

## MINERALOGICAL STUDY OF MALCHITE AND AZURITE FROM THE BELOVODE LOCALITY (VELIKO LAOLE)

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Five samples from the archaeological site of Belovode near Veliko Laole were mineralogically studied : three amorphous pieces of green, blue and brown colour, green pendant and green bead. Amorphous pieces were ground to fine powder, while worked objects (pendant and bead) were analyzed without any treatment (they were fastened on sample holder). It was used diffractometer Philips PW 1710 with copper radiation for identification of samples.

The amorphous (unworked) piece of green colour consists of malachite with admixtures of tenorite and calumetite (fig. 1). According to the intensity of reflections' malachite is a dominant compound.

The unworked piece of blue colour is of concentric structure and it contains mostly azurite. Malachite and probably tenorite were less abundant compounds (fig. 2).

The amorphous piece of brown colour resembling to thermal treated material, consists of tenorite, malachite and kolwezite (?) (fig. 3).

X-ray diffraction study of worked pieces of green colour has shown that they contain malachite as a dominant compound and small amounts of tenorite and perhaps kolwezite (fig. 4 and 5).

Malachite,  $\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$ , contains 59,3 % copper and occurs in nature in dish-shaped, spheroidal, botryoidal and other aggregates, as well as in films and incrustations. It appears in the surface parts of sulfide copper deposits where is formed by alteration of copper sulfides. Azurite,  $2\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$ , contains somewhat less copper than malachite (55,3 %), and it occurs in nature in spherical, radially divergent and

earthy aggregates, as well as in films and incrustations, but rarely in crystals. It is usually formed as malachite, but it is rarely in crystals. It is usually formed as malachite, but is rarely mineral than malachite. Azurite gradually transforms to malachite in time. Tenorite,  $\text{CuO}$ , is characterized by black or grey colour an by earthy or massive structure. It is also formed by alteration of copper sulfide minerals, but never in great amount. Calumetite and kolwezite are secondary copper minerals that sporadically occur in the surface parts of copper mineralizations and frequently associated with malachite and azurite.

In Serbia malachite is found at Bor, Majdanpek, Beliki Krivelj and Mali Krivelj, as well as in the other places in the Timok eruptive massif (eastern Serbia). It is also uncovered in red sandstones of eastern Serbia (Kablar Mountain) in diabase-chert formation. Azurite usually occurs with malachite at the abovementioned places, but it is less abundant mineral than malachite.

According to mineral compositions of unworked and worked pieces from the Belovode locality it may be concluded that mineral associations found in analyzed samples are common natural associations of secondary copper minerals. These minerals often occur in the surface parts of copper sulfide deposits in Serbia. By X-ray diffraction there were not established minerals which could be the products of thermal treatment of copper minerals (malachite and azurite).

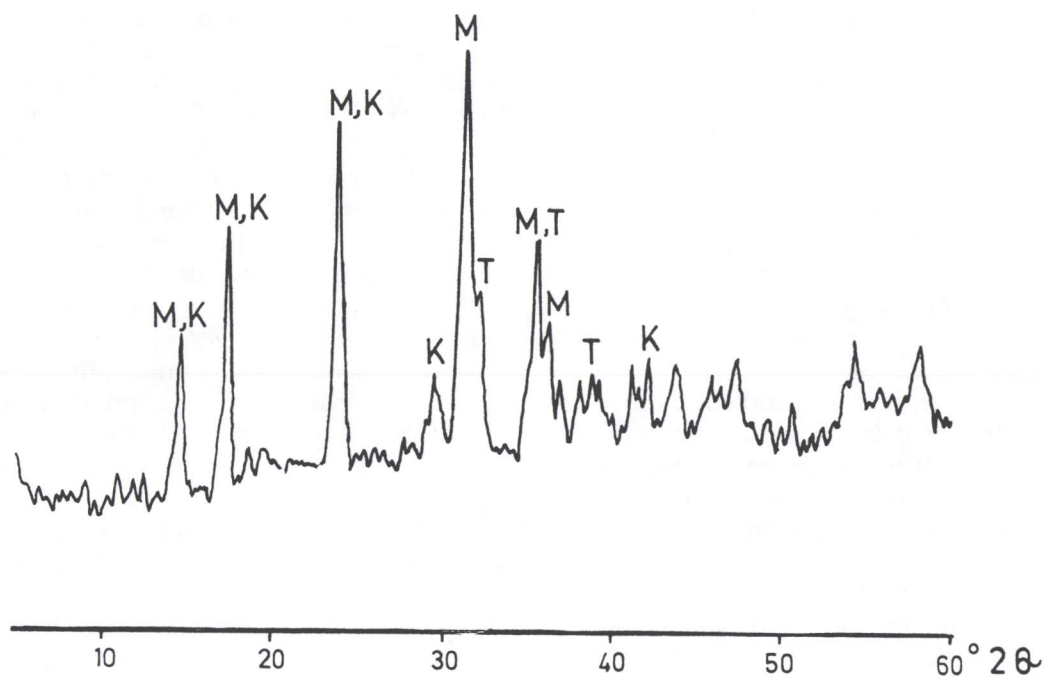


Fig. 1 : X-ray diffraction pattern for unworked green piece from Belovode.  
M - Malachite; T - tenorite; K - calumetite

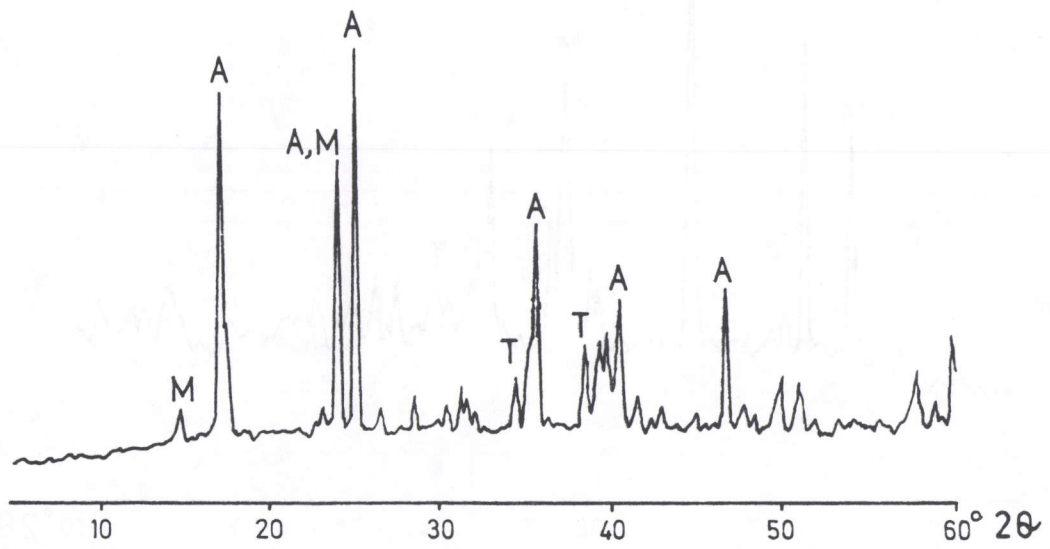


Fig. 2 : X-ray diffraction pattern for unworked green piece from Belovode.  
A - azurite; M - malachite; T - tenorite

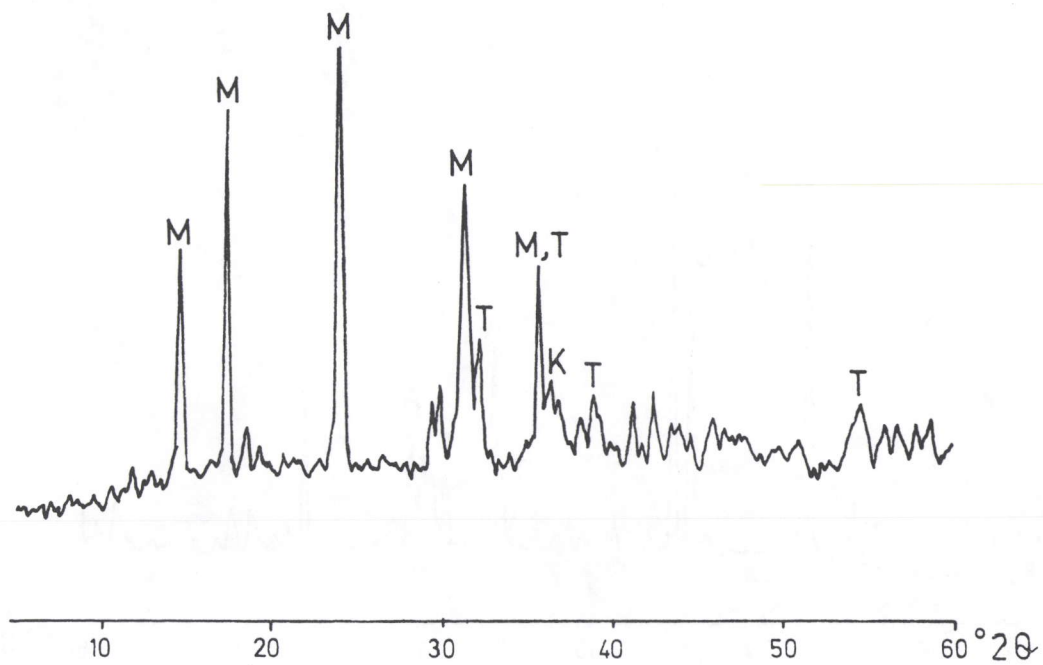


Fig. 3 : X-ray diffraction pattern for unworked brown piece from Belovode.  
T - tenorite; M - malachite; K - kolwezite

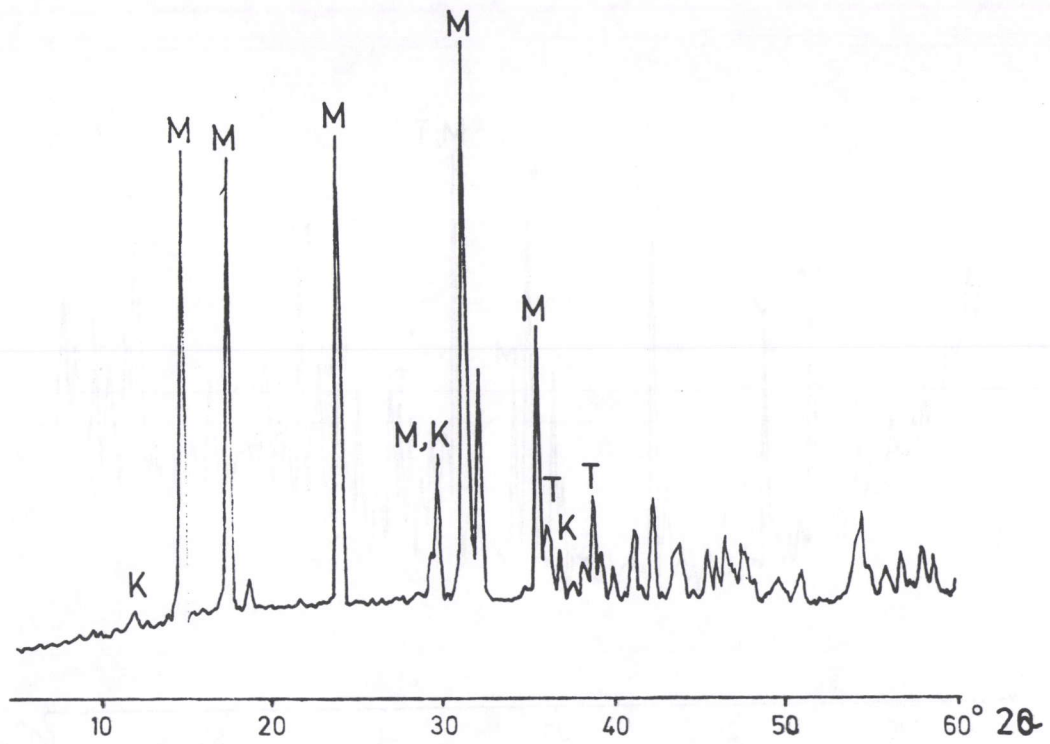


Fig. 4 : X-ray diffraction pattern for green pendant from Belovode.  
M - malachite; T - tenorite; K - kolwezite

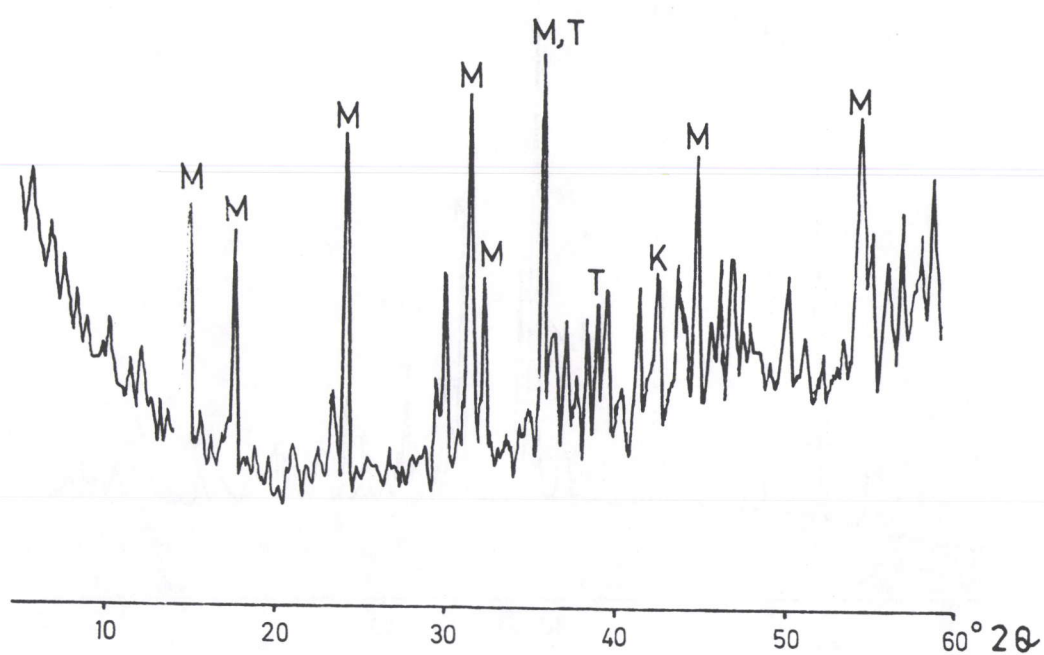


Fig. 5 : X-ray diffraction pattern for green bead from Belovode.  
M - malachite; T - tenorite; K - kolwezite