Extensive muographic survey of Esztramos Hill

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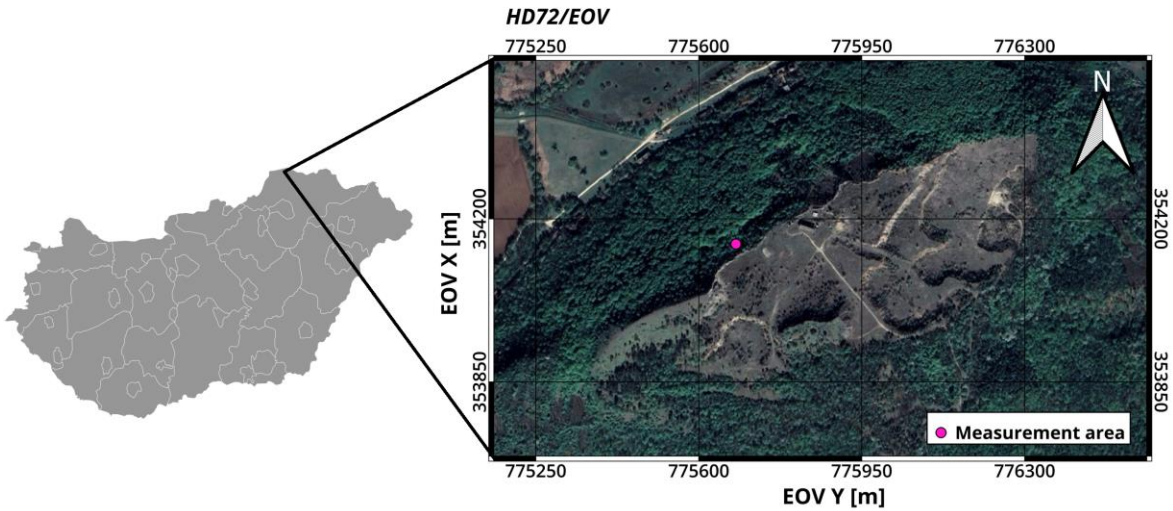
Motivation behind the study

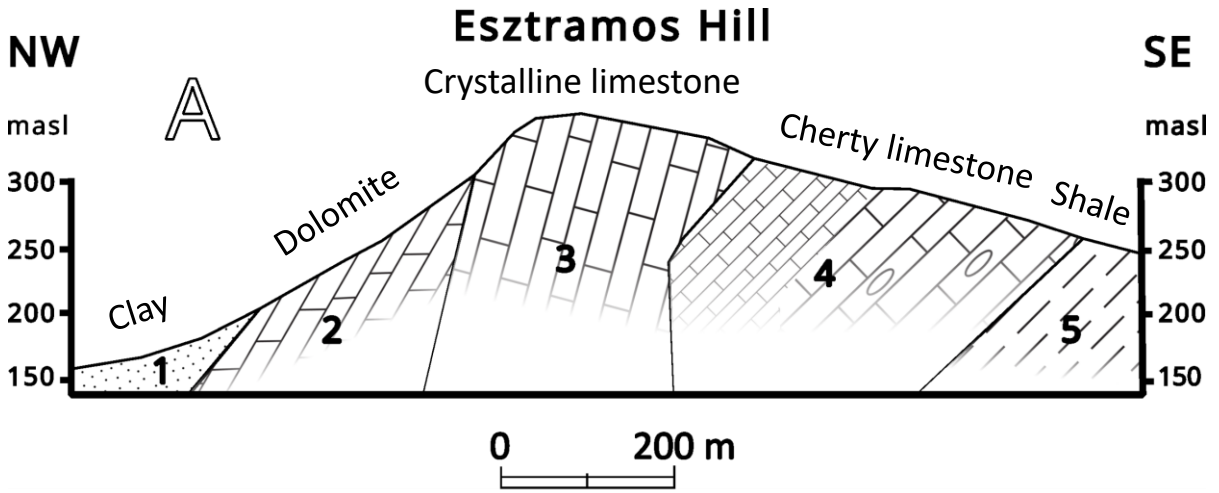
- Abandoned mines provide **suitable measurement locations**
- Limestone quarry → the top is flat and exposed → easy to create an **accurate topographic model**
- **Many possible targets**: inaccessible parts of the mine, cave systems (UNESCO World Heritage)

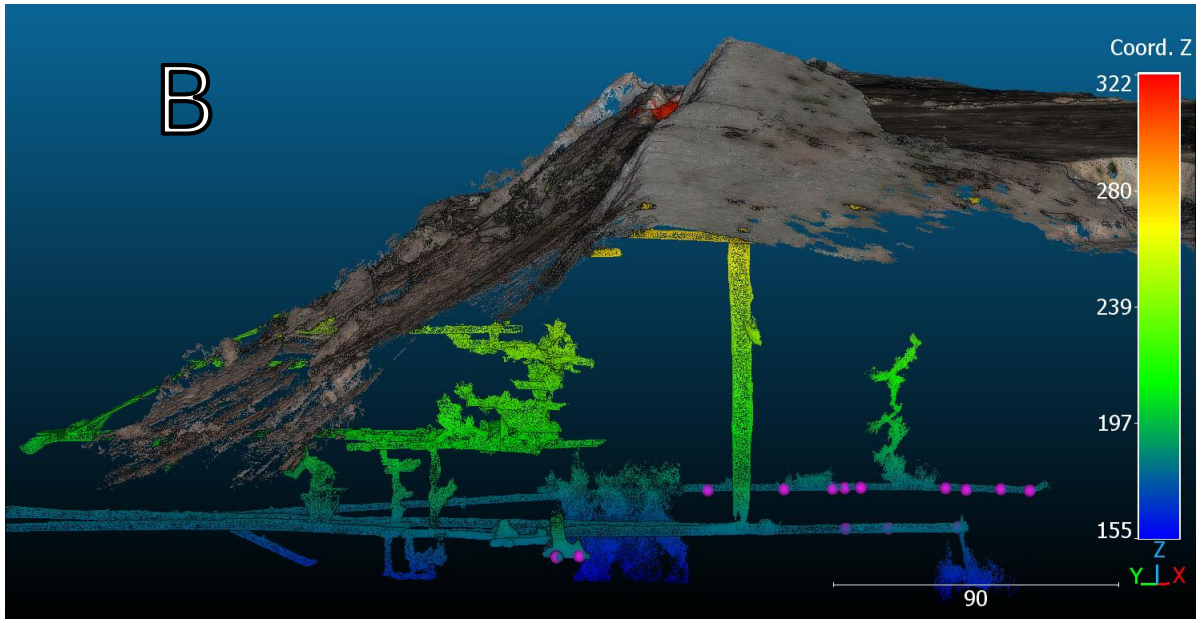
Overview of the measurement area

- The hill is mostly made up of two types of limestone and dolomite → iron ore deposites and **caves formed on the geological boundaries**
- The hill hosts an abandoned iron ore mine → **three main drifts at ~120-140 m depth** provide excellent measurement locations



Location of Esztramos Hill inside Hungary





A: Geological profile of Esztramos Hill

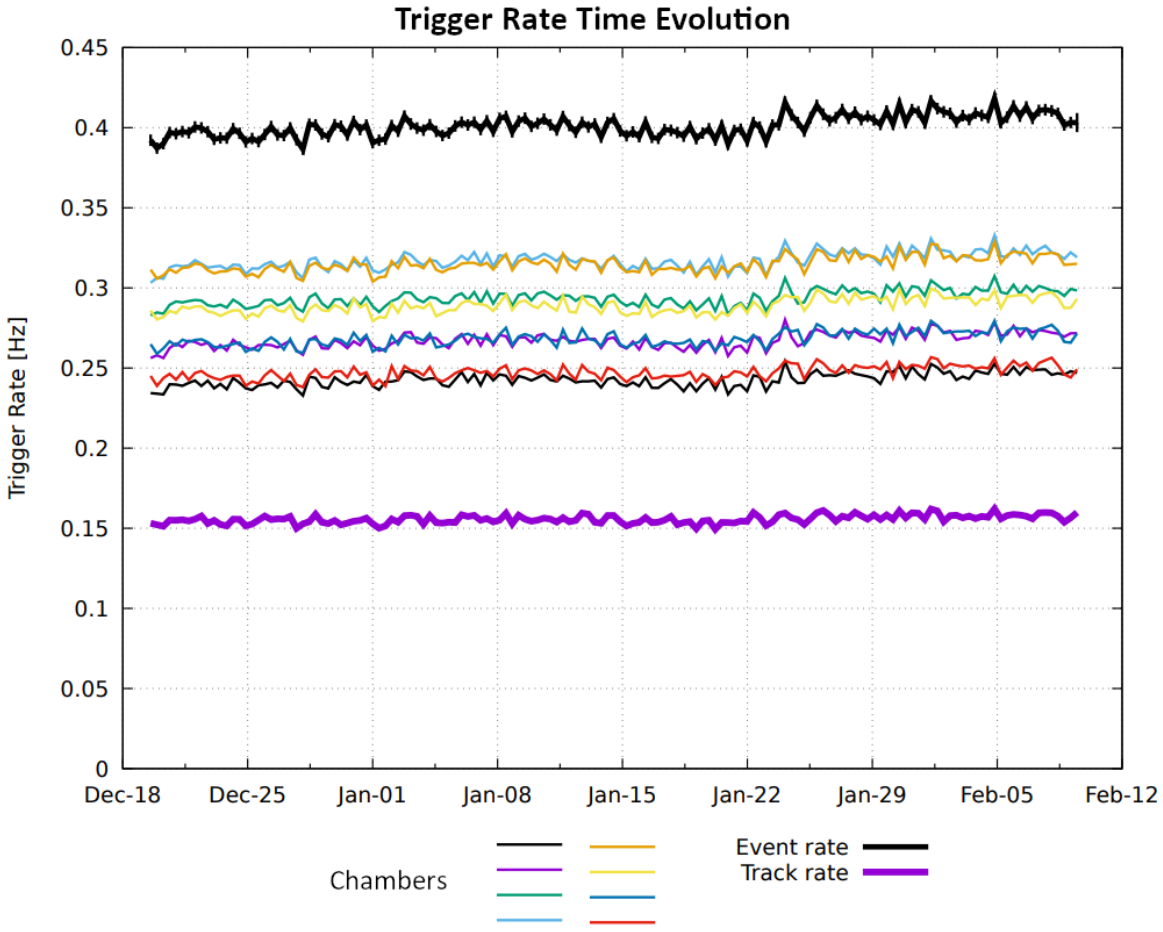
B: The laser scanned cavities and surface

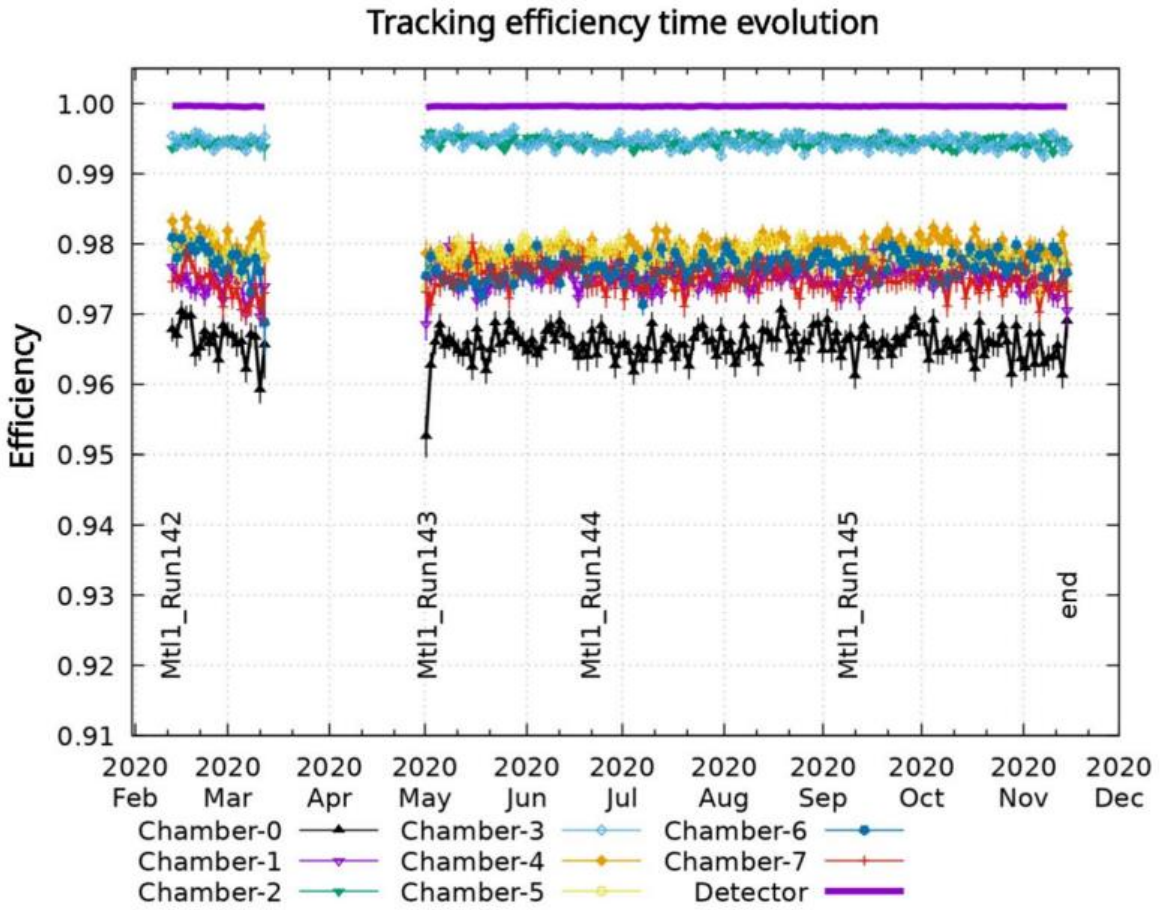
Deployed detector systems

- Most of the campaign was done by the **80x80 cm MWPC** detector system with 8 chambers (Mtl-1)
- Last year **two 50x50 MWPC** systems were added (8 chambers each)
- Power source: local eletrical grid, gas refill: every 2-3 months

Deployed detector systems

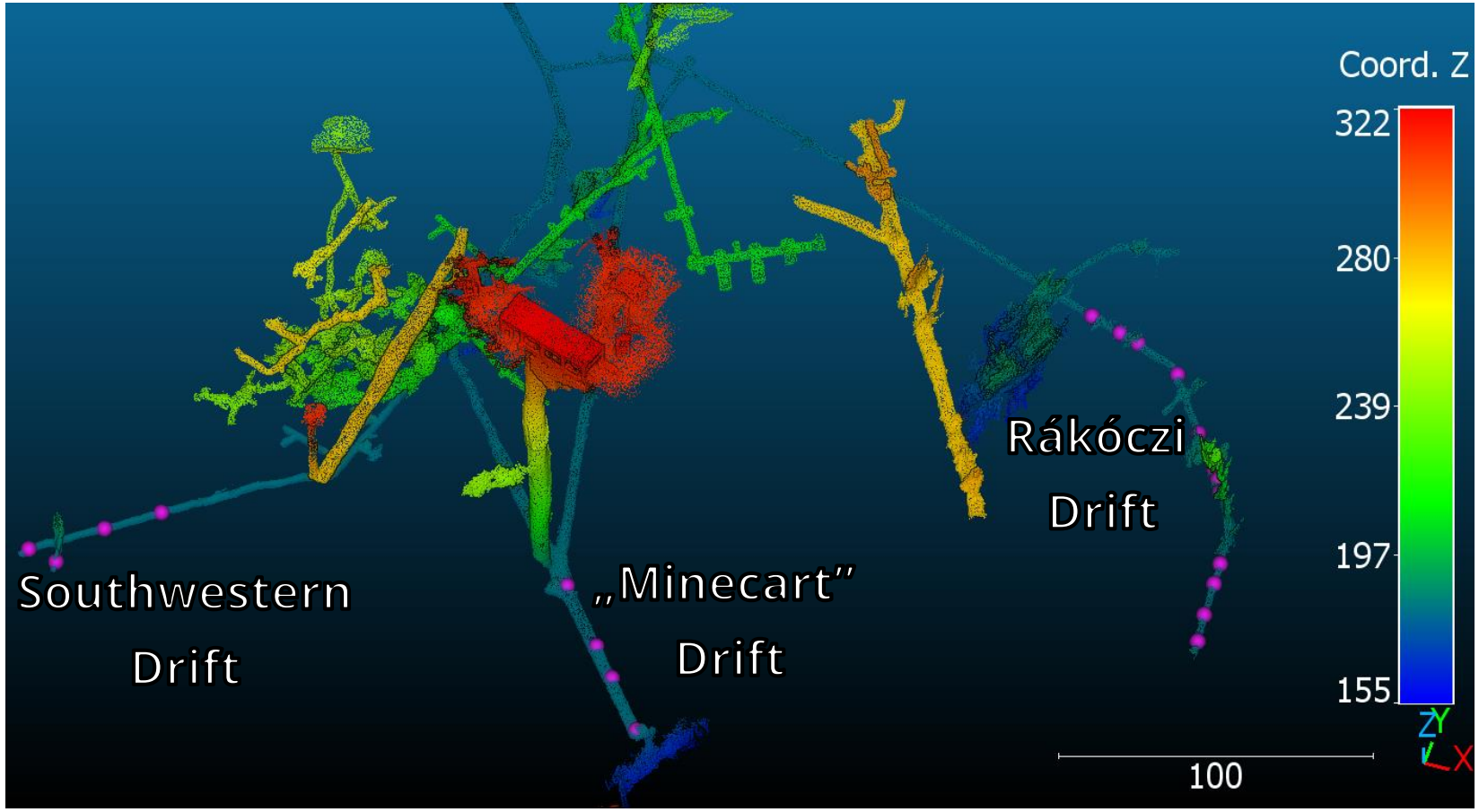
- Low evergy parts of the spectrum are absorbed by the rock above → **negligible scattering, constant track rate**
- **Tracking efficencies** were **above 99%** consistently





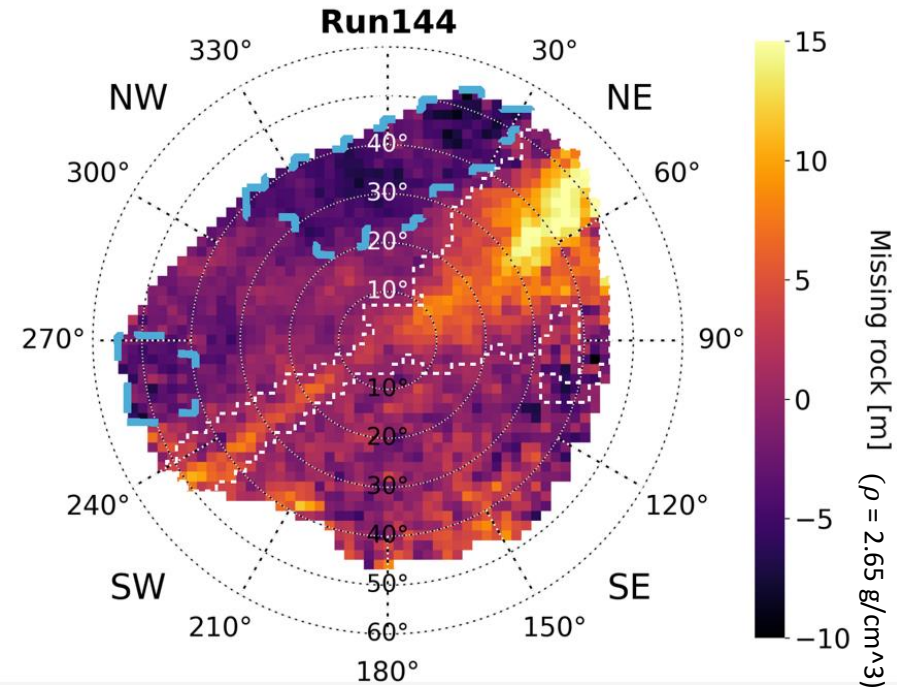
Results - overview

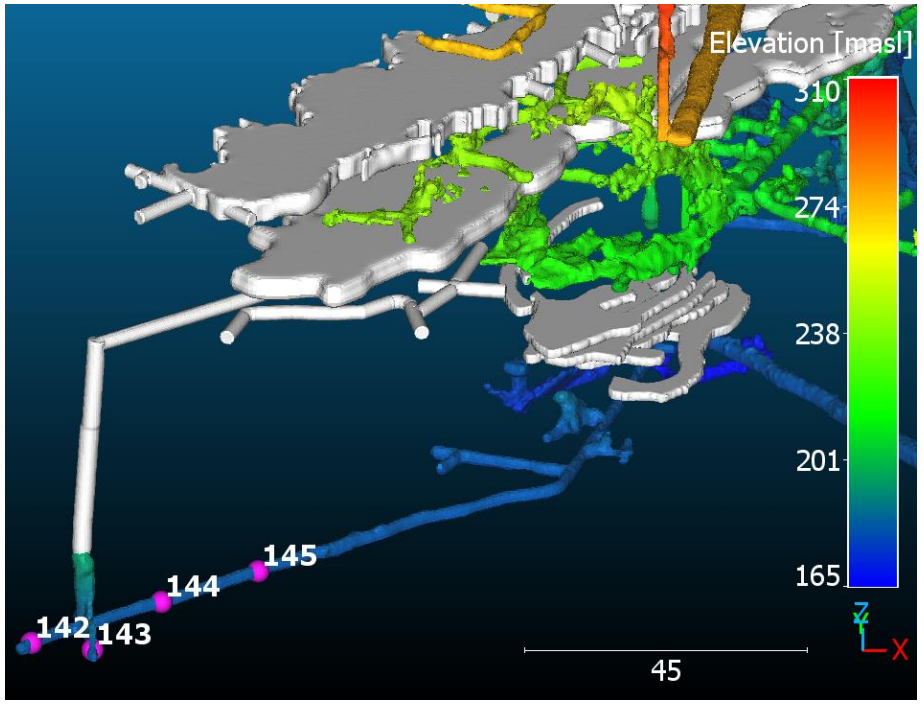
- **Southwestern Drift:** 4 positions → 3D inversion complete → results published
- **„Minecart” Drift:** 4 positions → scouting for future targets
- **Rákóczi Drift:** 12 positions and counting → preliminary 3D inversion for identifying targets



Results – Southwestern Drift

Measured Flux —(Reyna's)→ Density Lenght —(Topography Average Density)→ Missing Rock

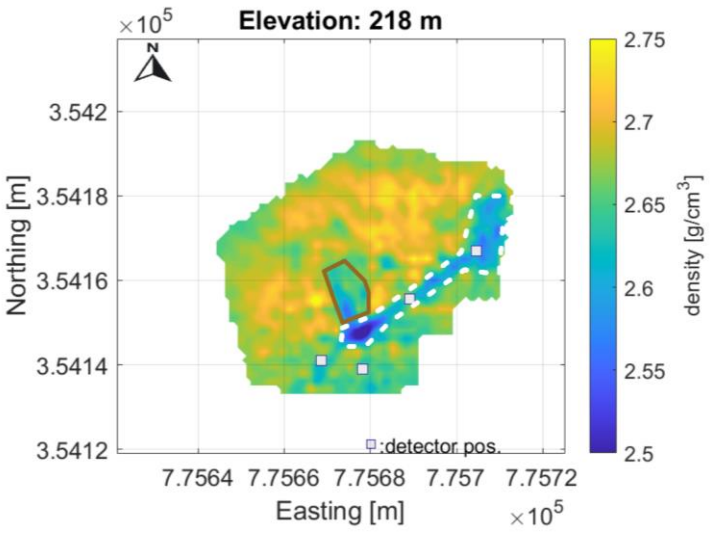


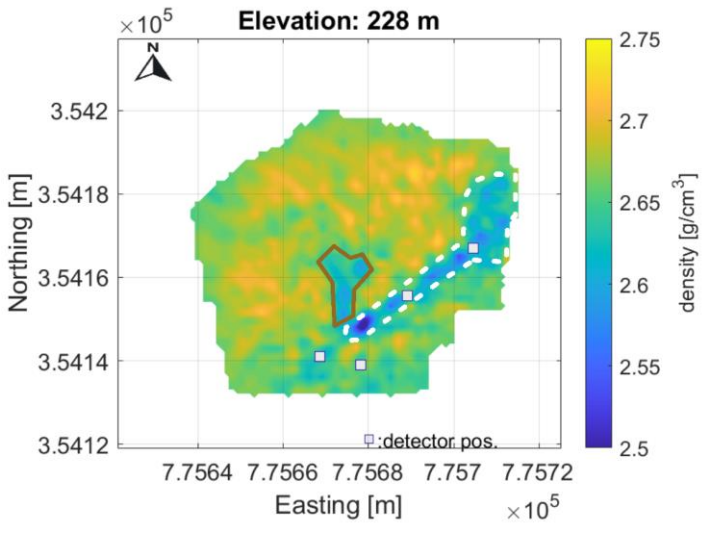


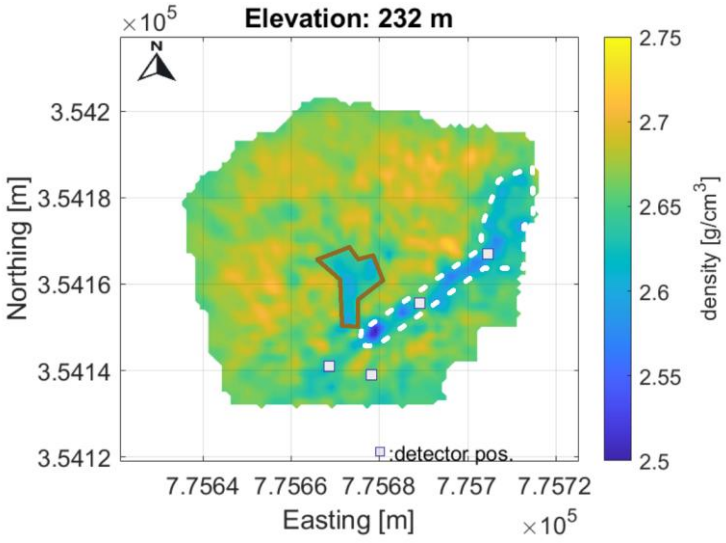
- **Inaccessible parts of the mine identified** → they match with the original mining maps (white parts)
- **Geological boundary can be identified** based on average density difference (Nortwest vs Southeast)

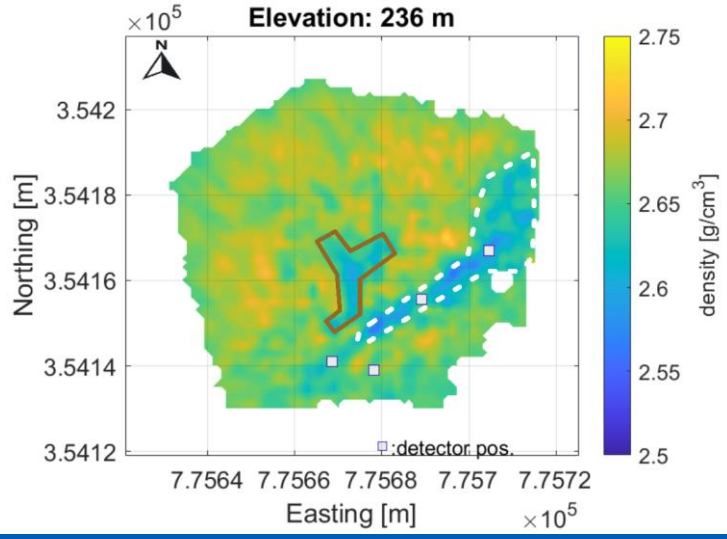
Results – Southwestern Drift

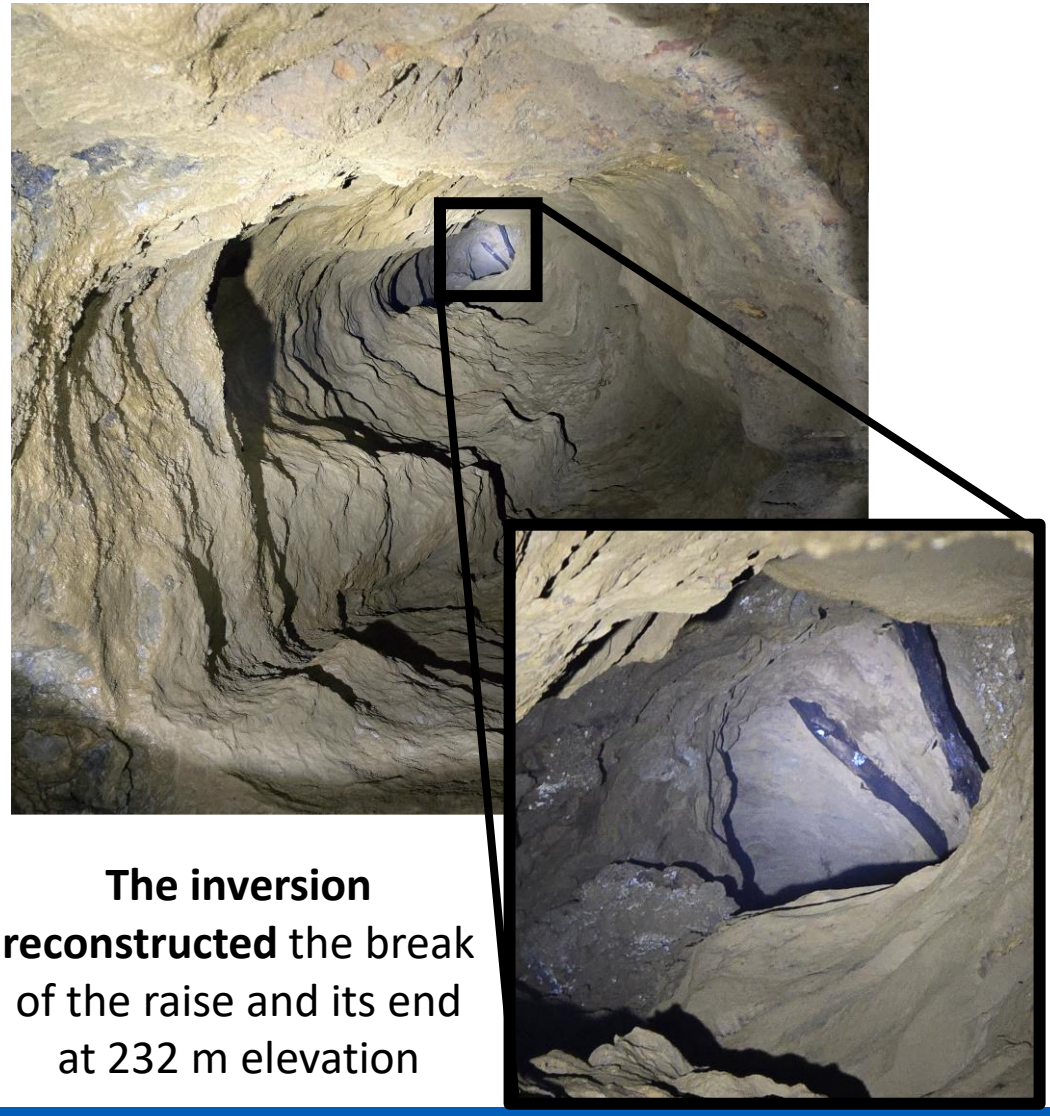
Inaccessible mine parts could be reconstructed, a new anomaly was detected → possible unknown cave









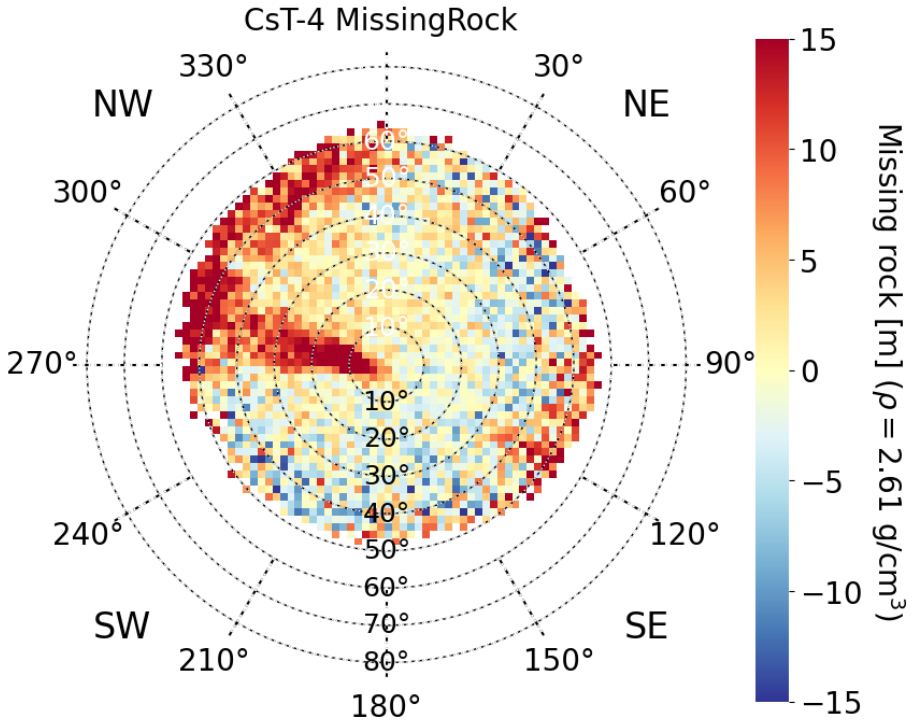


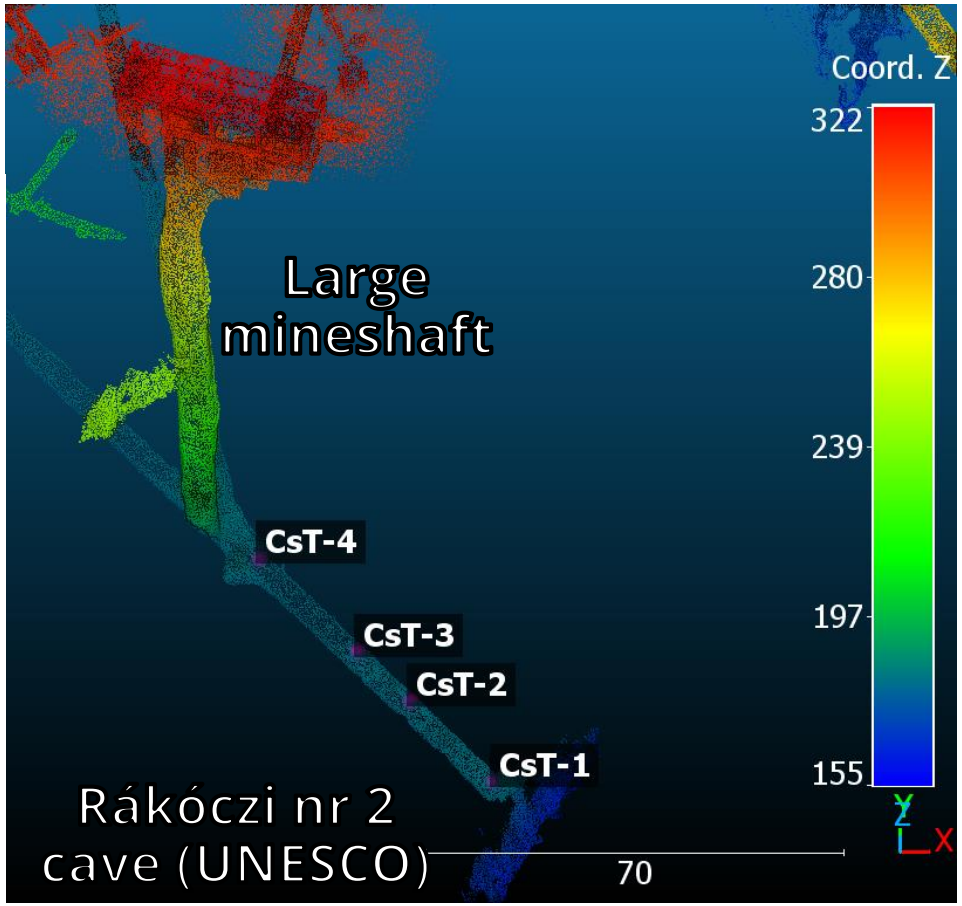
The inversion reconstructed the break of the raise and its end at 232 m elevation

Results – „Minecart” Drift

Measured Flux —Guan's→ Density Lenght —Topography Average Density→ Missing Rock

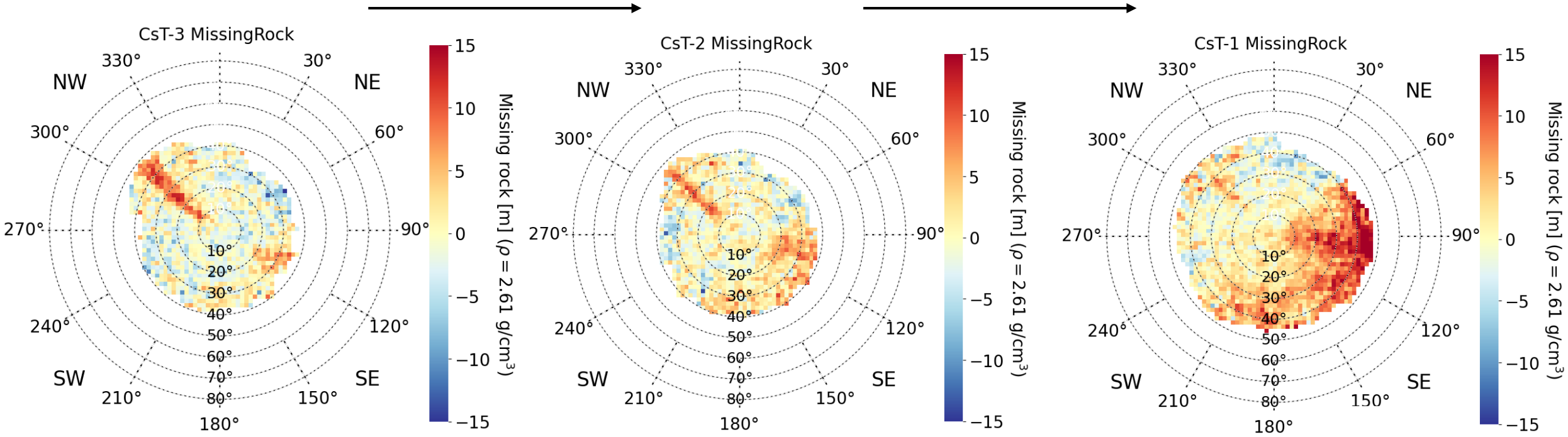
- The **effect of the large mineshaft** and the sorrounding parts of the mine can be seen at the Northwestern direction
- **No unknown anomaly** can be identified confidently





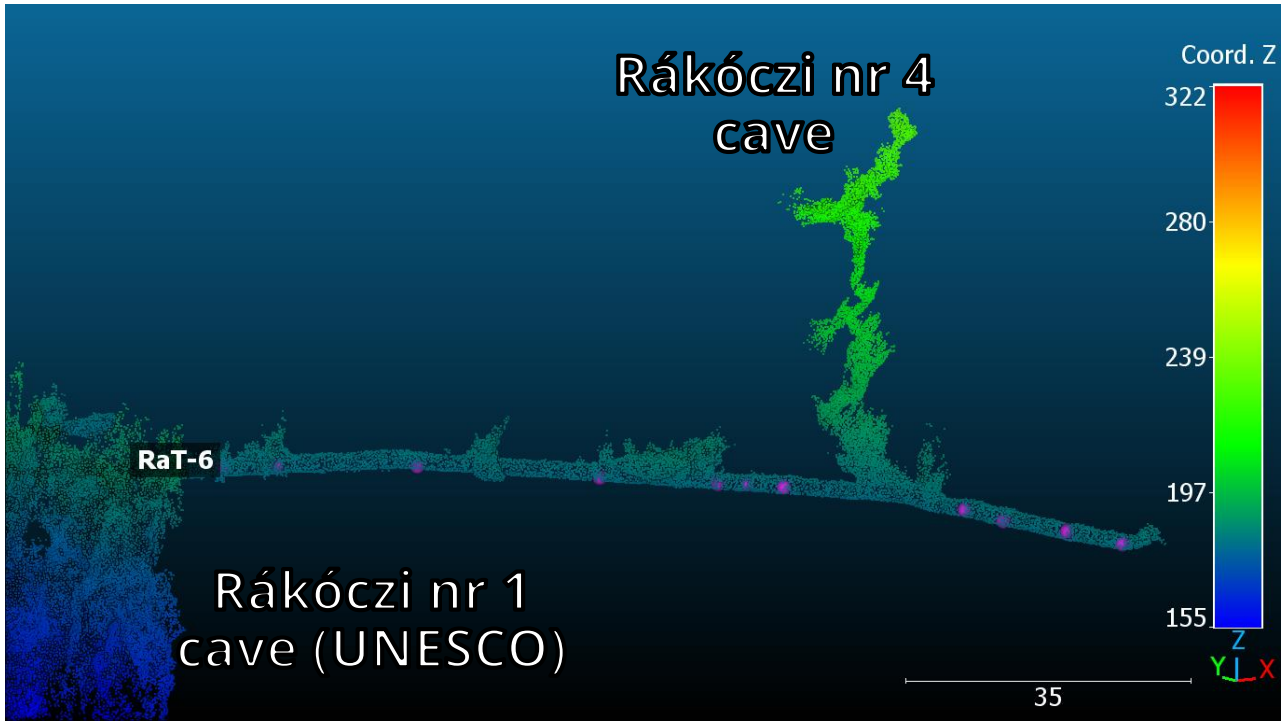
Results – „Minecart” Drift

- Moving further inside the drift reveals an **unknown anomaly** (while the known one fades)
- The anomaly is in the direction of the **main cave-forming fault line** of the hill → to be explored further!

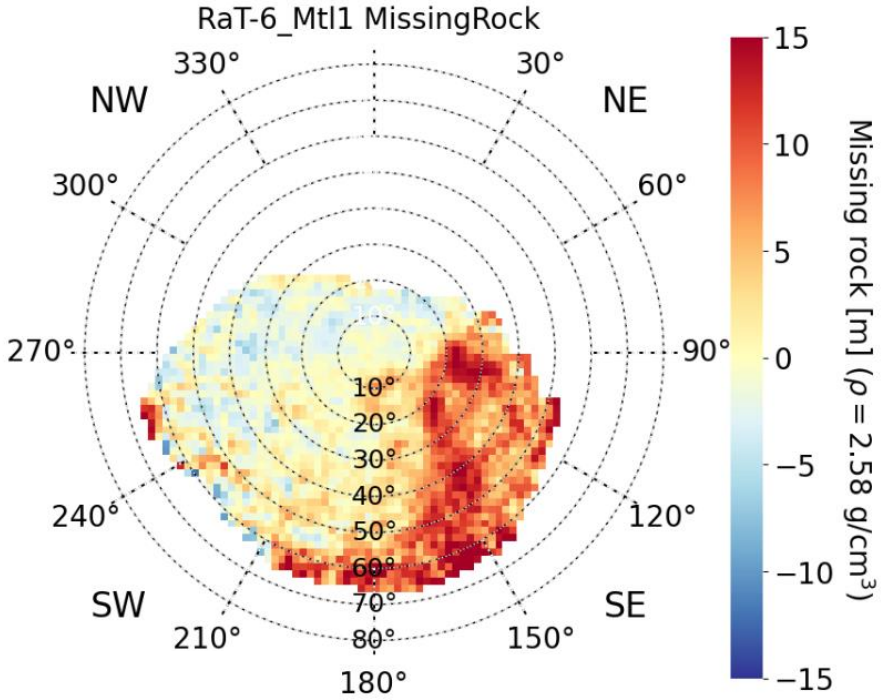


Results – Rákóczi Drift

Measured Flux —Guan's→ Density Lenght —Topography Average Density→ Missing Rock

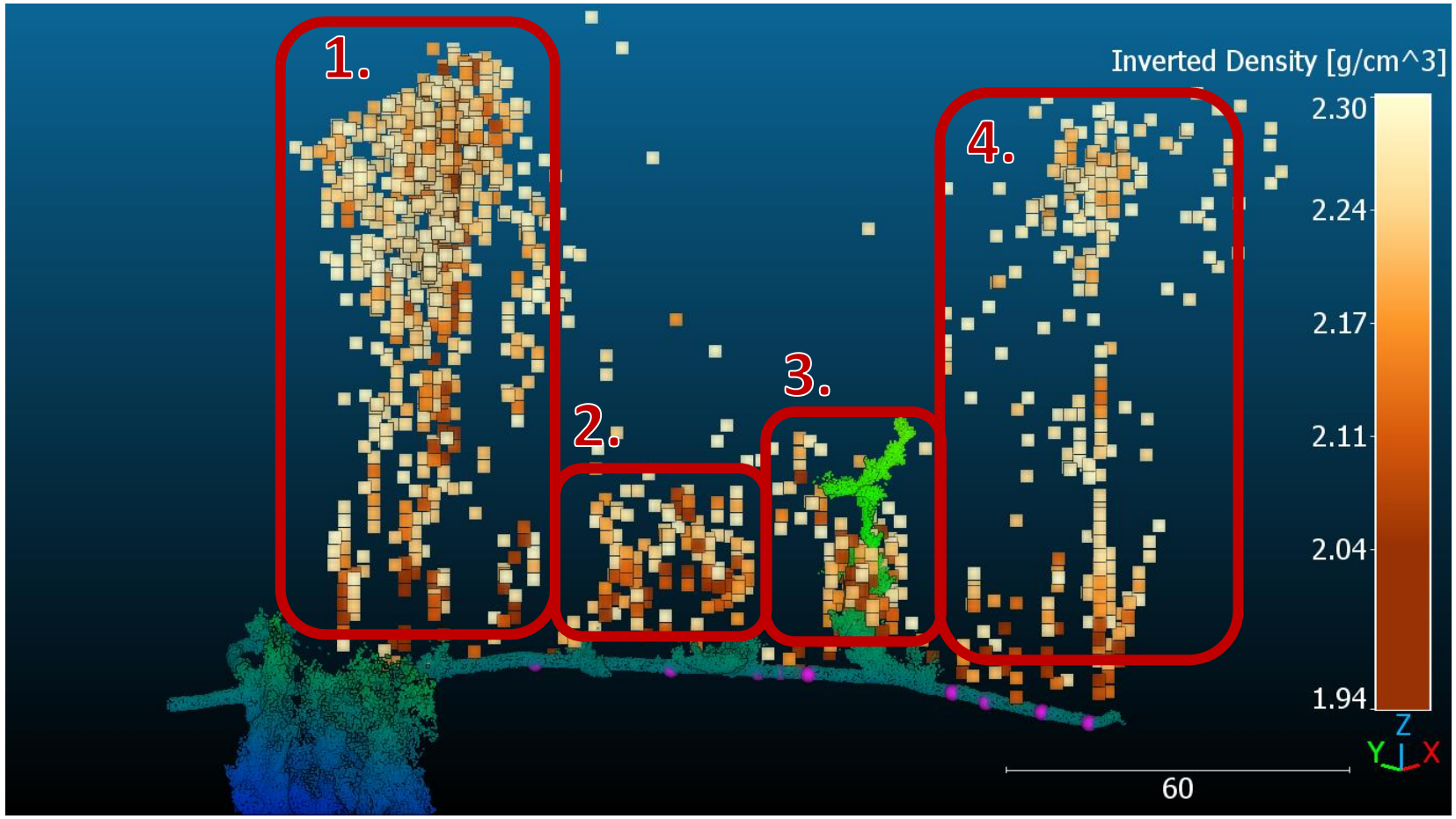


- **Large missing rock values** detected all along the drift → too complex for interpretation based on 2D muograms



Results – Rákóczi Drift

- **Anomaly #1:** Large in both size and effect, located on the cave-forming fault line near Rákóczi number 1 cave
- **Anomaly #2:** Small in size, with a large effect, located just above the drift
- **Anomaly #3:** Very similar to anomaly #2, but it is caused by a known cave → **verification!**
- **Anomaly #4:** Large in size but small in effect, located near the limestone-shale boundary



Thank you for your attention!

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