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Daqingshanite——A New Mineral Recently Discovered in China

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Introduction

In the study of material composition of the Bayan Obo iron ore deposit during 1980, a strontium-rare earth-bearing phosphate-carbonate mineral with a pale-yellow color was discovered in the REE-bearing dolomite at the foot wall of an iron ore body. The definition of it as a new mineral is based on repeated examination.

The new mineral has a name for Daqingshanite after the Mt. Daqingshan near the Bayan Obo deposit. We presented the data on the mineral to the Commission on New Minerals and Mineral Names, I.M.A. last year, and the mineral and its name have been approved by a majority of votes.

Mode of Occurrence

This mineral occurs in the western part of the Bayan Obo deposit which lies in the Bayan Obo Group of the Proterozoic (Fig. 1). The low grade metamorphosed dolomite intercalated with lenses of calc-mica schist and arkose is the ore-bearing member. Relics of micrite and oncolite found in the dolomite are characteristic of the semi-closed lagoon sedimentation. Exposed in the mining district are granite (Hercynian), gabbro, syenite, lamprophyre and carbonatite dikes (REE-bearing) as well as volcanic rocks.

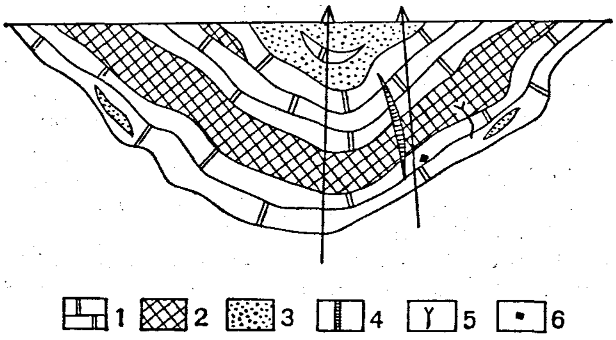

Fig. 1. Schematic cross section of Bayan Obo Fe-REE ore deposit.
1. Dolomite; 2. Fe-REE ore body; 3. arkose; 4. carbonatite dike (REE-bearing); 5. Alpine-type vein; 6. location where daqingshanite was found.

Stratiform occurrence of the iron-rare-earth ore bodies which are generally conformable with the dolomite, together with other lines of evidence, indicates that sedimentation is prominent during the ore-forming process. The banded structure of the ore, the elongation and orientation of mineral grains and the occurrence of Alpine type veins are attributive to regional metamorphism the ore bodies and their host rocks underwent contemporaneouly.

There have been recognized various kinds of Alpine type veins, such as Ba-REE carbonate, siderite, barytocalcite, benstonite veinlets, etc. which are compositionally comparable with the stratiform Fe-REE ore in the host rocks. In addition there occur net-work veins consisting of Fe-REE aggregates of different origins. Hydrothermal replacement (riebeckitization and aegirine augitization) in the mining district is fairly developed.

The REE deposit is complicated in mineralogy with more than 120 kinds of minerals, including Fe, Mg, and Mn carbonates, Ba-REE carbonates and many other varieties occurring in series. This indicates a diversity of ore-forming processes and the complexity of physico-chemical conditions in the semi-closed lagoon sedimentary environment. There have been identified 10 Nb-bearing and 12 REE-bearing minerals in the deposit, of which baotite, huanghite, cebaite, bafertisite, were first found here as new minerals.

Daqingshanite was found in the biotite-dolomite at the foot-wall of the west orebody. Like dolomite, it occurs as elongated, oriented grains which are coincidant with the bands in the host dolomite, or as irregular net veins cross-cutting the host. The net veins are about 0.3 cm wide, and in the centre of them daqingshanite occurs as loose monomineralic aggregate. The associated minerals, such as benstonite, huntite, strontianite, pyrite, phlogopite and monazite occur at the vein wall.

Physical and Optical Properties

The crystal form of daqingshanite is usually unperfect, and it occurs mostly as platy crystals with rounded edges, occasionally as rhombohedron. The grain size is about 0.05 mm across. Pale-yellow in colour, luster glassy-greasy, streak white, cleavage $\{10\bar{1}1\}$ perfect, and conchoidal fracture. Hardness VHN (20)=335 kg/mm^2. Density (g/cm^3)=3.81 (meas.), 3.71(calc.). Optically it is uniaxial (—). Refractive indices. $Ne=1.609$. and $No=1.708$. Colourless in thin sections. Non-fluorescent under ultraviolet light.

Data on Infrared Absorption Spectrum

Daqingshanite has clear C-O and P-O absorption bands at 1,438,872cm^{-1}. and at 1,178,

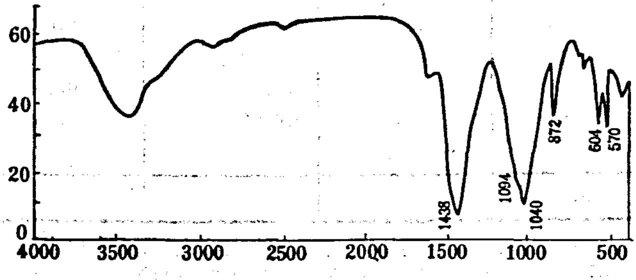

Fig. 2. Infrared absorption spectrum of daqingshanite.

1,078 and 1,040 cm^{-1}. It is noticed from a comparison with the mineral that with the increase of CO_3^{-2}, dahllite has a saddle absorption kurtosis in the range 1,550—1,420 cm^{-1}, and sidorenkite [$Na_3Mn(PO_4)(CO_3)$] has a double absorption kurtosis, while daqingshanite has a single absorption kurtosis because of its higher CO_3^{-2} content. Moreover, daqingshanite has distinct H_2O^+ absorption bands.

Chemical Properties and Composition

Daqingshanite is hardly soluble in ammonium acetate but readily in dilute chlohydric acid along with effervescence. Based on this property this mineral is different from bensto-

Table 1. Chemical analyses (wt.%) of daqingshanite

Component	Weight percent	Number of molecules	Number of cations and atoms	Number of ions on the basis of one(PO_4)	Number of oxygen
BaO	15.98	0.1042	0.1042	0.6308	0.1042
SrO	26.10	0.2519	0.2519	1.5248	0.2519
CaO	6.17	0.1100	0.1100	0.6659	0.1100
MnO	0.02	0.0003	0.0003		0.0003
MgO	0.72	0.0178	0.0178	0.1077	0.0178
La_2O_3	7.88	0.0242	0.0484		0.0726
Ce_2O_3	10.16	0.0309	0.0618		0.0927
Pr_6O_{11}	0.70	0.0006	0.0036		0.0066
Nd_2O_3	1.59	0.0049	0.0098		0.0147
Sm_2O_3	0.106	0.0003	0.0006		0.0009
Eu_2O_3	0.02	0.00006	0.00012		0.00018
Gd_2O_3	0.12	0.0003	0.0006		0.0009
Tb_4O_7	0.05	0.00006	0.00024 } 0.1259	} 0.7621	0.00042
Dy_2O_3	0.03	0.00008	0.00016		0.00024
Ho_2O_3	0.03	0.00008	0.00016		0.00024
Er_2O_3	0.01				
Tm_2O_3	0.01				
Yb_2O_3	0.02	0.00012	0.00024		0.00036
Lu_2O_3	0.01				
ThO_2	0.04	0.00015	0.00015		0.0003
Al_2O_3	0.18	0.0018	0.0036	0.0218	0.0054
Fe_2O_3	0.21	0.0013	0.0026	0.0157	0.0039
P_2O_5	11.73	0.0826	0.1652	1.0000	0.4130
CO_2	16.19	0.3680	0.3680	2.2276	0.7360
K_2O	0.03	0.0003	0.0006	0.0290	0.0003
Na_2O	0.13	0.0021	0.0042		0.0021
H_2O^+	0.68	0.0378	0.0756	0.4576	0.0378
F	0.80	0.0421	0.0421	0.2548	
$-O=F_2$	0.34	−0.0179			
Total	99.20				1.8549

The empirical formula is given as: $(Sr_{1.53}Ca_{0.67}Ba_{0.63}Mg_{0.11}Na_{0.03})_{2.97}(TR_{0.76}Al_{0.02}Fe^{3+}_{0.02})_{0.80}(PO_4)_{1.00}(CO_3)_{2.23}[(OH)_{0.46}F_{0.26}U_{0.07}]_{0.76}$, and simplified as: $(Sr,Ca,Ba)_3TR(PO_4)(CO)_{3-x}(OH,F)_y$, where Sr>Ca, Ba and OH>F, $x \doteq y \doteq 0.8$.

nite, barytocalcite and monazite.

Highly pure samples were collected from the monomineralic veins of daqingshanite. Before analysis, the samples were separated centrifugally with methylene iodide as heavy liquid and examined under the polarized microscope, followed by X-ray powder diffraction and physical phase analysis. It is evident that these samples contain no benstonite, dolomite, monazite and apatite. The data on CO_2 and H_2O are based on the mean value of two-time physical phase analyses, and approximate to the values given by gas chromatography.

X-Ray Crystallography of Daqingshanite

A single crystal of daqingshanite was chosen under the stereoscope. The crystal is granular in shape with a grain size of about 0.02 mm across. Single crystal analysis was performed by oscillating-crystal photography and Weissenberg photography (experimental conditions: Ru-200 X-ray generator, CuKα radiation, Ni filter, 40 kV, 120 mA). It is well determined that daqingshanite belongs to the trigonal system with a rhombohedral lattice. The lattice parameters obtained from the single-crystal studies were refined by least-squares from single-crystal four-circle diffractometer data (experimental conditions: RASA-II four-crcle automatic diffractometer with graphite monochromatized, MoKα radiation, 50 kV, 20 mA). The lattice parameters with hexagonal orientation are: $a=10.058 \pm 0.003$ Å, $c=9.225$ ±

Table 2. Powder-diffraction data for daqingshanite

Sequence No.	I/I_0	d(obs)	d(calc)	$hkil$
1	3	5.02	5.0290	$2\bar{1}\bar{1}0$
2	1	4.06	4.0762	$0\bar{1}\bar{1}2$
3	6	3.95	3.9383	$20\bar{2}\bar{1}$
4	10	3.16	3.1666	$20\bar{2}2$
5	1	2.89	2.9034	$3\bar{3}00$
6	7	2.52	2.5145	$22\bar{4}0$
7	2	2.315	2.3370	$31\bar{4}\bar{1}$
8	1	2.225	2.2294	$0\bar{1}14$
9	5	2.110	2.1111	$30\bar{3}3$
10	6	2.040	2.0381	$20\bar{2}\bar{4}$
11	3	1.964	1.9530	$2\bar{5}31$
12	6	1.941	1.9465	$2\bar{4}23$
13	4	1.895	1.8889	$21\bar{3}4$
14	1	1.828	1.8336	$23\bar{5}2$
15	1	1.801	1.8049	$1\bar{1}05$
16	1	1.690	1.6988	$02\bar{2}5$
17	4	1.620	1.6205	$6\bar{4}\bar{2}1$
18	4	1.552	1.5503	$42\bar{2}2$
19	1	1.455	1.4662	$4\bar{1}\bar{3}5$
20	4	1.358	1.3555	$23\bar{5}5$
21	1	1.170	1.1685	$26\bar{8}2$
22	1	1.079	1.0802	$71\bar{8}3$
23	1	1.071	1.0700	$62\bar{8}4$
24	4	1.035	1.0330	$25\bar{7}6$
25	1	1.000	1.0040	$54\bar{9}4$

0.003 Å, Z=3, V=808.2026 Å^3. Systematic extinction: hkil with $-h+k+1 \neq 3n$. Diffraction symbol: $\bar{3}mR$. Possible space groups: $R3m$, $R\bar{3}m$ or $R32$. According to rhombohedral orientation the lattice parameters are: $a_R = 6.570 \pm 0.003$ Å^3, $\alpha_R = 99.87° \pm 0.03°$, Z=1, V=269.34 Å^3.

Preliminary study of the crystal structure shows that daqingshanite is of calcite-type structure. The ordered model of cations is similar to that of huntite [$Mg_3Ca(CO_3)_4$], i.e., the Mg^{2+} sites were substituted by Sr, Ca, Ba, etc. and the Ca^{2+} sites by TR, etc. One out of each four CO_3^{-2} groups was substituted by a PO_4^{-3} group. The ideal formula is $Sr_3TR(PO_4)(CO_3)_3$. Chemical and structural analyses indicate the deficiency of both anions and cations in the structure in which extensive isomorphous substitution exists.

X-ray powder diffraction data on daqingshanite are available as shown in Table 2 (experimental conditions: 114.6 mm diameter Debye-Scherrer camera, FeKα radiation, Mn filter, 35kV, 12 mA, intensities visually estimated, interplanar (d) spacings not refined). The powder diffraction patterns can be indexed with a=10.058Å and c=9.225Å.

References

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