A SECOND DISCOVERY OF INDERITE*

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Abstract

A second occurrence of inderite ($Mg_2B_6O_{11} \cdot 15H_2O$), which was first described in 1937 by Boldyreva from the West Kazakstan, U.S.S.R., has been discovered. New chemical and powder x-ray data indicate the identity of the two materials. By Weissenberg x-ray methods the mineral is found to be triclinic with $a_0=8.14$ Å, $b_0=10.47$ Å, and $c_0=6.33$ Å. It has two good cleavages, a density of 1.860, hardness of 3, and is clear and colorless. The optical properties are: X=1.488, Y=1.508, Z=1.515, and 2V=63°.

Previous Work

Inderite was first named and described by A. M. Boldyreva (1937). It derives its name from the Inder borate deposits in West Kazakstan, Inder mountains, U.S.S.R. Until the discovery of the American material, the mineral had not been found elsewhere. In 1941 a specimen was submitted for identification by M. Vonsen of Petaluma, California, to the Harvard Mineralogical Laboratory where a complete investigation of the substance was undertaken.

Occurrence

In Russia, according to the published account, inderite is found at the Kzyl-tau deposit, West Kazakstan, where it occurs as small, white to pink, reniform nodules disseminated in a brick-red clay. The clay is composed of quartz, calcite and "hydrous basic magnesium carbonate." The only other borate present is hydroboracite which occurs in veinlets and lenses (Boldyreva, 1937). Information on the location and occurence of the American material has been withheld at the request of the discoverer.

Identification

The identification of the American mineral as inderite is based on four lines of evidence:

1. Identical chemical composition.
2. Partial similarity with published optical properties of the type material.
3. Similarity of x-ray powder data of the American material and that published for the type inderite.
4. Identity of the American mineral with artificially prepared inderite as shown by x-ray powder photographs.

X-Ray Investigation

No crystals of the mineral were discovered, but the specimen ex-

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amined may be a fragment from a large single crystal. It is a tabular plate 3.5 cm. long, 2.5 cm. wide and 1 cm. thick. Two cleavages, making an angle of 66° 20′, are easily recognized. The intersection of these cleavages is parallel to the longest direction of the specimen.

X-ray rotation and Weissenberg photographs were taken on a cleavage fragment with the cleavage intersection as the axis of rotation. These photographs indicate a triclinic unit cell with the dimensions:

$$a_0 = 8.14\ \text{Å}, \quad b_0 = 10.47\ \text{Å}, \quad c_0 = 6.33\ \text{Å}.$$
$$\alpha = 96°56\tfrac{1}{2}', \quad \beta = 106°28', \quad \gamma = 106°03'.$$
$$\text{Axial ratio: } a_0:b_0:c_0 = 0.768:1:0.604.$$

The two cleavages become $b\{010\}$ and $\{1\bar{1}0\}$ and the rotation axis the $c[001]$ axis. The calculated volume of the unit cell is:

$$V_0 = a_0 b_0 c_0 \sin\alpha \sin\beta \sin\gamma^*$$
$$V_0 = 485.43\ \text{Å}^3.$$

With this value and the measured density (1.86), the molecular weight (M) of the unit cell is:

$$M = 547.28.$$

Physical Properties

One cleavage is perfect parallel to $b\{010\}$; the second is good parallel to $\{1\bar{1}0\}$. Cleavage faces have a vitreous to pearly luster; whereas the irregular surfaces have a dull, greasy appearance. The mineral is clear and colorless. The density is 1.860 (average of determinations on three different grains by the Berman microbalance). The hardness is 3; it is not scratched by calcite, nor does it scratch that mineral.

No cleavages are reported for the type inderite, which occurs as fine, prismatic needles in nodular aggregates. The hardness of the Russian mineral is stated to be less than 1, and the density is reported as 1.79. Because of the occurrence as aggregates of needles, a measurement of the density of the type material probably would result in a value lower than one obtained from determinations made on single crystal fragments which were without fractures or air spaces. Likewise, it is apparent that the true hardness of the original inderite was probably not measured and that only the separation of the small needles was observed.

Optical Properties

Orientation	n_{Na}	
X near b	1.488	Bx (−)
Y	1.508 ± .002	2V = 63° ± 03°
Z∧c = −22°	1.515	$r > v$, weak

The optical data for the type inderite were listed as follows:

$N_g(nX?) = 1.488$
$N_m(nZ?) = 1.504$
2V large
Bx (−)
$Z \wedge c = 5°$

Boldyreva (1937) states, "No direct N_p (or nY?)measurements could be done, because the minute prisms lay down always almost with N_p vertical." Previously he states, "It is optically a biaxial, negative mineral, with a diffuse figure in convergent light and with a large 2V." These two statements are contradictory, for, if the slender prisms gave a negative biaxial figure from which 2V could be estimated, then from these needles only nZ and nY could be measured and not nX.

Chemistry

Table 1

	1	2	3	4	5	6		7
MgO	14.70	14.34	14.65	14.36	14.82	14.40	Mg	2.07
B_2O_3	36.41	35.60	36.20	37.31	36.69	37.32	B	5.95
H_2O	48.12	48.20	48.20	48.88	48.49	48.29	O	11.00
Rem.	0.86	2.62	0.97				H	30.40
Total	100.09	100.76	100.02	100.55	100.00	100.00	O of H_2O	15.20

1. Inderite from American locality; F. A. Gonyer, *analyst.*
   Remainder is: Insoluble 0.54, CaO 0.32.
2. Inderite from Inder Basin, U.S.S.R.; E. N. Egorova, *analyst*
3. Remainder for 2 is: SiO_2 0.71, Al_2O_3 0.10, Fe_2O_3 0.23, CaO 1.02, K_2O and N_2O 0.18, CO_2 0.38.
   Remainder for 3 is: SiO_2 0.13, Al_2O_3 0.02, Fe_2O_3 0.32, CaO 0.16, K_2O and Na_2O 0.17, CO_2 0.17.
4. Inderite, artificial; Feigelson, Grushvitsky, and Korobochkina (1939).
5. Analysis 1, recalculated to 100%.
6. Theoretical composition of $Mg_2B_6O_{11} \cdot 15H_2O$.
7. Atomic ratios of Analysis 1.

The new analysis approximates closely the formula $Mg_2B_6O_{11} \cdot 15H_2O$, which has already been proposed. The unit cell contains one formula weight of $Mg_2B_6O_{11} \cdot 15H_2O$. The calculated density agrees closely with the measured density:

$$d_{calc.} = 1.87$$
$$d_{meas.} = 1.86.$$

By means of the Law of Gladstone and Dale, it is possible to calculate approximately the mean index of refraction (n):

$$\frac{n-1}{\text{density}} = K$$

	p	k
MgO	14.82	.200
B_2O_3	36.69	.220
H_2O	48.49	.3355

The k values are from Larsen and Berman (1934).

$$\frac{n-1}{1.86} = K = .27304$$

$$n = 1.508.$$

This value compares favorably with the measured mean index of refraction, 1.504.

Inderite is easily soluble in warm dilute HCl. Before the blowpipe on charcoal it fuses at about 600°C. to an opaque white bead. Flame tests produce a very strong green flame of boron. Heated in the closed tube, inderite gives off large amounts of water with marked intumescence. The water gives a slight basic reaction.

Investigation by X-ray Powder Method

Boldyreva (1937) has given x-ray powder data for inderite and inyoite with iron radiation. Unfortunately, his method of presentation is somewhat ambiguous. He does not list the spacings (d) directly but tabulates the values $d\alpha/n$ with $n=2$ and α the α-wave length of iron radiation.

Feigelson, Grushvitsky and Korobochkina (1939) have synthesized inderite by using borax and magnesium sulfate heptahydrate in the proportions necessary to produce the substance. A water solution of these two salts was placed by them in a stoppered jar and kept at about 35°C. At the end of 24 days a crystalline precipitate had formed and was removed and analyzed (Table 1, 4). From this analysis and the optical properties, these authors were able to state, "that the salt obtained is a synthetic inderite."

Using the method outlined above, the author repeated the experiments and obtained a precipitate of rounded crystals at the end of three weeks.

X-ray powder photographs with iron radiation were taken of the American inderite and of the precipitate obtained by the Russian method. In Table 2 the results are given and compared with the data published by Boldyreva (1937).

TABLE 2. *X*-RAY POWDER DATA FOR INDERITE.
IRON RADIATION

	Inderite from America		Synthetic Inderite		Inderite from Inder Basin, U.S.S.R.	
	I	*d*	*I*	*d*	*I*	*d**
1	9	7.314	9	7.361		
2	5	5.955	5	5.923		
3	10	5.000	10	5.000		
4	3	4.235	2	4.230		
5	4	3.965	3	3.970	3	3.872
6	7	3.481	6	3.492	10	3.490
7	1	3.388	1	3.375	2	3.394
8	8	3.177	9	3.180	9	3.032
9	2	3.055	3	3.065	4	2.936
10	7	2.866	7	2.880	9	2.768
11	3	2.696	2	2.687	5	2.644
12	1	2.602	1	2.587	2	2.578
13	3	2.543	2	2.543	6	2.512
14	6	2.475	6	2.477	8	2.432
15	3	2.398	3	2.400		
16	3	2.280	3	2.282	4	2.214
17	2	2.095	1	2.096	3	2.060
18	4	1.963	6	1.965	2	2.014
19	1	1.927	1	1.925	2	1.968
20	2	1.872	2	1.873		
21	1	1.826	1	1.824		
22	2	1.782	2	1.780	2	1.756
23	3	1.739	3	1.739	7	1.736
24	1	1.662	1	1.659		
25	3	1.636	1	1.632	2	1.638
26	1	1.596	2	1.598	3	1.616
27	3	1.577	2	1.574		
28	2	1.538	2	1.539	5	1.542
29	1	1.504	1	1.491	2	1.504
30	1	1.473			3	1.458
31	2	1.421				
32	1	1.362				
33	1	1.345				
34	1	1.330				
35	1	1.293				
36	1	1.262				
37	1	1.219				
38	1	1.200				
39	1	1.175				
40	1	1.164				
41	1	1.155				
42	1	1.141				
43	1	1.069				
44	2	1.048				

* Recalculated from given values of $d\alpha/n$.

The identity of the inderite with the material synthesized is immediately apparent. The agreement with the reported spacings of the type material is not so complete, but the discrepancies must be ascribed to differences in measurement of the two films. It may be noted that values obtained for inyoite showed identical deviations from the *d* values for Russian inyoite.

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