

SiO_2	57. 55
Al_2O_3	21. 53
Fe_2O_3	Trace.
CaO	6. 18
K_2O	1. 64
Na_2O	7. 43
H_2O	3. 23
Cl	2. 82
	100. 38
O equivalent to Cl	. 63
Total	99. 75

The only data on which specimen of the several described above was used for the analysis is furnished by the statement that the analyzed material came from a gulch on the east side of Italian Mountain. It is presumed that the material first described, being the most showy and purest appearing, was selected for analysis. In this case the analyzed material doubtless contained an appreciable amount of zeolites, particularly scolecite, which would account for the high-water content shown.

QUARTZ

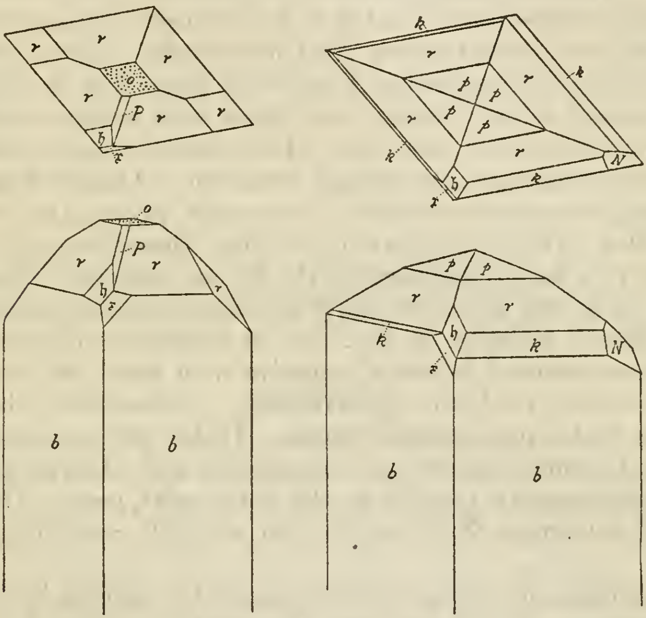
Quartz is rare and occurs in small crystals. The barite crystals of the barite specimen rest upon a crust of normal prismatic quartz in minute crystals. A few minute crystals of quartz of ordinary prismatic habit rest as a later deposit on the crusts of albite crystals of some of the specimens which contain pinkish albite in seams in diorite.

One specimen of albite is overlain by a few quartz crystals which, while minute and poorly developed, have such a peculiar habit as to merit notice. These have certain faces suppressed, giving them a habit so like topaz to lead to their being mistaken for that mineral until the crystal angles and optical properties had been measured. Two of the crystals which were measured are represented by Figures 14 and 15, the forms being tentatively identified as those of quartz by comparison with the angles of the Winkeltabellen. Actually the crystals are much less perfect than indicated in the figures, since, although the faces give good signals, the interfacial angles are largely replaced by rounded etched areas.

SCOLECITE

Although in no case forming good or attractive mineral specimens, the comparatively rare zeolite scolecite is the most common and widely distributed zeolitic mineral of the Italian Mountain locality. It occurs not only associated with the other zeolites, chabazite and stilbite as a late deposit in cavities but is also common in minute cavities in the dense garnet hornfels which forms the matrix of the best vesuvianite specimens and replaces, to a greater or less extent, the mizzonite variety of scapolite in almost all specimens of the latter mineral.

In the hornfels which, in its cavities, bears the fine vesuvianite crystals, tiny vugs in massive pale-brown garnet which are lined with minute grossularite crystals are partly filled with a white fibrous zeolite which ranges from translucent compact radial or divergent fibrous



14 15

FIGS. 14–15.—CRYSTALS OF QUARTZ

tough material to loosely grouped separable fibers. The former continue out and terminate in the latter (No. 84553). The free fibers have negative elongation and a small inclined extinction, $X \wedge c = 16°$. The mineral is apparently optically negative, the birefringence is low, and the mean index of refraction is about 1.510. These properties identify the mineral as scolecite. The compact-fibrous material has the same index, birefringence, and elongation and, although the inclined extinction can not be seen, owing to the fine fibrous character, it is doubtless the same mineral. Another specimen of garnet-diopside hornfels which was examined contains abundant minute pores filled with a soft radial-fibrous white zeolite of the same properties, and it is probable that all of the fibrous white material in the hornfels is this mineral. This zeolite is of common occurrence in the best vesuvianite specimens not only in the hornfels but also in the cavities with the vesuvianite where it is always in small amount and never conspicuous. It forms thin fibrous crusts varying from dense and tough to aggregates of tufted cottony fibers. It rests upon vesuvianite and garnet but is clearly older than the chabazite which occurs in the same cavities. It is recognized, microscopically, by its negative elongation, small inclined extinction, medium low birefringence and index of refraction which approximates 1.51.

In the scapolite specimens the scolecite is even less well characterized. The best large specimens of scapolite (No. 84567) show no scolecite to the naked eye but look like large columnar masses of mizzonite with the interstices filled with calcite. Under the microscope, however, the mizzonite is seen to in large part be replaced by fibers parallel to the vertical axis, which have negative elongation, index approximating 1.515 and where coarse enough these show evidence of twinning and inclined extinction. Another large group of scapolite specimens consist of mizzonite prisms the interstices being filled with pale gray green byssolite. These masses of scapolite are also very largely replaced by the fibrous scolecite. These specimens (No. 84566) also show nearly lusterless masses of radiating fine white fibrous scolecite up to 2 cm. in maximum diameter. This fine-fibrous material is biaxial negative with small inclined extinction, $\alpha=1.510$, $\beta=1.515$, approximately. Occasionally the zeolite coarsens to lustrous acicular prisms. Under the microscope these all show twinning lamellæ like a plagioclase and all lie on a cleavage face approximately parallel to the optic axial pane. They show inclined extinction, $Z \wedge c=14°$ with $\alpha=1.512$, $\gamma=1.518$, approximately.

The scolecite occupying cavities with other zeolites is similar to the foregoing. In one specimen (No. 84545) a little white-radiating compact-pearly material resting on vesuvianite is clearly older than both stilbite and chabazite. A specimen (No. 84578) consisting largely of minute rosettes of pearly pale brown blades of stilbite has the latest cavities filled with radiating compact fibrous scolecite, apparently later than the stilbite. In another specimen sheaves of stilbite up to 7 or 8 mm. long (No. 84581) are underlain by rosettes up to 1 cm. across of fairly coarse radiated pearly needles. Under the microscope these fairly coarse needles show the twinning and inclined extinction, $X \wedge c=12°$. The mineral is biaxial negative, 2V moderate, refractive indices $\alpha=1.510$, $\beta=1.515$, $\lambda=1.516$. Another single specimen shows large crystals of sahlite projecting into a mass of stilbite and fine fibrous white scolecite. The stilbite forms minute pale brownish bladed rosettes apparently older than the scolecite (No. 84580). The latter mineral forms radiating hemispheres, up to 1 cm. in diameter, of fine fibers of snow-white color. Under the microscope this fine fibrous material is somewhat opaque from included air but has negative elongation and apparently small inclined extinction with an index of refraction approximating 1.510.

The age relation of scolecite and stilbite seems reversible, sometimes one and sometimes the other being oldest.

A sample of scolecite was analyzed by Eakins, but which specimen furnished the material is not known. None of the specimens was originally catalogued as scolecite. The analysis gave the following results:

Analysis of scolecite

SiO_2	45.90
Al_2O_3	26.51
Fe_2O_3	-----
CaO	14.17
MgO	Trace
Na_2O	Trace
H_2O plus	13.79
Total	100.37

The specific gravity of the analyzed material is given as 2.247 at 17.2° C. The results of the analysis are almost in exact agreement with the theoretical composition of scolecite as given by Dana.

THOMSONITE

One specimen of this mineral forms a vein in altered diorite some 3 cm. in thickness. This is bordered by a 2 to 3 mm. crust of blackish green sahlite and is filled with broad plates of glistening specularite and a white zeolite in radiating pearly blades. Under the microscope the latter is colorless and free from alteration. It has a perfect cleavage upon which the plates lie and the acute bisectrix is perpendicular to this cleavage. The mineral is biaxial and positive (+) with $2V=50$ to 60°, dispersion $r < v$, weak. The refractive indices are approximately, $\alpha=1.515$, $\beta=1.520$, $\gamma=1.538$, Birefringence=0.023. These properties indicate that the mineral is a variety of thomsonite.

STILBITE

Although less abundant that scolecite and chabazite, stilbite is common in the materials, usually as comparatively inconspicuous crystals, drusy crusts, or rosettes. In one or two specimens it is present as sheaves of such size and quality as to make fair stilbite specimens.

The stilbite is often associated with the grossular garnet or occurs in the cavities in the hornfels with vesuvianite and chabazite. In those specimens which contain the vesuvianite the stilbite often forms a single rosette of radiating blades in the cavity in garnet-diopside or garnet hornfels. Often associated with the rosette are a few crystals 2 mm. or less long of the common stilbite habit. One specimen contains scattered compound white pearly stilbite crystals up to 3 by 5 mm. in size projecting through and older than a crust of chabazite. The stilbite overlies some scolecite or rests upon vesuvianite in a cavity in hornfels. (No. 84545.)

Specimens of loosely aggregated masses of amber crystals of grossular garnet have all the interstices lined with drusy crusts of minute colorless crystals of stilbite of the usual habit. A similar mass of large brown garnets has thin drusy crysts made up of very minute sharp and colorless crystals of epidesmine habit, with heulandite, resting on garnet crystals or on albite which occurs in small amount. The grains of stilbite, under the microscope, lie on a perfect cleavage, which is parallel to the optic plane and show rectangular outline. The indices are $\alpha=1.486$, $\gamma=1.498$. The optic orientation, assuming the best cleavage to be (010) and the long direction vertical is $Z=a$, $Y=b$, $X \wedge c=3°$. In one case stilbite on garnet crystals is overlain by later chabazite and calcite. (No. 84551.) In one specimen small colorless stilbite crystals resting on a mass of the light colored grossular garnet are partly overlain by a thin coating of pinkish clay. The larger of the stilbites, which reach only 2 mm. in length, show normal habit—a rectangular prism determined by the front and side pinacoids with pearly luster on the broad face (010), surmounted by a basal pinacoid and with four truncating pyramid faces, the whole modified somewhat by the aggregate character with slight divergence. The smaller crystals of this specimen have a very unusual triclinic appearance. They are flat prismatic by elongation of the faces (100) and (010), truncated at the summit by a single oblique face, probably one face of the unit pyramid, developed to the exclusion of the other terminal faces.

In a few specimens the stilbite is the most conspicuous mineral. Its age relation to the other zeolites is not always clear. One specimen (No. 84575) shows a few obscure rosettes of blades of stilbite up to mm. in diameter, partly underlying a drusy crust of heulandite encrusting a dense whitish hornfels. This specimen is labeled heulandite from the Bidwell Range. Another specimen labeled as from Taylor Peak, Italian Mountain, consists largely of pale buff stilbite in small rosettes of radiating blades. This, when crushed and examined under the microscope, shows elongate fragments which lie on a good cleavage perpendicular to the optic normal or on a less perfect cleavage at right angles to this. This shows rather high birefringence and a considerable range in refractive indices, γ varying from 1.495 to 1.500. (No. 84578.) This stilbite incloses occasional small plates of specular hematite. It appears to have grown outward from the walls of open cavities, leaving some small unfilled centers which were later occupied by finely fibrous radiating white scolecite. Another specimen (No. 84580) from Taylor Peak shows very similar brownish stilbite and dense scolecite, but here the first lining of the cavity consists of large crystals of the sahlite variety of pyroxene. The best specimens of stilbite are from Taylor Peak, and consist of sheaves of divergent imperfect crystals of stilbite up to 6 or 7 mm. long, resting on much-altered dull and rusty diopside rock. These grow outward from radiations of coarse pearly needles of the zeolite here referred to scolecite, the stilbite in this case being distinctly younger than the scolecite, although elsewhere clearly older. Another specimen shows abundant stilbite in poorly developed crystals tending to form sheaves 2 by 1 mm. in size in calcite, which has exposed them by partly leaching away. (Nos. 84581, 84582.)

A sample of stilbite from the Italian Mountain collection was analyzed by Eakins with the following results:

Analysis of stilbite

SiO_2	57.75
Al_2O_3	16.64
CaO	8.58
Na_2O	Trace.
H_2O	17.17
Total	100.14

HEULANDITE

Heulandite occasionally makes up a fairly conspicuous constituent of a specimen and in many other cases occurs in small amount. One of the most showy specimens of heulandite in the collection (No. 84575) shows this zeolite occurring along a crack in massive coarse granular garnet rock. The heulandite forms large crystalline masses to 4 cm. long showing perfect cleavage in one direction with pearly luster on the cleavage face. Interspersed with these larger masses are also small, 1–2 mm., clear glassy perfectly developed crystals scattered sparsely over the rock or aggregated into small clusters. These have the habit of the "beaumontite" of Jones Falls, Maryland. The locality for this specimen is Bidwell Range, Gunnison County. Another specimen of heulandite having the same number consists of a crust of heulandite coating a crack in reddish sandstone. The heulandite overlies a druse of small prismatic quartz crystals.

Minute heulandite crystals of "beaumontite" habit make up small drusy bristling masses overlying small greenish-buff crystals of grossular garnet. (No. 84553.) Other crystals too minute for their form to be made out make up radiating masses or drusy crusts on scattered albite in the interstices of a mass of large brown garnets. Optically these are biaxial positive with the acute bisectrix perpendicular to the most perfect cleavage. The axial angle approximates 50 to 60° and the crystals are zoned in refractive index the indices being approximately $\alpha = 1.486-1.490$, $\beta = 1.492$, $\gamma = 1.498$.

A large specimen of mizzonite has a cavity on one side lined over a considerable area by a drusy crust made up of perfect terminations of minute colorless heulandite crystals (No. 84567). Specimens composed principally of mizzonite, scolecite, and byssolite (No. 84566) contain small hexagonal-appearing crystals embedded in the byssolite. These reach 3–4 mm. in diameter, are pearly lustered on the broad face and are colored greenish by included fibers of byssolite. Under the microscope their material is colorless, shows low birefringence and rests upon a perfect cleavage which is perpendicular to the acute bisectrix. The mineral is optically positive with 2V very small, dispersion $r < v$ perceptible, $\beta=1.500$. This mineral is doubtless heulandite.

CHABAZITE

Chabazite occurs most commonly in the cavities in the vesuvianite specimens where it overlies vesuvianite crystals and is almost an invariable associate of this mineral. It forms white crystals, mostly simple rhombohedrons with a few penetration twins which vary from 1 to 5 millimeters or more on an edge. Many of these are almost model-perfect. While chabazite is the most abundant zeolite in these cavities it is often associated with small amounts of stilbite and scolecite, both of which seem to be older than the chabazite.

In one specimen a few small rhombohedral crystals are associated with scattered quartz and titanite crystals overlying a druse of albite.

Another specimen (84572) from the south slope of the Sawtooth Range has colorless to white simple rhombohedral crystals of chabazite up to 2 millimeters in diameter coating one broad surface of a mass of unaltered diorite.

Under the microscope the material associated with the vesuvianite shows very low birefringence and a refractive index of about 1.482–1.484.

GRAPHITE

A specimen (No. 84552) from North Italian Mountain is a schist which in places is largely massive graphite. This probably represents a highly metamorphosed carbonaceous shale. It contains very numerous black dodecahedral garnets up to 5 mm. in diameter.

MAGNETITE

Magnetite, in massive granular form, makes up the bulk of several specimens from North Italian Mountain (No. 84557). The magnetite masses contain numerous small cavities which contain small masses of pearly talc folia or are lined with tiny sulphur-yellow garnet crystals.

HEMATITE

Small aggregates of thin tabular plates of specular hematite occur in specimens consisting chiefly of acicular vesuvianite in calcite (No. 84554). Another specimen shows minute specularite plates in masses composed of fine rosettes of radiating pale brown stilbite blades. The largest plates of this mineral reach 2 cm. in breadth and are contained in thomsonite in sahlite-bordered veinlets in altered diorite.

CHALCEDONY

Chalcedony was noted in two specimens (No. 84560). In the first of these a peculiar rounded mass 8 mm. in diameter, of grayish-white chalcedony folds around and partly encloses imperfect epidote prisms in a cavity in a mass of translucent epidote. The second specimen shows a very similar mass of chalcedony of the same size resting on adularia in an adularia-epidote mass.

SIDERITE

A single specimen of buff limestone contains cavities lined with minute saddle-shaped siderite crystals. These are brown in color and iridescent with a more or less metallic luster. They are overlain by scalenohedral crystals of calcite. (No. 84573.)

ANKERITE

A specimen of bluish-gray impure limestone contains veins of carbonate up to 4 or 5 cm. thick. White scalenohedral calcite crystals rest on a brown-weathering crust 1 cm. or less in thickness. This contains cavities lined with minute saddle-shaped crystals. This mineral is probably iron-bearing dolomite or ankerite.

CALCITE

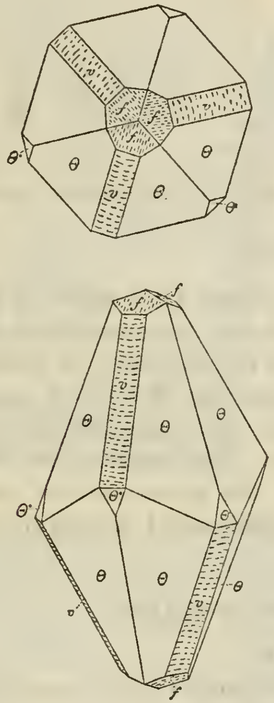
Calcite occurs as colorless "dogtooth" crystals averaging 5 mm. or more in length lining open cavities in seams in a dark gray limestone containing abundant finely disseminated pyrite. The calcite overlies a first lining of the open spaces which consists of a ferriferous dolomite or ankerite which weathers brown and, where it forms free surfaces, develops saddle-shaped aggregates of curved rhombohedral crystals. The calcite is all of similar habit and is rather simple, the forms present being (11$\bar{2}$2), (22$\bar{4}$1), ($\bar{4}$481), and ($\bar{4}$151). The habit is essentially as shown in the drawing, Figure 16. The faces of *f*(11$\bar{2}$2) are striated vertically as shown and give poor reflections. *v*(22$\bar{4}$1) is rounded and gives no signals but was identified by its zonal position. The other faces are bright.

PYRITE

Pyrite is generally distributed in the specimens associated with nearly all of the other minerals. It forms scattered crystals up to nearly 1 cm. in diameter, practically all of which have been completely altered and are now glossy pseudomorphs of hard vitreous limonite. While the crystal form is in a few places dominated by the pyritohedron or octahedron, the majority of the crystals are of complex appearance, and their development is probably controlled by diploids. The crystallography was not completely worked out.

Indistinct small crystals of pyrite altered to limonite occur in small vugs in massive garnet rock, overlying small crystals of grossularite. Scolecite and a little chabazite are associated with the pyrite and appear to be later than it (No. 84553). Scattered crystals of pyrite occur in cavities in specimens containing anorthite, adularia, titanite, epidote, and chlorite. The pyrite crystals, which reach 8 mm. in diameter and are of complex form, are probably the last mineral deposited in this assemblage. They are altered to limonite pseudomorphs (No. 84560). Similarly pyrite crystals up to 1 cm. in diameter occur in coarse brown grossularite garnet (No. 84559). Pyrite crystals ranging from minute to a diameter of 2 mm., the form of which is dominated by the pyritohedron, rest upon a crust of small green garnets. These are younger than the adularia crystals of the same specimen (No. 84576). Complex pyrite pseudomorphs, 3 mm. in diameter, which rest on vesuvianite, are apparently older than the prismatic quartz crystals which line the same cavity (No. 84559). Crystals up to 5 mm. in diameter rest upon mizzonite in a specimen composed of radiating mizzonite prisms (No. 84567).

While all of the preceding specimens are described as pyrite, no fresh pyrite remains in them, this mineral in all these cases being now represented by perfect pseudomorphs of limonite. Unaltered pyrite was, however, observed in a few specimens. Embedded imperfect pyrite crystals up to 4 mm. in diameter occur in limestone which contains vugs lined with siderite and calcite (No. 84573), and



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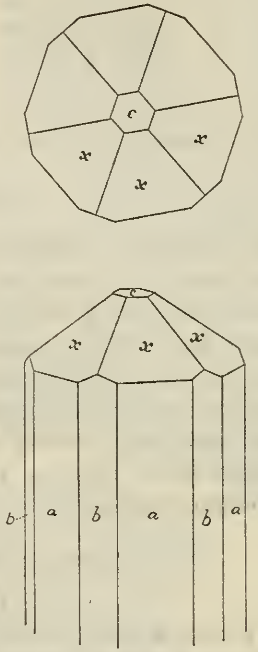


17

FIGS. 16–17.—16, CRYSTAL OF CALCITE. 17, CRYSTAL OF APATITE

another specimen of the same number shows a thin layer of fresh pyrite underlying a crust of calcite crystals resting on unaltered limestone. A specimen (No. 84562) consisting principally of anorthite contains scattered partly altered grains and imperfect crystals.

APATITE

Apatite forms small yellowish-white to colorless transparent crystals up to 3 mm. in diameter by 6 mm. long interspersed with sahlite crystals in cavities in solid masses of sahlite and occurs also as transparent pale greenish crystals embedded in calcite and ill-defined brownish masses up to 2 cm. long embedded in sahlite rock. The former crystals have the habit illustrated in Figure 17. The measurements obtained on such a crystal are as follows:

Measurements of apatite, Figure 17

Form		Symbol		Quality description	Measured		Calculated	
No.	Letter	Gdt.	Miller		ϕ	ρ	ϕ	ρ
					° ′	° ′	° ′	° ′
1	*c*	0	0001	Very good----	--------	0 00	--------	0 00
2	*a*	∞0	10$\bar{1}$0	Excellent-----	0 00	90 00	0 00	90 00
3	*b*	∞	11$\bar{2}$0	Good---------	30 00	90 00	30 00	90 00
4	*x*	10	10$\bar{1}$1	Excellent-----	0 00	40 10	0 00	40 16

Optically this apatite is uniaxial with the refractive index $\varpi = 1.634$.

BARITE

Barite is present in a single specimen (No. 84569) where it coats opposite surfaces of a mass of dense metamorphosed sedimentary rock. The crystals are flattened as though they had grown in a constricted space and reach a maximum size of about 8 mm. Crystals split on the basal cleavage show zoning in more and less transparent layers parallel to the unit prism. The crystals are very poorly defined and are bounded only by the prism *m*(110) and the base *c*(001). This gives them a rhombohedral appearance and they greatly resemble chabazite.

EXPLANATION OF PLATES

Plate 1

Upper left: Flattened barite crystals of rhombic outline resembling chabazite coating surface of rock along fracture.

Upper right: Twinned crystals of diopside lining cavity in diopside hornfels.

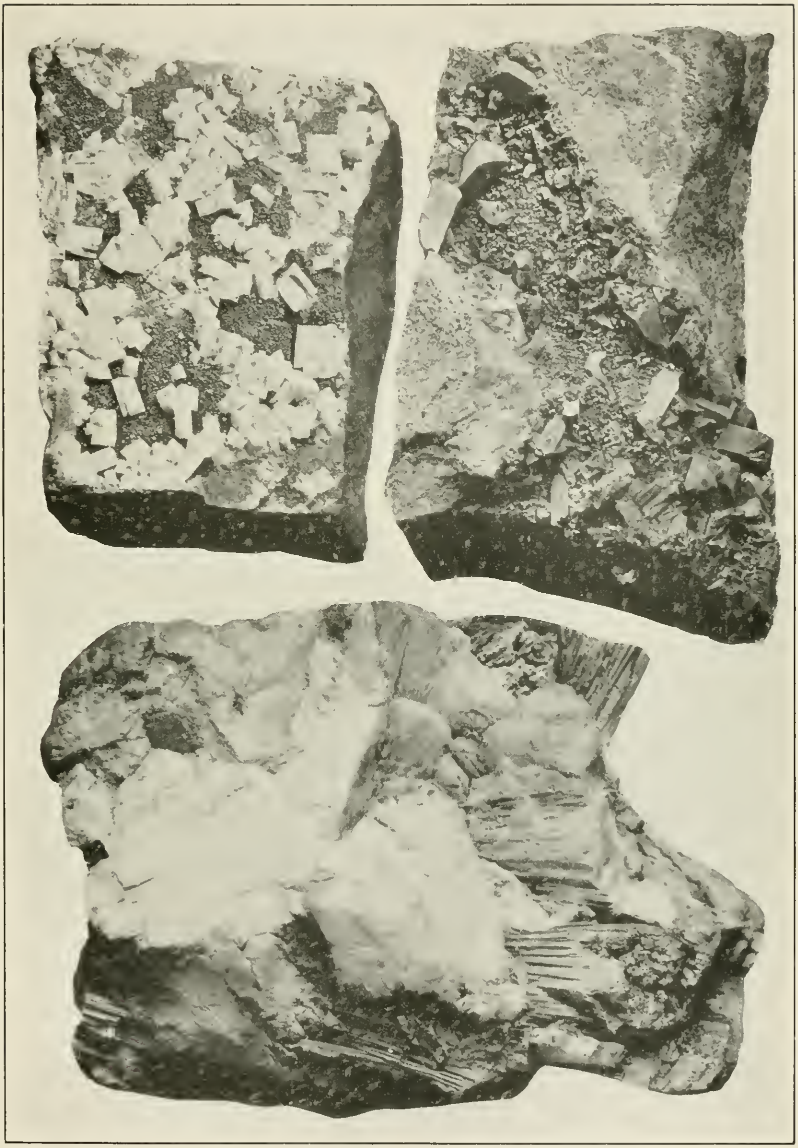
Lower: Coarse crystalline columnar mass of scapolite partially replaced by scolecite.

Plate 2

Upper: Perfect crystals of vesuvianite lining cavity in diopside rock.

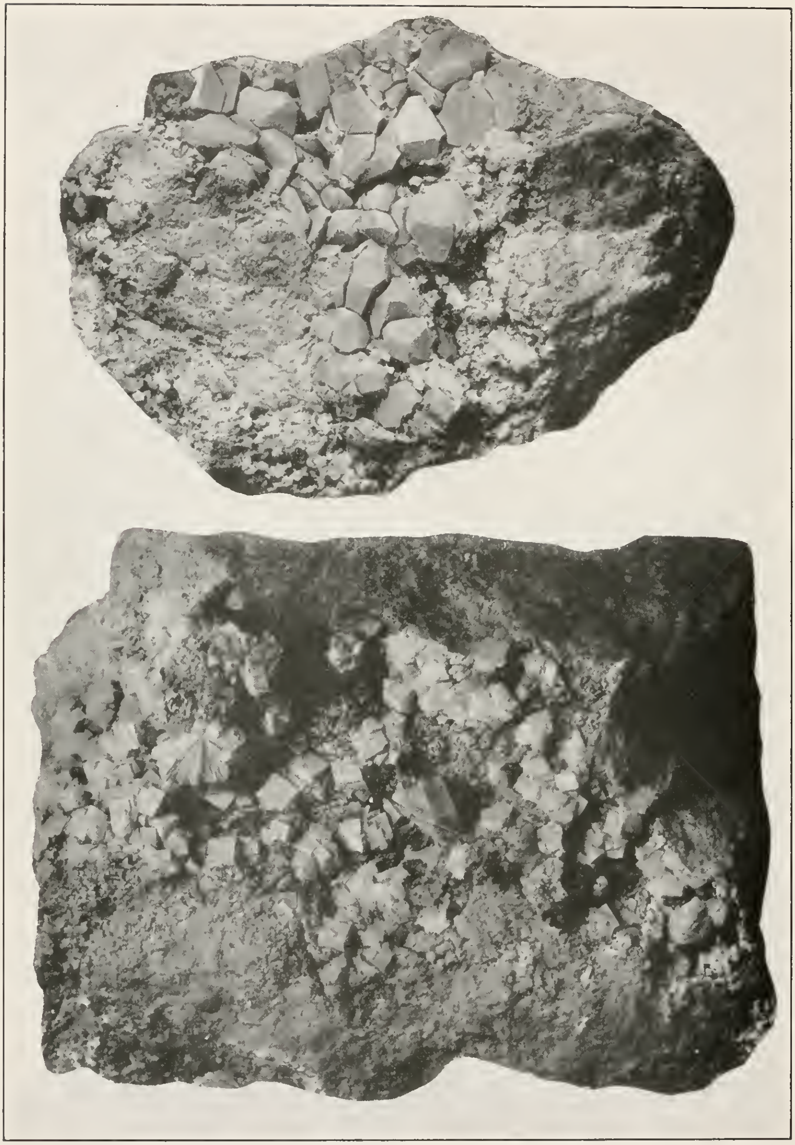
Lower: Rhombohedral crystals of chabazite, crystals of vesuvianite and a rosette of stilbite in a vug in massive diopside rock.

○



BARITE, DIOPSIDE, AND SCAPOLITE

FOR EXPLANATION OF PLATE SEE PAGE 42



VESUVIANITE, CHABAZITE, AND STILBITE

FOR EXPLANATION OF PLATE SEE PAGE 42