



ARMT-5 - NEW EFFECTIVE SOLUTION
FOR ELECTROMAGNETIC STUDIES
IN WIDE FREQUENCY RANGE

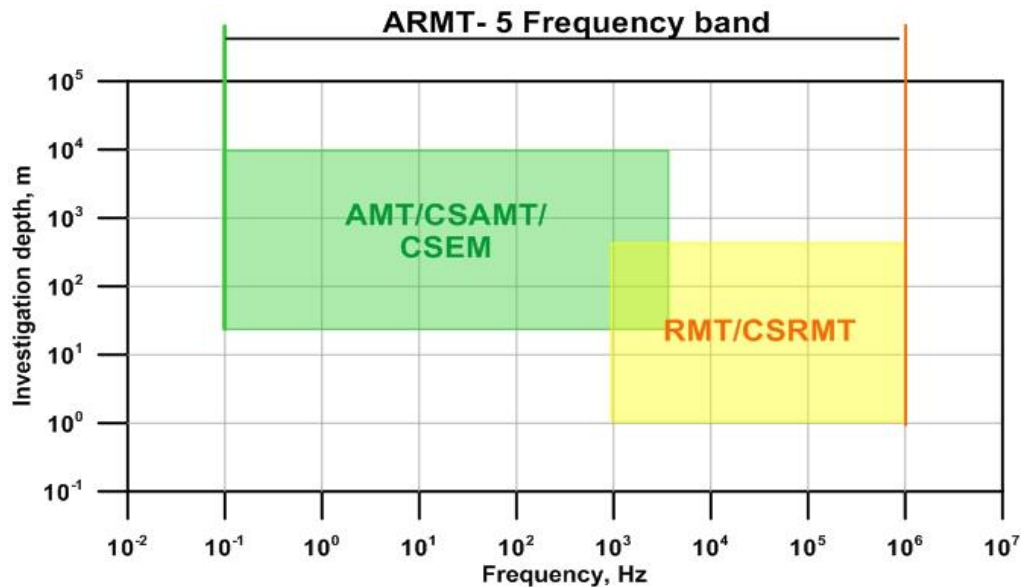
ARMT-5 system is designed for implementation of a variety of electric survey methods: AMT, CSAMT, CSEM, RMT, CSRMT, airborne and vehicle-towed versions of RMT.

- Its wide frequency range (0.1 Hz – 1 MHz) enables applying this tool to explore depths from first meters up to several kilometers for a broad spectrum of targets
- It consists of the digital 5-channel recorder, electric and magnetic sensors.
- Special case with tripod for magnetic sensors simplify their installation at the measurement station.



Wide range geophysical equipment

The equipment set is intended for electromagnetic field measurements in both AMT (0.1 Hz – 10 kHz) and RMT (10 kHz – 1 MHz) frequency bands.



Skin-depth $d \approx 500\sqrt{(\rho/f)}$ limits the investigation depth of MT methods so it becomes dependent on both frequency of electromagnetic wave and electric resistivity of subsurface.

| | | Frequency (f), Hz | | | | | | | |
|------------------------------|-------|-------------------|--------|-------|-------|-------|--------|---------|-----------|
| | | 0,1 | 1 | 10 | 100 | 1 000 | 10 000 | 100 000 | 1 000 000 |
| Resistivity (ρ), Om·m | 1 | 1 600 | 500 | 160 | 50 | 16 | 5 | 1,6 | 0,5 |
| | 10 | 5 000 | 1 600 | 500 | 160 | 50 | 16 | 5 | 2 |
| | 100 | 16 000 | 5 000 | 1 600 | 500 | 160 | 50 | 16 | 5 |
| | 1 000 | 50 000 | 15 800 | 5 000 | 1 600 | 500 | 160 | 50 | 16 |



Geological mapping



Geotechnical studies



Mapping of fracture zones



Application range



Hydrogeological studies



Permafrost studies



Geothermal studies



Mineral prospecting



Search for oil and gas



Environmental studies

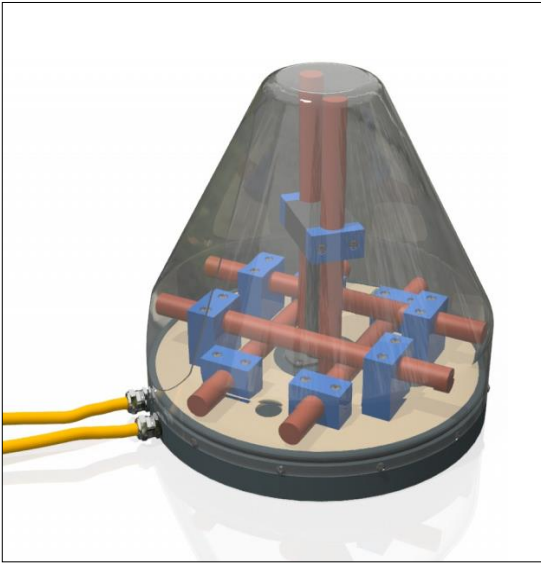


| | |
|-----------------------------|--|
| Frequency bandwidth | 0.1 Hz – 1 MHz |
| A/D converter | 24-bit SAR and 16-bit Σ - Δ |
| Dynamic range | 110 dB (0.1 Hz – 10 kHz) and 90 dB (10 kHz – 1 MHz) |
| Sampling frequency | 4, 32, 400, 4 000 kHz |
| Number of channels | 5 (2 electric and 3 magnetic) |
| Display | Color high-contrast 7" (1024×600) |
| Keyboard | Membrane (22 buttons) |
| Drive | SSD (128 GB) |
| OS | Linux |
| Communication interfaces | 1000BASE-T Ethernet, 802.11b / g Wi-Fi, external radio modem for remote control of generator |
| GNSS | Built-in and external antennas for time synchronization and position evaluation |
| Calibration | Automatic with built-in sine-wave generator |
| Gain | 1 – 256 |
| Operating temperature range | -30°C ÷ +40°C |
| Power | Built-in battery or 12 V |
| Weight | 4 kg |

Specifications of the ARMT-5 recorder

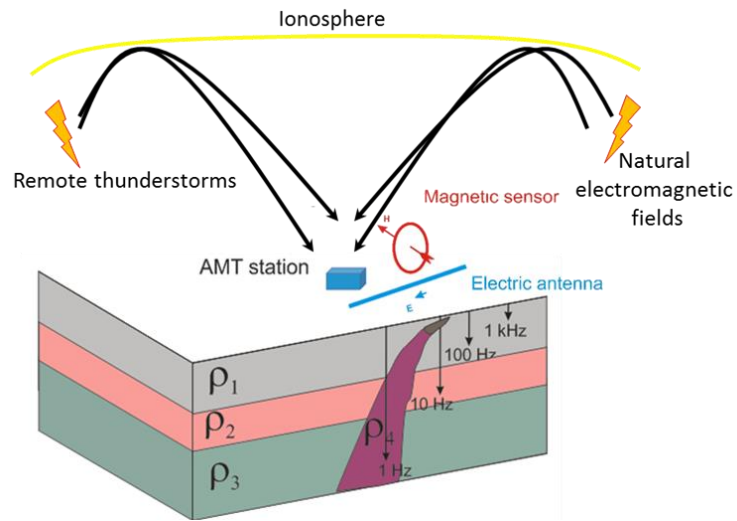


Specifications of ARMT-5 magnetic sensors

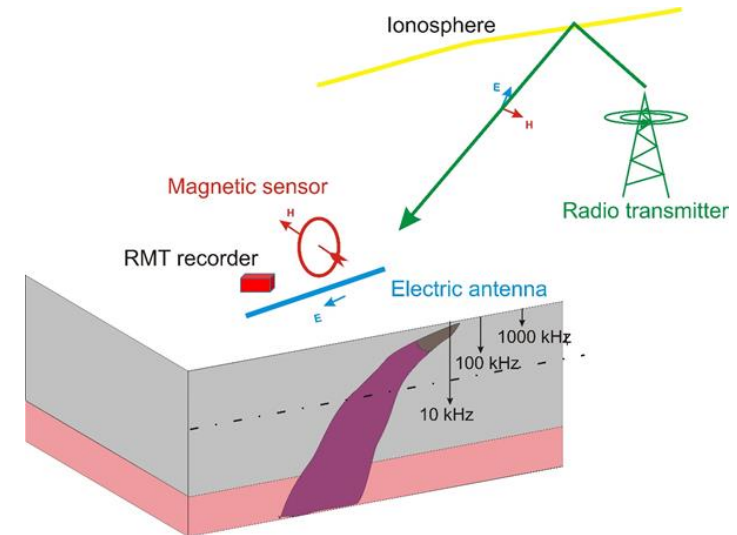


| | ARMT-LF | ARMT-MF | ARMT-HF |
|--------------------------------|--|--|---|
| Frequency bandwidth | 0.1 – 20 000 Hz | 4 – 50 000 Hz | 1 – 1 000 kHz |
| Length | 1 110 mm | 300 mm | 200 mm |
| Diameter | 70 mm | 25 mm | 25 mm |
| Weight | 4.8 kg | 360 g | 200 g |
| Transformation coefficient | F ≤ 0.5 Hz: 160 mV/nT·Hz F ≥ 0.5 Hz: 80 mV/nT | 10 mV/nT | 25 mV/nT |
| Noise level (spectral density) | F = 10 Hz: 8 fT/Hz ^{1/2} F = 1 000 Hz: 2 fT/Hz ^{1/2} | F = 10 Hz: 1 800 fT/Hz ^{1/2} F = 100 Hz: 100 fT/Hz ^{1/2} F ≥ 1 kHz: ≤ 25 fT/Hz ^{1/2} | F = 1 kHz: 100 fT/Hz ^{1/2} F ≥ 10 kHz: ≤ 8 fT/Hz ^{1/2} |
| Current consumption | 18 mA | 3-5 mA | 6 mA |
| Power | ±(7 – 10) V | 5 V | 5 V |

Audiomagnetotelluric soundings



Radiomagnetotelluric soundings



Frequency range

0.1 – 10 000 Hz

10 – 1 000 kHz

Investigation depth

From 20-50 m to 5-10 km

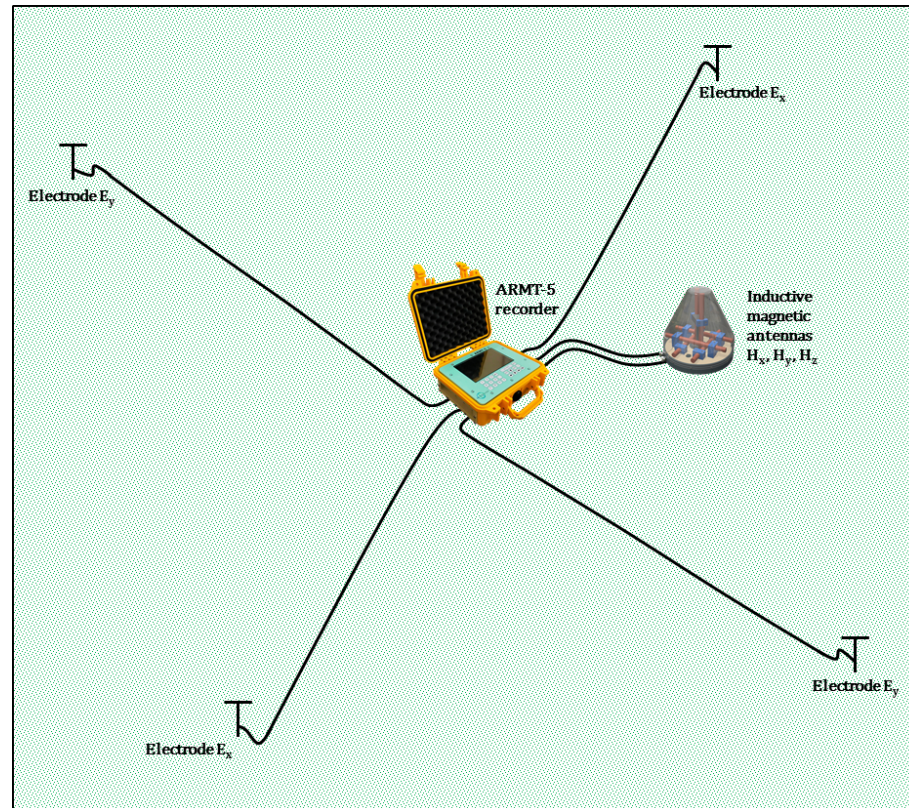
From 2-5 m to 30-50 m

Areas of application

Structural studies, geophysical prospecting, geothermal investigations, etc.

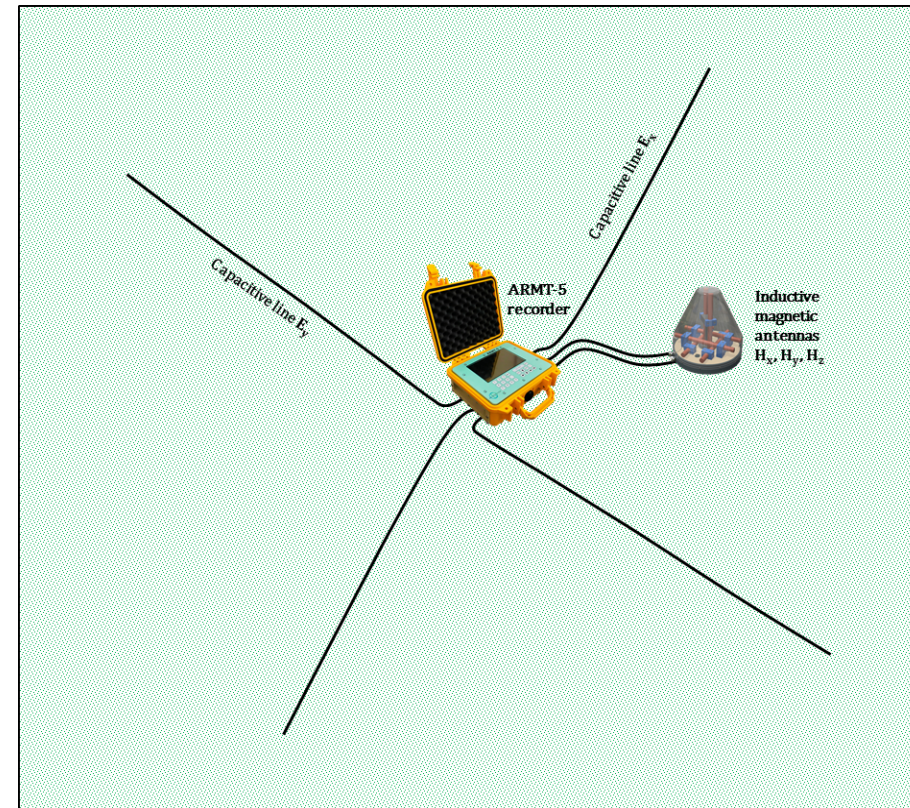
Hydrothermal and environmental studies, near-surface geophysics, etc.

Audiomagnetotelluric soundings



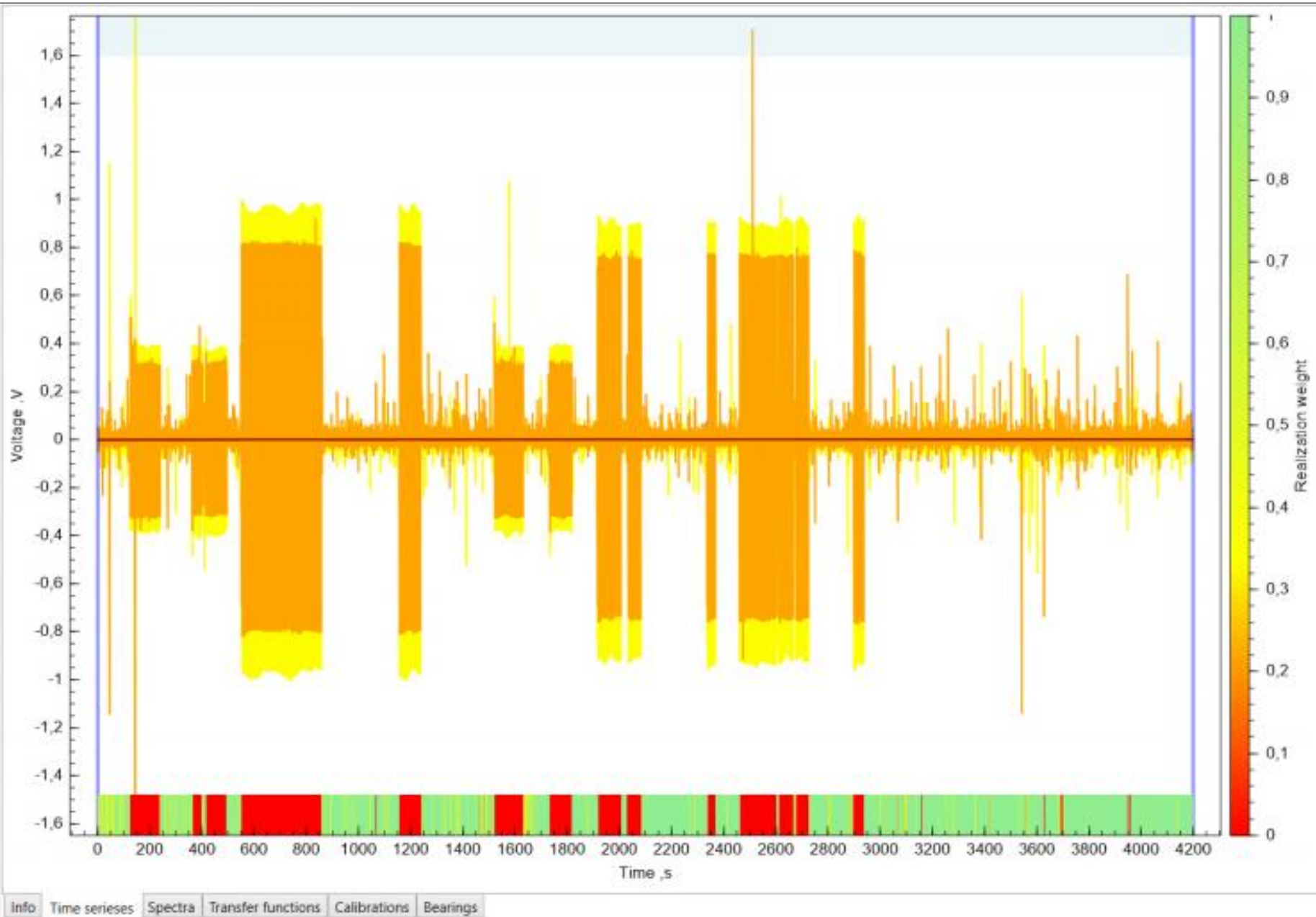
- Grounded electric antennas
- LF & MF magnetic sensors
- Measurement time: 5 – 30 min

Radiomagnetotelluric soundings



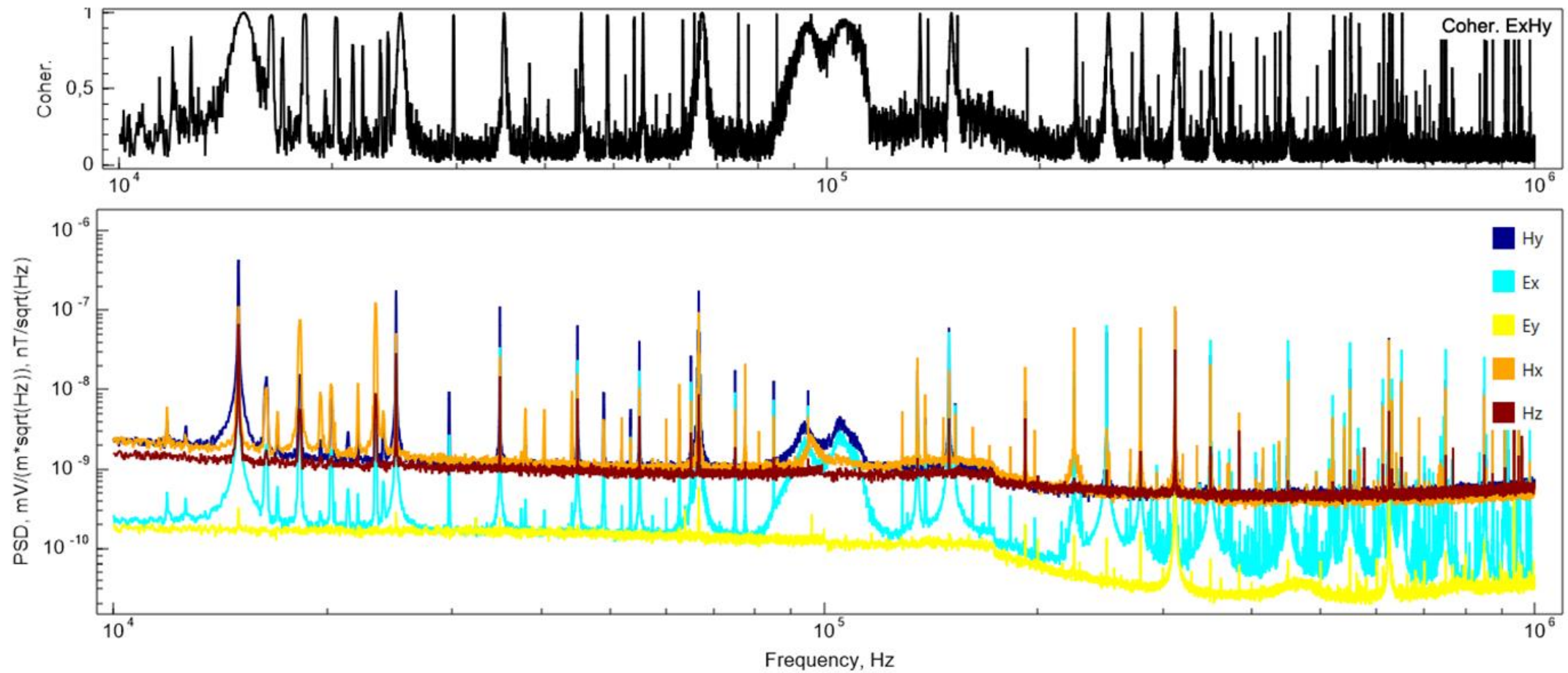
- Ungrounded electric antennas
- HF magnetic sensors
- Measurement time: few seconds

Data processing

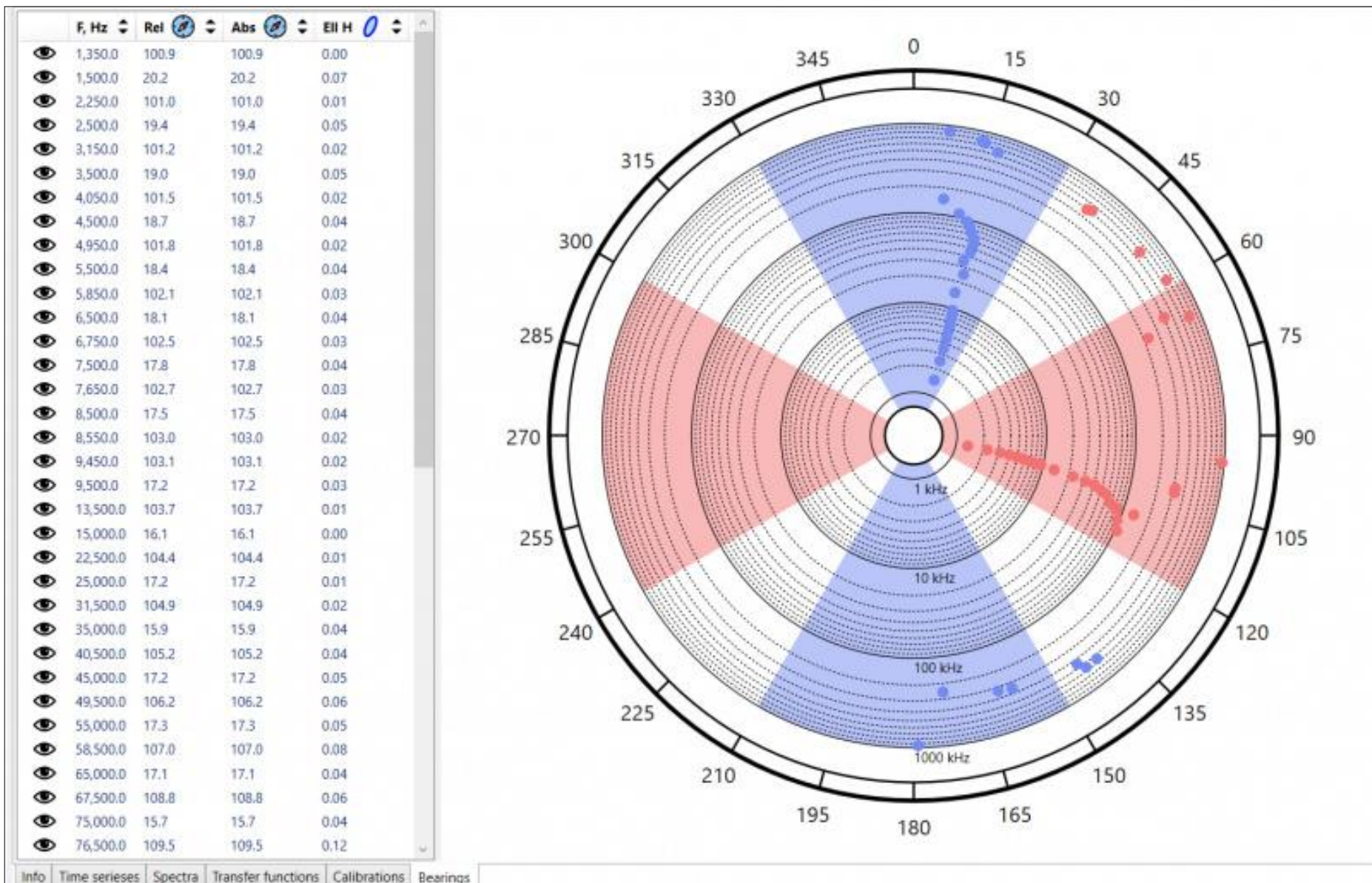


Time series of measured electromagnetic field components, rejection of noisy segments

Power spectrums and coherence calculation
in RMT frequency range (10 kHz – 1 MHz)

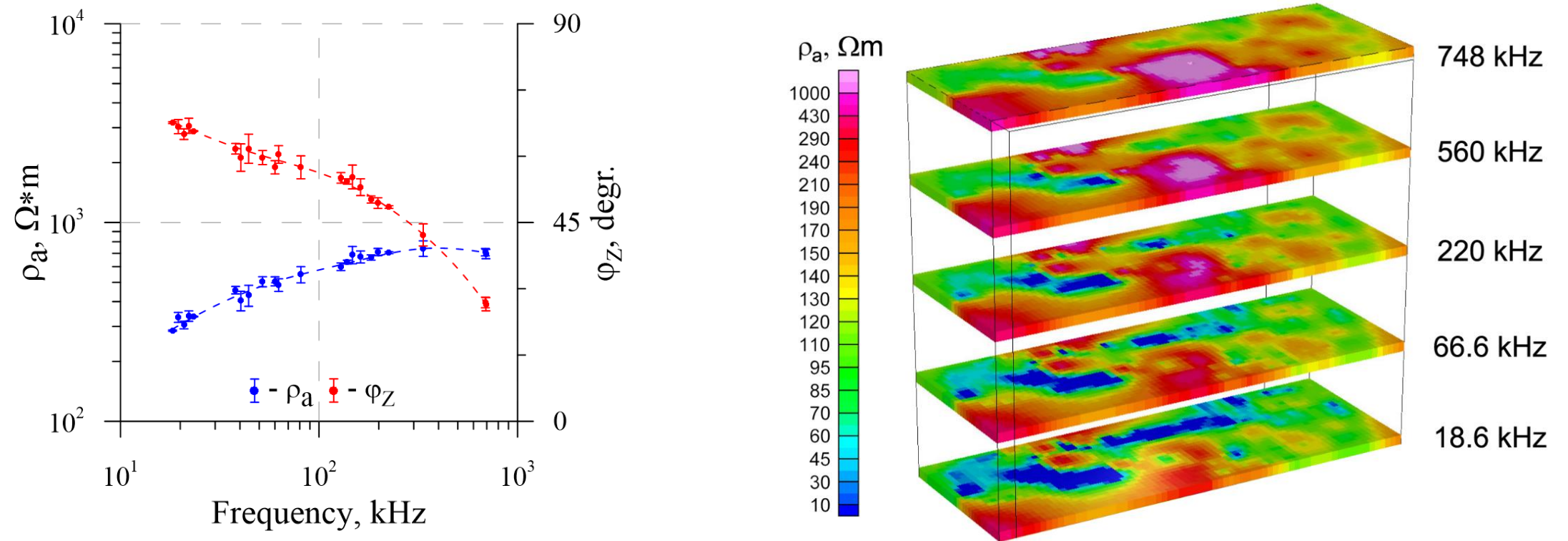


Data processing

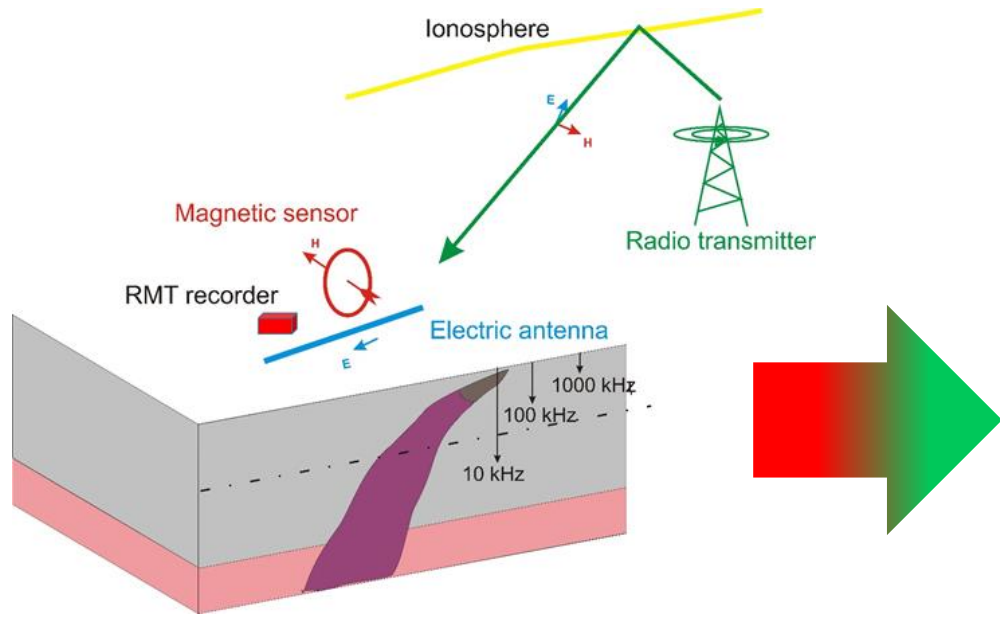


Analysis of signal sources, azimuth determination (for CSRMT data). Colored sectors limit signal sources that are eligible for further processing

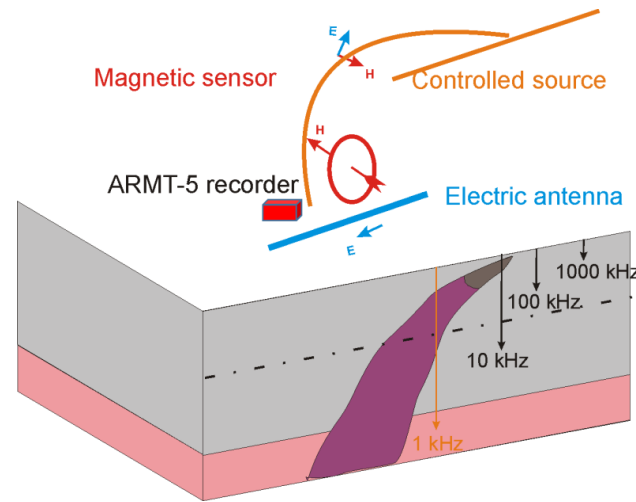
An example of sounding curves (ρ_a and φ_z) and primary RMT data presentation (pseudo sections of ρ_a)



RMT sounding



CSRMT sounding



RMT vs. CSRMT



Dependency on existence of radio transmitters signals



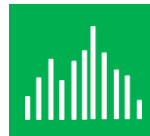
Dependency on the position of radio transmitters



Depth of investigation is limited by the lowest frequency of radio transmitter



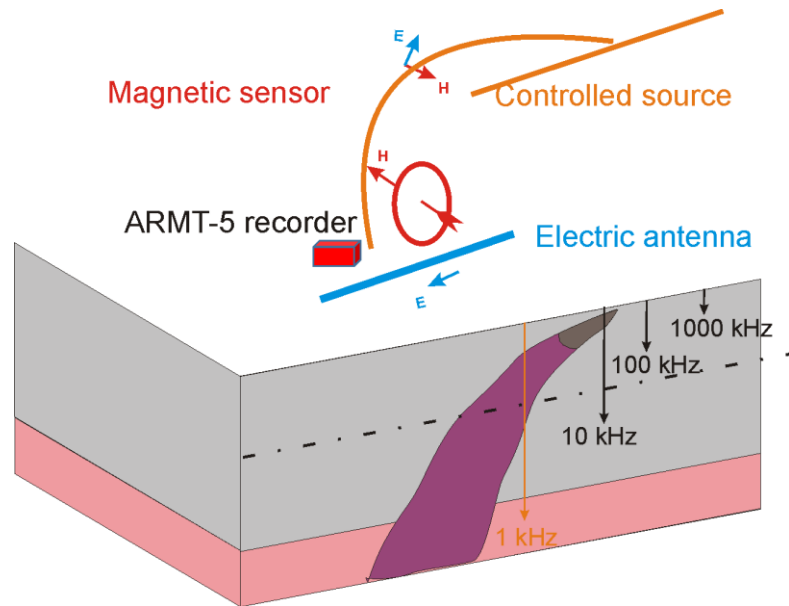
Usage grounded wire or loop with CS transmitter



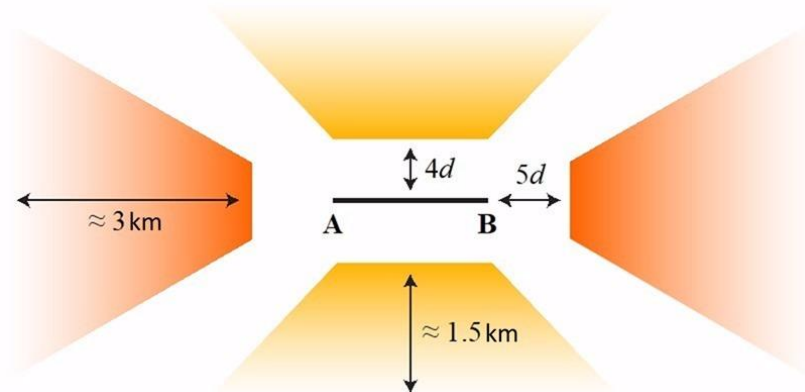
Extended frequency range that includes a part of AMT and provides larger depth of investigation



Better signal stability and data quality



Survey areas around the controlled source (grounded cable)

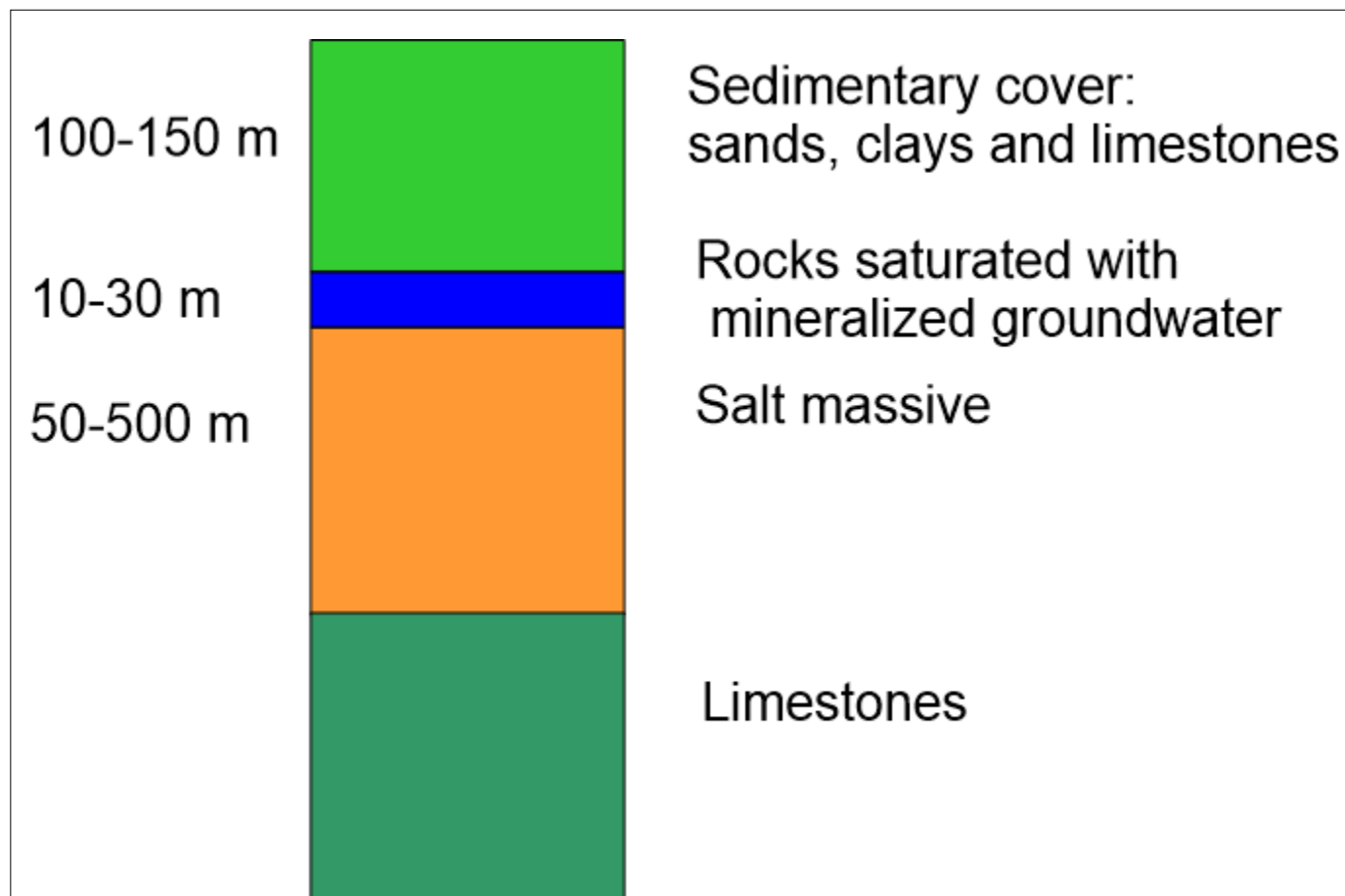


Specifications of CS transmitter

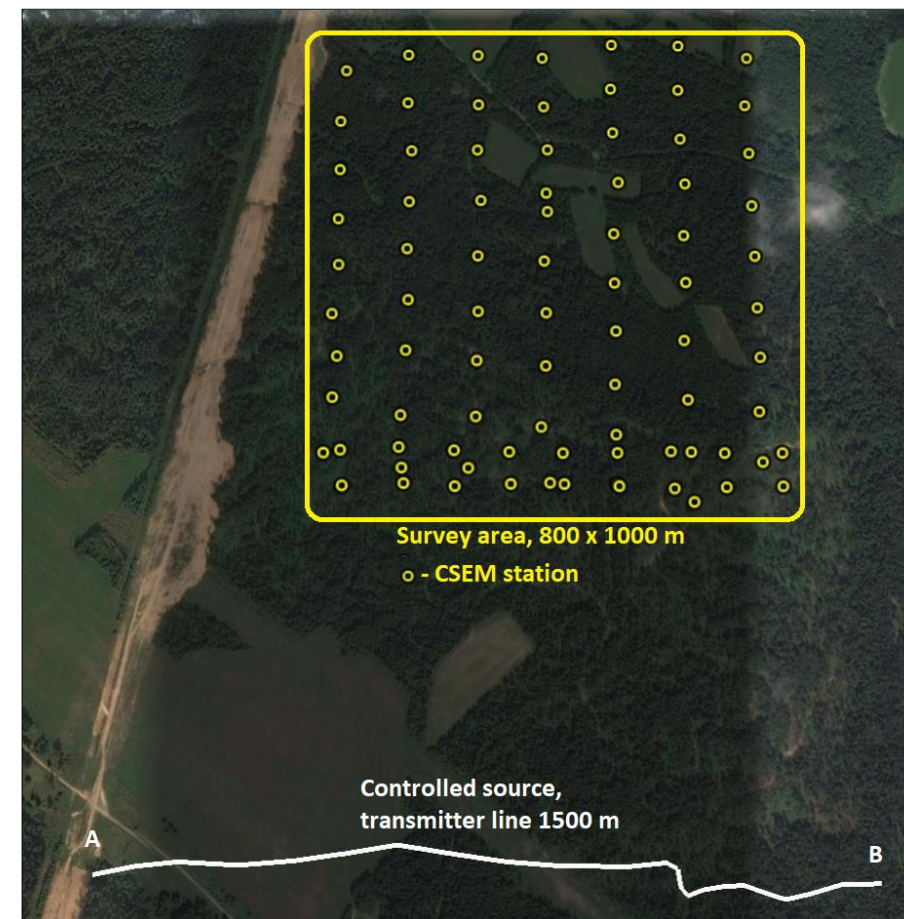
| | | | | |
|-----------------------------|--|------------------------|------|--------------------|
| Output power | 2 kW | | | |
| Max output voltage | 1.4 kV | | | |
| Max output current | 6 A | | | |
| Signal type | Square, duty cycle 100% | Square, duty cycle 50% | Sine | Arbitrary waveform |
| Frequency range | 0.001 Hz - 1 MHz | 0.001 Hz - 30 kHz | | |
| Output current stability | 0.5 % | | | |
| Control | Built-in display and keypad or external PC | | | |
| Connection interface | USB, Radio | | | |
| Synchronization | GPS | | | |
| Output current digitization | Yes | | | |
| Load resistance | 10 Ohm – 1 kOhm | | | |

Mapping of salt deposit using CSEM technique (Siberia, 2018)

Stratigraphy of the area



Survey area



Preparation of CS line



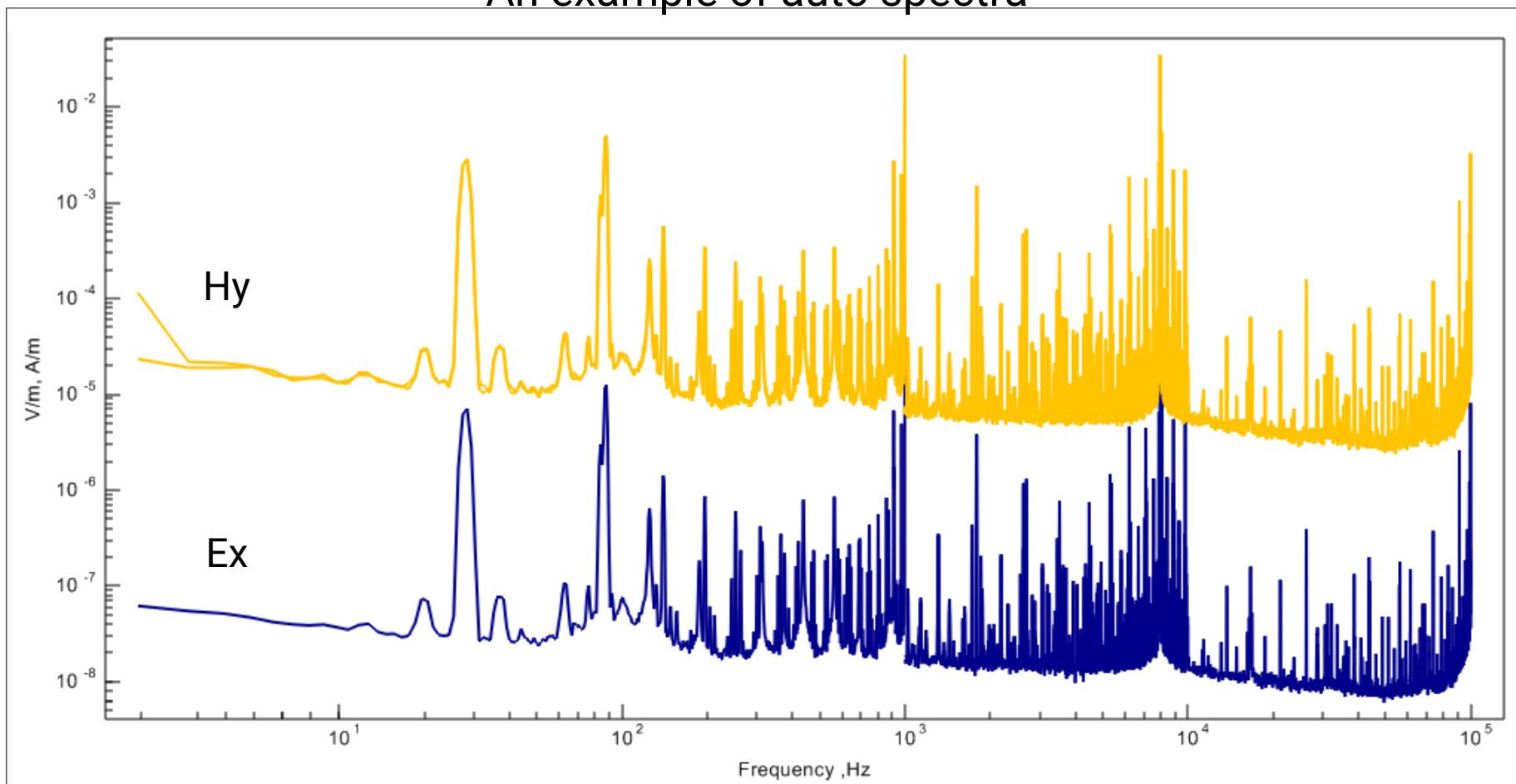
ARMT-5 at the measurement site



CS transmitter

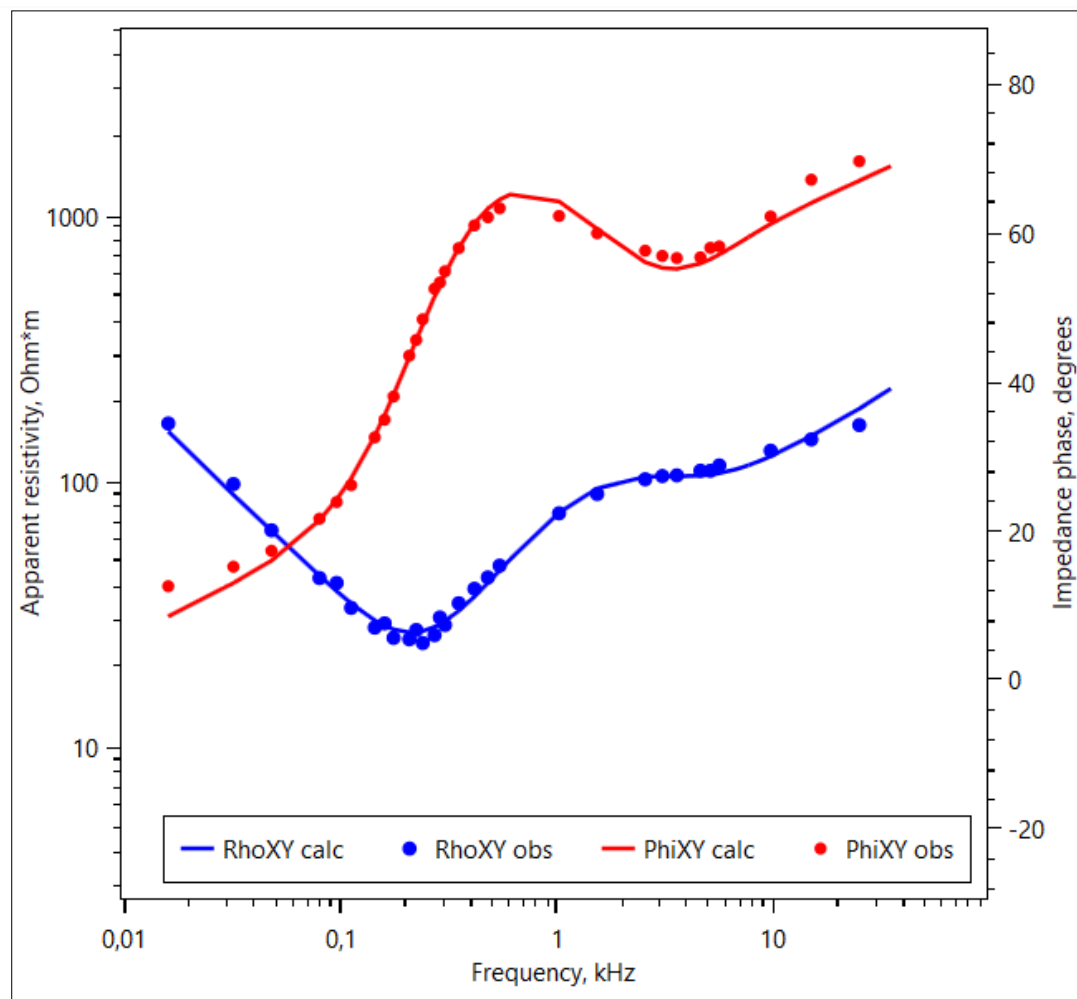


An example of auto spectra

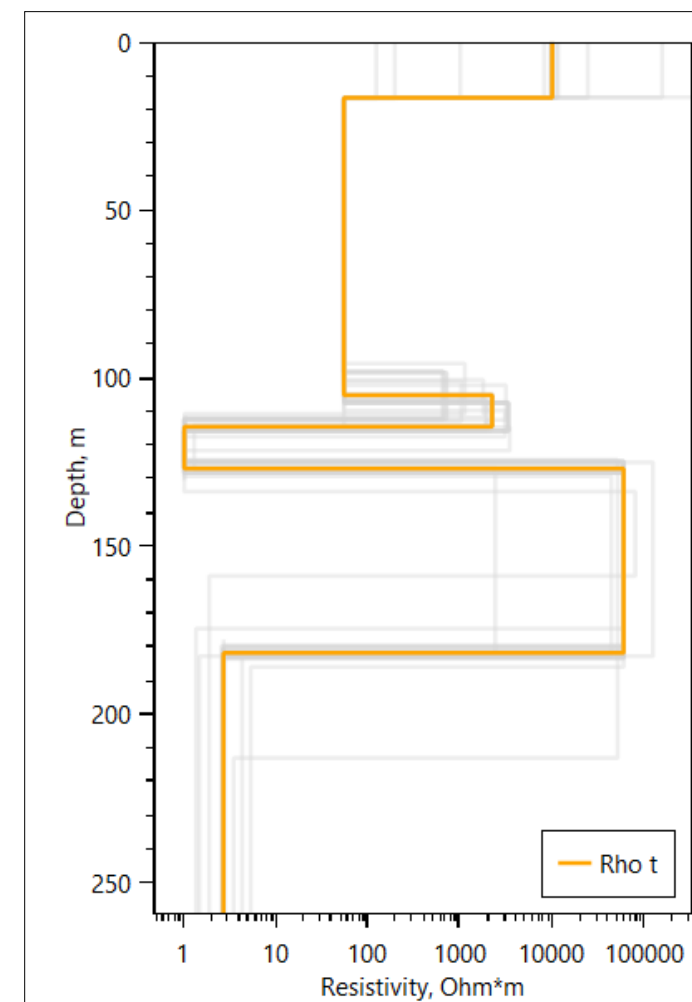


Six CS frequencies in the band 16 Hz – 50 kHz have been transmitted during the survey. Their odd harmonics allowed us to enrich the sounding curves with approximately 7-10 frequencies per decade.

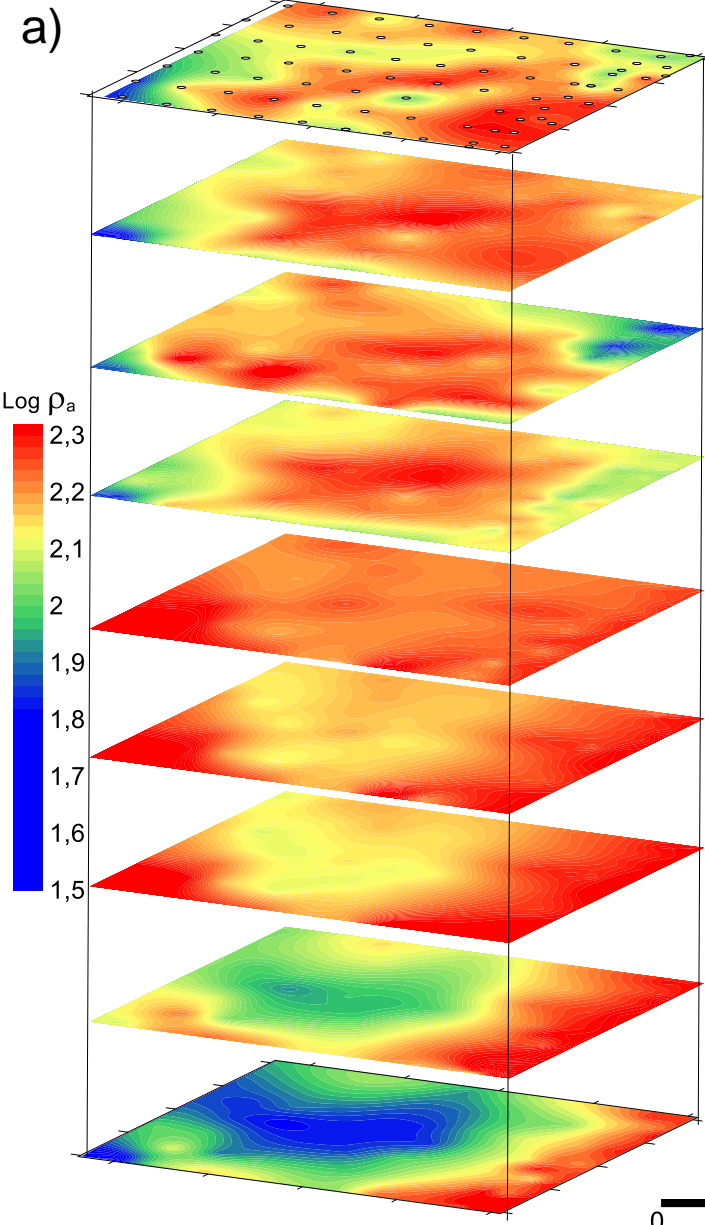
Sounding curves



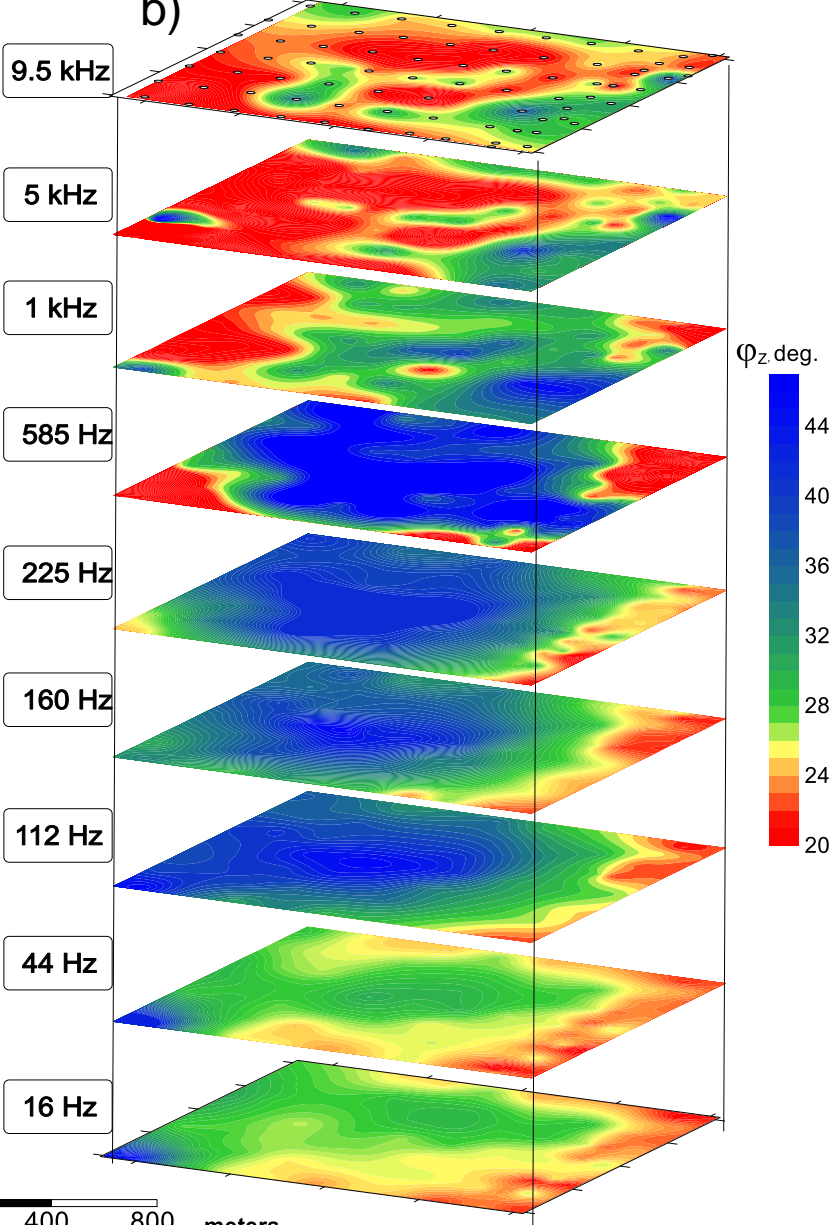
1D inversion, resistivity model



Apparent resistivity



Impedance phase

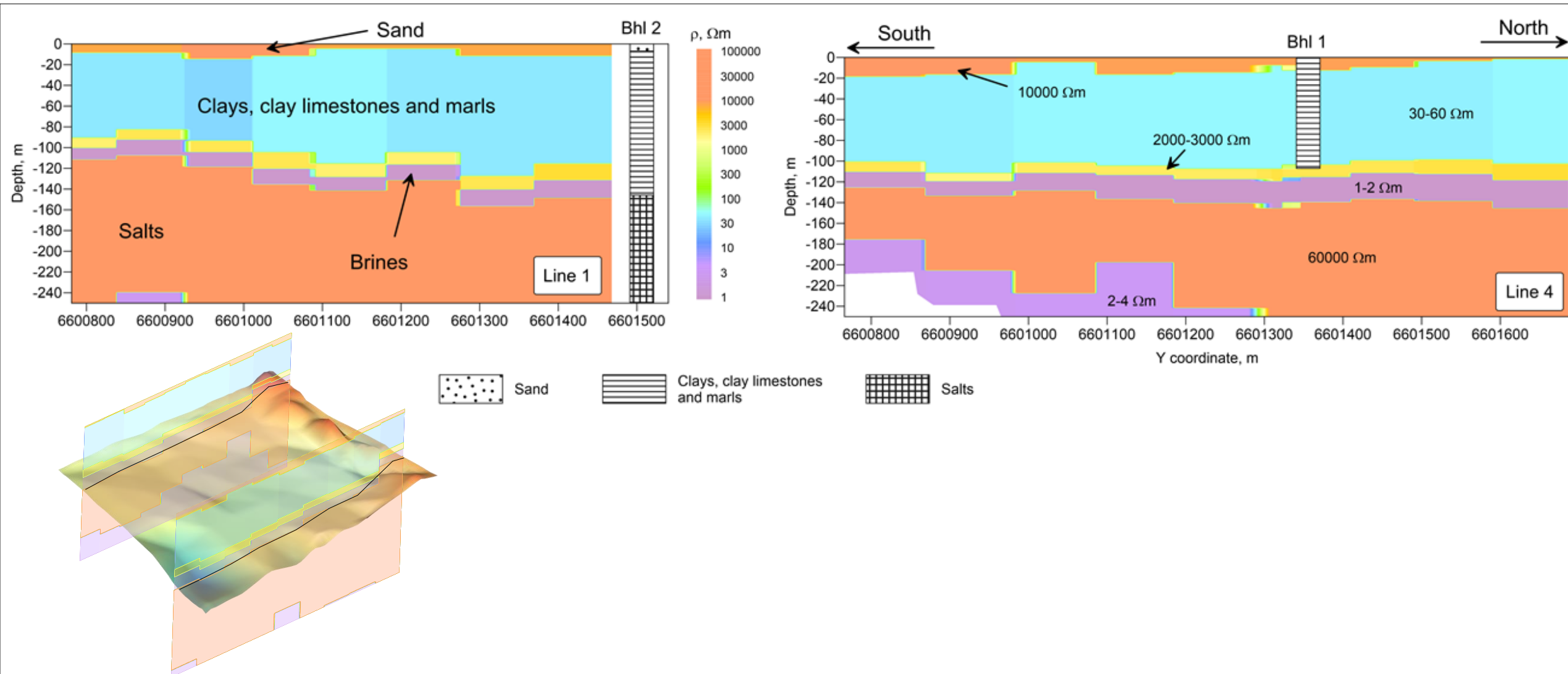


Data presentation: spatial distribution of measured values at different frequencies (a, b). They enable one to detect geoelectric anomalies even without the inversion.

1D inversion results

Case study

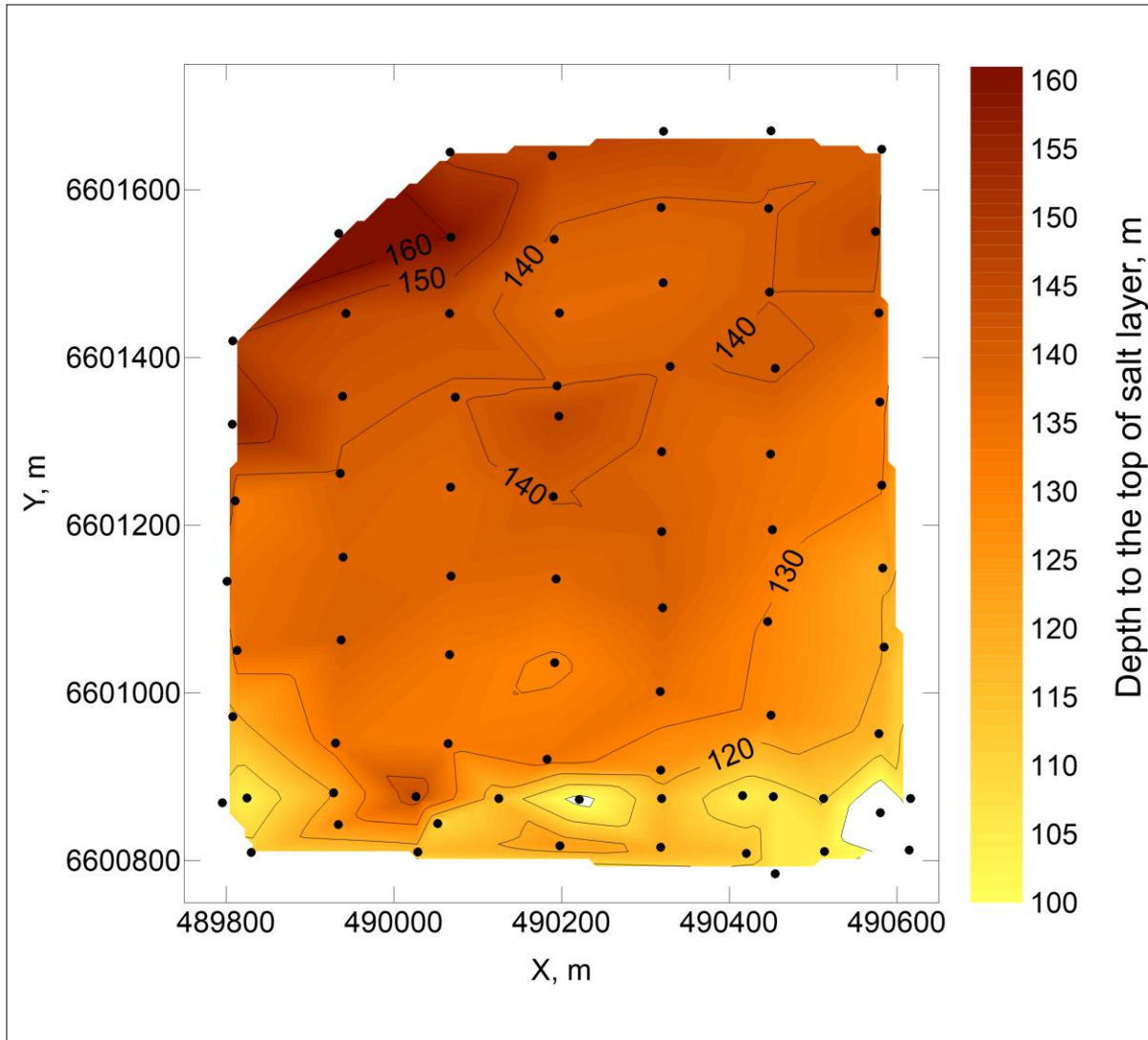
Geoelectric sections along lines 1 & 4



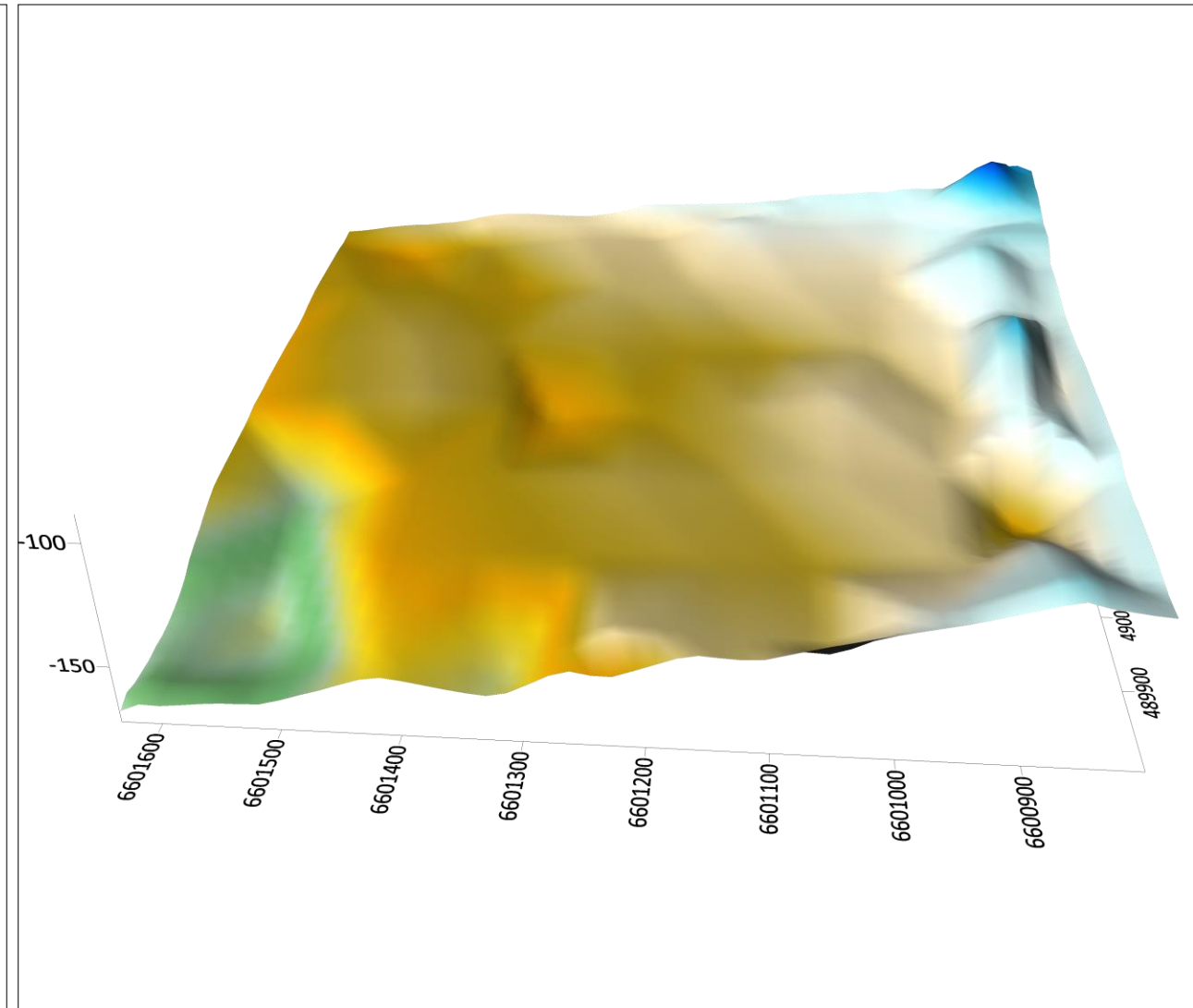
1D inversion results

Mapping of salt layer surface

Depth from surface

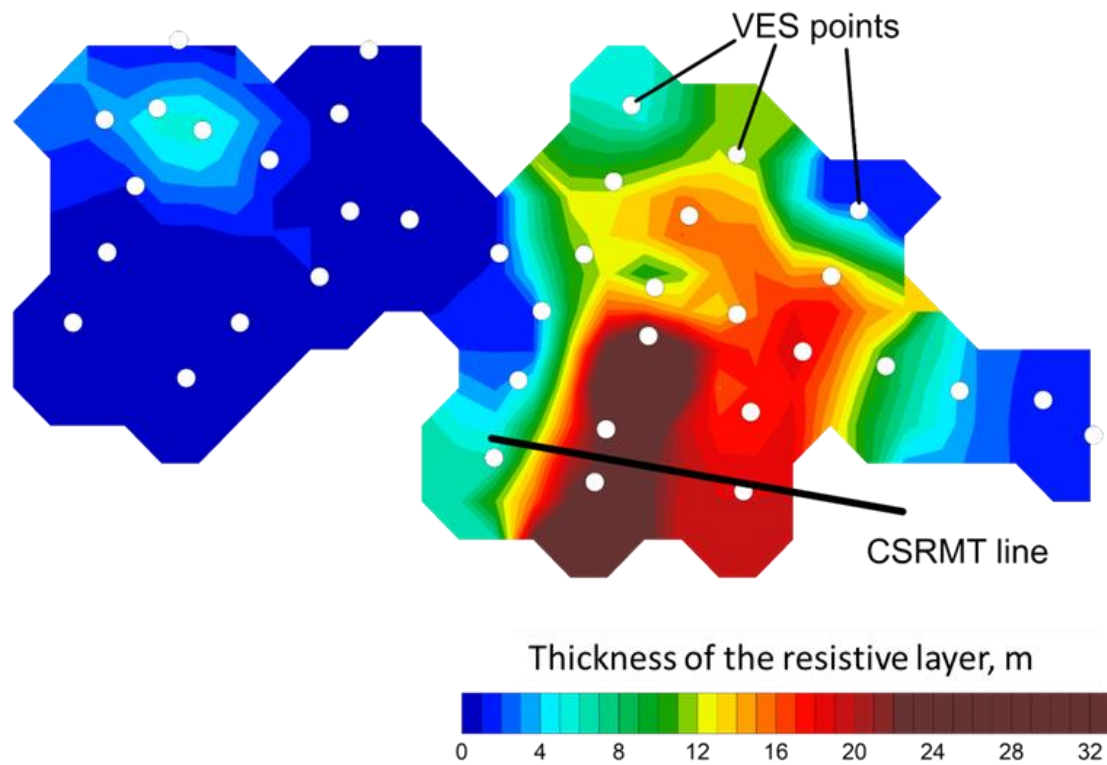


Axonometry

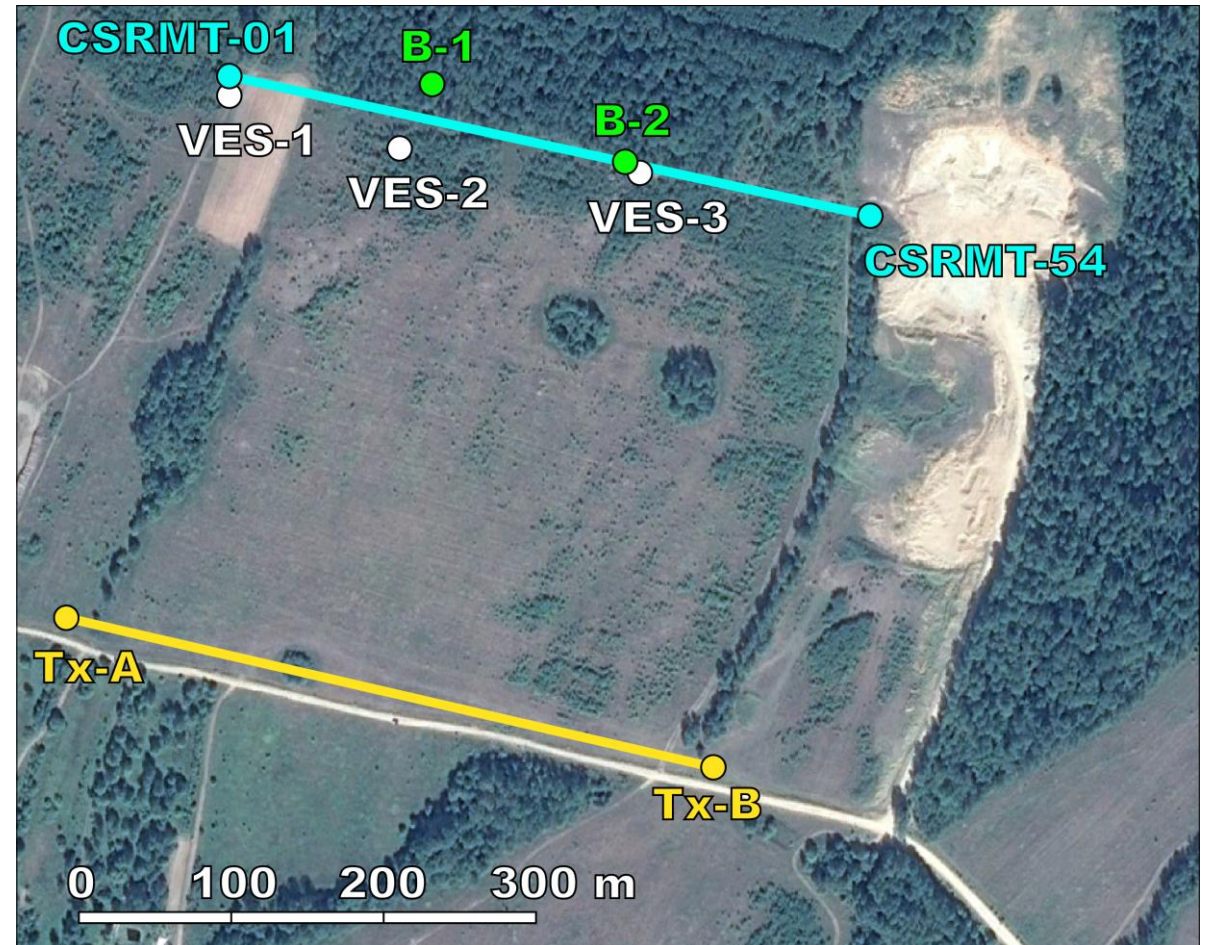


Mapping of sand and gravel deposit (CSRMT)

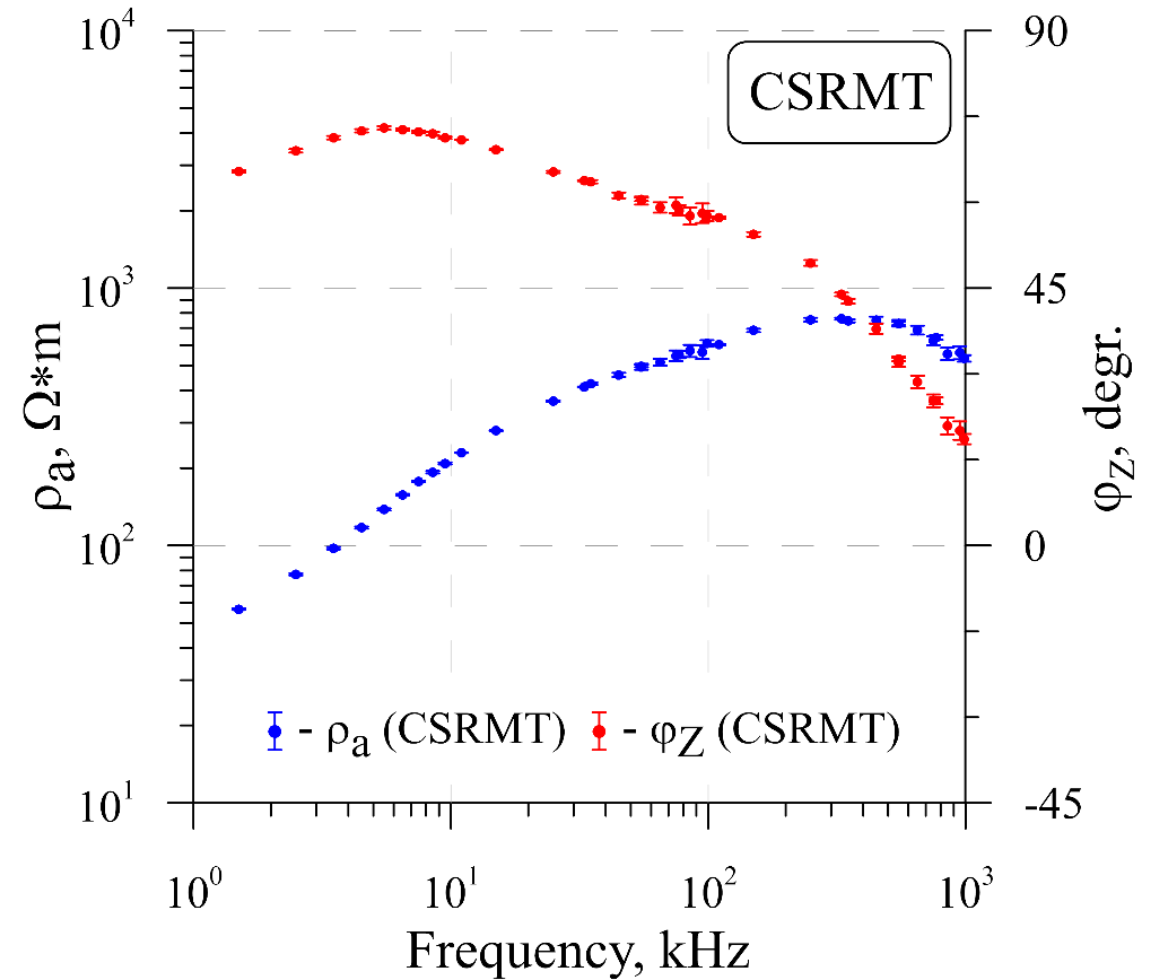
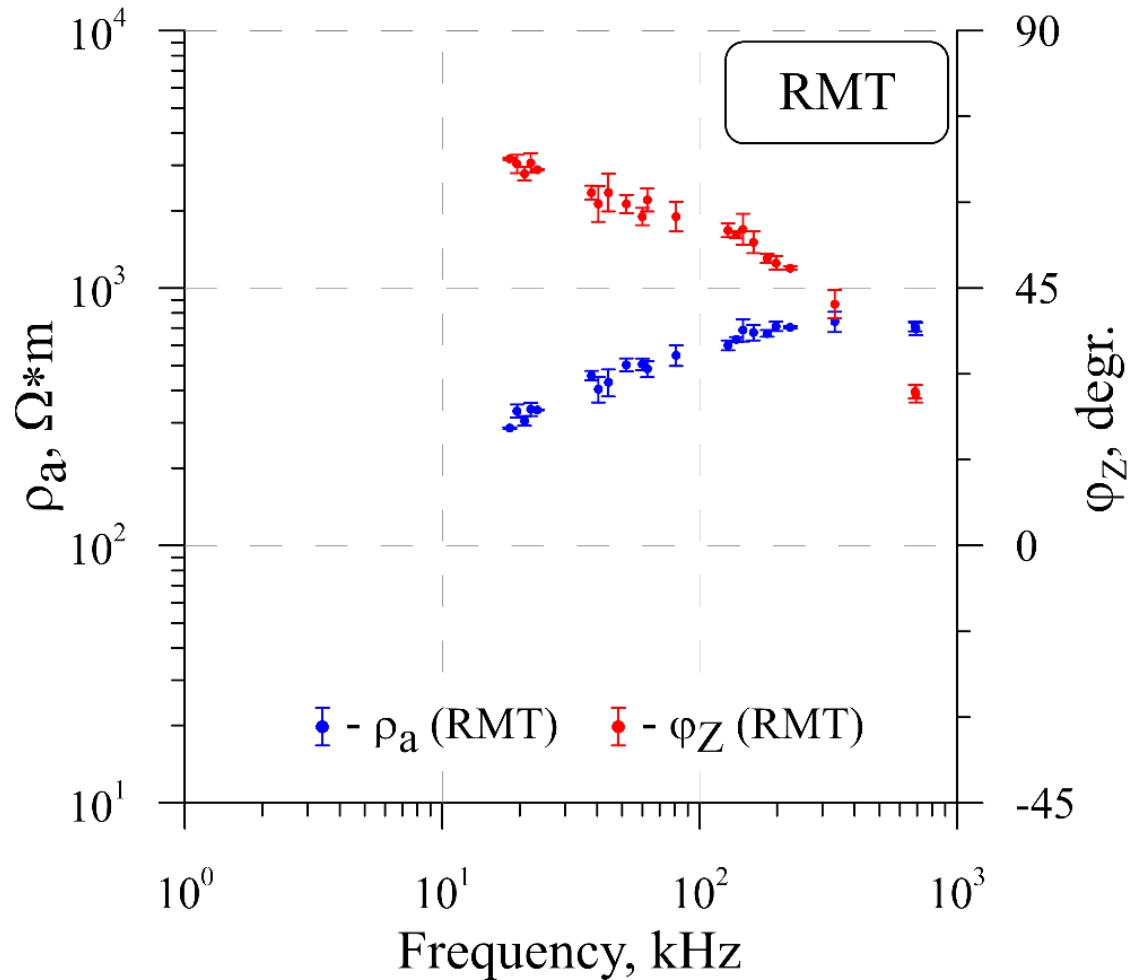
Previous vertical electric soundings data



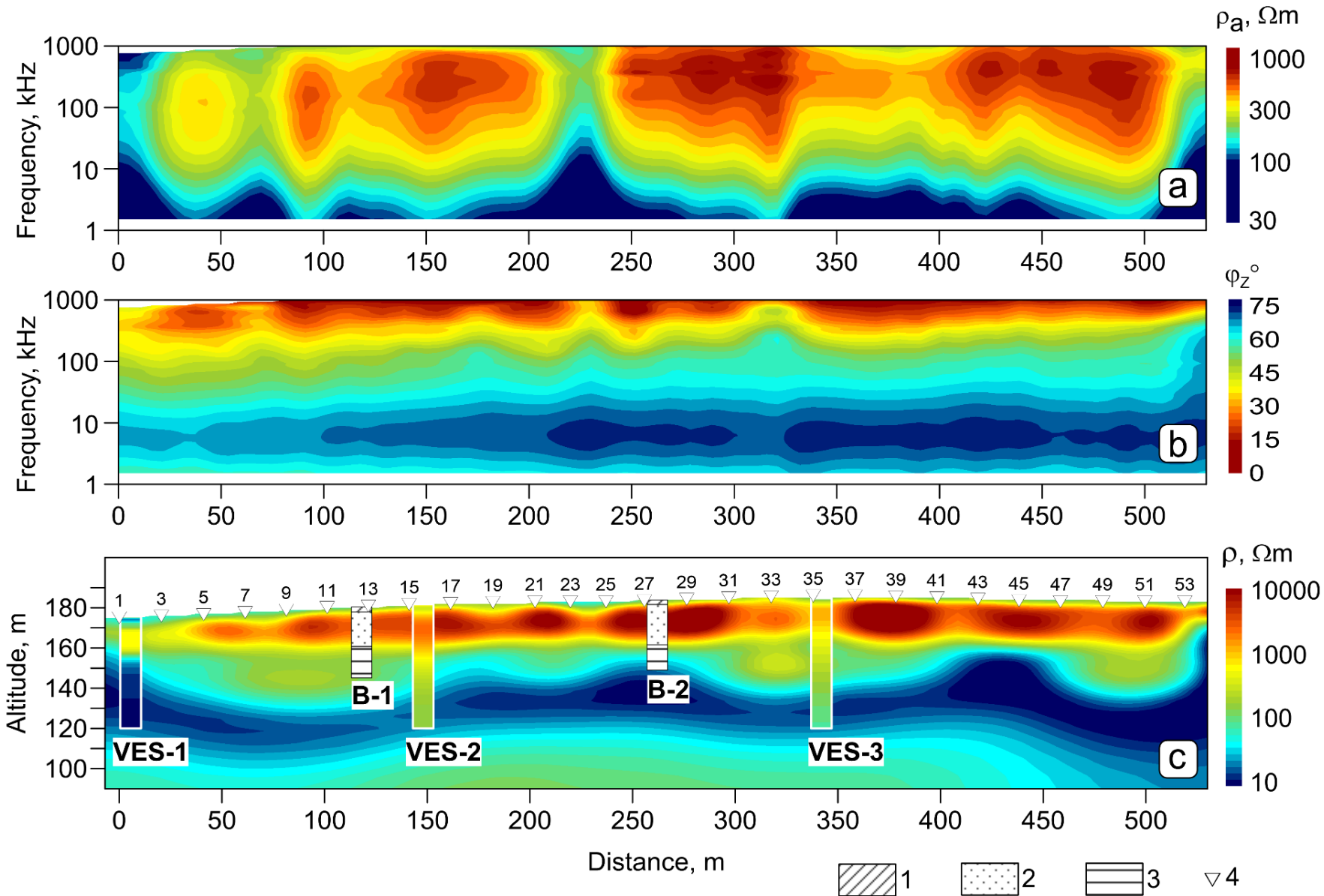
CSRMT survey area



Comparison of RMT and CSRMT data



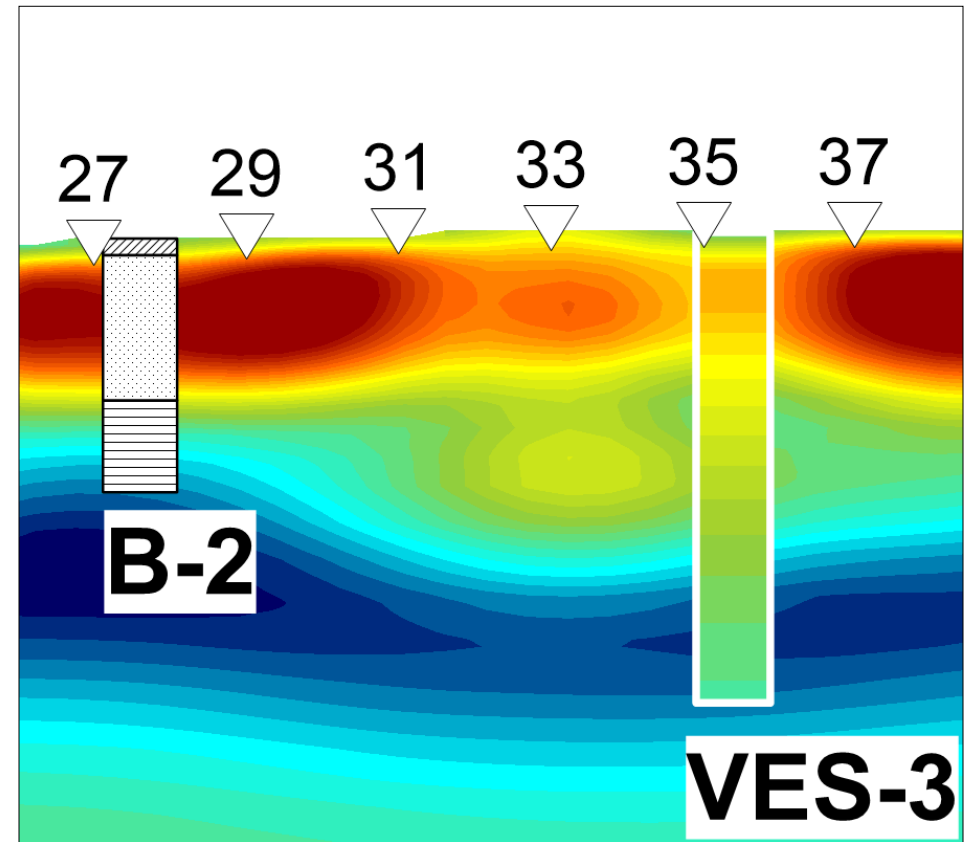
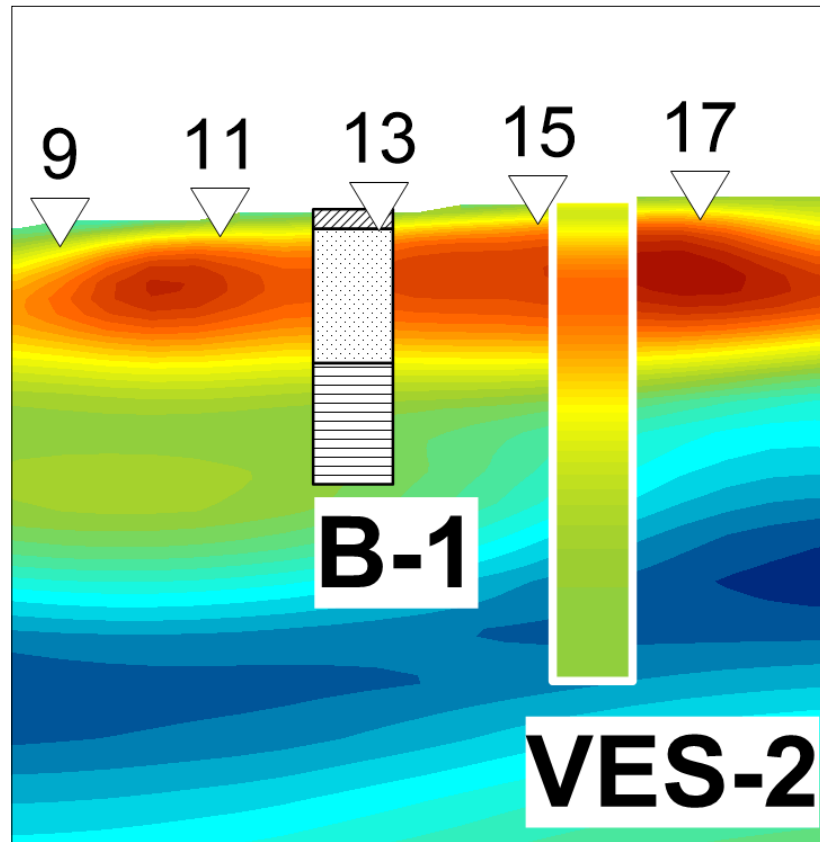
Case study



Pseudo-sections of apparent resistivity (a), impedance phase (b) and geoelectrical section (c) (2D inversion results).

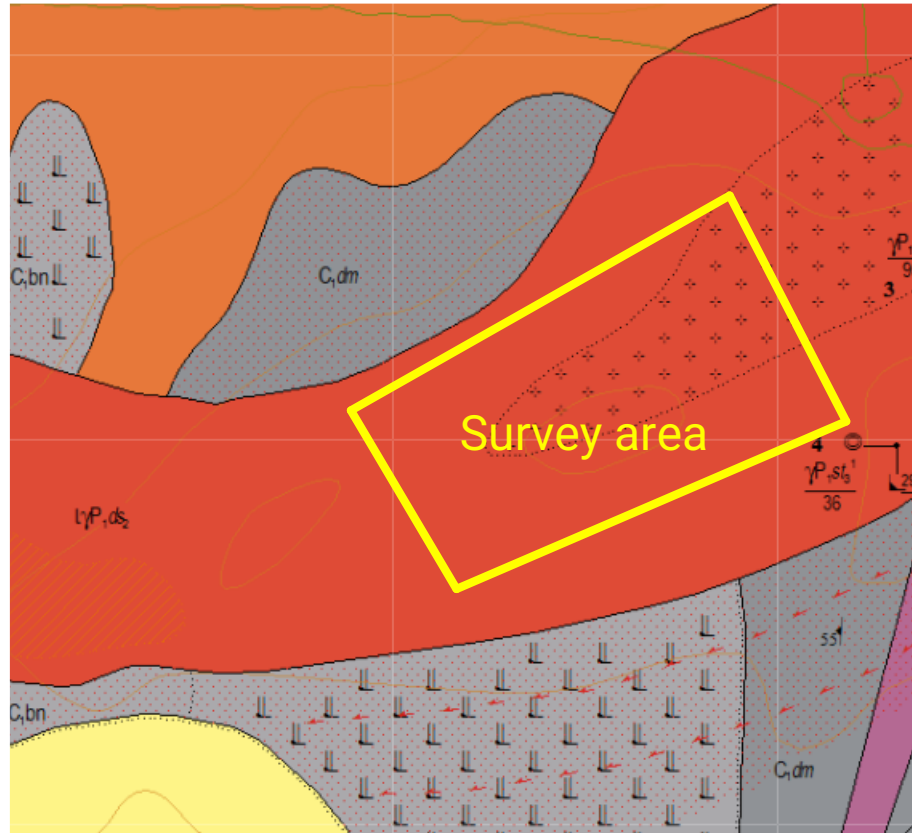
1 – loams, 2 – sands and gravels, 3 – clays, 4 – CSRMT stations.

Comparison with borehole and VES data



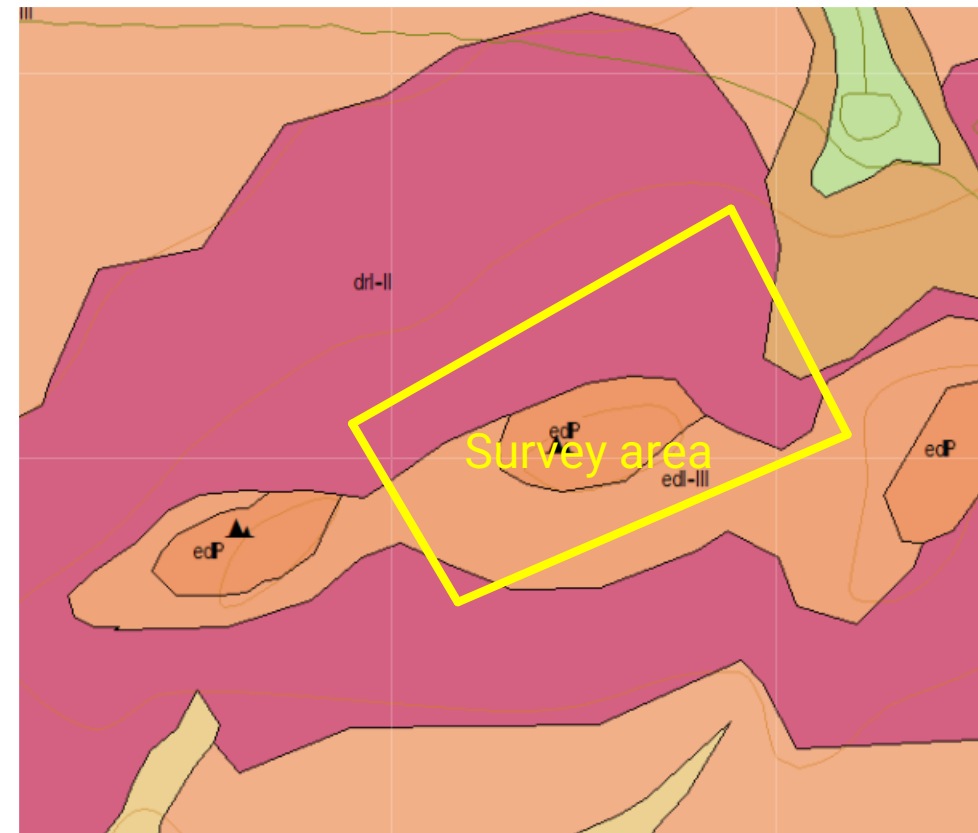
Mapping of granite deposit using CSEM technique (Siberia, 2019)

Geological map



- $\gamma P_1 ds_2$ Permian granites of type 1
- $\gamma P_1 st_3$ Permian granites of type 2

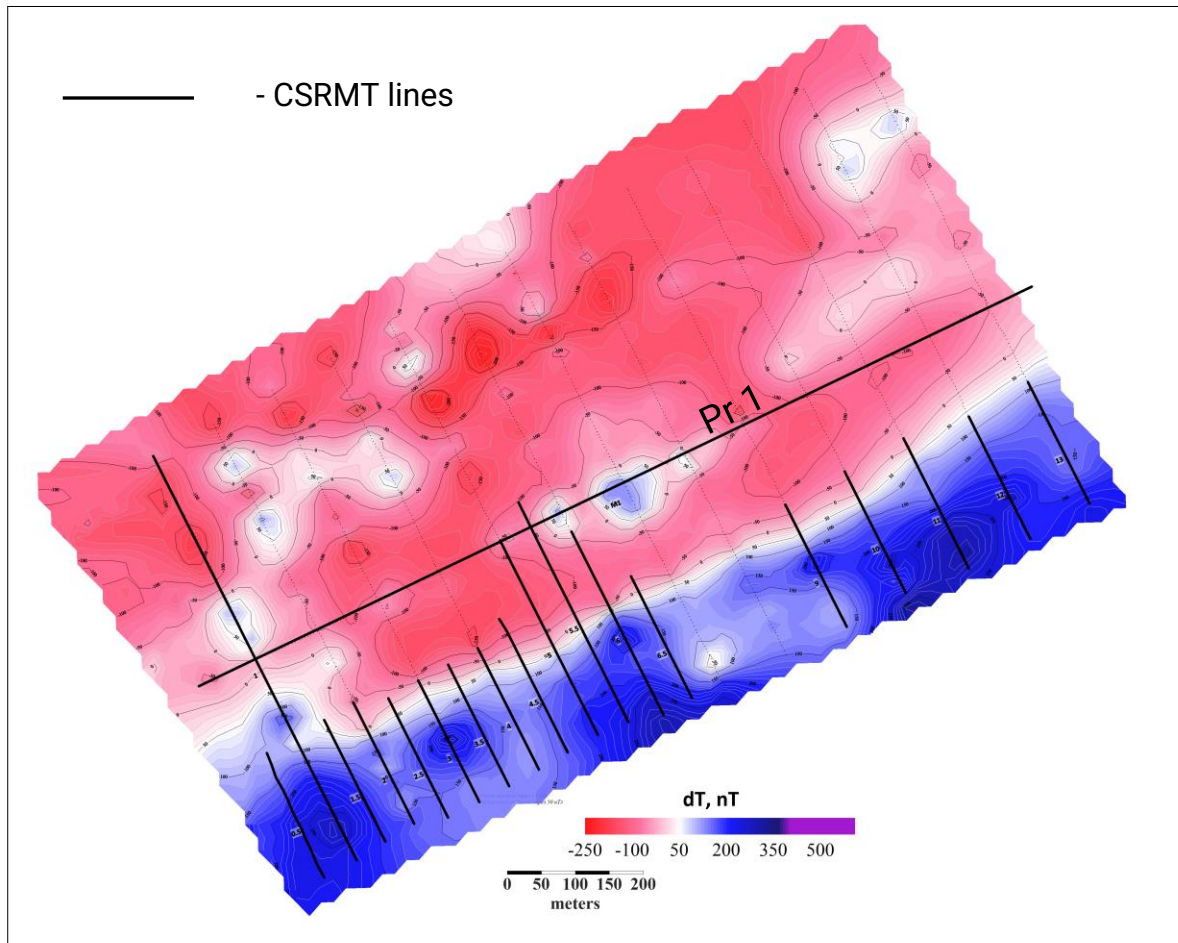
Map of sediments



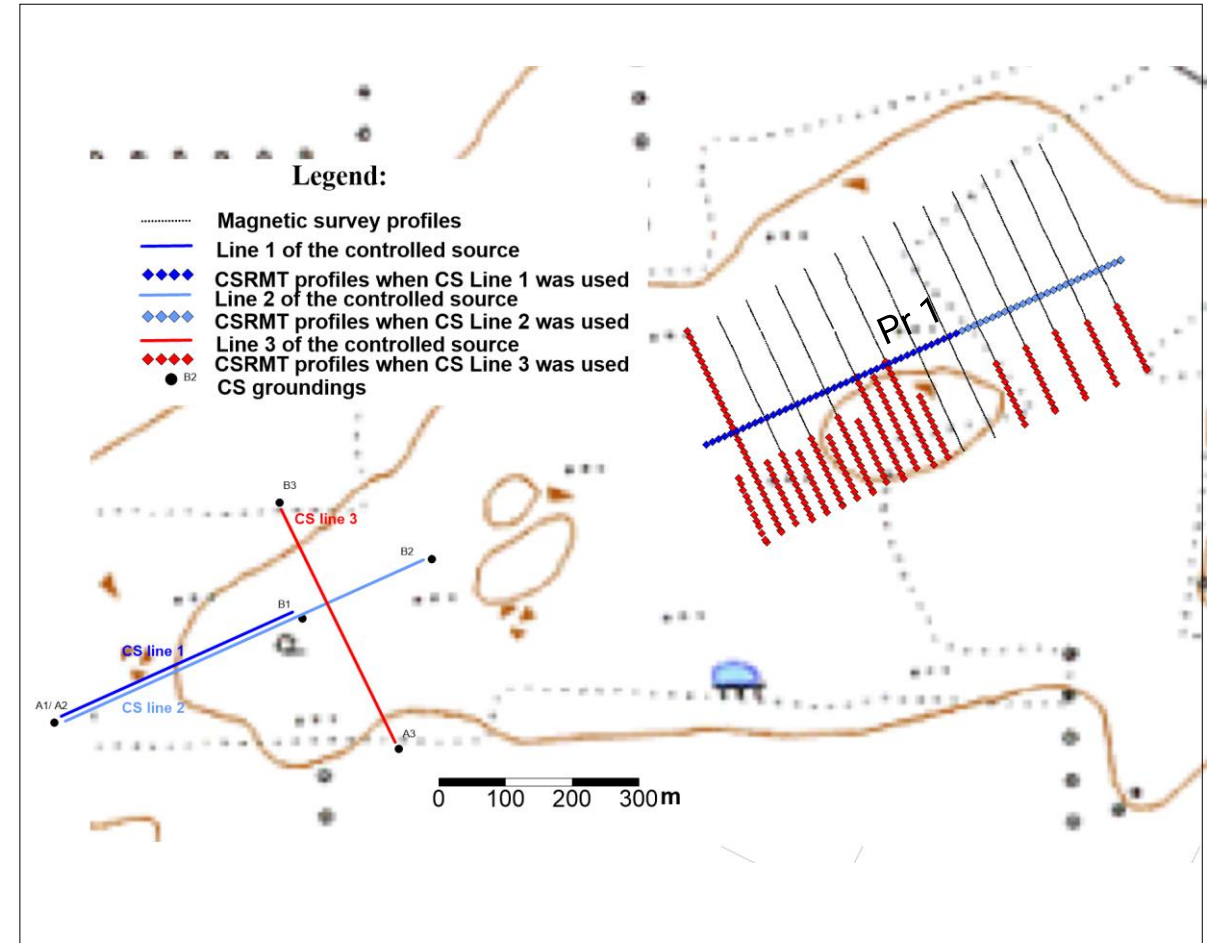
- edP Quaternary eluvial loams
- $edl-III$ Quaternary eluvial loams and sands
- $drl-II$ Quaternary loams trains and rubbles

Mapping of granite deposit using CSEM technique (Siberia, 2019)

Magnetometry data



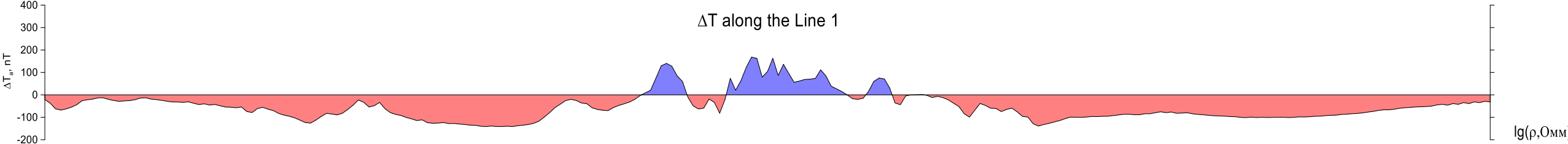
CSRMT survey area



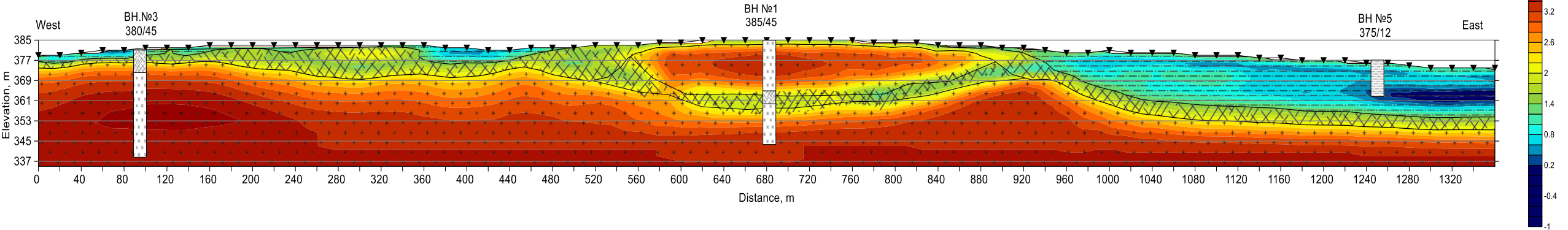
Mapping of granite deposit using CSEM technique (Siberia, 2019)

Survey results

ΔT along the Line 1



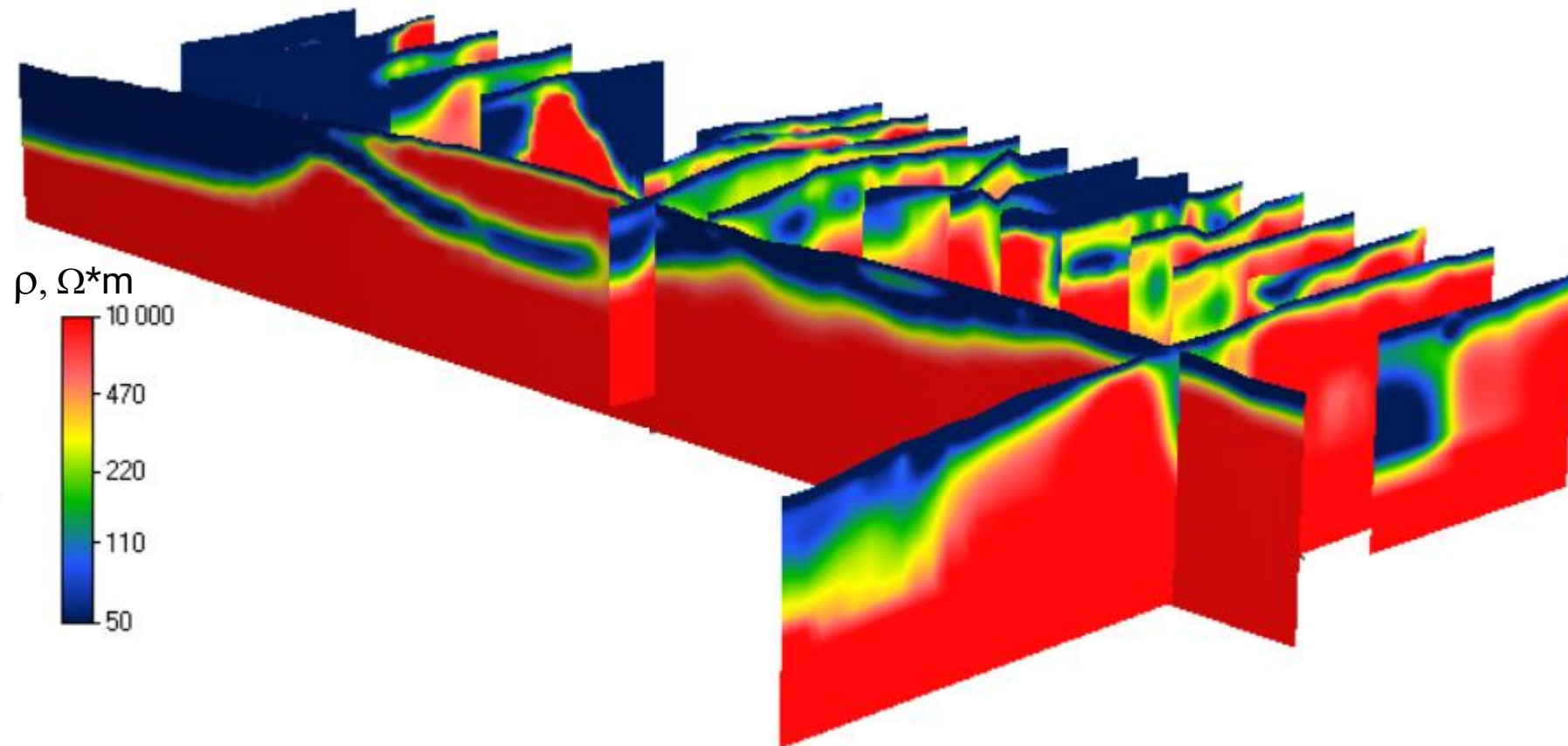
Geological cross-section along Line 1



- ↙ - CSRMT stations
- BH.№5 375/12
- borehole number, elevation/depth
- Quaternary rocks
- Fractured granite
- Massive granite

Mapping of granite deposit using CSEM technique (Siberia, 2019)

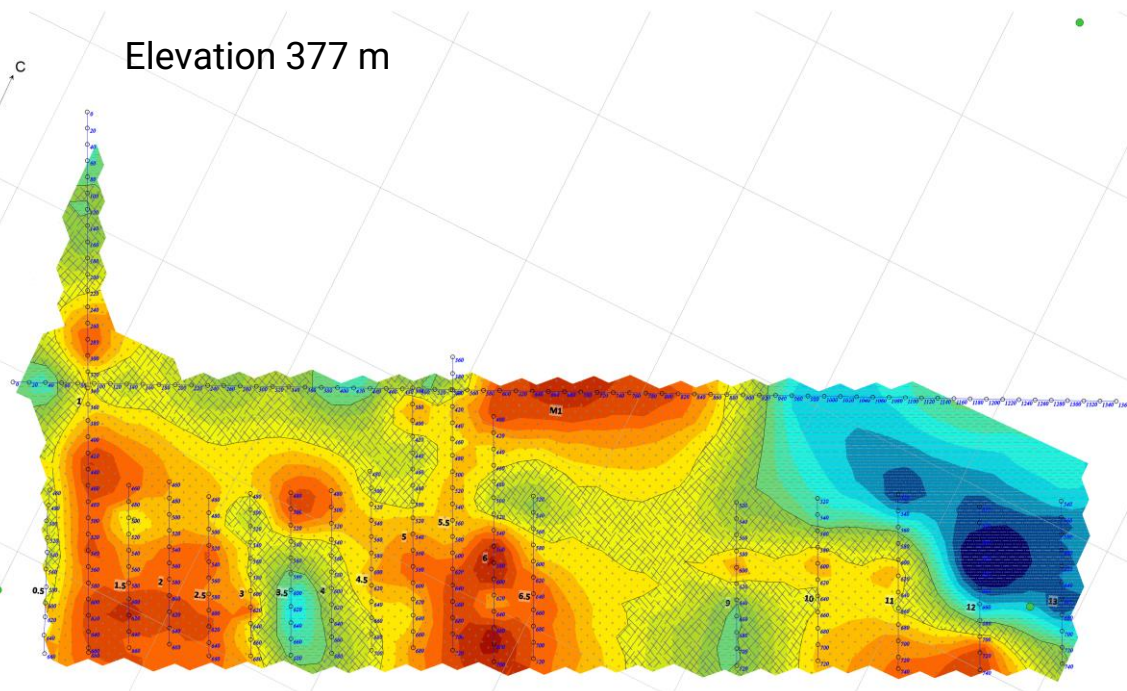
Geoelectric sections up to 50 m depth, 3D view



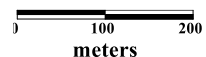
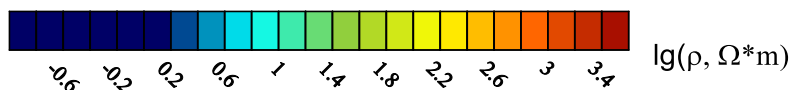
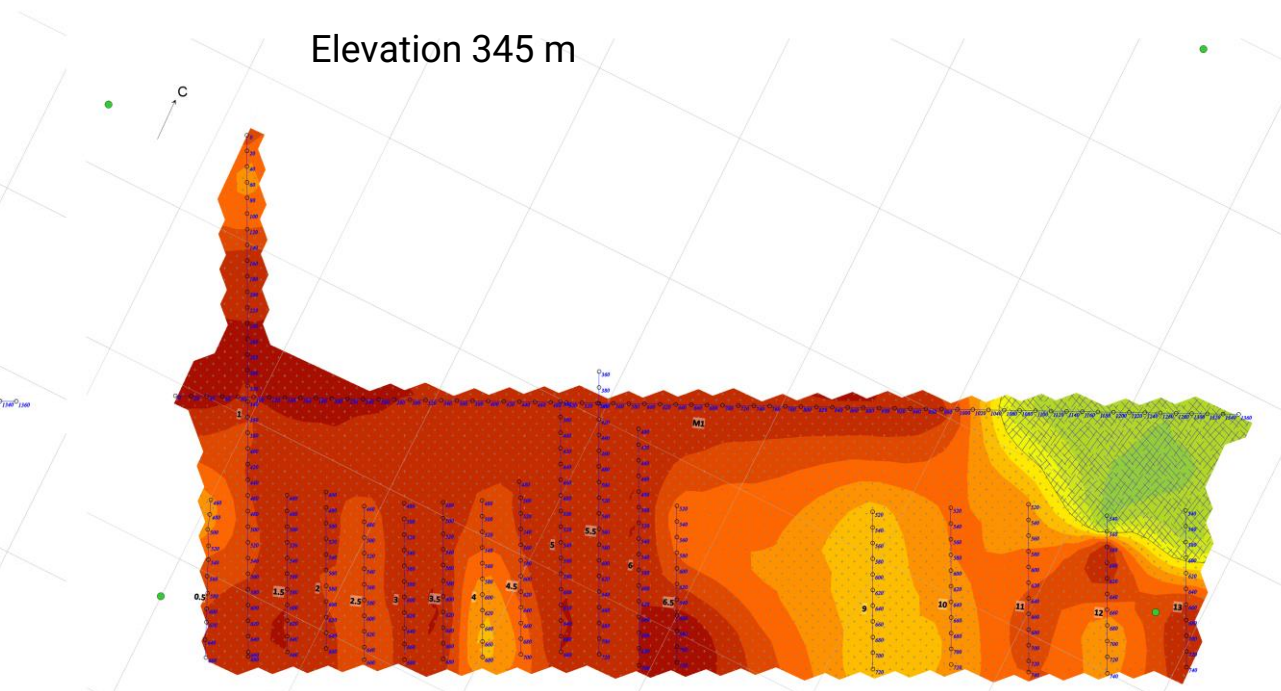
Mapping of granite deposit using CSEM technique (Siberia, 2019)



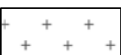
Resistivity maps on different depths, according to CSRMT 2D inversion results

Elevation 377 m



Elevation 345 m



-  - Quaternary rocks
-  - Fractured granite
-  - Massive granite

- New ARMT-5 system along with specially developed controlled source transmitter enables to carry out surveys by AMT, CSAMT, RMT, CSRMT and CSEM methods in the frequency range from 0.1 Hz to 1 MHz
- Joint measurement array of AMT and RMT sensors connected to a single receiver simplifies measurements and data-processing
- Controlled source allows to both improve data quality and increase the depth of investigation
- The investigation depths are ranging from first meters to several kilometers



Designs, manufactures, supports and supplies
Equipment & Software for geophysical surveys:

- Seismic
- Geoelectric & Electromagnetic
- Magnetic
- Gamma radiation detection

Advanced options:

- Rentals
- Field demonstrations
- Test surveys
- Projects startup
- Training courses

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