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THE PEGMATITE MINERALS FROM NEAR AMELIA, VIRGINIA*

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1. INTRODUCTION

The first commercial mica mines near Amelia Court House, Virginia, were opened in the early seventies, and the remarkable size and quality of the mica early awakened a keen economic interest in the pegmatite dikes of the region, but the richness of the locality in rare and beautiful mineral specimens has promoted a scientific interest which has persisted for sixty years. Thirty-six mineral species have been reported from the Rutherford mine alone, and the variety and perfection of many of these have led to their inclusion in most of the museums of the world. The concentration of unusual minerals in an easily accessible deposit attracted various scientific investigators and mineral collectors to this locality for successive generations. Such intensive investigation of a locality might suggest that little remains to be learned about its minerals, but the recent opening of a new mine near Amelia and the reopening of the Rutherford mine have given new

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opportunities for study. Moreover, most of the minerals from Amelia were described before the development of modern methods for the study of minerals.

In May 1932, a group of geologists from the United States Geological Survey visited the Amelia region. The fresh dump from recent mining operations at the old Rutherford mine, which was at that time being operated for its output of gem-quality amazonstone, furnished a new supply of most of the rare and interesting minerals for which the locality is famous. Although the specimens collected do not contain examples of all the minerals reported from the Rutherford mine, a representative group of minerals, whose optical properties have not previously been determined, were selected for microscopic and spectrographic study. The opening of a new deposit, referred to as the Morefield mine, a few years previous, disclosed a similar set of minerals with the added occurrence of zinnwaldite, triplite, unaltered and well formed phenacite crystals, and large crystals of topaz.

The following mineralogical descriptions refer chiefly to the less common minerals—notably microlite, phenacite, topaz, and zinnwaldite. Several varieties of sericite are described, with analyses, and notes on nearly all the minerals, with new optical determinations, are added.

This paper is essentially descriptive of the minerals of the Amelia pegmatites and so mineral relations have been only touched upon and paragenesis has not been considered. However, it is recognized that these problems are of fundamental interest and it is planned to follow the present paper by another, in which the mineral sequence as shown by the individual mineral relations will be described, and the paragenesis, thus indicated, discussed.

The writer wishes to acknowledge the courtesy of Mr. Ezell Keener and of Mr. S. V. Morefield, whose permission to collect much of the material here described, has made this paper possible. She also wishes to express her appreciation to the following chemists of the United States Geological Survey for the several analyses, the determinations of the alkalies in several minerals, and for the spectrographic examinations. The complete analyses were made by J. J. Fahey, J. G. Fairchild, and R. E. Stevens; the alkali determinations by R. E. Stevens and R. C. Wells; and the spectrographic examinations by George Steiger. In addition, she wishes to thank C. S. Ross and W. T. Schaller, of the United States Geo-

logical Survey, for their helpful criticisms and advice during the preparation of this paper.

2. Rutherford Mine

The earliest working of the mica deposits of what is known as the Rutherford mine is thought to have been done by Indians. Early settlers observed evidence of excavation and the removal of mica from the upper 10 feet of the vein, but it was not until 1873 that the deposit was opened for commercial mining.

The first report on the minerals of this area was made by Fontaine[1] in 1883. Since that time more than 40 papers have been published on the subject. These papers deal primarily with the descriptive mineralogy, the chemical analyses, and economic importance of the individual minerals. Detailed descriptions of the Virginia pegmatite mines and minerals are contained in the works of T. L. Watson,[2] D. B. Sterrett,[3] and E. S. Bastin.[4] The most recent publication on this region and one in which the geology and petrology of the pegmatites have been discussed was written by A. A. Pegau.[5]

The Rutherford mine is developed on two large parallel dikes $1\frac{1}{4}$ miles northwest of Amelia Court House and half a mile west of the Richmond-Danville Railroad.

The two openings are about 100 yards apart. The one to the northeast, recently reopened, is on a gently sloping hillside and consists of an L-shaped excavation 165 feet deep, opening through a 100-foot vertical shaft. The other opening is at the foot of the hill, where the deepest workings are reported to have reached a depth of 150 feet. These workings were abandoned in 1912, and at the present time there is a small pond about 50 feet wide and 100 feet long that marks the site of the old mine.

[1] Fontaine, W. M., Notes on the occurrence of certain minerals in Amelia County, Virginia: *Am. Jour. Sci.*, 3d ser., vol. **25**, pp. 330–339, 1883.

[2] Watson, T. L., Mineral resources of Virginia: *Virginia-Jamestown Exposition Commission*, pp. 275–285, 385–392, **1907**; Annual report on the mineral production of Virginia during the year 1908: *Virginia Geol. Survey, Bull.* **IA,** pp. 101–106, 1909.

[3] Sterrett, D. B., Gems and precious stones: *U. S. Geol. Survey, Mineral Resources* **1912,** pt. 2, pp. 1045–1048, 1913; Mica deposits of the United States: *U. S. Geol. Survey, Bull.* **740,** pp. 20–23, 307–330, 1923.

[4] Bastin, E. S., Quartz and feldspar: *U. S. Geol. Survey, Mineral Resources* **1910,** pt. 2, pp. 971–973, 1911.

[5] Pegau, A. A., Pegmatite deposits of Virginia: *Virginia Geol. Survey, Bull.* **33,** 1932.

3. Morefield Mine

The Morefield mine is $1\frac{1}{2}$ miles southeast of Winterham, and about $4\frac{1}{2}$ miles east of Amelia Court House. The elevation is about 300 feet and the surface slopes eastward toward the Appomattox River. The geological features of the region are shown on the Geologic Map of Virginia.[6] The mine is in a nearly vertical parallel-sided pegmatite, about 15 feet wide, which strikes southwest, and is reported to outcrop continuously along the surface for about 1,500 feet. The adjacent country rock like that at the Rutherford mine[7] is described by Pegau as a pre-Cambrian porphyritic biotite gneiss, which was originally a biotite-quartz monzonite. In the region of the Morefield mine these rocks are intruded also by numerous narrow diabase dikes, which are distinctly later in age than the pegmatites.

The Morefield mine was opened by Mr. S. V. Morefield in 1929, and was operated first by the Seaboard Feldspar Company of Baltimore, Md., and later intermittently by Mr. Morefield. The workings in June 1933 consisted of an open cut 10 or 15 feet deep following the dike for a distance of 200 feet, and a shaft which had been sunk to about 40 feet. More extensive work was resumed by Mr. Morefield in 1934.

The minerals of the Morefield dike show a symmetrical zonal arrangement, with an irregular middle zone of smoky gray quartz, intergrown on its borders with large crystals of beryl and topaz. The blue-green microcline (amazonstone) borders the quartz zone on both sides; albite and muscovite with occasional crystals of garnet form an irregular zone on the wall side of the amazonstone. The narrow, fine-grained selvage bands composed of biotite and quartz occupy the contact between the coarse-grained pegmatite mass and the country rock, and are probably reaction zones with the country rock.

The texture of the dike is coarse-grained with unusually large well formed crystals, particularly of topaz, zinnwaldite, amazonstone, and beryl. The deposit differs mineralogically from the Rutherford pegmatite bodies chiefly in the presence of a considerable quantity of phenacite and in the abundance of large crystals of topaz and of zinnwaldite. The largest known crystal of zinnwaldite was obtained from this deposit.

[6] Geologic map of Virginia, *Virginia Geological Survey*, **1928.**

[7] Pegau, A. A., *op. cit.*

4. Minerals

A total of 31 mineral species have been identified from the pegmatites of Amelia. Of these, eight—bertrandite, biotite, chalcopyrite, phenacite, pyrolusite, topaz, triplite, and zinnwaldite—are here described in detail for the first time. In addition 12 unconfirmed species have been reported in the literature.

The well established species from the Rutherford and Morefield mines are as follows:

Table 1

Well Established Species from the Rutherford (R) and the Morefield (M) Mines, near Amelia, Virginia

(The species marked with a star (*) are established by the writer.)

Mineral	Mine		Remarks	First reference[a]
	R	M		
Albite	R	M	....	Fontaine, W. F.
Allanite	R	—	Described by Fontaine under the name Orthite.	Fontaine, W. F.
Almandite	R	—	Almandite-spessartite.	Pegau, A. A.
Apatite	R	—	....	Rowan, G. H.
*Bertrandite	R	—	....	
Beryl	R	M	....	Fontaine, W. F.
*Biotite	—	M	....	
Calcite	R	—	....	Pegau, A. A.
Cassiterite	R	M	....	Gordon, S. G.
*Cerussite	R	—	....	
*Chalcopyrite	R	—	....	
Columbite	R	M	Described by Lee and Wherry as manganotantalite	Fontaine, W. F.
Fergusonite	R	—	....	Fontaine, W. F.
Fluorite	R	M	....	Fontaine, W. F.
Galena	R	M	....	Fontaine, W. F.
Helvite	R	—	....	Fontaine, W. F.
Manganotantalite	R	M	Same as Fontaine's columbite.	Lee, O. I., and Wherry, E. T.
Microcline	R	M	....	Fontaine, W. F.
Microlite	R	M	....	Fontaine, W. F.
Monazite	R	M	....	Fontaine, W. F.
Muscovite	R	M	....	Fontaine, W. F.
Phenacite	R	M	....	Yeates, W. S.
Pyrite	R	—	....	Fontaine, W. F.

[a] See selected bibliography at end of paper.

TABLE 1 (*Continued*)

Mineral	Mine R	Mine M	Remarks	First reference
*Pyrolusite	—	M	....	
Quartz	R	M	....	Fontaine, W. F.
Spessartite	R	M	....	Fontaine, W. F.
Topaz	R	M	....	Yeates, W. S.
Tourmaline	R	M	....	Pegau, A. A.
*Triplite	—	M	....	
*Zinnwaldite	—	M	....	
Zircon	R	M	....	Watson, T. L.

TABLE 2

UNCONFIRMED SPECIES FROM RUTHERFORD (R) AND MOREFIELD (M) MINES, NEAR AMELIA, VIRGINIA

Mineral	Mine R	Mine M	Remarks	Reference
Andradite (topazolite)	R	—	Probably helvite.	Pegau, A. A.
Anglesite	R	—	Mentioned by early writers but not described.	Pegau, A. A.
Cyrtolite	R	—	Probably zircon. No description.	Gordon, S. G.
Hatchettolite	R	—	Reported but not described.	Gordon, S. G.
Ilmenite	R	—	Specimen said to have been obtained at Rutherford mine was presented to Watson.	Watson, T. L.
Lepidolite	R	—	Pegau reported this later to be pink muscovite.	Peagu, A. A.
Leverrierite	R	—	Reported but not described. Possibly sericite.	Gordon, S. G.
Labradorite	R	—	Now known to be chatoyant albite.	Fontaine, W. F.
Oligoclase	R	—	Now known to be chatoyant albite.	Watson, T. L.
Orthoclase	R	—	Probably microcline. Fontaine described it as light green in color.	Fontaine, W. F.
Pyrochlore	R	—	Reported by G. W. Fiss. No description given.	Fontaine, W. F.
Stibnite	R	—	Reported by G. W. Fiss. No description given.	Fontaine, W. F.

A brief description is given of the minerals collected by the writer in 1932 and 1934. The optical determinations are grouped in two tables, one for the micas and the other for the remaining minerals, placed at the end of the mineralogical description. No extended descriptions of the more common minerals of these pegmatites, ordinary microcline, muscovite, and quartz, are given.

Albite.—Two distinct varieties of albite are prominent at the Rutherford mine. The most abundant is the well known cleavelandite variety, in distinct platy crystals which were common in both the older and the newer workings. The new dump is largely composed of such specimens. The angular cavities between the network of interlocking platy crystals contain the rarer minerals. Chemical determinations made by Mr. Stevens of the alkalies of this cleavelandite showed: $K_2O = 0.33$ per cent, $(Na, Li)_2O = 11.65$ per cent, Rb_2O none, Cs_2O none.

The second variety of albite is in large masses, of a pearl-gray tint and exhibits delicate blue chatoyancy on the cleavage faces. Called labradorite by Fontaine, and oligoclase and oligoclase-albite by others, optical determinations show it to be about 94 per cent albite. This chatoyant albite, in distinction from the cleavelandite variety, is not in distinct crystals and is not the host of many of the rarer minerals. Only the olive-colored microlite and the olive-buff colored muscovite have been found in it.

Strikingly different from both types of albite in the Rutherford mine are two varieties at the Morefield mine, where small white to transparent glassy crystals about 1 centimeter in length form a granular mass intermingled with mica and garnet in the outer feldspar zone, and a more fragile and splintery nile-blue variety which encloses small crystals of olive-colored microlite.

Bertrandite.—The rare hydrous beryllium silicate, bertrandite, has been found only at the Rutherford mine. It forms small prismatic colorless crystals about 1 mm. in length implanted on the walls of cavities in the deeply etched honey-colored variety of beryl, and in cavities in albite.

Beryl.—The early literature reported pale bluish-green and dingy yellow crystals of large size, some 3 or 4 feet in length and as much as 18 inches in diameter, from the Rutherford mine. Only small groups of tiny yellow crystals in cavities of albite were seen in the new workings of this mine. Some of the beryl crystals found at the Morefield mine are equal in size to those formerly reported from the Rutherford mine. So far, most of the beryl found at the Morefield mine is opaque, with a color range from white to pale bluish-green (lichen green).[8] The crystals are euhedral and are intergrown with the amazonstone and quartz. Some show muscovite crystals projecting at right angles from the prism faces, or hexagonal cup-like imprints where muscovite crystals have been removed. The alkalies present in the beryl were found by Mr. Stevens to be: $K_2O = 0.12$ per cent, $(Na,Li)_2O = 0.54$ per cent, Rb_2O none, $Cs_2O = 0.08$ per cent.

Biotite.—The contact between the pegmatite body and the wall rock in the Rutherford mine is sharp. In the Morefield mine, however, a conspicuous contact zone is developed. The wall between the coarse pegmatite mineral zone and the country rock is lined with a fine-grained felt-like layer of biotite 8 to 11 inches thick.

The biotite occurs mostly in scale-like plates 3 to 5 mm. across, loosely matted together, but slightly oriented so as to give the mass a suggestion of schistosity. Fine-grained quartz is the most common interstitial mineral. Small nodules and crystals of spessartite are interspersed through the mass. Microscopic crystals of apatite and zircon are also present.

The biotite is splendent black and in its physical properties closely resembles lepidomelane. Chemical determinations, however, by J. J. Fahey show that this is an iron rich biotite, having 26.72 per cent FeO, 2.87 per cent Fe_2O_3, and 3.60 per cent TiO_2.

Calcite.—Calcite is rare but several masses 2 cm. long were collected from the fresh dump of the Rutherford mine. The color ranges from opaque ivory yellow to transparent pale amber. It forms wedge-shaped or triangular masses in the interspaces of the cleavelandite albite. Some of the ivory colored calcite forms thin detached plates, loosely arranged like tiny cards in a file, occupying the box-like cavities in the cleavelandite. The plates are parallel to the base $c\{0001\}$ and give a perfectly centered uniaxial optical figure. This habit represents the high temperature form.[9] Calcite has not been found in the Morefield mine up to the present time.

Cassiterite.—Cassiterite from the new dump at the Rutherford mine is glossy pitch-black with adamantine luster. It is massive, in angular pieces 1 to 4 cm. long, and is embedded in the cleave-

[8] Ridgway, Robert, Color Standards and Nomenclature, used throughout.

[9] Schaller, W. T., The crystal cavities of the New Jersey zeolite region: *U. S. Geol. Survey, Bull.* **832,** p. 47, 1932.

landite albite. At the Morefield mine, the cassiterite has a dull gray submetallic luster, and is found in irregular fragments about 3 cm. long, scattered sparsely through the disintegrating albite in the zone of weathering.

Cerussite.—The lead carbonate forms a thin crust of dark grayish black crystals on the surface of the galena masses. The crystals are about 1 mm. in diameter and are pyramidal in form with prominent p $\{111\}$ faces.

Chalcopyrite.—Chalcopyrite forms flattened crystals or scale-like plates on the walls of the interspaces in the cleavelandite albite. It sometimes occupies portions of cavities partly filled with the platy calcite, and occurs also in the cavities partially filled with sericite.

Fluorite.—One of the most remarkable varieties of fluorite known is the chlorophane associated with microlite and other rare minerals in the pegmatite dikes at Amelia, Va., where it occurs at both the Rutherford and Morefield mines. Most of the material is extremely fractured, so that it readily crumbles when touched. This fragile variety is pale fluorite green in color. Early observers noticed the unusually strong fluorescence exhibited by this fluorite while subjected to heat just below redness. In addition to the fluorescence, a brilliant light green phosphorescence is obtained when the mineral is exposed to ultra-violet radiation.

After exposure to sunlight, these chlorophane specimens produce dense images on a photographic plate similar to those produced by radioactive substances. This photographic effect is not obtained, however, on repeating the experiment with a sheet of black paper interposed between the specimen and the plate, but the effect is marked when a piece of colorless glass is interposed. After the specimens had been kept in darkness for several hours they did not produce photographic images. The radiation phenomenon appears to be due to some solarization effect.

The same specimens were tested in a gold-leaf electroscope. The specimens that had been exposed to sunlight showed a remarkably strong activity response (.093), but after they had been kept in darkness for 24 hours no activity response could be observed.

At the Morefield mine fluorite is present in two forms; one, the chlorophane variety described above; and another, a colorless variety, in flattened octahedrons embedded in sheets of muscovite (Fig. 1).

Galena.—Galena has been found only at the Rutherford mine, some of the masses weighing 500 grams. The galena has been deposited in the interstices between the plates of albite. A crust composed of cerussite crystals forms a coating on the surface of some of the galena.

Manganotantalite, also called columbite, a tantalate of manganese and iron, is abundant in both mines. Crystalline masses 12 cm. thick, 10 cm. across, and 13 cm. long were reported from the old Rutherford mine where the mineral from the upper portion of the deposit is black and that from the lower levels is dark red with a higher specific gravity. The manganotantalite obtained from the

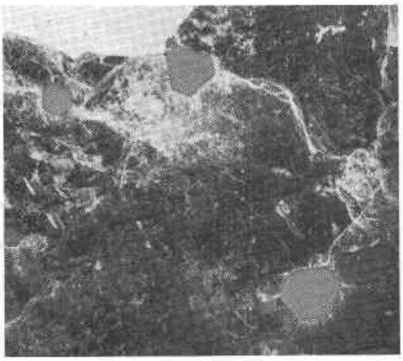

FIG. 1. Flattened octahedra of fluorite in muscovite. $\frac{2}{3}$ natural size. Morefield mine, near Amelia, Virginia.

fresh dump at the Rutherford mine is deep reddish-brown in thin splinters and has an adamantine luster. It occupies interstices in the cleavelandite albite and is completely unaltered by weathering.

Manganotantalite occurs in well developed crystals at the Morefield mine in association with amazonstone and quartz near a zone of topaz and beryl. Some of the crystals are 5 cm. in length and show a distinct tabular or rectangular prism form. Heart-shaped contact twins are abundant. More than 100 pounds of this mineral was mined from a single pocket of the dike near the surface. The brightness of the crystal faces is remarkably well preserved in view of the fact that the mineral occurs in the weathered portion of the dike. The color in hand specimen is black with a purple iridescence but in thin section the mineral is golden brown, nearly opaque.

Microcline.—Green microcline (amazonstone) is present in abundance in the Amelia pegmatites and is one of the most conspicuous minerals in the mines. The color ranges from light turquoise-green to sulphate-green. The green microcline forms cleavage masses which are commonly marred by fractures and seldom show crystal form, although several large well-formed crystals have been found. In the zone of oxidation leaching solutions have followed the fractures and destroyed the green color of the mineral near the crevices, leaving a white ground mottled with patches of green. From the deeper part of the mines, however, the mineral is of gem quality in both color and texture.

The amazonstone obtained from the recent operation of the Rutherford mine shows a minimum of the common perthitic character and has a uniform deep blue-green color. The cleavage is so perfect that pieces of the mineral may easily be split into very thin plates. This variety exhibits marked pleochroism from colorless to deep green in millimeter thick sections.

Spectrographic analysis of this deeper colored variety of amazonstone was made by George Steiger, who found in addition to the usual constituents, lithium, rubidium, lead, and probably a trace of tin.

The following percentages of the alkalies were found by R. E. Stevens on separated portions of the green and white microcline which formed sharp contact in the same cleavage piece.

	Green microcline	*White microcline*
K_2O	14.38	15.44
$(Na, Li)_2O$	1.54	0.92
Rb_2O	1.02	0.42
Cs_2O	trace	0.10

Microlite.—The rare mineral, microlite, essentially a calcium tantalate containing accessory columbium, fluorine, uranium, and rare elements, was especially abundant in the early workings of the Rutherford mines. Well formed octahedral crystals up to 5 cm. in diameter have been collected, and crystalline masses, some of which weighed 8 pounds, were described by Fontaine.[10] Perfect octahedra 2 to 3 cm. in diameter could be obtained from the dump of the new workings, although anhedral masses were small and rare.

Microlite in the Rutherford mine is of two distinct types. One

[10] Fontaine, W. M., *op. cit.*

is translucent and varies in color from dark olive-buff to dark olive; this type occurs as well formed single octahedral crystals having highly polished surfaces. The other type is transparent and varies in color from a reddish-yellow to dark amber, and resembles closely some types of garnet and of monazite. It occurs occasionally in imperfect, complex, isometric forms, but more commonly in irregular crystalline masses. The density of this variety is 6, and that of the olive-colored variety is 5.5 to 5.7; the amber variety is also harder and more brittle than the olive-colored variety. The indices of refraction also are slightly different. The mode of occurrence and the association of the two types are somewhat different. The octahedra of the olive-colored variety are embedded in the grayish chatoyant albite in close association with an olive-buff muscovite; the amber variety, apparently of a younger generation, occurs in spaces between plates of the cleavelandite albite.

Observations made by the electroscope showed that the olive-colored variety gave a marked radioactive response, whereas the amber-colored variety showed only an exceedingly feeble response, if any.

X-ray patterns of the two varieties show that the olive and amber colored microlites agree in structure. The olive-colored variety exhibits so much absorption of the x-rays that one must assume that heavy elements have entered the microlite lattice.

A comparison of the physical and optical properties of the two varieties is given in table 3.

TABLE 3

COMPARISON OF PHYSICAL AND OPTICAL PROPERTIES OF THE TWO VARIETIES OF MICROLITE FOUND AT THE RUTHERFORD MINE

	Olive-colored microlite	*Dark amber-colored microlite*
COLOR	Olive-buff to dark olive.	Reddish-yellow to amber brown (resembles monazite).
CRYSTAL SYSTEM AND HABIT	Isometric. Perfect octahedral. Occurs in individual crystals, faceted and undistorted.	Isometric. Modified octahedral. Faceted crystals rare. Forms distorted. Occurs mostly as fractured crystalline masses.
FRACTURE AND CLEAVAGE	Conchoidal, compact (not brittle). Cleavage lacking or nearly so, probably parting.	Uneven fracture, seldom conchoidal. Brittle. Cleavage good, distinct.

TABLE 3 (*Continued*)

LUSTER	Waxy, opaque, some fragments translucent. Submetallic on crystal faces.	Vitreous to resinous, transparent.
HARDNESS	Can be scratched by the amber-brown microlite. Scratches apatite. H=about 5.5.	Harder than the olive microlite. Scratches orthoclase, can be scratched by quartz. H=about 6.
SPECIFIC GRAVITY	5.49 to 5.74	5.9 to 6.0
INCLUSIONS	Microlite crystals inclose cavities in center filled with small albite crystals.	None
ASSOCIATION	In chatoyant-albite in close association with pale olive-buff muscovite.	In cavities of the white reticulated cleavelandite type of albite.
RADIOACTIVITY	Strong (electroscope test).	Weak, hardly perceptible. (electroscope test)
INDEX OF REFRACTION	$n=1.93$ to 1.94.	$n=1.98$ to 2.02.

At the Morefield mine microlite occurs more sparingly. The largest octahedrons observed are about $1\frac{1}{2}$ cm. in diameter, are dark olive in color, and are found most commonly in a nile-blue variety of very fragile, crumbly albite. A sample of this microlite, when crushed to a coarse powder and then placed on a glass plate and exposed on an Eastman process photographic plate for 7 days, gave a faint but distinct image. The same sample placed directly on the photographic plate for the same length of time gave a dense black image. The optical properties of this microlite are identical with those of the olive-colored variety from the Rutherford mine.

A pale honey-colored variety of microlite is also present at the Morefield mine, but it occurs in very small granular masses and as tiny flattened crystals in the white albite. This form of microlite closely resembles helvite in appearance and has a refractive index of 2.00.

Monazite.—Until recently the only locality in Virginia where monazite has been reported was the Rutherford mines. Here large coarse crystalline masses, or aggregates of crystals, some of which equaled the largest microlite masses in weight (8 pounds) were found in the early workings. At first the monazite was not recognized as such because the specimens so closely resembled microlite. The slight visible difference was assumed to be due to surface alteration of the microlite; the real difference was discovered by chemical analysis. Some of the early literature describes monazite under the name of microlite. Fontaine[11] calls attention to this error. It is evident that the physical appearance of the two minerals is confusing where crystal faces are missing. No specimens of monazite were available from the new dump at the Rutherford mine, but a specimen which had been obtained from the same mine several years ago and labeled "monazite" was examined by the writer. It was found to be optically isotropic, $n=2.00$, and had a specific gravity of 6.

Monazite occurs sparingly at the Morefield mine. The crystals have an amber color, but are well formed and easily distinguished crystallographically from the microlite, which they resemble in color. So far as has been observed at the Morefield mine, the monazite occurs as single flattened crystals which penetrate or partially enclose manganotantalite crystals of about the same size. This interlocked association with manganotantalite is a conspicuous characteristic of the monazite.

Muscovite.—The pale amber transparent variety of muscovite, which for a long time was the important economic mineral of the Amelia pegmatite deposits, has been described repeatedly by other writers. In the new workings of the Rutherford mine, an olive-buff colored muscovite commonly associated with the olive-colored microlite in the chatoyant albite, is shown by spectrum analysis to contain beryllium, tin, and boron; and a shell-pink variety, which occurs in tiny fan-shaped plates in the cavities of cleavelandite, is found to contain germanium.

A sericitic variety of muscovite, sometimes designated as "damourite," although abundant at the Rutherford mine, has received little or no attention. This type of muscovite is characterized by compact fibrous to scaly structure, a silky luster, and a talc-like feel. It is closely associated with microcline and albite, and contains fragmental inclusions of topaz, of which it probably is an alteration product. Although called hydrous micas, these minerals do not appear by chemical analyses to contain any more water than ordinary muscovite.

[11] Fontaine, W. M., *op. cit.*

Five varieties of sericite were studied and their physical and optical properties and mode of occurrence are recorded in table 5. The composition of these sericitic muscovites is shown in table 4, the last column of which also gives the analysis of the zinnwaldite to be described later.

Some of the rarer elements contained in these muscovites but not recorded in the chemical analyses are shown in the table of spectrographic analyses (Table 7).

Variety 1 of sericite is water-green in color and is composed of irregular aggregates of micaceous plates of microscopic size. These aggregates have a roughly schistose or fibrous habit and split into splintery tabular plates parallel to schistosity, and are terminated by smooth planes inclined at about 60° to the elongation. Many of the cleavage plates show a wavy, terrace-like structure. This green variety is penetrated by veinlets of the lilac-colored variety with cleancut contacts. The minerals most closely associated with these sericitic muscovites are albite and a few fragments of topaz about 5 mm. long.

Variety 2 is maize yellow, and its aggregates split into tabular plates terminated by smooth planes varying from 60° to 75° to the elongation. The minerals associated with this variety of muscovite are topaz and albite, the topaz crystals 5 mm. long being enclosed in a matrix of the muscovite.

The purple sericitic muscovites (varieties 3 and 4) vary in color from aniline lilac to grayish lavender. They occur in two forms—tiny scales or granules closely fitted together, and in compact, waxy, talc-like masses which, under high magnification, appear to be aggregates of minute scales or fibers, a little more rounded than those in variety 5, although somewhat sericitic. Varieties 3 and 4 are optically identical. These varieties of muscovite are found intimately associated with the bluish colored cleavelandite albite, in some places filling interstices between the albite plates.

Variety 5 is an opaque massive type of sericite, consisting of aggregates of microscopic crystals, some platy but mostly fibrous, arranged in diverse positions. It ranges in color from marguerite yellow to chalcedony yellow, and bears a striking similarity to massive talc in its greasy feel and silky luster. This variety occurs in greater abundance than the others of this group and is associated with the microlite-bearing chatoyant albite. It contains a higher percentage of iron and manganese than do the others as is shown in table 4.

TABLE 4
ANALYSES OF SERICITE (RUTHERFORD MINE) AND OF ZINNWALDITE (MOREFIELD MINE) FROM AMELIA, VIRGINIA

	1 Sericite Water green	2 Sericite Maize yellow	3 Sericite Aniline lilac	4 Sericite Grayish lavender	5 Sericite Chalcedony yellow	6 Zinn-waldite Bronze
SiO_2	48.06	47.22	46.81	46.80	49.16	43.70
Al_2O_3	32.14	32.00	36.09	35.84	30.81	22.96
Fe_2O_3	1.12[a]	1.20[a]	0.25[a]	0.24[a]	none	0.59
FeO					1.43	11.67
TiO_2	n.d.	n.d.	0.01	0.01	0.04	0.32
MgO	1.39	1.25	0.62	0.56	2.22	0.03
CaO	Trace	Trace	0.29	0.29	0.15	0.02
Na_2O	0.17	none	0.68	0.60	0.48	0.74
K_2O	9.21	8.89	10.24	10.08	10.90	9.58
H_2O-	2.06	3.14	0.42	0.64	0.15	0.08
H_2O+	5.46	5.65	5.00	5.05	4.73	1.35
P_2O_5	Trace	0.12	n.d.	n.d.	n.d.	n.d.
MnO	0.20	0.14	n.d.	n.d.	n.d.	1.95
F	none	none	n.d.	n.d.	n.d.	5.52
Li_2O	none	none	n.d.	n.d.	n.d.	1.92
BeO	none	Present	none	n.d.	n.d.	n.d.
Rb_2O	n.d.	n.d.	n.d.	n.d.	n.d.	1.04
Cs_2O	n.d.	n.d.	n.d.	n.d.	n.d.	0.10
	99.81	99.60	100.41	100.11	100.07	101.58
Less O						2.32
						99.26

[a] Iron determined as Fe_2O_3 and recalculated to FeO.

1 and 2, J. G. Fairchild, analyst; 3, 4, and 5, R. E. Stevens, analyst; and 6, J. J. Fahey, analyst. Determination of caesium by R. E. Stevens, remaining alkalies by R. C. Wells.

Phenacite.—Phenacite was found at the Rutherford mine only once by W. S. Yeates in 1890, and reported as "phenacite crystals cracked and not good specimens." At the Morefield mine the mineral is fresh and clean, both massive and in distinct crystals. The largest piece of massive material collected by the writer is 10 cm. long and 5 cm. wide. A few transparent rhombic crystals varying from 2 to 5 cm. in diameter were collected by Mr. Morefield and submitted to this laboratory for identification. These crystals were studied by J. H. Pough of Harvard University, who found that they were a "little unusual in that the form *d* $\{01\bar{1}2\}$ is poorly developed, where usually it is one of the dominant forms."[12]

The massive phenacite is intergrown with beryl, quartz, zinnwaldite, and green microcline. The phenacite so closely resembles the topaz that frequently it cannot be distinguished therefrom except by gravity separation or by microscopic examination.

Pyrite.—Sulphides are very rare among the Amelia pegmatite minerals, and pyrite is the most widespread though its total quantity is small. Scales and minute crystals are occasionally found in the cleavage cracks of the green microcline, and clusters of small cubical crystals were seen along the fracture faces and in the spaces between crystals of zircon and on the sericite at the Rutherford mine. No pyrite has as yet been found in the Morefield mine.

Pyrolusite.—Pyrolusite was noted only at the Morefield mine. In the zone of oxidation the weathering of the spessartite garnet has left a concentration of the manganese in the form of black earthy or soot-like masses of pyrolusite, completely enclosing the nodules of garnet, and as cementing material in the spaces between the granular garnet fragments. Much of the albite in the garnet zone is covered with a dense film of pyrolusite which, due to its metallic luster, resembles graphite. Dendritic coatings of pyrolusite are frequently observed on the surfaces of albite and amazonstone.

Quartz.—Quartz of several varieties has been reported from the Rutherford mine, but with the exception of a few small crystals on the walls of cavities in the cleavelandite, the common massive glassy variety is the only kind found on the dumps at present. Quartz at the Morefield mine is almost entirely the common glassy pegmatite variety. Only a few rounded crystals of smoky quartz have been found.

Spessartite.—Spessartite, the manganese garnet, was abundant in the early workings of the Rutherford mine. It was described by Fontaine as occurring in poorly formed crystals which are penetrated with a multitude of fissures so that the mineral readily shatters to pieces. This form, he said, has a hyacinth-red to brownish red color, and is embedded in the ordinary feldspar of the vein. He also described another form of spessartite as having a flesh-red to brownish purple color and occurring as granular masses intimately mixed with helvite.

Spessartite of a brownish red color, found in the platy albite and

[12] Personal communication.

similar in form to the first one described above, was plentiful on the new dumps of the Rutherford mine. This form of spessartite has an index of refraction of 1.795 and a specific gravity of 4.21.

A deep wine-red garnet found in small individual crystals 2 mm. in diameter, embedded in the olive-buff muscovite, has a refractive index of 1.805 and corresponds to spessartite.

At the Morefield mine the spessartite is found in the mica-albite zone near the outer edge of the pegmatite body and in the contact zone, as described under biotite. This spessartite forms imperfect crystals or loosely aggregated nodular masses coated on the outside by pyrolusite and resembles black walnuts in external appearance. After the manganese oxide coating is removed by acid treatment the spessartite has a flesh-red color and a refractive index of 1.804. The spessartite-almandite associated with the biotite has a deep red color and a refractive index of 1.810.

Topaz.—At the Rutherford mine topaz ranks among the scarcest of the minerals, occurring only in centimeter thick fragments scattered through the sericitic muscovite. At the Morefield mine, however, topaz is abundant and in crystals of unusual size. Some of the irregular crystal masses weighed 200 pounds; one crystal with a single termination weighed 125 pounds; three with double terminations, apparently hemimorphic, weighed 20, 25 and 28 pounds respectively. Mr. Morefield reported one large crystal which measured 44 inches in length and weighed 500 pounds. Some of the topaz is colorless and transparent, and some white and nearly opaque. The transparent glassy variety is full of fractures and shatters easily. The white massive type is dense and contains numerous bubble inclusions. The topaz crystals are associated with the green microcline, quartz, and beryl. Small topaz crystals are frequently found penetrating the cleavage plates of zinnwaldite.

A quantitative determination of the alkalies by R. E. Stevens, showed that the Morefield topaz contains 0.10 per cent K_2O and 0.37 per cent $(Na, Li)_2O$. Spectrographic analysis shows that this variety of topaz also contains germanium, beryllium, and tin.

Tourmaline.—Black tourmaline occurs rarely in small aggregates of prismatic radiating crystals, usually associated with albite, beryl and quartz at the Rutherford mine. Nest-like clusters of tourmaline needles and crystals as large as a pencil, flattened and striated, have been found frequently in the Morefield mine. In thin section the Rutherford tourmaline is brown-black and the Morefield is blue-black.

Triplite.—Triplite is here reported for the first time from the Amelia locality. It is found in crystalline masses at the Morefield mine. The specimens collected exhibit cores of unaltered translucent salmon-colored triplite masses measuring about 2 cm. in diameter surrounded by zones of brownish-black triplite showing adamantine luster. The triplite is embedded in a matrix of albite and quartz, both stained black with manganese oxide. Other associated minerals are green microcline and topaz.

Zinnwaldite.—The iron lithium mica zinnwaldite (a rare member of the mica group), is present in considerable quantity at the Morefield mine. This is the first occurrence of zinnwaldite reported from the Amelia locality. In the upper portion of the mine the zinnwaldite was found only in small crystals and cleavage plates varying from 1 centimeter to 5 centimeters across. The mineral is best described as having a dark rum brown color with a bronzy luster, and for convenience is referred to as bronze colored. This zinnwaldite is closely associated with topaz and albite. The bronze colored plates are frequently penetrated by crystals of topaz and other plates are interlaminated with small crystals of topaz and albite. A small quantity of another variety of zinnwaldite forms short prismatic crystals about 1 centimeter across, silvery-gray in color, embedded in phenacite and beryl, and infrequently in topaz and quartz.

Recent workings at a lower level in the mine, about 20 feet from the surface, have yielded zinnwaldite crystals of remarkable size. One dark bronze colored specimen collected from the dump, showing probably one-half or two-thirds of the original crystal, measures 19 centimeters along the *a*-axis, 21 centimeters along the *b*-axis and 11 centimeters along the *c*-axis, and weighs 11 kilograms (24 pounds). So far as is known this is the largest zinnwaldite crystal ever recorded. It is shown in Figure 2, reduced to $\frac{1}{3}$ natural size. The incomplete crystal is bounded by $c(001)$ cleavage, and the gliding plane $\rho(\bar{2}05)$. Other smaller pieces show faces of the gliding plane $\zeta(135)$. The axial plane is parallel to $b(010)$ and hence normal to the intersection edge of $c(001)$ and $\rho(\bar{2}05)$.

A complete analysis of zinnwaldite was made by chemists in the laboratory of the United States Geological Survey on a carefully selected sample of zinnwaldite from the upper level of the mine where the zinnwaldite was associated with topaz. The results of this analysis are given in the last column (No. 6) of table 4.

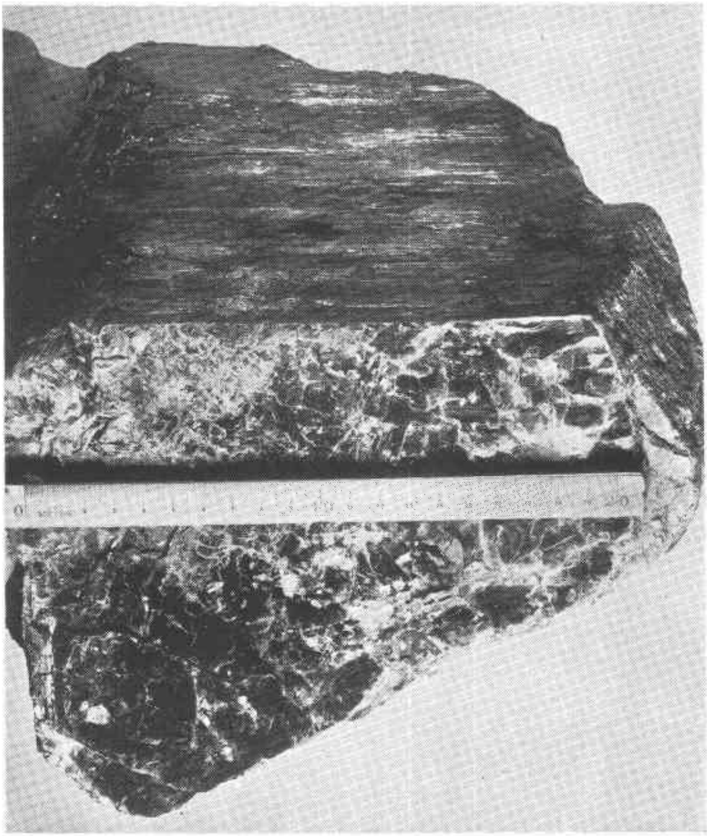

FIG. 2. Largest recorded crystal of zinnwaldite, measuring nearly a foot (21 cm. along the b-axis, in horizontal position) wide. The ruled face at the top is the gliding plane $\rho(\bar{2}05)$. $\frac{1}{3}$ nat. size. Morefield mine, near Amelia, Virginia.

Associated minerals are green microcline, gray quartz, nile-green albite, and black manganotantalite.

Zircon.—Zircon is rare and has been found only in a few small patches in the albite in the Rutherford mine, where clusters of slender elongated radiating crystals occupy narrow wedge-shaped cavities between the interlacing crystals of the cleavelandite albite. In the Morefield mine zircon occurs as minute specks in the quartz

TABLE 5

PROPERTIES AND OCCURRENCES OF THE MICAS FROM AMELIA, VIRGINIA, AS DETERMINED BY THE WRITER

Mineral name	Mine	Color	Indices			Sign 2V dispersion	Crystallization and structure	Distinctive characters	Occurrence
			α	β	γ				
Biotite	M	Black	1.588	1.645	1.645	(−) 2V=0°–8°	Disseminated and cleavable scales.	Resembles lepidomelane.	Along the wall contact.
Muscovite	M, R	Pale amber	1.553	1.583	1.589	(−) 2V=47°	Hexagonal plates.	Perfect cleavage. Transparent. Colorless in thin plates.	Occurs as blocks or books along contact of feldspar and quartz.
Muscovite	R	Shell pink	1.552	1.583	1.590	(−) 2V=45°	Small fan-shaped plates.	Satiny luster.	Occurs in cavities in cleavelandite.
Muscovite	R	Olive-buff	1.562	1.590	1.595	(−) 2V=42°	Small hexagonal crystals.	Perfect cleavage. Vitreous luster.	Associated with microlite and chatoyant albite.
Muscovite (Sericite)	R	Water-green	1.543	1.560	1.575	(−) 2V=70°–80° Ext. parallel	Fibrous, splits into splintery cleavage plates, terminated by 60° angle. Wavy terrace-like structure.	H=2.5 Translucent. Luster waxy to silky. Pleochroism distinct. Y and Z colorless, X dark brown.	Associated with albite and carries inclusions of topaz. Green variety is penetrated by veinlets of purple mica.
Muscovite (Sericite)	R	Maize yellow	1.545	1.564	1.574	(−) 2V=70°–75° Ext. parallel	Fibrous to tabular. Plates terminated planes 60° to 75° to the elongation.	Luster waxy. Translucent. Talc-like feel.	Associated with albite and fragments of topaz.
Muscovite (Sericite)	R	Aniline lilac to lavender	1.553	1.582	1.588	(−) 2V=30°–40° variable	Varies from tiny scales, almost granular to compact.	Cleavage micaceous. H=2. Luster pearly to waxy. Greasy, talc-like feel. Translucent to transparent.	Associated with bluish cleavelandite albite.
Muscovite (Sericite)	R	Chalcedony yellow	1.548	1.579	1.585	(−) 2V=0°–3°	Compact aggregate of scaly and fibrous arranged in diverse positions.	Opaque in hand specimen. Resembles massive talc. Silky luster. Greasy feel	Occurs in great abundance. Associated with the microlite-bearing chatoyant albite.
Zinnwaldite	M	Rum brown or bronze to gray	1.550–1.558	1.580–1.589	1.580–1.590	(−) 2V=0°–33° variable	Coarse bronze colored crystals and tabular cleavage plates. Gray short prismatic crystals, hexagonal.	Perfect cleavage. Bronzy to pearly or silvery luster. Fuses to black magnetic bead. Gives lithium flame.	Bronze variety associated with topaz and albite; gray variety associated with phenacite and beryl.

Table 6

Properties and Occurrences of the Minerals, except Micas, from Amelia, Virginia, as Determined by the Writer

Name of mineral	Mine	Color	Indices of refraction			Sign 2V dispersion	Crystallization and structure	Distinctive characters	Occurrence
			α / ϵ	β / n	γ / ω				
Albite	R	Bluish pearl-gray	1.529	1.533	1.539	+ $2V=79°$	Cleavage masses.	Ab. 94. Shows delicate blue chatoyancy.	Associated with olive-colored microlite and light olive-buff (greenish) muscovite.
Albite	R	Pale nile-blue to white	1.528	1.531	1.538	+ $2V=78°$	Reticulated plates.	Ab. 96.	Host for rare minerals.
Bertrandite	R	Colorless	1.589	1.602	1.613	− $2V=78°$ $r<v$	Orthorhombic, prismatic. Distinct terminations.	Tiny columnar crystals in aggregates. Cleavage (110) perfect.	On cavity walls in etched beryl with quartz and albite crystals.
Beryl	M	Lichen green	1.572		1.578	−	Large hexagonal prisms.	Opaque, subtranslucent. G=2.66. Cleavage imperfect.	Intergrown with green microcline and quartz.
Beryl (Golden)	R	Honey yellow	1.568		1.575	− Abn. small 2V	Crystalline lumps. Deeply etched surfaces.	Transparent, vitreous.	In cavities of albite.
Calcite	R	Ivory to amber	1.488		1.660	− Abn. biaxial $2V=20°$	Small wedge-shaped plates.	Opaque to transparent.	In interstices in cleavelandite albite.
Cassiterite	R, M	Brownish-gray to jet black	2.09		2.00	+ Abn. biaxial	Irregular compact masses.	G=6.86. Fresh surfaces glossy black. Transparent in thin section. Poly. Tw.	In interstices in cleavelandite albite.
Cerussite	R	Gray to gray-black	1.803	2.075	2.077	− $2V=5°-10°$ $r>v$	Orthorhombic, pyramidal.	Adamantine luster. Transparent.	On galena masses.
Columbite (see manganotantalite)									
Fluorite	M	White		1.433			Tabular crystals.	Flattened octahedra, some resembling rhombohedral crystals.	Enclosed in muscovite crystals.

TABLE 6 (*Continued*)

Fluorite (Chlorophane)	R, M	Fluorite green		1.434			Brittle shattered masses.	Strongly luminescent.	In cavities in microcline and albite.
Manganotantalite	R, M	Black				+ 2V large	Orthorhombic. Rectangular prisms. Heart-shaped twins.	$G=7.296$. Nearly opaque. Streak brown. Submetallic luster. Iridescent, non-magnetic. Reacts for manganese.	Interstices in cleavelandite.
Microlite	R, M	Olive		$1.94\pm.002$			Isometric. Octahedral crystal.	$H=5.5$. $G=5.49$–5.78. Waxy luster. Translucent.	In gray chatoyant albite
Microlite	R, M	Dark amber		$2\ 02\pm.002$			Irregular masses. Occasionally crystal face of some isometric form.	$H=6$. $G=5.9$–5.0. Vitreous to resinous luster.	In cavities in reticulated cleavelandite.
Microcline (amazonstone)	R, M	Green	1.516	1.520	1.523	− $2V=80°\pm$	Cleavage pieces. Crystals rare.	Pleochroism strong. X pale green, Y deep green, Z colorless.	Forms parallel zones or bands in main pegmatite body. Associated with quartz, beryl, topaz, etc.
Monazite	R, M	Reddish amber	1.785	1.790	1.837	+ $2V=15°$ $r<v$	Monoclinic. Flat tabular crystals, terminations wedge-shaped, prism faces elongated.	$H=5$. $G=5.2$. Luster resinous. Resembles amber colored microlite.	Associated with albite. Often enclosing crystals of manganotantalite.
Phenacite	M	White or colorless	1.671		1.655	+	Massive. Few transparent rhombohedral crystals.	Cleavage distinct. $H=7.5$. Crystals small, 5 mm. long.	Associated with beryl, quartz, and green microcline.
Pyrolusite	M	Black					Non-crystalline.		Coating on surface of altered spessartite.
Spessartite	R, M	Salmon to red		1.795–1.810			Granular nodules, crystalline masses, and rounded grain-like dodecahedrons.	Crystals very rare.	Associated with albite, muscovite, and biotite.
Topaz	M	White or colorless	1.615	1.619	1.624	+ 2V medium	Crystalline masses and apparently hemimorphic orthorhombic crystals.	$H=8$. $G=3.60$. Doubly terminated crystals 12 to 14 inches long.	Associated with beryl, quartz, green microcline, and zinnwaldite.
Tourmaline	R, M	Jet black	1.637		1.667	−	Hexagonal. Prismatic radiating masses.	Pleochroism strong. ω = brown, ϵ = yellow.	Associated with quartz, topaz and green microcline.
Triplite	M	Salmon	1.660	1.669	1.679	+ 2V near 90°	Crystalline masses.	Resembles spessartite. Resinous to adamantine luster.	Associated with albite, quartz, and green microcline.
Zircon	R, M	Wood brown	1.98		1.928	+	Elongated prisms.	Radiating slender crystals and square prisms.	In cavities of cleavelandite. Pyrite crystals occur in joint cracks in zircon crystals.

and microcline, and as well formed square prisms in the albite. One of the largest crystals seen by the writer was a square prism $2\frac{1}{2}$ cm. long.

The properties and occurrences of the minerals studied are summarized in tables 5 and 6. Only those determinations made by the writer are included.

5. Rarer Elements Identified by Spectrographic Analyses

Spectrum analysis is being widely adopted in mineralogical laboratories as an accessory means of identification of mineral species and for the determination of the presence of rare elements in their composition.

Analyses by this method were made by Mr. George Steiger on 28 specimens from Amelia, Va. Mr. Steiger tested each specimen for only eight elements—copper, lead, bismuth, tin, zinc, germanium, beryllium, and boron. These particular metals were selected because they give distinct spectral lines and tests could be made by placing finely ground material directly in the arc, without preliminary concentration by chemical treatment. The tests are accurate to .02 or .03 per cent, probably larger for copper.

The graphite electrode contains sufficient copper to give two persistent lines, and unless other copper lines were visible copper was not reported as present.

Tests were made, after concentration, on three specimens for lithium, rubidium, and caesium. Two samples of amazonstone, one from each mine, and the zinnwaldite from the Morefield mine, show lithium and rubidium. Any caesium lines that may have been present were obscured by other interfering lines.

Twelve of the samples contained boron. Without an exception all the micas contained boron, and this element is also present in the chatoyant albite and in the phenacite.

A wide distribution of beryllium is indicated by the fact that nearly half of the samples tested showed its presence.

Copper occurs "doubtful" in beryl and in spessartite.

Germanium is a characteristic constituent of topaz. In a compilation of spectrum analyses by Fitch[13] of London, topaz from 38 localities in different parts of the world contained germanium. Fifteen samples of topaz from various localities, including a sample from Morefield mine, have been examined by Mr. Steiger and all

[13] Fitch, A. A., Spectrum analysis in mineralogy, *London*, Adam Hilger, Ltd.

were found to contain germanium. The shell pink muscovite from the Rutherford mine, however, is the only mica which contains germanium. Spessartite from both mines contains germanium.

Lead appears in all of the feldspars, fluorite, manganotantalite, and the shell pink muscovite.

Tin is the most widely distributed metal of this group; it occurs in 17 out of 28 specimens. Tin is present in all the micas but one.

The lithium content of the Amelia minerals as a whole is remarkably low for pegmatites of this type. Except in zinnwaldite, so far as has been observed, lithium occurs only in the amazonstone and the beryl.

TABLE 7

RARER ELEMENTS IN MINERALS FROM AMELIA, VIRGINIA, IDENTIFIED BY SPECTRUM ANALYSES

(R=Rutherford mine; M=Morefield mine)
x=present; t=trace; d=doubtful.

Name of mineral	Mine	Bi	B	Be	Cu	Ge	Pb	Sn	Zn
Albite (chatoyant)	R		x				x	x	
Albite (white)	R						d	x	
Beryl	R			x					
Beryl	M			x	d				
Cassiterite	R							x	d
Fluorite	M, R			x			x	x	
Manganotantalite	R						x	x	
Manganotantalite	M			d				x	d
Microcline (white)	M						x		
Microcline (green)	M, R						x		
*Microlite	R			x				x	
Muscovite (amber)	M, R		x						t
Muscovite (pink)	R		x			x	x	x	
Muscovite (olive)	R		x					x	
Phenacite	M		x	x					
Sericite (lilac)	R		x					x	
Sericite (green)	R		x	x				x	
Sericite (yellow)	R		x	x				x	
Sericite (buff)	R		x					x	
Spessartite	R					x			
Spessartite	M				d	x		x	
Topaz	M, R			x		x		x	
Tourmaline	R		x	x					
Zinnwaldite	M		t	x				x	t

* Crowded lines in the spectrum obscured everything except Be and Sn.

Rubidium is present in the zinnwaldite and in the green microcline.

A trace of zinc appeared in the amber muscovite and in the zinnwaldite.

6. Luminescence of Minerals from Amelia, Va.

A description of the "phosphorescence" of the chlorophane type of fluorite from the Rutherford mine is contained in the early literature on the Amelia County minerals, but luminescent properties of other minerals in that locality have not been recorded.

While making confirmatory tests of previous observations on chlorophane, a group of other minerals from the same locality were examined for reaction to heat and to ultra-violet radiation.

Chlorophane, which exhibits very unusual luminescent phenomena, has been described under fluorite.

The opaque white variety of topaz was found to be remarkably thermoluminescent. When powdered fragments of the mineral were sprinkled on an iron plate heated to just below redness the grains gave off a bright, steady glow of pure white light. The glassy transparent variety, however, glows only feebly.

The chatoyant albite shows an active response to heat and also to friction produced by rubbing (triboluminescence), the light given off in both cases being bluish-white.

The fragile somewhat altered albite, which occurs associated with the manganese garnet (spessartite) at the Morefield mine, responds readily to heat and gives off a white luminous glow. Calcite from the Rutherford mine exhibits a spectacular and colorful luminescent effect when heated. The glow is an intense flame color grading into deep orange, which persists for a much longer period than the white glow of the silicates. Other minerals which exhibit thermoluminescence, although briefly and feebly, are cleavelandite, phenacite, and microlite.

Under ultra-violet light (mercury vapor lamp) the chlorophane glows with a vivid green fluorescence with persists for some time after the mineral has been removed from the source of radiation. Calcite gives off a brilliant crimson fluorescence, but does not show an afterglow. Zircon glows with a soft golden yellow light which dies away when the mineral is removed from the ultra-violet rays.

TABLE 8

LUMINESCENCE OF MINERALS FROM AMELIA, VIRGINIA

Name of mineral	Color and structure	Locality	Response to ultraviolet radiation	Response to heat
Albite	White, argentite type inclosing nodules of spessartite.	Morefield mine.	Negative.	Glows quietly with a white light.
	White to blue-green cleavelandite type.	Rutherford mine.	Negative.	Glows feebly with blue-white light.
Chatoyant albite	Bluish-gray splintery cleavage pieces.	Rutherford mine.	Negative.	Blue-white luminous glow. Also triboluminescent.
Calcite	Ivory-yellow, opaque to transparent amber. Small wedge-shaped pieces.	Rutherford mine.	Bright crimson.	Brilliant orange-colored persistent glow.
Chlorophane	Fluorite-green, very much fractured. Brittle.	Rutherford and Morefield mines.	Bright green glow persists after specimen is removed from the source of radiation.	Emerald green—very brilliant persistent glow. Also triboluminescent.
Microcline	White. Cleavage pieces.	Morefield mine.	Negative.	Feeble, white glow.
Microcline (amazonstone)	Green. Cleavage pieces.	Rutherford and Morefield mines.	Negative.	Feeble glow. Green color completely disappears below red heat.
Microlite	Olive and amber crystals.	Rutherford mine	Negative.	Feeble, white glow.
Phenacite	White, massive.	Rutherford mine.	Negative.	Feeble, white glow.
Quartz	Smoky, massive.	Rutherford and Morefield mines.	Negative.	Feeble, white glow. Smoky color disappears below red heat.
Topaz	(1) White, massive.	Morefield mine.	Negative.	Pure white luminous glow.
	(2) Colorless, transparent.	Morefield mine.	Negative.	Feeble, white glow.
Zircon	Wood-brown. Elongated radiating crystals.	Rutherford mine.	Golden yellow.	Negative.

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