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Geoelectrical Imaging of a Hardpan on a Mining Dump

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Introduction

Hardpan formation on mining dumps is a phenomenon observed in many places for example in Pena de Hierro and Selebi Phikwe (2003, Rammlmair, 2003). Hardpan formation is presumably caused by solution of primary unstable minerals by rain water, upward capillary transport of dissolved ions and colloids, and subsequent precipitation of secondary minerals on the capillary fringe of the dump due to evaporation. If a hardpan forms, it may prevent further leakage of contaminants into the groundwater and may act as an effective seal. The hardpan may confine drainage to preferential pathways already depleted in contaminants. In order to study the geophysical expression of the hardpan the resistivity and the induced polarisation (IP) on a mining dump is measured in detail. The Spectral Induced Polarisation (SIP) effects of hardpan samples are studied in the laboratory. The investigations aim at the discovery of geophysical indications of the hardpan and its function as sealing agent.

Site description

A slag heap from residues of the steel production is investigated. The material consists mainly of magnetite, cohenite (Fe_3C), graphite, metallic ions, Fe-oxides and (sodium) silicate glass. The slag heap is about 200m long, about 70 m wide and the height is about 14m above ground level. The slag heap was completed in 1995 and a hardpan formed on the capillary fringe. The thickness of the hardpan varies (20cm – 2m) and the formation mechanism is studied in detail as part of an integrated research project (Regenspurg et al., 2004).

During the years 1998 and 1999 three geoelectrical profiles on the slag heap were measured. Resistivity changes by an artificial rain event were studied (Niederleithinger, 2000). Laboratory measurements hinted to strong SIP effects of Fe-minerals (Grissemann et al., 2000). In 2004 the existing data were completed by fourteen 2D resistivity profiles and during three months the resistivity changes along a profile were measured on a daily basis. The studies on site were combined with laboratory -SIP measurements of saturated hardpan samples from different depths.

Results of the measurements

The inversion of the fourteen 2D-geelectrical profiles (electrode spacing of 1m and 2m) across the slag heap show a high resistive ($>100\ \Omega$m) cover over most parts of the heap. The thickness of this cover varies between some 1 m – 2 m. This cover is interpreted as hardpan indication. The resistivity of the covering layer varies and the resistivity variation might indicate different stages of hardpan development. Physical reasons for the resistivity variations are differences in material, in saturation, and in pore water conductivity. The effects of these parameters are studied with laboratory experiments. Hardpan samples at different depth were saturated with distilled water for 24 h. In the following two months the apparent resistivities of the samples decreased and the conductivities of the pore fluids increased due to mineral solution. The SIP measurements of the samples show strong polarisation effects ($\Delta\theta$= 50 mrad). The data can be fitted by a Cole-Cole model. The curve minimum remains at the same frequency during the solution process, thus indicating no major pore size change.

Conclusions

Resistivity imaging of a slag heap showed near surface resistivity variations which are attributed to different hardpan development stages. However, further research is necessary to relate the resistivity and SIP variation to mineralogical and physical hardpan parameters such as pore size, grain size, hydraulic conductivity and mineral content. By the combination of SIP and resistivity measurements on site and in the laboratory the effects of the different parameters are studied in detail and first results show no pore size change due to solution in hardpan material.

Literature

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