Detection of karst dissolution zones using seismic methods

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Surface geophysical, non-invasive prospection techniques are instrumental for the early detection of karst dissolution zones and cavities. The relatively recent method of seismic refraction diving wave tomography is most appropriate for this task.

The procedure is based on the analytical derivation of the distribution of seismic propagation velocities in the subsurface. These are directly proportional to the rock strength. The derived velocity field thus images in detail the depth and spatial extent of areas with reduced subsoil stability.

The industrial region east of Basel (Switzerland) is known for its difficult soil conditions due to wide spread karst leaching. In the run-up to redevelopment projects in this area, these conditions must be taken into account so that a comprehensive and reliable reconnaissance procedure can be used for planned civil engineering projects.

Along a 480 m long test line (see Fig. 1), trial measurements using four seismic prospecting techniques were conducted. The results of the refraction diving wave tomography proved to be the most informative ones.

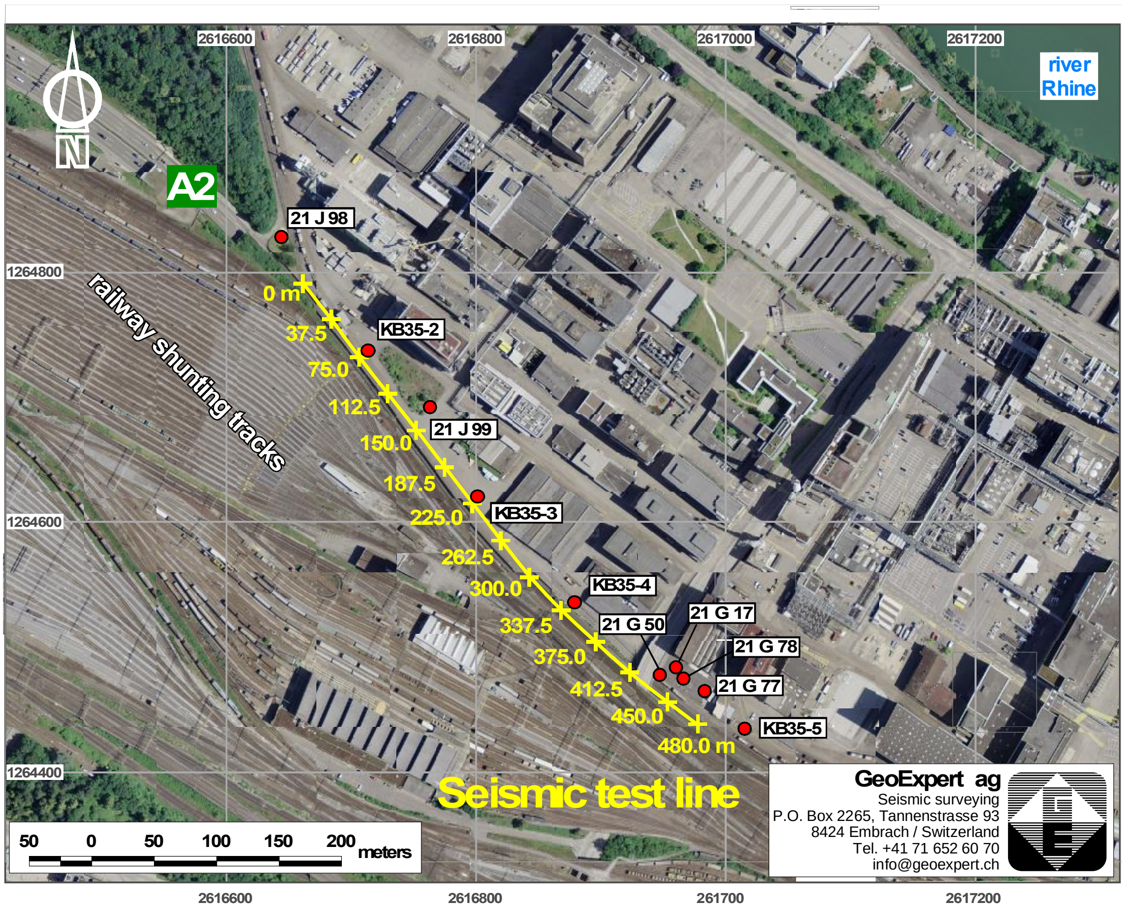


Fig. 1 Seismic trial line in the industrial region east of Basel (Switzerland).

The revealing refraction tomographic velocity field (RTVF)

The focus of the interpretation of the RTVF is on mapping zones with the relatively undisturbed limestone / dolomite bedrock. The seismic propagation velocity (Vp) in this type of consolidated rock is at least 3,500 m/s. Subsoil areas with velocities of less than 3,500 m/s contain either quaternary sediments or material consisting of decay products from karst leaching processes, typically from sinkholes.

In Fig. 2, the behaviour of the iso-velocity contour line for 3,500 m/s (IVCL3500) in the RTVF reveals several zones enclosed by the IVCL3500 and are marked red-white. These zones thus contain karst dissolution decay material.

On the 155 m long south-eastern portion of the profile a zone of about 90 m in length and max. 35 m height is enclosed by the IVCL3500 and is very much in evidence. The broken-up roof, characterized by fragments of harder rock, is bound to collapse in geologically foreseeable time (i.e. already tomorrow or in a couple of 100 years) by the progressive leaching, and with the consequence of a larger spontaneous ground failure.

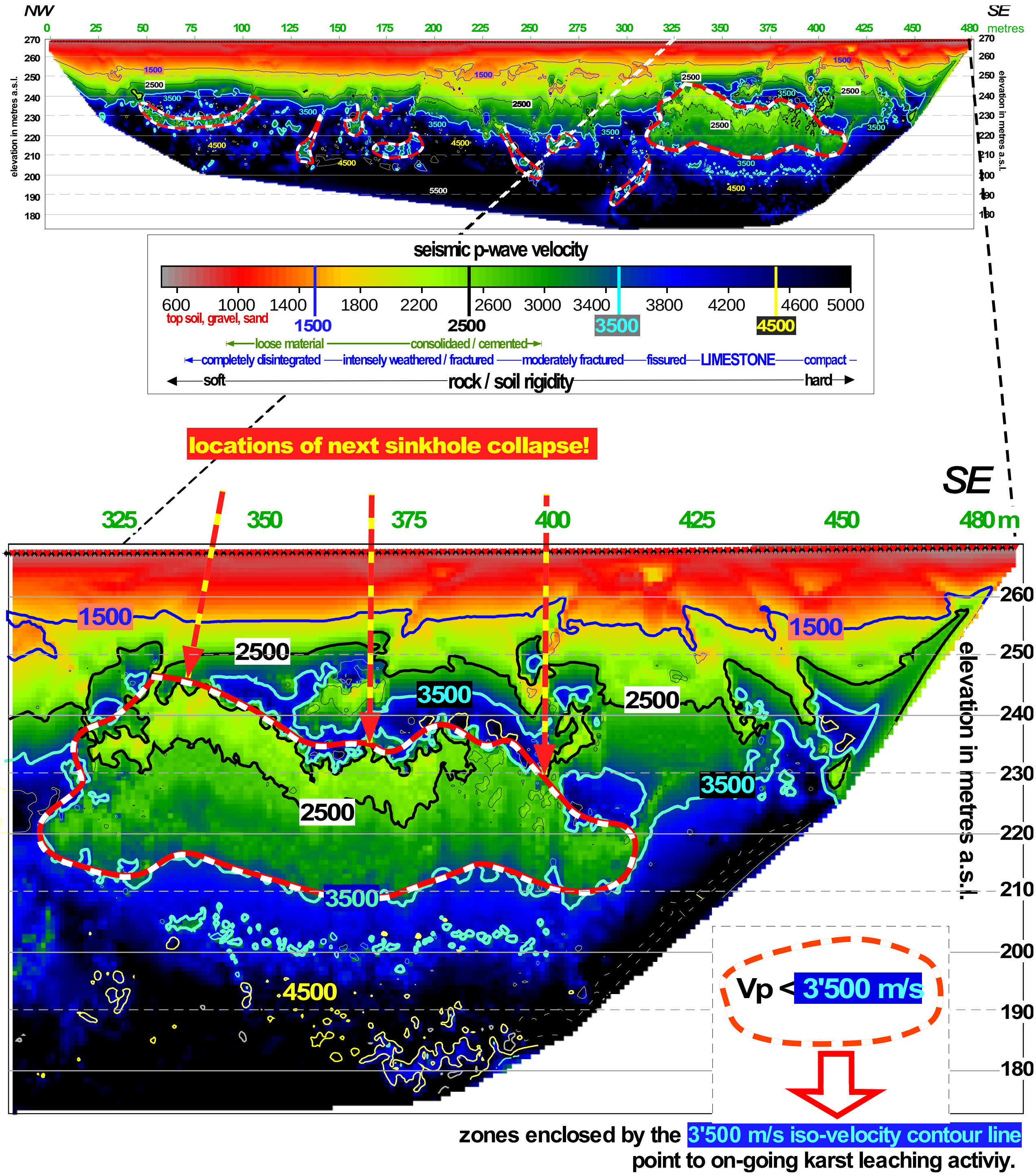


Fig. 2 Emergence of a 90 m long and approximately 30 m high cavity by progressive karstification in approximately 20 m depth

Noteworthy in the upper part of the forming cavity is the softer material with seismic propagation velocities of <2'500 m/s, which indicates a more intense dissolution process here.

Water is the critical agent for karst leaching. On the hybrid seismic profile - the combination of the RTVF with the reflection seismic depth section - of Fig. 3, clear indications of water-bearing fault zones are evident. The groundwater level here is hardly lower than the respective water level in the Rhine river being at a distance of abut 400 m to the north-east from the seismic line.

The intense block faulting tectonics is shown in Fig. 3 by the numerous references to steeply incident fractures, documented also by the fragmentarily still existing roof of the forming cavity.

Note the highly consistent refraction tomographic image of the roof of the sinkhole with its reflection seismic rendering. This spatial congruence of the imaged structures is to be regarded as a quality feature for the reliability and detail accuracy of the images.

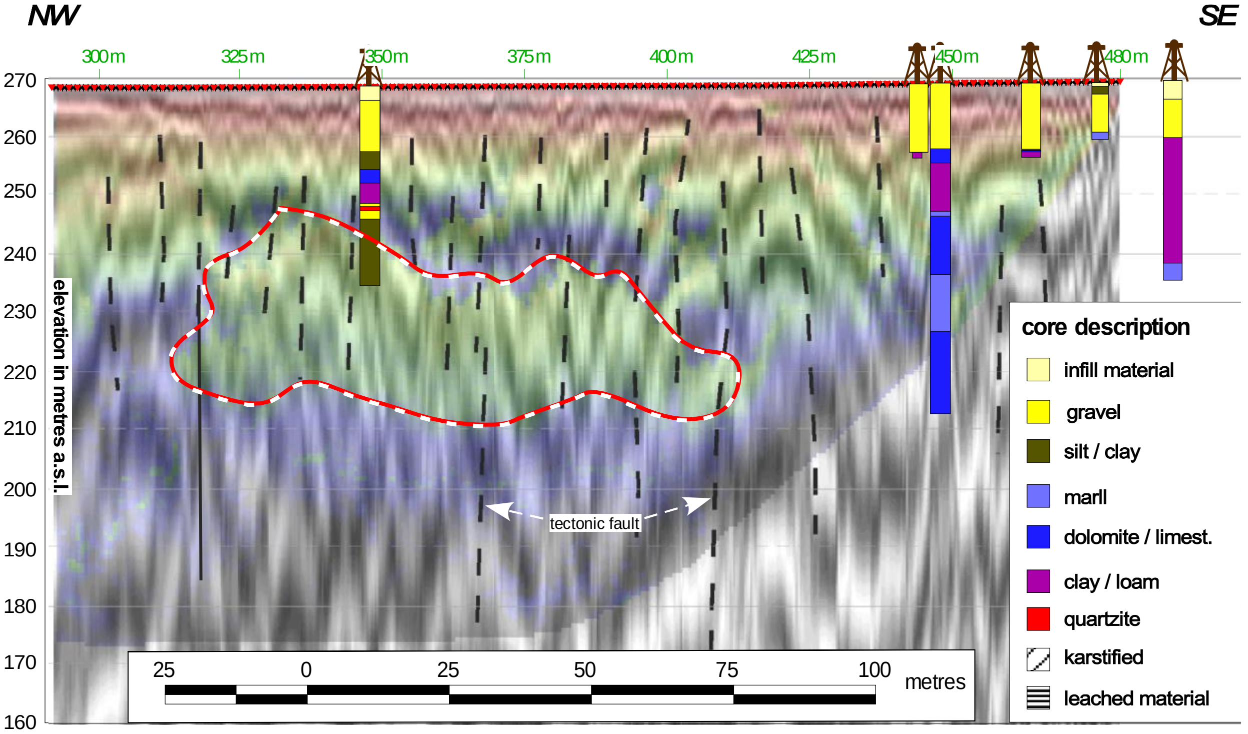
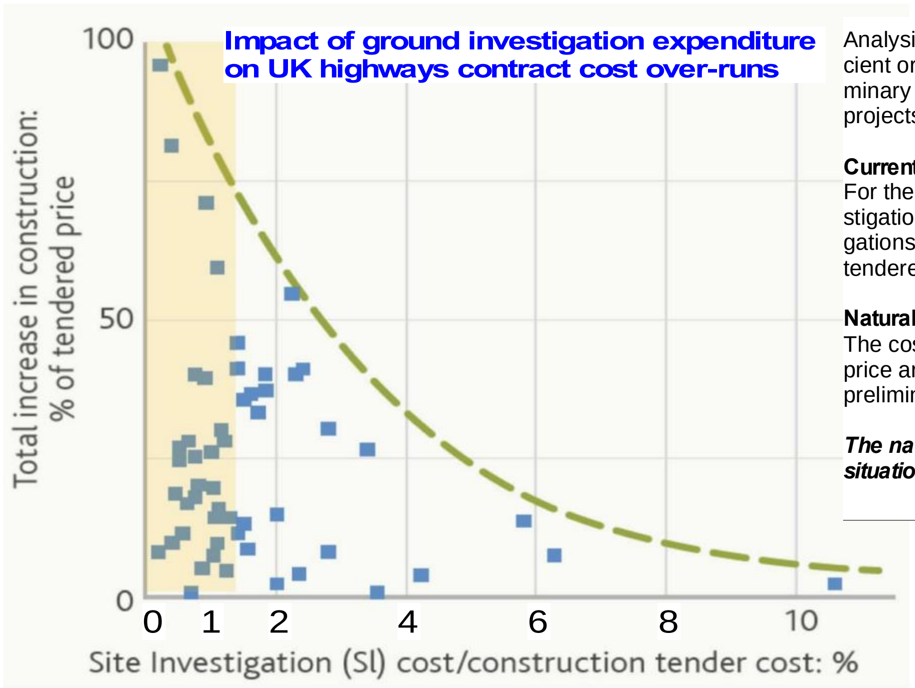


Fig. 3 Hybrid seismic imaging of the forming cavity with evidence of vivid fault tectonics.

The procedure presented here is to be understood as a preventive and cost-effective measure for major construction projects in karst regions.

The principle hereby applies: "*No drilling without prior seismic imaging of the subsurface*"

If this maxim were consistently adhered to, the graphic below would look entirely different:



Analysis and financial implications of insufficient or even non-existent geological preliminary investigations in civil engineering projects:

Current situation
For the vast majority of projects under investigation, the costs of geological site investigations are l**ower than 1.5%** (!) of the tendered price.

Natural law
The cost over-runs in % vs. the tendered price are higher the less money is spent on preliminary geological site investigations.

The natural law is global, the current situation unfortunately seems immutable.

MACDONALD, M., Soil Mechanics Ltd.,1994: Study of the Efficiency of Site Investigation Practices - TRRL Project **Report 60,** Transport Research Laboratory, Workingham, UK;