



Tracing the mobilization of toxic metals from the tailings of the Lojane Sb-As-Cr mine, Macedonia

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At the abandoned Lojane Sb-As-Cr mine (Macedonia) an unprotected dump of very As-rich flotation tailings has been subjected to weathering processes for at least 40 years. Chemical and mineralogical analyses of tailings samples show that they are mostly composed of fine-grained realgar, quartz, and gypsum, followed by stibnite, pararealgar, sulfur, scorodite, compositionally variable Fe-As-Sb-Ca-(Ni)-O(OH) phases belonging to the roméite-group minerals (RGM), and relic (magnesian)chromite.

The weathering of primary sulfides proceeded under mostly oxidizing, acidic, and temporarily wet conditions. Highly acidic conditions on the surface of the tailings dump imply dissolution of arsenolite and scorodite, thus causing contamination of the environment and high mobility of arsenic. This assumption is supported by reported high arsenic soil and groundwater concentrations determined in close proximity to the tailings.

The oxidation of primary sulfides releases significant amounts of potentially toxic elements, mostly Sb, As, and Ni, which are hosted differently in these oxidation products. The concentration of arsenic is the highest in arsenolite, scorodite, and amorphous to poorly crystalline RGM. However, minor amounts of arsenic are also present in gypsum, sulfur, and pickeringite, which is explained by the abundance of realgar in the tailings and the consequently As(V)-rich weathering solutions percolating through the porous tailings material. This observation shows that migration of As into the environment may also depend on the role of secondary sulfates in the tailings. Dissolved antimony, released by oxidative weathering of stibnite, mostly enters nano-crystalline Fe(III)-rich roméite-group phases. At Lojane, antimony is less mobile compared to As. The mobilization of nickel during oxidation of primary Ni-bearing minerals (vaesite, Ni-bearing pyrite, gersdorffite) is reflected in the appearance of minor secondary annabergite, and Ni-bearing RGM (with up to 3.8 at.% of Ni). Grains of chromite and magnesiochromite are unaffected by weathering processes.

Considering the only minor presence of pyrite in the Lojane mineralization, and the pH-buffering host rocks (mainly silicified serpentinite) as well as carbonate gangue that produce neutral to slightly alkaline local waters, it is likely that As and partly Sb stay in the solution and can be transported to greater distances. The remediation of this environmental hot-spot stays unresolved due to the local socio-political tensions.

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