

45. **Cerussite** trilling on **malachite**.
FOV: 1.8 cm. **Zone 3**, level +235 m.
Specimen and photo: Maria D. Milshina.



crusts (up to 2–3 cm in size), where it is intimately intergrown with various arsenates and phosphates. In one specimen from **Zone 3**, we found a trilling of 1.5 cm in size on malachite (*Fig. 45*).

The mineral was identified by its chemical composition (only Pb in the cation part) and the SCXRD data (*Table 4, no. 2*).

Sulfates and Molybdates

The geochemical environment representative of the Phosphatno-Arsenatnaya vein did not facilitate the formation or preservation of sulfates. This was probably caused prolonged interaction of hydrocarbonate water with the oxidation zone. Here, CO₂ may have been sourced from limestone of host sediments followed by arsenate, phosphate, chromate and vanadate ions' entrance in supergene solutions that resulted in dissolution and/or replacement of preexisting sulfates and the formation of supergene minerals of other classes. The almost total absence of copper sulfates in the oxidized ores of the vein (in which Cu is one of the main "ore" elements of the system) is observed along with abundant secondary copper sulfides, phosphates and arsenates. The extremely low pyrite content in the vein also did not facilitate deposition of sulfates. In addition to rare anglesite and relict baryte, some species of the alunite supergroup with species-defining anion group (SO₄)²⁻, were identified in the oxidized ores. These species, along with other members of this supergroup, are described in the next chapter devoted to arsenate, phosphate, and vanadate classes. Chromates, molybdates, and tellurates with the phosphate or arsenate anion groups are reported in that chapter too.

Anglesite, PbSO₄ was observed in specimens from **Zone 1** (level+248 m), where it replaces galena and aikinite as thin veinlets (up to 0.1 mm long) and is associated with bismoclite, tetradymite, chalcocite and chalcopyrite.



46. Bright-orange **wulfenite** crystals on yellow **beudantite**. FOV: 0.2 cm. **Zone 2**, level +243 m.
Specimen: Anatoly V. Kasatkin.
Photo: Maria D. Milshina.

47. Bright-orange, tabular **wulfenite** crystal. FOV: 0.1 cm. **Zone 3**, level +235 m.
Specimen: Anatoly V. Kasatkin.
Photo: Maria D. Milshina.



The chemical composition of the mineral corresponds to the ideal formula PbSO₄.

Baryte, BaSO₄ is one of the major gangue minerals of many orebodies in the Murzinskoe deposit, but in the oxidized ores of the Phosphatno-Arsenatnaya vein it is very uncommon. Baryte grains (up to 0.1 mm in size) are observed in the gossan of **Zone 1** (where it is possibly supergene), baryte is also observed in quartz-limonite aggregates of **Zones 2** and **3**.

Wulfenite, PbMoO₄ is the only molybdate without additional anions that was identified in the oxidized ores of the vein. In the specimens from level +243 m, it is observed as crusts of fine grained (<0.1 mm in size) bright orange crystals with adamantine luster (*Fig. 46*) on yellow powdery beudantite and quartz in association with As-bearing corkite, malachite, pyromorphite, segnitite, chalcocite, and cerussite. This wulfenite contains (wt.%) PbO 60.52, MoO₃ 38.97, total 99.49, that corresponds to ideal formula PbMoO₄. In the ores at level +245 m, wulfenite occurs as orange grains (up to 0.1 mm in size) and replaces beudantite associated with arsenates (bayldonite, gartrellite, duftite), phosphates (pyromorphite, fluorpyromorphite, phosphohedyphane), acanthite, arsenopyrite, baryte, and kuzminite. In **Zone 3** (level +235 m), wulfenite is more frequent and larger. Bright orange tabular crystals (up to 0.5 mm in size) are observed overgrowing beudantite, vauquelinite, mimetite, pyromorphite, segnitite and other minerals (*Fig. 47*). Chemically, wulfenite from the chromate-vanadate association contains minor As and Te. It contains (wt.%) PbO 60.80, As₂O₅ 1.96, MoO₃ 35.95, TeO₃ 1.38, total 100.09., this composition corresponds to the empirical formula (calculated on the basis of 4 O atoms) Pb_{1.00}(Mo_{0.92}As_{0.06}Te_{0.03})_{Σ1.01}O₄.

Wulfenite is one of the latest supergene minerals of the Phosphatno-Arsenatnaya vein.