debted to Professor Yoshinori Kawano of Tohoku University for his kind advice and constant help with this work.

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THE AMERICAN MINERALOGIST, VOL. 51, NOVEMBER–DECEMBER, 1966

CELL DIMENSIONS AND SPACE GROUP OF TAMARUGITE

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Tamarugite, $NaAl(SO_4)_2 \cdot 6H_2O$, is a secondary mineral formed from the oxidation of sulfides, usually under arid conditions. Optical examination of crystals found with sideronatrite in a sample from Mina de la Compania, Sierra Gorda, Chile (U. S. National Museum, Smithsonian Cat. No. R6287) revealed $\alpha = 1.485$, $\beta = 1.487$ and $\gamma = 1.498$, all ± 0.002. These thus agree with the values, $\alpha = 1.484$, $\beta = 1.486$, $\gamma = 1.497$, all ± 0.001—reported by Gordon (1940). Similarly, the morphological and physical properties observed in the tamarugite of this present study confirm those reported by Gordon (1940). Published x-ray data on tamarugite were not found by the writers. Thus it was necessary to determine

TABLE 1. INDEXED POWDER DATA FOR TAMARUGITE

d(obs)	I/I¹	d(calc)	hkl	d(obs)	I/I¹	d(calc)	hkl
12.538	16	12.612	020	2.544	8	2.545	091
7.034	6	7.033	110	2.521	4	2.522	0·10·0
6.339	2	6.333	120	2.509	2	2.513	15$\bar{2}$
5.530	8	5.523	130	2.462	9	2.462	062
4.923	6	4.923	031	2.350	2	2.350	23$\bar{2}$
4.557	4	4.563	12$\bar{1}$	2.333	4	2.330	0·10·1
4.424	3	4.413	111	2.329	6	2.328	31$\bar{1}$
4.370	4	4.374	041	2.300	6	2.299	32$\bar{1}$
4.223	100	4.223	121	2.281	3	2.281	24$\bar{2}$
4.207	80	4.204	060	2.269	4	2.269	28$\bar{1}$
4.157	12	4.155	150	2.228	4	2.226	290
3.964	32	3.955	131	2.189	7	2.188	1·11·0
3.861	2	3.866	14$\bar{1}$			2.190	311
3.647	59	3.646	160	2.116	3	2.115	26$\bar{2}$
3.355	3	3.351	151	2.102	6	2.102	0·12·0
3.266	3	3.267	20$\bar{1}$	2.060	2	2.060	182
3.170	10	3.167	240			2.059	092
3.162	12	3.163	22$\bar{1}$	2.045	3	2.044	36$\bar{1}$
3.153	21	3.153	080	2.025	2	2.024	003
3.036	5	3.036	002			2.024	27$\bar{2}$
2.949	2	2.952	022	1.969	1	1.968	033
		2.896	180			1.967	32$\bar{2}$
2.899	23	2.901	24$\bar{1}$			1.904	14$\bar{3}$
		2.902	17$\bar{1}$	1.904	3	1.903	1·10·$\bar{2}$
2.876	5	2.879	11$\bar{2}$			1.902	113
2.823	2	2.824	12$\bar{2}$			1.876	1·13·0
2.766	5	2.761	260	1.876	2	1.877	371
2.739	3	2.740	13$\bar{2}$			1.877	2·11·$\bar{1}$
2.733	4	2.736	042	1.831	2	1.831	400
2.711	7	2.705	112			1.830	0·11·2
2.604	5	2.602	052	1.702	3	1.702	1·12·$\bar{2}$
		2.580	26$\bar{1}$			1.703	083
2.582	5	2.579	181	1.679	2	1.679	460

the cell dimensions and space group of tamarugite as a first step in a contemplated crystal-structure analysis.

Weissenberg photographs of the h0l, h1l, h2l, and hk0 reflections for copper Kα radiation were made for two single crystals of tamarugite, both from specimen R6287. The indexing of these photographs showed that the only systematic extinctions were of the type $k \neq 2n$ for (0k0). Accordingly the space group is $P2_1$ or, if the crystal is centrosymmetrical, $P2_1/m$. The latter agrees with the $2/m$ crystal class reported by Palache *et al.* (1951) on the basis of morphologic data.

Accurate lattice parameters were obtained by use of a least squares FORTRAN IV program written by Fang and Wolf following the scheme proposed by Main and Woolfson (1963) in which α_1-α_2 separations in the high angle regions of zero level Weissenberg photographs are utilized. The cell parameters were then slightly refined so as to minimize the difference between d(calc) and d(obs) for the powder diffraction data. The cell parameters thus obtained are: $a=7.35_3$, $b=25.22_5$, $c=6.09_7$ and $\beta=95°12'$. Ungemach (1935) reports β to be 94°50′ on the basis of morphologic data.

The amount of tamarugite in specimen R6287 was too small for a powder pattern to be obtained other than the powder photograph earlier made by Robinson (1962). However, the U. S. National Museum kindly supplied two specimens of tamarugite—Nos. C4703 from Cerro Pintados, Chile and R9117 from Alcaparrosa, Chile—for which powder patterns were obtained in a Norelco wide-angle diffractometer using CuKα radiation. The powder patterns for these two specimens appeared indistinguishable. The pattern obtained from a $1/8^0$ (2θ) per minute scan of the Cerro Pintados material, internally calibrated with spinel, was satisfactorily indexed on the basis of the cell parameters reported above (Table 1). The observed d spacings for the Cerro Pintados pattern closely matched those measured by Robinson (1962) from a powder photograph of tamarugite collected from the Sierra Gorda specimen.

The axial ratios calculated from the lattice parameters here reported—that is, 0.2915:1:0.2417—compare with those of Ungemach (1935)—namely, 0.2919:1:0.2415.

The calculated density of tamarugite, assuming $Z=4$, is 2.066 gm/cm^3. The measured density, by the flotation method, is 2.06 ± 0.01 gm/cm^3. Gordon (1940) and Ungemach (1935) report the density of tamarugite to be 2.07 gm/cm^3.

The authors wish to thank Mr. Lloyd A. Wolf for his assistance in computer programming.

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