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[Manuscript received 25 September 1969]

MINERALOGICAL MAGAZINE, DECEMBER 1970, VOL. 37, NO. 292

Schulzenite, cuprian heterogenite, from Mina Pabellón, Copiapó, Chile

NATURALLY-occurring cobaltic hydroxide, heterogenite (Frenzel, 1872; Hey, 1962), may evidently accept extensive solid solution of copper (Hey, 1962). Cuprian heterogenite was first described by Martens (1895) from a poorly defined locality, probably northern Chile, and was named schulzenite. Hey (1962) presented a chemical analysis of a specimen from Chile, perhaps with the same provenance as the material studied by Martens, and concluded that the high copper content (CuO 14.5 wt %) was 'essential'. The purpose of this note is to report an occurrence of cuprian heterogenite in northern Chile, and possibly from the source of the type schulzenite.

Cobalt ores have been worked (Hornkohl, 1942; Ruiz, 1965) to a very limited extent from shallow shafts in the immediate vicinity of the settlement of Pabellón, in the valley of the Río Copiapó, Atacama Province (~ Lat. 27° 39.5' S.; Long. 70° 14.9' W.). The hypogene ores of the Mina Pabellón comprised 'smaltite-chloanthite' and 'safflorite-rammelsbergite' (Hornkohl, 1942), in association with pyrite, chalcopyrite, magnetite, hematite, tourmaline, and quartz. The veins, possibly of Lower Tertiary age (Sillitoe, Mortimer, and Clark, 1968), are exposed on a bedrock island projecting through the thick, polyphase alluvial fill of the Río Copiapó cañon. Upper Miocene and subsequent drainage incision has here removed any pre-existing massive supergene sulphide ores, but superficial oxidation has occurred at least since the exhumation of the mineralized zone from its mantle of aggradation.

A single specimen collected from the small dump of the shaft to the west of the *rió* exhibits anhedral grains of skutterudite enclosed in quartz, and cross-cut by numerous hair-line veinlets of chalcopyrite. The surface of the specimen is irregularly coated by a fine-grained, black to bluish-black powder, at first assumed to consist of 'sooty chalcocite', a friable aggregate of one or more copper sulphides formed in the latest,

continuing episode of supergene sulphide enrichment in this area (Sillitoe, Mortimer, and Clark, 1968). However, X-ray examination of two carefully separated fractions of the powder, using a Nonius Guinier-de Wolff quadruple-focusing camera, revealed a distinct powder pattern, which closely corresponds to that found for heterogenite from Katanga by Hey (1962). The majority of the reflections were rather diffuse (cf. Hey, 1962), but their relative intensities and angular spacings are in good agreement, up to $d \simeq 1.50 \text{ \AA}$, with those tabulated by Hey (in the second case, to the first decimal place). No additional lines (e.g. those of malachite, goethite, or erythrite, each a possible contaminant) were observed.

Qualitative X-ray fluorescence and electron microprobe analysis of this mineral demonstrated the presence of major cobalt and copper, and minor amounts of iron ($\leq 1.5 \%$ Fe_2O_3); no other elements (e.g. As) were detected. The cobalt and copper are irregularly and strongly zoned, and display a consistent antipathetic distribution. This zonation is paralleled by variations in the optical properties of the mineral in reflected light; increasing copper:cobalt ratios result in a diminished white light reflectivity (estimated) and a weaker bireflectance. In general, the mineral forms radial clumps of acicular crystals, similar to the 'colloform stainierite' described by Cooke and Doan (1935).

Semi-quantitative estimation indicates that the Co_2O_3 :CuO weight ratio of the heterogenite ranges from 100:1 to at least 1:0.8, but wavelength scanning suggests an approximate bulk composition close to that determined by Hey (1962; Co_2O_3 :CuO = 72.3:14.5) for schulzenite (spec. no. B.M. 87097) from 'Chile'. No additional cobalt- or copper-bearing minerals were observed in impregnated mounts of the sooty coatings, and Hey's conclusion that heterogenite tolerates extensive solid solution of copper is confirmed.

The name schulzenite may usefully be retained for intermediate members of the $\text{CoO} \cdot \text{OH}-\text{Cu}(\text{OH})_2$ solid solution series, with between 20 and 80 mol % $\text{CoO} \cdot \text{OH}$. The schulzenite briefly described herein apparently closely resembles that studied by Hey (1962), but there is insufficient evidence that Mina Pabellón is the type-locality for this mineral.

Acknowledgements. Fieldwork in Chile is carried out in co-operation with the Instituto de Investigaciones Geológicas de Chile, and is supported by the National Research Council of Canada.

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 [Manuscript received 16 December 1969]