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Behavior of a Freiberg Mining Waste Dump During Leaching Processes

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Mined ores and mining tailings are often treated by leaching methods using chemical or biochemical reactants to extract metals. But leaching processes which affect mining dumps also occur naturally. Weathering of mining dumps may lead to their self-organization and finally to a reduction of pollution of the environment (Rammlmair & Grissemann, 1999). Inside a dump certain solid phases are dissolved and mobilized, so that colloidal material is transported by ascending capillary water, which precipitates as gels near the surface due to the evaporation of the solution (Rammlmair, 1996). Consequently, an *in-situ* alteration (Benvenuti et al., 2000) may be overlaid by an absolute enrichment of elements. The strength of mobilization inside a dump as well as the dissolving of the secondary crust by rain water will be considered here.

The leachability of mining waste material from a Freiberg mining dump (tailings of sulfide ore flotation) was investigated by shaking-flask experiments. Two drilling samples (clay to sand size), originating from the oxidized cap of the dump (1 - 2 m depth) and from a relatively unaltered zone (16 - 17 m depth), were examined. Two kinds of leaching agents were used. 1. distilled water, 2. media inoculated with a mixed bacterial culture of *Thiobacillus thiooxidans* and *T. ferrooxidans* previously isolated from the same dump. The metal content of the solution was measured by ICP MS for six weeks. Every week, XRF analyses of the residues were used to determine their chemical compositions.

The first experiment, using distilled water, was designed to differentiate between the leachability of weathered mining waste material and unaltered material. In most cases, the metal concentration in the supernatant of the material from the oxidized top was about 10 times higher than the supernatant of the unaltered material. The highest concentration was determined for Ca, emphasizing the importance of evaporites such as gypsum and calcite. Si and Al also play an important role. Only small amounts of Fe are dissolved due to neutral (unaltered) or weakly acidic (weathered) pH values.

The development of the specific surface area was measured by N_2 adsorption (BET method). The starting value of the material from the oxidized top (4.67 m^2/g) was three times as high as the value of the unaltered material (1.59 m^2/g) due to precipitation of mobile phases, increasing the surface roughness of grains in the near-surface zone of the dump. Compared with a calculated model of ideal grains (smooth surfaces), the specific surface area of the weathered material was increased by the factor 17, while the factor of the unaltered material was increased to 8 (Jung et al., 2000). After two and four weeks, respectively, of leaching, the specific surface area of the weathered material reached a maximum of 6.55 m^2/g and 2.33 m^2/g in the case of the unaltered material. The leaching process increased the specific surface area by further enhancing the surface roughness of the components. The results are supported by SEM micrographs, which show the development of the surface roughness.

In the second experiment the influence of chemolithoautotrophic bacteria (*Thiobacilli*) on the leaching rate was investigated by simulating conditions approximating the natural situation. In both cases, weathered and relatively unaltered material, *Thiobacilli* could not extract metals in significantly different amounts compared with sterile experiments. In the case of the weathered material from the oxidized top of the dump the substrate conditions (scarcity of sulfides) are too poor for a great population of bacteria to feed on. In the case of the unaltered material, which contained sufficient amounts of sulfides left over from the flotation, the well buffered pH (6.5 - 7) limits the growth of the bacteria population, because *Thiobacilli* prefer acidic conditions.

The results seem to depend on the mineralogical structure of the leachable phases. Due to their high specific surface area, gels, which are more accessible, seem to be much more leachable than crystals. Therefore, the crust of a dump is highly susceptible to dissolution due to its high content of gel phases. If rain water does not reach deeper regions of a dump, leached components of the crust should precipitate again and the process then leads to a reorganization of the crust.

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