Soils of the European Arctic Transect (EAT)
Yamal Peninsula and Franz Jozef Land, Russia

George Matyshak

Lomonosov Moscow Sate University, Department of Soil Science, Moscow, Russia

Coauthors:

D.A. Walker[2], H.E. Epstein[3], M.O. Leibman[4], N.G. Moskalenko[4], P.T. Orekhov[4]

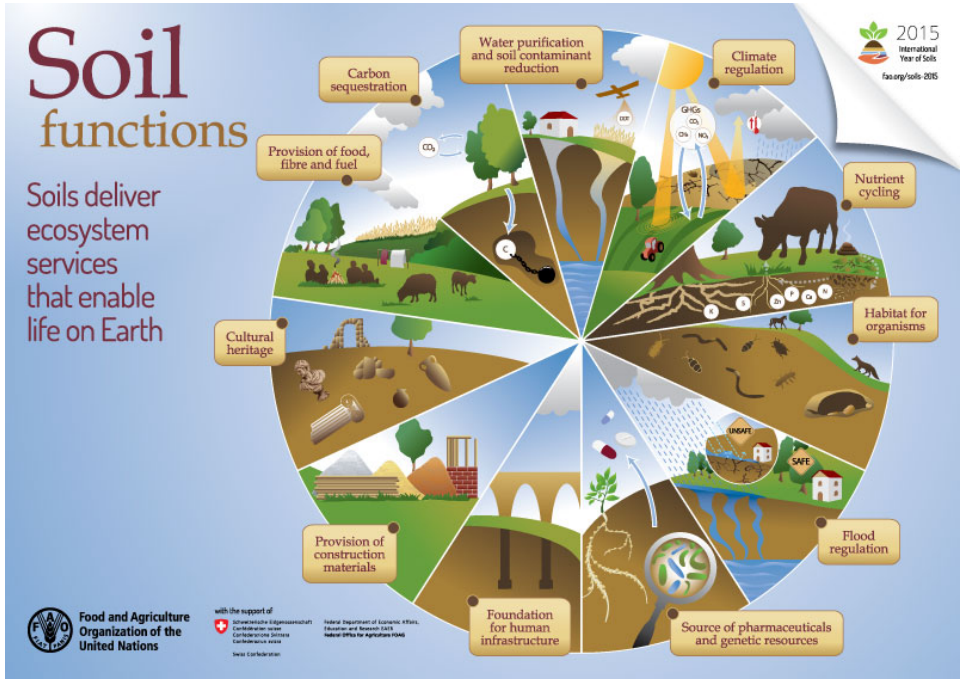
[2]*University of Alaska Fairbanks, Fairbanks, USA.*

[3]*University of Virginia, Charlottesville, USA.*

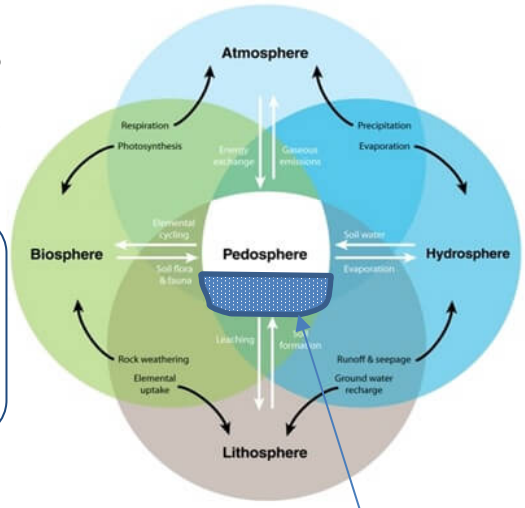
[4]*Earth Cryosphere Institute, Tyumen, Russian Federation.*

The Arctic Science Summit Week 2017

31 March – 7 April 2017, Prague, Czech Republic



Soil is called the *Skin of the Earth* and interfaces with the lithosphere, the hydrosphere, the atmosphere, and the biosphere.



Soil - is a mirror of landscape

(*Dokuchaev - russian soilsciencist*)

Soil is a product of the influence of climate, relief, plants, parent materials interacting over time.

Cryopedosphere ***(25%)***

Permafrost in Russia - more than 60% area

The main function is fertility.

At the north - the carbon cycle and a medium for the life of organisms and plants.

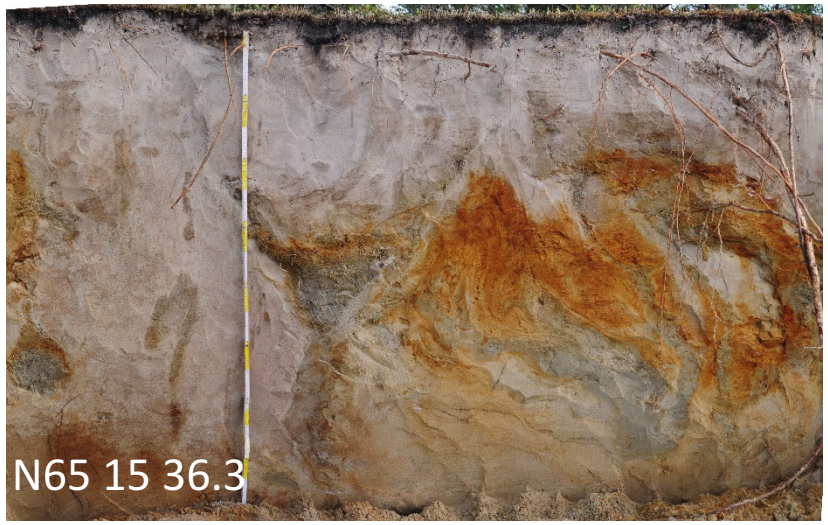
- Cryogenesis is a factor of soil formation
- All world soil classifications (except Russian) use permafrost to determine higher soil orders

Latitudinal changing of soil types

Cryogenic processes are well reflected and preserved in the soil profile

South

North

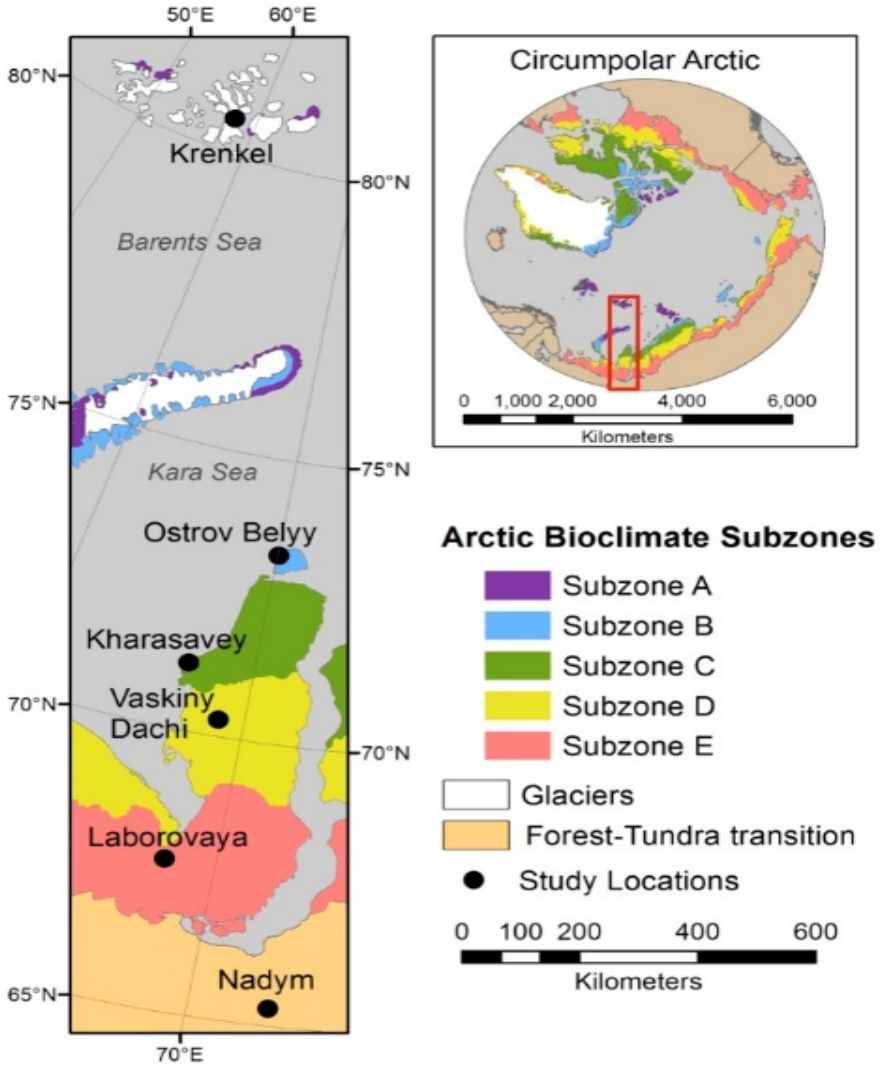


Permafrost affected soils are characterized by cryoturbations, irregular or broken horizons, cracking and incorporation of surface organic matter into the lower soil horizons

Research questions

- **How does soils vary along the <u>Latitudinal</u> EAT transect?**
- **What factors and how determine the development and properties of soils?**
- **Soil - biomass? What is the relationship between the soil properties and biomass.**

During 2007-2010 we studied soils of five Arctic bioclimate subzones from the extreme High Arctic in Franz Josef Land across the full length of the Yamal Peninsula, to forest-tundra transition near Nadym in northwest Siberia (6 locations).

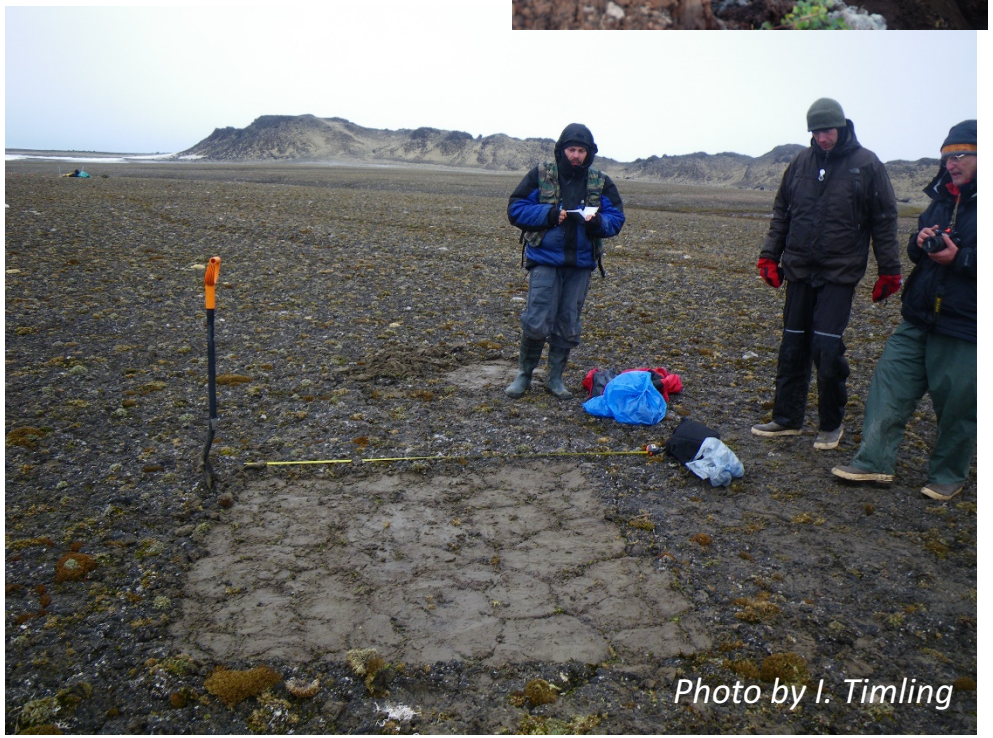


The Eurasia Arctic Transect study locations within the five Arctic Bioclimate subzones (based on the Circumpolar Arctic Vegetation Map (Walker et al. 2005).

Methods

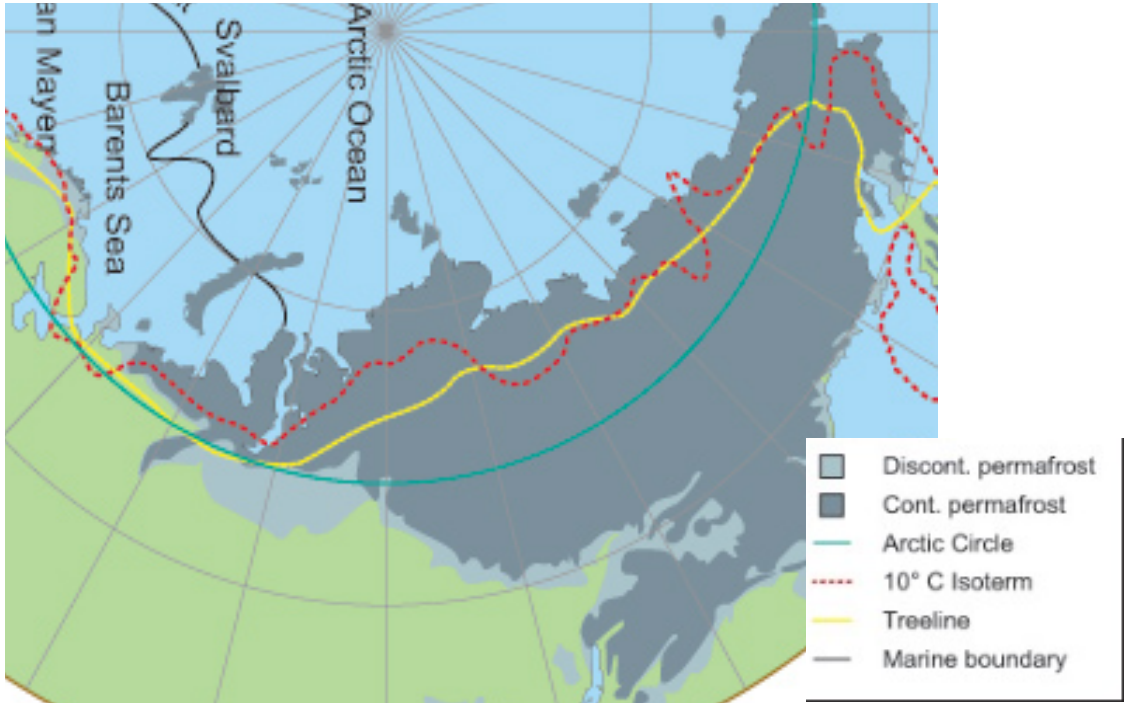
- In each location, soils were studied on **2 types of sites**: ***LOAMY AND SANDY*** *(mesic or dry conditions)*.
- At each sites we had **1 key soil pit**. The excavations were made so that the vertical (or horizontal) face exposed a complete cycle of the cryogenic patterns (*boil-interboil*).

- Soil profiles were described and sampled according to the Soil Survey Manual (Soil Survey Division Staff, 1999). Soil samples were taken from each genetic horizon of soil pit and 5 replicates from soil surface.
- At some sites measured CO2 efflux.
- All chemical analyzes were made on the basis of the USDA National Soil Survey Laboratory procedures (Soil Survey Laboratory Staff, 1996). Results processed using the analysis of variance and regression analysis in Statistica 7.0 program.



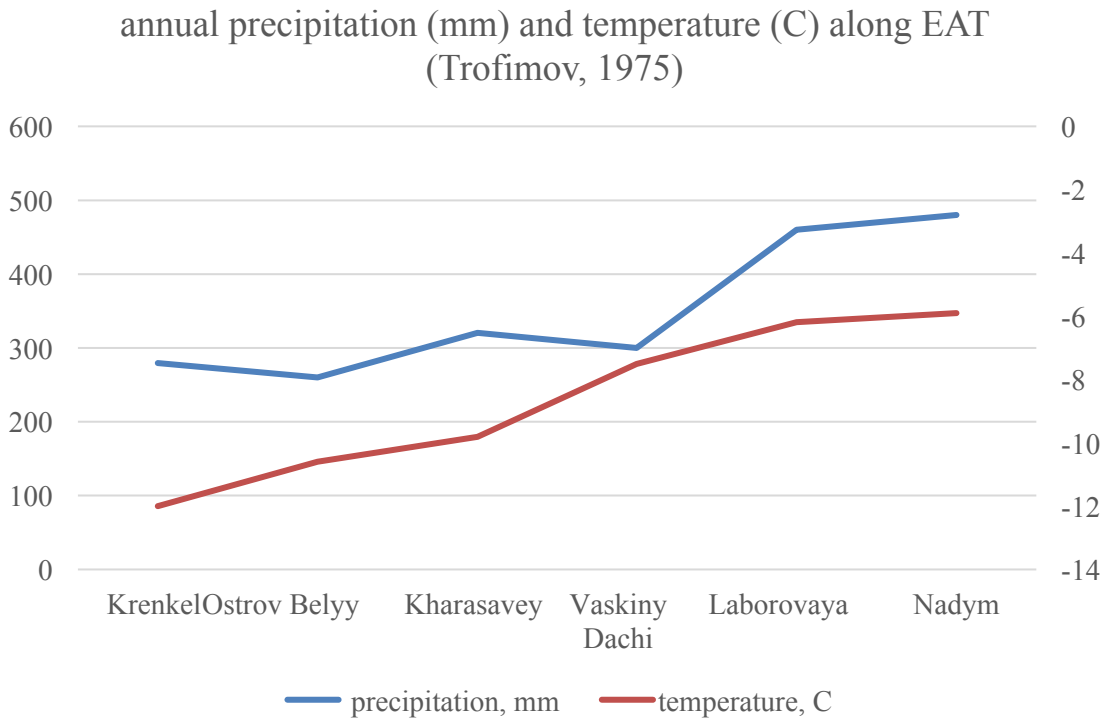
What determines the formation of soils on this transect?

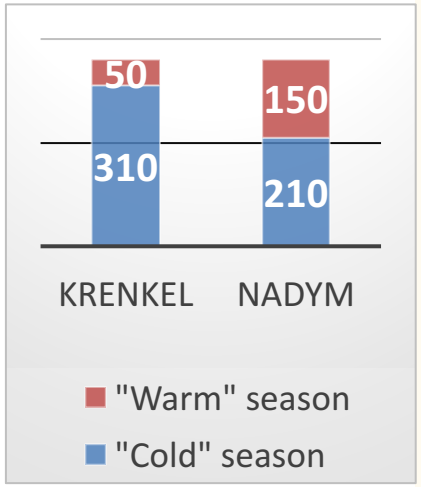
The north of Western Siberia (Yamal) has several peculiarity



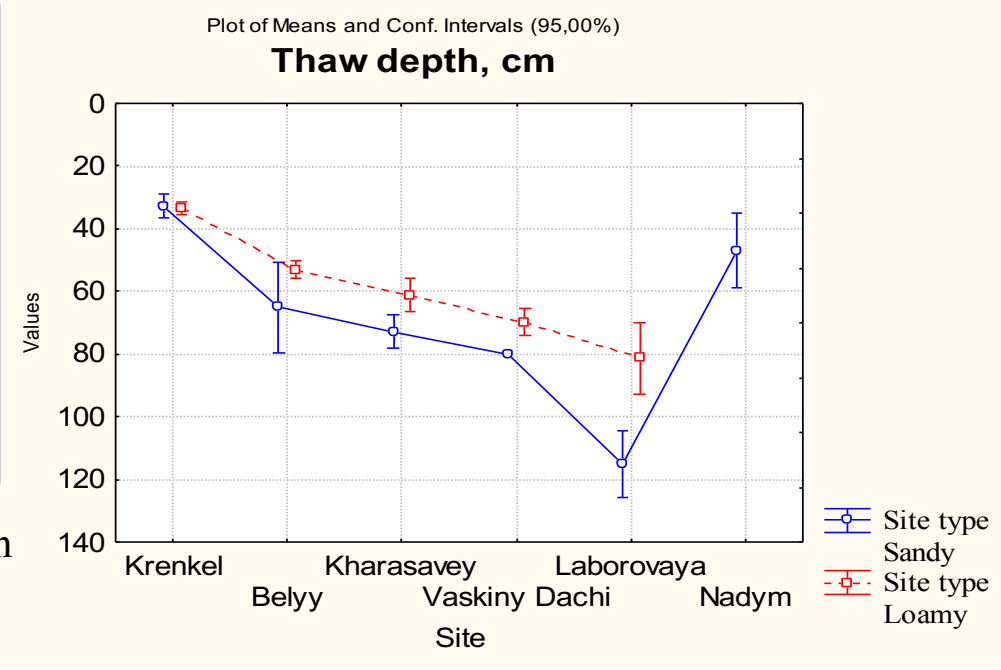
- Yamal is flat - the maximum elevations are only about 100 m
- 2 main types of landscape: watersheds and river lowlends
- Predominance of sand fraction in mineral deposits, with a low content of microelements. Sometimes are saline
- A lot of thermokarst lakes and wetlands
- Many surface disturbance due wind, snow and thermal erosion.

Main factor – temperature (Bioclimatic gradient) - The transect is about 1500 km long!





Days without snow on soil surface (average, 2010-2015)



Nadym is 2 times warmer and has 2 times more precipitation than Krenkel

Nadym has 3 times more thaw depth than Krenkel

The thaw depth declined to the north and is always approximately 10-15%, less at the "loamy" sites

On our sites - ***A small set of soil types with similar processes. Soil profile is significantly reduced in the north.***

Loamy (mesic) sites

Krenkel

Ostrov Belyy

Kharasavey

Vaskiny Dachi

Laborovaya

Nadym

Loamy (mesic) sites

Sandy (dry) sites

Sandy (dry) sites

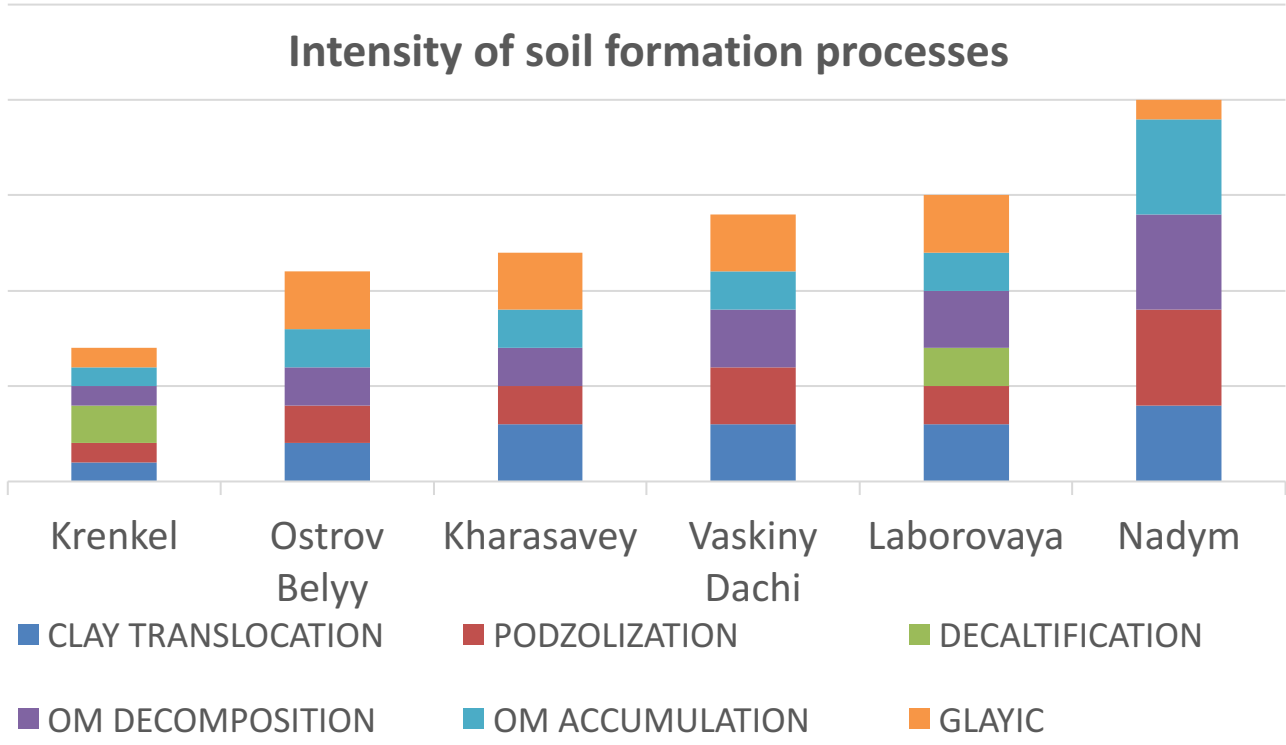
Sites along the transect are characterized by the predominance of the mineral soils (Turbels).

Organic soils (Histels) are widespread only in the taiga subzone (Nadym).

MAJOR PROCESSES OF SOIL FORMATION

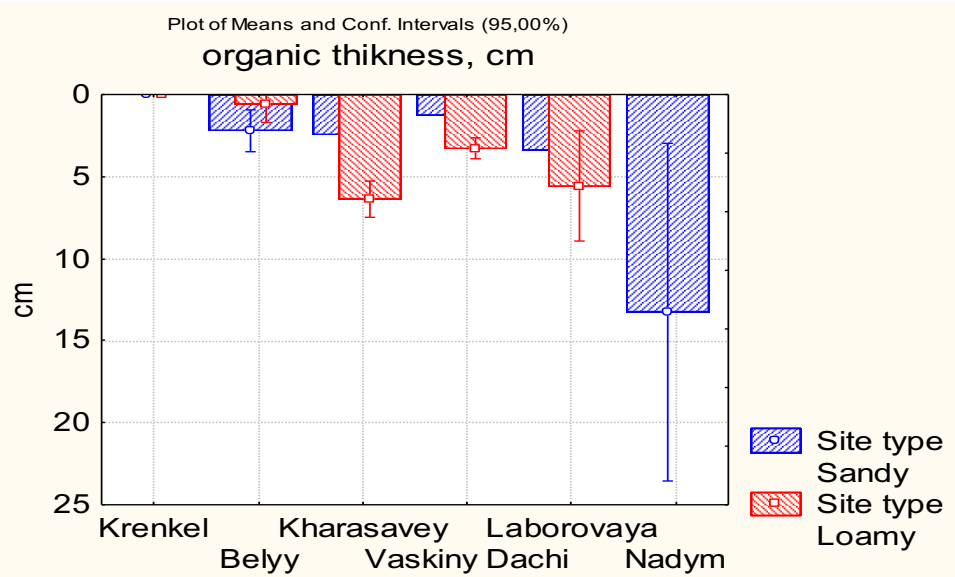
- Organic matter accumulation and transformation
- Gleyic processes
- Podzolization
- Transfer and accumulation of R_2O_3 (Fe, Mn)
- Clay translocation
- Decalcification

The main difference is the intensity of soil formation processes which increases from north to south



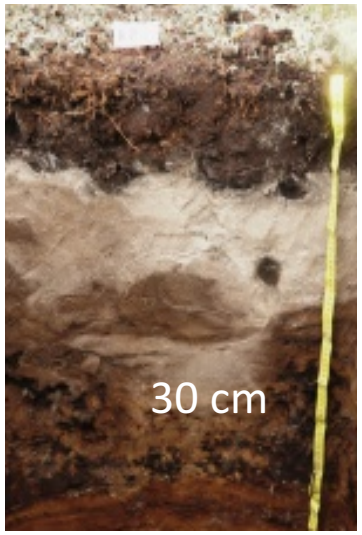
*The peculiarity is the **low intensity of glayic processes** and weak peat accumulation despite often high soil moisture values*

Organic matter accumulation



Krenkel ***Ostrov Belyy*** ***Vaskiny Dachi*** ***Nadym***

Nadym has 10-50 times more organic profile than Krenkel



Podzolization

Cryogenesis plays a dual role:
sometimes bringing **chaos** sometimes **order**ing structure.
In any case, it have the highest influence on the soils properties and soil formation.

Cryogenic processes, including cracking, heaving and cryoturbation, determine the formation and high heterogeneity of the transect soils, resulting with well-defined microrelief features such as non-sorted circles and small nonsorted polygons. Patterned ground features influence on the properties of soils and soil formation

Sometimes only a soil scientist can see this heterogeneity

One Pattern- 2 (or more) of soil types

In the pattern (**P**) and between the patterns **(IP)** develop soils with different properties. ***Interpattern soils - more heterogeneous***

IP

IP

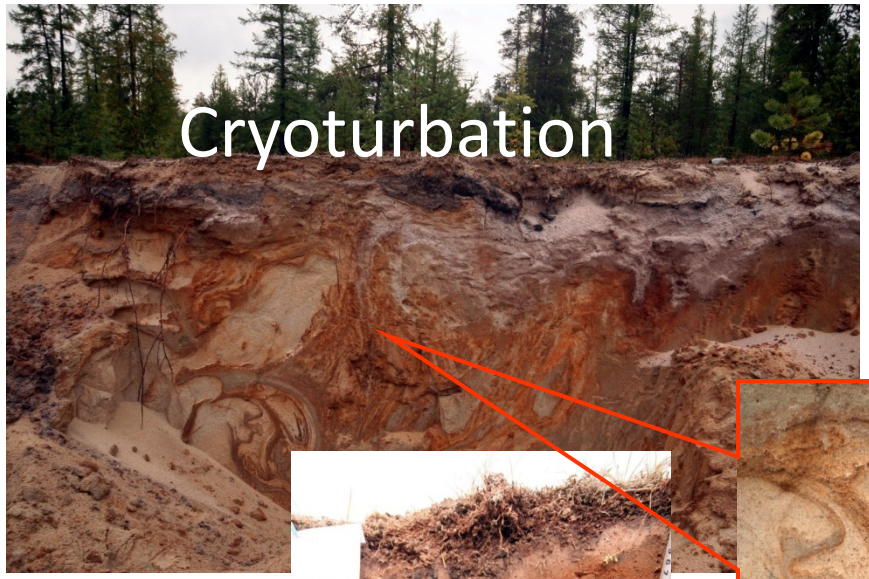
Krenkel ***Ostrov Belyy*** ***Vaskiny Dachi*** ***Laborovaya*** ***Nadym***

P

P

Profile heterogeneity

Cryoturbation is the most typical process, but other cryogenic processes are widespread and active in all soils of EAT transect



Cryoturbation was recognized as one of the unique soil features in the Arctic [Tedrow, 1974; Everett and Brown, 1982].

Freezing-thawing, cracking, heaving determine the specifics of soil formation processes

The specific processes of Arctic soil formation:

- Retinization (accumulation of carbon on the permafrost table)
- Migration solutions to the boundary of freezing
- Cryogenic sorting, mixing or homogenization
- Cryogenic decomposition of mineral

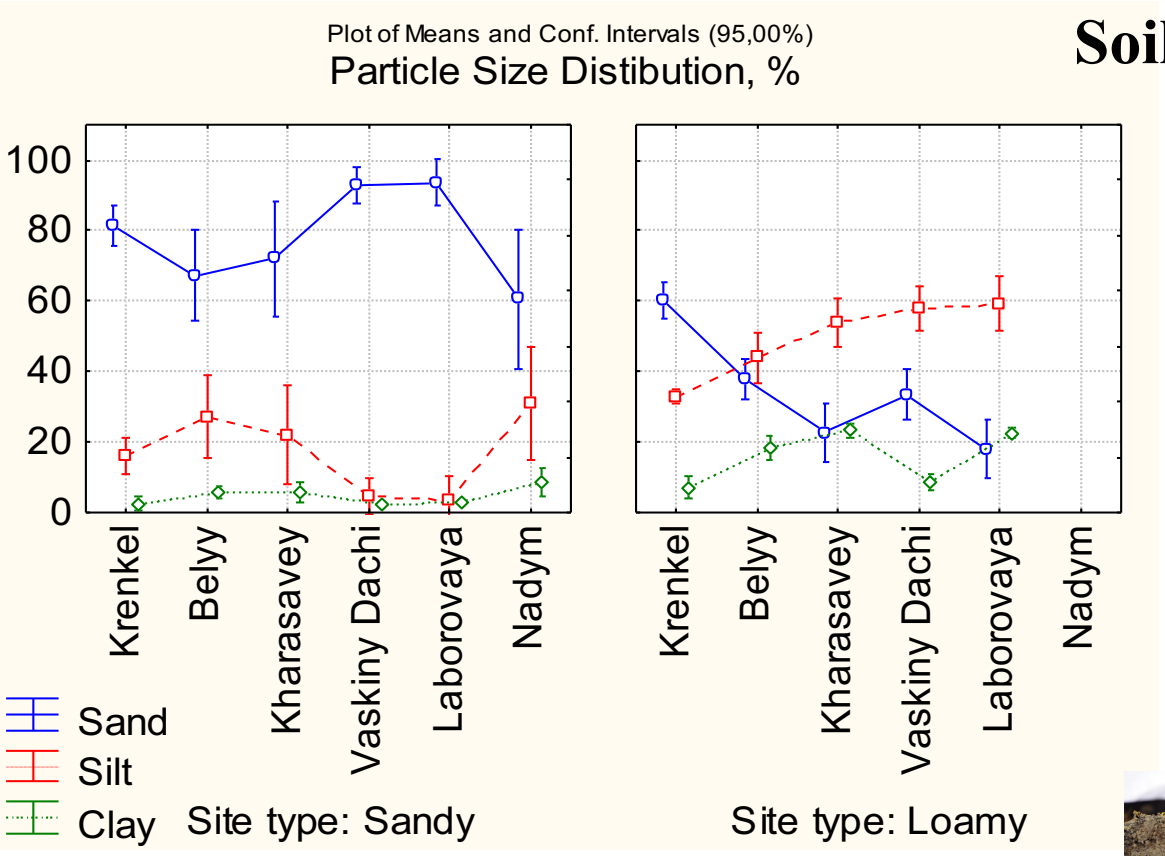
Ice lenses

Angular structure (cryometamorphic)

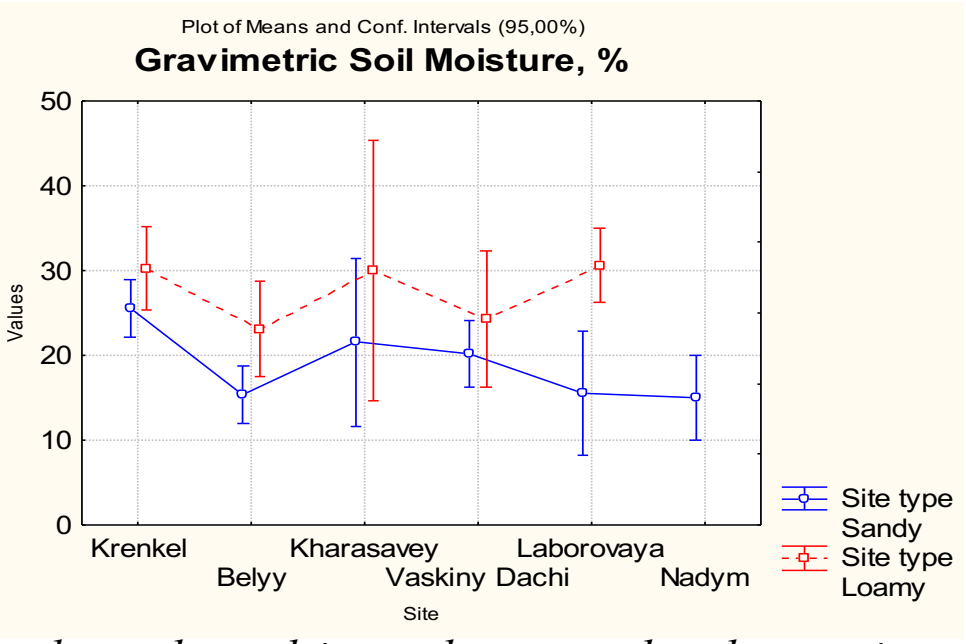
*The next peculiarity of transect soil: Soil structure is platy or angular, **generally weak** at all sites because of the predominance of sand fraction.*

Platy structure of mineral soil horizon

Soil properties

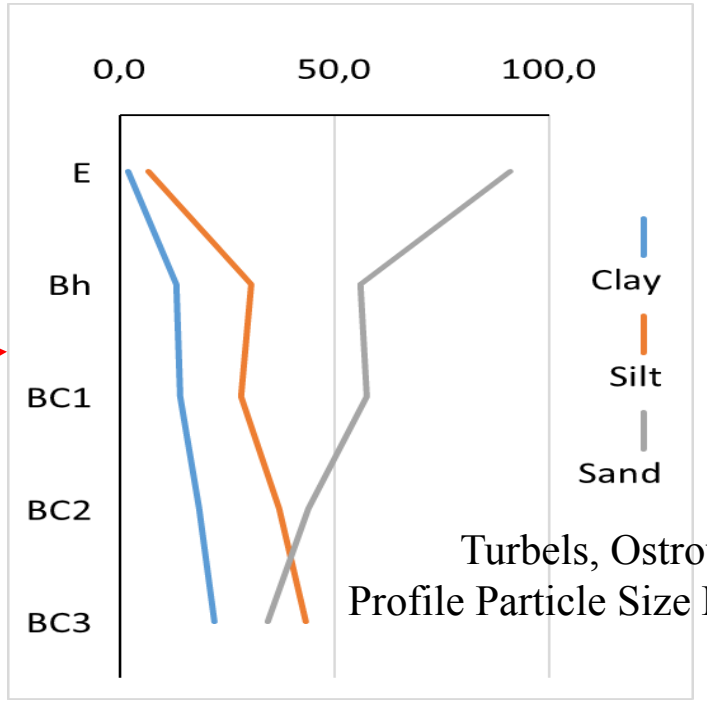


The peculiarity of transect locations is that there is low content of clay fraction in all sites



Sandy sites have always been drier and warmer than loamy sites

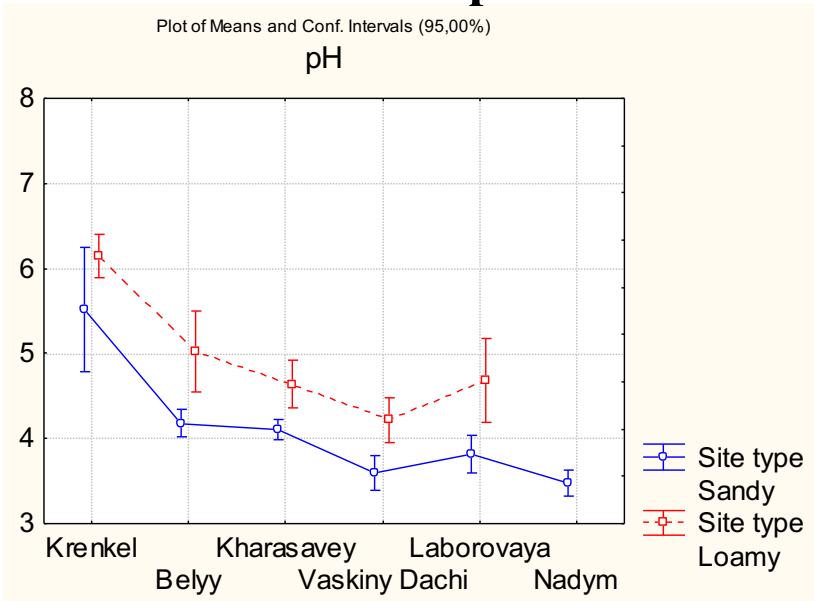
On the sandy sites of all locations, **clay translocation** processes are clearly visible not only morphologically but and after PSDA analysis



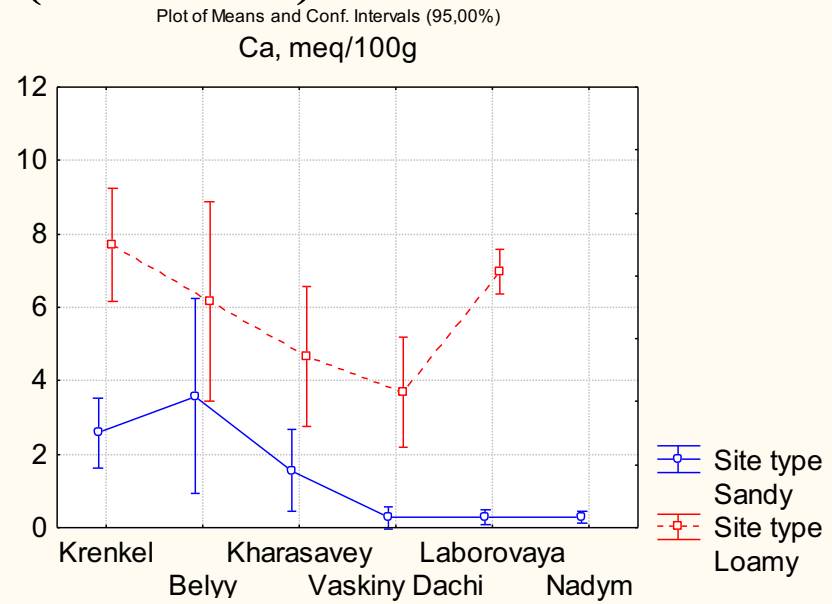
Turbels, Ostrov Belyy
Profile Particle Size Distibution, %

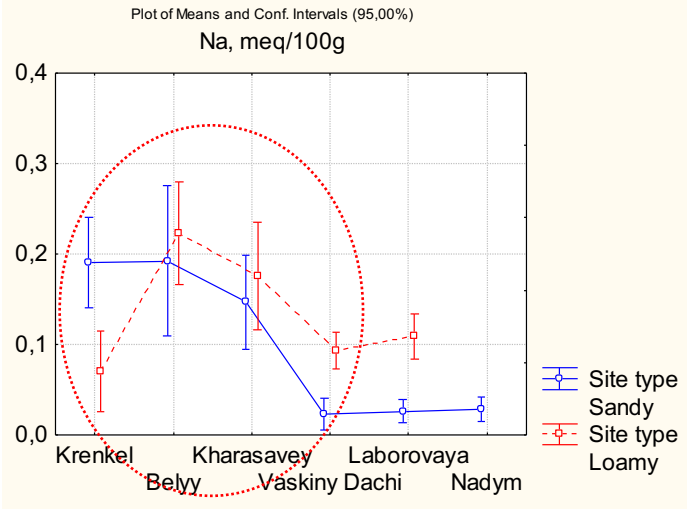
E – horizont. Even on Krenkel there are conditions for good drainage and removal of elements from the soil profile -

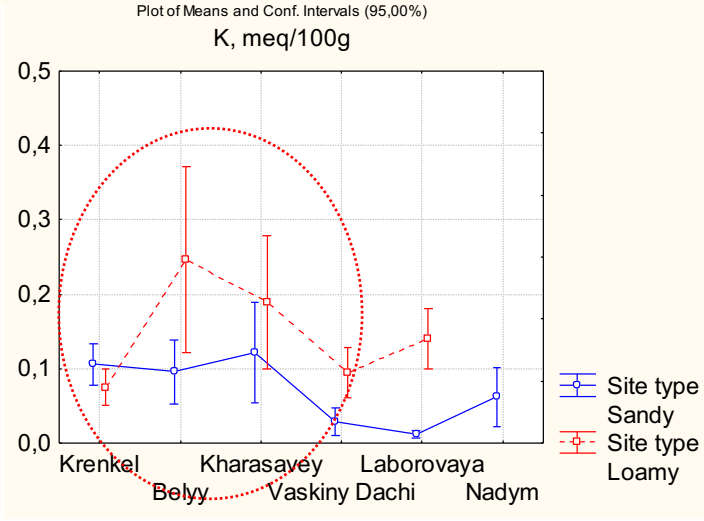
pH and content of exchangeable cations along the EAT (surface soil)

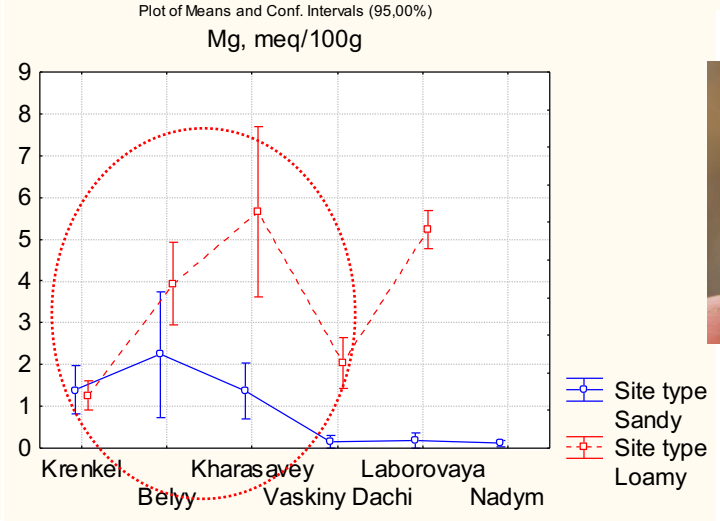


The next peculiarity of transect is pH. Soils are generally acid (4-5), with the exception of Hayes Island, where the pH close to neutral





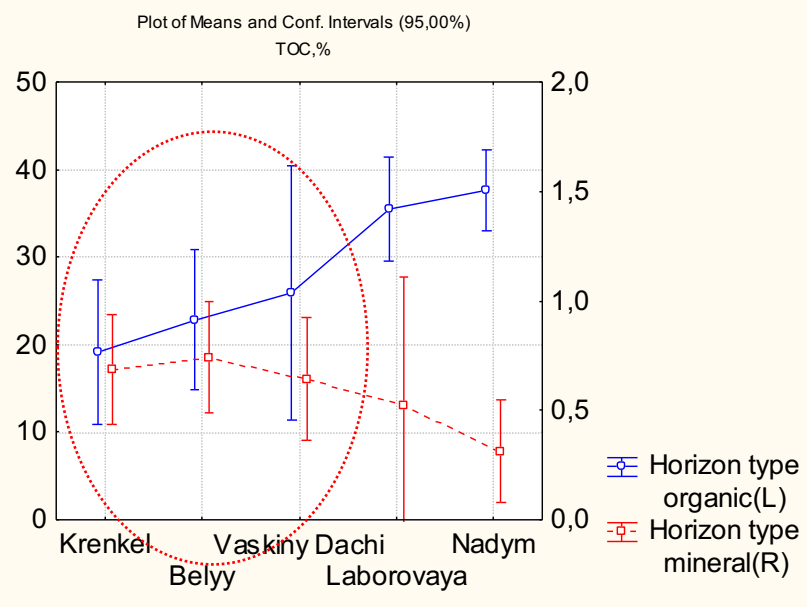


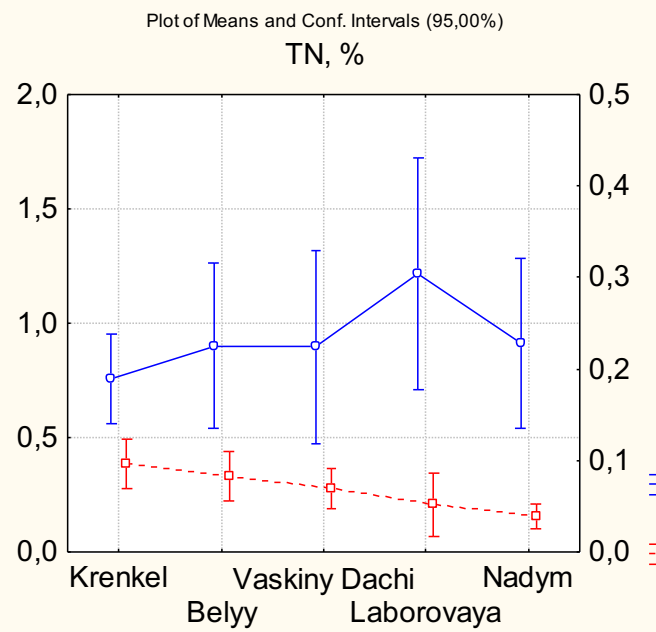


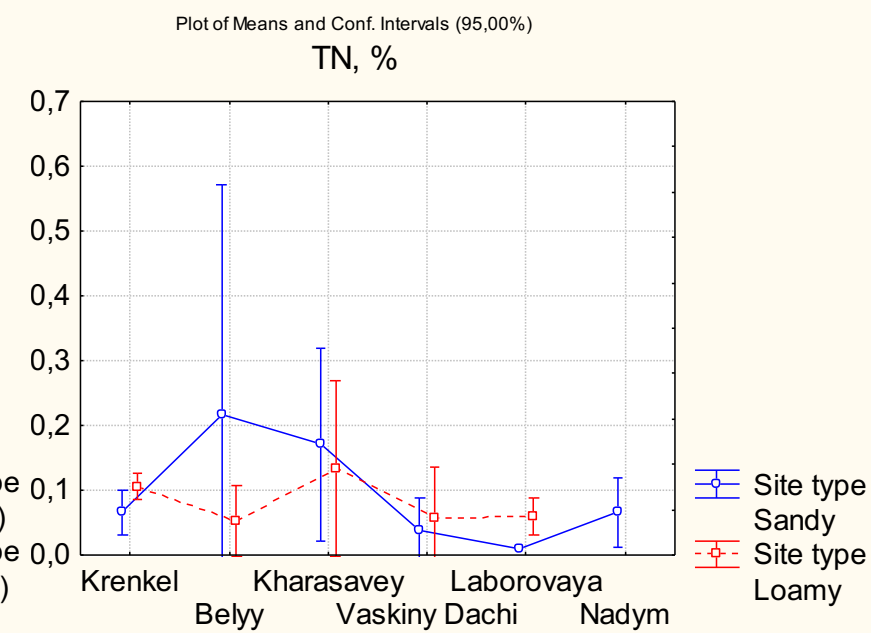
Salt on the soil surface, Krenkel

The content of exchangeable cations is greatest in the northern part of the transect, which is due to the proximity of the sea and the property of deposits. The loamy sites generally less acidic and had significantly higher values of these cations compared to the sandy sites.

Soils are characterized by generally low total carbon (< 1%) and nitrogen content (<0,5%)



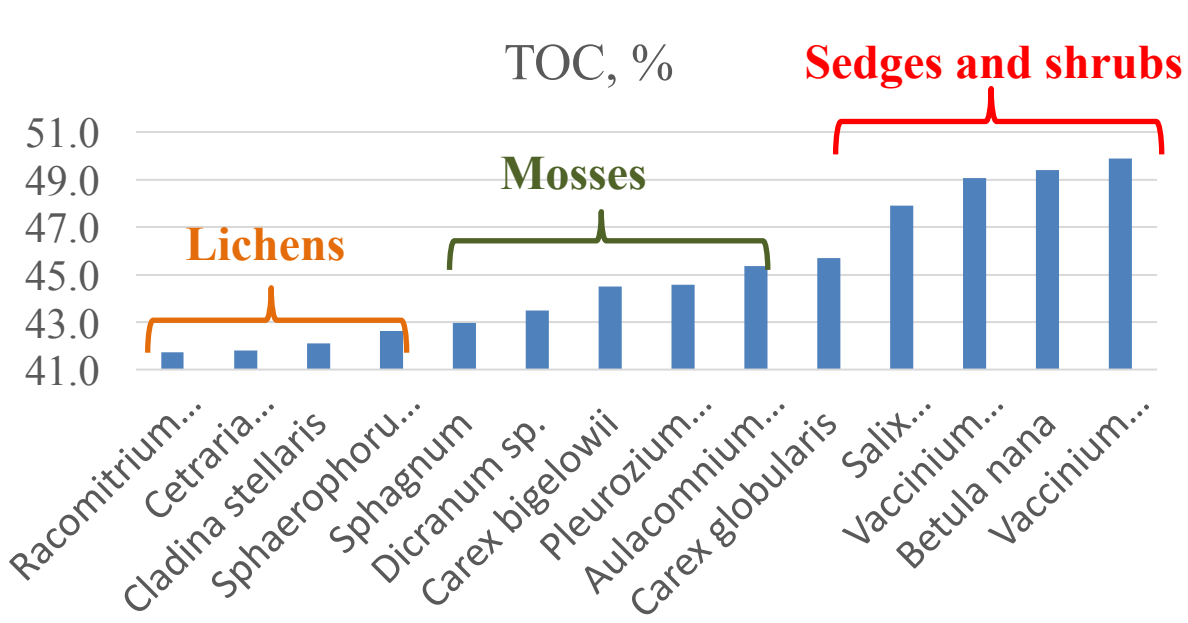


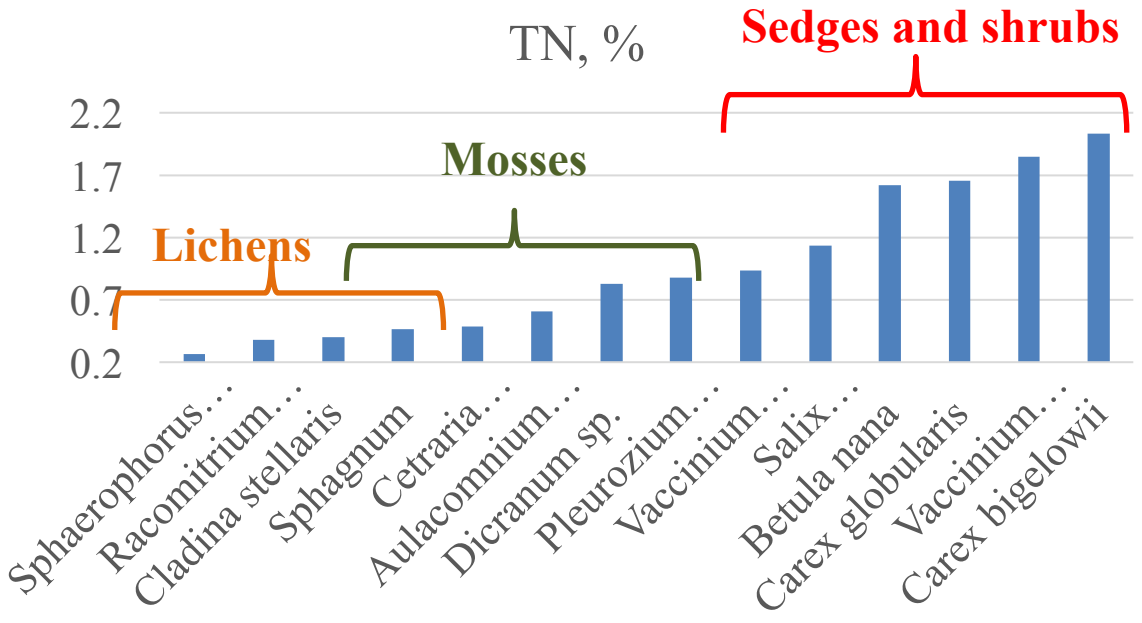


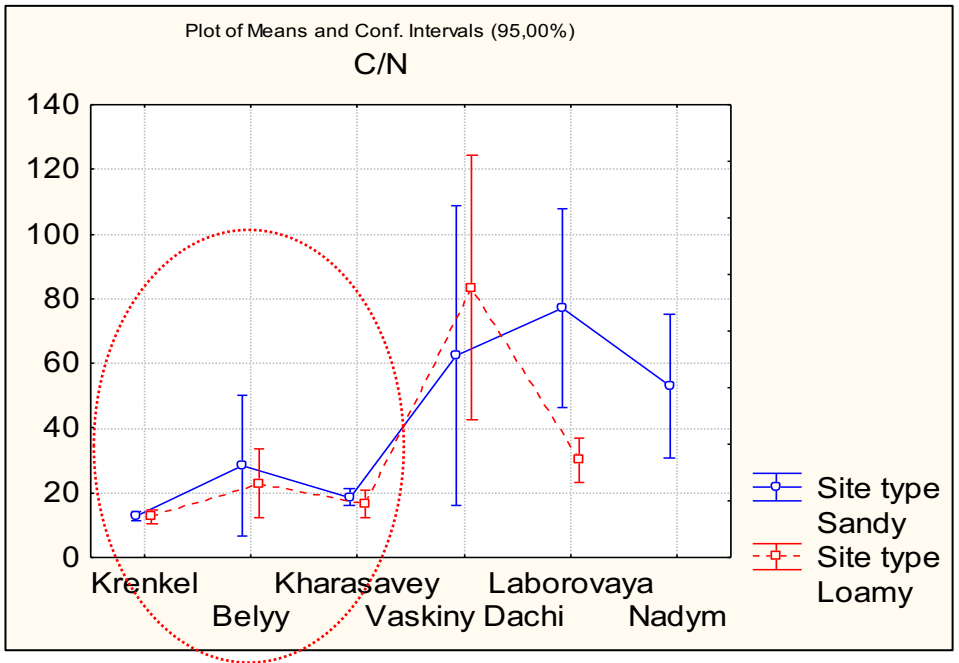
The content of carbon and nitrogen increases to the south in the organic and decreases in mineral horizons

Carbon and nitrogen accumulate in locations with the small thaw depth.
The greatest content on sandy sites (warmer and dryer).

Degree decomposition of the organic matter – C:N ratio *(average for **VD, Laborovaya, Nadym** sites, n =166)*

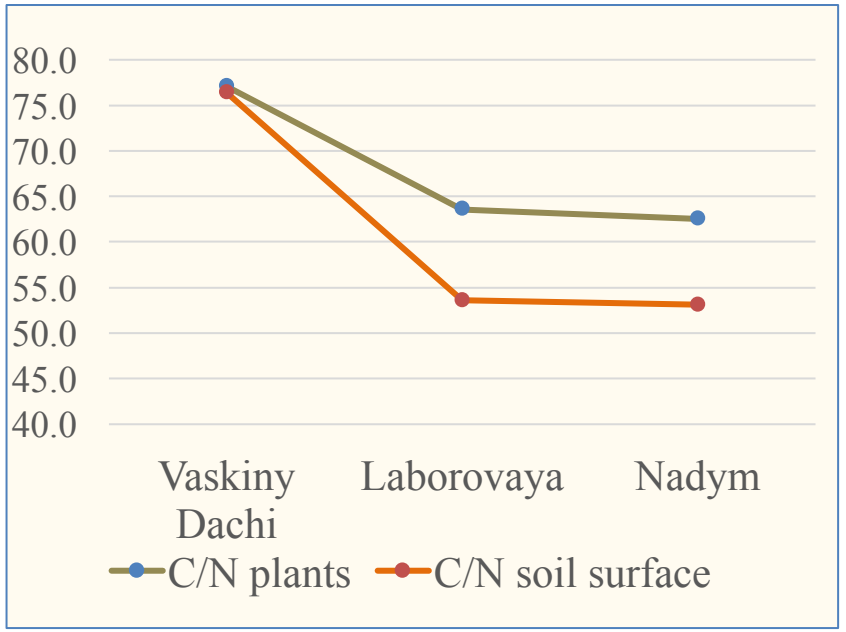




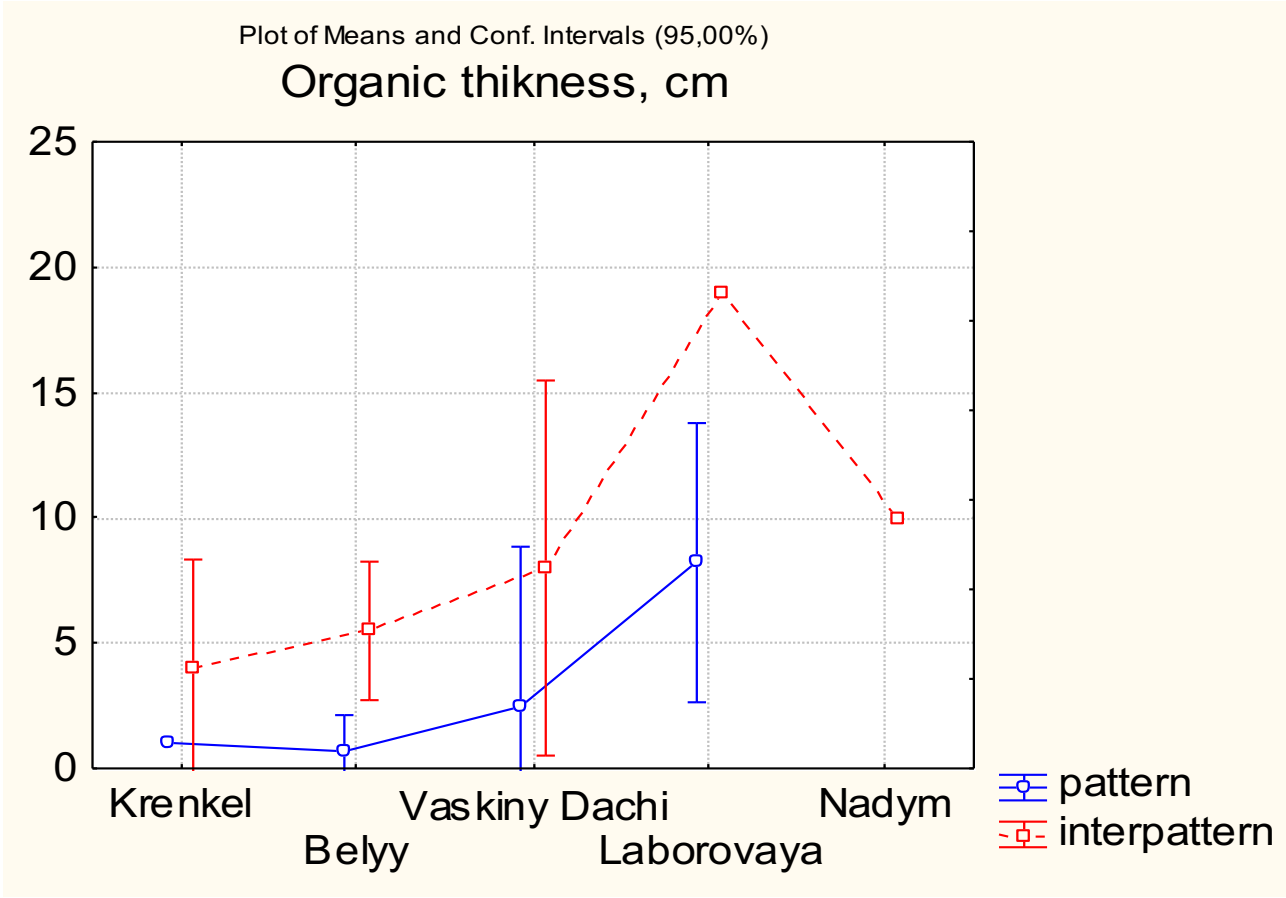


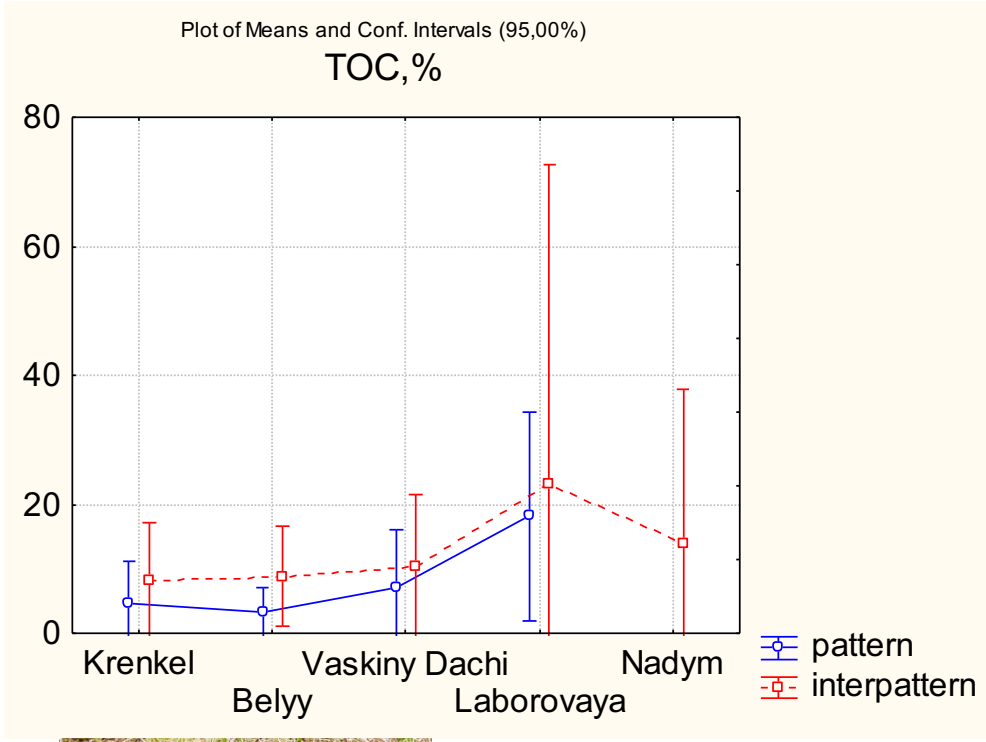
There is big different between southern and northern part of the transect in relationship C : N. *Change vegetation types and quality of high lignin contents*

Vegetation has an effect on the quality of soil organic matter in that grasses and sedges produce humus with a narrow C/N ratio, whereas shrub - a wider. (Ping, 1997)



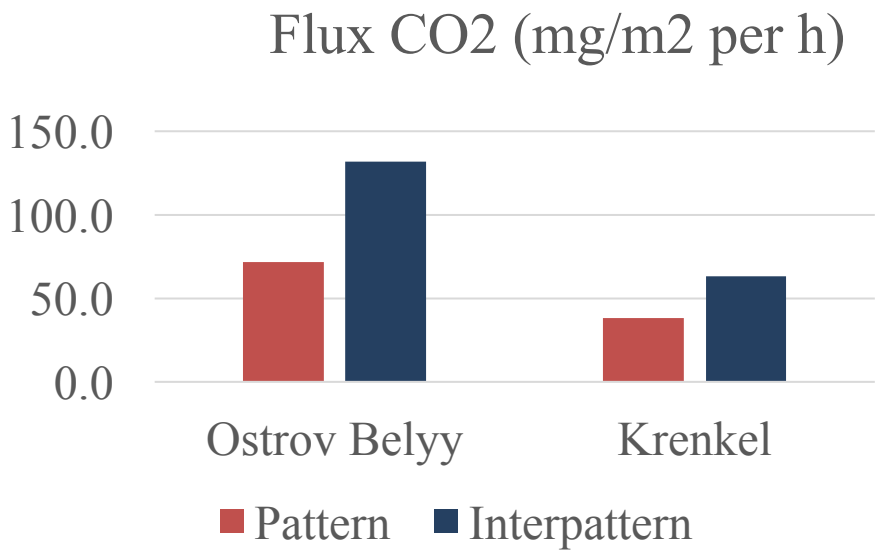
The pattern ground and the soil properties (P/IP)





Organic thikness, carbon and nitrogen more in microdepressions (interpattern)

Soil CO_2 efflux (*Krenkel, Ostrov Belyy, Nadym*)



CO2 flux along the EAT transect, august

Location	Flux CO2 mg/m2 per h	number of cases
Krenkel	57,2	26
Ostrov Belyy	102,1	42
Nadym	138,1	300

Under optimal conditions (August), soils have a similar low biological activity (CO2 flux)

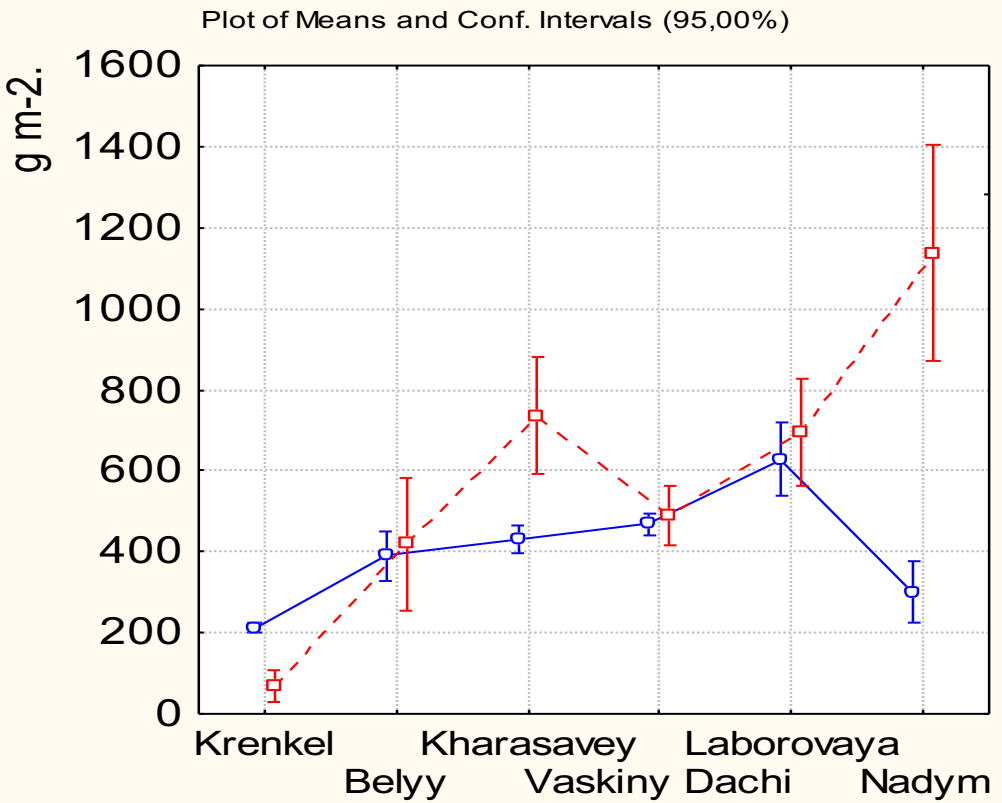
but there was about a 3x increase CO2 flux from south to north.

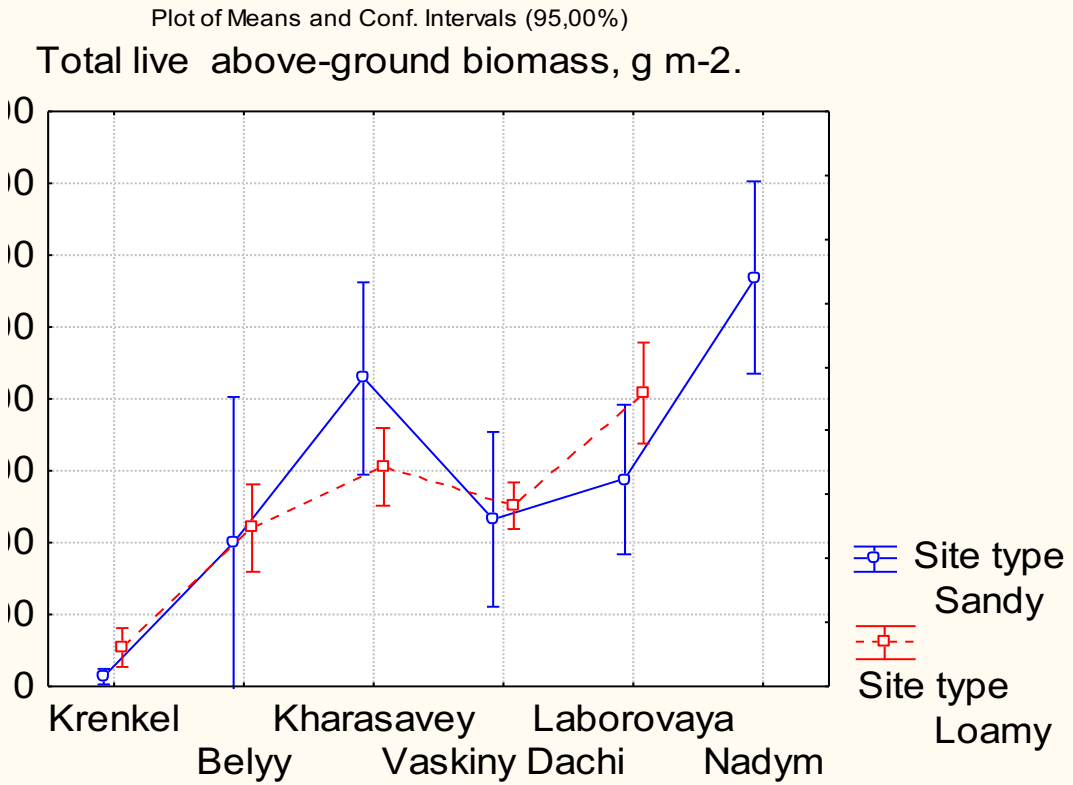
Above the cracks and on sandy sites the fluxes are higher

Soil - live Biomass interaction

Dependent: Live biomass No. of cases: 74
R2= ,52921389 p = ,000000
Location beta=-,57 thaw depth beta=-,34 pH beta=-,38
Sand beta=-1,0 Silt beta=-,96

There is no corellation with other soil properties





Biomass and thaw depth on different types of sites along EAT

Major conclusions

- EAT characterized by small set of soil types (mostly mineral) with similar processes. The intensity increases from north to south.
- Cryogenic processes, determine the formation and high heterogeneity of the transect soils structure and properties
- Soils are mainly acidic, with a low carbon content
- Most soils have low percentages of clay
- The northern part of EAT has more exchangeable cations, pH, TOC, TN. This is due to the proximity of the sea and deposits features and weak leaching of elements due to a small thaw depth.
- Soil texture is important. Sandy sites are warmer, drier, have more thaw depth. The loamy sites generally had significantly higher values of exchangeable Ca, Mg, and K. There is a high correlation of biomass and soil texture.
- The most important for biomass are temperature, soil texture, thaw depth and pH.

Thank you for attention

This work was funded by the NASA Land Cover Land Use Change (LCLUC) Program, grant No. NNX14AO90G