Geocryological Map of the USSR, 1: 2 500 000, 1991

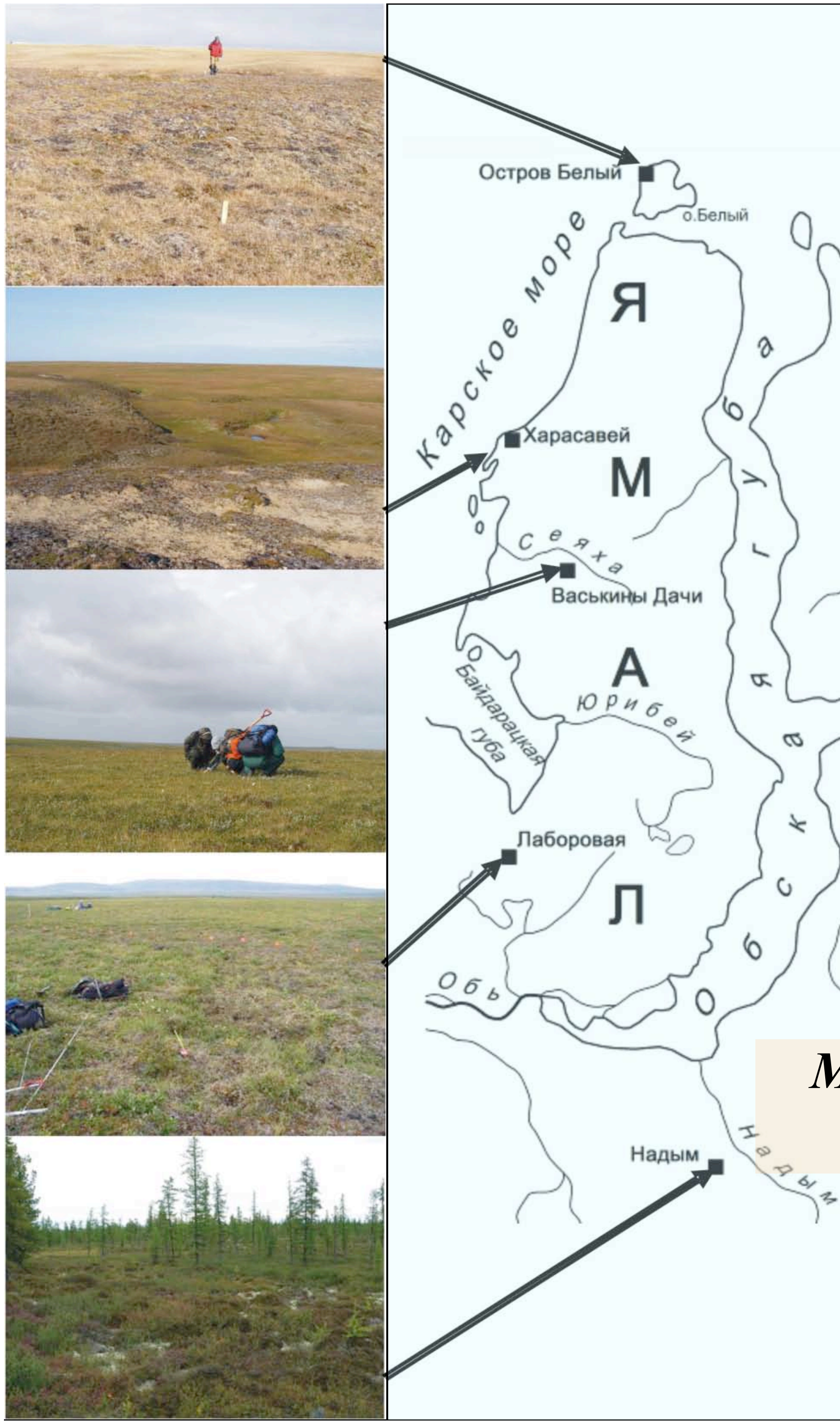
(Editor E.D.Ershov, Moscow State University, Faculty of Geology, Geocryological department)

Global Level GIS

Geological map of the USSR

- Compiled for almost 20 years;
- Based on modeling (Kudryavtsev model):
  - $T_{ground} = T_{air} + \Delta T_{snow} + \Delta T_{vegcover} + \Delta T_{rain} + \Delta T_{insolation}$
- Based on cross-regioning matrix
  - *eg.* In Russia: West Siberian Lowland>superimposed 3 climatic zones>superimposed 3 snow cover provinces>superimposed lithologic, relief and so on, areas
  - "calculation table" is built with initial and boundary conditions, and substrate properties covering real combination of local factors: snow and vegetation insulation, slope insolation, water infiltration, and so on, controlling thermal properties.
- Mapped is a range of realistic calculated ground temperatures. Can be mapped in any scale.
- Reflects a time slice of 20 years from 50-s to 70-s.

Active layer and permafrost boreholes along the Yamal transect



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Forcing factors for ground temperature (T) and active layer depth (ALD)

Temporal:

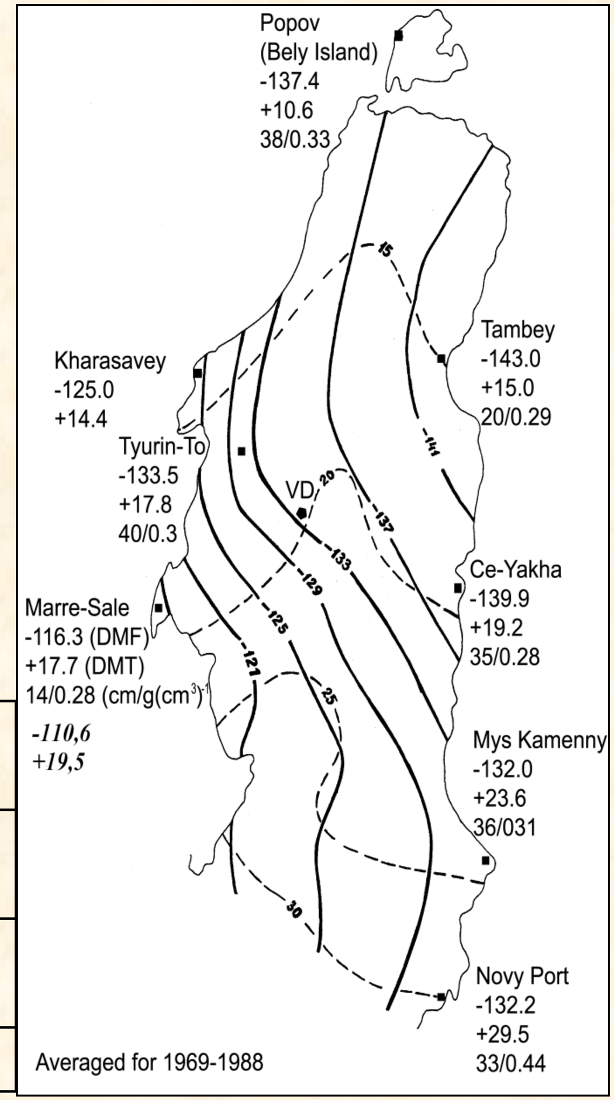
Short-term
Summer and winter air temperature;
Winter and summer precipitation;
Moisture content in the active layer

Long-term
Vegetative cover
Surface deposits
Ice content in permafrost

Spatial:
Topography
Lithology
Cryogenic structure

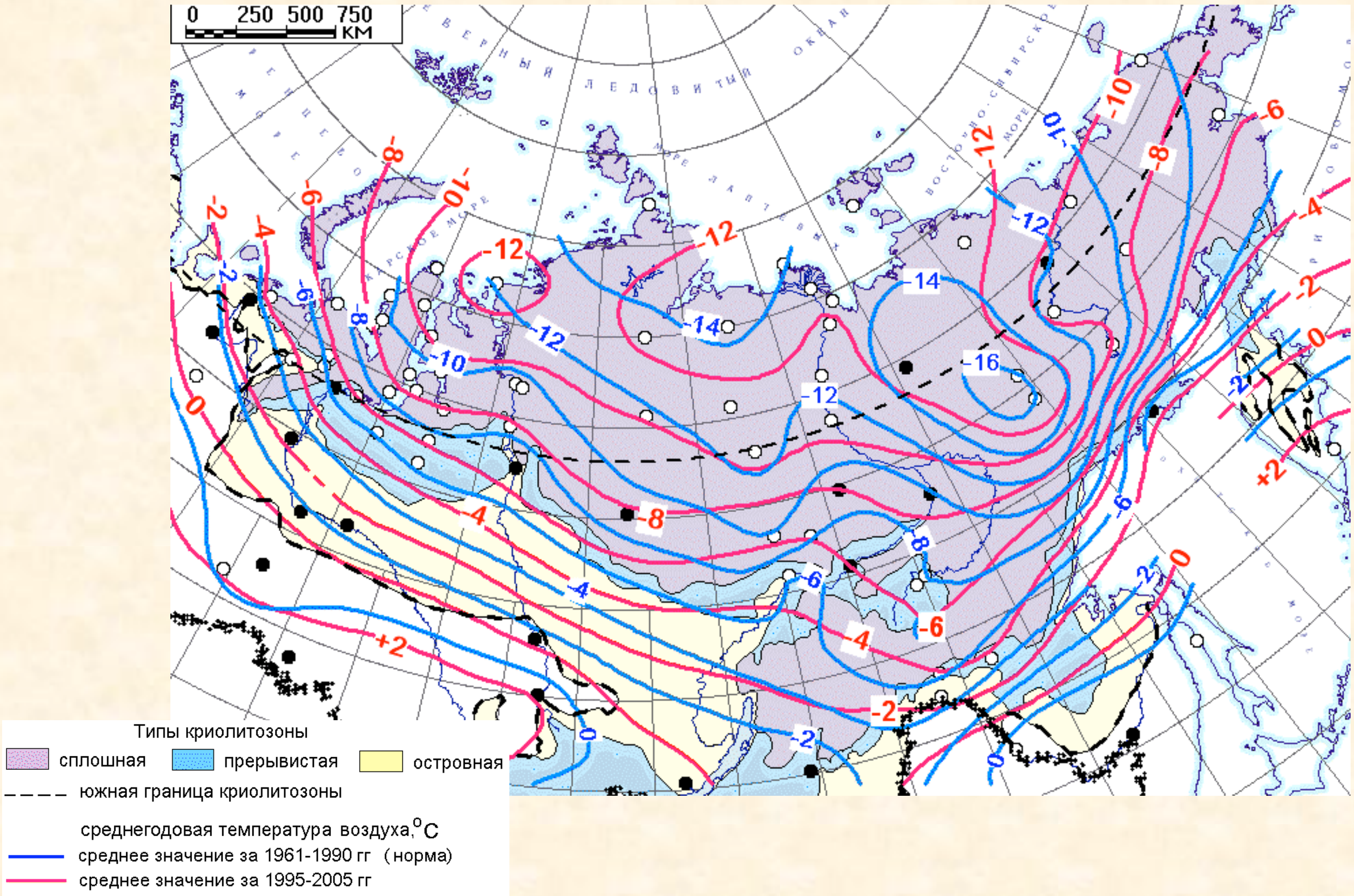
Specific environmental and climatic features affecting permafrost on Yamal

- Zonal (general lowering northward):
  - Air temperature gradient
  - Topography gradient
  - Vegetation mat thickness
  - Peat cover thickness
- Azonal:
  - Thaw index rising landward
  - Topography rising landward
  - Freeze index rising westward
  - Highly diverse lithology from sandy (even gravel) to clay and peat



	1969-1988	1991-1999	Warming degree month	Ground temperature rise, °C
Freeze index	**−116,3**	**−110,6**	**5,7**	**0,08*5,7=0,46**
Thaw index	**+17,7**	**+19,5**	**1,8**	**0,18*1,8=0,32**
Sum	**−98,6/12=−8,2**	**−91,1/12=−7,6**	**7,5**	**0,78**

Averages of mean annual air temperature for 1961-1990 and 1995-2005 (after G.V.Malkova and A.V.Pavlov, 2005)



Lithology, ice content, cryogenic structure

- Plain with relatively low altitudes.
- Highly dissected topography, providing good drainage at the hilltops and terraces.
- A wide range of lithologic complexes from sand, sometimes with gravel, to clay and peat.
- Polygonal structures with either ice or sand wedges contribute to erosion rates and good drainage.
- Tabular ground ice in 10 and even more meters thick layers, found at various depths, including those close to the surface.
- Salinity, resulting from marine sedimentation, well preserved in permafrost (near the surface) north of Yuribei river, and 5-10 m deeper south of it.

Factors specific for research polygons in Tundra zone with continuous permafrost distribution

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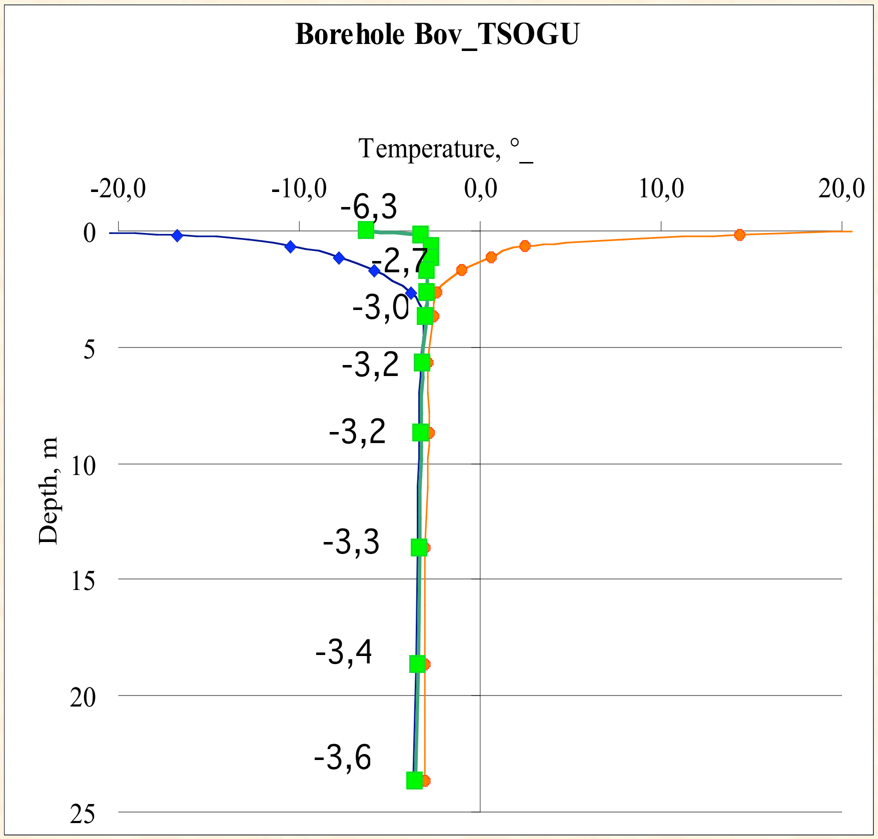
Ground temperature

Geothermal gradient ~ 0,03°C/m.
Depth of zero annual amplitude 10-15 m depending on ground temperature.
TG-TAL=0,3 to 0,45°C.



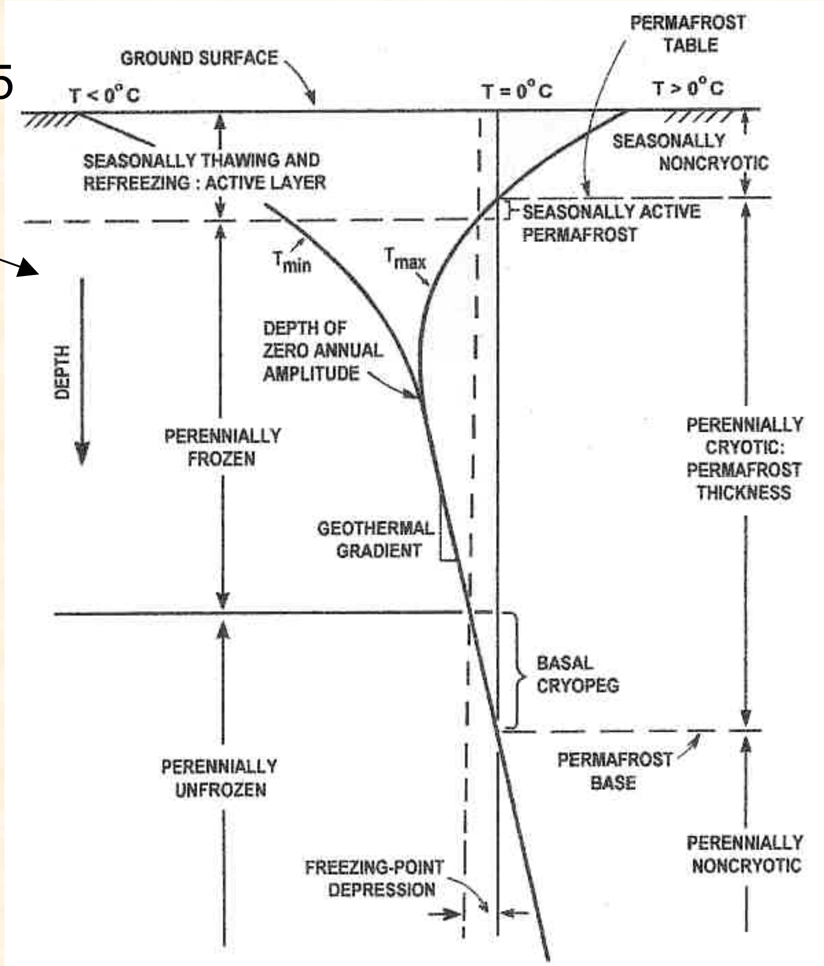
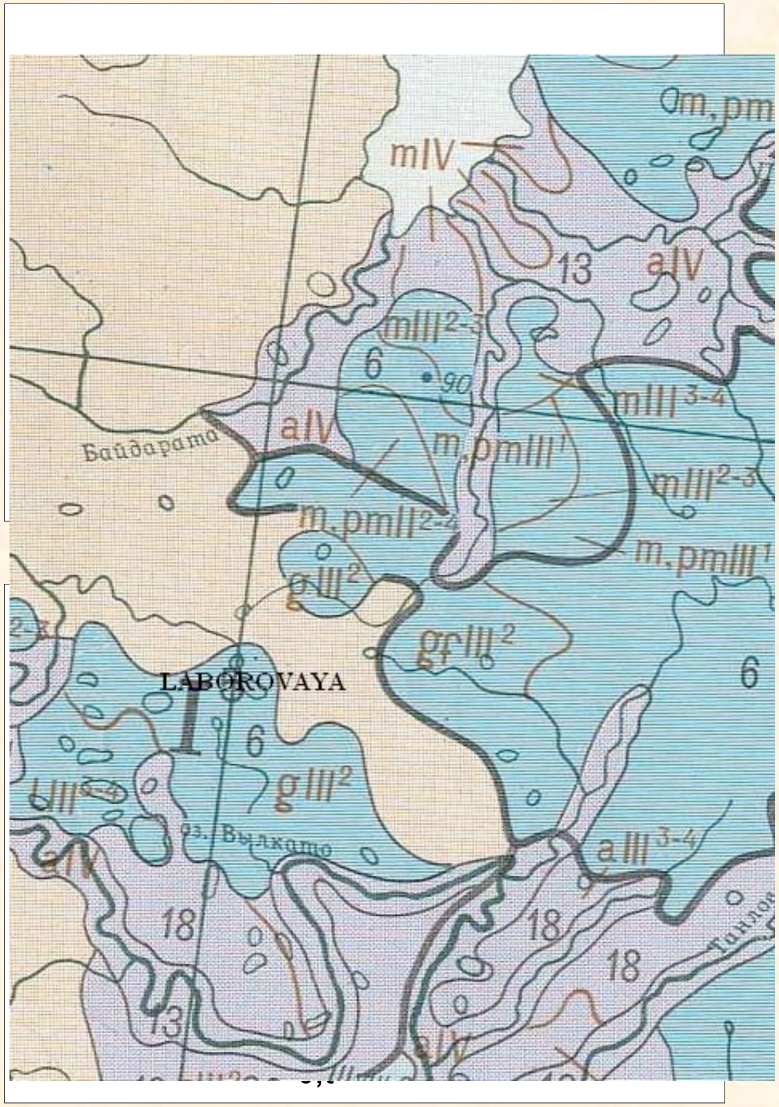


Figure 2. Terms used to describe the ground temperature relative to 0°C, and the state of the water versus depth, in a permafrost environment (modified from van Everdingen, 1985}. In **MULTI-LANGUAGE GLOSSARY of PERMAFROST and RELATED GROUND-ICE TERMS** Compiled and Edited by: **Robert O. van Everdingen 1998 (revised 2005)**

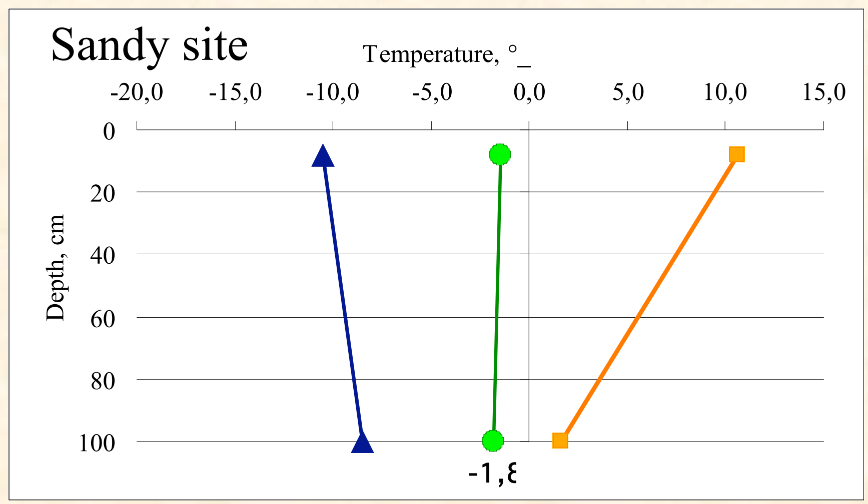
Mean annual ground temperature at the active layer base, Laborovaya, sandy and clayey sites



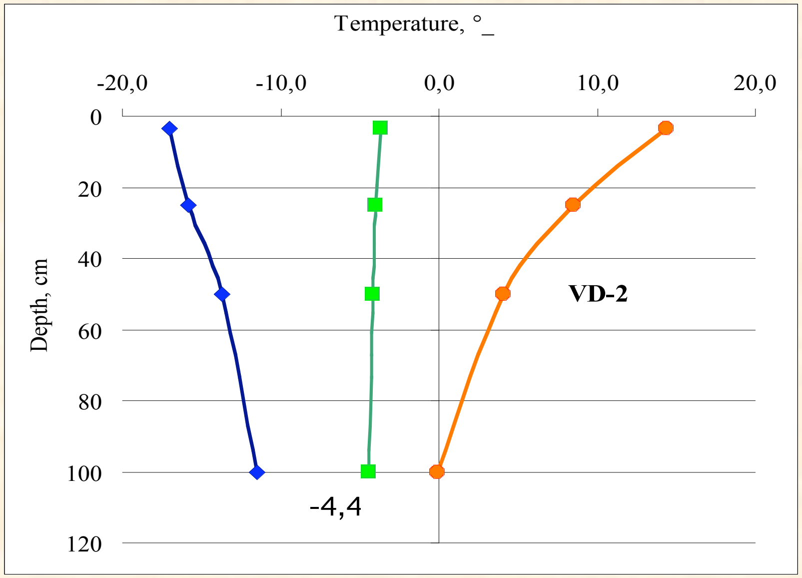
Dates of the thaw and refreezing period in boreholes Lab 1-1 and 1-2 at a clayey site

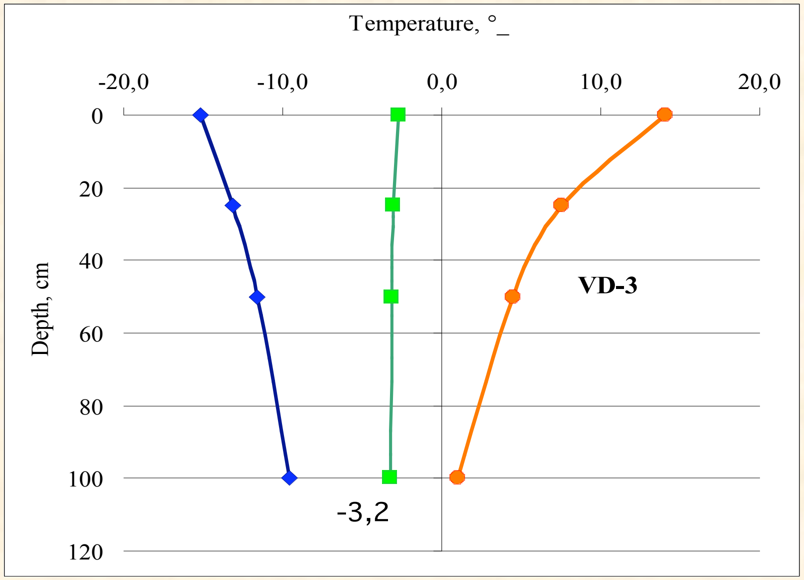
Borehole	Lab 1-1	Lab 1-2	Lab 1-1	Lab 1-2
Depth, cm	Spring thaw		Fall refreezing	
0	06.06	09.06	28.09	07.10
20	18.06	18.06	19.10	11.10
50	14.07	08.07	14.10 (?)	05.11
90/99	31.07	28.07	15.10(15.12)	15.10

Spring	Fall
09.06.2008	11.10.2008
02.08.2008	19.12.2008



Mean annual ground temperature at the active layer base, Vaskiny Dachi, GOA



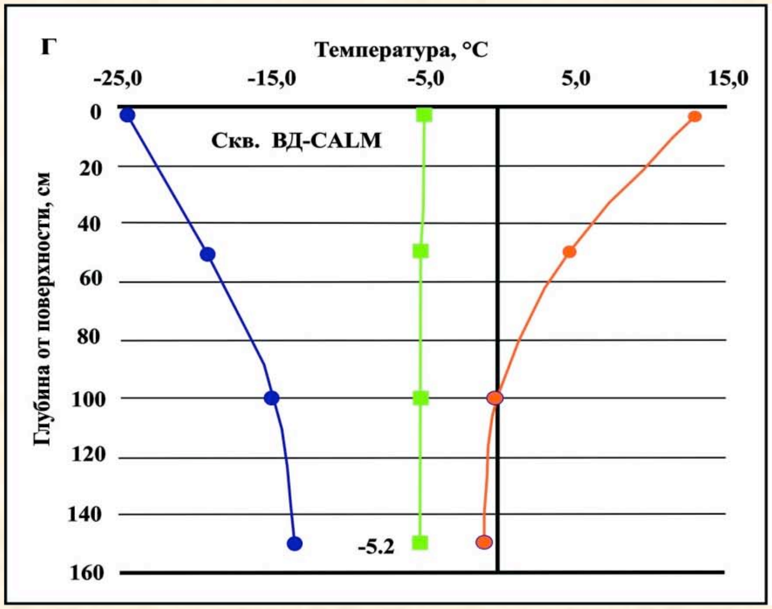


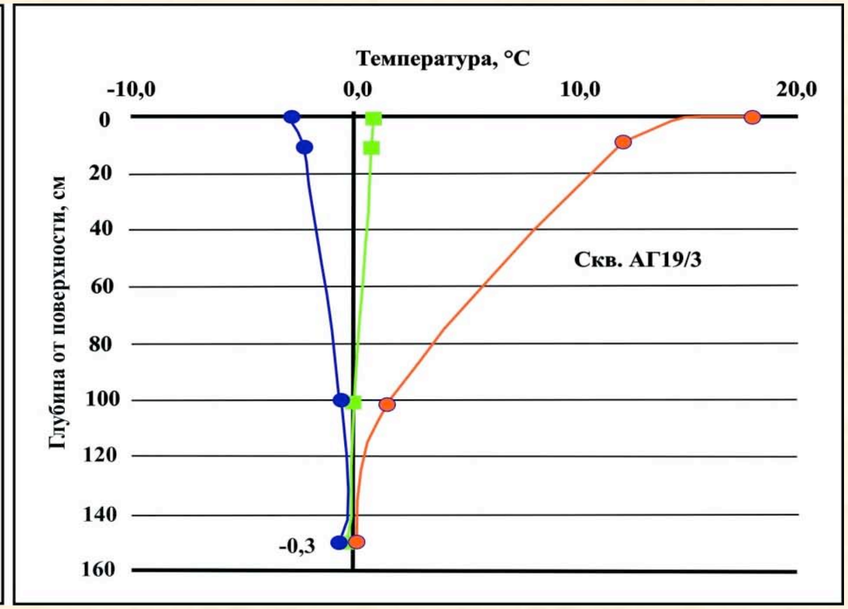
Dates of the thaw and refreezing period in boreholes VD-1 (clayey), VD-2 (clayey) and VD-3 (sandy)

Borehole	VD 1	VD 2	VD 3	VD 1	VD 2	VD 3
Depth, cm	Spring thaw			Fall refreezing		
0-6	13.06.08	11.06.08	11.06.08	30.09.08	29.09.08	28.09.08
25	24.06.08	21.06.08	27.06.08	10.10.08	01.10.08	01.10.08
50	-	02.07.08	12.07.08	-	02.10.08-02.11.08**	02.10.08
100	-	16.09.08*	06.08.09	-	30.09.08***	01.10.08

*Date of maximum negative temperature -0,14°C. ** Zero curtain. ***Date of the start of lowering of negative temperature: start of refreezing upward.

Mean annual ground temperature at the active layer base, Vaskiny Dachi, CALM and SBRAS





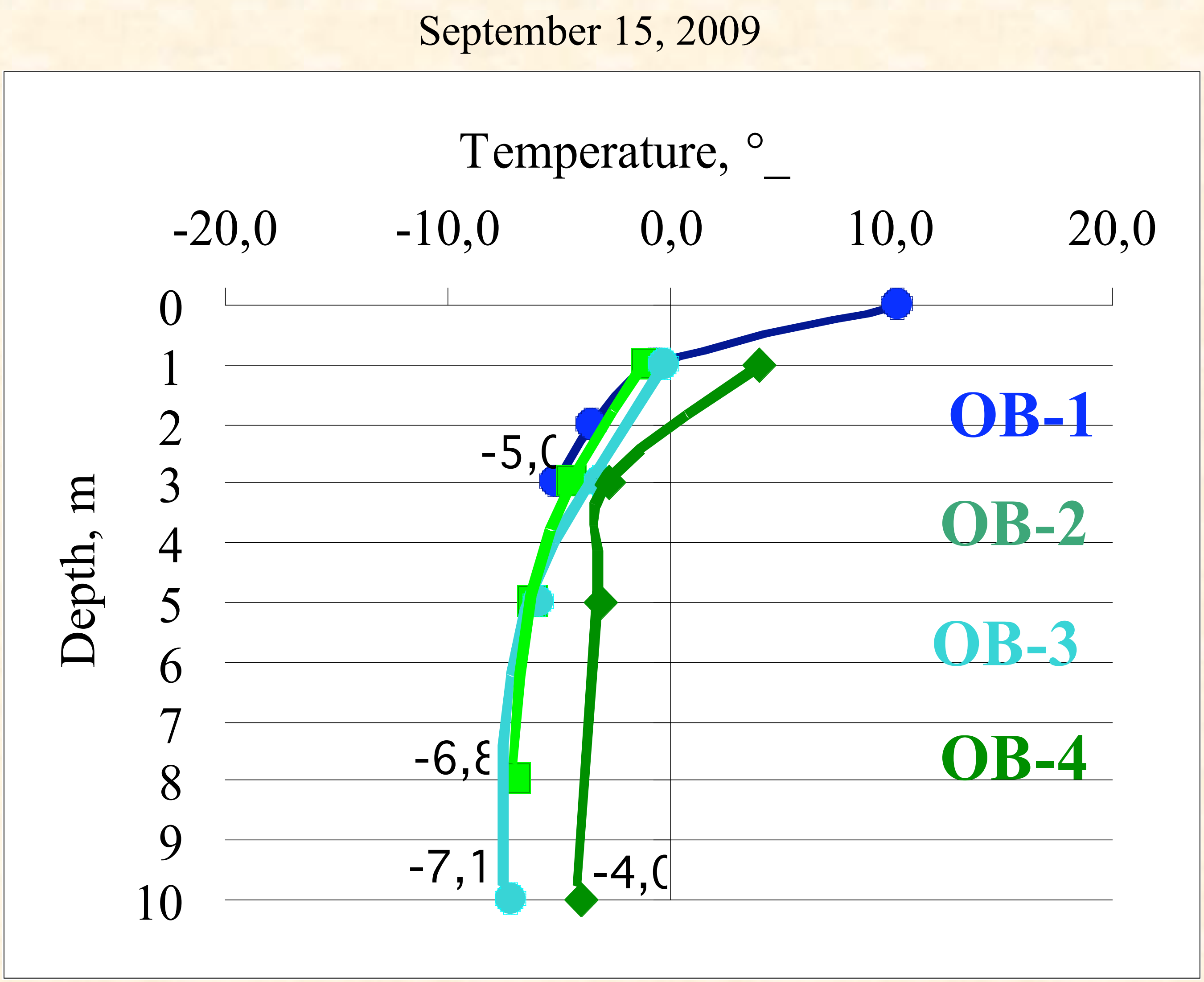
Dates of the thaw and refreezing period in boreholes VD-CALM (sandy), AG19/3 (clayey)

Borehole	VD CALM	АГ19/3	VD CALM	АГ19/3
Depth, cm	Spring thaw		Fall refreezing	
0-3	11.06.08	03.07.08	28.09.08	07.10.08
10	09.07.08	04.07.08	04.10.08	09.10.08
100	30.07.08*	06.08.08	15.11.08**	05.10.08
150	24.08.08*	30.09.08*	24.11.08**	04.12.08**

* Date of maximum negative temperature -0,16°C at 100 cm and 1,06°C at 150 cm.

** Date of the start of lowering of negative temperature: start of refreezing upward.

Mean annual ground temperature at the active layer base, Bely Island



Mean annual ground temperature at the active layer base, conclusion

- Mean annual ground temperature at the active layer base (and layer of zero annual amplitude) follows zonal pattern when compared are similar landscape conditions. As a rule, on sandy plots temperature is lower, than on clayey ones.
- Distortion is found when snow accumulation is higher than average. Even in the coldest Arctic tundra on Bely Island ground temperature beneath the snowpatch is higher, than on bare windblown sands of Vaskiny Dachi in typical tundra.

Average active layer depth

Zonal changes of the climatic parameters affecting permafrost

Polygons	Date		Length of the thaw period	Mean annual air temperature, °C	Mean annual ground temperature at the AL base °C
	Start of the thaw period	Finish of the thaw period			
Nadym (W/s Nadym)	14.05.08	07.10.08	146	-3,5	-0,1
Laborovaya (W/s Salekhard)	26.05.07	12.10.07	137	-3,6	-0,9…-2,1
Vaskiny Dachy (W/s Marre-Sale)	13.06.08	07.10.08	117	-7,2	-6,4
Bely Isalnd (W/s Popov)	20.06.09	14.10.09	117	-9,7	-

Calculation of maximum thaw depth (GOST…, 1984)

Sites	Thaw index, degree hours		$K_{max}(\Omega_{max}/\Omega)^{1/2}$ **(% of thaw by the probe date)**	Average thaw depth by probe, cm	Maximum average thaw depth calculated (measured)
	Annual (Ωmax)	By the probe date (Ω)			
Nadym peat	32806	28347	1,075/93%	84	90
Nadym sand				147	158
Laborov sand	~24300	~21816	1,0554/95%	104	110
Laborov clay				80	84
VD CALM sand	19452	16457	1,0872/92%	93	101
VD IV terrace				75	82
VD III terrace				72	78
VD II terrace				113	123
Kharasavey clay	19452	12811	1, 23/81%	61	75
Kharasavey sand		13210	1,21/82%	75	91
Kharasavey sand		13450	1,20/83%	78	94
Bely sand	12284	2996	2,02/50%	58	117 (99,8/98,3)*
Bely clay		3175	1,97/51%	32	63 (54,4/53,8)*

Averages of calculated maximum active layer depth on Yamal transect

Sites	Maximum thaw depth, cm
Nadym, sand	158
Nadym peat	90
Laborovaya clay	84
Laborovaya sand (surface cover)	110
Vaskiny Dachi, CALM (surface cover)	101
Vaskiny Dachi, clay	82
Vaskiny Dachi, silt	78
Vaskiny Dachi, sand (bare surface)	123
Kharasavey, clay	75
Kharasavey, sand	92,5
Bely Island, sand (bare surface)	117
Bely Island, clay	63

Conclusions

- It is established that, on the whole, zonal distribution of bioclimatic subzones northward determines the consecutive change of various parameters of permafrost. However, local factors connected to relief, drainage degree, location of plots on different landforms, which determine snow accumulation and vegetation mat thickness, distort zonal pattern which is much more apparent when similar landscapes are compared.
- The zonal changes in the depth of thaw and ground temperature from south northward in similar landscape conditions are determined by the lower air temperature and reduction of vegetation mat in this direction. Non-zonal relief lowering northward contributes to the zonal pattern, which is clearer traced within the landscapes on clayey soils rather than on sandy ones.


Thank you for your attention
UTair
ЮТэйр