Asbestos

The term **asbestiform** describes a mineral habit characterized by long, thin, strong, flexible fibers equivalent to hairs or whiskers.

How long? Definition varies
FAVORABLE PROPERTIES OF ASBESTOS

- nonflammable
- flexible
- high strength
- high durability
- chemically resistant
- thermal and electrical insulator
- can be woven
- relatively low-cost
USES OF ASBESTOS

Early uses - limited
  to strengthen earthenware pots (esp. anthophyllite in Finland)
  textiles
  cremation cloth
  tablecloths
  lamp wicks
  purses
Modern Uses of Asbestos

Modern - after about 1860
- brake and clutch facings or linings
- electrical and heat insulation
- fireproofing materials
- cement water pipe
- tiles
- filters
  - for gas masks
- packings, esp. those exposed to acid and salt water (crocidolite)
- construction materials
- insulation for steam boilers, locomotives, and pipes
- used extensively on WWII ships
- sprayed on coating to fireproof ships, railroad cars, buildings and other structures
  - in Europe (commonly crocidolite through WWII)
  - in US (mostly chrysotile) - sprayed-on coatings used on steel building girders and acoustical coatings in schools and offices (not used on ships)
- wallboard
- ceiling tiles
- fireproof shields and clothing - for firefighters
- gaskets - for steam pipes, etc., that are too hot for rubber
- soundproofing
### Table 1. Asbestos Minerals

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Asbestos name</th>
<th>Mineral Group</th>
<th>Approx. Formula</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riebeckite</td>
<td>Crocidolite (blue)</td>
<td>clino-amphibole</td>
<td>Na$<em>2$Fe$</em>{3+2}$(Fe$_{2+}$,Mg)$_3$Si$<em>8$O$</em>{22}$(OH)$_2$</td>
<td>only in pC BIF</td>
</tr>
<tr>
<td>Grunerite</td>
<td>Amosite (brown)</td>
<td>clino-amphibole</td>
<td>(Fe$_{2+}$)$<em>2$(Fe$</em>{2+}$,Mg)$_5$Si$<em>8$O$</em>{22}$(OH)$_2$</td>
<td>only in pC BIF, Transvaal, S. A.</td>
</tr>
<tr>
<td>Anthophyllite</td>
<td></td>
<td>ortho-amphibole</td>
<td>Mg$_7$Si$<em>8$O$</em>{22}$(OH)$_2$</td>
<td>Alpine UM rocks, East Finland, rarely asbestiform</td>
</tr>
<tr>
<td>Actinolite</td>
<td></td>
<td>clino-amphibole</td>
<td>Ca$<em>2$(Mg,Fe$</em>{2+}$)$_5$Si$<em>8$O$</em>{22}$(OH)$_2$</td>
<td>rarely asbestiform</td>
</tr>
<tr>
<td>Tremolite</td>
<td></td>
<td>clino-amphibole</td>
<td>Ca$_2$Mg$_5$Si$<em>8$O$</em>{22}$(OH)$_2$</td>
<td></td>
</tr>
<tr>
<td>Serpentine</td>
<td>Chrysotile (white)</td>
<td>trioctahedral, t-o</td>
<td>Mg$_3$Si$_2$O$_5$(OH)$_4$</td>
<td>serpentinized UM rx, Quebec, Russia, U.S.</td>
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Amphiboles are chain silicates and are inherently and predictably elongate or fibrous.

It’s not surprising that most asbestos minerals are amphiboles.
Amphiboles

• General Formula:
  \[(\text{Na,K})_{0-1}(\text{Ca,Na,Fe,Mg})_2(\text{Mg,Fe,Al})_5(\text{Si,Al})_8\text{O}_{22}(\text{OH})_2\]
  – large medium small tetrahedral cations

• Simple Amphibole (Tremolite):
  \[\text{Ca}_2\text{Mg}_5\text{Si}_8\text{O}_{22}(\text{OH})_2\]

• Double Chain Silicates (Inosilicates)

• note \((\text{Si}_8\text{O}_{22})^{12-}\) in formula

• they’re hydrous (OH-bearing) Minerals
Amphiboles are Double-Chain Silicates

Medium cations (Ca)

Small cations (Fe,Mg)

Large cations (Na\(^+\),K\(^+\)) or empty
Amphibole Structure
Igneous Amphiboles

Big Hornblende Crystals called Phenocrysts
# Amphibole Asbestos Minerals

## General Amphibole Formula:

\[(\text{Na,K})_{0.1}(\text{Ca,Na,Fe,Mg})_2(\text{Mg,Fe,Al})_5(\text{Si,Al})_8\text{O}_{22}(\text{OH})_2\]

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large medium small tetrahedral cations
Crocidolite (blue) Asbestos
Other Fibrous Amphiboles

Actinolite
Chrysotile “white” asbestos

- Is a form of serpentine
  \[ \text{Mg}_3\text{Si}_2\text{O}_5(\text{OH})_4, \text{ a sheet silicate} \]
- Sheet silicates are usually flaky, formed of thin flexible sheets, or leaf-like

- **How can a sheet silicate be fibrous?**
Serpentine is a tetrahedral-octahedral (t-o) Sheet Silicate

Mg$_3$Si$_2$O$_5$ (OH)$_4$

Si$_2$O$_5$ tetrahedral (t) sheet

Mg surr. by O and OH forms octahedral (o) sheet

The trouble with serpentine: the o-sheet is bigger than the t-sheet
In normal serpentine, Antigorite, the sheets are wavy or corrugated.
In asbestos serpentine, Chrysotile, the sheets roll to accommodate the misfit. HRTEM pictures down fibers.
Chrysotile (white)
Asbestos
Chrysotile vs. Amphibole Asbestos

- **CHrysotile**
  - Wavy/curlY fibers
  - More soluble
  - Contains little iron
  - Water clings to fibers

- **Amphibole**
  - Straight/stiff fibers
  - Less soluble
  - Contains abundant iron
  - Fibers repel water

- These minor physical/chemical differences may result in significant differences in the way that the body interacts with the asbestos fibers…

- [http://academic.brooklyn.cuny.edu/geology/powell/core_asbestos/society/societal/asbestos_hazard.htm](http://academic.brooklyn.cuny.edu/geology/powell/core_asbestos/society/societal/asbestos_hazard.htm)
Most of the asbestos used worldwide is Chrysotile (>95% in U.S.)

Chrysotile is much less dangerous than amphibole asbestos, in fact, there is little evidence that chrysotile poses any health hazard to those who are exposed casually (e.g., in buildings)!!!!
In the 1950s asbestos was the miracle fiber

Flame dancer protected from fire by asbestos costume

Combines fire resistant asbestos with Portland cement to make shingles that defy weather and termites

Give your house a “new face” with asbestos cement siding

1951

1955
In the early 1950s, Kent decided that the introduction of Blue Asbestos (Crocidolite) into their cigarette filters would enhance their protective ability and help to protect the public from the dangers of smoking whilst at the same time improving sales. Kent cigarettes with the micronite filter became hugely popular and a large scale marketing campaign was launched. With tag lines like ‘takes out up to 7 times more nicotine and tars – leaves in full, rich flavour’ millions of Kent Micronite Cigarettes’ were sold from 1952 to 1956.
Asbestos-related Diseases

• Asbestosis – a pneumoconiosis, like silicosis
  – Caused by long-term, occupational exposure to any kind of asbestos

• Lung cancer – bronchiogenic carcinoma
  – Same as “smoker’s lung cancer”
  – Caused by long-term, occupational exposure to asbestos, especially in those who smoke cigarettes

• Mesothelioma - diffuse malignant mesothelioma (cancer of the pleural lining of the lung cavity)
  – Caused by low, casual exposure or occupational exposure to crocidolite (blue) asbestos, only associated with amphibole asbestos
Macrophages on Asbestos Fiber

“frustrated phagocytosis”
Castranova, NIOSH, Morgantown
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