INTERNATIONAL MIRE CONSERVATION GROUP

Russian Academy of Sciences
Institute of Forest Science

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ECOLOGICAL RESTORATION IN PERMAFROST ZONE
WORKSHOP

Field Excursion
MIRES IN THE NENETS AUTONOMOUS AREA: DIVERSITY, IMPACTS, MONITORING, RESTORATION

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ClimaEast

UNDP Россия

Care for Ecosystems

Field Excursion
«MIRES IN THE NENETS AUTONOMOUS AREA: DIVERSITY, IMPACTS, MONITORING, RESTORATION»

The excursion focuses to introduce experts to mire diversity in Bolshezemelskaya Tundra and the Pechora delta, as well as to experimental studies on monitoring and ecological restoration of peatlands and shallow peat lands.

Mire diversity in **Bolshezemelskaya Tundra** can be observed during a trip along two roads that are open in summer only: (1) in the direction of Krasnoye township and (2) along the Layavozh Road in the direction of the Shapkina River and natural landmark of the same name. Mires in **the Pechora Delta and Barents Sea coast** will be observed during a boat excursion and from helicopter.

GENERAL INFORMATION ABOUT NENETS AUTONOMOUS AREA

The Nenets Autonomous Area (NAA) is situated in the boundaries of Archangelsk Province. It is the northernmost administrative area of European Russia. The NAA covers an area of 176,000 km^2, which is a home for nearly 44,000 people. Climate varies across the territory, with mean long-term January temperatures of −12 °C in Naryan-Mar, −22 °C in the east portion of the NAA, and −3 °C on the west coast. Winter duration is 220-240 days. Mean temperature of July is 12 °C. Mean annual precipitation is about 400 mm. Most of the NAA is situated in the tundra zone, 15% in the forested tundra, and some small areas in the northern taiga zone. The greatest river of the NAA, the Pechora with its numerous tributaries, has its head in the Komi Republic. The Barents Sea with several large (Kolguyev, Vaigach) and many small islands forms the northern border of the NAA. The Area has two uplands – the Timan Ridge and Pay-Khoy Ridge. The rest of the area is waterlogged plains that are traditionally referred to as Malozemelskaya Tundra (west from the Pechora) and Bolshezemelskaya Tundra (east from the Pechora). The NAA possesses most part of the Europe's richest Timan-Pechora gas and oil basin. Migratory birds of at least three flyways (East Atlantic, West Asian/African, and Mediterranean/Black Sea) nest in the Nenets Autonomous Area. The area is of key

Compiler: T.Yu. Minayeva
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Layout: E.A. Volkova
Translation: O.V. Sikora

importance for some ten species of sea mammals. The territory has been actively developed; nevertheless, landscapes are more or less intact. The NAA has two federal protected natural areas – the Nenets State Nature Reserve (zapovednik) and Nenets Federal Nature Reserve (zakaznik) – and eight regional PAs.

MIRE MASSIF TYPES IN THE NENETS AUTONOMOUS AREA

The predominant mire type in the Nenets Autonomous Area is **palsa mires. Low-mound palsa mires or peat plateau, flat-mound palsa mires**[1], and **domed palsa mires** have been described there. The flat-mound palsa mires can differ by mound shapes as well as by size of hollows and presence of pools. Mounds may have polygonal or irregular shape and hollows of 1 to 100 meters across, with pools, lakes, or with hardly any water. Till now the sporadic distribution of **high-mound palsa mires** in Bolshezemelskaya Tundra had been reported from the surroundings of Vorkuta by Marina Botch and Nadezhda Solonevitch (1967). There are no other reliable data of the high-mound palsa mires distribution and the NAA in general. In some publications experts take domed palsa mires or hill-hollow spotted tundra for the high-mound palsa mires. The mire massifs could be identified as high-mound palsa mire, if the palsas are situated at a large distance (tens of meters) from each other and their height is 5-10 m.

True **polygonal mires** are extremely rare: they occur on alluvial marine plains at the Kara Sea coast, on Vaigach Island, and were described by us at the Korovinskaya Guba coast in Malozemelskaya Tundra. Aapa mires can be found on the slopes of the alluvial-marine planes and marine terraces.

Most of the area is **shallow peat lands** – tundra landscapes that can have flat, polygonal-fissure, or mound nano-relief. The tundra is bound to drained slopes and edges of mire massifs. Slopes are covered with the so-called “spotted” tundra that forms hills tens to hundreds meters in diameter covered with tundra vegetation, waterlogged tundra, or sands overgrown with psammophytes. The hills are divided by runoff ditches (that sometimes have a peat layer) with willow and sedge groves. Tundra on the hills can have a fractured surface with polygonal patterns that can be mistaken for polygonal mire. Landscape of the hill and hollow spotty tundra is sometimes identified on images as high-mound mires, which is not correct. Positive landforms here are shaped by the formation of runoff ditches and do not originate from frost heave. **Shallow peat tundra on edges of watershed mire massifs** looks similar

[1] Low palsa mires in Scandinavian therminology.

to flat-mound mires, but has very shallow peat depths (5-15 cm) and minerotrophic hollows. This landscape type is called “plateau” in North America, where it covers expansive areas.

Mires in the floodplain and delta of the Pechora River can be divided to regularly flooded freshwater marshes, with organic sediments and without true peat, and to sedge-hypnum peatlands that cover more elevated habitats and can be flooded once a year or once in several years. There are elevated sites in the floodplain, such as parts of the old floodplain overlain with 6-10 meters deep sand layers. They are covered with coastal waterlogged tundra that sometimes has fractured surface or low-mound nano-relief. Similar sites can be seen on islands and in the delta.

Coastal mires include all types of marshes (from high to low, saline or freshwater marshes); flat-mound mires with mean peat depth of 2 meters (up to 5 meters) and often with polygonal mounds; and waterlogged tundra (polygonal, low-mound, and flat-mound types). It is at the coast that rare occasions of polygonal mires take place; these mires are wider spread on Yamal and further east, at the Arctic coast of Asia.

Spotty tundra hill and hollow topography on slopes.

Human disturbances of mires in the Nenets Autonomous Area are confined to impacts from linear structures, areal disturbances (quarries, drilling sites), and reindeer overgrazing. Linear structures (pipelines, roads) cause changes in water and temperature regimes and lead to band thaw of permafrost. Areal disturbances lead to erosion, formation of sand bulges, and subsidence of permafrost top. Solid waste pollution is a widespread impact type in the area, particularly in the Pechora Delta and at the coast. Much industrial waste still remain at exploratory drilling sites from 1970s and 1980s in the upland part of the tundra. Pollution impacts are the greatest in the floodplain and delta of the Pechora River.

Landscape **monitoring and studies** in the Nenets Autonomous Area mainly had applied purposes. Landscape structure and quaternary sediments were mapped both small-scale for the whole Timan-Pechora oil and gas basin and large-scale for individual licensed sites. Permafrost studies have been carried out in the region since the 1920s; permafrost temperature monitored since the 1930s and using extended standard programs since the 1980s, including on Bolvansky Cape and Shapkina site. The observations were stopped in 1990 and then resumed in 1999 on Bolvansky Cape, in 2009 on Kashin Island, and in 2012 at Shapkina site (under support from UNDP/GEF/EU project). Flora and vegetation have been studied in detail since the 1920s, including in mires. Paleoecology studies are few. Other topics studied in detail are recolonization dynamics on disturbed sites and revegetation methods, in particular using local plant species. Distribution of carbon reserves and greenhouse gas fluxes in natural and disturbed habitats have been studied since recently under the UNDP/GEF/EU project.

Experimental efforts on ecological restoration were started under the UNDP/GEF/EU project on "Strengthening Protected Area System of the Komi Republic to Conserve Virgin Forest Biodiversity in the Pechora River Headwaters Region" and its component "Conservation of carbon pools of forest and wetland ecosystems in the permafrost zone of the Republic of Komi and the Nenets Autonomous Area": plots surveyed in 2012, detailed surveys and designing fulfilled in 2013-2015. The efforts comprised major disturbance types and background sites: open soil pit, exploratory drilling sites, winter roads (the so-called "zimniki") and were carried out in different locations within the NAA – Bolshezemelskaya Tundra (Verkhnyaya Kolva, Shapkina) and the Pechora Delta (Kumzha site, Kashin Island). For the time being, the experimental restoration was completed at four sites, where monitoring and assessment of results have been carried out.

MIRES IN BOLSHEZEMELSKAYA TUNDRA

Types of mire massifs are associated with certain landscape types. To identify distribution zones of mire types in Bolshezemelskaya Tundra, we used the landscape map compiled by G.V. Malkova and Yu.V. Korostelev.

Alluvial marine terraces are evenly and heavily waterlogged. Mire massifs on the second alluvial marine terrace (II am) are flat-mound and domed palsa mires stretched in the longitudinal direction. They are up to one kilometer wide and several kilometers long, alternating with slopes of hill-gully topography drained by river network. Hills on slopes are covered by tundra of varying waterlogging degree that is crossed by broad peaty gullies with willows and sedges. The plain is a long (20 km or less), gentle slope towards the Pechora River with a vertical drop from 20 to 5 m a.s.l. Moving in the latitudinal direction, about ten flat-mound and domed palsa massifs can be observed on the slope. Domed palsa mires predominate on the upper slope, while flat-mound massifs (or "plateau") are typical in the lower slope.

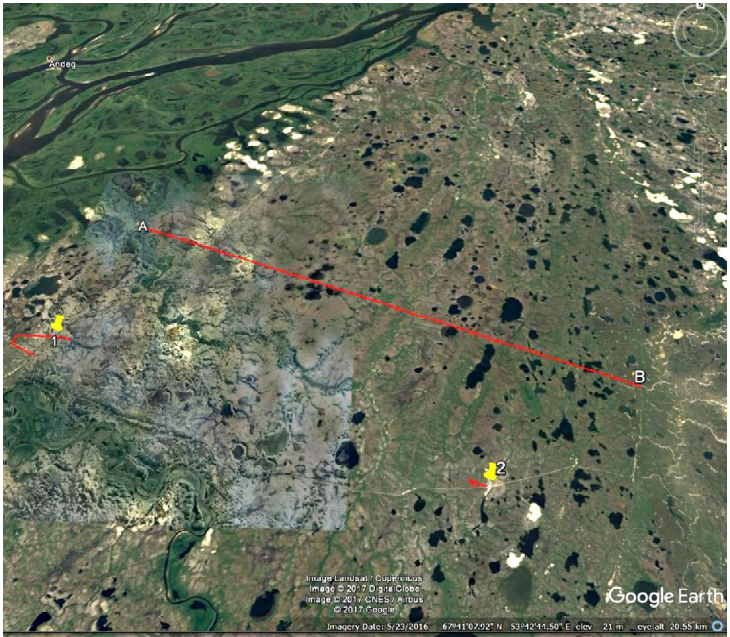
Large (up to 10 km across), domed palsa massifs are scattered on dished watershed tops of marine plains and terraces. They are usually surrounded by waterlogged tundra or flat-mound edge massifs, while more elevated locations are occupied by domed palsa lake-hollow complexes. Mire massifs are usually located on the sixth marine terrace (VI m) and show a lower distribution density compared with those on alluvial plains. The mire massifs are separated by flat-mound and small-mound waterlogged tundra stretching to tens of kilometers and modest-size low-mound and flat-mound mire massifs with poorly outlined boundaries.

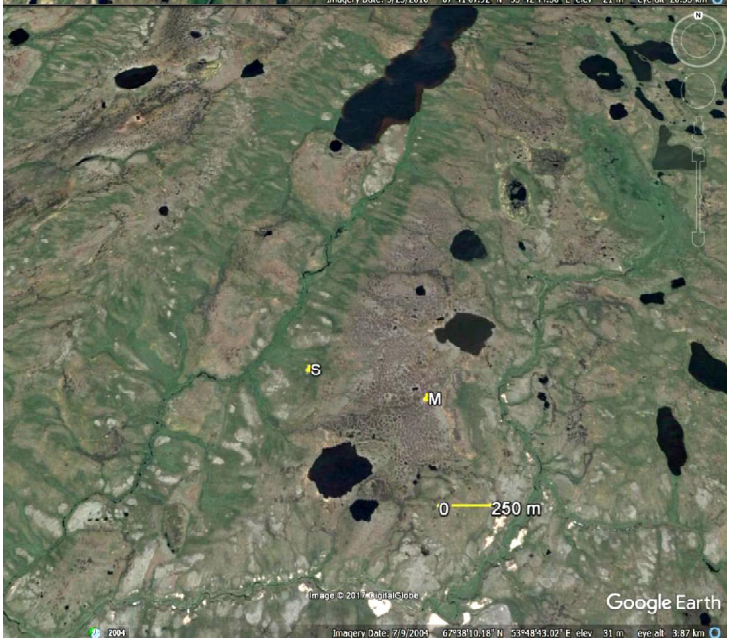
To provide an insight into mire diversity **in Bolshezemelskaya Tundra**, we selected a series of sites along roads. The following **seven demonstration sites** were selected:

Sites 1-2: Mires and waterlogged tundra on second alluvial marine terrace (II am).

The plain is covered with Upper Quaternary alluvial marine sediments of Kargin and Sartan horizons (sands with gravel and pebbles, loamy sands) up to 25 m deep. Absolute altitudes are 15-35 m a.s.l. The starting point of the excursion is at the junction of the road to Krasnoye township and gas pipeline to Vasilkovo (67°40′29.85″ N; 53°24′20.28″ E).

Site 1 is a flat-mound mire east of the road, which is part of a large massif divided by the road. According to study results from 2016, the active layer depth varies from 40 cm to 2.5 m in the end of the slope. Age of sediments at the 2-m depth were 5960 ± 100 years BP (uncalibrated GIN 15494 data). The peat layer was described in the deepest section (peat depth of 257 cm) at the channel levee.



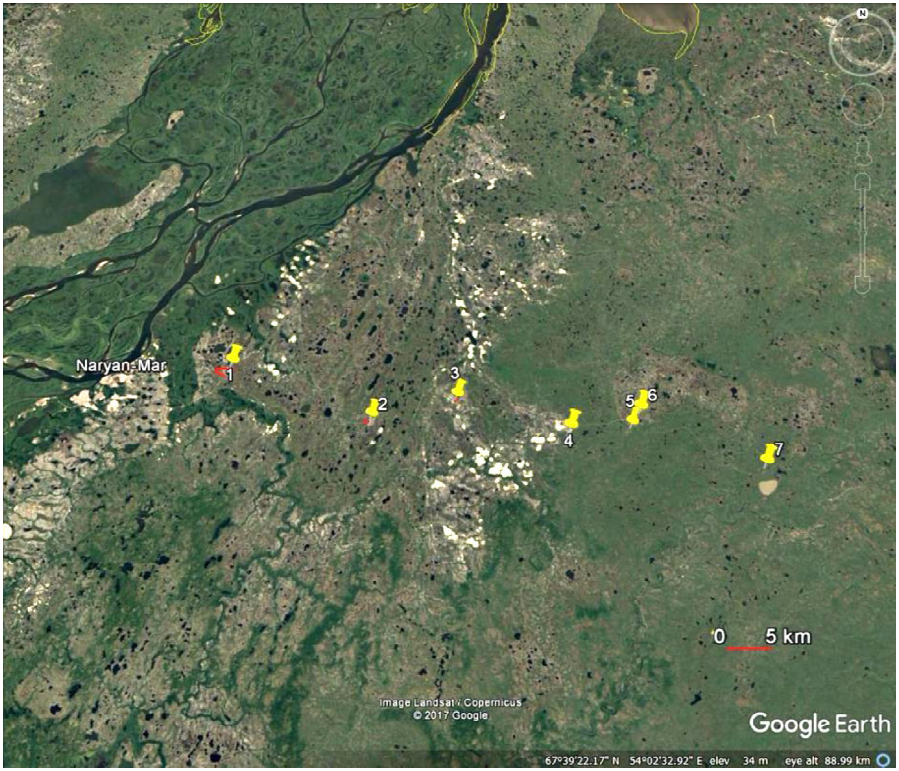


Waterlogged landscapes on the second alluvial marine plain (II am); A-B – slope of he second alluvial plain (transect A-B = 25 km); M – domed palsa mire, S – slopes of hill and hollow tundra.

West off the road, a pipeline crosses the mire. The following human impact types can be observed at the site: impacts of permanent road, permafrost thaw along the pipeline trench, impacts of temporary roads.

Several types of shallow peat lands can be observed within a 500-m distance west off the road: waterlogged tundra, domed palsa mires, and flat-mound mires with polygonal mounds.

More abundantly waterlogged territories dominated by flat-mound mires with irregularly shaped mounds and heavily waterlogged hollows are located in the upper part of the gently sloping second alluvial marine terrace (II am) closer to the borders of the third alluvial marine terrace (III am) and fourth marine terrace (IV m). Peat deposits in the mires are 1.0-1.5 m deep, while the permafrost top, especially in hollows, descends to 2.5 m. Sediments, such as clay and loam, are found in particular in the zone of lake-mire poorly broken relief (A1). Areas of thaw mires can occur on slopes of dissected plains (A2).



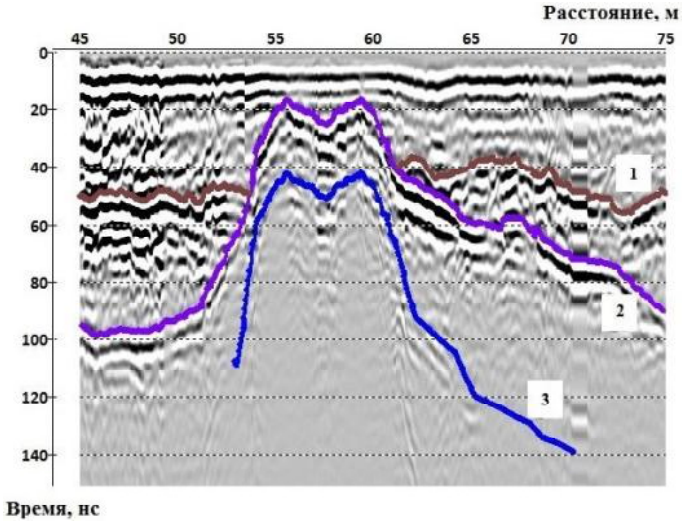
Demostration sites in Bolshezemelskaya Tundra.

Site 3 presents mires of the third alluvial marine plain, of which most are heavily waterlogged domed palsa mires and thaw mires. Peat depths are modest, 0.5-1.0 meters.

Site 4 exemplifies waterlogged hill and hollow landscape that was disturbed as a result of exploration drilling. The ecological restoration method was tested at this site. The site is owned by OAO Surgutneftegaz since 2007. The well was suspended in May 2013. An ineffective attempt of technical and biological restoration was made at the site using traditional methods. In 2015, the ecological restoration test was launched. A baseline assessment was carried out that included mapping of vegetation, soils, and permafrost, as well as measuring greenhouse gas flows. A concept of activities was compiled, studies fulfilled, and project developed. Approaches included measures to prevent soil erosion and restoration of eroded landscape forms, creation of accumulative landforms, water retention, and promotion of organic matter accumulation.

Sites 5 and 6 are located on the sixth marine plain (VI m) overlain with Middle Quaternary (Rogov horizon) glaciomarine sediments: loamy sands, loams, clay, sometimes sands up to 150 m deep. Absolute altitudes vary from 100 to 240 m a.s.l. The sites are a large mire massif (the Neruta River origin) situated on a dished watershed top measuring 3*10 km (Site 6) and its waterlogged peripheries (Site 5).

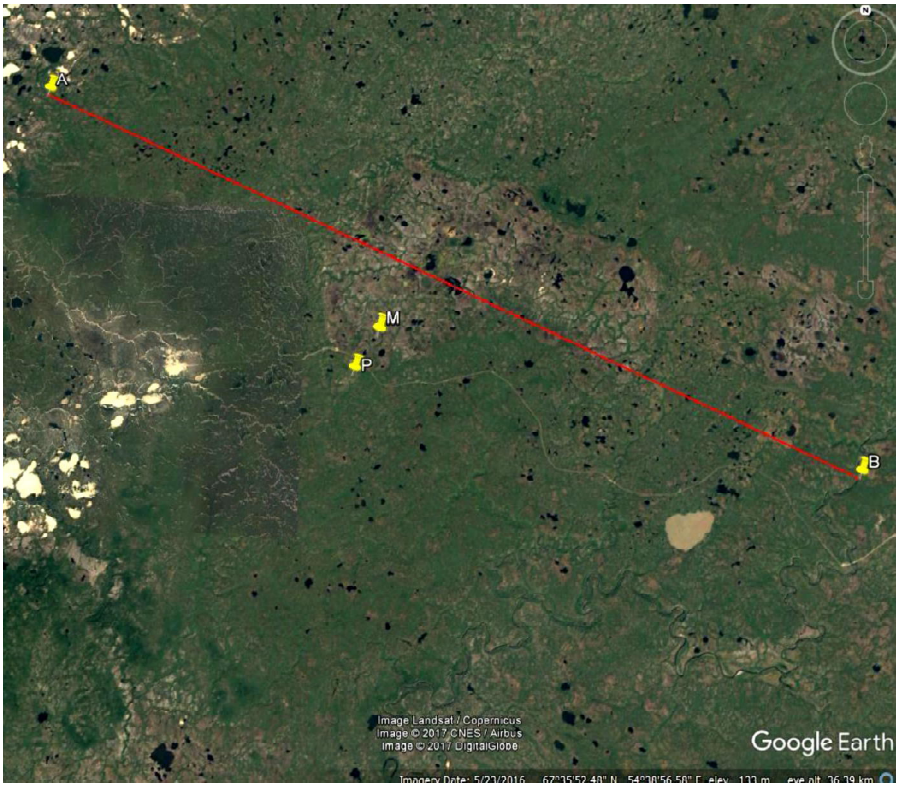
On Site 5 (67°36′39.9″ N; 54°33′06.2″ E), observations of active layer depth, vegetation status, soil temperature regime, and greenhouse



Fragment of georadar imaging profile at Site 2 with interpretation. 1 – peat bottom (about 100 cm), 2 – permafrost top (40 to 240 cm), 3 – multiple reflection from permafrost top.

gas flows have been carried out for four years. Maximum thaw depth of the permafrost horizon varies spatially and annually from 40 to 120 cm. Peat depth does not exceed 30 cm between hummocks and in wet hollows for bottom sediments aged 2460±30 years (uncalibrated date GIN 15362) and averages 20 cm for sediments aged 1040±40 years (uncalibrated date GIN 15361), while in some places it reaches 50 cm. Sedge-hypnum minerotrophic communities with a rich flora of hypnum mosses and a peat layer of 10-15 cm aged 510±30 years (uncalibrated date GIN 15361) have developed at the border of mineral hills and waterlogged areas.

The mire massif dominated by domed mounds and waterlogged hollows occupies a dished watershed top and stretches to several kilometers. According to data from geophysical studies (transect beginning at 67°36′49.8″ N; 54°33′24.5″ E) that included georadar imaging and test drilling, peat layer depth varies from 150 to 200 cm.



Mire massif forming the Neruta River origin and surrounding waterlogged areas. Transect A-B = 45 km. M – mire massif, P – waterlogged massif edges and tundra.

This mire massif is the most widespread type in Bolshezemelskaya Tundra.

Domed palsa mires alternating with flat-mound palsa mires form expansive waterlogged plains on slopes of the fifth (V m) and sixth (VI m) marine plains and have peat depth of over 2 m. At Site 7, one can observe a commonest disturbance type – impact of winter roads. Experimental ecological restoration plots (recovery after winter road disturbance) are situated at this site as well (67°33′37.2″ N; 54° 53′59.7″ E).

MIRES IN THE PECHORA DELTA AND BARENTS SEA COAST

Mires in the Pechora Delta and the Barents Sea coast can be observed during visit to Kumzha Site and Kashin Island (by boat) and Bolvansky Cape (by helicopter).

The excursion to Kumzha includes a visit to floodplain mires and waterlogged tundra on the first upper floodplain terrace with examples of human disturbance. The sites are located within Kumzhinskoye oil and gas deposit in the Pechora River delta, 60 km downstream (northwards) from Naryan-Mar. The site margins a federal protected natural area – Nenetsky State Nature Reserve. There are several suspended exploration drilling sites nearby. In 2008, restoration activities started that were confined to clearing the area from metal scrap. Moreover, the area was disturbed in an accident of 1979 where a fugitive gas emission took place in well Nr 9. To eliminate the emergency, an underground nuclear explosion was fired on May 25, 1981, at the depth of 1470 m, after which the deposit was suspended. The decision to resume exploitation of the deposit was made recently.

Kumzha 1. A typical structure of a floodplain, including waterlogged river margins and shallow-peat floodplain minerotrophic sedge-shrub mires can be observed at a less disturbed site (68°11.519363′ N; 53° 44.244903′ E) near suspended well 19. Soddy floodplain soils at the river margins contain a high proportion of inert organic matter; nevertheless, they are not peat deposits. At the depths of 20-25 cm, the organic matter had an age of 1150±80 years (uncalibrated date GIN 15359). Minerotrophic mires are separated from the river margins with willow groves on alluvial soils.

Kumzha 2. Suspended well Nr 1-2 (68°11.586100′ N; 53°47.130102′ E) is located at an elevation on the first residual floodplain terrace of the Pechora River. Natural vegetation is dwarf shrub – lichen waterlogged tundra with polygonal elements; projective dwarf shrub cover being 15% or less, lichens cover 100% of the surface. The permafrost top is 150-180 cm deep on intact sites and up to 250 cm on disturbed sites. 4 meters deep sand sediments overlay peat deposits found at the depth

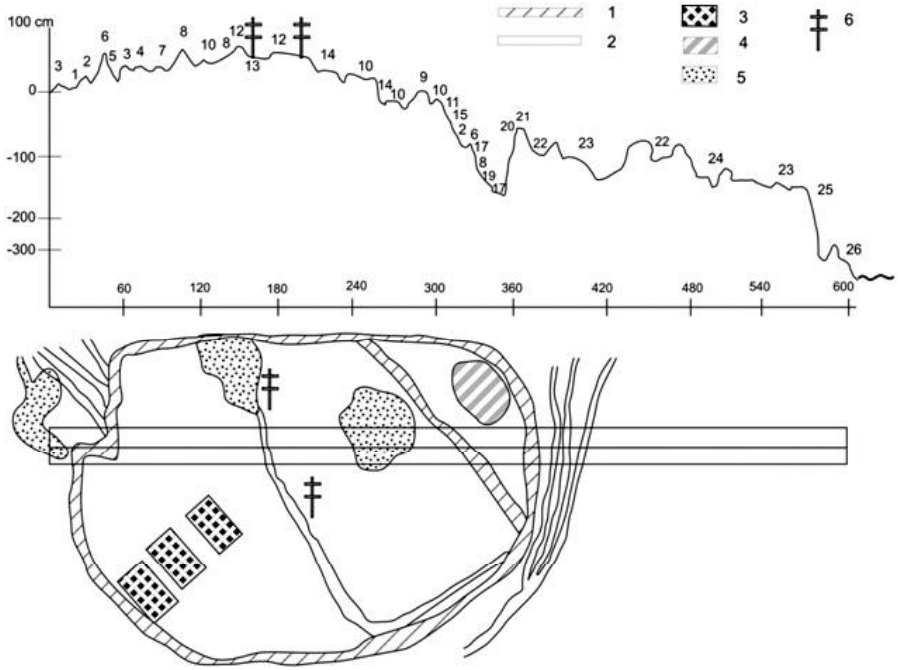
of 4.5 m that are 6060±30 years old (uncalibrated date $IGAN_{AMS}5342$). A watery stratum was registered at the depth of 1.6-2.2 m, and a layer of frozen peaty brownish-grey loam (data by G.V. Malkova). Permafrost monitoring on CALM plots and temperature monitoring in wells have been carried out at the site.

Over 50% of the site surface are affected. They are sand blows and exposed loamy sands in hollows that have been gradually occupied by vegetation. Ecological restoration activities were carried out in 2016 and included fixing erosion landscapes, creating accumulative landforms by terracing and promotion of organic matter accumulation by introduction of fragmented peat and dwarf-shrubs.

Kashin Island. Kashin Island is likely a remainder of an upper floodplain terrace. It is located in the alluvial fan area of the Pechora Delta. Vegetation is represented by waterlogged lichen tundra with a polygonal pattern, small sedge-dwarf shrub mires around lakes and along streams, and ephemeral psammophyte and marsh communities on sand blows and in the coastal zone. Permafrost top is 1 m deep

under peaty soils and 3 m deep under sands. Well drilling on peaty soils showed a presence of buried peat at the depths of 0.9 to 3.7 m overlain with Aeolian sands and a 10-cm deep surface peat layer. The peat is underlain with loamy sands, sands, and loams (at the depths of more than 6.9 m). The buried peat was dated at 3205±50 years old (uncalibrated date COAH-8829) at the depth of 1.2 m and 5215±75 years old (uncalibrated date COAH-8829) at the depth of 2 m.

Cape Bolvansky. "Bolvansky" is one of several geocryological stations established in the 1980s in the European North of Russia to study cryogenic processes. The station is located in the Pechora River mouth near the weather station that operated in 1935-1999) at the south coast of the Pechora Bay, in the southern tundra subzone, on the eroded IV glaciomarine plain with absolute altitudes of 25 to 100 m. The plain has a rolling topography dissected by lake basins, ravines, and runoff gullies. Soils are tundra gley and boggy-tundra peaty gley and peat gley types in association with dry peat and dry peat – humus soils on hummocks and raised bog soils in mires. Predominant are waterlogged low-mound tundra, low palsa mires (plateau), flat-mound

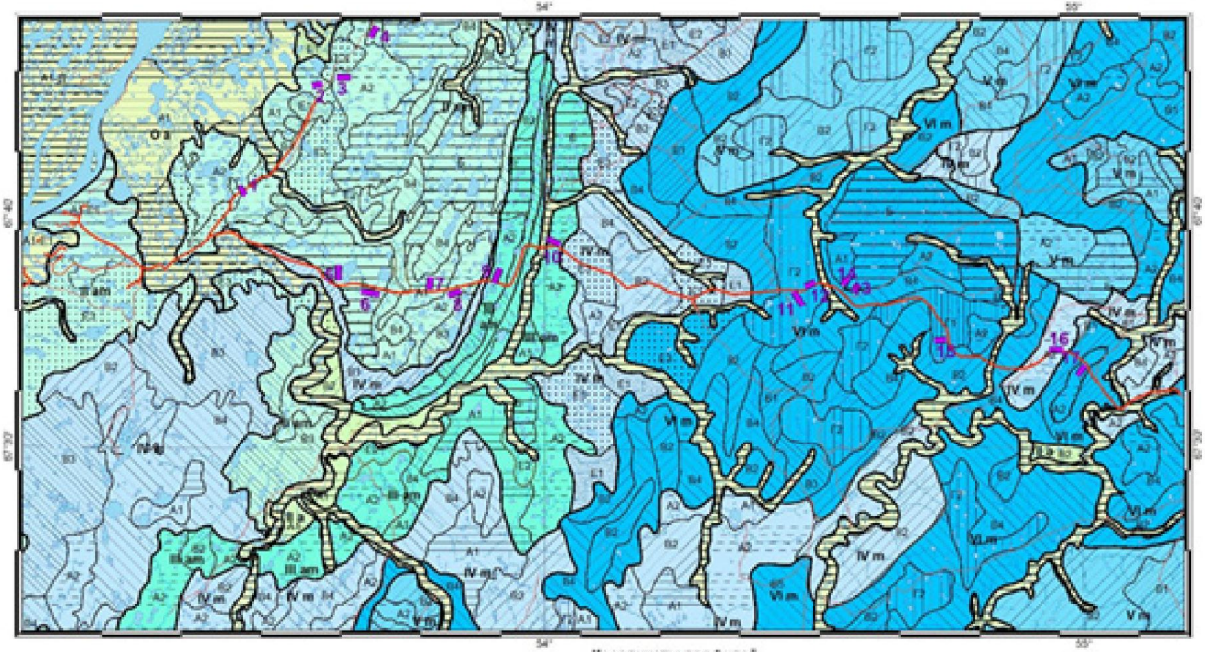


Overview of disturbed exploration drilling site 1-2 of the Kumzha deposit. *Map symbols*: 1 - gravel packing, 2 – roads, 3 – mud pits, 4 – exposed mud pit, 5 – sand blows in disturbed places, 6 – suspended drilling wells.

Cape Bolvansky.

mires with polygonal and irregularly shaped mounds and drained lakes (khasyrey). Surface deposits are mostly permanently frozen. Depth of the permafrost layer is 100-200 m. Frozen rocks rest directly under the seasonal thaw layer. A deeper, subsided to 3-5 meters or deeper permafrost top can only be observed in ravines with dense willow groves, on edges of lake basins, and on slope bottoms where deep snow drifts accumulate. Nonperforating taliks are found under virtually all lakes that do not freeze through in winter. Perforating taliks have developed under the bottoms of the Pechora River, Bolvanskaya Bay, and Pechora Bay. New permafrost rocks have formed under drained lakes (khasyrey). Palsa mires have 2-5 m deep peat layers.

More information on the site will be presented during the excursion.



Ландшафтная карта района работ

Масштаб 1:250 000

5 2,5 0 5 10 15 20 25 км

Составили: Малкова Г.В., Коростелев Ю.В.

Координаты профилей

номер	ландшафт	долгота	широта
1	IIIm A2	53° 25' 38,1"	67° 41' 11,069"
2	IIIm A1	53° 33' 45,1"	67° 45' 34,898"
3	IIIm A2	53° 38' 33,1"	67° 46' 56,479"
4	IIIm A1	53° 40' 17,1"	67° 47' 39,649"
5	IIIm б	53° 36' 53,1"	67° 37' 12,179"
6	IIIm Б	53° 39' 28,1"	67° 36' 46,140"
7	IIIm A1	53° 47' 0,6"	67° 36' 51,680"
8	IIIm A2	53° 49' 11,1"	67° 36' 38,853"
9	IIIm A2	53° 54' 19,1"	67° 37' 8,669"
10	IIIm A2	54° 0' 15,8"	67° 39' 1,841"
11	VIm Г2	54° 27' 57,1"	67° 36' 43,941"
12	VIm Г2	54° 29' 10,1"	67° 36' 56,787"
13	VIm A1	54° 33' 24,1"	67° 37' 3,988"
14	VIm Б	54° 34' 38,1"	67° 36' 42,202"
15	VIm Г1	54° 43' 41,1"	67° 34' 35,468"
16	IVm A2	54° 58' 36,1"	67° 34' 8,903"
17	VIm A2	55° 0' 30,1"	67° 33' 25,565"