Fun with Asbestos[1]

WARNING: DO NOT OPEN BOTTLES CONTAINING ASBESTOS.

Asbestos may cause lung damage. Do not breathe fibers. The crocidolite (blue asbestos) is considered most hazardous, but the other varieties still pose a threat.

Read Box 3.2 on page 52 of your text!

Asbestos refers to a group of minerals that were once used for insulation and fire protection. Over the past few decades, asbestos has been identified as causing cancer and is now classified as a carcinogen. A lot of money has been spent removing asbestos from old public buildings to protect people from exposure. At one time, it was thought that asbestos posed an extreme health risk. Some asbestos does, sometimes. However, most common asbestos is (the mineral variety) chrysotile, and probably it is not as dangerous as we once thought. (But, its still not good, and should be treated with care.) According to some experts, “non-occupational exposure to chrysotile asbestos, despite its wide dissemination in urban environments throughout the world, has not been shown by epidemiological studies to be a significant health hazard.” Furthermore, removing asbestos puts a lot of fibrous dust in the air and exposes a new generation of asbestos workers to its threats, and the removed material has to be disposed of safely at great expense. So, many experts now advocate leaving chrysotile where it is, but sealing it so it does not release dust. Blue asbestos, crocidolite, and brown asbestos, amosite, are still thought to be very dangerous. They are always removed and disposed of.

Mineralogists usually reserve the designation “asbestos” for fibrous minerals with a length to width ratio (aspect ratio) of at least 10:1. However, the Occupational Safety and Health Administration (OSHA) defines asbestos as any of the six silicates listed in Table 1 with a length to width ratio of 3:1 or greater, a diameter of less than 5 microns, and a length of greater than 5 microns.

Table 1: Asbestos Minerals

Mineral	Asbestos Variety	Mineral Group	Comments
riebeckite $Na_2Fe^{3+}_2(Fe^{2+},Mg)_3Si_8O_{22}(OH)_2$	crocidolite (blue asbestos)	monoclinic amphibole	mostly from Precambrian Fe formation
grunerite $Fe^{2+}_2(Fe^{2+},Mg)_5Si_8O_{22}(OH)_2$	amosite (brown asbestos)	monoclinic amphibole	mostly from Precambrian Fe formation
anthophyllite $Mg_7Si_8O_{22}(OH)_2$	anthophyllite	orthorhombic amphibole	mostly from ultramafic rocks
actinolite $Ca_2(Fe^{2+},Mg)_5Si_8O_{22}(OH)_2$	actinolite	monoclinic amphibole	generally <u>not</u> asbestiform
tremolite $Ca_2Mg_5Si_8O_{22}(OH)_2$	tremolite	monoclinic amphibole	generally <u>not</u> asbestiform
serpentine $Mg_6Si_4O_10(OH)_8$	chrysotile (white asbestos)	hexagonal or monoclinic sheet silicate	mostly from altered ultramafic rocks

[1]Exercise based on an article by Lang and Halsor (in Brady, Mogk and Perkins, Teaching Mineralogy, Mineralogical Society of America, 1997)

Notice that serpentine, a sheet silicate, can be asbestiform. Aren't sheet silicates mostly micas? How can sheets yield a needle-like crystal? The answer is that serpentine has two different kinds of layers in its sheet structure. And the dimensions of the layers are mismatched--one is a little bit too small for the other. So, when they get piled up, the result is a structure that tends to curl. And if it curls all the way around in a circle, the result is a fiber.

Questions for you:

1. All the asbestos minerals are amphiboles except serpentine (the most common form of asbestos). What is the difference between amphiboles and sheet silicates? Make a sketch showing how silica tetrahedra are arranged in amphiboles and sheet silicates.

2. Amphiboles are a type of "chain silicate." This means that silica tetrahedra link to form long chains in one direction. How do you suppose this direction corresponds to the long dimension of amphibole fibers when they are asbestiform?

3. How are tremolite and actinolite related? How do they relate to hornblende (a mineral which has no known asbestiform varieties)?

4. Heat and acids destroy asbestos. What are the advantages of melting or chemically destroying asbestos on site rather than just hauling it to a landfill?

Petrographic Exercise

Be sure to read, and understand, the box 4.3 on page 78 of your textbook before you bug the instructor or the TAs about how to do all this!

We have given you nine grain mounts; they are ground up samples mounted in a special oil and covered with a cover slip. #0 is insulation taken from heating pipes in the basement of Leonard Hall. One of the others is hornblende, which we give you simply for comparison. Each of the others is one of the asbestos minerals.

Amphiboles are either monoclinic (hornblende, riebeckite, grunerite, actinolite, tremolite), or orthorhombic (anthophyllite). Serpentine is triclinic or hexagonal. What this means is that they are all optically anisotropic, unlike glass and a few other minerals that are isotropic. The asbestos minerals vary in color and pleochroism, and in birefringence and a few other optical properties.

5. Some alarmed UND geology grad students thought the insulation on Leonard Hall heating pipes was asbestos. Check it out (grain mount #0) under the microscope. Examine it in PP light. What is its color? Examine it in XP light. What do you see? What do you conclude about the optical properties of this substance? What do you suppose this substance is? What do you conclude about the (intelligence of) UND geology grad students?

6. Mounts #1 through #8 each contain one of the asbestos minerals (or hornblende). Use the information in Table 2 (page 5 of this handout) to figure out which grain mount is which mineral. To do this:

> -First look at the mineral's color and pleochroism (PP light). *Beware: pleochroism can be subtle and may only show well on thick grains. Check several grains.* Identify the colorless samples, the blue samples, and also the green samples.
>
> -Cross the polars (XP light) and determine if the mineral has "parallel extinction." That is, does it go extinct when

the grains are parallel to either of the polarizers (i.e., oriented north-south or east-west). You may have to switch back and forth from XP to PP light to do this. *Be careful, some of the minerals have very small extinction angles and may appear to have parallel extinction when they don't. Also, be sure to check several different grains because extinction angle depends on orientation.*

-Under XP light, determine whether the mineral is “length fast” or “length slow”. (This means: determine whether light vibrates faster or slower when it vibrates parallel to the long dimension of the crystals compared to when it vibrates parallel to the short dimension.) To do this, orient the long dimension of the grain or needle northeast-southwest. Insert the gypsum plate and see whether the interference colors decline to lower order colors or increase to higher order colors. Note especially the edges of the grain where it is thin (where low order colors will be more easily seen if they are present). The gypsum plate is manufactured with its slow direction oriented northeast-southwest. So, if the interference colors have shifted to lower order, the birefringence of the mineral and the gypsum have subtracted from each other, the mineral and the gypsum have opposite optical orientations, and the mineral is “length fast.” If the interference colors shift to higher order, then the birefringence of the mineral and the gypsum have added, the two have the same optical orientation, and the mineral is “length slow.” To make sure you have seen things correctly, rotate the grain so the long dimension is northwest-southeast and insert the plate again. The effect should be the opposite of what you observed for a grain oriented northeast-southwest.

This is not a completely trivial exercise and will take time! Fill in the blanks below when you get it all figured out:

grain mount #	what is the material in the grain mount?
0	Leonard Hall insulation = ???
1	
2	
3	
4	
5	
6	
7	
8	

7. Amphiboles in hand specimen are characterized by a 60° cleavage angle. That's one way we identify them. But the samples in the grain mounts don't show this–at least I couldn't find any good grains showing two cleavages at 60°. So, what gives? Did I give you bogus amphiboles? Why can't you see the cleavage angle?

Table 2. Properties of Hornblende and Some Asbestoform Minerals

Mineral	Color; Pleochroism	Length fast or slow?	Birefringence / Interference colors	Other Properties
hornblende	this sample is clear to light blue-green; slightly pleochroic; hornblendes may have more color	slow	low to moderate (some thicker grains show 2nd or 3rd order colors; most are lower)	amphibole cleavage (breaks into long skinny tabs or needles with diamond shaped cross sections)
crocidolite	pleochroic in neutral, blue or purple, but may need high magnification to see	fast	very low (often shows anomalous interference colors)	high relief; max. extinction angle 0-30°; long wavy fibers like yarn or hair
amosite	brown to colorless; no pleochroism	slow	moderate to high (even flat lying small fibers show 2nd order or greater)	high relief; max. extinction angle 0-15°; mostly thin straight fibers, perhaps with a slight curve
anthophyllite	yellow, brown, or colorless; weak or no pleochroism	slow	low (max. colors are first order yellow; most are gray)	moderate relief; parallel extinction; straight needles, mostly short
actinolite	strong green color; pleochroic in green	slow	moderate (2nd and 3rd order colors are typical)	amphibole cleavage, rarely asbestiform, usually stubby or lathe-like grains
tremolite	colorless	slow	low-moderate (some 2nd order colors are seen but most are gray)	amphibole cleavage; short to long straight needles
chrysotile (hexagonal)	colorless	slow	low (most int. colors are gray, rarely yellow)	fibers show parallel extinction; sometimes mats of short wavy fibers; also extremely long threads
clino-chrysotile (monoclinic)	colorless	slow	low (only thick grains show >1st order colors)	sometimes mats of short wavy fibers; also extremely long threads; fibers should show inclined extinction, but it is hard to see and measure