Jinshajiangite—— a New Ba-Mn-Fe-Ti-Bearing Silicate Mineral

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Abstract

Jinshajiangite, $(Na, K)_5(Ba, Ca)_4(Fe^{2+}, Mn)_{15}(Ti, Fe^{3+}, Nb)_8(SiO_4)_{15}$ $(F, O, OH)_{10}$, is a new mineral which occurs as thin tabular crystals in an arfedsonite-rich albite dyke near the Jinshajiang River winding through Sichuan Province, China. Jinshajiangite is monoclinic. Possible space group $C2/m$, Cm or $C2$. Unit cell: $a=10.732$, $b=13.847$, $c=20.817$ Å, $\beta=95°3'$, $z=2$. The strongest lines in the X-ray diffraction pattern [d in (hkl)] are: 10.2 (7) (002), 3.44 (10) ($\bar{3}11$, 310, $\bar{2}05$, 006), 3.15 (8) (205), 2.630 (8) (136, 243), 2.570 (8) ($\bar{4}30$), 2.202 (4) (405), 1.755 (4) ($\bar{5}36$), and 1.715 (5b) (3. 1. 10). The new mineral is black red brownish red or golden red in color. Lustervitreous. Streak light yellow. Cleavges {010} and {100} perfect. H. (Vicker) 430 kg/mm². Specific gravity 3.61 (meas.). Density 3.56 (calc.). It is optically biaxial positive, $2V=72$, $r<v$; refractive indices: $N_x=1.792$, $N_y=1.801$, $N_z=1.852$. Oblique extinction angle $c\wedge X=13°$, sign positive. The new mineral is strongly pleochroic: $X=$libht golden yellow, $Y=$ brownish yellow, $Z=$ brownish red. The DTA shows two endothermic peaks at about 795°C and 995°C. Infrared spectrum absorption bands are observed at 308, 380, 492, 520, 620, 965, and 1,000 cm^{-1}.

Introduction

Jinshajiangite is a new mineral which occurs in alkaline synites in the study area near the Jinshajiang River in the western Sichuan Province, Southwest China. The new mineral was discovered in an arfvedsonite-algite dyke exposed 15—20 km north of the Jinshajiang River. Thehe arfvedsonite-algite dykes, generally small in size, are distributed as swarms. Jinshajiangite is intimately associated with albite, arfvedsonite, aegirine, pyrochlore, monazite, tscheffkinite, apatite, fluorite etc.

The mineral is named after the Jinshajiang River where it was discovered.

The mineral and the name have been approved by the Commission on New Minerals and Mineral Names I. M. A. Typical material is preserved in the Institute of Geochemistry, Academia Sinica, Guiyang, Guizhou Province, the People's Republic of China.

Physical and Optical Properties

Jinshajiangite is tabular in shape with length by width ranging from 20 by 2 to 10 by 1 mm, or even smaller in size. Some specimens are lamellar or foliate (Photos 1 and 2). The mineral is black red or brownish red or golden red in color. Luster vitreous. Fracture uneven. Streak light yellow. Cleavages {010} and {100} perfect. Hardness (Vickers) 430 kg/mm².

Measured with a torsion microbalance, the specific gravity is 3.61. It matches well with

the density (3.56 g/cm^3) calculated from the empirical formula, the refined unit-cell parameters and $Z=2$.

Jinshajiangite is optically biaxial positive. $2V=72°$. Dispersion of the optic axes is clear, $r<v$. The principal refractive indices are: $N_x=1.729$, $N_y=1.802$, $N_z=1.852$. The mineral is strongly pleochroic: X=light golden yellow, Y=brownish yellow, Z=brownish red, $X=Y>Z$. Oblique extinction angle $c\wedge X=13°$, sign positive.

X-ray Diffraction Data

Of the numerous jinshajiangite crystals examined, one foliate-shaped single crystal about 0.1 mm long has been proved satisfactory for detailed single-crystal refinement and Weissenberg-camera examination. X-ray single-crystal study showed that the mineral is monoclinic with the extinction law described as follows: (1) *hkl: h+k=2n; (2)hol: h=2n;* and (3) *oko: k=2n*. These are consistent with the possible space group *C2/m, Cm* or *C2*. Medsured cell parameters from precession films are: $a=10.732$, $b=13.847$, $c=20.817$ Å, $\beta=95°3'$, $Z=2$. The powder diffraction pattern was prepared with Fe radiation. The diffracto-

Table 1. X-ray powder diffraction data on jinshajiangite

I	*D* (obs.)	*D* (calc.)	*hkl*
7	10.2	10.3	002
3	4.4	4.42, 4.49	$\bar{2}03$, 023
3	4.05	4.06	203
2	3.80	3.83	$\bar{1}15$
10	3.44	3.43, 3.45, 3.45, 3.45	$\bar{3}11$, 310, $\bar{2}05$, 006
8	3.15	3.156	205
7	2.85	2.860	241
3	2.77	2.777	225
7	2.63	2.635	136, 243
8	2.570	2.570	$\bar{4}03$
3b	2.450	2.466, 2.449	353, 040
2	2.320	2.328	245
4	2.202	2.210	405
3	2.062	2.052	209
2	2.020	2.019	$\bar{5}14$
4	1.755	1.753	536
5b	1.715	1.714	3.1.10
3	1.587		
2	1.570		
3	1.422		
2	1.350		
2	1.292		
1	1.090		
3b	1.033		
3b	1.022		
3b	1.001		

Note: Fe target, 2-hr exposure, $D=57.3$mm, b = line width.
Analysts: Wang Guanxin (王冠鑫) and Chen Jingyu (陈静瑜).

grams were obtained by using a Philip wide-angle diffractometer, and the powder photographs by using a 57.3 mm-diameter Dan-Dong camera. X-ray powder diffraction data on jinshajiangite are given in Table 1. The strongest lines in the X-ray powder diffraction pattern are: 10.2(7) (002), 3.44(10) ($\bar{3}11$, 310, $\bar{2}05$, 006), 3.15(8) (205), 2.630(8) (136, 243), 2.570(8) ($\bar{4}03$), 1.715(5b) (3.1.10). When $Z=2$, the calculated density, based on the chemical formula (Table 2), is 3.56 g/cm^3, in reasonable agreement with the measured value.

Table 2. Chemical composition of jinshajiangite

Oxide	Content (wt. %)	Number of molecules	Number of oxygen atoms	Structural formula based on F+O+OH=70
SiO_2	27.10	0.4512	0.9024	14.90
TiO_2	15.90	0.1990	0.3980	6.59
$(Zr, Hf)O_2$	0.70	0.0056	0.0112	0.18
Fe_2O_3	1.64	0.0103	0.0309	0.68
Al_2O_3	0.36	0.0035	0.0105	0.23
TR_2O_3	0.30	0.0014	0.0044	0.09
Nb_2O_5	1.032	0.0038	0.0190	0.25
Ta_2O_5	0.073	0.0002	0.0010	0.01
BaO	9.80	0.0639	0.0639	2.11
SrO	0.078	0.0008	0.0008	0.02
FeO	19.07	0.2651	0.2651	8.77
MnO	12.93	0.1823	0.1823	6.02
CaO	2.94	0.0524	0.0524	1.73
MgO	0.28	0.0069	0.0069	0.23
K_2O	2.31	0.0245	0.0245	1.62
Na_2O	3.15	0.0508	0.0508	3.36
H_2O^+	0.33	0.0183	0.0183	1.21
H_2O^-	0.36			
F	2.657	0.1398	0.1398	0.1398
$-O=2F$	1.12		2.1822	
Total	99.89		−0.0699	
			2.1123	

Analysts: Yang Qishun (杨启顺) and Shen Yunjie (沈芸洁).

Chemistry of Jinshajiangite

The results of bulk chemical analysis and the derived chemical formula are presented in Table 2. The empirical formula calculated on the basis of F + O + OH = 70 is: $(Na_{3.36}K_{1.62})_{4.98}(Ba_{2.11}Ca_{1.73}TR_{0.09}Sr_{0.02})_{3.95}(Fe^{2+}Mn^{2+}_{6.02}Mg_{0.05})_{14.84}(Ti_{6.57}Fe^{3+}_{0.68}Nb_{0.26}Mg_{0.18}Zr_{0.18}Al_{0.12}Ta_{0.01})_{8.00}(Si_{14.90}Al_{0.11})_{15.01}O_{64.17}(F_{4.62}OH_{1.21})_{5.83}$. The ideal formula of jinshajiangite with Z = 2 is $(Na,K)_5$ $(Ba, Ca)_4$ $(Fe^{2+}, Mn^{2+})_{15}$ $(Ti, Fe^{3+})_{15}$ $(Ti, Fe^{3+}Nb)_8$ $(SiO_4)_{15}(F, O, OH)_{10}$, where Na > K, Ba > Ca, Fe > Mn, Ti > Fe^{3+}, Nb and F > 0 and OH. The grouping of silicate radical in the given formula is tentatively adopted. Of course, other groupings are also possible, such as $(SiO_4)_{15}$ $(F, O, OH)_{10}$, $(SiO_4)_5$ $(Si_2O_7)_5(O, F, OH)_{15}$, $(Si_3O_{10})_5(O, F,OH)_{25}$, etc. If the second or the third grouping is valid, then O > F, OH in the proposed formula instead of F > O, OH.

Thermal Analysis

In Fig. 1 are the DTA and TGA curves for jinshajiangite obtained by means of a Model-58 thermoanalyzer under the following experimental condition: sample weight 100 mg, analysis in air, heating time 20 minutes, heating rate 10° C/min. The DTA curve shows a strong endothermic peak at about 795° C and a wide endothermic peak at 995° C. The TGA curve shows the weight loss begins at about 825° C until 1,000° C. The TGA curve shows a weight loss approximately fitting with the total H_2O+F content.

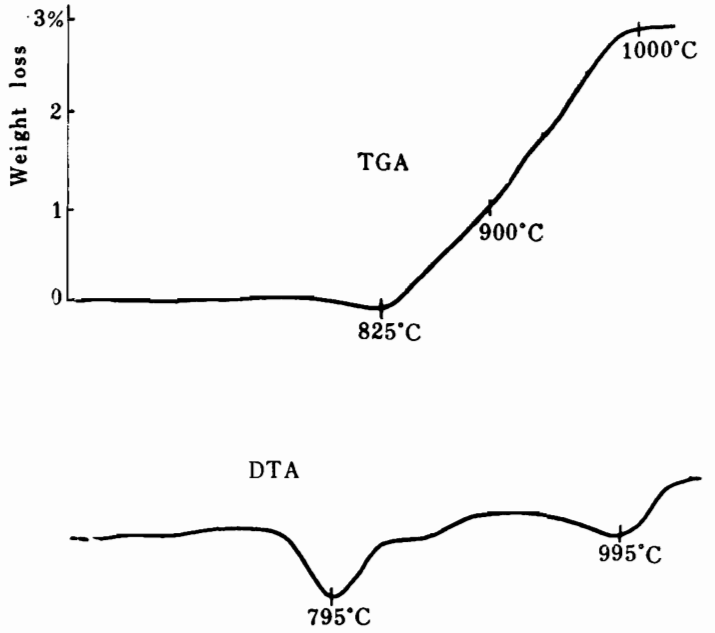

Fig. 1. DTA and TGA curves for jinshajiangite (after Chen Guoxi (陈国玺)).

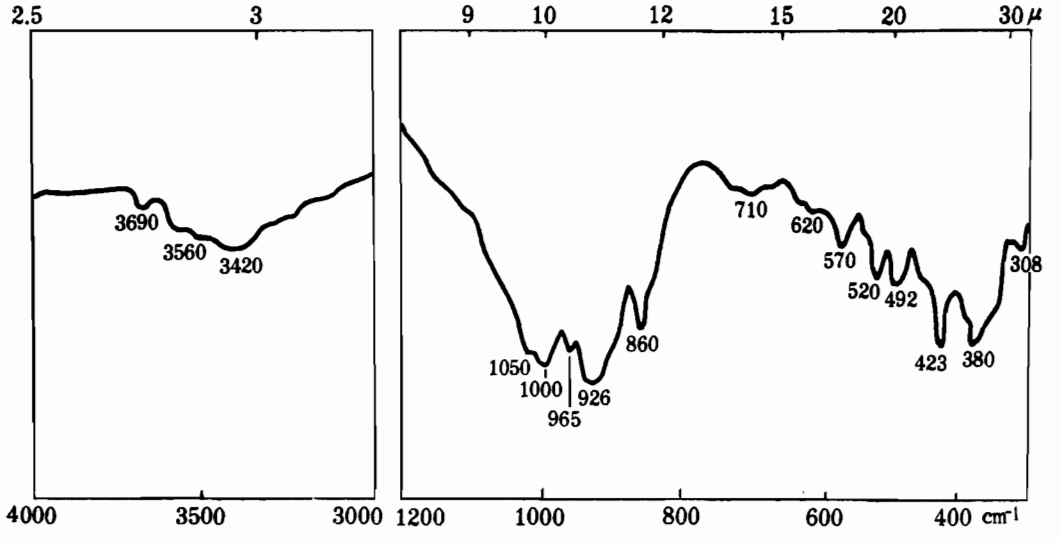

Fig. 2. Infrared spectrum curve for jinshajiangite
(after Liu Gaokui (刘高魁) and Peng Wenshi (彭文世)).

Infrared and Polarized Absorption Spectrum Analyses

The results of infrared spectrophotometric analysis of jinshajiangite are given in Fig. 2 As a result, infrared spectrum absorption bands are observed at 308, 380, 423, 492, 520, 570, 620, 710, 860, 926, 965, 1,000 and 1,050 cm^{-1}.

Fig.3 shows the polarized absorption spectrum curves for jinshajiangite. The curves show three strong absorption peaks at 400—500 m μ in the α axis and only one absorption peak in the γ axis.

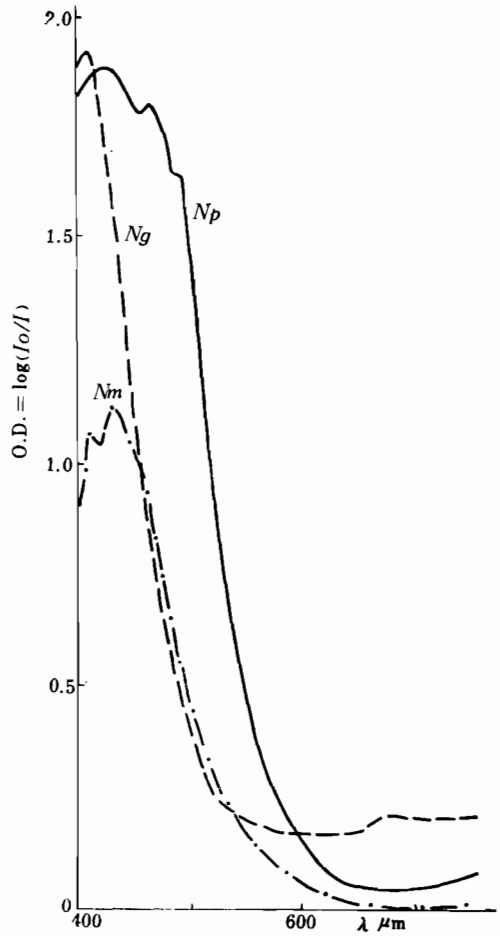

Fig. 3. Polarized absorption spectrum curves for jinshajiangite (after Zheng Chusheng (郑楚生)).

Mössbauer Spectrum Analysis

Mössbauer spectra of the powdered samples were obtained at room temperature on a constant acceleration Mössbauer spectrometer with a 5-mc Co^{57} (Pd) source.

Fig.4 shows the experimentally determined spectrum of the sample. Spectral area ratios and hyperfine parameters of Fe^{2+} and Fe^{3+} in jinshajiangite are listed in Table 3. Mössbauer

data show that jinshajiangite exhibits not only Fe^{2+} *QS* (quadrupole splittings) and *IS* (isomer shifts), but also Fe^{3+} *QS* and *IS*. The *QS* and *IS* decrease from $Fe^{2+}_{aa'}$ to $Fe^{3+}_{dd'}$. $Fe^{2+}_{aa'}$: $Fe^{2+}_{bb'}$: $Fe^{2+}_{cc'}$ for jinshajiangite is 0.17: 1.0: 0.38 at room temperature, and 0.025: 1.0: 0.48 at nitrogen-liquid temperature. The Fe^{3+}/Fe^{2+} ratios are 0.062 and 0.070, respectively.

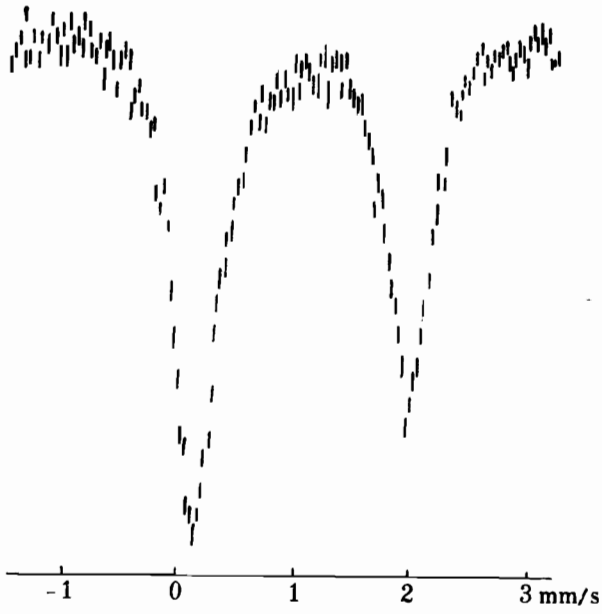

Fig. 4. Typical Mössbauer spectrum of jinshajiangite (after Kan Xuemin (阚学敏) et al.).

Table 3. Typical Mössbauer parameters for jinshajiangite

Temp. (°C)	Line doublets	*IS*(mm/s)	*QS*(mm/s)	*T*(mm/s)	$Fe^{2+}_{aa'}$: $Fe^{2+}_{bb'}$: $Fe^{2+}_{cc'}$
Room	$Fe^{2+}_{aa'}$	1.08	2.73	0.31	0.17:1.0:0.38
	$Fe^{2+}_{bb'}$	1.11	1.90	0.31	
	$Fe^{2+}_{cc'}$	1.06	1.53	0.32	
	$Fe^{3+}_{dd'}$	0.70	0.38	0.30	$Fe^{3+}/Fe^{2+} = 0.062$
Nitrogen-liquid	Fe^{2+}_{a}	1.20	2.56	0.31	0.025:1.0:0.48
	$Fe^{2+}_{bb'}$	1.17	2.26	0.31	
	$Fe^{2+}_{cc'}$	1.19	1.98	0.31	
	$Fe^{3+}_{dd'}$	0.76	0.56	0.31	$Fe^{3+}/Fe^{2+} = 0.070$

Note: *IS* = isomer shift relative to metallic iron; *QS* = quadruple splittings; *T* = line width.

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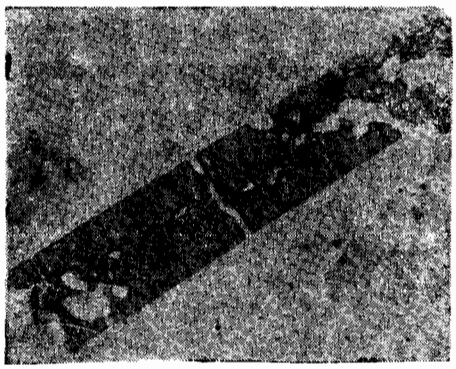

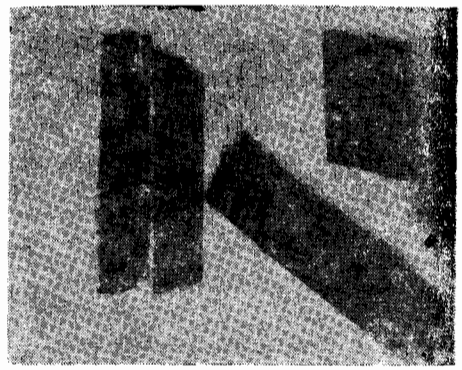

Photos 1—2: 1 left. Tabular jinshajiangite crystal in thin section (parallel polarized light, ×126) 2 right. Crystal forms of jinshajiangite (×64).

References

[1] 洪文兴和傅平秋: 1981, «矿物学报», No. 1, 16—23.
[2] 林德松,洪文兴: 1973, «地球化学», No. 1, 39—45.
[3] 谢苗诺夫,Е. И., 洪文兴: 1960, «地质科学»,No. 1, 1—2.