

Arsenates, Phosphates, Vanadates (including those with other anion groups)

Minerals of these classes in the described vein are undoubtedly of major interest. They are the most diverse in regard to the number of species and chemical composition. These minerals are abundant and many specimens are of high collection quality. Therefore, it is not surprising that the name of both the whole vein and individual mineral associations was based on these minerals.

Minerals of the adelite-descloizite group

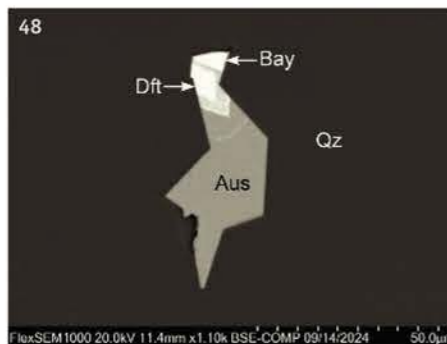
At present, the adelite-descloizite group consists of 15 species that crystallize in the orthorhombic system, mainly arsenates (7) and vanadates (6), as well as one phosphate and one silicate. The idealized general formula of this group is $M1^{2+}M2^{2+,3+}(T^{4+,5+}O_4)(OH)$, where $M1 = Ca, Pb$; $M2 = Mg, Mn^{2+}, Fe^{2+}, Co^{2+}, Ni^{2+}, Cu, Zn, Al$; $T = Si, P, V, As$ (Effenberger, 2002; Đorđević *et al.*, 2016). In the oxidized ores of the Phosphatno-Arsenatnaya vein, we identified five members of this group (i.e., one third of all existing group members): austinite, descloizite, duftite, conicalcite, and mottramite. Duftite and mottramite were found in the samples of high collection quality. The minerals were identified on the basis of EMPA (Table 5) and XRD (Table 4) data.

Austinite, $CaZn(AsO_4)(OH)$ was observed in **Zone 3** (level +235 m) and occurs as subhedral grains ($>40 \mu m$ in size) in quartz, these grains are observed as isolated and intergrown with duftite and bayldonite (Fig. 48). Vauquelinite, wulfenite, gartrellite, goethite, hidalgoite, iodargyrite, corkite, malachite, mimetite, mottramite, pyromorphite, tennantite-(Fe), tennantite-(Zn), philipsbornite, florencite-(Ce), phosphohedyphane, cerussite, and yancowinaitite are also observed in this association. Compositionally, this mineral is close to the endmember; only minor Pb and Cu were detected (Table 5, anal. 1). Although austinite is common in the oxidation zone of many polymetallic deposits around the world (more than 70 localities of this arsenate from 20 countries are known, according to mindat.org), it has been described only once before in Russia – at the Khovu-Aksy deposit in Tuva (Yakhontova, 1971).

Therefore, this is likely the second finding of austinite in the territory of the Russian Federation.

Descloizite, $PbZn(VO_4)(OH)$ was observed during EMPA of a sample from **Zone 3** as anhedral grains (up to $20 \mu m$ in size) in goethite and quartz associated with copper and malachite. Apart from the much more common mottramite, descloizite is the only vanadate that was identified at the Murzinskoe deposit. Other adelite group members were also found in this sample. Goethite contains abundant inclusions (up to $50 \mu m$ in size) of duftite–mottramite series

48. Intergrowth of austinite (Aus), duftite (Dft), and bayldonite (Bay) in quartz (Qz). **Zone 3**, level +235 m. SEM/BSE image: Anatoly V. Kasatkin.



51. Dark green, bipyramidal duftite crystals in powdery limonite. FOV: 0.2 cm. **Zone 2**, level +245 m. Specimen: Anatoly V. Kasatkin. Photo: Maria D. Milshina.



52. Cluster of duftite crystals on goethite. FOV: 0.3 cm. **Zone 2**, level +245 m. Specimen and photo: Maria D. Milshina.