NSSGA
Comments on the
NIOSH
Current Intelligence Bulletin
Asbestos Fibers and Other Elongate Mineral Particles:
State of the Science and Roadmap for Research
Version 4

April, 2010

Executive Summary

Page vii

Second paragraph, last sentence:

"It remains uncertain whether other thoracic-sized EMPs with mineralogical compositions similar to the asbestiform minerals also warrant substantial health concern".

NIOSH states that it is uncertain whether cleavage fragments (thoracic-sized EMPs) cause asbestos disease yet its longstanding policy position continues to state that cleavage fragments cause asbestos-like disease. NIOSH's statement above supports the NSSGA position that cleavage fragments should not be counted as asbestos unless there is a quantifiable risk that indicates that they should be counted.

Page ix

Third paragraph, second to last sentence:

"In fact, NIOSH's policy decision in 1990 to include the nonasbestiform analogs of the asbestos minerals as covered minerals under its definition of "airborne asbestos fibers" was largely based upon evidence from these long-term animal studies."

The NSSGA has been studying this issue for nearly 25 years and has been unable to identify a single study that indicates (much less is *evidence*) that the nonasbestiform analogs of the asbestos minerals cause asbestos-like disease. The studies referenced in the NIOSH 1990 testimony have been reviewed again and none of those studies demonstrate an asbestos-like risk from cleavage fragment exposure. Please identify which specific study(s) is NIOSH referring to as providing this evidence? NIOSH's policy decision that cleavage fragments cause asbestos-like disease in the face of substantive contradictory science/research continues to have a significant influence on legislative and regulatory action that is not protective of human health.

Page x, second paragraph, first sentence:

"Developing a broader and clearer understanding of the important determinants of toxicity for EMPs will involve systematically conducting in vitro studies and in vivo animal studies to ascertain which physical and chemical properties of EMPs influence their toxicity and their underlying mechanisms of action."

A very large portion of the NIOSH research focus is on studying EMPs via cellular and animal toxicity studies rather than a comprehensive mineralogical, chemical and physical characterization of the exposures that **actually caused human disease** as reported in numerous epidemiological studies. Research that is focused on what causes disease in humans versus what injures cells or rats and then trying to relate those findings to humans, is a very direct approach to resolving the issue. This research would then inform the cellular and animal toxicologist of what to test first (those EMPs similar to the ones that really injured and killed people). We believe the failure to focus the research on what exposures are known to cause disease in humans is a fundamental error in the Roadmap. Even NIOSH's own work on the archived air samples of the South Carolina asbestos textile mill, where hundreds of workers were exposed and injured, provided invaluable information on the ***nature*** of that exposure and is extremely important to this scientific endeavor. Similar work is vital to understanding what mineral, chemical and physical characteristics are important.

Introduction

Page 1, lines 30 – 33

*"Some hard rock miner populations are exposed to EMPs, including elongate "cleavage fragments" of nonasbestiform amphiboles**, which some laboratory studies have found to demonstrate asbestos-like toxicity**, while epidemiological studies to date remain inconclusive."* [Emphasis added]

It is imperative that NIOSH identify which specific laboratory studies demonstrate the basis for the above statement. Based on nearly 25 years of examining the health science of cleavage fragments, the NSSGA has found no evidence in the literature or research that supports this position. The ramifications of NIOSH's continued restatement of this position in the face of clearly contradictory science are significant and are causing our industry to deploy resources on issues that are not protective of human health.

Page 2, lines 15-16

"OSHA has estimated that 1.3 million workers in general industry continue to be exposed to asbestos; NIOSH has estimated that nearly 45,000 mine workers may be exposed."

The OSHA reference is pertaining primarily to asbestos abatement activities and maintenance/janitorial workers. What is the basis for the NIOSH estimate regarding mine workers? This is implying that miners are being exposed to asbestos and we are aware of no data to support this statement. If this statement is actually referring to primarily ***cleavage fragments*** and some asbestos as indicated on page 10, then please change this statement to be consistent with page 10.

Overview of Current Issues

Page 5, lines 16-19 The Nature of Harmful Exposures

"Although a large amount of health information has been generated on workers occupationally exposed to asbestos, limited mineral characterization information and the use of non-mineralogical names for asbestos have resulted in uncertainty and confusion about the ***specific nature of exposures*** *described in many published studies."* [Emphasis added]

This is a factual statement and the NSSGA believes that the NIOSH Roadmap should make it a priority to clarify the ***specific nature of exposures*** described in the published studies that resulted in adverse human health outcomes. Not to pursue this is a significant shortcoming of the Roadmap research agenda since it would relate directly to those exposures known to cause asbestos-related diseases in humans. It would allow putting research to practice by clearly characterizing those fibers responsible for human death and disease. Knowing the ***nature of those exposures*** would allow health scientists, mineralogists, geologists, regulators and all other stakeholders to focus on exposures of a similar nature.

Page 5 lines 42-43 Fibrous versus Asbestiform – Understanding the difference

"Both asbestiform (fibrous) and nonasbestiform (massive) versions (i.e. analogs) of the same mineral can………"

The NAS requested that NIOSH use correct mineralogical terminology in the Roadmap. Fibrous is not a synonym of asbestiform and NIOSH's use of it as a synonym serves to confuse the distinction between asbestos fibers and non-asbestos cleavage fragments. Asbestiform is a unique type of fibrosity relating to a mineral habit where the fibers occur as bundles of fibrils and are extremely long and thin. Fibrous is much too general to be equated to the term asbestiform. Please replace the word "fibrous" with the word "asbestiform" when referring to asbestos to be consistent with the comments from NAS.

Page 8 lines 2-5 - Commonality of Nonasbestiform versus Asbestiform Minerals

"Nevertheless, asbestiform and nonasbestiform habits are commonly found together, and an asbestos deposit or product derived from it may not include wholly asbestiform material in the same way in which minerals not considered as asbestos may contain asbestiform material."

It is important to note that when asbestos is found in the natural environment, it will always be accompanied by its nonasbestiform analog. The converse is rarely true. This is because asbestiform minerals must undergo a unique set of geologic circumstances in order to form the long thin bundles of fibers. There must be mineral-rich fluids associated with metamorphic conditions and open spaces for the long fibers to grow. These conditions are restricted to the upper portions of the earth's crust in environments that contain faults, joints, folds, intrusions, etc. The nonasbestiform analogs of these asbestos minerals do not need these unique conditions and consequently are common rock minerals found in many areas of the planet. The fact that nonasbestiform minerals are much more common in ordinary rocks is one of the basic reasons the NSSGA believes NIOSH should be extremely certain of the risk they pose before effectively labeling much of the land on the east and west coasts and upper Midwest as hazardous.

Page 15 lines 33-34 Pleural Plaques as a Marker of Asbestos Exposure

"The presence of characteristic pleural plaques, especially if calcified, can also be used as evidence of past asbestos exposure [ATS 2004]."

A review of non-asbestos related pleural plaques was published in the Archives of Environmental and Occupational Health in 2007 titled: Pleural Plaques: A Review of Diagnostic Issues and Possible Nonasbestos Factors by Chester Clark, MD et al. A copy of this paper is attached to these comments. Based on these authors' review of the literature, the simple presence of pleural plaques is **not** evidence of asbestos exposure and knowledge of exposure to asbestos is necessary to relate the finding of pleural plaques to asbestos.

Page 16 – 17 lines 35 – 2 The NIOSH Recommendation for Occupational Exposure to Asbestos

"In addition, airborne cleavage fragments from the nonasbestiform habits of the serpentine minerals antigorite and lizardite, and the amphibole minerals contained in the series cummingtonite-grunerite, tremolite-ferroactinolite, and glaucophane-riebeckite shall also be counted as fibers provided they meet the criteria for a fiber when viewed microscopically."

NIOSH's recommendation to treat cleavage fragments of the six asbestos minerals, when they fit an arbitrary fiber counting criteria, as equivalent in toxicity to asbestos is not based on any demonstration of risk. In 1990, NIOSH simply stated that this was its new policy but no quantitative risk assessment was made to support this change in policy. In 2010, the Institute still has not provided a demonstration of risk that cleavage fragments are equal in risk.

As stated above, it is NIOSH's position that antigorite and lizardite, the nonasbestiform analogs of chrysotile asbestos, are equivalent in potency to chrysotile asbestos and need to be counted along with the asbestos in determining compliance with its REL. This position is based simply on the fact that antigorite and lizardite are analogs of chrysotile versus any scientific study demonstrating equal (or any) ability to cause asbestos-related diseases. If these forms of the minerals are equally potent, then NIOSH needs to explain why published studies of chrysotile exposed workers such as those in textile production have a dramatically steeper exposure-response curve than the chrysotile miners whose higher exposure is primarily to EMPs of antigorite and lizardite with lesser quantities of chrysotile. The research outlined in the Roadmap does not address this very important discrepancy. These nonasbestiform minerals are extremely common rock forming minerals (as are the nonasbestiform amphiboles also included in NIOSH's REL). The ramifications of this position are enormous; not only from economic and legal perspectives, but also from a public health perspective.

In a mixed dust environment, counting a non or less potent particle as equally significant as one that is unquestionably potent leads to poor risk assessments, poor risk management, poor communication of reality, and poor use of economic and unfortunately, legal resources. In a non-asbestos dust environment (cleavage fragments only), counting non-potent particles as if they were asbestos, leads to the same set of poor consequences and may result in choosing to control the non-potent exposure circumstance over an asbestos exposure circumstance. This results in an increased risk to public health and an unwarranted misdirection of resources. In these cases, counting more does not mean being more protective of human health.

Page 18 lines 7-8 - Bundles – a Critical Difference Between Mineral Habits

"Longitudinal splitting of fibers after entering the lung represents one way that air sample PCM counts may underestimate the cumulative dose of fibers in the lung."

This disaggregation of chrysotile fiber bundles is a classic characteristic of the asbestiform mineral habit (including amphiboles) and is not shared with the non-asbestiform habit of the same mineral. This is one of the key differences between these mineral habits and it is one of the reasons why an asbestiform and nonasbestiform exposure can never be "similarly sized" as is frequently stated by NIOSH and others.

Page 18 lines 20-22 - Dose-response of Antigorite and Lizardite

*"It has been proposed that exposures in the textile mills were almost exclusively to chrysotile asbestos while exposures in the miners were to a mixture of chrysotile asbestos and **related nonasbestiform minerals** [Wylie and Bailey 1992]." [Emphasis added]*

The **related nonasbestiform minerals** referred to in the Wylie and Bailey study were **antigorite or lizardite cleavage fragments** meeting the counting criteria advocated by NIOSH as stated in the published paper. NIOSH needs to clarify this statement in the Roadmap by identifying antigorite and lizardite versus "related nonasbestiform minerals". These are the same non-asbestos "fibers" (cleavage fragments) that NIOSH says are equal in risk to chrysotile. If these cleavage fragments are just as potent as chrysotile, the difference in lung cancer risk does not support the NIOSH policy and we request that NIOSH explain its position in light of this fact.

Page 20 lines 21-24 Asbestiform versus Fibrous Terminology

Similar to the situation in Libby, MT, a study of a cluster of malignant mesothelioma cases in eastern Sicily has implicated an etiological role for a fibrous amphibole in the fluoro-edenite series, initially identified as in the tremolite-actinolite series [Comba et al 2003]."

In a review of this paper, the fluoro-edenite referenced above is in the asbestiform mineral habit and is not simply "fibrous". The NSSGA has advocated that all ***asbestiform amphiboles*** be treated as equally hazardous as asbestos. The asbestiform habit is defined mineralogically by NIST on its certificate of analysis of its asbestos standards as follows:

"Asbestiform: crystallizes with the habit of asbestos. These asbestos minerals possess properties such as long fiber length and high tensile strength. Under the light microscope, some portion of these samples exhibit the asbestiform habit as defined by several of the following characteristics: 1) mean aspect ratios ranging from 20:1 to 100:1 or higher for fibers longer than 5 µm, 2) very thin fibrils, usually less than 0.5 µm in width, 3) parallel fibers occurring in bundles, 4) fiber bundles displaying splayed ends, 5) fibers in the form of thin needles, 6) matted masses of individual fibers, and 7) fibers showing curvature."

The Roadmap uses terms such as "fibrous" that confuse the morphological distinctions between cleavage fragments and asbestos fibers. Consistent with the NAS comments, NSSGA requests that the Roadmap be further updated with correct mineralogical terms to avoid confusion and misinterpretation. Asbestos grows in an asbestiform habit not a fibrous habit. The term asbestiform has very specific meanings (e.g. polyfilamentous growth or bundles showing splayed ends, very high aspect ratio fibers with very thin widths, fibers with parallel sides, etc.). These morphological characteristics are the hallmark properties of asbestiform minerals. NIOSH uses the term "fibrous" interchangeably with asbestiform and then uses it again to describe elongated cleavage fragments that meet an analytical counting criteria leading one to the scientifically unsupported conclusion that they may indeed be similar in morphological properties.

Page 20 lines 25 – 28 – Monitoring Nomenclature Changes

" In the face of past and future nomenclature changes in the mineralogical sciences, workers need to be protected against exposures to pathogenic asbestiform minerals. The health and regulatory communities will need to carefully define the minerals covered by their policies and monitor the nomenclature changes to minimize the impact of these changes on worker protections."

NSSGA has always advocated that all asbestiform (mineralogically defined) amphiboles be treated as asbestos as well as asbestiform erionite. The reason for this is that they are durable true asbestiform fibers. Since much of the recent nomenclature changes involve amphiboles, this policy position would essentially eliminate this issue.

Page 20 - 21 lines 41 – 2 - Epidemiological Studies

"The first element comprised results of epidemiological studies of worker populations exposed to EMPs from nonasbestiform mineral analogs of the asbestos varieties (e.g. cleavage fragments). The 1990 testimony characterized the existing evidence as equivocal for excess lung cancer risk attributable to exposure to such nonasbestiform EMPs."

On page 11 lines 34-36, NIOSH states that in the absence of specific diagnostic criteria for lung cancers caused by asbestos, ongoing surveillance (and causation) cannot be done for asbestos-related lung cancer. Yet NIOSH is using the questionable or slight lung cancer increase as a rationale for discounting the absence of asbestos-related disease in the epidemiological studies pertaining to cleavage fragment exposure. Please provide a detailed scientific rationale for this conclusion in light of the negative animal and cellular toxicity studies that complement the negative epidemiology.

Page 21 lines 6-10 – Animal carcinogenicity studies

"The 1990 testimony characterized the results of the studies as providing strong evidence that carcinogenic potential depends on a mineral particle's length and width and reasonable evidence that neither chemical composition nor ***mineralogic origin*** *are critical factors in determining a mineral particle's carcinogenic potential." [Emphasis added]*

With respect to the animal studies involving the nonasbestiform mineral habit of the six asbestos minerals, the NSSGA believes that NIOSH has misinterpreted these studies. **In all cases where tumors were found above a background level, fibers of the asbestiform habit were present at some level in the exposure to the animals therefore, mineral habit is a critical factor with respect to these exposures. In studies of nonasbestiform cleavage**

fragments where fibers of the asbestiform habit were not present, no tumors above the background level were found. In addition, the mineral habit is critical because ***it is the primary reason*** for a mineral exhibiting a particular range of lengths, widths and aspect ratios. Because of different mineral habits, asbestiform fibers and cleavage fragments have significantly different particle dimensions and surface properties. To say that mineralogic origin, or how a mineral is formed, is not a critical factor in why a mineral displays a range of length, width and aspect ratio dimensions is not consistent with the undisputed science of mineralogy or the mineralogical facts that distinguish asbestos from non-asbestos. **The mineral habit determines the dimensions.**

Contrary to what NIOSH states, chemical composition is also critical since it has much to do with durability/biopersistence. The **substance** being tested in the Stanton experiments was found to be an important factor as well as dimension as reported by Dr. Gary Oehlert in his reanalysis of the Stanton experimental data. This 1991 paper was previously provided to NIOSH and is referenced in the Roadmap. NIOSH refers to Dr. Oehlert's work but does not reconcile his findings with what NIOSH is concluding. **Chemical composition does matter.**

Page 21 lines 12-19 Analytical Methods - Too Difficult to Distinguish

"The third element comprised the lack of routine analytical methods to accurately and consistently distinguish between asbestos fibers and nonasbestiform EMPs in samples of airborne [sic]. The 1990 testimony argued that asbestiform and nonasbestiform minerals can occur in the same area and that determining the location and identification of tremolite asbestos, actinolite asbestos and anthophyllite asbestos within deposits of their nonasbestiform mineral analogs can be difficult, resulting in mixed exposures for some mining operations and downstream users of their mined commodities."

First, it is important to understand that relatively speaking, the nonasbestiform habit of the minerals in question will be present much more frequently (without the presence of their asbestiform analogs) than will the asbestiform habits of these minerals. This is a mineralogical fact since the formation of asbestiform fibers requires a specific set of geological conditions to be present that are not common. See the attached 2007 paper published in Environmental & Engineering Geoscience by Van Gosen titled: The Geology of Asbestos in the United States and Its Practical Applications for a description of the rock types where asbestos may occur. It is true that when the asbestiform minerals are present, the nonasbestiform analogs of those minerals will also be present in even more abundance. **The converse is simply and mineralogically not true.**

This is a very important mineralogical fact that NIOSH should acknowledge in the Roadmap. Furthermore, if NIOSH is going to advocate regulation of cleavage fragments simply because they are too difficult to distinguish from asbestos, it will condemn large portions of the US when asbestos may not be present at all. Determining the location and identification of asbestos within deposits is not difficult if you are knowledgeable and experienced with how asbestos is formed. Once asbestos has been located and identified in a bulk sample, the properties of the asbestiform fibers in these bulk samples serve as an extremely useful reference for analyzing air filters for the same fibers in a mixed dust sample. This is not difficult if one is knowledgeable of the mineralogical and geological differences between the habits.

Many distinguishing properties of asbestos and their nonasbestiform analogs can be seen using different analytical microscopes. Using only PCM using the simple 3:1 aspect ratio and 5 micron minimum length does not allow one to make the distinction in a mixed dust, or environmental sample and is not supported from a health nor mineralogical perspective. These distinguishing properties are listed in the table attached to these comments.

In addition to these distinguishing properties seen by various analytical instruments, the presence of an asbestiform airborne exposure can be detected by comparing the population characteristics of the fibers on a filter to what is known about the nature of asbestos versus non-asbestos. The detection of asbestos fiber population characteristics on an airborne sample, if the concentration were close to the current PEL of 0.1 fiber/cc (100 fibers/L), should not present a problem since at the recommended sampling flow rate of 4 L/minute and 100 minutes of sampling duration (NIOSH 7400), a filter would have 40,000 fibers/filter. Assuming the fibers are evenly distributed across the filter, at a 400 L sample volume, and counting the necessary grids in a PCM analysis, one would count 80 fibers at a concentration of 0.1 fibers/cc and 40 fibers at a concentration of 0.05 fibers/cc. This number of fibers at the PEL or one-half the PEL is more than adequate to determine population characteristics and therefore allows a determination of the presence of asbestiform fibers.

The National Institute of Standard and Technology (NIST) lists these asbestiform population characteristics on a certificate accompanying each NIST asbestos reference standard and they have been previously described in these comments.

The asbestiform population characteristics are consistent with recent analytical examinations of asbestos and cleavage fragments performed by Dr. Eric Chatfield and presented at the past two ASTM conferences dealing with asbestos analyses (see attached presentation provided with the permission of Dr. Chatfield). Dr. Chatfield reports that for non-asbestiform amphibole fibres longer than 5 µm and thinner than 1.5 µm:

- Fibres with lengths > 5 µm and ≤ 10 µm do not have aspect ratios exceeding 35:1
- Fibres with lengths > 10 µm and ≤ 20 µm do not have aspect ratios exceeding 30:1

- Fibres with lengths > 20 μm do not have aspect ratios exceeding 20:1

What these data show is that length is dependent upon width. The longer the fragment, the wider it must be and hence as fragment length increases the length to width aspect ratio decreases. This is very consistent with what is known mineralogically about cleavage fragments. They are brittle and if they are thin they will break perpendicular to their length. This is very different from the characteristics of asbestiform fibers.

Dr. Chatfield concludes that these distinguishing characteristics could easily be applied to air samples:

- "The numerical concentration of definitive asbestos fibres longer than 5 μm in the respirable size range for tremolite of various morphologies correlates very strongly with the observed tumor incidence in the Davis et al. studies (R=0.997)"

- "There seems little reason why this protocol could not be applied to exclude non-asbestiform amphibole fragments in the analysis of air samples for asbestos for the purpose of risk estimation"

In earlier published work on asbestiform and nonasbestiform population characteristics, Siegrist and Wylie (1980) report the following:

"The usefulness of the various shape definitions including length, width, and aspect ratio (length/width) in characterizing and discriminating between samples is explored and evaluated. Significant results include: (i) Frequency distribution of log length, log width, and log aspect ratio show very apparent differences between asbestos and nonasbestos populations. (ii) Dimensional differences and accurate classification according to dimensions are enhanced by regressing log width and/or log aspect ratio against log length. (iii) Discriminant function analysis is able to quantify the distinction between asbestos and nonasbestos particle dimensions such that over 95% of the population assignments are correct. (iv) Log width is a more efficient classifier than log aspect ratio using either linear regression of discriminant function analysis for these particular samples. (v) The choice of instrumentation, i.e., TEM vs SEM, may affect the sample characterization. (vi) Quantitative descriptions of the dimensions of small particles may be related to the habit of the mineral and the structure of the mineral groups to which the particles belong."

In later work, Virta, R.L. et al (1983) utilize the asbestiform habit's independence and the cleavage fragment's dependence of the width relative to the length to develop the "fibrosity index" to help classify a population of particles as either asbestiform, nonasbestiform or mixed. In the conclusions section of this publication the authors state:

"Correlation between fibrosity indices can be used to determine whether an airborne amphibole population is from an asbestos or a nonasbestos source. Thus, the linear least-squares regression technique is suitable for quantitatively describing the morphology of particle populations as well as aiding in the identification of a predominantly asbestiform or nonasbestiform amphibole source for the airborne amphibole particles."

The logic of the fibrosity index is consistent with the NIST descriptors and with Dr. Chatfield's findings.

In addition, the publication by Wylie et al (1993) titled: "*The Importance of Width in Asbestos Fiber Carcinogenicity and Its Implications for Public Policy*" [AIHAJ], demonstrates clearly that asbestiform minerals with typical widths less than 1 micron show a high correlation with tumor incidence in animals while cleavage fragments typically wider than 1 micron do not. An asbestiform fiber that is wider than 1 micron will be a bundle of fibers while cleavage fragments do not exist as bundles. This difference in width between asbestos and cleavage fragments is easily seen in a mixed dust sample. A more recent demonstration of this uniqueness of width between asbestos and nonasbestos minerals was presented in the publication by D. Van Orden et al (2009) titled: *"Width Distribution of Asbestos and Non-asbestos Amphibole Minerals"* [Indoor and Built Environment]. These characteristics are mineralogical facts that are key to discriminating asbestos from nonasbestos.

Finally, another recent publication regarding distinguishing asbestiform from nonasbestiform properties by M. Sanchez et al (2008) titled: *"Extinction Characteristics of Six Tremolites with Differing Morphologies"* [Microscope], also demonstrates how the mineral habit of a sample can be classified as asbestos, mixed or nonasbestos using the NIST morphological properties and the polarized light microscopic parameter of extinction angle.

Considering all of the above, we request that NIOSH further justify its position that cleavage fragments cannot be reliably distinguished from asbestos with some level of reliable accuracy or that the Institute change its position in this regard. A copies of the cited papers are attached to these comments.

Page 21 line 27 – 35

"However, even if such EMPs were not hazardous, the inability of analytical methods to accurately distinguish countable particles as either asbestos fibers or cleavage fragments (of the nonasbestiform analog minerals) presents a problem in the context of potentially mixed exposures (i.e., asbestos fibers together with EMPs from the nonasbestiform analogs). NIOSH's 1990 recommendation provided a prudent approach to potentially mixed environments—limiting the concentration of all countable particles that could be asbestos fibers to below the

REL would assure that the asbestos fiber component of that exposure would not exceed the REL."

NIOSH's approach to treat cleavage fragments as equally potent to asbestos is not a protective approach to public or occupational health since efforts to minimize the exposures to both will force competition for limited resources. As stated above, the presence of cleavage fragments of the asbestos minerals **without the presence of asbestos** is very common so treating vast areas of the country as presenting a potential asbestos risk (*"even if such EMPs were not hazardous")* because common rock-forming amphibole is present is a misuse of safety and health resources. As Dr. Berman's report on exposure metrics relative to asbestos states, counting more is not necessarily more protective.

Page 23 lines 15 – 35 - Studies of New York Talc Miners and Millers

The discussion of mesothelioma rates in upper New York is very concerning because it appears to rely on soft data or to down play facts that do not support the Institute's current controversial policy regarding cleavage fragments. In this discussion, NIOSH cites Enterline and Henderson (1987) on female and male mesothelioma cases in Jefferson County, NY (no talc mines in this county) as having the 2nd and 6th highest rates for mesothelioma respectively, in the nation. Then goes on to cite Hull et al (2002) reporting "*5 – 10 times the mesothelioma background rate*" for Jefferson County. Finally, NIOSH admits the earlier citations dealt with an ICD code that is not specific for mesothelioma and when the more specific ICD code is used, Jefferson County and St. Lawrence County (where talc mines did operate) become no different than the rest of the nation. NIOSH again uses this unsupported conclusion in its summary on page 27 lines 23-27. The fact appears to be that there is no increase in mesothelioma cases in St. Lawrence County and the Roadmap should be amended accordingly.

Page 27 lines 1-5

"Thus, when the exposure index used to assess the effect of EMPs is based on a surrogate measure, such as respirable dust, rather than on specific measurement of EMP concentrations, the lack of an exposure-response relationship between the exposure index and the health outcome must be considered suspect, particularly where the composition of a mixed exposure varies by work area."

This statement for dismissing the most recent and most comprehensive epidemiological study on the most exposed population to amphibole cleavage fragments is not supported by a reasonable or scientific rationale. Regardless of whether respirable dust is a proper surrogate for EMP exposure, it appears obvious that people who have been exposed longer to dust or EMPs should show a greater dose-response than those with less tenure. As stated on page 25 lines 33-34:

"As in previous investigations of the RTV cohort, Gamble [1993] found that the risk of lung cancer ***decreased with increasing duration of employment*** *at RTV."* [Emphasis added].

This lack of a dose-response for lung cancer in this cohort for either respirable dust or duration of employment is significant especially when the respirable dust exposure shows a dramatic and logical dose – response with respect to talcosis. The deposit mined by this cohort of miners and millers was nearly 60% nonasbestiform tremolite. Mineralogically, amphiboles typically cleave along two planes which create elongated fragments. It is unsupported by any science or research that the dust created by crushing and screening this ore would not follow this mineralogical reality and not present an EMP exposure of significant proportions.

Page 28 lines 38- 43 Homestake Gold Miners

"Taken together, the studies of Homestake gold miners provide, at best, weak evidence of an excess risk of lung cancer. Although small excesses of lung cancer have been reported in the most recent studies of the Homestake gold miners, the increased mortality has not been found to increase with measures of cumulative dust exposure. The uncertainty of the relationship between contemporary dust and EMP exposures hinders the usefulness of historical dust measurement data in estimating EMP exposures [Zumwalde et al. 1981]."

It is remarkable that with the extremely high silicosis mortality and morbidity of the Homestake cohort that any slight increase in lung cancer would be assigned to the EMPs versus the crystalline silica which NIOSH and others believe is also a known human lung carcinogen. This cohort was exposed to high levels of respirable dust containing the amphibole cummingtonite-grunerite. Just as the tremolite amphibole in the NY talc, it cleaves to form elongated fragments fitting the EMP definition and it is likely that the documented dust exposures contained significant amphibole EMPs.

Page 31 lines 23-33 - Summary of Nonasbestiform EMP Epidemiological Studies

"An excess of respiratory cancer was observed in the occupational studies of New York talc workers and a small excess was observed in the most recent study of Homestake gold miners. In both studies, the excess of respiratory cancer was not found to increase with cumulative exposure to dust. Relationships between health outcomes and exposure to an agent of interest can be attenuated when a nonspecific exposure indicator is used as a surrogate for exposure to that agent [Blair et al. 2007; Friesen et al. 2007]. Thus, when the exposure index used to assess the effect of EMPs is based on a surrogate measure, such as respirable dust, rather than on specific measurement of EMP

concentrations, the lack of an exposure-response relationship between the exposure index and the health outcome must be considered suspect, particularly where the composition of a mixed exposure varies by work area."

NIOSH's dismissal of the use of respirable dust exposures as a nonspecific exposure indicator for EMP is without merit. If NIOSH or OSHA used the same rationale to determine the applicability of the asbestos epidemiological studies relied upon for establishing PELs or RELs, there would be few "reliable" asbestos epidemiological studies. Many studies relied upon by the government used results from impinger or other particle counting devices for surrogates for fiber or EMP exposure assessments. Many of these were not even measuring respirable dusts yet these nonspecific surrogates for EMP exposures showed a dose-response for asbestos disease. We request that NIOSH either provide additional rationale for why the standard for applicability of studies appears to be different or that the Institute change its position on this issue.

Page 32 lines 38 -43- Animal Studies

"Literature reviews by Lippmann [1988] and Pott et al. [1987] enhance the hypothesis that any mineral particle can induce cancer and mesothelioma if it is sufficiently durable to be retained in the lung and if it has the appropriate aspect ratio and dimensions. Similarly, Wagner [1986] concluded that all mineral particles of a ***<u>specific diameter and length size range</u>*** *may be associated with development of diffuse pleural and peritoneal mesotheliomas."* [Emphasis added]

The specific diameter and length size ranges referred to in the review by Lippmann, with respect to lung cancer and mesothelioma, are as follows: lung cancer – diameter 0.15 – 0.8 microns with lengths greater than 10 microns (minimum aspect ratios of 12.5 -67:1) and for mesothelioma – diameter less than 0.1 micron and length between 5-10 microns (minimum aspect ratios of 50 - 100:1). These dimensional properties do not describe the typical cleavage fragment but clearly describe the asbestiform fiber. The 1987 Pott et al reference, dealing with animal experiments using intraperitoneal injection and intratracheal instillation, does not provide a specific diameter and length size range that is associated with cancers in test animals. The reasons for this are stated by the author (pg 148):

"The available data for the fibre size distributions are not comparable in all cases because measurements were carried out at different times using different methods and by different working groups."

The 1987 Pott et al paper does say that extremely low doses of ***<u>asbestos</u>*** between 0.05 and 0.5 mg led to tumor induction by these invasive testing techniques. The Wagner 1986 review paper does indeed make the statement that NIOSH cites above, however, Wagner references Stanton's work relative to the ***<u>specific diameter and length size range</u>*** that leads to mesothelioma. This is characterized on page 1909 of Wagner's paper as fibers with diameters of less than 0.25 micron and lengths greater than 5 microns (minimum aspect ratio of 20:1). Again, these dimensions are not characteristic of cleavage fragments.

Page 33 lines 20 -24 – Animal Studies Continued

"Another sample that was predominantly nonasbestiform but contained a small amount of asbestiform tremolite resulted in mesothelioma in 67% of animals. Of note, the nonasbestiform material associated with the 12% mesothelioma incidence and this latter material contained an approximately equal number of EMPs longer than 8 µm and thinner than 0.5 µm."

We request that NIOSH add to the Roadmap a more supported explanation that the sample causing the 67% tumors (Italian tremolite – Ala di Stura) had 9% of the federal fibers meeting the Stanton critical fiber dimensions of **<u><0.25 um in diameter</u>** (not 0.5 um) and > 8.0 um long while the 12 % tumor tremolite (Dornie) had zero percent based on Davis et al measurements. In addition, the recent work by Dr. Eric Chatfield (attached to these comments with permission) demonstrated that the Italian tremolite in these experiments had an asbestos concentration of 1.4 % (330 million asbestos fibers/gram) while in the Dornie sample, the asbestos concentration was 0.0044 % (29 million asbestos fibers/gram) in their respective respirable fraction. In the original crushed sample of these two tremolites, the Italian sample had a weight percentage of 0.64 (150 million fibers/gram) while the Dornie tremolite had a weight percentage of 0.0018 (12 million fibers /gram). This 10 fold difference in asbestos content very likely explains the different outcomes from the exposures especially in light of the work cited earlier by Pott et al from 1987 on the effects of low doses of asbestos (see above).

Page 59 lines 11-23 Surrogates for Asbestos Exposure in Epidemiological Studies

"Risk assessments of workers occupationally exposed to asbestos were reviewed by investigators sponsored by the Health Effects Institute [1991]. They found that dose-specific risk is highly dependent on how the measurement of dose (exposure) was determined. A common problem with many of the epidemiological studies of workers exposed to asbestos was the quality of the exposure data. Few studies have good historical exposure data and those data which were available are mostly area samples with concentrations reported as millions of particles per cubic foot of air (mppcf). Although correction factors were used to convert exposures measured in mppcf to f/cm3, the conversions were often based on more recent exposure measurements collected at concentrations lower than those prevalent in earlier years. In addition, a single conversion factor was typically used to estimate exposures throughout a facility, which may not accurately represent differences in particle sizes and counts at different processes in the facility."

We request that NIOSH further justify its position that these accepted studies in asbestos risk analysis use even more tenuous surrogates for exposure than the RT Vanderbilt Hondo study which NIOSH dismissed.

Page 69 lines 8 -12 – Nonasbestiform Studies not Sufficient

"The results of human, animal, and in vitro studies performed to date on a limited number of nonasbestiform EMPs are not sufficient to conclude that exposures to EMPs from this large and highly variable group of minerals are not capable of causing substantial adverse health outcomes. Additional data are needed to develop risk assessments."

There are twenty-four *in vitro* studies or reviews of the science that contrast the toxicological outcome between the asbestiform and nonasbestiform habits of the same minerals. Most of these studies involve chrysotile and its nonasbestiform counterpart, antigorite, crocidolite and its nonasbestiform counterpart, riebeckite and amosite and its nonasbestiform counterpart, cummingtonite-grunerite. These studies were conducted in a variety of species and cell types including hamster tracheal explants, hamster tracheal epithelial cells, rat lung epithelial cells, rat and hamster alveolar macrophages, rat pleural mesothelial cells, sheep red blood cells, and Chinese hamster ovary cells. All of these studies clearly show a difference between the nonasbestiform and asbestiform habits of the same minerals.

There are ten *in vivo* studies that also demonstrate significant differences in toxicological outcome (tumor generation) between the two mineral habits of the same mineral. Most of these studies used tremolite asbestos and nonasbestiform tremolite, ferro-actinolite asbestos and nonasbestiform actinolite under various exposure routes including inhalation, intrapleural injection, intrapleural implantation or intratracheal instillation in either rats or hamsters. As in the *in vitro* studies, clear differences are seen between the two mineral habits. Samples with the asbestiform or mixed asbestiform/nonasbestiform mineral habits caused tumors while the nonasbestiform variety of the same minerals did not.

There are three groups of workers who have been exposed to the nonasbestiform amphiboles, cummingtonite-grunerite (Homestake Gold miners and Minnesota Taconite miners) and nonasbestiform tremolite and anthophyllite (New York Tremolitic Talc miners). Each has at least two or more separate epidemiological studies published in the literature. When these epidemiological studies are contrasted with cohorts that were exposed to either amosite asbestos (asbestiform cummingtonite-grunerite) or tremolite asbestos, the differences again are very clear. The tremolitic talc mine has 50 - 60 percent nonasbestiform tremolite in the deposit, while the Libby, Montana vermiculite mine had only 4-6 % asbestiform amphibole. The health outcomes of both are very different.

The consistency of these health findings in cellular, animal and human studies are very striking and are very informative. We would expect similar findings for other asbestiform and nonasbestiform habits of the same mineral that are not currently regulated as asbestos. This is a large body of scientific evidence that does not support NIOSH's current position. The NSSGA believes that NIOSH is dismissing it for tenuous reasons simply because it can not scientifically reconcile these findings with its policy.

Page 69 lines 18 -21 Similarly Sized Exposures

"Any assessment of risk needs to address the influence of dimension, so studies that systematically compare effects of asbestiform and nonasbestiform particles of similar dimensions from the same mineral (e.g., crocidolite and nonasbestiform riebeckite) are needed for a variety of mineral types."

NIOSH policy advocates that cleavage fragments with similar dimensions as asbestos fibers be treated equally with respect to risk if they are the same mineral. NIOSH now says it is uncertain, however, its formal policy still stands. This position/policy does not reflect a mineralogical understanding of the asbestiform and nonasbestiform mineral habits. The six regulated asbestos minerals are asbestiform fibers that are composed of many, many thinner fibrils. A fibril cannot be further divided and is on the order of 0.01 micron in diameter depending on the asbestos mineral. Cleavage fragments do not exist in these dimensions and are not composed of bundles of thinner and thinner cleavage fragments. When looking at the two mineral habits through an optical microscope, such as the phase contrast microscope (PCM) at 400X, all, or the vast majority, of cleavage fragments will be seen while the majority of asbestos fibers and fibrils will not be seen. When an asbestos fiber is seen under PCM, it is very likely a fiber bundle versus a single fibril and there is a real likelihood that the bundle will disaggregate once inside the lungs. In exposures to asbestos, ALL of these particles are inhaled not just ones that can be seen and counted under PCM. This is why the NIOSH PCM method provides only an index of exposure. In the case of cleavage fragments, this index accounts for nearly the 100% of the particles counted while for asbestos, the index represents a much smaller fraction of what is actually present. **This mineralogical fact demonstrates that cleavage fragments and asbestiform fibers can never have the same dimensions in a real exposure circumstance. There will always be a population of asbestiform fibers present that cannot be duplicated in a cleavage fragment exposure.** The most recent science (Berman and Crump, 2008a and b), points to these very thin and very long, mostly non-PCM countable fibers as being the most potent fraction of an asbestos exposure. Under the analytical methods that are being used (PCM 7400 and PCME 7402), and this mineralogical difference between the mineral habits, a cleavage fragment exposure will be more severely regulated than a true asbestos exposure. The Berman and Crump references above have been previously provided to NIOSH.