

ERT Measurements on Tailings Dams using Multi-channel Spectral Induced Polarization (SIP)

S. Kruschwitz, E. Niederleithinger, Federal Institute for Materials Research and Testing (BAM), Berlin, Germany

Safety of Tailings Facilities

The often poor construction and low maintenance level of tailings dams has caused serious accidents. The EC funded project TAILS SAFE is aimed at the non-destructive assessment of tailings facilities for stabilization analyses and the development of better management methods.

The focus of geophysical field studies was on the discrimination of different layering and construction steps as well as the determination of the spatial (relative) water content in the dams. SIP measurements at three tailings facilities different in their geological backgrounds, composition and age have been conducted.

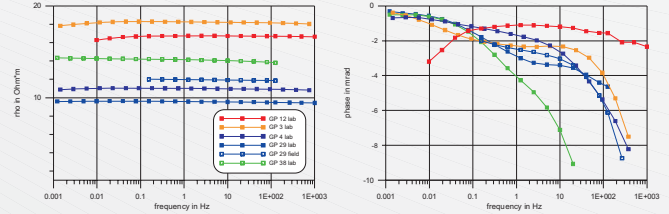
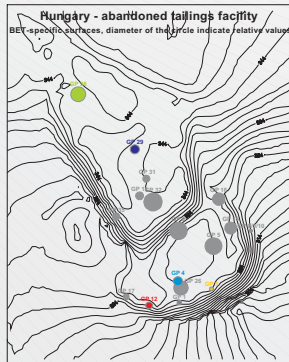


Figure 1: SIP lab spectra measured on grab samples of a tailings facility. The coarse dry dam material (GP 3, GP 12) and the saturated plateau fines (GP 4, GP 29, GP 38) have different amplitude but resembling phase spectra. However, a weak correlation between grain sizes and the steepness of the phase curves is indicated. Both, grain size analyses and measurements of the specific surface (BET, Fig. 1 right) allow a clear classification of the material in terms of their mean grain sizes. A correlation of specific surface S_{por} and the imaginary part of the conductivity σ'' from the SIP spectra was not found.

SIP measurements at the test sites

Amplitudes

The coarse dam material has high resistivities and can be clearly discriminated from the fine, water retaining tailings below. Dam thicknesses vary between 5 - 15 m. Critical seepage indications were not detected. In case of the abandoned german site even the tailings dried out, so that an outline of the old dam layer is not possible. At the active romanian site a discharge system prevents from unwanted seepage through the dams. As an effect of that the tailings of the plateau have relatively low water contents up to depths of 15 m.

Phases

The dry sands of the dams show at all sites low and not frequency dependant polarization effects ($\phi < -0.3^\circ$). At two sites (RO and GER) increasing phases are observed at greater depths and on the plateau. This effect comes along and can be explained with decreasing mean grain sizes (see Fig. 3) and an increase of the water content (known from lab analyses). However, no phase change can be observed at the plateau of the hungarian site. Very high salt concentrations of the pore fluid reducing polarisation effects could be an explanation. Chemical analyses of water samples are ongoing.

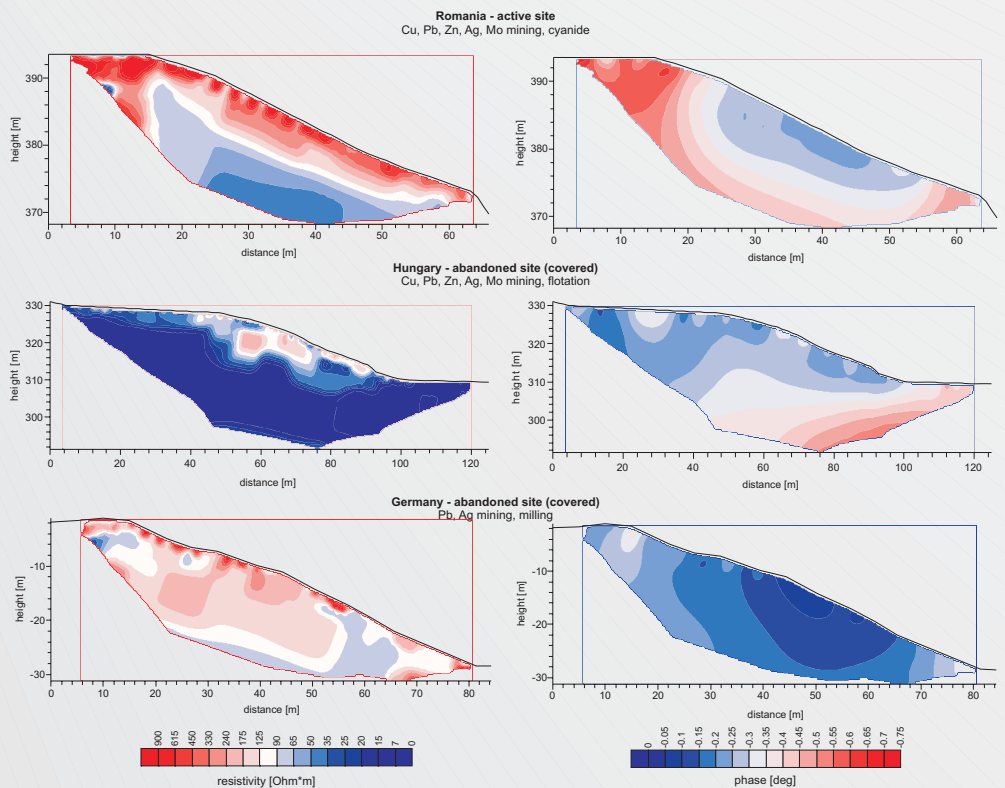


Figure 2: Multi-channel measurements of the complex resistivity at different tailings sites. Inversion results of the 1.25 Hz frequency.

Conclusions and Outlook

Dams and plateaus of different tailings facility types were investigated in complex ERT measurements. A clear discrimination of dam and saturated tailings can be made from the amplitude sections. Anomalously high water contents (seepage indications) near the surface can be outlined. However, in ERT measurements different construction steps of the site are not assessable. The phase sections contain information on mean grain sizes, saturation and the salt content of the fluid. Hence, interpretation is often ambiguous without additional information. If possible, pore water and grab samples (drilling is often not possible, because the tailing facilities have limited access possibilities) should be analysed and results combined to not misinterpret the data. Where no clear assessment of the internal dam structure is possible from ERT data, for example the multistation SASW technique provides a reliable mean to determine layering and calculate elastic parameters (Fig. 4).

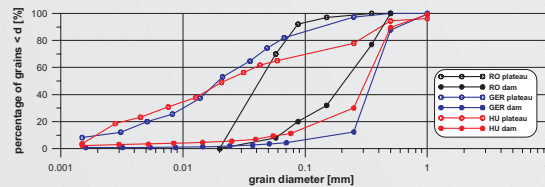


Figure 3: Grain size distributions of samples from the dams and the plateaus of each site. Medium and fine sands cover the dams, whereas silts are found on the plateaus.

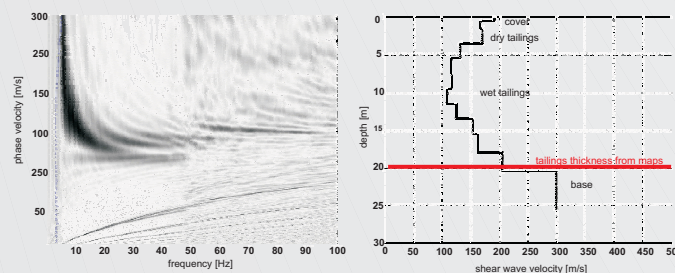


Figure 4: SASW results from the plateau of the german site: Dispersion analysis (left) and modeled average shear wave phase velocity profile with interpretation (right).

Acknowledgements

Most of the works described here was done in the frame of the EC funded project TAILS SAFE (Sustainable Improvement in Safety of Tailings Facilities, EVG1-CT-2002-00066).