NOTE – *NOTIS*

A Phengite Gneiss from the Lower Part of the Caledonian Overthrust Rocks in Troms, North Norway

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The petrography and chemistry of a phengite-epidote-albite-microcline-quartz gneiss from Troms are discussed. Chemical analyses, crystallographic and some optical data are given for the phengite and the epidote. The gneiss is probably an old granite that has recrystallized completely under greenschist facies conditions.

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OCCURRENCE AND PETROGRAPHY OF THE GNEISS

The lower part of the Caledonian overthrust rocks (i.e. the rocks lying on top of the non-metamorphic sediments of the Hyolithus zone) in inner Troms consist mainly of crushed granitic rocks ('kakirites') and phyllonitic quartz phyllites ('Hartschiefer'). The quartz phyllites grade upward into biotite and garnet-bearing mica schists, which also often have phyllonitic characters (Kalsbeek & Olesen 1968).

Within these 'lower mica schists' (formation 3 in the 'lower sequence', see Kalsbeek & Olesen 1968) large lenses, up to hundreds of metres in length, of rock types such as rather coarse-grained hornblende gneiss, garnet-rich gneiss and spinel-bearing peridotite have been encountered. These rocks probably represent large tectonic inclusions within the lower mica schists.

Near the top of the lower mica schists, bands and lenses, up to 50 m thick, of a rather fine-grained greenish-white muscovite-rich gneiss occur. In the area around the mountains Njunis and Bangfjell mapped by the author, good outcrops of these rocks are found, for example at the following localities: coordinates 35.5–33.1 (Sandelva) 46.1–28.0 (Skjerbekken) 39.5–24.5 (Oaresgår'sa) on the 1:50000 sheets Dividalen (1532I) and Altevatn (1532II).

In thin section the rock consists mainly of quartz, albite, microcline, muscovite (with a distinct greenish colour, suggesting phengite), epidote and minor amounts of apatite, sphene, opaque minerals (hematite according to X-ray analysis, and very small amounts of magnetite), zircon and some dark greenish-brown mica, probably biotite.

Table 1. Chemical compositions of mineral concentrates.

	A	B
SiO_2	48.10	37.28
TiO_2	0.55	0.34
Al_2O_3	22.38	20.85
Fe_2O_3	9.20	15.12
MnO	0.17	0.70
MgO	3.42	0.86
CaO	1.90	20.17
Na_2O	0.41	0.20
K_2O	9.10	0.69
P_2O_5	0.03	0.13

A. Concentrate consisting of approx. 93% weight of mica and 7% epidote. B. Concentrate consisting of 91.5% epidote and 8.5% mica.
Analyst: Ib Sørensen, GGU Copenhagen.
Fe_2O_3: Total iron calculated as Fe_2O_3.

In the field and in hand specimen the rock is fairly homogeneous. Concentration of the muscovite in thin bands is seen especially in thin section and may give rise to a slight lamination of the rock. Also the epidote may be concentrated in thin layers. The gneiss shows a well-developed foliation which may be very regular, but sometimes the mica-rich laminae prove to be irregularly folded in thin section, and the mica flakes (several mm long) may be deformed. Locally the rock shows a well-developed lineation.

The quartz and feldspar are granoblastically recrystallized, the grain size is in the order of a few tenths of a mm, but local porphyroblasts of albite and microcline (1 mm) also occur. Local larger feldspar grains (up to a few mm) may perhaps be regarded as porphyroclasts. The albite of these grains is often turbid and may contain numerous epidote inclusions and the microcline is microperthitic, whereas the albite in the matrix and the porphyroblasts is fresh and the microcline not perthitic. The amount of such possible porphyroclasts is small, and they are hardly ever seen in hand specimen.

PHENGITE AND EPIDOTE

During the concentration of the muscovite it proved impossible to separate the mica completely from the epidote. Therefore two concentrates were prepared, one consisting of mica with some epidote, the other of epidote with some mica. The results of the chemical analysis of the two concentrates are shown in Table 1. To calculate the composition of the mica and the epidote it was assumed that the mica did not contain CaO and the epidote no K_2O. With the help of the contents of CaO and K_2O in the two concentrates, the amounts of epidote in the mica concentrate and mica in the epidote concentrate were calculated to be respectively 7% and 8.5%. The values were in good agreement with those found for the concentrates by point counter analysis.

Table 2. Chemical composition, structural formula, optical properties and cell constants for the phengite.

SiO_2	49.23				
TiO_2	.57	Si	3.36	4.00	
Al_2O_3	22.54	Al	.64		n_y = 1.621 ± 0.001
Fe_2O_3	8.58	Al	1.17		n_z = 1.625 ± 0.001**
MnO	.11	Ti	.03		$2V_x$ 30–32°
MgO	3.69	Fe	.44	2.02	a = 5.240 ± .003 Å
CaO	–	Mn	.01		b = 9.078 ± .005 Å
Na_2O	.43	Mg	.37		c = 19.955 ± .011 Å
K_2O	9.98	Na	.06	.93	β = 95.790 ± .052°
P_2O_5	.02	K	.87		cell vol. = 944.37 Å
H_2O* calc.	4.40				
	99.55				

* H_2O calculated, corresponding to 2 OH in the muscovite formula.
** Refractive indices of different grains are not quite the same. Most values fall within the indicated ranges.

Table 3. Chemical composition, structural formula and cell constants for the epidote.

SiO_2	36.39				
TiO_2	.32	Si	2.98	3.00	
Al_2O_3	20.73	Al	.02		
Fe_2O_3	15.61	Al	1.99		
MnO	.74	Ti	.02	2.97	
MgO	.65	Fe	.96		a = 8.863 ± .022 Å
CaO	21.67	Mn	.05		b = 5.650 ± .015 Å
Na_2O	.18	Mg	.08		c = 10.174 ± .030 Å
K_2O	–	Ca	1.90	2.06	β = 115.05 ± .22°
P_2O_5	.14	Na	.03		
H_2O* calc.	1.82				
	98.25				

* H_2O calculated, corresponding to 1 OH in the epidote formula.

The chemical composition of the mica and the epidote were then calculated and are shown in Tables 2 and 3. H_2O contents corresponding to 2OH in the mica and 1OH in the epidote formula have been calculated and entered in Tables 2 and 3.

The high Si/Al ratio and the large amounts of Fe and Mg compared with normal muscovite show that the mica undoubtedly is a phengite.

The tables also show the structural formulas of the minerals and some optical and crystallographical data. The refractive indices of the mica are higher than those of most phengites reported in the literature. The measurements were made using glass grains as an internal standard (Micheelsen 1957). The unit cells were determined using Guinier camera films and silicon as standard. The density of the mica seems to vary. Most of the mica

Table 4. A. Chemical composition; B. molecular norm; and D. mode of the phengite gneiss. For comparison Daly's average granite as quoted by Barth (1952, p. 69) is given (C). Analyst: Ib Sørensen, GGU Copenhagen.

	A		B		C		D
SiO_2	71.10	q	29.8	SiO_2	70.18	quartz	32% vol.
TiO_2	0.37	or	25.0	TiO_2	0.39	albite	28
Al_2O_3	13.35	ab	30.5	Al_2O_3	14.47	microcline	9
Fe_2O_3	2.98	an	8.5	Fe_2O_3	1.57	phengite	24
FeO	0.46	c	0.5	FeO	1.78	epidote	5.8
MnO	0.08	he	2.1	MnO	0.12	sphene	0.4
MgO	0.88	hy	2.8	MgO	0.88	apatite	0.2
CaO	1.82	ap	0.2	CaO	1.99	opaque	0.6
Na_2O	3.30	il	0.6	Na_2O	3.48		
K_2O	4.09			K_2O	4.11		
P_2O_5	0.08			P_2O_5	0.19		
H_2O+	1.05			H_2O	0.84		
	99.56						

has D 2.90–2.93 (heavy liquids), the calculated density D=2.87–2.90, depending on the amount of FeO present.

CHEMICAL AND MINERALOGICAL COMPOSITION OF THE GNEISS

A chemical analysis of the phengite gneiss is shown in Table 4A. Table 4B shows the molecular norm.

Comparison with average granite, Table 4C (Barth 1952) shows that the phengite gneiss has a normal granitic composition, apart from a high Fe^{III}/Fe^{II} ratio.

Point counter analysis (1 slide, 1000 points) gave: quartz+feldspar 69.0, phengite 24.3, epidote 5.4, apatite 0.4, sphene 0.3, opaque 0.6% by volume. Because of the slight banding of the rock the point counter analysis is not quite dependable.

Assuming that all CaO in the rock (apart from small amounts in apatite and sphene) is contained in the epidote – extinction angle measurements in the albite show hardly any anorthite – 7.16% by weight of epidote should occur (the 5.4% of epidote found by point counter analysis is equivalent to approx. 6.7% by weight). After reducing the analysis for the phengite and epidote, and small amounts of sphene, apatite and hematite, the remaining oxides could be recalculated to quartz, sodium feldspar and potassium feldspar. The mineralogical composition shown in Table 4D fits both the chemical analysis and the point counter analysis fairly well.

ZIRCON

Most zircon crystals separated from the gneiss proved to be strongly metamict but clear crystals were also found. A few crystals were more or less euhedral but most had an irregular shape. Well-rounded grains were not found.

DISCUSSION

The chemical composition and the homogeneity of the phengite gneiss suggest that the rock is an orthogneiss deriving from a granite. The morphology of the accessory zircons does not conflict with this conclusion. The mineralogical composition, especially the presence of albite, epidote and phengite indicate that the rock belongs to the greenschist facies. Phengite is restricted to low grade rocks (Ernst 1963, Turner 1968, p. 55, Beran 1969).

The phengite gneisses may originally have been emplaced as granitic sheets within the lower mica schists, or alternatively they may represent tectonic inclusions, comparable with the lenses of hornblende gneiss and peridotite mentioned earlier in the strongly tectonized lower mica schists. Whereas, however, in the hornblende gneisses and peridotite high grade mineral parageneses have survived, the phengite gneiss is completely recrystallized under greenschist facies conditions, only local larger feldspar grains may be remnants of the original rock.

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