Compositional analysis and morphological relationships of amphiboles, talc, and other minerals found in the talc deposits from the Gouverneur Mining District, New York, USA

UNC Asheville — Department of Environmental Studies

University of Idaho — College of Science

Brittani D. McNamee[1] and Mickey E. Gunter[2]

[1]Department of Environmental Studies, University of North Carolina at Asheville, Asheville, North Carolina, USA

[2]Department of Geological Sciences, University of Idaho, Moscow, Idaho USA

Introduction and Methods

This project is part of a larger series of studies to fully characterize the minerals within the rock samples and processed products from former talc mines owned by the R. T. Vanderbilt Co. in the Gouverneur Mining District, New York. This particular study focuses on providing modern compositional data and morphological observations of these minerals using a variety of methods and instruments. The main minerals within these samples are talc, tremolite, anthophyllite, and serpentine with minor quartz, calcite, and diopside.

The rock samples were prepared as polished thin sections and the products were prepared as polished grain mounts for analysis in the electron microprobe and polarized light microscope (PLM). Precise compositional data of individual grains were collected by wavelength dispersive spectroscopy (WDS) using an electron microprobe. Mineral formulas are expressed in atoms per formula unit (APFU) and were calculated from the resulting weight percent oxides. The morphology of the different mineral phases was observed with backscatter electron (BSE) images and PLM.

Conclusions

- Tremolite occurs in a blocky habit and is unaltered (Figs.1 and 3).
- Anthophyllite occurs as highly splintered and fractured non-asbestiform crystals (Figs. 1, 2, and 4), which allow for more surface area to be exposed to metamorphic reactions (Veblen and Buseck 1980), encouraging alteration.
- Talc occurs in a fine-grained, asbestiform habit as an alteration product of anthophyllite (Figures 1 and 4) and other minerals such as diopside (Fig. 6), manganoan-cummingtonite (Fig. 7), and calcite, but not tremolite. Talc also occurs in a platy habit (Figs. 1 and 2).
- Serpentine occurs in a platy habit (Fig. 5).
- The only observed difference between the Talcville Mine and the Arnold Pit Mine is the amount of each mineral phase within the rocks and products, observed from the XRD spectra (Fig. 8).
- All of the mineral phases analyzed have near end member compositions, which have also been noted in previous studies on the minerals in this mining district (Engle 1965; Rabbitt 1948; Ross et al. 1968); however, in the current study we also more clearly show the morphological relationships with the aid of newer analytical methods.

Tailing Samples

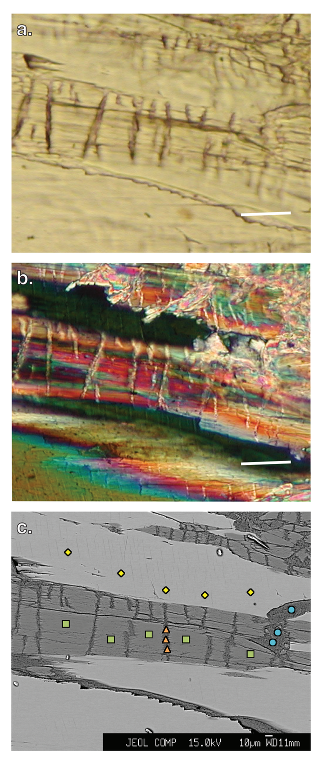

Figure 1: Series of microphotographs of an amphibole-talc schist from the Arnold pit: a) plane polarized light image, b) crossed polarized light image, and c) a back scatter electron (BSE) image. The white lines in a and b show the vibration direction of the lower polarization; the PLM photos were taken in these orientations to match the orientation of the BSE images. Scale bar in c applies to both a and b. Tremolite (yellow diamonds) occurs in the sample as seemingly unaltered crystals; anthophyllite (green squares) in the samples, as in most of our samples, occurs as elongate crystals in acicular habit with fractures perpendicular to the long axis of the crystal; the fractures in the anthophyllite are filled with fine-grained talc (orange triangles); and talc as platy crystals (blue circles) are also present. Note when comparing images in the PLM with those in the BSE, please keep in mind that the light is transmitted through the entire 30 mm thin section, whereas the BSE only images the upper few microns of the sample.

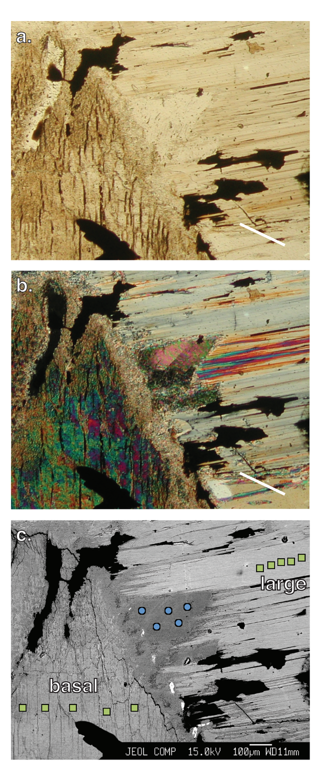

Figure 2: Series of microphotographs of an amphibole-talc schist from the Talcville mine: a) plane polarized light image, b) crossed polarized light image, and c) a back scatter electron image. See Figure 1 caption for details. On the left side of the photographs, there is an anthophyllite crystal oriented with the c-axis coming out of the slide (green squares, basal). On the right side of the photographs, there is the end of a 3 cm long anthophyllite crystal showing an acicular habit (green squares, large). Between the two anthophyllite crystals is a crystal of platy talc (blue circles).

Table 1: Average weight percent oxides and calculated APFUs with site occupancies of tremolite, anthophyllite, and talc grains in the thin sections marked in the BSE images within Figures 1 and 2. Oxide total does not include the weight percent of fluorine and chlorine or H_20 (as it was not measured). OH^- was calculated from F^-. Tremolite and anthophyllite APFUs are calculated based on 24 anions and talc is calculated based on 12 anions. The precision of the data is related to the standard deviations of the data shown in parenthesis. The colored shapes correspond to the shapes in the BSE images in Figures 1 and 2.

	Figure 1				Figure 2		
	trem ◇	anth ■	fine grained talc ▲	platy talc ●	anth basal ■	anth large ■	platy talc ●
SiO_2	57.81(18)	60.79(88)	61.55(81)	62.12(145)	61.53 (20)	61.37(49)	62.71(41)
Al_2O_3	0.17(3)	0.14(1)	0.06(2)	0.00(2)	013(2)	0.11(1)	0.12(3)
TiO_2	0.01(1)	0.00(0)	0.00(0)	0.00(0)	0.01(1)	0.01(0)	0.03(1)
FeO	0.02(2)	0.11(1)	0.03(2)	0.00(0)	0.17(1)	0.18(1)	0.02(2)
MnO	0.05(1)	0.25(2)	0.07(4)	0.02(1)	0.38(6)	0.35(1)	0.01(1)
MgO	25.80(23)	35.35(43)	31.98(35)	31.70(2)	35.02(161)	36.07(8)	32.35(20)
CaO	12.37(19)	0.60(8)	0.23(6)	0.08(6)	0.25(9)	0.31(4)	0.01(1)
Na_2O	0.45(1)	0.13(2)	0.05(1)	0.01(0)	0.14(3)	0.16(1)	0.07(1)
K_2O	0.06(1)	0.01(0)	0.01(1)	0.01(0)	0.00(1)	0.00(0)	0.01(1)
Oxide Total	97.46(29)	97.84(1.15)	94.27(8)	94.21(134)	98.05(158)	98.98(54)	96.16(50)
F	0.71(4)	0.44(3)	0.28(2)	0.27(1)	0.41(3)	0.42(4)	0.82(7)
Cl	0.01(0)	0.01(0)	0.01(0)	0.01(0)	0.00(0)	0.00(0)	0.00(0)
SiO_2/MgO	2.24(2)	1.72(2)	1.92(4)	1.96(6)	1.76(9)	1.70(1)	1.94(1)
Si^{4+}	7.91(2)	7.96(2)	3.95(2)	3.98(3)	8.02(12)	7.95(2)	3.96(1)
Al^{3+}	0.03(0)	0.02(0)	0.00(0)	0.00(0)	0.02(0)	0.02(0)	0.01(0)
Ti^{4+}	0.00(0)	0.00(0)	0.00(0)	0.00(0)	0.00(0)	0.00(0)	0.00(0)
Fe^{2+}	0.00(0)	0.01(0)	0.00(0)	0.00(0)	0.02(0)	0.02(0)	0.00(0)
Mn^{2+}	0.01(0)	0.03(0)	0.00(0)	0.00(0)	0.04(1)	0.04(0)	0.00(0)
Mg^{2+}	5.26(4)	6.90(6)	3.06(4)	3.03(6)	6.81(23)	6.96(3)	3.05(1)
Ca^{2+}	1.81(3)	0.08(1)	0.02(0)	0.01(0)	0.03(1)	0.04(1)	0.00(0)
Na^{1+}	0.12(1)	0.03(1)	0.01(0)	0.00(0)	0.04(1)	0.04(0)	0.01(0)
K^{1+}	0.01(0)	0.00(0)	0.00(0)	0.00(0)	0.00(0)	0.00(0)	0.00(0)
F^-	0.31(2)	0.18(1)	0.06(0)	0.06(0)	0.17(1)	0.17(2)	0.16(1)
OH^-	1.69(2)	1.82(1)	1.94(0)	1.94(0)	1.83(1)	1.83(2)	1.84(1)
A	0.13	0.04			0.00	0.04	
B	2.08	2.03			1.96	2.06	
C (O)	5.00	5.00	3.07	3.03	5.00	5.00	3.05
T	7.93	7.98	3.96	3.98	8.02	7.96	3.97

Products

Table 2: Average weight percent oxides and calculated APFUs with site occupancies of tremolite, anthophyllite, talc, serpentine, and diopside grains in the grain mounts marked in the BSE images within Figures 3 - 6. Oxide total does not include the weight percent of fluorine and chlorine or H_20 (as it was not measured). OH^- was calculated from F^-. Tremolite and anthophyllite APFUs are calculated based on 24 anions, talc is based on 12 anions, serpentine is based on 9 anions, and diopside was based on 6 anions. The precision of the data is related to the standard deviations of the data shown in parenthesis. The colored shapes correspond to the shapes in Figures 3 - 6.

	Figure 3	Figure 4		Figure 5	Figure 6		Figure 7	
	trem ◇	anth ■	fine-grained talc ▲	serp ✚	diopside ★	fine-grained talc ▲	manganoan-cum ■	fine-grained talc ▲
SiO_2	56.29(94)	60.34(73)	28.36	41.88(55)	55.96(32)	58.62(254)	57.55(106)	61.90(123)
Al_2O_3	0.38(2)	0.12(1)	0.15	0.74(4)	0.01(1)	0.11(2)	0.08(3)	0.08(2)
TiO_2	0.01(0)	0.01(0)	0.00	0.03(0)	0.01(0)	0.00(0)	0.02(0)	0.00(0)
FeO	0.06(2)	0.10(2)	0.35	0.03(1)	0.08(2)	0.19(2)	0.27(2)	0.21(3)
MnO	0.09(0)	0.23(6)	0.11	0.04(0)	0.05(2)	0.03(2)	12.01(26)	0.69(42)
MgO	25.74(73)	34.06(54)	13.59	42.53(29)	19.03(18)	27.63(27)	25.47(81)	29.41(122)
CaO	12.27(19)	0.47(11)	0.23	0.08(2)	24.93(2)	0.55(23)	1.89 (7)	0.06(2)
Na_2O	0.93(5)	0.15(2)	0.03	0.03(1)	0.01(0)	0.02(0)	0.12(2)	0.07(1)
K_2O	0.44(1)	0.01(0)	0.01	0.26(1)	).00(1)	0.01(0)	0.01(1)	0.01(1)
Oxide Total	97.58(187)	95.78(1.23)	43.83	86.02(75)	100.08(40)	87.30(290)	97.59(62)	92.77(102)
F	1.36(4)	0.27(2)	0.08	0.34(1)	-0.01(3)	0.06(1)	0.17(1)	0.31(4)
Cl	0.02(0)	0.03(1)	0.94	0.04(1)	0.01(0)	0.09(5)	0.01(1)	0.02(1)
SiO_2/MgO	2.19(3)	1.77(3)	2.09	0.98(1)	2.94(4)	2.12(8)	2.26(11)	2.11(12)
Si^{4+}	7.79(2)	8.04(4)	4.01	1.97(1)	2.01(1)	4.04(3)	7.98(11)	4.04(7)
Al^{3+}	0.06(0)	0.02(0)	0.02	0.04(0)	0.00(0)	0.01(0)	0.01(0)	0.01(0)
Ti^{4+}	0.00(0)	0.00(0)	0.00	0.00(0)	0.00(0)	0.00(0)	0.00(0)	0.00(0)
Fe^{2+}	0.01(0)	0.01(0)	0.04	0.00(0)	0.00(0)	0.01(0)	0.03(0)	0.01(0)
Mn^{2+}	0.01(0)	0.03(1)	0.01	0.00(0)	0.00(0)	0.00(0)	1.41(3)	0.04(2)
Mg^{2+}	5.31(5)	6.77(7)	2.86	2.98(1)	1.02(1)	2.84(8)	5.27(19)	2.86(12)
Ca^{2+}	1.82(3)	0.07(2)	0.03	0.00(0)	0.96(0)	0.04(2)	0.28(1)	0.00(0)
Na^{1+}	0.25(1)	0.04(1)	0.01	0.00(0)	0.00(0)	0.00(0)	0.03(1)	0.01(0)
K^{1+}	0.08(0)	0.00(0)	0.00	0.02(0)	0.00(0)	0.00(0)	0.00(0)	0.00(0)
F^-	0.60(0)	0.11(1)	0.03	0.05(0)	0.00(0)	0.01(0)	0.07(0)	0.06(1)
OH^-	1.40(0)	1.89(1)	1.97	3.95(0)		1.99(0)	1.93(0)	1.94(1)
A	0.33	0					0.03	
B	2.15	1.93					2.00	
C (O)	5.00	5.00	2.94	2.99	1.98	2.86	5	2.91
T	7.86	8.04	4.01	2	2.01	4.05	8	4.04

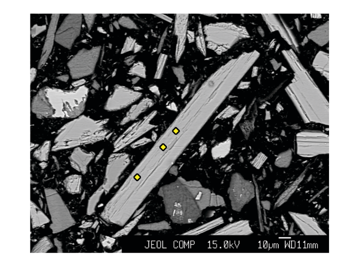

Figure 3: Backscatter electron image of a tremolite grain in the R.T. Vanderbilt product Nytal-99 produced from the Arnold pit mine. The tremolite grain (yellow diamonds) is blocky and shows no alterations.

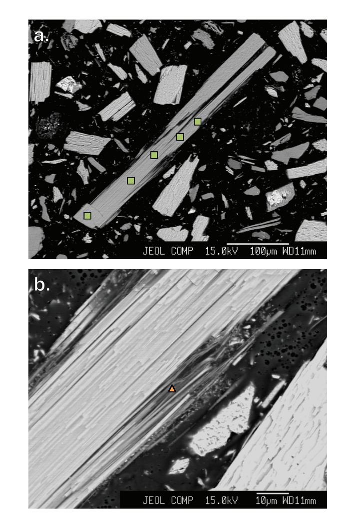

Figure 4: Backscatter electron images of an anthophyllite grain in the R.T. Vanderbilt product Nytal-100 produced from the Arnold pit mine. Figure 4b is a close-up of the anthophyllite's edge, showing the non-asbestiform anthophyllite (green squares) altering to fibrous talc (orange triangle).

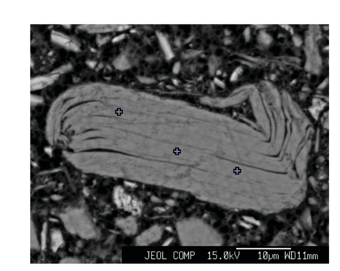

Figure 5: Backscatter electron image of a platy serpentine grain in the R.T. Vanderbilt product Nytal-300 produced from the Arnold pit mine. The serpentine (purple crosses) is oriented with the cleavage planes perpendicular to the polished grain mount.

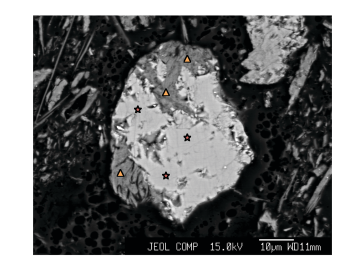

Figure 6: Backscatter electron image of a diopside grain in the R.T. Vanderbilt product Mouldene produced from the Talcville mine. The diopside (red stars) is altering to fibrous talc (orange triangles) on the edges.

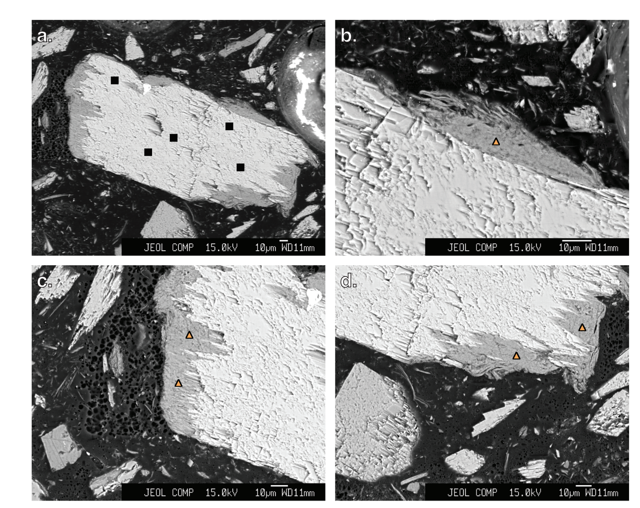

Figure 7: Backscatter electron images of a manganoan-cummingtonite grain (analysis points marked with black boxes) in the R.T. Vanderbilt product Mouldene produced from the Talcville mine: a) large blocky grain, b) top-right edge, c) left edge, and d) bottom-right edge. The edges of the grain, shown as a darker shade of gray, are the amphibole (black squares) altering to fibrous talc (orange triangles). Figures 7b and 7d show the talc bending and separating as fibers.

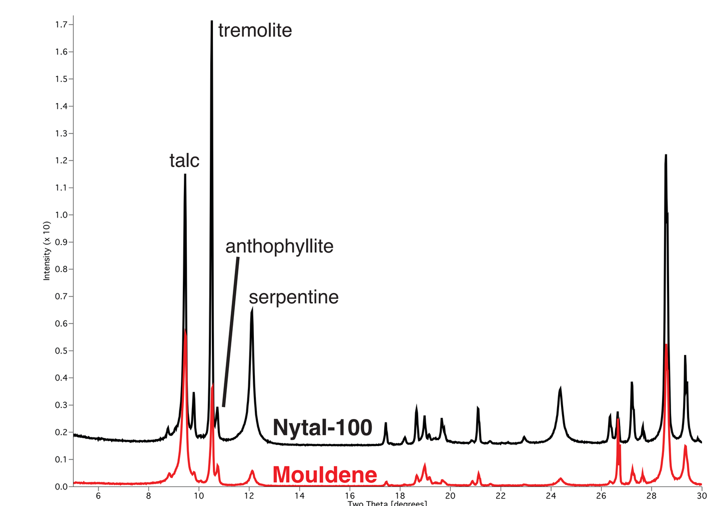

Figure 8: Powder X-ray diffraction patterns of the R.T. Vanderbilt talc product Nytal-100 (black) and Mouldene (red). Both products have a similar assemblage of minerals, but of differing amounts.

References

Engel, A.E.J. (1965) The Precambrian geology and the talc deposits of the Balmat-Edwards district, northwest Adirondack Mountains, New York. USGS Open File Report, 1962-648.

Rabbitt, J.C. (1948) A new study of the anthophyllite series. American Mineralogist, 33, 263-323.

Ross, M., Smith, W.L., and Ashton, W.H. (1968) Triclinic talc and associated amphiboles from Gouverneur Mining District, New York. American Mineralogist, 53, 751-769.

Veblen, D.R. and Buseck, P.R. (1980) Microstructures and reaction mechanisms in biopyriboles. American Mineralogist, 65, 599-623.