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THE MANGANESE MINERALS OF A VEIN NEAR BALD KNOB, NORTH CAROLINA

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INTRODUCTION

One of the authors (C. S. R.) has been engaged in a study of the copper deposits of the southern Appalachian region, and in the course of that work has had opportunities to study mineral deposits of various other types in the region. One of the most interesting of these is a vein near Bald Knob, North Carolina, which is characterized by an unusual group of manganese silicates and oxides. This locality was visited in 1927, in company with Mr. E. B. Crabill of Galax, Virginia, who has long been interested in the geology and minerals of this region, and has often given his kindly and valuable assistance to visiting geologists.

A study of the minerals in the Bald Knob vein was begun in 1927, and Mr. Earl V. Shannon of the National Museum, made chemical analyses of the more interesting minerals. Optical and chemical data indicated the presence of at least one new mineral, but full confirmation required careful *x*-ray diffraction studies. These have now been completed and a final report can be made on the minerals of this vein. In the meantime, further work was done on the vein, and it has been visited (in May, 1931) by Mr. D. F. Hewett of the United States Geological Survey, in company with Mr. Crabill. Additional specimens and data on the vein were secured by Mr. Hewett and these have been a valuable help in completing this study.

The Bald Knob vein contains an unusual group of minerals, among which two are new. It also presents a most interesting problem in the paragenesis of hypogene manganese silicates, but only the mineralogy of the vein will be considered in this paper.

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LOCATION AND CHARACTER OF VEIN

The manganese vein is situated in Alleghany County, North Carolina, and has been prospected at a point about $1\frac{1}{2}$ miles (2.4 kilometers) south of the North Carolina-Virginia State line and 6 miles (9.6 kilometers) northwest of the southeast corner of the Wytheville topographic quadrangle. Independence, Virginia, is about 7 miles (11.26 kilometers) northwest and Sparta, North Carolina, about 3 miles (4.83 kilometers) southwest. Bald Knob, a small peak that rises to a height of 3,650 feet (1,112 meters), lies one-half mile (0.8 kilometers) northwest and New River is about $2\frac{1}{2}$ miles (4 kilometers) north from this locality. The region is a deeply dissected northward-dipping peneplain rising to an elevation of about 3,000 feet (914 meters) where the vein outcrops.

This part of Virginia and North Carolina was, in the 50's of the last century, a noted mining region that produced large supplies of copper from secondary ores. Sixteen miles northeast (25 kilometers) is the southwestern end of the Great Gossan Lead, a copper-bearing pyrrhotite vein 35 to 150 feet (10.7 to 49.2 meters) wide, and during mining activity, marked by mines scattered for 18 miles (29 kilometers) along its course. The Ore Knob copper mine of North Carolina is 16 miles (25 kilometers) southwest. Less important veins are the Peachbottom, a few miles south, and the so-called native copper lead to the east. The whole region was intensely prospected about 75 years ago, but manganese-bearing veins have not been previously reported.

Mr. Crabill reports that similar veins have been traced for over 20 miles (32 kilometers) by the gossan and, where prospected, they were found to lie parallel to, and almost in contact with, a lens of the pre-Cambrian Roan gneiss which follows the general strike of the foliated country rock, which is southeast. The vein is explored by a 60-foot (18 meter) inclined shaft which exposes a width of from 5 to 7 feet (1.5 to 2.1 meters). Oxides of manganese are the most abundant minerals to a depth of 10 feet (3 meters), but none persist more than 40 feet (15 meters), the depth at which the water table was encountered. Mr. Hewett made the following observations on the relationships in the unoxidized portion of the vein. The country rock strikes N. 45° – $50'$ E. and dips 50° to 60° SE. In contact with the southwest, or foot wall, is a lens of massive garnet about 2 feet wide (0.6 meter). Next is a lens about 1 foot (0.3 meter) wide composed largely of carbonate and the new mineral, alle-

ghanyite, but with lesser amounts of tephroite and the new spinel, galaxite. Next is a zone about 2 feet (0.6 meter) wide of massive garnet and in contact with the hanging wall a 3-foot (0.9 meter) zone of rhodonite, and lesser amounts of spessartite and tephroite. Of these lenses the one characterized by carbonate and the new minerals, alleghanyite and galaxite, is of greatest interest.

VEIN MINERALS AND THEIR GENERAL RELATIONS

The minerals of the Bald Knob vein, named in the order of their relative abundance, are as follows:

TABLE 1. HYPOGENE MINERALS OF THE BALD KNOB, N.C., MANGANESE MINE

Spessartite	Ferro or mangano (?) anthophyllite
Rhodonite	Actinolite
Calcite (manganiferous)	Phlogopite
Alleghanyite (new mineral)	Margarite
Tephroite	Chlorite
Galaxite (new mineral)	Apatite
Quartz	Pyrite
Magnetite	Pyrrhotite
Gruenerite	Chalcopyrite

The first eight minerals in the above list are the dominant ones of the vein and specimens can easily be found in which they are abundant. The others are commonly discernible only on microscopic examination.

The vein is very distinctly banded. This is best shown by narrow alternating lenses of the new manganese silicate, which it is proposed to call alleghanyite, and manganese bearing calcite. The tephroite and rhodonite also form wider but less sharply bounded lenses. The garnet, spessartite, which is the most abundant mineral of the vein, forms massive lenses and is also scattered through much of the rhodonite. The massive lenses of nearly pure spessartite have a maximum width of 2 feet (0.6 meter), and fine-grained yellowish spessartite forms irregular areas associated with manganese rich carbonate in rhodonite. Irregular areas of a brownish red, coarser grained garnet are closely associated with quartz. Rhodonite, the second mineral in relative abundance, forms at least one pure lens 10 centimeters wide, but it is more commonly intergrown with lenses of calcite and is cut by irregular masses of pale yellow spessartite, and vein-like areas of tephroite. Slightly pink, manganese-

bearing calcite is somewhat more abundant than alleghanyite, and forms nearly pure lenses, which alternate with that mineral or is irregularly disseminated through much of the rhodonite and tephroite. Red brown to bright pink alleghanyite forms lenses, many of which are not more than one millimeter wide, but a few reach 15 millimeters in width. The new mineral of the spinel group, which it is proposed to call galaxite, forms minute shining black grains which are commonly intergrown with alleghanyite. Magnetite and grunerite occur in close association and are commonly inclosed in fine-grained, granular quartz. The vein quartz forms pure masses that reach 5 to 8 centimeters in width, but associated with it are large areas of the coarse-grained, brownish red garnet, and lesser amounts of sulphides. The magnetite-quartz lens appears to be later and the vein quartz is clearly later than the manganese minerals. Alleghanyite and tephroite (an orthosilicate) are sub-silicic minerals and are chemically incompatible with quartz, so that obviously they could not form together. This is confirmed by sharp-walled veins of quartz which cut the manganese minerals. The sulphides are associated with quartz and it seems probable that the brownish red garnet also belongs to this generation of mineralization, and is distinctly later than the granular and massive spessartite. The actinolite, the ferro- or mangano-anthophyllite, phlogopite, and chlorite are secondary minerals that formed by alteration of the primary manganese silicates of the vein.

DESCRIPTIONS OF MINERALS

CALCITE

The manganese-bearing carbonate of the Bald Knob vein has been studied by Philip Krieger² by means of *x*-ray diffraction patterns and found to be a member of the calcite group, isomorphous with rhodochrosite. Most of the calcite is manganese bearing, but wide variations in the manganese content are indicated by the indices of refraction.

The following calculation of the various carbonate molecules present in a sample of coarse grained manganese-bearing calcite is based on a chemical analysis by J. J. Fahey, chemist of the U. S. Geological Survey:

² Krieger, Philip, Notes on an *x*-ray diffraction study of the series calcite-rhodochrosite: *Am. Mineralogist*, vol. 15, pp. 23-29, 1930.

TABLE 2. COMPOSITION OF CALCITE FROM BALD KNOB VEIN

MnCO ₃	42.17
CaCO ₃	56.31
MgCO ₃	1.71
FeCO ₃	0.08
Insol.	0.25
Total	100.52

TEPHROITE

GENERAL RELATIONS. Tephroite, the manganese olivine, forms anhedral, equidimensional grains that average 0.5 millimeters or less in diameter. They are gray in the hand specimen and colorless to slightly gray in individual grains. In thin section the mineral is colorless and without cleavage. Tephroite and alleghanyite both show equidimensional grains without cleavage, but the two do not occur together, and the color in the hand specimen and the complete absence of twinning in thin section distinguishes tephroite from alleghanyite.

OPTICAL AND PHYSICAL PROPERTIES. The optical properties of tephroite from the Bald Knob vein, together with those of tephroite from Franklin Furnace, are as follows:

TABLE 3. OPTICAL PROPERTIES OF TEPHROITE

	Bald Knob	Franklin Furnace, N. J. ³
Indices of refraction	$\left\{ \begin{array}{l} \alpha=1.785 \\ \beta=1.803 \\ \gamma=1.820 \end{array} \right.$	$\left\{ \begin{array}{l} 1.770 \\ 1.792 \\ 1.804 \end{array} \right.$
$\gamma-\alpha$	0.035	0.034
Dispersion	$\rho > \nu$	$\rho > \nu$
Axial angle	72°	large
Optical character	(-)	(-)
Specific gravity	4.082	
Hardness	6	

The optical properties given above for tephroite show that the indices of refraction of the Bald Knob material are only slightly higher than those for Franklin Furnace material. Otherwise the optical properties are similar.

³ Larsen, E. S., The microscopic determination of the nonopaque minerals: *U.S. Geol. Survey, Bull.* 679, p. 143, 1921.

The tephroite from this new locality has been studied by means of x -ray diffraction patterns and compared with samples from Franklin Furnace and Långban, Sweden. They were all found to be similar and are discussed and compared with the x -ray diffraction patterns of alleghanyite on page 10.

CHEMICAL COMPOSITION. The following analysis of tephroite from the Bald Knob vein has been made:

TABLE 4. CHEMICAL COMPOSITION OF TEPHROITE* FROM BALD KNOB, N.C.

SiO ₂	25.94
TiO ₂	None
Al ₂ O ₃	0.32
Fe ₂ O ₃	None
FeO	3.02
MnO	60.98
MgO	1.58
CaO	4.84
CO ₂	3.75
H ₂ O	0.34
	100.77

* Earl V. Shannon, analyst.

The sample was obviously contaminated with carbonate. Since the carbon dioxide is just equivalent to the lime, the two are deducted together, although the carbonate doubtless contains some manganese and a little lime probably enters the tephroite. The tephroite, recalculated to 100 per cent after this correction, gives the following:

TABLE 5. RECALCULATED COMPOSITION OF TEPHROITE

	Per cent	Molecular proportions		Ratios
SiO ₂	28.24	468	468	95 or 1×95
Al ₂ O ₃	0.35			
FeO	3.27	20	} 999	204 or 2×102
MnO	66.42	936		
MgO	1.72	43		
	100.00			

Thus it corresponds very closely to the olivine formula, 2MnO·SiO₂.

ALLEGHANYITE

GENERAL RELATIONSHIPS. The most interesting mineral of the Bald Knob manganese-bearing vein is the new mineral, which it is proposed to call alleghanyite after the county in North Carolina in which it occurs. Its occurrence is similar to that of tephroite, but the two always form separate lenses that evidently formed under slightly different conditions although probably not at a distinctly different time.

In the hand specimen the color of alleghanyite is bright pink to grayish pink (from strawberry pink, 5.00 R.d. to vinaceous-rufous 7.R O.i, of Ridgway's color standard). Most of the mineral grains are imbedded in calcite and resemble garnets so closely that they were not distinguished until examined microscopically. These average about 0.5 millimeter in diameter, but a few reach a maximum diameter of several millimeters. Most grains are nearly equidimensional, rounded and somewhat etched, but very rarely a crystal face can be observed. Not more than two such faces have been observed on a single crystal, and therefore the crystal habit can not be definitely determined. The faces observable seem to represent pyramids and the general form suggests a nearly pseudo-isometric symmetry but the optical properties show that it is orthorhombic.

OPTICAL AND PHYSICAL PROPERTIES. The optical properties are given in the following table:

TABLE 6. OPTICAL AND PHYSICAL PROPERTIES OF ALLEGHANYITE

Indices of refraction.....	$\left\{ \begin{array}{l} \alpha=1.756 \\ \beta=1.780 \\ \gamma=1.792 \end{array} \right.$
$\gamma-\alpha$	0.036
2V.....	72°
Dispersion of the axes.....	$\rho > \nu$
Optical character.....	(negative)
X = Acute bisectrix	
Z = Obtuse bisectrix	
Crystal system orthorhombic.	
Pleochroism not observable in thin section.	
Characterized by lamellar twinning.	
Sp. Gr.....	4.020
H.....	5.5
Fracture.....	Conchoidal

The pleochroism is not perceptible in thin section and only a slight pink color is observable. In thick grains the pleochroism varies from colorless, through pink, to light buff. The most striking property shown by alleghanyite in thin section is the almost in-

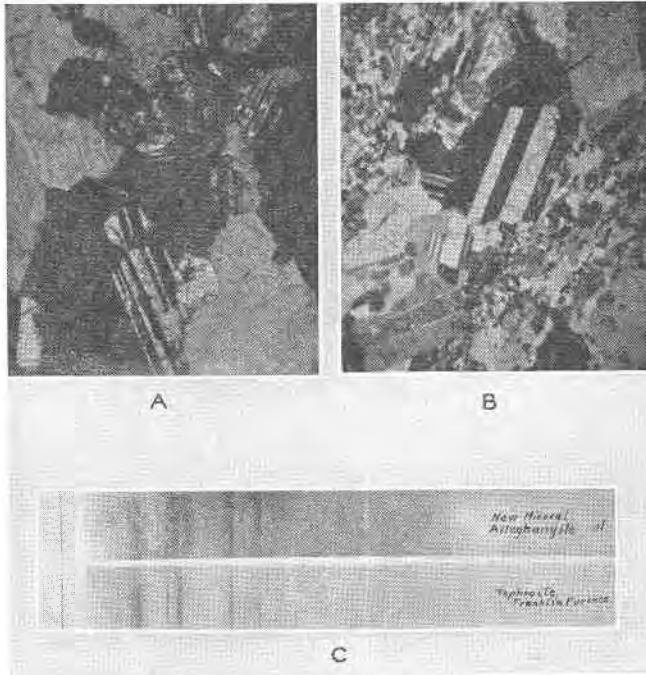


Plate I

FIGS. A and B. Photomicrographs of thin sections from Bald Knob vein. Twinned areas are the new mineral alleghanyite, and the black ones galaxite. The non-striated areas are manganiferous calcite.

FIG. C. X-ray diffraction patterns of tephroite, and new mineral alleghanyite.

variable presence of lamellar twinning, as shown in Plate I, Figs. A and B. Under the microscope the grains show no external crystal form and no cleavage, so that only the relation of the twinning to the optical directions of the crystal can be determined. Sections that show the maximum, symmetrical extinction on either side of the twinning plane are also perpendicular to the obtuse bisectrices of both individuals, and in such sections the angle of extinc-

tion is about 22° with the twinning plane. Extinction is symmetrical on the two sides of that plane in all sections cut perpendicular to the twinning plane, with extinctions varying 0° to 22°, and is parallel in all the sections cut perpendicular to a plane normal to the twinning plane. A section perpendicular to an acute bisectrix in one individual of a twinned crystal is 44° from perpendicular to the other individual and extinction in both is parallel to the twinning plane. The bilateral symmetry of the twinning in two perpendicular planes indicates that the mineral is orthorhombic.

CHEMICAL COMPOSITION. The mineral, alleghanyite, forms large brownish pink grains up to 5 millimeters in diameter and a hand-picked sample of these coarser grains is represented by analysis A. Smaller grains of bright pink color were used in making analysis B. These were intergrown with calcite and, very commonly, with the new spinel, galaxite. Grains free from galaxite were sorted by hand, recrushed, and the calcite removed by heavy solution. Standard methods of analyses were used and need no discussion.

The analyses and the molecular ratios calculated from them are given in the following table:

TABLE 7. CHEMICAL ANALYSES AND RATIOS OF ALLEGHANYITE

	Per cent*	Molecular proportions		Ratios	Per cent†	Molecular proportions		Ratios
SiO ₂	24.90	413	413	194 or 2×97	25.60	425	425	204 or 2×102
TiO ₂	none				trace			
Al ₂ O ₃	trace				1.50	15		
Fe ₂ O ₃	none							
FeO	1.40	19	1077	506 or 5×101	1.62	23	1067-15 =1072	496 or 5× 99
MnO	70.35	991			68.67	962		
MgO	2.16	54			2.34	58		
CaO	0.74	13			0.24	24		
TOTAL	99.55				99.97			

* Earl V. Shannon, analyst.

† F. A. Gonyer, analyst.

The material on which analysis B was made contained a small amount of the spinel, galaxite, and the Al₂O₃ and an equal molecular amount of RO bases are set aside as admixed spinel.

The two analyses agree very closely in giving a ratio of MnO

to SiO_2 of 5 to 2. Only small amounts of FeO , MgO , and CaO are present and the analyses conform very closely to the formula $5\text{MnO} \cdot 2\text{SiO}_2$.

COMPARISON OF TEPHROITE AND ALLEGHANYITE

Chemically this new manganese silicate is related to tephroite, the manganese olivine ($2\text{MnO} \cdot \text{SiO}_2$), but the manganese ratio is higher, that is, 5 to 2 for alleghanyite, while it is 4 to 2 (2 to 1)

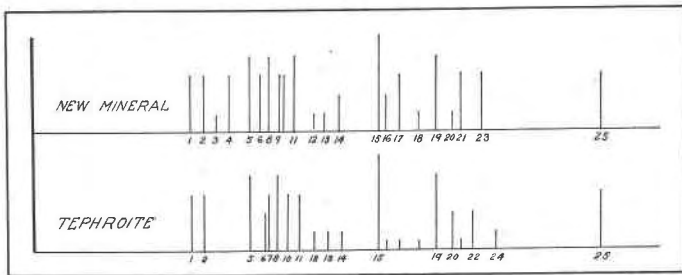


FIG. 1. Chart of the x -ray diffraction lines of the new mineral alleghanyite compared with tephroite. The line numbers refer to Table 8.

for tephroite. The mineral is remarkably fresh and so transparent that the possibility of admixture is excluded. No known primary manganese silicates are known whose admixture would increase the manganese-silica ratio over that of tephroite, and the black secondary oxides are visibly absent.

X-RAY DIFFRACTION PATTERNS. X -ray diffraction patterns of the new manganese mineral, alleghanyite, have been taken and compared with x -ray patterns of tephroite photographed under similar conditions of exposure. At the first glance the two sets of patterns might be thought to be the same. Careful observation, however, brings out a difference. Repetition of photographs, followed by measurement, further emphasizes their difference.

Tephroite patterns used for comparison with the new mineral were secured from samples originating in the following localities:

- Långban, Sweden,
- Franklin Furnace, New Jersey,
- Sparta, North Carolina.

An x -ray diffraction pattern of the Franklin Furnace tephroite, which agrees with the tephroite patterns from the other localities, is shown in Plate I, Fig. C, together with a pattern of the new min-

eral. The patterns were secured with some difficulty, fine grinding and careful weighing of samples being necessary to produce patterns of even fair quality.

The patterns were taken under standard conditions of exposure, employing the K-alpha radiation of molybdenum and a zirconium oxide filter. The radius of film holder employed was 114.6 mm., and the two patterns were taken at the same time side by side in the same film holder.

A chart of the two patterns is shown in Fig. 1. Numbers are assigned arbitrarily to the lines in this figure, and same numbers are used in Table 8.

TABLE 8. COMPARISON OF X-RAY DIFFRACTION MEASUREMENTS OF TEPHROITE AND THE NEW MANGANESE MINERAL, ALLEGHANYITE

New Manganese Mineral, Alleghanyite			Tephroite		
Line No.	Est. Intensity	d in Å.U.	Line No.	Est. Intensity	d in Å.U.
1	f	3.94	1	f	3.94
2	f	3.64	2	f	3.66
3	fff	3.40		absent	
4	f	3.19		absent	
5	m	2.86	5	m	2.88
6	f	2.75	6	ff	2.70
	absent		7	f	2.66
8	m	2.64	8	m	2.56
9	f	2.53		absent	
10	f	2.475	10	f	2.46
11	m	2.375	11	f	2.345
12	fff	2.215	12	fff	2.215
13	fff	2.135	13	fff	2.115
14	ff	2.035	14	fff	2.025
15	s	1.800	15	s	1.810
16	ff	1.755	16	trace	
17	f	1.695	17	trace	
18	fff	1.620	18	trace	
19	m	1.550	19	m	1.550
20	fff	1.497	20	ff	1.497
21	f	1.463	21	trace	
	absent		22	ff	1.433
23	f	1.393		absent	
	absent		24	fff	1.357
25	f	1.110	25	f	1.110

Measurements of the interplanar spacings in Ångstrom Units are given in Table 8. Lines of approximately the same interplanar spacing in the two patterns have been assigned the same number. Lines are rated according to estimated intensity as follows: s-strong, m-medium, f-faint, ff-very faint, fff-measurable with difficulty, trace—may be detected but not measured,—and absent—entirely missing. The measurements have been corrected against similar films taken in film holders with sodium chloride.

Although the measurements for the two patterns are distinctly different it is interesting to note that there are a considerable number of lines in common in the two patterns. Several such instances of different substances giving somewhat similar patterns have been noted by various investigators. The classic example has been provided by the x -ray diffraction patterns of sillimanite and mullite which are so alike that they were at first described as being identical. The difference in the present instance, however, is much more noticeable than between sillimanite and mullite, and it is believed that the x -ray diffraction patterns clearly demonstrate a difference between the internal structures of the two minerals.

The indices of refraction of alleghanyite are $\alpha = 1.756$, $\beta = 1.780$, $\gamma = 1.792$; while those of tephroite are $\alpha = 1.785$, $\beta = 1.803$, $\gamma = 1.820$. That is, alleghanyite, the mineral with the higher manganese content, has the lower indices of refraction. This indicates that in tephroite there is a closer spacing of the atoms in the space lattice than in alleghanyite. This relation is confirmed by the specific gravities of the two minerals which are 4.086 for tephroite and 4.020 for alleghanyite. These values are very close together but the specific gravity is slightly higher for tephroite than for alleghanyite; that is, the mineral with the higher manganese content has a slightly lower specific gravity. It is difficult to accurately determine hardnesses, but alleghanyite appears to have a lower hardness than tephroite.

The foregoing descriptions of tephroite and the new manganese silicate show that they differ from one another in optical properties, in x -ray diffraction patterns, in chemical composition, and probably in the spacing of the lattice. This clearly differentiates the tephroite, the manganese olivine, from the mineral which it is proposed to call alleghanyite after the county in North Carolina in which it occurs.

ALLEGHANYITE FROM SAN JOSE, CALIFORNIA

A mineral with characteristics similar to alleghanyite has been described by Rogers⁴ from San Jose, California. The mineral occurred in an erratic boulder in which Rogers identified tephroite, hausmannite, pyrochroite, ganophyllite, rhodochrosite, barite, and psilomelane.

TABLE 9. OPTICAL PROPERTIES OF RHODONITE

	Bald Knob	Harstig mine
Indices of refraction.....	$\left\{ \begin{array}{l} \alpha=1.723 \\ \beta=1.727 \\ \gamma=1.734 \end{array} \right.$	1.720 1.725 1.733
$\gamma-\alpha$	0.011	0.013
Dispersion.....	$\rho < \nu$	
Axial angle.....	72°	75°
Optical character.....	(+)	(+)
Angles of extinction.....	$\left\{ \begin{array}{l} 17^{\circ}30' \pm 30' \\ 23^{\circ} \pm 1^{\circ} \end{array} \right.$	

Under the heading "tephroite," Rogers says,

Tephroite as a megascopic constituent of the ore is rare but in several specimens it was noted as a massive grayish red mineral which was at first thought to be rhodonite. . . .

The indices of refraction, determined by the immersion method, are greater than 1.740. Thin sections show almost colorless anhedra with interference colors ranging up to bluish-green of the second order, which proves that the double refraction is higher than that of rhodonite ($n_{\gamma}-n_{\alpha}=0.011$) but lower than that of olivine ($n_{\gamma}-n_{\alpha}=0.036$). Polysynthetic twinning is a prominent feature in the thin sections, a property not previously reported for tephroite. In some areas the twinning resembles an intergrowth of two minerals. The twinning is recognized largely by differences in interference colors rather than by extinction angles.

The grayish red color and the very characteristic polysynthetic twinning make it almost certain that the mineral from the San Jose boulder is identical with alleghanyite.

RHODONITE

GENERAL RELATIONS. Rhodonite forms pure lenses up to 10 centimeters in diameter and lenses of intergrown rhodonite and spessartite are even wider. Irregular and vein-like areas of rhodonite are included in tephroite. The dominant color is rhodonite pink (71''V-RR.d of Ridgway's color standard), but some areas are

⁴ Rogers, A. F., An interesting occurrence of manganese minerals near San Jose, Calif.: *Am. Jour Sci.*, 4th ser., vol. 48, pp. 443-449, 1919.

eosene pink (1 Red d). The largest grains are about 10 millimeters in length, but millimeter sized grains are more abundant.

OPTICAL PROPERTIES. The optical properties of rhodonite from Bald Knob and of material of similar composition from Harstig Mine, Pajsberg, Sweden, that has been studied by Hey,⁵ are given in Table 9.

CHEMICAL COMPOSITION. The results of a chemical analysis of hand picked grains of Bald Knob rhodonite are shown in the following table, and an analysis of the material from the Harstig mine

TABLE 10. CHEMICAL ANALYSES OF RHODONITE

	Bald Knob vein*			Harstig mine†	
	Per cent	Molecular Proportions	Ratios	Per cent	
SiO ₂	45.49	747	755	98×1	46.33
TiO ₂	Trace				
Al ₂ O ₃	0.78	008			
Fe ₂ O ₃			788	102×1	0.26
FeO	3.74	052			
MnO	44.88	632			
MgO	1.56	039			0.83
CaO	3.64	065			n.d.
ZnO	Trace?				44.28
Ignition					0.04
					8.02
					0.07
					0.22
Total	100.09				100.05

* Analysis by Earl V. Shannon.

† Analysis by H. H. Hey.

is included for comparison. This gives the formula MnO·SiO₂, with the ratio of CaO:MnO only about 1:10.

The analysis of the Bald Knob rhodonite reveals another example of a member of the rhodonite-bustamite series near the pure manganese end member. It is even lower in calcium than the Harstig material of Hey, but it is considerably higher in magnesium. Table 9 shows that the optical properties, including the positive optical character, are similar as would be expected from the chemi-

⁵ Hey, H. H., On the rhodonite-bustamite series: *Mineralogical Mag.*, vol. 22, pp. 193-205, 1929.

cal composition, and confirms the conclusion of Hey⁶ that rhodnite-bustamite represents a completely isomorphous series including the pure manganese end member.

A NEW SPINEL, GALAXITE

GENERAL RELATIONS. A mineral that proves to be a new member of the spinel group is intergrown with alleghanyite and calcite. It forms rounded to euhedral grains that range from 0.01 to 0.5 and average 0.2 millimeter in diameter, and in the hand specimen the mineral is brilliant black and the streak is red-brown.

OPTICAL AND PHYSICAL PROPERTIES. The index of refraction of this spinel is $n = 1.923$. The color is mahogany red, 7.R-OL of the Ridgway color Standard. Sp. Gr. = 4.234, H = 7.5.

CHEMICAL COMPOSITION. The chemical composition is as follows:

TABLE 11. CHEMICAL COMPOSITION OF SPINEL FROM VEIN NEAR BALD KNOB, N.C.*

	Per cent
SiO ₂	0.96
TiO ₂	Trace
Al ₂ O ₃	45.71
Fe, determined as FeO	16.36
MnO	34.03
MgO	1.50
CaO	Trace
ZnO	Trace?
	98.56

* Earl V. Shannon, analyst.

With iron recalculated to give the spinel ratio, i.e. most of it recalculated to Fe₂O₃, we have present the following spinel molecules:

TABLE 12. MINERAL COMPOSITION OF SPINEL IN BALD KNOB, N.C.

Spinel MgO · Al ₂ O ₃	5.27
Hercynite FeO · Al ₂ O ₃	5.22
Jacobsite MnO · Fe ₂ O ₃	22.83
Galaxite MnO · Al ₂ O ₃	65.79
Quartz	0.96
	100.07

⁶ *Op. cit.*

Thus the principal component is a spinel having the composition $MnO \cdot Al_2O_3$. This has not heretofore been described as a natural mineral, although it has been found as a furnace product and described by Krenner⁷ under the name "manganspinel." This name has not been recognized in the mineralogical literature and it seems best to give this distinct spinel an individual name. The town of Galax, Virginia, the home of Mr. Crabill, lies about 12 miles to the northeast, and in the Hillsville topographic quadrangle, that lies

TABLE 13. CHEMICAL ANALYSIS OF SPESSARTITE AT THE BALD KNOB VEIN*

	Per cent	Molecular Proportions		Ratios	
SiO ₂	35.04	581	581	194×3	96×3
TiO ₂	Trace				
Al ₂ O ₃	21.63	212	212	212×1	104×1
Fe ₂ O ₃	None	—			
FeO	1.86	026	625	208×3	102×3
CaO	1.78	032			
MnO	39.83	561			
MgO	0.26	006			
	100.40				

* Earl V. Shannon, analyst.

immediately east of the Wytheville quadrangle in which the Bald Knob vein is located. The beautiful plant, galax, that is so widely used for holiday decorations and after which the town of Galax is named, grows abundantly in the region. Therefore, Galax seems to provide a suitable name and it is proposed to call this new spinel galaxite.

SPESSARTITE

GENERAL RELATIONS. The manganese-alumina garnet, spessartite, is an abundant mineral in the Bald Knob vein. Massive spessartite forms lenses up to 15 or 20 centimeters wide that are buff colored, and irregular masses and vein-like areas of fine-grained granular spessartite are abundant in rhodonite.

⁷ Krenner, J., Manganspinelle in der Hochofenschlake von Menyhaza: *Zeit. f. Kryst. und Min.*, vol. 43, p. 474, 1927.

OPTICAL PROPERTIES. The indices of refraction of the garnets of the Bald Knob vein are as follows:

Fine-grained granular	$n=1.796$
Massive buff	$n=1.802$
Granular pink	$n=1.813$

CHEMICAL COMPOSITION. The chemical analysis shown in Table 13 has been made of the fine grained buff spessartite associated with carbonate and rhodonite. Calculated as mineral molecules and recalculated to 100%:

Spessartite	90.03
Almandite	4.36
Grossularite	4.82
Pyrope	0.79
	<hr/>
	100.00

The massive garnet has nearly the same indices of refraction and was formed under similar conditions, and so probably has a similar composition. The pink garnet appears to have formed at a later stage of mineralization and probably has a somewhat different composition as is indicated by the slightly higher index of refraction.

AMPHIBOLES

Three types of amphiboles have been observed in the Bald Knob vein. One of these is an orthorhombic variety that forms fibrous areas in rhodonite. The indices of refraction are $\alpha=1.653$, $\gamma=1.676$. These indices correspond to ferro-anthophyllite, but since it is a pink alteration product of rhodonite it is probably a mangananthophyllite. Rosettes of a monoclinic amphibole which have replaced calcite have the indices of refraction $\alpha=1.662$, $\gamma=1.675$. This is almost colorless even though the indices of refraction are rather high, and it, too, is probably manganese bearing. These two amphiboles are both secondary and are the result of later replacement of the primary minerals. The third and most abundant amphibole is grüenerite, which is associated with magnetite.

MAGNETITE

Magnetite is associated with grüenerite or quartz in lenses that reach 5 centimeters in width. It has not been completely analyzed;

but qualitative tests show that it contains about 0.3 per cent of manganese.

The other minerals need little discussion as they are sparse and add little to the knowledge of the vein. These are phlogopite, margarite, and chlorite and are all secondary minerals. The sulphides pyrite, pyrrhotite and chalcopyrite are associated with quartz and appear to be younger than the manganese silicates.

SUPERGENE MINERALS

The manganese silicates have undergone complete oxidation in the upper 10 feet only but show partial oxidation to about 40 feet. The most easily oxidized mineral is alleghanyite which is followed closely by tephroite. Rhodonite is readily oxidized, but somewhat less rapidly than these, and spessartite is more slowly altered. In the zone 10 to 20 feet below the surface spessartite merely disintegrates into fine sand. The spinel, galaxite, almost completely resists alteration and is an abundant inclusion in the oxidized ores.

The supergene manganese minerals that have been recognized are pyrolusite, wad, neotocite, and bementite. Intimate mixtures of pyrolusite and wad make up most of the oxidized material. Areas of neotocite, several centimeters across are characterized by glistening black color and conchoidal fracture. Microscopic examination shows that most of it is reddish brown and amorphous, but a part forms rosettes of bi-refracting material. The index of refraction is somewhat variable and ranges from 1.49 to 1.51.

Bementite forms dull brown radial, bi-refracting groups of crystals with an index of refraction of 1.65.