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# Berichte
## zur Polar- und Meeresforschung
## Reports on Polar and Marine Research

# Russian-German Cooperation: Expeditions to Siberia in 2017

Edited by

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with contributions of the participants

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*Titel: Das neu installierte klimatisierte Feldobservatorium-Iglu auf der Insel Samoylov, Lena Delta, beherbergt empfindliche Messgeräte, die an den meteorologischen Messturm im Hintergrund angeschlossen sind (Foto: Peter Schreiber, AWI).*

*Cover: The newly installed and climate-controlled observatory igloo on Samoylov Island, Lena Delta, houses sensitive measuring devices connected to the meteorological instrument tower in the background (Photo: Peter Schreiber, AWI).*

# Russian-German Cooperation: Expeditions to Siberia in 2017

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# Expeditions to Siberia in 2017

**Research Station Samoylov Island and Lena Delta 02.04 - 26.09.2017**

**Drilling Campaign on Bykovsky Peninsula: Spring 2017 06.04 - 24.04.2017**

**Summer campaign on Bykovsky Peninsula 09.07 - 08.08.2017**

## Chief scientists

**Julia Boike (AWI Potsdam), Dmitry Bolshiyanov (AARI), Svetlana Evgrafova (SIF), Alexey Fage (IPGG, NSU), Mikhail Grigoriev (MPI, IPGG), Guido Grosse (AWI Potsdam), Nikolay Mikhaltsov (IPGG, NSU), Anne Morgenstern (AWI Potsdam), Pier Paul Overduin (AWI Potsdam), Lasse Sander (AWI Sylt), Jens Strauss (AWI Potsdam)**

# Contents

## 2.19 Multidisciplinary research of cryolithic zone evolution: selected features of permafrost environment in Lena Delta case study

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### Fieldwork period and location

July 5th to August 23rd, 2017 (on Samoylov Island, Kurungnakh Island, Bykovsky Peninsula)

### Objectives

The main goal of our research in the Lena River Delta is to construct an integrated picture of cryolithic zone evolution. We develop a multidisciplinary approach to permafrost studies and pay attention to correlation of data from various methods. With this objective, we studied typical objects in the region using a variety of geophysical, geological, geobotanical, and soil methods as well as remote sensing. During the expedition, several aspects were studied on Samoylov and Kurungnakh Islands.

### Methods

1. Electrical resistivity tomography (ERT): SibER-48 (http://nemfis.ru) (Figure 2.19-1) at 5 and 10 m step (45 and 90 meters penetration depth respectively).
   Schlumberger and dipole-axis installations were used for taking measurements. The distance between the electrodes was 5 or 10 meters, that chosen based on the expected depth of the anomaly.

2. Ground penetrating radar (GPR): OKO-2 (Figure 2.19-1) with 150 and 700 MHz antennas

3. Magnetic survey: proton magnetometer MMPOS-2 (Figure 2.19-1) and magnetic base station GEM-19T

4. Geological observations in outcrops

5. Soil studies: soil pits were dug to the bottom of the active layer using shovel, afterwards a permafrost core was extracted using a metal tube and sledgehammer. Active layer was sampled according to its genetic soil horizons. Permafrost cores were taken in subsamples of 10 cm to the depth of 100 cm. The meso- and micro-relief, plant community and soils morphology were described visually at every soil sampling location.

Sample analyses:

- measurements in the field: frozen sample volume and weight
- magnetic susceptibility - measured with kappameter KT-5
- laboratory studies (Table A.2-21)

6. Temperature monitoring: autonomous temperature stations ASTM (IPGG SB RAS) with 10 temperature sensors (calibrated DS18B20 with accuracy of 0.06 °C) at 0, 10, 20, 30, 40, 50, 60, 70, 80, 100 cm depth Table 2.19.1
7. Geobotanical studies. Descriptions of plant communities on standard plots 10 by 10 meters in different community types, at least 10 descriptions per each type. Collection of plant specimens (herbarium) for the further determination in laboratory conditions.

Figure 2.19-1: *Geophysical equipment: wires for ERT station "SibER-48" and GPR "OKO-2" (left); magnetometer MMPOS-2 (right)*

**Preliminary results**
Fieldwork map is shown on Figure 2.19-2.


Figure 2.19-2: *Fieldwork map: 1 - Northern lakes, 2 - planned borehole area, 3 - recently drained alas, 4 - thermoerosional gully, 5 - ancient time drained alas*

*Samoylov Island*

A number of studies were conducted in 2017 in addition to earlier results (Tsibizov et al., 2017). The research also develops integrated approach of the island, which was started by Boike at al. (2013). The fieldwork map is shown in Figure 2.19-3.

Based on aerial images (ca. 3 cm/pixel) and digital elevation model (ca. 10 cm relative precision) of the island, a preliminary geobotanical map was produced prior to fieldwork (Figure 2.19-4).

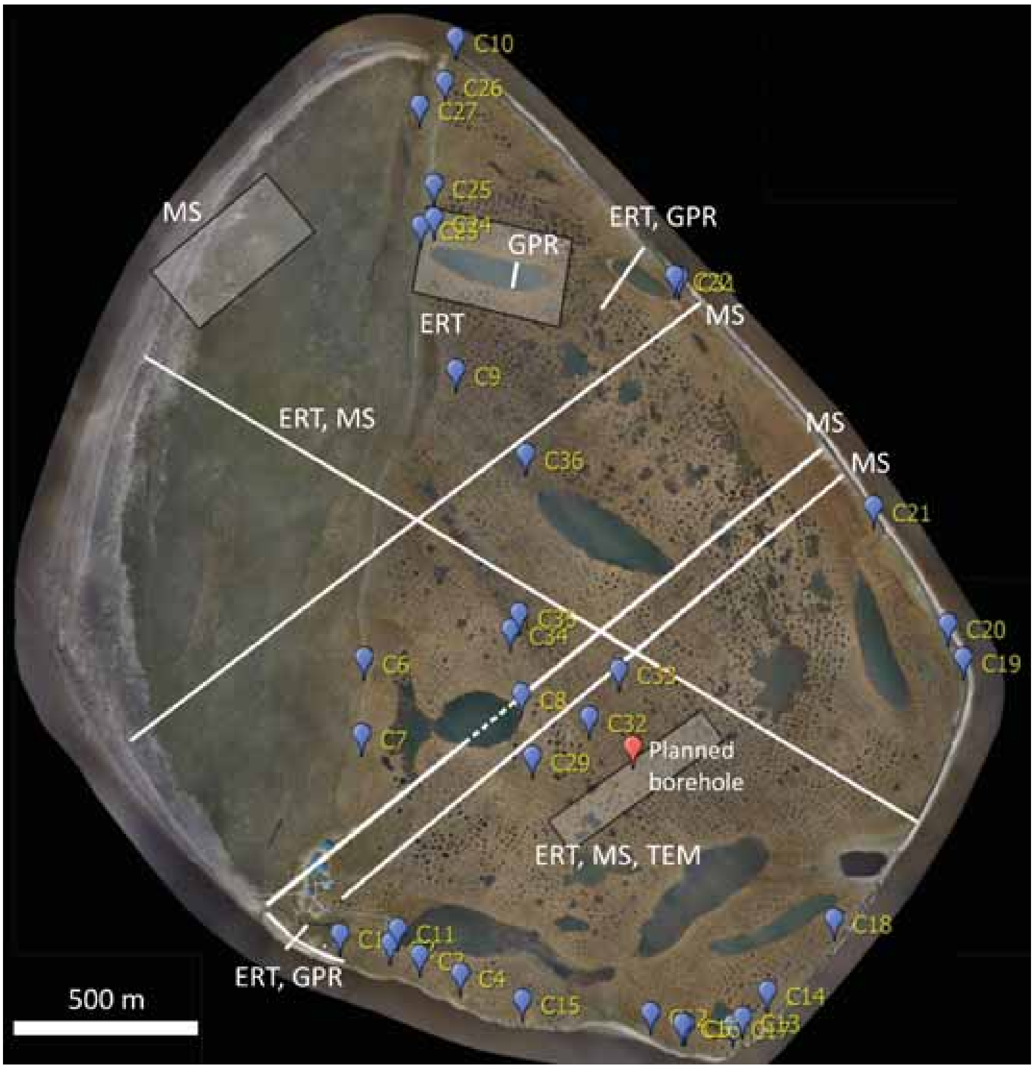


Figure 2.19-3: *Fieldwork map on Samoylov Island (base - aerial photo): ERT – electrical resistivity tomography, GPR – ground penetrating radar, MS – magnetic survey, TEM - transient electromagnetics, blue marks – soil sampling sites; lines – profiling, rectangles – aerial survey or composed parallel profiles covering an area*

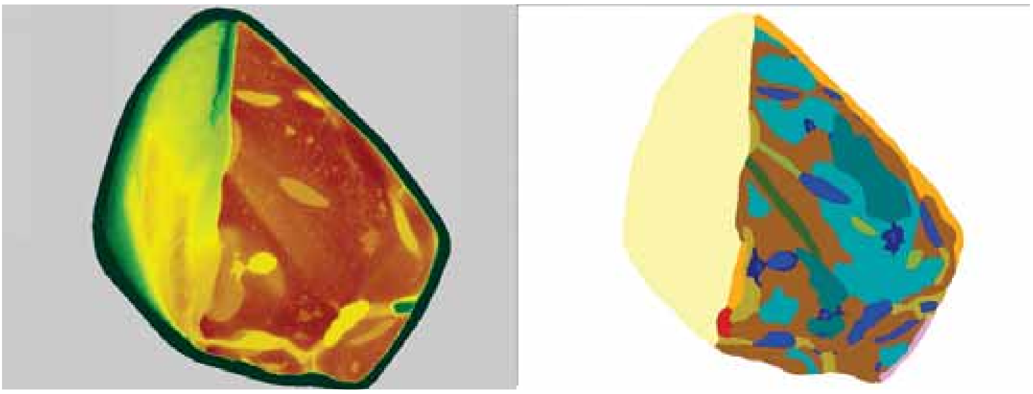

Figure 2.19-4: *Digital elevation model (left) and preliminary geobotanical map of Samoylov Island (right): colors designate different vegetation types*

10 by 10 meter sample plots were established in 5 to 10 replicas in each of the recognized areas in Figure 2.19-4 for a total of 80 plots. Each plot was described with coordinates, species composition (mainly higher vascular plants) and their abundance (coverage). In total, 112 herbarium specimens were collected for the determination.
A detailed geo-geomorphological study of quaternary sediments has been performed on Samoylov Island: near-surface layers of the first upland fringe (mostly seen in the eastern part of the island). Across the southern part of the island, a geological section has been described in the 90 meter long river bank outcropping. Geological cross section uncovered structural nonconformity: a layer of alluvial sediments of the second bottom is overlaid by a layer of the first upland fringe peat. In the course of clearings study we performed a macrovisual description of sediments and built a lithological column of uncovered alluvial structures; hand-drawn a set of texture-structural features of sediments; performed photo shooting of clearings. We also performed a study of a few clearings in the river bank across the northern, north-western, western and south-western parts of the island. Across the western part of the river bank, we observed single geological bodies of alluvial sediments, nonconformly embedded into the first upland fringe. They can be traced both macrovisually (in the course of river bank cross section studies) and in the process of geomorphological inspection of the first upland fringe's micro-relief. Different areas of micro-relief form distribution were allocated, contoured, and described by means of remote sensing (aerial imaging) and field studies. Allocated micro-relief areas differ from one another by a set of morphometric characteristics: ice-wedges polygonal network size, vertical stratification magnitude, average slope angle and micro-relief surface exposition etc., as well as lake abundance (wetness) on the surface. Based on this new knowledge, we plan to refine the genesis of the formation that forms the first upland fringe. We also plan to specify conditions of alluvial sediments formation and their facial attribution.
Soil map of the island will be made on the basis of soil studies. Soil samples were taken with consideration for preliminary geobotanical map and relief pattern distribution. Sampling points and planned analyses are provided in the Table A.2-21.
Talik under "Northern" lakes (site 1 in Figure 2.19-2) was studied using 3-dimensional ERT survey and GPR profiling. These lakes are quite similar but the second one is partially drained, so the case was both to reveal underlake taliks and detect the influence of drainage on their structure. Schlumberger and dipole-dipole array were used to create 3-dimensional model of talik in ERT and also GPR profiling as an auxiliary method. There were 9 profiles crossing North lake and adjoining territory. As well for comparison, one profile (10) crossed Small Lake located to the east of the North Lake (Figure 2.19-5). GPR studies were made with antenna set to 150 MHz central frequency along profile 7 and 10 on the Small Lake.
According to the available data, a zone of lower resistances is clearly visible on geoelectric sections which corresponds to higher temperatures of frozen or thawed rocks. However, it is difficult to determine the exact boundary between them. We also made geoelectric sections at different depths,

according to those, the low resistivity zone can be traced to a depth of approx. 35 m. The resistivity slice at a depth of 12.2 m is depicted in Figure 2.19-7.
GPR cross sections were constructed along profiles 7 and 10 (Figure 2.19-6). They give us detailed information about lake bottom structure. Also on both profiles, the boundary of permittivity change is well traced, but its geological interpretation is yet to be carried out.
GPR data along the profile 7 (Figure 2.19-7) is shown in Figure 2.19-8.

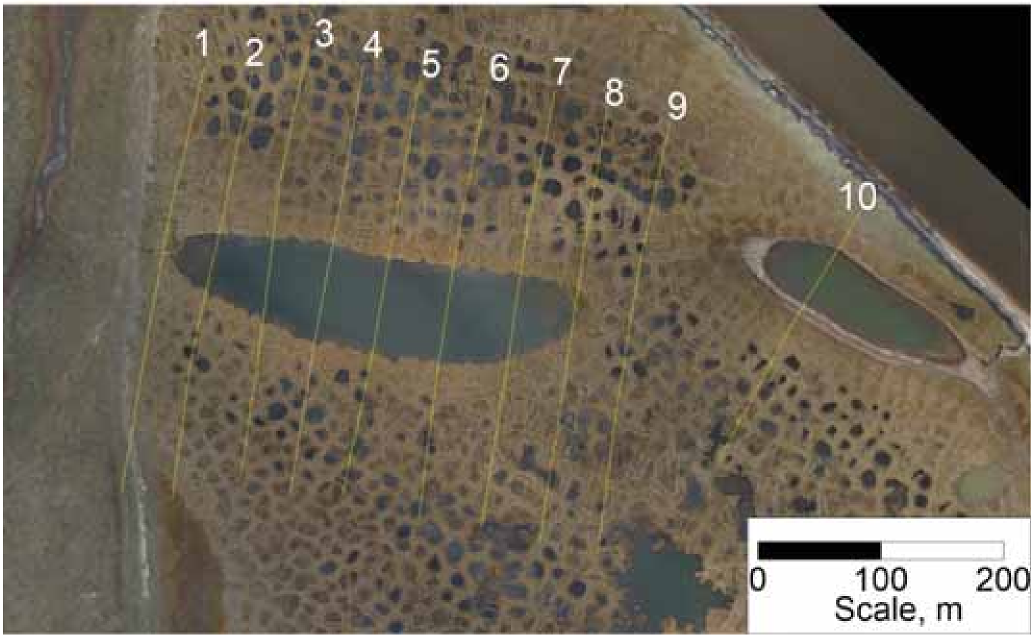


Figure 2.19-5: *The layout of the ERT profiles: the profile numbers are located at the beginning of each profile.*

Figure 2.19-6: *GPR profiling in progress*

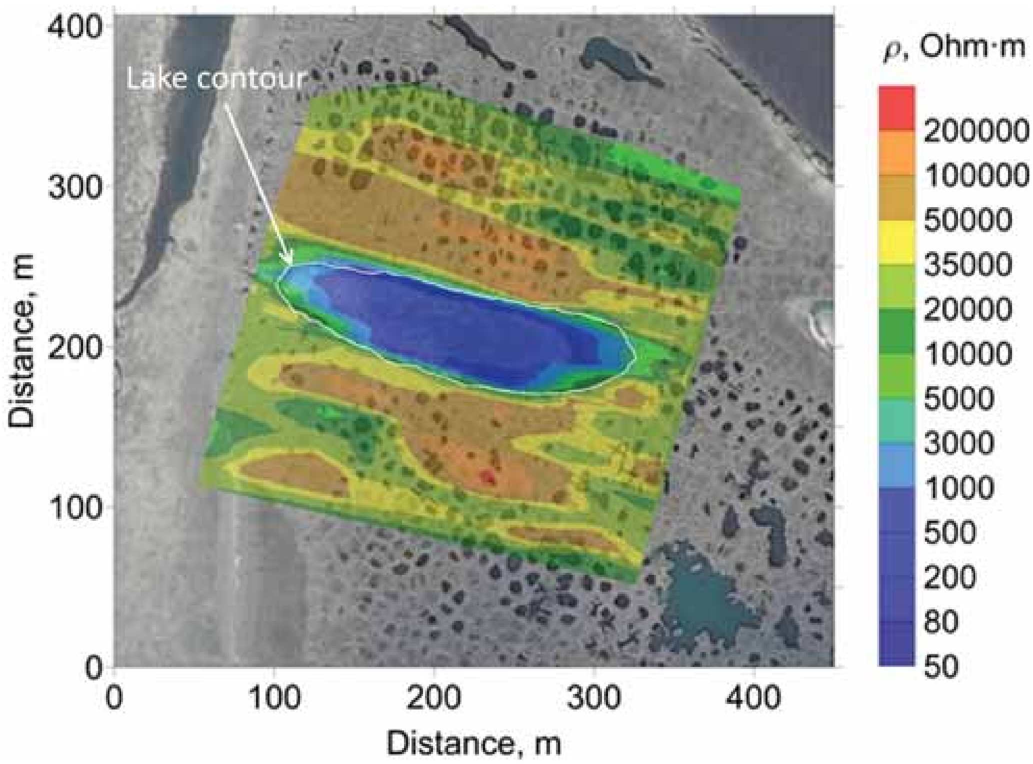


Figure 2.19-7: *Geoelectric section at a depth of 12.2 m*

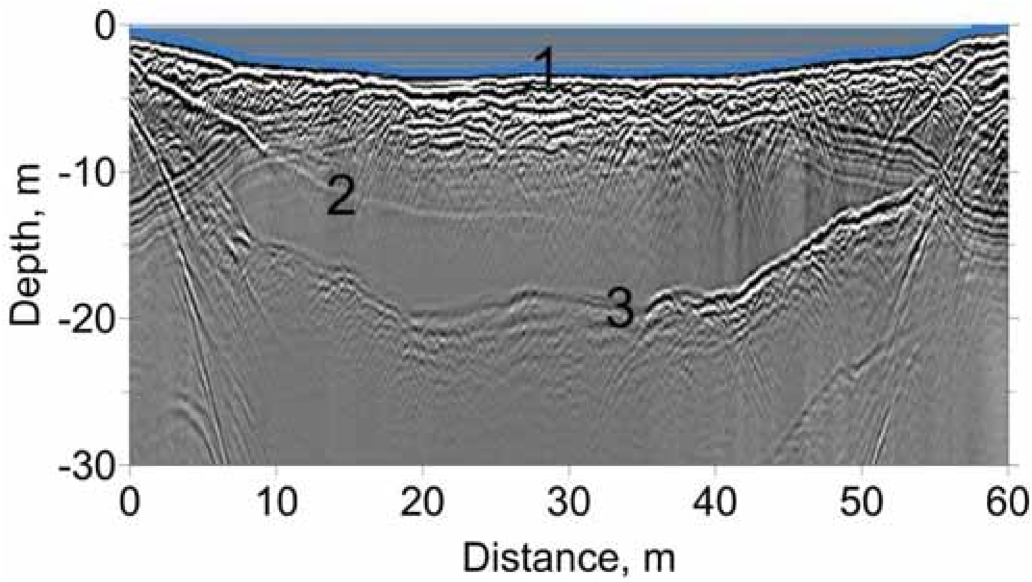


Figure 2.19-8: *GPR cross section along profile 7 (Figure 2.19-7) through the North Lake. 1. – a boundary between lake and bottom sediments, 2 – a boundary which origin has not been established yet, 3 – a boundary caused by multiple reflections.*

Planned temperature borehole area in the center of Samoylov Island (site 2 in Figure 2.19-2). The area is situated on the prolongation of a lineament - linear wet zone crossing the island from the north-west to the south-east (Figure 2.19-9).

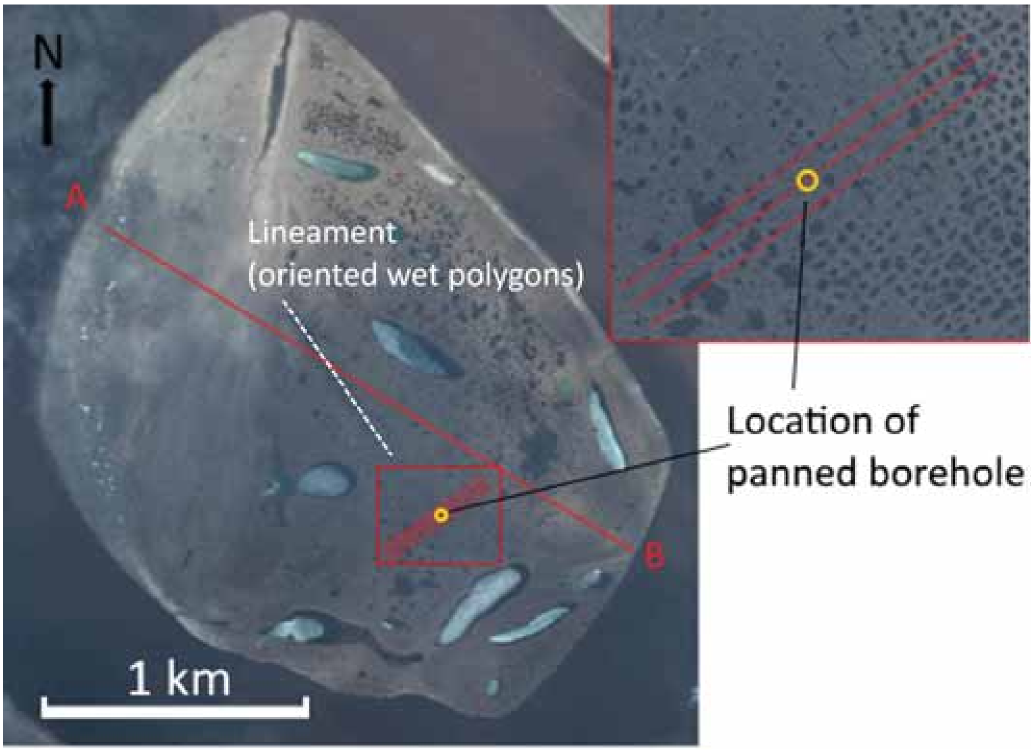


Figure 2.19-9: *Planned borehole area: ERT profiles*

Magnetic and ERT survey results along the profile AB are shown in Figure 2.19-10.

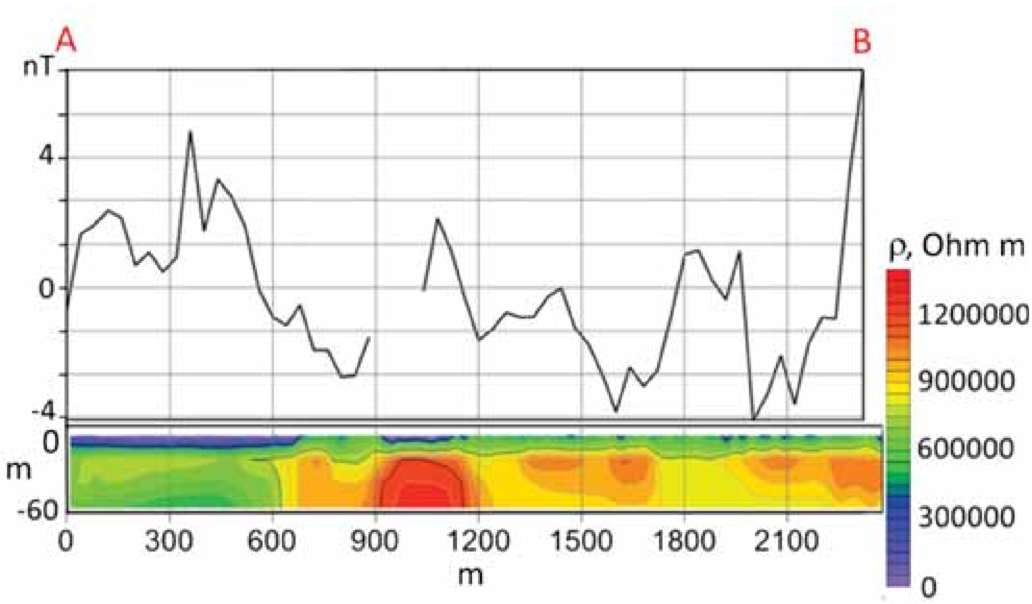


Figure 2.19-10: *Resistivity section and anomalous total magnetic field along the profile AB (Figure 2.19-9)*

Positive magnetic anomaly at the left part of the profile related presumably to the alluvial deposits of the western part of the island. Resistivity is quite high through all the section - lower values are observed in western part on the flood plain. High-resistivity anomaly were revealed under the central lineament of the island (900-1200 m in Figure 2.19-10) and could be probably linked to high ice content.

Two-dimensional and three-dimensional models of resistivity distribution were made as a result of areal ERT surveys. Figure 2.19-11 shows a 3D model of a log. resistivity distribution in the medium and a proposed borehole on Samoylov Island.

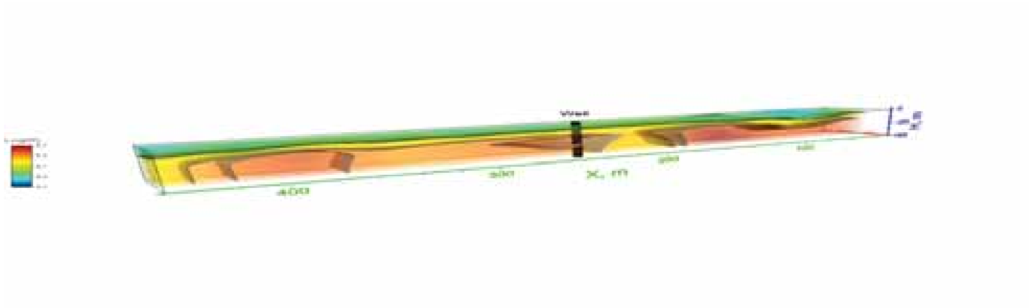

Figure 2.19-11: *3-dimensional resistivity model*

The model in Figure 2.19-11 shows that proposed borehole will go through the localized nonconformity zone of high resistivity, which in its turn is only 20 meters apart from the linear zone of low resistivity (x-coordinate 200 - 230 m). From the cross-section's homogeneity point of view, the best place to make a borehole is the interval 300 - 340 m (x-coordinate). This interval is characterized by vertically non-changing, flat structure of the cross section with no localized nonconformities.
Anomalous total magnetic field within the area is shown on the Figure 2.19-12.

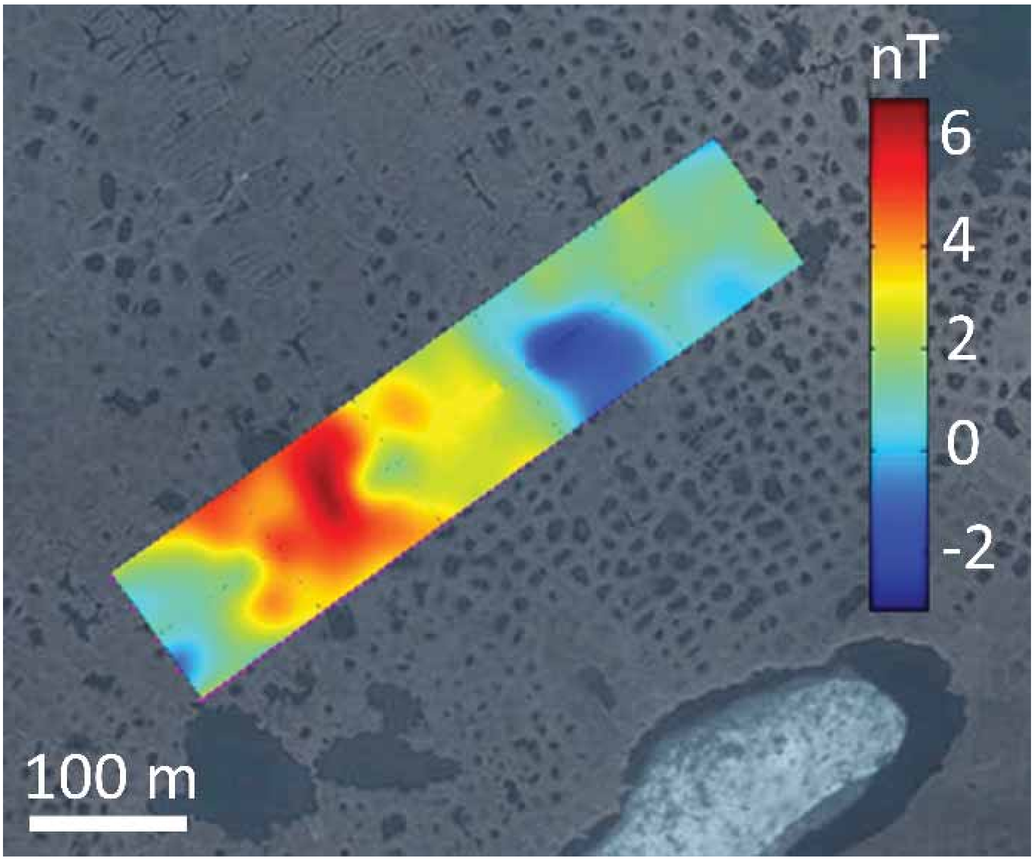


Figure 2.19-12: *Anomalous magnetic field within the planned borehole area*

Negative magnetic anomaly in the central part is situated on the lineament prolongation and could originate from a zone with high ice content or fault structure. One more area was studied with

magnetic survey to reveal whether the presumable fault stretches further to the north-west (Figure 2.19-3), but no similar anomalies were found there.
Experimental work with TEM device showed no convincing results. Due to very high resistivity of the medium and small size of the generating loop, the electromagnetic field is not developing properly and the measured signal is rendered only by the measuring device's inner transient process.

*Kurungnakh Island*
Three local features were studied during the expedition on Kurungnakh Island: recently and long ago drained alases and erosional gully. Alas which was drained between 1970-1980 years was already the object of research in 2016 (Tsibizov et al., 2017).
The bottom of recently drained lake (site 3 in Figure 2.19-2) has been studied using 3-dimensional ERT survey. Preliminary results are shown in Figure 2.19-13.

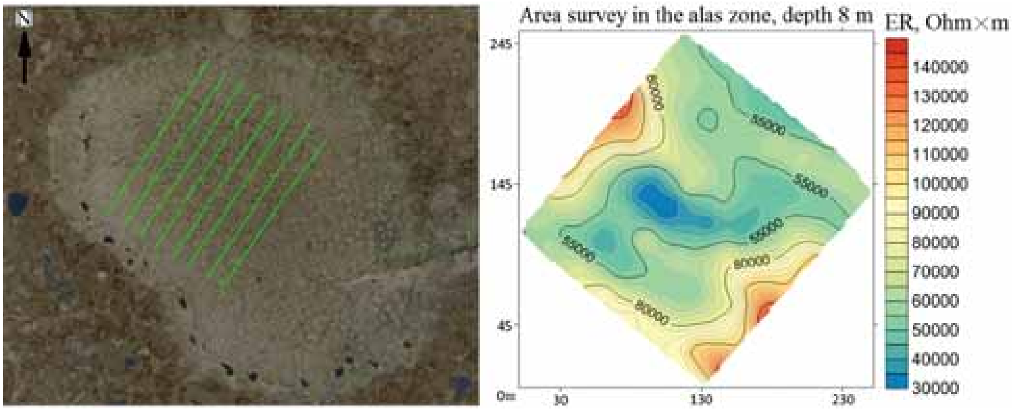


Figure 2.19-13: *Measurement design on aerial photo (left) and horizontal section of 3-dimensional ERT inversion at 8 m depth (right)*

Low resistivity area at the center of the section presumably indicates higher temperature of permafrost. It could be a residual of talik: the lake was drained in the recent past (circa 30-40 years before) and temperature has not still stabilized to the values, which are typical for the region.
Soil sampling was made on sites K1-K5 on the slope of the drained lake (Table A.2-21). Erosional valley and the area of its propagation (site 4 in Figure 2.19-2) were studied using ERT, GPR and magnetic survey.
Measuring scheme is shown in Figure 2.19-15.

Figure 2.19-14: *Erosional gully (left); GPR with 700 MHz antenna (right); studying area is on the background on both photos*

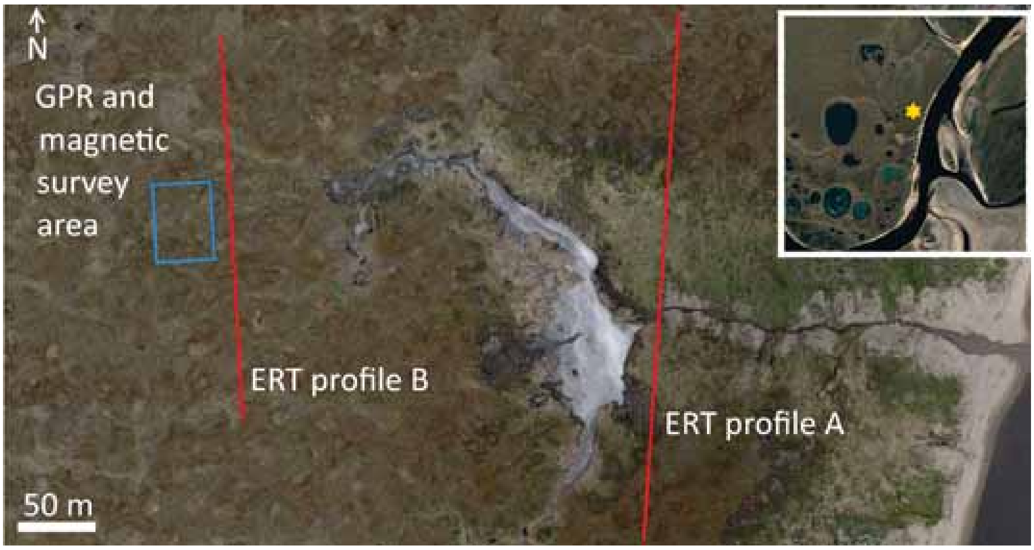


Figure 2.19-15: *Scheme of the measurements on the erosional gully, southern tail of the gully, which is shown on Figure 2.19-14*

High resistivity anomalies probably related to higher ice content areas are on both sides of the gully (Figure 2.19-15, profile A) and on the right part of the section (Figure 2.19-15, profile B).

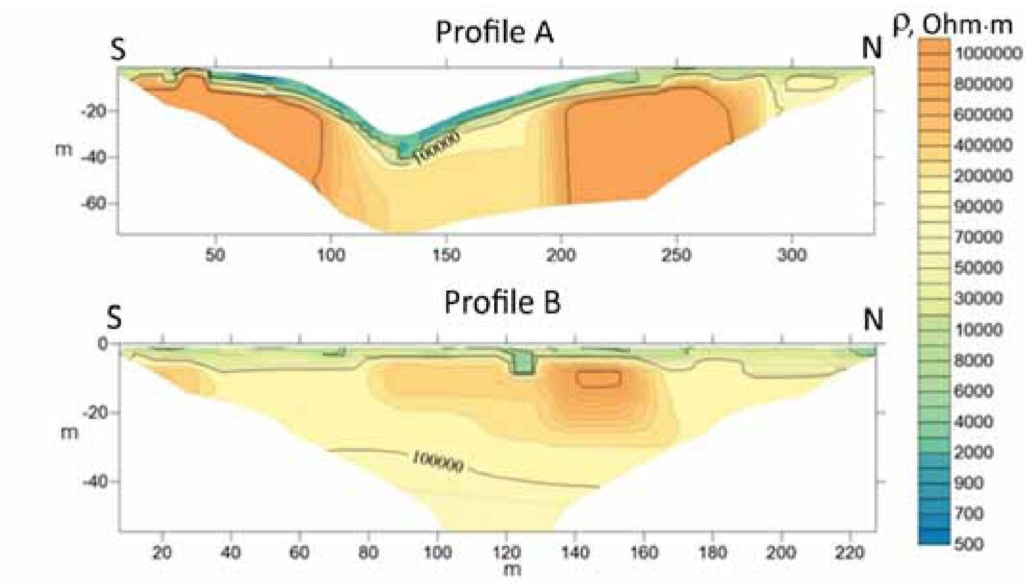


Figure 2.19-16: *ERT profiles (Figure 2.19-15): crossing the gully (upper) and its future propagation area (lower)*

Magnetic survey revealed a polygonal ice-wedge structure of permafrost in the area, where the gully propagates (Figure 2.19-16).

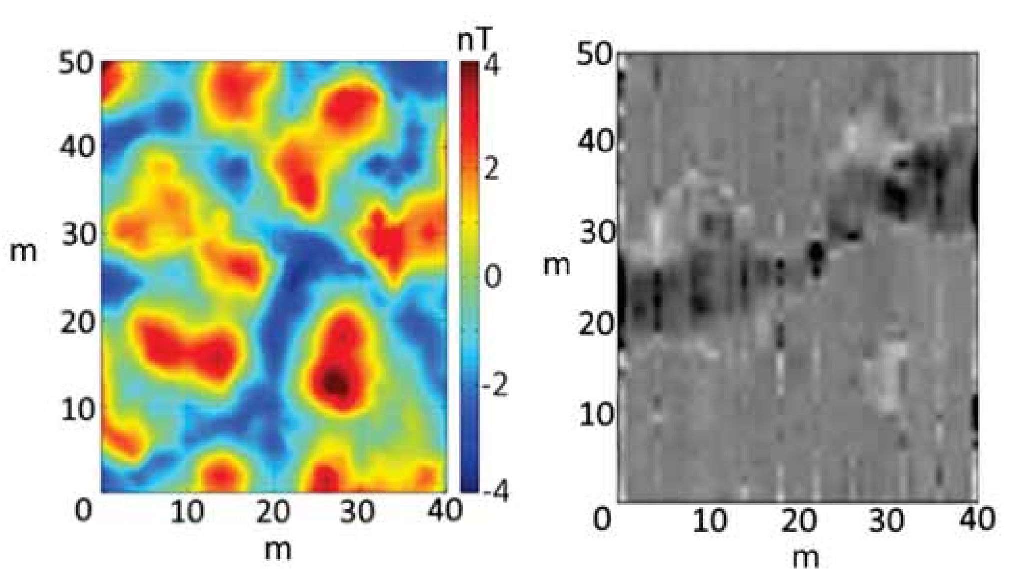


Figure 2.19-17: *Anomalous total magnetic field (left) and GPR data - amplitude slice of reflected energy (right)*

It should be noted that there is a some kind of ranking between magnetic anomalies caused by ice wedges: polygons of big diameter with thick ice wedges on their edges enclose the smaller ones. GPR data (Figure 2.19-17) reveals the area which could be linked with a wet zone. One might assume that thermoerosion follows ice wedge structure, in this case the wet zone is formed initially and indicates the way which the gully propagation will follow.
Alas drained a long time ago (site 5 in Figure 2.19-2) at the southern part of Kurungnakh Island was already the object of research in previous years, published in (Grosse et al., 2017; Tsibizov et al., 2017). A borehole, 17 m deep, was drilled in 2015, where magnetic susceptibility measurements, grain size and palynological analyses were conducted, and a temperature chain was installed. This data is still being processed. Magnetic survey, ERT and soil sampling were conducted, shallow temperature stations (up to 1 m depth) were installed in 2016. A map of the 2017 fieldwork season is shown in Figure 2.19-18.

Table 2.19.1: Temperature measuring sites

| Label | Coordinates | Start time | Comments |
|---|---|---|---|
| c1 | N 72.28911 E 126.18870 | 24.07.2016 16:00 | outside of alas |
| c2 | N 72.28974 E 126.1868 | 24.07.2016 20:00 | alas slope (k6 sampling point) |
| c3 | N 72.29131 E 126.1864 | 25.07.2016 16:00 | alas bottom (k9 sampling point) |
| c4 | N 72.29058 E 126.18959 | 26.07.2016 16:00 | alas slope |
| c5 | N 72.28960 E 126.18301 | 26.07.2016 16:00 | alas slope |

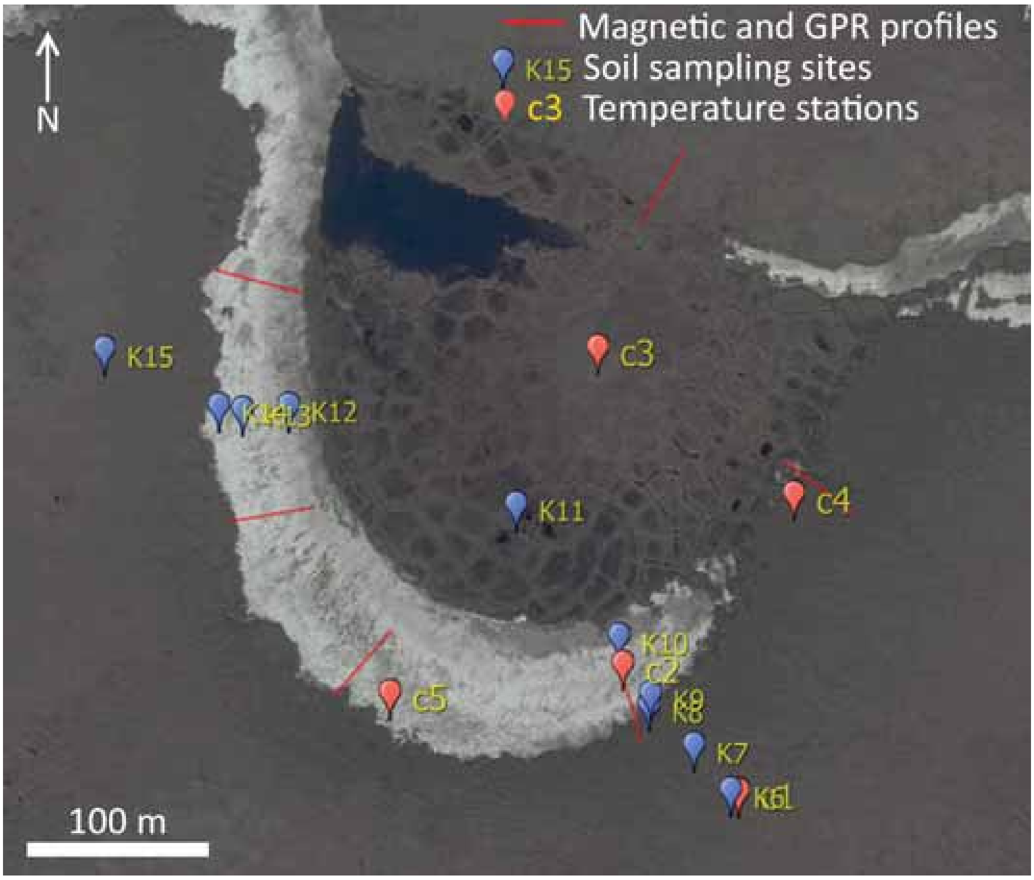


Figure 2.19-18: *Ancient time drained alas: soil sampling sites, GPR and magnetic profiles, temperature stations*

Alas studies are able to help evaluate the potential of northern biological systems, reveal factors that provide their high productivity and better understand how they change with time. The study of basic soil properties will help better understand present mechanisms of ecosystem functioning and predict their behavior in the evolving environment.
It is expected that differences of alas slope structure are going to be found based on magnetic and GPR data along profiles shown in Figure 2.19-18.

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