Davanite, $K_2TiSi_6O_{15}$, in the Smoky Butte (Montana) lamproites

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Abstract

Davanite, a new alkali titanosilicate recently described from Siberia, has been found associated with coexisting orthorhombic and rhombohedral Ca-Sr carbonates in the Smoky Butte lamproite. The new chemical composition and X-ray diffraction pattern agree closely with those of the type specimen. The presence of this late-crystallizing mineral is explained by the peculiar Ti-rich, K-rich peralkaline silica-saturated composition of the Montana lamproites.

Introduction

Lamproites occurring at Smoky Butte, Montana, are typical ultrapotassic Ti-rich lavas, composed of Ti-rich phlogopite, diopside, leucite (replaced by analcite), olivine (altered) pseudobrookite, and glass (Velde, 1975). Accessory minerals include K-richterite, carbonates, priderite, and barite; Cr-spinels are found exclusively in the olivines (Wagner and Velde, 1986). The purpose of this short note is to report the occurrence of davanite, yet another K-rich Ti-rich phase at this locality. Davanite has been previously described (Lazebnik et al., 1984; abstracted in Dunn et al., 1985) from contact rocks in the Murunski alkaline massif, extreme western Yakut, USSR, where it is found associated with aegirine, pectolite, and titanite in rocks containing quartz, K-feldspar, calcite. It presumably results from the fenitization of the country rock by alkali-rich fluids.

Occurrence and chemical composition

Davanite is found in massive rock, lining vugs in which it is closely associated with Ca-Sr carbonates. Two carbonates are visible (Fig. 1). Prismatic sections of a Sr-rich orthorhombic variety (with strontianite contents from 77 to 84 mol%) are surrounded by anhedral sections of a Ca-rich carbonate (with strontianite contents between 16 and 34 mol%). The Sr-rich orthorhombic carbonate is Ba rich relative to the associated Sr-poor rhombohedral phase (2–3% BaO instead of 0.2–0.8%). Representative analyses are listed in Table 1.

Davanite is a magmatic phase and does not result from a metamorphic event. The mineral forms euhedral colorless crystals (Figs. 2 and 3) with hexagonal outlines and minute dimensions (130 μm × 40 μm). The composition (Table 2, analysis 2) is identical with that found in the Davan Springs locality (Table 2, analysis 1). Our data show that elements present in trace amounts are Fe (0.03–0.61% FeO), Na (0.01–0.16% Na_2O), and Zr (0.09% ZrO_2); Mg was not detected. The crystals are twinned (Fig. 3); a study with the universal stage indicates that the twins are
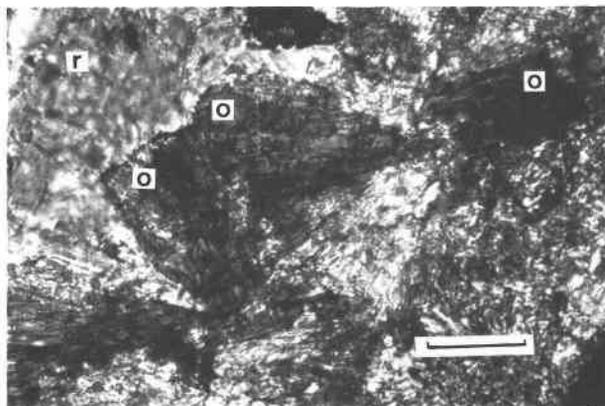

Fig. 1. Prismatic sections of Sr-rich orthorhombic carbonate (o) surrounded by anhedral rhombohedral carbonate (r), crossed nicols. Length of bar, 40 μm.

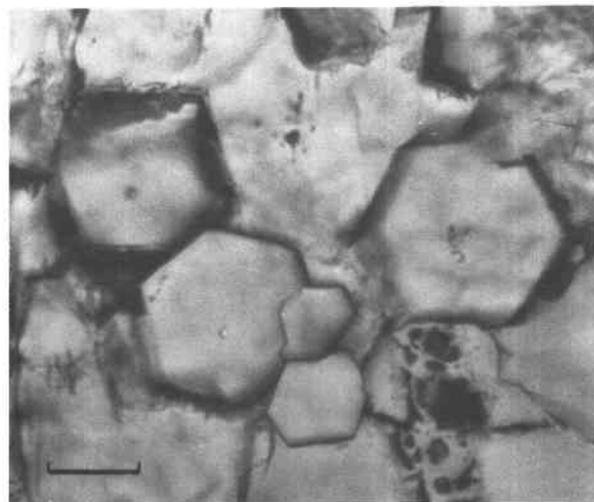Fig. 2. Davanite crystals, with hexagonal outline, in a Sr-Ca carbonate matrix. Plane-polarized light. Length of bar, 20 μm.

Table 1. Representative partial analyses of carbonates

	1	2	3	4
SrO	54.55	42.07–56.16	15.24	7.09–23.45
BaO	1.87	1.66–2.97	0.57	0.00–0.67
CaO	12.76	9.21–11.90	43.56	37.05–52.06

Note: (1) Sr-rich carbonate. (2) Range of 4 analyses. (3) Sr-poor carbonate. (4) Range of 13 analyses.

Table 2. Representative analyses of davanite

	Murunski 1	Smoky Butte 2	Smoky Butte 3
SiO_2	67.47	66.70	65.54–67.99
TiO_2	15.07	14.48	13.61–14.77
K_2O	17.40	17.67	17.04–17.85
Na_2O	tr	0.02	0.01–0.16
FeO	tr	0.15	0.03–0.63
MgO	tr	—	
ZrO_2		0.09	0.00–0.10
Total	99.59	99.11	
Si	6.01	6.002	
Ti	1.01	0.980	
K	1.98	2.029	
Na		0.003	
Fe		0.011	
Zr		0.004	

Note: Analyses have been done with a CAMEBAX automated microprobe; 15-kV acceleration voltage; 15-nA image current; counting time, 20 s. (1) Average of 4 determinations from Lazebnik et al. (1984). (2) Representative analysis. (3) Range of 17 analyses.

parallel or complex, with the composition plane parallel to the twin axis. As mentioned by Lazebnik et al. (1984), davanite is optically biaxial positive.

X-RAY DIFFRACTION

The twinning prevented single-crystal study, and X-ray data were obtained with a Gandolfi camera. Table 3 lists
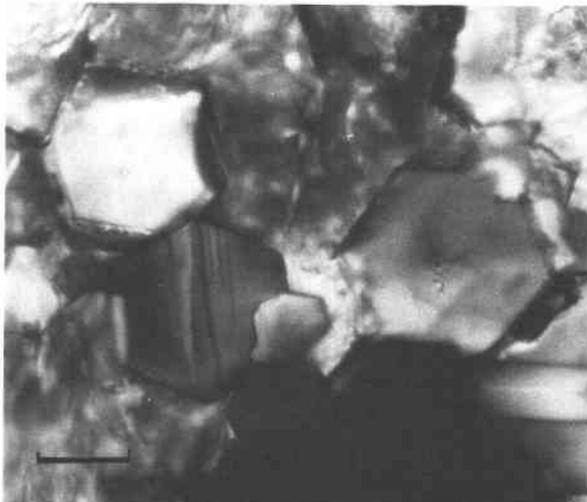

Fig. 3. Davanite crystals (same as Fig. 2), crossed nicols. Complex twinning is visible. Length of bar, 20 μm.

Table 3. X-ray powder data for davanite

	Murunski davanite				Smoky Butte davanite		
I	d_{meas} (Å)	d_{calc} (Å)	*hkl*	*I**	d_{meas} (Å)**	d_{calc} (Å)†	*hkl*†
				w	6.375	6.467	100
5	5.88	5.874	$\bar{1}01$	m	5.878	5.927	$\bar{1}01$
1	4.31	4.330	$\bar{1}11$	w	4.290	4.347	$\bar{1}11$
5	4.09	4.089	011	ms	4.104	4.093	011
				vw	3.878	—‡	—‡
				w	3.605	3.606/3.603	020/$\bar{2}01$
10	3.51	3.543	$\bar{2}01$	s	3.490	3.556	0$\bar{2}1$
				w	3.423	3.415	$\bar{1}20$
5	3.34	3.346	$\bar{1}12$	s	3.349	3.340	$\bar{1}12$
				w	3.305	3.262	$\bar{2}11$
5	3.19	3.190	200	ms	3.179	3.185	$2\bar{1}1$
10	3.022	3.020	002	vs	3.022	3.003	002
				w	2.970	2.964	202
				vvw	—	—	—
7	2.789	2.784	$\bar{1}22$	mB	2.790	2.781	$\bar{1}22$
				vw	2.706	2.705	0$\bar{2}2$
9	2.615	2.623	$\bar{2}12$	mB	2.623	2.639	$\bar{2}12$
				mB	2.588	2.588	$\bar{2}21$
				vw	2.514	2.512	$2\bar{2}1$
3	2.391	2.397	$\bar{1}30$	w	2.391	2.395	$\bar{1}30$
				vw	2.340	2.339	$\bar{3}11$
2	2.215	2.219	$2\bar{1}3$	w	2.201	2.203	$\bar{2}03$
				w	2.144	2.146	$\bar{1}31$
2	2.119	2.121	130	w	2.115	2.115	230
				vvw	—	—	—
				vw	2.076	2.070	112
1	2.057	2.051	$\bar{2}23$	w	2.053	2.056	$\bar{2}23$
				w	1.974	1.973	$\bar{2}31$
<1	1.929	1.940	$\bar{3}22$				
1	1.886	1.883	$\bar{1}33$	w	1.880	1.876	0$\bar{4}1$
				vw	1.866	1.874/1.853	$\bar{1}33/\bar{3}13$
				w	1.833	1.837	$3\bar{1}1$
1	1.799	1.800	040	w	1.802	1.803/1.801	040/$\bar{4}02$
1	1.762	1.761	$\bar{3}30$	w	1.766	1.766	$\bar{3}30$
				vvw	—	—	—
				w	1.684	1.687/1.681	$\bar{3}32/\bar{2}04$
3	1.667	1.667	$\bar{3}32$	w	1.668	1.669/1.667	$2\bar{1}2/\bar{4}21$
				vvw	—	—	—
				vvw	—	—	—
				w	1.613	—‡	—‡
3	1.604	1.604	$\bar{3}33$	w	1.607	—‡	—‡
				vvw	—	—	—
<1	1.542	1.538	$\bar{2}43$	vvw	—	—	—
				w	1.510	—‡	—‡
				w	1.500	—‡	—‡
4	1.498	1.499	$\bar{3}22$	w	1.496	—‡	—‡

* B = broad lines; vs = very strong; s = strong; ms = medium strong; w = weak; vw = very weak; vvw = very very weak. The vvw reflections were not measured.

** X-ray diffractometer conditions were Ni-filtered; Cu$K\alpha$ = 1.5405; 50 kV and 30 mA; exposure = 72 h.

† Indices and d_{calc} were obtained using the computer program of Williams (1964).

‡ Reflections not indexed.

the X-ray diffraction pattern published by Lazebnik et al. (1984), compared with data obtained from the Smoky Butte material. The two patterns are similar, but the Smoky Butte davanite gives twenty-four reflections that have not been reported for the Murunski davanite. The intensity of most of these reflections is very weak, and this could explain why they were not previously reported. One weak reflection (d = 1.929 Å) was observed in the Murunski davanite but not found in the Smoky Butte specimen. More interesting is the fact that the strong reflection with d_{meas} = 3.49 Å in the Smoky Butte davanite and d = 3.51

Table 4. Cell parameters of davanite

	Murunski	Smoky Butte*
a (Å)	7.14(2)	7.254(3)
b (Å)	7.53(2)	7.519(4)
c (Å)	6.93(2)	6.903(4)
V (Å³)	323.8	327.036
α (°)	103.35	102.98(3)
β (°)	114.48	115.10(2)
γ (°)	93.88	93.42(3)

* Data obtained from refinement of X-ray powder data (Table 3), using a program published by Williams (1964). Figures in parentheses repressent the estimated standard deviation (esd) in terms of least units cited for the value to their immediate left.

Å in the Murunski specimen does not correspond to any calculated value (the nearest d_{calc} is 3.556 Å). The cell dimensions of the two davanites are not identical (Table 4): the a parameter reported here differs by 0.11 Å from the Murunski value. The c/a calculated value is 0.9706 for Murunski davanite and 0.9516 for Smoky Butte davanite.

DISCUSSION

The occurrence of a phase with the composition of davanite is in keeping with the Ti-rich, potassic and peralkaline characters of these lamproites. No information is available on the thermal stability of this mineral. Existing studies on low-pressure phase relations in the system $SrCO_3$-$CaCO_3$ (Chang, 1965) indicate that the crystallization temperature of the Sr-rich orthorhombic and Sr-poor rhombohedral carbonate association described above should be close to 800°C. In view of the close spatial relationship of the carbonates and davanite, it would seem reasonable to propose for davanite a crystallization temperature around 800°C.

It is interesting to note that davanite has not been reported from Western Australia, where some lamproites show chemical characteristics similar to those of Smoky Butte and where, besides priderite (also found in Montana), other K-rich and Ti-rich phases have been described (e.g., noonkanbahite, Prider, 1965; jeppeite, Pryce et al., 1984).

REFERENCES

Chang, L.L.Y. (1965) Subsolidus phase relations in the systems $BaCO_3$-$SrCO_3$, $SrCO_3$-$CaCO_3$, and $BaCO_3$-$CaCO_3$. Journal of Geology, 73, 346–368.

Dunn, P.J., Chao, G.Y., Fleischer, M., Ferraiolo, J.A., Langley, R.H., Pabst, A., and Zilczer, J.A. (1985) New mineral names. American Mineralogist, 70, 214–221.

Lazebnik, K.A., Lazebnik, Yu.D., and Makhotko, V.J. (1984) Davanite, $K_2TiSi_6O_{15}$, a new alkali titanosilicate. (in Russian) Zapiski Vsesojuznogo Mineralogiceskogo Obscestva, 118, 95–97.

Prider, R.T. (1965) Noonkanbahite, a potassic batisite from the lamproites of Western Australia. Mineralogical Magazine, 34, 403–405.

Pryce, M.W., Hodge, L.C., and Criddle, A.J. (1984) Jeppeite, a new K-Ba-Fe titanate from Wolgidee Hills, Western Australia. Mineralogical Magazine, 48, 263–266.

Velde, D. (1975) Armalcolite–Ti-phlogopite–diopside–analcite-bearing lamproites from Smoky Butte, Garfield County, Montana. American Mineralogist, 60, 566–573.

Wagner, C., and Velde, D. (1986) The mineralogy of K-richterite-bearing lamproites. American Mineralogist, 71, 17–37.

Williams, B.E. (1964) LCR2: A Fortran lattice constant refinement program. U.S. Atomic Energy Commission Report I.S. 1052.