

PARAGONITE IN THE SCHIST OF GLEBE MOUNTAIN,
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During the writer's investigation of the metamorphic rocks of the Saxtons River area* in southern Vermont, certain facts aroused curiosity concerning the composition of sericite in the chlorite-sericite schist on Glebe Mountain, one of the larger mountains comprising the eastern range of the Green Mountains. First of all the sericite is greasy-feeling. Secondly it occurs in a schist that is believed to be stratigraphically equivalent to the schist containing kyanite at Gassetts, Vermont (Thompson, 1950; Currier, 1934, p. 335-339). With this information in mind, J. B. Thompson suggested to the writer that the greasy-feeling mineral might well be pyrophyllite, the dioctahedral analogue of talc and also a mineral which had been described elsewhere in the region (Hitchcock et al., 1861, p. 504-505). Pyrophyllite would be expected to metamorphose to the higher grade assemblage, kyanite-quartz, found at Gassetts.

Accordingly a specimen of schist was collected at an elevation of approximately 2,215 feet above sea level on the west side of Glebe Mountain about 9,000 feet northeast of Winhall Station in the town of Londonderry. The schist at that locality consists of approximately 50% sericite (unspecified white mica(s)), 22% quartz, 18% chlorite, 5% magnetite, 2% epidote, 2% ilmenite, 1% garnet, and minor amounts of sphene, apatite, tourmaline, and albite. It was noted in immersion that the sericite consists of 2 micas. About 70% of the sericite consists of a very fine-grained approximately uniaxial mica. The remaining 30% is relatively coarser in grain size and has an optic angle more nearly characteristic of common muscovite ($2V = 40^\circ$).

The schist was crushed, and the fraction that passed through a 70 mesh screen and caught on a 200 mesh screen was saved for separation of the sericite. Separation was performed using a twofold method. Most of the magnetite, chlorite, ilmenite, epidote, garnet and tourmaline was removed magnetically. The sericite was separated from the remaining quartz, apatite, sphene, and albite by using a 500 cc. Pyrex beaker. It was noted that, when the relatively non-magnetic fraction was tumbled in the dry beaker, the sericite tended to cling preferentially to the wall

* The material contained in this paper has been taken in large part from a dissertation, entitled, "*Geology of the southern part of the Chester dome, Vermont*," submitted in May, 1954, to the faculty of Harvard University in partial fulfillment of requirements for the degree of Doctor of Philosophy.

of the beaker. It proved a simple matter to pour off the predominantly granular fraction, recovering the sericite on a separate sheet of paper by giving the beaker a rather sharp blow. After considerable recycling to improve the purity of the sericite sample, about 3 grams were obtained and submitted to Forrest Gonyer for chemical analysis (Table 1). The

TABLE 1. CHEMICAL ANALYSIS OF SERICITE FROM SCHIST ON GLEBE MOUNTAIN, VERMONT
(Spec. No. K34-1; Lab. No. 505, Department of Mineralogy, Harvard University)
Analyst: Forrest Gonyer (May 11, 1949)

	Weight %		Structure Formula*	
SiO ₂	44.41	K	0.19	1.00
TiO ₂	0.22	Ca	0.05	
Al ₂ O ₃	40.09	Na	0.76	
Fe ₂ O ₃	1.72	(Fe ^{''})	0.02	
FeO	0.28	(Mg)	0.02	2.03
MnO	0.02	Fe ^{'''}	0.11	
MgO	0.16	(Ti)	0.01	
CaO	0.67	Al	1.92	
Na ₂ O	5.80	Al	1.13	4.00
K ₂ O	2.22	Si	2.87	
H ₂ O -	—	O	10.06	12.00
H ₂ O +	4.45	(OH)	1.92	
F	0.08	F	0.02	
	100.12			
Less O=F	.03			
	100.09			

* Elements included in parenthesis probably due to minor impurities.

structural formula calculated under the assumption that $(O + (OH) + F) = 12$ appears alongside the chemical analysis. The calculated structural formula gives some indication of the purity of the sample and the accuracy of the analysis, as such a result could hardly be fortuitous. The small amounts of MgO, FeO, and TiO₂ in the analysis are probably due to minor amounts of chlorite and ilmenite that remained in the sample. It is clear from the analysis that the sericite consists largely of paragonite with subordinate muscovite either as a separate phase or in solid solution. The analysis further indicates a small amount of margarite, probably in solid solution.

X-ray powder diffraction photographs were taken of the sample using

a Straumanis-type Phillips camera with Fe-radiation and a Mn-filter. The diffraction lines are similar in relative arrangement and intensity to those of muscovite, although they differ in the values for θ . The value of $d_{(002)}$ based on the (006) and (0010) lines is $9.60 \pm 0.02 \text{ \AA}$. This low value reflects the relatively small size of the sodium ions, which occupy the alkali positions in paragonite. There was no indication of separate resolution of muscovite lines in the observed photographs. This was undoubtedly the result of the low percentage of muscovite in the sample and the relative insensitivity of the film to reflections from minerals in low concentration.

At the writer's request in 1950 W. F. Bradley confirmed, using more sensitive x-ray equipment, the presence of two micas in the sample. Quoting with his permission, "The predominant phase is a mica of $c \sin \beta$ length = $9.65 (\pm .05) n \text{ \AA}$. It appears to be a two layer polytype analogous with muscovite; i.e., $c \sin \beta = 19.3 \text{ \AA}$. The secondary phase in abundance is of the order of 10%, and it is probably muscovite." Recently Evan Zen has resolved (006) and (0010) lines for both paragonite and muscovite in a similar schist of the same formation a few miles away. Both have confirmed the writer's earlier observation, based on studies in immersion, that the coarser mica is muscovite.

Optical methods do not at present appear very satisfactory for distinguishing between paragonite and muscovite generally. Schaller (verbal communication) has pointed out to the writer that many chemically normal muscovites have abnormally small optic angles similar to that here attributed to paragonite ($2V \sim 0$). The indices of refraction for the coexisting micas in the Glebe Mountain sericite are remarkably close together. For the paragonite $\beta \sim \gamma = 1.609$ using Na_D light. For the muscovite $\gamma = 1.606$ and $\beta = 1.604$, and $2V = 40^\circ$. Due to distortion of the grains it was not possible to determine α on either mineral accurately. $\alpha \sim 1.580$ for both the paragonite and muscovite.

Further studies within the Saxtons River area show that the assemblage, paragonite-quartz, decomposes somewhere within the staurolite-kyanite zone, forming kyanite and sodic plagioclase. Also within the same zone, the assemblage, paragonite-ilmenite-quartz, decomposes into the assemblage, sodic plagioclase-staurolite-rutile. Such reactions point toward the deduction that paragonite is stable within the area only in the relatively lower grades of metamorphism (from the lower grade part of the staurolite-kyanite zone down). In the presence of calcite and quartz the paragonitic component of sericite breaks down within the garnet zone to give the assemblage, sodic plagioclase-zoisite. The parallel reaction of the assemblage muscovite-calcite-quartz to form the assemblage, microcline-zoisite, occurs in the higher grade part of the staurolite-

kyanite zone. The upper limit on the stability of paragonite is determined by its decomposition into sodic plagioclase and corundum. This latter assemblage was not observed in the Saxtons River area, probably because of the presence of quartz in most specimens examined.

As to the relatively finer grain size of paragonite relative to coexisting muscovite, it is of interest to note the parallel contrast in grain size between the sodic feldspar, albite, and the coexisting potassium feldspar, microcline (e.g. augen gneiss), in many metamorphic rocks. In both cases the sodic mineral tends to be finer grained than the potassic mineral.

Paragonite was found in one other type of occurrence within the Saxtons River area. The coarse micaceous alteration of kyanite in a boulder of kyanite-quartz rock found north of Houghtonville, Vermont (Town of Grafton), proved to be paragonite. The *x*-ray powder diffraction photograph (Fe radiation, Mn filter) was identical to that obtained for the sericite on Glebe Mountain. In addition $\gamma \sim \beta = 1.610$, similar to the indices of the paragonite from the schist within the limits of error. The optic angle of the mica from the pegmatite boulder is approximately 5° . Spectrographic analysis by Harrison showed Na greatly in excess of K in this mica.

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