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TELYUSHENKOITE $CsNa_6[Be_2(Si,A1,Zn)_{18}O_{39}F_2]$ — A NEW CESIUM MINERAL OF THE LEIFITE GROUP

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A new mineral, telyushenkoite, was discovered in the Dara-i-Pioz alkaline massif (Tajikistan). It occurs as white or colorless vitreous equant anhedral grains up to 2cm wide in coarse-grained boulders of reedmergnerite associated with microcline, polylithionite, shibkovite and pectolite. The mineral has distinct cleavage, Mohs hardness = 6, VHN_{100} = 714(696-737) kg/mm^2, Dmeas. = 2.73(1), Dcalc. = 2.73g/cm^3. In transmitted light, telyushenkoite is colorless and transparent. It is uniaxial positive, ω = 1.526(2), ε = 1.531(2). Single-crystal X-ray study indicates trigonal symmetry, space group *P*-3*m*1, a = 14.3770(8), c = 4.8786(3) Å, V = 873.2(1) Å^3, Z = 1. The strongest lines in the powder-diffraction pattern are [d(I,*hkl*)]: 12.47(7,010), 6.226(35,020), 4.709(21,120), 4.149(50,030), 3.456(40,130), 3.387(75,121), 3.161(100,031), 2.456 (30,231). The chemical composition (electron microprobe, BeO by colorimetry) is SiO_2 64.32, Al_2O_3 7.26, BeO 3.53, ZnO 1.71, Na_2O 13.53, K_2O 0.47, Cs_2O 6.76, Rb_2O 6.76, F 2.84, -O = F 1.20, total 99.37 wt.%, corresponding to $(Cs_{0.69}Na_{0.31}K_{0.14}Rb_{0.02})_{1.16}Na_{6.00}[Be_{2.04}(Si_{15.46}Al_{2.06}Zn_{0.30})_{17.82}O_{38.84}F_{2.16}]$. Telyushenkoite, ideally $CsNa_6[Be_2(Si_{15}Al_3)_{18}O_{39}F_2]$, is the Cs-dominant analogue of leifite, ideally $NaNa_6[Be_2(Si_{15}Al_3)_{18}O_{39}F_2]$.
3 tables, 2 figures and 6 references .

Introduction

Examination of specimens collected at the Dara-i-Pioz alkaline massif has resulted in the discovery of a new mineral, the cesium analogue of leifite with the chemical formula $CsNa_6[Be_2(Si,Al,Zn)_{18}O_{39}F_2]$. The mineral was named telyushenkoite in honor of Tamara Matveyevna Telyushenko (1930—1997), a petrographer who made major contributions to our knowledge of the geology of Central Asia, and who headed the Young Geologists' School of Ashkhabad for over thirty years, educating many future geologists. The mineral and its name have been approved by the Commission on New Minerals and Mineral Names of the International Mineralogical Association. The type specimen of telyushenkoite is in the collection of the Fersman Mineralogical Museum, Moscow, Russia, catalogue number 90435.

Location and occurrence

Telyushenkoite was discovered in reedmergnerite boulders found on the moraine of the Dara-i-Pioz glacier close to the mouth of the Ledovy Ravine in the Upper Dara-i-Pioz alkaline massif (Dusmatov 1970, 1971). The massif is located in the upper part of the Dara-i-Pioz valley, 45 km north-north-east of the village of Khait, Garmskiy district, at the junction of the Zeravshan, Alay and Gissar Ranges of the South Tien-Shan Mountains, Tajikistan.

Telyushenkoite occurs in a rock consisting primarily of coarse-grained reedmergnerite (85—90%) (Dusmatov *et al.*, 1967; Grew *et al.*, 1993) in which the reedmergnerite grains reach up to 15 cm in diameter. Euhedral grains of microcline (up to 5 cm) and their aggregates constitute ~10% of the rock; pectolite, hyalotekite, kentbrooksite, polylithionite and albite make up the remaining 5% of the rock.

Telyushenkoite occurs as equant grains up to 2 cm across within veinlets cutting reedmergnerite (Fig.2) and microcline, in close association with hyalotekite, shibkovite, nordite-(Ce) and leucophanite. It also occurs in interstices between grains of reedmergnerite.

Physical properties

Telyushenkoite is white to colorless, and vitreous with a white streak. It has distinct cleavage. Mohs hardness is 6. Vickers hardness data, obtained using a PMT-3 unit calibrated by NaCl at a loading of 100 g, is as follows: VHN_{100} = 714 kg/mm^2 (mean of 8 measurements ranging from 696 to 737 kg/mm^2). The

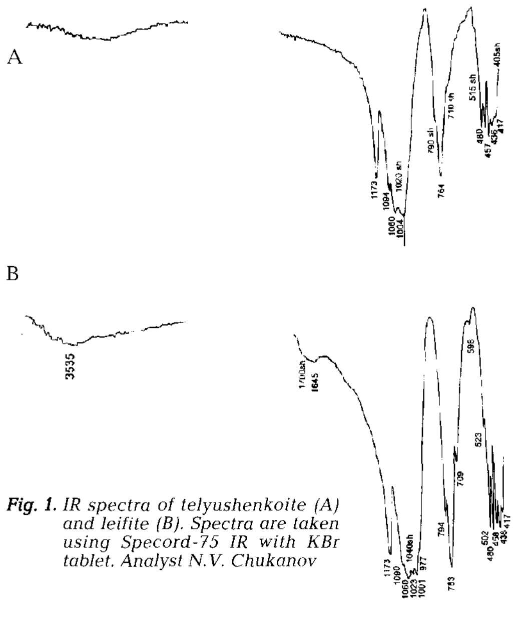

Fig. 1. IR spectra of telyushenkoite (A) and leifite (B). Spectra are taken using Specord-75 IR with KBr tablet. Analyst N.V. Chukanov

density was measured by suspension of mineral grains in Clerici solution, giving a value of 2.73 g/cm^3; the calculated density is 2.73 g/cm^3 for Z = 1. In transmitted light, the mineral is colorless and transparent. It is uniaxial positive, and the refractive indexes, measured using the rotating-needle method, are ω = 1.526(2), ε = 1.531(2). There is very dim dark-purple fluorescence under short-wave ultraviolet radiation, which allows telyushenkoite to be easily distinguished from albite and other visually similar minerals in this association.

N.V. Chukanov obtained the IR spectrum of telyushenkoite (Fig.1) using a Specord 75 IR spectrophotometer. The spectrum is very similar to that of leifite, but differs in the absence of OH (vOH 3535 cm^{-1}) and H_2O (vHOH 1645 cm^{-1}) bands, consistent with the structural and chemical data. There are strong IR-absorption bands at 405 417, 436, 457, 480, 500, 515, 710, 764, 790, 1004, 1020, 1060, 1094 and 1173 cm^{-1}.

Chemical composition

The chemical composition of telyushenkoite was determined using a JXA-50A electron-microprobe equipped with three wavelength-dispersion spectrometers (Table 1). Five different grains (30 points) were analyzed at the following conditions: excitation voltage 20 kV; specimen current: 20 nA; beam size 3 μm. The following standards were used: microcline USNM 143966 (Al, K), gahnite USNM 145883 (Zn), CsHo[PO3]$_4$ (Cs), $RbSc(WO_4)_2$ (Rb), chkalovite (Si, Na), and synthetic fluorphlogopite (F). Grains of telyushenkoite are homogenous for all elements analyzed. Raw data were corrected using the PAP procedure. The beryllium content was measured by the colorimetric method with quinalizarin. The mean chemical composition of analyzed grains (Table 1) was recalculated on the basis of O + F = 41 *apfu* (atoms per formula unit) to give the empirical formula $(Cs_{0.69}Na_{0.31}K_{0.14}Rb_{0.02})_{\Sigma=1.16}Na_{6.00}[Be_{2.04}(Si_{15.46}Al_{2.06}Zn_{0.30})_{\Sigma=17.82}O_{38.84}F_{2.16}]$. The formula of telyushenkoite can be written generally as $(Cs,Na,K)Na_6[Be_2(Si,Al)_{18}O_{39}F_2]$ and the end-member formula is $CsNa_6[Be_2(Si_{15}Al_3)O_{39}F_2]$. The Gladstone-Dale compatibility index (Mandanno, 1981) for telyushenkoite (1 – *Kp/Kc)* is -0.004 (superior).

Table 1. **Chemical composition of telyushenkoite (wt. %)**
(Mean value of 7 microprobe analyses, WDS)

Component	wt.%	Range
SiO_2	64.32	63.76 – 65.56
Al_2O_3	7.26	7.14 – 7.48
BeO*	3.53	
ZnO	1.71	1.54 – 1.90
Na_2O	13.53	12.59 – 14.32
K_2O	0.47	0.35 – 0.53-
Cs_2O	6.76	5.75 – 7.49
Rb_2O	0.15	0.11 – 1.26-
F	2.84	2.10 – 2.84
Sum	100.57	
$-O=F_2$	-1.20	
Total	99.37	

**BeO was determined by the colorimetric method with quinalizarin.*
Analysts: L.A.Pautov and A.A.Agakhanov

X-ray powder pattern

The X-ray powder-diffraction pattern for telyushenkoite was obtained with a DRON-2 diffractometer equipped with Fe$K\alpha$-radiation and a graphite monochromator, and using quartz as an internal standard. The pattern (Table 2) was indexed in the space group *P*-3*m*1 based on cell parameters obtained from the refined crystal-structure.

Crystal structure

The crystal structure of telyushenkoite was refined by Sokolova *et al.* (2002) using single-crystal X-ray data. Telyushenkoite is trigonal, space group *P*-3*m*1 with cell parameters a = 14.3770(8)Å, c = 4.8786(3) Å, V = 873.2(1) Å^3, Z = 1. The em-

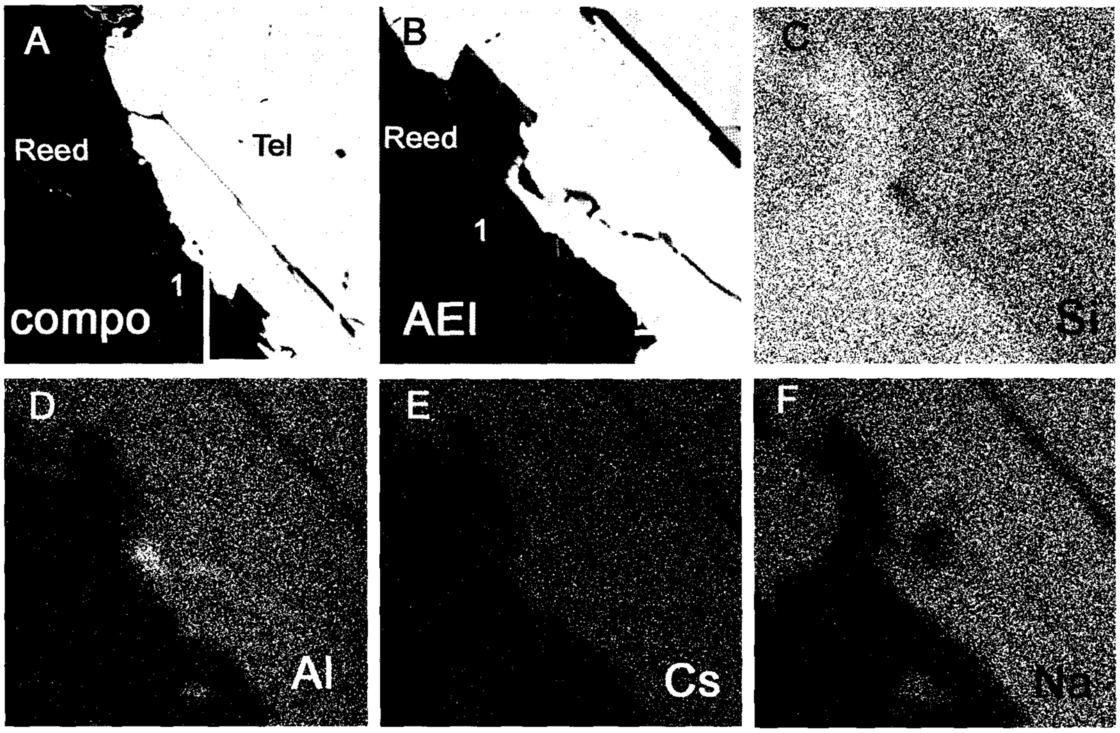

Fig. 2. Intergrowth of telyushenkoite (Tel) with reedmergnerite (Reed) and phase (1), corresponding by composition to SiO_2. A – image in the COMPO mode, B – fragment of the previous image. The absorbed current (AEI) image. C, D, E, F – images in X-ray characteristic radiation of specified elements

pirical formula of the mineral from the structural study is $(Cs_{0.72}K_{0.15}Na_{0.11}Rb_{0.02})_{\Sigma=1.00}Na_{6.00}[Be_{2.00}Si_{6.00}(Si_{4.89}Al_{1.11})_{\Sigma=6.00}(Si_{4.5}Al_{1.20}Zn_{0.30})_{\Sigma=6.00}O_{39}F_2]$.

The main elements of the telyushenkoite structure are shown in Figure 3. Six-membered rings of vertex-sharing (Si,Al,Zn)-bearing tetrahedra are linked together by four-membered rings of (SiO_4) tetrahedra. Triplets of adjacent four-membered rings are linked by (BeO_3F) tetrahedra. As a result, seven-membered rings, involving all four types of tetrahedra, are formed (Fig. 3). Down the c axis, six-membered rings are connected by 4-membered rings of (SiO_4) tetrahedra. The six-membered rings of tetrahedra stack along [001] to form channels parallel to the c axis, and the *A* (Cs, Na) and *B* (Na) sites occur within these channels. The *Na* site occurs within the channels formed by the seven-membered rings. Three (NaO_6F) polyhedra share edges with the (BeO_3F) tetrahedron, and these $[Na_3(BeO_4)O_{13}F]$ clusters share vertices along the c direction. As a result, the F site is tetrahedrally coordinated by one B and three Na atoms; hence there can be no substitution of (OH) for F at this site, as there is no room for the H atom within the tetrahedron of cations surrounding the F site.

The main structural difference between telyushenkoite and leifite is the occupancy of the octahedrally coordinated *A* site; it is occupied by Cs in telyushenkoite, whereas in leifite, this site is occupied by Na and surrounded by six atoms of oxygen and two (H_2O) groups. The *B* site in telyushenkoite is not occupied, whereas in leifite, it is partly occupied by (H_2O).

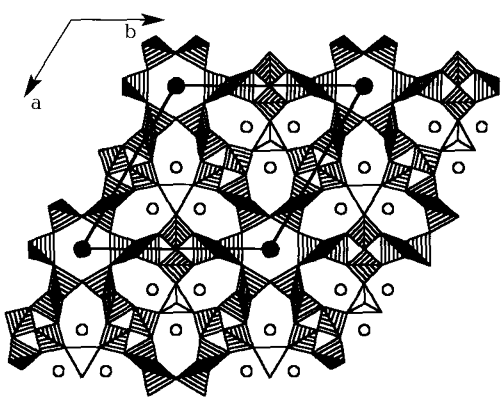

Fig. 3. The crystal structure of leifite viewed down the c-axis; $(Si,Al,Zn)O_4$ tetrahedra are dashed-line shaded, (BeO_3F) tetrahedra are unshaded, A sites (Cs) are shown as black circles, B sites are shown as highlighted circles

Table 2. **X-ray powder pattern of telyushenkoite**

I	d(meas.)* (Å)	d(calc.) (Å)	*h k l*
7	12.46	12.451	0 1 0
35	6.226	6.225	0 2 0
21	4.706	4.706	1 2 0
50	4.149	4.150	0 3 0
10	3.840	3.840	0 2 1
7	3.598	3.594	2 2 0
40	3.456	3.453	1 3 0
75	3.382	3.387	1 2 1
100	3.162	3.161	0 3 1
36	3.113	3.113	0 4 0
8	2.717	2.717	1 4 0
30	2.465	2.465	2 3 1
25	2.396	2.396	3 3 0
4	2.375	2.374	1 4 1
2	2.309	2.310	1 1 2
15	2.218	2.218	0 5 1
6	2.151	2.151	3 3 1
5	2.217	2.119	2 4 1
4	2.104	2.103	0 3 2
8	1.910	1.910	0 6 1
2	1.899	1.899	1 6 0
2	1.816	1.815	1 4 2
4	1.796	1.797	4 4 0
3	1.771	1.770	1 6 1
7	1.744	1.743	0 5 2
4	1.708	1.709	3 3 2
4	1.695	1.694	2 4 2
5	1.629	1.628	2 6 1
5	1.627	1.626	0 0 3
3	1.581	1.581	0 6 2
2	1.568	1.569	3 6 0
5	1.493	1.493	3 6 1

Note: *Diffractometr DRON-2, (FeKα–radiation, graphite monochromator, internal standard: quartz)*

Table 3. **Comparatison of the properties telyushenkoite and leifite**

	Telyushenkoite	Leifite
Chemical formula	$CsNa_6[Be_2(Si,Al,Zn)_{18}O_{39}F_2]$	$NaNa_6[Be_2(Si,Al,Zn)_{18}O_{39}F_2](H_2O)$
Space group	P-3m1	P-3m1
a, Å	14.3770	14.352
c, Å	4.8786	4.852
Z	1	1
Strongest X-ray lines	12.47(7)	12.429(25)
d(meas.) (Å), (I)	6.226(35)	6.215(10)
	4.709(21)	4.698(40)
	–	4.520(25)
	4.149(50)	4.143(17)
	3.456(40)	3.588(17)
	3.387(75)	3.375(70)
	3.161(100)	3.151(100)
	2.456(30)	2.458(25)
Color	White, colorless	White, colorless
Luster	Vitreous	Vitreous
D(meas.) g/cm^3	2.73	2.58
Mohs hardness	6	6
Optical properties	Uniaxial positive	Uniaxial positive
ω_o	1.526	1.511 – 1.518
ε_e	1.531	1.519 – 1.522

The leifite group

The properties of telyushenkoite are similar to those of leifite (Table 3), and there is probably an isomorphous series between these minerals. Petersen *et al.* (1994) reported Cs-bearing leifite from Greenland with a Cs_2O content ranging between 0.23 and 1.38 wt.%. The presence of 1.52B2.55 wt.% K_2O in the Greenland lefite indicates existence of a new K member of this group. Three of four analyses of leifite from Greenland shows K in excess of 0.50 *apfu*. If K occupies the *A* site, as Cs does in telyushenkoite, there will be a new mineral with the chemical formula $KNa_6[Be_2(Si_{15}Al_3)_{18}O_{39}F_2]$ (Sokolova *et. al.*, 2002).

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