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Clinobisvanite, eulytite, and namibite from the Pala pegmatite district, San Diego Co., California, USA

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THE 100 Ma complex LCT-type composite pegmatite-aplite dykes, intruded into various units of the Southern California Batholith, are known to contain bismuth minerals. Jahns and Wright (1951) reported the following primary and secondary bismuth minerals from the quartz-rich cores of a number of dykes in the Pala district, San Diego Co., California: native bismuth, bismuthinite, bismite, bismutite, and beyerite. The Little Three pegmatite-aplite dyke in the Ramona district, contains minor amounts of native bismuth, beyerite, bismite, bismutite, and pucherite (Shigley *et al.*, 1986; Foord *et al.*, 1989). The Himalaya dyke system in the Mesa Grande district contains bismuth, bismutite, pucherite and beyerite. All of these minerals are sparse but characteristic of highly evolved granitic pegmatites.

Additional mineralogical studies in the Pala district indicate that at least three additional bismuth minerals not reported by Jahns and Wright (1951) or Jahns (1979) are present. The occurrence of namibite from Bohemia was recently reported by Mrázek *et al.* (1994). Namibite was reported in 1991 from the Pala district by Foord *et al.* (1991).

All minerals were identified by X-ray diffraction, SEM-EDS analyses and by electron-microprobe analyses. Fine-grained emerald-green namibite intergrown with fine-grained, tan clinobisvanite and beyerite occurs in small pod-like masses in quartz-rich 'pocket-pegmatite' in the White Queen mine on Hiriart Mountain. A total of several tens of grams of

material was recovered. Electron-microprobe analyses of the clinobisvanite and namibite are given in Table 1.

An 0.5 kg mass of red-orange crystalline (individual crystals to several mm long) clinobisvanite and cream-white to tan radiating hemispheres (to several mm) of eulytite, $\text{Bi}_4(\text{SiO}_4)_3$, and associated albite occurring in quartz-rich core-zone pegmatite was found in the Elizabeth "R" mine on Chief Mountain. While eulytite is known to be cubic, and occurring in hextetrahedral crystals, the radiating and semi-globular aggregate habit agrees perfectly with that of material from both Schneeberg and

TABLE 1. Electron-microprobe analyses for clinobisvanite and namibite from the White Queen mine

	Clinobisvanite (ave. of five analyses)	Namibite (ave. of five analyses)
V ₂ O ₅	27.0	14.1
CuO	—	12.5
Bi ₂ O ₃	72.0	71.9
CaO	0.9**	0.1
H ₂ O	—	1.4*
Total	99.9	100.0

* —by difference. ** — minor beyerite contaminant.

Johanngeorgenstadt, Saxony (Frondel, 1943). Small amounts of namibite with associated chrysocolla and pseudomalachite also were found in quartz-rich pegmatite in the Stewart mine on Tourmaline Queen Mountain.

Three polymorphs of BiVO_4 are known: clinobisvanite (monoclinic), pucherite (orthorhombic), and dreyerite (tetragonal). Only the first two have been found thus far in San Diego Co.

Empirical formulae for the two minerals are as follows: (using 4 oxygen atoms for clinobisvanite and 7 oxygen atoms for namibite) $\text{Bi}_{1.01}\text{V}_{0.97}\text{O}_4$ and $\text{Cu}_{1.01}(\text{BiO})_{1.99}\text{V}_{1.00}\text{O}_4(\text{OH})_{1.00}$ respectively. Electron-microprobe analyses were not made of the eulytite from the Elizabeth R mine. The revised formula for namibite proposed by Mrázek *et al.* (1994) is supported by the analytical data for the White Queen namibite. Water determination for the namibite was not possible because of the intimate intergrowth with clinobisvanite and beyerite. Eulytite is new to the State of California and probably represents a new mineral for the United States. Namibite has now been identified from about 11 different world-wide localities.

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