Benavidesite $Pb_4(Mn,Fe)Sb_6S_{14}$

Crystal Data: Monoclinic. *Point Group:* $2/m$. As acicular crystals, to 200 μm long, or rounded grains, to 50 μm. *Twinning:* Polysynthetic twinning is common parallel to crystal elongation.

Physical Properties: Hardness = n.d. VHN = 77–116 (15 g load). D(meas.) = n.d. D(calc.) = 5.60

Optical Properties: Opaque. *Color:* Lead-gray; white with a greenish tint under reflected light, with rare dull red internal reflections. *Streak:* Dark gray with a brownish tint. *Luster:* Metallic. *Pleochroism:* Weak. *Anisotropism:* Strong, with tints of brown and blue. R_1–R_2: (400) 40.7–42.0, (420) 39.6–42.0, (440) 39.3–42.0, (460) 39.5–42.4, (480) 39.9–43.0, (500) 39.7–42.9, (520) 39.5–42.7, (540) 39.0–42.4, (560) 38.9–42.2, (580) 38.7–41.8, (600) 38.3–41.3, (620) 37.9–40.8, (640) 37.5–40.9, (660) 36.8–39.5, (680) 36.1–38.7, (700) 35.6–37.8

Cell Data: *Space Group:* $P2_1/a$. $a = 15.74$ $b = 19.14$ $c = 4.06$ $\beta = 91.50°$ $Z = 2$

X-ray Powder Pattern: Uchuc-Chacua deposit, Peru.
3.45 (100), 2.829 (40), 4.10 (30), 2.737 (30), 3.85 (20), 3.169 (20), 3.098 (20)

Chemistry:

	(1)	(2)
Pb	39.9	39.9
Cu		0.1
Zn		0.1
Mn	2.2	1.8
Fe	0.8	1.1
Sb	34.8	33.0
Bi		2.6
S	21.1	21.7
Total	98.8	100.3

(1) Uchuc-Chacua deposit, Peru; by electron microprobe, corresponding to $Pb_{4.06}(Mn_{0.84}Fe_{0.30})_{\Sigma=1.14}Sb_{6.00}S_{13.80}$. (2) Sätra mine, Sweden; by electron microprobe, average of five analyses, corresponding to $Pb_{4.09}(Mn_{0.69}Fe_{0.42}Cu_{0.03}Zn_{0.03})_{\Sigma=1.17}(Sb_{5.74}Bi_{0.26})_{\Sigma=6.00}S_{14.38}$.

Polymorphism & Series: Forms a series with jamesonite.

Occurrence: In a metamorphosed iron sulfide deposit associated with submarine felsic volcanism (Sätra mine, Sweden); in telescoped polymetallic mineralization associated with dacitic intrusions (Uchuc-Chacua deposit, Peru).

Association: Galena, manganoan sphalerite, pyrite, pyrrhotite, alabandite, uchucchacuaite, quartz, bustamite, rhodonite, calcite (Uchuc-Chacua deposit, Peru); galena, freibergite, gudmundite, manganoan sphalerite, bismuth, spessartine (Sätra mine, Sweden); pyrite, calcite (Dachang district, China).

Distribution: From the Uchuc-Chacua deposit, Cajatambo Province, Peru [TL]. In the Sätra mine, Doverstorp, Bergslagen metallic province, Sweden [TL]. In the Dachang district, Guangxi Autonomous Region, China.

Name: To honor the contributions of Alberto Benavides (1920–), Peruvian mining engineer, to the development of mining in Peru.

Type Material: National School of Mines, Paris, France (Uchuc-Chacua deposit, Peru); Institute of Earth Sciences, Free University of Amsterdam, Amsterdam, The Netherlands (Sätra mine, Sweden).

References: (1) Oudin, E., P. Picot, F. Pillard, Y. Moëlo, E.A.J. Burke, and M.A. Zakrzewski (1982) La bénavidésite, $Pb_4(Mn,Fe)Sb_6S_{14}$, un noveau minéral de la série de la jamesonite. Bull. Minéral., 105, 166–169 (in French with English abs.). (2) (1983) Amer. Mineral., 68, 280 (abs. ref. 1). (3) L.L.Y. Chang, X. Li, and C. Zhang. The jamesonite – benavidesite series. Can. Mineral., 25, 667–672.