

A BOULDER OF OUACHITITE FROM INDERSKÄR, ÅLAND ISLANDS, FINLAND

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The ouachitite is composed of phenocrysts of olivine, diopside, phlogopite, set in a fine-grained matrix with phlogopite, clinopyroxene, ore and calcite. Analyses of the rock and of several minerals are given. It is concluded that the boulder most likely originates from an alkaline complex, genetically and geographically related to the Alnö complex in central Sweden.

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This paper is a more detailed investigation of a boulder found at Söderören, Inderskär, 3 km W of Enklinge, Åland islands, SW Finland, previously described by Edelman (1974). The boulder was $10 \times 8 \times 3$ cm in size, subrounded, with mica phenocrysts in a brownish grey matrix.

In thin section, phenocrysts of olivine, often completely altered into serpentine, phlogopite, diopsidic pyroxene and rarely, magnetite and apatite, are found. The matrix is composed of fine-grained phlogopite and clinopyroxene, with abundant ore and calcite. The mode is given in Table 1. From its composition, the rock might most aptly be termed ouachitite (Tröger 1935, p. 176). The chemical composition of the ouachitite shows somewhat lower contents of silica and alumina than the type rock.

Phlogopite is light brown in thin section. Pheno-

crysts often show bleached, groundmass phlogopite darkened margins, which is probably explained by varying titanium contents. Reversed pleochroism has been observed in groundmass phlogopite. The chemical analysis (1, Table 2) shows rather high titanium contents; the Mg/(Mg + Fe) ratio is 0.79, which is within the limits for phlogopite.

Olivine is rather abundant as a phenocrystal phase (mode, Table 1), but completely absent in the matrix. As mentioned earlier (Edelman 1974), many phenocrysts are completely altered into pale green serpentine. In sections made for this study, fresh olivine was found and analysed (2–3, Table 2). Both rounded and euhedral phenocrysts occur; The latter seem much more altered than the former.

Clinopyroxene occurs both as phenocrysts

Table 1.

Chemical composition, norm and mode of the ouachitite

SiO ₂	30.4	Norm	Mode (0.33 × 0.40 mm grid,	
TiO ₂	2.9	Ne	2.19	3811 points counted)
Al ₂ O ₃	8.6	An	11.50	Phenocrysts
Fe ₂ O ₃	7.9	Cc	9.58	Olivine
FeO	6.3	Ap	4.45	Serpent. olivine ..
MnO	0.28	Ft	1.79	Phlogopite
MgO	13.7	Mt	7.89	Diopside
CaO	15.8	Il	4.10	Magnetite
BaO	0.35	Py	1.80	Apatite
Na ₂ O	0.4	Wo	8.47	Matrix
K ₂ O	3.5	Di	4.86	Phlogopite
H ₂ O—	0.7	Ol	8.62	Clinopyroxene....
H ₂ O+	2.6	Bi	33.60	Ore
P ₂ O ₅	2.10			Apatite
CO ₂	3.85			Calcite
S	0.68			Remainder
F	0.40			
Cl	0.01			
Total	100.47			
O corr.	— 0.34			
Sum	100.13			

(single grains, or monomineralic clusters) and as a major constituent of the matrix. Phenocrystal pyroxene is colourless to pale brown in thin section, weakly pleochroic, and sometimes weakly zoned (darkened margins). Two analyses (4—5, Table 2) proved the pyroxene to be diopside, with rather high titanium contents. Frequently, fluid inclusions, occupying arcuate planes (healed cracks) are encountered. The inclusions are very similar to those described for kimberlite pyroxenes (Mitchell *et al.* 1973) as well as for pyroxenes from the Alnö complex (v. Eckermann 1966). Matrix clinopyroxenes are more strongly coloured and, according to semi-quantitative analyses, richer in both iron and titanium than phenocrystal clinopyroxenes.

Magnetite occurs rarely as phenocrysts, but is quite abundant in the matrix (mode, Table 1). Both forms contain about 6% TiO₂, and may properly be termed titanomagnetite (Table 2). No exsolution lamellae have been noted. Matrix pyroxene is a common inclusion in magnetite; pyrite is sometimes found to form coatings around magnetite grains.

Apatite occurs both as larger (0.5—1 mm) short-prismatic grains, and tiny acicular crystals in the matrix. *Pyrite* forms coatings on magnetite, and irregular (almost vermicular) masses associated with interstitial calcite. *Calcite* is found both as an interstitial phase, in cracks in phenocrysts, and together with serpentine, chlorite and other phases replacing primary minerals.

Chlorite (clinochlore) has been found to replace phlogopite. Occasionally, greyish felt-like masses with low birefringence occur, which could not be identified. They always occur together with serpentine and calcite, and are thus alteration products. Very rarely, small brownish cubes are seen, sometimes forming clusters. The mineral might be perovskite rather than garnet, as suggested earlier (Edelman 1974).

As pointed out by Edelman (1974), two possible places of origin of the boulder exist: either the boulder has been transported from the Alnö alkaline complex, situated about 300

Table 2.

Mineral analyses (electron microprobe, Geol. Surv. of Sweden)

	1	2	3	4	5	6	7
SiO ₂	36.6	39.5	39.5	49.0	47.8	—	—
TiO ₂	4.8	—	—	1.3	1.2	5.8	6.6
Al ₂ O ₃	17.4	0.1	0.0	4.6	4.4	—	—
Fe ₂ O ₃	—	—	—	—	—	53.2*)	54.7*)
FeO	9.3	14.0	13.0	6.5	6.5	35.9*)	35.1*)
MnO	0.1	—	—	0.2	0.2	—	—
MgO	18.2	47.0	46.3	14.8	14.2	—	—
CaO	—	0.3	0.3	23.3	23.4	—	—
Na ₂ O	—	—	—	0.7	0.7	—	—
K ₂ O	9.7	—	—	0.0	0.0	—	—
	96.1	100.9	99.1	100.4	98.4	94.9	96.4

Nr	0	22	4	4	6	6
Si ⁴⁺	..	5.282	0.980	0.991	1.821	1.820
Al ³⁺	..	2.718	0.003	—	0.179	0.180
Al ³⁺	..	0.248	—	—	0.021	0.016
Ti ⁴⁺	..	0.526	—	—	0.036	0.035
Fe ²⁺	..	1.121	0.290	0.274	0.202	0.204
Mn ²⁺	..	0.002	—	—	0.006	0.005
Mg ²⁺	..	3.912	1.736	1.734	0.822	0.806
Ca ²⁺	..	—	0.008	0.008	0.929	0.954
Na ⁺	..	—	—	—	0.049	0.048
K ⁺	..	1.784	—	—	—	—
Mg						
Mg+Fe		0.79	0.86	0.86	0.80	0.79

*) Calculated from total FeO

1. Phlogopite, phenocryst.
2. & 3. Olivine, phenocrysts.
4. Clinopyroxene, monomineralic cluster.
5. » , phenocryst.
6. Titaniferous magnetite, large phenocryst.
7. » , » , from matrix.

km WNW of Inderskär, or the boulder may derive from some alkaline complex north of Åland, the existence of which is at present unknown. The chemical composition of the Åland ouachitite does not differ greatly from the composition of alnöitic, ouachititic and kimberlitic dikes in the Alnö complex (v. Eckermann 1948, 1958). The high titanium and barium contents, in particular, agree with the data for Alnö rocks. The mineralogical composition of the Åland ouachitite differs from the composition of the Alnö alkaline dykes encountered so far in one important point: diopside has not been recorded as a constituent of the Alnö dikes. Instead augite, aegirine-augite, titaniferous augenite and pigeonitic pyroxene have been recorded (v. Eckermann 1948, 1958, 1966, 1974). Also, the ouachitites at Alnö contain major amounts of melanite, which is absent from the Åland specimens.

Very recently, a large nodule of diopside was discovered by one of us (P. K.) in the alnöitic breccia at Hovid (*cf.* v. Eckermann 1948, p. 100).

This seems to be the first record of diopside within the Alnö complex. This diopside is, however, rather different in chemical composition to the ones occurring as phenocrysts in the Åland rock, and probably represents upper mantle material (Kresten & Persson 1975).

Summarizing the evidence, it may be stated that rocks comparable to the Åland ouachitite are not known to occur in the Alnö alkaline complex. Because of the great similarity between the ouachitite and the Alnö rocks, we suggest that the boulder originates from a subsidiary intrusion, related to the main Alnö intrusion both geographically and genetically. It might be situated east or southeast of Alnö, covered by the Gulf of Bothnia.

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