THE DEUTERIC AND LATER ALTERATIONS OF THE UNCOMPAHGRITE OF IRON HILL, COLORADO

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Abstract

The uncompahgrite, a coarse-grained melilite rock from Iron Hill, Colorado, offers an unusually good opportunity to follow a series of reactions and replacements of melilite and other minerals ranging from those caused by the residual liquor of the crystallizing magma before it separated from the crystal-mesh to those caused by hydrothermal solutions that gathered into fractures and were probably relatively dilute.

The first replacement formed a very small amount of light colored perofskite in narrow rims, associated with some phlogopite, about the darker colored magmatic perofskite and to a less extent about magnetite. This was followed by a larger scale replacement of melilite by a dark titaniferous garnet, that formed either irregular grains or more commonly, rims about perofskite, magnetite, and pyroxene; and to a less extent about melilite grains. In part the garnet replacement was concentrated in veinlike masses. The replacement of melilite by perofskite and probably much of that by garnet was brought about by the residual liquor of the magma before it had moved from the crystal-mesh. A part of the garnet was deposited by solutions moving in fractures.

The garnet became lighter colored and lower in titanium content toward the end of its period of deposition and it was joined by vesuvianite and this in turn by a colorless diopside. The replacement of melilite by vesuvianite and diopside took place along fractures in the rock, was unevenly distributed, and locally yielded large bodies.

The next alteration was to sheaves of a finely fibrous new mineral, called juanite. Juanite was followed by an undetermined fibrous mineral (mineral A) and this by cebollite. The cebollite, was, in turn, followed by a second undetermined mineral (mineral B).

Brugnatellite was found locally. Hastingsite replaced the pyroxene in small amount and soda tremolite and aegirite were formed in seams; they were probaby a result of the intrusion of the uncompahgrite by a pyroxenite.

In the replacement of melilite by vesuvianite and diopside, by juanite, and by cebollite, there was very little change in chemical composition.

Juanite occurs in fibrous growths. It is probably orthorhombic with Z parallel to the length. It appears to be optically positive with a moderate axial angle. $\alpha = 1.640$; $\gamma = 1.647$. Fusibility about 3; Hardness $5\frac{1}{2}$. It has the composition $10CaO \cdot 4MgO \cdot Al_2O_3 \cdot 11SiO_2 \cdot 4H_2O$.

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INTRODUCTION

The field data and the material described in this report were collected by the senior author while making a geological map of the San Juan region, Colorado, for the United States Geological Survey. The laboratory work was carried on in the Department of Mineralogy and Petrography of Harvard University.

The Iron Hill stock of alkaline rocks is located in Gunnison County, Colorado, about 20 miles south 20° west of the town of Gunnison and a few miles southeast of Powderhorn Post Office.

THE UNCOMPAHGRITE AND ITS GEOLOGICAL OCCURRENCE

The alkaline stock is about 8 miles across. It intruded pre-Cambrian gneisses and granitic rocks, is overlain by the Tertiary volcanics, and as the minerals peculiar to the stock are found in the heavy concentrates of a nearby sandstone of Jurassic age, it is believed to be pre-Jurassic. The oldest rock within the stock is a great mass of marble about a mile across. This was intruded by the uncompahgrite. The main mass of the stock is a pyroxenite of somewhat variable composition, carrying masses of magnetite-perofskite rock. This pyroxenite intruded the uncompahgrite and was in turn intruded by dikes and less regular bodies of ijolite. The next intrusion was a soda syenite, followed by a nepheline syenite, and the last intrusions were dikes of nepheline gabbro and a gabbro carrying some quartz and orthoclase. Numerous veins of calcite carrying some aegirite, amphiboles, phlogopite and other minerals are present.

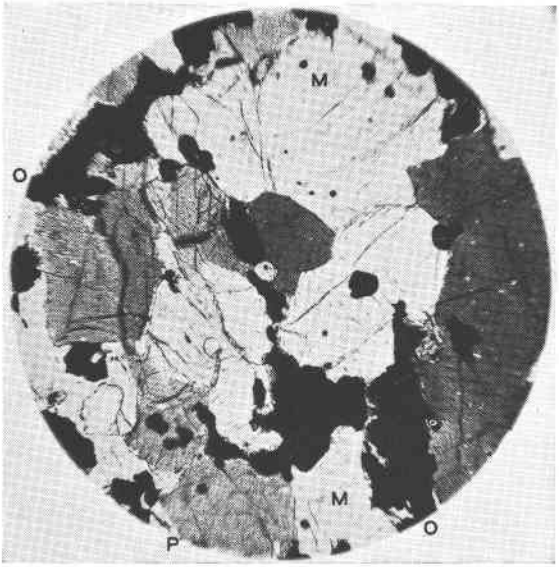

FIG. 1. The fresh uncompahgrite, melilite (M), primary pyroxene (P), and iron ore (O). Crossed nicols ×35.

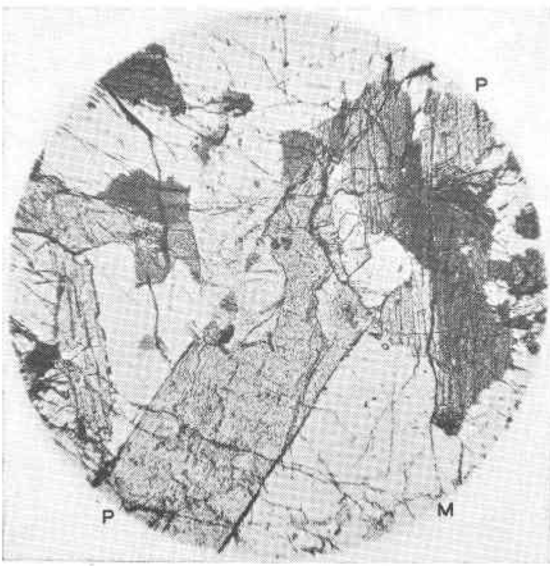

FIG. 2. The fresh uncompahgrite showing primary pyroxene (P) with corroded outlines. Crossed nicols ×20.

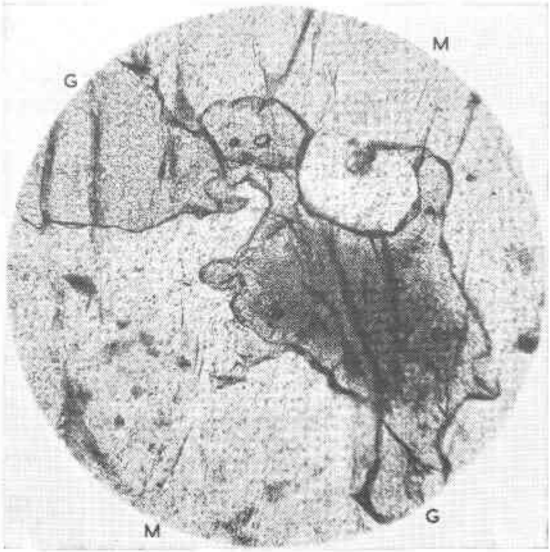

FIG. 3. Irregular patches of garnet (G) in melilite (M). The right-hand grain of garnet shows the two-color varieties, the brown center and the olive-green border. Partly crossed nicols ×70.

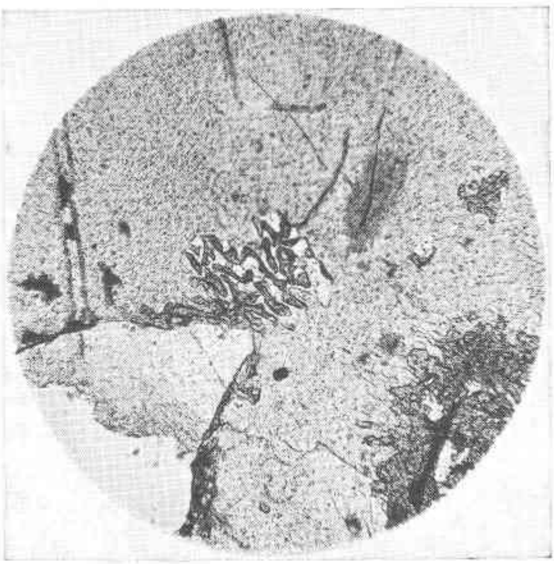

FIG. 4. Micrographic growth of garnet in melilite. partly crossed nicols ×70.

The uncompahgrite is present only in the drainage area of Beaver Creek, north of Iron Hill, in several disconnected masses, the largest of which is about a mile long and half a mile wide. The fresh rock is blue-gray in color and consists of about two-thirds of melilite with the balance chiefly green diopside, magnetite, perofskite, and apatite. The grain size varies greatly and is determined chiefly by the melilite, which varies from less than a millimeter to over 50 centimeters in cross section. In the finer-grained varieties the texture is granular, while in the coarse varieties the huge melilite crystals enclose the other constituents. Primary (?) calcite is present in small amount as an interstitial constituent, and commonly shows reaction rims of garnet. Very pale green or brown phlogopite which crystallized very late is present in small amount as plates or irregular grains, or as rims around perofskite, apatite, and magnetite. Where it adjoins perofskite it shows pleochroic halos. Nepheline, mostly altered, is a rare constituent. Typical photomicrographs of the unaltered medium-grained uncompahgrite are shown in figures 1 and 2.

THE ALTERED UNCOMPAHGRITE

Though considerable parts of the uncompahgrite show little alteration, much of it is partly altered and some parts of it are almost completely altered. The nepheline, where present, is the mineral most susceptible to alteration; the melilite is also altered, whereas the other minerals are rather resistent. The alteration may replace either large masses of the melilite or be confined to streaks, seams, or veinlets, giving the rock a streaked or banded appearance.

Late Perofskite

The first alteration, which shows in only a few specimens, formed narrow rims—a fraction of a millimeter across—of perofskite about both magnetite and primary perofskite next to melilite. This late perofskite is yellow-brown and much lighter in color than the early perofskite. Small grains of perofskite are either associated with, or incorporated in small bands of garnet which surround magnetite.

Titaniferous Garnet

Following the late perofskite, garnet formed either in vein-like masses, in individual euhedral or subhedral crystals (figure 3) or in irregular borders about the earlier minerals (figures 5 and 11).

It formed borders most commonly about magnetite, perofskite, and calcite, less commonly about mica and apatite, and rarely about pyroxene and coarse calcite. In some specimens pale phlogopite is associated with this garnet and appears to have been formed with it. The garnet and mica also occur in narrow veinlets cutting the melilite or as narrow borders between melilite grains. In a few slides patches a millimeter across in large melilite crystals are made up of vermicular intergrowths of garnet and melilite much like symplektitic or micrographic textures (figure 4). In one section a similar intergrowth of garnet and primary pyroxene was found. The main part of the garnet, especially that next the magnetite, is dark-brown under the microscope, has an index of refraction of 1.95 and is a titaniferous andradite. The borders are light olive-green to nearly colorless and have an index of refraction as low as 1.85. The two varieties grade into one another (figure 3).

In part the phlogopite was later than the garnet as it formed narrow ragged fringes about garnet crystals. In places the mica appears to have replaced the garnet.

In several specimens magnetite is surrounded by a narrow layer of pale perofskite, about this is a narrow layer of garnet, and about the latter a less regular layer of phlogopite. Fresh melilite is next the phlogopite.

For the most part the garnet replaced melilite, but it may to a small extent have replaced other minerals. In some specimens the garnet might be considered as due to a reaction between melilite and magnetite, but in others it is present about perofskite, apatite, and all other primary minerals as well as between the melilite grains and in veinlets cutting the melilite grains. This replacement is irregularly, but widely distributed, and differs in amount from place to place. In most specimens only a few per cent of garnet and mica were formed but in some, 30 per cent or more; and in a few veinlike bodies, up to 20 centimeters or more across, over 50 per cent of garnet was formed. In all cases the garnet is surrounded by fresh melilite, unless the melilite has been later altered.

A vein about 10 centimeters wide cutting the uncompahgrite exposed in the bed of the gully south of Beaver Creek, three-quarters of a mile above the mouth and about 250 yards below the fork of the gully, was formed by moving solutions. The borders of this vein are made up chiefly of the brown garnet with some pale green phlogopite, pleochroic green chlorite, calcite, and fibrous zeolites.

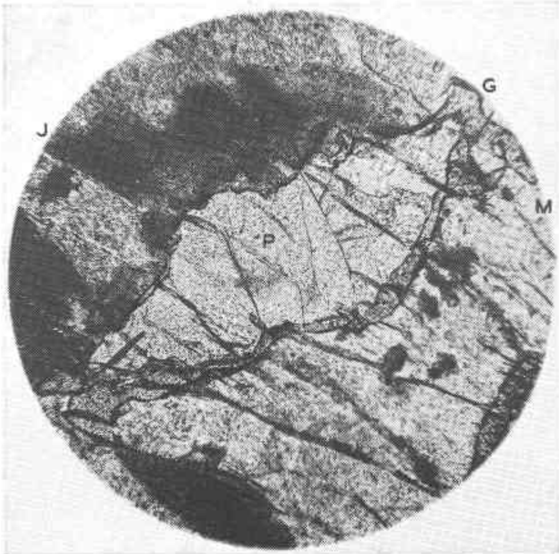

FIG. 5. Garnet (G) bordering an irregular grain of primary pyroxene (P); the outer surrounding mineral is melilite (M) partly altered to juanite (J) etc. Partly crossed nicols ×70.

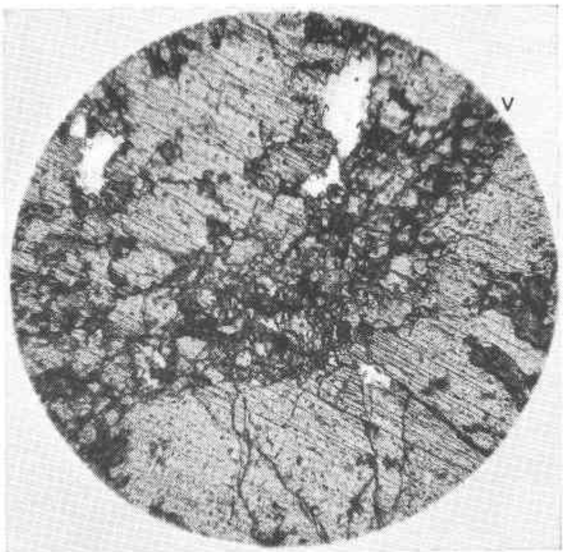

FIG. 6. A large grain of primary pyroxene being replaced by vesuvianite (V). Partly crossed nicols ×40.

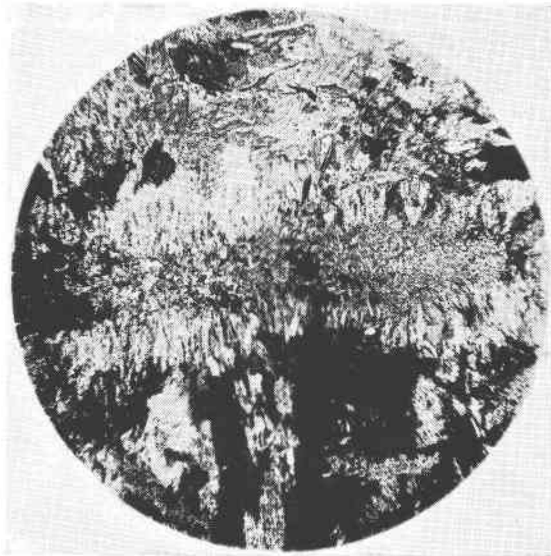

FIG 7. Secondary diopside and vesuvianite in a highly altered uncompahgrite. The diopside is in fibres arranged at right angles to the fracture crossing the centre of the slide. Crossed nicols ×70.

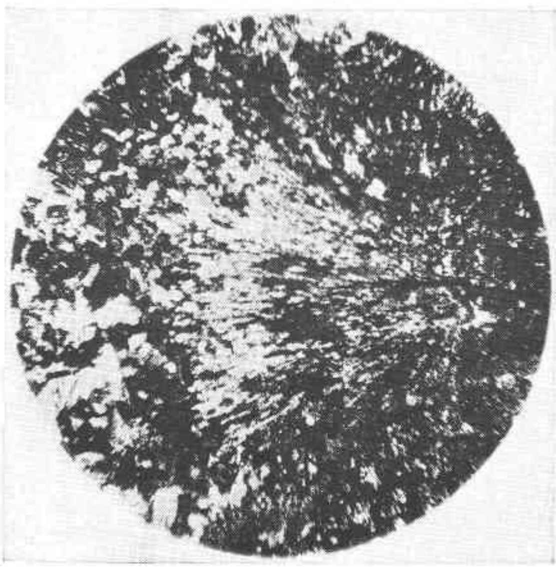

FIG. 8. Radiating secondary diopside (light) and vesuvianite (dark) in the altered uncompahgrite. Crossed nicols ×40.

Next to this zone and grading into it is a zone made up mostly of coarse vesuvianite in which are embedded crystals of monticellite. The center is made up of large grains of cancrinite containing embedded grains of monticellite[2] and some of the brown garnet.

At the time of the deposition of the garnet and phlogopite the magma must have been almost completely crystalline and the amount of interstitial liquid could not have exceeded a few per cent. The formation of the garnet may have been partly caused by the residual interstitial liquid before that liquid had moved from the interstices between the crystals but the uneven distribution of the replacement and particularly the presence of the vein-like bodies of garnet rock show that the liquid had moved somewhat and had collected in fractures and other channelways. It seems probable that this replacement was transitional between a truly magmatic reaction and a hydrothermal reaction (due to moving solutions enriched in water).

Vesuvianite and Diopside

Following the deposition of the garnet, but in part contemporaneous with it, vesuvianite and colorless diopside began to replace melilite. In some large bodies of uncompahgrite the melilite is completely replaced, in other large bodies the melilite is unaltered except for scattered thin veinlets of the secondary minerals. In places the veinlets are so abundant that only remnants of fresh melilite remain. The alteration took place chiefly from fractures in the rock and worked out from them (figure 7). In part it began at the borders of the melilite grains, or about grains of magnetite or other minor constituents as centers, and spread out forming spherulitic bodies of the secondary minerals (figures 8 and 12). In one specimen a thin network of diopside separates the melilite grains and areas of diopside enclosing several melilite grains give simultaneous extinction.

The minerals of this replacement are colorless diopside, colorless garnet, and vesuvianite with some calcite. Chlorite, muscovite, titanite, and amphibole are in places associated with these minerals and are probably of late origin. The minerals are in fine intergrowths in many of the rocks, in part resembling micropegmatitic intergrowths. In part the diopside is in plumose or arboroscent aggregates penetrating the garnet or vesuvianite and in part it formed in

[2] Larsen, E. S. and Foshag, W. F., Cancrinite as a high temperature hydrothermal mineral from Colorado: *Am. Min.*, **11**, 300–303, 1926.

widely radiating aggregates from the grains of magnetite, apatite, perofskite, and other minerals or from the plane of the fracture along which the altering solutions moved.

Though in most places the three minerals are so intimately intergrown as to leave no reason to believe that one preceded the other, locally garnet preceded vesuvianite and diopside was last. Veinlets of diopside cut the vesuvianite and crystals of the diopside project into the vesuvianite from the walls of veinlets.

In some of the rock where the replacement is most complete the replaced rock is a coarse-grained aggregate of garnet, vesuvianite, diopside, and some calcite with the original minerals of the uncompahgrite, except the melilite. In these aggregates the minerals tend to intergrow much as they do in the lime-silicate hydrothermal contact metamorphic replacements of limestone. Indeed, these rocks were at first called contact metamorphic limestones but the fact that they still have all the original minerals of the uncompahgrite, except melilite and nepheline, and that the alteration of uncompahgrite can be found in all stages of development, shows conclusively that they represent altered uncompahgrite.

Vermicular or symplectitic intergrowths between the secondary minerals, or between them and the primary minerals, are common. In one slide a peculiar vermicular intergrowth of melilite and diopside occurs around magnetite and apatite grains where they are in contact with melilite. Commonly between the magnetite and this vermicular growth is a narrow zone of light colored perofskite, the latter generally partly altered to leucoxene. Along the adjacent melilite grain borders are small irregular blebs of diopside but they do not form the delicate intergrowth. No diopside-hedenbergite similar to that which crystallized early from the uncompahgrite magma was noted in the two slides showing this texture.

In one slide tiny veins change character when passing through magnetite. These veins are formed of calcite where in altered melilite but in magnetite they are formed of vesuvianite in minute terminated prisms, jutting out at high angles to the walls with the centre of the vein composed of calcite. Another section shows a similar vein in altered melilite and magnetite with both calcite and vesuvianite along its entire course, the later, however, had not crystallized in prisms but occurred in streaks along the vein walls.

Juanite

Following the replacement of melilite by vesuvianite and diopside, the remaining melilite was subjected to attack by four or more successive waves of hydrothermal alteration. In each wave the fresh melilite was chiefly attacked leaving the other mineral, including the older alteration products, practically unchanged. These changes took place along fractures and no large bodies of rock were affected, but the alterations were widespread and no large body of fresh uncompahgrite is free from veinlets of these alteration products. The relative ages of the different products are easily determined as veinlets of later types cut the older kinds.

The earliest of these alterations and probably the most abundant yielded a new fibrous, nearly white mineral, called juanite. It is arranged in sheaf-like aggregates about a millimeter long. In part this alteration to juanite follows cleavages or crystal boundaries of the melilite but for the most part its position does not seem to be determined by any structural control (figures 9 and 10). The mineral is described in a later section. It has a composition much like that of the melilite but some soda has been removed and some water added.

Undetermined Mineral A

Sheaf-like fibrous aggregates, much like those of juanite but with a somewhat stronger birefringence and lower indices of refraction, are commonly mixed with the juanite sheaves in small amount and in one section they make up a considerable part of the mass. This will be called Mineral A. The aggregates of Mineral A are commonly clearer then the juanite and in places grow out from grains or apatite. Small veinlets of Mineral A traverse the juanite and it is therefore younger, or perhaps in part contemporaneous with the juanite.

Cebollite

The next alteration product to form was cebollite, described in 1914 by Larsen and Schaller[3] from this area. The cebollite, colorless in thin section and minutely fibrous in habit, is definitely related to

[3] Larsen, E. S. and Schaller, W. T., Cebollite, a new mineral: *Jour. Wash. Acad. Sci.*, **IV**, pp. 480–2, 1914. Kranck, E. H., On turjaite and the ijolite stem of Turja, Kola: *Fenia.*, **51**, No. 5, p. 27, 1928. Tilley, C. E. and Harwood, H. F., The dolerite-chalk contact of Scawt Hill, Antrim: *Min. Mag.*, **22**, pp. 455–6, 1931.

fractures in the melilite, and forms only in close proximity to these fractures (figs. 10, 11, and 12). The cebollite fibres form along the walls of the fractures with their long axes usually perpendicular or at high angle to the fracture direction. In one section melilite, altered almost completely to juanite, was cut by a fracture at an angle to the cleavage of the melilite, and cebollite had formed along this fracture (fig. 10); the juanite fibre aggregates had replaced the melilite with their long axes parallel to the cleavage of the host and the cebollite was replacing the juanite in like manner. The cebollite is associated with a colorless, granular, isotropic mineral that resembles garnet but has a low index of refraction ($n=1.67$).

Undetermined Mineral B

An alteration product called Mineral B found in only one thin section, occurs in a tiny veinlet cutting the juanite and the cebollite. The vein has tiny apophyses. The mineral is fine grained in the center of the vein but in the apophyses and along the borders of the veinlets it forms tiny needles arranged at an angle to the vein. This mineral has a low birefringence and the indices of refraction are between those of juanite and Canada balsam.

Brugnatellite

A micaceous mass of nearly colorless brugnatellite, a hydrous carbonate of magnesium and ferric iron, was found as another kind of alteration of the melilite in small amount and in a few places, especially in the lower part of the gully south of Beaver Creek, and half a mile above the wagon road. It is present in vein-like streaks and as it is very soft it may be fairly common but rarely exposed. It is associated with a little calcite and hornblende.

The formation of the brugnatellite can not be placed in the sequence of alterations of the melilite. Its character indicates a very late hydrothermal alteration.

Zeolites

The nepheline, which is rare in the uncompahgrite, is largely altered to mixtures of analcite, cancrinite and a fibrous zeolite, probably natrolite or hydronephelite. In some parts the cancrinite has a low birefringence and is probably sulphatic cancrinite.

Amphibole, Chlorite, Aegirite, and Mica

The pyroxene, apatite, magnetite, perofskite, and mica, are mostly fresh, even where the melilite and nepheline have been com-

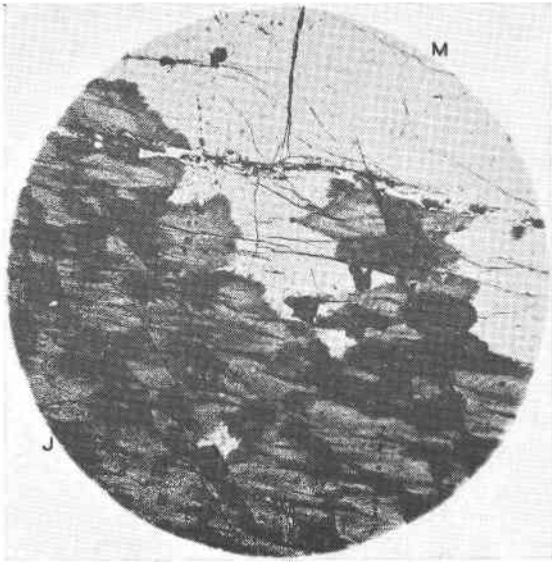

FIG. 9. Juanite (J) and alteration A attacking melilite. The long direction of the juanite sheaves are parallel to the cleavage of the melilite. Ordinary light ×20.

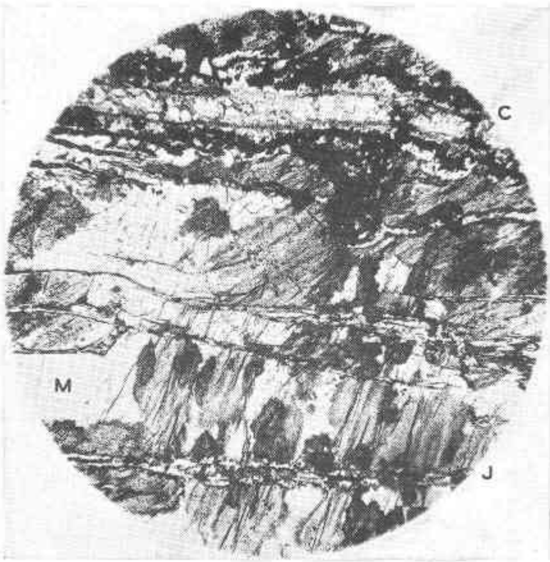

FIG. 10. Melilite (M) altered partly to juanite (J) and cut by a vein bordered by cebollite (C). The centre of the veinlet is mainly filled with fine-grained carbonate. Ordinary light ×20.

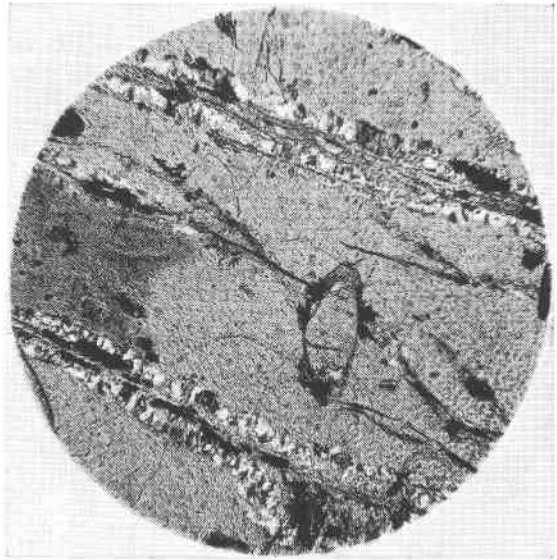

FIG. 11. Cebollite in veinlets cutting melilite; the cebollite fibres are arranged perpendicular to the veinlet. The centres of the veinlets are filled with fine-grained carbonate. Near the centre of the photomicrograph is a grain of apatite partly surrounded by garnet. Crossed nicol ×70.

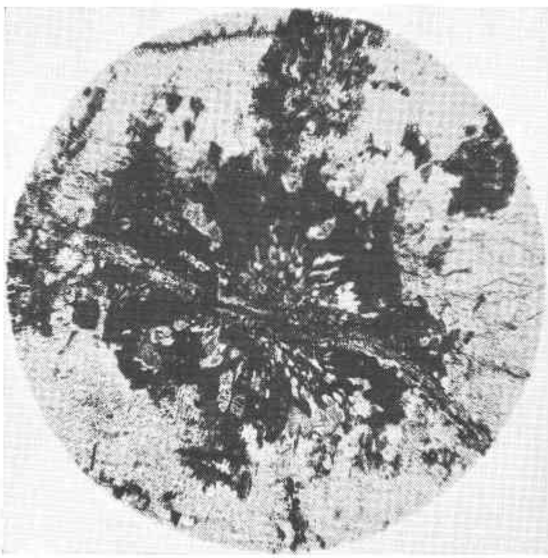

FIG. 12. A veinlet of cebollite and carbonate in melilite and vesuvianite. The dark mineral surrounding the veinlet is vesuvianite containing small prismatic crystals of secondary diopside. Crossed nicols ×70 .

pletely replaced. However, in places the pyroxene is more or less altered to magnesic hastingsite and to some green, uniaxial positive, chlorite. In part this alteration is scattered through the rock, in part along veinlets associated with calcite or zeolites that cut the altered melilite rock and are distinctly later than the vesuvianite-garnet-diopside rock. In one specimen the magnetite is bordered by a narrow zone of pale garnet, outside of this is a layer of pale green phlogopite, and beyond this a layer of blue-green amphibole.

In one specimen there are areas of coarsely crystalline nearly colorless phlogopite and calcite.

In some places aegirite, phlogopite, and an amphibole near soda-tremolite are developed in the uncompahgrite.

SUCCESSION OF ALTERATIONS

The alteration of the uncompahgrite reveals a long sequence of changes from the intrusion of the magma to the present time.

After intrusion, on cooling and gradual loss of mineralizers, crystallization began with the formation of the diopside-hedenbergite. This was followed by the crystallization of magnetite and perofskite and then melilite. After the rock was almost completely crystallized the small amount of residual liquid, now greatly enriched in mineralizers, reacted with the crystallized minerals and first deposited a little perofskite about the magnetite and early perofskite, then dark titaniferous garnet about perofskite, magnetite, pyroxene, and apatite where these minerals were in contact with melilite and rarely about individual grains of melilite, or in veinlets cutting the older minerals. Later, phlogopite was formed with the garnet. The last of the garnet was lighter colored and poorer in iron and titanium. The preceding alterations were probably partly brought about by the residual magmatic liquid before it had moved from the interstices between the crystals but in part after the liquid had gathered into channelways.

Vesuvianite with colorless garnet next replaced the melilite and colorless diopside was later added to the vesuvianite. Calcite also was deposited to some extent. The liquids forming this vesuvianite-diopside rock were separated from between the crystal mesh and were clearly moving along fractures and only locally replaced the melilite. The products of this alteration are much like the high temperature hydrothermal contact metamorphic rocks derived from limestones and were no doubt produced under about the same temperature conditions.

Following the formation of the vesuvianite-diopside rock four or more other replacements of melilite, all by fibrous minerals growing out from fractures, affected parts of the melilite in regular order. Omitting the minor alteration products, the first was to juanite; then Mineral A. Later came the cebollite and finally Mineral B.

The replacements of melilite heretofore described appear to have been paulopost—caused by solutions that originated in the uncompahgrite magma itself. The evidence for this is:

1. The gradational character of the replacements beginning with reaction by the interstitial liquid.
2. The distribution of the replacement bodies without regard to contacts with the later pyroxenite.
3. The replacements are entirely different from those caused by the pyroxenite in intruded limestone, granite, and other rocks, which is characterized by soda-tremolite, aegirite, and phlogopite.

The sequence in the crystallization and later replacements in the uncompahgrite are summarized in table 1.

TABLE I
SEQUENCE IN THE CRYSTALLIZATION AND PAULOPOST REPLACEMENTS OF THE UNCOMPAHGRITE. DECREASING TEMPERATURE ⟶

	Magmatic	Magmatic reaction	Moving solutions
Diopside-hedenbergite	—		
Magnetite	—		
Apatite	—		
Perofskite	—		
Melilite	—		
Green phlogopite	—	—	
Carbonate (coarse-grained)	—	—	
Perofskite (light-colored)		—	
Garnet (titaniferous)		—	—
Garnet (light-colored)			—
Green phlogopite			—
Vesuvianite			—
Diopside (colorless)			—
Carbonate (medium-grained)			—
Juanite			—
Mineral A			—
Cebollite			—
Mineral B			—
Carbonate (fine-grained)			—

The brugnatellite was formed along fractures at a later time.

The rare hastingsite probably replaced the pyroxene after the intrusion of the pyroxenite as it is similar to the hastingsite that replaced the diopside of the pyroxenite. Likewise the rare vein-like bodies of aegirite and soda-tremolite are like the abundant alteration products caused by the pyroxenite and were no doubt formed by solutions from the pyroxenite.

CHEMISTRY OF THE ALTERATION PRODUCTS

The analyses of the melilite and of some of the alteration and replacement products, arranged in the order in which they are formed, are given in table 2. The first replacement product, perofskite, involved chiefly a substitution of silica by titania and took place on a very small scale. The second product, titaniferous garnet, formed partly in the very late magmatic stage but continued into the very early hydrothermal stage when the solutions were collecting and moving along fractures and other channelways. An analyses of a similar titaniferous garnet from the ijolite of the Iron Hill area is shown in table 2, column 2. This replacement of melilite by garnet involved a loss of silica, alumina, magnesia, lime, and alkalies, a large gain in ferric iron, and considerable gain in titania. Some of the alumina and magnesia may have gone into the biotite which commonly accompanies the garnet in small amount. The late light-colored garnet has much less titania and iron.

The third replacement appears to have followed the first closely and was clearly caused by moving solutions. In it, the melilite was replaced by a mixture composed chiefly of vesuvianite and diopside, with some carbonate, garnet, and other minerals. An analysis of uncompahgrite in which the melilite was completely altered to a coarse aggregate made up chiefly of vesuvianite and diopside is shown in column 3. It should be compared with analysis (1a) which represents fresh uncompahgrite. The approximate composition of this alteration product indicates, as does an examination under the microscope, a mixture made up about half of vesuvianite and a quarter of diopside. In this replacement there was little change in bulk composition—an oxidation of iron, a loss of nearly all the alkalies and a gain of about two per cent of water.

In the next large scale replacement to juanite, shown in column 4, there was a loss of alumina and alkalies, and a gain in magnesia and water, although the changes were not great.

In the alteration to cebollite, column 5, there was a considerable gain in magnesia and water, moderate loss in lime and alumina, an oxidation of the iron, and a replacement of part of the soda by potash.

TABLE 2

ANALYSES OF MELILITE, UNCOMPAHGRITE, AND REPLACEMENT PRODUCTS

	1	1a	2	3	4	5
SiO_2	44.13	38.04	34.30	40.01	42.05	33.02
Al_2O_3	10.80	6.34	4.46	5.41	5.19	14.02
Fe_2O_3		8.45	24.09	7.12	3.26	3.43
FeO	2.04	5.90		1.08		0.21
MgO	4.35	7.81	0.52	8.89	9.52	4.69
CaO	34.63	27.19	31.06	30.99	34.68	35.72
Na_2O	3.40	2.16		0.60	1.06	2.57
K_2O	tr.	0.12		—	0.14	tr.
H_2O-		0.22		0.52	4.45	none
H_2O+	0.49	0.48		2.00		6.26
TiO_2		1.98	5.08	1.00	none	
CO_2		0.30		1.51		
P_2O_5		0.24		0.88		
MnO	0.16	0.23		0.11	0.09	
S		0.02		0.06		
BaO						
SrO		0.26		0.21		
	100.00	99.74	99.51	100.39	100.44	99.92
Sp. Gr.	2.98	3.29	3.67	3.24	3.015	2.96

1. Melilite from Iron Hill computed free of impurities, W. T. Schaller, analyst.
1a. Typical fresh, fine-grained uncompahgrite, F. A. Gonyer, analyst.
2. Titaniferous garnet from ijolite of Iron Hill. Much like the garnet of the uncompahgrite. Approximate analysis by W. T. Schaller.
3. Uncompahgrite in which the melilite is altered to a coarse aggregate of vesuvianite, diopside, etc. F. A. Gonyer, analyst.
4. Juanite. F. A. Gonyer, analyst.
5. Cebollite. W. T. Schaller, analyst.

The approximate percentages of losses and gains in the major oxides and the changes in specific gravity that took place during the successive alterations are shown in table 3.

JUANITE,[4] A NEW MINERAL

The occurrence and general character of juanite have been described in the preceding pages. It remains to add a few details.

[4] Named from the San Juan Mountains of Colorado and pronounced huanite.

TABLE 3
APPROXIMATE CHEMICAL CHANGES IN THE REPLACEMENTS OF MELILITE

	Perofskite	Titaniferous garnet	Diopside and Vesuvianite	Juanite	Cebollite
SiO_2	Large loss	−10		−2	−10
TiO_2	Large gain	+ 5			
Al_2O_3	Loss	− 6		−5	+ 3
Fe_2O_3 / FeO		+22	Oxidation	Oxidation	Oxidation +3
MgO	Loss	− 4		+4	
CaO		− 3			
Na_2O	Loss	− 3	−2	−3	− 1
K_2O					
H_2O			+2	+4	+ 6
Change in Sp.Gr.	+Large	+Large	Little	+0.03	−0.02

The mineral is in such finely-fibrous aggregates that reliable optical data could not be had. The following measurements were made but they are due to aggregate effects. Parallel extinction; positive elongation; orthorhombic (?); optically+; $2V=50°$ (?); $\alpha=1.640$; $\gamma=1.647$; $\pm.003$; fusibility about 3; B. B. to a translucent glass; hardness 5.5; decomposed by acid.

Two analyses of juanite by F. A. Gonyer from different localities, both in the Beaver Creek drainage area follow. They are very similar and lead to the formula $4H_2O \cdot 10CaO \cdot 4MgO \cdot Al_2O_3 \cdot 11SiO_2$.

	1.	2.	Molecular proportions of average
SiO_2	42.54	42.05	702 = 11×64
TiO_2		none	
Al_2O_3	5.65	5.19	53 } = 1×70
Fe_2O_3	2.68 }	3.26	17 }
FeO	0.56 }		8 }
MnO	0.11	0.09	} = 4×59
MgO	8.64	9.52	226 }
CaO	35.00	34.68	622 }
Na_2O	0.84	1.06	15 } = 10×64
K_2O	0.04	0.14	1 }
P_2O_5	0.04		
H_2O-	0.18 }	4.45	
H_2O+	4.06 }		244 = 4×61
	100.34	100.44	
Sp.Gr.	3.01		

NEW OPTICAL DATA ON CEBOLLITE

New optical data on cebollite by Goranson are given below with the older data by Larsen.

	Goranson	Larsen
Optical Sign	+	+
Crystal System	Orth. (?)	Orth. (?)
2V	Med. Large	58° ±
Dispersion of 2V	$\rho > v$, weak	
$\alpha =$	1.592	1.595
$\beta =$	1.597	1.60
$\gamma =$	1.630	1.628