Hydrogeological and geoelectrical monitoring of mining reclamation covers to assess the accuracy of moisture content estimations

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Tailing storage facilities (TSF) are large structures used to store uneconomic mineral. They are generally reclaimed after mine operations with engineered covers that limit the flow of water or oxygen in order to prevent tailings oxidation. One of the most promising reclamation approaches is to build multilayer covers with capillary barrier effects (CCBEs), which act as oxygen barriers when a retention layer remains above 85% of saturation, reducing oxygen migration by a factor of 10 000. Long-term monitoring programs traditionally use moisture content sensors in the layers of interest in order to evaluate if the cover performance decreases over time. However, since they have a limited investigation volume, many sensors may be needed to perform a large-scale monitoring, which represents important costs for monitoring programs.

In this context, time-lapse electrical resistivity tomography (TL-ERT) is a promising tool to spatially extend point data since conductivity images can be converted into distributions of moisture content. Although TL-ERT has been successfully applied to monitor spatiotemporal changes in moisture content for different contexts, few studies assess the accuracy of TL-ERT regarding moisture content estimations for mine wastes. However, accuracy is critical when TL-ERT is applied to monitor CCBEs performance as small changes in saturation (typically around 85%) must be precisely detected to determine whether the cover meets the performance criteria as an oxygen barrier.

This study presents preliminary results from the hydrogeophysical monitoring of a large-scale experimental CCBE at the TSF of Canadian Malartic Mine, an active open-pit gold mine in Quebec. A total of 30 moisture content sensors and 372 stainless-steel electrodes buried at different depths in the cover are used to monitor the changes in water content, temperature and conductivity due to natural precipitations. The lateral spacing between electrodes ranges between 10 cm and 2m to form 2D and 3D imaging grids with different spatial resolutions. The electrodes are located at the bottom and the top of the 1m-high retention layer of the CCBE to maximize measurement sensitivity in the layer acting as the oxygen barrier. The monitoring database includes one year of continuous measurements from moisture content sensors and a total of 55 ERT images during a two-month period in summer 2020. The protocol used for each ERT image contains 2500 measurements with both inline and crossline, direct and reciprocal Wenner, dipole-dipole and gradient configurations.

We propose a methodology to assess the accuracy of moisture content distribution calculated from geoelectrical monitoring with both field measurements and numerical modelling. We compare (1) point moisture content measurements made by capacitance sensors, (2) distributions of moisture content modelled with PFLOTRAN and (3) moisture content distributions derived from ERT. The time-lapse resistance measurements are inverted using E4D and the conductivity distribution is converted into moisture content using petrophysical relationships determined from laboratory and in-situ sensors. These results will be useful to assess the accuracy of TL-ERT and will help to optimize the long-term autonomous monitoring of the experimental covers starting in winter 2021 with a PRIME instrument in collaboration with the British Geological Survey.