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

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Sediments of the Kafue River that drains the whole of the Copperbelt region were found to contain up to 1 wt% Cu, 0.1 wt% Co, 1.3 wt.% Mn and a number of other toxic elements like Pb, As and Hg. The study of heavy minerals in both types of sediments was intended to identify the sources of contamination. Heavy minerals found in uncontaminated sediments of this river comprise mostly of ilmenite, limonite, rutile, amphibole and tourmaline, while apatite, clinochlore epidote and zircon are minor. On the other hand, the contaminated sediments contain, besides rock-rorming minerals, chalcopyrite, pyrite, bornite, malachite and azurite the concentrations of which vary considerably. Chalcopyrite and pyrite evidently come from leaks of tailings still in operation in which the sulfides were not yet oxidized. Washing out and erosion of old flotation tailings ponds are responsible for enhanced contents of malachite, azurite, bornite, copper metal and chrysocolla together with limonite with high contents of copper and other elements in the contaminated Kafue River sediments. Particles of slag rich in magnetite and also particles of intermediate solid solution of Cu-Fe-S (ISS) affected by various degree of oxidation were found in sediments close to the smelters. The identification of heavy metals and their relative proportions enabled to assess the extent of contamination of stream sediments and also the character of individual sources of contamination. No extensive dissolution of copper and cobalt minerals in stream sediments takes place due to the neutral or slightly alcaline character of surface water in the area. However, occassional accidents in chemical plants processing copper and cobalt concentrate (acid spikes) result in short term but sharp increase in acidification of surface water (pH 3-4) which consequently leads to sharp increase in copper contents in these water. The study originated within the UNESCO/IGCP 594 Project 'The impact of ore mining and processing on the environment and human health in Africa'.

Combining phase petrology, reaction balancing and partial pseudosections – Theory and examples

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Both classical phase petrology and phase diagram modelling by pseudosections have their strengths and weaknesses. Phase petrology is well suited for generic P-T grids and phase diagrams in relatively simple chemical systems or subsystems (e.g. KFASH in metapelites), but is hard to use in more complex systems, unless pure phases exist from which to project. Pseudosections [1, 2] are complementary to grids in portraying all reactions that may potentially operate in a given bulk composition as a function of P and T. Both petrological tools assume equilibrium conditions that may not always be appropriate. Reaction overstepping, re-entering of inclusions into a reacting assemblage during host breakdown, kinetic barriers, etc., all highlight the local absence of equilibrium or the operation of patchy equilibrium [3]. In addition, pseudosections assume constant bulk chemistry, which may be invalid during melt loss [2] and when certain phases (e.g. inclusions) or cores of zoned minerals do not participate in a reaction [3].

Hence, deriving P-T-t paths is a subtle process that requires a multi-faceted approach combining textural analysis, mineral chemistry, reaction balancing [4], qualitative pseudosections using model reactions [5], quantitative P–T pseudosections for selected microdomains, and thermobarometry on selected textures apparently close to equilibrium. In addition, P-T vectors may be constrained by modelling of reaction line slopes [6], a technique that merits far more attention and use. Examples are given from migmatites (Finland), granulites (Sri Lanka) and xenoliths (Spain) to highlight this approach.

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