

Peculiarities of the initial and secondary distribution of elements in the tailing body

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A man is the most important factor of the modern surface geochemical processes. He modifies the history of metals and forms new compositions. These compositions interact with the environment. A new geological process is developing, and the result of its evolution is unknown for us (Vernadsky V.I.). The first major problem facing the geologists is the study of this process and the prediction of its far-reaching consequences. Here we present peculiarities of the initial distribution and secondary redistribution of toxic elements (Sb, As) in the tailing body, where an oxidation zone is formed under an impact of residual cyanide solutions.

The Komsomolsky tailing impoundment was filled by wastes of gold-arsenopyrite-quartz ores and the Kadamzhay antimony sludge (8.6% Sb) without preliminary neutralization of solutions. The mineral composition of ores is simple. The sulphide minerals are pyrite, pyrrhotite, arsenopyrite, galena, chalcopyrite, and sphalerite. In addition, magnetite and ilmenite present here. Gangue minerals are presented by quartz, feldspar, mica and calcite. The initial phases of antimony are Si-Sb-Fe and Sb-S-O compounds, oxides and "native" antimony (98 wt.% of Sb). The share of the sludge is not higher than 1 %, however, the tailings material is significantly enriched by Sb (0.1%). The unique high concentration of soluble Sb is established in the technogenic lake (up to 3600 µg/l) and in underground waters (5500 µg/l) (Bortnikova, 1998).

Methods of investigations

The Komsomolsky tailing impoundment was sampled by the lateral and vertical profiles. Contents of metals were determined by the X-ray-fluorescent analysis. Polished sections were fabricated from heavy concentrates, most interesting structural elements of tailing body, and material of the Kadamzhay sludge. Compositions of minerals and phases were studied with the help of electron

microscope and microprobe analyses. Identification of the secondary minerals by the X-ray diffraction method is difficult because amounts and sizes of their separations are very small. Therefore, we will use the term 'mineral' in relation to only euhedral forms of secondary compounds.

Results

The tailing body has the lateral and vertical heterogeneity formed as a result of gravitational differentiation of the material during the tailing impoundment filling. Heavy and most coarse-grained fractions (for this object the latter is 0.1–0.16 mm) enrich the sites adjacent to the pipeline. Contents of the heavy fraction represent about 5% here (the average is less than 1%). The surface distribution of metals confirms the mineralogical observations. The data processing of analyses establishes the correlation between elements of heavy concentrate minerals, namely, Fe, Ti, As, Zn and Cd. The separate correlation pair is Sb and Pb. Increased contents of Sb and Pb are determined in the sites removed from the pipeline and/or consisted of the fine-grained material with the large amount of mica. The light fractions are enriched by Sb and Pb, mainly in the form of initial Si-Sb-Fe phase (Table 1). Antimony and lead sorption by aluminosilicates is assumed to provide their accumulation here.

The closer examination of the tailings body constitution shows that lenses of heavy concentrate which mainly consists of pyrite, magnetite, and

TABLE 1. Composition of Si-Sb-Fe phases (wt.%)

| K | Ca | As | Al | Si | Sb | Pb | Fe |
|------|------|-------|------|-------|------|------|------|
| 1.08 | 1.59 | 0.098 | 3.67 | 15.45 | 11.6 | 1.90 | 6.83 |
| 0.52 | 3.22 | 0.906 | 3.09 | 9.33 | 20.4 | 1.34 | 7.00 |

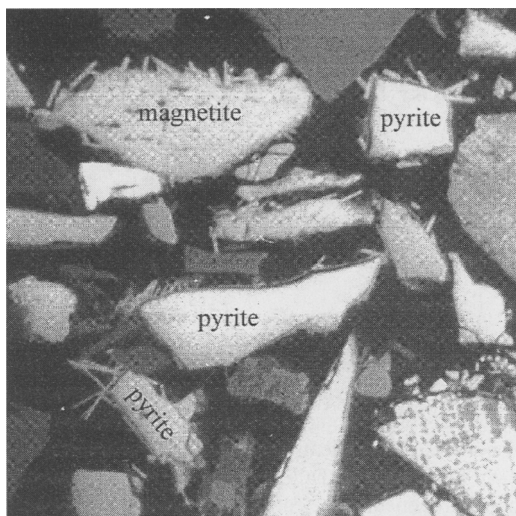


FIG. 1. Mineral X is formed on the surface of the Fe-minerals. Electron microscope photo (compo). Scale bar is 0.2 mm across.

arsenopyrite, are located in the coarse-grained quartz sand. Oxidation processes are active here. The microscopic examination of the mineral phases revealed the following general order of alteration susceptibility: Sb oxides > galena > pyrrhotite > pyrite > arsenopyrite > sphalerite, in accordance with the experimental investigation of Rimstidt (1994). Sulphides are 'fresh' in the sites, where they compose less than 1%. On the basis of the degree of sulphide oxidation and associations of secondary minerals, we distinguish four zones (from the centre to the periphery of lenses).

(1) The primary sulphides are 'fresh' and cemented by the metacrystals of gypsum.

(2) Oxidation of sulphides is insignificant. Thin alteration rims over arsenopyrite and pyrite are observed. There are pseudomorphs of iron (oxy)hydroxides over pyrrhotite. Specula crystals of the Fe-Sb mineral X are formed on the surface of Fe-minerals, namely, pyrite, magnetite, and arsenopyrite (Fig. 1). Different Al-Si secondary minerals are formed in the intergrains space together with the mineral X, phase Y, and abundant iron hydroxides.

(3) Sulphides have broad alteration rims of secondary minerals. Pyrrhotite is substituted by iron (oxy)hydroxides as it was described before. Pyrite has the alteration rims of iron (oxy)hydroxides. Arsenopyrite is surrounded by rims of the phase described by Canadian investigators as Fe-Ca arsenate hydrate (Paktunc, 1998), but in our case this phase has an admixture of S, Sb, and Pb;

(4) Zonal iron (oxy)hydroxides are formed around grains of sulphides and gangue minerals.

The most abundant secondary phase is iron hydroxides. They have admixtures of Sb, As, Pb, Zn, and S. Despite the concentration of Sb in underground water is one order higher than that of As (500 µg/l), content of Sb in iron (oxy)hydroxides is similar to that of As. Consequently, the sorption degree of arsenic is higher than that of antimony. This observation confirms the study of Bowell and Bruce (1995). Finally, the oxidation zonality of gravitational lenses differs from zonality known for the natural oxidation zone (Jakhontova, 1987). The zone of mineral X develops on the place of jarosite zone.

Conclusions

The initial distribution of material in the tailing body depends on its gravitational differentiation during the filling of tailing impoundment. Secondary redistribution of metals is determined by peculiarities of physical-chemical conditions in tailings.

The general order of alteration susceptibility of mineral phases is as follows: Sb oxides > galena > pyrrhotite > pyrite > arsenopyrite > sphalerite.

Fe-Sb mineral X was determined as the main secondary antimony mineral, formed in the zones of gravitational enrichment under the action of oxidizing factors.

Simultaneously with formation of As and Sb minerals and phases, the sorption of iron (oxy)hydroxides plays a significant role in the process of precipitation of As and Sb. It is indicated by their high concentrations in iron hydroxides (up to 2.0 and 2.90%, correspondingly).

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