Lepidolite from the Litjern pegmatite, Iveland

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During an investigation of lithium in micas from granite pegmatites Oftedal (1941) observed that several of the brownish micas from cleavelandite pegmatites in Iveland (Landås, Katterås and Skripeland) contained appreciable amounts of lithium. Among samples collected by Olaf Andersen in 1909 and labelled Frikstad, Iveland a brownish mica was examined by Oftedal. It was found to be still richer in lithium than any of the other investigated micas. Using optical spectrography the content of lithium was determined to be about 3 wt.% Li_2O. Like the other Li-enriched micas from Iveland it contained significant amounts of Fe and Mn. Oftedal (1941) mentioned that the Li-rich mica possibly came from one of the small quarries at Kjørka, west in the Frikstad area, where cleavelandite was known to occur. The exact locality, however, has not been exactly known until now.

Kjørka is situated 100 m south of the mainroad near Litjern, approximately 1.25 km WSW of Frikstad. Barth (1931, p. 139) reported that there are several small quarries at Kjørka carrying microcline, oligoclase, cleavelandite, beryl, and red to yellow garnets. Recently the locality has been opened to the public as a mineral collecting site by the name *the Litjern quarry*. In addition to the minerals mentioned above, the following species have been found: muscovite, biotite, topaz, pyrite, fluorite, and rarely gahnite. Tantalite, microlite and zircon were found as well-developed micro-crystals in vugs in cleavelandite. Most of the muscovite in the locality is pale green in colour, rarely greyish. Violet, fine-scaly muscovite has been observed as an up to 1 cm thick zone around partly altered topaz.

During a private excursion on August 26, 2006 by the first author accompanied by Ingulv Burvald, Peter Andresen and Knut Edvard Larsen, the last-mentioned collector came across a pale brownish mica in the largest cleavelandite bearing quarry at Kjørka. The sample was shown to the first author, who immediately, using a lighter for testing the fusibility[1], concluded that it was a lithium-rich mica. The mineral occurs as mica "books" up to 8 cm across and 2 cm thick. The find was restricted to a confined area on the dump. At this spot, however, the lithium-rich mica was quite abundant. It is therefore reason to believe that the mineral has a limited occurrence in the part of the pegmatite that has been uncovered so far. The Li-rich, brownish mica was, however, not observed *in situ*. The other micas (pale greenish, greyish and violet) were qualitatively tested for Li, but with negative results.

Li-rich micas of the lepidolite and zinnwaldite series have been found only at very few localities in Norway. Therefore, it would prove interesting to confirm the correct identity of the mica from Litjern. The X-ray powder diffraction pattern of the Litjern mica shows that it is in agreement with that of a trioctahedral 1*M* mica polytype. The refined cell dimensions are a = 5.258(2), b = 9.097(3), c = 10.125(3) Å, β = 100.66(3)°, V = 475.9 Å^3.

[1] Very thin flakes of lithium-rich micas melt in the flame of a lighter. Muscovites do not melt.

Ten spots along a traverse from the rim to the centre of an approximately 6 cm wide plate of the Litjern mica was analysed by a CAMECA SX-100 microprobe[2]. The result showed that there was no significant zoning in the analysed sample. A representative part of the sample was ground in an agate mortar. Subsamples of this material were used for the determination of Fe^{2+}, Li and H_2O. Fe^{2+} was analysed by $K_2Cr_2O_7$ titrimetry after decomposition by HF and H_2SO_4. Li was analysed by ICP-AES after the sample was decomposed by HF and HNO_3. Total H_2O was determined using the Penfield method for decomposition combined with Karl Fischer aquametry. Adsorbed water (H_2O-) was determined as loss of weight at 110 °C. The results are shown in Table 1. The empirical formula for the Litjern mica is $(K_{0.81}Rb_{0.10}Na_{0.04}Cs_{0.02})_{\Sigma=0.97}(Li_{1.54}Al_{0.98}Mn_{0.29}Fe^{2+}{}_{0.25}Fe^{3+}{}_{0.03}Zn_{0.03}Mg_{0.01}Ti_{0.01})_{\Sigma=3.14}$ $(Si_{3.30}Al_{0.70})_{\Sigma=4.00}O_{10}(F_{1.56}OH_{0.42}O_{0.02})_{\Sigma=2.00}$. The Litjern mica is strongly enriched in F, Li, Rb, Cs and Mn, typically for micas from highly fractionated crustal granite pegmatites (Tischendorf et al. 2001).

The mica classification, elaborated by the IMA CNMMN Mica Subcommittee, considers the main principles of mica nomenclature (Rieder et al. 1998). Although this nomenclature is straightforward for compositions close to the end-members, classifying real solid-solutions members becomes complicated. Because micas, as a rule, are distinguished by poly-dimensional substitutions, the IMA 50/50%-rule is difficult to apply. Therefore, Tischendorf et al. (2004) proposed a specialized, descriptive subdivision scheme for the common K-micas based on the octahedral occupancy expressed by the parameters (Mg – Li) [= *mgli*] and (Fe_{tot} + Mn + Ti – ^{VI}Al) [= *feal*]. All common true tri- and dioctahedral K-micas can be shown in a single polygon outlined by seven main compositional points forming its vertices. Using this scheme the Litjern mica has the parameters (*mgli,feal*) = (-1.53,-0.40), which plot the Litjern mica in the lepidolite field of trioctahedral K-micas (Fig. 1). The position is, however, very close to the zinnwaldite border.

The present find represents most probably the rediscovery of the locality, in which Olaf Andersen collected the mica nearly 100 years ago, and the same type of mica that Oftedal analysed and described 66 years ago. The Litjern occurrence is the first and hitherto sole Li-rich pegmatite in the Evje-Iveland district. A thorough search among the micas from the cleavelandite bearing pegmatites in the Evje-Iveland district may reveal more Li-rich pegmatites. In Norway lepidolite and zinnwaldite in significant amounts have previously only been found in Tørdal (Oftedal 1942, Neumann 1985).

Acknowledgements
K. E. Larsen is saluted for his sharp eye for minerals, which led to the discovery of the Litjern lepidolite. Thanks are due to Norsk Bergverksmuseum by F. S. Nordrum for financially support on the microprobe analyses. We are indebted to R. Johannessen and B. Nenseter, both at Norsk Hydro Research Centre in Porsgrunn, for help on the Li and H_2O analyses, respectively. Special thanks to the owner of the Litjern quarry, Ole Magne Omdal, for his positive attitude towards field work at the locality.

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[2] Operating voltage of 15 kV, a beam current of 10 nA, and a defocussed beam spot of 10 µm. The instrument was operating in wave-length dispersive mode. The following standards were used: Wollastonite (Si*K*α, Ca*K*α), Al_2O_3 (Al*K*α), Fe_2O_3 (Fe*K*α), $MnTiO_3$ (Mn*K*α, Ti*K*α), MgO (Mg*K*α), ZnS (Zn*K*α), albite (Na*K*α), orthoclase (K*K*α), $RbNO_3$ (Rb*L*α), CsCl (Cs*L*α), synthetic F-phlogopite (F*K*α). Counting time was 10 s for all elements, except for Zn (20 s).

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Chemical composition		Number of atoms	
SiO_2	47.22	Si	3.297
TiO_2	0.24	Ti	0.013
Al_2O_3	20.42	Al	1.681
Fe_2O_3	0.47	Fe^{3+}	0.025
FeO	4.25	Fe^{2+}	0.248
MnO	4.91	Mn	0.290
ZnO	0.57	Zn	0.029
MgO	0.11	Mg	0.011
Li_2O	5.49	Li	1.542
Na_2O	0.30	Na	0.040
K_2O	9.11	K	0.811
Rb_2O	2.26	Rb	0.102
Cs_2O	0.50	Cs	0.015
F	7.06	F	1.559
H_2O+	0.90	OH	0.420
H_2O-	0.28		
-O=F	2.97		
Total	101.12		

Table 1. Chemical composition (in wt.% oxides, mean of 10 spots by microprobe and classical chemical analyses on Fe^{2+}, Li and H_2O) and number of atoms based on 12 (O,OH,F) of the lepidolite the Litjern pegmatite, Frikstad, Iveland.

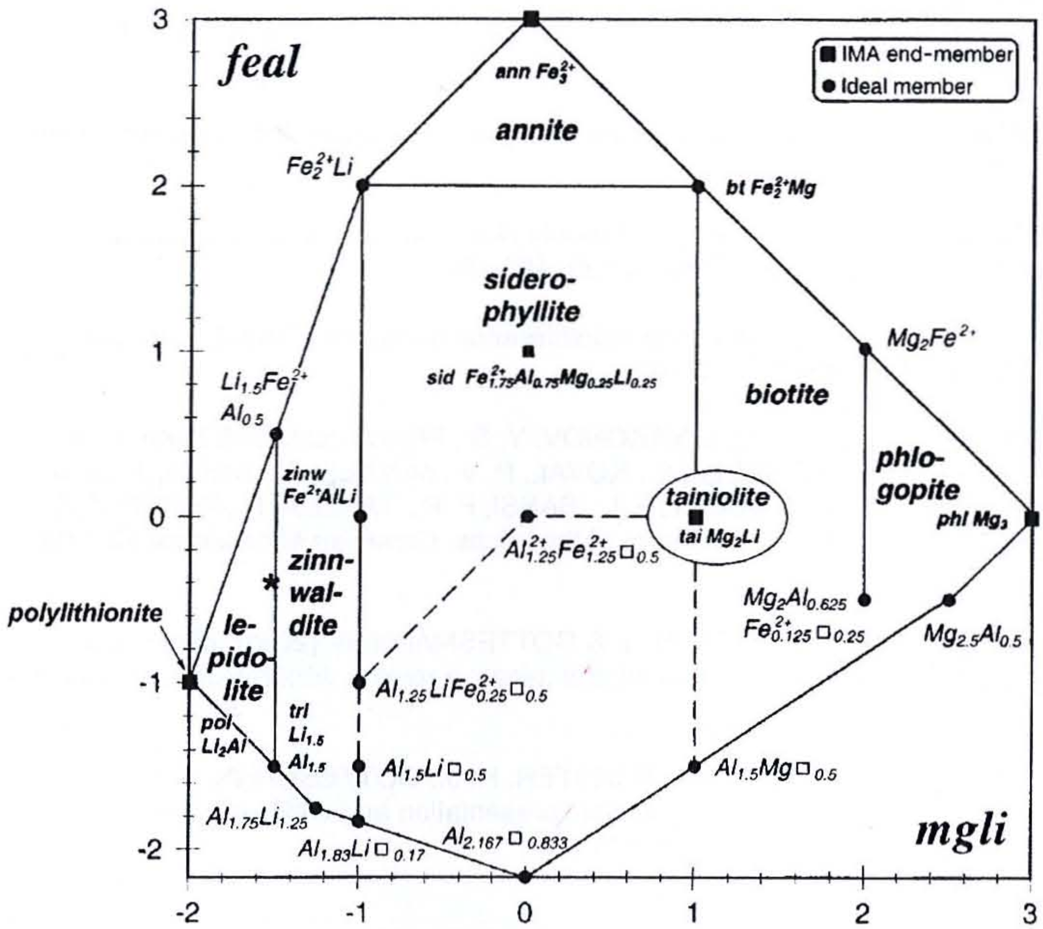

Fig. 1. Subdivision of the trioctahedral K-micas in the *mgli-feal* diagram from Tischendorf et al. (2004). The broken line marks the boundary between trioctahedral and dioctahedral micas. The Litjern lepidolite is marked by a star.