Hydrogeophysical Tools for Investigating Groundwater Storage in the Subsurface of a Karst System


*University of Mons, **Royal Observatory of Belgium, *British Geological Survey

1. Introduction and Aim of the Research

Present knowledge of karst systems has evidenced the importance of the unsaturated zone on water dynamics. However, for a better understanding of the infiltration processes within the epikarst, a continuous monitoring of spatial and temporal changes in the water content has been applied in the subsurface of a karst system.

Gravimetric monitoring is crucial to evidence water storage changes through time. An electrical resistivity tomography (ERT) monitoring system is also needed to image, at least on a daily basis, the spatial variability of resistivities due to the complex geometry of the epikarst. ERT analysis provides valuable data to help the characterization of the subsurface.

2. Hydrogeophysical Monitoring Results

2.1. Gravimetric monitoring

Continuous monitoring with a GFG micro-g LaCoste absolute gravimeter for calibration measuring every 2 weeks.

Surface laboratory of Rochefort Cave

Perspectives

• A supersolidifying gravimeter will be installed in the cave while keeping monitoring in the surface.

2.2. Electrical Resistivity Tomography monitoring

Methodology

- ALERT acquisition system BGS (Kuris et al., 2009)
- 48 electrodes, 1 m spacing
- Located on top of the limestone massif: 20 electrodes are cut along the side of a hill.
- Repeated dipoles – dipoles and Werner-Schulmberger’s.
- Started in February 2014, a breakdown occurred in middle of June 2014

Discussion

- The high resistive area at the top of the limestone massif shows the highest variations through time.
- It is interpreted as changes in the water content within the epikarst.
- The significance of low resistivities next to the side of the doline is not clear.
- Bedding joints filled with claysh materials could indeed lead to anisotropy that will be investigated in the next steps of the research.

3. What brings H/V Spectral Ratio Analysis?

Methodology

- 10 minutes of measuring time
- CityShark II connected to three-component accelerometer (3LC-5D50 Lemniscus)
- Profile: Two meters along the top of the ERT profile
- Profile: 30 meters above the main room of the cave

Discussion

- High frequency H/V peaks (20 – 40 Hz) variations are correlated to ERT shallow interferences + epikarst morphology.
- Significance of lower frequency H/V peaks, interrupted by deep regional contract, are not clear. Cavities influence the signal.

4. Conclusions

This experiment shows the usefulness of hydrogeophysical monitoring in the context of karst aquifer research. It highlights the fact that gravimetry combined with ERT are valuable tools to monitor the hydrodynamics of the unsaturated zone of karst systems. The use of HVSR analysis in such environment seems, moreover, to be an additional input to validate ERT data and to calibrate the spatial extension of the epikarst. In dry conditions, the use of ERT technique alone could not always help identifying epikarst boundaries because of the lack of clear contrast in saturation.

Gravimetry evidences charges and discharges of the epikarst, matter its dynamics and their origin (slow recharge through winter, rapid recharge of the epikarst due to the overland flow over the karstic formations all the way to a resurgence. The epikarst is also charged by water infiltrating the massif from the top, crossing the unsaturated zone.

Water infiltration has complex dynamics given the alternative of microfractures (caves fractures bedding joints, karstic joints, joints), tectonic discontinuities (tissues, porous matrix, calcite joints). These characteristics lead to localized, highly non-linear dynamics, time-dependent geometry.

For a better understanding of the infiltration processes several tools are combined (ERT monitoring, gravimetry, GRF monitoring, seismic refraction, HVSR analysis) in order to improve the knowledge of the karstic aquifer system.