Comments of Ann Wylie, Professor of Geology, University of Maryland, College Park, MD on the Document entitled " Talc, Asbestiform and Non-asbestiform: Result of the NIEHS Report on Carcinogens Review Group Review"

My interest in and study of the relationships between minerals and human disease extends back for 34 years, when, as a first year graduate student, I had the opportunity to work for one summer at Mt. Sinai in the laboratory of Irving Selikoff under the direction of Arthur Langer. When I was appointed as a professor at the University of Maryland in 1972, I began in earnest my exploration of this interesting and complex topic, and over the last 28 years, I have published extensively on the physical and chemical properties of minerals that have been implicated in disease. For your review, I have attached my curriculum vitae, which summarizes these activities.

I decided to comment on the draft of the NIEHS report on Carcinogens Review Group Review of Talc, Asbestiform and Non-Asbestiform because many confusing and incorrect statements on mineralogy have been made, and the relevance of several important studies has been overlooked. I believe these mistakes are so significant that they impact the validity of the analysis.

1. The document uses interchangeably the following terms: fibrous talc, asbestiform talc, and talc containing asbestiform fibers. These three terms do not mean the same thing, and the incorrect interchangeability of the terms obfuscates the issues.
    a. **Fibrous talc** was first described in the mineralogical literature in 1960, by one of the world's foremost mineralogists, G.W. Brindley and his student I. S. Stemple. It has been studied and described (Stemple and Brindley, 1960; Wright, 1960; Virta, 1985; Felius, 1986; Veblen and Wylie, 1993; Greenwood, 1998; Crane, 2000) and this work has established that fibrous talc is the fibrous form of the mineral talc, and furthermore, that in this fibrous form, it may or may not be intergrown on an extremely fine, scale with variably but commonly small amounts of amphibole and/or other chain silicates.
    b. Fibrous talc may be asbestiform, in that it can form in bundles of parallel fibers of narrow diameter and high aspect ratio, or it may be acicular. Therefore, **asbestiform talc** is a habit of fibrous talc. When so designated, it is used to describe talc that has grown in a habit that resembles that of asbestos. That does not make it asbestos; there are other asbestiform minerals that are also not asbestos. Another way to say this is that minerals with an asbestiform habit look like asbestos. In the Introduction to the document, the following statement appears: **"Asbestiform talc** generally refers to talc containing asbestiform tremolite/actinolite, anthophyllite, or chrysotile." This is a different meaning of asbestiform talc, and not one that any mineralogist would understand. If this is the meaning intended, then I recommend that throughout, this term be replaced with the term "mixtures of talc and asbestos" so that there is no confusion. The definition of asbestos has already been well established in the regulatory literature.

c. **Talc containing asbestiform fibers** seems to refer to mixtures of talc and crocidolite, or talc and amosite, or talc and any other type of asbestos. In fact, when the results of animal and genotoxicity studies that employed asbestos are cited, the authors imply that industrial talc contains asbestos. Asbestos has been well established as a carcinogen, and it is difficult to see how the fact that asbestos is a carcinogen informs the discussion of the carcinogenicity of talc, whether fibrous or not. It is possible that some industrial talc deposits may contain trace amounts of asbestos. However, if asbestos is found in industrial talc, it is still asbestos and is covered by existing regulatory policy.

The confusion throughout the document about what is meant by the terms talc, asbestiform talc, fibrous talc, and talc containing asbestiform fibers makes the interpretation of the medical data presented impossible to evaluate without a careful reading of each source cited to determine which term pertains.

2. General Mineralogical errors. Taken individually, the errors I point out below may be dismissed as irrelevant to the larger question. However, they contribute to the distinct impression that those who have written this document know very little about the material about which they have written. The structure, composition, and physical properties of minerals are well known. It is essential that our regulatory process not ignore this vast body of knowledge.

   a. Under 1.1, **Chemical Identification**, the statement that minerals "such as calcite, quartz, magnesite, etc., have chemical properties similar to those of mineral talc" occurs. This is incorrect. There is no similarity between the chemical properties of the minerals listed and talc.
   b. In **Table 1.1**, under the column **Properties**, entries occur for carbonates, anthophyllite, and mica. These statements are irrelevant and, in the case of anthophyllite, are specific only to the asbestiform variety. Anthophyllite may be found associated with talc in a blocky or massive form. I suggest removing this superfluous column.
   c. In **Table 1-2**, the physical and chemical properties of talc are listed. I have consulted all the mineralogical texts in my library and none agree that the hardness of talc can be greater than 1. In fact, hardness number 1 is defined by talc.
   d. Under **1.3**, the first statement suggests that asbestiform fibers are something mysterious and poorly understood. This is simply incorrect. It reflects ignorance of the mineralogical literature.
   e. Also under **1.3, paragraph 5**, the following statement occurs: "the limiting upper diameter of "whisker" usually is considered to be 15 _m; the same diameter may be used for the definition of asbestiform fibers." I have measured thousands of asbestos fibers and am familiar with almost every published study on the dimensions of asbestos fibers. Asbestos fibers have diameters that are orders of magnitude thinner than 15 _m.
   f. In the **eighth paragraph of 1.3**, the document refers to published reports that talcum powders contained measurable amounts of chrysotile, tremolite, and anthophyllite fibers that "may be of asbestiform nature". In fact, most of these so-

called fibers were cleavage fragments (hence the term "may" was used) and are irrelevant to the discussion.

g. In the **ninth paragraph of 1.3**, the confusion between fibrous or asbestiform talc and talc containing asbestos is again made. How **Table 1-3** is relevant to the use of the term asbestiform talc is beyond me. Actinolite asbestos is not a synonym for actinolite; amosite is not a synonym for grunerite; tremolite is not a synonym for tremolite-asbestos, and asbestos fiber is not a synonym for a sodium hydroxide coated non-fibrous silicate.

3. Under the topic **Studies of Cancer in Experimental Animals**, the work of Merle Stanton and his co-workers is discussed and summarized in Table 4-5. Their talc 6 contains both fibrous and nonfibrous talc. It was mined in New York and was labeled in Stanton's notes (personally examined in his archives by me) as Nytal 200. It is noteworthy that Stanton et al. report that it contains concentrations of fibers 0.25 _m x > 8_m that are equal to or greater than several of the asbestos fibers populations also used in these experiments. However, no statistically significant tumor probability resulted. The work of Stanton et al. predicts that similar concentrations of asbestos fibers would result in a tumor probability of more than 60%. The results of these experiments underscore the fact that the biological activity of fibrous talc is not the same as that of asbestos.

4. Under **Asbestiform talc, section 4.2,** the following statement occurs: "For evaluation of the carcinogenicity of asbestiform talc, asbestos is considered a reasonable surrogate, in part, because asbestos is the generic term for all naturally occurring fibers of mineral silicates of the serpentine and amphibole series." A similar analogy is used in discussing genotoxicity. The fact that the authors equate the fibrous form of the mineral talc with asbestos is without foundation. Talc is neither amphibole nor serpentine. These are different minerals: they have different physical properties (such has hardness, surface charge, density, hyrophilicity, solubility, tensile strength, surface roughness, surface area, etc.) different chemical compositions, different atomic structures, different numbers and types of structural defects, different dimensions, and based on animal (Stanton et al. 1972, Smith et al., 1979) and cell culture experiments (Wylie et al., 1998) they have different biological activities. The document suggests that the composition, structure, physical properties and surface properties of mineral fiber should not be relevant to the regulatory process. Based on the wide range of physical and chemical properties of minerals, such a position is unjustified. If talc in any form is a carcinogen, this determination should rest on evidence of carcinogenicity derived from human exposure to it and/or animal experimentation with it. Classifying a mineral as a carcinogen without this type of evidence would threaten the validity of the scientific foundation of our regulatory process.

5. The study of W.E. Smith et al. is relevant to the discussion and has been overlooked. In 1979, W.E. Smith et al. published the results of intrapleural injection of industrial talc in hamsters in a paper published in Dusts and Disease entitled "Biologic tests of tremolite in hamsters". In this paper, Smith et al. report that the injection in hamsters of a New York State industrial talc (FD-14), a material that contains cleavage fragments of tremolite and serpentine as well as fibrous and nonfibrous talc, produced very little fibrosis and no

tumors. This result contrasts sharply to those reported in the same paper on the tumors and fibrosis resulting from the injection of tremolite-asbestos under the same experimental conditions.

6. In 1997 Wylie et al. published a study that compared fibrous talc to asbestos by using a colony-forming efficiency assay with rodent tracheal epithelial and pleural mesothelial cells. The work suggests strongly that fibrous talc has a biological activity that is very different from that of asbestos. It showed that asbestos has a proliferative potential, while fibrous talc does not, and that surface area and fiber dimensions could not explain the difference in response. In relegating this paper to one that informs on fiber dimensions and mineralogy, rather than to one that addresses directly the biological effects of fibrous talc, its importance is underestimated.

In summary, this document is replete with substantive errors. The case for the carcinogenicity of asbestos is confused with a case for the carcinogenicity of talc. Therefore, it should not form the basis for any regulatory action, direct or indirect, and it should not be included in the National Toxicology Program Report on Carcinogens.

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Brian Hart "A Potential Field Study of the Magnetite Bearing Deposits of the Central Portion of the Sykesville Mining District" (1984)
Katherine Heller "A Reconnaissance Study of the Origin of Small Talc and Serpentine Bodies in the Wissahickon Formation within the Maryland Piedmont" (1984)
Dan Linder "Comparison of the James Run with the Sykesville and Morgan Run Formation" (1987)
Bethany Baker "Observation on the Geology of Montgomery County from geomagnetic, aeroradioactivity and gravity surveys" (1987)
Valerie Gray "Reconnaissance Study on the Source of Gamma Radiation Fluctuation in Eastern Montgomery County" (1987)
Tom Davis "Comparative Geothermometry by Using Garnet-Biotite and Fe-Ti Oxides in the Loch Raven Schist (1988).
Dan Galasso "Geochemical Prospecting of Heavy Minerals to Determine if a Marker Exists for the Sykesville District of Carroll County, MD" (1991).
David Berry "Analysis of Trace Quantities of Amphibole Asbestos Based on the Fractal Model for Mass Distribution" (1994).
Bob Schultz "Determination of Asbestos in a Matrix Through Employment of the Fractal Model for Mass Distribution" (1995).
Allan Jackson-Gewirtz "A Comparison of Methods of Analysis of Powdered Samples" (1995).
Roberta Winters "Biological Effect of Fiber Size and Mineralogy: The Case of Talc Fibers in Hamster Tracheal Epithelial (HTE) and Rat Macrophage Cells (RMC)" (1995).

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[1]Winner of the AAPG National Undergraduate Research Award

[2]2nd Place Winner of the AAPG National Undergraduate Research Award

Mi Lim "Anomalous Optical Properties of Tremolite-Actinolite Fibers" (1995).
Tom Biolsi "Effects of absorption and thickness in measuring the index of refraction of blue glass and riebeckite and its application to crocidolite" (1996).
Katherine White "X-ray diffraction and optical analysis of picrolite from the State Line Quarry, Pennsylvania (1996).
Matt McMillan "Lattice dimensions *vs*. chemical composition and optical properties of tremolite (1997).
Russell Meyer – Lattice Dimensions, chemical composition and optical properties of crocidolite (1999).
John Ossi, M.S., "A New Petrographic Method For Interpreting Coal-Forming Environments of Deposition" (1985).
Robert Virta, M.S., "An Evaluation of the Adequacy of Morphological Data for Determining the Carcinogenicity of Minerals (1988).
Dan Linder, M.S., "The Mineralogy and Origin of the State Line Talc Deposit, Lancaster Co., Pennsylvania" (1990).
Tim Rose, M.S., "Petrology and Chemical Variation of Peraluminous Granitic Rocks from the Northern Lobe of the PhillipsPluton,Maine"(1991).Jiang Feng, M.S., "Evidence for compositional variation in phyllite from Carroll and Frederick Counties, MD" (1996).
Diane Hanley, M.S., "Overland flow evaluation of lava flow platform" (1998).
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Mark Watson M.S., Effects of intergrowths on the Physical Characteristics of fibrous Anthophyllite (1999)
James Crowley, Ph.D., "Geochemical Study of Playa Efflorescent Salt Crusts and Associated Brines by Using Spectral Reflectance, X-ray Diffraction and Brine Chemical Data" (1991).
Martitia Tuttle, Ph.D., "Late Holocene Earthquakes and their Implications for Earthquake Potential of the New Madrid Seismic Zone, Central United States" (1999).