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JACKO

WORKSHOP ON
ASBESTOS: DEFINITIONS AND MEASUREMENT METHODS
National Bureau of Standards
Gaithersburg, Md.
July 18-20, 1977

Sponsored by NBS and OSHA

FINAL PROGRAM

		Abstract Page
Sunday, July 17, 1977		
7:00- 9:00 p.m.	Registration and Informal Reception --Sheraton-Silver Spring Hotel	
Monday, July 18, 1977		
8:00 a.m.	Buses leave from Hotel (Breakfast available in NBS cafeteria)	
8:30 a.m.	~~Registration and Coffee~~	
9:15 a.m.	Purpose and Procedures of Workshop Philip D. LaFleur, Chief Analytical Chemistry Division National Bureau of Standards	

164- 921-~~1000~~ -2851 NBS

I. Mineralogical Aspects: Chairman - Brian Mason,
Smithsonian Institution
Washington, D.C.

9:30 a.m.	History of Asbestos-Related Mineralogical Terminology Tibor Zoltai University of Minnesota Minneapolis, Minnesota	8
10:05 a.m.	Fibrous and Asbestiform Minerals J. R. Kramer McMaster University Ontario, Canada	9
10:40 a.m.	Coffee	

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11:00 a.m.	Minerals Commonly Occurring in the Earth's Crust that Might be Defined as Asbestos by Various Regulatory Agencies	10
	Malcolm Ross U.S. Geological Survey Reston, Virginia	
11:35 a.m.	X-ray Crystallographic Structure of Minerals Related to Asbestos	11
	Jack Zussman University of Manchester Manchester, England	
12:10 p.m.	General Discussion of Mineralogical Definitions	
1:00 p.m.	Lunch	

II. Relationship between Chemical and Physical Properties and Health Effects: Chairman - Marvin Schneiderman
NCI, NIH
Bethesda, Maryland

2:00 p.m.	Epidemiological Evidence on Asbestos	12
	I. Selikoff, W. Nicholson, and A. Langer Mt. Sinai Hospital New York, New York	
2:35 p.m.	Measurement of Asbestos Retention in Humans Related to Health Effects	13 & 14
	J. Bignon Université Paris Centre Hospitalier Intercommunal France and P. Sebastien and A. Gaudichet Direction Départementale des Affaires Sanitaires et Sociales France	
3:10 p.m.	Review of Epidemiological Evidence of the Effect of Types of Asbestos and Fiber Dimensions on the Production of Diseases in Man	15
	Clark Cooper Equitable Environmental Health, Inc. Berkeley, California	
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4:00 p.m.	<u>Pathophysiology in Relation to the Chemical and Physical Properties of Fibers</u>	16
	Paul Kotin Johns-Manville Corporation Denver, Colorado	
4:35 p.m.	<u>The Carcinogenicity of Fibrous Minerals</u>	17
	Mearl F. Stanton and Maxwell Layard NCI, NIH Bethesda, Maryland	
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6:00 p.m.	Buses leave NBS for Hotel	
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Tuesday, July 19, 1977

8:00 a.m.	Buses leave from Hotel (Breakfast available in NBS cafeteria)	
8:30 a.m.	Buses leave from Hotel	
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Relationship Between Chemical and Physical Properties and Health Effects (continued)

9:15 a.m.	<u>Effects of Injested Asbestos</u>	18
	R.D. Pontefract Dept. of Health and Welfare Ottawa, Canada	
9:50 a.m.	<u>NIEHS-Oral Asbestos Studies</u>	42
	J.A. Moore and Dave Jones NIEHS, Research Triangle Park, North Carolina IITRI, Chicago, Illinois	

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10:25 a.m.	EPA Study of Biological Effects of Asbestos-like Mineral Fibers	19 & 20
	Lalita Palekar, Northrop Services Inc., Research Triangle Park, North Carolina and David L. Coffin, EPA Health Effects Research Lab., Research Triangle Park, North Carolina	
10:40 a.m.	Coffee	
11:00 a.m.	General Discussion of Health Effects	

III. Analytical Methods: Chairman - K. Heinrich,
Analytical Chemistry Division
National Bureau of Standards

12:00 p.m.	Identification of Selected Silicate Minerals and Their Asbestiform Varieties	21
	William Campbell, Bureau of Mines, College Park, Maryland	
12:30	Electron Microscopy Methods	22 & 23
	Clayton A. Ruud, Denver Research Institute, University of Denver, Denver, Colorado	
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	Ian Stewart, Walter C. McCrone Associates, Inc., Chicago, Illinois	
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	D.R. Beaman and H.J. Walker, Dow Chemical Co., Midland, Michigan	

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3:00 p.m.	Identification of Asbestos by Polarized Light Microscopy John Delly Walter C. McCrone Associates, Inc. Chicago, Illinois	27
3:30 p.m.	Coffee	
3:50 p.m.	Statistics and Interpretation of Analytical Results James Leineweber Johns-Manville Corporation Denver, Colorado	28
4:20 p.m.	Selection and Characterization of Fibrous and Non-Fibrous Amphiboles for Analytical Methods Development Janet C. Haartz, B.A. Lange, NIOSH, Cincinnati, Ohio and Ron G. Draftz, R. Scholl, IITRI, Chicago, Illinois	29
4:50 p.m.	Asbestiform Minerals in Industrial Talc: Commercial Definitions Versus Industrial Hygiene Reality John M. Dement NIOSH-MRB Cincinnati, Ohio	30
5:20 p.m.	The Detection and Identification of Asbestos and Asbestiform Minerals In Talc Harold D. Stanley and Robert E. Norwood Pfizer, Inc. Easton, Pennsylvania	31
5:50 p.m.	Misidentification of Asbestos in Talc Jerome B. Krause, Colorado School of Mines Research Institute and William H. Ashton, Johnson & Johnson, New Jersey	32
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Wednesday, July 20, 1977

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IV.	Regulatory Aspects:	Chairman - John Martonik, OSHA, Washington, D.C.	
	1:30 p.m.	MESA Regulations and Methods Aurel Goodwin MESA Arlington, Virginia	38
	2:00 p.m.	OSHA Regulations and Methods Willard C. Dixon OSHA Salt Lake City, Utah	39
	2:30 p.m.	FDA Projects and Methods Irvin Asher, John Wenniger and Philip McGrath FDA Washington, D.C.	40
	3:00 p.m.	CPSC Regulations and Methods Robert Hehir CPSC Washington, D.C.	43
	3:30 p.m.	Coffee	
	3:50 p.m.	Impact of Asbestos Regulations on the Mining Industry C.S. Thompson Vanderbilt Co. East Norwalk, Connecticut	41
	4:20 p.m.	General Discussion of Regulations	
	5:30 p.m.	Buses leave NBS for Airports and Hotel	

HISTORY OF ASBESTOS-RELATED MINERALOGICAL TERMINOLOGY

Tibor Zoltai
University of Minnesota
Minneapolis, Minnesota

Asbestos pollution is a major health problem and its solution requires an extensive cooperation between several distinct scientific disciplines. A more effective interdisciplinary communication and more successful cooperation could be assured if we eliminate the current, implicative misinterpretations of the asbestos-related mineralogical terminology. The erroneous use of terms like *asbestos, asbestiform, fiber and fibrous* is not only contrary to mineralogical traditions and definitions but also affects the effectiveness of our scientific language to describe the structural characteristics of the various mineral particles considered and to understand their potentially harmful physical-chemical properties.

The character of mineralogical concepts and the definitions of the asbestos-related mineralogical terms will be explained through their development in the history of scientific mineralogy. An attempt will be made to demonstrate that the relevant mineralogical terms are unambiguous, inspite of the seemingly confusing and extensive list of "asbestos-mineral" names introduced throughout the various evolutionary phases of mineralogy. The essential concepts and criteria associated with these terms will be summarized.

FIBROUS AND ASBESTIFORM MINERALS

J.R. Kramer
McMaster University
Ontario, Canada

The terms asbestos, asbestiform, and fibrous are used in overlapping definitions on many occasions. Often it is impossible to differentiate between the terms at the electron microscopic level. Lack of differentiation requires that a large number of minerals common in the earth's crust be included in a group definition. In the attempt to further define this group of minerals, electron diffraction analysis is carried out on a "finger print" basis and elemental analysis is carried out. These two techniques in the general environmental case are often not sufficient enough to characterize the mineral species. And it is not clear what relationship can be demonstrated between the analyses and environmental effects once a characterization is made. Other factors relating to surface details are suggested as being important in the study of fibrous minerals in context to environmental concern. Surface composition, surface charge and crystallographic modifications relative to mineral orientation are proposed as tools to define relationships of mineralogy to environmental effects.

MINERALS COMMONLY OCCURRING IN THE EARTH'S CRUST THAT MIGHT BE DEFINED AS ASBESTOS BY VARIOUS REGULATORY AGENCIES

Malcolm Ross
U.S. Geological Survey
Reston, Virginia

Chrysotile, amosite, crocidolite, anthophyllite, tremolite, and actinolite particles having length > 5μm, diameter < 5 μm, and length-to-width $\geq$ 3, are presently defined by the U.S. Occupational Safety and Health Administration as "asbestos" (U.S. Federal Register, October 9, 1975, p. 47652,47660).

These minerals form complex chemical series and a variety of crystal structures and commonly have such ambiguous names that the common non-fibrous amphiboles hornblende and cummingtonite may be included within the definition. The drafting and/or application of asbestos regulations by those unappreciative of these complexities of rock-forming silicates may cause many igneous and metamorphic rocks to be considered "asbestos-bearing."

X-RAY CHRYSTALLOGRAPHIC STRUCTURE OF MINERALS RELATED TO ASBESTOS

Jack Zussman
University of Manchester
England

The crystal structures of the two main asbestos-forming minerals, the amphiboles and serpentines, are surprisingly very different. The amphiboles are "chain silicates" in which SiO_4 tetrahedra are linked to form bands four tetrahedra wide and of very great length. These bands run parallel to the asbestos fiber axis and are linked laterally by cations, mainly Ca and Mg in tremolite; Na, Mg and Fe in crocidolite; Mg and Fe in amosite and anthophyllite. The tempting correlation of the chain unit of crystal structure with asbestiform nature is, however, too facile. Many amphiboles are not asbestiform, and as the serpentine minerals show, some asbestiform minerals do not have a chain structure.

The serpentine minerals are "layered silicates" in which SiO_4 tetrahedra are linked to form thin sheets of great lateral extent. The tetrahedra all point in the same direction and their apical oxygens are part of an (O,OH)-Mg-(OH) sheet which is itself formed by Mg-(O,OH) octahedra. Thus the fundamental serpentine layer is polar and has a tetrahedral and octahedral component. The mismatch in dimensions of these two components generally leads to curvature of the layers and in chrysotile asbestos the layers form either scrolls or concentric cylinders with very high length/breadth ratio and with length parallel to the fiber axis. Other forms of serpentine, however, with chemistry very similar to that of chrysotile do not exhibit asbestiform morphology.

EPIDEMIOLOGICAL EVIDENCE ON ASBESTOS

I. Selikoff, W. Nicholson and A. Langer
Mt. Sinai Hospital
New York, New York

Data on the human health effects from occupational and environmental exposure to asbestos will be presented with special emphasis on the role of different asbestos minerals. Further, human tissue burdens of fibers and their association with asbestos related diseases will be discussed. Experimental animal data from various species and utilizing different routes of administration will also be presented, again with emphasis on differing fiber types.

MEASUREMENT OF ASBESTOS RETENTION IN HUMANS RELATED TO HEALTH EFFECTS

J. Bignon
Université Paris-Val de Marne
Institut de Recherche sur l'Environnement
Centre Hospitalier Intercommunal
94010 Créteil, France

and

P. Sebastien and A. Gaudichet
Direction Départementale des Affaires Sanitaires et Sociales
75013 Paris, France

The retention pattern of particulate pollutants in humans is related to four mechanisms: penetration into the body, deposition on the surface of epithelial cells, intra-tissular translocation and clearance. Knowledge of such retention patterns for people exposed to asbestos dusts could provide useful information concerning the role of these mechanisms and the pathogenicity of fibers.

So, a biological monitoring program for asbestos has been carried out. This program, still in progress, involves measurement of asbestos burden in several kinds of biological samples ("in vivo" and "post mortem" samples) from people diversely exposed to asbestos dusts and affected by various asbestos-related diseases.

So far, most of the samples studied were from the respiratory tract: sputum, broncho-alveolar washing fluid, lung parenchyma, lymph nodes, parietal pleura and pleural fluid. Asbestos burden in these samples has been assessed by light and electron microscopy. In each sample, asbestos fibers, identified as chrysotile or amphiboles, have been counted and measured (length and diameter).

It has been assumed that asbestos fibers found in broncho-alveolar washing fluid were related to the deposited fraction of the inhaled aerosol whereas those found in sputum seemed more related to clearance of fibers from the lung.

The search for asbestos bodies in sputum has been found to be a good means to detect past occupational exposure, whereas TEM size fibers were present in sputum of some cases environmentally exposed.

The measurement program in tissue samples has been principally designed to compare asbestos burden in lung parenchyma, lymph nodes and parietal pleura. Concentration, type and size distribution of fibers encountered in such samples could be accurately assessed. Detailed analytical data will be given in the final document. Regarding asbestos burden in respiratory tissues, the results can be summarized as follows:

- Despite the fact that most of the consumed asbestos is of chrysotile type, the burden of amphibole in lung parenchyma was much more important in most cases.
- Most of fibers retained in lung tissues were less than 0.5 μm in diameter and shorter than 5 μm.
- Differences in size distribution according to the type of tissue samples have been observed.
- There was no evident correlation between fiber concentration in lung parenchyma and fiber concentration in parietal pleura.
- While was found a mixture of amphibole and chrysotile fibers in lung parenchyma, it seemed that amphibole-type fibers moved preferentially towards mediastinal lymph nodes and chrysotile type fibers towards parietal pleura.

The signification of these data, concerning the topographic variation in the fiber type and size, will be discussed in relationship with adverse health effects, particularly cancerogenesis.

REVIEW OF EPIDEMIOLOGICAL EVIDENCE OF THE EFFECT OF TYPES OF ASBESTOS AND FIBER DIMENSIONS ON THE PRODUCTION OF DISEASES IN MAN

W. Clark Cooper
Equitable Environmental Health, Inc.
Berkeley, California

There is epidemiologic evidence to indicate that all types of commercial asbestos, i.e., chrysotile, crocidolite, amosite, tremolite, and anthophyllite, when inhaled, can cause pulmonary fibrosis and increase the risk of lung cancer. All but anthophyllite have been associated with malignant mesothelial tumors. There is also strong evidence to support a decreasing gradient of pathogenicity as one proceeds from crocidolite to amosite to chrysotile, but this evidence does not clearly rule out the interrelated influence of fiber dimension, shape, and co-factors.

Clear-cut epidemiologic evidence related to differing fiber dimensions is scanty. Such information is critically needed. The most pressing need is to determine the pathogenicity of ultrafine fibers in the electron-microscope size range, particularly those shorter than 3 micrometers, whether inhaled or ingested. Methods for epidemiologic study will be suggested.

PATHOPHYSIOLOGY IN RELATION TO THE CHEMICAL AND PHYSICAL PROPERTIES OF FIBERS

Paul Kotin, M.D.
Johns-Manville Corporation
Denver, Colorado

The array of asbestos-related diseases are reviewed in relation to their pathogenesis, pathology, and natural history. Biological availability following host entry is especially critical for the biological effect of asbestos. Experimental data consistently demonstrate that hazard is related to the geometry of fibers, with fiber diameter and fiber length being primary determinants. Controversy exists as to the extent of influence of the two major classes of asbestos fiber: chrysotile and amphibole. Considerations affecting the anatomic and metabolic fate of asbestos fibers are also discussed.

THE CARCINOGENICITY OF FIBROUS MINERALS

Mearl F. Stanton and Maxwell Layard
National Cancer Institute
National Institutes of Health
Bethesda, Maryland

The carcinogenicities of 37 different dimensional distributions of seven different durable fibrous materials have been correlated with fiber dimension. Optimum carcinogenicity is attained with fibers that measure ≤ 0.25 µm x > 8 µm. Morphologic studies suggest that fibers in this dimensional range lie free in interstitial tissues, while fibers of smaller dimension are readily phagocytosed and fibers of larger dimension are sequestered by adherent phagocytes and fused phagocytic giant cells. Fibers that are fine and long may be more carcinogenic than others, simply because they are uncompromised by phagocytic activity.

EFFECTS OF INJESTED ASBESTOS

R. D. Pontefract
Department of Health and Welfare
Ottawa, Canada

There is relatively little information in the literature concerning the effects of injested asbestos. A summary of the work accomplished will be presented with comments on what effects the objectives of the various workers had on their findings. Comments will also be made on some approaches that might be tried to help yield results that can perhaps clarify some of the many problems that yet exist with this difficult subject.

EPA STUDY OF BIOLOGICAL EFFECTS OF ASBESTOS-LIKE MINERAL FIBERS

Lalita Palekar
Northrop Services Inc.
Research Triangle Park, North Carolina

and

David L. Coffin
EPA Health Effects Research Laboratory
Research Triangle Park, North Carolina

A large amount of the earth's crust is composed of rock containing mineral fibers which resemble asbestos to varying degrees in their physical and chemical properties. Consequently, such materials are likely to be encountered inadvertently during the extraction of various ores, the extraction of rock for commercial purposes, and even from rock moving operations encountered during highway construction, and the like.

Because the air and water may become contaminated by these fibers, it is of interest from the standpoint of environmental protection to know how the biological effect of such materials compares with that of asbestos. Consequently, a study has been instituted by EPA to investigate the relative biological potency of such materials. The project is being approached on both in vivo and in vitro levels. The material being studied at the outset are fibrous amphiboles from a taconite mine, but it is the intent to broaden these studies as soon as possible. The animal studies are being conducted in pathogen free rats by intra-tracheal instillation (with and without interacting organic carcinogens) and by intra-plural injections. The end points are tumor induction and other chronic diseases. Attention is also being given to early pathogenic sequences.

The in vetro studies consist of red cell lyses of pulmonary macrophage systems and various biological and chemical studies connected with the influence of these agents on cell membranes and interaction with mutagens and carcinogens. The prime objective is to compare the biological effect of the minerals studied to the corresponding asbestos species to determine the comparative influence of such co-variables as fiber length, trace element content, surface area, zeta potential, and the like, on the biological outcome. Thus the study will relate biological activity to mineralogical characterization so that generalization can be made on the basis of such factors.

IDENTIFICATION OF SELECTED SILICATE MINERALS AND THEIR ASBESTIFORM VARIETIES

William Campbell
Bureau of Mines
College Park, Maryland

The asbestiform particulate problem, with its environmental and health implications, has been compounded by the lack of precision with which the term "asbestos" has been used. In many instances, non-asbestiform mineral particles have been identified as microscopic fibers of asbestos-related minerals. This lack of precision in identifying these particulates not only works to the disadvantage of the minerals industry, but is also a handicap to rational science-based decision making by regulatory agencies.

This report summarizes methods and terminology suggested by the Bureau of Mines for the identification and characterization of asbestiform minerals and also sharpens the distinction between common serpentine, and amphibole minerals and their relatively rare asbestiform varieties. The continuing effort of the Bureau's Particulate Mineralogy Unit is to characterize mineral particulates by morphological, compositional, and structural data using various instrumental analytical techniques and by developing new methods for identification and characterization.

ELECTRON MICROSCOPY METHODS

Clayton O. Ruud
Denver Research Institute
University of Denver
Denver, Colorado

According to a recent National Academy of Sciences Report, animal deposition model studies have shown the fiber size has some effect upon the toxicity of mineral fiber fragments, the long thin ones appearing to be most active. However, the extrapolation of these results to the relative carcinogenicity in humans must be tempered by the consideration that an experimental animal model has not been established. Moreover, the size range to be considered long thin fiber fragments is not clear, that is to say the shortest length may be on the order of one micron or ten microns. For this and other reasons most scientists in the field consider that it is necessary to obtain length and width data, as well as concentration and species of mineral fibers fragments in the environment.

Due to these considerations, microscopy methods are necessary for mineral fiber fragment analysis, and because of the small size of the particles, electron microscopy is necessary. This paper will describe the methods and techniques of electron microscopy which are most generally applied. These are the transmission electron microscope-selected area electron diffraction (TEM-SAED) and the scanning electron microscope-energy dispersive X-ray (SEM-EDX) methods. The advantages and disadvantages of these two techniques will be discussed including their relative proficiency in detecting sub-micron fiber fragments. Their ability to identify the species of mineral, sample preparation techniques, statistical considerations and the time required for analysis will also be reviewed.

The application of various techniques and methods based upon the TEM-SAED or SEM-EDX systems will be discussed including situations where one or the other is the optimum method. The advantages of combined systems, scanning transmission electron microscopy with SAED and EDX, will be discussed. Also new approaches of combination and computer controlled methods using both TEM and SEM will be described.

In conclusion, the state of the art will be discussed in terms of general considerations necessary for the selection of an electron microscopy technique for mineral fiber fragment analysis.

TEM METHODS

Ian Stewart
Walter C. McCrone Associates, Inc.
Chicago, Illinois

The necessary requirements for the TEM identification and quantification of asbestos will be reviewed. Techniques currently in use will be described, and their relative merits discussed.

MINERAL FIBER IDENTIFICATION USING THE ANALYTICAL TRANSMISSION ELECTRON MICROSCOPE

D.R. Beaman and H.J. Walker
The Dow Chemical Company
Midland, Michigan

In a transmission electron microscope equipped with an energy dispersive spectrometer (EDS), it is possible to obtain the high resolution morphology, crystal structure, and elemental composition of submicron mineral fibers, particulate, and thin films. The reliability of fiber analysis is enhanced when fiber identification is based on the nearly simultaneous determination of these three characteristics because each of the individual modes can yield ambiguous information. Energy dispersive spectrometer data can be converted to elemental fiber compositions using known standard spectra or relative sensitivity factors which can be calculated or experimentally determined for a given instrumental configuration. Calculated and experimental sensitivity factors are found to agree within 15% for photon energies above 1.5 keV. The relative error in composition calculated from EDS spectra will generally be better than 10%, but only if the TEM column and components have been properly modified to reduce the effects of extraneous x-ray generation and electron scattering. The sources of these problems are described and a procedure for minimizing the effects outlined. Proper aperturing, collimation, selection of materials of construction, and operating conditions can provide useful mineral spectra. It is often necessary to correct for x-ray absorption even in fine mineral fibers, and this may be done using reference standards or sensitivity factors corrected for absorption. The effect of absorption increases rapidly as the difference between the mass-absorption coefficients of the elemental constituents by the mineral increases. Carbon contamination which degrades both EDS spectra and electron diffraction patterns can be minimized by using low current density and short analysis times.

Less than 15% of the chrysotile fibrils in a standard provided positive selected area electron diffraction patterns (SAED), but up to 50% did have the correct layer line spacing. The fraction of fibers providing good diffraction increases rapidly as the number of fibrils in a fiber increases. The reported differences in SAED quality arise primarily because investigators use differing criterion for defining a positive SAED pattern and the fiber size distribution examined varies. Sample preparation methods were reviewed and it was found that condensation washing is only reliable if loss corrections are applied, particularly in the case of amphibole fibers. In spite of the many problems, inter-laboratory and multiple sample reproducibility in the measurement of fiber concentrations can be ±30% when using good procedure.

IDENTIFICATION OF ASBESTOS BY POLARIZED LIGHT MICROSCOPY

John Delly
Walter C. McCrone Associates, Inc.
Chicago, Illinois

A number of analytical tools can be used to characterize and identify asbestos: infrared absorption, x-ray diffraction, DTA, SEM, TEM, and the light microscope. Each has advantages and limitations. The polarized light microscope (PLM) has many advantages, and the only disadvantages are: 1) the asbestos particles must be at least a micrometer in largest dimension, and 2) considerable training in optical crystallography is needed.

PLM, on the other hand is very sensitive (ppm range), extremely rapid (1-5 minutes to identify all components of most samples) and, of all the methods, only PLM will identify the individual amphiboles.

STATISTICS AND INTERPRETATION OF ANALYTICAL RESULTS

James Leineweber
Johns Manville Corporation
Denver, Colorado

The analysis of asbestos fibers by electron microscope methods involves many operations each of which can have an effect on the final results. The potential errors in each of the steps as well as the influence of normal statistical fluctuations is discussed. Recommendations are made on how the controllable errors can be minimized and for a uniform reporting format.

SELECTION AND CHARACTERIZATION OF FIBROUS AND NON-FIBROUS AMPHIBOLES FOR ANALYTICAL METHODS DEVELOPMENT

J.C. Haartz and B.A. Lange
National Institute for Occupational Safety and Health
Cincinnati, Ohio

and

R.G. Draftz and R. Scholl
IIT-Research Institute
Chicago, Illinois

More than 50 mineral specimens of fibrous and non-fibrous amphibole species, including specimens of actinolite, tremolite, grunerite, and cummingtonite were collected and characterized to determine their suitability for use as reference materials in the development of analytical methods. These methods will be used for the detection and measurement of hazardous materials which are found as workplace contaminants. While the existing sample of each mineral is quite limited, the source of each of the specimens and the appropriate methods of sample preparation have been carefully documented should additional quantities be desired.

These specimens have been characterized using light microscopy, X-ray diffraction (XRD) and thermal analysis (DTA). Some of these specimens have been purified by appropriate physical or chemical techniques and then ground to provide a material with a mass median particle size of less than 10 μm diameter. The effects of characterization studies of the minerals, including a comparison of the properties determined for each of the specimens, will be presented. Differences in physical properties, as determined by DTA and XRD, of the fibrous and non-fibrous specimens are indicated by the data obtained.

ASBESTIFORM MINERALS IN INDUSTRIAL TALCS: COMMERCIAL DEFINITIONS VERSUS INDUSTRIAL HYGIENE REALITY

John M. Dement
National Institute for Occupational Safety and Health
Cincinnati, Ohio

As part of its industry-wide study of the talc industry, the National Institute for Occupational Safety and Health (NIOSH) has conducted detailed industrial hygiene studies of mine and mill operations processing talcs contaminated with asbestiform minerals. The principal analytical method used for studies of asbestiform minerals in talc bulk samples and airborne dust samples is analytical transmission electron microscopy utilizing selected area electron diffraction and microchemical analysis for fiber identification. This presentation includes a discussion of the methods of analysis being used by NIOSH and comparisons of results of analysis with other analytical techniques. Also included are results of NIOSH industrial hygiene studies in asbestiform talc operations and comparisons of airborne fiber characteristics (fiber length, diameter, aspect ratios, etc.) in these operations with other industrial processes using asbestos fibers.

THE DETECTION AND IDENTIFICATION OF ASBESTOS AND ASBESTIFORM MINERALS IN TALC

Harold D. Stanley and Robert E. Norwood
Pfizer Inc.
Easton, Pennsylvania

Concern with the health hazards associated with the presence of chrysotile asbestos and/or the asbestiform minerals in talc has prompted widespread investigation of methods of analysis which would be consistent with good analytical practices. Of all the currently available techniques examined and evaluated, the two most reliable have been found by us to be Step Scanning X-ray Diffraction and Transmission Electron Microscopy, (TEM), with Selected Area Electron Diffraction, (SAED). The Step Scanning X-ray Diffraction technique allows quantitative detection and identification of tremolite and the asbestiform minerals down to 0.1% by weight. In the absence of chlorite it can detect and quantitatively determine chrysotile asbestos at the 0.5% level. Chlorite, however, is often associated with talc ore bodies. When present, chlorite will mask most of the main X-ray diffraction peaks of chrysotile. Additionally, the X-ray diffraction technique cannot distinguish between fibrous and non-fibrous forms of the asbestiform minerals. TEM is ideally suited to determinations of this type because of its high resolution and magnification capabilities, the morphological nature of the problem and the mineralogical identification capability through SAED.

MISIDENTIFICATION OF ASBESTOS IN TALC

Jerome B. Krause
Colorado School of Mines Research Institute

and

William H. Ashton
Johnson & Johnson
New Jersey

Both optical microscopy and x-ray diffraction (XRD) are widely used to detect minerals associated with talc. Optical microscopy can determine the morphology of a particle, but cannot always fully identify the specific mineral. Although XRD is an excellent screening technique for the detection of minerals associated with talc, the method can misidentify minerals due to interferences, interpretive errors, and the inability to determine morphology.

Methods for reduction or elimination of these problems include special techniques of sample preparation and x-ray diffraction, combined with microscopic examination (both optical and electron).

AMBIENT AIR MONITORING FOR CHRYSOTILE IN THE U. S.

— Richard Thompson
Environmental Protection Agency
Research Triangle Park, N.C.

The only continuing national air monitoring has been conducted by the National Air Surveillance Network. The objective is long-term trend assessment of air quality. The information has proven of value in setting standards, in consideration of health effects, in estimation of economic effects and in showing patterns of pollutant distribution in both urban and non-urban areas.

In order to provide samples which could be analyzed for constituents not determinable in particulate matter samples collected with glass fiber filters, a membrane sampling network was instituted. The only analyses of the samples conducted thus far has been for airborne asbestos using in part a method developed under contract which provides for the determination of mass of chrysotile in the particulate samples.

A viewpoint will be presented on the method needed for air monitoring and an assessment of the mass method as the most suitable for this purpose. Data obtained will be examined which will include information on inter- and intra-laboratory replication.

THE ENVIRONMENTAL PROTECTION AGENCY INTERIM METHOD FOR DETERMINING ASBESTOS IN WATER

Charles H. Anderson
Environmental Protection Agency
Athens, Georgia

The discovery of asbestos and asbestiform minerals in water supplies and drinking water has resulted in the requirement for a reliable analytical method. In order to meet this requirement, an interim method, based upon the state-of-the-art in asbestos analytical methodology, has been issued. In this paper, the broad elements of the method are set forth and discussed.

ASTM E-4 REPORT

K.S. Chopra
Union Carbide Corporation
Niagara Falls, New York

ASTM Committee E-4 has been experimentally evaluating high magnification microscopic techniques being used for the analysis of fiber contamination in water. This paper will describe the procedures and present status of this technique evaluation.

THE STANDARD FOR OCCUPATIONAL EXPOSURE TO SBESTOS
BEING CONSIDERED BY ASTM COMMITTEE E-34

M. Cassette and A.A. Winer
University of Sherbrooke
Quebec, Canada

This presentation reviews the consensus reached by the Task Group on Naturally Occurring Inorganic Fibers of ASTM Committee E-34. Significant differences with the OSHA regulation are pointed out on the following topics: Definitions, exposure limits, record keeping, monitoring, and the counting method. The reasons for these differences are outlined and a rationale in support of a dual standard is presented. This Task Group document is now under study according to official ASTM procedures.

IMPORTANT CONSIDERATIONS IN THE IDENTIFICATION AND COUNTING OF MINERAL FRAGMENTS

R.J. Lee, J.S. Lolly and R.M. Fisher
U.S. Steel Research Lab.
Monroeville, Pennsylvania

Positive identification of some micron diameter mineral fragments, and especially of amphiboles, required both chemical and crystallographic analysis of the unknown particle. At present only electron optical methods can be used for this purpose and considerable care must be taken to ensure that: 1 - the x-ray spectra and diffraction patterns pertain only to the particle in question (i.e., spatial resolution limitations must be recognized); 2 - x-ray data are compared with well characterized referenced standards; 3 - overlapping chemical composition and/or similar crystal structures of mineral series are recognized; 4 - crystal fragment is tilted into a zone-axis orientation before recording the electron diffraction pattern; 5 - appropriate statistical criteria are used to evaluate the significance of the results on individual or groups of samples. These problems and the analytical procedures used to minimize them will be described.

MESA REGULATIONS AND METHODS

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MESA
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MESA regulations for exposure to asbestos require that no employee be exposed to airborne concentrations greater than 5 fibers/ml (soon to be reduced to 2 fibers/ml) greater than 5 micrometers in length on a time-weighted average basis. We are proceeding with public meetings to obtain necessary data to reduce this permissible exposure even further. We use the membrane filter method for sampling and phase contrast microscopy for counting. Our regulations specify that the term asbestos refers to chrysotile, amosite, crocidolite, anthophyllite asbestos, tremolite asbestos, and actinolite asbestos. In order to analyze for specific minerals we have contracted with Dr. Ruud at the University of Denver.

OSHA REGULATIONS AND METHODS

Willard C. Dixon
OSHA
Salt Lake City, Utah

OSHA uses the membrane filter method at 400 - 450x magnification (4mm objective) with phase contrast illumination for the analysis of asbestos in air. This method is substantially the same as is used by NIOSH.

In an atmosphere known to contain asbestos, all particulates with a length to diameter ratio of 3:1 or greater and a length greater than 5 micrometers are, in the absence of other information, considered to be asbestos fibers and counted as such.

The equipment for optical analysis of asbestos in use at the OSHA Salt Lake City Laboratory includes Zeiss microscopes having 40x objectives and 10x eyepieces, rotating stages, phase contrast illumination, polarized light, and retardation plates. The transmission electron microscope equipment in use by OSHA at the Salt Lake Laboratory is a Jeol model JEM 100C with a side entry goniometer and ASID-45 Model EM-15 SPS-2 scanning image display unit. We also have an Ortec-Delphi x-ray energy dispersive system.

X-ray diffraction, atomic absorption and other instrumentation are also available.

The techniques used for the identification of asbestos include sight recognition based on morphology, and optical tests including polarized light, index of refraction, angle of extinction, dispersion staining, and retardation. Electron microscopy tests include morphology, selected area diffraction and a determination of elemental composition by x-ray energy dispersive analysis.

A plan is presented for distinguishing between asbestos and other fibers which may be mistaken for asbestos. A system for differentiating between the various kinds of asbestos fibers is also presented.

FDA PROJECTS AND METHODS

Irvin Asher, John Wenniger, and Philip McGrath
Food and Drug Administration
Washington, D.C.

An overview of FDA projects related to asbestos detection and quantitation is presented. The results of a recent FDA symposium on the availability of suitable techniques are included. We then review the technical and regulatory issues in the food and cosmetics area with regard to asbestos contamination with emphasis on the analysis of perenteral drugs and cosmetic talc. For the present, SEM using Nucleapore filters as a substrate and EDXA for chemical analysis appears to be a reasonable, cost effective method for routine detection of asbestos in foods, drugs and biologicals, although quantitation and reduction in the number of ambiguous fibers is still a problem.

IMPACT OF ASBESTOS REGULATIONS ON THE MINING INDUSTRY

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No one in the mining industry objects to proper regulation of toxic substances. No one in the mining industry has any objection to the reasonable control of asbestos as long as the regulations apply to the truly asbestiform varieties of specific minerals. Unfortunately, the regulators have ignored basic mineralogical data and have included numerous minerals which bear no resemblance to the asbestos upon which essentially all health data have been obtained. This gross extrapolation of the known health hazards of excessive exposures to true asbestos, to the non-asbestiform varieties of common rock-forming minerals is totally unwarranted.

The full assessment of the economic impact of the asbestos regulations, as with other restrictive legislation, will undoubtedly take many years. This impact is also greatly dependent upon the outcome and recommendations resulting from this workshop. As of today, if the regulatory agencies apply their present rules and definitions regarding "asbestos", the entire mining industry and those dependent on it face an adverse economic impact unparalled in its history. Furthermore, proposed regulations, based on the same erroneous definitions and extrapolations are so restrictive they threaten the existence of major segments in a wide variety of areas within the mining industry. The continued promulgation and enforcement of mineral legislation based on errors and misconceptions will have astronomical economic effects on the total U.S. economy and on the individual taxpayer.

NIEHS-ORAL ASBESTOS STUDIES

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Epidemiologic data clearly associates inhalation of asbestos with an increased incidence of cancer. In addition to pulmonary thoracic neoplasia, there is data which associates an increased incidence of gastrointestinal and peritoneal tumors. Controversy exists as to whether these latter types of neoplasia result from asbestos fibers that were injested subsequent to clearance from the respiratory system. Exposure to injested asbestos does occur in the general population through the presence of fibers in water and food.

The NIEHS oral asbestos studies in rats and hamsters represent a systematic attempt to assess the biological effects associated with primary injestion of selected asbestos fibers. The objectives of the studies include: assessment of biological (carcinogenic) effects as a consequence of exposure to one of several types of asbestos; assess if an interaction may exist between a chemical carcinogen which is known to produce bowel cancer and injestion of asbestos. The specific experimental design of this series of ongoing studies will be presented.

CPSC REGULATION OF NON-OCCUPATIONAL EXPOSURE TO ASBESTOS IN CONSUMER PRODUCTS

Robert Hehir, Steven P. Bayard, and June Thompson
Consumer Products Safety Commission
Bethesda, Maryland

The Consumer Products Safety Commission (CPSC) has found that exposure to respirably free-form asbestos in two consumer products poses an unreasonable health risk. The Commission has recently voted to ban the use of free-form asbestos in consumer patching compounds, and in artificial fireplace ash or emberizing materials under Section 8 of the Consumer Products Safety Act. The broad regulatory provisions under CPSA, as well as those under the Transferred Acts are discussed.

Data on consumer exposure to asbestos are very limited. One study of airborne asbestos resulting from the use of consumer spackling/patching compounds has reported levels of airborne asbestos fibers exceeding the occupational exposure excursion levels.

Direct evidence exists of asbestos inhalation in non-occupationally exposed individuals from autopsy findings of asbestos fibers in lung tissue, and indirect evidence of asbestos-related cancers in non-occupationally exposed individuals from epidemiological studies.

A risk assessment has been made of the potential increase of lung cancer resulting from heavy consumer exposure to asbestos-containing patching compounds.