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NATURAL MICA STUDIES

By

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SUMMARY

During the quarterly period March 1, 1953, to May 31, 1953, we have attempted to finish most outstanding phases of research in preparation for the Final Report which is scheduled to be available on October 1, 1953. We have succeeded in this task and have also been able to begin the writing of several sections of the Final Report. At the time of this writing about 40 pages of the Final Report have been completed, including the following topics: a) Introduction, b) Description of work carried out and techniques used, c) History of mica studies, d) Nomenclature and synonomy, and e) Classification.

During the summer months a small amount of work will be carried out on selected mica specimens by means of differential thermal analysis techniques. In particular it is hoped that the different polymorphs may be identified by this method.

Professor Heinrich and Dr. Levinson attended the Signal Corps Symposium in Asbury Park in May and were very pleased with the interesting, varied program. Before their return to Ann Arbor they visited Doctors H. S. Yoder and W. T. Schaller in Washington to discuss certain problems concerning the micas. Visits were also paid to Massachusetts Institute of Technology (Professor Harold Fairbairn and Professor Patrick Hurley) and to Columbia University (Professor Paul F. Kerr). Dr. Levinson also visited the Electrochemical Laboratory, U. S. Bureau of Mines, Norris, Tennessee, for 2 days and discussed phases of the mica work concerned with isomorphism and structure.

In the course of our work we have had 9 articles translated from the Russian by Mrs. E. G. Smith. They include:

1. Tchirvinskii, P. N. (1948) Shilkinite and muscovite: Mem. Soc. Russe. Min., 77(3), pp. 246-9.

2. Misharev, D. T. (1932) Mama-Vitim-Chuisky Deposit of Mica, Vitim-Lena Region of Siberia: Trans. Un. Geol. Prosp. Serv. U.S.S.R. Fasc. 154.

3. Buryanova, E. Z. (1940) Mineralogy of granite pegmatites of the Korosten Plutone in Volhynia and study of ferrous biotites: Mem. Soc. Russe. Min., 69 (4) pp. 519-540.

4. Grigoriev, D. P. (1936) On the interrelations of biotites and muscovites in pegmatite veins: Bull. Soc. Nat., Moscow, 17 (4-5) pp. 14-30.

5. Serdiutchenko, D. P. (1948) On the chemical constitution and classification of micas: Akad. Nauk. S.S.S.R. (Dokl.) 59 (3) pp. 545-548

6. ____________ (1948) On the crystallochemical role of titanium in micas: Akad. Nauk. S.S.S.R. (Dokl.) 59 (4) pp. 739-742.

7. Micas of the U.S.S.R.: P. M. Tatarinov, editor; Moscow, Leningrad, 1937.

8. Ostrovsky, I. A., and Petrov, V. P. (1940) Materials in connection with the optics and chemical composition of the magnesia-ferrous micas: Akad. Nauk. S.S.S.R., Inst. geologicheskikh, Nauk. Traveaux, Vol. 36, Petrographic series (No.11) pp. 1-32.

9. Belshterli, M. K., and Turtzev, A. A. (1940) The thermo-magnetic investigations of biotite: Akad. Nauk, S.S.S.R., Inst. geologicheskikh Nauk, Tr. vol. 44, Petrographic series (No. 14).

In view of the imminence of the Final Report and the desire of not repeating information, this report will contain only a detailed summary of "Overgrowths among the micas".

OVERGROWTHS AMONG THE MICAS

Introduction

Several species of micas are not uncommonly found in regular to semiregular overgrowths and intergrowths with each other. The following types have been studied:

1) Marginal Overgrowths. One species of mica partially or completely surrounds another species. The boundary may be sharp and represent the euhedral crystal outline of the core species, it may be irregular, or it may show corrosion of the core. Combined species found in this type of association are muscovite and biotite, muscovite and lepidolite, and biotite and lepidolite.

2) Irregular Intergrowths. No general systematic relation between the two species appears. Boundaries are either straight or irregular. Biotite and muscovite are the two micas found in this type of association.

In both these types of occurrences the two species generally share a common basal cleavage plane.

The information presented in this summary has been drawn both from the literature and from the examination of specimens in the mica collection of the Mineralogical Laboratory of the University of Michigan.

Biotite and Muscovite

Of the three mineralogical combinations listed above the biotite-muscovite one is the most common.

The only nonpegmatitic occurrence of muscovite and biotite intergrowths was reported by Johannsen (1948). A nepheline-bearing diorite called dungannonite contains small amounts of yellow to greenish grown biotite intergrown with muscovite. However, subparallel intergrowths of the two micas are not uncommon in two-mica granites.

Books of biotite and muscovite, as much as 12 inches across, have been reported from the following representative localities:

Southeastern Piedmont District. The Mitchell Creek Mine, Upson County, Georgia, has produced muscovite-biotite intergrowths of several varieties. Furcron and Teague (1943) report sheet muscovite books wrapped by sheet biotite, biotite books included in muscovite, and muscovite included in biotite. Both species have a common cleavage plane. Lester (1946) found two types of intergrowths at this locality. The first is a tight intergrowth in which the two micas possess a common cleavage plane. Thin sheets of this type can be cleaved as easily across the line of contact as within the individual micas. The second type is a loose intergrowth with straight boundaries; the two micas possess common planes of cleavage, but tend to separate readily when cleaved across the contact.

Rum-colored muscovite showing heavy "A" structure and containing six-sided inclusions of biotite has been reported by Furcron and Teague (1943) from the Peters Mine in Monroe County, Georgia. They also found a minor occurrence of biotite crystals included in sheets of muscovite from the following localities in Georgia:

Dick Fletcher Mine, Monroe County
W. M. Gooch Mine, Lumpkin County
W. A. Sullivan Mine, Union County
Chapman Mine, Elbert County.

In Mitchell County, North Carolina, Sterrett (1923) found crystals and sheets of biotite with included crystals of muscovite and vice versa. The two micas generally occur in parallel intergrowth and have a common cleavage. Studies of a specimen of biotite enclosing a rhombic crystal of muscovite showed the two micas to have approximately parallel percussion figures and optic planes.

Some pegmatites of the Spruce Pine District, North Carolina, contain biotite intimately mixed with oligoclase and muscovite. Maurice (1941) reports that, in the outer zone of the pegmatites, muscovite frequently forms an outer zone around biotite crystals. Thin flaky sheets or laths of biotite occur as veinlets in parallel intergrowth with muscovite. The laths are usually less than 4 inches long and 1/16 inch thick.

Sterrett (1923) also reported parallel intergrowths of biotite and muscovite from the Hamilton Mine, Ashe County, North Carolina, the Big Ridge Mine, Haywood County, North Carolina, and the Chalk Hill Mine, Macon County, North Carolina. Pogue (1911) found six-sided plates of biotite enclosed in muscovite at the Buck Creek deposit, Macon County, North Carolina.

Northeastern United States. Several occurrences of biotite-muscovite intergrowths have been reported from New England pegmatites. However, none of the descriptions are detailed; apparently the occurrences are not common. Generally, the micas intergrow in parallel position with a common basal cleavage. The reported localities are:

Island Mine, Creshire County, New Hampshire
Sterrett (1923) and Olson (1942)

Holden Mine, Granton County, New Hampshire
Sterrett (1923)

Patten Mine, Granton County, New Hampshire
Sterrett (1923)

Old Lithia Mine, Chatham Connecticut
Shannon (1920)

Middletown, Connecticut
Pogue (1911)

Philadelphia, Pennsylvania
Hall (1882)

Lenni, Delaware County, Pennsylvania
Hall (1882)

Western United States. Biotite-muscovite intergrowths from the Western states have been described from a few pegmatites. Hanley et al. (1950) describe green-gray, heavily stained muscovite from the Rosemont Mine, Micanite District, Park and Fremont Counties, Colorado. The muscovite is ruled, ribboned, has pronounced "A" structure, and is commonly intergrown with biotite. The same authors also report blades of intergrown muscovite and biotite as much as 6 feet long from the School Section Mine, Eight Mile Park, Fremont County, Colorado. Other scattered occurrences were at the following localities:

Levi Anderson Mine, Latch County, Idaho
Sterrett (1923)

Custer County, South Dakota
Pogue (1911)

Canada. Spence (1930) reports parallel intergrowths of muscovite and biotite from dikes of the lower St. Lawrence area. The following three varieties of intergrowths have been found at the Pied des Monts mica mine near Murray Bay, Quebec:

1) core of muscovite surrounded by a rim of biotite
2) books that are part muscovite and part biotite, the boundary running diagonally across the cleavage sheet
3) alternate layers of muscovite and biotite

Minas Gerais, Brazil. Occurrences of intergrown biotite and muscovite were noted by Pecora, et al. (1950). Generally, the intergrowths are in parallel position and occur in the border zones of the pegmatites.

Germany. Linck (1910) reported regular and irregular intergrowths of biotite and muscovite from Veltlin. He found that the rays of a percussion figure near the boundary would cross the boundary without interference. The two species of micas have a common cleavage plane, but the planes of the optic axes are at an angle of 60°.

Scharizer (1887) described regular overgrowths of muscovite and lepidomelane from the pegmatites of Schüttenhofen, Germany. A six-sided crystal of lepidomelane is completely surrounded by a rhombic crystal of muscovite. Both species have a common basal cleavage. The axial plane of the lepidomelane is parallel with the long ray of a percussion figure, whereas the axial plane of the muscovite is normal to the long ray of the percussion figure; the two optic planes are therefore at an angle of 60°.

Kimito, Finland. Pehrman (1945) reports weathered books of interlayered biotite and muscovite from the granitic pegmatite of Kimito.

Orientation Observations. A group of specimens of intergrown muscovite and biotite was selected from the Michigan mica collection for opitcal study. An attempt was made to find the relationship between percussion figures and optic planes in the two species. In all cases, the percussion figures are essentially parallel. The greatest deviation from parallelism was found to be 9°. The most common angle between the optic planes of the two species is approximately 60°. However, angles of 0° and 90° were also noted. Generally, the line of contact between species is sharp. In a few specimens, the contact is ragged or feathered. In no specimens was a gradation found between muscovite and biotite. The data obtained are listed below.

Specimen Number	Locality	Angle Between Main Ray of Percussion Figures
Optic Planes Perpendicular		
85	Putnam, Haywood County, North Carolina	0°
Optic Planes Parallel		
149	Mauldin Road prospect, Upson County, Georgia	5°
1393	Location unknown	0°
1394		0°
Optic Planes at an Angle of 60°		
47	Ledford Cove, Macon County, North Carolina	9°

Specimen Numbers	Locality	Angle Between Main Ray of Percussion Figures
Optic Planes at an Angle of 60° (cont.)		
48	Ledford Cove, Macon County, North Carolina	0°
68	Big Ridge, Haywood County, North Carolina	6°
84	Lower East Fork, Haywood County, North Carolina	4°
153	Mitchell Creek, Georgia	3°
177	M and G, Alabama	6°
282	Eight Mile Park, Fremont County, Colorado	0°
1391	Hebron, Maine	0°
1392	Delaware County, Pennsylvania	0°
1394	North Carolina	0°

Conclusion. Grigoriev (1936), who studied the interrelations of muscovite and biotite, concluded that the similarity in crystal structure, cleavage, and crystal form fully admits the possibility of (1) regular overgrowths of one mica by another, (2) oriented intergrowths, and (3) possible mutual replacement.

Specimens examined in our laboratory display the following relationships.

1) idiomorphic biotite surrounded by muscovite
2) idiomorphic muscovite surrounded by biotite
3) semiregular intergrowths of biotite and muscovite

Grigoriev (1936) recognizes all the above types of relationships and explains them all as either inclusions of biotite in muscovite or as replacement of biotite by muscovite.

Muscovite and Lepidolite

Overgrowths of lepidolite on muscovite have been found in pegmatites from several localities. The lepidolite commonly forms a thin rim surrounding a broad core of muscovite. The junction between the two species may be sharp and show the general euhedral crystal outline of the muscovite core, or it may be irregular and appear to be somewhat corroded. In one type a narrow band of lepidolite in parallel position and having a common basal cleavage plane with the muscovite is found in direct contact with the muscovite; a third zone of granular lepidolite forms the extreme margin of the crystal. This latter type of lepidolite is highly twinned in tiny rhombic units. In a few cases pink fibrous muscovite coats the exterior of the crystal (Bowman, 1902).

Under the microscope the twinned lepidolite aggregate does not extinguish as a unit. Because of the small size of the lepidolite units it is almost impossible to obtain the relationship of percussion figures and optic planes between the two species near the boundary. However, three successful determinations were made that show the optic planes of the two species to be either parallel or at an angle of 30°. The results of a study of a group of specimens of lepidolite overgrown on muscovite are given in the following table:

Specimen No.	Location	Notes
417	Colorado (?)	granular lepidolite rim, straight boundary
461	Auburn, Maine	single-crystal lepidolite rim, common basal cleavage, border irregular and corroded, optic planes parallel
467	Topsham, Maine	granular lepidolite rim, boundary straight in some sections and corroded in others
468	Topsham, Maine	granular lepidolite rim, boundary corroded
469	Topsham, Maine	granular lepidolite rim, boundary corroded
470	Topsham, Maine	granular lepidolite rim, boundary corroded
539	Southern Rhodesia	broad sheet of muscovite with inner rim of uniaxial muscovite and outer rim of biaxial lepidolite, all three zones have common cleavage, optic planes at 30°
651	Auburn, Maine	granular lepidolite rim
652	Auburn, Maine	single-crystal lepidolite rim, boundary straight, common basal cleavage

Specimen No.	Location	Notes
656	Auburn, Maine	single-crystal rim of lepidolite, boundary straight, common basal cleavage, optic planes at angle of 30°
713	Topsham, Maine	muscovite core, thin rim of single crystal lepidolite, outside rim of granular lepidolite, boundaries corroded, muscovite and thin rim of lepidolite have common cleavage
717	Auburn, Maine	granular lepidolite rim, corroded boundary

Reports of overgrowths from Maine have been made by Clarke (1888), Wolff and Palache (1902), Bastin (1911), and Baumhauer (1913). Overgrowths have been found at Paris, Auburn, Mount Apatite, and Minot. Generally, the lepidolite is fibrous or granular around a core of muscovite. A few occurrences of crystallographically continuous lepidolite on muscovite have been reported from the Wade and Pulsifer gem quarries, Androscoggin County, Maine. One diamond-shaped book of muscovite a foot across with a border aone of lepidolite 4 inches wide was found there.

The occurrences at Haddam Neck, Connecticut, have been studied by Bowman (1902) and Sterrett (1923). The columnar mica crystals occur with smoky quartz, albite, microcline, cookeite, and tourmaline. The outer surface of the mica crystals has a fibrous appearance caused by a thin layer of fibrous pink muscovite. The fibers are parallel with the long axis of the crystal. Cleavage in the fibers is perpendicular to their long axis. The lilac lepidolite surrounds a rhombic or hexagonal core of green-white muscovite. All three zones have a continuous cleavage. Under the microscope, the lepidolite does not extinguish completely because of the superposition of layers of material in twin position.

Jahns and Wright (1951) report lepidolite rims fringing a green core of muscovite. The two micas are crystallographically continuous and have a common basal cleavage.

A regular overgrowth of lepidolite on muscovite has been reported by Scharizer (1887, 1888) from Schüttenhofen, Germany. A rhombic core of muscovite is surrounded by a broad crystallographical continuous rim of pink lepidolite. Three separate irregular units were found in one specimen. In two of these units the optic plane is normal to the optic plane of the muscovite; in the third unit, the optic plane makes an angle of 30° with the optic plane of the muscovite.

Muscovite and Zinnwaldite

Only one occurrence of a zinnwaldite overgrowth on muscovite has been reported. Lemke et al. (1953) found such an overgrowth at the Morefield Mine, Morefield-Denaro Area, Amelia District, Virginia. In the northeastern part of the mine nearly all the mica is zinnwaldite. However, some books of mica, supposedly intermediate between muscovite and zinnwaldite, occur in the deposit. The following relations have been found between the two micas:

1) continuous gradation from muscovite at the core to zinnwaldite at the rim
2) discontinuous rim of later zinnwaldite around a core of muscovite.

Biotite and Lepidolite

Overgrowths of biotite on lepidolite are rare and have been reported from only a few localities; no reports of optical relationships have been found. Landes (1925) describes a 6 mm-wide zone of lepidolite around biotite gneiss xenoliths in the granite pegmatites of central Maine. He attributes the lepidolite to reaction between the biotite xenoliths and the and the lithia-rich magma.

Clarke (1888) reports an overgrowth from Cape Ann, Massachusetts, of two species of mica similar to biotite and lepidolite. He found a crystal of black lepidomelane surrounded in part by a border of small crystals of a "dark greenish black lithia mica, presumably cryophyllite". Analyses of the two micas are as follows:

Constituent	Granular Cryophyllite	Lepidomelane
SiO_2	52.17	31.69
Al_2O_3	16.39	11.93
Fe_2O_3	4.11	8.06
FeO	6.08	30.35
MnO	0.32	0.21
CaO	Trace	0.23
MgO	Trace	0.05
Li_2O	5.03	Trace
Na_2O	0.60	1.54
K_2O	10.54	8.46
H_2O	1.43	4.25
F	7.02	Trace
TiO_2	-----	3.42

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