is readily detected when the calibration strips are aligned on the usual measuring device. Since the cylindrical position of the film is supposed to be fixed when the film is fitted in the cassette in the dark room it will be subject to any small errors in trimming of film, folding of the protective black paper sheath or securing of the metal parts of the cassette.

4. If the two calibration strips have been found to indicate a satisfactory approach of the film to perfect cylindrical shape during exposure, measurements may be made with equal confidence on any part of the film and need not be confined to the region "close to the calibration pattern."

A limiting factor in any calibration method that involves the use of a standard substance is the constancy of the *d* values of that substance. The range of variation of cell dimensions cited for quartz by Frondel and Hurlbut (1955) is only of the order of 1/10,000. This is well within the limits of precision assigned to the method of calibrated Weissenberg patterns by Christ. Hence the arbitrary use of Wilson and Lipson's (1941) cell dimensions as a basis of 2θ values of quartz for calibration seems justified.

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SERPENTINES WITH 6-LAYER ORTHO-HEXAGONAL CELLS*

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A new variety of serpentine mineral from Unst, Shetland Isles, was described by Brindley and v. Knorring (1954). The most prominent lines of its powder pattern were indexed on the basis of an ortho-hexagonal

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cell with $a_0=5.322$ Å, $b_0=9.219$ Å, $c_0=14.53$ Å, but an additional series of eleven closely spaced weak lines following 020 could be associated with a superlattice parameter $S=43.8$ Å in either the x or z direction. The data then available were insufficient to distinguish between these alternatives. The former suggested an analogy with antigorite (Mikonui; $a_0=43.5$ Å, Aruja 1945) while the latter implied a large cell containing six serpentine layers. Some discussions of these alternatives occur elsewhere (Brindley and v. Knorring, *loc. cit.;* Zussman, 1956; Zussman, Brindley & Comer, 1957) but in the course of more recent studies on serpentine minerals new results have been obtained which throw light on the true nature of the serpentine from Unst.

Table 1 gives x-ray powder data obtained from a synthetic Mg-Ge serpentine, the preparation of which was described by Roy and Roy (1954), who kindly supplied us with the material; the first and second columns give reflection intensities and d values measured with a Norelco x-ray diffractometer. The pattern was first indexed using approximate cell dimensions and these were refined by least square solutions of two series of reflections, $20l$'s for a and c and $02l$'s for b and c. The orthohexagonal cell derived, $a_0=5.436$ Å, $b_0=9.415$ Å, $c_0=44.66$ Å $(=6 \times 7.443)$, gives good agreement between observed and calculated d values for a wide range of reflections (see Table 1, second and third columns).

The three last columns of Table 1 list corresponding powder data for the Unst serpentine as given by Brindley and v. Knorring (1954) but indexed for a 6-layer cell. Making allowance for differences in cell dimensions and intensities through substitution of Ge for Si, the similarity of the two patterns is evident. From the well-ordered Mg-Ge serpentine, however, an excellent pattern was obtained showing many strong lines of the 6-layer cell throughout its range.

Electron diffraction patterns were obtained from thin, platy single crystals of the Mg-Ge serpentine (Zussman, Brindley and Comer (1957); Fig. 7), which show a simple hexagonal array of spots with no evidence of a superlattice or "large cell" in the xy plane. This is in marked contrast to the patterns from antigorites in similar orientations (see Figures 4 and 5 in the above paper). The large parameter in the present case is c which is parallel to the electron beam and therefore is not indicated in the electron diffraction pattern.

Electron micrographs of the Unst serpentine show that it has a lath-like morphology. Electron diffraction patterns from single laths showed strong spots in positions similar to those of orthochrysotile which has cell dimensions $a_0=5.32$, $b_0=9.2$, $c_0=14.6$ Å, $\beta=90°$ (Whittaker and Zussman, 1956), and has a parallel to the fibre axis. (For illustrations see

TABLE 1. X-RAY POWDER DATA FOR 6-LAYER ORTHO-SERPENTINES

Synthetic Mg-Ge serpentine			Indices hkl for both structures	Serpentine (Unst), Brindley & Knorring (1954)		
I	d(obs.)	d(calc.)		d(obs.)	d(calc.)	I
58	7.46	7.44	006	7.33	7.265	10
30	4.695	4.707	020	4.597	4.610	6B
30	4.612	4.606	022			
57	4.484	4.488	023	4.403	4.393	1
18	4.340	4.338	024	4.250	4.245	1
13	4.167	4.165	025	4.088	4.075	1
30	3.981	3.979	026	3.903	3.892	½
12	3.792	3.788	027			
70	3.730	3.730	0, 0, 12	3.662	3.632	10
15	3.601	3.599	028	3.528	3.519	½
43	3.414	3.415	029	3.348	3.338	½
8	3.242	3.240	0, 2, 10	3.172	3.167	½
4	3.073	3.075	0, 2, 11	3.015	3.005	½
10	2.921	2.920	0, 2, 12	2.865	2.853	½
4	2.776	2.775	0, 2, 13	2.720	2.711	½
57	2.716	2.718	200			
25	2.673	2.674	203	2.623	2.618	3
5	2.644	2.641	0, 2, 14			
100	2.551	2.554	206	2.502	2.499	10
15	2.522	2.516	0, 2, 15	2.450	2.458	1
18	2.486	2.481	0, 0, 18	2.425	2.422	1
3	2.404	2.401	0, 2, 16			
17	2.386	2.384	209	2.335	2.332	7
2	2.327	2.325	043			
1	2.305	2.303	044			
1	2.291	2.294	0, 2, 17			
1	2.243	2.246	046			
50	2.196	2.195	2, 0, 12	2.149	2.147	6
2	2.168	2.169	048			
6	2.127	2.127	049			
1	2.103	2.103	0, 2, 19			
1	2.084	2.082	0, 4, 10			
3	2.034	2.036	0, 4, 11			
60	2.008	2.008	2, 0, 15	1.9629	1.9626	7
3	1.992	1.989	0, 4, 12			
9	1.941	1.938	0, 2, 21			
2	1.895	1.894	0, 4, 14			
13	1.863	1.861	0, 0, 24	1.8154	1.8162	½
3	1.847	1.847	0, 4, 15			
62	1.831	1.831	2, 0, 18	1.7905	1.7911	1
3	1.799	1.799	0, 4, 16			
½	1.794	1.795	0, 2, 23			
3	1.780	1.780	310	1.7392	1.7424	1B

TABLE 1—*Continued*

Synthetic Mg-Ge serpentine			Indices *hkl* for both structures	Serpentine (Unst), Brindley & Knorring (1954)		
I	*d*(obs.)	*d*(calc.)		*d*(obs.)	*d*(calc.)	*I*
5	1.774	1.774	312			
15	1.765	1.767	313			
4	1.758	1.757	314			
5	1.734	1.731	0, 2, 24			
2	1.695	1.695	318			
25	1.674	1.675	2, 0, 21	1.6360	1.6368	4
2	1.654	1.654	0, 0, 27			
1	1.618	1.620	0, 4, 20			
2	1.603	1.605	3, 1, 12			
7	1.580	1.580	3, 1, 13			
83	1.569	1.569	060	1.5354	1.5367	8
83	1.536	1.536	2, 0, 24	1.5013	1.5033	7
2	1.5011	1.5005	3, 1, 16			
7	1.4914	1.4885	0, 0, 30	1.4520	1.4530	$\frac{1}{4}$
2	1.4629	1.4637	0, 2, 29			
40	1.4457	1.4459	0, 6, 12	1.4148	1.4152	2
2	1.4200	1.4188	3, 1, 19			
13	1.4144	1.4131	2, 0, 27	1.3793	1.3803	2
5	1.3662	1.3678	0, 6, 16			
7	1.3602	1.3591	400			
7	1.3550	1.3535	403	1.3271	1.3252	1
40	1.3362	1.3370	406	1.3092	1.3090	5
12	1.3264	1.3262	0, 6, 18	1.2958	1.2975	$\frac{1}{4}$
			4, 0, 9	1.2832	1.2832	$\frac{1}{2}$
25	1.3076	1.3060	2, 0, 30	1.2759	1.2752	$\frac{1}{2}$
			0, 0, 36	1.2100	1.2108	1
				and six additional indexed reflections.		
Lattice parameters: $a_0 = 5.436$ Å, $b_0 = 9.415$ Å, $c_0 = 44.66$ Å				$a_0 = 5.322$ Å, $b_0 = 9.219$ Å, $c_0 = 43.59$ Å		

Since $b = \sqrt{3}a$, alternative indices can be assigned for equivalent planes of equal *d* values, but these are not listed.

Zussman, Brindley and Comer, 1957.) In these patterns, which are of a rotation type because the laths have components in all orientations about *a*, a few very weak spots were observed on the first layer line which could not be indexed with the above cell, but may belong to the $11l$ series of a cell having $c \simeq 43.8$ Å.

While studying the thermal transformation of serpentines to forsterite

(Brindley and Zussman, 1957) some *x*-ray fibre photographs were obtained from the blue columnar serpentine from Unst described by Brindley and v. Knorring (Specimen No. 3). This had given a powder pattern similar to that from the massive specimen but with weaker "superlattice" lines. The *x*-ray fibre photograph shows clearly the *a* axis rotation pattern of the two layer ortho-cell although misorientation within the fibre bundle prevents measurement of accurate cell dimensions. Careful study of the photograph reveals a series of additional arcs on the first layer-line proceeding from 110 on the high angle side which are approximately in positions for 11*l*'s of a six-layer cell.

Conclusions

A synthetic Mg-Ge platy serpentine possesses a six-layer ortho-hexagonal cell. The similarity between its *x*-ray powder pattern and that of serpentine from Unst, Shetland Isles, together with other evidence described, suggests that the latter mineral also has a 6-layer ortho-cell rather than one of the antigorite type; the name "ortho-antigorite" is therefore no longer apposite for the Unst serpentine.

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