Materials of the future from old mines

M. Kraft[1], R. Hofmann[1], M. Bertau[1]

[1]Institute of Chemical Technology, Technische Universität Bergakademie Freiberg, Freiberg, Saxony, 09599, Germany

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Presenting author email: michael.kraft@chemie.tu-freiberg.de

Old mining - the misunderstanding of contaminated sites

Below the foot area of the Davidschacht dump development site is the "Rote Graben" (RG), an artificially constructed watercourse dating back to the 17th century. It serves to drain various pits and still mobilises metals from flooded mine workings. These mine waters are heavily contaminated with heavy metals, including cadmium as a priority hazardous substance according to the EU Water Framework Directive, as well as aluminium, arsenic and zinc, which are fed into the river Mulde via several outlets. Due to a lack of maintenance, the RG is now heavily silted. The current estimated sludge volume is approx. 13,000 m³. Efficient, ecological and economic solutions to this challenge must be found in a timely manner. There is a general consensus that this is a legacy of the old mining industry, i.e. a contaminated site. However, the question remains unanswered in this context as to whether this view is still valid today or whether, in view of new methods and technologies, old mining does not have potential for the future.

Future topic of old mine workings

The need for action at abandoned mine sites is indisputable. The underground cavities collect water that is enriched with various elements in different ways through the action of water, air and microbial activity. Often, complex iron hydroxide slurries (IHS) precipitate already in the mine, brought to light by the transport effect of the water.

At the RG, the immediate need for action arises from the fact that the sludge absorption capacity of the hydraulic structure is exhausted and significant amounts of sludge enter the river Mulde during heavy rainfall events (Figure 1). Economically and ecologically sensible utilisation of the sludge in practice has not yet been achieved.

The solution lies in the joint processing of dewatered mine sludge with iron-containing slags from a regional smelter for the extraction of raw materials and the generation of elution-stable geopolymers for use as special building materials. A simple chemical analysis shows how effective this approach can be. According to this analysis, the IHS consists of 30-45% Fe, 2.5-5% Zn, ~0.1% Cu, 10-15% Al as well as variable amounts of quartz and silicate components in the dry substance. Heavy metal impurities with As, Pb and Cd are in total ~0.5-1.0 %.

The focus here is primarily on the recovery of the valuable substances contained: Fe, Zn and Cu could be recovered from the sludge by >80 % in the laboratory through cover smelting (Figure 2). During the subsequent technical conversion, the pollutants As, Pb and Cd are removed via the electrostatic precipitator in accordance with the applicable emission control regulations. The stabilisation of the Al- and Si-containing residues takes place in the form of geopolymers, i.e. novel elution-stable building materials in which possible heavy metal contaminants are immobilised for geological periods of time (Figure 2). The aim is to make a future-oriented and sustainable contribution to environmentally relevant issues in the field of mine water and sludge, which can be scaled up internationally by regional partners and which integrates public acceptance. In this way, alternatives for disposal, conservation of landfill space, reduction of CO_2 emissions and ecological improvements for flora and fauna are to be achieved.

What we had previously understood by contaminated sites are raw materials that can be extracted and recycled sensibly and economically if the right approach is taken. In view of the EU Water Framework Directive with its obligation to treat mining water, this can make a significant contribution at an early stage to meeting official requirements. In addition, landfill areas can be conserved through a technology for the utilisation of mine sludge.

The technical work is centred on a test container at the Davidschacht rinsing dump development site, which combines mining and tailings leachates. The mobile plant is used and operated directly at the site in a real environment. The modular design allows the sludge to be dewatered, the filtrate water to be treated using membrane technology and concentrate treatment, and, based on this, metals and building materials to be recovered.

The aim of the current project is to develop technologies for the eternal consequences of mining while actively involving the population in the World Heritage region of the Erzgebirge/Krušnohoří in future issues. The aim is to create an awareness of (domestic) mining and raw material extraction as well as the inherent potential of mining residues for the supply of tomorrow and to generate new jobs. With social acceptance, the developed processes can be applied in the future through the modular, mobile plant design not only for water solution tunnels in Saxony, but also for the treatment of iron-containing residues from lignite mining in Lusatia and other regions; last but not least, similar materials or products from old mining operations in Germany can be tested and validated under these aspects.

In this way, old mine workings contribute to the global goals of protecting the climate and resources in the form of marketable, innovative products made from mine sludge.

The legacy of Saxon mining is thus being inverted from a problem case into a new raw material extraction concept that has already attracted nationwide attention.

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Figure 1: a) Overflowing “Roter Graben” [G.E.O.S., 2013], b) Dried IHS from the “Roter Graben”.

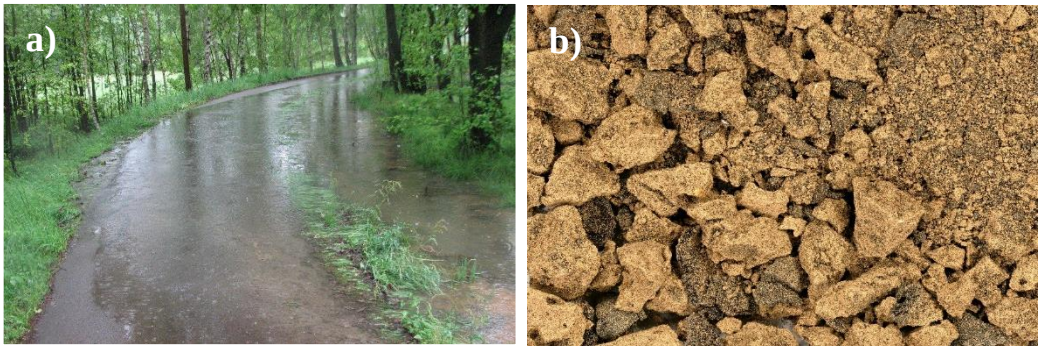

Figure 2: a) Molten metal from IHS of the “Roter Graben”, b) Geopolymer bricks based on residues and IHS.