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A chromian hydrogrossular from Jordanów, Lower Silesia, Poland

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SUMMARY. A new variety of garnet, a chromian hydrogrossular, has been found in a loose block of diopside–albite rock in a quarry of serpentinite in Jordanów, Lower Silesia. Its chemical formula is given. Although the water content of this garnet barely exceeds 1 %, the X-ray, thermal, infra-red spectrophotometric, and optical examinations give evidence that this water, in the form of $(OH)_4$ groupings, substitutes for the SiO_4 tetrahedra. The chromian hydrogrossular from Jordanów belongs to the numerous calcium-rich silicates that were formed there during the process of alteration of serpentinites by lime-rich hydrothermal solutions.

IN the vicinity of Jordanów, a series of basic and ultrabasic igneous rocks occurs (gabbros, dunites, and serpentinites) showing different degrees of autometamorphic alteration. In an old quarry of serpentinite in Jordanów the intense calcium autometasomatism gave rise to the formation of numerous calcium silicates (grossular, diopside, idocrase, zoisite, clinozoisite, prehnite, pumpellyite, tremolite, and actinolite) described in detail in W. Heflik's paper (1967). Recently, in the same quarry, in a loose block, the authors have found a new variety of garnet, a chromian hydrogrossular.

Experimental data. Macroscopically this garnet is light green. It occurs as microcrystalline aggregates in a diopside–albite rock containing dispersed chromite crystals. Thin sections of this rock show pale green, rounded, or shapeless garnet grains, 0·05–0·15 mm in diameter. In most of the grains darker and turbid 'nuclei' can be observed, surrounded by lighter rims, which often show anomalous birefringence. Some of them exhibit 'quadrant' anisotropic zones typical of many natural hydrogarnets (Żabiński, 1966). The refractive index measured for different grains in Na-light varies around 1·757. The aggregates of hydrogarnet are often associated with chromite and sometimes form fine intergrowths with the latter.

A quantitative chemical analysis was kindly performed by A. Stenzel. The sample for analysis was prepared by concentrating in heavy liquids and finally by purifying using hand-picking. Since X-ray analysis of the final concentrate showed a small admixture of albite, $Ab_{92}An_8$, intergrown with the garnet, the amount of this feldspar was calculated on the basis of the total Na_2O content and its molecular proportion subtracted from the analysis. The chemical composition of the hydrogarnet is shown in table I.

From X-ray diffraction patterns the cell-edge of the garnet, *a* 11·93±0·005 Å, was calculated by graphical extrapolation to 90°. This value is distinctly high as compared with the lattice constant of anhydrous chromian grossular with a similar Cr_2O_3 content; the latter, calculated on the basis of Vegard's law, should be 11·89 Å, taking for grossular *a* 11·85 Å and for uvarovite *a* 12·00 Å. It is also higher than the lattice constant of the chromian grossular described by Knorring (1951): 12·25 % Cr_2O_3, *a* 11·881 Å. The considerable increase in the cell edge is obviously caused by substitution of $(OH)_4$ groupings for SiO_4 tetrahedra.

On the basis of the chemical formula and the lattice constant the density of the garnet was calculated as 3·64. This value is in fairly good agreement with the measured density, 3·59, determined by the suspension method, taking into account that the latter is lowered by the presence of the inevitable fine intergrowths of albite.

TABLE I. *Chemical analysis of chromian hydrogrossular (A) from Jordanów, Lower Silesia, Poland, recalculated (B) after deduction of all* Na *as albite*

	A	Albite, $Ab_{92}An_8$	Hydro-grossular	B	Ions on the basis of 24 oxygen		
SiO_2	40·11	4·53	35·58	38·20	Si	5·83	6·09
TiO_2	0·67	—	0·67	0·72	H/4	0·26	
Al_2O_3	15·23	1·42	13·81	14·83	Ti	0·08	3·81
Cr_2O_3	6·04	—	6·04	6·48	Al	2·66	
Fe_2O_3	2·38	—	2·38	2·55	Cr	0·78	
FeO	0·98	—	0·98	1·05	Fe^{3+}	0·29	
MnO	0·54	—	0·54	0·58	Fe^{2+}	0·13	6·05
CaO	29·36	0·12	29·24	31·39	Mn	0·08	
MgO	2·94	—	2·94	3·16	Ca	5·13	
Na_2O	0·74	0·74	—	—	Mg	0·71	
K_2O	trace	—	—	—			
H_2O+	0·97	—	0·97	1·04			
	99·96			[100·00]			

The d.t.a. curve of the mineral shows two weak but distinct endothermic peaks at 860 and 980 °C, followed by a slight exothermic effect (fig. 1*a*). Such features of the d.t.a. curve are typical for hydrogrossulars, e.g. from Nikorzminda (fig. 1*b*), previously described by Belyankin and Petrov (1941) and recently by Żabiński (1966). The difference in the peak temperatures should be ascribed to a considerably lower $(OH)_4$ content in the hydrogrossular from Jordanów, and presumably also to its somewhat different chemical composition. Two endothermic effects of hydrogrossular are caused by its two-step dehydroxylation.

The infra-red spectrum of the garnet showed a broad and weak OH-band in the region of *c.* 3600 cm^{-1}.

Discussion. Although the water content in the garnet from Jordanów barely exceeds 1 %, the X-ray, thermal, infra-red spectrophotometric, and optical examinations give evidence that this water in the form of $(OH)_4$ groups substitutes for the SiO_4 tetrahedra. Thus this mineral is proved to be a new variety of hydrogarnet, a chromian hydrogrossular.

On the basis of purely geometric considerations it has already been shown (Żabiński, 1966), that the optimum stability region in the series grossular–$Ca_3Al_9(OH)_{12}$ corresponds to the hydrogrossular with a SiO_4:$(OH)_4$ ratio of *c.* 2:1. The replacement of Al^{3+} in hydrogrossular by larger Fe^{3+} or Cr^{3+} ions leading to the expansion of the crystal lattice should shift the optimum stability region towards anhydrous members. In fact, both the water-bearing andradite from the Totalp serpentine complex (1·0 % H_2O), recently described by Peters (1965) and the chromian hydrogrossular from Jordanów fall in this region. In the case of the hydrougrandite from Hsiao-sungshan (Tsao-Yung-Lung, 1964) the expansion of the unit cell caused by the high water (5·19 %) and Fe^{3+} content is evidently compensated by the abundant Mg^{2+} ions.

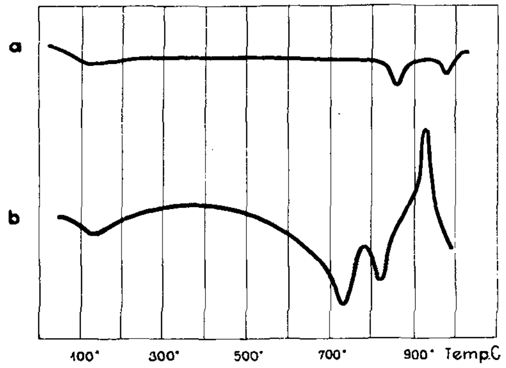

FIG. 1. D.t.a. curves of hydrogarnets: *a*, chromian hydrogrossular from Jordanów; *b*, hydrogrossular from Nikorzminda (after Żabiński, 1966, up to scale).

The chromian hydrogrossular from Jordanów belongs to the paragenesis of numerous calcium-rich silicates, which were formed there presumably during the process of alteration of serpentinites by lime-rich solutions post-dating gabbroic intrusions. The sources of chromium were chromite grains disseminated in the ultrabasic rocks (serpentinites). It is worth mentioning that in the same quarry in Jordanów both hydrous and anhydrous garnets occur. This may be ascribed to the marked local variation of both physical and chemical conditions that is typical of metasomatic processes.

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