

# Mineralogy of aegirine from Låven Island, Langesundfjorden, southern Norway

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Murad, E. 2006: Mineralogy of aegirine from Låven Island, Langesundfjorden, southern Norway. *Norwegian Journal of Geology*, Vol. 86, pp. 435-438. Trondheim 2006. ISSN 029-196X.

A crystal of aegirine from the type locality, the island of Låven in Langesundfjorden, was studied by electron microprobe analysis, X ray diffraction, Mössbauer and infrared spectroscopy, and optical microscopy. In spite of its apparently homogeneous appearance, the crystal contained minor inclusions of other minerals, especially biotite and sodalite. Microprobe analyses and Mössbauer spectroscopy showed that the crystal classifies as an aegirine, consisting of 78 % end-member aegirine with lesser proportions of the “quadrilateral” Ca Fe Mg pyroxenes and jadeite.

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## Introduction

The sodic pyroxenes aegirine,  $\text{NaFe}^{3+}\text{Si}_2\text{O}_6$ , and aegirine-augite,  $(\text{Na,Ca})(\text{Fe}^{3+},\text{Fe}^{2+},\text{Mg})\text{Si}_2\text{O}_6$ , are common mafic constituents of alkali-rich igneous rocks, in which they are often associated with albite, nepheline, arfvedsonitic amphiboles and sometimes otherwise rare Zr- and Ti-bearing silicates such eudialyte, aenigmatite, astrophyllite, etc. The type locality for aegirine is the small (ca.  $40 \times 80$  m) island of Låven in Langesundfjorden, southern Norway (Berzelius 1835). A nepheline syenite pegmatite that is exposed on Låven makes this island, which is the type locality for six further mineral species, a classic mineral locality, which is protected since 1970.

Larsen & Raade (1997) observed an “aegirine” collected from the border zone of the pegmatite in the southern part of Låven to correspond to an aegirine-augite rather

than aegirine *sensu stricto*. To establish the identity of aegirine from Låven, the author collected several samples from this pegmatite, including one piece that contains large euhedral crystals of aegirine (Fig. 1). In the present paper selected properties (chemical composition, Mössbauer and infrared spectra, X-ray diffraction and optical microscopy data) of such an aegirine crystal from Låven, about 1.5 centimeters in diameter, are presented and their relevance is discussed.

## Results

X-ray powder diffraction shows the sample to be predominantly aegirine, but the presence of other constituents, in particular a micaceous phase with distinct peaks at 10 and 3.34 Å (Fig. 2) is also apparent. A thin section

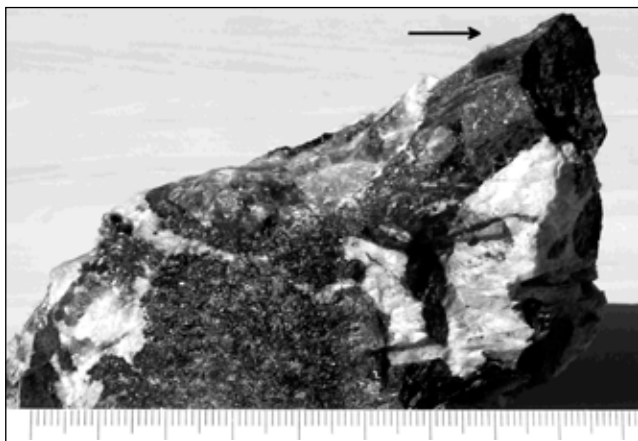


Fig. 1. Photograph of a sample of the nepheline syenite pegmatite showing a crystal of dark aegirine several centimeters in size (indicated with an arrow) at the upper right corner. The scale at the bottom is in millimeters.

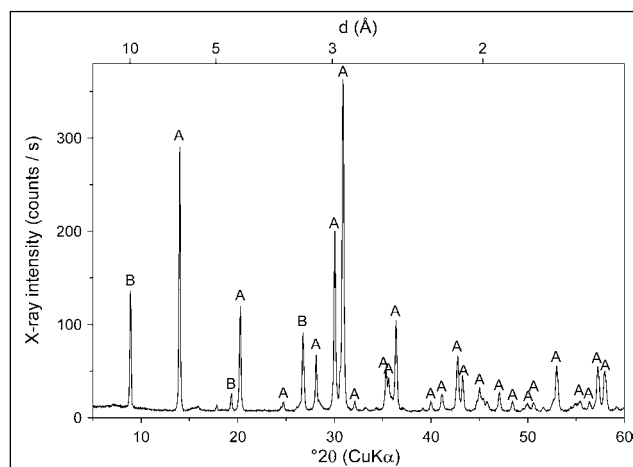


Fig. 2. X-ray diffraction diagram of the Låven aegirine. The y-axis scale divisions correspond to 20 counts/s; diffraction peaks of aegirine are indicated with “A” and peaks of biotite with “B”.

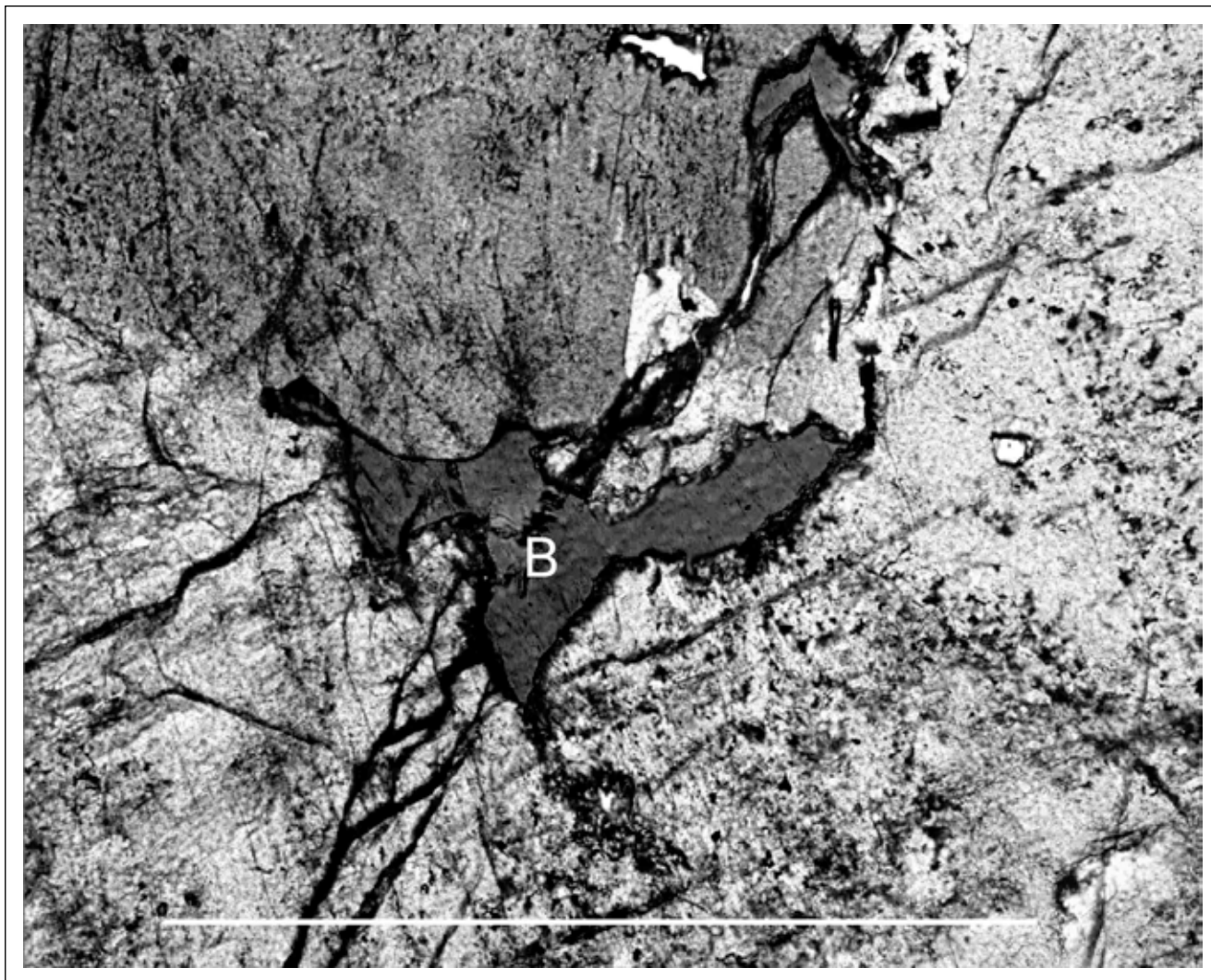


Fig. 3. Micrograph of a thin section of the sample showing a dark irregular crystal of biotite (indicated with a "B") enclosed within the aegirine. The white scale bar corresponds to 1 mm.

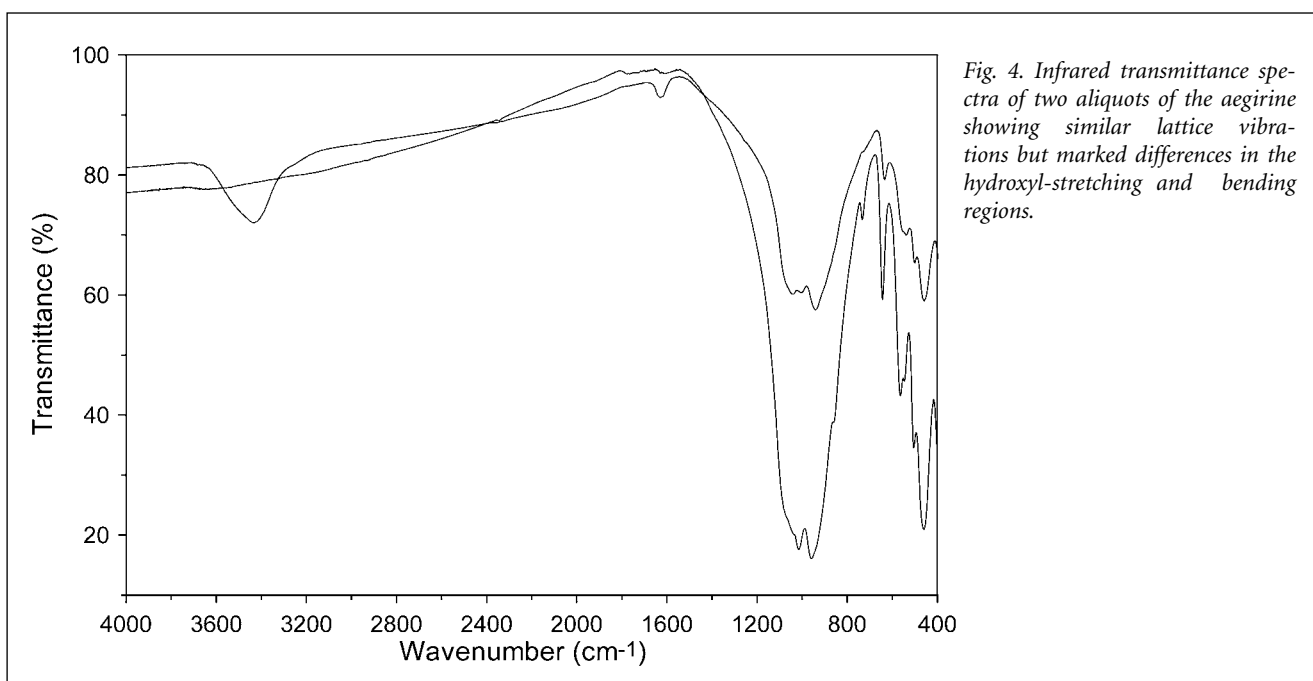


Fig. 4. Infrared transmittance spectra of two aliquots of the aegirine showing similar lattice vibrations but marked differences in the hydroxyl-stretching and bending regions.

**Table 1. Microprobe analysis of aegirine from Låven: averages of 7 analysis points**  
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| Basis :                        | wt. %        | 6 O          | cat = 4      |
|--------------------------------|--------------|--------------|--------------|
| SiO <sub>2</sub>               | 52.99 ± 1.12 | 2.116        | 1.994        |
| Al <sub>2</sub> O <sub>3</sub> | 0.94 ± 0.03  | 0.044        | 0.042        |
| TiO <sub>2</sub>               | 0.61 ± 0.15  | 0.018        | 0.017        |
| MgO                            | 1.03 ± 0.24  | 0.061        | 0.057        |
| FeO                            | 28.11 ± 0.73 | 0.117*       | 0.110*       |
| Fe <sub>2</sub> O <sub>3</sub> |              | 0.822*       | 0.775*       |
| MnO                            | 0.74 ± 0.09  | 0.025        | 0.024        |
| Na <sub>2</sub> O              | 11.18 ± 0.51 | 0.866        | 0.816        |
| CaO                            | 4.11 ± 0.51  | 0.176        | 0.166        |
| <b>Sum</b>                     | <b>99.71</b> | <b>4.245</b> | <b>4.000</b> |

\* Recalculated on the basis of the Fe<sup>2+</sup>/(Fe<sup>2+</sup>+Fe<sup>3+</sup>) ratio determined by Mössbauer spectroscopy. Errors correspond to the standard deviations calculated from the individual point analyses.

shows the principal constituent of the sample to be a strongly pleochroic (green ↔ yellow-brown) aegirine which exhibits lamellar twinning. Minor inclusions of other minerals, in particular up to almost 1 mm large, irregularly shaped biotite grains (Fig. 3), and smaller sodalite crystals are also discernible. Finally, infrared spectra of the sample show the characteristic bands of aegirine (Kodama 1985); some spectra, however, exhibit additional hydroxyl-stretching and -bending bands at

3440 and 1635 cm<sup>-1</sup> (Fig. 4).

Electron microprobe analyses taken on 7 different spots of the sample (Table 1) show the aegirine to be relatively homogeneous in composition. The relatively minor variations of elemental concentrations – in particular the concentration of Na – between the individual points measured by electron microprobe (Table 1) indicate the average chemical analysis of the aegirine studied here to be relatively reliable in spite of the inclusions of other minerals, in particular biotite. The presence of significant quantities of Ca and Mg, however, shows that this is not a pure end-member aegirine, but that it contains significant proportions of hedenbergite and diopside components. <sup>57</sup>Fe Mössbauer spectra taken at 77 K over different velocity ranges indicate the sample to be free from magnetically ordered phases, but show a noticeable proportion of Fe<sup>2+</sup> (Fig. 5). The Fe<sup>2+</sup>/(Fe<sup>2+</sup>+Fe<sup>3+</sup>) ratio, corrected according to Eeckhout & De Grave (2003) for the somewhat different recoil-free fractions of Fe<sup>2+</sup> and Fe<sup>3+</sup>, amounts to 0.125, so that the average chemical analysis and Mössbauer spectra give the formula of the aegirine, calculated as outlined by Morimoto (1978), as (Ca<sub>0.17</sub>Na<sub>0.82</sub>)<sub>2</sub>(Al<sub>0.04</sub>Fe<sup>3+</sup><sub>0.78</sub>Ti<sub>0.02</sub>Mg<sub>0.06</sub>Mn<sub>0.02</sub>Fe<sup>2+</sup><sub>0.09</sub>)(Si<sub>1.99</sub>Al<sub>0.01</sub>)<sub>2</sub>O<sub>6</sub>.

### Discussion

The composition of the aegirine studied here differs from that of an aegirine from Låven determined by Larsen & Raade (1997) using X-ray fluorescence and electron microprobe by having a higher Na content, lower Ca and Mg contents, and in particular a significantly lower

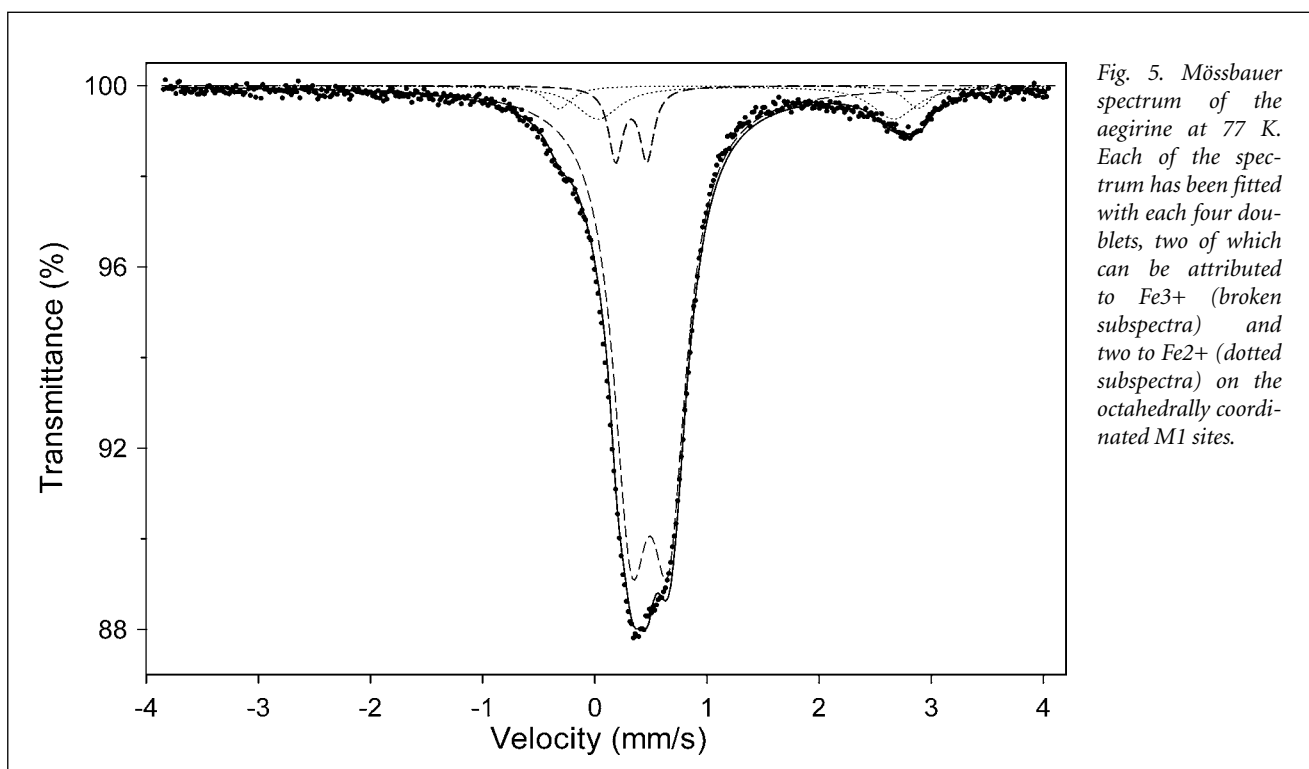


Fig. 5. Mössbauer spectrum of the aegirine at 77 K. Each of the spectrum has been fitted with each four doublets, two of which can be attributed to Fe<sup>3+</sup> (broken subspectra) and two to Fe<sup>2+</sup> (dotted subspectra) on the octahedrally coordinated M1 sites.

$\text{Fe}^{2+}/(\text{Fe}^{2+}+\text{Fe}^{3+})$  ratio, i.e. the composition of the sample described here is closer to that of an “ideal” aegirine.

Although the  $\text{Fe}^{2+}/(\text{Fe}^{2+}+\text{Fe}^{3+})$  ratio determined by Mössbauer spectroscopy is an average for all iron-bearing minerals in the sample, the parameters are quite similar to published data on aegirine (e.g. by De Grave et al. 1988) to be considered representative for this mineral. The spectra were best fitted with two  $\text{Fe}^{2+}$  and two  $\text{Fe}^{3+}$  doublets, the former two of which can be assigned to  $\text{Fe}^{2+}$  in slightly different geometries on the M1 sites. The  $\text{Fe}^{3+}$  doublets differ markedly in intensity and isomer shift. The subordinate doublet (relative area ~ 6 %) might be interpreted as resulting from  $\text{Fe}^{3+}$  in tetrahedral coordination, but this possibility is ruled out on the basis of the chemical data, so that both  $\text{Fe}^{3+}$  doublets are also assigned to the M1 sites.

Because optical microscopy – in contrast to the X-ray diffraction data – shows biotite to be present in only subordinate amounts, this indicates that the 001 and 003 X-ray peaks of biotite to have been enhanced as a result of sample texture, and the fact that these are the only peaks which can be unequivocally assigned to biotite supports this notion. The marked differences between the two infrared spectra shown in Fig. 4 probably result from the small amounts (~ 1 mg) of material used for this technique, which greatly amplifies effects of sample heterogeneity – in this specific case the presence or absence of biotite.

On the basis of the chemical analyses and Mössbauer spectra, the studied sample is a mixed crystal consisting of 78 % aegirine and 4 % jadeite end-members, plus 19 % of a Ca Fe Mg “quadrilateral (Q)” pyroxene component (11 % hedenbergite and 8 % diopside). In the ternary jadeite-aegirine-“Q” diagram of Morimoto (1988), the sample is located close to the aegirine/aegirine-augite boundary, just within the aegirine field.

The chemical composition of the aegirine described in the present paper thus differs noticeably from that of the aegirine-augite from Låven described by Larsen & Raade (1997), but is quite similar to aegirines from the neighbouring islands Vesle Arøya and Arøyaskjaer described by these authors. The mentioned differences in composition between the sample described here and the study by Larsen & Raade (1997) probably result from the resorption of constituents from the surrounding basaltic rocks at the border zone of the pegmatite, leading to more of the “Q” component in the latter sample (A.O. Larsen, personal communication).

*Acknowledgments:* - I am indebted to Roman Liebach, Monash University, Melbourne, for carrying out the microprobe analyses, to John D. Cashion, Monash University, for providing access to Mössbauer spectrometers, to G. Endlicher, Universität Regensburg, for thin section preparation, and to A.O. Larsen for helpful comments on an earlier draft of the manuscript.

## References

- Berzelius, J. 1835: [untitled note on aegirine]. *Neues Jahrbuch für Mineralogie, Geognosie, Geologie und Petrefaktenkunde* 1835, 184-185.
- De Grave, E., Van Alboom, A. & Eeckhout, S.G. 1988: Electronic and magnetic properties of a natural aegirine as observed from its Mössbauer spectra. *Physics and Chemistry of Minerals* 25, 378-388.
- Eeckhout, S.G. & De Grave, E. 2003: Evaluation of ferrous and ferric Mössbauer fractions. Part II. *Physics and Chemistry of Minerals* 30, 142-146.
- Kodama, H. 1985: *Infrared Spectra of Minerals. Reference Guide to Identification and Characterization of Minerals for the Study of Soils*. Minister of Supply and Services Canada, Ottawa, 197 pp.
- Larsen, A.O. & Raade, G. 1997: Pyroksener fra Oslofeltets syenittpegmatitter. *Norsk Bergverksmuseum Skriftserie* 12, 16-21.
- Morimoto, N. 1988: Nomenclature of pyroxenes. *American Mineralogist* 73, 1123-1133.