

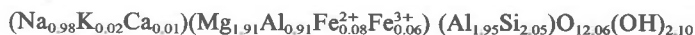
## Preiswerkite,<sup>1</sup> an Al-rich trioctahedral sodium mica from the Geisspfad ultramafic complex (Penninic Alps)

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### Abstract

The properties and occurrence of an Al-rich trioctahedral sodium mica are described. From microprobe analysis the formula



is derived. The idealized composition  $\text{NaMg}_2\text{Al}[(\text{OH})_2(\text{Al}_2\text{Si}_2\text{O}_{10})]$  is related to phlogopite by the coupled substitutions  $\text{Na} \rightleftharpoons \text{K}$  and  $\text{AlAl} \rightleftharpoons \text{MgSi}$ . The mica was formed during Alpine metamorphism (upper greenschist to lower amphibolite facies) with Al-pargasite and zoisite in a rodingite dike within the harzburgitic ultramafic mass of the Geisspfad ultramafic complex.

### Introduction

In the petrographic study of the Geisspfad ultramafic complex a sodium mica was observed. The X-ray powder data excluded paragonite and although the value of the (060) reflection seemed small and the amount of  $\text{Al}_2\text{O}_3$  high for a trioctahedral mica, the material was provisionally designated as a sodium phlogopite (Keusen, 1972). It was thought necessary to obtain more data on the composition and the physical properties of this mica, especially since in the meantime further sodium-rich micas were discovered in nature (Kulke, 1976; Spear, personal communication) or synthesized (Carman, 1974; Hewitt and Wones, 1975; Franz and Althaus, 1976), and their relevance for the crystal chemistry of the mica group (Hazen and Burnham, 1973; Hewitt and Wones, 1975) became evident. Hewitt and Wones suggested that the amount of coupled substitution of Al for Si in the tetrahedral layer and Al for Mg in the octahedral layer in trioctahedral micas is determined by the size of the interlayer cation. The bond length between interlayer cation and open oxygen of the tetrahedral layer would limit the tetrahedral rotation

necessary to compensate the dimensional differences between tetrahedral and octahedral layer.

### Occurrence and genesis

Preiswerkite has been found in a slightly schistose basic dike within the ultramafic body. The mica occurs in greenish white nodular aggregates (from 1–40 mm in diameter) of mica and zoisite surrounded by the Al-pargasite±zoisite assemblage of the dike. From geologic and chemical evidence (Keusen, 1972) the formation of the rock is envisaged as follows: intrusion or segregation of basaltic material in a harzburgite; rodingitization of the dike during serpentinization of the surrounding harzburgite; regional Alpine metamorphism in upper greenschist to lower amphibolite facies. The mica nodules have rims of  $\alpha$ -zoisite with some “garben” of this mica, but  $\alpha$ -zoisite can also be observed in the center of many of the nodules. Around the nodules the Al-pargasite is partly transformed along (110) into  $\alpha$ -zoisite and mica. This observation indicates the possibility that this mica was formed from the decomposition of pargasite, whereby the Ca was incorporated in newly-formed zoisite. The reactions that lead to its formation are not clear. The mineral paragenesis in the ultrabasic and surrounding rocks suggests a temperature of 520°C and a pressure of at least 5 kbar for the culmination of the Alpine metamorphism in this area. The preiswerkite must have formed either during the peak of metamorphism or shortly afterwards.

<sup>1</sup> In honor of H. Preiswerk (1876–1940), Professor in Basel. Mineral name approved by the IMA Commission on New Minerals and Mineral Names.

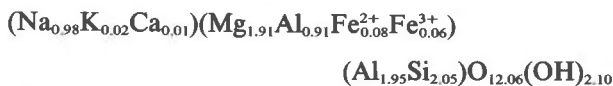
## Mineralogical data

The crystals are macroscopically pale greenish, platelike, up to 1 mm in size, and have a perfect (001) cleavage. The Mohs hardness is 2.5, the measured density is 2.96 g/cc and the calculated density 2.94 g/cc. Optically the mineral is colorless in thin section;  $\alpha = 1.560 \pm 0.004$ ,  $\beta = 1.614 \pm 0.002$ ,  $\gamma = 1.615 \pm 0.002$ ; O.A.P. = (010);  $2V_x = 5-7^\circ$ .

*h0l* and *0kl* Weissenberg photographs were taken with  $\text{CuK}\alpha$  radiation and they were used to determine the monoclinic space group  $C2/c$  of a  $2M_1$ -type mica and the lattice parameters  $a = 5.22$ ,  $b = 9.05$ ,  $c = 19.42 \text{ \AA}$ ,  $\beta = 95^\circ 10'$  [ $Z = 2$ ]. A powder pattern was made with a Nonius Guinier camera with Fe-radiation and the most intense reflections are given in Table 1.

## Chemistry

A microprobe investigation showed the material to be very homogeneous. Analyses done by J. Sommerauer and one of the authors in Zürich and H. S. Schwander in Basel gave almost identical results (Table 2).  $\text{H}_2\text{O}$  and  $\text{Fe}_2\text{O}_3/\text{FeO}$  determined on a slightly impure concentrate gave 4.6% and 0.7 respectively. From the calculation based on 11 oxygens of the anhydrous formula of the average of the Zürich analyses the formula results:



The formula corresponds to a trioctahedral mica which can be related to phlogopite by the exchange  $\text{Na} \rightleftharpoons \text{K}$  for the interlayer cation and  $\text{AlAl} \rightleftharpoons \text{MgSi}$  for the octahedral and tetrahedral site.

The natural sodium phlogopite described by

Table 1. X-ray powder data of preiswerkite from Geisspfad (Penninic Alps). Guinier camera.  $\text{FeK}\alpha_1$

Int.	$d$ in $\text{Å}$	hkl	Int.	$d$ in $\text{Å}$	hkl
50	9.64	002	20	2.402	008
10	4.84	004	40	2.382	204, 133
60	4.52	020	20	2.328	134
30	4.48	110	30	2.209	135
20	4.42	111	60	2.149	009
20	3.68	023	40	2.117	135
15	3.62	113	10	1.926	00, 10
50	3.215	006			137
15	2.931	025	15	1.848	046
50	2.775	007	25	1.618	139
100	2.572	202	100	1.508	060
		131			331
70	2.457	202	30	1.489	13, 11
		133			

Table 2. Analyses of preiswerkite, associated minerals, and bulk rock sample

	1	2	3	4	5	6
$\text{SiO}_2$	30.5	29.9	2.046	39.71	43.6	41.8
$\text{Al}_2\text{O}_3$	35.0	35.4	2.855	33.46	18.55	21.0
$\text{Fe}_2\text{O}_3$					0.30	0.6
FeO	2.5	2.8	0.144	0.22	4.95	4.1
MgO	18.3	18.7	1.907	-	15.10	14.7
CaO	0.1	0.09	0.007	24.46	11.18	11.5
MnO	-	-	-	-	0.10	0.08
$\text{Na}_2\text{O}$	7.7	7.35	0.975	-	3.12	4.31
$\text{K}_2\text{O}$	0.2	0.19	0.016	-	0.28	0.36
$\text{TiO}_2$	0.1	-	-	-	0.09	0.11
$\text{Cr}_2\text{O}_3$	-	-	-	0.13	0.05	0.05
$\text{H}_2\text{O}$	4.6 <sup>+</sup>	4.6 <sup>+</sup>	1.051	2.0 <sup>+</sup>	2.3	1.3
F	0.1	-	-	-	-	-
Total	99.1	99.03		99.98	99.62	99.91

- 1 microprobe analyses made in Basel (preiswerkite)
- 2 " " " " Zürich ( " )
- 3 At. prop. based on 11 oxygens ( " )
- 4 microprobe analyses of  $\alpha$ -zoisite
- 5 wet chemical analyses of Al-pargasite
- 6 " " " " bulk rock

\* determined on impure concentrate

Kulke (1976) and the synthetic sodium phlogopite described by Carman (1974) are related to pure potassium phlogopite by the exchange  $\text{Na} \rightleftharpoons \text{K}$  of the interlayer cation. Both samples showed reversible hydration. From the analyses presented of Kulke's material a layer charge of less than one (calculated on the basis of 12 oxygens) that might be responsible for the tendency to hydration can be inferred. The weight loss curve of preiswerkite shows no significant decrease in weight up to  $750^\circ\text{C}$ , and most of the OH is given off between  $850^\circ$  and  $950^\circ\text{C}$ . Preiswerkite corresponds to the synthetic mica that was called Na-aluminous eastonite by Hewitt and Wones (1975), for which they gave the formula  $\text{NaMg}_2\text{AlAl}_2\text{Si}_2\text{O}_{10}(\text{OH})_2$ . This mica showed also reversible hydration to 12 $\text{Å}$  and 15 $\text{Å}$  phases. Franz and Althaus (1976) synthesized  $\text{NaMg}_2\text{AlAl}_2\text{Si}_2\text{O}_{10}(\text{OH})_2$ , which they called Na-brittle mica and which showed no hydration, in contrast to a mica of the composition  $\text{NaMg}_{2.5}\text{Al}_{0.5}\text{Al}_{1.5}\text{Si}_{2.5}\text{O}_{10}(\text{OH})_2$  designated as Na-eastonite that could be hydrated.

Strunz (1977) abandoned the name eastonite, because the original material from Easton, Pennsylvania, was a mixture of vermiculite and phlogopite. In

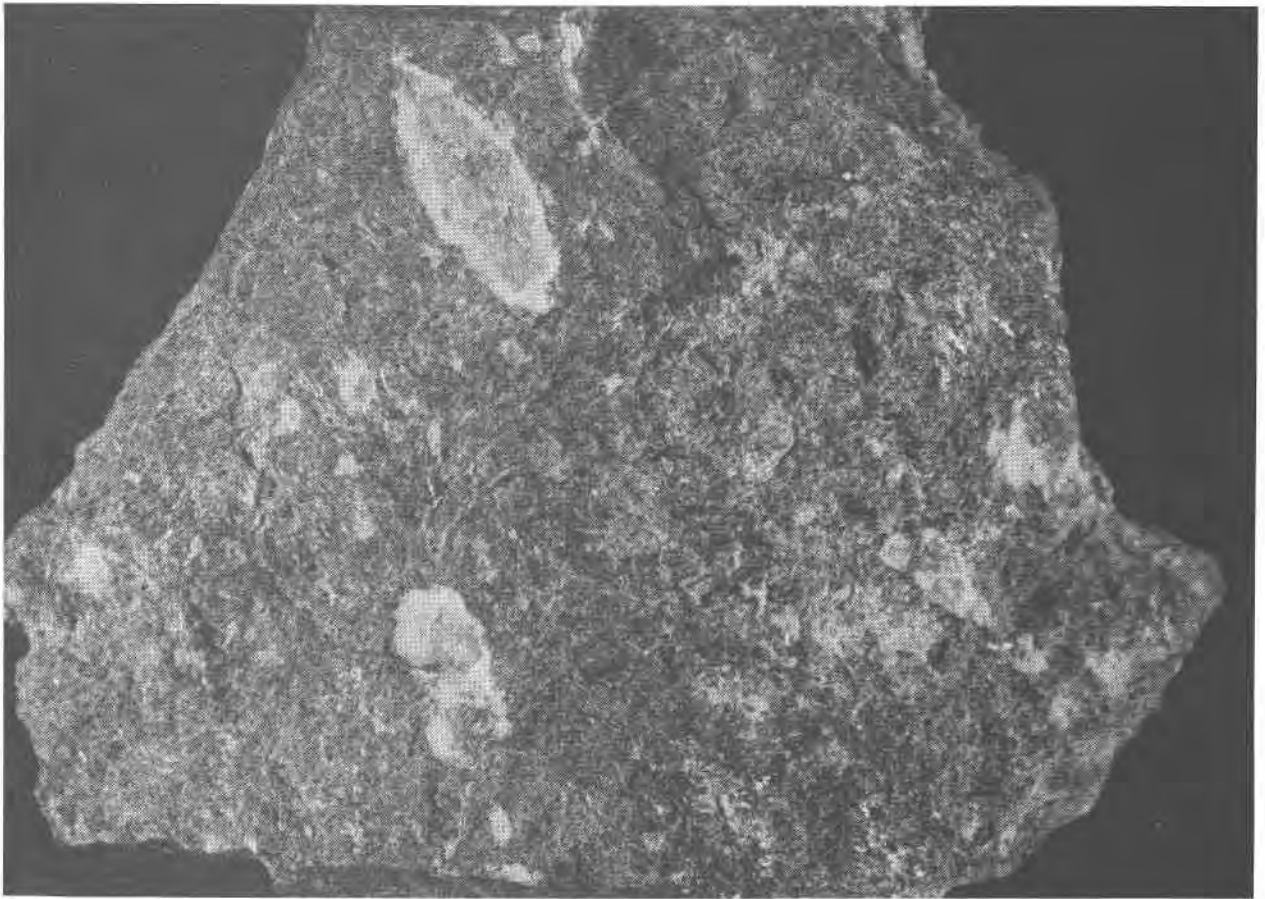


Fig. 1. Metarodingite composed of Al-pargasite with nodular aggregates of preiswerkite; clear rims of the nodules consist of  $\alpha$ -zoisite (natural size).

preiswerkite and in the synthetic material of Hewitt and Wones (1975) and of Franz and Althaus (1976) the exchange  $\text{AlAl} \rightleftharpoons \text{MgSi}$  is more complete than in the original eastonite formula  $\text{KAl}_{0.5}\text{Mg}_{2.5}\text{Al}_{1.5}\text{Si}_{2.5}\text{O}_{10}(\text{OH})_{20}$ . Assuming an ideal mica structure the  $\text{AlAl} \rightleftharpoons \text{MgSi}$  exchange would enlarge the  $a$  and  $b$  dimensions of the octahedral layer in trioctahedral mica. To compensate this theoretical misfit a rotation of the tetrahedra is assumed (Donnay *et al.*, 1964). With this rotation the interlayer cation-oxygen distance decreases also, which puts a constraint on the size of the interlayer cation (Hewitt and Wones, 1975). The amount of  $\text{Al} \rightleftharpoons \text{Si}$  substitution in the tetrahedral layer would thus be small with  $\text{K}^+$  as interlayer cation, more with  $\text{Na}^+$ , and considerably more with  $\text{Ca}^{2+}$  as in xanthophyllite, where the Al:Si ratio in the tetrahedral layer reaches 3 and a rotation of  $23^\circ$  was measured (Takeuchi and Sadanga, 1966). In preiswerkite and in the synthetic material of Hewitt and Wones (1975), calculation of the Na-O bond

length with the method of Donnay *et al.* gives  $2.6\text{\AA}$ , corresponding to the Na-O bond length in paragonite. This indicates that the Al:Si ratio of 2/2 in the tetrahedral layer of preiswerkite results in a relatively stable structure. The tendency towards hydration in the sodium trioctahedral micas with less Al in the tetrahedral layer as in the synthetic products of Carman (1974) and Franz and Althaus (1976) could be the result of the weakness of the Na-O bonds, due to large bond lengths. As there are structural constraints for a much larger exchange  $\text{AlAl} \rightleftharpoons \text{MgSi}$  in sodium trioctahedral micas than shown in preiswerkite, smaller amounts of  $\text{NaAlAl} \rightleftharpoons \text{KMgSi}$  substitutions in trioctahedral micas could be described with preiswerkite endmember.

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