New Hampshire Biotite Group Minerals

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The biotite mica group (black mica) is represented in New Hampshire by several species. Although it is appropriate to label a specimen with a group name when the species is uncertain, it is much less satisfying than indicating the exact species.

Mindat.org states the biotite name "is most commonly used generically for any unanalyzed or incompletely analyzed dark-colored, Fe-rich micas, including Annite, Fluorannite, Tetra-ferri-annite and Siderophyllite." Mindat.org also states: "The CNMMN Subcommittee on Nomenclature of the Micas (1998, 1999) has recommended that the name biotite be used for any minerals in the "series" between the joins Annite-Phlogopite and Siderophyllite-Eastonite and is therefore no longer to be regarded as a species name, more strictly a subgroup. Other closely related species such as Fluorophlogopite and Fluorotetraferriphlogopite are usually included in the subgroup."
Mindat.org includes the species tabulated below.

Annite	$KFe^{2+}_3(AlSi_3O_{10})(OH)_2$	Requires Al
Eastonite	$KMg_2Al(Al_2Si_2O_{10})(OH)_2$	Requires Mg and Al
Fluorannite	$KFe^{2+}_3(Si_3Al)O_{10}F_2$	Requires F, Al optional
Fluorophlogopite	$KMg_3(Si_3Al)O_{10}F_2$	Requires Mg and F
Fluorotetraphlogopite	$KMg_3(Fe^{3+}Si_3O_{10})F_2$	No Al required, Requires F
Oxyphlogopite	$K(Mg,Ti,Fe)_3[(Si,Al)_4O_{10}](O,F)_2$	Requires Mg. Fe & Al optional, O>F
Phlogopite	$KMg_3(AlSi_3O_{10})(OH)_2$	Requires Mg & Al. Low to no Fe
Siderophyllite	$KFe^{2+}_2Al(Al_2Si_2O_{10})(OH)_2$	Requires 3 Al, only 2 Si
Tetraferriannite	$KFe^{2+}_3(Si_3Fe^{3+})O_{10}(OH)_2$	No Al required, 4 Fe
Tetraferriphlogopite	$KMg_3(Fe^{3+}Si_3O_{10})(OH,F)_2$	Requires Mg, No Al

In the course of my mindatnh species project, I have had several NH black mica specimens analyzed. One of the first of these was a biotite mica from a pegmatite outcrop in area of Richmond Soapstone Quarry, Richmond, NH, Figure1. A 2003 Excalibur EDS analysis, Figure 2, included a report stating "This sample is slightly closer to annite than the siderophyllite counterpart." I have accepted this for many years. A program that I wrote in the fall of 2022 (APFU.exe) to compute mineral chemistry from EDS weight% oxide data, when applied to the Excalibur report, gave a chemistry of $K_{0.90}(Mg_{1.49}Fe_{0.99}Mn_{0.06}Ti_{0.12})_{\Sigma 2.66}Al_{1.88}Si_{2.73}O_{12}$, normalized for 12 O. With Mg >> Fe, this cannot be annite. It is much closer to a phlogopite composition. 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", $K(Mg,Fe)_3(AlSi_3O_{10})(OH)_2$
Several of the EDS analyses presented here are from recent MMNE sponsored EDS analysis at the MMGM lab.

Figure 1. PHLOGOPITE Richmond, NH
2.4 cm phlogopite crystal

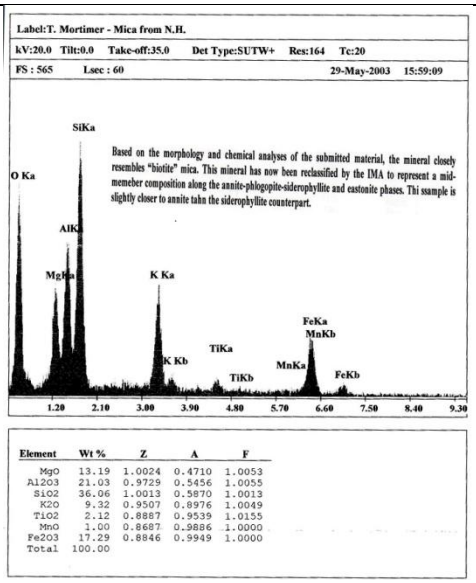


Figure 2. Excalibur analysis of my Richmond, NH biotite.

My mineral knowledge has greatly expanded since the 2002 Excalibur analysis. In hindsight, now knowing that this area of the Richmond Soapstone Quarry was very magnesium rich, {cordierite: $(Mg,Fe)_2Al_4Si_5O_{18}$ and magnesiohornblende = soapstone, $Ca_2[Mg_4(Al,Fe^3)](Si_7Al)O_{22}(OH)_2]$}, a phlogopite mica makes most sense.

Continuing with phlogopite mica, Phillip Morrill's NH localities booklet lists talc, $Mg_3Si_4O_{10}(OH)_2$ occurring at the Francistown, NH Soapstone Quarry. As talc is a very Mg rich mineral, this seemed to be a good place to look for phlogopite. (At the date of my visit, I did not have a confirmed NH phlogopite.) The dump across the road from the quarry had many rocks with a light brown mica, (and a load of lush poison ivy!) A Kerry Day qualitative EDS clearly showed Mg >> Fe, supporting a phlogopite identification. Phlogopite mica often has the brown tint seen in this specimen.

Figure 3. Phlogopite. Francistown, NH Soapstone Quarry. 2.5 cm specimen.
Brown-black phlogopite mica in feldspar matrix.

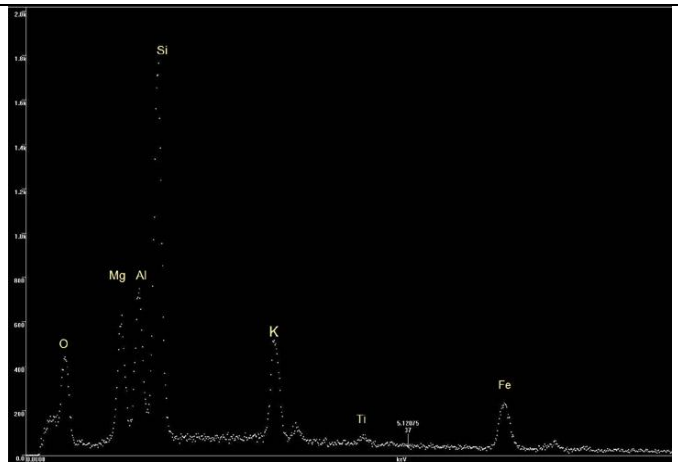
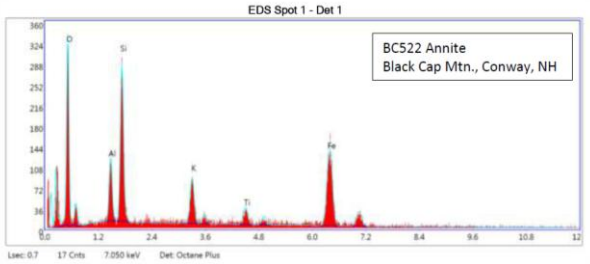


Figure 4. A Kerry Day qualitative analysis of the Francistown phlogopite.

Now moving on to some annite specimens. My analyzed White Mountains biotites are iron dominant. The Figure 5 Conway example analysis had no Mg, so essentially an annite end member, with a computed chemistry of $K_{0.86}(Fe_{4.65}Ti_{0.46})AlSi_{2.24}O_{12}$. The Fe oxide coating likely contributed to the high Fe analysis value. A moderate fluorine peak (@ 677 eV) was not quantified, suggesting fluorannite

Figure 5. Annite. Black Cap Mtn., Conway, NH 4.5 cm specimen with crude hexagonal habit.



eZAF Smart Quant Results with Oxides

Element	Weight %	Atomic %	Net Int.	Error %	Kratio	Z	A	F
Al 2O3	8.58	6.07	1328.35	11.12	0.0298	1.0218	0.5873	1.0023
Si O2	22.54	27.04	3469.89	7.69	0.0821	1.0437	0.6833	1.0027
K 2O	6.75	5.17	1291.90	8.96	0.0568	0.9654	0.9432	1.0207
Ti O2	6.18	5.58	576.82	13.65	0.0370	0.8894	0.9791	1.0532
Fe O	55.95	56.14	3040.98	5.64	0.4152	0.8709	0.9979	1.0081

Figure 6. Black Cap annite EDS. (No Mg peak below the Al peak)

Figure 7. Annite. Rt. 16 construction site, Bartlett, NH
4 cm specimen with 1.5 cm black annite mica cleavage

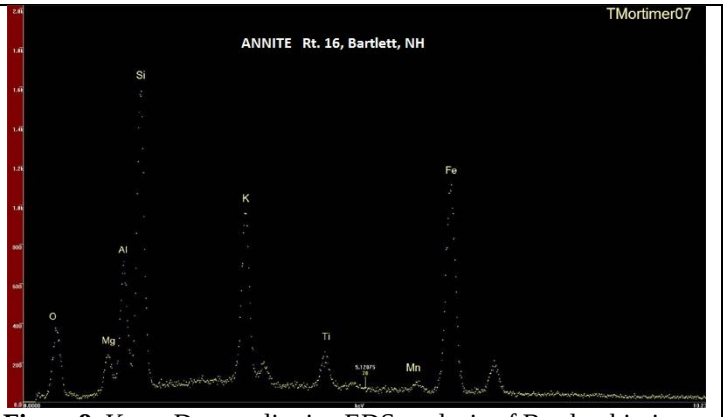


Figure8. Kerry Day qualitative EDS analysis of Bartlett biotite.
Fe >> Mg so annite.

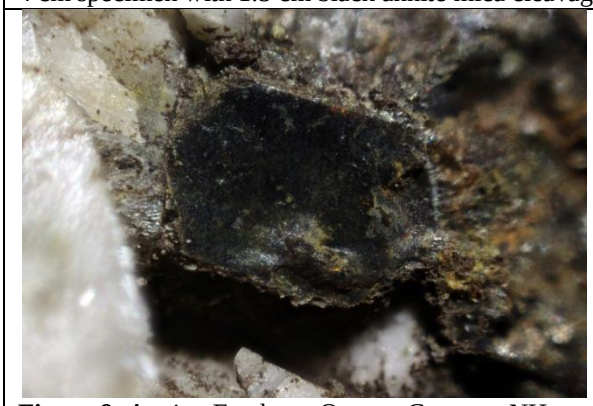


Figure 9 Annite Frechette Quarry, Conway, NH
1.8 mm hexagonal annite book.
Collected by Jim Parella.

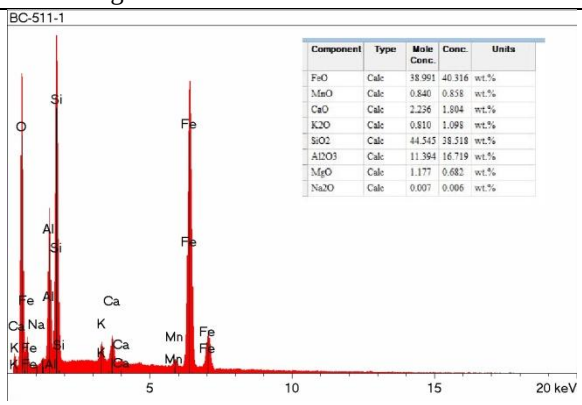


Figure 10. Annite. $(K_{0.12}Ca_{0.16}Mg_{0.08})Fe_{2.80}Mn_{0.06}Al_{1.63}Si_{3.20}O_{12.0}$ normalized for 12 O. The sum cation content (K, Mg, Ca) from this analysis is very low, (< 0.5 APFU), but with Fe >> Mg, definitely an annite mica.

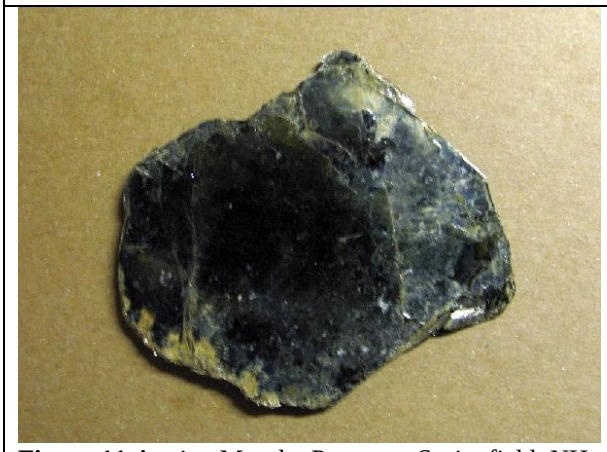


Figure 11 Annite Murphy Prospect, Springfield, NH
9.5 cm annite cleavage

Element	Weight %	Atomic %
Mg O	2.01	3.61
Al 2O3	20.67	14.65
Si O2	34.29	41.23
K 2O	11.54	8.85
Fe O	31.49	31.66

Figure12. Weight % oxide analysis of Murphy Prospect annite.
$K_{1.14}Fe_{2.04}Mg_{0.23}Al_{1.89}Si_{2.66}O_{11}$ normalized for 11 O.

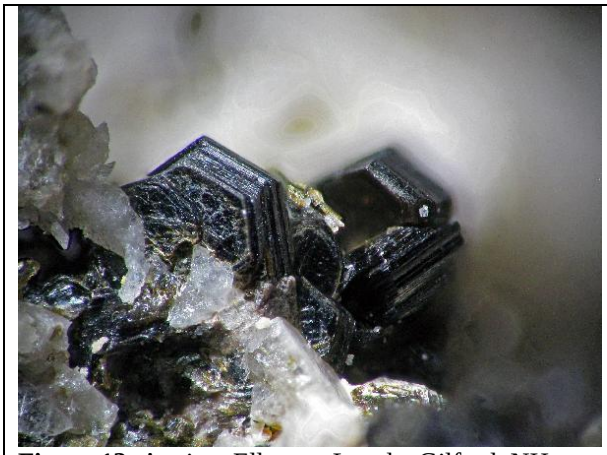


Figure 13. Annite Ellacoya Locale, Gilford, NH
Foreground mica crystal is 0.7 mm

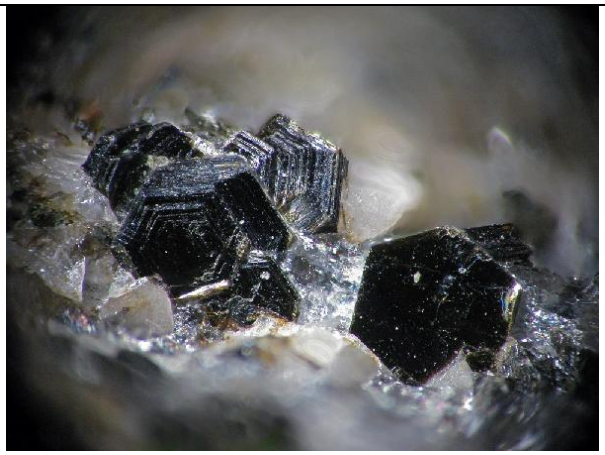


Figure 14 Annite Ellacoya Locale, Gilford, NH
EDS chemistry -> $K(Fe_{1.87},Mg_{1.02})Al_{0.92}Si_{2.62}O_{11}Cl_{0.1}$.