as the first step in recrystallization is the lack of a driving force for such a reaction. Tuttle and Bowen (1958, p. 138) have shown why recrystallization of feldspars takes place, but no one has shown why quartz recrystallizes; although Turner (1948, p. 192–211) and Tuttle (1952) have shown that the quartz of many plutonic rocks is recrystallized.

In the light of Tuttle and Bowen's work, the reactions between crystals and groundmass in a volcanic rock probably take place after the rock has solidified but is still hot. Such reactions could be due to a late liquid phase (Tuttle and Bowen, 1958, p. 102–103). They could also be due to a reaction between the hot glassy or cryptocrystalline groundmass and the quartz crystals, perhaps through the medium of an intergranular film.

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"HYDROMUSCOVITE WITH THE $2M_2$ STRUCTURE—A CRITICISM"

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A recent paper by Threadgold (1959) has reported chemical, differential thermal and *x*-ray diffraction data on a hydromuscovite from Mt. Lyell in Tasmania. Threadgold gives data which are claimed to show that this hydromuscovite has the $2M_2$ structure, a mica polymorph previously only found amongst the lepidolites (Levinson, 1953). Radoslovich (1959) has recently suggested, however, that the theoretical polymorphs 20, $2M_2$ and 6H, which are based on 60° rotations between layers (Smith and Yoder, 1956) may be expected to be rare or non-existent among the muscovites, because of the markedly ditrigonal symmetry of the oxygen network (Radoslovich, 1960, in press).

Since this specimen is the first reported $2M_2$ mica other than lepidolite it was decided to re-examine it. A careful survey did not reveal any material sufficiently coarse-grained for single crystal methods, so that powder diffraction techniques must be used. For this purpose a 19 cm. diameter evacuated powder camera was used to record consecutively (under the same conditions) the diffraction patterns of various polymorphs and mixtures of polymorphs. The camera is equipped with knife-edges, and has been carefully calibrated using a quartz standard. A Hilger film-measuring rule was used for obtaining θ values, and the corresponding d spacings were determined by extrapolation from the table published by Rose (1957).

The following mica specimens were photographed under standard conditions.

(a) Hydromuscovite from Lyell Comstock Mine, Mt. Lyell, Tasmania; kindly supplied by I. Threadgold, C.S.I.R.O., Melbourne.
(b) 1M muscovite from Iron Monarch quarries, Sth. Australia; kindly supplied by E. R. Segnit, University of Adelaide.
(c) $2M_1$ muscovite from Spotted Tiger Mine, Central Australia as studied by Radoslovich (in press, 1960).
(d) A 2:1 mixture of (b) and (c).
(e) $2M_2$ lepidolite from the Brown Derby pegmatite, Gunnison County, Colorado, described as #505 by Levinson (1953); kindly supplied by Prof. E. Wm. Heinrich, Univ. of Michigan.

The d spacings for each of these micas are given in Table 1, with the visually estimated intensities.[1] By direct comparison of the photographs—which show high resolution—it is clear that the Mt. Lyell hydromuscovite is not identical with the $2M_2$ lepidolite specimen, but in fact shows considerably better agreement with the 2:1 mixture of 1M and $2M_1$ polymorphs. These are, of course, subtle variations in relative line intensities, but these are not unexpected in layer-silicates, both because of orientation effects and because the hydromuscovite differs a little chemically from the 1M and $2M_1$ specimens. A print of the photographs of specimens (*a*), (*d*) and (*e*) is given in Fig. 1; the detail does not reproduce well.

In view of the slight intensity discrepancies between the Mt. Lyell hydromuscovite and the authentic muscovite polymorphs examined it cannot be claimed categorically that this hydromuscovite is a mixture

[1] Victor (1957) has also given data for a mixture of 70% 2M, and 30% 1M muscovite.

TABLE 1. *X*-RAY POWDER PHOTOGRAPH DATA FOR FIVE MICAS

(*d* values in Å)

a		*b*		*c*		*d*		*e*	
9.96	s	10.07	s	10.02	s	9.97	s	9.93	m
4.97	m	5.00	w-m	4.99	m-s	4.98	m	4.97	m
4.448	vs	4.487	s	4.453	vs	4.460	vs	4.465	s
4.342	w	4.342	w-m			4.343	w	4.327	w
4.258	w			4.278	w	4.268	w		
4.093	vw (br.)	4.093	w-m	4.089	w	4.087	w-m		
				3.951	vw			3.969	w
3.868	m			3.868	m	3.866	w-m	3.855	m
3.780	vw								
3.713	vw			3.721	m	3.718	w-m	3.710	vw
3.647	m-s	3.647	s			3.640	m-s	3.611	m-s
				3.575	vvw				
3.478	m-s	3.482	vvw	3.480	s (br.)	3.478	m	3.473	m-s
3.316	vs	3.337	s	3.326	vs	3.327	vs	3.314	m-s
		3.208	vvw	3.250	vw	3.245	vvw		
3.1820	m			3.190	m-s	3.1836	w	3.195	m-s
3.1180	vw			3.0830	vw			3.0710	m
3.0382	m	3.0593	s	3.0480	vw	3.0570	m		
2.9675	w-m			2.9798	m-s	2.9728	w-m	2.9714	vw
2.9145	w-m	2.9211	w			2.9142	w		
								2.8860	m
2.8454	m			2.8542	m-s	2.8475	w-m	2.8490	m
2.7818	m			2.7818	m	2.7769	w	2.7700	w-m
2.6986	vw	2.6772	w-m			2.6736	w		
2.5745}	vs	2.5875	w-m	2.5820	m	2.5783	m	2.5686	vs
2.5495}	(br.)	2.5585	v.s. (br.)	2.5530	vs	2.5528	vs		
2.4800	vw	2.4773	vvw	2.4922	vw (br.)	2.4986	vvw	2.4780	vw
				2.4540	w	2.4530	vw		
2.4336	w (br.)	2.4327	w	2.4313	w	2.4319	w		
2.4083	w			2.4075	vvw			2.4148	m (br.)
2.3834	w (br.)	2.3918	w	2.3887	vw	2.3890	w		
				2.3720	m	2.3708	w	2.3744	vw
2.3249	vvw	2.3509	w			2.3525	vw		
2.2934	vvw							2.3006	vw (br.)
2.2666	vvw	2.2440	w						
2.2381	w-m			2.2401	w-m (br.)	2.2384	w	2.2438	m
2.1999	w	2.2096	vw	2.1982	w-m			2.2156	vw
		2.1901	vvw					2.2027	vw
2.1730	w			2.1752	w			2.1733	w
2.1372	w			2.1429	w-m				
2.1180	w	2.1020	vw	2.1224	m-s	2.1236	w-m	2.1230	vw
2.0727	w-m (br.)	2.0766	w-m	2.0590	vw	2.0766	w	2.0902	vw
2.0402	w			2.0475	w			2.0551}	
2.0314	w							2.0266}	w
2.0144	w								
1.9912	w-m	2.0022	w-m (br.)	1.9944	m (br.)	1.9945	m (v. br.)	1.9824	m-s
1.9628	vvw			1.9658	w-m	1.9637	w		
1.9390	vvw	1.9454	v.w. (br.)	1.9440	w	1.9436	w		
1.9102	vvw								
				1.8881	vw				
				1.8161	vw				
				1.7420	vvw				
				1.7269	w	1.7274	vvw		
1.7079	vw			1.7084	vw	1.7081	vw		
1.6942	vw			1.6947	vw				
1.6821	vw	1.6856	vvw	1.6862	vw	1.6871	vvw	1.6884	m
				1.6723	vvw			1.6731	w-m
1.6581	w (br.)	1.6662	w-m	1.6627	w	1.6629	w (br.)		
1.6407	vw			1.6439	m	1.6423	vw		
1.6302	w-m	1.6307	m (v.br.)			1.6307	w		
				1.6237	w			1.6296	w
				1.6104	w				
1.6011	w			1.5980	w-m	1.5919	vw (br.)	1.6041	w
1.5783	w	1.5717	w			1.5681	vw	1.5856}	
								1.5707}	w

a Hydromuscovite, Mt. Lyell, Tasmania
b 1M muscovite
c $2M_1$ muscovite
d 2:1 mixture of (b) and (c)
e $2M_2$ lepidolite

vs very strong
s strong
m-s medium to strong
m medium
w-m weak to medium
w weak
vw very weak
vvw just discernible
br broad
bracket = band

TABLE 1 (*continued*)

a		*b*		*c*		*d*		*e*	
1.5594	w			1.5531	w-m	1.5491	vvw		
				1.5406					
								1.5377	vw (br.)
				1.5228	w-m	1.5225	vw		
				1.5065	vw				
1.4947	s	1.4978	vs (br.)	1.4959	vs	1.4955	s	1.4985	s
		1.4791	w	1.4804	vvw	1.4794	w		
				1.4678	vvw				
1.4465	vvw			1.4521	w				
1.4220	w (v.br.)	1.4299	vw	1.4289	vw				
		1.4234	vw	1.3938	vvw				
		1.3746	w (br.)	1.3712	vvw	1.3722	w. band		
1.3483	w	1.3405	w (br.)	1.3516	m				
1.3346	vw			1.3374	w-m	1.3377	w (br.)		
1.3220	vw	1.3293	vvw	1.3206	vw band			1.3123	w (v.br.)
1.2949	w	1.2972	w	1.2923	m band	1.2947	w	1.2957	m-s
1.2904		1.2880				1.2868			
1.2745	vw band			1.2760	w				
				1.2707	w				
1.2463	w-m	1.2484	vw	1.2459	w-m	1.2436	w band		
1.2426		1.2414		1.2369	w-m				
				1.2181	w (br.)	1.2173	w band		
		1.1878	vw						
		1.1624							
1.1694	w-m								
1.1173									
		1.1118	vvw	1.1118	w (br.)				
		1.1015	vw	1.1017	w (br.)				
1.0930	w	1.0923	w (v.br.)						
1.0870									
1.0124	v.w.	1.0136	v.w.						
1.0085		1.0087							

of 1M and $2M_1$ polymorphs, though the diffraction data are in better agreement with this mixture than with $2M_2$ lepidolite. It should be further remarked that the pattern of a $2M_2$ muscovite (when found) will not necessarily be identical with the observed pattern of $2M_2$ lepidolite. This re-examination therefore clearly shows that the Mt. Lyell hydromuscovite has not been proved to be a $2M_2$ polymorph. Indeed it will be very difficult to demonstrate conclusively that the $2M_2$ polymorph of muscovites exists at all, by powder methods. For this reason it will, in the writer's opinion, first be necessary to find a $2M_2$ muscovite (if such exists) by single crystal methods, in order to provide standard $2M_2$ muscovite powder data, against which unknown polymorphs can be compared with certainty.

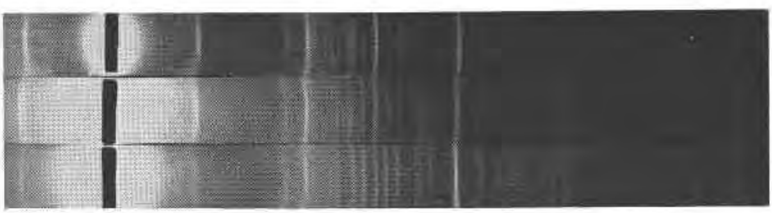

FIG. 1. *X*-ray powder photographs. (Above) 2:1 mixture of 1M muscovite and $2M_1$ muscovite, (*d*). (Middle) Hydromuscovite from Mt. Lyell, Tasmania, (*a*). $2M_2$ lepidolite (*e*).

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INTERFERENCE FIGURES OF LARGE CRYSTALS IMMERSED IN A SPHERE OF LIQUID

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It is frequently necessary to determine rapidly and non-destructively the approximate orientation of a non-cubic single crystal which either due to its mode of preparation or subsequent treatment is lacking in regular external crystallographic form. A typical example is a corundum boule. Although the orientation can be determined roughly by simply rotating the crystal in air between two crossed polarizers, the conditions for observation can be considerably optimized by immersion of the crystal in a refractive index oil and making the determination under a microscope. If one can then rotate the crystal in a simple way, it is possible to find the orientation by obtaining a centered interference figure. It has been found that with a small spherical flask, all of these conditions can be easily met. The simplicity and usefulness of the technique suggests it may be of interest to others.

The glass spheres should be perfect in shape and free of mold marks, striae and bubbles. The most perfect bulbs experimented with were blown by hand, by Wilmad Glass Co., Buena, N.J., and made of borosilicate glass. Fig. 1A shows a sphere of 40 ml. capacity, 4.5 cm. diameter. Sometimes a chemist's boiling flask is found in stock, which is good enough for the purpose. Fig. 1B shows such a sphere of 33 ml. capacity, 4.0 cm. diameter. To determine the effect of mold marks, we have used two different sizes of machine-made bulbs of a soda-lime-silica glass blown in a two-piece mold. These are General Electric Company bulbs, designation G12-1, 3.9 cm. diameter, 26 ml. capacity, Fig. 1C; and designation G9A2, 3.0 cm. diameter, 11 ml. capacity, Fig. 1D. These bulbs