CRYOLITHOLOGICAL COMPOSITION AND PHYSICAL PROPERTIES OF THE ACTIVE LAYER AND UPPER HORIZON OF PERMAFROST AT THE BEO RESEARCH SITE.

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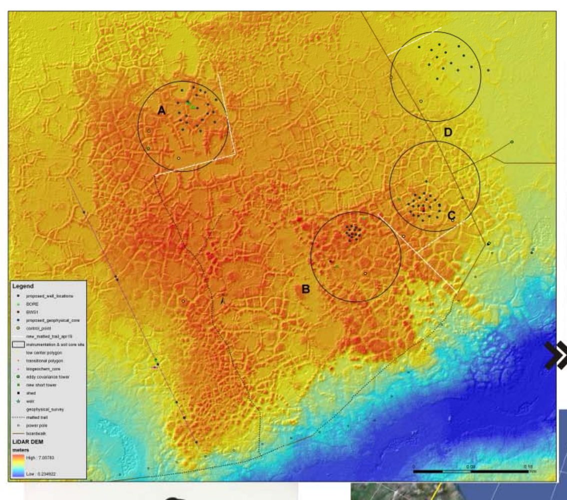


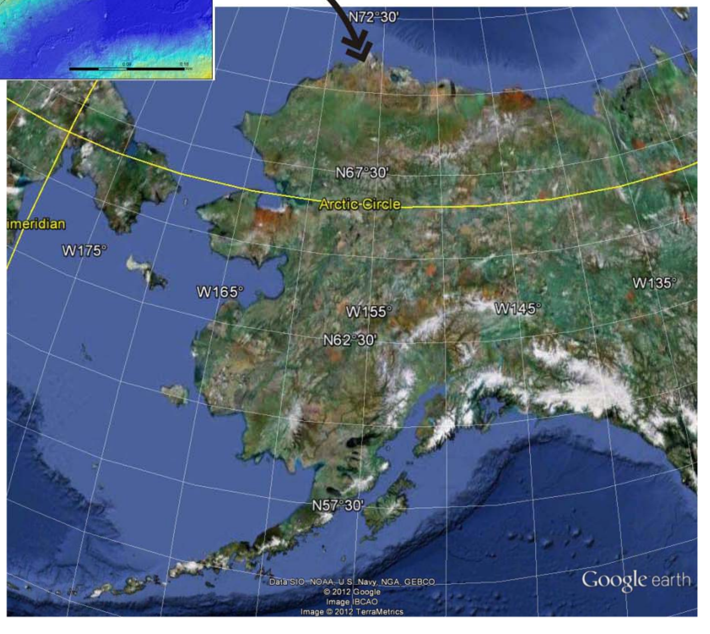

Totally 3 cores were taken using the SIPRE corer during the May 2012 drilling campagne. The main purpose of drilling was installation of water level sensors.

Effective analyses of geophysical, microbiological and biogeochemical analyzes of soils in the Arctic environment require detailed description of the frozen soil and its physical properties. Cryogenic structures, i.e. total ice content and forms of ice patterns, reflect important processes, which include water migration due to freezing in frozen active layer soils and the history of sedimentation and freezing in underlying perennially frozen deposits.

The presented results were part of a small addition to UAF's involvement in the Next-Generation Ecosystem Experiments (NGEE Arctic), which is supported by the Office of Biological and Environmental Research in the DOE Office of Science. The main goals were to:

- ***develop procedures for frozen core processing using the standard methods and techniques ;***
- ***determine physical properties of near-surface soil cores.***

CORES LOCATION AND METHODS

Figure 1. Boreholes location.

Cores 45 and 55 (site D) were taken from the holes located in the interior part of low center polygons (Figure 1, a and b) and core 67 (site B) from the elevated mound of a high center polygon (Figure 1c).

Core processing was made in the Permafrost Laboratory of Geophysical Institute University of Alaska Fairbanks. Procedure includes the following:

1. Soil description (i.e. lithological composition, soil color and texture, inclusions etc.) The boundary between the green vegetation (grass or moss) and dead moss, peat or mineral soil was mentioned as a 0 depth;
2. Cryogenic structure (i.e. forms of ice inclusions) description;
3. Bulk density determination;
4. Ice/water content determination (both gravimetric and volumetric);
5. Thermal conductivity measurement.

Bulk density was determined by the direct measurements of cylindrical shape sample dimensions and weight. Gravimetric ice content was determined after repeated weight of sample after drying with temperature 85°C during 48 to 60 hours as a ratio:

$IC_g=(m_i-m_d)/m_d$;

where m_i – initial weight of sample and m_d – weight of sample after drying.

Volumetric ice content was calculated as

$IC_v=IC_g/BD$;

where BD is bulk density.

Thermal conductivity of frozen soil was measured using the single probe needle sensor. A needle probe inserted into the core along the core axe was heated during 2 minutes and rate of temperature changes was measured.

Thermal conductivity was calculated based on the temperature increasing rate by the equation:

$k=q/(4\pi s)$; where s is the slope obtained by regressing T (temperature) on ln(time) and q is the power can be found as $q=U^2*1041.5$; (U is the voltage coming through the probe and 1041.5 Ω/m – is the resistance per unit of probe length for this particular instrument).

RESULTS

Core #45

Location: Center of low-centered polygon. Located in a drained lake basin (Site "D")
Core length - 56 cm
Active layer depth around the core location at the end of 2012 summer season: 44-46 cm.

Core description

Depth	Soil description	Cryogenic structure	Photos
0 - 6.5	Dark brown peat or fibrous. Degree of decomposition – low. Plants macrofossils (pieces of shrubs branches, roots).	Pore ice, no visible ice inclusions.	
6.5 - 18	Brown moderately decomposed peat with plants macrofossils.	Pore ice, no visible ice inclusions.	
18 - 23	The same peat without plants macrofossils	Pore ice, no visible ice	
23- 31.5	Brown peat reach silt.	Layered. Ice layers about 1 mm thick. Intervals between layers 3-4 mm. Single subvertical ice veins up to 2 mm thick.	
31.5 – 39.5	Light brown peaty silt with spots of peat.	Pore ice with single subvertical ice veins similar to the previous unit.	
39.5-56	Brown massive peat.	Pore ice with visible ice pseudomorphoses.	

Figure 2a. Vertical distribution of the ice content in the core #45 (left panel – volumetric, right - gravimetric).

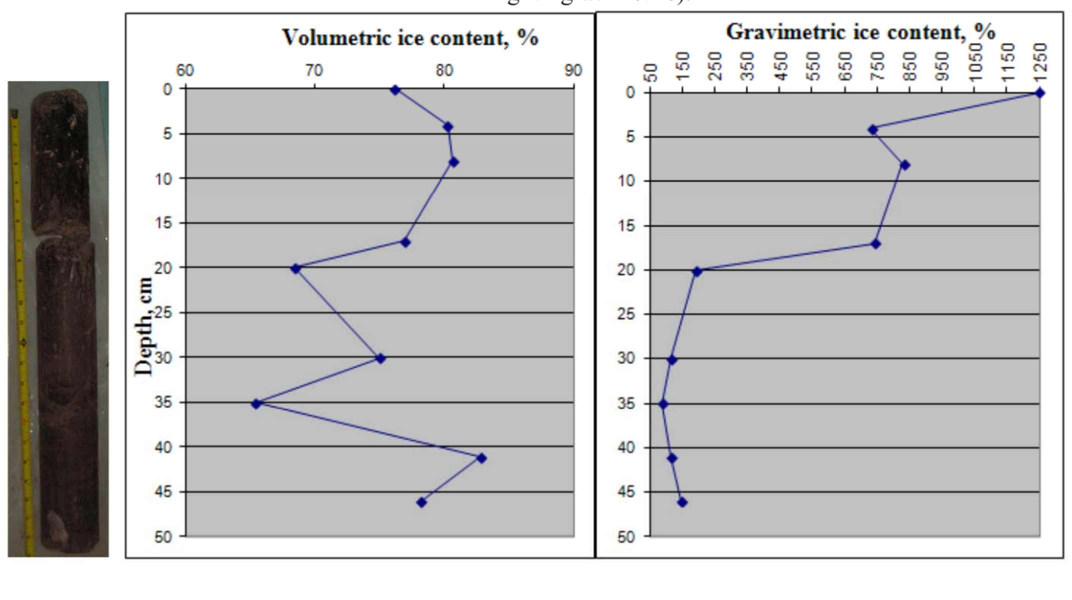

Table 1a. Soil properties of the core # 45

# of sample	Depth, cm	Type of soil	Soil density, g/cm^3	Soil moisture, volumetric, %	Soil moisture, gravimetric, %	Thermal conductivity W/(m*°K)
						Frozen
1	0	Fibrous	0.82	76.20	1247.23	
2	4	Fibrous	0.91	80.26	730.28	1.20
3	8	Fibrous/Peat	0.90	80.63	830.32	
4	17	Peat	0.87	76.94	743.01	
5	20	Peat	1.04	68.43	190.57	1.67
6	30	Peat	1.40	74.98	114.64	1.66
7	35	Peaty silt	1.39	65.45	89.32	
8	41	Peat	1.55	82.78	114.94	
9	46	Peat	1.32	78.22	146.70	1.72

Core #55

Location: Center of low-centered polygon. Located in a drained lake basin (Site "D")
Core length - 76 cm
Active layer depth at the end of 2012 summer season: 37-40 cm

Core description

Depth	Soil description	Cryogenic structure	Photos
0 - 4	Gray peaty silt.	Reticulated cryogenic structure. Ice veins thickness 1-2 mm.	
4 - 8	Gray peaty silt.	Suspended cryogenic structure.	
8-30	Dark peat or fibrous with plant remnants.	Pore ice	
30-55	Brown peaty with some silt ammount. At the depth interval 38-48 cm spots of peat 1 to 3 cm in diameter caused by the cryoturbation.	Subvertical ice veins up to 4-5 mm thick.	
55-58	Gray peaty silt.	Suspended cryogenic structure.	
58-65	Gray silt	Reticulated cryogenic structure	
65-66	Ice	Massive ice	
66-72	Brown-gray silt	Reticulated cryogenic structure	
72-73	Ice	Massive ice	
73-76	Brown-gray silt	Reticulated cryogenic structure	

Figure 2b. Vertical distribution of the ice content in the core #55 (left panel – volumetric, right - gravimetric).

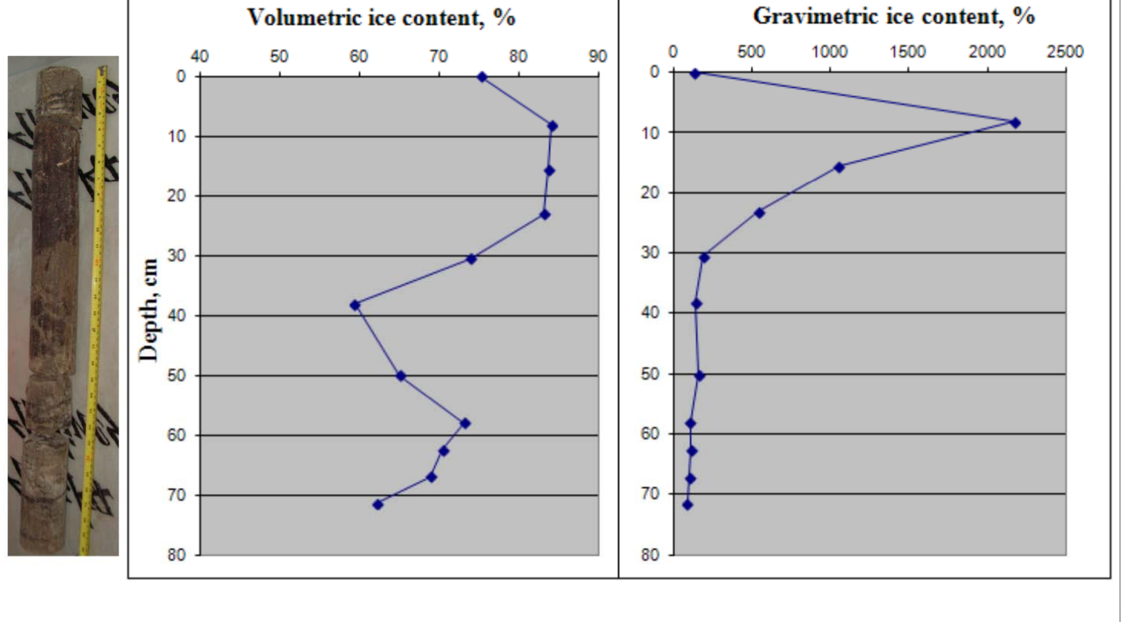

Table 1b. Soil properties of the core # 55

# of sample	Depth, cm	Type of soil	Soil density, g/cm^3	Soil moisture, volumetric, %	Soil moisture, gravimetric, %	Thermal conductivity of frozen soil W/(m*°K)
23	0	Peaty silt	1.31	75.19	134.21	2.17
24	8	Fibrous	0.88	84.04	2174.44	2.02
25	15.5	Fibrous	0.92	83.73	1052.51	2.62
26	23	Fibrous	0.98	83.08	542.02	2.30
27	30.5	Peat	1.13	73.90	187.51	2.29
28	38	Peat	1.01	59.36	142.91	1.92
29	50	Peaty silt	1.05	64.96	160.82	1.49
30	58	Silt	1.41	73.09	107.33	2.13
31	62.5	Peaty silt	1.32	70.42	113.61	
32	67	Peaty silt	1.37	68.91	101.31	2.88
33	71.5	Silt	1.33	62.11	88.11	

Core #67

Location: Center of the high-center polygon.
Core length - 70 cm
Active layer depth at the end of 2012 summer season: 38-40 cm.

Core description

Depth	Soil description	Cryogenic structure
0-5	Peaty silt. Gray-brown color. Abandon roots and plants fossils.	Layered cryostructure. Ice layers up to 2 mm thick, intervals between layers – up
5-10	Gray silt.	
10-21	Gray silt.	Pore ice.
21-30	*Lost piece of core.*	
30-40	Gray silt.	Ice layers up to 3 mm thick.
40-45	Inclined peat layer.	Pore ice.
45-50	Gray silt.	Suspended cryogenic
50-61	Peat	Pore ice
61-64	Inclined contact of peat and silt	
64-70	Gray silt	Reticulated cryogenic structure. Ice veins 2-3 mm

Figure 2c. Vertical distribution of the ice content in the core #67 (left panel – volumetric, right - gravimetric).

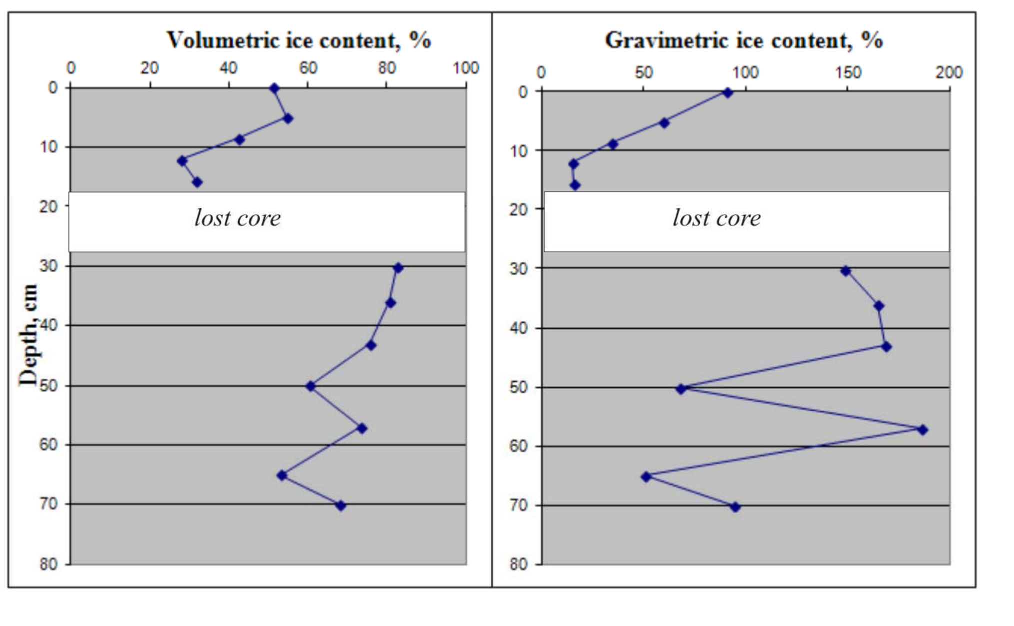

Table 1c. Soil properties of the core # 67

# of sample	Depth, cm	Type of soil	Soil density, g/cm^3	Soil moisture, volumetric, %	Soil moisture, gravimetric,	Thermal conductivity of frozen soil,
11	0	Organic layer	1.08	51.08	90.41	
12	5	Silt	1.46	54.76	59.85	
13	8.5	Silt	1.66	42.38	34.32	
14	12	Silt	2.09	27.97	15.46	2.81
15	15.5	Silt	2.28	31.46	16.01	
16	30	Silt	1.38	82.44	148.25	1.91
17	36	Peaty silt	1.29	80.47	164.50	1.57
18	43	Peat	1.21	75.73	168.37	
19	50	Peaty silt	1.50	60.42	67.34	2.27
20	57	Peat	1.13	73.49	186.31	1.40
21	65	Silt	1.58	53.07	50.56	2.39
22	70	Silt	1.40	68.01	94.19	

RESULTS AND DISCUSSION.

The lithological composition of the active layer reflects the local deposition environment. Thus, the two low center polygon cores are mostly composed by peat and peat rich silt, while the core taken from the elevated mound of the high center polygon has an organic layer that is only 5 cm thick and the core is mostly composed by silt. Evidence of cryoturbation during freezing was noticed in one of the two cores at the low centered polygon area (the core #55, peat spots right under the active layer bottom).

The portion of active layer that is composed by organic soil at the low centered polygon sites consists of 70 to 80% volumetric ice content. The thin organic layer of the mound of the high centered polygon has less than 60% volumetric ice content. Ice content of underlying syncryogenic perennial frozen deposits is about 70%. No clear evidences of soil moisture redistribution due to freezing of active layer were noticed in the cores composed by the organic soil. Thevariations in ice content are caused by the differences in soil type and organic content. In core #55 (low centered polygon), the reduction of ice content at the depths 10 to 20 cm can be explained by the water migration to the freezing fronts both up and downward during the period of freezing in the silty soil.

Organic soil does not show any clear cryogenic structures. Ice usually fills the pores and follows the plants fibers. Mineral soil has recticulated cryogenic structure (ice forms grid like patterns with vertically oriented cells) with some thin (up to 2 cm thick) layers of soil particles and aggregates suspended in ice.

Thermal conductivity of frozen samples varies in the range from 1.5 to 2.8 W/(m*°K). It has a positive correlation with soil density and negative with gravimetric ice content (Figure 3). Mineral soils have a higher bulk density and average thermal conductivity in the range 2.15 W/(m*°K), organic soils have a lower density and average thermal conductivity about 2 W/(m*°K). Samples, composed by fibrous has an extremely high ice content and low bulk density. Its average thermal conductivity is close to the values typical for ice (2.3 W/(m*°K)).

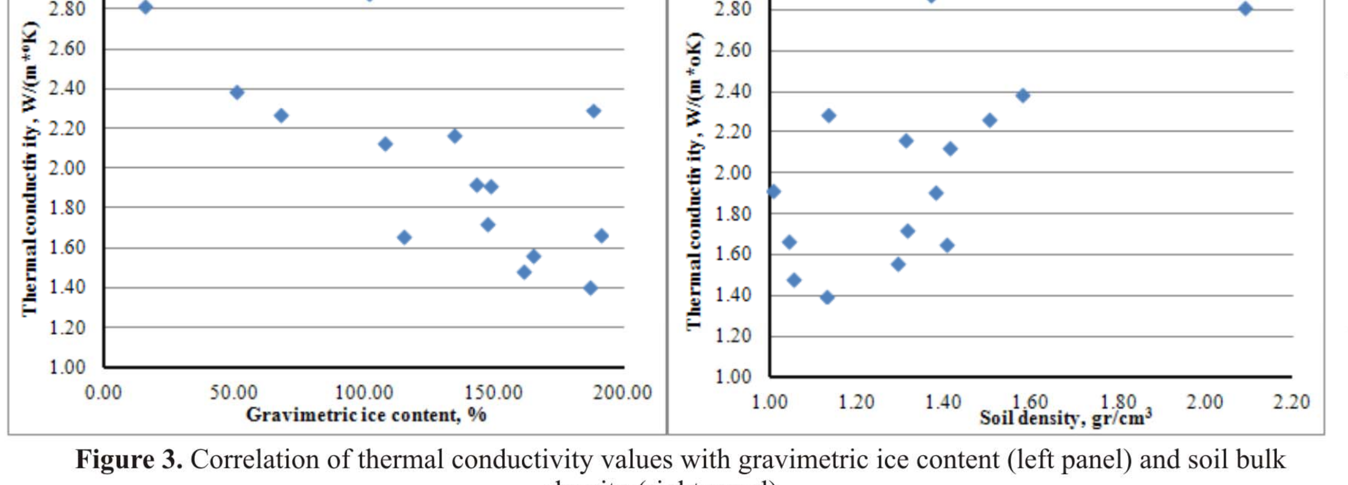

Figure 3. Correlation of thermal conductivity values with gravimetric ice content (left panel) and soil bulk density (right panel).

FUTURE PLANS AND RECOMMENDATIONS .

If funds become available, we would like to continue to contribute with soil analyses by:

- determine thermal conductivity of thawed soil samples;
- establish a procedure of unfrozen water content determination in the range of temperature close to freezing/thawing zone.

Additional analyses can include:

- Granulometric composition (soil texture) determination;
- Total organic content estimation (lost by ignition?).

Three cores is not enough to do any reliably conclusions about the variations in soil properties across the larger area. therefore, we strongly recommend additional frozen cores sampling. We propose to establish 2 drilling transects (5-7 cores each) across the polygons at the B-site (high center), 1 at C-site (low center with trough) and 1 at D-site (low center)in order to get better understanding the differences between high- and lowcenter polygons. The depth of drilling would be 1.5 - 2 m. Cores should be taken from edge of polygon, next to polygon rim and in the central part.

See the link to download this poster, text of report or data sheet

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