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Resistivity assessment of an earth-filled dike with a permanent hydraulic head (Canal de Roanne à Digoin, France): 4D effects on 2D ERT monitoring

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Several geophysical and geotechnical techniques were tested on an earth-filled canal dike in the framework of a French research program (labelled DOFEAS). The aim of this program was to test the ability of geophysical techniques, first, to image the body of the dike and to detect weak zones associated with known leakages and, second, to monitor the evolution of geophysical parameters (mainly electrical resistivity) with time in relation with the evolution of water circulation and internal erosion. The chosen site is an earth-filled dike (3 to 4m high) relying upon Jurassic marly limestones. The dike contains a permanent hydraulic head and exhibits 2 leakage zones in the study area. Repair works, conducted after the canal was emptied, allowed to visually identify the seepage entries (a few tens of cm each in diameter) within the canal. Drillings, in situ and laboratory tests allowed to build a hydrogeotechnical model of the site. Probes were installed in boreholes to monitor the water table variation over time. Active geophysical experiments including seismic refraction and tomography (P- and S-waves), surface wave inversion (SWI) and electrical resistivity tomography (ERT), were used to characterize the geometry of the sub-surface.
Concerning the time-lapse ERT survey, 128 electrodes, spread each 1 m, were permanently installed on the dike crest. Measurements were conducted using a Wenner-Schlumberger protocol (around 3600 measurements). 7 sequences were acquired during 2 months prior, during and after repair works. These works induced variations in the water level within the canal. The combined effects of the complex 3D geometry of the dike and of the varying water level were numerically determined to correct the geometric factor k. Compared to the analytical k, the geometric factor corrected from the topographic effects induced complex resistivity variations between 8 and 18%, depending on the electrode spacing but also on the water level into the canal. Furthermore, numerical simulations also showed that, depending on the water level into the canal, the electrical current density within the dike could also be affected by a factor of up to two. This indicates that a more or less important part of the measured resistivity carries information which originates from the water. However, a full 3D correction of the measured apparent resistivity would require to know the 3D resistivity distribution within the ground.

The time-lapse inversion of the ERT data allowed to locate the main pipe within the dike, at a depth of around 3.4m, just above the interface between the bedrock and the dike body. This location was in agreement with the visual location of the seepage. Corrected resistivity were found to be more realistic than with the analytical k factor and allowed a better detection of the main pipe. However, the second and smaller pipe was not detected, probably because of a too low contrast.

These results confirm the applicability of calibrated geophysical techniques for assessing earth dike geometry. They also suggest that the correction for the 3D to 4D effects provides a better detection of anomalies (i.e. seepage pipe) evolving with time.