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Duhamelite, $Cu_4Pb_2Bi(VO_4)_4(OH)_3 . 8H_2O$, a new Arizona mineral

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ABSTRACT. Found by J. E. DuHamel, at a prospect near Payson, Arizona, where it occurs with chrysocolla, malachite, rare fornacite, wulfenite, and bismutite. Colour chartreuse green (RHS 1A), H = 3, D = 5.80. Pleochroism in yellow weak; $\alpha = 2.08$, $\beta = 2.11$. Crystals are minute orthorhombic fibres $a = 7.49$ Å, $b = 9.66$, $c = 5.87$, Z = 1, D_{calc} 5.99 g/cm^3. Strongest lines: 5.014(4), 4.828(3), 3.493(5), 3.159(7), 2.950(10), 2.642(9), 1.870(3), 1.755(3). Wet analysis (avg. of 3) gave CuO 20.4 %, PbO 28.4, Bi_2O_3 15.9, V_2O_5 23.1, H_2O 11.8.

Occurrence. The occurrence of duhamelite is described by J. E. DuHamel:

Specimens of the new mineral were found in quartz veins cutting Precambrian greenstones, 5 kilometers southwest of Payson, Arizona. The locality is on the banks of Lousy Gulch.

The greenstone host rocks are exposed over an area of approximately 130 square kilometers south and west of Payson and are part of the Yavapai Series of schists which form the older Precambrian basement of Arizona. The greenstones contain many small gold-bearing quartz veins of probable metamorphic origin which were prospected intensively in the 1880's. The mines developed were short-lived and ceased production by the 1890's.

Andesitic and basaltic flows, fragmental units, and tuffs comprise the bulk of the extrusive rocks, but minor flows of rhyolite and quartz latite as well as volcanic-derived sediments are present. The extrusive rocks and sediments have been intruded, prior to regional metamorphism, by basic rocks of diabasic, dioritic, and tonalitic composition. Most of the mineralized quartz veins in the district occur in or near the intrusives.

The quartz veins have been metamorphosed together with the host rocks and typically contain actinolite or chlorite as major constituents along with the quartz. Metallic mineralization is rare in the district, and is most often observed as isolated areas of patchy chrysocolla and hematite in the veins and adjacent wall-rock. Traces of chalcopyrite, pyrite, and gold occur in some of the veins.

The initial, and best, specimens were found in the dump material of a two-meter deep pit dug at the contact of greenstone with coarse-grained metadiorite. Radiated crystals occur in vugs of dirty, gray vein material which also carries inclusions of chlorite, plagioclase, chrysocolla, hematite, and akaganéite. Additional specimens, principally compact fibrous and reniform material was found in place in veins cutting metadiorite at a small pit 50 meters east of the first occurrence.

In addition to primary pyrite and chalcopyrite, the veins may have contained traces of bismuthinite, for bismutite was noted in one sample. The source of lead in duhamelite is more uncertain, for no evidence of lead sulphide was seen. Other lead minerals also occur in traces, namely fornacite and wulfenite, but the total lead content of vein and wallrock matter is invariably less than 100 ppm. Probably it is important that lead be present only in traces, otherwise mottramite would be expected.

Most of the duhamelite found occurs as bundles of fibres resting on corroded chrysocolla or directly upon the gangue. It was not noted in close association with partly oxidized chalcopyrite or with malachite.

Physical properties. Crystals are small, no longer than 0.4 mm or 0.02 mm in width. They may be free-standing or compacted into barrel-shaped bundles. The colour of isolated fibres is chartreuse green (RHS 1A) and in bundles is darker olive green (RHS 146A). The streak is a pale yellow-green. Crystals are brittle, and the estimated Mohs hardness is 3. A small sample (1.87 mg) weighed three times on the Berman balance yielded a specific gravity of 5.80 ± 0.05.

X-ray study. Despite the small grain size, weak diffraction data were obtained from rotation and Weissenberg exposures using Cu-Kα radiation. Crystals are orthorhombic, $a = 7.49$ Å, $b = 9.66$, $c = 5.87$ (the values refined from powder data). The X-ray powder data are presented in Table I.

Optics. In thin section as well as hand specimen, duhamelite closely resembles creaseyite, and distinguishing the two would be difficult were not the indices of creaseyite considerably lower. The prism axis was taken as [001] and is coincident with γ; the orientation of the other two directions is unknown due to minute grain size. Pleochroism is in yellows but is weak, with $\alpha = \beta > \gamma$. Indices of refraction determined for NaD are $\alpha(np) = 2.08$, $\beta = 2.11$.

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TABLE I. *X-ray powder data for duhamelite Cr-K radiation, 114 mm camera*

I_{est}	d_{meas}	d_{calc}	*hkl*	I_{est}	d_{meas}
½	7.490	7.493	100	1	2.508
1	5.909	5.920	110	1	2.416
4	5.014	5.018	011	2B	2.301
3	4.828	4.828	020	2	2.246
2	4.176	4.170	111	2	2.136
1	4.059	4.058	120	1	2.082
1	3.744	3.746	200	3	1.870
5	3.493	3.493	210	½	1.781
7	3.159	3.159	201	3	1.755
2	2.982	3.002	211	2	1.735
10	2.950	2.957	130	½	1.669
—	—	2.960	220	1	1.636
—	—	2.937	002	2	1.579
½	2.818	2.823	031		
—	—	2.810	012		
9	2.642	2.641	131		
		2.643	221		
		2.631	112		

Chemistry. Preliminary spectrographic analysis of a tiny sample showed only Bi, Pb, V, and Cu as major constituents and no trace elements worthy of analysis. Results of wet chemical analysis on three samples of 1318, 322, and 869 μg are given in Table II. Water was determined (and seen) by Penfield method on 127 μg.

Duhamelite is soluble in cold, dilute HCl or HNO_3, not in water. It fuses readily to a syrupy black slag.

TABLE II. *Chemical analysis of duhamelite*

	1	2	3
CuO	20.4%	0.256	20.8%
PbO	28.4	0.127	29.1
Bi_2O_3	15.9	0.034	15.2
V_2O_5	23.1	0.127	23.7
H_2O	11.8	0.655	11.2
Total	99.6		100.0

1. Average of 3 determinations
2. Ratios
3. Theory for $Cu_4Pb_2Bi(VO_4)_4(OH)_3 \cdot 8H_2O$

Additional comments. Duhamelite does not appear to be similar to other known vanadates, and confusion with older or ill-defined species seems unlikely.

I am grateful to J. E. DuHamel (geologist for Phelps Dodge Corp.) for his enthusiastic support of this project. The mineral is named in his honour as the discoverer. BaSaw Khin brought the mineral to my attention. Marjorie Duggan performed her usual impeccable chemical work on such minute samples.

Although a number of specimens were found (about a dozen), they represent only a few tens of milligrams of mineral. Type specimens will be provided for the British Museum (NH) and the Geological Museum, University of Arizona.

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