

SVERIGES GEOLOGISKA UNDERSÖKNING

SER. C

Avhandlingar och uppsatser.

N:o 475.

ÅRSBOK 39 (1945) N:o 8.

THE COMPOSITION OF
ECKERMANNITE AND ITS POSITION
IN THE AMPHIBOLE GROUP

BY

N. SUNDIUS

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STOCKHOLM 1946
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When A. E. Törnebohm in 1906 described the katapleite syenite from the neighbourhood of Grenna¹ he also published an analysis by R. Mauzelius of a bluish green amphibole and some optical determinations made on it by A. Hamberg. The amphibole later escaped the attention of the mineralogists until the katapleite syenite in 1942—1944 was submitted to a renewed investigation by O. Jungstedt Adamson, who also made a more thorough study of the properties of the amphibole². In view of the results obtained he concluded that the amphibole was a new species in the amphibole group and proposed for it the name eckermannite in honour of H. von Eckermann, the Swedish mineralogist and petrologist.

In connection with a compilation of amphibole analyses for a systematic work on the hornblende group the present writer among other things also made a survey of eckermannite. The special chemical property that distinguishes eckermannite from other amphiboles is, according to the analysis published by Mauzelius, a great surplus of alkalis over the amount demanded by the hornblende formula and an analogous deficit in the amount of metal atoms of intermediate size. Adamson therefore proposed a new type of amphiboles, whose formula should be characterized by four atoms of Na, Ca and K (+ minor amounts of Fe'', Zn, Mn'') instead of 2—3 and with 4 metal atoms of intermediate size (Al, Fe''', Mg) instead of 5, when compared with the relations in the ordinary hornblende formula. However, considering that, as in the case of eckermannite, the greater part of the atoms in the first named group should be alkalis, this proposal is not very probable. It supposes that atoms of great size and in considerable amounts should substitute smaller ones in the pattern, and it is problematic whether the latter would sustain the stress originating from a replacement of this kind.

Upon inspecting the atom numbers calculated from Mauzelius's analysis quoted on p. 5, it appears that the total sum of the metal atoms when calculated on the basis of 24 O-atoms accords with that required by the hornblende formula (8 Si + 5 Al, Mg etc. + 2 to 3 Na, Ca, K). On the other hand, there is in group X (Na, Ca, K) a surplus of 0.61 atoms, and in group Y (atoms of intermediate size)³ a deficit of 0.66 atoms. In reality these figures may be due to some incompleteness in the analysis. The most likely explanation would be that some Li₂O has been included in the amount determined as Na₂O.

¹ S. G. U., Ser. C, Nr 199.

² G. F. F., 66: 195—205.

³ X and Y are here taken in the sense of Machatschki.

As is well known lithium is easily overlooked if its presence is not established by a spectrographical test. On the other hand, Li has a small atomic radius, similar to Mg, and the presence of it would mean that a corresponding number of atoms would be transported from the group of large atoms to that of the smaller ones. With this in mind a sample of the powder once separated from the rock by Dr Mauzelius and kept in the collections of the Geological Survey was handed over to Dr S. Landergren, who kindly tested it spectrographically for Li and found that it really contained a considerable amount of this metal.

As eckermannite is of great interest from a systematic point of view, it was subjected to a renewed and very careful analysis, performed by Dr A. Bygdén, who has given the following communication about it.

»As material for the analysis was used what remained of two fairly coarse-grained mineral fractions isolated from the rock by Dr. Mauzelius. The powders contained a considerable amount of foreign minerals, essentially yellow green aegirine, which were removed by treatment with Clerici solution and were subsequently picked out under a binocular microscope. Thanks to the good cleavage of the amphibole and its homogeneity a practically pure fraction of 3.5 g could be gained. It should be noted that the powder analysed by Dr. Mauzelius was not identical with the impure coarse samples used for the new analysis. A further cleaning with the aid of Thoulet solution, probably followed by picking out by hand, had also been performed by him. For the new analysis the following quantities were used:

- I 0.7034 g for the determination of SiO_2 , F and metal oxides except alkalis. Decomposition with KNaCO_3 .
- II 0.7518 g for the determination of metal oxides alkalis included. Decomposition with $\text{HF} + \text{H}_2\text{SO}_4$.
- III 0.4985 g for the determination of alkalis according to L. Smith.
- IV 0.4733 g for the determination of FeO .
- V 0.7826 g for the determination of H_2O .

The figures for the basic oxides given in the analysis are the means of double determinations showing differences of 0.00 to 0.03 %, in one case (Al_2O_3) 0.06 %. The determination of Li_2O was made in the laboratory of the Boliden Mining Co. on sulphates of the alkalis originating from II and III. The analyses were performed in a spectrograph according to Lundegårdh's flame method with the standard solution in alkaline milieu. The figures obtained were 1.15 and 1.08 %, the former of which is the more reliable due to the fact that lithium is only incompletely extracted with H_2O from the reaction products when using the method of L. Smith. Two further decompositions, after addition of H_4NCl and extractions of the undissolved rest with H_2O were necessary in order to obtain the figure 1.08 %. A direct determination of Li_2O on the mineral powder in a spectrograph by means of the intermittent arc method performed at the geochemical laboratory of the Geological Survey by S. Landergren yielded the figure 1.03 % Li_2O , which may be regarded as a minimum value, in view of the influence of the standard used.

The determination of F was made according to Berzelius's method. The figure obtained was checked by G. Assarsson by titration with thorium nitrate with the result of 2.7 %.

	1 Weight %	Mol. No.	No. of met. atoms and OH, F		2 Weight %	Mol. No.	No. of met. atoms and OH, F	
SiO ₂	56.45	0.936	8.03	8.03	57.10	0.952	8.02	8.02
Al ₂ O ₃	5.47	0.054	0.92	}	6.19	0.061	1.02	}
TiO ₂	0.39	0.005	0.04		0.35	0.004	0.04	
Fe ₂ O ₃	9.49	0.059	1.02	}	8.01	0.050	0.84	}
MgO	9.43	0.234	2.01		4.34	9.13	0.228	
Li ₂ O				}	1.15	0.038	0.65	}
FeO	1.90	0.026	0.22		2.69	0.037	0.31	
ZnO	0.67	0.008	0.07	}	0.59	0.007	0.06	}
MnO	0.52	0.007	0.06		0.34	0.005	0.04	
Na ₂ O	11.30	0.182	3.12	}	9.77	0.158	2.66	}
CaO	0.35	0.006	0.05		3.61	0.31	0.006	
K ₂ O	2.41	0.026	0.44	}	2.38	0.025	0.43	}
H ₂ O < 105°					10.08			
H ₂ O > 105°	0.33	0.018	0.30	}	0.50	0.028	0.47	}
F	2.59	0.136	1.17		1.47	2.69	0.142	
	101.30				101.28			
—O for F	1.09				1.13			
	100.21				100.15			

¹ Of which 0.01 in H₂SO₄-exsiccator.

1. Eckermannite anal. by R. Mauzelius.
2. » » » A. Bygdén.

The generally slight differences found by the two chemists may chiefly be due to a slightly larger amount of impurities being present in the powder used by Dr Mauzelius, excepting the figures for Na₂O and Li₂O, which latter is included in the figure for Na₂O in analysis 1.

An inspection of the figures obtained in the calculation of the atomic numbers in Bygdén's analysis discloses that the ratio of the different metal groups accords fairly well with the hornblende formula.

The physical properties given by Adamson are:

Spec. Gr.	α	β	γ	$\gamma - \alpha$	$c : a$	$2V_\alpha$	opt. orient.
3.16	1.636	1.644	1.649	0.013	25—53°	75°	$b = \beta$

The axial dispersion is strong with $\rho > \nu$. The pleochroism is α bluish green $> \beta$ light bluish green $> \gamma$ pale yellowish green, almost colourless.

One of the most conspicuous properties of eckermannite when studied in thin slides is the inhomogeneity of its extinction and of its absorption power. On this subject Adamson writes (p. 195): »The amphibole is built up of alternating lighter and darker parts. The darker parts have a distinct pleochroism in bluish green and yellowish green colours. The light parts have weaker pleo-

chroism in paler colours» and on p. 196: »The amphibole has a very flamy extinction so that it is not possible to measure the extinction angle with any great accuracy. The darker parts show the most consistent extinction angle, the value being about 25° ($X/\wedge c$), whereas the light parts show a maximum extinction angle of 53° ($X/\wedge c$). Otherwise there seems to be little difference between the different parts of the amphibole.» And: »Optical determinations in convergent light give the same results for both components.» . . . »The indices of refraction are approximately the same, the variations lying within the limits of error of the immersion method. Nor do the two components show any perceptible difference in spec. gravity.»

From the relations cited Adamson concludes that there may be some slight difference in chemical composition between the differently coloured parts of the amphibole. The great variation in light absorption and extinction angle may be due to the low double refraction, on account of which »only a small variation in the indices of refraction is necessary to cause a great change in the position of the indicatrix». An opinion of this kind has earlier been expressed by Rosenbusch-Wülfing in order to explain the different extinction angle in different specimens belonging to the groups arfvedsonite and riebeckite. On the other hand, in the eckermannite the differences in refraction seem to be too small, nor should they influence the light absorption power. Possibly this variation is connected with a small supersaturation of large atoms in the amphibole or with the presence of radio active elements in small amounts, which both may produce stresses in the crystal structure. In either case the distribution in the amphibole must be somewhat irregular.

Eckermannite has a unique position in the amphibole group. On account of its colour it might be thought to be allied to glaucophane. Like the members of this type, it is also high in MgO and holds a moderate amount of Fe-oxides. On the other hand, it is lower in Al_2O_3 and very high in alkalis, probably the most alkali-rich amphibole known. Finally, the physical properties are quite different from those prevailing in glaucophane. Thus eckermannite represents a type not previously known. We can get a conception of the position of this type and its relations to other amphibole types if we deduce it from tremolite through substitution. The formula of tremolite is $Ca_2Mg_5Si_8O_{22}(OH)_2$. In this formula Ca can be substituted, more or less, by Na (K). In richterite one atom of Ca is substituted by $2Na(K)$ and the formula is then $Na_2CaMg_5Si_8O_{22}(OH)_2$. No change in the other metal atoms is necessary because the balance of the valences is maintained. But also the Ca-atom remaining in richterite may be exchanged for Na. In this case, which is realized in eckermannite, the valences made free by the exchange of Ca for Na require an exchange of divalent atoms in the Y group for trivalent ones and the formula may be written $Na_3Mg_4AlSi_8O_{22}(OH)_2$. This is the most alkali-rich type possible in the amphibole group. In the Fe-bearing hornblende series it has its analogy in arfvedsonite, the formula of which may be written $Na_3Fe''_4Fe'''Si_8O_{22}(OH)_2$.

The agreement between the formula deduced above and the atom ratios calculated from the analysis of eckermannite is shown by the following table.

The calculated ratios differ from the formula essentially in a partial replacement of Mg by atoms of similar size.

	Atoms in the type formula	Eckermannite
Si	8	8.02
Al	1	1.02
Ti		0.04
Fe'''		0.84
Mg	4	1.92
Li		0.65
Zn		0.06
Fe''		0.31
Mn		0.04
Ca		0.05
Na }		2.66
K }	3	0.43
OH }		0.47
F }	2	1.19

A feature in the composition of the analysed eckermannite worthy of mention is the low sum of F + OH. This cannot be explained by errors in the analyses, for the determinations were made with great care, and, as regards H₂O in No 2, in a special furnace with arrangements for the oxidizing of any hydrogen that might appear and for the retention of F. Thus, in the analysed specimen there may have been some exchange of OH for O and a corresponding increase in the amount of Fe''' at the cost of Fe'', analogous to what has happened in the so-called oxyhornblendes. This and the presence of the monovalent Li has caused the relatively high amount of Fe'''.

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