

Secondary minerals and compounds of toxic elements precipitated from drainage water of Berikul sulphide wastes

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The sulphide oxidation in mine wastes leads to formation of acid waters, which pollute environment by heavy metals and arsenic. Partially toxic components remove from solution by deposition of secondary phases. It is that solubility of these phases controls content of dangerous elements in drainage waters. The objective of this work is to characterize minerals and compounds deposited from acid waters inside wastes heaps of Berikul gold extracting plant. During 1942-1962 years 100000 tons of waste material was produced by cyanide leaching of the sulphide flotation concentrate. Initially they contained 30 wt.% pyrite, 10 wt.% arsenopyrite, 5–10 wt.% chalcopyrite, sphalerite and galena. The quantities of acid neutralizing minerals (carbonates and micas) reach up to 10–15%. The tailings stored as heap near the river M. Berikul exposed to the weathering agents to the nova day.

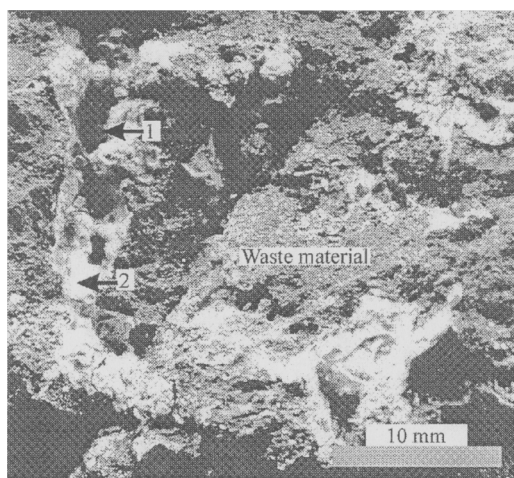


FIG. 1. The cavern fills in by jarosite, gypsum (1) and amorphous substance (2).

Methods

Pore water was pressed under hydrostatic pressure 200 bar from solid samples of weathered Berikul wastes. The concentration of metals and arsenic was detected by atomic adsorption spectrometry using 'Perkin Elmer 3030'. The mineral identification was carried out by electron microscopy, X-ray diffraction and infra-red spectroscopy. The secondary minerals and compounds were analysed by microprobe with the help of 'Camebax-Micro' and X-ray fluorescent method.

Results and discussion

Composition and acidity (pH = 1.1) pore water is caused by the process oxidation of pyrite and arsenopyrite in the Berikul waste heaps. In this solution the concentrations of elements are Fe 22 g/l, As 1 g/l, Cu 100 mg/l, Zn 64 mg/l, Pb 1.1 mg/l and Cd 1.1 mg/l. The presence of caverns in the solid material is an indicator of wastes leaching by acid waters. The caverns fill in by jarosite, gypsum and amorphous substance, which contains Fe 54.69 wt.%, As 21.85 wt.%, Cu 0.24 wt.%, Zn 0.19 wt.%, Pb 0.14 wt.% (Fig. 1). Infra-red spectra of this amorphous material show the presence H-O, As-O

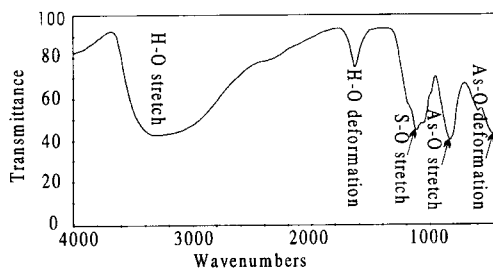


FIG. 2. Infra-red spectra of amorphous material.

TABLE 1. Composition of amorphous compounds and inclusions (wt.%)

	K ₂ O	CaO	As ₂ O ₅	Al ₂ O ₃	PbO	SO ₃	Fe ₂ O ₃	CuO
Amorphous matrix, variety I								
Average content	0.016	0.060	33.032	3.819	1.025	10.762	31.925	0.120
Standard derivation	0.008	0.020	2.605	0.767	0.389	1.570	1.726	0.043
Amorphous matrix, variety II								
Average content	0.152	0.021	18.656	2.915	0.261	12.045	45.890	0.050
Standard derivation	0.136	0.005	0.969	1.390	0.186	1.049	3.339	0.014
Solid inclusions I, anglesite								
Average content	0.174	0.757	9.141	0.616	50.910	16.113	10.825	0.056
Standard derivation	0.006	0.203	1.620	0.232	2.932	0.616	1.253	0.036
Solid inclusions II, voltaite								
Average content	3.973	0.021	7.409	7.415	3.323	18.103	35.510	0.049
Standard derivation	0.418	0.004	0.549	0.555	0.698	0.543	0.309	0.009
Solid inclusions III								
Average content	0.930	0.010	14.364	3.445	10.570	11.530	38.845	0.051
Standard derivation	0.099	0.007	0.673	0.191	1.442	0.028	0.785	0.033
Solid inclusions IV								
Average content	0.109	9.830	27.420	2.205	1.660	18.495	25.200	0.177
Standard derivation	0.001	0.255	0.474	0.049	0.014	0.601	0.580	0.011

and S-O bond (Fig. 2). The two varieties of the amorphous substance were defined on the base of microprobe analyses (Fig. 3). Average atomic ratio Fe:As:S for first group of analyses is 1.3:1:1.8 and for group presenting second variety is 3.3:1:3.5. The small standard derivations of ratios Fe:As (0.1 and 0.3, correspondingly) and Fe:S (0.3 and 0.4) for both group demonstrates that two variety of amorphous substance are separate compounds.

Microscopic investigations showed the presence of small solid inclusions up to 5 μ k. This size did not allow to analyse only inclusion without the matrix. It was detected the four types of fine particles based on their composition (Table). The inclusions anglesite

(PbSO₄) and sulphate of potassium and iron, with composition resembling voltaite ($\{K_2Fe_5Fe_3Al(SO_4)_{12}\}18H_2O$) were detected clearly. The minerals with the composition corresponding to that of two inclusions types (III and IV) did not found. Inclusions III are enriched by sulphur, lead and potassium in comparison with matrix. Probably it would be plumbojarosite ($(Pb_{0.5}K)Fe_3(SO_4)_2(OH)_6$) or mixture of jarosite and anglesite. In the composition of inclusions VI the main cation is calcium. Atomic ratio Ca:Fe:S:As in this particles is 4.4:1:2.9:0.8. The excess of calcium atoms relatively to sulphur shows that these inclusions are not gypsum, but the presence of calcium sulphoarsenate is more possible.

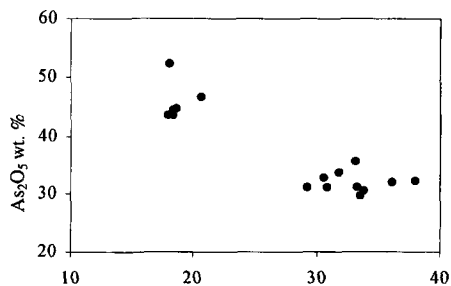


FIG. 3. Variations of As₂O₅/Fe₂O₃ ratio in the randomly selected places of amorphous substance.

Conclusions

(1) From acid wasters of Bericul waste heaps precipitate compounds of toxic elements, arsenic and lead. The low extend crystallinity indicates a rapid deposition of these elements.

(2) Arsenic is presented as two amorphous compounds with stable ratios Fe:As:S 1.3:1:1.7 and 3.3:1:3.5. Probably, part of arsenic deposited in the form of calcium sulphoarsenate.

(3) The modes of occurrence of lead are anglesite and plumbojarosite.