THE MINERALOGY AND SIZE OF AIRBORNE CHRYSOTILE AND ROCK FRAGMENTS: RAMIFICATIONS OF USING THE NIOSH 7400 METHOD

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The length and width of chrysotile and rock fragments that were collected on nine air-monitoring filters in the mine and plant of the Lowell asbestos mine in Vermont have been measured by transmission electron microscopy (TEM). Selective area electron diffraction (SAED) and energy dispersive x-ray analysis (EDS) were used to identify particles longer than 5 μm with a length-to-width aspect ratio of at least 3:1 (federal fiber). All federal fibers were found to be chrysotile or serpentinite rock fragment; no tremolite or other amphiboles were detected. Magnifications of 400× and 19 000× were used on five filters in an attempt to compare the size distributions of the federal fibers likely to be measured by using phase contrast optical microscopy (PCM) at 400× to those measured by TEM at higher magnification. The data from the mine show that (1) the size distribution of chrysotile determined at 19 000× differs substantially from that determined at 400× but the size distribution of rock fragment is nearly independent of the magnification; and (2) at 400×, 34% of the federal fibers were chrysotile, 39% were serpentinite rock fragment, and 27% were composite particles, not fibers. At 19 000×, the proportion of chrysotile increased to 77%, reflecting the increased visibility of chrysotile at high magnification. The proportions of chrysotile, serpentinite rock, and composite particles are such that if an air filter were analyzed at 400×, and 1.0 f/cc were determined to be the exposure, 0.3 f/cc would be chrysotile, 0.4 f/cc would be serpentinite rock, and 0.3 f/cc would be composite particles. If TEM were used at high magnification, the total federal fiber burden would rise to 1.6 f/cc with 1.2 f/cc chrysotile and 0.4 f/cc rock fragment. These results suggest that the proportion of federal fibers obtained by the standard PCM method that are actually asbestos may be lower in the chrysotile asbestos mining environment than that obtained in the commercial asbestos handling environments that were used in government quantitative risk assessments. The Occupational Safety and Health Administration excluded epidemiologic studies of asbestos miners and millers from its quantitative risk assessment because evidence showed the risk to be lower than in other industrial environments because of fiber size. Likewise, the use of the PCM National Institute for Occupational Safety and Health 7400 method, which was developed from data taken in commercial asbestos handling as an "index" of exposure, may not be valid in mining environments. TEM analysis of air filters may be necessary to assess chrysotile exposure adequately in mining environments.

Within any given industrial setting, there exists a positive correlation between the incidence of the asbestos-related diseases and the level of exposure to asbestos as established by phase contrast optical microscopy (PCM) and the membrane filter method.[1] However, it is generally not possible to predict closely the risk of disease within one industry by comparing exposures of its workers to exposures and disease incidence from a different industrial environment. For example, the incidence of asbestos-related diseases among Canadian chrysotile miners is less than would be predicted from the experience of textile workers or asbestos insulation workers.[2–5] Also, there is no elevated incidence of mesothelioma among anthophyllite asbestos miners of Paakila, Finland, although high incidence would be predicted based on the experience of crocidolite miners in Australia and South Africa.[6–8]

These observations lead to several possible hypotheses to explain the discrepancies. First, it may be that there are significant differences in the biological activity among the different asbestos minerals. For example, chrysotile fibers appear to dissolve or in some other way be removed from the body but crocidolite fibers do not, and because of this, the long-term effects of exposure to chrysotile may be quite different from the same level of exposure to crocidolite.[9] In fact, because of the behavior of chrysotile fibers in vivo, tremolite-asbestos, which in some cases has been identified as a contaminant in chrysotile, has received much attention as the possible etiologic agent for the diseases that are observed in those "solely" exposed to chrysotile.[10–13] Second, there may be significant differences in the size and shape of the respirable mineral particles making up the dust clouds in different industrial settings; differences that are simply not reflected in the PCM exposure measurements.[14]