

of ferruginous bodies isolated from lungs of urban dwellers in sufficient numbers to yield statistically significant data.

Although identification of the central fiber of ferruginous bodies and of naked fibers has been accomplished by electron diffraction¹⁰ and electron microprobe analysis,¹¹ these techniques are laborious and time consuming. Furthermore, for the large-scale investigation necessary to obtain statistically reliable data, extensive use of the above techniques could prove enormously expensive, since it would tend to monopolize the costly equipment involved and the time of trained technicians.

Also, the need exists for a method which would facilitate acquisition of necessary data rapidly and economically. This communication suggests a means to satisfy these needs. A procedure, essentially a screening method, is described for classifying naked fibers and the central filaments of ferruginous bodies into asbestos or nonasbestos fibers. The cores of ferruginous bodies are made accessible for such classification by freeing them from the encrusting ferruginous shell by chemical or physical means, i.e., either with oxalic acid or ultrasonic vibrations.

Materials and Method

The classification of inhaled fibers isolated from lungs¹² is based on the fact that asbestos fibers are composed of compactly apposed finer fibrils, whereas nonasbestos fibers are homogeneous units. Because of this difference in structure, the fractured ends of these two types of fibers differ in a very important way. The end of an asbestos fiber is irregular and resembles that of a bundle of fragile sticks which has been broken transversely. As might be expected, different fibers of the bundle break at somewhat different points. At an appropriate magnification, therefore, (as described below, using electron microscopy) the fractured end presents an irregular profile with multiple step-like projections and depressions, some of the steps being shallow and others deep (Fig 1). In contrast, inhaled transparent fibers other than asbestos but of similar diameter are likely to be homogenous in character, and, because of this, to fracture so as to present uninterrupted linear profiles at the fractured ends (Fig 2).

Another important difference between inhaled asbestos and nonasbestos fibers is also

based on the multi-unit composition of asbestos fibers and the unitary structure of nonasbestos fibers. A surface view (scanning electron microscope) of the former at a magnification of approximately 20,000 $\times$ shows longitudinal, parallel delineation of individual fibrils (Fig 3). The surface view of a nonasbestos fiber is devoid of such longitudinal lines (Fig 4).

To test the validity of these concepts, electron photomicrographs were made of the ends of several chrysotile, amosite, and crocidolite fibers, as well as the ends of a similar number of glass, ceramic aluminum silicate, and silicon carbide fibers, all of which had diameters within a range of 0.1 μ to 2.0 μ . Without the observer's knowing the identity of the fibers on the photographs, the latter could be sorted easily, quickly, and correctly into asbestos and nonasbestos categories based on the above concepts. A magnification of 20,000 or 25,000 $\times$ appeared optimal for this purpose.

However, the method is not free of possible error. According to the findings of J. P. Leineweber, PhD, (written communication, October 1969), the ends of occasional asbestos fibers, particularly those substantially thinner than 1 μ , may cause them to be categorized wrongly. For such fibers, higher magnifications and use of the scanning microscope is advised.

Comment

A basic criterion of asbestos fiber identification is its tendency toward longitudinal splitting. Initially, there was uncertainty in some photographs in which several fibers known to be glass (one thick and one or two much thinner) were found parallel and in close apposition, giving the appearance of possible longitudinal splitting (Fig 5). The profiles of the fractured ends were interrupted also. However, the interruption consisted of only one or two steps; and there was sufficient width of uninterrupted linear profile to allow differentiation from asbestos. As the diameter of the fiber in question decreases, the component subunits also become smaller so that the magnification must be increased to visualize them. The chance for error appears to increase with substantial decreases in diameter below 0.1 μ . However, inasmuch as the average diameter of naked fibers isolated from lungs of city dwellers in our experience is about 2 μ (unpublished data), we believe the chance of error will be small.

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step profile; paucity of steps and
s nonasbestos fiber ($\times 20,000$).

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