Eckermannite, a new alkali amphibole.

Preliminary note.

By

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Analysis of a rockforming amphibole from the Norra Kärr area in Southern Sweden corresponds with the formula

$$Na_4Mg_2Al\,Fe^{III}\,(Si_4O_{11})_2\,(O, OH, F)_2$$

The name Eckermannite is proposed for this mineral in honour of Professor Harry von Eckermann.

While working with the singular alkaline rocks of the Norra Kärr area in southern Sweden the writer's attention was attracted to a peculiar amphibole occurring in one of the rocks which Törnebohm designated by the bulk name Lakarpite.[1] Besides amphibole, the main minerals of this particular Lakarpite are feldspar, decomposed nephe-line, pectolite, and aegerite. Apatite, titanite, and a mineral very closely related to titanite but with optical negative sign are found in subordinate amount. The rock has centimeter-large phenocrysts of nonperthitic microcline. The feldspar of the groundmass is essentially albite, but grains of microcline and orthoclase have also been observed. The average grain diameter of the groundmass is one mm. The rock has a marked protoclastic schistosity.

The amphibole generally occurs as laths 1—2 mm long and 0.2—0.5 mm wide, euhedral after the prismatic zone. They are occasionally larger, up to 4 mm in length and 1 mm in width. Under the micro-scope the amphibole seems quite homogeneous except for some spots of irregular outline which have a lighter colour than the mineral in main. The plane of the optic axis lies in the plane of symmetry, $Y = b$. The extinction angle is $X \wedge c \sim 25°$. (For the light parts it may be as much as $X \wedge c \sim 53°$.) The axial dispersion is strong with $r > \varrho$. The optical character is negative, and the axial angle $2V\alpha \sim 74°$.

[1] A. E. Törnebohm. Katapleiit-Syenit. S. G. U. Ser. C, N:o. 199, 1906, p. 18. Törnebohm distinguished four types of lakarpites.

The pleochroism is: X bluish green
Y light bluish green
Z pale yellowish green, almost colourless
$X > Y > Z$

Indices of refraction are: $\alpha_{Na} = 1.636 \pm 0.003$
$\beta_{Na} = 1.644 \pm 0.003$ $\gamma \div \alpha = 0.013$
$\gamma_{Na} = 1.649 \pm 0.003$

Some of the data given above were already determined by A. Hamberg. (Törnebohm, op. cit. p. 26). The writer's results were in good agreement with those of Hamberg.

The mineral has generally no inclusions of any kind, a circumstance which makes its separation easy.

Törnebohm presented without comment an analysis of the amphibole, carried out by the excellent mineral chemist R. Mauzelius.

SiO_2	56.45
TiO_2	0.39
Al_2O_3	5.47
Fe_2O_3	9.49
FeO	1.90
MnO	0.52
ZnO	0.67
MgO	9.43
CaO	0.35
Na_2O	11.30
K_2O	2.41
H_2O	0.33
F	2.59
	101.30
Less O for F	1.09
	100.21
	s. g. 3.16

The high alkali content, the insignificant amount of calcium, and the relatively low iron content combined with high magnesia and a considerable amount of aluminium are conspicuous. The analysis was computed, taking advantage of the recent advances in the study of the amphibole group. Before presenting the result of the calculation it is appropriate to give a short synopsis of our present conceptions of this group. It will then be seen that this amphibole occupies a natural place in the modern classification of the amphiboles. It should be remembered that this classification is purely chemical and structural. Berman[1], in his paper »Constitution and classification of the

[1] Amer. Min. 22, p. 387. 1937.

natural silicates», writes as follows: ».... . it is no wonder that so many species names have been proposed for members of the hornblende series. Unfortunately, some of the names in the literature are based on habit or optical properties. For our purpose these names are of no value, since our classification is chemical and structural, and any other basis of classification cannot consistently be superimposed on it.»

Berman (op. cit. p. 354) writes as general formula for the amphibole group, representing half the content of the unit cell:

$$(W\ X\ Y)_{7-8}\ (Z_4\ O_{11})_2\ (O,\ OH,\ F)_2,$$

where W principally stands for Na, K, Ca
» X » » » Mg, Fe^{II}, Mn, Al
» Y » » » Al, Fe^{III}, Ti
» Z » » » Si, Al

This is a modification of the original formula deduced by Warren after studies of the crystal structure of various amphiboles[1]. The terms of Berman will be used throughout this paper. The main factor governing the distribution of the elements among the element symbols W, X, Y, Z is the ionic radii.

W	K^+	1.33 Å	O^{--}	1.32 Å
W	Ca^{2+}	1.06 »	F^-	1.33 »
W, X	Na^+	0.98 »	OH^-	1.4—1.5 Å
X	Mn^{2+}	0.91 »		
X	Zn^{2+}	0.83 »		
X	Fe^{2+}	0.83 »		
X	Mg^{2+}	0.78 »		
Y	Fe^{3+}	0.67 »		
Y	Ti^{4+}	0.64 »		
Y, Z	Al^{3+}	0.57 »		
Z	Si^{4+}	0.39 »		

Elements lying on the border between two groups may belong to both of them. This is indicated in the table by their being embraced by two brackets. Berman (op. cit. p. 359) divides the amphibole group into four series: The orthorhombic anthophyllite series including gedrite, the monoclinic cummingtonite series including grünerite, the tremolite-actinolite series, and the hornblende series including the alkali amphiboles arfvedsonite, holmquistite, glaucophane, and riebeckite. »Within each series there is isomorphism to the extent indicated in the formula, but between these series little overlapping is found.»

[1] The crystal structure and chemical composition of the monoclinic amphiboles. Z. f. K. 72. p. 493. 1930.

Anthophyllite series	$X_7(Z_4O_{11})_2(OH)_2$
Cummingtonite series	$X_7(Z_4O_{11})_2(OH)_2$
Tremolite-actinolite series	$W_2X_5(Z_4O_{11})_2(OH)_2$
Hornblende series	$W_3(XY)_5(Z_4O_{11})_2(O, OH, F)_2$

We shall now return to the amphibole from Norra Kärr. For our purpose it is convenient to arrange the oxides according to the ionic radii of the metals. This makes some difference from the ordinary presentation of an analysis, Al_2O_3 comes before TiO_2, MgO comes between Fe_2O_3 and FeO, and CaO between Na_2O and K_2O.

Calculation of the Eckermannite analysis.[1]

	1 Weight %	2 Mol. numb.	3 Numb. of O, OH, F	4 Numb. of metal atoms and of O, OH, F a		b	c	5 Ideal comp.	
SiO_2	56.45	0.936	1.872	8.03		8.03	8.03	8	8
Al_2O_3	5.47	0.054	0.162	0.92	0.96				1
TiO_2	0.39	0.005	0.010	0.04					
Fe_2O_3	9.49	0.059	0.177	1.02			3.99	4	1
MgO	9.43	0.234	0.234	2.01		4.34			2
FeO	1.90	0.026	0.026	0.22					
ZnO	0.67	0.008	0.008	0.07	0.35				
MnO	0.52	0.007	0.007	0.06					
Na_2O	11.30	0.182	0.182	3.12			3.96	4	4
CaO	0.35	0.006	0.006	0.05		3.61			
K_2O	2.41	0.026	0.026	0.44					
H_2O	0.33	0.018	0.018	0.30		1.47	1.47	2	2
F	2.59	0.136	0.136	1.17					
	101.30		2.864						
Less O for F	1.09	$\div \frac{0.136}{2}$	= 0.068						
	100.21		2.796						
s. g. 3.16		$\frac{24}{2.796}$	= 8.58						

The actual amount of Si lies as close to the theoretical as can be desired. It can therefore be taken for granted that there is no replacement of Si by Al. Between the element groups X Y and W, however, it is evident that replacement occurs to a certain extent, for the XY-group exceeds a whole number by almost the same amount as the W-group is less than a whole number. In column 4b Fe^{II}, Zn, and Mn are reckoned with X as usual although they are known to be interchangeable with Na, particularly Mn but also Fe^{II} and Zn in small amounts. By reckoning Fe^{II}, Zn, and Mn to W (4c), both groups come very near to whole numbers, four in each. The correct value

[1] For explanation of the method of calculation see Warren, op. cit. p. 515.

for the OH, F content is assumed to be two. Considering the difficulty in the determination of water and fluorine the difference from the ideal value is not surprising.

The calculation gives the following general formula

$$W_4(XY)_4(Z_4O_{11})_2(O, OH, F)_2,$$

where W includes the small amount (0.35) of the bivalent elements Fe^{II}, Zn, and Mn.

It should be pointed out that the sum X + Y is only four, whereas in all other amphiboles known it is five. Thus this amphibole will occupy a unique position in the classification of the amphibole group, with whose general formula $(WXY)_{7-8}(Z_4O_{11})_2(O, OH, F)_2$, it is in full agreement. The maximum alkali content of hitherto calculated amphiboles when computed on a basis of 24 (O, OH, F) is three. A slight excess of alkali sometimes occurring may, under certain conditions, fill vacant positions in the space lattice in order to make the total positive and negative valences balance[1].

The amount of alkali over three in the calculation of the new amphibole is as much as 0.61, which together with the content of Fe^{II}, Zn, and Mn makes aproximately one. It is therefore more appropriate to reckon with a deficit of alkali in the formula which is substituted by Fe^{II}, Zn, and Mn.

Study of the X Y-group in the calculation of the new amphibole shows that Mg is the only representative of the X-elements, and that it occurs in an amount of two. Reckoning Ti with Al, the amounts of the Y-elements Al and Fe^{III} are both equal to one. Mentioning the structure-bearing elements alone, the formula may be written

$$Na_4Mg_2AlFe^{III}(Si_4O_{11})_2(O, OH, F)_2$$

This is not only an entirely new species, it is also a representative of a new series in the amphibole group of minerals.

The general formula $W_4(XY)_4(Z_4O_{11})_2(O, OH, F)_2$ may be resolved into $W_4X_2Y_2(Z_4O_{11})_2(O, OH, F)_2$. Comparing it with the other amphiboles it is evident that it follows the hornblende series in Berman's classification.

Anthophyllite series	$X_7(Z_4O_{11})_2(OH)_2$
Cummingtonite series	$X_7(Z_4O_{11})_2(OH)_2$
Tremolite-actinolite series	$W_2X_5(Z_4O_{11})_2(OH)_2$
Hornblende series	$W_3(XY)_5(Z_4O_{11})_2(O, OH, F)_2$
New series	$W_4(XY)_4(Z_4O_{11})_2(O, OH, F)_2$

[1] Warren, op. cit. p. 513.

For the variation of X, Y, and Z in the hornblende series Berman (op. cit. p. 355) has put forward the following scheme:

Species	X	Y	Z = Si : Al
Hornblende-edenite	5	0	7 : 1
Hastingsite	4	1	6 : 2
Glaucophane	3	2	8 : 0
Arfvedsonite	4	1	8 : 0

The relation of these element groups in the new amphibole is

	2	2	8 : 0

For this new amphibole species

$$Na_4Mg_2AlFe^{III}(Si_4O_{11})_2(O, OH, F)_2,$$

is proposed the name Eckermannite, in honour of Professor Harry von Eckermann, who has already gained such important results in connection with his investigations of Alnö, another classic alkaline area in Sweden.

A more complete description of the Eckermannite will be given in a forthcoming publication dealing with the rocks and minerals of the Norra Kärr area in general.

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