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CONFERENCE & EXHIBITION
NEAR SURFACE GEOSCIENCE'19

10th International Workshop on Advanced Ground Penetrating Radar

Using GPR on a problematic agricultural field for groundwater protection in a karst environment

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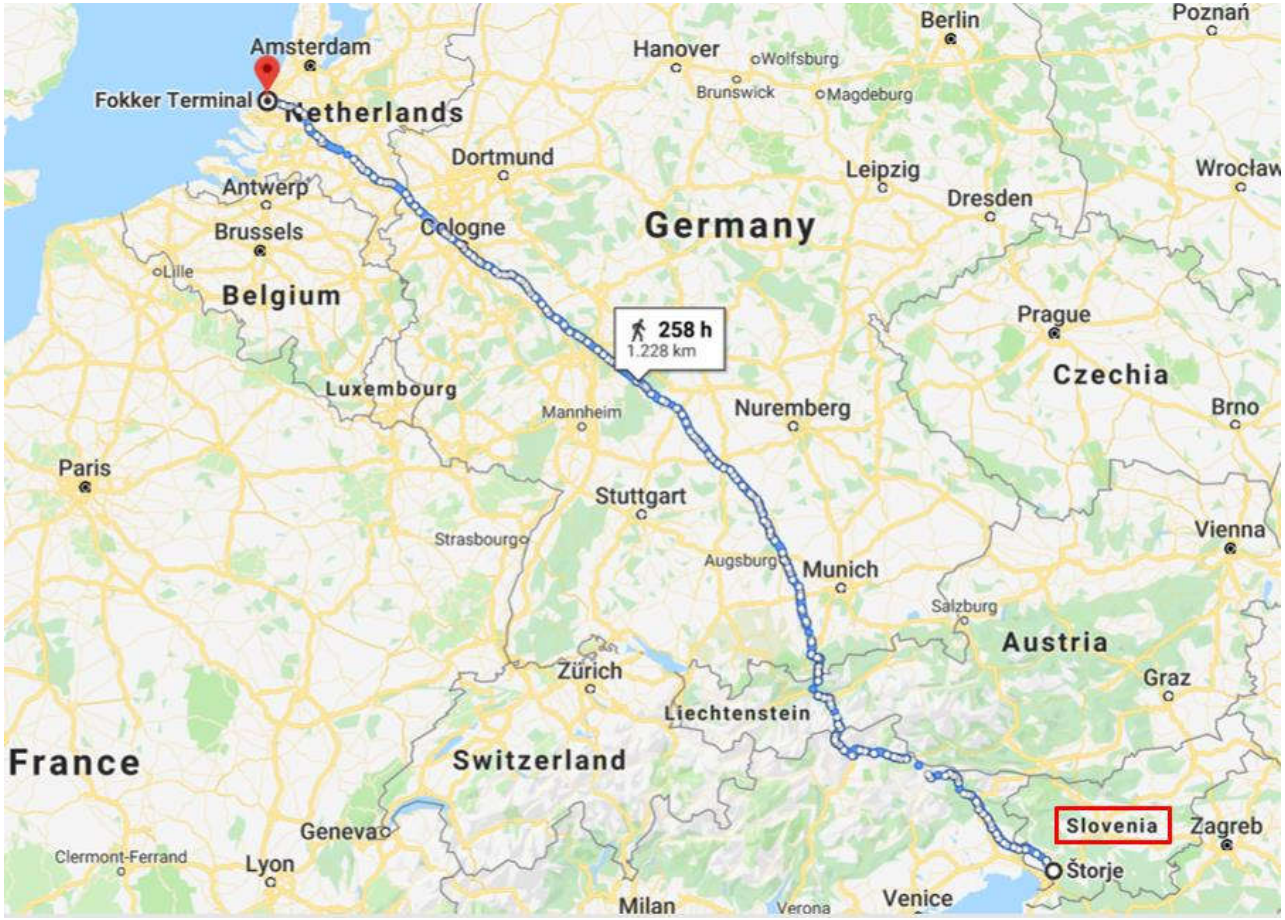
EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND

REPUBLIC OF SLOVENIA
MINISTRY OF EDUCATION, SCIENCE AND SPORT

VITRUM LASER
3D Visualization Technologies

Introduction

- Problematic agricultural field
- Karst aquifer
- Groundwater vulnerability
- GPR survey
- GPR results
- Borehole televiewer data
- Conclusions



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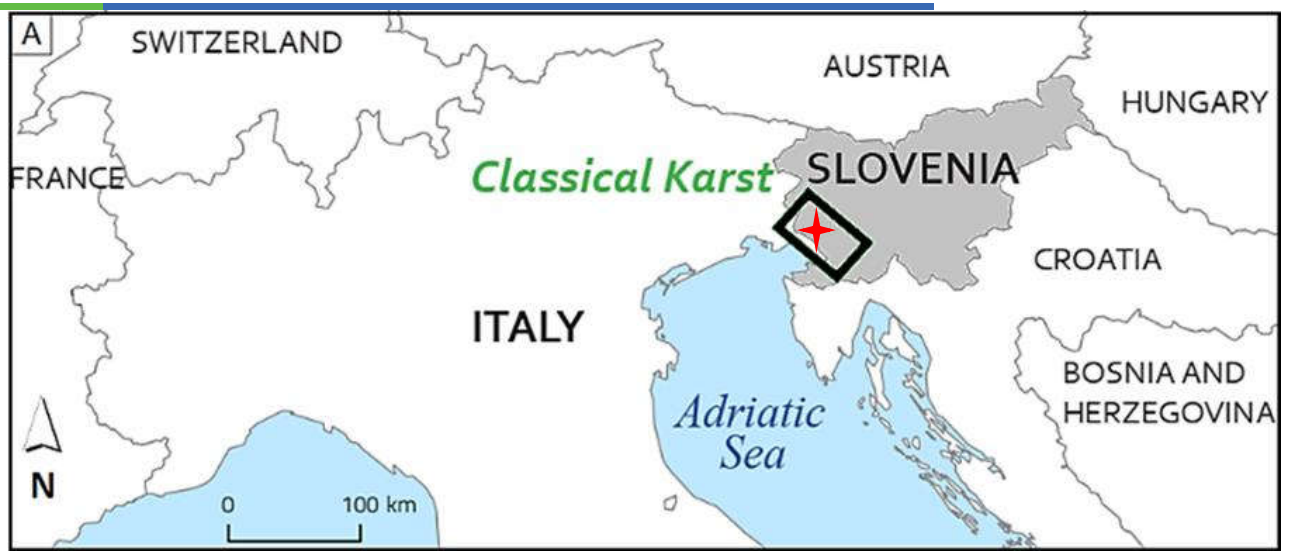
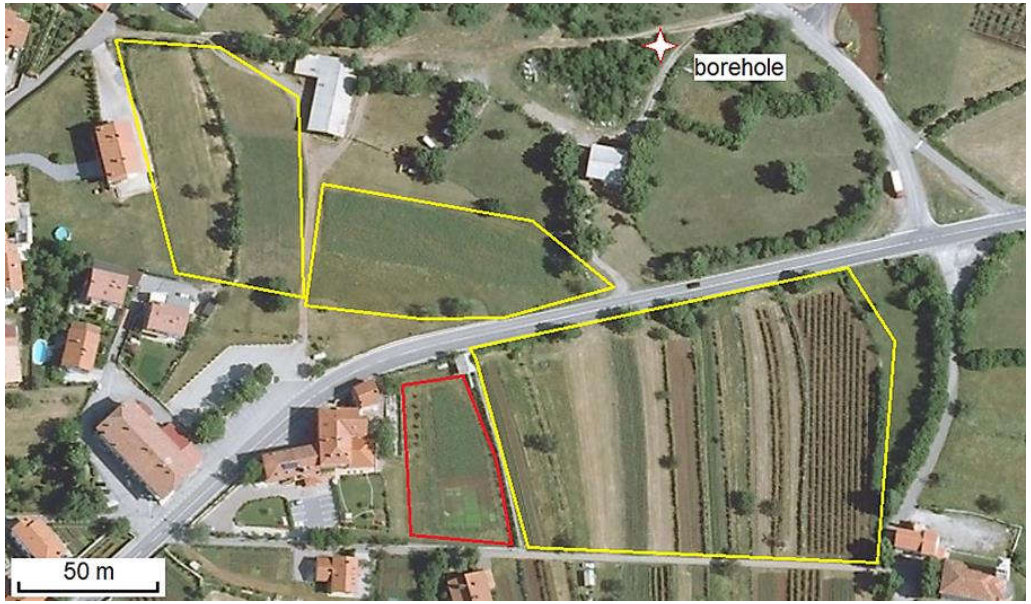
Problematic agricultural field

- Situated in a karst area
- No problems on neighbouring fields (yellow)





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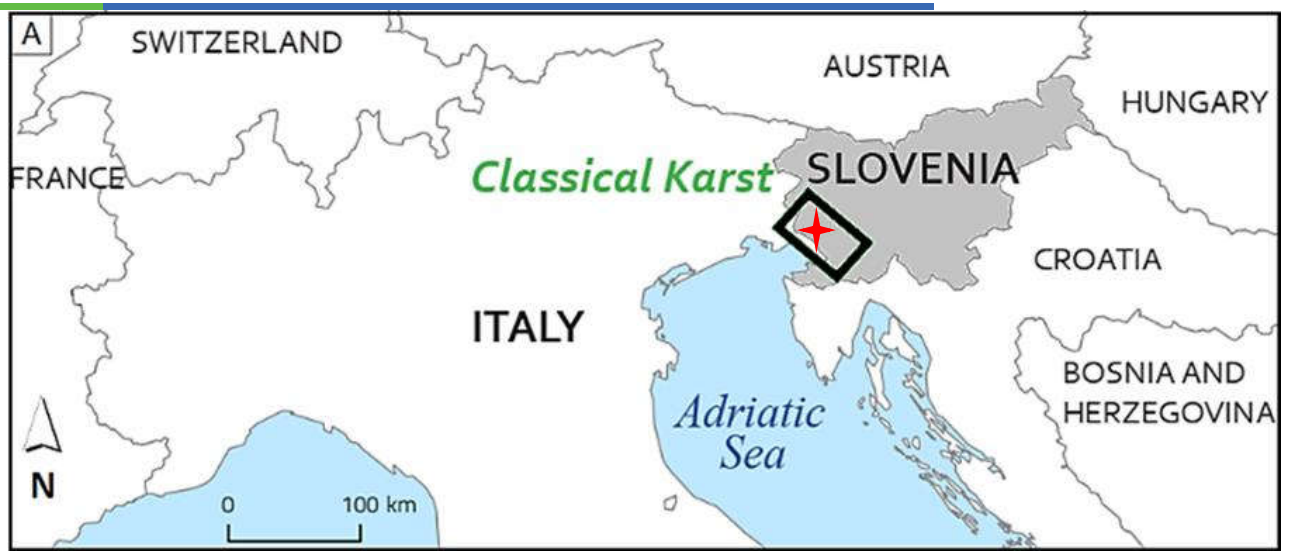
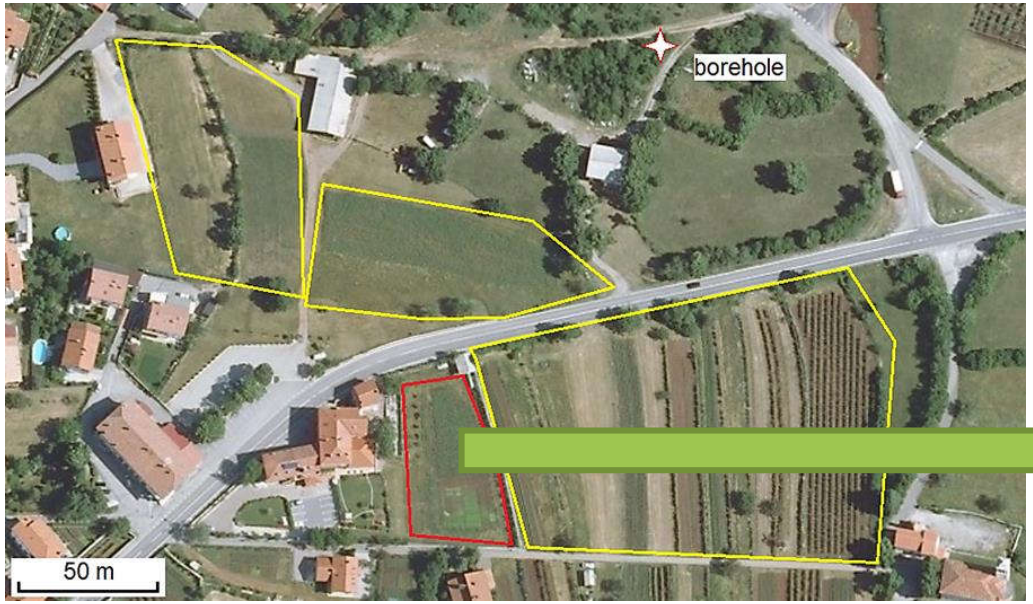
Problematic agricultural field

- Situated in a karst area
- No problems on neighbouring fields (yellow)
- Patchy and poor growth despite additional irrigation and fertilization (red)





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Karst aquifer

- **Classical karst aquifer:**
  - important transboundary aquifer
  - vital source of drinking water for Slovenia and Italy
  - specific hydrogeological conditions
    - → complex and heterogenous area
    - → high groundwater vulnerability
  - remains inadequately protected (Turpaud et al., 2018)

Turpaud, P. et al. 2018. Development of a protocol for the karst water source protection zoning. Application to the Classical Karst Region (NE Italy and SW Slovenia), Water Resources Management, vol. 32, 2018, pp. 1953–1968

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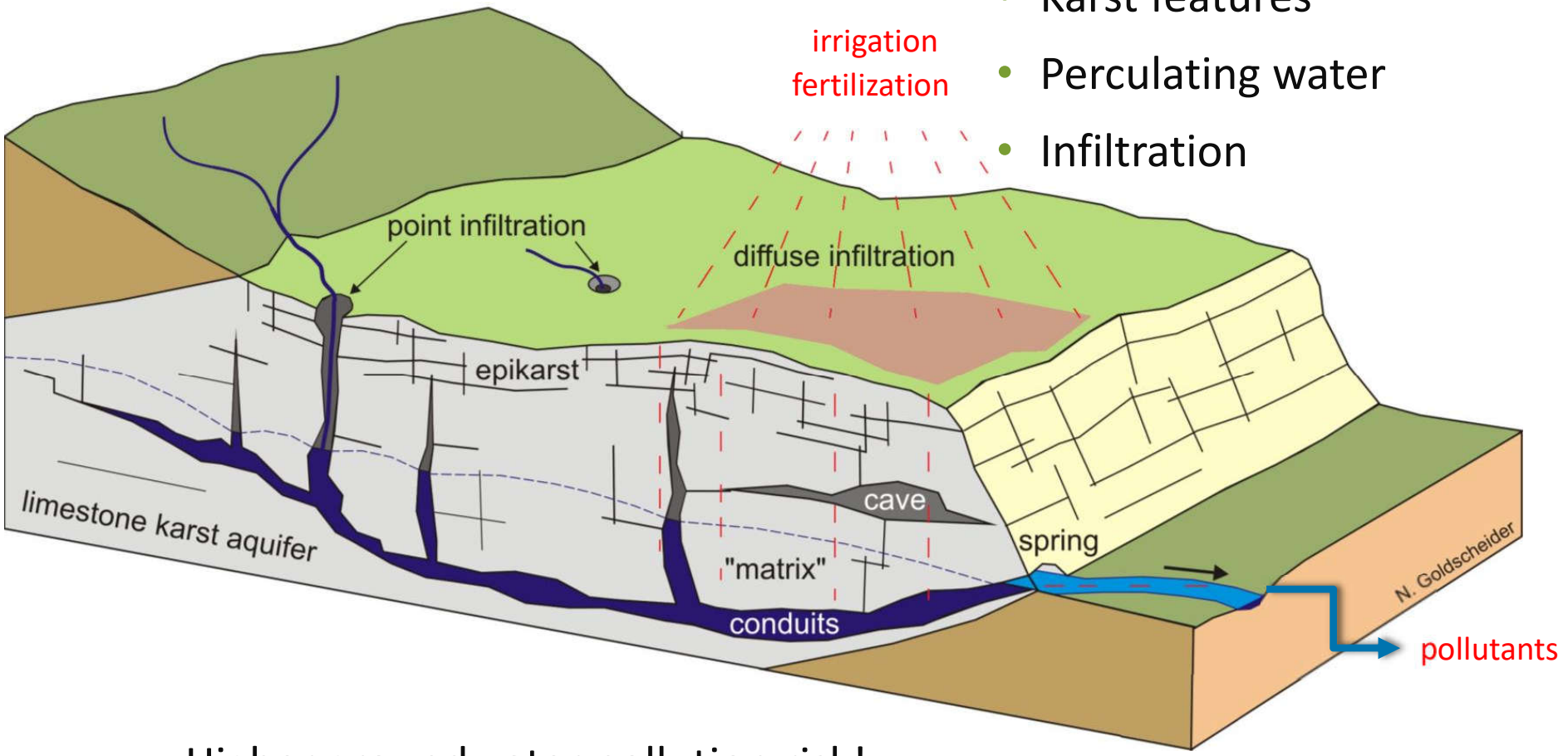
Karst aquifer + agricultural field + pollutants

- Thin soil cover
- Karst features
- Perculating water
- Infiltration



Higher groundwater pollution risk!

Goldscheider N, Drew D (eds) (2007) Methods in Karst Hydrogeology. International Contributions to Hydrogeology 26, International Association of Hydrogeologists, Taylor & Francis, London, 264 pp

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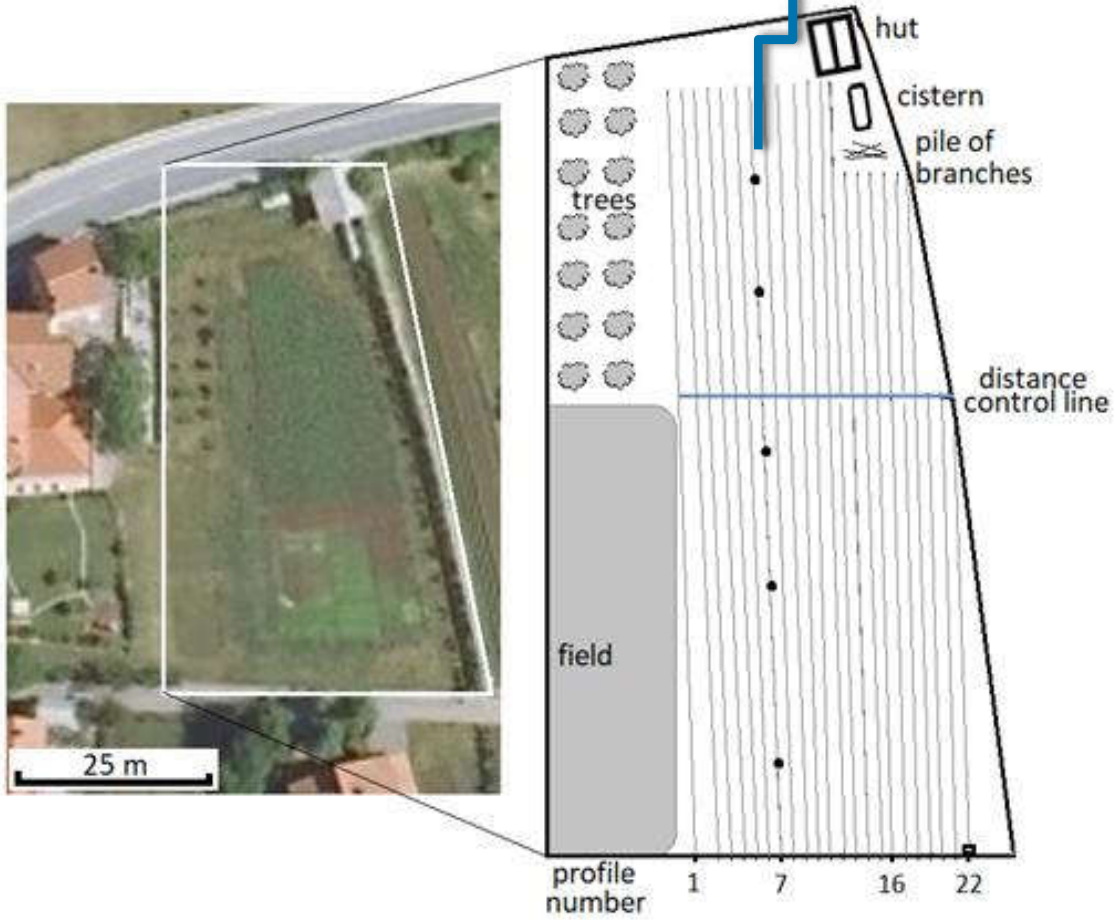
GPR survey

- 22 GPR profiles across the entire field
- Malå ProEx recording unit,

  250MHz, 500 MHz antennas
- Parallel profiles 1 m apart
- Wheel aquisition mode 0.02 m
- Top soil thickness calibration:

  digging of 5 holes along P7
- Processing in ReflexW Sandmeier
  - Time-zero adjustment
  - DC shift
  - Background removal
  - Gain
  - Bandpass filtering
  - Time-to-depth conversion by hyperbola fitting



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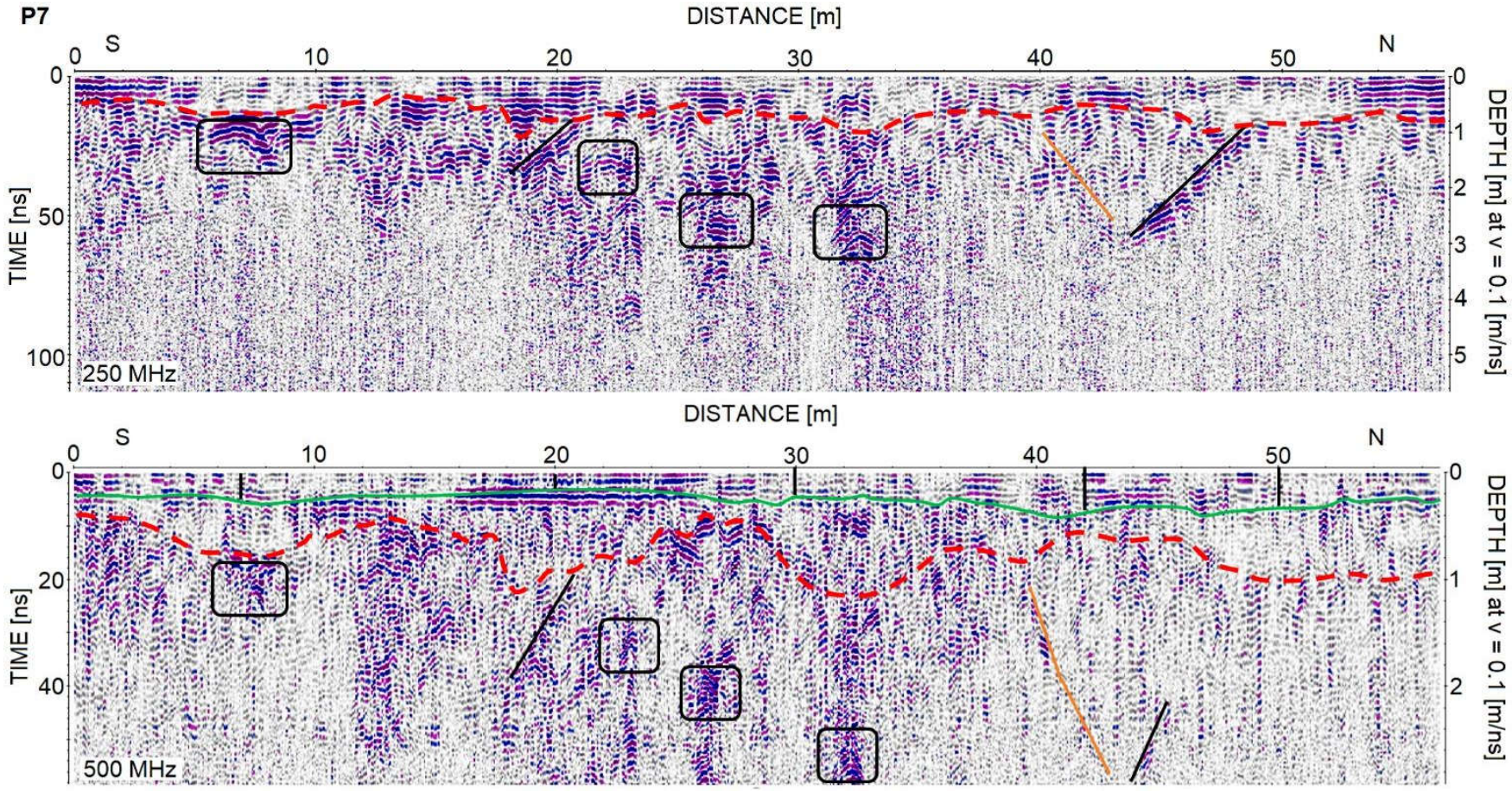
GPR results

- Profile 7: soil cover much thinner than previously thought – only 17 to 32 cm!



- Top soil depth (green line), south-dipping discontinuities (black lines), cavities (black frames)
- Transitional boundary between less/more compact limestone (dashed red line)

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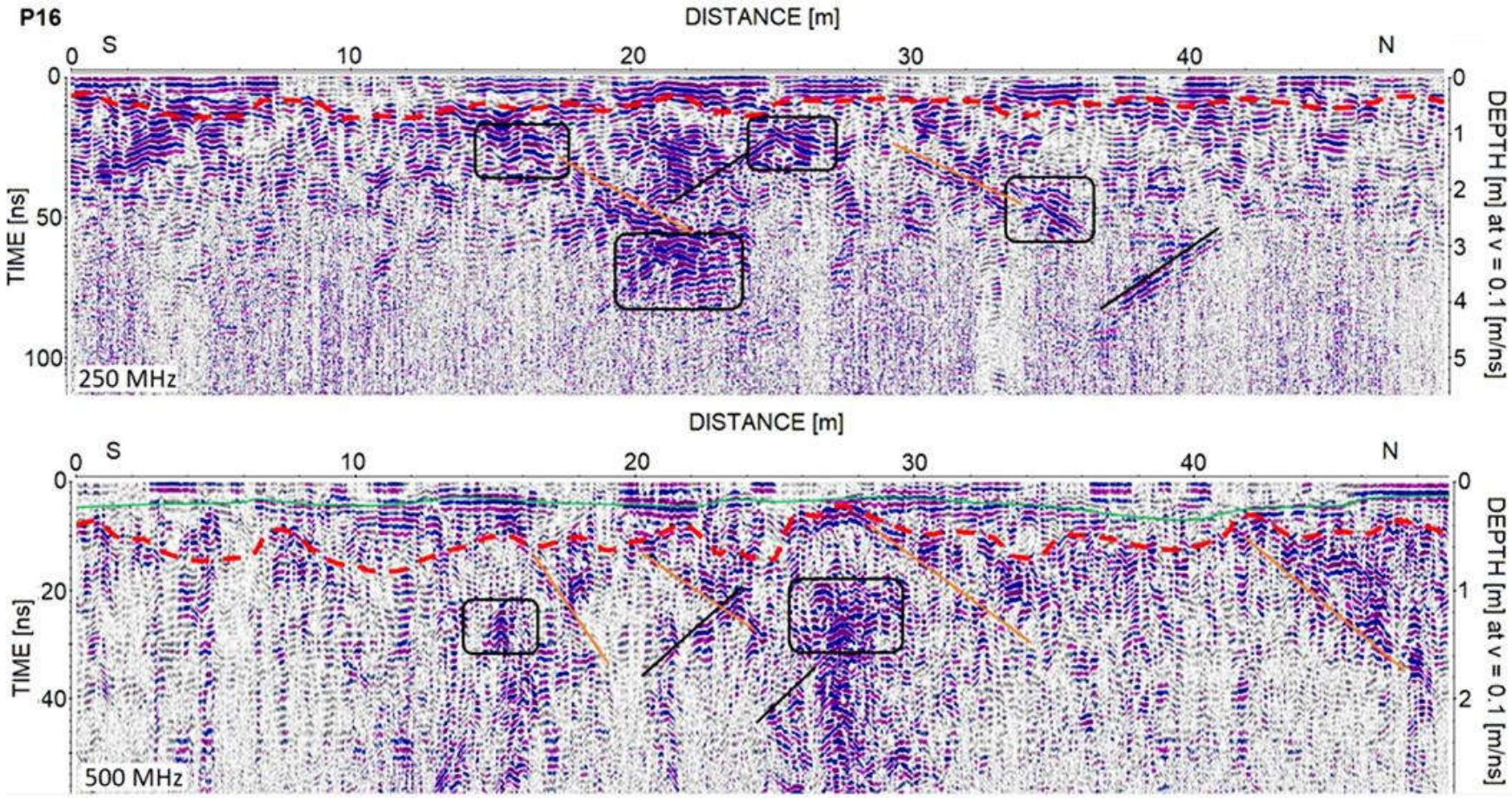
GPR results

- Profile 16



- Top soil depth (green line), south-dipping (black lines) and north-dipping (orange lines) discontinuities, cavities (black frames)
- Transitional boundary between less/more compact limestone (dashed red line)

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Borehole televiewer (OBI – optical borehole imager)

- Produces a continuous image of the borehole wall in 360°
- Unwrapped image shows sine wave patterns of dipping discontinuities

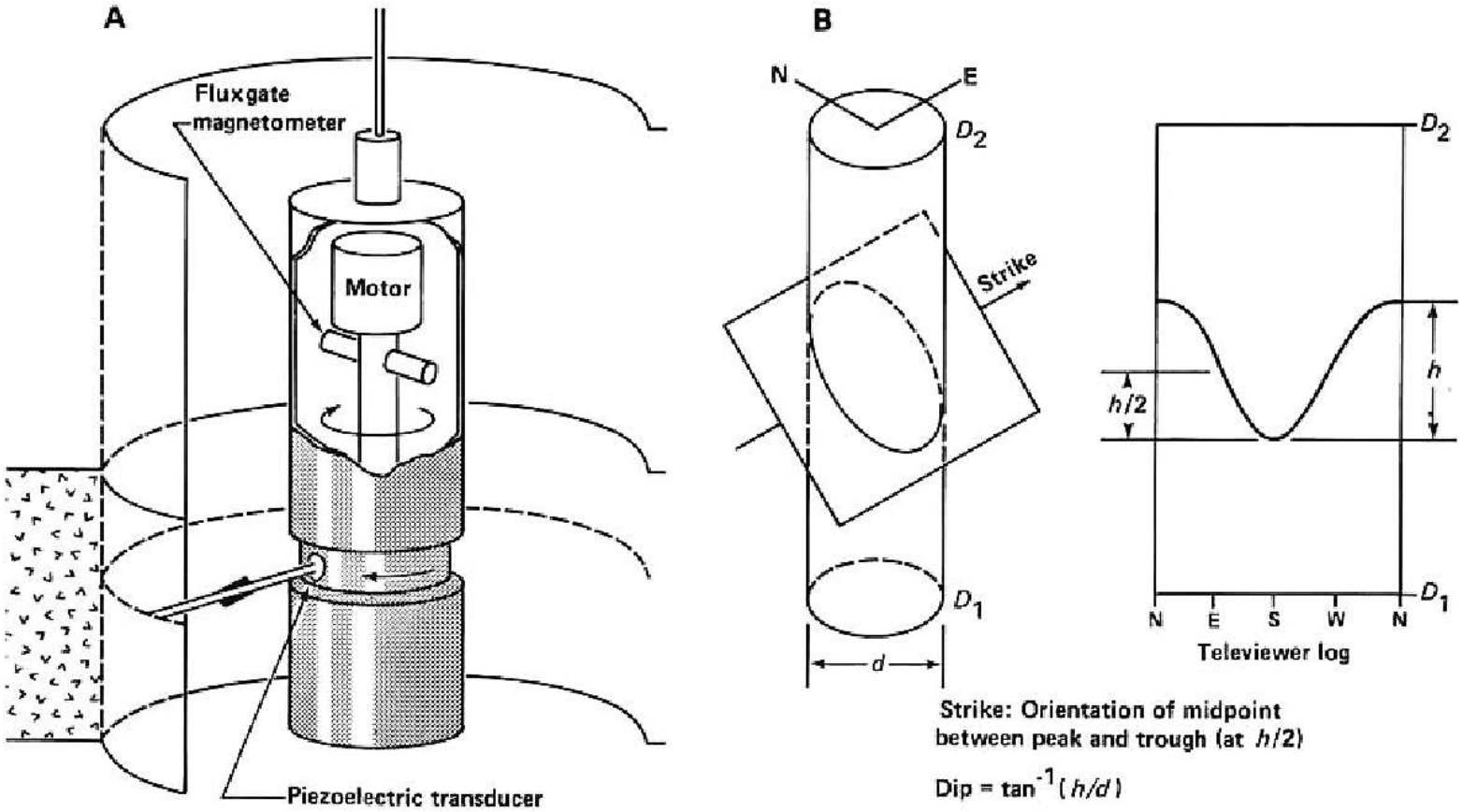

Image: Zemanek et al. 1970. Formation evaluation by inspection with the borehole televiewer.

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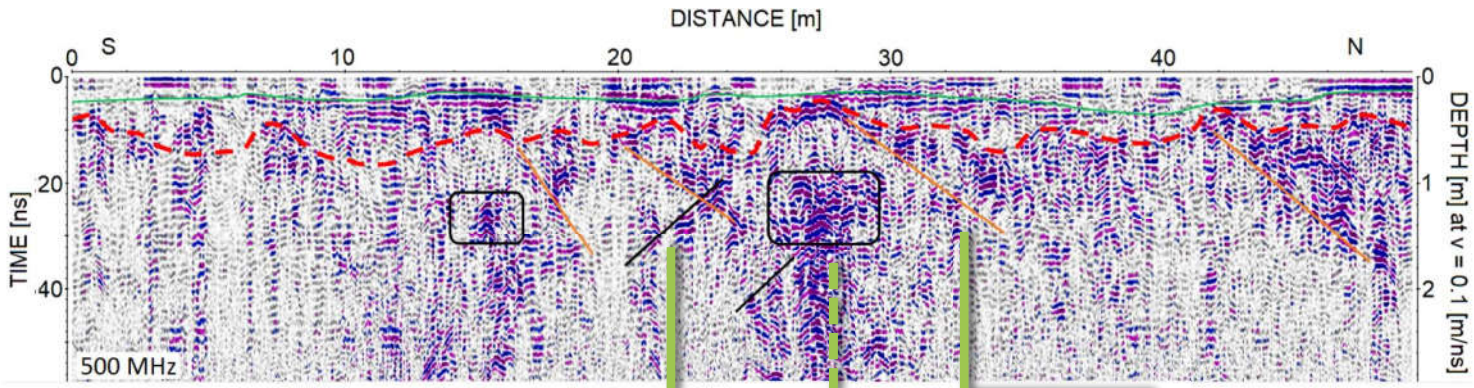
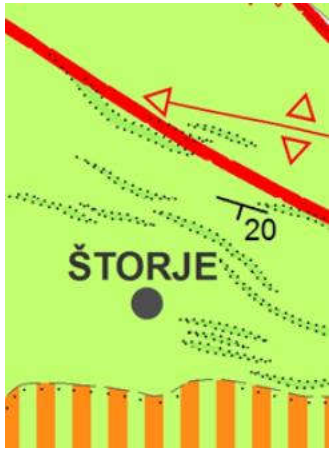
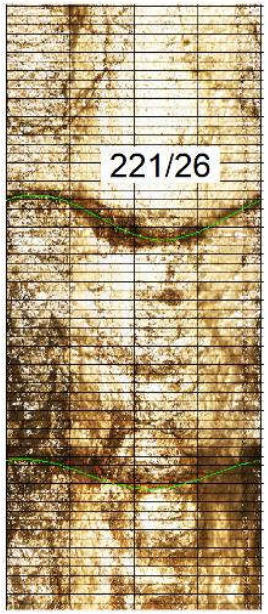
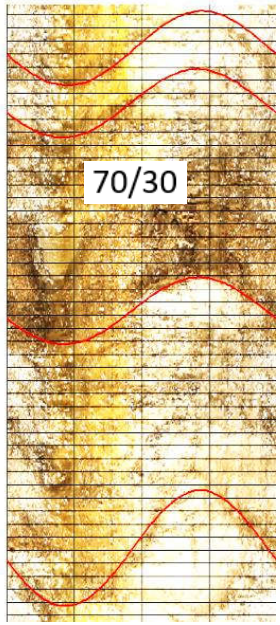
Comparison of GPR and borehole televiewer results









limestone bedding cavities fractures

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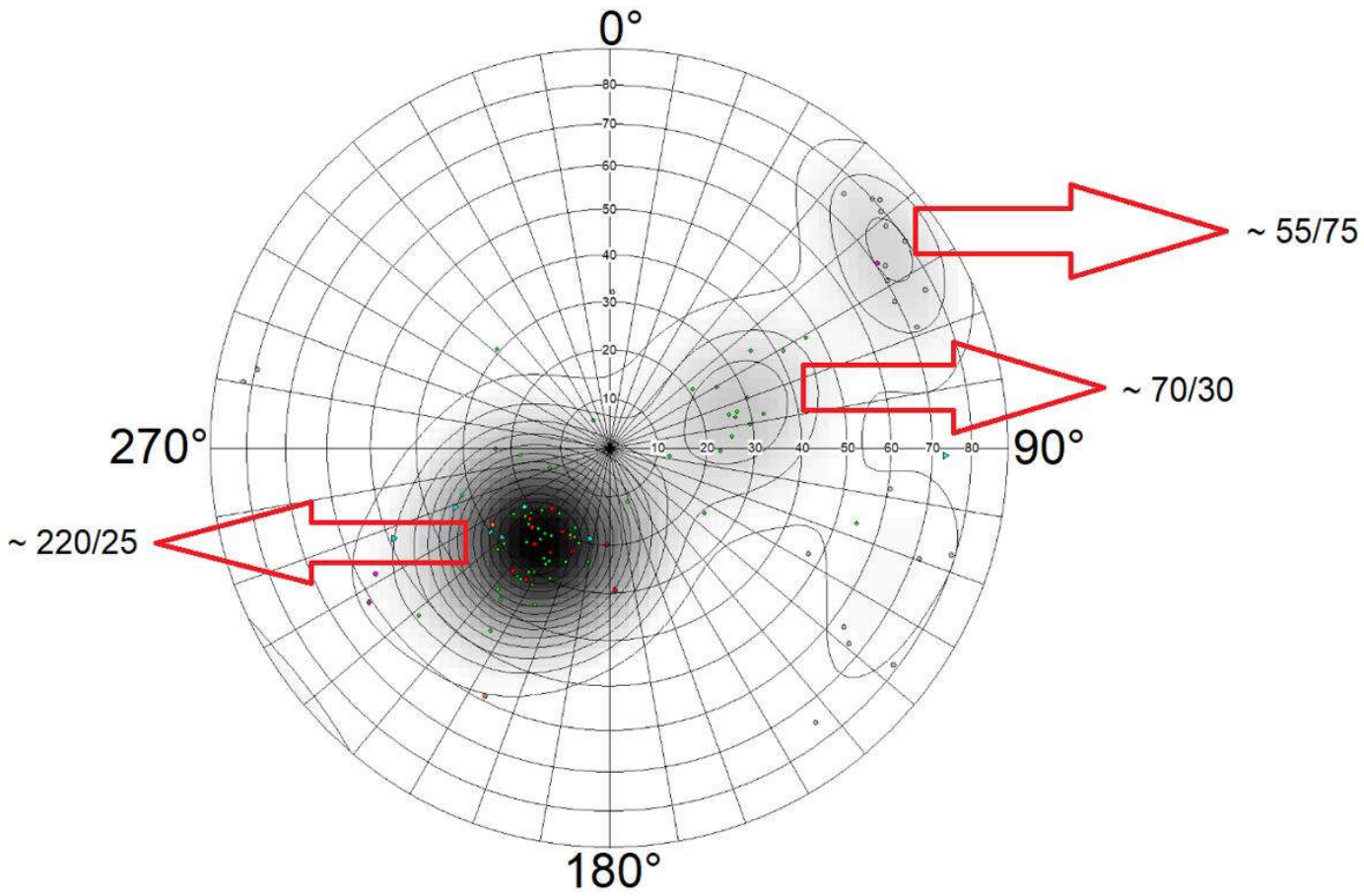
Borehole televiewer results

- Schmidt plot of discontinuities in borehole (196 m deep) with average azimuths and dips



Conclusions

- 500 MHz → top soil thickness more accurate (32 cm to 17 cm)
- 250 MHz → discontinuities more pronounced (different sets)
- Both antennas → presence of karst cavities
- Reduced crop growth = thin soil cover + karstified limestone

- GPR results confirmed with borehole logs

- Additional irrigation and fertilization would increase groundwater pollution risk

  -> owner will no longer use this land for agricultural activity

- GPR useful for more accurate groundwater vulnerability and risk assessments

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Thank you for your attention.

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