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Hashemite, $Ba(Cr,S)O_4$, a new mineral from Jordan

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Abstract

Hashemite, $Ba(Cr,S)O_4$, from west-central Jordan is associated with chromian ettringite, apatite, and calcite in a phosphatic carbonate analogous to the Hatrurim Formation in Israel. The mineral is orthorhombic, *Pnma*, with a = 9.112(2)Å, b = 5.541(1)Å, c = 7.343(1)Å, Z = 4. It occurs as small, euhedral, dark-brown, commonly zoned crystals with an averaged D(meas.) = 4.59 g/cm^3 and a hardness of 3.5. Hashemite is biaxial (+); refractive indices on light and dark material are: (dark) α = 1.952(2), β = 1.960(2), γ = 1.977(2); (light) α = 1.810(2), β = 1.813(2), γ = 1.824(2). $2V_z$ (+) varies from 35° to 57°. Microprobe analyses of zoned crystals yield BaO = 61.4, CrO_3 = 31.3, and SO_3 = 7.50 summing to 100.00.

Description

Hashemite is the isostructural, chromate analog of barite. This first natural occurrence of hashemite, with the general formula of $Ba(Cr,S)O_4$, is reported from Jordan. With the gracious permission of his Majesty, King Hussein, the authors have named the new species hashemite in honor of the Hashemite Kingdom of Jordan. Hashemite has received the approval of the International Commission of New Minerals and Mineral Names.

The mineral was discovered in specimens from building stone quarries, 60 km southeast of Amman, in west-central Jordan. (Fig. 1.) The host rock is a phosphatic carbonate that is part of a sedimentary sequence of Cretaceous age described by Bender (1974). This unit has been correlated with the Mottled Zone of the Hatrurim Formation in Israel by Heimbach and Rosch (1980). The detailed mineralogy of the Hatrurim Formation has been described by Gross (1977).

Hashemite is found sparsely disseminated in veinlets in the host rock associated mainly with a chrome-bearing ettringite $Ca_6(Cr,Al)_2(OH)_{12}(SO_4)_3{\cdot}26H_2O$, a blue-green apatite, and minor calcite. The mineral occurs as euhedral brown crystals, less than 1 mm long, perched on the yellow ettringite. It ranges from dark-colored (sulfate poor) to light-colored (sulfate enriched) varieties; some grains are zoned and have dark cores and light rims. Table 1 summarizes the physical properties of hashemite.

Unit cell parameters shown at the head of Table 2 were computed from the powder diffraction data listed in Table 2, using the Vantrump and Hauff (1978) version of the Appleman and Evans (1973) least-squares refinement computer program for cell-parameter determinations. These data compare favorably with data for synthetic $BaCrO_4$ (Pistorius and Pistorius, 1962, JCPDS card No. 15-376) (Table 2). Single-crystal precession photographs (0 to 3rd level) show orthorhombic symmetry consistent with the space group *(Pnma)* requirements for barite-hashemite. Hashemite crystal morphology is illustrated by scanning-electron micrograph in Figure 2.

Quantitative chemical data obtained by electron micro-

Table 1. Physical properties of hashemite

COLOR:	brown...zoned from light yellowish brown to darker greenish brown.
LUSTER:	adamantine
HARDNESS:	3.5
DENSITY:	4.59(5) g/cm^3 (observed) Berman microbalance 4.49 (calculated)
CLEAVAGE:	(001)--perfect; (010), (100)--good
OPTICS:	
Refractive index (Na light)	Dark material: α = 1.952(2), β = 1.960(2), γ = 1.977(2) Light material: 1.810(2), 1.813(2), 1.824(2)
2V	56°-57° obs (69° calc) 35°-45° obs (55° calc)
Dispersion:	r<v, extreme
CRYSTAL FORMS:	dark crystals are stubby, doubly terminated. light crystals are tabular. observed forms: {100} {010} {001} {110} {011} {101} {201} {102} {210} {203} {111} and {211}; C* is polar. growth hillocks and striations are on some faces.

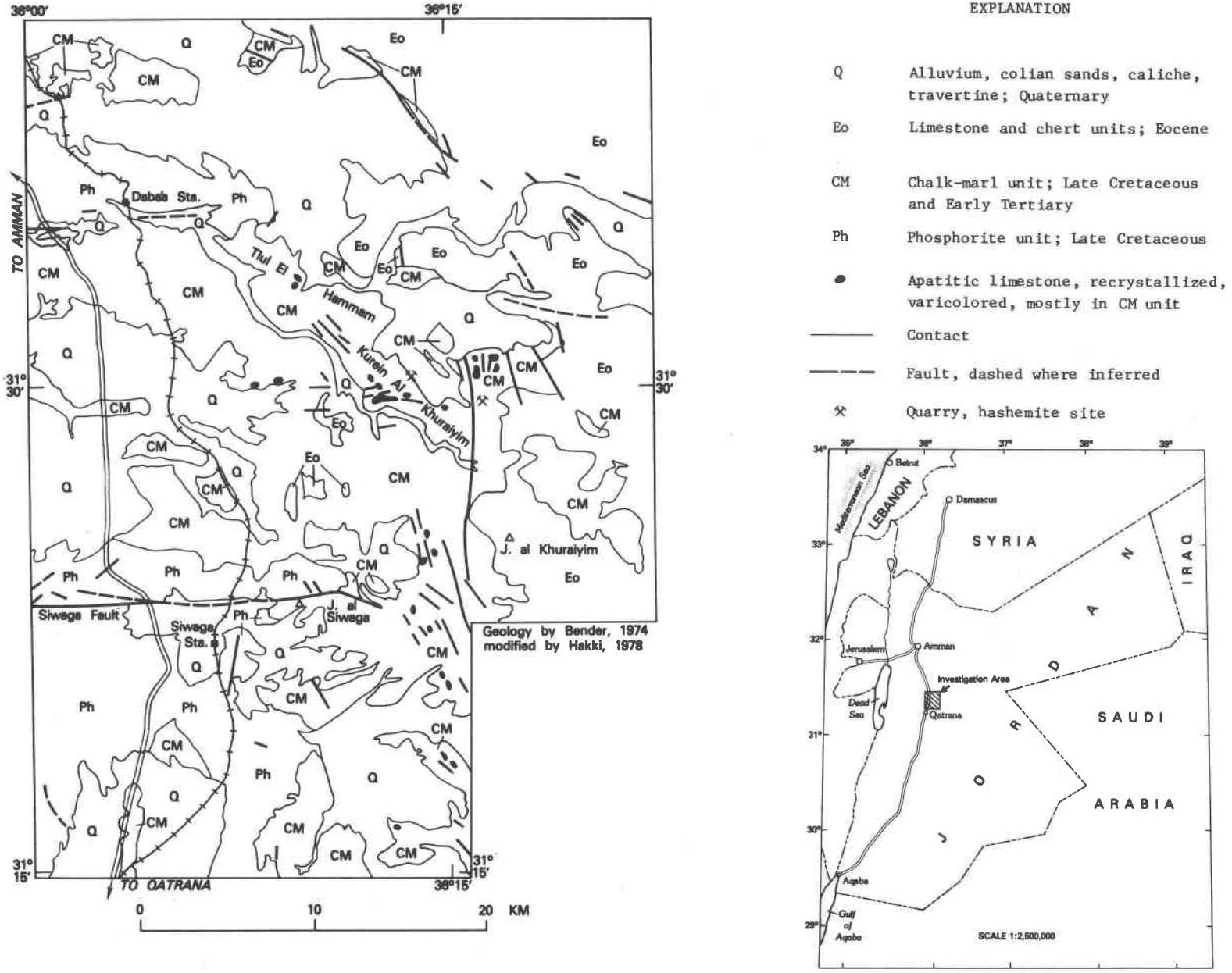

Fig. 1. Geologic map of the Daba'a-Siwaga marble area, west-central Jordan.

Table 2. X-ray powder data and unit cell parameters

Natural hashemite a=9.112(2)Å, b=5.541(1)Å, c=7.343(1)Å				$BaCrO_4$ - PDF No. 15-376 a=9.105Å, b=5.541Å, c=7.343Å	
dÅ (obs)	dÅ (calc)	Intensity	hkl	dÅ	Intensity
4.55	4.556	7	200	4.55	6
4.428	4.425	13	011	4.42	16
3.978	3.979	25	111	3.978	40
3.871	3.875	8	201	3.869	6
3.669	3.672	60	002	3.670	25
3.516	3.519	100	210	3.518	90
3.403	3.405	35	102	3.405	50
3.171	3.173	80	211	3.172	100
2.901	2.901	35	112	2.901	55
2.805	2.807	10	301	2.805	10
2.770	2.770	40	020	2.770	45
2.542	2.540	14	212	2.539	12
	2.504	--	311	2.503	2
2.495	2.493	5	121	2.495	6
	2.367	--	220	2.367	10B
	2.364	--	103	2.362	8B
	2.340	--	302	2.337	6
2.253	2.253	20	221	2.253	16
2.211	2.211	5	022	2.213	6
2.175	2.174	60	113,401	2.174	60
2.157	2.156	30	203,312	2.154	40B
2.150	2.149	45	122	2.149	50B
2.106	2.107	10	410	2.105	10
1.972	1.972	5	321	1.971	8
1.905	1.906	15	303	1.905	16
1.835	1.836	10	004	1.836	6
1.799	1.799	10	104,123+	1.800	12
	1.759	--	420	1.758	2
	1.757	--	131		
1.711	1.712	30	114,230	1.710	25
1.702	1.703	5	204	1.703	8
	1.701	--	223		
1.686	1.685	5	511		
	1.668	--	403	1.667	8
	1.667	--	231		
1.627	1.628	7	214		
	1.623	--	132	1.625	8
	1.571	--	304	1.570	12
1.569	1.570	11	323		
1.530	1.530	5	024	1.530	6
1.511	1.511	5	314		
	1.509	--	124	1.509	10
	1.462	--	503	1.462	8
	1.451	--	224	1.451	8
	1.450	--	105		
1.449	1.449	5	332		
1.437	1.436	5	611		
	1.435	--	430	1.435	8
	1.419	--	015	1.419	6
1.414	1.413	3	513		
1.397	1.398	4	205		
1.224	1.224	20	006		

Diffractometer: scan speed--1/2 degree 2 theta per minute
$CuK\alpha_1$ radiation, nickel filter

Diffractometer scan
CoKα radiation

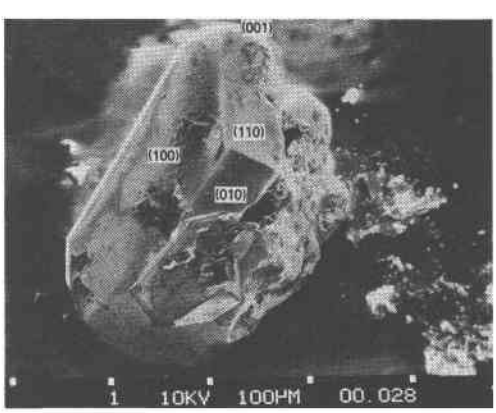

Fig. 2. Scanning electron micrograph of a hashemite crystal with common faces labeled.

Table 3. Compositional data for hashemite by electron microprobe

Dark crystal	(Average of five analyses in percent)
BaO	60.8
CrO_3	37.0
SO_3	2.18
Total	99.98
Structural formula	$Ba_{1.00}(Cr_{.93}S_{.07})_{1.00}O_4$
Light crystal	(Average of four analyses in percent)
BaO	62.55
CrO_3	26.15
SO_3	11.75
Total	100.45
Structural formula	$Ba_{1.00}(Cr_{.64}S_{.36})_{1.00}O_4$
Zoned crystal	
BaO	61.40
CrO_3	31.10
SO_3	7.50
Total	100.00
Structural formula	$Ba_{.99}(Cr_{.77}S_{.23})_{1.00}O_4$

probe for the light- and dark-colored varieties (which comprise the range of compositions for the Jordanian hashemite) are summarized in Table 3. Structural formulae have been computed for each type of material.

A type specimen is on deposit at the U.S. National Museum in Washington, D.C.

Acknowledgments

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