# *Wollastonite and CERCLA Section 108(b)*

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**Introduction:**

On July 28, 2009 the U.S. Environmental Protection Agency (EPA) issued a Priority Notice of Action titled "Identification of Priority Classes of Facilities for Development of CERCLA Section 108(b) Financial Responsibility Requirements." A footnote to this notice refers to a memorandum which excludes 59 mineral commodities from this rulemaking. This list principally includes industrial minerals that are mined and processed with little or no attending use of hazardous materials for beneficiation and/or little or no hazardous waste. In effect, the notice is geared toward the placement of additional financial requirements on mining segments with a known or reasonably foreseeable elevated environmental impact with an eye toward better ensuring proper environmental management (remediation, etc.).

Surprisingly, wollastonite did not appear on the exclusion list although no elevated environmental impact is associated with the mining and processes of wollastonite. Importantly, wollastonite has received a reasonable level of attention in respect to the absence of any significant pulmonary disease endpoints (carcinogenic and nonmalignant respiratory disease). The following summary and attachments is offered in the hopes that wollastonite be considered for inclusion on the final minerals exception list. Wollastonite producers within the Industrial Minerals Association – North America (IMA-NA) strongly believe it should be.

**General Information on Wollastonite:**

Wollastonite is the only naturally occurring nonmetallic white mineral that produces acicular (needlelike) crystal fragments. This morphology and the mineral's chemistry are the main reasons for wollastonite's rise in commercial use, which began in the 1970's and has continued to the present. An overview of the geology, chemistry, processing, particle morphology, producers and market uses are provided by the United States Geological Survey (2006 Mineral Yearbook) and the wollastonite excerpt from Industrial Minerals and Rocks ***(Appendix A).***

**Basis of EPA Concern:**

No clear explanation has been provided as to why wollastonite did not appear on the preliminary exclusion list. However, IMA-NA did recently met with EPA staff working on this regulatory initiative and obtained some insight into this question. Based on that discussion and risk issues previously raised in respect to wollastonite, the following areas hopefully address EPA's concerns:

- **Particle Morphology and Risk:** Because wollastonite particulate is acicular or elongated in form, it has been considered a possible substitute for asbestos in some applications. The view that wollastonite is therefore "fibrous" in nature and might then possibly pose a health risk similar in type and magnitude to asbestos may exist.

- **Asbestos or Other Fiber Contamination:** Because one wollastonite producer once initially reported a finding of trace asbestos in a mined wollastonite ore for a short period, the belief that asbestos fibers may be a common contaminant in wollastonite may exist.

Each of these possible concerns are addressed below.

## Particle Morphology and Risk

**<u>Morphology</u>***:*

While particle morphology unquestionably plays a role in pulmonary risk, debate continues on the matter of other properties likely to also influence particulate risk. These questions involve (but are not limited to) bio-durability, surface area, mineral specific elemental components and precisely what morphology (particle size and crystal formation) is most key. It is not the intent of this submission to address these issues in detail but rather to compare what is known about the morphology and risk of wollastonite to a known, well defined risk like asbestos.

To begin, acicular wollastonite particles do not achieve the common dimensions of asbestos fiber (or even close to the most extreme dimensions). Further, light microscopy observable asbestos fibers are almost always fiber bundles (always in the case of chrysotile) composed of extremely fine individual crystal fibers called fibrils formed through a very unique crystal growth process. In contrast, a wollastonite particle is a single crystal fragment formed by mechanical manipulation – not growth.

The mechanically derived acicularity of wollastonite compared to the natural growth formation of asbestos fiber is an important distinction often stressed by mineral scientists. Due to this distinction, the longer the wollastonite particle, the wider it tends to be. The exact opposite is observed in respect to asbestos fibers where width is independent of length. These important distinctions influence lung deposition and important particle breakdown/clearance characteristics once in the lung.

Wollastonite particles are not similar in respect to the length **<u>to</u>** width dimensions (aspect ratio) of asbestos fibers. Wollastonite is marketed as either low-aspect ratio (generally 5:1 or less) and high-aspect ratio (generally 12:1 and higher). Asbestos fibers generally have higher aspect ratios (20:1 and higher) even as relatively thick fibriller bundles. Because asbestos fiber bundles separate, asbestos fibers achieve even higher length to width ratios (100:1 and higher depending upon the asbestos mineral type and means of commutation). In contrast, as wollastonite particles are further broken down (fragmented) aspect ratios diminish.

Far more importantly than aspect ratio from a risk perspective is the actual length **and** widths of wollastonite particulate contrasted to asbestos fiber. Wollastonite particles rarely fall below 2 micrometers in width and can often be found in widths greater than 40 micrometers. As noted above, the thinnest wollastonite particles will also be the shortest. Asbestos fibers, in contrast, are typically much thinner than 2 micrometers. Published literature describing the dimensions of asbestos fibers in air, bulk material and lung tissue routinely report over 50% of asbestos fibers longer than 5 micrometers as having widths equal to or less than 0.5 micrometers with lengths commonly exceeding 10 and 20 micrometers.[1-8] Additional detail on wollastonite particle size distributions can be obtained from IMA-NA member company wollastonite producers and documents appended to this submission.

Beyond differences in particle size and particle habit (formation/appearance), the question that might then be asked is whether these differences are meaningful from a health risk perspective. Fortunately, a number of risk studies are available which address that question.

**Risk:**

In 1995 the International Agency for Research on Cancer (IARC) updated its Report on Carcinogens monograph (Vol 64) on Wollastonite (***Appendix B***). In that monograph IARC concluded that there was inadequate evidence in humans for the carcinogenicity of wollastonite and inadequate evidence in experimental animals for the carcinogenicity of wollastonite. More recently (2005) the World Health Organization (WHO) produced a symposium summary that included a carcinogen assessment of wollastonite as a substitute for chrysotile. WHO concluded “that the hazard was likely to be low” (***Appendix C***). In addition a broad review of wollastonite risk was published in Inhalation Toxicology by Maxim and McConnel (***Appendix D***). The authors concluded in this review that “there is inadequate evidence for the carcinogenicity in animals and, based on strong evidence that wollastonite is not biopersistent, believe that a well-designed animal inhalation bioassay would have a negative result.” We believe these references provide a complete overview of all risk information currently available.

***Animal Studies:*** Among the animal studies addressed in the cited references is work by Pott et al (intra-peritoneal injections of wollastonite in rats 1987 – ***Appendix E***), McConnell et al (rat inhalation of wollastonite 1991 – ***Appendix F***), studies by Warheit et al (rat inhalation of wollastonite to address bio-persistence 1994– ***Appendix G***), Bellmann & Muhle (bio-durability of wollastonite after rat inhalation 1994 – ***Appendix H***) and Stanton et al (plural implantation of wollastonite in rats –***Appendix I)***.

In the first two studies, wollastonite produced no carcinogenic response in contrast to asbestos tested in the same way. In the McConnell work it is noted that while wollastonite produced an alveolar macrophage response in rat lung tissue, it resolved after exposure ceased and appeared to maintain a steady state of respirable wollastonite particulate in the lung after a certain exposure plateau was reached. The author felt this observation was best explained by the low bio-persistence of wollastonite in the lung. Dr. McConnell also points out that: “It is noteworthy that most researchers in the field of fiber toxicology consider wollastonite as the prototype negative control for studying the hazard of natural mineral fibers.” McConnell further notes that the wollastonite aerosol used in his inhalation study did include high acicular wollastonite particulate (see McConnell correspondence to Kelse – ***Appendix J***). In the Warheit study results showed “that inhaled wollastonite fibers were cleared rapidly with a retention half-time of < 1 week. The low bio-durability of wollastonite in various particle size distributions is further confirmed by the work of Bellmann & Muhle.

In the fifth study referenced above (Stanton et al) three of four wollastonite samples containing elongated particles greater than 4 micrometers with diameters less than 0.4 micrometers did produce a moderate to slight increase in pleural sarcomas by pleural implantation in rats. There was no information on the purity of the samples used. As discussed by Dr. McConnell (see correspondence to Kelse), the reliability of this finding has been called into question due to the unknown origin and type of wollastonite used (how pure and/or representative) as well as the method of installation. In contrast to Pott who introduced wollastonite (intraperitoneal injection) in saline solution and observed no tumor promotion, Stantons technique involved embedding the test material in “hardened gelatin” prior to implanting it. Such an installation technique is likely to have adversely impacted the low bio-durability of wollastonite.

Referring back to the issue of fiber dimension in respect to Stanton’s work, it should be noted that no wollastonite elongated particles in any of the four wollastonite samples contained “fibers” referred to as “critical dimension” fibers (0.25 micrometers or less in width and 8 micrometers or more in length). In contrast, asbestos samples tested by Stanton contained significant numbers of fibers that fit those size parameters.

***Human Studies:*** Only one mortality study of wollastonite miners and millers (referenced in the IARC monograph – Huuskonen et al) is known. The study involved a Finnish limestone operation with a mining cohort of 138 workers with more than one year of employment. The study covered the period 1923 – 1980. Mortality due to lung cancer was found to be below that expected. This study, however, involved small numbers and is low in statistical power.

Also discussed in the IARC monograph are nonmalignant respiratory disease studies of the same Finnish wollastonite miners (Huuskonen) and more extensive study of wollastonite miners and millers in Willsboro, New York (Shasby et al - NIOSH initial and follow-up study – ***Appendix K***). These studies suggest that wollastonite may cause a mild industrial bronchitis and this effect may occur only in smokers. There is no substantial impairment of respiratory health related to wollastonite exposure reflected in these studies. More detail can be found in the IARC monograph and other wollastonite health reviews previously referenced.

***In Vitro Studies:*** Several in vitro studies involving wollastonite have been conducted and lend no support to the premise that wollastonite may pose a risk similar in type and magnitude to asbestos, quartz and assorted other materials using various cell types and biologic end points (cytotoxicity, proliferative effects, generation of reactive oxygen species, blood cell alternations, enzyme releases, etc.). These studies are briefly summarized in the appended IARC monograph and other attachments.

**Health Summary:** Taken together, human, animal and cell studies do not support a "same as asbestos" risk for wollastonite. Wollastonite is, in fact, generally viewed and regulated in the United States as a nuisance dust (currently referred to as "particles not otherwise regulated").

## Asbestos or Other Fiber Contamination:

The second area of possible concern to the EPA involves the perception that wollastonite mining deposits can be, or are commonly, contaminated with asbestos or other "suspect" fibers. While this is simply not the case, it can also be argued that this concern involves minerals other than just wollastonite. Any regulatory action designed to protect public health against an elevated/known risk (i.e. asbestos) should identify that material risk and unambiguously address it aligned with the intent of the regulation. In our opinion, to address risk with broad brush imprecision diminishes rather than enhances both public health and the economic vitality of the nation's mining industry. The purpose of this submission is to address the mineral wollastonite and whether available risk information supports or does not support including it on the CERCLA exemption list.

While we believe all minerals should be addressed as separate entities, it is important to understand that asbestos is not common in the earths crust. In fact, only a very small proportion of the amphiboles and serpentine minerals actually form as asbestos. For asbestos to form, there must be mineral rich fluids that are either associated with regional metamorphism or contact metamorphism around crystallizing igneous bodies. The vast majority of the occurrences of asbestos are rare because, in addition to metamorphic fluids, there must be open spaces into which the fibers can grow, and a certain amount of directional stress, conditions restricted to the upper portions of the earth's crust in structurally specific environments such as faults, joints, shear planes and the axes of folds. Only rarely are large portions of rock composed of asbestos. These are not the geologic conditions under which wollastonite deposits are found.

If an isolated vein of asbestos is found in a mining environment it should be appropriately managed. Management typically involves identification then covering and maintaining the contaminated area in an undisturbed state. If it is felt financial requirements are desirable in such instances, then they should apply to these rare instances – not an entire mining segment involved in the processing and sale of a non-asbestos mineral.

In the single instance in which a wollastonite producer initially did report an isolated/trace asbestos contamination, it is of particular importance to note that the mineral fiber in question turned out not be asbestos. However, when the company believed it had encountered asbestos contamination it publically announced the discovery and ceased mining the suspect ore. Further analytical work later determined that there was actually no asbestos contamination present. This work further addressed the difficulties of proper asbestos identification in the natural environment. Despite this analytical error, the producer still established a protective product stewardship program that remains in place. A copy of this proactive approach is appended and includes an extended discussion regarding the analytical error noted (***Appendix L).***

**Contamination concern summary:** In respect to exemption consideration we believe that each mineral should be separately addressed within the framework of the proposed CERCLA financial requirements. Mineral commodity exemptions should unambiguously and separately address specific minerals that may contaminate or otherwise coexistence in an ore deposit.

## CONCLUSION

From both a risk and mineral identification perspective, we believe wollastonite should be included on the mineral exemption list for the proposed CERCLA regulation. Based upon the risk criteria applied to minerals presently on the exemption list, the IMA-NA wollastonite producers believe there is no justification to do otherwise.

# References:


1. Campbell, W. J. et al: *Chemical and Physical Characterization of Amosite, Chrysotile, Crocidolite and Nonfibrous Tremolite for Oral Ingestion Studies by the National Institute of Environmental Health Sciences.* U.S. Bureau of Mines Report of Investigation No. 8452, page48 (1980)
2. Gibbs, G. W., et al: *Dimensions of Airborne Asbestos Fibers in Biological Effects of Mineral Fibers,* Vol. 1, J.C. Wagner Edition, IARC Scientific Publication No. 30, pp 79-86, Lyon France (1980)
3. Pooley, F. D., et al: *Comparison of Fiber Dimensions in Chrysotile, Crocidolite, and Amosite Particles from Sampling in Airborne Dust and from Post Mortem Lung Tissue Specimens*, Biological Effects of Mineral Fibers, Vol. 1 J. C. Wagner Edition, IARC Scientific Publication No 30, Lyon France (1980)
4. Wylie, A. G. et al: *The Effects of Sample Preparation and Measuring Techniques on the Shape and Shape Characterization of Mineral Particles, The Case of Wollastonite* Environmental Research, Vol. 27 pp 52-73 (1982)
5. Eckert, J.: *Dimensions of Airborne Cummingtonite Particles from the Homestake Mine, Lead, South Dakota, Unpublished Senior Thesis, Department of Geology, University of Maryland, p 10 (1981)*
6. Campbell, W. J. et al: *Selected Silicate Minerals and Their Asbestiform Varieties.* U.S. Bureau of Mines Information Circular No. 8751, p. 56, (1977)
7. Campbell, W. J. et al: *Relationship of Mineral Habit to Size Characteristics for Tremolite Cleavage Fragments and Fibers.* U.S. Bureau of Mines Report of Investigation, No. 8367, p. 18 (1979)
8. Wylie. A. G.: *Relationship Between the Growth Habit of Asbestos and the Dimensions of Asbestos Fibers, Mining Engineering, pp 1036-1040, (1988)*