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Geochemistry, mobility and bioavailability of contaminants in mine tailings of Namibia

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Namibia is a country with dry climate, ranging from semiarid in the northeast to the hyperarid in the west and southwest. Mining is very important source of national revenue and there are many mining wastes including waste rock piles and flotation mine tailings dispersed across the country.

Three sites have been investigated, analysing solid phase composition and mineralogy, and water leachates: Berg Aukas and Kombat in the Otavi Mountainland in the northwest and Rosh Pinah in the Namaqualand in the south.

Relatively old (>30 y) Berg Aukas mine tailings are rich in vanadium in primary mineral descloizite, $(Pb,Zn)_2(OH)VO_4$ and zinc in willemite, Zn_2SiO_4. A part of descloizite has been dissolved and implemented into hematite confirmed by Mössbauer spectroscopy. In contrast, dissolved zinc has been implemented mainly into secondary smithsonite, $ZnCO_3$ and dissolved lead has been implemented into secondary cerussite, $PbCO_3$. Vanadium in hematite is immobile in spite of highly alkaline conditions favouring mobility of oxyanions, but zinc and lead in carbonates are more mobile [1].

Relatively young (<10 y) well-neutralized mine tailings at Kombat are rich in copper and lead and arsenic contents are also significant. A part of contaminants remains in primary sulphides and released copper and lead form malachite, $Cu_2CO_3(OH)_2$ and cerussite, respectively. Released arsenic is immobilized in secondary hematite, but copper and lead in carbonate minerals can be easily released are relatively mobile with high dissolved water leachate concentrations [2].

Last mine tailings at Rosh Pinah are very young (ca. 2 y) are also completely neutralized and rich in zinc, lead, and barium. Zinc and lead released from primary sulphides precipitate in respective secondary carbonates smithsonite and cerussite and barium released from primary carbonate mineral norsethite, $BaMg(CO_3)_2$ precipitates as secondary barite in sulphate-rich pore water. Arsenic is again immobilized in highly crystalline Fe-oxyhydroxides. Simulated gastric leachates concentrations were in the order Ba>Pb>Zn>Cu>As. Analyses of groundwater from pond south of mine tailings indicated a significant portion of contaminants in suspension (>70% for zinc) [3].

In summary, mobility and gastric availability of contaminants forming secondary carbonates such as copper, zinc, and lead can be relatively high. On the other hand, contaminants forming oxyanions such as vanadium and arsenic are relatively immobile in spite of alkaline conditions because they are implemented in highly crystalline and insoluble ferric phases like hematite. Concentration of barium released from Ba-rich carbonates at Rosh Pinah site is controlled by precipitation of barite. Formation of hematite seems to be fast under tropical conditions with distinct dry and rainy periods [4]. Funding for the research was provided by the Czech Science Foundation (GACR 16-13142S).

References

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