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Procedia Earth and Planetary Science 17 (2017) 261 – 264

Procedia
Earth and Planetary Science

15th Water-Rock Interaction International Symposium, WRI-15

As and Sb in wastes of Komsomolsk gold-extraction factory: results of investigation of water-wastes-bacteria interaction

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Abstract

We investigate correlations between content of As, Sb, Zn, Cu, Fe and microbiological composition of the wastes in the vertical and horizontal directions at the Komsomolsk tailings, Kemerovo region, Russia. Concentrations of As up to 30 g/l and Sb up to 91 mg/l were revealed in pore waters. Seventeen strains were cultured from the wastes. The northern part of Komsomolsk tailings is characterized by a large amount of bacterial diversity in the wastes. Among Gram-positive bacteria, there is domination of *Bacillus*. The positive correlation between concentrations of As and *Bacillus subtilis* and *Bacillus globigii* indicates the role of the bacteria in the formation of the secondary mineral phases of As^{3+} - Schneiderhöhnite $Fe^{2+}Fe_3^{3+}[As_5O_{13}]$, detected in the wastes composition.

Peer-review under responsibility of the organizing committee of WRI-15

Keywords: Mine tailings; bacteria; pore waters; arsenic spesiation

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1. Introduction

To study the behavior of chemical elements in the system "water-wastes- bacteria" we investigated solid wastes of 8 test pit samples (depth ~ 30 cm) located along of two horizontal profiles and wastes sampled layer by layer in three pits (depth ~ 200 cm) at the tailing area of Komsomolsk gold-extraction factory, Russia. Pore waters from the wastes sampled in the pits, water-soluble and exchange forms of elements, mineral and microbial composition of the wastes were thoroughly studied. The main objective was to estimate of chemical elements migration and transformation of their modes of occurrence under "water-wastes-bacteria" interaction.

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Peer-review under responsibility of the organizing committee of WRI-15
doi:10.1016/j.proeps.2016.12.050

2. Field area and methods

Komsomolsk tailings are located in the Kemerovo region of southwestern Siberia near village Komsomolsk (Fig. 1). The tailings dump contains waste materials produced by the cyanidation of gold–arsenopyrite ores processing between 1937 and 1940. The amount of accumulated waste materials is about 3.5 million tons. The main sulfide minerals are arsenopyrite and pyrite. Sphalerite, galena, pyrrhotite, ilmenite are minor minerals. Quartz, plagioclase, micas are the most abundant gangue minerals. Drainage waters from the tailing dump passing through a purification system discharge into the river Voskresenka. Water from the river is used by residents of the village Komsomolsk in everyday needs. Therefore, the study of forms of migration of chemical elements during “wastes-seasonal flows” interaction is very important and essential.

Visually, the northern and southern parts of the tailings vary in oxidation degree of wastes: more oxidized - southern part and less oxidized - northern part. To construct the distribution of elements in the tailings dump, wastes were sampled along the vertical and horizontal directions (Fig. 1). Vertical sampling was carried out in three pits. Two pits are situated in the southern part (P-1, P-2, see Fig. 1, the depth of the pits was ~ 220 cm.). One pit in the northern part (P-3, ~ 70 cm deep). The pits were sampled layer by layer for geochemical and mineralogical analysis. Wastes, along the longitudinal profiles extended from the NW to the SE direction, was sampled at a depth of about 30 cm in oxidized part of the tailings dump (samples № K-1p - K-4p) with step of 10 m, and in the unoxidized part (samples № K-5p - K-8p) with step of 60 m. At the same time samples for microbiological analysis were taken in the test tube Eppendorf.

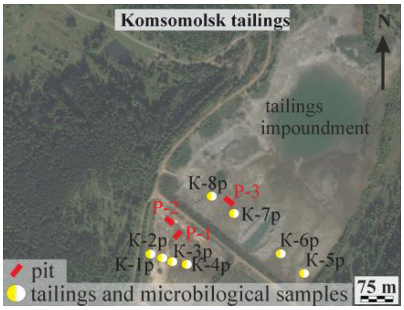

Fig. 1. Localization of the studied plots and pits at the Komsomolsk tailings (Kemerovo region, Russia).

In the laboratory, pore waters was squeeze out of the sampled materials of the pits P1 and P2. Arsenic speciation in the pore solutions was determined by hydride generation atomic absorption spectrophotometry (ICAP 6000 Series Thermo Scientific). The aqueous soluble portion of the sample was separated from 10 g of material by distilled water to determine the mineral composition. Extraction was conducted several times from the same sample to flush the greatest amount of water-soluble phase under controlling of conductivity and pH values. The volume of the resulting solution was in averages 500 ml. Ten ml of the resulting solutions were remained for elemental analysis. The second part was evaporated in 1 liter beakers at 90°C first and then in 50 ml crucibles to dry residue within two weeks. The composition of the obtained samples was carried out by X-ray analysis on a DRON 4 with monochromatic CuKα radiation. Remaining insoluble phase of the sample was weighed and divided into heavy and light fractions using water. The mineral composition of heavy fraction were determined by optical and electron microscopy JEOL JXA-8100 with energy dispersive analysis (EDS (Oxford) spectrometer).

In order to estimate water-rock interaction water-soluble and exchanged forms of elements were obtained. Water soluble metal species were separated by water extraction. Soluble compounds were extracted from 10g sample with distilled water (100 ml). After the separation of the first stage solution (water extraction), the sample was dried and an exchange form was extracted by the ammonium acetate buffer at pH = 4.7 in W:R ratio was 5:1. The samples were shaken and mixed for one day. Then, the solution was passed through a membrane filter.

Geochemical composition of tailings and experimental solutions was determined using ICP-MS, by X-ray fluorescence (XRF) analysis, and by the ICP-AES method. Main ion composition of the solutions was determined by ion chromatography (883 IC Basic Plus, Metrohm, Switzerland).

Determination of the strains was performed according to standard methods based on morphological and