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X-RAY STUDY OF CHRYSOTILE

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X-ray diffraction work on serpentine minerals has revealed the structural scheme of this group, particularly of chrysotile and antigorite (Aruja, 1945; Whittaker, 1952, 1953, 1955, 1956; Zussman, 1954), and it has been shown that curving of the structural sheets occurs in chrysotile, forming cylindrical tubes. It has also been suggested, and in some cases demonstrated, that the platy rather than fibrous habit in serpentine minerals is connected with the chemical composition of the specimen (Hess *et al.*, 1952; Nagy 1953; Roy and Roy 1953; Bates 1959). With regard to the structural difference between the fibrous and splintery varieties of chrysotile as they appear under the electron microscope, Zussman *et al.* (1957) have shown that the splintery varieties have a greater degree of structural order than do the silky varieties.

From the museum of the Department of Mineralogy and Petrology we have selected for our study seventy specimens of serpentine minerals, chosing those which had marked differences in texture and/or appearance. *X*-ray powder photographs have been taken with a camera of 19 cm diameter using Cu-Ni filtered radiation. In order to obtain predominant morphological features, all specimens have also been examined by means of the electron microscope.

The criteria used for the identification of serpentine minerals were those of Whittaker and Zussman (1956). The following results have been obtained: four specimens were identified as antigorites, nine as six-layer orthoserpentines, twenty-five as lizardite, and the rest were classed as clinochrysotiles; orthochrysotile being present only in a few specimens in minor amounts. From the clinochrysotile group we have separated one group of specimens, 16 in number, which we named "Povlen-type" clinochrysotile, all of which showed identical fiber patterns. It is well known that all reflections on the fiber pattern of chrysotile can be divided into two groups: sharp reflections that occur on all even-layer lines including the zero layer, and diffuse bands on odd-layer lines. Clinochrysotile of the "Povlen-type" shows sharp reflections on all layer lines up to sixth, recorded with Cu radiation using the technique described by Whittaker (1953, 1956). All of the reflections on the fiber pattern were indexed on a cell having the following constants:

$a=5.30$ Å $\quad b=9.20$ Å $\quad c=14.56$ Å $\quad \beta=93°12'$

Reflections on the even layers were similar in intensities to those of chrysotile asbestos, but several reflections with l index odd, of medium intensities, were present as well. The powder pattern (Table 1) is characterized by the sharp reflections; the region at 2.5 Å shows good resolution, with the 131 reflection of medium intensity. These observations are similar to those of Zussman *et al.* (1957) made by electron diffraction on splintery clinochrysotile from Zermat. However it is important to note that all of the clinochrysotiles which we have examined so far by taking

TABLE 1. X-RAY POWDER DATA FOR "POVLEN-TYPE" CLINOCHRYSOTILE. Cu $K\alpha$ RADIATION

hkl	$d_{calc.}$ (Å)	$d_{obs.}$ (Å)	$I_{obs.}$
002	7.27	7.35	10
020	4.60	4.54	5
004	3.66	3.64	9
130	2.653	2.652	2
131	2.598	2.604	3
201	2.584	2.592	3
$20\bar{2}$	2.532	2.533	2
202	2.445	2.446	9
203	2.270	2.272	1
$20\bar{4}$	2.198	2.210	1
204	2.085	2.088	4
205	1.906	1.902	$\frac{1}{2}$
$20\bar{6}$	1.844	1.842	$\frac{1}{2}$
008	1.817	1.824	1
206	1.742	1.746	3
060	1.534	1.532	8
062	1.500	1.503	1
00 10	1.454	1.456	1
064	1.410	1.414	$\frac{1}{2}$
$40\bar{2}$	1.310	1.317	3
$20\ \overline{10}$	1.305	1.307	3

fiber diagrams and which appear massive or platy in hand specimen, belong to the "Povlen-type." Examined under the electron microscope they show lath-like character, and they cannot be distinguished from 6-layers orthoserpentines by morphological features alone. It can therefore be assumed that there are two types of clinochrysotiles: one type has a layer structure based on a cylindrical lattice and the other type is represented by specimens whose layers are much less curved and whose structure shows a greater degree of order. Our investigation did not reveal the presence of any transitional type of clinochrysotile between these two groups. Further structural work on "Povlen-type" clinochrysotile as well as on 6-layer orthoserpentine, which occurs closely associated in many Yugoslavian localities, is now in progress in our laboratory.

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GROWTH SPIRALS ON PRISM FACES OF CULTURED QUARTZ

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Employing precision optical techniques, we have examined microstructures on faces of about seventy crystals of cultured quartz. We were interested in examining remarkably plane surfaces, with an expectation of growth spirals on them, which might throw light on understanding the mechanism of growth of such crystals. Spirals are seldom observed on prism faces of cultured quartz, and as far as we know there is no report of growth spirals on them.

We have recently obtained several specimens of cultured quartz of electronic grade, synthesized by overseas manufacturers. We have observed a variety of growth spirals on a number of prism faces of several synthetic crystals. Figure 1 shows a region of a prism face on which a number of spirals appear. Here AB represents the m-R edge. Of all the spirals observed on different prism faces, the longer arms are found to be strictly oriented at 60° to the m-R edge. Figure 2 is a positive phase contrast photomicrograph which illustrates a growth spiral at a higher magnification. Several such single spirals have been observed. Besides these, spirals of opposite sign have also been observed, one such case being shown in Fig. 3 which is a positive phase contrast photomicro-