

## Three-layer monoclinic lepidolite from Tørdal, Norway

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### Abstract

A 3-layer monoclinic lepidolite from a pegmatite at Tørdal, Norway, previously described as 2-layer orthorhombic, has been identified as the  $3M_2$  polytype. The space group is  $C2$  with  $a = 5.239(2)$ ,  $b = 9.070(3)$ ,  $c = 29.886(5)$  Å, and  $\beta = 92.58(2)^\circ$ . The X-ray powder pattern differs in detail from those of the conventional mica polytypes. Electron microprobe analysis gives  $\text{SiO}_2$  48.78,  $\text{Al}_2\text{O}_3$  23.87,  $\text{FeO}$  1.39,  $\text{MgO}$  0.02,  $\text{MnO}$  4.61,  $\text{TiO}_2$  0.07,  $\text{K}_2\text{O}$  9.88,  $\text{Na}_2\text{O}$  0.20,  $\text{BaO}$  0.03, F 6.21 weight percent for the  $3M_2$  flakes and  $\text{SiO}_2$  53.41,  $\text{Al}_2\text{O}_3$  21.43,  $\text{FeO}$  0.06,  $\text{MgO}$  0.02,  $\text{MnO}$  1.82,  $\text{TiO}_2$  0.06,  $\text{K}_2\text{O}$  9.85,  $\text{Na}_2\text{O}$  0.19,  $\text{BaO}$  0.03, F 7.63 weight percent for associated  $2M_1$  lepidolite flakes.

Heinrich *et al.* (1953) described a 3-layer monoclinic lepidolite from a pegmatite at Skuleboda, Sweden. Neumann *et al.* (1957) and Christie (1961) have described other lepidolite specimens from pegmatites at Varuträsk, Sweden, and Tørdal, Norway, that give X-ray powder patterns similar to that of the Skuleboda specimen. This note reports a more detailed study of the Tørdal material.

Single-crystal X-ray precession photographs of over 50 individual flakes of lepidolite from Tørdal showed three polytypic structures to be present— $1M$ ,  $2M_1$ , and  $3M$ . The  $3M$  flakes represent the same material that was originally described as 2-layer orthorhombic by Christie (1961).

The  $3M$  lepidolite has diffraction symmetry that could be described as  $C2/m$ ,  $C2$ , or  $Cm$ . Single-crystal intensities were collected on an automated Syntex diffractometer and used for comparison with intensities calculated from the six possible 3-layer stacking sequences. Good agreement was found for only one model, which has ideal symmetry  $C2$ . Relative to a fixed initial set of axes, the intralayer shifts of  $a/3$  in this model are directed in the sequence  $-X_1$ ,  $+X_2$ , and  $-X_3$  within the three successive layers. The resultant shift then is  $a/3$  along  $-X_2$  of the initial axes to give an ideal  $\beta$  angle of  $93.4^\circ$ .

The structure deduced above is identical to the ideal structure described as  $3M_2$  by Ross *et al.* (1966) in their systematic study of possible mica polytypes. Comparison of Weissenberg photographs of the Tørdal specimen with those illustrated by Heinrich *et al.* (1953, Figs. 10–12) indicates that the latter specimens also have the  $3M_2$  structure.

Table 1 lists the powder pattern of a pure sample of lepidolite- $3M_2$  from Tørdal. Indexing was achieved by direct comparison of the powder data with observed single-crystal intensities. The pattern differs in detail from those of the conventional mica structures and is characterized by the occurrence of several non-overlapping triplets of indices  $\bar{1}1l$ ,  $02l$ , and  $11l$ . Least-squares refinement of the powder data gave cell dimensions  $a = 5.239(2)$ ,  $b = 9.070(3)$ ,  $c = 29.886(5)$  Å, and  $\beta = 92.58(2)^\circ$ .

Table 2 lists electron microprobe analyses of flakes of  $3M_2$  and  $2M_1$  lepidolite from Tørdal. Although this method does not give Li or OH, the high F-contents and the individual oxide totals are characteristic of lepidolite. The  $3M_2$  flake has less  $\text{SiO}_2$  than the  $2M_1$  flake but higher  $\text{Al}_2\text{O}_3$ ,  $\text{MnO}$ , and Fe (expressed as FeO) contents. The  $\text{Li}_2\text{O}$  contents must be approximately 4 to 5 weight percent for each flake,

Table 1. Indexed powder pattern of Tørdal lepidolite- $3M_2$ 

hkl	Int.	d(obs)	d(calc)	hkl	Int.	d(obs)	d(calc)
003	80	9.97 Å	9.952 Å	13.13	12	1.709	1.707
006	20	4.988	4.976	20.14	7	1.690	{ 1.691 1.689
021	60	4.488	{ 4.484 4.456	20.13			
111			13.14	12	1.672	{ 1.672 1.641	
114	5	3.940	3.943				155
024	7	3.877	3.876	246			
114	10	3.809	3.809	20.14	2	1.615	1.618
025	7	3.614	3.611	246			
115	30	3.544	3.545	13.15	12	1.601	{ 1.602 1.599
116	2	3.419	3.418	157			
026	70 B	3.350	3.352	247	5	1.568	{ 1.574 1.567
009				3.314			
117	35	3.171	3.169	158	5	1.552	{ 1.566 1.553
027	15	3.112	3.107	20.16			
117	5	3.044	3.048	158	60	1.513	{ 1.549 1.512
118	20	2.939	2.938	331			
028	20	2.883	2.882	060	9	1.496	{ 1.512 1.498
118	23	2.827	2.828	332			
119	2	2.728	2.728	15.10	5	1.362	{ 1.496 1.495
029	5	2.679	2.677	063			
131	100	2.595	{ 2.603 2.598 2.597 2.589	24.11	2	1.467	1.469
202				04.16			
201				13.18	7	1.416	{ 1.416 1.415
132				22.17			
203	11.20	2	1.402	1.402			
202	04.17				5	1.387	{ 1.388 1.387
133	13.18	2	1.375	1.375			
11.10	20.19				5	1.362	{ 1.364 1.361
00.12	22.18	13.19					
134	15	2.447	{ 2.453 2.437	04.18	10	1.336	{ 1.339 1.334
205				13.19			
204	15	2.425	{ 2.435 2.418	20.20	5	1.309	{ 1.314 1.310
135	5	2.364	2.378	22.18			
206	5	2.349	{ 2.360 2.358	13.20	25 B	1.309	{ 1.309 1.308
205				261			
136	2	2.293	{ 2.339 2.296	260	3	1.287	{ 1.307 1.306
207				400			
040	15	2.267	{ 2.277 2.268	262	3 B	1.228	{ 1.307 1.306
220				261			
223	5	2.228	{ 2.229 2.192	06.12	8 B	1.287	{ 1.292 1.286
223				33.13			
207	4	2.189	{ 2.187 2.166	267	7	1.244	{ 1.244 1.244
138	7	2.167	2.166	268			
138	2	2.123	{ 2.121 2.120	00.24	3 B	1.228	{ 1.226 1.222
045				424			
209	13	2.096	{ 2.101 2.099	356	3 B	1.207	{ 1.222 1.222
208				175			
226	9	2.078	{ 2.094 2.078	22.21	3 B	1.207	{ 1.222 1.222
139				176			
046	10	2.033	{ 2.063 2.033	355	3 B	1.207	{ 1.222 1.210
139				177			
00.15	35	1.989	1.990	06.15	3 B	1.207	{ 1.204
229	2	1.839	1.838				

Pattern taken with  $\text{CuK}\alpha$  radiation in 114.59 mm diameter camera. Intensities estimated visually.  $d$ -values calculated on basis of  $a = 5.239$ ,  $b = 9.070$ ,  $c = 29.886$  Å, and  $\beta = 92.58^\circ$ .

Table 2. Electron microprobe analyses of Tørdal lepidolites

	$3M_2$	$2M_1$
$\text{SiO}_2$	48.78 wt. %	53.41 wt. %
$\text{Al}_2\text{O}_3$	23.87	21.43
FeO	1.39	0.06
MgO	0.02	0.02
MnO	4.61	1.82
$\text{TiO}_2$	0.07	0.06
$\text{K}_2\text{O}$	9.88	9.85
$\text{Na}_2\text{O}$	0.20	0.19
BaO	0.03	0.03
F	6.21	7.63
Sums	95.06	94.50

Analyses run on ARL microprobe with an accelerating potential of 15 KV. The correction procedure devised by Bence and Albee (1968) has been followed, with incorporation of the alpha factors of Albee and Ray (1970).

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## References

- Albee, A. L. and L. Ray (1970) Correction methods for electron probe microanalysis of silicates, oxides, carbonates, phosphates, and sulfates. *Anal. Chem.*, 42, 1408-1414.
- Bence, A. E. and A. L. Albee (1968) Empirical correction factors for the electron microanalysis of silicates and oxides. *J. Geol.*, 76, 382-403.
- Christie, O. H. J. (1961) On the occurrence of a two-layer orthorhombic stacking polymorph of lepidolite. *Z. Kristallogr.*, 115, 464-467.
- Heinrich, E. W., A. A. Levinson, D. W. Levandowski and C. H. Hewitt (1953) Studies in the natural history of micas. *Univ. Michigan Engr. Res. Inst. Report, Proj. M978*, 241 p.
- Neumann, H., T. Sverdrup and P. C. Saebø (1957) X-ray powder patterns for mineral identification. Part III. Silicates. *Avh. Norske Vid. Akad. Oslo. I. Mat. Nat. Kl.* no. 6.
- Ross, M., H. Takeda and D. R. Wones (1966) Mica polytypes: Systematic description and identification. *Science*, 151, 191-193.

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but lower for the  $3M_2$  flake than for the  $2M_1$  flake, as based on the observed F contents and oxide sums.

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