Investigation of a remediated sink hole with S-wave seismic and geoelectric methods

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Introduction

In 2001 a sinkhole appeared in the vicinity of a small town in Hungary. The sinkhole was rapidly increasing, in a few days it had reached 6m depth and the surface diameter of 8-10 m.

During remediation the sinkhole was completely filled with limestone debris and thus the further collapse was successfully stopped.

Figure 1. *The sinkhole before and during remediation in 2001*

Geophysical Investigations

Fig. 2. *Location of the geophysical surveys: 2D geoelectic lines (yellow), S-wave seismic line (red) and 3D geoelectric layout (blue). Red triangles are borehole locations*

In 2016 a geophysical survey campaign was organized in the site of the former sinkhole to monitor the quality of the remediation and to observe the possibilities of the investigation of buried sinkholes as an analogy of remediated sites of surface and near-surface nuclear explosions.

The parameters of the measurements are listed below.

S-wave seismic acquisition with DAQlink System

	Type	Distance
Source	S-wave hammer	72 x 1 m
Reciever	Vertical S-geophones (10 Hz self freq.)	72 x 1 m

Geoelectric acquisition with AGI SuperSting R8

	Type	Electrode distance	Dimensions
2D profiling	Inv. Schlumberger	5 m	310 m
3D grid	Dipole-dipole	3 m	18 m x 30 m

Results

Local geological settings

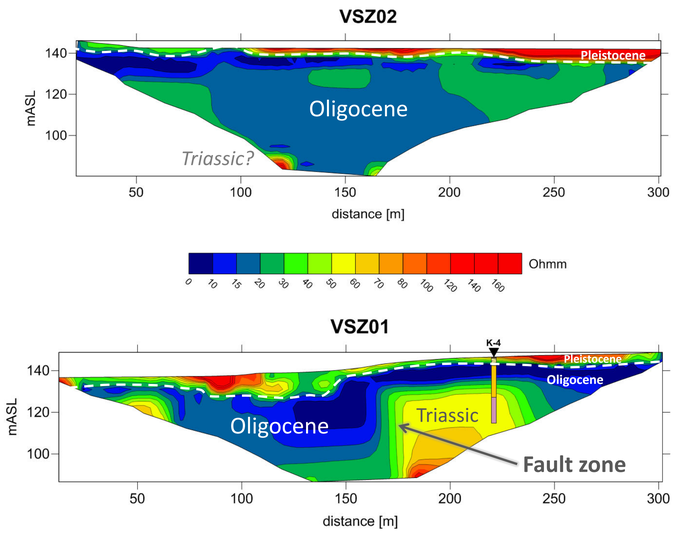

Figure 3. *Interpretation of the 2D geoelectric sections*

Two dimensional geoelectric profiling was used to build up the image of the subsurface geological structure. Besides several borehole drilling profiles were used to validate the results of the 2D electric measurements (see *Figure 4.*).

Combining geoelectric sections and borehole profiles we were able to:

- determine large resistivity contrast between sandy gravel and (sandy) clay deposits as the **Pleistocene-Oligocene boundary**
- identify a **fault zone** on profile VSZ01 between Oligocene clay deposits and Triassic limestone

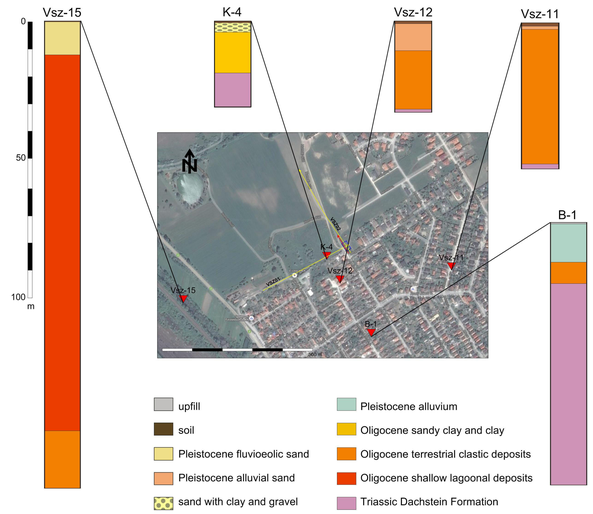

Figure 4. *Borehole profiles used for the interpretation of the geoelectric sections. Note the variable depth of Triassic limestone (purple)*

The vicinity of the former collapse zone was investigated with **S-wave seismic** measurements:

- alterations in seismic characteristics imply the presence of **faults**
- the **decrease of seismic signal strength** can be observed at the location of the sinkhole

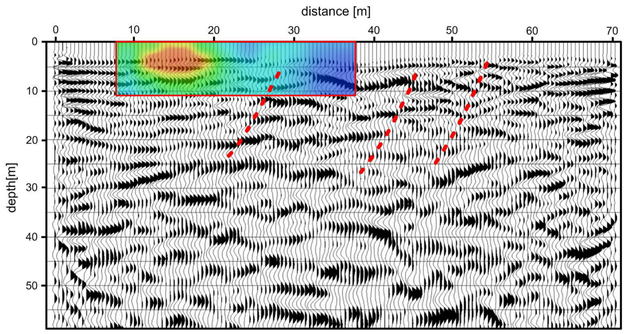

Figure 5. *Migrated S-wave seismic depth section with fault lines (red) and the corresponding 3D geoelectric section*

3D image of the sinkhole

The marked contrast in electrical resistivity between the surrounding clayey/sandy deposits and the limestone debris filling helped the identification of the sinkhole:

- the (detected) dimensions of the sinkhole were ca. 4x6x8 meters
- the sinkhole extends in the direction of the neighbouring road

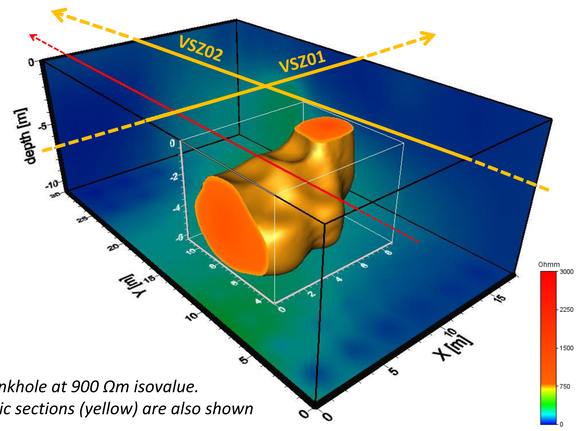

Figure 6. *Volumetric interpretation of the former sinkhole at 900 Ωm isovalue. The locations of the S-wave seismic (red) and 2D geoelectric sections (yellow) are also shown*

Summary

The former sinkhole and its environment were successfully investigated with S-wave seismic, 2D and 3D geoelectric methods.

Based on the evidences in the local geological properties (e.g. faults, shallow depth of limestone basement) it can be assumed that the appearence of the sinkhole is connected to the collapse of a formerly developed natural cavity.

S-wave seismic and geoelectric sections were combined to examine the different geophysical properties of the site and the quality of the remediation.

The combined interpretation of the geophysical measurements can facilitate the investigation of a buried sinkhole at a near-surface nuclear explosion site.

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