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NEAR SURFACE GEOSCIENCE 2016 CONFERENCE & EXHIBITION

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NETWORK ON THE INDUSTRIAL HANDLING OF RAW MATERIALS FOR EUROPEAN INDUSTRIES

Downhole Physical Properties Measurements Supporting Iron-oxide Deep Exploration and Mining in Blötberget, Sweden

Georgiana Maries[1], Alireza Malehmir[1], Emma Backstrom[2]

[1] Uppsala University
[2] NIO

SGU Sveriges geologiska undersökning Geological Survey of Sweden

VINNOVA

Tekes

YARA

Nordic Iron Ore™

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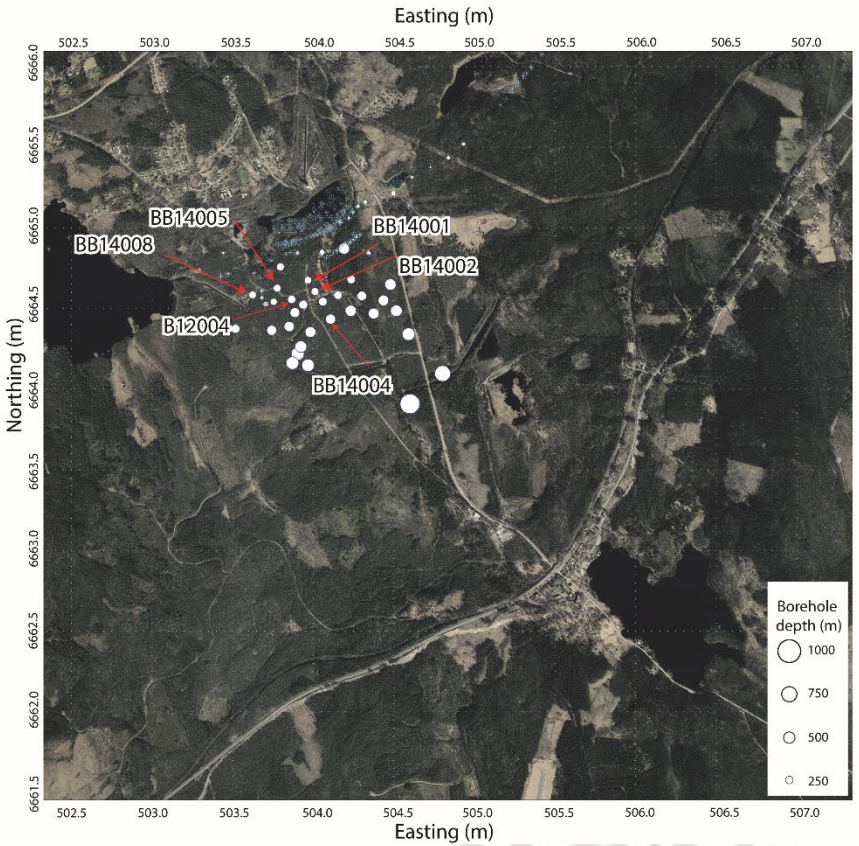
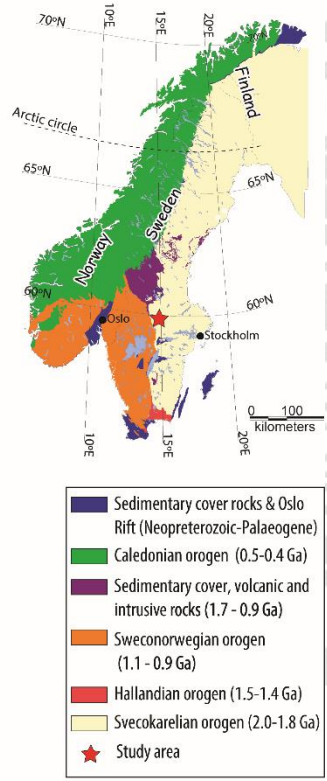
Motivation

- **Blötberget (Bergslagen) –** one of the most important mineral districts in south-central Sweden
- Iron-oxide deposits → **magnetite** and **hematite** mineralization (several boreholes)

- Delineate the mineralization at depth and understand the relationship between the host rocks and the ore body
- Analyze physical properties and provide better control for surface measurements
- Part of extensive studies for **future exploration** and mining!





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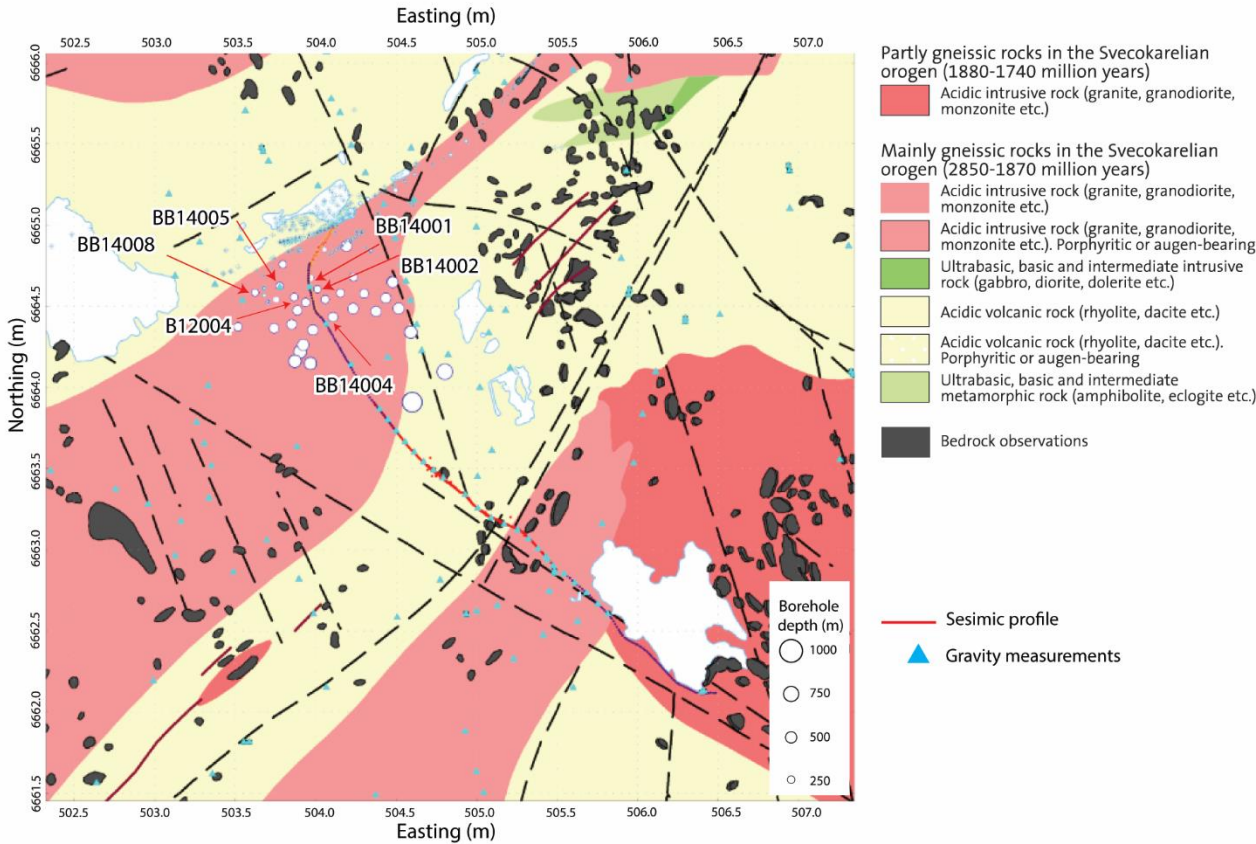
Study Area & Surveys

- Vulcano-sedimentary rocks (Svecokarelian orogen)
- Iron-oxide mineralization: found between 350 to 600 m depth (down to at least 700 m), dipping southeast
- Host rocks: metavolcanics
- **Measurements**:
  - **Downhole geophysical logging**:
    - magnetic susceptibility
    - natural gamma
    - formation resistivity
    - fluid temperature and conductivity
    - **full-waveform triple sonic**
  - **Laboratory measurements**:
    - density
    - magnetic susceptibility
    - magnetite content



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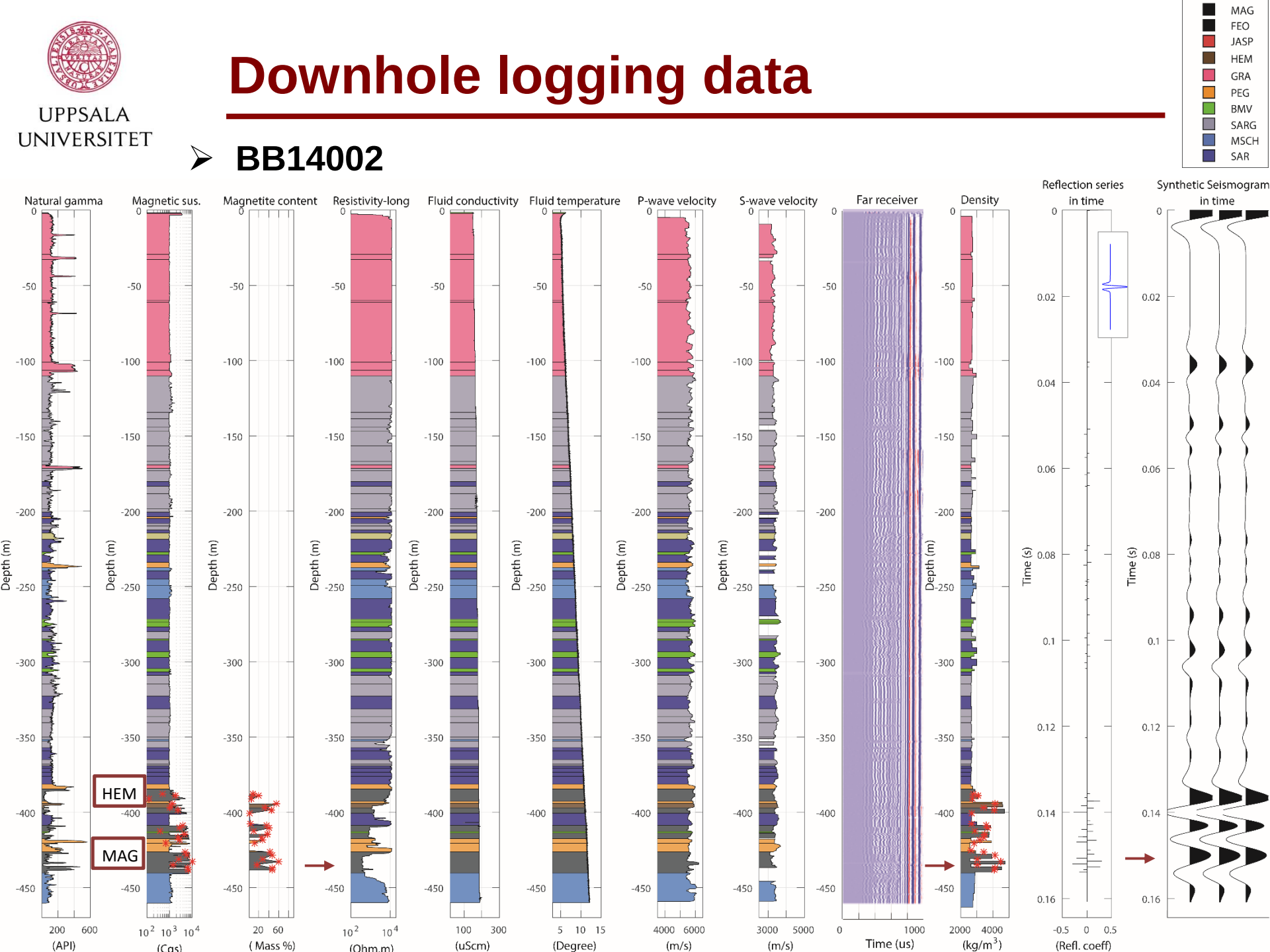
Downhole logging data

- **BB14002**



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Downhole logging data

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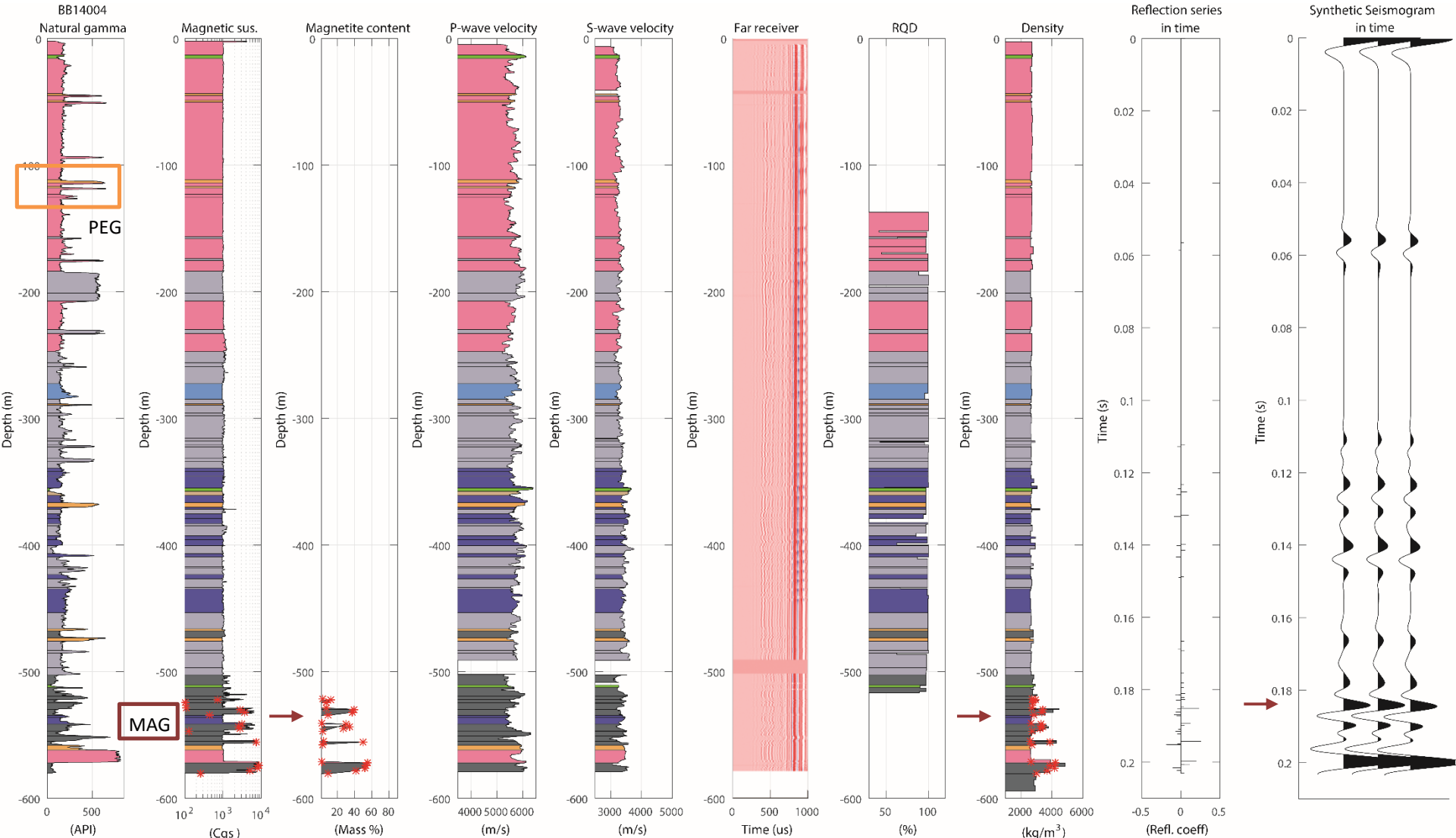

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Downhole logging data

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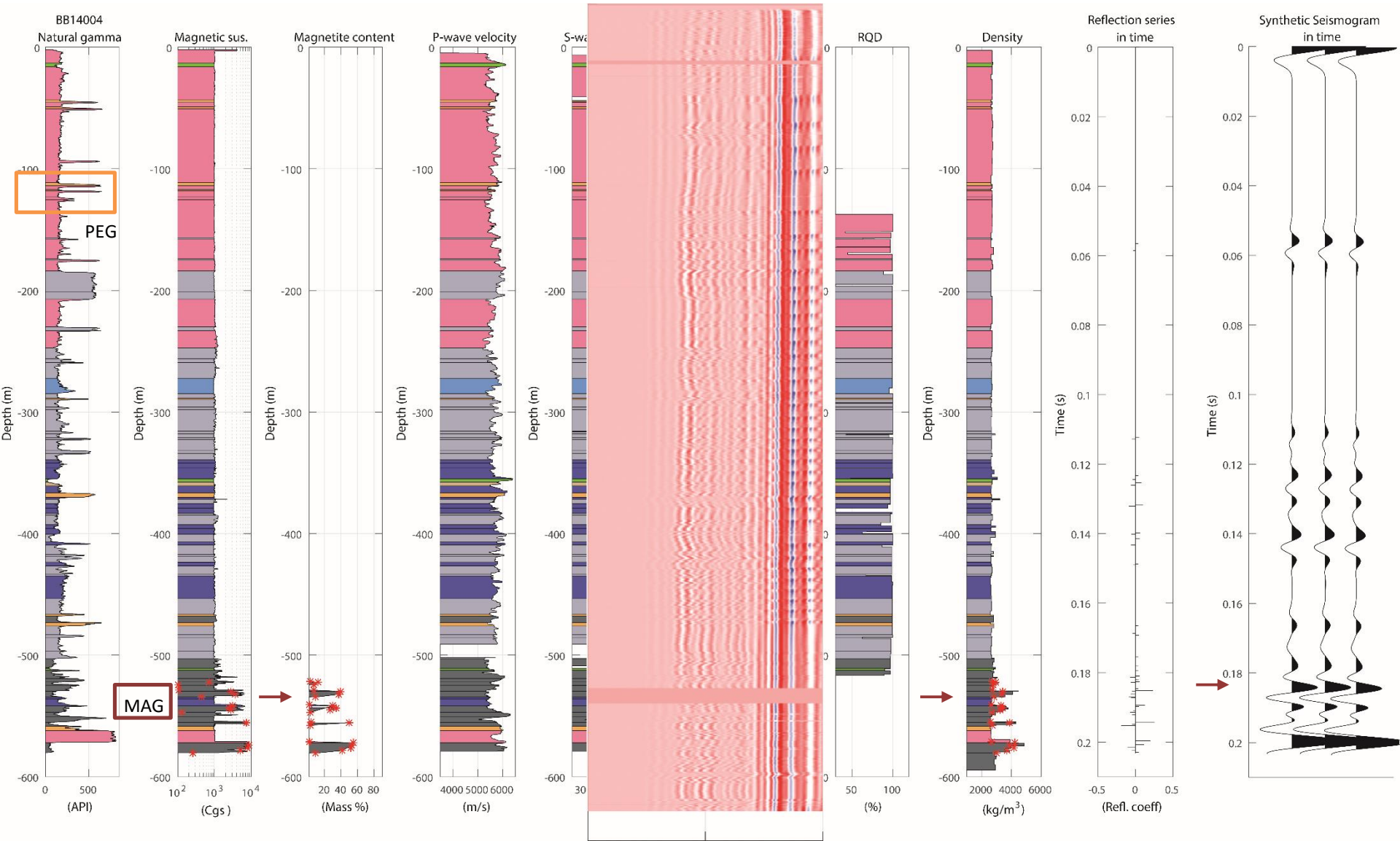

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Downhole logging data

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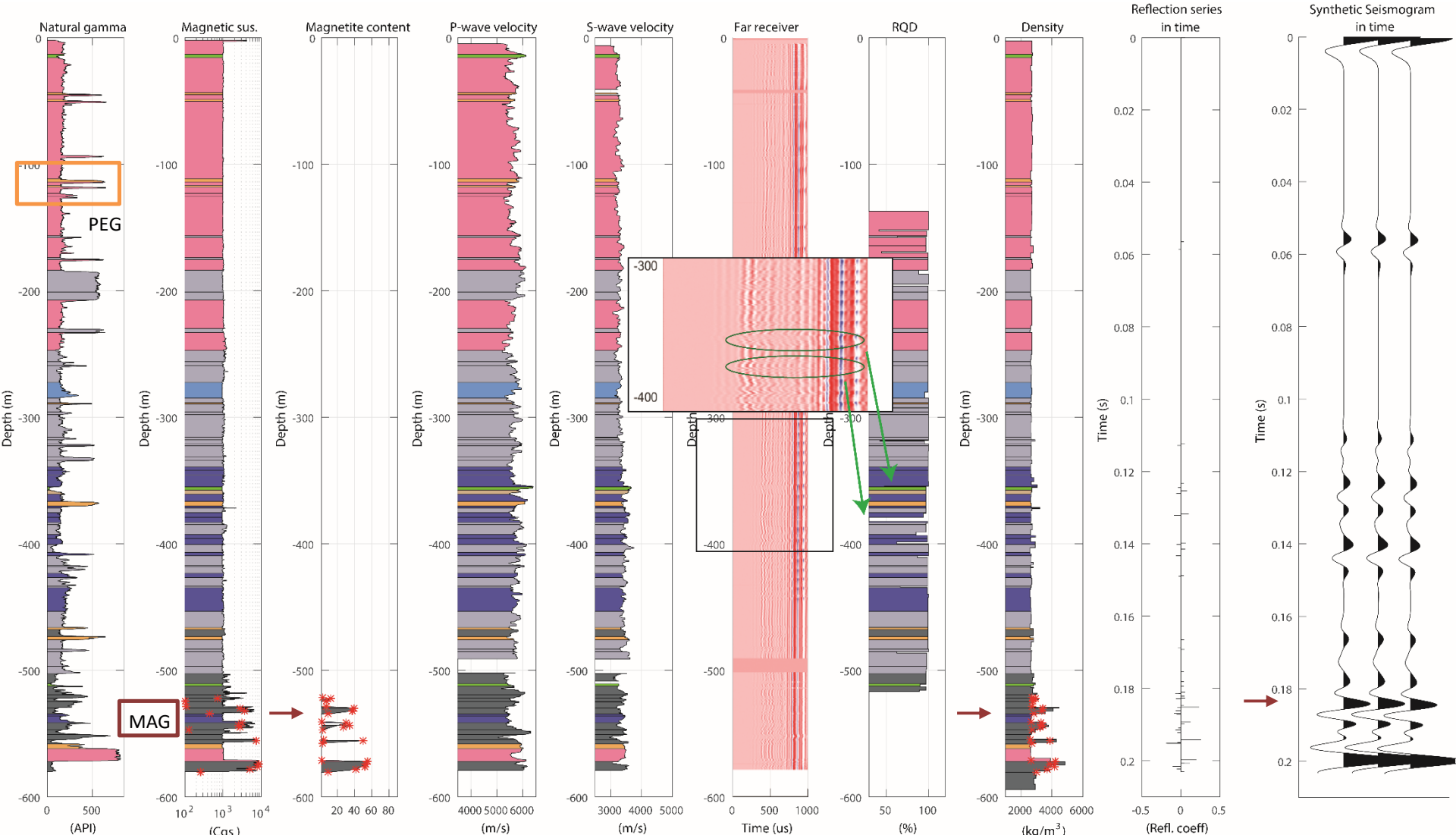

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Downhole logging data

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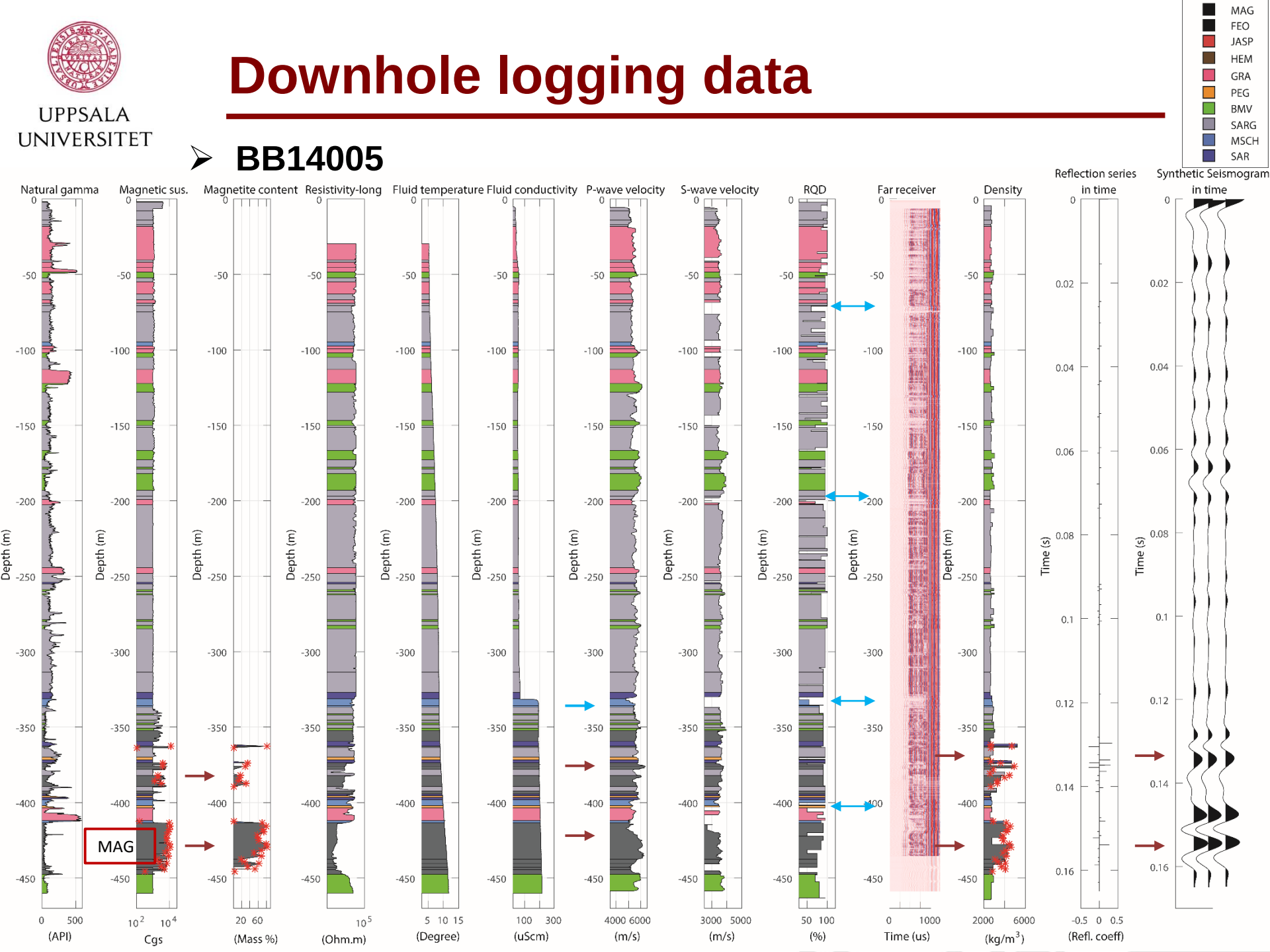

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Downhole logging data

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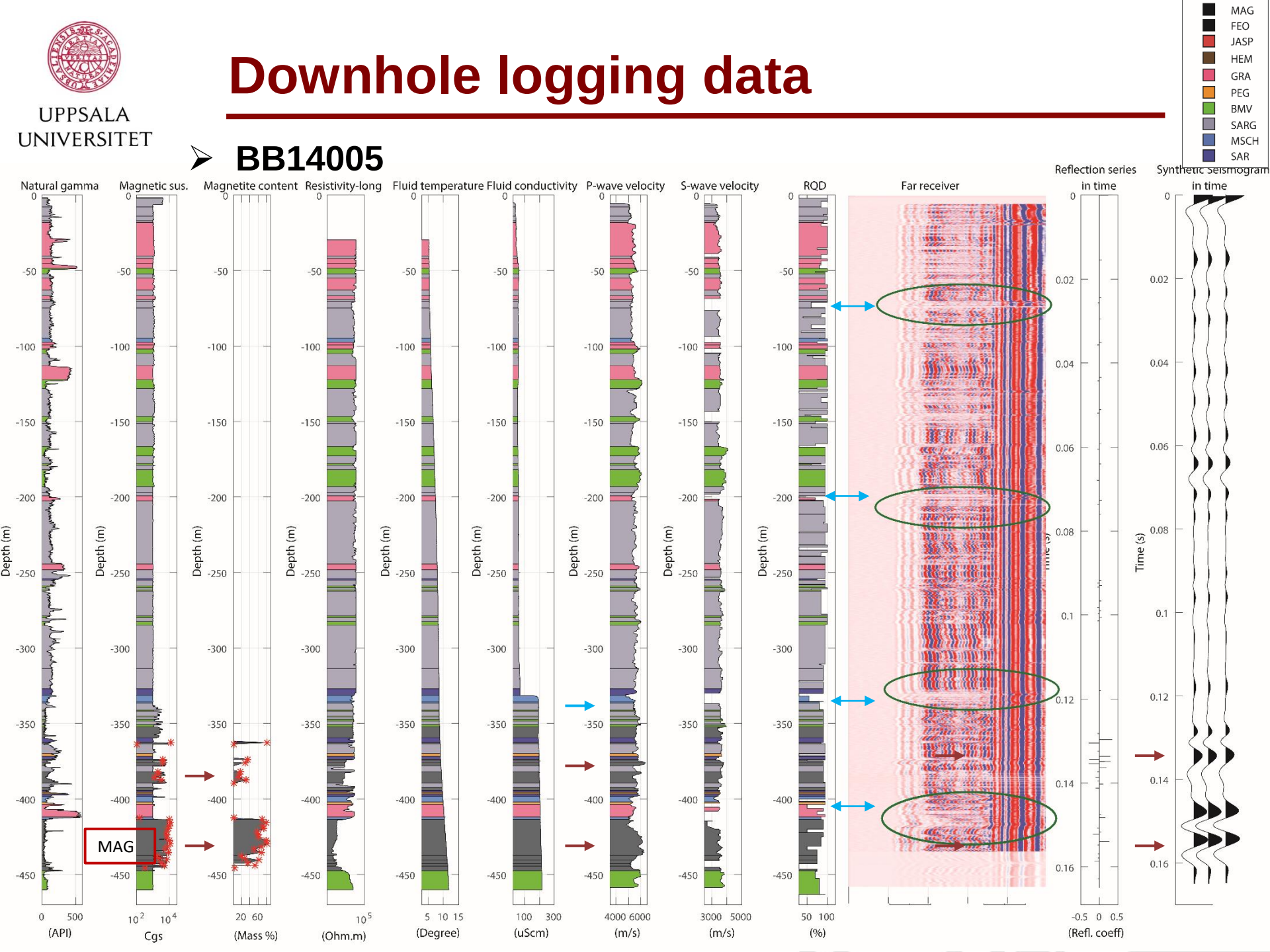

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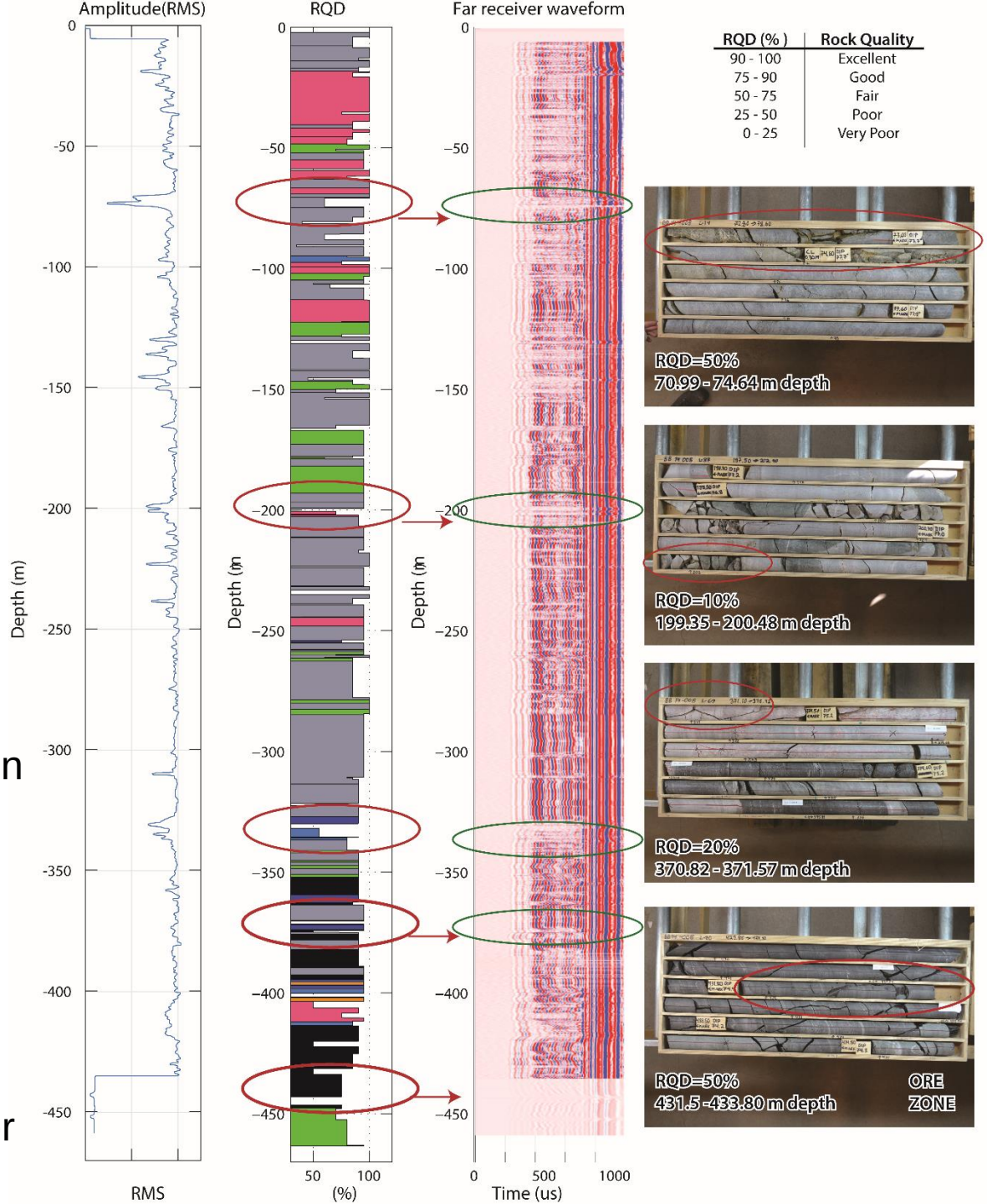
➢BB14005

- **Sonic waveform** and **RQD** analysis:
- poor RQD and decreased amplitude zones correlate (washed-up amplitude in the waveform logs)
- There is potential to extract indirect rock quality information from sonic logging
- Next step: extract amplitude information from all three receivers (near, mid, far) and calculate the attenuation factor



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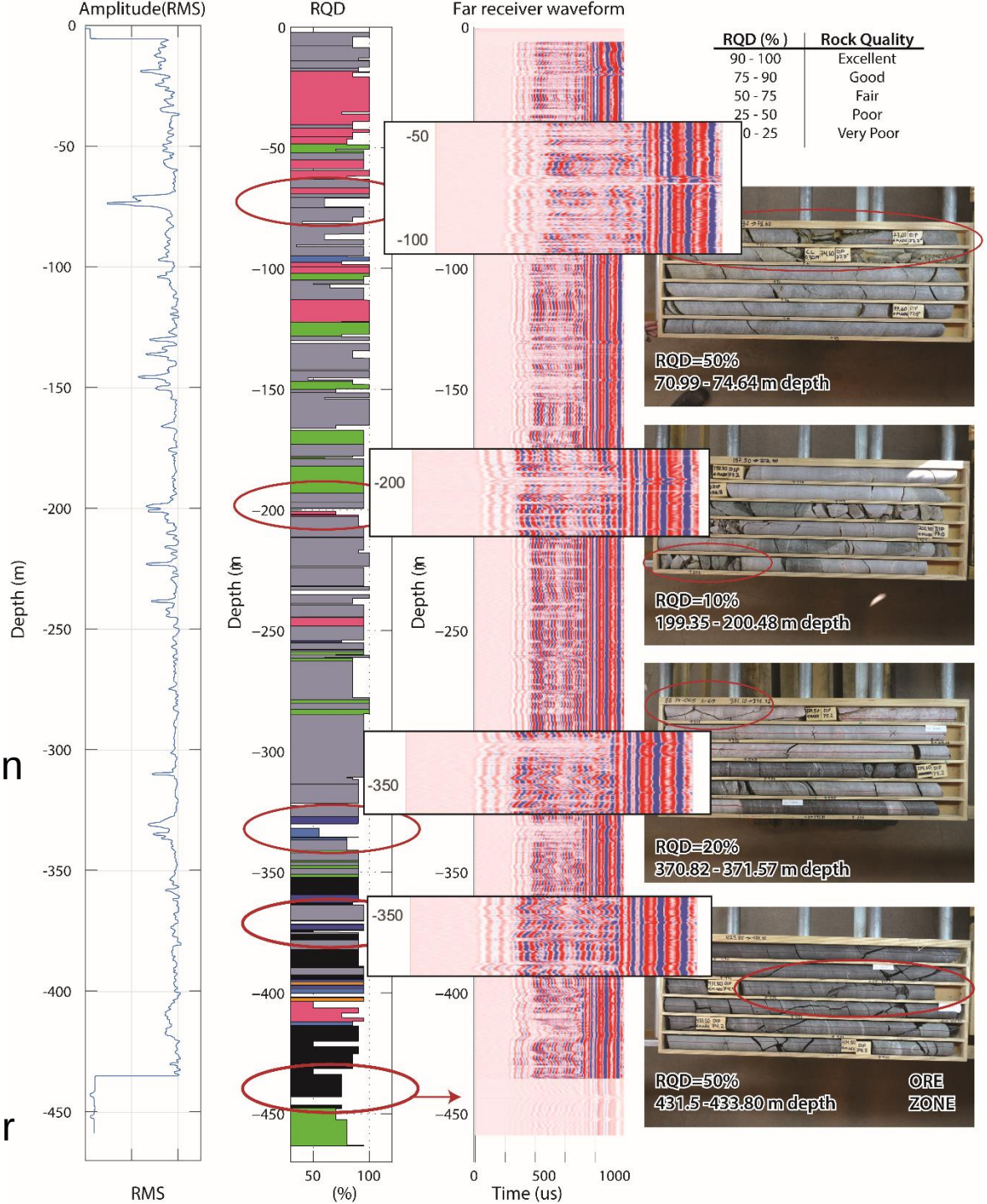

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Downhole logging data

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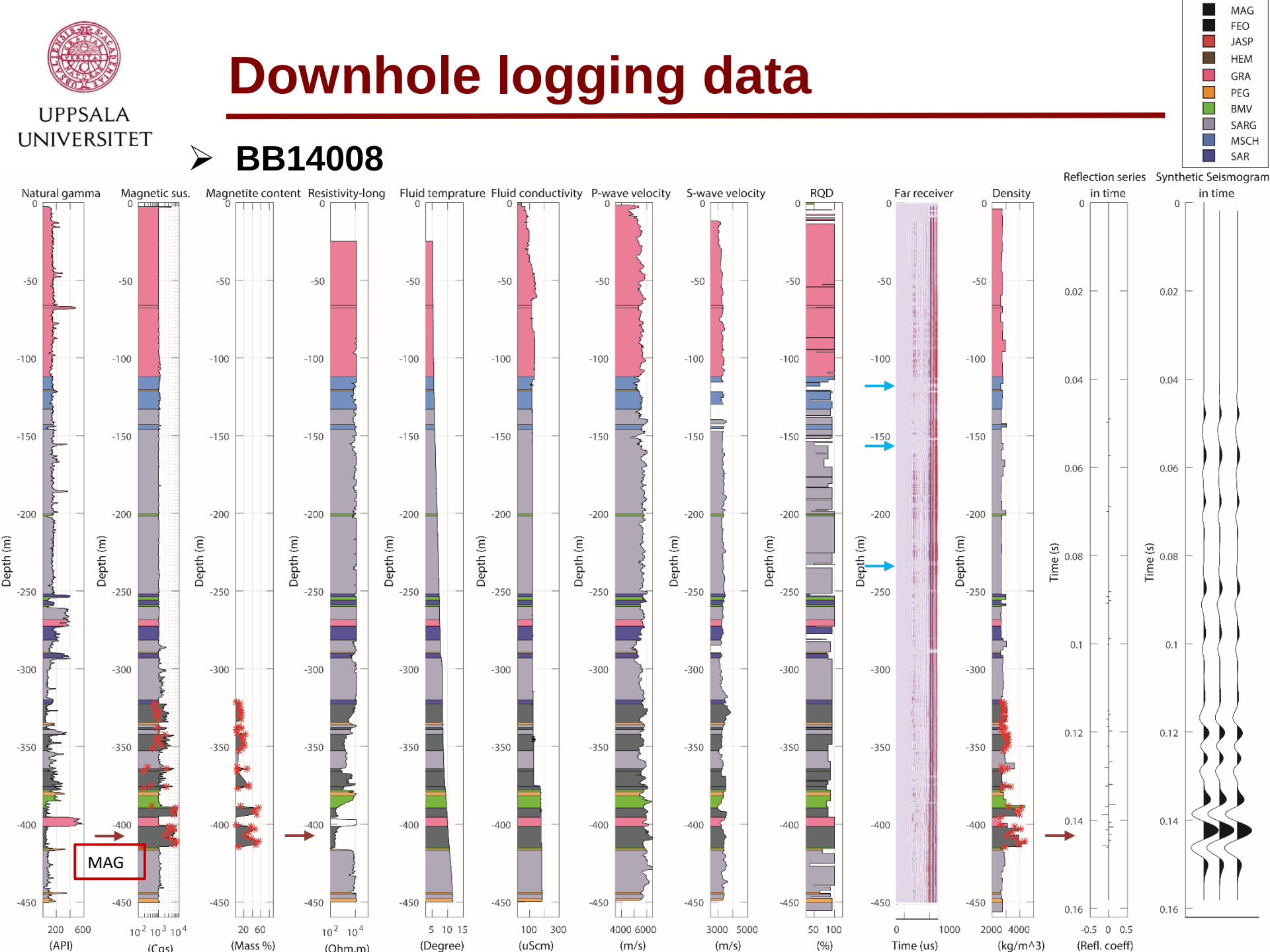

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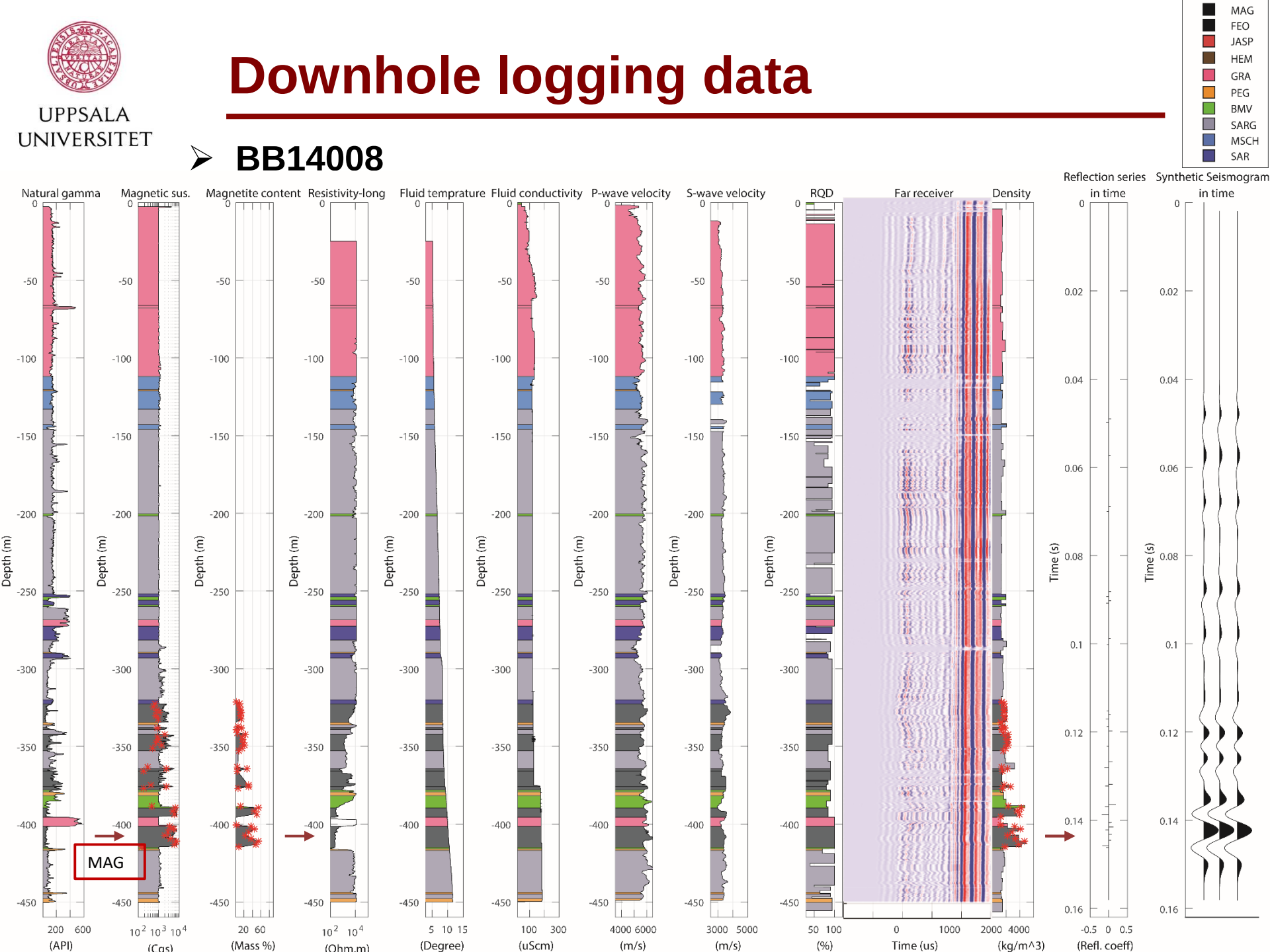

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Downhole logging data

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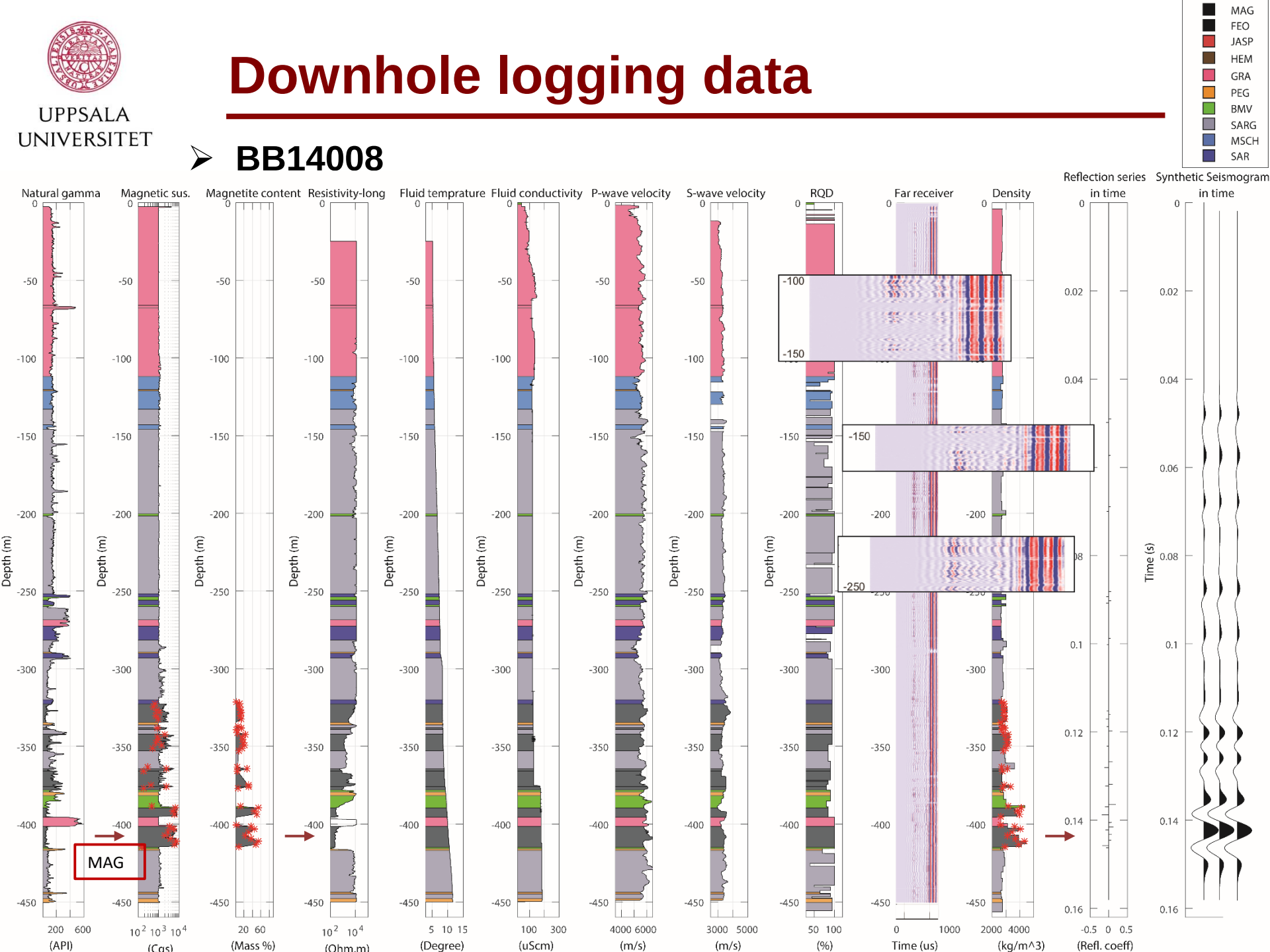

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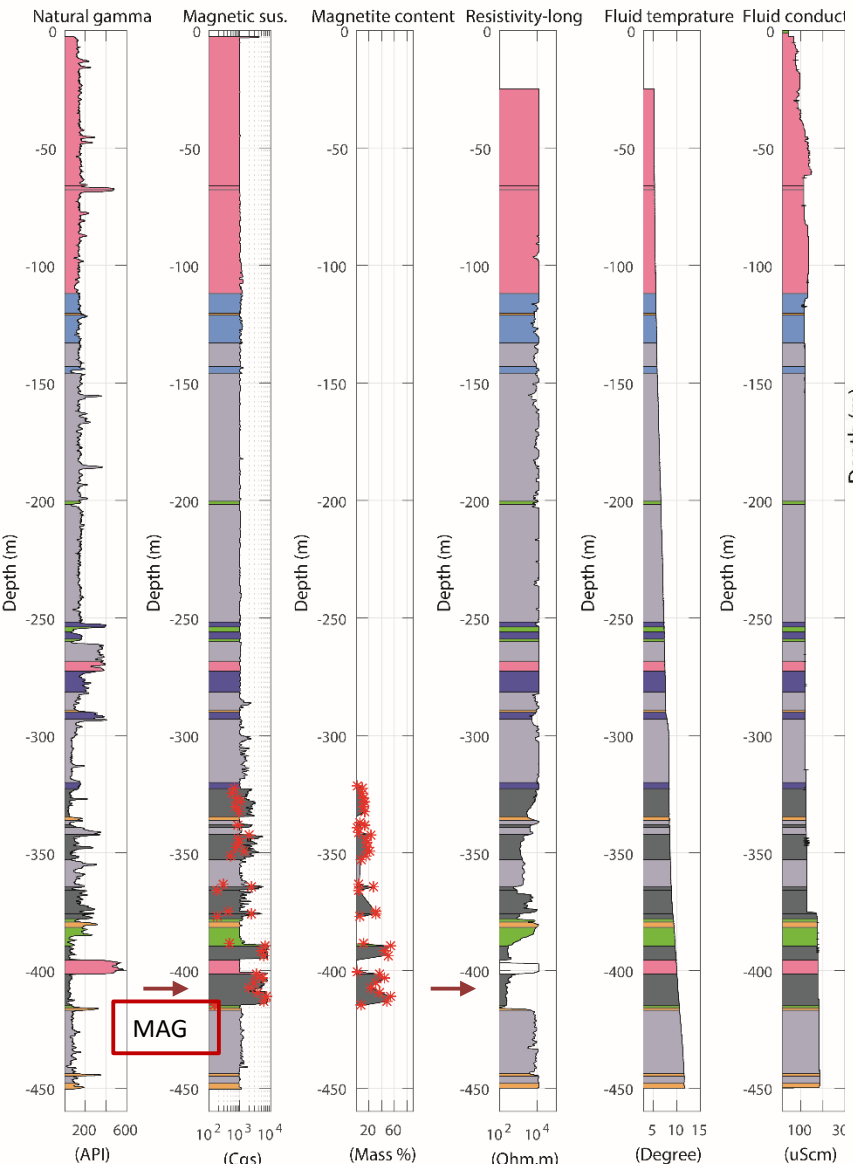
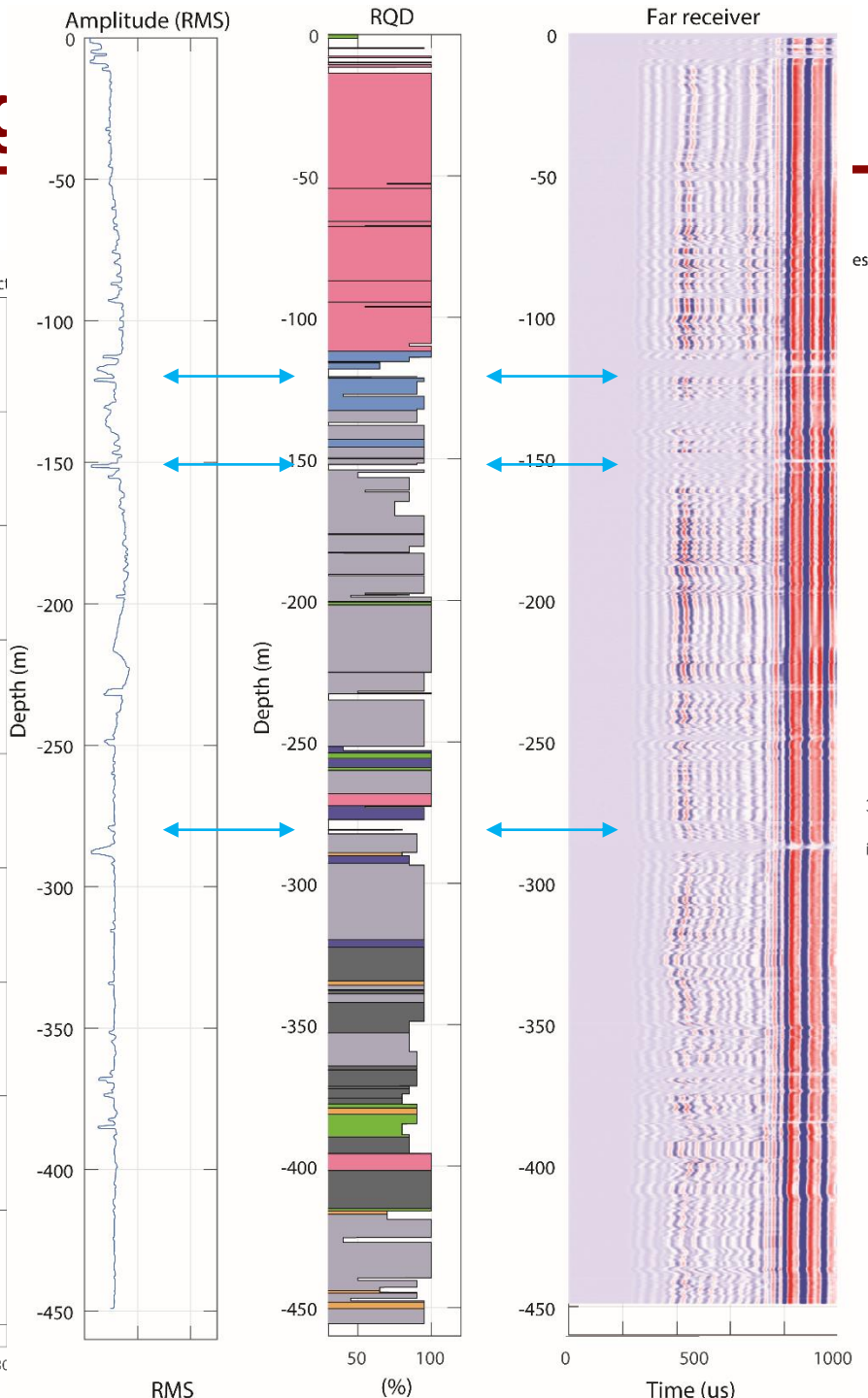
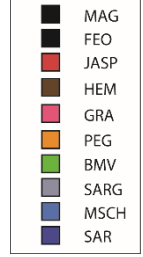
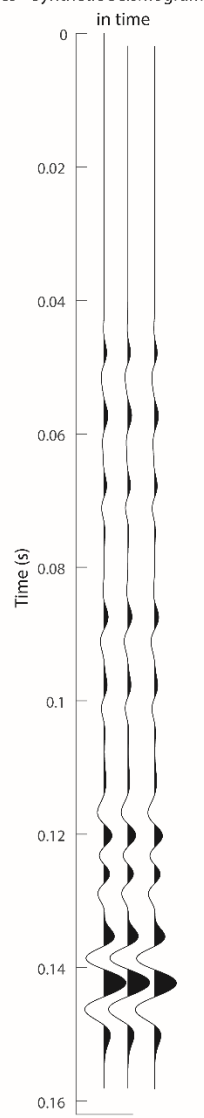
Downhole log

- **BB14008**









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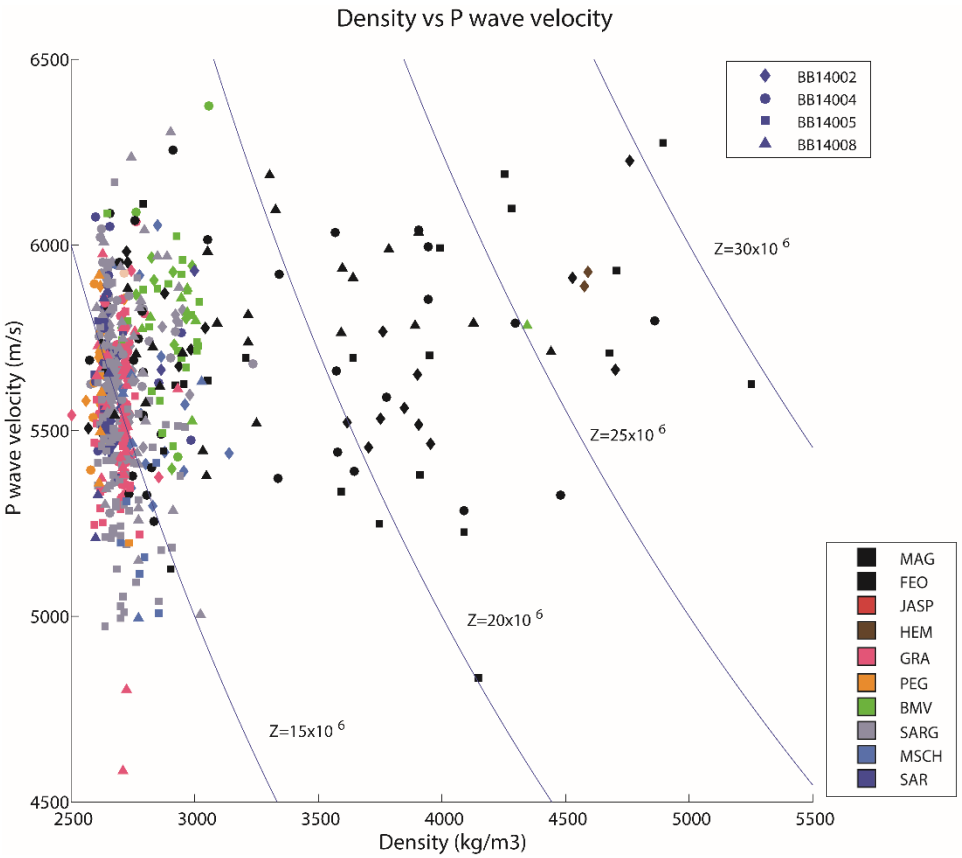
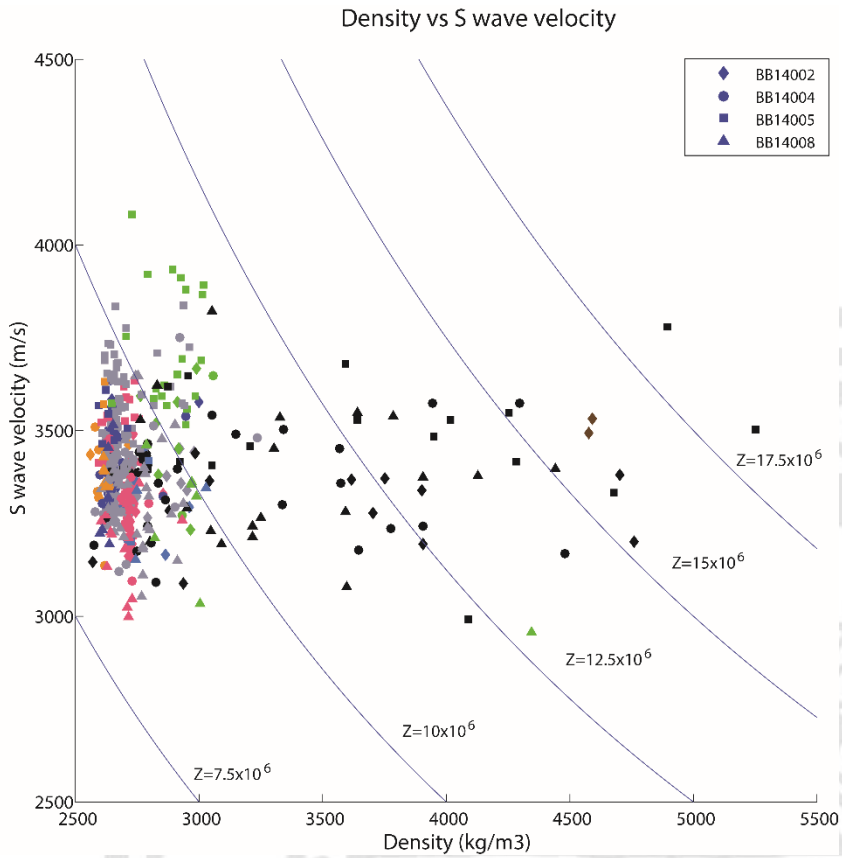
Results

1) Physical properties and expected seismic response





- Observations
  - Magnetite and hematite show a significantly higher contrast compared to the other rock types, but primarily due to density.
  - Velocities overlap a wide range over all rock types.

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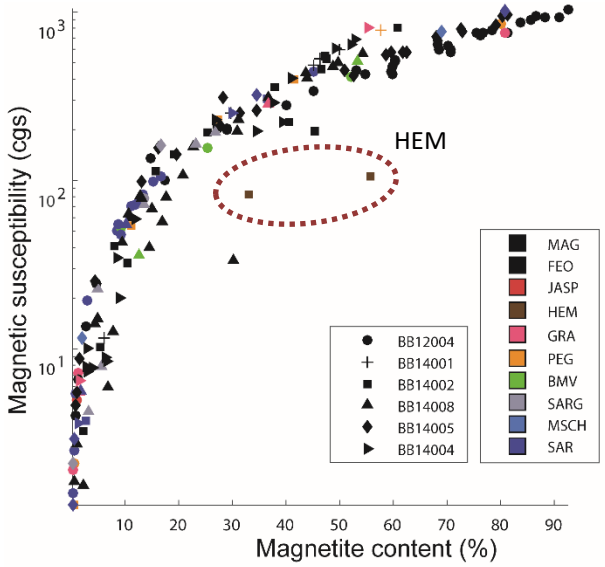
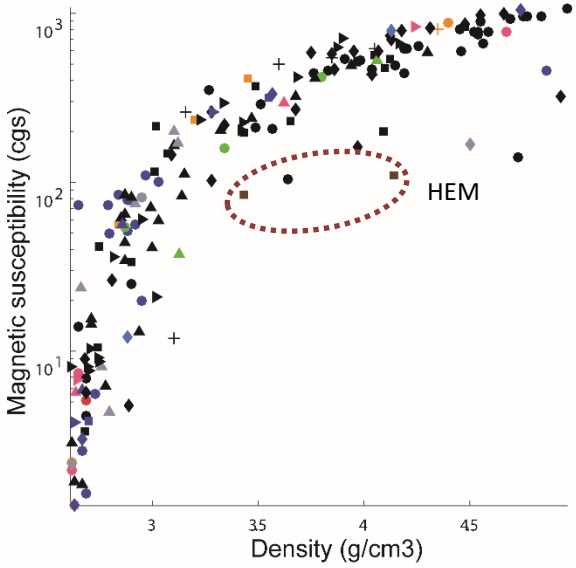
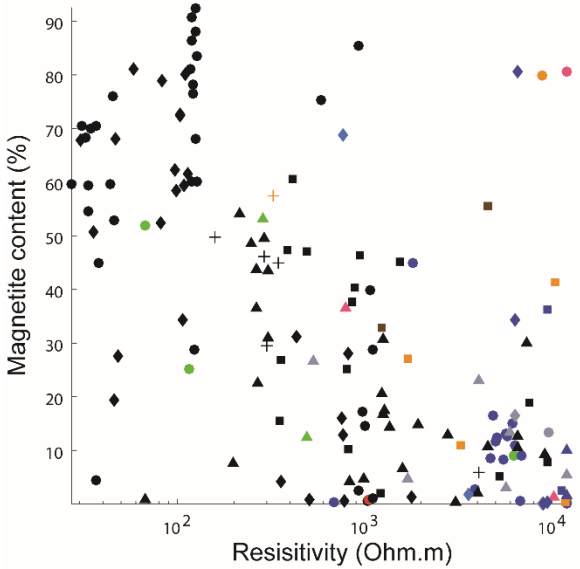
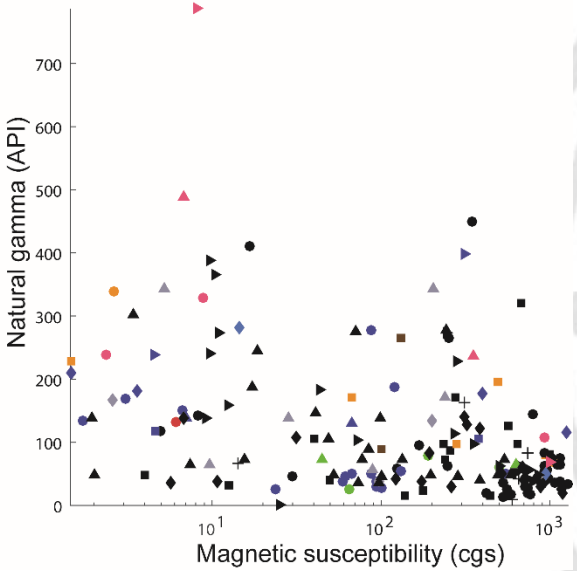
Results

2) Physical properties (from the mineralized zone)





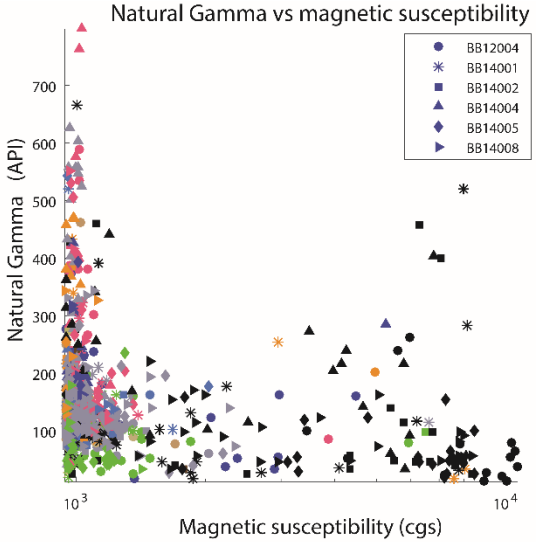


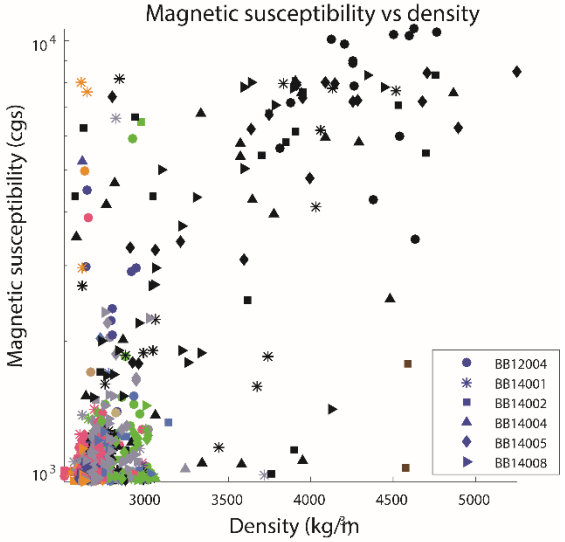


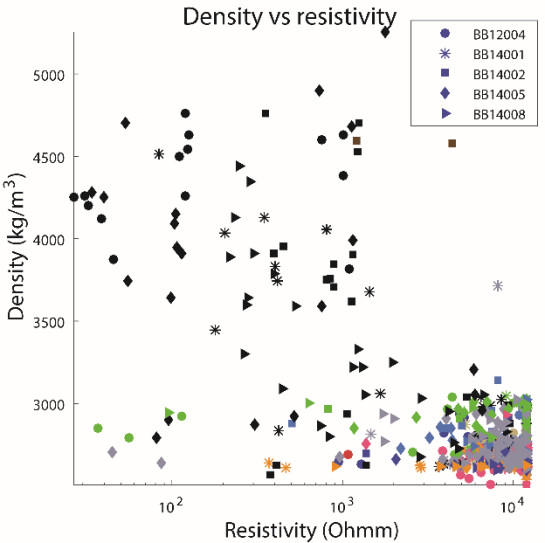
- Hematite vs magnetite
  - Far less samples of hematite mineralization but their paramagnetic character is illustrated
  - Most mineralized rocks show high conductivity but not all
  - Mineralized rocks show lowest gamma radiation

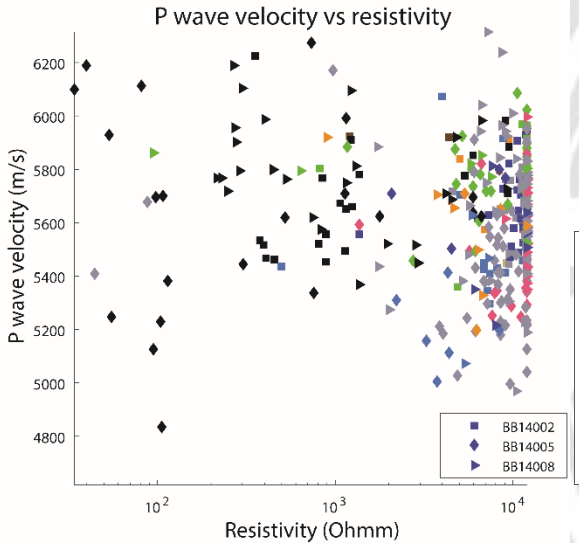
Results

3) Physical properties (all depths)



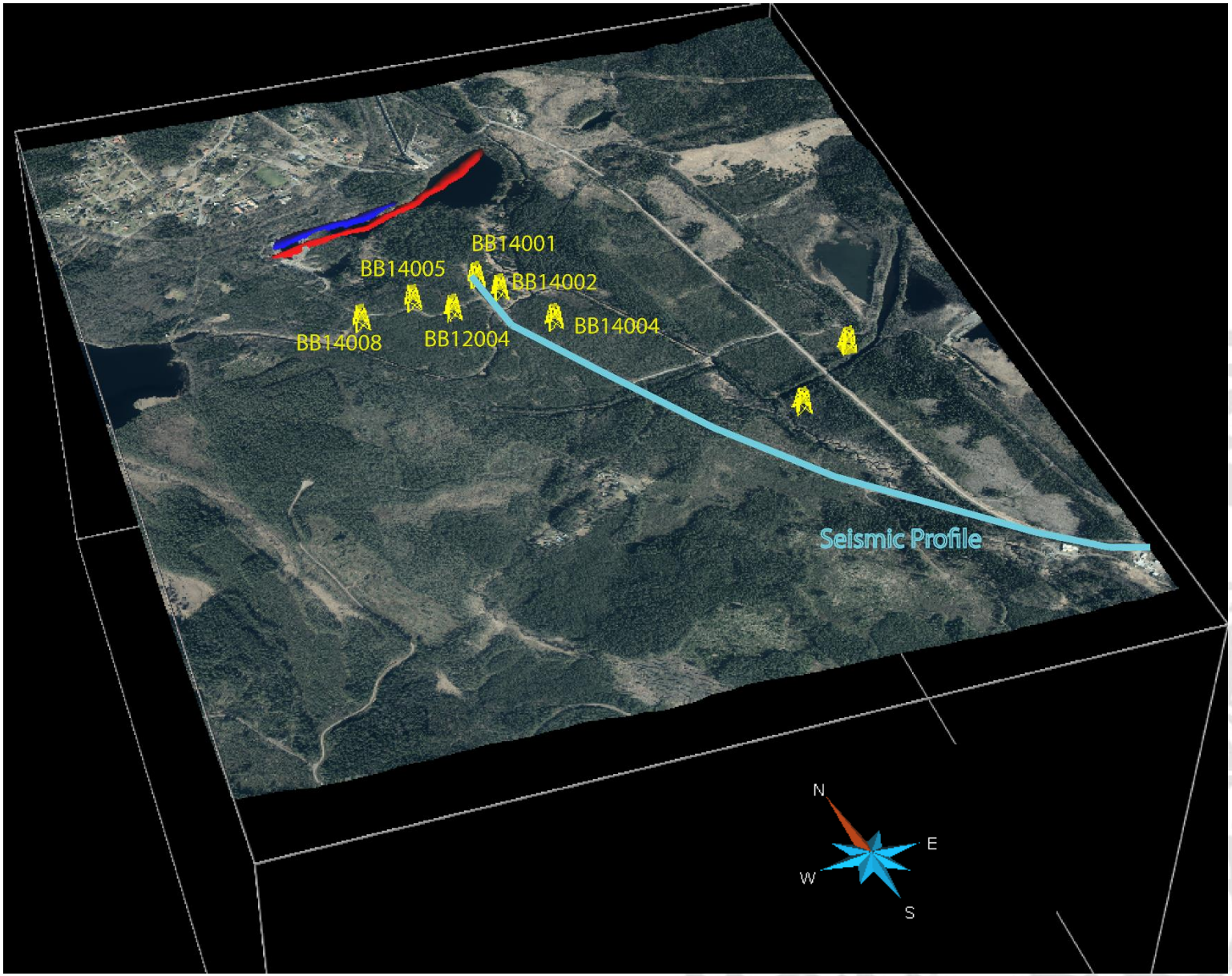






- Observations
  - Granite and pegmatite intrusions show highest gamma radiation
  - Magnetic susceptibility increases with density (some pegmatite shows increased mag. susceptibility)
  - Most mineralized rocks show high conductivity but not all (depending on magnetite content primarily)
  - Density controls the response of the mineralized zone rather than velocity

Surface measurements



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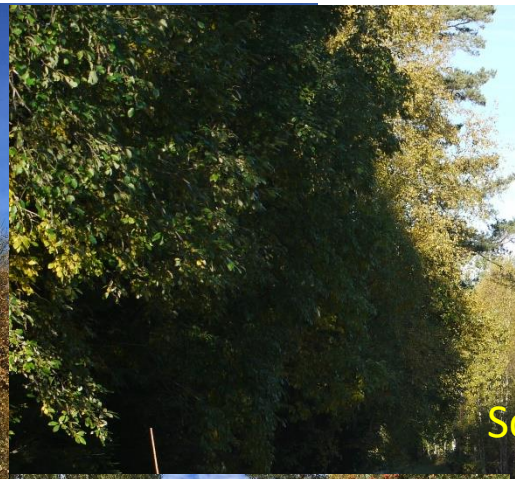
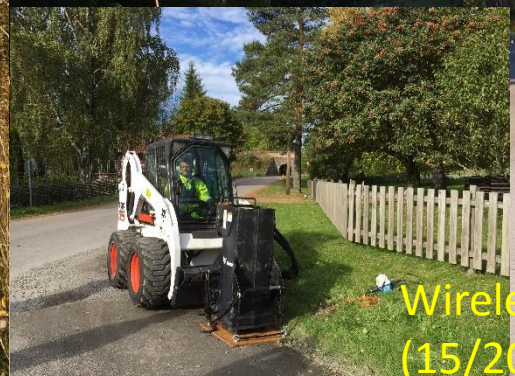
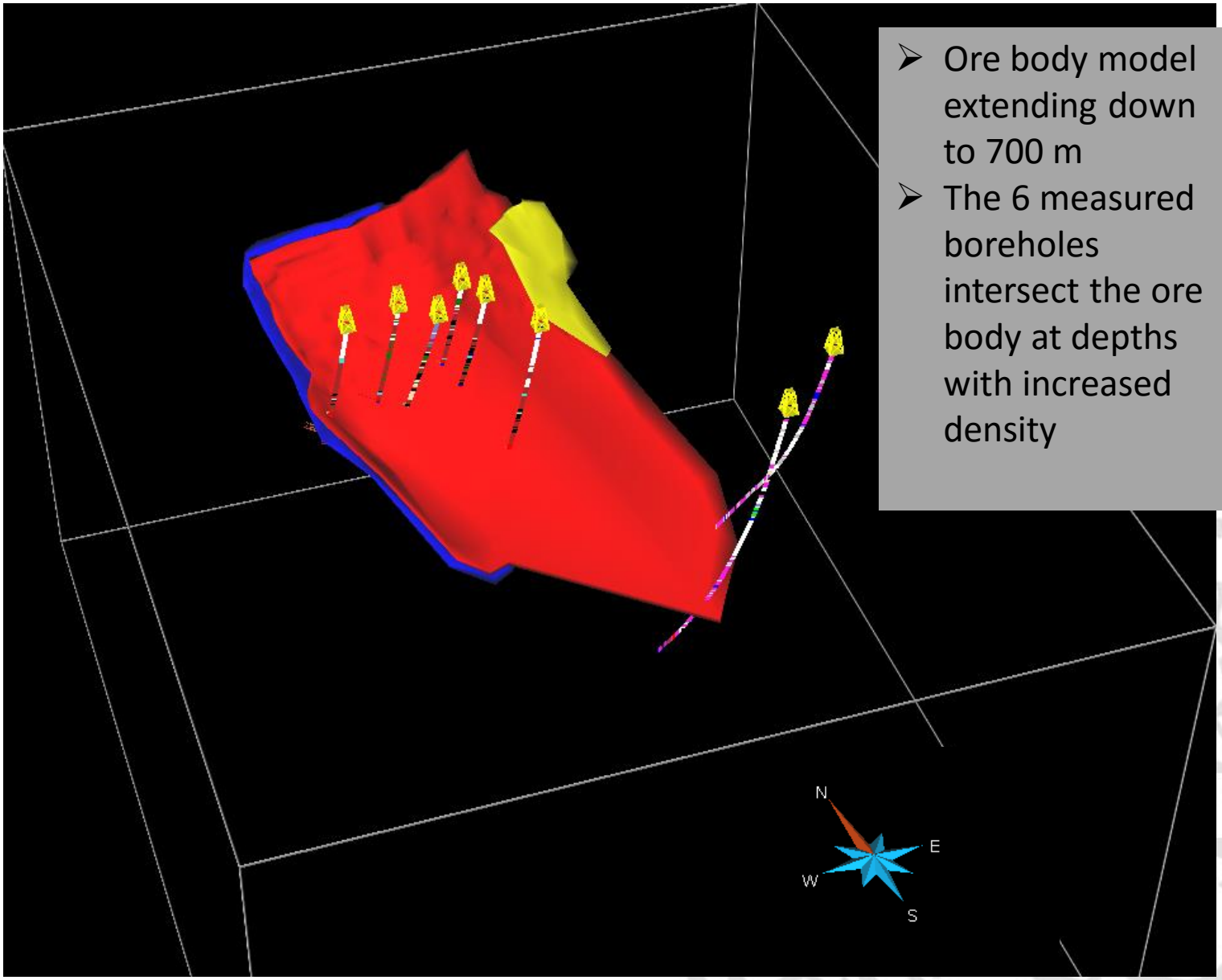
Seismic reflection profile

- **Pilot seismic reflection profile (September 2015)**
  - Uppsala University broadband seismic landstreamer (200 sensors) and wireless sensors (52 sensors) connected to 10 Hz geophones
  - 4 m shot spacing, Bobcat mounted drop hammer as source (also explosives)
  - Total length: 3km (only part of it shown here)

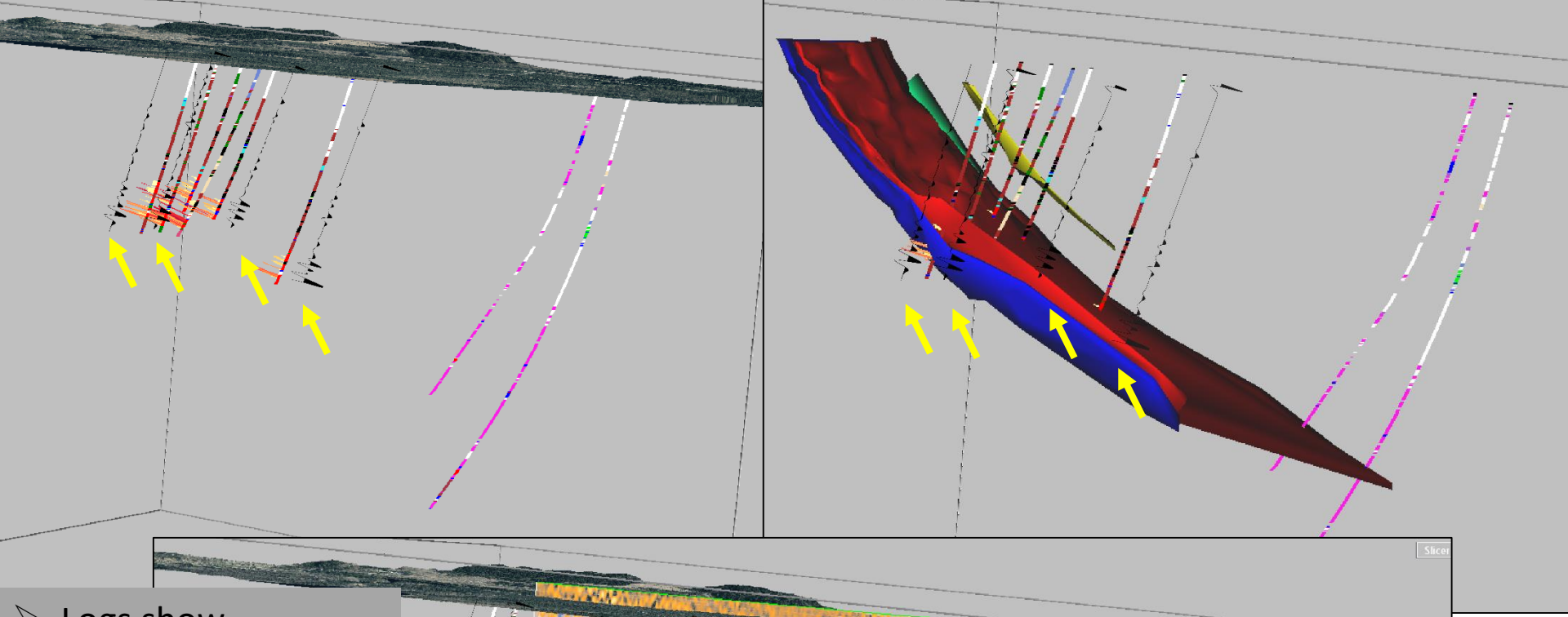




Results



- Ore body model extending down to 700 m
- The 6 measured boreholes intersect the ore body at depths with increased density



- Logs show increased density and a strong response in the synthetic seismograms at the ore body zone
- Matched with a reflection event in the preliminary seismic section

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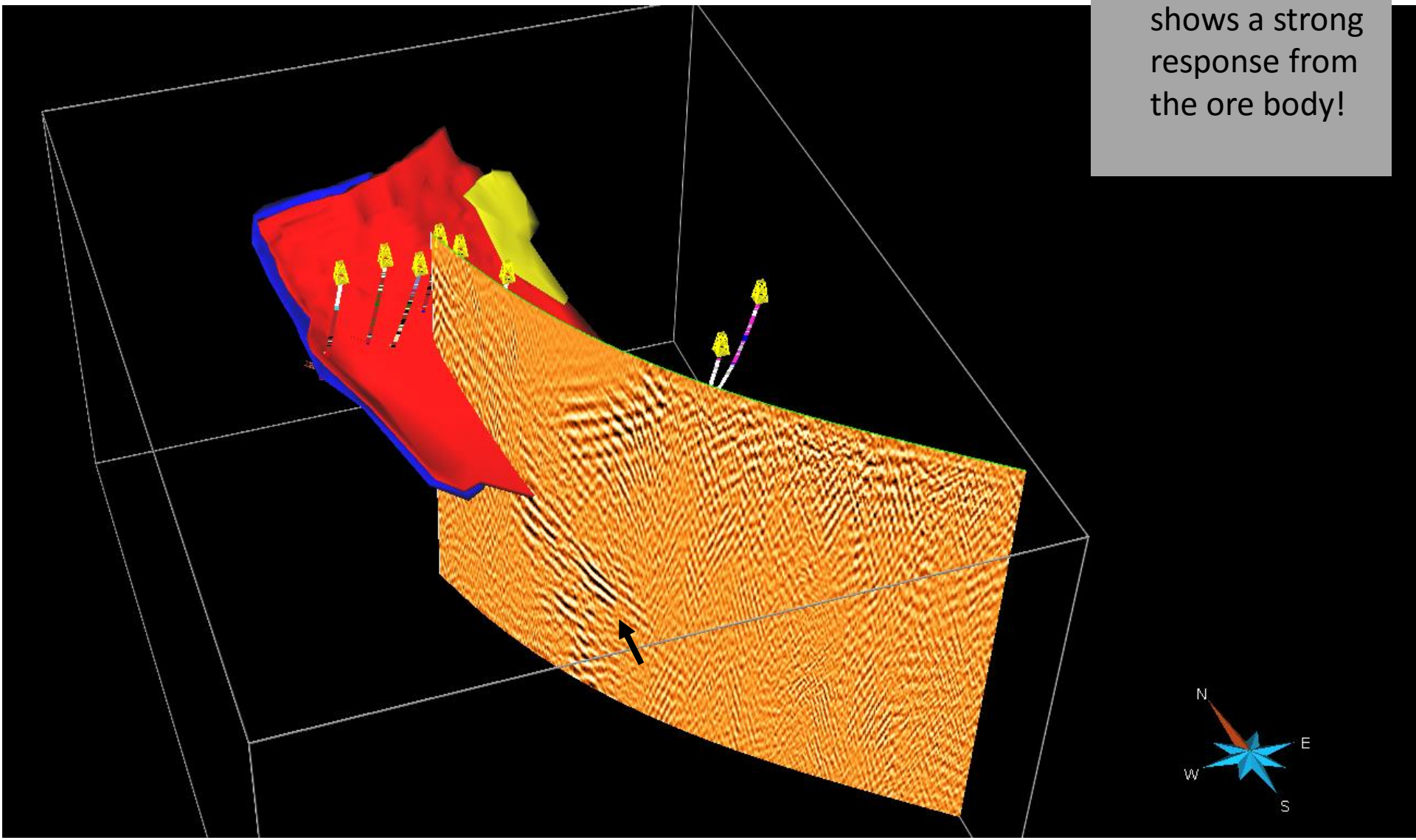
Overview so far

- Seismic data shows a strong response from the ore body!



Summary & Conclusions

- According to the density and downhole velocity measurements, a strong seismic response can be expected from the mineralized zone (confirmed by the test seismic reflection survey).
- A good correlation was observed between RQD and amplitude response in the sonic logs.
- Full-waveform sonic data could be used for rock quality estimations (very important for mine planning).
- Sonic data can be used for studying the amplitude attenuation in the 3 receivers and ultimately within the mineralized zone.

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Thank you!

Old ironworks in Blötberget area

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