A multiscale accuracy assessment of moisture content predictions using time-lapse electrical resistivity tomography in mine tailings

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Accurate and large-scale assessment of volumetric water content (VWC) plays a critical role for mining waste monitoring to mitigate the geotechnical and environmental risks they can represent. In recent years, time-lapse electrical resistivity tomography (TL-ERT) has emerged as a promising monitoring approach that can be used in combination with traditional invasive and point-measurements techniques to predict VWC in mine tailings across larger scales. Generally, the bulk electrical conductivity (EC) imaged using TL-ERT is converted into VWC in the field using petrophysical relationships that have been calibrated in the laboratory at sample scales. This study is the first to assess the scale effect on the accuracy of ERT-predicted VWC in mine tailings.

A simultaneous and co-located monitoring of bulk EC and VWC is carried out in mine tailings at five different scales, ranging from a few centimeters sample-scale cells, to a 20 m-long experimental cover in the field. At each scale, the hydrogeophysical datasets are used to calibrate an Archie petrophysical model, which is used to predict VWC from TL-ERT data at the other scales. Overall, the accuracy of ERT-predicted VWC is ±0.03 m^3/m^3 at the scales studied, and the petrophysical models determined at sample-scale in the laboratory remain valid at larger scales. Notably, the impact of temperature and pore water EC evolution plays a major role for VWC predictions at the field scale (tenfold reduction of accuracy), and therefore, must be properly taken into account during the TL-ERT data processing using complementary hydrogeological sensors. Based on these results, we suggest that future studies using TL-ERT to predict VWC in mine tailings could use sample-scale laboratory apparatus (similar to the electrical resistivity Tempe cell presented here) to calibrate petrophysical models, and carefully upscale them to field monitoring applications.

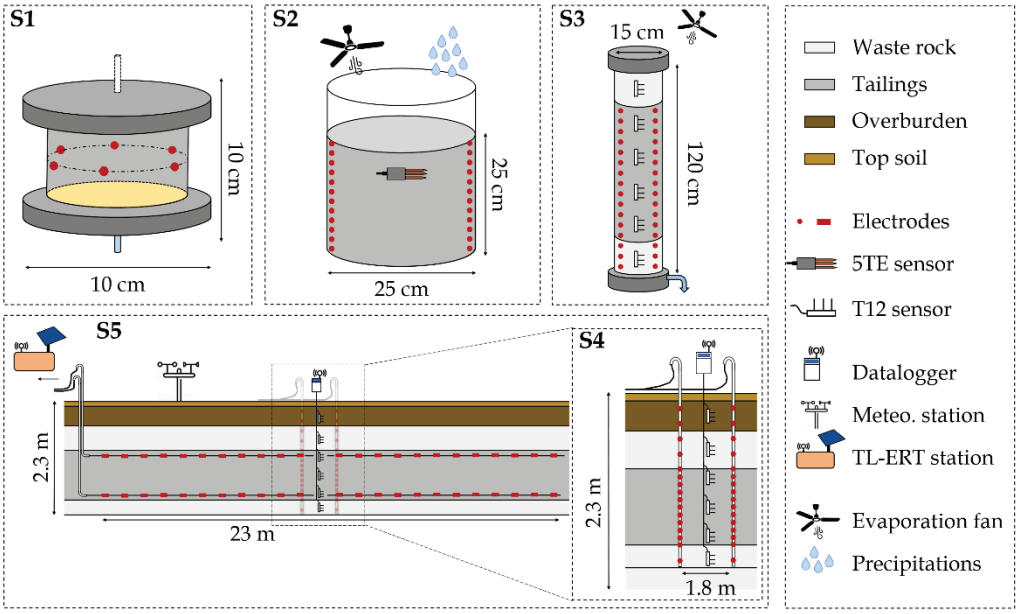

Figure: Illustration of the five scales studied to assess the accuracy of predicted VWC in tailings. S1 to S3 refer to laboratory application (≈ cm). S4 and S5 refer to experimental field scale covers (≈ m) at Canadian Malar-tic gold mine in Québec, Canada.