



St. Petersburg State University

Faculty of geology

**Monitoring of apparent resistivity
variations, electromagnetic emission
and ionosphere effects in the audio-
and radio frequency ranges**

Overview

1. General approach
2. Instruments
3. Apparent resistivity variations measurements
4. Electromagnetic emission registration
5. Ionosphere disturbances study

General approach

- ✓ application of digital instruments with registration of time series of investigated parameters in wide frequency range:

0.1 Hz – 1 MHz or ULF – ELF – VLF – LF – MF

- ✓ minimum number of instruments types with the possibility of simultaneous multi-parametric registration;
- ✓ possibility of measurements in conditions of the raised noise level;
- ✓ development and application of the technique of tensosensitive zones selection for the equipment installation;
- ✓ rather small expenses for equipment installation and operation.

Electromagnetic earthquake precursors investigated

- ✓ Apparent resistivity variations (frequency range 0.1– 1000 Hz)
- ✓ Electro telluric anomalies (frequency range 0.1-1 Hz)
- ✓ Electromagnetic emission anomalies from time series measurements (frequency range 0.1 Hz – 1 MHz)
- ✓ Ionosphere disturbances registration using measurements:
 - signals from remote radio transmitters in radio frequency range (10 kHz – 1 MHz)
 - natural electromagnetic field Schumann resonances in the audio frequency range (8-45 Hz).

Electromagnetic monitoring instruments

The audiomagnetotelluric ACF-4M system



Recorder of the ACF-4M system

Recorder

Number of channels	4
ADC, bits	24
Frequency range, Hz	0.1-1600
Frequency resolution, Hz	0.0005-12.5
Internal memory, Mb	512
Adapter for connection to PC	Ethernet
Display	LCD, monochrome, 320x240
Keypad, keys	18
Built-in accumulator, 5 A*h, V	12
operation, hours	14
External battery, V	12
Operating temperature, ° C	- 20 to + 50
Dimensions and weight	mm kg
	340x295x155 4.0

Magnetic coil

Frequency range	0.1- 4000 Hz
Transfer constant	
- frequency range 0.5-1000 Hz	80 mV/nT
- frequency range 0.1-0.5 Hz	160 mV/(nT*Hz)
Noise level	
- frequency 10 Hz	12 fT/√Hz
- frequency 1000 Hz	2.5 fT/√Hz
Voltage of external power supply	± (7-10) V
Current consumption	18 mA
Dimensions and weight	70 x 1110 mm
	5 kg



Magnetic sensor

The RMT-F radiomagnetotelluric system



Recorder

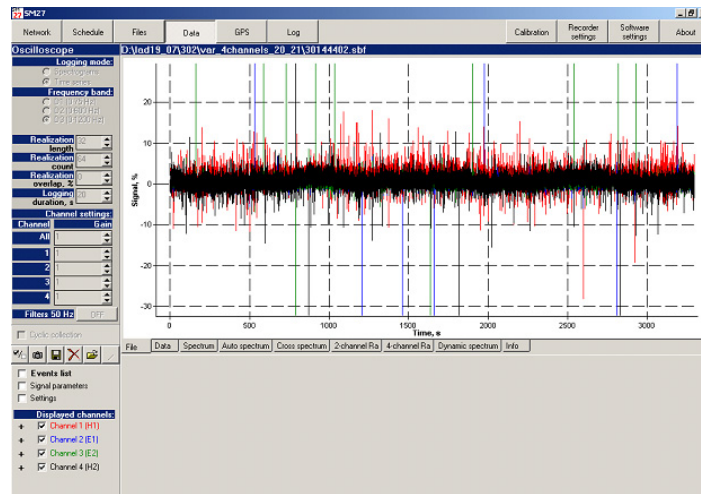
Number of channels	4
ADC, bit	16
Frequency range, kHz	1-1000
Internal memory, Mb	2048
Adapter for connection with PC	Ethernet
Display	LCD, monochrome, 320x240
Keypad, keys	18
Built-in accumulator, 5 A*h, V	12
operation, hours	8
External battery, V	12
Operating temperature, ° C	- 5 to + 50
Dimensions and weight of measuring unit	mm kg
	340x295x155 4.0



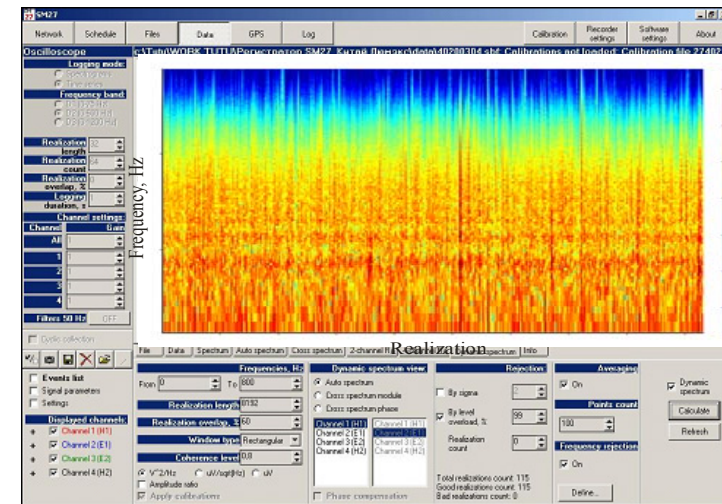
Magnetic sensor

Frequency range, kHz	10-1000
Transfer constant, mV/(nT*Hz)	25
Dimensions and weight	
	40 mm (diameter) 240 mm (length) 0.2 Kg (weight)
Noise level, pT/√Hz	0.4
Voltage of external power supply, V	± 8
Current consumption, mA	30
Cable length, m	2

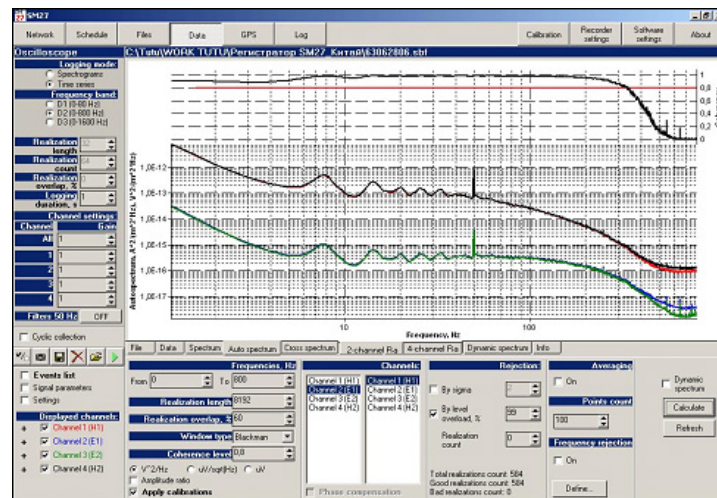
Features of measurements with the ACF-4M system



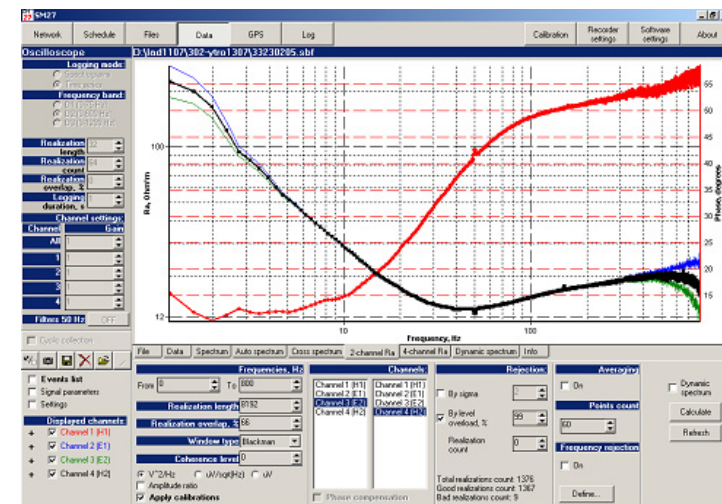
Time series



Dynamic spectrum

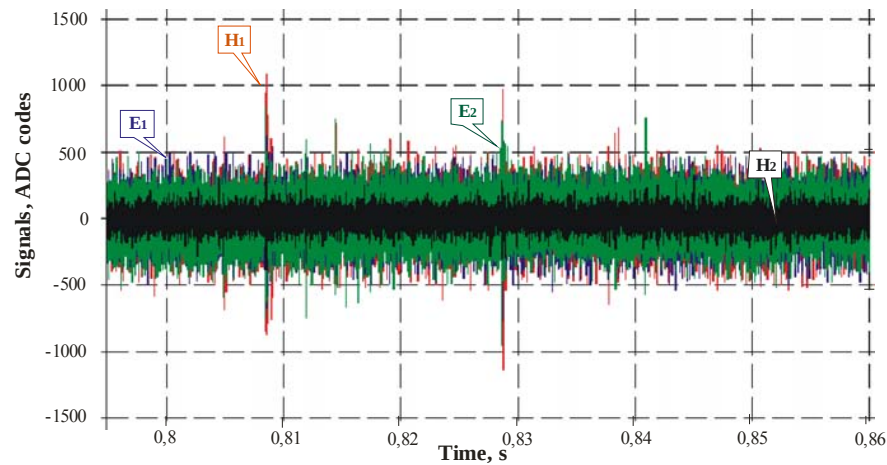


Autospectra and coherence

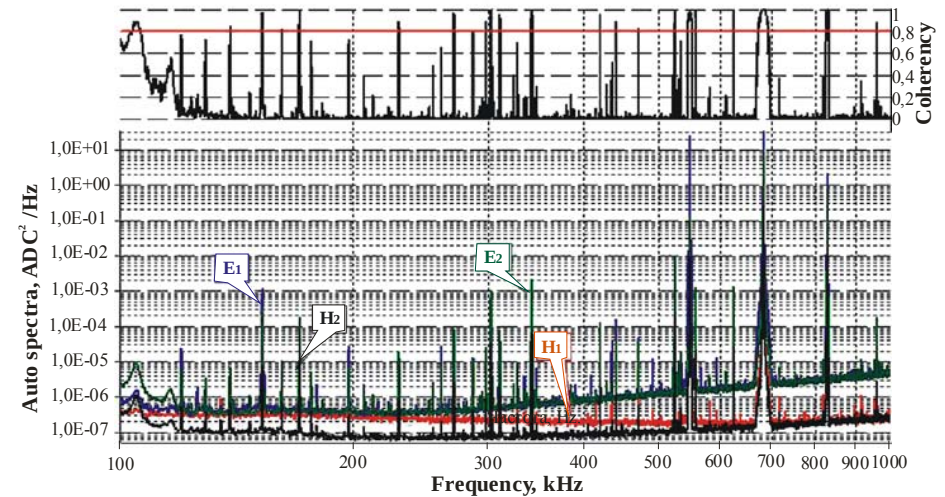


Curves of apparent resistivity and impedance phase

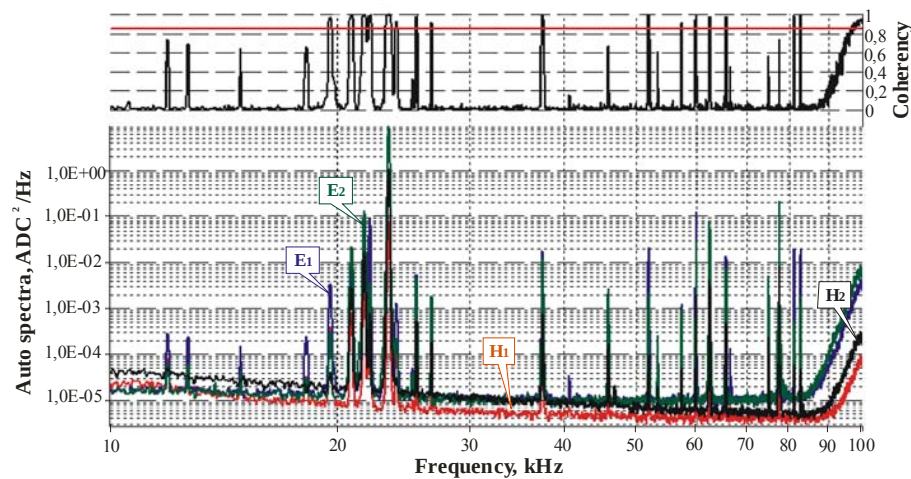
Features of measurements with the RMT-F system



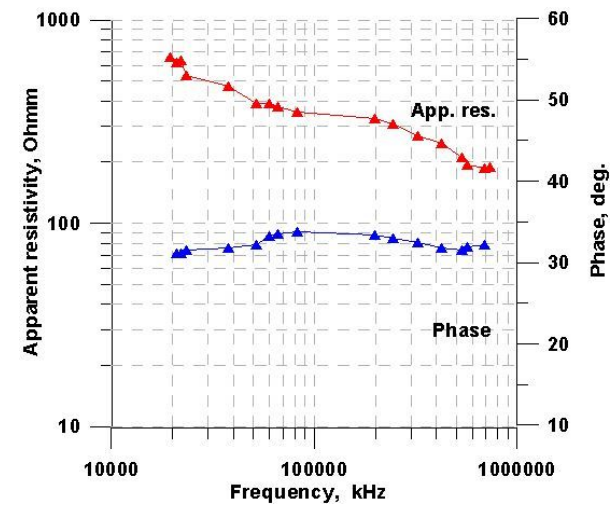
Time series



Autospectra and coherence (100-1000 kHz)



Autospectra and coherence (10-100 kHz)



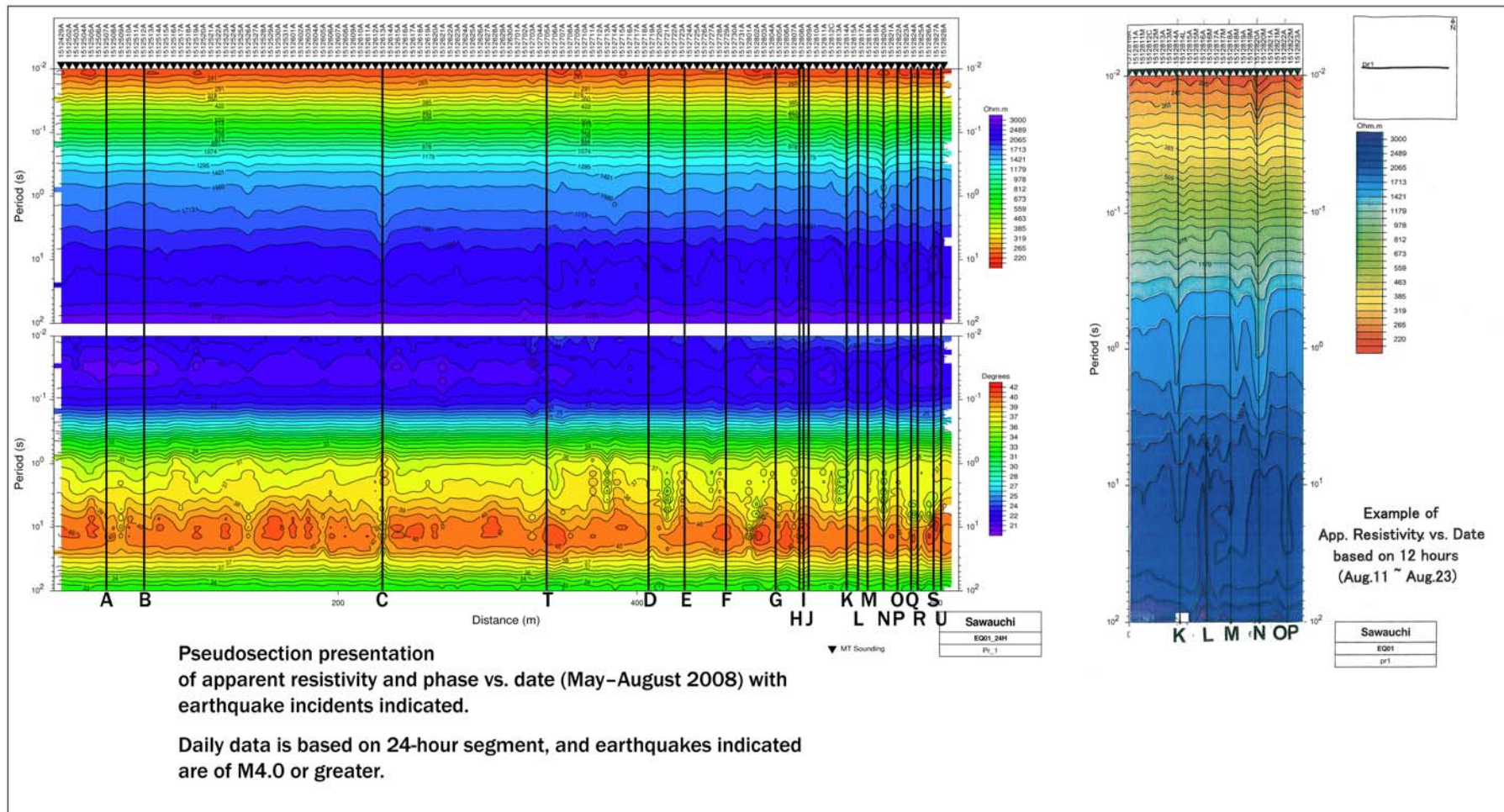
Curves of apparent resistivity and impedance phase

Apparent resistivity variations

Deep, middle-depth or shallow soundings for apparent resistivity variations measurements?

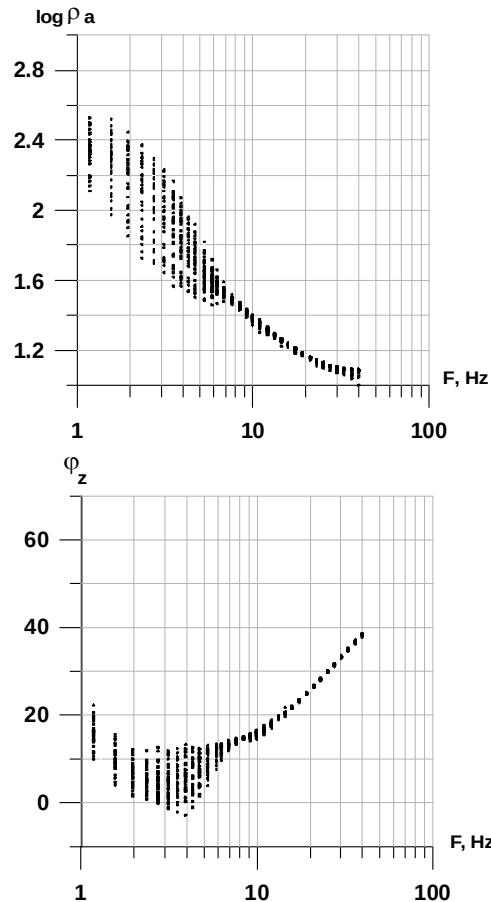
Apparent resistivity variations

■ Frequency range

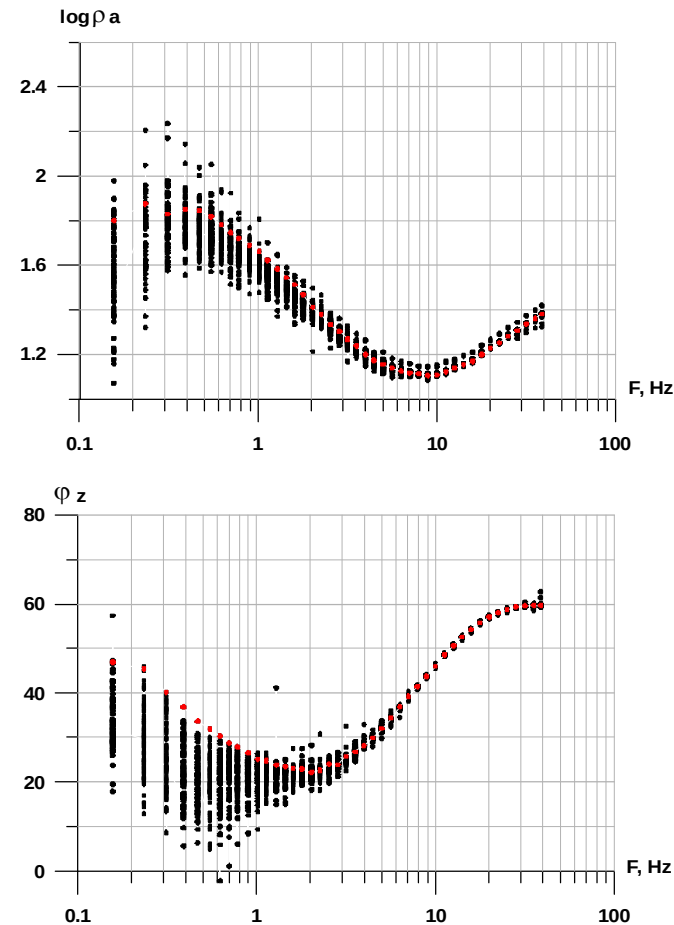


Apparent resistivity variations

■ Frequency range



Curves of apparent resistivity and impedance phase on 34 one-hours measurements, 18-19 March 2007, test site Ladoga, Leningrad region.



Curves of apparent resistivity and impedance phase on 50 one-hours and 23 two-hours measurements, 13-17 June 2008, test site Pasha. Red lines – curves in the period of strong magnetosphere radiation.

Apparent resistivity variations

- Tensosensitive zones selection:

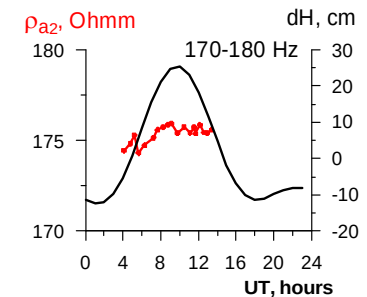
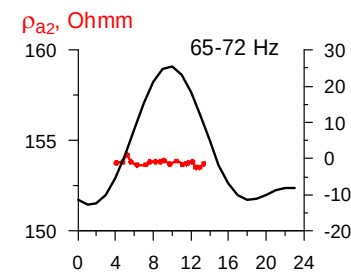
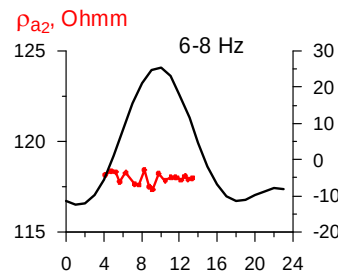
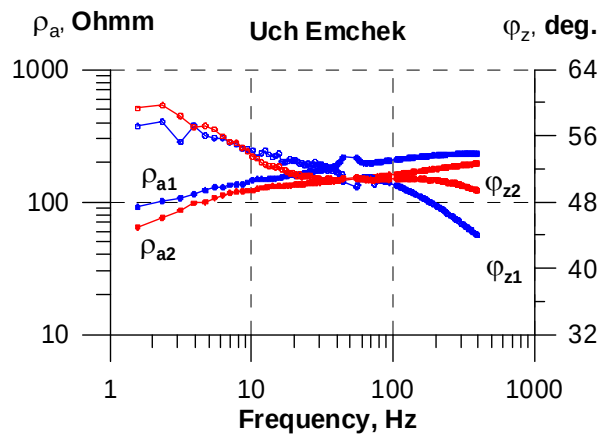
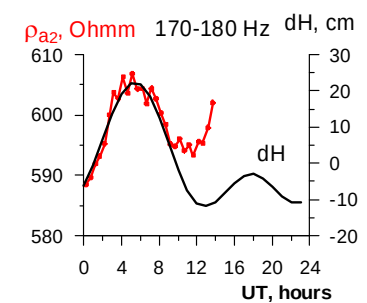
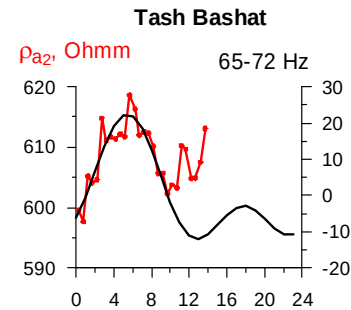
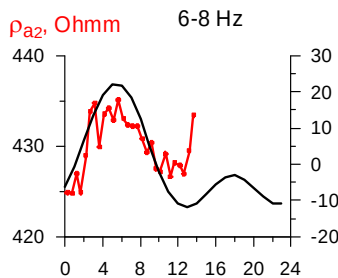
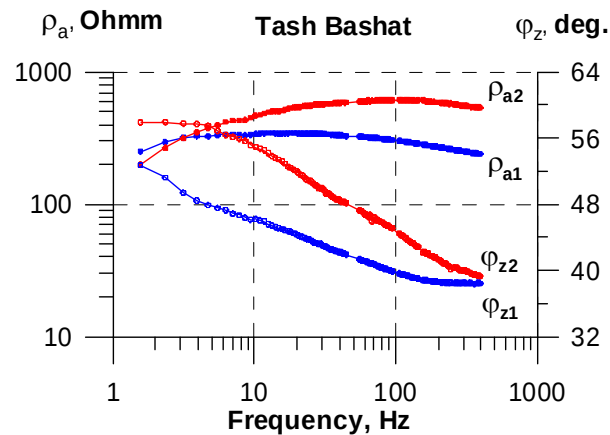
- ✓ Low thickness of overlying sedimentary rocks
- ✓ High resistivity of basement's rocks
- ✓ High degree of medium heterogeneity, which indicates the faults presence
- ✓ Registration of tidal variations of apparent resistivity at short testing monitoring

Sites for monitoring with low noise level are selected

Apparent resistivity variations

■ Tenzosensitive zones selection

Monitoring at sites in Kyrgyzstan, Bishkek region



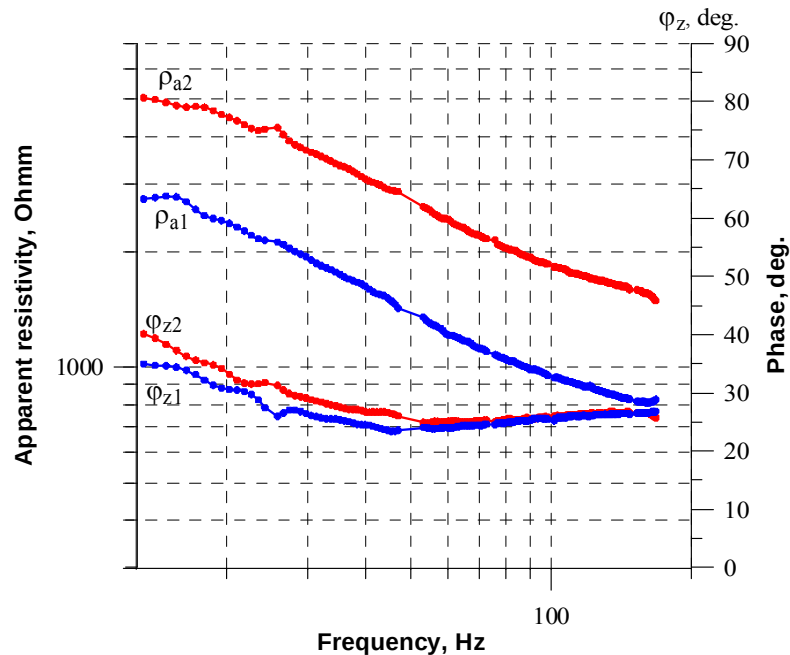
Results of monitoring at the sites Tash Bashat (4.06.2005) and Uch Emchek (27.05.2005)

AMT sounding curves at the sites Tash Bashat and Uch Emchek

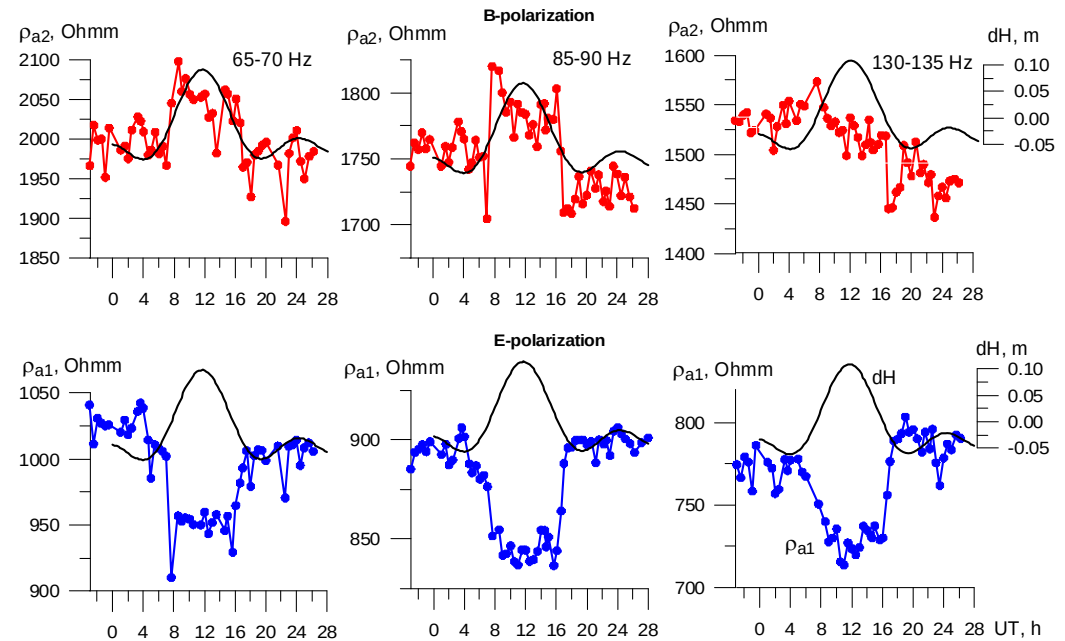
Apparent resistivity variations

■Tensosensitive zones selection

Monitoring at a site in St. Petersburg region, the Karelia isthmus

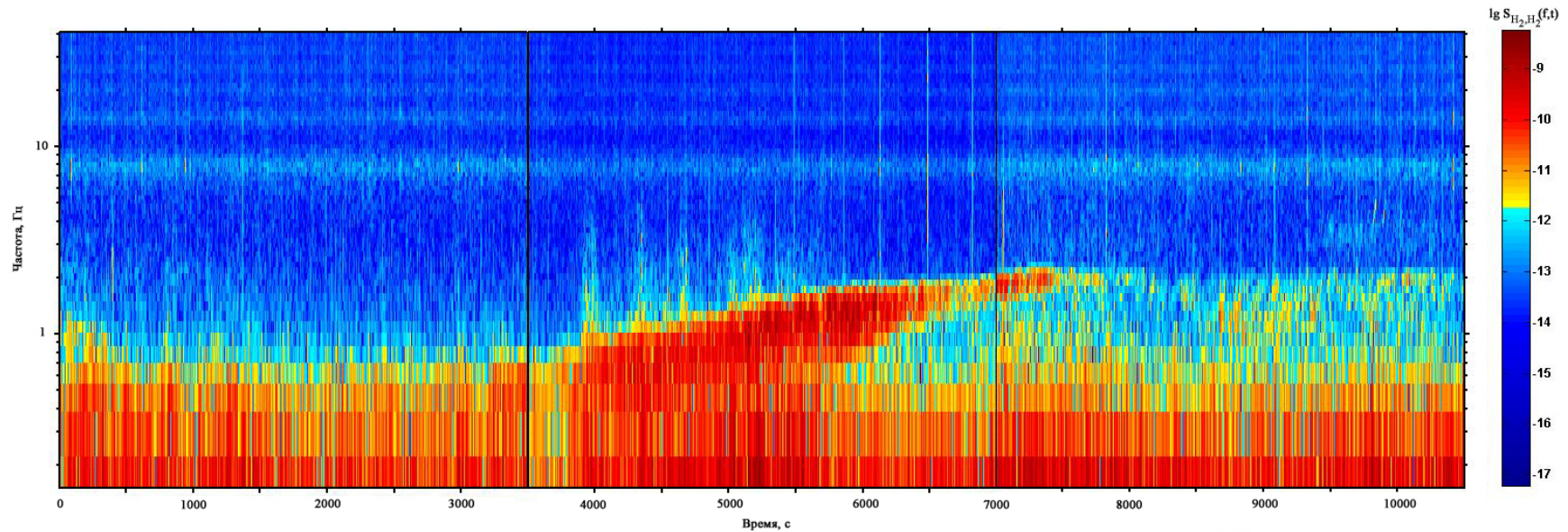


AMT sounding curves at a site on the Karelia isthmus



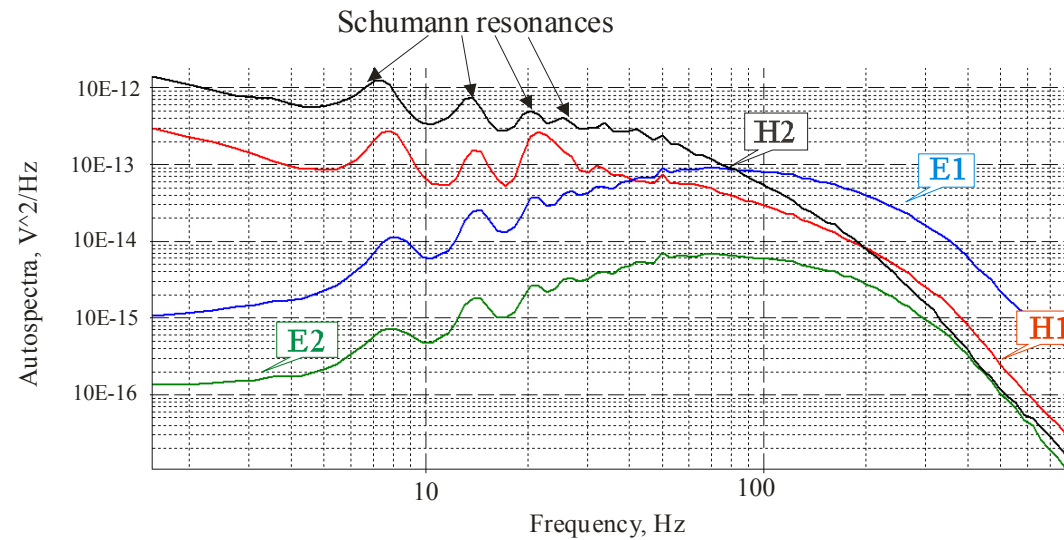
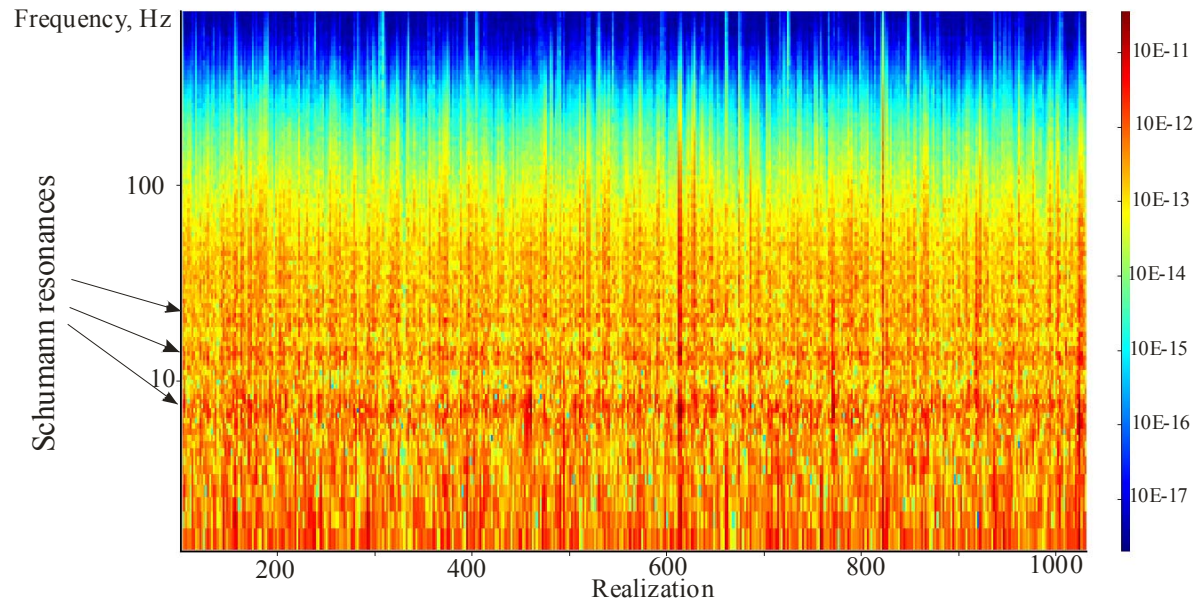
Results of monitoring at a site on the Karelia isthmus (26.07.1998)

Electromagnetic emission registration



An example of magnetosphere disturbance in dynamic spectrum of magnetic field (ACF-4M instrument)

Ionosphere disturbances study



Conclusions

The developing electromagnetic monitoring technology is based on the use:

- registration in the wide frequency range (0.1 Hz - 1 MHz) complex of parameters connected with the rocks electric properties variations, electromagnetic emission and ionosphere disturbances
- minimum number of instrument types with multi parametric measurements;
- big attention for the selection and testing of tensosensitive zones;
- integrated approach to the monitoring data interpretation.

Thank you for your attention!