Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1939. Volume XXII, № 5

MINERALOGY

CHKALOVITE

By V. I. GERASIMOVSKY

(Communicated by A. E. Fersman, Member of the Academy, 1.I.1939)

In the summer of 1936, in the south-eastern part of the Lovozero alkaline massifs (Punkaruayv mountain), situated in the central part of the Kola peninsula, the author found a mineral, by its external appearance somewhat resembling natrolite, though differing from the latter by a less distinct cleavage. This circumstance prompted the author to take several samples containing the discovered mineral for the purpose of investigation. When the mineral was studied, it became evident that by its properties it could not be identified with minerals already known, and was therefore named chkalovite, in honour of the great aviator of our times, Valery Pavlovich Chkalov who was the first to accomplish in 1936 the non-stop flight from Moscow, via north pole, to the United States of America.

Physical Properties. Chkalovite has not been encountered in crystalline form. It occurs in the form of grains, with dimensions 5×4×3, 7×4×3 cm. The mineral is of white colour. Lustre vitreous. Semi-transparent. Cleavage, as examined with the microscope, occurs in one direction, is of fair quality, and usually observed with difficulty. In one direction parting plane poorly expressed. Fracture from uneven to conchoidal. Hardness~6. Specific gravity determined by a pycnometer equal to 2.662.

In the blowpipe flame easily fused to a transparent colourless globule. With borax and phosphate gives a colourless bead both in oxidating and reducing flames.

Optical Properties. Chkalovite in thin-section is colourless. Optically biaxial, positive. $2V=78°$ (measurement taken on the Fedorov stage). Refraction indices (determined by the immersion method): $N_g=1.549$ and $N_p=1.544$. The plane of optic axes coincides with the cleavage plane, macroscopically observed, the latter being well pronounced in thin-sections. Apart from that, the thin-sections exhibit poor cleavage too, usually in one direction, rarely in two (in sections perpendicular to one of the optic axes). Measurement of the imperfect cleavage in parallel direction, in the same thin-section, yields data of wide divergence from one another. This is explained by the fact that the given cleavage is poorly expressed and is therefore determinable by measurement but with great difficulty.

By comparing the results of measuring in various thin-sections of imperfect cleavage in one and the same direction, as well as in different directions, more or less similar data are derived, namely, on the average:

$$P\ (\text{cleavage pole}) \begin{cases} N_g = 51° \\ N_m = 54°30' \\ N_p = 60° \end{cases}$$

It is hereby necessary to note that there are very considerable deviations between separate measurements of cleavage in relation to N_g, N_m and N_p: N_g ranging from 46 to 58°, N_m=50—59° and N_p=53—66°. It is probably the identical poorly expressed cleavage observed in different thin-sections. The angle between the different directions of the indistinct cleavage usually ranges from 68° to 76°, the average being$\sim$72 . In one of the thin-sections (in the section of the acute bisectrix) imperfect cleavage of different orientation has been found, namely:

$$P\begin{matrix} \diagup N_g = 51^\circ \\ \angle N_m = 89^\circ \\ \diagdown N_p = 39^\circ \end{matrix}$$

It forms a right angle with good cleavage and presents cleavage along the prism, if the mineral is to be considered orthorhombic, or along the dome, if it be monoclinic. In thin-sections parallel to the parting plane is observed the emergence of the optic axes of the ellipsoid.

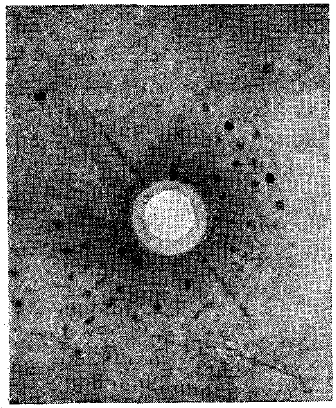

Fig. 1. Lauegram of chkalovite.

By its optical properties chkalovite may be identified as a mineral of the orthorhombic or monoclinic system. The optical data are inadequate for an ultimate solution of the question, as measurement on the Fedorov stage of the imperfect cleavage has shown great divergences between separate measurements of the same as well as of different directions of cleavage. Hence it is impossible to judge about the symmetrical arrangement of the imperfect cleavage in relation to the optical orientation of the ellipsoid, while deciding on the question of the syngony of chkalovite.

X-Ray Investigation. On the basis of the optical data it was impossible to determine to which one of the two systems—the orthorhombic or monoclinic—chkalovite could be referred, and therefore, in order to solve the problem, it became necessary to make an X-ray study of the mineral.

As chkalovite is unknown in crystalline form, it was necessary while investigating it by Laue's method to use a small grain bounded on one side by a distinct cleavage surface. During the X-ray procedure the aforesaid grain was oriented in such manner as to have the X-rays fall perpendicular to the cleavage surface. The X-ray picture was taken in the Roentgeno-Structural Laboratory of the Physical Department of the Academy of Sciences of the USSR. The X-ray procedure: rays Fe—series $K_\alpha \approx 1.93$ Å, tension 40 kV, current intensity 12 mA, duration of the exposure 2 hours, and the distance of the object from the film 15 mm.

On the basis of the obtained Lauegram of reflected rays, N. V. Belov (the Head of the Roentgeno-Structural Laboratory) considers chkalovite a mineral of orthorhombic syngony (Fig. 1).

Simultaneously with the Lauegram a powdergram was taken at the above-mentioned laboratory (Fig. 2). X-ray procedure: rays Fe—series $K_\alpha \approx 193$ Å, Evansen chambers D=57.37 mm, column diameter 0.75 mm, tension 40 kV, current intensity 12 mA, and duration of exposure 5 hours.

Table 1 shows dimensions of the interspacings for the reflecting chkalovite planes. They are given in case it would be possible to draw a comparison between chkalovite and minerals of analogous or similar chemical composition, which might be found elsewhere.

Table 1

Plane Spacings for Chkalovite

Dhkl in Å	Intensity of lines	Dhkl in Å	Intensity of lines
5.21	Medium	1.40	Strong
3.97	Very strong	1.38	»
3.27	Strong	1.33	Medium
2.74	»	1.31	»
2.46	Very strong	1.30	Very weak
2.41	» »	1.28	Weak
2.30	Medium	1.27	»
2.20	»	1.22	Very strong
2.02	»	1.17	Medium
1.99	»	1.16	»
1.79	Strong	1.15	Weak
1.75	Weak	1.12	Medium
1.71	Medium	1.11	Strong
1.69	»	1.09	Very strong
1.66	»	1.08	Weak
1.60	»	1.06	Medium
1.56	»	1.033	»
1,51	»	1.026	»
1.48	Strong	1.014	»

Chemical Properties. In diluted and strong acids HCl and NHO_3 chkalovite dissolves easily and without being heated, with separation of flaky silicic acid. In H_2SO_4 it dissolves with great difficulty.

The chemical analysis of chkalovite, performed by Pereverzeva (Geol. Inst. of Acad. of Sc. of the USSR) is given in Table 2. The latter contains (3rd column) quantitative determinations of Al and Be in chkalovite, effected by J. S. Nesterova (Geol. Inst. of Acad. of Sc. of the USSR).

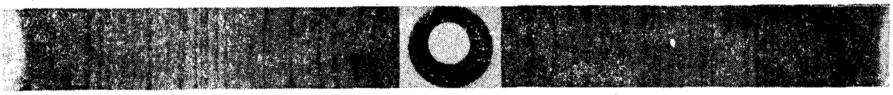

Fig. 2. Powdergram of chkalovite.

The formula of chkalovite, according to the chemical analysis, may be represented as follows: $Na_2O.BeO.2SiO_4$ or $Na_2Be(SiO_3)_2$. Thus, chkalovite is to be regarded as a metasilicate. The group of metasilicates comprises the following beryllium minerals: leukophanite, meliphanite, beryl, which, as known, differ very much by their chemical composition from chlakovite.

By its chemical composition the latter stands nearest to such minerals as eudidimite and epididimite (Table 2), occurring in small quantities in nepheline syenites on the Arö island, Langezundfjord, Norway, and at Narsarsuk, Greenland.

A spectroscopic study of chkalovite carried out by S. A. Borovick (Geol. Inst. of the Acad. of Sc. of the USSR) has detected, in addition to the compounds revealed by chemical analysis, but Mn (a very weak line).

Occurrence and Paragenesis. In Lovozero Tundras chkalovite has been found but on the eastern slope of the Maly Punkaruayv mountain in two ussingite deposits, one of them representing two pegmatite

Table 2

Chemical Analyses of Chkalovite, Leucophanite, Meliphanite, Epididimite and Eudidimite

Oxides	Chkalovite		Chkalovite	Leucophanite	Meliphanite	Epididimite	Eudidimite	
	%	equiv. quant.	%	%[1]	%[2]	%[3]	%[4]	%[5]
SiO_2	56.81	0.946	—	48.50	43.60	73.74	72.19	73.11
TiO_2	none	—	—	—	—	—	—	—
ZrO_2	none	—	—	—	—	—	—	—
Al_2O_3	none	—	0.75	0.45	4.61	—	—	—
Fe_2O_3	0.30	0.002	—	—	—	—	—	—
FeO	0.12	0.002	—	—	—	—	—	—
BeO	12.67	0.506	11.28	10.03	10.80	10.56	11.15	10.62
BaO	none	—	—	—	—	—	—	—
MnO	none	—	—	—	—	—	—	—
MgO	none	—	—	0.27	0.16	—	—	—
CaO	0.37	0.07	—	22.94	29.56	—	—	—
SrO	none	—	—	—	—	—	—	—
Na_2O	28.93	0.450	—	12.42	7.98	12.48	12.66	12.24
K_2O	0.13	0.010	—	—	0.23	—	—	—
H_2O, + 110°	none	—	—	} 1.08	—	} 3.73	3.84	3.79
H_2O, — 110°	0.23	0.013	—					
F	none	—	—	5.04	5.43	—	—	—
Cl	none	—	—	—	—	—	—	—
SO_3	0.22	—	—	—	—	—	—	—
	99.78	—	—	101.63	101.37	100.91	99.84	99.76
$—O=Cl_2$	—	—	—	2.48	2.29	—	—	—
Total	99.78	—	—	99.15	99.08	100.91	99.84	99.76

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[1] Analyst H. Bäckstrom, Z. Kryst., **16**, 287 (1890).
[2] » » » » **16**, 288 (1890).
[3] » G. Flink » » **23**, 344 (1894).
[4] » » » » }
[5] » A. E. Nordenskjöld » } **16**, 594 (1890).

veinlets in the form of expansions 30 and 50 cm thick, with visible length of 2—3 m, confined to the vertical fissures of plane partings, among eudialyte «Schlieren». The latter are lying among foyaite with sodalite. Pegmatite veinlets are packed in ussingite with a high content of natrolite. Both of these minerals were developed upon sodalite met at the present time in subordinate quantities. Of accessory minerals there occur: schizolite, marmanite, sphalerite, sometimes in considerable quantity, and insignificant quantities of steenstrupine, neptunite, erikite and individual deposits of galenite. Along the edges of the ussingite dilations are encountered: nepheline, microcline, aegirite, eudialyte and occasionally ramsayite as well.

The second deposit presents a segregation of an irregular form in the shape of «Schlieren», with dimensions 1×0.6×0.4 m, lying in the midst of foyaite with sodalite, the bulk of it being enclosed in ussingite. It contains the following accessory minerals: microcline, sodalite, eudialyte, schizolite, tainiolite(?), neptunite, ceolite, with isolated occurrence of sphalerite, steenstrupine and erikite.

In both of the aforementioned deposits chkalovite occurs in small quantities having developed there prior to ussingite, natrolite, sphalerite, galenite and neptunite. Its age correlation with other minerals is unclear, as it does not occur in immediate contact with them.

Conclusions

Among the minerals of Lovozero alkaline massif chkalovite is the only one independent beryllium mineral. In other minerals the presence of beryllium was not determined chemically, but by means of spectral analysis. By the latter method it has been detected in 21 minerals: microcline, orthoclase, nepheline, sodalite, ussingite, natrolite, aegirite, arfvedsonite, schizolite, steenstrupine, tainiolite (?), eudialyte, catapleit, sphene, astrophyllite, chinglusuite, novoelpidite, lovenite, neptunite, fluorite and galenite.

When studying chkalovite, the question arose as to what were the conditions which favoured the formation of an independent beryllium mineral—chkalovite, and why beryllium entering into its composition had not been dispersed among other minerals in the ussingite deposits, especially since chkalovite is contained in the latter in very small quantity. For that purpose 8 minerals were taken from the ussingite deposits containing chkalovite (sodalite, ussingite, natrolite, microcline, tainiolite(?), schizolite, steenstrupine and galenite) and subjected to spectral analysis for determination of the beryllium content. All of the enumerated minerals contained beryllium, whereby minerals (ussingite, natrolite and sodalite) from the ussingite deposits showed a high beryllium content—0.1—0.001 of one per cent (according to data of S. A. Borovick). It should be noted here that the spectral analysis of sodalite and natrolite from other places of the Lovozero massif points to a lower belyllium content therein. Consequently, the conditions under which the formation of ussingite had taken place, had been apparently more favourable to a higher beryllium concentration than had been the case at other places of the Lovozero alkaline massif. Therefore in this case the surplus of beryllium in excess of its ordinary concentration caused part of Be to segregate toward formation of an independent beryllium mineral. Hence the question arises whether beryllium, which by its physical and chemical properties is closely allied to aluminium, takes the place of the latter; in which case chkalovite ($Na_2OBeO.2SiO_2$) can be regarded as nepheline ($Na_2O.Al_2O_3.2SiO_2$) wherein aluminium had given way to beryllium.

Institute of Geological Sciences.
Academy of Sciences of the USSR.
Moscow.

Received
2. I. 1939.