

MORPHOLOGICAL DATA ON SOME MINERALS FROM THE CLIFF VEIN, KEWEENAW COUNTY, MICHIGAN

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Careful collecting by R. M. Beger and myself at the Cliff mine, Keweenaw County, Michigan, in 1961-62 revealed the presence of many well-crystallized minerals of a quality not previously described from the Keweenaw district. The area examined lies between the Avery shaft and the North Cliff mine, both of which are situated on the Cliff vein.

The Cliff mine is one of the oldest and richest mines in the Keweenaw district and has produced superb specimens of native copper, silver, and

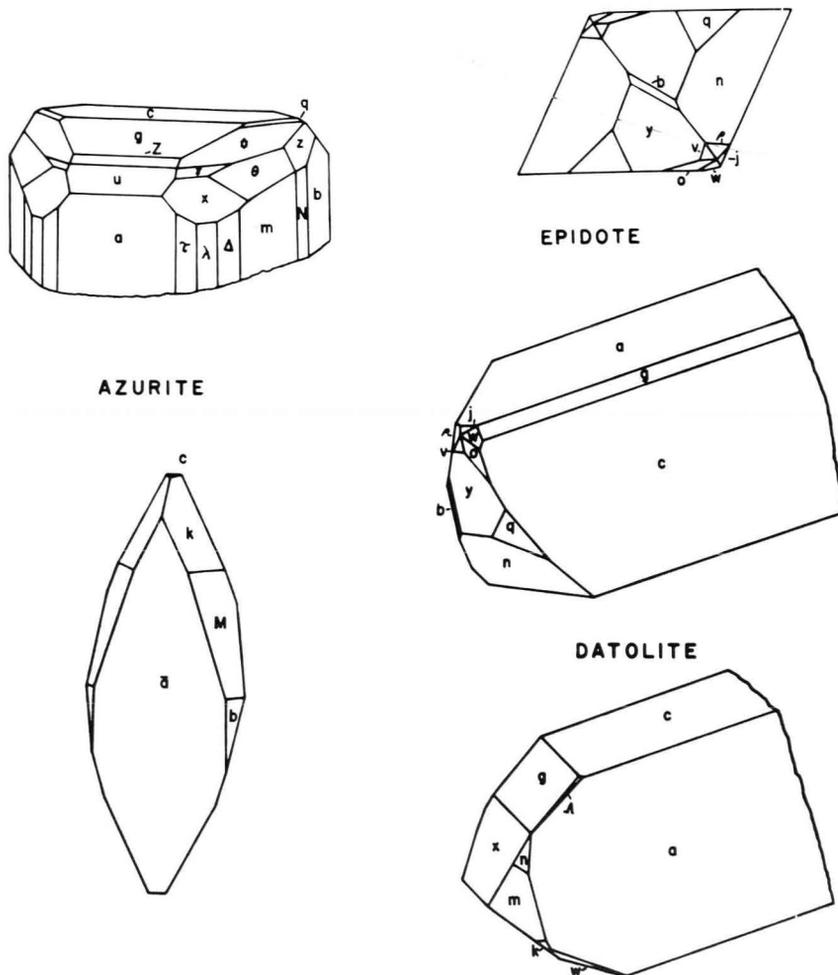


FIGURE 1. Sketches of crystals.

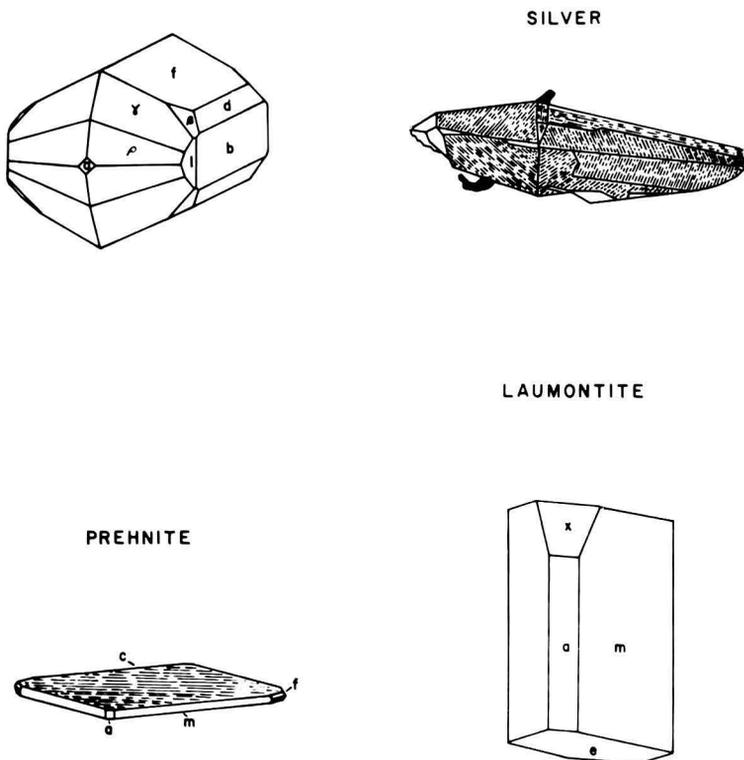


FIGURE 2. Sketches of crystals.

calcite (Palache, 1900). Despite the intense study the district has received, however, few purely descriptive mineralogic papers have appeared. Some of the species found during this study are described below and shown in Figures 1 and 2.

CHALCOCITE

Chalcocite occurs as small, sharp crystals up to 4 mm. in length. Most crystals occur on prehnite and have formed by direct replacement of native copper. The prehnite is replaced by delessite, gypsum, and anhydrite in approximate proportion to the degree of replacement of copper by chalcocite.

Often the chalcocite crystals are oriented on the copper with $[001]$ of chalcocite normal to $\{111\}$ of copper and either $[100]$ or $[010]$ of chalcocite parallel to $[\bar{1}01]$ of the copper. Complex arborescent or dendritic copper crystals are often faithfully preserved by delicate intergrowths of minute chalcocite crystals.

Three crystals were measured and all showed the following forms: $c \{100\}$, $b \{010\}$, $a \{100\}$, $l \{130\}$, $f \{012\}$, $d \{021\}$, $\beta \{113\}$, $y \{323\}$, and $p \{211\}$. The crystals are elongate on $[100]$ and $\{021\}$ and $\{211\}$ are normally

NATIVE SILVER

Native silver occurs as brilliant and unusually sharp, complex crystals perched on prehnite or delessite. Some crystals, such as the one shown in Figure 1, are pierced by copper wire and coated with a thin film of copper near the wire. Crystals associated with chalcocite may be filmed with small, twinned acanthite blades.

One highly distorted silver crystal was measured and showed $\{001\}$, $\{011\}$, $\{111\}$, $\{013\}$, $\{012\}$, $\{047\}$, and $\{344\}$. A sketch of the crystal shows the polysynthetic twinning on $\{111\}$.

NATIVE COPPER

Good copper crystals are abundant everywhere along the vein. The majority of the crystals studied were dominated by $\{124\}$, and modified by $\{001\}$, $\{011\}$, and $\{111\}$. Many distorted crystals are triangular plates on $\{111\}$ bounded by various hexoctahedra.

PREHNITE

Although prehnite is the most abundant gangue mineral, good crystals are exceedingly rare and only the smallest are measurable. A typical crystal selected for study showed $c \{001\}$, $a \{100\}$, $m \{110\}$, and $f \{218\}$. Striations are invariably present on $\{001\}$ parallel to $[010]$.

DATOLITE

Well-crystallized datolite is found in abundance at the North Cliff mine and in numerous test pits to the south (Osann, 1895). In places the vein is several feet thick and composed almost exclusively of datolite. Colorless, limpid crystals of complex habit are commonly associated with prehnite, apophyllite, analcime, and laumontite. Study of three crystals of diverse habit revealed that all had the same forms; these are $c \{001\}$, $a \{100\}$, $m \{110\}$, $g \{012\}$, $x \{011\}$, $\Delta \{112\}$, $k \{\bar{3}32\}$, $n \{321\}$, and $w \{\bar{3}12\}$.

HEMATITE

Hematite occurs sparingly at the Avery shaft as small, thin tablets which are blood red by transmitted light. The only forms detected are $c \{0001\}$, $m \{10\bar{1}0\}$, and $r \{10\bar{1}1\}$.

BARITE

Barite crystals of unusual complexity and beauty are found at the Avery shaft. They are commonly associated with chalcocite and hematite as encrustations on prehnite.

One crystal showed the following forms: $c \{001\}$, $b \{010\}$, $a \{100\}$, $N \{230\}$, $m \{110\}$, $\Delta \{430\}$, $\lambda \{210\}$, $\tau \{410\}$, $g \{103\}$, $Z \{203\}$, $u \{101\}$, $z \{111\}$, $q \{214\}$, $o \{213\}$, $\gamma \{212\}$, $\theta \{856\}$, and $x \{211\}$.

Superb epidote crystals up to 25 mm. long occur in vesicles with calcite. The crystals show pleochroism to the unaided eye and a few exhibit epoptic houpes. Smaller but equally unusual crystals line vesicles with pumpellyite. One crystal leached from calcite showed $c \{001\}$, $b \{010\}$, $a \{100\}$, $o \{011\}$, $g \{301\}$, $v \{332\}$, $p \{113\}$, $n \{111\}$, $j \{315\}$, $w \{612\}$, $q \{313\}$, and $y \{211\}$. The crystal is elongate on $[010]$ and dominated by $\{001\}$, $\{100\}$, $\{111\}$, and $\{211\}$.

LAUMONTITE

Laumontite is found everywhere along the vein but is generally weathered. A few fresh crystals were found in a vug with silver and prehnite. These showed a $\{100\}$, $m \{110\}$, $x \{301\}$, and $e \{201\}$. Cleavage is good on $\{110\}$.

AZURITE

Azurite is a rare mineral in the district (paratacamite is probably the most common supergene copper mineral) but was found in abundance in one pit near the North Cliff mine. The crystals occur in veinlets at the border of cuprite nodules filled with copper and silver. Vermicular malachite crystals often coat the azurite.

Most azurite crystals are distorted due to mutual interference and measurable crystals were found with difficulty. Three crystals showed the following forms: $c \{001\}$, $a \{100\}$, $w \{120\}$, $\{470\}$, $\{340\}$, $m \{110\}$, $l \{013\}$, $f \{012\}$, $\emptyset \{101\}$, $v \{101\}$, $\gamma \{302\}$, $h \{111\}$, $\{332\}$, $k \{111\}$, and $M \{332\}$. The crystal figured is shown in an unorthodox orientation to show the habit better.

CUPRITE

Cuprite occurs abundantly with azurite as massive lumps cemented by copper or occasionally silver. A few pockets lined with excellent crystals were found. Generally the crystals are bounded by $\{001\}$, $\{011\}$, and $\{111\}$ of roughly equal size. Some crystals, however, exhibit gyroidal symmetry very nicely with $\{321\}$ left, and when $\{321\}$ left occurs $\{211\}$ is an important form.

PARAGENESIS

The paragenetic sequence is typical of that for the entire district and is: pumpellyite (or chlorastrolite or both) first-epidote-prehnite-copper-silver-apophyllite-laumontite last. Somewhat unusual, however, is the appearance of sulfur in the system. The normal sequence was interrupted after the crystallization of silver by introduction of sulfide and excess water. First, copper was replaced by chalcocite while prehnite was simultaneously

replaced by hydrous silicates and sulfates. Barite and hematite marked the end of the sequence of sulfides-sulfates and the normal sequence was resumed with apophyllite.

Similar mineralogy is found near Painesdale farther south, and in both places hematite, not pyrite, is the only iron mineral to form.

ACKNOWLEDGMENTS

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