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Results of measurement with the GPR with abnormal big power output and continual spectrum

Pavel Kalenda, Rudolf Tengler

Extended abstract

The new kind of georadar receiver (GPR) called "Roteg" was built between 2012 and 2018. This Roteg GPR is specified by its wide spectral diapason from 100 kHz to 1 GHz. The wide dynamic range allows using extremely powerful sparking transmitters (by different manufacturers). Using wide range antennas allows to process data in the whole reflective spectrum. The result of these innovations was increasing the penetration depth by one order and maintaining high resolution.

The results of the tests in real environments show the possible maximum penetration depth in limestone, water and glacial moraine in real conditions and the real vertical and horizontal resolution of the detection of various inhomogeneities.

1) The results of karst measurements (detection of caves - Škocjan, Divaška, Postojna)

In 2015 – 2017 we tested "Roteg" GPR at several places (in brackets are positively verified penetrating depths): Pytlíková Cave (20 m) (Kalenda et al. 2016), the Malá Dohoda Quarry (20 m) (Kalenda et al. 2016), below the Na Bradinách Quarry (20 m) (Kalenda et al. 2016), the Holštejnská Cave (40 m) (Kalenda & Tengler 2016), the Spodní Suchdolská Cave (40 m) (Kalenda et al. 2016), the Lopač Cave (20 – 60 m) (Tengler et al. 2016), cave No.561A in the Velká Dohoda Quarry (40 m with 1-m antennas - 150 MHz) (Kalenda et al. 2016), the Amatérská Jeskyně Cave (90 – 110 m) (Tengler et al. 2016), the Pekárna Cave (140 m) (Kalenda et al. 2017a). After such positive results, we tested the most powerful version of …..in Slovenia above the Postojnska – Planinska Jama cave system. We clearly detected the Jama Na Poti Cave (40 m) (Kalenda et al. 2017b), the Črna Jama Cave and the Pivka Jama Cave (60 – 70 m) (Kalenda et al. 2017b), the Postojna Jama Cave(80 – 150 m) and the Planinska Jama Cave (180 m) (Kalenda et al. 2017c).

We verified the maximum penetration depth (and detection of caves, cavities and tectonics) at the measurement behind Divaška jama, Slovenia (Kalenda et al. 2018a). Although we only used 3 m long antennas (central frequency 50 MHz), we detected without any problems the Divaška cave at the depths between 20 m and 80 m in agreement with the

mapping and cross-sections of the cave (Gospodarič 1985). We also found new caves and cavities at the depths of 100 – 150 m (Fig. 1).

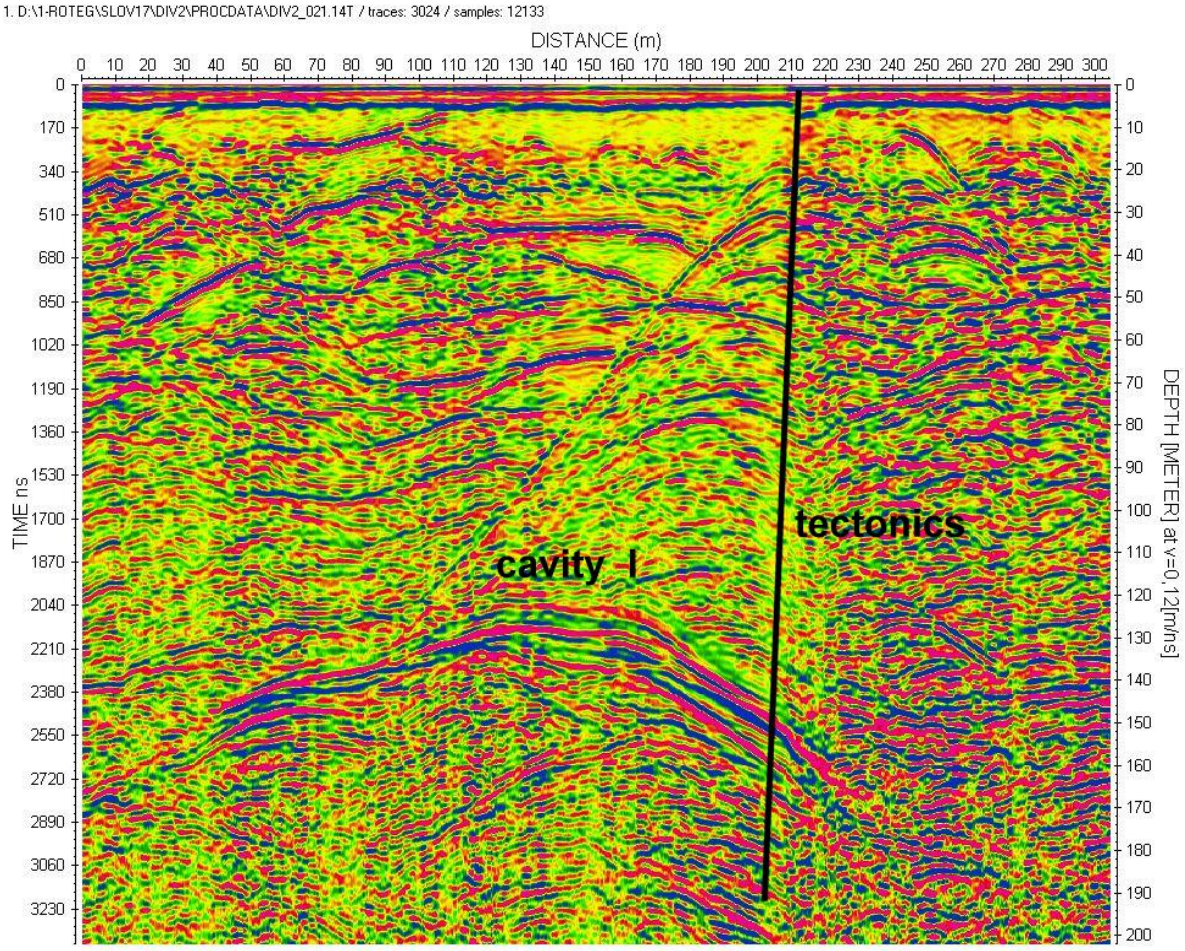

Fig. 1 – Radargram on profile P21 behind Divaška jama with interpretation (adopted from Kalenda et al. 2018a).

In 2017 we found new corridors to the west of Martelova Dvorana in the Škocjan Cave at the depth of 80 – 120 m below the surface. The speleologists from Divača discovered these corridors in 2018 exactly at the places detected before by GPR (Kalenda et al. 2018b, STA_Novice 2019, Kalc-Furlanič 2019).

2) The results of measurement in the quarry

In 2019 we tested the penetration depth in several quarries in Slovenia. The results were verified by drilling holes and geological profile in the vicinity. We clearly detected the thrust plane at the depth of 75 m below surface (Fig. 2). The cavities and tectonics were detected (using 3 m antennas) to the depths of 100 – 150 m.

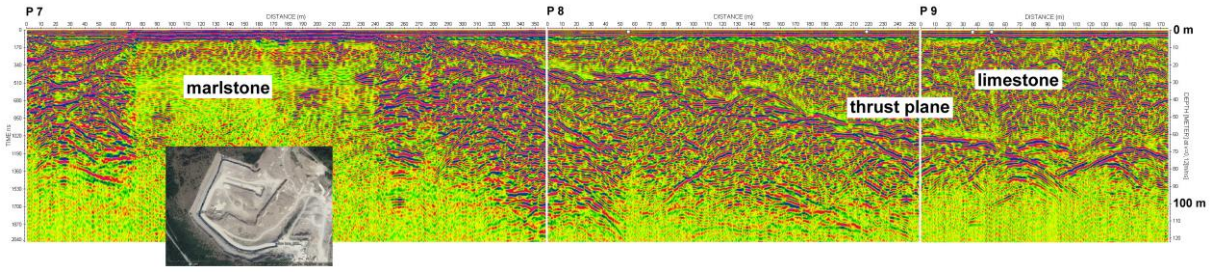

Fig. 2 - Radargram on profiles P7, P8 and P9. The area without reflections marks the part of profile, where marlstone reaches the surface.

3) The test of the maximum penetration depth in the karst

The test of the maximum penetration depth was made in the Malá Dohoda Quarry in the Moravian karst in 2017. We used 6 m antennas (central frequency 25 MHz) and the maximum power output of the newest version of the Roteg GPR (15 kV). The reflections from cavities (filled by water) were detectable on the radargram to the depths of 200 m, which is the drainage base before the Baden transgression (Fig. 3). All of lithological changes are well documented – between Lažánky and Vilémovice limestones and between limestones, clastics and granodiorit in the basement at depths of 350 m, 600 m and 650 m respectively (using the velocity of 9.1 cm/ns).

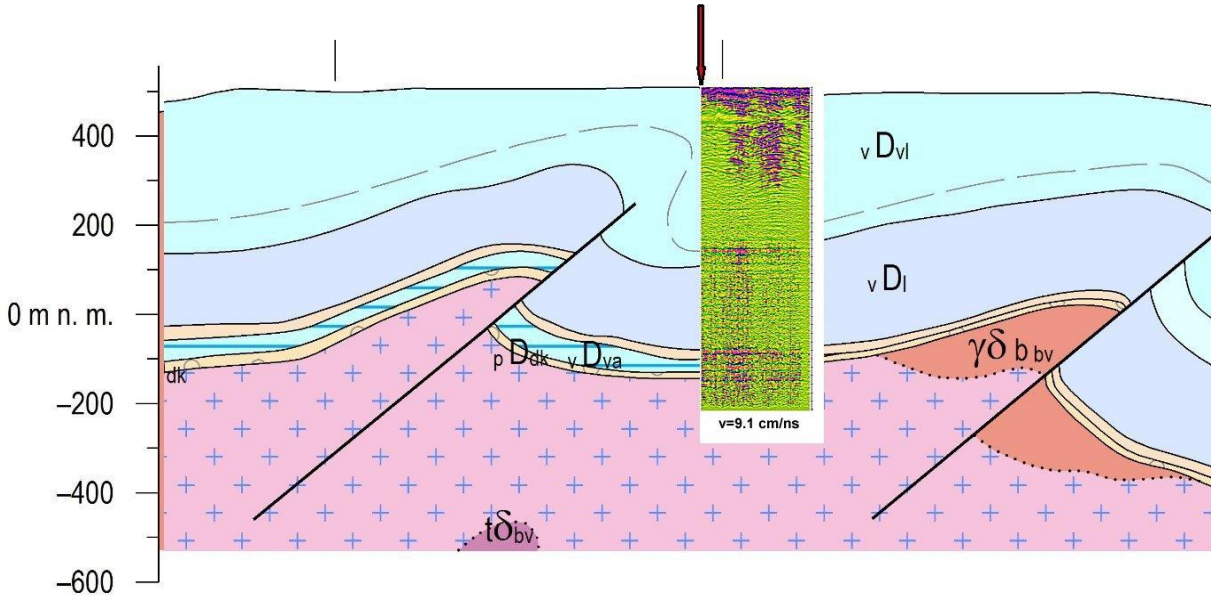

Fig. 3 – Geological cross-section of the northern part of the Moravian Karst (adopted from Baldík 2016). Dvl – devon Vilémovice limestone, Dl – devon Lažánky limestone, Dk – devon basement clastics on sitting on the granodiorites of the Brno massive.

4) The measurements on water surface (Vltava River, Tüttensee, ...)

Thanks to the enormous power output of the Roteg GPR, measurements similar to sonar on the lakes or rivers are possible. The 6 m antennas (central frequency 25 MHz) were used on the Tüttensee Lake, Germany and we clearly recognised the details on the bottom and below the bottom of the lake to the depths of 12 – 15 m.

A similar measurement was carried out on the Vltava River in Prague this year using only 1 m antennas, but with the 20 MW power output. All of details of the river bottom were seen to the depths of 3 – 5 m below the water level (Fig. 4).

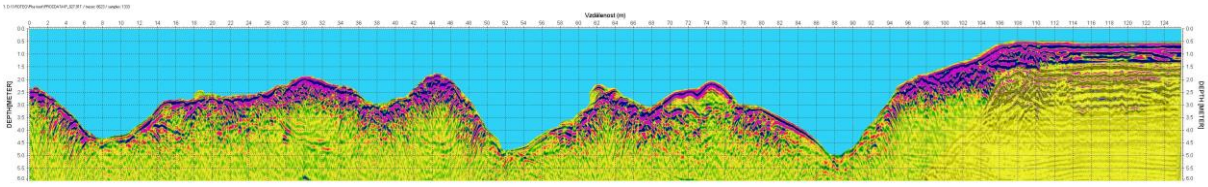

Fig 4. - Radargram on profile P27 along Charles Bridge in Prague.

5) Results

A new kind of GPR called Roteg with enormously high power output (up to 20 MW) was tested at more than 30 localities in the karst, on kristaline rocks and on the lakes and rivers. Due to the high power output, we were able to detect caves and cavities at the depths of more than 200 m, the lithology changes at the depths of more than 700 m (in optimal conditions without soil cover) and the strata below the river bottom at the depths of 15 meters. The horizontal and vertical resolutions were better than 1 m even using the longest antenna of 6 m (central frequency 25 MHz) due to the continual spectrum on the transmitting antenna.

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