MERLE BUNDY, M. D.

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Marko:

It was good to talk with you. The abstract is enclosed.

With kind personal regards.

MB/rp

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Identification of Fibrous and Non-Fibrous Amphiboles in the Electron Microscope

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Abstract

The extensive and systematic epidemiological and other studies of Dr. Selikoff and his associates at Mt. Sinai Hospital have aroused public recognition of adverse health effects due to exposure to asbestos dust, especially among insulation workers and others in the asbestos "trades."[1,2] In these cases, monitoring the airborne fibrous dust concentration in the work environment by phase contrast optical microscopy has been quite satisfactory. However, the suggestion that acicular fragments of non-fibrous amphiboles below the limit of optical microscopy may pose similar hazards has prompted almost exclusive reliance on electron microscopy for identifying and counting particles in air and water samples.[3]

Until the complexity of differentiating between the numerous mineral species which could be present was recognized, an apparent aspect ratio of 3:1 and the resemblance of a possibly incomplete selected area electron diffraction pattern to that from a standard sample seemed sufficient criteria for identification.[3] However, a large number of silicate minerals have prismatic cleavage and unit cells similar to the commercial asbestos mineral varieties.[4,5] Furthermore, the aspect ratio of fine particles produced by spontaneous or imposed comminution is a manifestation of anisotropy in crystallographic and physical characteristics. Thus, differences in macroscopic attributes, especially fibrosity and optical properties readily observed between hand samples of fibrous and non-fibrous mineral varieties[6] reflect differences in crystallization history and resulting microstructure at the fibril and crystal layer sequence levels. It is also evident that the surface properties and presumably the carcenogenic potency of asbestos fibers will be closely related to the particular crystal faces that predominate.[7]

Reliable techniques for positive identification of unknown particles in ambient air or water samples by combined scanning and high voltage electron microscopy have been developed.[8,9] Extension of these methods through the use of automatic image analysis in the SEM and concepts borrowed from quality control applications permit statistically significant characterization of particulate samples

for environmental monitoring purposes. Single crystal electron diffraction analysis has also permitted differences in the preferred orientation of asbestiform and non-fibrous amphibole particles to be determined in the electron microscope on a quantitative basis. Evidence that particle face orientations are related to crystal growth form has been developed by direct examination of transverse sections of several mineral varieties.

It is highly desirable that electron optical characterization of mineral dusts used for health effects studies include determination of crystal face orientations as well as the distribution of particle sizes and aspect ratios and the identity of the various minerals present. Such detailed information will be required in order that exposure to the particulate matter found in air samples from ambient or occupational environments can be distinguished from the known health hazard caused by asbestos or any other mineral species which may be suspect in the future.

References

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Research

MEMORANDUM

By R. M. Fisher and R. J. Lee
Basic Research-Physics

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Subject TRIP REPORT - WORKSHOP ON ASBESTOS: DEFINITIONS AND MEASUREMENT METHODS, NATIONAL BUREAU OF STANDARDS, GAITHERSBURG, MD, 7/18-20/77

Summary

The viewpoints of the minerals industry were generally well received at the workshop attended by more than 400 industry, government and academic representatives. The main viewpoints are: (1) mineral fragments should not be equated with asbestos fibers; (2) amphiboles should not be equated with commercial asbestos (these misconceptions have resulted from sloppy identification procedures and definitions); (3) there is no evidence to suggest occupational or incidental exposure to non-commercial asbestos poses a health hazard.

Introduction

The decision to hold this workshop grew out of an assignment to the Analytical Chemistry Division of the National Bureau of Standards last autumn to resolve a dispute concerning the alleged occurrence of "asbestos" in talc used for cosmetic or industrial applications. Dr. Heinrich (Section Head-NBS) soon became aware of considerable ambiguity concerning the definition of "asbestos" (by EPA, OSHA and some analysts - not by mineralogists), problems with analytical methods, and uncertainty about the interpretation and validity of available health effects data.

Originally, the workshop was to deal with the talc question and to involve about 50 participants. However, the final workshop was comprised of 32 papers concerned with mineralogy and definitions of all forms of "asbestos", analytical procedures, health effects, and the programs and policies of various government agencies (MESA, OSHA, FDA, CPCC - but not EPA). Over 400 people attended (including 25 from Canada, France, Belgium, and the UK) distributed about as follows (scaled from analysis of about one-quarter of the total attendance): hard rock mining and quarrying industries-90; federal regulatory agencies-85; talc and asbestos industries-75; universities, consultants, trade associations and press-50; analytical laboratories-35; state regulatory agencies-35; federal laboratories (Bureau of Mines, Geological Survey, NASA, etc.)-35.

The multi-disciplinary nature of the program, the active participation of a number of high level people from the various industrial, government and private organizations vitally concerned with "asbestos" issues and general awareness of the economic or public health consequences of faulty data or interpretation leading to wrong decisions regarding air or water quality standards all combined to make this a very exciting conference. Our work was well received to the point of formal compliments during the discussion from Malcolm Ross and Jack Zussman and others, and general appreciation from the members of the American Iron Ore Association (AIOA) in attendance.

At a recent AIOA Environmental Committee Meeting, Mr. Beukema stated that he believed that the discussions and opinions expressed at the workshop would have a major impact on the direction of future action by government agencies. We believe that this assessment proved to be correct and that the industry viewpoint scored ahead of that of the federal agencies with most of the audience.

Discussion

Because of the large amount of material presented during the talks and the very vigorous discussion and "statements" only the main points are recounted in this memorandum. Most of the points important to taconite mining and processing are discussed in a laboratory report just being completed.

1. All amphiboles or serpentines are not asbestos. Several chain or sheet silicates exhibit both fibrous and non-fibrous varieties. Large deposits of the former are very rare and are mined in South Africa, Quebec, and elsewhere for "commercial" asbestos for industrial use. Small veins of fibrous varieties sometime occur along with the non-fibrous form. Amphiboles and serpentines are ubiquitous - but "the earth's crust is not hazardous to man" (Malcolm Ross, U.S. Geological Survey).

2. Cleavage fragments of minerals are not asbestos fibers. The distinction between fibrous and non-fibrous minerals, so obvious to geologists used to examining bulk samples, or to mineralogists using the petrographic microscope, become blurred for very small particles only seen in the electron microscope, especially if a 3:1 aspect ratio is accepted for the criterion for a fiber (commercial asbestos fibers range from 100:1 to 10,000:1 in length to diameter ratio).

Fibers result from growth conditions producing long bundles of fibrils with weak interfaces between them, whereas fragments are a consequence of cleavage during quarrying or grinding and aspect ratios greater than 10:1 are extremely rare. Detailed electron diffraction studies (by R. J. Lee) have shown that the crystallographic orientations of the faces of amosite fibers (commercial asbestos) and grunerite fragments are distinctly different reflecting their different origins (growth vs. cleavage) even though they are essentially identical in composition and crystal structure.

3. Amphiboles have been incorrectly identified on numerous occasions. Because of their very similar crystal structure and chemical composition, small particles of non-amphiboles can be mistaken for amphiboles and non-fibrous amphiboles mistaken for the fibrous variety in the electron microscope. Work in this Laboratory has shown that if proper care is taken when taking the electron diffraction pattern (tilting into a zone axis, etc.), angles and spacing between spots are measured carefully, the chemical composition is determined by x-ray spectroscopy, and the data are compared by computer with all possible patterns from all minerals which could be present, positive identification with an acceptable degree of probability (~90%) can be achieved. Reliance on visual identification (as most labs. have done) leads to a high probability of misidentification. However, simple routine methods can be developed for specific applications, e.g. tremolite asbestos in talc where the presence of other minerals can be discounted.

4. Non-commercial forms of "asbestos" are less hazardous and cleavage fragments even less so. Most information about the health hazards due to commercial asbestos has come from epidemological studies of workers with occupational exposure during mining, processing, or end-use application (insulation, etc.). Laboratory animal studies have generally corroborated the interpretation of epidemological studies although effects of fiber length, surface coatings of organic carcinogens, and many other parameters have not been thoroughly documented as yet.

As stressed repeatedly during the discussions, there is no sound basis to extrapolate knowledge about commercial asbestos exposure to miners in other industries, e.g. talc, gold (Homestake Mine), quarries (Rockville, Md.), taconite (Reserve), or to the general public.

At the close of the conference, Dr. A. Langer of Mt. Sinai Hospital (close colleague of Selikoff) expressed the view that the available evidence would suggest that non-commercial asbestos fibers are less hazardous than the commercial varieties and that less stringent standards would be in order (as they do in the UK).

Preliminary data from an EPA-sponsored animal study of the effects of interplural injections of fine non-fibrous grunerite particles showed no ill-effects in contrast to controls using the fibrous varieties (amosite) of this amphibole silicate.

5. Synergistic effect of smoking. It has long been known that the risk of developing lung cancer from occupational exposure to commercial asbestos is increased considerably among moderate or heavy smokers. Although it appears that there is no "safe" threshold fiber concentration, it appears that the incidence disease can be associated to a time-weighted lifetime average exposure and that a "risk" factor can be developed on this basis, (e.g one chance in a hundred for a worker exposed 40 hours a week for 35 years of employment to a concentration of possibly 10 fibers/cc). This raises the question of whether industry (or society) should have to bear the heavy costs required for control facilities to protect heavy smokers.

General Comments

The various federal agencies received a great deal of sharp criticism from government, industry and university mineralogists for their careless use of terminology and sloppy analytical procedures - the term "federal fiber" was used with sarcasm by many commentators. They were also criticized for undue haste with proposed changes in regulations and for conflicting and overlapping jurisdiction between the various agencies.

A number of inquiries were received concerning analytical services or joint projects or proposals to utilize our techniques for particle identification or counting. It remains to be seen if any of these are followed up by more specific requests as we suggested.

RMF/RJL/d

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