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The heavy minerals in the Kafue River sediments, the Copperbelt Mining District, Zambia: Indicators of industrial contamination

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Mining and processing of copper and cobalt ores in the Zambian sector of the Copperbelt are reflected in contamination of stream sediments of the Kafue River that drains the whole of the Copperbelt Region. Contaminated sediments of the Kafue River were found to contain up to 0.8 wt.% Cu, 0.1 wt.% Co, 0.3 wt.% Mn and increased amounts of Pb, As and Hg compared with uncontaminated Kafue sediments.

XRD identified the presence of ilmenite, goethite, hematite, rutile, amphibole tourmaline-group minerals and small amount of apatite, clinochlore and zircon in both uncontaminated and contaminated sediments, which presumably originated from the geological background. In contaminated sediments, the XRD, SEM observations and EDS analyses confirmed the occurrence of angular particles of chalcopyrite, pyrite, bornite, covellite, malachite, pseudomalachite, and Cu-metal the concentrations of which increase with decreasing distance from single sources of contamination.

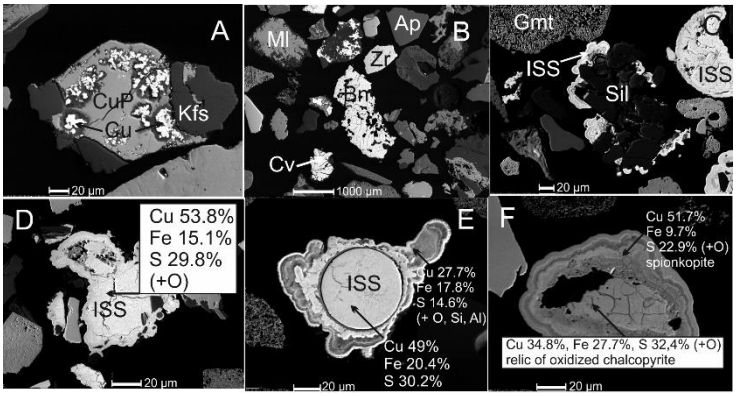

Figure 1. Heavy minerals fraction of contaminated sediments of the Kafue River, Zambia. A: Cu-phosphate (CuP - pseudomalachite) with accumulation of native copper (Cu) and grain of microcline (Kfs), B: Bornite (Bn), malachite (Mi), apatite (Ap) covellite (Cv) and zircon (Zr). C: Intermediate solid solutions of Cu, Fe and S (ISS), i.e., products of smelting. D-F. Chemical composition of different types of ISS. SEM, backscattered electrons.

In addition to clastic grains of sulfides and carbonates, particles of slag rich in magnetite and rounded particles of intermediate solid solution of Cu-Fe-S (ISS) mostly corresponding to high temperature Cu-sulfides (e.g., covellite, CuS; chalcocite, Cu_2S; bornite, $CuFeS_2$) were also detected (Fig. 1).

In the Kafue River sediments, chalcopyrite and pyrite evidently come from leaks of tailings ponds still in operation in which the sulfides were not yet oxidized. Reprocessing (re-washing) of old slimes for chemical leaching, and erosion of old flotation tailing ponds are responsible for enhanced contents of malachite, pseudomalachite, azurite, bornite, copper metal and chrysocolla together with limonite with high contents of copper and other elements. Particles of slag rich in magnetite and also particles of intermediate solid solution of Cu-Fe-S (ISS) indicate a dust fall-out from smelters or washing out of slag

deposits. The study results showed that heavy minerals are a very good indicator of the sources of contamination of stream sediments in the Zambian part of the Copperbelt.

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