The anthophyllite that wasn't anthophyllite – from the anthophyllite type locality at the Kjennerudvann lake, Kongsberg, Norway

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Introduction

The Kjennerudvann Anthophyllite Prospect along the shore of the Kjennerudvann lake near Kongsberg (Fig. 1) is considered to be the type locality of the orthoamphibole anthophyllite (*e.g.* https://www.mindat.org/loc-32596.html). To our knowledge, however, no modern mineralogical or petrological data exist from the locality. The only data we have found in the literature concerning anthophyllite from Kongsberg are two analyses listed as "modern" (from 1917 and 1930, Table 1) and four analyses listed as "poor and incomplete analyses of anthophyllite" in Rabbitt (1948). In the present contribution, we present the first results from a modern reconnaissance study of a sample from this locality.

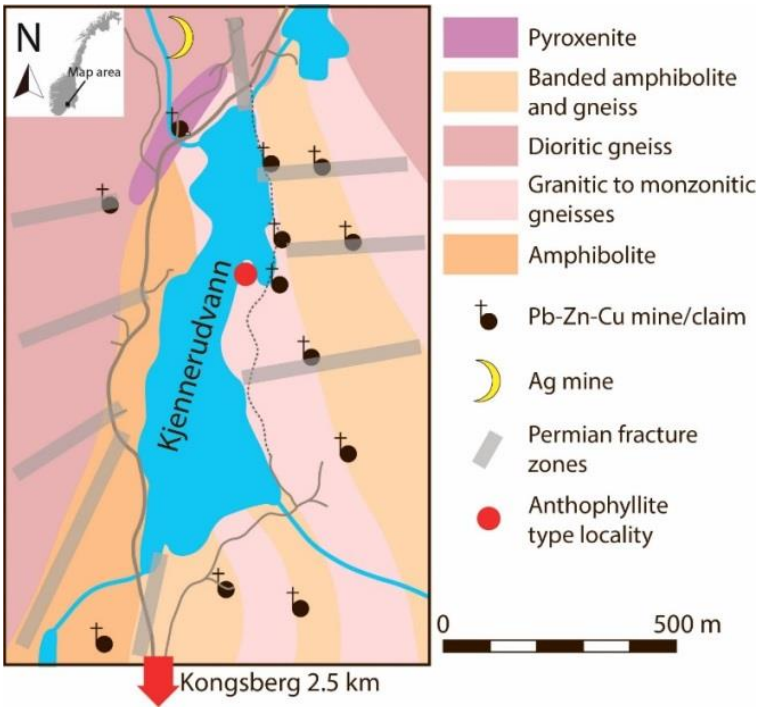

Fig. 1. *Geological map of the area around the Kjennerudvann lake, showing the anthophyllite type locality. Modified from Nilsen and Siedlecka (2003).*

Orthoamphiboles

Anthophyllite ($Mg_7Si_8O_{22}(OH)_2$) and gedrite ($Mg_5Al_2Si_6Al_2O_{22}(OH)_2$) are orthoamphiboles, *i.e.* they have an orthorhombic crystal structure. Following Leake *et al.* (1997) (see Fig. 2), Mg-rich orthoamphibole can be classified as anthophyllite when the number of atoms of Si in the formula is > 7, and as gedrite when Si is < 7. There is complete solid solution between anthophyllite and gedrite, and their Fe^{2+}-analogues ferro-anthophyllite and ferrogedrite. These amphiboles may also incorporate significant amounts of Na, and when the number of atoms of Na in the formula is > 0.5, they are given the prefix sodic (e.g. sodic-ferro-anthophyllite, see Leake *et al.* 1997).

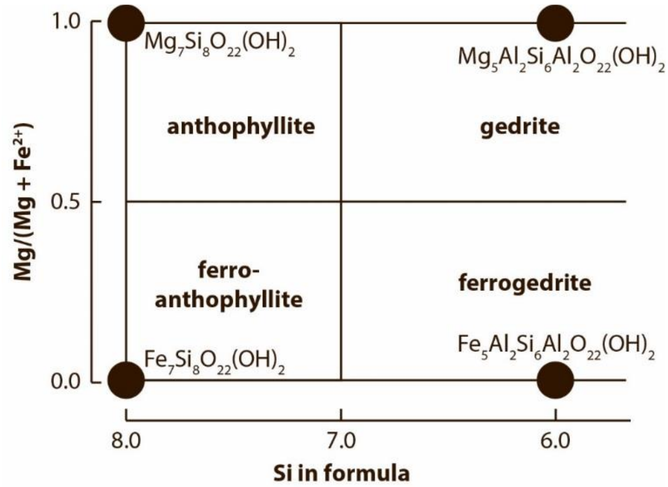

Fig. 2. *Classification scheme for Mg-Fe^{2+} orthoamphiboles, modified after Leake et al. (1997).*

The discovery of anthophyllite

Anthophyllite was first described by Schumacher (1801), who was a Danish surgeon, botanist and professor of anatomy at the University of Copenhagen. However, Schumacher (1801) did not give any exact locality of the finding, he only mentioned that it was found somewhere in the Kongsberg area ("in der Gegend von Kongsberg"). More than 20 years later, anthophyllite was reported from old mine tailings at the Kjennerudvann lake near Kongsberg by Möller (1825), and this locality has later been considered as the type locality of anthophyllite (e.g. https://www.mindat.org/loc-32596.html).

Gedrite was first described from Gèdre in the French part of the Pyrenees by Dufrénoy (1836).

The Kjennerudvann locality

The Kjennerudvann lake and the anthophyllite type locality is situated about 3.5 km NE of the city center of Kongsberg (Fig. 1). The orthoamphibole occurs in an ultramafic lens-shaped body, approximately 50 m x 20 m in size. According to the geological map, the ultramafic lens is hosted in granitic to monzonitic gneisses, however, no clear contact relationships between the ultramafic body and the host rock have been observed. The area is characterized by many old Pb-Zn-Cu mines/claims, of which many are associated with Permian fracture zones. To the north of the lake, the Kjennerudvann Silver Mine is located, which was operated through several periods between 1727 and 1782.

The orthoamphibole-bearing rock

The orthoamphibole-bearing rock is characterized by up to 1 cm thick and several cm long laths of light green-brown orthoamphibole in a darker green matrix (Fig. 3). Preliminary studies have shown that the matrix mineralogy includes calcic amphibole (ferrian-tschermakitic hornblende), phlogopite, chlorite, orthopyroxene and K-feldspar.

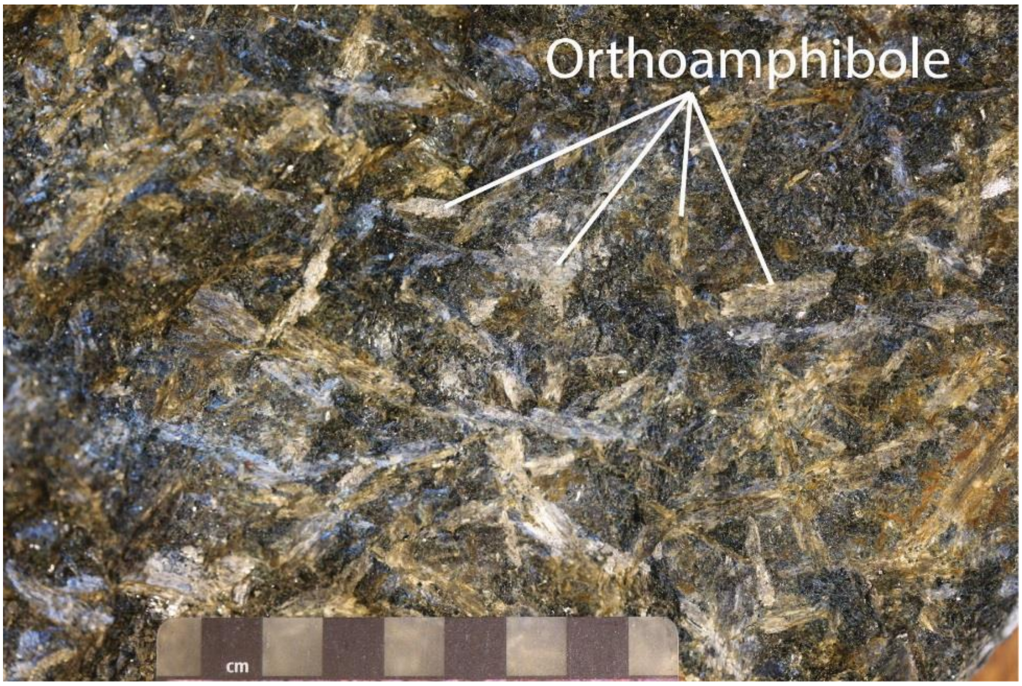

Fig. 3. *The studied orthoamphibole-bearing rock at Kjennerudvann lake.*

Early analyses of anthophyllite

Schumacher (1801) did not provide any chemical composition of the anthophyllite he discovered. A few years after Schumacher's discovery, however, the German professor in chemistry and pharmacology Johann Friedrich John published a comprehensive study on the physical and chemical properties of anthophyllite (John 1806). Unfortunately, John (1806) did not give any information about how he got hold of the material he studied and where it came from. In a short note where he provides an improved chemical analysis of anthophyllite (Table 1), John (1810) mention that it is Nordic. According to Rabbit (1948), the anthophyllite studied by John (1806, 1810) was from Kongsberg, presumably from the anthophyllite locality at the Kjennerudvann lake.

Important to notice for the anthophyllite analyses provided by John (1810) is its high content of Al_2O_3. This contrasts with the two analyses of anthophyllite from Kongsberg from Ishyul (1917) and Kunitz (1930), which are listed as "modern" in Rabbitt (1948), and show Al_2O_3 in the range of 2-3 wt.%.

Table 1. *Historical analyses of orthoamphibole, presumably from the Kjennerudvann type locality, and an average analysis from the present study.*

Locality given in Rabbitt (1948):		Kongsberg	Kongsberg	Kjernerud	
		John (1810)	Ishyul (1917)	Kunitz (1930)	Present study[2)]
SiO_2	Kieselerde[1)]	56.00	56.27	55.34	43.45
TiO_2					0.06
Al_2O_3	Alaunerde[1)]	13.30	2.07	2.56	20.72
Cr_2O_3					0.06
FeO	Eisenoxyd[1)]	6.00	14.17	15.29	10.46
MnO	Manganoxyd[1)]	3.00	0.59	0.51	0.20
MgO	Bittererde[1)]	14.00	23.99	22.80	20.10
CaO	Kalk[1)]	3.33	1.15	0.63	0.56
Na_2O				0.19	1.87
K_2O				0.12	0.01
H_2O	Wasser[1)]	1.43	1.83	2.34	
Structural formulas based on ΣCations – Na,K = 15					
Si			7.811	7.813	6.067
Al^{IV}			0.189	0.187	1.933
Al^{VI}			0.150	0.239	1.477
Ti					0.006
Cr					0.003
Fe			1.645	1.805	1.221
Mn			0.069	0.061	0.024
Mg			4.965	4.799	4.184
Ca			0.171	0.095	0.084
Na				0.052	0.506
K				0.022	0.002

1)Chemical components after John (1810).
2)Average of 20 analyses.

New analyses of orthoamphibole from the Kjennerudvann locality

Chemical analyses of orthoamphibole from Kjennerudvann have been collected from one thin section at the University of Potsdam, Germany, using a Jeol JXA-8200 electron microprobe analyser (EMPA) equipped with five wavelength-dispersive spectrometers. The EMPA was operated with a 15 kV acceleration voltage, 15 nA current and a beam diameter of 2 µm. The variations in the contents of Si and Na in A position (Na^A), and Mg/(Mg+Fe)-ratios are shown in Fig. 4. All analyses show Si < 6.5 atoms per formula unit and Mg/(Mg+Fe) in the range of 0.76-0.79, suggesting that the analysed orthoamphibole is gedrite, and not anthophyllite. Na^A varies in the range of 0.36-0.56 atoms per formula unit. The analyses show that the gedrite rims have $Na^A > 0.5$ atoms per formula unit, classifying them as sodic gedrite, while the cores have lower Na^A and classify as gedrite according to Leake (1997).

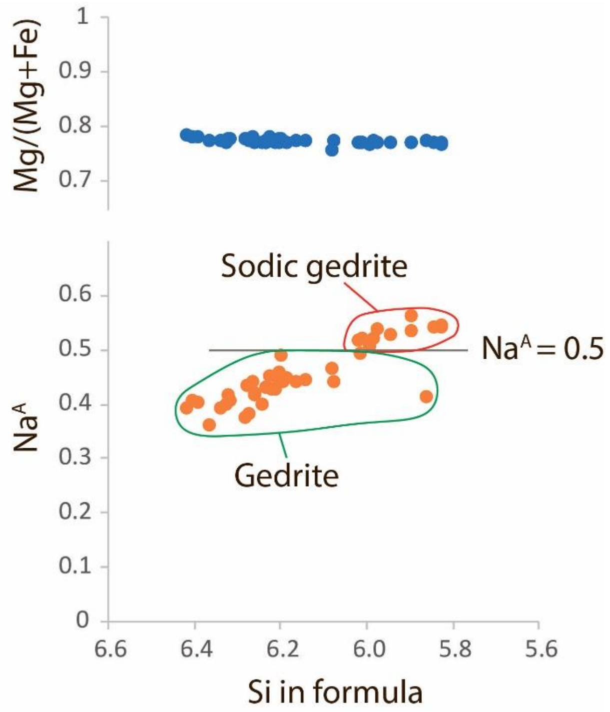

Fig. 4. *Compositional variations of orthoamphibole from the Kjennerudvann locality.*

Conclusions

The present study suggests that orthoamphibole from the type locality of anthophyllite at Kjennerudvann near Kongsberg, is not anthophyllite, but gedrite/sodic gedrite. The high content of Al_2O_3 of the incomplete anthophyllite analysis given by John (1810), may suggest that the material he analysed also was gedrite. However, the analyses from Ishyul (1917) and Kunitz (1930) show similar contents of Al^{IV} (1.19 atoms per formula unit) and Si^{IV} (7.81 atoms per formula unit) and classify as anthophyllite. Thus, the composition of orthoamphibole from the Kjennerudvann locality might be more variable than previously recognized.

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