

# New Hampshire Biotite Miccas

Tom Mortimer

A Richmond, New Hampshire “annite” specimen has been in my McAuliffe-Shepard Discovery Center NH mineral display since its 2009 construction. This specimen is shown in Figure 1. The species identification was based on a 2003 EDS analysis by Excalibur minerals that stated that the specimen was a “mid-member composition along the annite-phlogotite-siderophyllite and eastonite phases. This sample is slightly closer to annite than the siderophyllite counterpart.” Needing a nice annite specimen for my display, I selected this one.

A little background on this figure 1 specimen: It came from a pegmatite outcrop in area of Richmond Soapstone Quarry, Richmond, NH. Mike Undercofler and I found this outcrop while searching for the Richmond Soapstone quarry in June, 1977. We were both beginners at field collecting and thought this small outcrop, (that had been excavated), was the target soapstone quarry, the source of the world famous cordierite crystals. We found several large biotite mica crystals in this four-foot wide dike, the largest about three inches across and eight inches long, very hard and solid. Also in this dike were large (three inch across, stubby, tourmaline crystals – since analyzed to be dravite). The rear, uphill side of the dike had vertical drill marks in a dark-greenish country rock. A few years later we learned of and visited the actual soapstone quarry and collected cordierite. The cordierite forms at the contact between the amphibolite (soapstone) and intersecting veins of quartz-feldspar. At this point I realized that the small prospect we had found in 1977 would be a good spot to collect cordierite at the contact between the dike and the amphibolite wall rock. Mike and I made two return trips attempting to find the 1977 prospect. Never found it.

A program that I wrote in the fall of 2022 to compute mineral chemistry from EDS weight% oxide data, when applied to the Excalibur report, gave a chemistry of  $K_{0.90}Mg_{1.49}Fe_{0.99}Mn_{0.06}Ti_{0.12}Al_{1.88}Si_{2.73}O_{12}$ , normalized for 12 O. With Mg >> Fe, this cannot be annite. Mindat.org acknowledges ferroan phlogopite as a variety within the biotite group, although this is not given a species status, and states “Much so-called Biotite is actually Ferroan Phlogopite”,  $K(Mg,Fe)_3(AlSi_3O_{10})(OH)_2$ . So this Richmond biotite mica has been re-labeled “Phlogopite – ferroan.”

Annite has long been included on New Hampshire mineral species lists, but I now lacked a confirmed one for my display. Having many biotite (group) specimens in my collection, I added samples from several into my queue for Boston College SEM-EDS analysis.

Reviewing the chemistries of the biotite group minerals that are reported from New Hampshire, (including a few that may show up in some future analysis):

Species	Locality	Analysis source	Chemistry	Notes
Siderophyllite	Ideal	Mindat.org	$KFe^{2+}_2Al(Al_2Si_2O_{10})(OH)_2$	More Al, less Fe than annite
Polyolithonite	Ideal	Mindat.org	$KLi_2Al(Si_4O_{10})(F,OH)_2$	No Fe, 1 Al, 4 Si
Trilithonite	Ideal	Mindat.org	$K(Li_{1.5}Al_{1.5})(AlSi_3O_{10})(F,OH)_2$	No Fe, 2.5 Al, 3 Si
Annite	Ideal	Mindat.org	$KFe^{2+}_3(AlSi_3O_{10})(OH)_2$	More Fe, less Al than sidero-
Annite	Empirical	RUFF	$(K_{0.94}Na_{0.03}Fe_{2.07}Mg_{0.57}Mn_{0.33}Ti_{0.03})_{\Sigma=3}(Si_{2.98}Al_{1.02})O_{10}((OH)_{1.72}F_{0.28})_{\Sigma=2}$	
Fluorannite	China	Webmineral	$K_{0.9}Fe^{2+}_{1.8}Fe^{2+}_{0.5}Mg_{0.2}Li_{0.2}Al_{1.4}Si_{2.8}O_{10}F(OH)_{0.5}$	$\Sigma Fe = 2.3$ empirical
Annite	Ideal	Mindat.org	$KFe^{2+}_3(AlSi_3O_{10})(OH)_2$	Note 3 Fe and 3 Si. Lots of Fe
Phlogopite	Ideal	Mindat.org	$KMg_3(AlSi_3O_{10})(OH)_2$	Mn & Ti common impurities
‘Ferroan-phlogopite’	Ideal	Mindat.org	$K(Mg,Fe)_3(AlSi_3O_{10})(OH)_2$	Mn & Ti common impurities
Tetraferriphlogopite	Ideal	Mindat.org	$KMg_3(Fe^{3+}_3Si_3O_{10})(OH,F)_2$	No Aluminum

So, now to a review of the chemistry indicated by the EDS analysis results- reference the following photos.

**Phlogopite, Figure 1:** Pegmatite outcrop in area of Richmond Soapstone Quarry, Richmond, NH. Analysis indicated a Fe rich phlogopite, ferroan phlogopite:  $K_{0.90}Mg_{1.49}Fe_{0.99}Mn_{0.06}Ti_{0.12}Al_{1.88}Si_{2.73}O_{12}$

**Phlogopite, Figure 2:** Soapstone Quarry, Frankestown, NH. A Kerry Day EDS plot clearly showed Mg >> Fe. The Frankestown Soapstone Quarry is a very high Mg rich deposit. The brown color is common with phlogopite.

**Annite, Figure 3:** Ellacoya Locale, Gilford, NH.  $K_{1.01}Fe_{1.99}Mg_{1.02}Cl_{0.1}Al_{0.92}Si_{2.62}O_{11}$  Fe > Mg, but not too far from annite – phlogopite midpoint.

**Annite, Figure 4:** Stop & Shop Plaza, (Now, Ocean Job Lots) Milford, NH.  $K_{1.15}Fe_{1.87}Mg_{1.11}Ti_{0.24}Al_{1.57}Si_{2.70}O_{11}$

**Annite, Figure 5:** Worthy Hill power line pegmatite, Goffstown, NH.  $K_{1.04}Fe_{2.01}Mg_{0.41}Ti_{0.15}Al_{1.77}Si_{2.54}O_{11}$

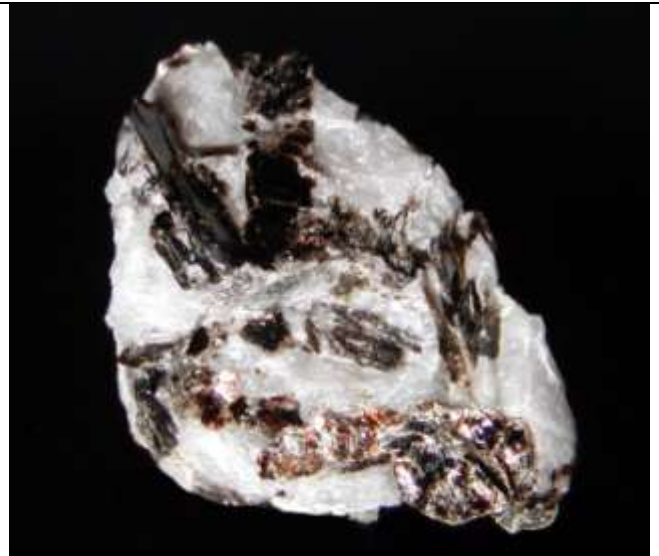
**Annite Figure 6:** Murphy Prospect, Springfield, NH.  $K_{1.14}Fe_{2.04}Mg_{0.23}Al_{1.89}Si_{2.66}O_{11}$

**Annite Figure 7:** Frechette Quarry, Albany, NH.  $(K_{0.40},Ca_{0.23})Fe_{4.36}Al_{1.13}Si_{2.76}O_{11}$  (Ca unexpected, No Mg !)

**Annite Figure 8:** Black Cap Mtn., Conway, NH  $K_{0.86}Fe_{4.65}Al_{1.01}Si_{2.24}O_{12}$  (Large Fe, No Mg !)



**Figure 1.** Phlogopite–ferroan 2.4 mm crystal cleavage  
Pegmatite outcrop in area of Richmond Soapstone  
Quarry, Richmond, NH



**Figure 2.** Phlogopite 2.5 cm specimen  
Soapstone Quarry, Frankestown, NH



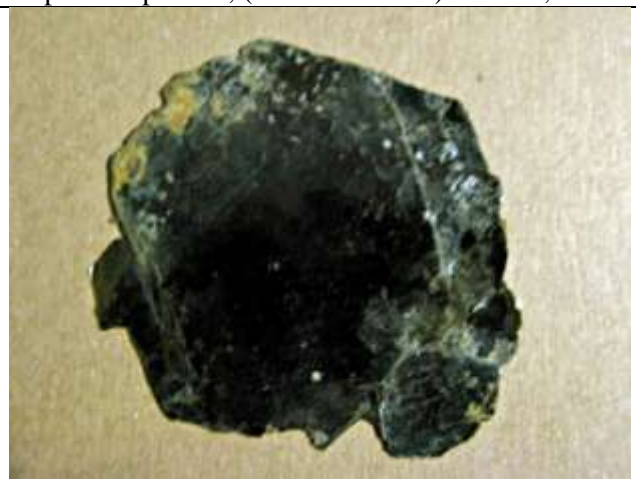
**Figure 3.** Annite Largest crystal is 0.7 mm  
Ellacoya Locale, Gilford, NH



**Figure 4.** Annite 2.0 cm specimen  
Stop & Shop Plaza, (Ocean Job Lots) Milford, NH



**Figure 5.** Annite in Muscovite 7 cm specimen  
Worthy Hill power line pegmatite, Goffstown, NH



**Figure 6** Annite 8 cm specimen  
Murphy Prospect, Springfield, NH



**Figure 7.** Annite 1.8 mm hexagonal annite book  
Frechette Quarry, Albany, NH

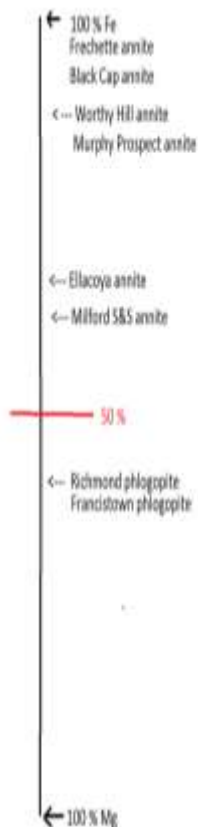


**Figure 8.** Annite 4.5 cm specimen  
Black Cap Mtn., Conway, NH

#### Notes on EDS analyses and chemistries:

- Many of the EDS analyses were performed on the Boston College SEM-EDS instrument, supported by MMNE funding.
- Mica species are not particularly amenable to polished grain sample preparation. EDS data was collected from small cleavage pieces affixed to carbon tape.
- The chemistries reported here are from single EDS data collections. A thorough study requires multiple data sets from multiple samples.
- Chemistries were computed using my APFU program. This program has been tested to be in agreement with chemistries computed from published webmineral.com data sets.
- Most biotite chemistries have been normalized for eleven oxygen atoms. A few are reported with twelve atoms.

#### Discussion and conclusions



The plot line to the left illustrates the Fe:Mg compositional variations of New Hampshire biotite micas.

The analyzed biotite micas indicated that many specimens labeled as annite contained substantial magnesium and that NH phlogopite contains substantial iron. The Richmond jet-black biotite is phlogopite, illustrating that very dark biotite is not necessarily annite.

Titanium (Ti) is frequently found in NH biotite micas.

Siderophyllite has been reported from New Hampshire. Siderophyllite chemistry has a Fe:Al ratio of 2:3. None of the analyzed biotites had that much aluminum.

The Frechette Quarry and Black Cap Mtn. annite appear to be end member species examples, with no magnesium. The iron content was very high, exceeding 3 APFU, suggesting a need for further study.