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Electrical resistivity tomography and self-potential case studies for fractured aquifer characterization and monitoring

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Electrical resistivity tomography (ERT) and self-potential (SP) investigations have been conducted in complex carboniferous limestones aquifers in Belgium (synclinorium structures). The aims of this study were (1) to detect and characterize fractured zones in hard rock aquifers, (2) to monitor groundwater flow/water content in these fractured or karstic areas and (3) to use geophysical data to support groundwater flow model set-up and calibration. The investigated areas lie in calcareous synclines.

Electrical images allowed us to detect and characterize (in terms of direction, width and depth) several less resistive anomalies, which are interpreted in terms of fractured and/or karstic zones. To interpret the ERT images, data errors as well as image appraisal indicators (resolution matrix, sensitivity matrix and DOI index) were analysed and compared. This allowed us to determine the depth of investigation of ERT and to avoid the misinterpretation of the resulting images. Inversions based on focusing scheme are tested against smoothness-constraint inversion on these field data to provide more realistic images on the basis of prior geological knowledge.

Self-potential measurements were performed along the electrical profiles and allowed us to find negative anomalies possibly related with groundwater preferential flow pathways. By taking the assumption that only the electrokinetic effect plays a role in the SP signals, we were able to estimate a first distribution of the water table along our profiles. The SP data showed that in this particular tectonic structure, two perpendicular hydraulic gradients are present. The first gradient is related with the main fold axis direction and is the major drainage system. The second hydraulic gradient is related with the flanks of the calcareous valley. Geophysical data concurrently with ‘ground truth’ geological and hydrogeological data allowed us to better understand the groundwater flow in these calcareous synclines and to verify the conceptual groundwater flow model.