sulfurous solutions of the next stage of mineralization.

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HYDROXYL BASTNÄSITE, A NEW VARIETY OF BASTNÄSITE[1]

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Abstract: A hydrous fluorocarbonate of rare earths of the cerium group was found by the author in 1962 in carbonatites of a stock of alkalic and ultrabasic rocks; the mineral differs physically and chemically from ordinary bastnäsite. This hydroxyl bastnäsite has higher refractive indices and lower specific gravity than ordinary bastnäsite.

In 1962, in carbonatites of a stock of alkalic and ultrabasic rocks, the author detected a rare earth carbonate of the bastnäsite group, differing physically and chemically from ordinary bastnäsite. The stock consists of magmatic rocks--pyroxenite, ijolite--postmagmatic rocks, forsterite-apatite-magnetite ore and carbonatites. The latter include varieties with the composition of calcite, dolomite-calcite, dolomite, calcite-dolomite-ankerite and quartz-ankerite (listed in order of their genesis). The carbonatites occur as vein-like bodies in intrusive rocks and in their host fenites.

The mineral being described was often as reniform aggregates and druses in the cavities of late carbonatites veining the pyroxenite. It is associated with barite, strontianite, amethyst, pyrrhotite, pyrite, chalcopyrite, galena, sphalerite, magnetite, anatase, monazite, ancylite, altered burbankite and other minerals. Aggregates of the mineral overgow concentrations of barite, ancylite and burbankite and replace rare earth carbonates. This mineral, in turn, was observed in cracks in ankerite and quartz.

Tables 1 to 3 give the results of a goniometric, X-ray and chemical study of the rare-earth carbonate found.

As shown by goniometric analysis, the outer symmetry of crystals of the mineral is hexagonal. Habitual forms are the {0001} pinacoid and the {$11\bar{2}0$} hexagonal prism. Less common are the {$12\bar{3}9$} dihexagonal dipyramid and the {$11\bar{2}2$}, {$10\bar{1}1$} and {$20\bar{2}1$} hexagonal dipyramids (Fig. 1). Representative of the crystals are {$11\bar{2}0$} and {$11\bar{2}2$} penetration twins, triplets and subparallel growths of many individuals.

The mineral has a waxy yellow to dark brown color, although it is occasionally colorless and quite transparent. The luster is vitreous on faces and greasy on chips. The {$11\bar{2}0$} cleavage is imperfect. The hardness is about 4. In thin section the mineral is yellowish or slightly brown in tone due to admixed iron hydroxide; its pure

Table 1

Spherical Coordinates of the Faces of Hydroxyl Bastnäsite Crystals

Form	Number of faces	Average measured values		Calculated values with allowance for a_0/c_0	
		φ	ρ	φ	ρ
0001	2	∞	0°00′	∞	0°00′
$11\bar{2}0$	12	29°46′	90°00′	30°00′	90°00′
$11\bar{2}2$	12	29°37′	35°06′	30°00′	36°18′
$12\bar{3}9$	21	19°59′	6°39′	19°06,5′	7°00′
$10\bar{1}1$	9	0°14′	39°26′	0°00′	40°18.5′
$20\bar{2}1$	7	0°24′	58°53′	0°00′	59°29′

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[1] Translated from: Novaya raznovidnost' bastnezit--gidroksil-bastnezit. Doklady Akademii Nauk SSSR, 1964, Vol.159, No.5, pp.1048-1050.

Table 2

X-Ray Data for Hydroxyl Bastnäsite

Hydroxyl bastnäsite		Bastnäsite [1]			Hydroxyl bastnäsite		Bastnäsite [1]		
I	*d/n*	*I*	*d/n*	*hkil*	*I*	*d/n*	*I*	*d/n*	*hkil*
2	4.97	3	4.9	0002	1	(1.761)			
3	(3.95)	3	(3.93)	$11\bar{2}0\beta$	7	1.698	8	1.673	$22\bar{4}2$
9	3.59	7	3.56	$11\bar{2}0$	4	1.600	7	1.571	3034
2	(3.21)	3	(3.19)	$11\bar{2}0\beta$	3	1.366	5	1.480	$11\bar{2}6$
10	2.92	10	2.87	$11\bar{2}2$	5	(1.460)	7	1.438	$22\bar{4}4$
1p	2.49	2	2.43	0004	4	1.369	5	1.344	$41\bar{5}0$
2	(2.32)	3	(2.28)	$30\bar{3}0\beta$	7	1.319	8	1.298	$40\bar{4}4$
1	(2.24)	2	(2.22)	$30\bar{3}1\beta$, $11\bar{2}1\beta$	2p	1.298	4	1.275	$30\bar{3}6$
9	2.09	9	2.05	$30\bar{3}0$	4	1.198	7	1.179	$33\bar{6}0$
8	2.05	8	2.01	$30\bar{3}1, 11\bar{2}4$					
9	1.923	9	1.892	$30\bar{3}2$	4	1.172	7	1.154	$42\bar{6}1$
1	(1.876)	2	(1.853)	$22\bar{4}2\beta$	1	1.086	3	1.044	$51\bar{6}3$
4	1.805	4	1.785	$22\bar{4}0$	1p	1.023	4	1.036	$50\bar{5}5$

Footnote. Analyzed by Ye. P. Sokolova (All-Union Geological Institute). Survey conditions: Fe anticathode, tube voltage 38 kv, current force 14 ma, exposure 2 hr, 2R of camera = 57.3 mm. Rectified by a special print of the mixture with NaCl.

Table 3

Chemical Composition of Hydroxyl Bastnäsite

Constituent	*1*	*2*	*3*
SiO_2	0.30		
TiO_2	0.04		
Fe_2O_3	2,17		
ThO_2	0.50	0.53	0.01
La_2O_3	26.86	74.31	0.98
Ce_2O_3	37.50		
Nd_2O_3	3.43		
Sm_2O_3	1.59		
$Y + DY)_2O_3$	1.47		
MnO	0.06		
MgO	0.16		
BaO	0.70		
CaO	0.40	0.19	0.01
Na_2O	0.13	0.14	0.01
H_2O^-	0.11		
H_2O^+	3.96	3.68	0.87
F	1.15	1,21	0.14
SO_3	0.40		
P_2O_5	0.23		
CO_2	19.70	20.44	1
Total	100.86	100.50	
$O = F_2$	0.50	0.50	
Σ	100.36	100.00	

Footnote. Analyzed by K. A. Baklanova. 1) analytical data in percent; 2) composition reduced to 100% (less the constituents quartz, anatase, hydrogethite, dolomite, barite, rhabdophane); 3) atomic quantities. Spectral analysis revealed 0.03% Y_2O_3, 0.02% ZrO_2 and traces of Pb, Be and Al.

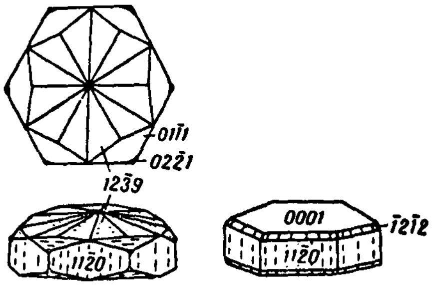

Fig. 1. Shapes of hydroxyl bastnäsite crystals.

crystals are colorless. It is uniaxial and postive. The mineral's refractive indices (ε = 1.870±0.006, ω = 1.760±0.003) are higher, and its specific gravity (d = 4.745) lower, than is the case with ordinary bastnäsite (where ε = 1.823, ω = 1.722, d = 5.00). It dissolves in cold HCl and H_2SO_4.

The powder pattern of the mineral shows a bastnäsite type structure (Table 2) with the unit cell constants a_0 = 7.23 ± 0.02 Å, c_0 = 9.98±0.05 Å and c/a = 1.380. For bastnäsite, however a_0 = 7.09 Å, c_0 = 9.72 Å, c/a = 1.371 [1]. The thermal diagram clearly reveals two endothermal effects, at 420 to 580° and 770 to 800°, due to the loss of water and to dissociation of the mineral.

On the basis of chemical analysis (Table 3), the mineral is composed of a hydrous fluorocarbonate of rare earths of the cerium group. The presence of SiO_2, TiO_2, Fe_2O_3, MgO, CaO, BaO, SO_3 and P_2O_5 is obviously related to the existence of mechanical impurities in the material analyzed--minute growths of quartz, anatase, hydrogoethite, dolomite, barite and, probably, rhabdophane--which could not be eliminated despite very careful sorting of the material under the binocular. After these mineral constituents have been deducted, the chemical analysis tallies well with the crystallochemical formula of bastnäsite, $TRCO_3$-(OH, F): $(TR_{0.98}Ca_{0.01}Th_{0.01} \cdot Na_{0.01})_{1.01}$ - $CO_3(OH_{0.87}F_{0.14})_{1.01} \cdot Ca$. Th and Na obviously replace TR isomorphously.

The amount of water (hydroxyl) considerably exceeds that of fluorine in the formula of the mineral. The literature [2] also reports bastnäsite containing up to 1.83% water. There appears to be an isomorphous series in the bastnäsite group: fluorobastnäsite $TRCO_3F$-hydroxyl bastnäsite $TRCO_3OH$. The mineral studied by us holds 87% of the hydroxyl bastnäsite constituent and 14% of the fluorobastnäsite component and closely corresponds to one of the end members of this series. According to A. K. Boldyrev's [3] classification principles for isomorphous series, it can be quite reasonably called hydroxyl bastnäsite. The variable chemical composition of minerals of the bastnasite series is obviously responsible for the regular change in their properties (refractive indices, specific gravity, unit cell constants, etc.). An analogous change in properties on the replacement $F^{-1} \leftarrow OH^-$ has long been known for the mineral groups fluoroapatite-hydroxyl apatite, herderite-hydroxyl herderite, triplite-triploidite, etc.

As for the genesis of hydroxyl bastnäsite in the carbonatites of the stock, it should be emphasized that this mineral appeared only in the late hydrothermal stage characterized by the processes of dissolution and reprecipitation of preformed minerals. The generation of hydroxyl bastnäsite (instead of bastnäsite) in the carbonatites seems to have been due to the low fluorine concentration in the late hydrothermal solutions. Analysis of the mineral parageneses in the carbonatites shows that the earliest TR carbonate typical of the stage of formation of dolomite-calcite carbonatite is burbankite, a complex anhydrous carbonate of Na, Ca, Sr, Ba and TR, stable in an alkaline medium. Carbocernaite and barite appeared in association with it in the later stage (formation of dolomite and ankerite-dolomite carbonatites), and the replacement of burbankite by ancylite (hydrous carbonate of Sr and TR) is detectable in various cases. The hydroxyl bastnäsite originated in the final stages of the hydrothermal process characterized by the leaching and silicification of carbonatite and replaced ancylite and other rare earth carbonates. Thus, the complex anhydrous TR carbonates specific to the early stages of rare earth mineralization were replaced in late stages by simpler hydrous carbonates in the following order: burbankite-carbocernaite-ancylite-hydroxyl bastnäsite. The TR content of minerals rises in the same direction. The genesis of hydroxyl bastnäsite in association with barite, quartz, sulfate-monazite and sulfides implies that it has formed in a neutral or slightly alkaline setting. Hydroxyl bastnäsite is unstable in surficial environments and breaks down into dispersed TR hydroxides.

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