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Electrical Resistivity Tomography of the Karstic Aquifer of Bittit spring (Middle Atlas, Morocco)

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The Tabular Middle Atlas reservoir is one of the most important aquifers in northern Morocco. It is mainly a water table fractured reservoir consisting of Lias limestone and dolomite. The matrix permeability is very low and water flows essentially along open fractures and karsts. The Bittit Spring belongs to this karstic system and constitutes an important aquifer lying at the junction between the tabular reservoir and the Sais basin.
Bittit spring, with an average annual discharge of about 1600 l/s, contributes largely to water supply of the big city of Meknes. Groundwater circulation is complex due to tectonics and to presence of karstic Quaternary travertine overlying Lias carbonate. In Bittit area, travertine is mostly covered by Quaternary basalt. Up to now water flow paths and the underground karst organization remain misknown, and turbidity affects the water quality after rain events. To highlight these issues, an integrated geophysical survey was performed in this area in the framework of a French-Moroccan scientific project.
The geophysical imaging was carried out mainly by Electrical Resistivity Tomography (ERT). Resistivity data were acquired by an ABEM Terrameter SAS1000 and a multi-electrode Lund system imaging using a Wenner array configuration of 64 electrodes and 5m spacing, reaching a depth of about 50m. Topographic corrections and 2D inversion models were performed using Res2Dinv software package.
Seven 2D resistivity high resolution images have been obtained allowing to detect, delineate important fractures and also to hydrogeological characterization of the underground karst. A borehole of 100m depth was drilled in order to correlate and calibrate geophysical data and proposed models.
Two sub-vertical fracture families have been identified with NE-SW and NW-SE directions respectively. These results correlate well with fracture data analysis gathered from remote sensing Spot images at large scale, and from local field fracture scanline surveys. A 3D picture of the fracture system has been drawn showing a mini-graben structure.
Geophysical scans and interpreted fractures were displayed with Gocad software leading to geometric construction of aquifer units and to 3D modelling of subsurface architecture.
Several horizontal electrical resistivity profiles and electromagnetic VLF profiles were also performed in order to discriminate between dry and favourable hydrological fractures.
ERT appears to be an appropriate geophysical method in this issue, especially by improving understanding of fracture geometry. This study initiates a hydrogeophysical research in the Middle Atlas karst in order to improve water resources management and reducing aquifer vulnerability in the region.