Proposed Addition of the Limnic Subgroup to Histels

Proposed by Lorene Lynn, Red Mountain Consulting, Shawn W. Salley, UDSA-NRCS, and Chien-Lu Ping, University of Alaska – Fairbanks

Summary of Changes in response to the NCSS Regional and National Taxonomy committee:

1) Removed 'Limnic Glaciestel' from the proposal. We believe this taxonomic concept could still exist across the North Slope; however, 'Liminic Glaciestels' were dropped from this proposal due to lack of supporting laboratory data.
2) Section added to identify coprogenous material in the field.
3) Section added to clarify high phosphorus concentration is not always an indicator of Coprogenous-Limnic materials.
4) Increased the maximum size criteria for Coprogenous-Liminc material.

Background

Limnic material occurs in some wetland soils deposited in water by aquatic organisms such as algae or from underwater and floating vegetation modified by aquatic fauna (SCWG, 1998). Coprogenous earth (also known as gyttja) is deposited in and is made up of a nutrient-rich sedimentary peat of plankton, fecal pellets (at least 50% by volume), other plant and animal residues, and mud. It forms in deep, standing water and is usually beneath the Oh, Om, or Of horizons of the control section (Agriculture and AgriFood Canada, 2010). Regions of the Arctic where limnic materials are encountered are important areas for migratory bird nesting, and the origin of the limnic materials may be from deposition of aquatic invertebrates and coprogenous earth from the numerous bird species that inhabit the Arctic in the summer.

Soil Taxonomy (Soil Survey Staff, 1999) describes limnic material as both organic and inorganic materials that are: (1) deposited in water by chemical precipitation, biological precipitation, or by aquatic organism (algae or diatoms), or (2) from underwater and floating aquatic plants modified by aquatic animals. Soil Taxonomy considers limnic material to include coprogenous earth, diatomaceous earth, and marl. Diagnostic criteria for Limnic material include a color of the sodium-pyrophosphate extract on white chromatographic or filter paper is above or to the left of a line drawn to exclude Munsell blocks 5/1, 6/2, and 7/3 and with few to no fibers present. Limnic soils are only currently described as a Subgroup within the Folists (Haplofibrists and Sphagnofibrists), Fibrists (Haplohemists), and Saprists (Cryosaprists and Haplosaprists) suborders of the Histosol Order.

Issue:

Currently the 12th edition 2014 Keys to Soil Taxonomy, page 24, states "The presence or absence of limnic deposits is taken into account in the higher categories of Histosols but not Histels". This statement infers that limnic deposits are only to be recognized for classification purposes in higher categories of Histosols but not any other soil orders. We have found no rationale in the literature for why coprogenous material has historically been excluded from organic matter material classification. Although this appears to stem from work of McKinzie (1974) and Lynn et al. (1974) who placed more emphasis on sapric, hemic, and fibric material and classification over coprogenous earth material which has since been recognized under the limnic category. Other soil scientists recognized the Limnic

subgroup shortcoming, and a recently approved proposal to U.S. Soil Taxonomy (Tallyn, Thorson, et al., Amendment #6, May 2016) which now allows for the use of: (1) the L master horizon outside of Histosols, (2) coprogenous earth textural modifier outside of Histosols, and (3) the Limnic subgroup outside of Histosols.

Coprogenous-Limnic material has previously been documented to occur in Histels of the North Slope, Alaska in the Glaciestels, Hemistels, and Saptristels Great Groups (Jorgenson, 2013; Lynn, 2009; Ping et al., 2015). Limnic material is not expected in Fibristels and Folistels, as the Folistels are saturated less than 30 cumulative days and Fibristels are comprised mostly of fibrous plant material. With the soil survey on the North Slope of Alaska about to launch, and the continued expansion of oil exploration infrastructure in the area, now is excellent timing to include the Limnic subgroup in Gelisols.

Geographic Setting and Estimate of Extent:

Due to the cost of retrieving arctic soils, select laboratory data and photographs are limited; however, a large geographic extent of these soils is expected. Soils presented in this proposal were found in areas which currently support or previously contained lakes or shallow moist marshland (Figures 1 and 2). These wetlands are important for migratory birds which nest during the arctic summer. The origin of the limnic materials may be from deposition of aquatic invertebrates and coprogenous earth from the numerous bird species that inhabit the arctic in the summer. Limnic materials can be found on the surface or as subsurface materials.

Evidence:

Profiles have been identified in the North Slope Alaska, a series of profiles in a transect near Prudhoe Bay (Figure 3, Table 1) and a Hemistels near Utqiaġvik (Barrow) (Figure 3, Table 2) as examples of Histels which contain Limnic material. The first (Figure 1) was identified in a series of soil profiles in a transect in Prudhoe Bay near West Dock and includes Limnic materials below 18 cm from the surface. Core samples with Total Carbon percent 10.2 to 32.3% (Table 1). These materials also had low bulk density values ranging from 0.26 to 0.46 g cm^{-3}. The Utqiaġvik examples include lab data with a Limnic horizon (10-16cm) with high levels of phosphorus (Table 2).

From our laboratory data, presence of high phosphorus is not always an indicator for coprogenous-limnic material criteria. Because of this, we recommend that field criteria of bulk density, color, or hand texture be used to identify the coprogenous material.

Field Characterization:

Texture, bulk density, and color can all be used to identify the coprogenous-limnic material in Histels. The color isn't unique to the region, but when paired with the very low bulk density and "soft, fleshy" texture, the three characteristics capture description of limnic materials. The material is simple to identify in the field. The pale color and granular texture of the limnic materials look like sand initially (Figure 5.). Once a sample is retrieved from the profile, the low bulk density and "soft" texture clearly distinguish the material from sand.

Proposed Changes to *Histels* "Key to Subgroups":

- Add Limnic Subgroup to Hemistels, and Saptristels., Below are proposed changes to the Keys to Taxonomy, 12th ed.

Hemistels:

Add: "Other Hemistels that have one or more limnic layers with a total thickness of 5 cm or more within the control section."

Limnic Hemistels

This proposed subgroup would be inserted in the Hemistels key before Terric and after Lithic to match similar described subgroup keys described in Folists, Fibrists, and Saprists. Further refinement of coprogenous-limnic material can aid in wildlife management decision-making and impact estimations of soil organic C stocks with implications for global climate change.

Saptristels:

Add: "Other Saptristels that have one or more limnic layers with a total thickness of 5 cm or more within the control section."

Limnic Saptristels

This proposed subgroup would be inserted in the Saptristels key before Terric and after Lithic to match similar described subgroup keys described in Folists, Fibrists, and Saprists. Further refinement of coprogenous-limnic material can aid in wildlife management decision-making and impact estimations of soil organic C stocks with implications for global climate change.

Proposed Changes to *Characteristics Diagnostic for Organic Soils*, "Kinds of Limnic Materials":

- Increase the size criteria for coprogenous earth material in 'Soil Taxonomy' and 'Keys to Soil Taxonomy'.

KEYS TO SOIL TAXONOMY (12th edition, 2014, pg. 25, proposed changes in red)

A layer of coprogenous earth (sedimentary peat) is a limnic layer that:

1. "Contains many fecal pellets with diameters between a few hundredths of a millimeter and a few ~~tenths of a~~ millimeters; and " …

SOIL TAXONOMY (Soil Taxonomy, 2nd edition, 1999, pg. 88-89, proposed changes in red)

"A layer of coprogenous earth (sedimentary peat) is a limnic layer that:

1. Contains many fecal pellets with diameters between a few hundredths of a millimeter and a few ~~tenths of a~~ millimeters; and " …

and

"Normally, layers of coprogenous earth contain almost no visible fragments of plants. These layers have a range in particle size and a C-N ratio (12 to 20) that are consistent with advanced decomposition, except when found in Gelisols. Yet, they have both a low and a narrow range in cation-exchange capacity (80 to 160 cmol(+) per kg of organic matter), which indicates little decomposition influenced by exposure to air. In places these layers have what appears to be platy structure. The individual plates are a little more than 0.5 mm thick and may be increments of annual deposition. Such structure certainly is not pedogenic. Olive or olive brown colors in organic layers of organic soils are characteristic of coprogenous earth layers. The most common colors are those with hue of 2.5Y or 5Y, value of 3 or 4, and chroma of 2."

References:

Agriculture and Agri-Food Canada. 2010. Glossary of terms in soil science [Online] Available: http://sis.agr.gc.ca/cansis/glossary/c/index.html [2020 Feb 20].

C.L. Ping, J.D. Jastrow, M.T. Jorgenson, G.J. Michaelson, Y.L. Schuur. 2015. Permafrost soils and carbon cycling. SOIL, 1 (2015), pp. 147-171

Jorgenson, M. T. 2013. Thermokarst terrains, in: Treatise on Geomorphology, Vol 8, Glacial and Periglacial Geomorphology, edited by: Shroder, J.F. (Ed.-in-chief), Giardino, R. and Harbor, J. (Vol. Eds), Academic Press, San Diego, 313–324.

Jorgenson, M. T. et al., 2013. Reorganization of vegetation, hydrology and soil carbon after permafrost degradation across heterogeneous boreal landscapes

Lynn, L. A. 2009. Impacts of coastal erosion on the soil properties of the Beaufort Sea coast, Alaska. MS Thesis, University of Alaska Fairbanks, 2009.

Michaelson, G.J., and C.L. Ping. 2017. Guidebook: Alaska Soil Geography Field Study -Permafrost-affected Soils. NRM-F489/689. Agricultural and Forestry Experiment Station Bulletin 118, School of Natural Resources and Extension, University of Alaska Fairbanks, Fairbanks, AK

Tallyn, E., E. Thorson, etal. 2016. Limnic Horizons & Materials, NCSS Taxonomy Proposal, Amendment #6.

http://www.nrcs.usda.gov/wps/PA_NRCSConsumption/download?cid=nrcseprd1039013&ext=pdf [Accessed 2020 MARCH 4].

Soil Classification Working Group. 1998. The Canadian System of Soil Classification. Agriculture and Agri-Food Canada, Ottawa, ON. Publ. 1646 (rev.).

Figures and Tables:

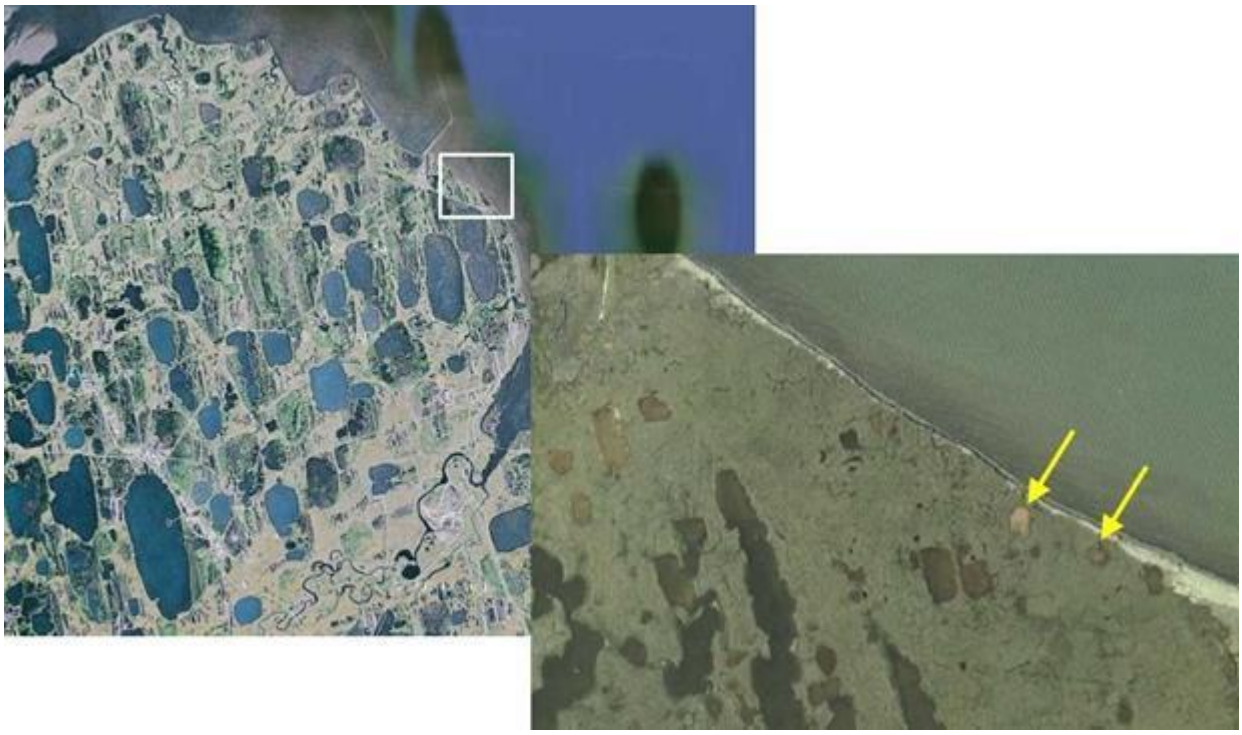

Figure 1: Geographic area in Northern Alaska where coprogenous-limnic material can be found in Geolisols. These shallow lakes and marshland (and areas where lakes and marshlands used to be) are where migratory birds nest during the summer.

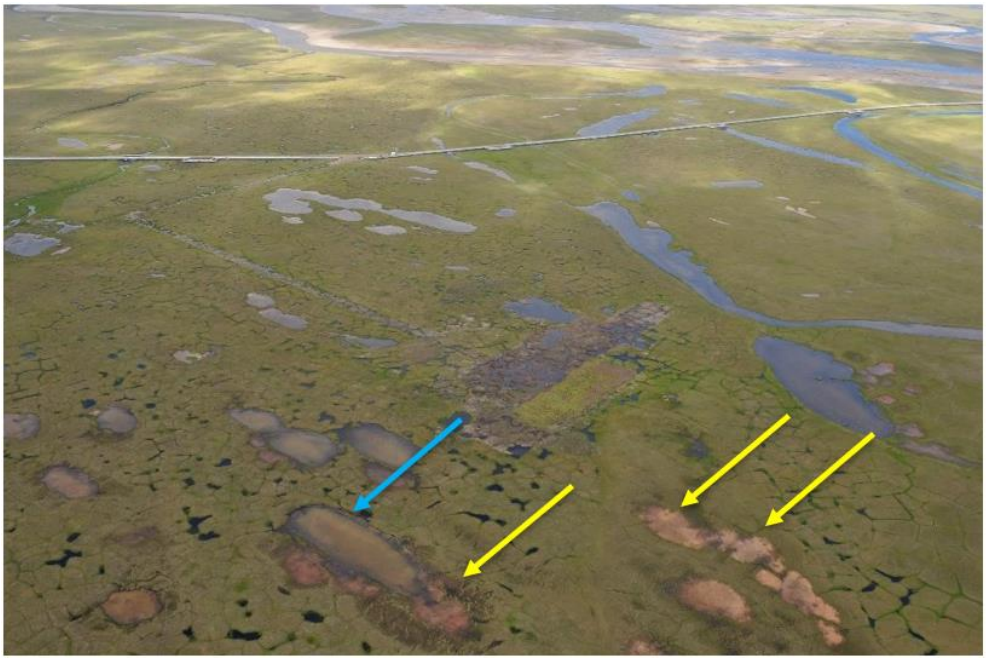

Figure 2: Aerial photograph showing areas where limnic materials are typically found, indicated by yellow arrows. The blue arrow points to an area where limnic materials are not typically found.

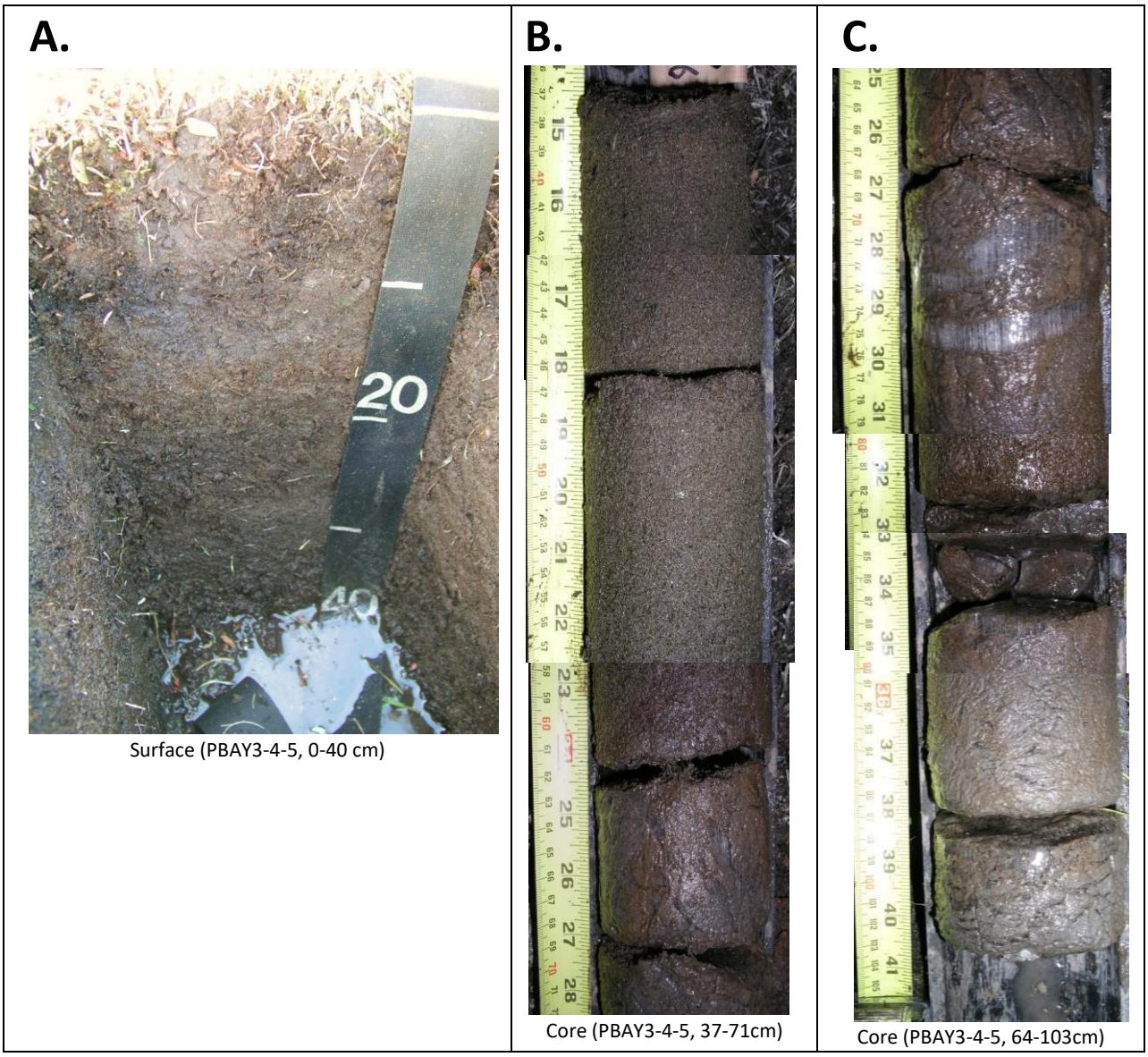

Figure 3. Proposed Limnic Glaciestels, with Limnic materials found from 38 cm to 83 (L horizon identified 20-40cm) cm in permafrost. This profile photo captures only the (A) active layer (the top portion of the soil that undergoes annual freeze and thaw), and (B, C) The portion of the permafrost that is continually frozen is extracted by cores. Laboratory data are presented in Table 1. Location coordinates of soil are N 70.37151˚ and W 148.50677˚.

Figure 4. Proposed Limnic Hemeistels for a soil from Utqiaġvik, Alaska. Limnic material are identified from 10 to 16 cm and are found over loamy mineral material.

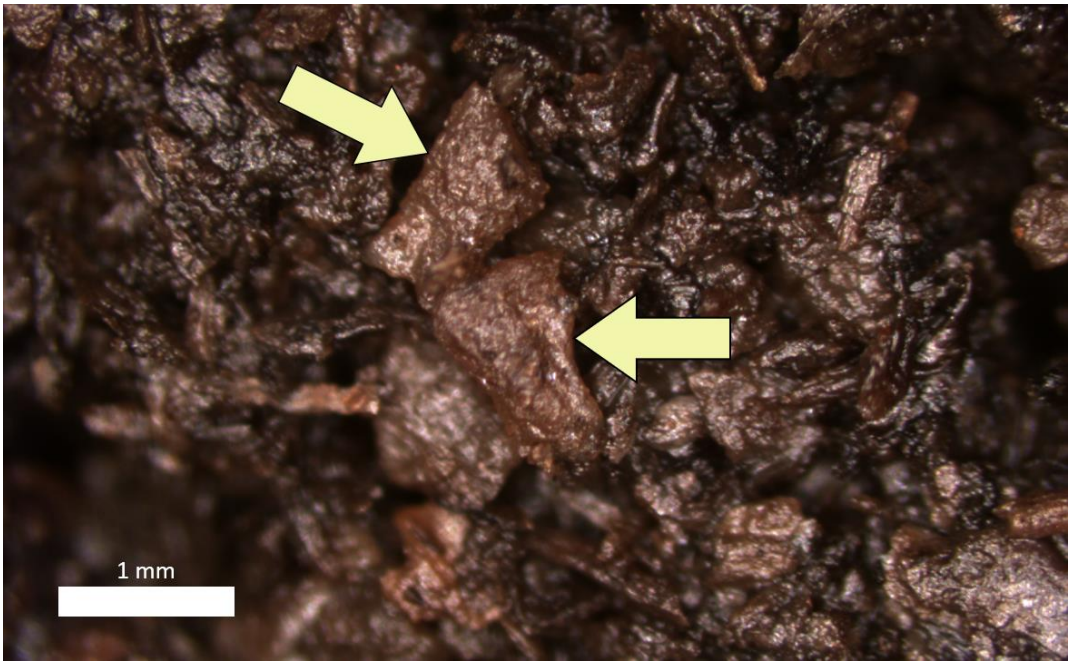

Figure 5. Microscopy of fecal pellets in limnic material from PBAY3-4-5 Core (Figure 3B). Fecal pellets are identified by the two yellow arrows.

Table 1. Lab data from 3 soil profiles near Prudhoe Bay (Figure 1). Limnic materials are identified as "L".

Plot ID	Classification (tentative)	Top (cm)	Bot (cm)	Horz	Bulk Density	Color	pH	C %	N %	PO4 ppm
PBAY3-4-0	Typic Hemistel	0	16	Oe	0.68	10YR 3/3	5	24.91	1.53	<1.0
PBAY3-4-0		5	10	Oe	0.68	10YR 3/3	5.07	22.88	1.48	<1.0
PBAY3-4-0		20	25	Oe	0.35	10YR 3/2	5.15	32.89	1.97	<1.0
PBAY3-4-0		16	34	L	0.35	2.5Y 3/3	5.45	32.35	1.81	<1.0
PBAY3-4-1	Typic Hemistel	0	16	Oi	0.68	7.5YR 2.5/2	5	30.73	1.53	<1.0
PBAY3-4-1		33	35	Lf	0.37	10YR3/3	5.42	15.63	1.79	<1.0
PBAY3-4-1		37	58	Lf	0.26	10YR 3/3	6.51	23.31	1.82	
PBAY3-4-1		40	45	Lf	0.26	10YR3/3	6.86	10.14	0.83	
PBAY3-4-1		58	87	Oef	0.31	10YR 3/4	7.25	6.12	1.22	<1.0
PBAY3-4-1		60	65	Lf	0.41	10YR3/3	7.35	10.15	0.514	
PBAY3-4-5	Typic Sapristel	0	20	Oa	0.51	5YR 3/1	4.76	28.16	1.29	<1.0
PBAY3-4-5		5	10	Oa	0.51	5YR 3/1	4.91	34.45	1.44	<1.0
PBAY3-4-5		20	25	Oa	0.46	5YR 3/1	5.13	29.15	1.53	<1.0
PBAY3-4-5		20	40	Lf	0.46	7.5YR 3/3	5.51	26.91	1.38	<1.0
PBAY3-4-5		40	45	Lf	0.37	7.5YR 3/3	5.36	13.43	1.79	<1.0
PBAY3-4-5		40	60	Oaf	0.26	10YR 2/1	6.43	24.06	1.57	<1.0
PBAY3-4-5		60	65	Oaf	0.26	10YR 2/1	6	19.48	0.682	

Table 2. Lab data for soil from Utqiaġvik, Alaska (Figure 4). Limnic material are identified from 10 to 16cm in the proposed Limnic Hemeistels.

Top cm	Bot cm	BD (g/cm3)	pH	C %	N %	Sand %	Silt %	Clay %	CEC me/100g	NO_3^--N mg/kg	P mg/kg
0	4		7.58	25.78	1.38				83.63	81.17	2.14
4	9	0.26	7.42	26.12	1.39				107.61	60.24	8.61
10	16	0.30	6.24	33.12	2.27				109.88	110.05	30.51
14	46	1.51	5.06	4.30	0.21	44.2	36.2	19.6	21.08	7.09	<1
48	52	0.81	6.93	16.15	0.88	ns	ns	ns	50.21	1.04	<1
53	58	0.26		17.73	1.00						
59	63	0.21		21.66	1.20						
68	76	0.37		22.08	1.30						
82	94	0.24	6.85	16.34	0.93				63.69	<1	<1
105	110	0.31		20.15	0.96						
110	113	0.20		29.27	1.43						
132	140		6.84	13.04	0.72	87.2	4.2	8.6	4.86	<1	<1
140	145	1.92	7.52	2.53	<.01	91.5	2.6	5.9	1.46	<1	<1