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Application of Advanced Seismic Waveform Inversion for Detection of Underground Cavities – A Case Study

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INTRODUCTION AND MAIN RESULTS

Subsurface cavities are characteristic phenomena associated with underground nuclear explosions (UNE) which serve as key indicators during an On-Site Inspections (OSI). Active seismic methods, involving advanced inversion techniques, are essential for detecting these low velocity underground anomalies and to locate the cavity associated with the explosion.

This e-poster presents a case study in which joint travel-time and waveform inversion techniques were applied to seismic data acquired over a known geological cavity in Eastern Hungary. The results demonstrate the effectiveness of these advanced seismic processing approaches in resolving low-velocity anomalies, underscoring their potential utility in real-world OSI scenarios.

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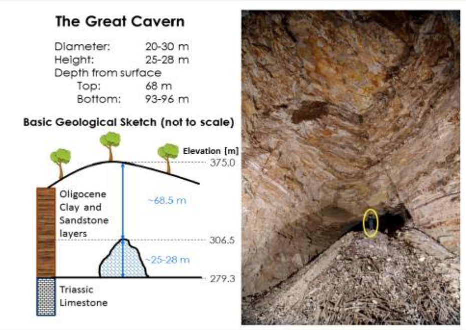
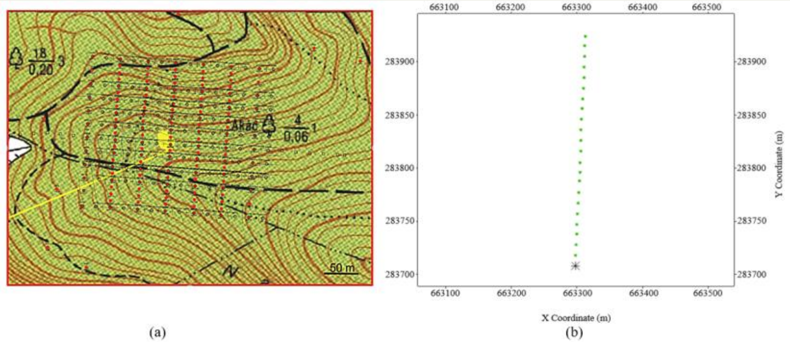
Objective

The feasibility study evaluates the effectiveness of advanced seismic waveform inversion in detecting underground cavities. The seismic data was acquired over a cavity in Romhány, eastern Hungary.

The target is a natural cavity located approximately 70 m below the surface, with an estimated diameter of 25 m (see Fig.1).



(Fig.1)

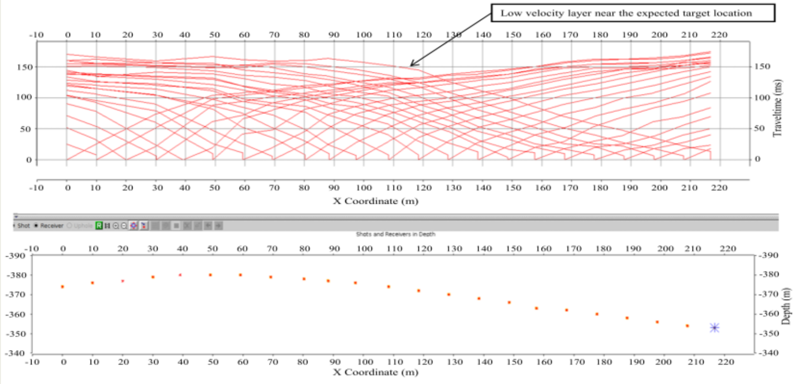


(Fig.2)

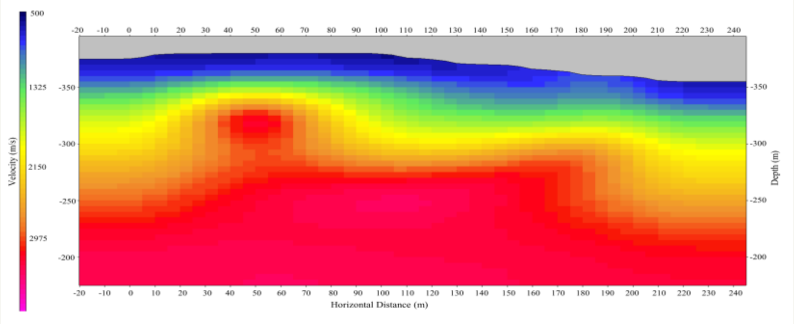
Fig. 2 shows the survey configuration. (a) Red dot is shot station and circles are receiver stations. (b) 2D line over the cavity is extracted for processing with co-located shots and receivers.

Methodology

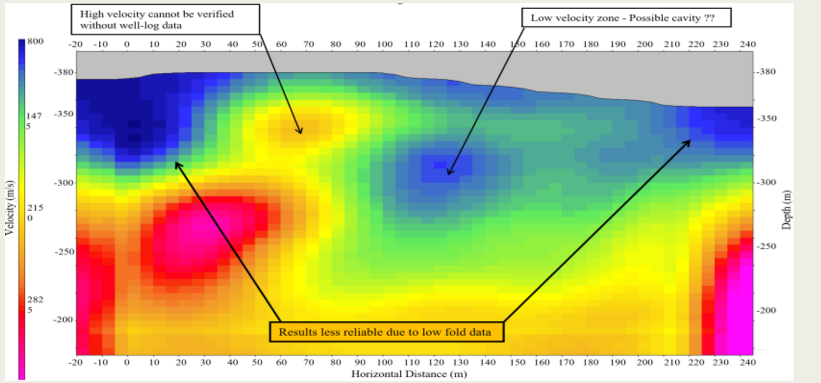
The first-break travel time was computed (Fig. 3), and an initial velocity model was derived from it. These inputs were used to generate an updated velocity using non-linear travel time tomography (Fig. 4). Advanced joint travel-time waveform inversion was performed, to a maximum frequency of 10 Hz, on static corrected shot gathers to delineate the subsurface velocity (Fig. 5).



(Fig.3)



(Fig.4)



(Fig.5)

Conclusion

The inversion result (Fig. 5) highlights a low-velocity zone at a potentially accurate location. However, the target depth may not fully align with the schematic in Fig. 1, assuming the survey line passes through the depicted position. Results at either end of the model are less reliable due to low data fold in those areas. While the ground truth of the result cannot be fully verified in the absence of well-log data, the study successfully demonstrates the potential of advanced seismic waveform inversion for detecting underground cavities. These findings support further investigation and application of such methods in On-Site Inspection scenarios.