

Heavy metals mobility: Surface water processes (The Copperbelt Case Study)

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Exemplary well monitored mining areas such as the Copperbelt in Zambia with contaminated reservoirs may provide a better insight into the heavy metals mobility as well as defining principles of the system stability by precipitation or sorption onto either sedimentary clay or organic content at the river bottom sediments.

Processes and heavy metals mobility were evaluated using Surfer[®] Mapping System Ver. 8.00 and Geochemist's Workbench[®] ver. 8.0.11 and 9.0.7 modelling on data acquired in the years 2004 – 2008 during a case study of the semiarid central African Copperbelt in surface waters in the Kafue river and its tributaries, and adjacent soils. Results indicate fluxes and main processes relations affecting the elements mobility.

Mostly all the contamination in tributaries does not exceed limits entering the Kafue river. Important role is attributed to the leaching process, dilution and decomplexation.

The main contaminants Cu and Co mined as a source sulphidic ore are processed in smelters using liming. Fine-grained fraction is washed from the mine waste deposits during rainy seasons and therefore contaminates surface water.

The 4-year monitoring reflected a time evolution and seasonal changes in system parameters. Mostly neutral and slightly alkaline pH decreased down to 2, accompanied by high EC in the vicinity of processing plants and causing metals mobilisation from the bottom sediments.

Griffin and Shimp [1] found the relative mobility of nine metals through montmorillonite and kaolinite: $Cr^{VI} > Se > As^{III} > As^V > Cd > Zn > Pb > Cu > Cr^{III}$. However, the data from the Copperbelt assume the mobility observed in the real environment: $Co = Mn^{II} > Zn > Cu = Mo > Ni > Pb > Zn > Hg$ considering local redox conditions, sediments and subsoil.

Modelling showed the Co concentration was determined by decomplexation of $HCoO_2^-$ and by dissolution of secondary cobalt oxide Co_3O_4 in case of higher Co concentrations. Cu also showed boundary conditions between dissolved $CuOH^+$ Cu^{2+} and precipitates.

[1] Griffin & Shimp (1978) Attenuation of pollutants in municipal landfill leachate by clay minerals. EPA-600/2-78-157, pp. 128 - 135.

Hydrogeochemistry Technogenesis Zone Gold Deposits Baley Ore Field (Eastern Transbaikalia, Russia)

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Baley ore field in the middle of the last century was one of the main centers of gold mining in the f. Soviet Union. It is presented adjacent to each other deposits – Baley (BD) and Taseevsk (TD), which were developed respectively in the 1929-1983 and 1948-1995 years. During the period of operation produced more than 450 tons of Au reserves of it in both fields have not been developed.

The ore field is confined to the Mesozoic graben depression, made mainly of sandstones and conglomerates (J_3-K_1). Gold-bearing quartz veins of the BD are located in granodiorite stockwork forming a ledge of the foundation. The total content of sulfides (pyrite, arsenopyrite, chalcopyrite, and others) in the ores is 0.5-5%, and 20% of carbonates and sheet silicates and up to 20%. TD ore in the form of quartz veins and vein mineralization occur in sandstones and contain sulfides and veined minerals in about the same amount [1]. The enclosing sandstones are pyritized.

Different levels of sulfides in the host rocks resulted in the formation of two types of geotechnogenic hydrogeochemical systems with contrasting physical and chemical parameters. In mining objects TD (quarry, waste dumps, tailings) of sulfate acid water with pH less than 3-4 (at least 2.69) and high concentrations of Al, heavy metals, F, Ca, Mg. Identified concentrations reached (mg/l): SO_4^{2-} - 4900, Al - 150.8, Mg - 724.6, Fe - 774.1, Mn - 88.1, Cu - 3.18, Zn - 6.31, Pb - 1.94, Ni - 3.44, Co - 1.08, Cd - 1.1, F - 11.9, As - 1.3. The isotopic composition of sulfate sulfur is lighter than starting sulfides ($\delta^{34}S_{CDT}$ -1.7...-6.5 and -1.18...+1.10‰ respectively), which indicates the involvement of bacterial processes in the oxidation of sulfides and thus enrich acidic waters metals. Water quarry BD is alkaline (pH to 8.40), with relatively low concentrations of ore and petrogenic elements. According to thermodynamic calculations, metals are mainly in ionic form, fluorine, as in the acidic waters of tungsten deposits [2], in the form of complexes with Al. Equilibrium minerals are calculated (quartz, celestine, gypsum, fluoride and etc.).

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[1] Yurgenson & Grabeklis (1985) In: Mestorojdenia Zabaikalia, 19-32 (in Russian). [2] Zamana & Bukaty (2004) Dokl. Earth Sci. **396** (4), 522-524.