TAENIOLITE FROM MAGNET COVE, ARKANSAS*

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Introduction

Taeniolite is an exceedingly rare lithium-magnesium mica, first described from Narsarsuk on the Firth of Tunugdliarfik in southern Greenland.[1] It has also been mentioned by Fersman[2] without description as occurring in laminae resembling the Greenland mineral in the Kola Peninsula, U. S. S. R.

In November 1936, Mr. Miser secured specimens of a mica-like mineral at Magnet Cove, Arkansas, from Joe W. Kimzey of Magnet, Arkansas, and from J. S. Smith of Crystal Springs, Arkansas. Additional material was secured in February 1937 from Lawton D. Kimzey of Magnet and again in November 1937 when the locality was visited by Mr. Miser, Mr. Kimzey, W. T. Schaller and C. S. Ross.

The Arkansas mineral resembles sericitic muscovite with an unusually silky luster. Optical examination, and qualitative chemical tests indicated that it was not muscovite, and that it contained essential amounts of lithium. For this reason the mineral was analyzed (by R.E.S.) and proved to be the rare mineral taeniolite. Its discovery in Arkansas in amounts sufficient for a careful analysis permitted its chemical composition to be definitely established.

The Arkansas taeniolite was discovered in 1936 by Lawton D. Kimzey in the course of prospecting for rutile for the American Titanium & Alloy Co. on the Adam Smith property about 1 mile north of Magnet Post Office. It has been found in several openings—one a shaft 50 feet deep, a pit 55 feet long, 4 feet wide, and 15 feet deep, another pit 40 feet long, 12 feet deep, and 4 feet wide, and a small shaft-like pit—within an area measuring 400 (north-south) by 200 feet, on the crest of a wooded hill. From these openings the total amount of taeniolite, obtained and placed on the dumps with the other material from the pits, is estimated by Mr. Kimzey to be about a ton. The taeniolite occurs as irregular veins and pockets as much as a foot wide in red and yellow clay and a quartzite-like rock which is a recrystallized novaculite—a variety of chert of Devonian age. The novaculite, where the taeniolite is present,

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[1] Flink, Gustav, Taeoniolite: *Meddeleser om Grönland: Fire og tyvende Hefte*, vol. **24**, pp. 115–120, Kjobenhaven, 1901.

[2] Fersman, A. E., Minerals of the Kola Peninsula: *Am. Mineral.*, vol. **11**, p. 295, 1926.

varies in texture from almost chertlike to very coarse grained with inter-locking grains and contains numerous vesicular cavities up to several millimeters in diameter. The coarsest rock contains quartz grains about 4 millimeters in length, many of which are smoky in color and reveal crystal faces. A small area of nepheline syenite lies several hundred feet to the north, and a part of the main mass of the Magnet Cove igneous rocks outcrop about $\frac{1}{4}$ mile to the southwest of the taeniolite locality. These igneous rocks were intruded—apparently in early Upper Cretaceous time—into closely folded sedimentary strata of Ordovician, Silurian, Devonian and Pennsylvanian age.[3] The igneous rocks caused very noticeable metamorphism in the intruded sedimentary strata, accompanied by the introduction of a large group of unusual minerals, among which is taeniolite.

The minerals directly associated with taeniolite are quartz, dickite, rutile, and probably brookite. The taeniolite occurs as loose, friable masses associated with roughly shaped quartz crystals, or with quartz and dickite along fracture planes, or joint cracks, and also as disseminated flakes in the quartzite-like rock. One type grades into another. The loose friable taeniolite is somewhat coarser grained than the disseminated material, and forms plates that vary from 0.04 to 0.2 and average about 0.15 millimeter in diameter. The thickness is difficult to estimate, but is a very small fraction of a millimeter. These plates have an irregular, commonly lobate outline, and only very rarely show a roughly hexagonal outline.

The Arkansas material does not occur in the band or strip-like form that suggested the name taeniolite for the Greenland material.

PHYSICAL AND OPTICAL PROPERTIES

The cleavage is basal as in all micas.

The density was determined on a 0.4 gram sample by the pycnometer method, using boiled and cooled distilled water. Air was drawn off by suction and the sample allowed to stand overnight to insure complete removal of air. The density was found to be 2.819 and the specific gravity 2.828, referred to water at 25°C. Mauzelius[4] found the specific gravity of taeniolite from Greenland to be 2.86 at 16°C. by weighing in benzol.

[3] The following reports, illustrated by geologic maps, describe the geology of the part of the Magnet Cove district in which the taeniolite was found:

Williams, J. F., The igneous rocks of Arkansas: *Arkansas Geol. Survey, Ann. Report for 1890*, vol. **2**, 1891.

Parks, Bryan and Branner, G. C., A barite deposit in Hot Spring County, Arkansas: *Arkansas Geol. Survey, Information Circular* **1**, 1932.

[4] Flink, G., *Medd. om Grönland*, vol. **14**, p. 234, 1898; vol. **24**, p. 115, 1901.

Although nearly white or colorless in places, much of the material is stained brownish by iron oxide. The luster is pearly.

Under the microscope the flat-lying plates are isotropic or slightly birefracting where warped. The optical properties, determined by Dr. C. S. Ross of the U. S. Geological Survey, are as follows: Approximately uniaxial, optically negative, $\alpha = 1.522$, $\beta = 1.553$, $\gamma = 1.553$; all $\pm .002$; birefringence 0.031.

Chemical Analysis

Enough of the taeniolite from Magnet Cove, Arkansas, for a thorough analysis was separated from associated quartz by means of heavy solutions. The process of analysis was briefly as follows:

TABLE 1. ANALYSES OF TAENIOLITE

	Magnet Cove, Ark. (Stevens, analyst)	Greenland (Mauzelius, analyst)
SiO_2	58.82	52.2
Al_2O_3	1.29	2.7
Fe_2O_3	0.40	—
FeO	0.24	0.6
MgO	19.18	19.1
CaO	None	—
Li_2O	3.10	3.8
Na_2O	0.64	1.8
K_2O	10.44	11.5
Rb_2O	None	—
Cs_2O	None	—
H_2O-	0.09	—
H_2O+	0.59	8.7*
TiO_2	0.11	—
F	8.56	—
Cr_2O_3	Trace	—
MnO	None	—
BaO	None	—
	103.46	100.4
Minus O = F	3.61	
	99.85	

* Ignition loss.

Silica and fluorine in a one gram sample were separated by the Berzelius method as modified by Hoffman and Lundell,[5] silica was then obtained by dehydration in the usual way, and fluorine determined nephelometrically.[6] A trace of chromium was noted in the sodium carbonate leach.

Alkalies were extracted from a half gram sample by the J. Lawrence

[5] Hoffman, J. I., and Lundell, G. E. F., *Bur. Standards J. Research*, vol. **3**, p. 581, 1930.

[6] Stevens, R. E., *Ind. Eng. Chem., Anal. Ed.*, vol. **8**, p. 248, 1936.

Smith procedure. Potassium was separated and weighed as chloroplatinate and rare alkalies were shown to be absent in the insoluble chloroplatinate by methods described by Wells and Stevens.[7] Lithium and sodium were separated by the Palkin[8] method and weighed as sulphates.

The other constituents were determined by the methods of Hillebrand and Lundell[9] after solution of a half gram sample in hydrofluoric and sulphuric acids and removal of hydrofluoric acid by several evaporations to fumes. Water was determined by the Penfield method using a glass tube with a flux of sodium tungstate.

The results of the analysis and those of Mauzelius[10] on the Greenland taeniolite are given in Table 1.

The two analyses are enough alike to indicate that they are of the same mineral; the percentage of alumina in both analyses is unusually low for a mica, and the two analyses agree fairly well with regard to magnesia and the alkalies. The silica in the analysis by Mauzelius is probably low, however, due to volatilization as fluoride, and for this reason the two analyses do not calculate to the same formula. Fluorine was reported as probably present by Mauzelius but its interference with the silica determination could not be prevented in analyzing so small a sample (less than 0.1 gram).

The analyses show taeniolite to be a very unusual mica, as, unlike other micas, alumina is present only in small quantity. In spite of the absence of essential alumina taeniolite shows structural relationships in common with other micas. (See Fig. 1.)

Formula and Structural Relationship to Other Micas

X-ray data for the micas, the brittle micas, and talc, indicate that they are built in layers; SiO_4 tetrahedrons are thought to be linked together in continuous sheets to give a composition of Si_4O_{10}. In the common micas aluminum partially substitutes for silicon, giving the structural group $AlSi_3O_{10}$. Two of these sheets of silicon-aluminum tetrahedrons are joined by octahedral groups of aluminum, magnesium, etc., to form a double layer. In the micas these double layers are held together by a large cation, potassium, calcium, or sodium; in talc the sheets are internally neutral and held together only by stray forces.

According to Bragg[11] the structural unit of a mica consists of $12(O$,

[7] Wells, R. C., and Stevens, R. E., *Ind. Eng. Chem., Anal. Ed.*, vol. **6**, p. 439, 1934.

[8] Palkin, J., *Am. Chem. Soc.*, vol. **38**, p. 2326, 1916.

[9] Hillebrand and Lundell, Applied Inorganic Analysis. John Wiley & Sons, New York, 1929.

[10] Flink, G., *Medd. om Grönland*, vol. **24**, p. 115, 1901.

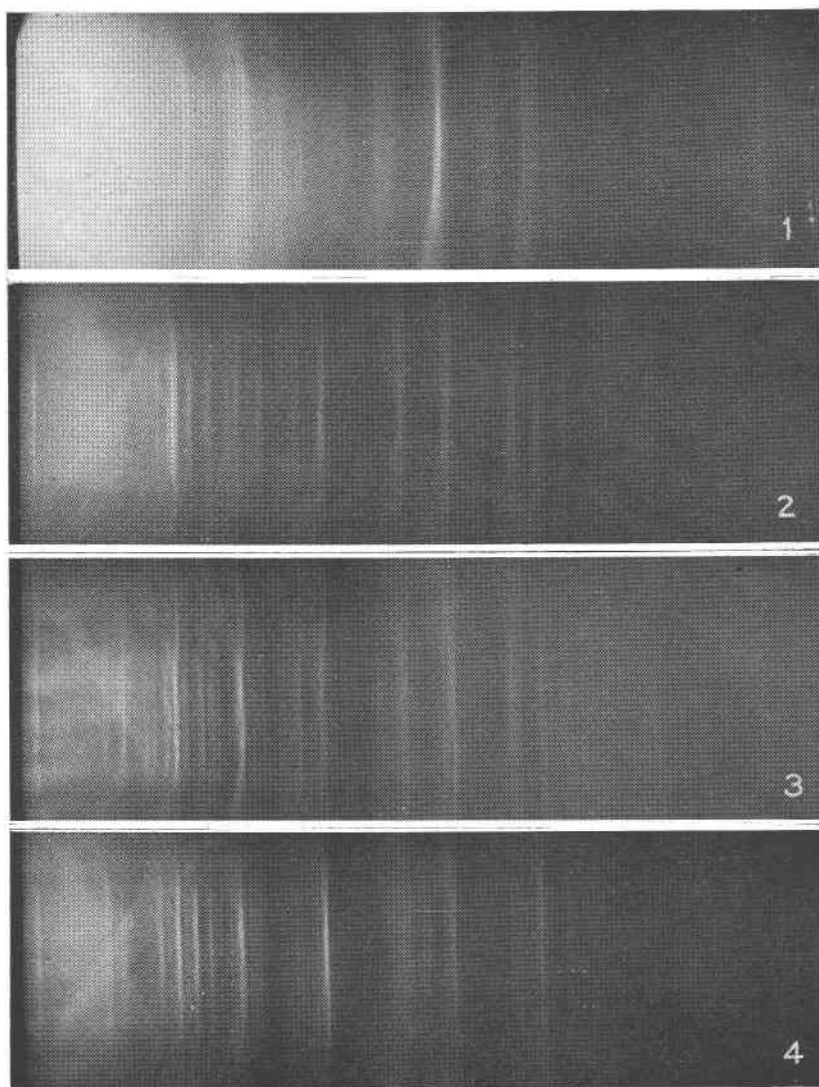[11] Bragg, W. L., The atomic structure of minerals: Cornell University Press, p. 38, 1937.

FIG. 1. X-ray powder photographs.
No. 1. Talc from New York.
No. 2. Taeniolite from Arkansas.
No. 3. Muscovite from New Mexico.
No. 4. Lepidolite from California.

OH, F) comprising 10 O, 2(OH, F); 4 tetrahedral positions, occupied by Si and Al; 2–3 octahedral positions, occupied by Mg, Al, Fe, Ti, Li; 0–1 positions for large cations, occupied by K, Ca, Na.

As the sum of anion equivalents is twenty-two (ten *bivalent* oxygens and two *univalent* hydroxyls or fluorines) the same number of cation equivalents are required for neutrality. For example, in muscovite, $KAl_2(AlSi_3O_{10})(OH)_2$, the twenty-two anion equivalents are balanced by one equivalent of potassium, nine of aluminum, and twelve of silicon.

TABLE 2. CALCULATION OF THE FORMULA OF TAENIOLITE

	Analysis	Equivalent Ratios			Theory
SiO_2	58.82	3.903	15.91	Si_4	59.35
Al_2O_3	1.29	.076	.31		
TiO_2	0.11	.006 ⎫			
FeO	0.24	.007 ⎬	3.94		
MgO	19.18	.952 ⎭		Mg_2	19.90
Li_2O	3.10	.207	.84	Li	3.69
		5.151	21.00		
Na_2O	0.64	.021			
K_2O	10.44	.222			
		.243	.99	K	11.63
H_2O+	0.59	.066			
F	8.56	.451			
		.517	2.11	F_2	9.38
Fe_2O_3, H_2O-	0.49				
	103.46				103.95
Minus O=F	3.61				3.95
	99.85				100.00

Therefore, in micas containing a univalent ion between the plates, usually potassium, the sum of equivalents in the octahedral and tetrahedral groups is twenty-one.

In Table 2 the formula of taeniolite is calculated in accordance with these relationships.

The formula for taeniolite is $KLiMg_2Si_4O_{10}F_2$. Although the equivalent ratio for lithium (.84) is slightly deficient for one lithium in the formula, a univalent ion in the octahedral group is essential for neutrality as one

potassium, two magnesium, and four silicon are definitely indicated. The ferric iron is not considered part of the mineral but merely pigmenting ferric oxide covering the mica plates. The small quantity of aluminum is not essential; it substitutes for silicon in the tetrahedral positions as well as for lithium and magnesium in octahedral positions. Deducting the formula for taeniolite ($KLiMg_2Si_4O_{10}F_2$) from the analysis, the remainder approximates the composition of muscovite ($KAl_2AlSi_3O_{10}(OH)_2$), which is probably present in isomorphous mixture and accounts for the presence of aluminum in the mineral. Although a small part of the alumina may have been present as admixed clay, the analysis of Mauzelius on the larger crystals of taeniolite, obtained from Greenland, shows that some alumina may be contained in the mineral taeniolite itself.

The relationship of muscovite, taeniolite, and talc may be indicated as follows:

	Large cation	Octahedral positions	Tetrahedral positions	$O_{10}(OH, F)_2$
	0–1	2–3	4	12
Muscovite	K	Al_2	$AlSi_3$	$O_{10}(OH)_2$
Taeniolite	K	$LiMg_2$	Si_4	$O_{10}F_2$
Talc	—	Mg_3	Si_4	$O_{10}(OH)_2$

The similarity in structure of taeniolite, talc, and the two micas, muscovite and lepidolite, is shown in the x-ray photographs by the powder method, Fig. 1, for which the writers are indebted to George Tunell and C. J. Ksanda of the Geophysical Laboratory.

Because of the absence of essential aluminum, taeniolite is unique among the micas. The place of aluminum in the octahedral group is taken by lithium and magnesium. Furthermore, taeniolite is one of the few micas in which Si_4O_{10} constitutes the double layers, with little or no substitution by the group $AlSi_3O_{10}$.