Since the structure is the complex *APD* structure of the type $([M]\,|\,[\bar{M}])$, we should have

$$\omega^{(1)}_{(s)} = \omega^{(2)}_{(s)} \quad \text{and} \quad \omega^{(2)}_{(s)} = \omega^{(1)}_{(s)} . \tag{A33}$$

As a result, we have

$$\omega_{(s)} = \omega^{(1)}_{(s)} + \omega^{(1)}_{(s)} = \omega_{(\bar{s})} \tag{A34}$$

and hence

$$\omega_{(s)} + \omega_{(\bar{s})} = 2\{\omega^{(1)}_{(s)} + \omega^{(1)}_{(\bar{s})}\} , \tag{A35}$$

this meaning that the following relation holds in general:

$$\{\Omega_r\} = 2\{\Omega^*_r\} . \tag{A36}$$

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Study of Microstructure of Chrysotile Asbestos by High Resolution Electron Microscopy

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(Dedicated to Professor Tadatosi Hibi in honour o. his 61st birthday)

Several samples of chrysotile asbestos from different localities, including a synthetic sample, were electron-microscopically observed by the lattice imaging method along two directions parallel and perpendicular to the fibre axis. The results are as follows: (*a*) The lattice fringes of 4·5 Å corresponding to 020 were often tilted to the edge of the fibrils with an angular distribution ranging up to about 10° with a peak value at a few degrees, depending on the sample. (*b*) Most of the fibrils examined were hollow cylinders and their circumferential lattice layers form spiral or multi-spiral layers. The perfectly concentric cylindrical layers were also found with a frequency depending on the sample. (*c*) Unusual growth patterns which cannot be explained by Jagodzinski and Kunze's model were observed. (*d*) The lattice images of the conical fibrils (cone-in-cone shape) were observed in the synthetic sample. (*e*) Most fibrils greater than about 350 Å in diameter showed traces of discontinuous growth in two or three steps, depending on the growth conditions, and this gave rise to various distributions of the fibril diameters.

Introduction

From studies using the methods of X-ray diffraction, electron microscopy and electron diffraction, it has been pointed out that there are morphological and structural variations in chrysotile asbestos (Whittaker, 1951; Jagodzinski & Kunze, 1954; Whittaker, 1955, 1956*a*,*b*,*c*, 1957; Whittaker & Zussman; 1956). In earlier X-ray studies, however, single crystals were not available, while in subsequent studies made on single crystals (individual fibrils), by means of electron microscopy combined with selected area electron diffraction, the instrumental resolution was not high enough to resolve the fine structures (Honjo & Mihama, 1954; Zussman, Brindley & Comer, 1957; Bates & Comer, 1957).

Recently, it has become possible to observe lattice planes in the individual fibrils of chrysotile (Fernández-Morán, 1966; Yada, 1967), and it has been found, for example, that the circumferential lattice images observed in the cross-section of a fibril show a spiral or multi-spiral structure. The previous work by the present author, however, was done for a sample from only one source (Quebec, Canada,) and, moreover, the observation of the detailed structure at the inter- and intra-fibril sites was hindered by the damage due to irradiation by the electron beam required for high magnification electron microscopy. Therefore, in order to obtain a comprehensive understanding of the microstructures and growth mechanism of chrysotile, it seemed desirable to study samples from different localities by the use of a improved technique by which the radiation damage was minimized.

The specimens and experimental technique

Table 1 shows a list of the samples examined. Most of these samples are chrysotile ores, except the last one which is powder Mg-chrysotile synthesized under controlled conditions (Noll, Kircher & Sybertz, 1958, 1960).

A small quantity of chrysotile was torn off with tweezers, and as in the previous work (Yada, 1967) observations were made from two directions, parallel and perpendicular to the fibre axis, employing the sectioning technique by ultramicrotomy as well as the