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Characterizing and Discriminating the Shape of Asbestos Particles

H. G. SIEGRIST, JR., AND A. G. WYLIE

Department of Geology, University of Maryland, College Park Maryland 20742

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The lengths and widths of approximately 1000 particles from each of four asbestos samples, two nonfibrous amphiboles, and one talc–serpentine sample were measured utilizing the SEM. The asbestos samples are commercially available and include chrysotile from Quebec, chrysotile from California, amosite from South Africa, and crocidolite from South Africa. The tremolite and talc–serpentine are from New York, and the riebeckite is from California. Beneficiation, including milling of amosite, crocidolite, and tremolite and air classifications of the two chrysotile samples, was done under commercial conditions; the riebeckite was milled in the laboratory. For comparison, the same measurements were made on the California chrysotile using TEM. Shape characterizations of the samples are compared using regression techniques. The usefulness of the various shape definitions including length, width, and aspect ratio (length/width) in characterizing and discriminating between samples is explored and evaluated. Significant results include: (i) Frequency distribution of log length, log width, and log aspect ratio show very apparent differences between asbestos and nonasbestos populations. (ii) Dimensional differences and accurate classification according to dimensions are enhanced by regressing log width and/or log aspect ratio against log length. (iii) Discriminant function analysis is able to quantify the distinction between asbestos and nonasbestos particle dimensions such that over 95% of the population assignments are correct. (iv) Log width is a more efficient classifier than log aspect ratio using either linear regression of discriminant function analysis for these particular samples. (v) The choice of instrumentation, i.e., TEM vs SEM, may affect the sample characterization. (vi) Quantitative descriptions of the dimensions of small particles may be related to the habit of the mineral and the structure of the mineral groups to which the particles belong. However, such mineralogical distinctions are probably not valid for particles whose longest dimension is less than about 1 μm.

INTRODUCTION

Morphology has often been used to characterize, define, and differentiate asbestos minerals. For example, the Occupational Safety and Health Administration defines an asbestos fiber as any particle of anthophyllite, tremolite, actinolite, chrysotile, amosite, or crocidolite longer than 5 μm with an aspect ratio (length/width) of 3 or greater (NIOSH, 1972). This morphological standard originated in England as the result of an air-monitoring program in an asbestos textile factory. The 5-μm length was chosen as a lower limit because the optical microscope was the instrument being used for monitoring. This choice can be justified based on reproducibility studies by Addingley (1966) and Lynch *et al.* (1970) which show that the counting of less than 5-μm fibers can lead to imprecise results. The choice of an aspect ratio of 3, however, was arbitrary, and not based on any systematic study. It has yet to be shown that this aspect ratio has any relationship to biological activity or disease, nor does such an aspect ratio uniquely define asbestos. Many materials break, cleave, or crystallize with aspect ratios in excess of 3.

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