Asbestos soup
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IN ANOTHER FORUM, the discussion turned to “asbestos” and the word was bantered about as though “asbestos” was a singular thing; rather like speaking of “benzene,” as a single carcinogenic entity. And, whereas a particular chemical structure may contain a benzene ring as a component of that structure, the final molecule is not benzene and the toxicology and chemical properties may be very dissimilar to benzene.

So it is with "asbestos" which contrary to common misconception, is not a mineral classification, further the chemical formulae often presented as representing asbestos is not, *per se*, particularly important.

Rather, asbestos is a general descriptor for any one of several naturally occurring minerals (not just the six or seven often found referenced in OSHA documents, that, because of their chemical composition and physical characteristics, have found use in industry. Contrary to common belief among even geology students “asbestos” and “asbestiform” are not synonymous; many “asbestos” products contain non-asbestiform minerals as the “asbestos” component (see for example U.S. Bureau of Mines Information Circular 8751 (1977) “*Selected Silicate Minerals and Their Asbestiform Varieties*” Campbell, W.J., *et al).*

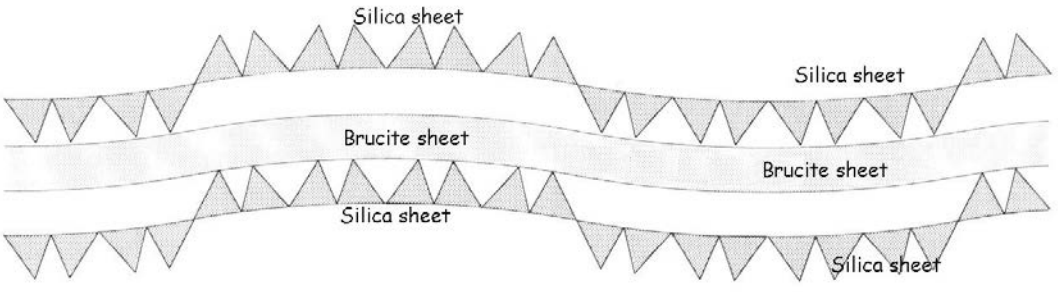
What is commonly referred to as white asbestos, the most common asbestos seen in the US, belongs to the "Serpentine" family of minerals and is called chrysotile. Some references state that the chemical composition of white asbestos is chemically indistinguishable from talc but, like so many other minerals, white asbestos has a typical, but not a definitive chemical composition. The general chemical formula for chrysotile is usually given as MgSiO(OH) and talc is usually cited as Mg3SiO(OH)2. The degree of hydration, in this case is particularly important; more so than usual (and which can begin to affect the "harshness" of the mineral).

Chrysotile contains approximately 13% water as hydroxyl groups. At elevated temperatures, structural water is driven from the crystal lattice, and chrysotile undergoes "dehydration" forming the mineral forsterite. The actual temperature at which dehydration takes place depends on the unique chemical makeup and the unique structural arrangement of the chrysotile mineral.

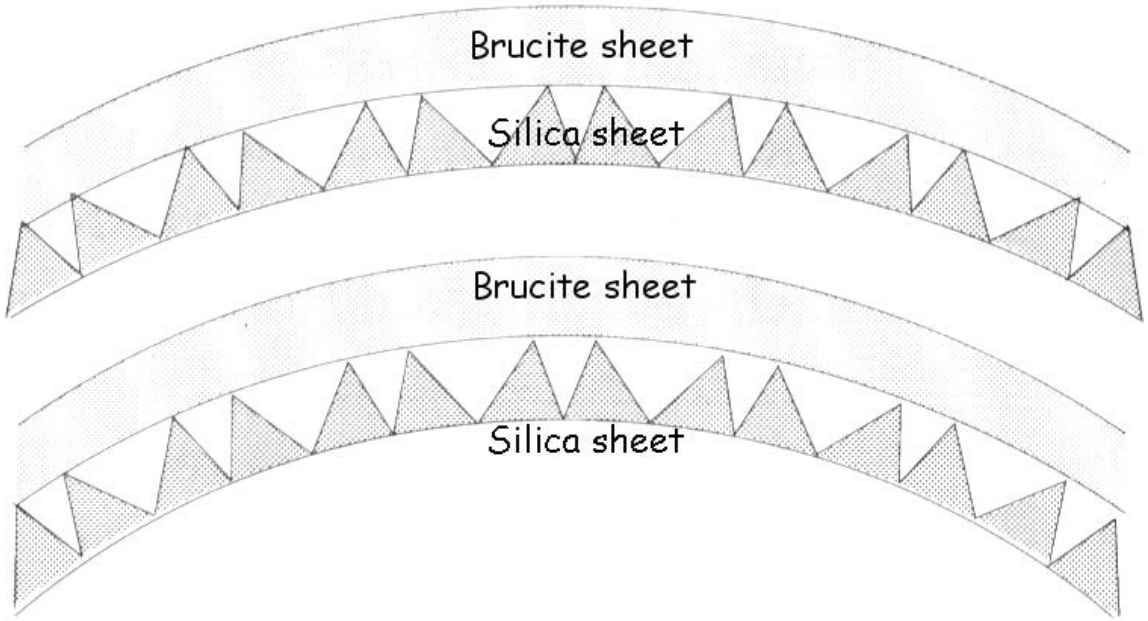
Similarly, two chrysotile specimens, although both serpentines, may actually have different chemical compositions, but are both called "chrysotile" based on morphological characteristics. Similarly, two minerals may have exactly the same chemical formula but may actually be two entirely different minerals. For example, chrysotile and antigorite both have the chemical composition of MgSiO(OH), but chrysotile is an asbestiform mineral and antigorite is not an asbestos or asbestiform mineral; again, the chemical composition is not the differentiating factor.

To complicate the matter even further, the complete mineral we call "chrysotile" is actually composed of alternating sheets of two other distinct sheet-like minerals, silica, (SiO) and brucite, Mg(OH)) which fit "uncomfortably" along side each other.

The minerals fit uncomfortably because of the mismatch of electronic charges surrounding the molecules in the sheet-like structures. To facilitate a "comfortable fit" between the two dissimilar sheets (i.e. match up the charges), the two component sheet minerals typically distort their shape in one of two ways. If the two sheets "flip-flop" in an alternating fashion, the wavy sheet-like mineral is called "antigorite" (see below):



If the two sheets simply layer one on top of the other, they form a curved sheet resembling a rolled up spiral; this is a form of chrysotile:



This structural arrangement produces irregular bond angles and non-symmetrical charge distributions which renders the microstructure inherently less stable than other silicates. It is for this reason that the Serpentine called chrysotile is readily attacked by organic acids and is rendered unstable in the biological environment. (As a side note, this is, in my opinion, one of the important aspects which begins to toxicologically differentiate the white asbestos from other asbestiforms).

Various trace elements (cations such as iron and nickel) "contaminate" the crystal lattice, essentially changing the "chemical formula" which further induce additional electrical charge abnormalities and alter the shape of the layers, and render the chemical composition more and more unimportant). In some deposits, entire sheets may be missing or the ordering of the sheets may be substituted, again altering the microstructure, but still resulting in a Serpentine mineral called "chrysotile."

Presuming that the definition of the mineral is, at least in part, incumbent on its structure, by inducing morphological changes, one changes the identification of the mineral. Thus, non-curling chrysotile (especially in the presence of aluminum) becomes known as a lizardite (Caruso L.J;, Chernosky J.V. *The Stability of Lizardite*, Canadian Mineralogist, Vol. 17, pp.757-769 (1979)). Since chrysotile is not a chemically defined substance, there is a spectrum of chemical compositions wherein the magnesium is substituted to varying degrees with aluminum and other cations. The more substitution by aluminum, the more probable that the structure of chrysotile will "flatten out" resulting in the non-asbestiform mineral called lizardite or antigorite. To say that Serpentines are necessarily asbestos, (as asserted by some individuals) ignores all this.

The very definition of "asbestos" will change depending on the reference and the purpose of the definition. For example if I look in my definitive "Dictionary of mining, mineral

and related terms – (US Department of Interior, Bureau of Mines, 1968, I see the following:

Serpentine: A hydrous magnesium silicate; monoclinic, but only as pseudomorphs. It is always of secondary origin. The translucent varieties are used for ornamental purposes; those with a fibrous habit (chrysotile) are called asbestos.

Asbestos, like “smoke” is more of a soup than a thing; a soup with an undefined mixture with specific properties.