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K. Seshan and H.-R. Wenk

March 1976

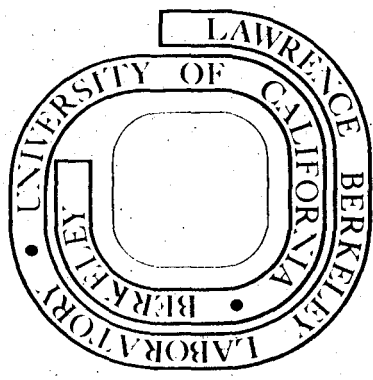
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IDENTIFICATION OF FAULTS IN ASBESTOS MINERALS AND
APPLICATION TO POLLUTION STUDIES

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Asbestos fibre texture occurs in various mineral groups (e.g. chrysotile, crocidolite, tremolite, grunerite, tourmaline) and it has been established that at least chrysotile is carcinogenic. We are investigating various aspects of the asbestos structure, with transmission electron microscopy (TEM) (1) in order to develop methods for unequivocal asbestos identification using minute samples and also to determine defects responsible for the fibre structure in these minerals which often occur as large, well-developed single crystals.

In order to do this, we have started by investigating clinoamphibole asbestos such as tremolite $\text{Ca}_2\text{Mg}_5[\text{Si}_8\text{O}_{22}](\text{OH}, \text{F})_2$ and crocidolite $\text{Na}_2(\text{Mg}, \text{Al}, \text{Fe}^{3+}, \text{Fe}^{2+})[\text{Si}_8\text{O}_{22}](\text{OH}, \text{F})_2$, from California localities. In crocidolite - asbestos we observed a high density of very narrow microtwins parallel to the fibre axis [001] (Fig. 1). They are often only 50-100Å wide. Diffraction patterns display the typical twin arrangement of spots and although preliminary contrast experiments are not yet conclusive the twin plane appears to be (100). We have also observed microtwins in tremolite asbestos. In tremolite we found additional faults parallel to [001] (Fig. 2). It was possible to get these faults out of contrast in darkfield images by having certain reflections operating. Thus we interpret them as stacking faults. In specimens with high fault densities streaking parallel to a^* has been observed in SAD's. These faults seem to be responsible for aperiodic interruptions in lattice fringe patterns which have been observed in high resolution photographs (Fig. 3). In some crystals we could identify another type of domains parallel to [001] which have (010) in common. It is produced by small misorientations of fibrils (Fig. 4).

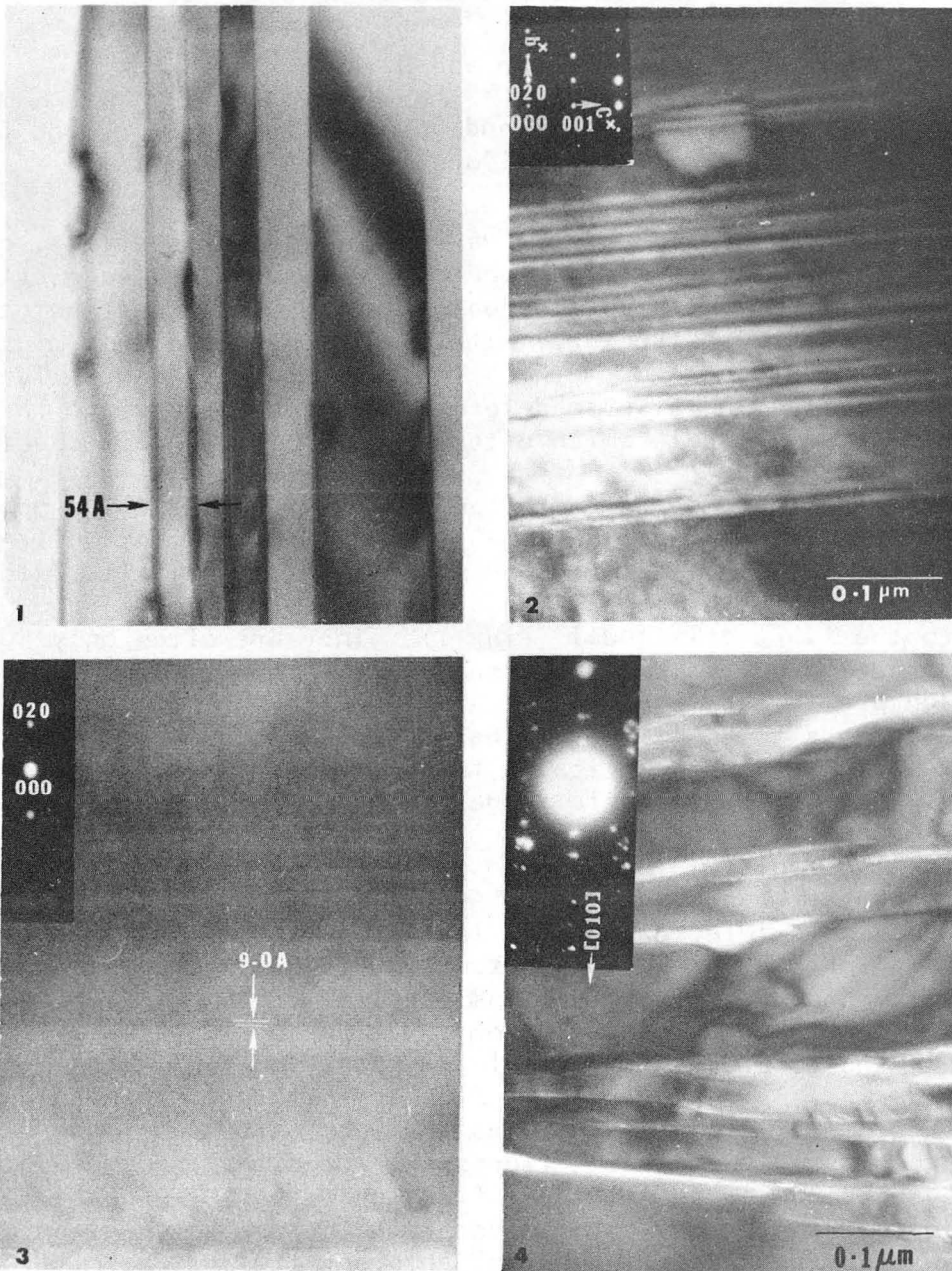
We regard these defects (twins, planes, stacking faults and misorientation boundaries) as causes for the fibrous texture in amphibole minerals. We have observed very similar features in asbestos samples from UICC standards and are presently analyzing fibres extracted from human lung tissue. We explore the value of defect identification with TEM by quantitative diffraction contrast experiments to determine asbestos varieties in very small amounts as they exist in medical samples, thus not permitting the use of standard X-ray diffraction and chemical methods. Implications of recent reports (2) and (3) are that diffraction patterns are insensitive to tilting and that indexing is ambiguous. We, on the contrary, feel that considering complexities introduced by the monoclinic symmetry and by faults and carefully separating Laue zones, the procedure for indexing diffraction patterns is straightforward as demonstrated with the figures.

We acknowledge discussions with Prof. J. Washburn and encouragement from Prof. G. Thomas and Dr. J. Wessolowski. The microscopes used in this study were acquired with ERDA funds.

(1) K. Seshan, LBL report 4549. Submitted to Env. Res.

(2) M.I. Skikne, J.H. Talbot, R.E.G. Rendall, Env. Res. 4, 141, (1971).

(3) R.L. Clarke, C.O. Rudd, Micron 5, 83, (1974).



- Fig. 1. Bright field image of crocidolite microtwins parallel to [001] = fibre axis
- Fig. 2. Dark field image ($g=020$) of stacking faults in tremolite asbestos indexed SAD in same orientation
- Fig. 3. High resolution micrograph of UICC tremolite showing 020 fringes and faults
- Fig. 4. Rotation boundaries in tremolite. Notice that they have (010) in common (SAD)

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