WCSS Post-Conference Tour #1

Cryosols and Arctic Tundra Ecosystems, Alaska

July 16-22, 2006

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18th WCSS 2006

UNIVERSITY OF ALASKA FAIRBANKS

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Chien-Lu Ping, Tour Leader

School of Natural Resources and Agricultural Sciences

University of Alaska Fairbanks

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Contents

18th WCSS Post-Congress Tour #1: Itinerary	
Date	Description of Stops
7/15	**Delegation arrives in Fairbanks**
7/16	**In Fairbanks** General tour to familiarize participants with permafrost features and land use interpretations associated with infrastructure development. **0830** Leave hotel and drive to Fox (16 km paved). **0900 – 0930 Stop 1.** Trans-Alaska Pipeline viewpoint along the Steese Highway **0945 – 1130 Stop 2.** Fox Permafrost Tunnel, Shur **1145 – 1230** Lunch stop at the Clear Summit lookout **1300 – 1500 Stop 3.** Steese Highway, effect of forest fire on permafrost, (75 km paved) Clark/Moore/Packee **1530 – 1630 Stop 4.** Chatanika gold dredge, Packee **1700** Back in Fairbanks hotel **1730** Leave hotel and head to Dr. Todd's property (Goldstream Valley) for a country-style barbecue dinner (16 km from Fairbanks)
7/17	**In Fairbanks** Study three pedons along a toposequence in the Smith Lake area near the university to demonstrate the effects of slope and aspect on the distribution of permafrost and hydrology, forest ecology, soil characteristics and classification. **0800** Leave hotel, bus ride to West Ridge of the university **0820 – 0920 Stop 5 (S-1).** Typic Eutrocryept (Haplic Eutric Cambisol) on south-facing slope **0940 – 1030 Stop 6.** Walking tour, examine the effects of land clearings in the 1950s on soil thermal regimes and vegetation succession **1050 – 1230 Stop 7 (S-2).** Typic Historthel (Static Histic Cryosol) on gentle south-facing toe slope **1230 – 1330** Lunch (brown bag) at the T-Field **1330 – 1500 Stop 8 (S-3).** Ruptic-Histic Aquiturbel (Turbic Histic Cryosol) in bottomland **1520 – 1700 Stop 9 (S-4).** Fluventic Historthel (Histic Cryosol) on north-facing slope **1800 – 2030** Outdoor reception at the Georgeson Botanical Garden at the university campus, Fairbanks (bus ride)
7/18	**0800** Drive up north (total driving distance 586 km/366 miles) Introduction to the boreal forest ecosystem, geomorphology, cryogenic features, and linear development on permafrost terrain. **1100 – 1200 Stop 10.** Lunch stop at Dalton Highway MP 55, Yukon Crossing to view the pipeline crossing (200 km/125 miles; 70 miles paved, 55 miles gravel) **1300 – 1340 Stop 11.** Finger Mountain (D-98) to see alpine environment, sorted circles, solifluction lobes, cryoplanation, and block tor (69 km/43 miles, gravel) **1410 – 1500 Stop 12.** Arctic Circle D-115 (66°33'24.9"N Lat.). (27 km/17 miles paved) **1500 – 1600 Stop 13.** Coldfoot Gas station (D-175). (96 km/60 miles, paved) **1630 – 1800 Stop 14.** Atigun Pass D-246.8, Continental Divide (1447m) (115 km/72 miles gravel) **1900** Arrive at Toolik Lake Field Research Station, D-285.5 (61 km/38 miles gravel)

7/19	**0800** Leave Toolik Lake Station and drive north (208 km/130 miles gravel) Study the arctic ecosystem, soil genesis and classification. **1100 – 1140 Stop 15.** Prudhoe Bay oil field and Arctic Ocean coast **1200 – 1230** Lunch stop at Sagavanirktok River bluff south of Deadhorse (D-414) **1230 – 1330 Stop 16 (S-5).** Sagavanirktok River bank erosion, ice wedge features, and degradation of polygons **1430 – 1530 Stop 17 (S-6).** D-390. Fluvaquentic Historthel (Histic Cryosol) in a low-center polygon **1700** Arrive back at Toolik Lake Field Research Station **1730 – 1830** Dinner
7/20	**0830 – 1030** Leave Toolik Lake and drive to Sagwon Hills (pack lunch) Study the arctic ecosystem, soil genesis and classification **1030 – 1200 Stop 18 (S-7).** D-359. Ruptic-Histic Aquiturbel (Turbic Histic Cryosol) soils associated with moist nonacidic tundra (117 km/73 miles) **1200 – 1300** Lunch at Sagwon Hills gravel pad, Wyoming Rain gauge site D-357 **1300 – 1600 Stop 19 (S-8).** Ruptic-Histic Aquiturbel (Turbic Histic Cryosol), soils associated with moist acidic tundra **1600 – 1830** drive back to Toolik Lake Field Research Station
7/21	**At Toolik Lake Field Research Station** Study the arctic ecosystem, soil genesis and classification. **0800 – 1030 Stop 20 (S-9).** Ruptic Histic Aquiturbel (Turbic Histic Cryosol) south of lake (walk) **1030 – 1200 Stop 21 (S-10).** Typic Hemistel (Hemic Cryic Histosol), south of lake (walk) **1220 – 1320** Lunch at Toolik Lake Station **1320 – 1500 Stop 22 (S-11).** Typic Histoturbel (Turbic, Histic Cryosol) east of Lake (walk) **1530 – 1730 Stop 23 (S-12).** Ruptic Histoturbel (Ruptic Histic Cryosol) Nonsorted circle formation at Galbraith Lake (19 km/12 miles) **1800** Dinner at Toolik Lake Station
7/22	**0830** Leave Toolik Lake Station and return to Fairbanks **1100** Coldfoot gas station (178 km/111 miles) **1100 – 1200** Lunch at the Visitor Center of the Gates of the Arctic National Park, D-175 **1220 – 1400 Stop 24 (S-13).** D-171 Typic Histoturbel (Turbic Histic Cryosol) under boreal forest **1400 – 1930** Drive back to Fairbanks (400 km/250 miles)

Participants

Chien-Lu Ping: Tour Leader, Professor of Soil Science, UAF, Palmer, AK, USA
Edmond Packee: Assistant Tour Leader, Emeritus Professor of Forestry, UAF, WI, USA
Joseph Moore: Assistant Tour Leader, State Soil Scientist, USDA-NRCS, Palmer, AK, USA
Gary J. Michaelson: Assistant Tour Leader, logistics coordinator, UAF, Palmer, AK, USA

Tour participants

Scott Burns, University of Portland, Portland, Oregon, USA
Gerald Coen, Edmonton, Alberta, Canada
Joyce Coen, Edmonton, Alberta, Canada
William Effland, USDA-NRCS, Myersville, Maryland, USA
Emmanuel Frossard, Institute of Plant Sciences, ETHZ, Lindau, Switzerland
John Handler, USDA-NRCS, St. Paul, Minnesota, USA
Yuko Itoh, Forestry & Forest Products Research Institute, Tsukuba, Japan
Ir. Harco Jellema, Deputy Director, Wageningen University, Diepenveen, The Netherlands
Johan Loch, Utrecht University, Bilthoven, The Netherlands
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Maryke Rogaar-Karsten, Wageningen, The Netherlands
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Kyoko Sato, Kitsato University, Towada, Japan
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Joseph Valentine, Quakertown, Pennsylvania, USA

Logistics supporting crew

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Acknowledgements

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The excavation, description, and sampling of the soils were the result of teamwork over the years, involving the participants of the UAF-Alaska Soil Geography Field Study class (NRM-495/695, NRM-489/689). We offer special thanks to Gary J. Michaelson, Dr. John M. Kimble (retired USDA-NRCS soil scientist), and Dr. Cynthia A. Stiles (University of Wisconsin-Madison) who played a major role in the field study, soil sampling, and data compiling. Gary Michaelson also helped compile this guidebook.

Soil climate monitoring data were provided by Dr. Vladimir Romanovsky, Geophysical Institute of the University of Alaska, Dr. Ron Paetzold, retired soil scientist, USDA-NRCS, and Dr. Kathy Seybold, soil scientist, USDA-NRCS National Soil Survey Center.

Tour Information

Objectives:

• To study the state factors of soil formation: parent material, landform, biota, climate, and time in arctic Alaska along a north-south transect along the Dalton Highway.

• To study the cryogenic nature of arctic tundra soils: pattern ground, thickness of the active layer, cryogenic features and structures.

• To discuss land use interpretations of permafrost-affected soils in the context of regional and global climate change.

Site Selection

Study sites were selected to represent the major land cover classes on the Arctic Coastal Plain, Arctic Foothills, the Northern Boreal Forest, and along a toposequence near Fairbanks. Six of the ten sites are associated with the NSF Arctic System Science Program LAII Flux/ATLAS and Biocomplexity projects. The objectives of these projects are to study trace gas flux and complexities of arctic ecosystems in representative land cover classes in the arctic tundra and their response to climate change over time.

Protocol

If patterned ground is present, a soil pit location will be excavated to cover its whole cycle. Before the soil pit is open, a plastic tarp will be laid next to the selected site. To expose the upper permafrost, soil pits will be excavated with shovels and a permafrost drill to 1x1 m^2 and >1 m deep. The organic mat will be sliced and put aside and mineral soil material will be placed on the plastic tarp. Soil pits will be open for soil morphology study and sampling. All personnel should keep off the face of the pit during excavation. Afterward, the soil pit will be backfilled according to the order of excavation and the organic mat will be put back to restore its original condition. All sites will be kept clean of any debris.

References

Brown, J., and R.A. Kreig. 1983. *Guidebook to permafrost and related features along the Elliott and Dalton Highways, Fox to Prudhoe Bay, Alaska*. Guidebook 4, Fourth International Conference on Permafrost, Alaska Dept. Natural Resources, Division of Geological and Geophysical Survey, Fairbanks, Alaska.

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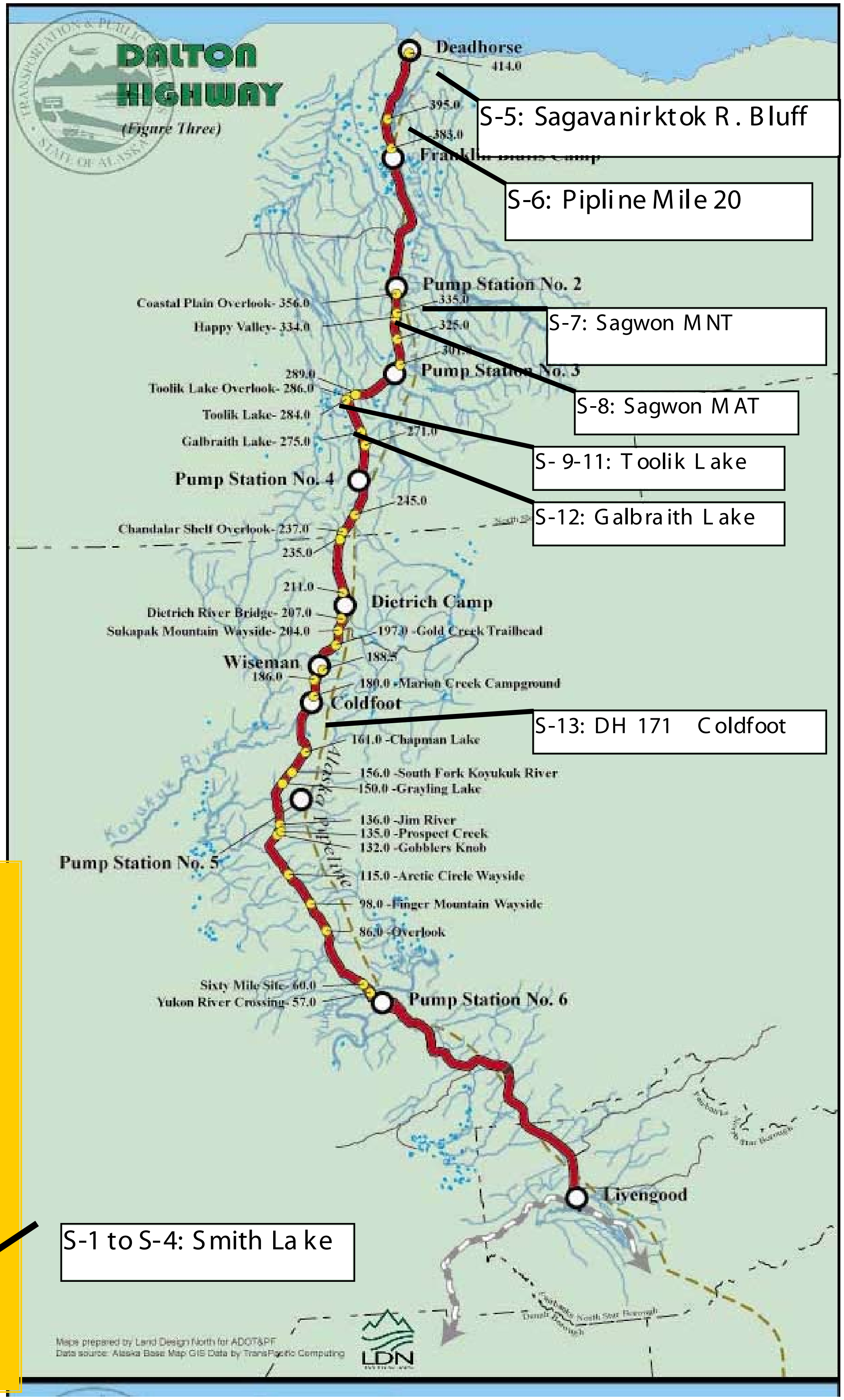
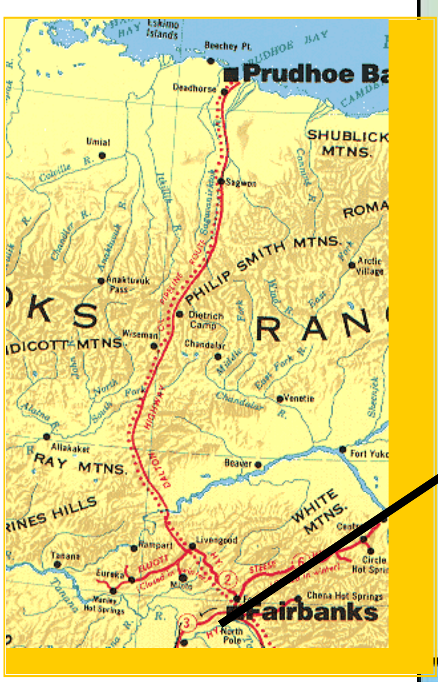
Ping, C.L., J.G. Bockheim, J.M. Kimble, G.J. Michaelson, and D.A. Walker. 1998. Characteristics of cryogenic soils along a latitudinal transect in Arctic Alaska. *Journal of Geophysical Research*, 103(D22): 28,917-28,928. (Appendix D).

Shur, Y., H.M. French, M.T. Bray, and D.A. Anderson. 2004. Syngenetic permafrost growth: Cryostratigraphic observations from the CRREL Tunnel, Fairbanks, Alaska. *Permafrost and Periglac. Process.* 15: 1-9.

Figure 1. Field trip route and site locations map.





Cyrosols & Arctic Tundra Ecosystems Tour

July 16, 2006, Sunday

General tour to familiarize participants with permafrost features and land use interpretations associated with infrastructure development in zone of discontinuous permafrost.

Stop 1. Trans-Alaska Pipeline View Point along the Steese Highway: general information. En route to Stop 1 view permafrost damage to structures, settling house, old radio station along Farmers Loop Road. En route to Stop 2 notice gold mine tailings from dredging along the way.

Stop 2. Fox Permafrost Tunnel: Study permafrost features from within (Y. Shur Reference: Shur et al., 2004 – Handout).

Stop 3. Steese Highway, effect of forest fire on permafrost (M.H. Clark, J.P. Moore, and E.C. Packee).

Stop 4. Chatanika Gold Dredging – Study the operation and impact of gold dredging in permafrost-affected area (E.C. Packee). En route to barbeque at Dr. Todd's, notice thermokarst in relation to landform position and vegetation along Goldstream Road.

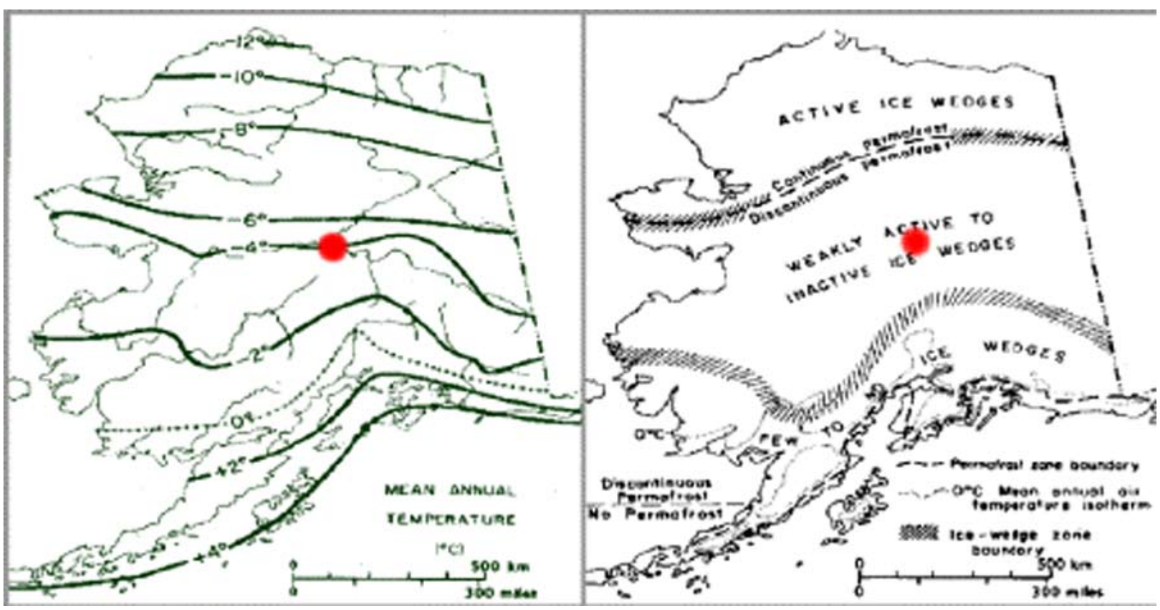


Figure 2. Distribution of permafrost in Alaska. (*Periglacial Processes and Environments* by A. Washburn. Palgrave Macmillan Press, June 1973)

July 17, 2006, Monday

Study three pedons along a toposequence in the Smith Lake area near the university to demonstrate the effects of slope and aspect on permafrost distribution, hydrology, forest ecology, soil characteristics, and soil classification.

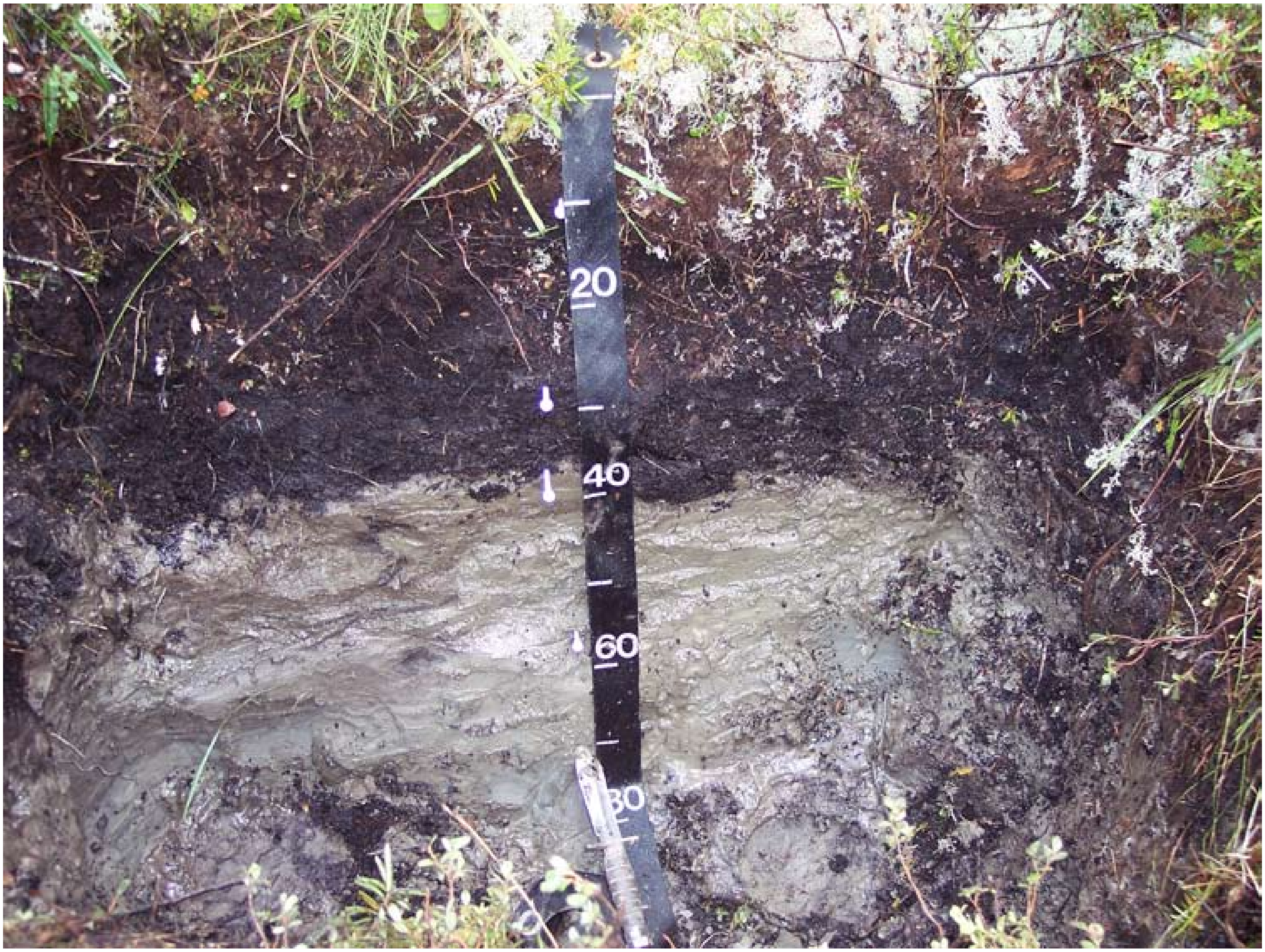
Stop 5. Walking tour: examine the effects of land clearing on soil thermal regimes and vegetation succession.

Thermokarst mounds in the Fairbanks area are polygonal or circular hummocks of loess and retransported silt 3 to 15 m in diameter and 0.3 to 2.5 m high. They formed due to thawing of large ground ice masses, and they are most common in cultivated fields and other cleared areas. The walking tour goes through an area cleared in 1908 for agricultural fields. Thermokarst mounds started to form two to three years after clearing. After 14 years of clearing, the mounds developed to 1 to 3 meters high, interfering with farm machinery operation.

The trail goes through an area that was left alone after the clearing for vegetation to recover. Now the area is dominated by hardwood species, including *Popular balsamifera, Populus tremuloides,* and *Betula neoalaskana*, with *Picea glauca* (white spruce) as understory. Compare this with the area east of the mounded area, which was not cleared. The field below Stop 6: S-1 was repeatedly graded (leveled) for hay fields.

Stop 6. S-1: Typic Eutrocryept (Haplic Eutric Cambisol) on upland south-facing slope

S-1 – Pit: Typic Eutrocryept (Haplic Eutric Cambisol)



S-2 – Pit: Typic Historthel (Static Histic Cryosol)

S-1 Pedon Description: Typic Eutrocryept (Haplic Eutric Cambisol)

Description Date: 09/06/2003

Describer: C.L. Ping, E.C. Packee, N. Zaman, C.H. Xu, and Lijie Zhu

Site ID: S03AK-176-008

Pedon ID: 04N0278

Physiographic Province: Yukon-Tanana uplands

Local: hills

Geomorphic Position: back slope

Parent material: loess

Lab Pedon #: S03AK-176-008

Soil Name as Described/Sampled: Fairbanks silt loam

Classification: Coarse-silty, mixed, frigid Typic Eutrocryept (Haplic Eutric Cambisol)

Geomorphic Setting: back slope, Microtopography: flat

State: Alaska

County: Fairbanks North Star Borough

Soil Survey Area: AK603—Fairbanks Area, Alaska

Latitude: 64°52.00'N

Longitude: 147°52.00'W

Surface Fragments: 0.0%

Upslope Shape: slightly convex

Cross Slope Shape: slightly convex

Diagnostic Features: Cambic horizon 17-62 cm

Slope: 5%

Elevation: 170 meters

Aspect: 146°

MAAT: -2.2°C　　**MSAT**: 2.1°C

MWAT: —　　**MAP**: 280 mm

Frost-Free Days: 94

Drainage Class: well

Pedon ID: S03AK-090-008

*** Primary Characterization Data ***

(Alaska, UNITED STATES)

Print Date: June 9, 2005

Sampled as on September 6, 2003: Fairbanks ; **Coarse-silty, mixed, frigid Typic Eutrocryept**
Revised to :

SSL - Project C2004USAK034 Interior Ak
- Site ID Smith Lake T-field - Powerline Lat: 64° 52' .00" north Long: 147° 52' .00" west MLRA: 176
- Pedon No. 04N0278
- General Methods 1B1A, 2A1, 2B

United States Department of Agriculture
Natural Resources Conservation Service
National Soil Survey Center
Soil Survey Laboratory
Lincoln, Nebraska 68508-3866

PSDA & Rock Fragments

				-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-9-	-10-	-11-	-12-	-13-	-14-	-15-	-16-	-17-
				(----- Total	------	)	(-- Clay	--)	(---- Silt	----)	(------	------	Sand	------	------)	(Rock Fragments (mm))				
				Clay	Silt	Sand	Fine	CO_3	Fine	Coarse	VF	F	M	C	VC	(-------- Weight			--------)	>2 mm
				< .002	.002 -.05	.05 -2	< .0002	< .002	.002 -.02	.02 -.05	.05 -.10	.10 -.25	.25 -.50	.5 -1	1 -2	2 -5	5 -20	20 -75	.1- 75	wt % whole soil
Layer	Depth (cm)	Horz	Prep	(-----	-----	-----	-----	% of <2mm Mineral Soil	-----	-----	-----	-----	-----	-----	-----)	(------- % of <75mm			------)	
				PSDAr1					PSDAr1		PSDAr1	PSDAr1	PSDAr1	PSDAr1	PSDAr1					
04N01280	0-8	Oe	S													–	–	–	–	–
04N01281	8-17	A	S	12.7	74.6	12.7			35.3	39.3	10.8	1.1	0.7	0.1	tr	tr	–	–	2	tr
04N01282	17-40	Bw1	S	10.2	70.2	19.6			25.2	45.0	17.2	1.8	0.5	0.1	tr	tr	–	–	2	tr
04N01283	40-62	Bw2	S	10.6	74.0	15.4			23.2	50.8	14.2	1.1	0.1	tr	–	–	–	–	1	–
04N01284	62-100	BC	S	7.1	74.8	18.1			21.1	53.7	16.6	1.3	0.1	0.1	tr	–	–	–	2	–
04N01285	100-150	C	S	5.8	76.6	17.6			20.6	56.0	16.4	1.0	0.2	–	tr	–	–	–	1	–

Carbon & Extractions

				-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-9-	-10-	-11-	-12-	-13-	-14-	-15-	-16-	-17-	-18-
				(----- Total	-----	-----)	Org	C/N	(--- Dith-Cit Ext	---)		(-------- Acid Oxalate Extraction					--------)	(--- Na Pyro-Phosphate			---)
				C	N	S	C	Ratio	Fe	Al	Mn	Al+½Fe	ODOE	Fe	Al	Mn	Si	C	Fe	Al	Mn
Layer	Depth (cm)	Horz	Prep	(------ % of <2 mm	------	------)			(------	------	------	% of < 2mm	------	------	------)	mg kg^{-1}	(------	------	% of < 2mm	------	------)
				TotNCS	TotNCS	TotNCS			DC1	DC1	DC1		Oxal1	Oxal1	Oxal1	Oxal1	Oxal1				
04N01280	0-8	Oe	S	33.42	1.129	0.09		30													
04N01281	8-17	A	S	2.44	0.119	–		21	1.4	0.1	0.1	0.56	0.17	0.72	0.20	1095.9	0.05				
04N01282	17-40	Bw1	S	0.41	0.054	–		8	1.1	0.1	tr	0.37	0.06	0.47	0.13	145.0	0.06				
04N01283	40-62	Bw2	S	0.36	1.065	–		tr	1.1	0.1	tr	0.28	0.07	0.33	0.12	255.7	0.07				
04N01284	62-100	BC	S	0.28	0.043	–		7	1.0	0.1	tr	0.27	0.04	0.32	0.11	253.0	0.08				
04N01285	100-150	C	S	0.29	0.061	–		5	1.0	0.1	tr	0.28	0.04	0.34	0.11	210.2	0.09				

Layer	Depth (cm)	Horz	Prep	Ca	Mg	Na	K	Sum Bases	Acid-ity	Extr Al	KCl Mn	Sum Cats	NH_4 OAC	Bases +Al	Al Sat	(- Saturation -) Sum	NH_4OAC
				(------	------	cmol(+) kg^{-1}	------	------	------	------)	mg kg^{-1}	(---- cmol(+) kg^{-1}		---)	(--------	%	--------)
				CECd	CECd	CECd	CECd		XAcid2	KCl1	KCl1		CECd				
04N01280	0-8	Oe	M	71.2	5.5	–	2.7		59.4				98.4				
04N01281	8-17	A	S	7.5	2.9	–	0.1	10.5	20.0	1.8	12.1	30.5	18.9	12.3	15	34	56
04N01282	17-40	Bw1	S	6.9*	2.4	–	0.1	9.4	5.8	–	–	15.2	9.2			62	100
04N01283	40-62	Bw2	S	6.9*	2.9	–	0.1	9.9	4.5			14.4	9.2			69	100
04N01284	62-100	BC	S	7.1*	3.1	–	0.1	10.3	2.8			13.1	8.0			79	100
04N01285	100-150	C	S	6.1*	3.0	–	0.2	9.3	2.3			11.6	7.5			80	100

Depth (cm)	Horz	------ pH ------ $CaCl_2$ 0.01M 1:2	H_2O 1:1	Sat Paste
		pHRou1	pHRou1	
0-8	Oe	5.6	6.2	
8-17	A	4.4	5.0	
17-40	Bw1	5.0	5.7	
40-62	Bw2	5.4	6.3	
62-100	BC	5.8	6.7	
100-150	C	6.3	7.1	

*Extractable Ca may contain Ca from calcium carbonate or gypsum. CEC7 base saturation set to 100.

Vegetative Information

Landcover type: forest

Plant Names: *Picea glauca, Betula neoalaskana, Viburnum edule, Alnus crispa, Cornus canadensis, Epilobium angustafolia, Hylocumium splendens Geocaulon lividum, Orthyla segundo, Shepherdia canadensis, Equisetum pratense, Rosa acicularis, Mertensiana paniculata*, and *Linnea borealis*.

Oe; 0 – 8 cm; dark brown (7.5YR 3/2) mucky peat; common very fine, fine and common medium roots; many coarse charcoal particles; abrupt smooth boundary.

A; 8 – 17 cm; dark yellowish brown (10 YR 3/4) silt loam; weak medium subangular breaking into moderate medium granular structures; very friable; slightly sticky and slightly plastic; many very fine, fine, medium and coarse roots; common medium charcoal particles; clear wavy boundary.

Bw1; 17 – 40 cm; light olive brown (2.5Y 5/4) silt loam; weak very thin platy structure; very friable; slightly sticky and slightly plastic; many fine and common medium roots; few fine and medium charcoal particles; clear smooth boundary;

Bw2; 40 – 62 cm; olive brown (2.5 Y 4/4) silt loam; moderate very thin platy structure; very friable; slightly sticky and slightly plastic; many fine and common medium roots; common fin root channels/remains; clear smooth boundary

BC; 62 – 100 cm; dark grayish brown (2.5Y 4/2, 70%) and dark gray (2.5Y4/1, 30%) silt loam; weak very thin platy structure; very friable, slightly sticky and slightly plastic; few fine and medium roots; abrupt smooth boundary

C; 100 – 150 cm; dark grayish brown (2.5Y 4/2, 60%), dark gray (2.5Y 4/1, 30%) silt loam with yellowish red (5YR 5/8, 10%) pore linings with pore size 3–4 mm in diameter; olive (5 Y 6/3), and 20% light gray (7.5 Y 7/1); moderately very thin platy structure; very friable; slightly sticky and slightly plastic; very few fine roots; common fine root remains.

Stop 7. S-2: Typic Historthel (Static Histic Cryosol): gentle south-facing toe slope

S-2 Pedon Description: Typic Historthel (Static Histic Cryosol)

Description Date: 08/07/1996

Describer: Kimble, Wilding, Everett, Ping

Site ID: 96AK090001

Pedon ID: 96AK090001

P**edon Note**: 75% fibers after rubbed in layer 1-Oi. 10% fibers after rubbed in layer 2-Oa. Many mica flakes in Mineral Horizons

Lab Pedon #: 96P0365

Soil Name as Described/Sampled: snd

Classification: Coarse-silty, mixed, subgelic Typic Historthel (Static Histic Cryosol)

Geomorphic Setting: on backslope of side slope of hillside on backslope of side slope of hills

State: Alaska

County: Fairbanks North Star Borough

Soil Survey Area: AK603—Fairbanks Area, Alaska

Latitude: 64°52'10.50"N

Longitude: 147°51'27.40"W

Surface Fragments: 0.0%

Upslope Shape: convex

Cross Slope Shape: convex

Diagnostic Features: histic epipedon 0 to 27 cm. cambic horizon 27 to 80 cm.

Slope: 4.0%

Elevation: 169.0 meters

Aspect: 135°

MAAT: -2.7°C **MSAT**: -.8°C

MWAT: — **MAP**: 280 mm

Frost-free days: —

Drainage class: poorly

Oi—0 to 15 centimeters; dark reddish brown (5YR 3/3) rubbed peat; weak coarse platy structure; many fine to coarse roots top of horizon; abrupt smooth boundary. Coarse roots abruptly stop in horizontal pattern w/contact of Oa.

Oa—15 to 27 centimeters; black (10YR 2/1) rubbed muck; weak coarse platy parting to weak very fine and fine granular structure; many fine roots throughout; abrupt wavy boundary.

Bg1—27 to 42 centimeters; dark grayish brown (2.5Y 4/2) broken face silt loam, silty clay loam; 1% fine faint irregular dark yellowish brown (10YR 4/4) and 3% coarse faint irregular gray (10YR 5/1) and 30% fine faint platy very dark grayish brown (10YR 3/2) mottles; strong fine platy structure; friable; few fine roots throughout; abrupt wavy boundary. Redox depletion, redox concentration and 10YR3/2 is an admixture.

Bg2—42 to 58 centimeters; very dark grayish brown (2.5Y 3/2) broken face silt loam; strong fine platy structure; friable; few fine roots throughout; abrupt wavy boundary. Lab sample # 96P02867

Bgf—58 to 80 centimeters; light olive brown (2.5Y 5/4) broken face silt loam; 1% coarse prominent irregular dark gray (5Y 4/1) mottles; strong fine platy structure; clear smooth boundary. Ice lenses 0.5-1mm in width/50% ice lenses. Many horizontal ice lenses, spaced 1mm apart, 1/2mm in size in lower 10cm. Structure massive when frozen.

Cf—80 to 100 centimeters; light olive brown (2.5Y 5/4) broken face silt loam; 1% coarse prominent irregular brownish yellow (10YR 6/6) and 1% coarse prominent irregular yellowish brown (10YR 5/4) and 1% coarse prominent irregular dark gray (5Y 4/1) mottles; strong very fine platy structure. 0.25-0.5mm horizontal ice lenses in a wavy pattern/layer at 50% ice. Vertical spacing also .25-.50 mm, with a few 2mm thick ice lenses. Structure is massive when frozen. Redox concentration, redox depletion.

S96AK-090-001

*** P R I M A R Y   C H A R A C T E R I Z A T I O N   D A T A ***
(FAIRBANKS DIVISION, ALASKA)

PRINT DATE 12/09/97

SAMPLED AS :
REVISED TO :

Classification: Typic Historthel

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
NATIONAL SOIL SURVEY CENTER
SOIL SURVEY LABORATORY
LINCOLN, NEBRASKA 68508-3866

SSL - PROJECT 96P 72, (CP96AK149) ALASKA - SMITH LAKE
- PEDON 96P 365, SAMPLES 96P 2864- 2869
- GENERAL METHODS 1B1A, 2A1, 2B

SAMPLE NO.	DEPTH (CM)	HORIZON	-1-- CLAY LT .002	-2-- SILT .002 -.05	-3-- SAND .05 -2	-4-- FINE CLAY LT .0002	-5-- CO3 CLAY LT .002	-6-- FINE SILT .002 -.02	-7-- COARSE SILT .02 -.05	-8-- VF SAND .05 -.10	-9-- F SAND .10 -.25	-10- M SAND .25 -.50	-11- C SAND .5 -1	-12- VC SAND 1 -2	-13- COARSE FRACTIONS WEIGHT 2 -5	-14- 5 -20	-15- 20 -75	-16- .1- 75	-17- (>2MM) WT PCT OF WHOLE SOIL
			<- PCT OF <2MM (3A1)											->	<- PCT OF <75MM(3B1)			->	
96P2864H	0- 15	Oi													--	--	--		--
96P2865H	15- 27	Oe													--	--	--		--
96P2866S	27- 42	Bg1	10.1	76.3	13.6			33.6	42.7	12.1	1.0	0.3	0.1	0.1	--	--	--	1	--
96P2867S	42- 58	Bg2	8.2	70.7	21.1			26.6	44.1	18.1	2.2	0.6	0.1	0.1	--	--	--	3	--
96P2868S	58- 80	Bgf	5.7	69.9	24.4			18.8	51.1	22.0	1.9	0.2	0.1	0.2	--	--	--	2	--
96P2869S	80-110	Cf	5.0	74.6	20.4		2.1	22.7	51.9	18.9	1.2	0.1	0.1	0.1	--	--	--	1	--

DEPTH (CM)	ORGN C 6A1c PCT	TOTAL N 6B4a <2MM	EXTR P 6S3b PPM	TOTAL S 6R3c	DITH-CIT EXTRACTABLE FE 6C2b	AL 6G7a	MN 6D2a	(RATIO/CLAY) CEC 8D1	15 BAR 8D1	(ATTERBERG - LIMITS -) LL 4F1	PI 4F	(- BULK DENSITY -) FIELD MOIST 4A5	1/3 BAR 4A1d	OVEN DRY 4A1h	COLE WHOLE SOIL 4D1	(- - WATER CONTENT - -) FIELD MOIST 4B4	1/10 BAR 4B1c	1/3 BAR 4B1c	15 BAR 4B2a	WRD WHOLE SOIL 4C1
				<- PERCENT OF <2MM -->						PCT <0.4MM		<- - G/CC - - ->			CM/CM	<- - -PCT OF <2MM - ->				CM/CM
0- 15	37.3	1.149			0.6	0.1	--					0.06				53.0			83.0	
15- 27	31.9	1.204			1.4	0.4	TR					0.25				194.5			73.2	
27- 42	2.01	0.124			1.8	0.1	TR	2.11	0.73				1.48	1.52	0.009			26.2	7.4	0.28
42- 58	0.89	0.075			1.7	0.1	TR	1.82	0.67				1.55	1.58	0.006			14.6	5.5	0.14
58- 80	0.23	0.044			1.5	0.1	TR	1.61	0.68				1.66	1.69	0.006			19.9	3.9	0.27
80-110	0.25	0.046			1.5	0.1	TR	1.74	0.74				1.58	1.62	0.008			21.2	3.7	0.28

DEPTH (CM)	-1-- (- NH4OAC EXTRACTABLE BASES -) CA 5B5a 6N2e	-2-- MG 5B5a 6O2d	-3-- NA 5B5a 6P2b	-4-- K 5B5a 6Q2b	-5-- SUM BASES	-6-- ACID-ITY 6H5a	-7-- EXTR AL 6G9c	-8-- (- - -CEC - - -) SUM CATS 5A3a	-9-- NH4-OAC 5A8b	-10- BASES + AL 5A3b	-11- AL SAT 5G1	-12- -BASE SAT- SUM 5C3	-13- NH4 OAC 5C1	-14- CO3 AS CACO3 <2MM 6E1g	-15- RES. OHMS /CM 8E1	-16-	-17- COND. MMHOS /CM 8I	-18- (- - -PH - - -) KCL 1N 8C1g	-19- CACL2 .01M 8C1f 1:2	-20- H2O 8C1f 1:1
	<- - - - - -MEQ / 100 G									->	<- - - -PCT			- ->						
0- 15	31.6	9.5	0.1	2.2	43.4	97.5	0.5	140.9	105.9	43.9	1	31	41					3.2	3.6	4.0
15- 27	99.7	25.2	0.2	0.3	125.4	73.8		199.2	157.5			63	80					5.1	5.3	5.8
27- 42	14.4	5.9	0.1	0.1	20.5	6.0		26.5	21.3			77	96					5.6	6.2	7.0
42- 58	10.3	4.6	0.1	0.1	15.1	3.1		18.2	14.9			83	100					6.0	6.6	7.4
58- 80	8.4	3.5	0.1	0.2	12.2	0.5		12.7	9.2			96	100	TR				6.9	7.4	8.1
80-110		4.4	0.1	0.2					8.7			100	100	1				7.1	7.5	8.2

ANALYSES: H= HISTOSOL ANALYSES ON 80 MESH SAMPS= ALL ON SIEVED <2mm BASIS

Stop 8. S-3: Ruptic Histoturbel (Turbic Histic Cryosol): valley bottom

S-3 Pedon Description: Ruptic Histoturbel (Turbic Histic Cryosol)

Description Date: 07/01/1991
Describer: Kimble, Ping
Site ID: 91AK090003
Pedon ID: 91AK090003
Pedon Note: Vegetation: tussocks - *carex*, *eriophorum*, *equisitum*, *Betula, Larix, Ledum*, salix, *Picea mariana*, feathermoss, *calamagrostis*, sphagnum. Impermeable below organic mat due to permafrost. Depth to permafrost 14 inches. Cryoturbation and Permafrost at 35 cm
Lab Pedon #: 91P0970
Soil Name as Described/Sampled: snd
Classification: coarse-loamy, mixed, subgelic Ruptic Histoturbel (Turbic Histic Cryosol)
Geomorphic Setting: valley bottom

State: Alaska
County: Fairbanks North Star Borough
Soil Survey Area: AK603 — Fairbanks Area, Alaska
Latitude: 64°52'2.00"N
Longitude: 147°51'19.00"W
Surface Fragments: 0.0%
Diagnostic Features: histic epipedon 0 to 28 cm.
Slope: 1%
Elevation: 152.0 meters
Aspect: 0°
MAAT: -2.2°C **MSAT**: -.8°C
MWAT: — **MAP**: 280 mm
Frost-Free Days: —
Drainage Class: very poorly

Oi— dark reddish brown (5YR 3/2) peat; 95% unrubbed fiber, 90% rubbed; many very fine and fine roots; clear smooth boundary many very fine and fine roots

Oa—very dark brown (10YR 2/2) muck; 50% unrubbed fiber, 15% rubbed; many very fine and fine roots and few medium roots; abrupt smooth boundary. few medium roots; many very fine and fine roots

Bg—very dark grayish brown (2.5Y 3/2) silt loam; massive; very friable, nonsticky, nonplastic; few very fine roots; abrupt smooth boundary. small fragments of organic matter throughout; horizon is 1 to 2 inches thick; 25% fibers; few very fine roots

Oabf—centimeters; very dark grayish brown (10YR 3/2) muck; 35% unrubbed fiber, 10% rubbed; clear smooth boundary. no living roots; many nonliving very fine to medium roots in buried O's

Oebf—dark brown (7.5YR 3/2) mucky peat; 80% unrubbed fiber, 40% rubbed; abrupt smooth boundary. no living roots; many non-living very fine to medium roots in buried O's

Cf—dark olive gray (5Y 3/2) very fine sandy loam; massive; very firm, nonsticky, nonplastic. no living roots; many non-living very fine to medium roots in buried O's

S91AK-090-003

*** P R I M A R Y   C H A R A C T E R I Z A T I O N   D A T A ***
(FAIRBANKS DIVISION, ALASKA)

PRINT DATE 05/20/93

SAMPLED AS : SND ; coarse-loamy, mixed, subgelic Ruptic Histoturbel
REVISED TO : ;

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
SOIL SURVEY LABORATORY
NATIONAL SOIL SURVEY CENTER
LINCOLN, NEBRASKA 68508-3866

SSL - PROJECT 91P 163, (CP91AK223) ALASKA DELTA/FAIRBANKS
- PEDON 91P 970, SAMPLES 91P 6090- 6095
- GENERAL METHODS 1B1A, 2A1, 2B

SAMPLE NO.	DEPTH (CM)	HORIZON	TOTAL CLAY LT .002	TOTAL SILT .002 -.05	TOTAL SAND .05 -2	CLAY FINE LT .0002	CLAY CO3 LT .002	SILT FINE .002 -.02	SILT COARSE .02 -.05	SAND VF .05 -.10	SAND F .10 -.25	SAND M .25 -.50	SAND C .5 -1	SAND VC 1 -2	COARSE FRACTIONS (MM) WEIGHT 2 -5	5 -20	20 -75	.1- 75	(>2MM) WT PCT OF WHOLE SOIL
			<- PCT OF <2MM (3A1)											->	<- PCT OF <75MM(3B1)			->	
91P6090H	0- 0	OI													--	--	--		--
91P6091H	0- 0	OA													--	--	--		--
91P6092M	0- 0	OBs	6.9	75.4	17.7			26.8	48.6	15.8	1.5	0.3	0.1	TR	--	--	--	2	--
91P6093H	0- 0	OABF													--	--	--		--
91P6094H	0- 0	OEBF													--	--	--		--
91P6095H	0- 0	CF	4.5	47.2	48.3			8.8	38.4	42.8	4.7	0.7	0.1	TR	--	--	--	5	--

DEPTH (CM)	ORGN C 6A1c PCT	TOTAL N 6B3a <2MM	EXTR P 6S3 PPM	TOTAL S 6R3a	DITH-CIT EXTRACTABLE FE 6C2b	AL 6G7a	MN 6D2a	(RATIO/CLAY) CEC 8D1	15 BAR 8D1	(ATTERBERG LIMITS) LL 4F1	PI 4F	BULK DENSITY FIELD MOIST 4A3a	1/3 BAR 4A1d	OVEN DRY 4A1h	COLE WHOLE SOIL 4D1	WATER CONTENT FIELD MOIST 4B4	1/10 BAR 4B1c	1/3 BAR 4B1c	15 BAR 4B2a	WRD WHOLE SOIL 4C1
				<- PERCENT OF <2MM -->						PCT <0.4MM		<- - G/CC - - ->			CM/CM	<- - -PCT OF <2MM - ->				CM/CM
0- 0	56.8		1	0.3	0.2	TR	TR												70.6	
0- 0	31.5		1	0.3	1.5	0.2	0.1						0.21	0.89	0.618		293.2	290.5	49.3	0.51
0- 0	4.16		2	TR	0.5	0.1	--	3.00	1.15	43	8		1.08	1.15	0.021		50.8	48.6	7.9	0.44
0- 0	31.1			0.4	1.1	0.4	TR						0.48	0.88	0.224		145.9	145.2	51.1	0.45
0- 0	46.3			0.6	1.1	0.4	TR						0.31	0.50	0.173		252.9	244.8	76.6	0.52
0- 0	1.86			--	0.3	0.1	--	2.71	0.96	26	1		1.44	1.45	0.002		28.5	22.9	4.3	0.27

DEPTH (CM)	NH4OAC EXTRACTABLE BASES CA 5B5a 6N2e	MG 5B5a 6O2d	NA 5B5a 6P2b	K 5B5a 6Q2b	SUM BASES	ACID-ITY 6H5a	EXTR AL 6G9b	CEC SUM CATS 5A3a	CEC NH4-OAC 5A8b	CEC BASES + AL 5A3b	AL SAT 5G1	BASE SAT SUM 5C3	BASE SAT NH4 OAC 5C1	CO3 AS CACO3 <2MM 6E1g	RES. OHMS /CM 8E1	COND. MMHOS /CM 8I	PH NAF 8C1d	PH CACL2 .01M 8C1f 1:2	PH H2O 8C1f 1:1
	<- - - - -MEQ / 100 G - - -									->	<- - - - -PCT - - - ->								
0- 0	34.2	22.7	0.3	1.4	58.6	39.4		98.0	67.0			60	87				6.9	5.1	5.7
0- 0	52.0	20.7	0.3	--	73.0	60.3	26.1	133.3	98.1	99.1	26	55	74				7.9	4.8	5.5
0- 0	10.5	3.8	TR	--	14.3	8.5	--	22.8	20.7			63	69				8.5	5.0	5.6
0- 0	48.6	13.9	0.2	--	62.7	65.9		128.6	98.1			49	64				8.2	5.1	5.4
0- 0	62.6	17.3	0.2	TR	80.1	73.8		153.9	39.3			52	100				8.0	5.1	5.8
0- 0	5.3	2.2	--	TR	7.5	5.9	TR	13.4	12.2			56	61				8.6	4.7	5.1

Stop 9. S-4: Fluventic Historthel (Histic Cryosol): North-facing slope

S-4 Pedon Description: Fluventic Historthel (Histic Cryosol)

Description Date: 08/07/1996

Describer: Kimble, Everett, Ping, Paetzold, Hoey

Site ID: 96AK090003

Pedon ID: 96AK090003

Pedon Note: Many mica flakes throughout.

Lab Pedon #: 96P0367

Soil Name as Described/Sampled: snd

Classification: Coarse-silty, mixed, subgelic Fluventic Historthel (Histic Cryosol)

Geomorphic Setting: on backslope of hills (north facing slope)

State: Alaska

County: Fairbanks North Star Borough

Soil Survey Area: AK603 — Fairbanks Area, Alaska

Latitude: 64°51'56.30"N

Longitude: 147°51'12.90"W

Surface Fragments: 0.0%

Upslope Shape: convex

Cross Slope Shape: convex

Diagnostic Features: histic epipedon 0 to 16 cm cambic horizon 16 to 23 cm.

Slope: 4.0%

Elevation: 154.0 meters

Aspect: 0°

MAAT: -2.8°C **MSAT**: -1.0°C

MWAT: — **MAP**: 280 mm

Drainage Class: poorly

Oi—0 to 16 centimeters; yellowish brown (10YR 5/6) broken face peat; many fine and medium roots throughout and common coarse roots throughout; abrupt smooth boundary.

Bg—16 to 23 centimeters; olive brown (2.5Y 4/3) silt loam; weak fine and medium subangular blocky parting to weak fine and medium granular structure; very friable, slightly hard, nonsticky, nonplastic; many very fine roots throughout; abrupt smooth boundary.

Oab—23 to 37 centimeters; black (10YR 2/1) muck; massive; many very fine roots throughout; gradual smooth boundary.

Af—37 to 47 centimeters; black (10YR 2/1) mucky* silt loam; massive; very friable, slightly hard, nonsticky, nonplastic; common very fine roots throughout; gradual smooth boundary.

Cf1—47 to 54 centimeters; very dark grayish brown (2.5Y 3/2) silt loam; massive; very friable, slightly hard, nonsticky, nonplastic; few very fine roots throughout; gradual smooth boundary. Has 1 to 2 cm ice lenses.

Cf2—54 to 74 centimeters; very dark grayish brown (2.5Y 3/2) silt loam; massive; very friable, slightly hard, nonsticky, nonplastic. 70% ice lenses with a little sill con. better than some areas ice 3-4cm thick.

S96AK-090-003 *** PRIMARY CHARACTERIZATION DATA *** (FAIRBANKS DIVISION, ALASKA)

PRINT DATE 12/09/97

SAMPLED AS :
REVISED TO :

Coarse-silty, mixed, subgelic Fluventic Historthel

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
NATIONAL SOIL SURVEY CENTER
SOIL SURVEY LABORATORY
LINCOLN, NEBRASKA 68508-3866

SSL - PROJECT 96P 72, (CP96AK149) ALASKA - SMITH LAKE
- PEDON 96P 367, SAMPLES 96P 2875- 2880
- GENERAL METHODS 1B1A, 2A1, 2B

SAMPLE NO.	DEPTH (CM)	HORIZON	TOTAL CLAY LT .002	TOTAL SILT .002 -.05	TOTAL SAND .05 -2	CLAY FINE LT .0002	CLAY CO3 LT .002	SILT FINE .002 -.02	SILT COARSE .02 -.05	SAND VF .05 -.10	SAND F .10 -.25	SAND M .25 -.50	SAND C .5 -1	SAND VC 1 -2	COARSE FRACTIONS WEIGHT 2 -5	WEIGHT 5 -20	WEIGHT 20 -75	.1- 75	(>2MM) WT PCT OF WHOLE SOIL
	-1--	-2--	-4--	-5--	-6--	-7--	-8--	-9--	-10-	-11-	-12-	-13-	-14-	-15-	-16-	-17-	-18-	-19-	-20-
			<- PCT OF <2MM (3A1)											->	<- PCT OF <75MM(3B1)->				
96P2875H	0- 16	Oi													--	--	--		--
96P2876S	16- 23	Bg	5.3	63.2	31.5			16.6	46.6	28.6	2.2	0.3	0.2	0.2	--	--	--	3	--
96P2877H	23- 37	Oa													--	--	--		--
96P2878S	37- 47	Oa	5.6	64.3	30.1			26.0	38.3	13.5	10.9	3.2	1.9	0.6	--	--	--	17	--
96P2879S	47- 54	Cf1	12.1	66.2	21.7			28.0	38.2	17.7	2.9	0.9	0.1	0.1	--	--	--	4	--
96P2880S	54- 74	Cf2													--	--	--		--

DEPTH (CM)	ORGN C 6A1c PCT	TOTAL N 6B4a <2MM	EXTR P 6S3b PPM	TOTAL S 6R3c	DITH-CIT EXTRACTABLE FE 6C2b	AL 6G7a	MN 6D2a	(RATIO/CLAY) CEC 8D1	15 BAR 8D1	(ATTERBERG LIMITS) LL 4F1	PI 4F	BULK DENSITY FIELD MOIST 4A5	1/3 BAR 4A1d	OVEN DRY 4A1h	COLE WHOLE SOIL 4D1	WATER CONTENT FIELD MOIST 4B4	1/10 BAR 4B1c	1/3 BAR 4B1c	15 BAR 4B2a	WRD WHOLE SOIL 4C1
			PPM	<- PERCENT OF <2MM -->						PCT <0.4MM		<- - G/CC - - ->			CM/CM	<- - -PCT OF <2MM - ->				CM/CM
0- 16	49.0	1.231			0.1	TR	--					0.09				151.5			116.7	
16- 23	1.83	0.097			1.0	0.1	TR	2.66	1.09				1.56	1.59	0.006			21.8	5.8	0.25
23- 37	44.5	1.742											0.51	0.74	0.132			142.1	92.5	0.47
37- 47	17.5	0.961			0.8	0.3	TR	13.79	5.23				0.70	0.89	0.083			91.9	29.3	0.44
47- 54	4.71	0.273			0.2	0.1	--	1.97	0.77										9.3	
54- 74					--	--	--													

DEPTH (CM)	NH4OAC EXTRACTABLE BASES CA 5B5a 6N2e	MG 5B5a 6O2d	NA 5B5a 6P2b	K 5B5a 6Q2b	SUM BASES	ACIDITY 6H5a	EXTR AL 6G9c	CEC SUM CATS 5A3a	NH4-OAC 5A8b	BASES + AL 5A3b	AL SAT 5G1	BASE SUM 5C3	SAT- NH4 OAC 5C1	CO3 AS CACO3 <2MM 6E1g	RES. OHMS /CM 8E1	COND. MMHOS /CM 8I	PH KCL 1N 8C1g	CACL2 .01M 8C1f 1:2	H2O 8C1f 1:1
	-1--	-2--	-3--	-4--	-5--	-6--	-7--	-8--	-9--	-10-	-11-	-12-	-13-	-14-	-15-	-16-	-18-	-19-	-20-
	<- - - - -MEQ / 100 G - - - ->										<- - -PCT - - ->								
0- 16	21.2	11.9	0.2	3.6	36.9	93.8	0.3	130.7	99.1	37.2	1	28	37				3.2	3.5	3.9
16- 23	8.5	3.5	0.1	0.1	12.2	5.7		17.9	14.1			68	87				5.1	5.7	6.4
23- 37	131.3	30.6	0.5	0.2	162.6	65.8		228.4	191.2			71	85				5.3	5.6	6.1
37- 47	53.8	13.3	0.2	0.1	67.4	39.1		106.5	77.2			63	87				5.5	5.9	6.5
47- 54	15.8	4.8	0.2	0.1	20.9	12.3		33.2	23.8			63	88				5.2	5.6	6.4
54- 74																			

ANALYSES: H= HISTOSOL ANALYSES ON 80 MESH SAMPS= ALL ON SIEVED <2mm BASIS

July 18, 2006 Tuesday

Introduction to the boreal forest ecosystem, geomorphology, cryogenic features, and linear development on permafrost terrain.

Stop 10. Dalton Highway Mile Post 55.5 Yukon River Crossing: Lunch stop and view of the Alaska Pipeline Yukon River bridge crossing.

Stop 11. Finger Mountain Mile Post 98: alpine ecosystem and sorted circles, solifluction lobes, cryoplanation, and block torres.

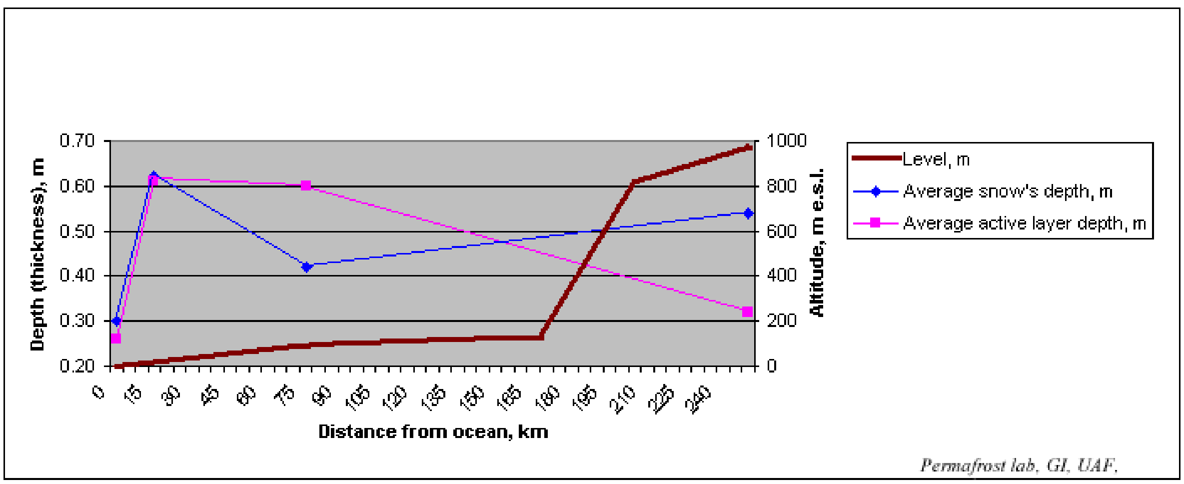
Stop 12. Arctic Circle Mile Post 115 (66°33'24.9"N) photo stop.

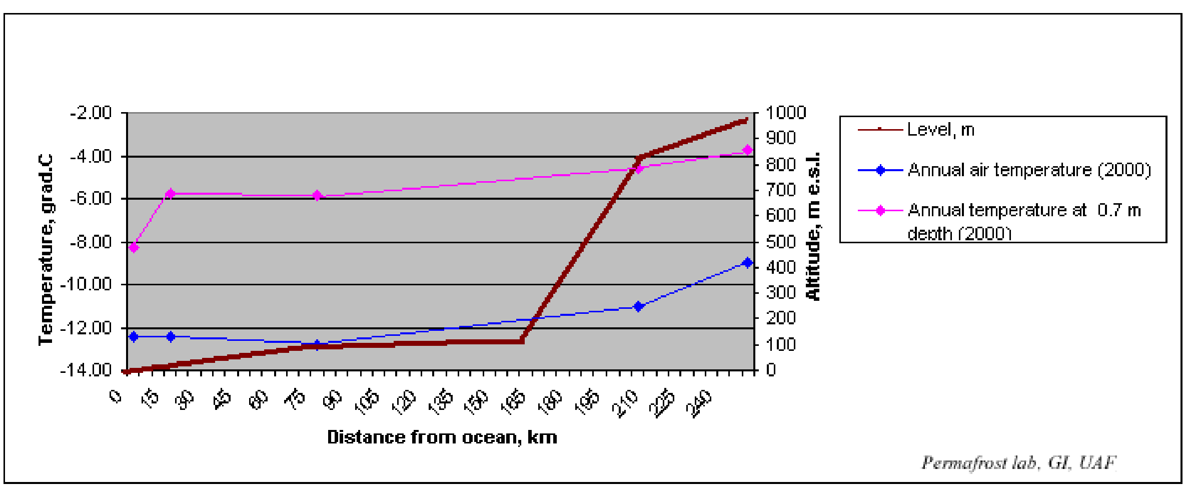
Stop 13. Coldfoot, Gas Station Mile Post 175.

Stop 14. Atigun Pass Brooks Range, continental divide (elev. 5000'/1524m), photo stop.

Overnight at Toolik Field Research Station

Temperatures, and depth of snow and active layer on the north slope of Alaska

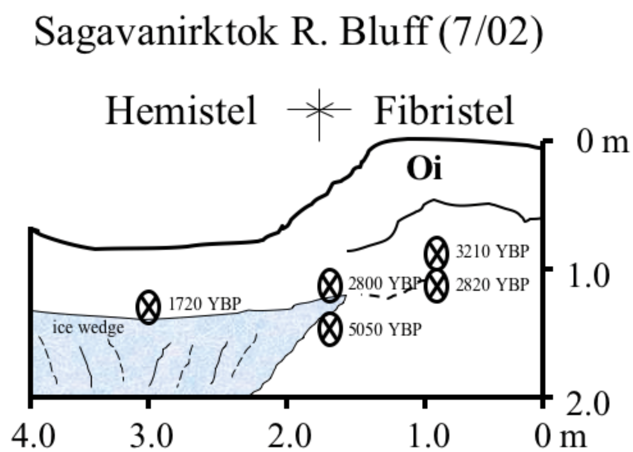




July 19, 2006 Wedneday

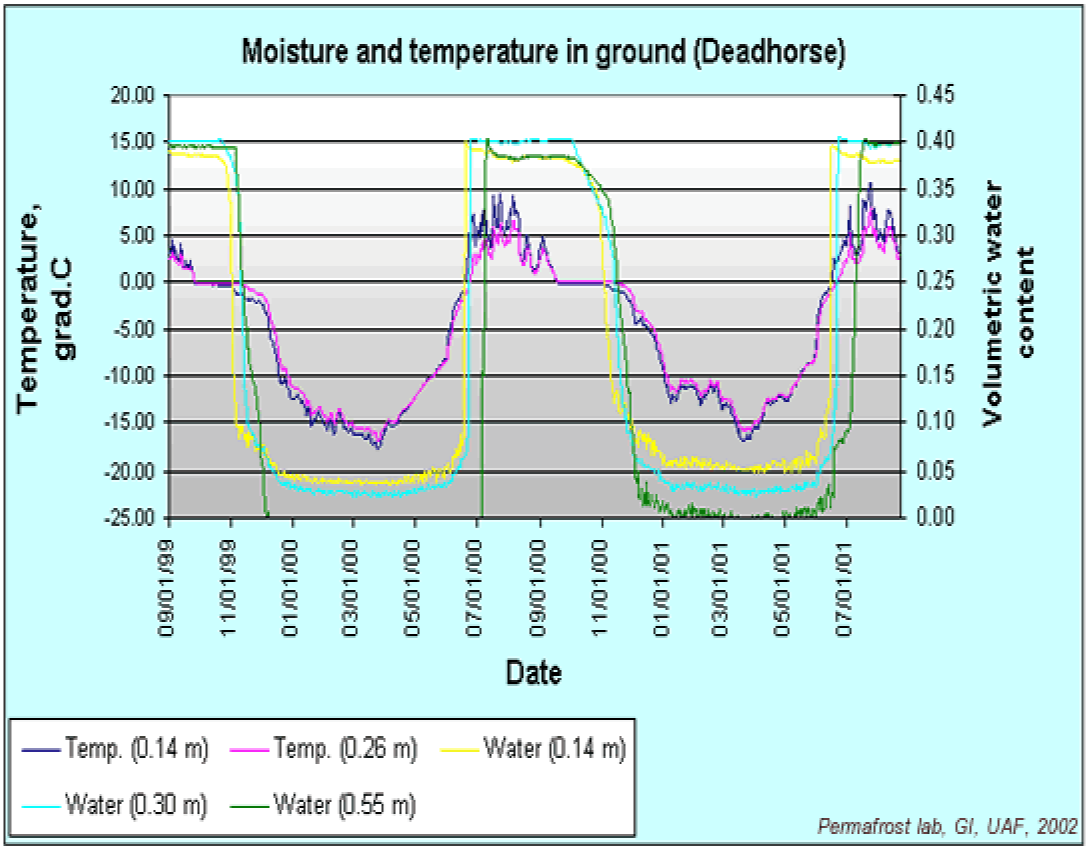
Stop 15. Prudhoe Bay Oilfield and Arctic Ocean coast, Lunch at Sagavanirktok River Bluff Mile Post 412, just south of Deadhorse.

Stop 16. S-5: Sagavanirktok River bank erosion, ice wedge features and thermal degradation of polygons.

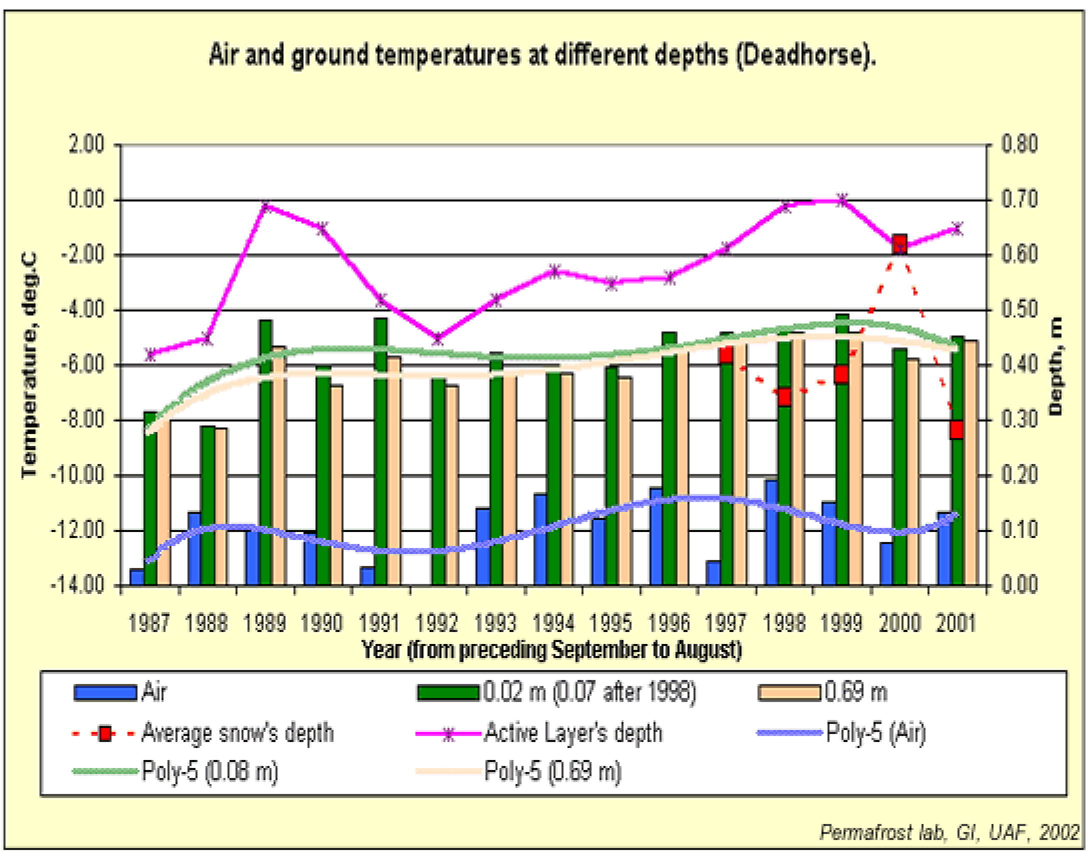


S-5: Sagavanirktok River bank, above.

Detail showing ice wedge features, right.



Deadhorse, AK: Ground liquid-water content with temperature (top) and ground temperature with air temperature (bottom)



Stop 17. S-6: Fluvaquentic Historthel (Histic Cryosol) in low center polygons.

S-6 - Pit: Fluvaquentic Historthel (Histic Cryosol)

Pipeline Mile Post 20

S-6 Pedon Description: Fluvaquentic Historthel (Histic Cryosol)

DATE Sampled: 08/22/2003
USDA-NSSC Site Identification: 03AK-185-004
Lab Pedon #: 04N0276
Soil Survey Area #: 185 Arctic Coastal Plain
Latitude: 69°59.046'N
Longitude: 148°41.619'W
W0432662 UTM 7187078 Zone 6
Slope: 0%
Aspect: 0
Horizontal Shape: plane
Vertical Shape: plane
Elevation: 37 m asl
Physiography: Arctic Coastal Plain
Local: flood plain
Geomorphic Position: River terrace
Microtopography: low-centered polygon, 9-15 m dia.
Parent Material and or/Bedrock Information
Parent material: alluvium

Landcover type: wet nonacidic tundra
Plant Names: *Carex aquatis, Salix arctica, S.reticulata, Eriophrum vaginatum, Dryas integrifolia* M. Vahl, *Arctostaphylos rubra*, and mosses
Drainage: very poor
Runoff: negligible
Climate: **MAP**: 250 mm, est. **MAAT**: -2°C est. **MAST**: - 5.5°C
Type of Erosion: none
Degree of Erosion: none
Classification: Coarse-loamy, mixed, hypergelic Fluvaquentic Historthel (Histic Cryosol)
Land use: wildlife habitat
Described and sampled by: C.L. Ping, John Kimble, Gary Michaelson, Patrick Borden, Lynn Everett, E.C. Packee, Carolyn Rosner, C.A. Seybold (all colors are for moist unless specified)

Oi — 0 to 2 cm; peat; abrupt smooth boundary

Oe — 2 to 18 cm; very dark grayish brown (10YR 3/2) mucky peat; weak, medium platy structure; very friable, nonplastic and nonsticky; many fine roots; abrupt smooth boundary (AK03094)

Bg1 — 18 to 30 cm; dark gray (2.5Y 4/1) mucky fine sandy loam; saturated; weak coarse platy structure; very friable, slightly stick and slightly plastic; many fine roots; abrupt smooth boundary (AK03095)

Oe' — 30 to 40 cm; very dark gray (10YR 3/1) muck peat; massive (wet); very friable, nonstick and nonplastic; many fine roots; 0.5 cm sand lens at the bottom; abrupt wavy boundary (AK03096)

Bg2 – 40 to 45 cm; dark gray (2.5Y 4/1) fine sandy loam; massive, saturated; slightly firm, slightly stick and slightly plastic; abrupt smooth boundary (AK03097)

Bgf – 45 to 60 cm; dark gray (5Y4/1) sandy loam; massive; extremely firm (frozen), nonstick and nonplastic; vertical ice veins 2mm thick and 4-5 cm apart; abrupt irregular boundary (AK03098)

Cf/Oejj — 60 to 70 cm; 60% dark gray (5Y 4/1) loamy sand and 40% very dark gray (10YR 3/1) muck; common, medium (3-4 mm in dia.) distinct (7.5YR 3/1) Fe concentrations around root channels and root remains; strong fine reticulate structure with vein ice of 2-3 mm thick in Cf and thin ice lens (1mm) in massive Oejj, extremely firm (frozen), nonsticky and nonplastic; abrupt wavy boundary (AK03099)

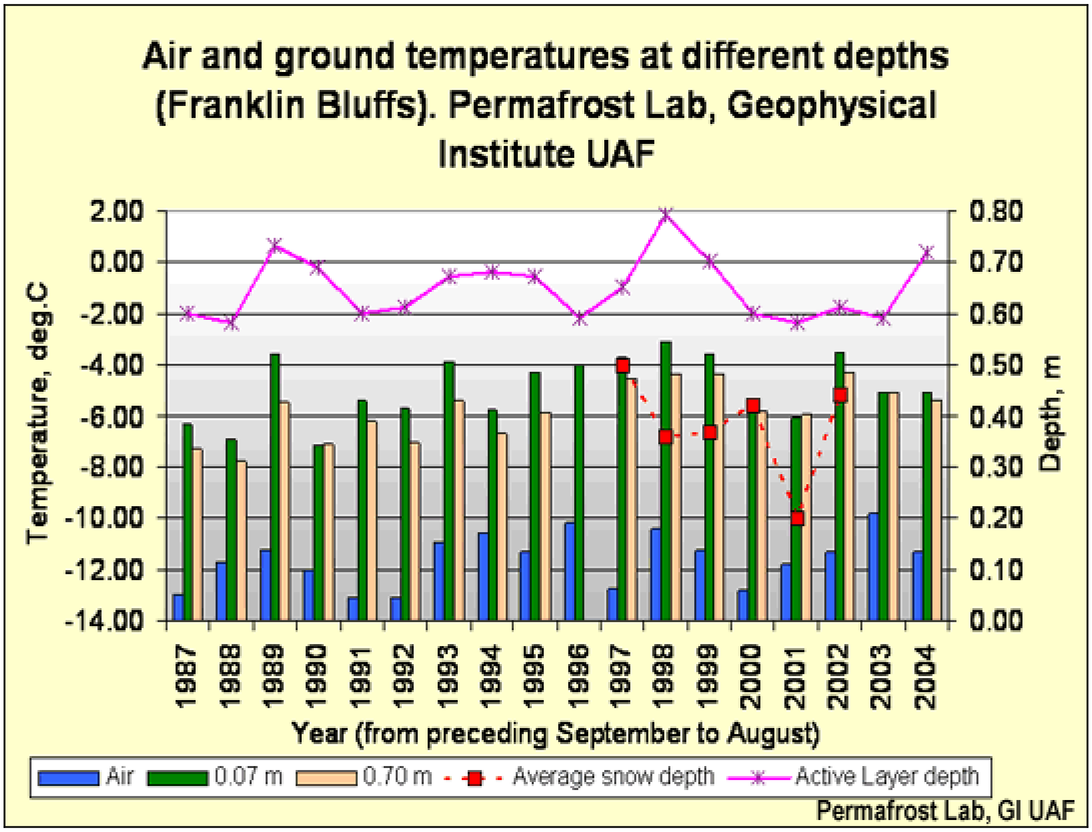
Oabf — 70 to 95 cm; very dark gray (7.5YR 3/1) muck with 1 cm light gray (10YR 7/1) band of shell; massive; extremely firm (frozen), nonsticky and nonplastic; abrupt smooth boundary (AK030100)

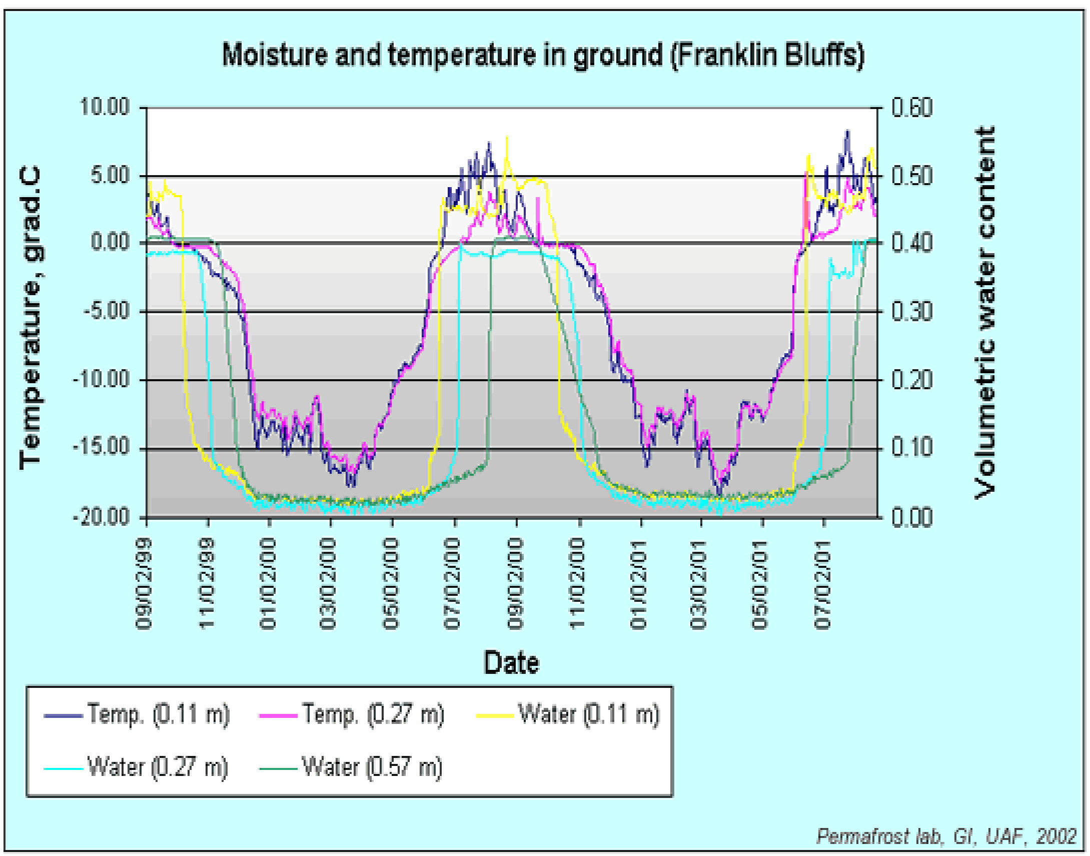
Cf/Wfm — 95 to 110 cm; dark gray (5Y 4/1) sandy loam; massive; moderate medium reticular structure; extremely firm (frozen), nonstick and nonplastic; 3% pebbles; 45% vein ice as ice net (AK030101)

Low Centered Polygons - Pipeline Mile 20

Hor.	Hor. Depth	Paste pH	E.C.	C	N	Sand	Silt	Clay	CEC	K	Ca	Mg	Na	Inorg. Carbon	>2 mm	P
	cm		ds	---------------------%--------------------					------------meq/100g soil------------					%	%	mg/kg
Oe	2 - 18	7.63	0.35	7.11	0.18	73.6	20.8	5.6	12.16	0.10	41.4	0.50	0.10	1.42	<1	1
Bg1	18 - 30	7.68	0.29	7.65	0.20	56.8	36.8	6.4	9.97	0.05	42.4	0.45	0.08	0.86	<1	<1
Oe'	30 - 40	7.65	0.25	10.67	0.40	68.8	24.8	6.4	13.71	0.03	44.6	0.44	0.09	1.48	<1	<1
Bg2	40 - 45	7.76	0.33	6.30	0.18	44.8	41.6	13.6	14.49	0.02	36.0	0.40	0.07	0.84	<1	<1
Bgf	45 - 60	7.58	0.35	6.37	0.19	60.8	33.6	5.6	14.23	0.02	36.0	0.50	0.06	0.65	<1	<1
Cf/Oejj	60 - 70	7.65	0.33	9.28	0.53	56.8	37.6	5.6	16.29	0.02	41.1	0.58	0.04	0.45	<1	<1
Oabf	70 - 95	7.30	0.38	12.84	0.90	52.8	41.6	5.6	26.92	0.02	48.0	0.84	0.09	0.49	<1	1
Cf/Wfm	95 -110	7.53	0.35	7.51	0.36	44.8	45.6	9.6	18.58	0.02	40.9	0.70	0.08	0.53	<1	1

Coastal Plain Franklin Bluffs, AK: Ground temperature with air temperature (top) and ground liquid-water content with temperature (bottom)





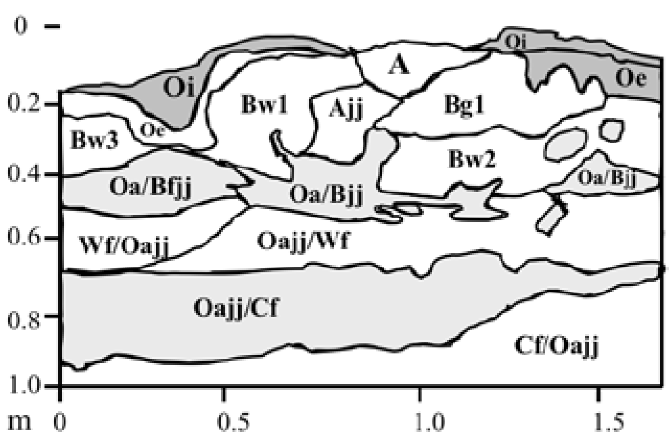
July 20, 2006 Thursday

Stop 18. S-7: Sagwon Hills Mile Post 357, Ruptic-Histic Aquiturbel (Turbic Histic Cryosol) soils associated with moist nonacidic tundra.

Stop 19. S-8: Ruptic-Histic Aquiturbel (Turbic Histic Cryosol), soils associated with moist acidic tundra.

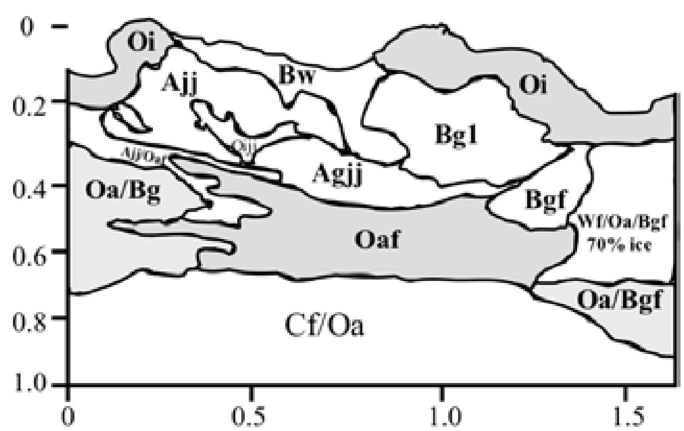
S-7

Sagwon MNT 7-26-02



S-8

Sagwon MAT 7-25-02



S-7 Pedon Description: Ruptic-Histic Aquiturbel (Turbic Histic Cryosol)

DATE Sampled: 07/26/2002
Soil Series: Sagwon MNT3
Location Information:
- **Latitude**: 69°20'25.0"N
- **Longitude**: 148°44'58.4"E

Slope Characteristic Information:
- **Slope**: 7%
- **Aspect**: 315°
- **Horizontal Shape**: slightly convex
- **Vertical Shape**: slightly convex

Landcover type: moist nonacidic tundra
Type of Erosion: none
Degree of Erosion: none

Physiography:
- **Major**: Arctic Foothills
- **Local**: Rolling hills

Geomorphic Position: side slope
Microtopography: hummocky, frost boils, tussocks
Surface stones: none
Parent material: loess over glacial till
Runoff: negligible
MAP: 300 mm, est. **MAAT**: -5°C est.
MAST: -3°C est.
Classification: Coarse-loamy, mixed, pergelic, Ruptic-Histic Aquiturbel (Turbic Histic Cryosol)

Vegetative Information

Plant Names:

Circle: *Vaccinium vitis-ideae, Cassiope tetragonae, Senecio atropurpurescens, Cladonia stygia, Cetraria cuculata, Dryas integrifolia, Tofieldia coccinea, Petisites frigida, Racomitrium lan., Eriophorum vaginatum, Carex membranaceae, Silene acaulis, Cladonia* sp.

Intercircle: *Salix reticulata, Vaccinium vitis-ideae, Cassiope tetragonae, Minuartia arctica, Thamnolia subuliformis, Cetraria cuculata, Carex bigelowii, Carex membranaceae, Hylocomium splendens, Peltigera* sp., *Eriophorum vaginatum, Tomentypnum nitens, Vaccinium uligunosum, Polygonum bistorta*.

Described and sampled by: P. Borden, A. Kade, G. Michaelson, C.L. Ping, C.A. Stiles, and L. Zhu.

Circle:

Oi – 0 to 2 cm; very dark brown (7.5YR 2.5/3); peat; few medium, many fine and very fine roots; clear wavy boundary. (0-13 cm) (1)

Oe – 2 to 4 cm; black (7.5 YR 2.5/1); mucky peat; common fine and very fine roots; abrupt broken boundary. (0-8 cm) (2)

A – 0 to 6 cm; matrix: dark brown (10YR 3/3) root channel: dark yellowish brown (10YR 4/4); silt loam; massive (wet); friable, slightly sticky and plastic; common very fine roots; clear broken boundary. (0-6 cm) (4)

Bw1 – 4 to 25 cm; matrix: (90%) dark grayish brown (10YR 4/2); root channel (10%) yellowish brown (10YR 5/6); silt loam; weak medium subangular blocky structure; friable; slightly sticky and plastic; few medium, many fine and very fine roots; clear broken boundary. (0-25) (3)

Bg1 – 6 to 27 cm; matrix: (96%) very dark grayish brown (10YR 3/2); mottle oxidized: (2%) dark yellowish brown (10YR 4/4); mottle reduced: (2%) dark grey (2.5Y 4/1); silt loam; massive (wet); saturated, slightly sticky, moderately plastic; common medium, many fine and very fine roots; reacts weakly to α'α'-dipyridyl, clear broken boundary; (0-25 cm) (5)

Bw2 – 27 to 43 cm; dark olive brown (2.5 Y 3/3); silt loam; strong medium to fine lenticular structure; slightly sticky, moderately plastic; common medium, many fine and very fine roots; abrupt broken boundary. (0-20 cm) (7)

Ajj – 21 to 43 cm; very dark grayish brown (2.5Y 3/2); silt loam; moderate fine to medium granular structure; slightly sticky and plastic; few medium, many fine to very fine roots; clear broken boundary. (0-25 cm) (6)

OAfjj – 43 to 72 cm; strong brown (7.5 YR 4/6); very dark grayish brown (10YR 3/2); mucky sandy loam; strong fine lenticular structure; extremely firm; slightly stick and plastic; 12% gavel; 60-70% ice; abrupt wavy boundary. (15-20 cm) (10)

Oa/BCgf – 72 to 92 cm; Oa: dark brown (7.5YR 3/2), muck; BCgf dark grey (2.5Y 4/1); sandy loam; weak fine lenticular structure; extremely firm; slightly sticky and plastic; reacts strongly to α'α'-dipyridyl; clear wavy boundary. (18-25 cm) (11)

2Cf/Oafjj – 92 to 105 cm; 2CF: very dark grey (2.5Y 3/1); sandy loam; Oafjj: dark grey (2.5Y 4/1); muck; transition from strong medium to fine lenticular to reticular structure; extremely firm, slightly sticky and plastic, 70% ice.

Intercircle:

Oi – 8 to 22 cm; very dark brown (7.5YR 2.5/3); peat; few medium, many fine and very fine roots; clear wavy boundary. (0-15 cm) (1)

Oe – 22 to 32 cm; black (7.5 YR 2.5/1); mucky peat; common fine and very fine roots; abrupt broken boundary. (0-12 cm) (2)

Bw3 – 20 to 39 cm; very dark grayish brown (10YR 3/2); silt loam; weak fine lenticular structure; saturated, slightly sticky and plastic; few fine and abundant very fine roots; abrupt broken boundary. (0-20 cm) (8)

Oaf/Bgfjj – 39-50 cm; Oaf: (80%) black (10YR 2/1); mucky; Bgfjj: (20%) very dark grayish brown (2.5Y 3/2); silt loam; strong very fine lenticular structure; extremely firm; slightly sticky and plastic; abrupt broken boundary. (0-16 cm) (9)

Wf/Oa – 39-70 cm; (0-20) (11)

Oa/BCgf – 72 to 92 cm; Oa: dark brown (7.5YR 3/2), muck; BCgf dark grey (2.5Y 4/1); sandy loam; weak fine lenticular structure; extremely firm; slightly sticky and plastic; reacts strongly to α'α'-dipyridyl; clear wavy boundary.

2Cf/Oafjj – 92 to 105 cm; 92 to 105 cm; 2CF: very dark grey (2.5Y 3/1); sandy loam; Oafjj: dark grey (2.5Y 4/1); muck; transition from strong medium to fine lenticular to reticular structure; extremely firm, slightly sticky and plastic, 70% ice.

Stop 19. S-8: Ruptic-Histic Aquiturbel, Moist Acidic Tundra

S-8 Pedon Description: Ruptic-Histic Aquiturbel

DATE Sampled: 07/25/2002
Soil Series: Sagwon MAT2
Location Information
Latitude: 69°25.505"N
Longitude: 148°41.714"W
Physiography:
Major: Arctic Foothills
Local: Rolling hills
Geomorphic Position: side slope
Microtopography: hummocky, frost boils, tussocks
Surface stones: none
Parent material: loess

Runoff: negligible
MAP: 300mm, est. **MAAT**: -5°C est.
MAST: -3.3°C est.
Type of Erosion: none
Degree of Erosion: none
Slope Characteristic Information
Slope: 5%
Aspect: 350°
Horizontal Shape: convex
Vertical Shape: convex
Classification: Coarse-loamy, mixed, pergelic, Ruptic-Histic Aquiturbel (Turbic Histic Cryosol).

Vegetative Information

Landcover type: moist acidic tundra

Plant Names:

Circle: *Ledum decumbens, Racomitrium lan, Betula nana, Vaccinium vitis-ideae, Cassiope tetragonae, Eriophorum vaginatum, Polygonum viviparum, Dactylina arctica, Cetraria cuculata, Cladonia stygia*.

Intercircle: *Ledum decumbens, Betula nana, Salix arctica, Vaccinium vitis-ideae, Cassiope tetragonae, Polygonum bistorta, Eriophorum vaginatum, Hylocomium splendens, Sphagnum* sp., *Peltigera* sp.

Described and sampled by: P. Borden, A. Kade, G. Michaelson, C.L. Ping, C.A. Stiles, and L. Zhu.

Circle

Oi1 – 0 to 12 cm; very dark gray (10YR 3/1); peat; abrupt broken boundary. (0-15 cm)

Bg1 – 12 to 35 cm; matrix: dark yellowish brown (10YR 3/4); root channels: dark reddish gray (2.5YR 4/1); fine sandy loam; firm, slightly sticky and plastic; many fine roots; clear wavy boundary. (0-25 cm)

Bg2 – 35 to 40 cm; oxidized (50%): yellowish brown (10YR 5/6) and dark brown (10YR 3/3), gleyed (50%): gray (2.5Y 5/1) and very dark gray (2.5Y 3/1); fine sandy loam; weak medium to coarse blocky structure; firm, slightly sticky and plastic; few fine roots; reacts weakly to α'α'-dipyridyl; abrupt broken boundary. (0-20 cm)

A/**Bjj** – 20 to 40 cm; A: 55%; very dark grayish brown (10YR 3/2); B: 45%; yellowish brown (10YR 5/6); sandy loam; friable, slightly sticky and plastic; few fine roots; abrupt broken. (0-20 cm)

Oajj – 40 to 45 cm; black (7.5YR 2.5/2); muck; weak medium granular structure; very friable; abrupt broken boundary. (0-10 cm)

Oa/Bg1 – 45 to 62 cm; Oa (70%): very dark brown (7.5YR 3/2); muck (66%) and peaty muck (34%); 1% pebbles, fine to medium woody fragments; Bg1 (30%): dark gray (2.5Y 4/1); sandy loam; strong fine to medium lenticular structure; 60% ice; reacts strongly to α'α'-dipyridyl; abrupt smooth. (20-30 cm)

Oaf – 56 to 70 cm; very dark gray (10YR 3/2); muck; strong very fine to medium lenticular structure; frozen; abrupt broken boundary. 0-15 cm)

Cf/Oaf – 70 to 105 cm; Cf (70%): matrix (90%): dark gray (2.5Y 5/1) and organic (10%): brown (7.5YR 4/2); sandy loam; strong medium lenticular structure; 5% pebbles; 75% ice; Oaf (30%): very dark gray (7.5YR 3/1); muck; moderate medium reticular and lenticular; 1% pebbles; 70% ice; reacts strongly to α'α'-dipyridyl; abrupt wavy boundary. (30-35 cm)

2Cf – 105 to 130 cm; gray (2.5Y 5/1); sandy loam; strong medium reticular structure; slightly sticky and plastic; 10% organic material: dark brown (7.5YR 3/2); 5% pebbles.

Intercircle:

Oi2 – 0 to 15 cm; very dark gray (7.5YR 3/2); peat; few coarse, many medium, fine and very fine roots; abrupt broken boundary. (0-15 cm)

Oe – 15 to 28 cm; very dark brown (10YR 2/2); peaty muck; common fine and very fine roots; abrupt broken boundary. (0-12 cm)

Bg2 – 28 to 35 cm; oxidized (50%): yellowish brown (10YR 5/6) and dark brown (10YR 3/3), gleyed (50%): gray (2.5Y 5/1) and very dark gray (2.5Y 3/1); fine sandy loam; weak medium to coarse blocky structure; firm, slightly sticky and plastic; few fine roots; reacts weakly to α'α'-dipyridyl; abrupt broken boundary. (0-15 cm)

Oaf/Bg2f – 35 to 60 cm; Oa (70%): very dark brown (7.5YR 3/2); muck (66%) and peaty muck (34%); 1% pebbles, fine to medium woody fragments; Bg1 (30%): dark gray (2.5Y 4/1); sandy loam; strong fine to medium lenticular structure; 70% ice; reacts strongly to α'α'-dipyridyl; abrupt smooth boundary. (0-20 cm)

Cf/Oaf – 60 to 105 cm; Cf (70%): matrix (90%): dark gray (2.5Y 5/1) and organic (10%): brown (7.5YR 4/2); sandy loam; strong medium lenticular structure; 5% pebbles; 75% ice; Oaf (30%): very dark gray (7.5YR 3/1); muck; moderate medium reticular and lenticular; 1% pebbles; 70% ice; reacts strongly to α'α'-dipyridyl; abrupt wavy boundary. (30-35 cm)

2Cf – 105 to 130 cm; gray (2.5Y 5/1); sandy loam; strong medium reticular structure; slightly sticky and plastic; 10% organic material: dark brown (7.5YR 3/2); 5% pebbles.

Overnight at Toolik Lake Field Research Station

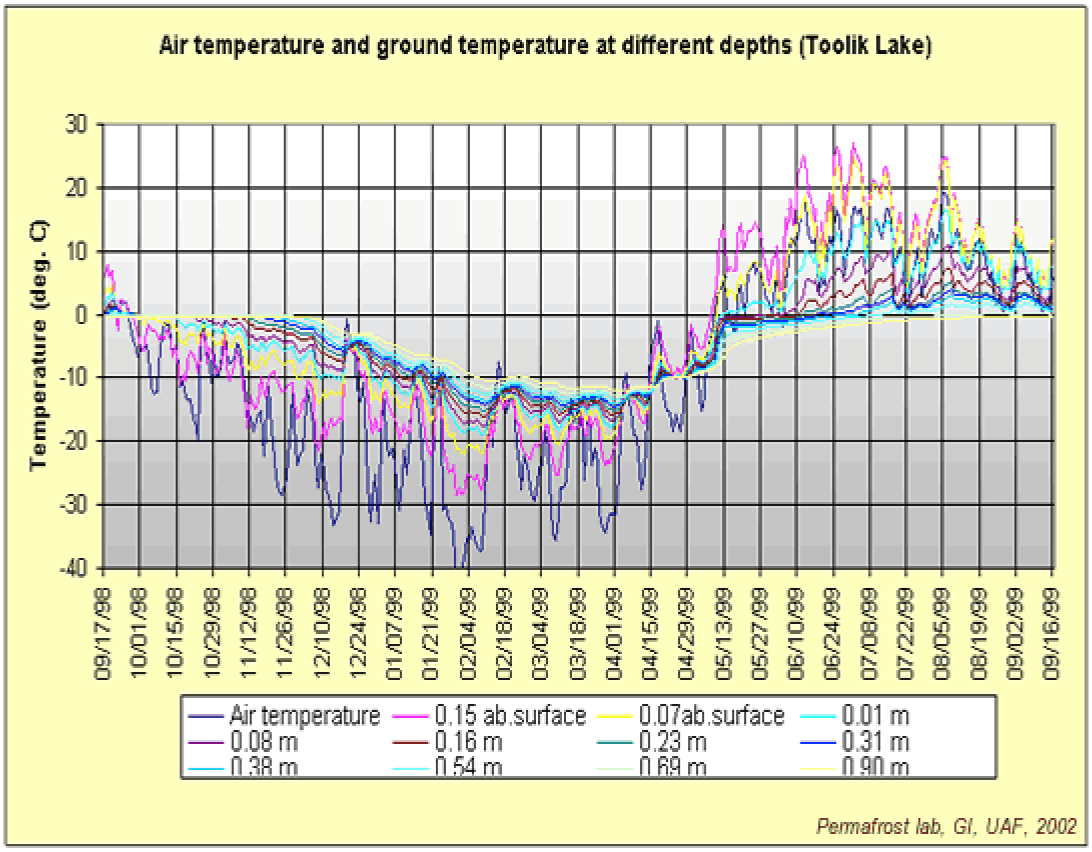
SOILS DATA

2001 Biocomplexity: Frostboil Project

Selected soil chemical and physical properties

Soil		1:1	Extr.	Extr.	Extr.						Base			USDA	<2mmwt.			Total			>2mm
Horizon	depth	pH	NH4-N	NO3-N	P	CEC	Ca	Mg	Na	K	Sat.	[H2O]	BD	Texture	Clay	Silt	Sand	C	N	[H2O]	wt.
	cm		mg kg-1	mg kg-1	mg kg-1	------me 100g-1-----					%	%wt.	g cm-1		%	%	%	%	%	%vol.	%
MNT SAGWON (7-26-02) 69°20'25.9"N 148°44'58.4"W																					
Oi	0-25	5.32	12.0	2.0	58	82	59	6	0.2	1.9	81	245	0.09	PEAT	na	na	na	40.41	1.07	22	<.1
Oe	0-15	6.71	16.0	2.0	34	99	95	9	0.2	1.2	100	340	0.11	PEAT	na	na	na	37.12	1.56	38	<.1
Bw1	2-32	6.70	1.0	1.0	<1	28	25	2	0.1	0.2	96	38	1.29	L	19	50	32	3.36	0.25	48	3
A	0-10	6.62	1.0	1.0	<1	26	24	2	0.1	0.2	100	37	1.49	SIL	21	53	26	3.43	0.25	55	3
Bg1	2-25	6.81	1.0	1.0	<1	28	26	2	0.1	0.2	98	41	1.28	SIL	21	57	22	3.25	0.26	52	2
Ajj	10-28	6.83	1.0	1.0	2	36	37	2	0.1	0.2	100	-	-	SIL	14	61	25	4.82	0.36	-	2
Bw2	18-40	6.62	1.0	1.0	<1	29	26	2	0.0	0.3	96	-	-	SIL	22	57	21	3.77	0.28	-	2
Bw3	22-40	6.77	2.0	1.0	<1	31	29	2	0.1	0.2	98	-	-	SIL	22	53	25	4.05	0.28	-	1
Oa/Bfjj	30-52	6.83	3.0	1.0	1	40	34	2	0.0	0.3	91	-	-	-	na	na	na	7.26	0.47	-	4
Wf/Oa	50-72	7.20	4.0	1.0	0	35	38	2	0.0	0.3	100	-	-	-	na	na	na	6.32	0.41	-	10
Oa/Cgf	65-95	7.65	8.5	1.5	3	34	62	2	0.1	0.3	100	-	-	-	na	na	na	8.19	0.44	-	41
Cf/Oajj	76-100+	7.64	28.0	1.0	1	16	49	6	0.2	0.2	100	77	0.48	-	na	na	na	4.96	0.21	36	19
MAT SAGWON (7-25-02) 69°25.505'N 148°41.714'W																					
Oi tussock	0-12	4.29	12	1	24	49	11	2.3	0.2	0.7	29	453	0.11	PEAT	-	-	-	18.8	0.49	49	<.1
Bg1	12-35	5.13	5	1	<1	24	6	0.9	0.1	0.1	28	34	1.60	SIL	17	54	29	4.3	0.25	54	<.1
Ajj/Oaf	25-52	5.41	15	1	<1	40	18	2.2	0.1	0.1	52	137	0.51	-	-	-	-	10.2	0.57	70	<.1
Oa/Bg	38-63	5.32	8	1	<1	36	15	1.8	0.1	0.1	47	206	0.38	-	-	-	-	7.6	0.43	79	<.1
Agjj	18-42	5.22	5	1	<1	38	13	1.4	0.1	0.1	38	67	0.84	SIL	10	59	32	8.9	0.50	56	1
Oaf	55-66	4.99	9	<1	<1	44	17	1.6	0.1	0.1	42	125	0.64		-	-	-	10.7	0.60	79	4
Bgf	27-47	5.27	2	<1	<1	26	8	1.1	0.1	0.1	37	67	1.00	L	16	46	38	4.8	0.30	66	1
Oa/Bgf Ataxatic	40-62	5.16	22	<1	<1	39	24	2.2	0.1	0.3	69	248	0.27	-	-	-	-	8.7	0.53	66	6
Oa/Bgf	36-72	5.68	18	<1	<1	49	30	2.9	0.1	0.3	67	173	0.41	-	-	-	-	8.8	0.52	71	4
Cf/Oa	70-105	7.53	30	1	<1	32	42	2.0	0.1	0.3	100	-	-	SIL	17	57	26	5.0	0.30	-	3
Oi2 interboil	0-18	5.24	12	1	52	76	46	6.9	0.1	1.8	72	199	0.45	PEAT	-	-	-	32.1	0.86	89	<.1
Oe interboil	18-30	5.66	10	2	32	84	54	6.5	0.1	0.9	74	268	0.08	PEAT	-	-	-	37.2	1.11	20	<.1
2Cf	105+	7.52	17	1	1	20	30	4.7	0.1	0.2	100	34	0.71	SIL	13	57	30	6.9	0.29	24	20

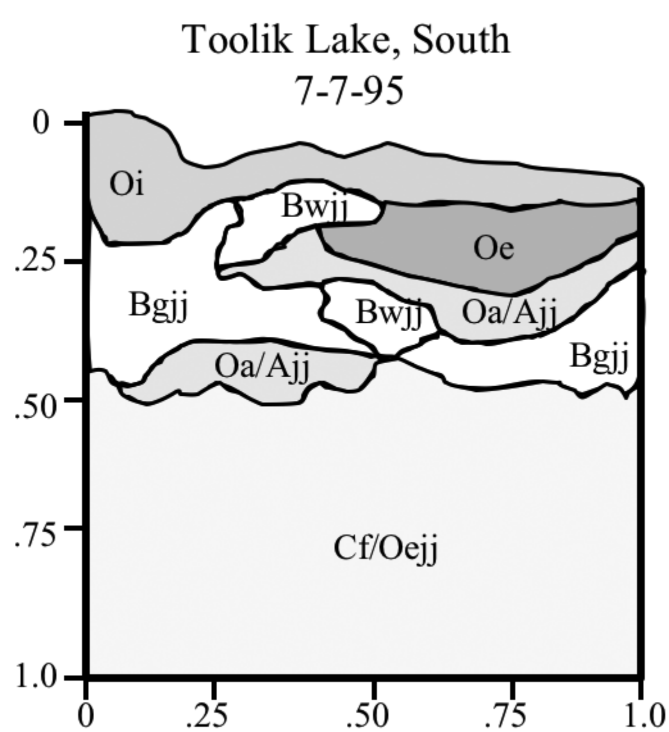
Toolik Lake air and ground temperatures.



S-9: Ruptic-Histic Aquiturbel (Tubic Histic Cryosol)

July 21, 2006 Friday

Stop 20. S-9: Toolik Lake Field Research Station, Ruptic-Histic Aquiturbel, (Tubic Histic Cryosol) moist acidic tundra younger surface (13-11 ka BP).



S-9 Pedon Description: Ruptic-Histic Aquiturbel (Turbic Histic Cryosol) Toolik Lake—South

Description Date: 07/07/1995
Describer: Kimble, Ping
Site ID: 95AK185
Pedon ID: 95AK185007007
Pedon Note: 5) ramge 5-20. 4) No free water today except from thawed Cf. 3) Frozen at about 20cm today. Horizon thickness range and % area: Oi=4-20; Oe=0-4; Oa/A=0-15; Bw=0-15; Bg=5-15. Tussocks 10-15cm high 30% of area; moss hummocks ~10cm high, 5m diameter 40% of area mudboils .5m diameter irregular shapes 5% of area.
Lab Pedon #: 95P0632
Soil Name as Described/Sampled: Toolik Site 6
Classification: Fine-loamy, mixed, pergellic Ruptic-Histic Aquiturbel (Turbic Histic Cryosol)
Geomorphic Setting on footslope of ground moraine Itkillik II (13-11 ka BP)

State: Alaska
County: North Slope Borough
Soil Survey Area: 185
Latitude: 68°37'27.50"N
Longitude: 149°37'0.20"W
Surface Fragments: 0.0%
Upslope Shape: concave
Cross Slope Shape: concave
Diagnostic Features:
Slope: 8.0%
Elevation: 741.0 meters
Aspect: 315°
MAAT: -4.9°C **MSAT**: -3.9°C
MWAT: -7.7°C **MAP**: 380 mm
Frost-Free Days: —
Drainage Class: poor

Oi—0 to 4 centimeters; dark brown (7.5YR 3/2) and yellowish brown (10YR 5/6) peat; clear wavy boundary. 10YR 5/6 is sphagnum peat.

Oe—4 to 8 centimeters; black (10YR 2/1) and dark brown (10YR 3/3) muck; many fine to coarse roots; clear broken boundary.

Oa/Ajj—8 to 20 centimeters; dark brown (7.5YR 3/2) muck, silt loam; massive; extremely firm*, slightly sticky, slightly plastic; few fine roots; clear broken boundary.

Bwjj—8 to 20 centimeters; dark yellowish brown (10YR 4/4) loam; moderate fine granular structure; extremely firm*, slightly sticky, slightly plastic; many very fine and fine roots; clear broken boundary.

Bgjj—20 to 35 centimeters; dark grayish brown (2.5Y 4/2) loam; medium prominent cylindrical mottles; weak medium angular blocky structure; extremely firm*, slightly sticky, slightly plastic; few very fine roots; clear wavy boundary. incomplete net cryogenic structure.

Cf/Oejj—35 to 55 centimeters; dark grayish brown (2.5Y 4/2) loam; massive; extremely firm*, slightly sticky, slightly plastic. horizon is about half pure ice; ataxitic structure.

S95AK-185-007

*** P R I M A R Y   C H A R A C T E R I Z A T I O N   D A T A *** (NOME DIVISION, ALASKA)

PRINT DATE 01/07/98

SAMPLED AS : TOOLIK SITE 6 ;
REVISED TO : ;

SSL - PROJECT 95P 96, (CP95AK216) PUDHOE BAY
- PEDON 95P 632, SAMPLES 95P 4615- 4620
- GENERAL METHODS 1B1A, 2A1, 2B

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
NATIONAL SOIL SURVEY CENTER
SOIL SURVEY LABORATORY
LINCOLN, NEBRASKA 68508-3866

SAMPLE NO.	DEPTH (CM)	HORIZON	-4-- TOTAL CLAY LT .002	-5-- TOTAL SILT .002 -.05	-6-- TOTAL SAND .05 -2	-7-- CLAY FINE LT .0002	-8-- CLAY CO3 LT .002	-9-- SILT FINE .002 -.02	-10- SILT COARSE .02 -.05	-11- SAND VF .05 -.10	-12- SAND F .10 -.25	-13- SAND M .25 -.50	-14- SAND C .5 -1	-15- SAND VC 1 -2	-16- COARSE FRACTIONS(MM) WEIGHT 2 -5	-17- 5 -20	-18- 20 -75	-19- .1- 75	-20- (>2MM) WT PCT OF WHOLE SOIL
			<- - -	- - -	- - -	- - -	- PCT OF <2MM	(3A1)	- - -	- - -	- - -	- - -	- - -	- ->	<- PCT OF	<75MM(3B1)		->	
95P4615H	0- 4	Oi													--	--	--		--
95P4616H	4- 8	Oe													--	--	--		--
95P4617H	8- 20	Oe/A	23.4	38.3	38.3			24.6	13.7	10.4	12.8	9.2	4.4	1.5	--	--	--	28	--
95P4618S	8- 20	Bw	26.6	39.6	33.8			24.9	14.7	9.7	12.1	7.8	2.9	1.3	2	2	1	28	5
95P4619S	20- 30	Bg	28.1	38.4	33.5			24.9	13.5	9.4	11.8	7.5	3.0	1.8	--	--	--	24	--
95P4620S	30- 55	Cf	27.5	37.9	34.6			24.9	13.0	9.3	11.9	7.5	3.6	2.3	2	2	--	28	4

DEPTH (CM)	-1-- ORGN C 6A1c PCT	-2-- TOTAL N 6B4a <2MM	-3-- EXTR P 6S3b PPM	-4-- TOTAL S 6R3c <- PERCENT	-5-- DITH-CIT EXTRACTABLE FE 6C2b	-6-- AL 6G7a OF	-7-- MN 6D2a <2MM -->	-8-- (RATIO/CLAY) CEC 8D1	-9-- 15 BAR 8D1	-10- (ATTERBERG - LIMITS -) LL 4F1 PCT	-11- PI 4F <0.4MM	-12- (BULK DENSITY) FIELD MOIST 4A5 <- -	-13- 1/3 BAR 4A1d G/CC	-14- OVEN DRY 4A1h - - ->	-15- COLE WHOLE SOIL 4D1 CM/CM	-16- (WATER CONTENT) FIELD MOIST 4B4 <- -	-17- 1/10 BAR 4B1c -PCT OF	-18- 1/3 BAR 4B1c <2MM	-19- 15 BAR 4B2a - ->	-20- WRD WHOLE SOIL 4C1 CM/CM
0- 4	49.2	1.559																	117.9	
4- 8	27.1	1.472											0.20	0.30	0.145			84.7	78.4	
8- 20	13.6	0.648						1.21	1.38										19.1	
8- 20	5.46	0.271	2		2.2	0.2	0.1	0.50	1.05										11.0	
20- 30	6.06	0.289	TR		2.4	0.2	0.1	0.56	0.64										12.7	
30- 55	6.67	0.335	2		1.5	0.2	TR	0.54	0.44										12.1	

DEPTH (CM)	-1-- NH4OAC EXTRACTABLE BASES CA 5B5a 6N2e	-2-- MG 5B5a 6O2d	-3-- NA 5B5a 6P2b	-4-- K 5B5a 6Q2b	-5-- SUM BASES	-6-- ACID-ITY 6H5a	-7-- EXTR AL 6G9c	-8-- CEC SUM CATS 5A3a	-9-- NH4-OAC 5A8b	-10- BASES + AL 5A3b	-11- AL SAT 5G1	-12- BASE SAT- SUM 5C3	-13- NH4 OAC 5C1	-14- CO3 AS CACO3 <2MM 6E1g	-15- RES. OHMS /CM 8E1	-16-	-17- COND. MMHOS /CM 8I	-18- PH KCL IN 8C1g	-19- CACL2 .01M 8C1f 1:2	-20- H2O 8C1f 1:1
	<- - -	- - -	- - -	- - -	-MEQ /	100 G - -	- - -	- - -	- - -	- ->	<- - -	- -PCT -	- - ->							
0- 4	16.7	7.0	0.3	3.3	27.3	65.8	0.3	93.1	73.6	27.6	1	29	37					4.0	4.2	4.8
4- 8	9.3	2.6	0.2	0.6	12.7	27.8	--	40.5	56.5			31	22					5.3	5.7	6.1
8- 20	4.2	1.2	0.1	0.2	5.7	29.2	0.4	34.9	28.3	6.1	7	16	20					4.7	5.0	5.6
8- 20	1.3	0.4	0.1	0.1	1.9	17.3	0.2	19.2	13.4	2.1	10	10	14				0.08	4.0	4.3	5.0
20- 30	1.2	0.4	0.1	0.1	1.8	20.2	2.6	22.0	15.6	4.4	59	8	12				0.01	3.8	4.0	4.8
30- 55	1.5	0.4	TR	0.1	2.0	19.2	2.4	21.2	14.8	4.4	55	9	14				0.02	3.8	4.1	4.9

ANALYSES: H= HISTOSOL ANALYSES ON 80 MESH SAMPS= ALL ON SIEVED <2mm BASIS

Stop 21. S-10: Typic Hemistel (Hemic Cryic Histosol), Toolik Lake Field Research Station.

S-10 Pedon Decription: Typic Hemistel (Hemic Cryic Histosol)

DATE Sampled: 09/28/2005
Soil Series: Not surveyed
Location Information
Soil Survey Area: 185
Latitude: 68°37.488'N
Longitude: 149°36.121'W
Physiographic Province: Arctic Foothills
Local: basin
Geomorphic Position: middle slope
Microtopography: hummocky (moss mounds)
Surface stones: none
Parent material: organic matter/outwash
Drainage: very poor
Runoff: none
Type of saturation: endosaturation (ground water; water table at surface)
Type of Erosion: none
Degree of Erosion: n/a
Described and sampled by: C.L. Ping, F. Dou
Slope Characteristic Information
Slope: 0%
Aspect: N/A
Horizontal Shape: plane
Vertical Shape: plane
Elevation: 2381 ft asl (GPS)
Classification: Euic, pergelic Typic Hemistel (Hemic Cryic Histosol)

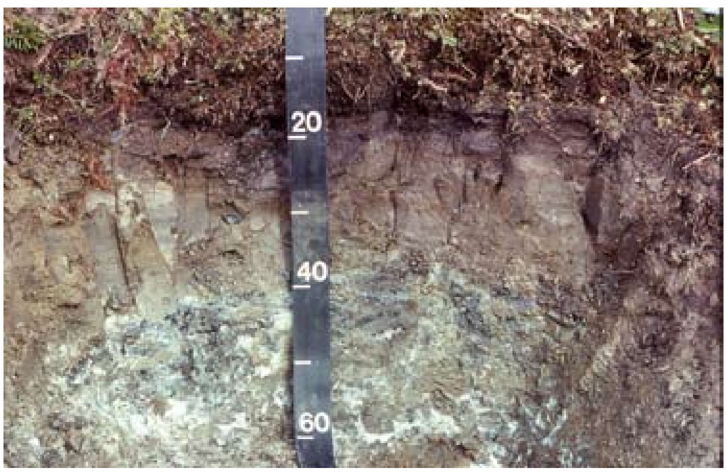
Vegetative Information

P**lant Names**: *Salix spp., Vaccinium uligonosium, Carex aquatilis, Sphagnum* sp.
Landcover type: marsh
Oi1 – 0 to 4 cm; black (7.5YR 2.5/1) peat; dead moss and sedge; many very fine, fine and common medium roots; abrupt irregular boundary. (TLK01)
Oi2 – 4 to 16 cm; dark brown (7.5YR 3/2) peat; mixed dead sedge, moss and shrub roots and twigs; saturated; many very fine, fine and few medium roots; abrupt smooth boundary (TLK02)
Oi3 – 16 to 25 cm; very dark brown (10YR 2/2) peat; dead sedge; saturated; common very fine, fine and few medium roots; abrupt smooth boundary (TLK03)
Oa – 25 to 37 cm; very dark brown (10YR 2/2) muck; saturated; abrupt smooth boundary (TLK04)
Oe – 37 to 58 cm; black (10YR 2/1) peaty muck; 65% unrubbed fiber and 20% rubbed fiber; abrupt smooth boundary (TLK05)
Oef1 – 58 to 68 cm; dark brown (7.5YR 3/2) peaty muck; frozen; common shrub fragments; no visible ice; clear smooth boundary (TLK06)
Oef2 – 68 to 80 cm; dark brown (7.5YR 3/3) peaty muck; frozen; no visible ice; clear smooth boundary (TLK07)
Oef3 – 80 to 100 cm; dark brown (7.5YR 3/3) mucky peat; frozen; 40-50% ice lens (TLK 08)

Toolik Lake Peat Sedge - Hemistel

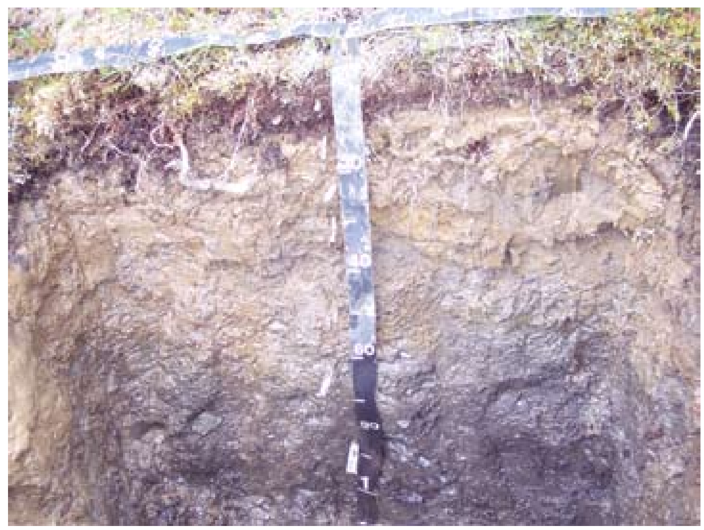
	Hor.	1:1														Inorg.
Hor.	Depth	pH	>2mm	C	N	sapric	fibric	NH+4-N	NO-3-N	P	CEC	K	Ca	Mg	Na	Carbon
	cm		%	------------------%------------------				---------mg/kg--------			-------------meq/100g soil------------					%
Oi1	0 - 4	6.25	<.01	42.94	1.37	-	-	20	8	<1	91.85	3.57	84.9	6.95	<.01	0.02
Oi2	4 - 16	5.55	<.01	38.02	2.20	-	-	4	5	<1	79.87	0.36	52.9	2.83	<.01	na
Oi3	16 - 25	5.23	<.01	33.70	2.02	-	-	4	1	<1	68.06	0.14	34.1	1.92	<.01	na
Oa	25 - 37	4.90	<.01	30.76	1.58	-	-	6	1	<1	63.46	0.06	29.7	1.49	0.04	na
Oe	37 - 58	5.04	<.01	28.04	1.71	-	-	<1	1	<1	62.84	0.08	30.9	1.55	<.01	na
Oef1	58 - 68	4.74	<.01	38.69	2.34	25	76	16	4	<1	77.15	0.03	27.2	1.42	<.01	na
Oef2	68 - 90	4.94	<.01	25.43	1.71	38	62	54	1	<1	51.02	0.02	19.1	1.09	<.01	na
Oef3	80 - 100	5.39	<.01	37.87	2.32	45	55	189	4	<1	59.71	0.04	28.2	1.27	<.01	na

Stop 22. S-11: Typic Histoturbel (Turbic, Histic Cryosol), soils associated with moist acidic shrub tundra (older surface: 25-17 Ka BP).



S-11 Pit excavation: 1995

Toolik Lake East



S-11 Pit excavation: 2005

S-11 Pedon Description: Typic Histoturbel (Turbic, Histic Cryosol)

Sampling date: July 10, 2005
Soil Survey Area: North Slope Borough
Location:
GPS position: 68°37.822'N; 149°34.95'W
South side of Toolik Lake airstrip access road
Physiographic region: Arctic Foothills
Landform: rolling hills
Local: midslope
Slope: 10%
Aspect: E

Slope shape: slightly concave
Parent material: Glacial moraine, Ikillik II age (25-17 Ka BP)
Soil climate: **MAAT** -10°C **MAP** 300mm
MAST **MWST** **MSST**
Soil Classification: Typic Histoturbel (Turbic, Histic Cryosol)
Sampled and described by: Anka Soonschen, Gary Michaelson, Shaunna Chase, Sarah

Profile description:

Oi – 0 – 5 cm: (7.5YR 3/2) peat; common very fine, fine and few medium roots; abrupt wavy boundary (3 – 10 cm) (1)

Oe – 5 - 16 cm; black (7.5YR 2.5/1) peaty muck; under Oi interboil; frozen, thick ice lens at lower boundary, 65% ice; massive; many very fine, fine, and few medium roots; abrupt irregular boundary (0 – 12 cm) (2)

Bw – 16 – 25 cm; (10YR 6/3) clay loam; under Oi in boil; weak subangular and strong medium granular structure; slightly firm, sticky and plastic; common very fine, many fine and few medium roots; few fine root remains; abrupt and irregular boundary (0 - 10 cm) (3)

Bg1 – 25 – 33 cm; (10YR 5/2) silty clay loam; faint Fe-concentrations (10YR 5/4) and Fe-depletions (2.5Y 5/2) in masses and root channels; strong fine lenticular structures; frozen (30% ice as lens), very firm; very stick and plastic; common fine and medium roots; 5% gravel, clean surfaced; common fine and few medium roots; clear smooth boundary (10 – 20 cm) (4)

Bg2 – 33 - 48 cm; (10YR 5/2) silty clay loam; (7.5YR 5/6) Fe concentrations in pore lining (15%); strong medium platy structure; very firm, frozen, pore ice, no visible ice lens; sticky and plastic; 10% gravel, clean surfaced; common very fine and fine roots; abrupt wavy boundary (0 – 25 cm)(5)

Bgfjj/Wf – 48 – 60 cm; (2.5Y 4/1) clay loam; under boil; 40% Fe-concentrations (10YR 4/4) as pore linings, 30% oxidized zone with Fe-depletions around root channels; strong fine lenticular structure with 40% ice lens; extremely firm, frozen, sticky and plastic; common very fine and fine roots; 10% gravel; clear smooth boundary (6)

Wf/Bg/Oajjf – 60 – 86 cm; (2.5Y 4/1) clay loam and 40% black (10YR2/1) muck; strong medium reticular structure; ataxitic fabric, 60% ice as ice net; extremely firm, frozen; clear smooth boundary (7)

Oajjf – 86 – 110 cm; black (10YR 2/1) muck; strong, medium reticular structure; frozen, 60 % ice; nonsticky and nonplastic; 10% gravel, angular and subrounded.; abrupt smooth boundary (8)

2Cf – 110 cm +; (2.5Y 4/1) very gravelly sandy loam; strong reticular structure, ataxitic (60% ice); extremely firm; slightly nonsticky and slightly nonplastic; 40% gravel and cobble stone, angular and subrounded (not sampled)

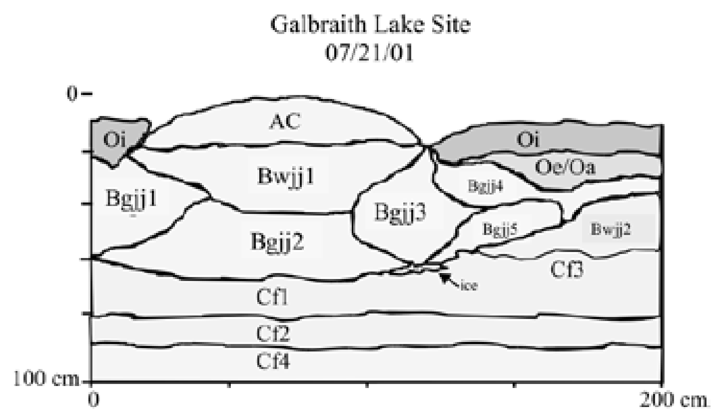
Toolik Lake - Typic Histoturbel, East of Lake 7/10/05

		pH	Gravel	USDA													
	Depth	1:1	>2mm	Texture	Sand	Silt	Clay	NH+4-N	NO-3-N	P	CEC	K	Ca	Mg	Na	C	N
	cm		%		%	%	%	mg/kg			meq/100g					%	%
Oi/Oe	0-16	4.13	<.01	-	na	na	na	15	2	63	71.1	2.29	15.6	4.64	<.01	42.6	1.16
Bw	16-25	4.18	1.59	SIL	34.2	52.0	13.8	2	1	<1	13.1	0.06	0.5	0.15	0.01	2.0	0.11
Bg1	25-33	4.38	4.58	SIL	39.2	50.0	10.8	<1	<1	<1	15.7	0.05	0.9	0.28	0.01	1.7	0.08
Bg2	33-48	4.51	3.88	CL	39.2	30.0	30.8	2	2	<1	11.7	0.04	0.9	0.26	0.02	2.0	0.11
Bgfjj/Wf	48-60	4.64	1.55	CL	33.2	31.0	35.8	5	1	<1	17.2	0.07	1.2	0.27	<.01	3.0	0.16
Wfm/Bgf/Oajjf	60-86	4.63	3.16	CL	32.2	33.0	34.8	31	1	<1	21.7	0.12	2.2	0.25	<.01	5.0	0.25
Oajjf	86-110	5.06	<.01	-	na	na	na	158	2	5	60.3	0.85	18.2	3.39	<.01	29.6	1.28
Ajj/Wf	86-110	4.70	6.21	CL	29.2	42.0	28.8	87	1	<1	33.8	0.26	6.3	0.77	<.01	10.5	0.55

Toolik Lake - Typic Histoturbel, East of Lake 7/10/05, continued

		Ammonium Oxalate			Dithionite-Citrate			Sodium Pyrophos.	
	Depth	Fe	Al	Si	Fe	Al	Mn	Fe	Al
	cm	%	%	%	%	%	%	%	%
Oi/Oe	0-16	-	-	-	-	-	-	-	-
Bw	16-25	1.12	0.32	<.01	1.15	0.14	0.01	0.54	0.18
Bg1	25-33	1.34	0.30	<.01	1.35	0.14	0.02	0.57	0.19
Bg2	33-48	1.06	0.27	<.01	1.33	0.14	0.01	0.60	0.22
Bgfjj/Wf	48-60	1.37	0.36	<.01	1.30	0.16	0.01	0.67	0.25
Wfm/Bgf/ Oajjf	60-86	2.46	0.38	<.01	2.18	0.24	0.04	0.96	0.25
Oajjf	86-110	-	-	-	-	-	-	-	-
Ajj/Wf	86-110	2.70	0.48	<.01	1.97	0.29	0.10	1.04	0.35

Stop 23. S-12: Ruptic Histoturbel (Ruptic Histic Cryosol) Nonsorted circle formation at Galbraith Lake



S-12 Pedon Description: Ruptic Histoturbel (Ruptic Histic Cryosol)

Galbraith Lake Frost Boil Study Site (07/21/2001)
Soil survey area #: 185
Latitude: 68°28'54"N
Longitude:149°28'34"W
Slope Characteristics Information
Slope: 0%
Aspect: NA
Horizontal Shape: slightly hummocky
Vertical Shape: slightly hummocky
Classification: Fine, mixed, pergelic Ruptic Histoturbel (Turbic Histic Cryosol)
Physiography: Brooks Range Foothills
Major: Valley
Local: lake basin
Geomorphic Position: Lake Basin

Vegetative Information

Plant Name: *Eriophorum triste, Betula nana, Salix arctica, S. rotundifolia, Dryas integrifolia, Tommenhypnum nitens, Polygonum* sp., *Arctos rubra, Carex membranaceae, Cetraria cuculata, Tofieldia pusilla, Rhododendron japponica, Eriophorum vaginata*

Described By: C.L. Ping, C. Stiles, G. Michaelson, P.P. Overduin, and J.M. Kimble

Galbraith Lake, Frost Boil Site (Sampled 07/21/01), 68°28'54"N, 149°28'0.784"W

Soil		1:1		Extr.	Extr.	Extr.						Base	Extr.	Oxalate Extractable			Citrate-Dithionite Extr.			Na-Pyrophosphate	
Horizon	depth	pH	E.C	NH4-N	NO3-N	P	CEC	Ca	Mg	Na	K	Sat.	H+	Fe	Si	Al	Fe	Al	Mn	Fe	Al
	cm		ds cm-1	mg kg-1	mg kg-1	mg kg-1	me 100g-1					%	me 100g-1	%	%	%	%	%	%	%	%
Oe	0-6	7.40	0.40	6	2	20	62	61	1.73	0.05	0.57	100	11.68	0.79	0.01	0.15	1.05	0.08	0.01	0.11	<0.01
Oe/Oa	6-16	6.92	0.29	<1	<1	4	33	21	0.83	0.02	0.12	68	9.86	1.49	0.15	0.20	1.21	0.07	0.04	0.33	0.01
Oajj	16-22	7.56	0.27	<1	<1	5	17	23	0.61	0.03	0.06	100	3.08	0.64	0.09	0.14	0.47	0.05	<0.01	0.13	<0.01
Acjj	0-18	7.94	0.25	<1	<1	3	15	20	0.79	0.03	0.20	100	3.97	1.72	0.21	0.30	1.48	0.09	0.02	0.07	<0.01
Bwjj1	18-43	7.89	0.29	<1	<1	3	14	21	0.70	0.03	0.20	100	5.95	1.65	0.20	0.29	1.51	0.09	0.02	0.07	<0.01
Bwjj2 (sand)	22-38	7.92	0.27	<1	<1	2	9	24	0.28	0.03	0.07	100	1.46	0.71	0.08	0.12	0.86	0.06	0.01	0.09	<0.01
Bgjj1	20-55	7.87	0.29	1	<1	3	14	16	0.58	0.02	0.20	100	8.87	2.16	0.25	0.35	1.64	0.10	0.03	0.06	<0.01
Bgjj2	38-70	7.92	0.31	<1	<1	3	22	16	0.44	0.02	0.19	76	4.38	1.90	0.23	0.32	1.45	0.09	0.03	0.07	<0.01
Bgjj3	20-62	7.84	0.33	1	<1	3	23	14	0.43	0.03	0.20	64	8.35	2.16	0.27	0.36	1.65	0.10	0.02	0.05	<0.01
Bgjj4	20-45	7.86	0.31	<1	<1	3	19	17	0.70	0.03	0.20	93	7.20	1.99	0.25	0.34	1.57	0.11	0.03	0.07	<0.01
Bgjj5	38-60	7.92	0.29	<1	<1	3	16	16	0.44	0.03	0.19	100	6.88	2.12	0.25	0.34	1.63	0.10	0.03	0.06	<0.01
Cf1	53-75	7.86	0.33	<1	1	1	15	13	0.36	0.02	0.21	92	7.20	2.10	0.24	0.33	1.50	0.08	0.04	0.21	<0.01
Cf2	75-88	8.00	0.40	3	<1	2	14	18	0.53	0.02	0.21	100	6.26	2.12	0.24	0.35	1.51	0.07	0.04	0.34	<0.01
Cf3	53-75	8.12	0.42	3	<1	2	10	19	0.39	0.02	0.13	100	5.72	1.47	0.17	0.24	1.17	0.06	0.03	0.27	<0.01
Cf3	-	8.07	0.46	1	<1	2	20	21	0.42	0.02	0.15	100	4.69	1.49	0.18	0.26	1.15	0.06	0.03	0.26	0.01
Cf4	88-100+	8.10	0.40	2	1	2	13	14	0.59	0.01	0.19	100	7.19	2.02	0.23	0.32	1.37	0.07	0.04	0.29	0.01
Cf4	-	8.08	0.42	5	1	2	20	15	0.56	0.02	0.17	78	4.38	1.82	0.20	0.28	1.28	0.06	0.04	0.31	<0.01

Galbraith Lake, Frost Boil Site (Sampled 07/21/01), 68°28'54"N, 149°28'0.784"W, continued

Soil		Bulk	USDA	<2mmwt.			>2mm	Total		Water		
Horizon	depth	Density	Texture	Clay	Silt	Sand	vol.	C	N	Content	IC	OC
	cm	g cm-1		%	%	%	%	%	%	%vol.	%	%
Oe	0-6	0.16	PEAT	na	na	na	0.58	10.96	0.58	36	0.0	10.96
Oe/Oa	6-16	0.75	SL	11.6	34.8	53.6	0.11	6.26	0.39	74	0.0	6.26
Oajj	16-22	1.00	SL	12	24.8	63.2	0.29	4.02	0.16	64	1.0	2.98
Acjj	0-18	1.48	C	50	30.8	19.2	0.58	2.29	0.08	28	0.6	1.70
Bwjj1	18-43	1.73	C	48	30.8	21.2	0.49	2.36	0.09	40	0.6	1.75
Bwjj2 (sand)	22-38	1.35	SL	16	16.8	67.2	0.49	4.05	0.15	37	1.1	3.00
Bgjj1	20-55	1.51	C	52	26.8	21.2	0.23	2.21	0.08	42	0.6	1.64
Bgjj2	38-70	1.57	C	52	26.8	21.2	0.20	2.44	0.11	38	0.6	1.81
Bgjj3	20-62	2.03	C	54	28.8	17.2	0.33	2.08	0.06	53	0.5	1.54
Bgjj4	20-45	1.54	C	52	28.8	19.2	0.73	2.20	0.07	52	0.6	1.63
Bgjj5	38-60	1.70	C	54	26.8	19.2	0.31	2.12	0.01	44	0.5	1.57
Cf1	53-75	1.32	C	52	26.8	21.2	0.55	2.28	0.08	50	0.6	1.69
Cf2	75-88	0.96	C	48	28.8	23.2	0.48	2.46	0.08	45	0.6	1.82
Cf3	53-75	0.77	CL	35.6	26.4	38	0.15	3.14	0.10	41	0.8	2.33
Cf3	-	0.77	CL	35.6	26.4	38	0.25	3.24	0.13	43	0.8	2.40
Cf4	88-100+	0.35	C	47.6	30.4	22	0.15	2.43	0.01	42	0.6	1.80
Cf4	-	0.35	C	43.6	26.4	30	0.17	2.72	0.09	29	0.7	2.02

Intercircle

Oi — 0 to 20 cm; dark brown (7.5YR 3/3), peat, many fine few medium, abrupt wavey,(1 to 8)

Oe—20 to 27 cm; very dark brown (7.5YR 2.5/2) mucky peat, weak medium granular, very friable, nonplastic nonsticky, many fine few medium, abrupt irregular, (2 to 5 cm)

Bwjj2—27 to 48 cm; very dark grayish brown (10YR 3/2) and dark grayish brown (10YR 4/2, 30%) fine sandy loam; weak medium platy structure; friable, slightly sticky slightly plastic; many very fine and fine roots; abrupt smooth boundary (0 to 18cm)

Cf3—48 to 65 cm; very dark gray (10YR 3/1) clay; strong medium reticulate structure; extremely firm, sticky very plastic; 50 – 60% ice; clear wavy boundary

Wf/Cf4 —65 to 100 cm; very dark gray (10YR 4/1) clay; strong medium reticulate (ataxitic) structure; very firm, sticky very plastic; 75% ice.

Circle

ACjj—0 to 18 cm; dry: dark grayish brown (2.5Y 4/2), moist: very dark grey (2.5Y 3/1), clay; strong medium columnar structure, extremely firm, very sticky, very plastic, clear smooth, (0 to 18 cm).

Bwjj1—18 to 41 cm; dark gray (2.5Y 4/1) clay, moderate medium platy structure; very firm, very sticky, very plastic, common very fine, fine and few medium roots; clear smooth, (0 to 22 cm).

Bgjj1—20 to 52 cm; dark grey (2.5Y4/1) clay; 30% Fe-concentrations (10YR4/3); massive; saturated; very sticky, very plastic, few very fine and fine roots; clear irregular boundary (0 to 32 cm).

Bgjj2—52 to 65 cm; dark brown (10YR 3/2) clay; weak fine platy structure; very firm, very sticky, very plastic, few fine roots, clear irregular boundary (0 to 20cm).

Bgjj3—20 to 60 cm; very dark grayish brown (2.5Y 3/2) clay; massive; sticky very plastic; common fine roots; clear irregular boundary (0 to 40 cm)

Bgjj4 – 25 to 40 cm; dark grayish brown (2.5Y 4/2) clay; massive (saturated); sticky very plastic; many fine roots; clear irregular boundary (0-15 cm)

Bgjj5 – 40 to 48 cm; dark grayish brown (2.5Y 4/2) and dark gray (2.5Y 4/1) clay; massive (saturated); sticky very plastic; few very fine and fine roots; clear irregular boundary (0-10 cm)

Cf1—65 to 75 cm; very dark gray (10YR 3/1) clay; strong medium reticulate (ataxitic) structure; soil 3-5 mm and ice 2-3 mm thick, 40% ice; very firm (frozen); sticky very plastic, abrupt smooth boundary

Cf2 – 75 to 88 cm; dark grey (2.5Y 4/1) clay; strong thick reticulate (ataxitic) structure; soil 5-10 mm and ice 2-5 mm thick; very firm (frozen); sticky very plastic.

Cf4 – 88 to 100 cm; very dark gray (10YR 4/1) clay; strong medium reticulate (ataxitic) structure; very firm, sticky very plastic; 75% ice.

Remarks: All but A horizon positively react to α'α'-dipyridyl.

July 22, 2006 Saturday

Stop 24. S-13: Typic Histoturbel (Turbic Histic Cryosol), Soils formed in glacial moraine, northern boreal forest, Coldfoot northern boreal forest, Interior Alaska

S-13: Typic Histoturbel (Turbic Histic Cryosol)

S-13: Soil Description Dalton Highway 171 Boreal Forest

DATE Sampled: 07/04/2005
Location Information
Soil Survey Area: 185
Latitude: 67°12'1"N
Longitude: 150°15'13"W
Slope Characteristic Information
Slope: 2%
Aspect: 136°
Horizontal Shape: plane
Vertical Shape: plane
Elevation: 137 m asl (GPS)
Physiography:
Local: hills
Major: glaciated upland
Microtopography: hummock
Geomorphic Position: Glaciated valley
Parent material: glacial moriane
Drainage: poor
Runoff: negligible
Climate:
MAP: 400mm **MAAT**: -3.3°C est.
MAST: -1.3°C.
Classification: Coarse-loamy, mixed, superactive, subgelic Typic Histoturbel (Turbic Histic Cryosol)

Vegetative Information

Landcover type: Boreal forest
Plant Names: *Picea mariana, Betula nana, Rosa aci., Ledum decumbens, Vaccinium uligonosium, Vaccinium vitis-ideae, Sphagnum* spp., *Hylocumium splendens*.
Land use: forestry and wildlife habitat
Described and sampled by: C.L. Ping, Gary Michaelson, Cindy Stiles, and E.C. Packee (all colors are for moist unless specified)
Oi – 0 to 25 cm; brownish yellow (10YR 6/6) peat; dead Sphagnum roots; many very fine, fine and common medium roots; abrupt smooth boundary
Oa - 14 to 35 cm; black (10YR 2/1) mucky; many fine, common and few coarse roots; abrupt wavy boundary (4-8 cm)

Ajj – 29 to 90 cm; black (7.5YR 2.5/1) mucky silt loam; weak medium subanguar to weak medium granular structures; very friable, nonstick and nonplastic; few fine and medium roots; abrupt irregular boundary (0-35 cm)

Bg1 – 29 to 80 cm; dark gray (2.5Y 4/1) silt loam; common Fe-concentrations (7.5YR 5/6) in pore linings and in mass; massive; slightly firm, slightly stick and slightly plastic; common fine and few medium roots; clear irregular boundary

Bg2 – 50 to 90 cm; dark gray (2.5Y 4/1) sandy clay loam; massive to weak medium lenticular structure; slightly firm, sticky and slightly plastic; 30% ice lens (3-10 mm); few fine roots; clear wavy boundary

Bgf – 75 to 105 cm; dark gray (2.5Y 4/1) silt loam; strongly thin lenticular structures; extremely firm (frozen), slightly sticky and slightly plastic; 60% ice; positive reaction to α'α'-dipyridyl; clear smooth boundary

Cf –90+ cm; dark gray (2.5Y 4/1) silt loam; strongly thin lenticular structures; extremely firm (frozen), slightly sticky and slightly plastic; 60% ice as thin ice lens (<1mm).

Dalton Highway MP 171 Boreal Forest (7/4/05)

	Depth	pH		USDA												Inorg.		
	range	1:1	> 2mm	Tex-ture	Sand	Silt	Clay	NH+4-N	NO-3-N	P	CEC	K	Ca	Mg	Na	Car-bon	C	N
	cm		%			%		mg/kg					meq/100			%	%	%
Oi	0-25	4.20	<.01	-	na	na	na	15	<1	40	94.4	1.18	38.7	7.86	<.01	na	44.14	1.24
Oa	14-35	5.12	1.42	-	na	na	na	3	34	<1	108.9	0.18	61.2	5.97	0.04	na	34.39	2.08
Ajj	29-90	5.16	6.65	SIL	31.8	57.8	10.4	3	5	<1	43.0	0.06	20.0	1.89	0.03	na	10.59	0.64
Bg1/ Bg2/ Bgf	29-105	6.03	5.49	SIL	24.4	53.2	22.4	2	3	10	13.4	0.03	8.2	0.95	0.01	<.01	1.58	0.11
Cf	90+	6.35	1.97	SIL	20.4	57.2	22.4	2	2	26	13.7	0.04	10.1	1.16	0.02	<.01	2.09	0.13

	Depth	Ammonium Oxalate				Dithionite-Citrate				Sodium Pyrophos.	
	range	Fe	Al	Si		Fe	Al	Mn		Fe	Al
	cm	%	%	%		%	%	%		%	%
Oi	0-25	na	na	na		na	na	na		na	na
Oa	14-35	na	na	na		na	na	na		na	na
Ajj	29-90	1.29	0.28	0.06		1.50	0.25	0.03		0.95	0.19
Bg1/Bg2/Bgf	29-105	0.96	0.19	0.03		1.52	0.11	0.04		0.29	0.08
Cf	90+	0.95	0.19	0.02		1.59	0.11	0.05		0.29	0.08

Appendix A

Handouts from Yuri Shur

See:

1. "CRREL Benchnotes, U.S. Army Corps of Engineers Information Exchange Bulletin," No. 17, February 1991. CRREL Permafrost Tunnel article.

2. "Further Cryostratigraphic Observations in the CRREL Permafrost Tunnel, Fox, Alaska. M.T. bray, H.M French, and Y. Shur. In: *Permafrost and Periglacial Processes*. 17: 233-243 (2006). Published on line 15 June 2005 in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/ppp.558.

3. "Syngenetic Permafrost Growth: Cryostratigraphic Observations from the CRREL Tunnel near Fairbanks, Alaska. Y. Shur, H.M. French and D.A. Anderson. In: *Permafrost and Periglacial Processes*. 15: 339-347 (2004). Published on line in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/ppp.486.

Appendix B. Boreal Forest of Alaska

The Northern Forest of Alaska

Edmond C. Packee, Ph.D.; CF, CPSSc, Professor Emeritus of Forest Management

Alaska is the largest state in the union, with 148 million hectares, which includes 143 million hectares of forested land with the Northern Forest (*Picea-Betula-Populus*) (taiga or boreal forest) and 5.4 million hectares of Coastal Forest (*Picea-Tsuga*) (Hutchison 1967). The Coastal Forest Formation is primarily on the south side of the Coast Ranges and is climatically distinct (high humidity, high precipitation, and temperate temperatures) from the Northern Forest Formation north of the Coast Ranges, which is characterized by low humidity, low precipitation, cold in winter, and hot in summer.

The Northern Forest Formation consists of five provinces:

Kenai-Alaska peninsulas: Portions of the Kenai and Pacific Slope of the Alaska peninsulas where *Picea glauca* and *P. sitchensis* hybridize yielding the hybrid *Picea* X *lutzii*. *P. mariana* stands are abundant, the subspecies of *Populus balsamifera* ssp. *balsamifera* and spp. *trichocarpa*) intergrade, *Betula kenaica*, the most common trees (*Betula* and *Tsuga mertensiana*) often dominates the subalpine forest and parkland. Coastal Formation shrub and herb species commonly dominate the understory community. Climate is transitional between maritime temperate and continental. Glacial features (including steep valley walls, morainal terraces, and outwash terraces) characterize the landscape. Soil parent materials include tephra, alluvium, glacial moraine, outwash, lacustrine, and marine sediments. Forest productivity ranges from high to very low.

Sustina-Matanuska valleys: South of the Alaska Range (exclusive of the Copper River Basin to the east) and where *P. sitchensis* and *T. mertensian*a are confined to areas adjoining the Chugach Mountains, especially adjacent to Turnagain Arm south of Anchorage, *Larix laricina* is absent, and *B. neoalaskana* replaces *B. kenaica*. Dominant tree species are *P. glauca, P. mariana, Betula*, and *Populus*. *Populus balsamifera* ssp. *balsamifera* and spp. *trichocarpa*) intergrade. Coastal Formation shrubs and herb species commonly dominate the understory community. Climate is transitional between maritime temperate and continental; permafrost is locally present. Landscape is characterized by glaciated uplands with drumlins, broad outwash plains, large depressions, steep mountain slopes, and glaciers at higher elevations. Forest productivity is high to low.

Copper River Basin: This area of eastern Alaska is south of the Alaska Range, north of the Chugach Mountains, and east of the Matanuska and Sustina drainages. Dominant tree species include *P. glauca, P. mariana*, *B. neoalaskana, P. tremuloides*; *Larix* is absent. Boreal species dominate the understory. Climate is strongly continental with discontinuous permafrost abundant. The heavily glaciated landscape is characterized by hills, terraces, fluvial flats, and steep mountain slopes, and glaciers at higher elevations. Soil parent materials include moraine, lacustrine, loess, and outwash. Forest productivity is moderate to low.

Western Interior Alaska: Located north of the Alaska Range and south of the Brooks Range from west of the Kokrine Hills (well to the west of Fairbanks) to the Bering Sea (Kotzebue area), this region includes the majority of the Koyukuk, lower Yukon, and Kuskowim Rivers. *P. glauca* and *P. mariana* dominate with *L. laricina, B. neoalaskana*, and *Populus* occurring locally. The forest is a mosaic of closed forest along waterways and on warmer sites and parkland. Understory vegetation is a mixture of cold maritime tundra and boreal forest plants. Climate ranges from cold maritime in the west to strongly continental in the east. Permafrost is discontinuous but dominates the landscape. The landscape is largely unglaciated and characterized by mountains, rolling hills, and lowlands; glaciation occurred locally. Soil parent materials are residual, fluvial, aeolian and organic. Forest productivity is moderately low to very low, except along rivers, where it is moderate.

Eastern Interior Alaska: Located North of the Alaska Range to the Brooks Range from the Kokrine Hills to the Yukon/Canada border, this area includes the Tanana, middle and upper Yukon, and upper Koyukuk rivers. (The forested portion of the field tour is located within this province.) *P. glauca, P. mariana, B. neoalaskana*, and *Populus* dominate; *L. laricina* is abundant on wetter sites in the Tanana Valley and scattered elsewhere. P. *mariana* and *P. tremuloides* do not occur north of Wiseman (north of Coldfoot); *L. laricina* is not found east of the Gerstle River (east of Delta Junction) in the Tanana River Valley nor north of the Yukon River. Understory vegetation is distinctly boreal. The north side and upper Tanana Valley and the south slopes of the Brooks Range were glaciated during both the Illinoian and Wisconsinan glaciations; the Interglacial had periods of warm and moist conditions that supported ferns in the understory; little or no permafrost was present during the Interglacial; the source of moisture is believed to have been the summer, largely ice-free Arctic Ocean. Today, discontinuous permafrost dominates the province. The landscape is characterized by mountains, hills, and broad valleys. Soil parent materials include moraine and outwash, aeolian (loess and sand dunes) fluvial, colluvial, and residual deposits. The extreme eastern portion of the province has a blanket of White River ash from the Mt. Bono area to the southeast near the Canadian border. Forest productivity ranges from high in the middle Tanana Valley, moderately high to low elsewhere in the Tanana Valley to the Yukon River, moderate to very low north of the Yukon River to the lower slopes of the Brooks Range.

Important Alaska Northern Forest Tree Species and Silvical Characteristics

Species	Shade Tolerance	Successional Status	Regeneration Strategy	Major Disturbance Agents
P. glauca	I	Seral/Climax	Seed	Fire;Dendroctonus, Ips; Inonotus
P. mariana	T	Seral/Climax	Seed (semi-serotinous)	Fire; Lepus
L. laricina	VI	Seral	Seed	Lepus; Dendroctonus, Pristiphora
B. kenaica	I	Seral	Seed/Stump sprout	Alces, Lepus; dieback
B. neoalaskana	I	Seral	Seed/Stump sprout	Alces, Lepus; dieback
P. balsamifera	VI	Seral	Seed/Stump sprout/ Root sucker	Alces, Castor; Phellinus
P. tremuloides	VI	Seral	Root sucker/Seed	Alces; Phellinus, Peniophora, Phibalis

Note: *Pinus contorta* and *Abies* species do not occur naturally in the Northern Forest of Alaska. *P. contorta* is present in the Coastal Forest Formation as far north and west in the Yakutat area.

Disturbance: Disturbance is the driving factor in maintaining the productivity of the Northern Forest, and the major disturbance agent is fire. Fires recycle through the Northern Forest from less than a 100-year to more than a 200-year cycles. Hence, Northern Forest stand types have evolved with fire. Fires in *Picea* forests are often stand replacement events that result in a single cohort replacement stand of the same species or seral species; nearly pure to highly mixed species stands can result. The type of fire (Continuous Crown, Intermittent Crown, and Surface) and severity depend upon tree species, understory vegetation, and dead or down material, as well as topography and moisture conditions. Conifer forests can produce severe crown fires whereas hardwood forests rarely crown. Open forests with heavy understory vegetation, especially the grass, *Calamagrostis canadensis*, can have fast moving, surface fires. Lightning is the major cause of large fires in most of Alaska.

In early June 1996, the man-caused Miller's Reach Fire (Sustina-Matanuska Province) in the urban-wildland interface burned 15,110 ha and destroyed 344 structures (including businesses, homes, and outbuildings) in less than 15 days. Here, the fire crowned severely in *P. mariana* and ran rapidly through hardwoods with a heavy, cured *C. canadensis* understory to the next Picea stand. In 2004 approximately 2,689,600 ha and in 2005 approximately 1,778,600 ha burned in Alaska's Northern Forest for a total of 4,468,200 ha, most of which was north of the Alaska Range. These fires were lightning caused. The tour goes through "burns" of various ages and sizes.

The role of fire in the ecosystem cannot be ignored. Fire is the cauterizing agent for ecosystems: It reduces insect and disease populations. It warms the soil, converts nutrients into available forms, re-establishes young stands of seral species essential for moose habitat (moose are a major subsistence staple of natives) and also support wildlife such as hawks, grouse, and songbirds. Nutrient loss and increase in the surface soil depends upon the pre-burn forest cover and depth and type of the organic horizons; pH generally increases after a burn. The type of forest floor vegetation and thickness of the organic matter control the intensity and duration fire (heat) at the soil surface.

Insects also catastrophically affect the forest. *Dendroctonus rufipennis* attacks *P. glauca*. This bark beetle has killed, in 20 years or less, nearly all *P. glauca* of appropriate size (<12-15 cm dbh) on about 1,200,000 ha in the Kenai-Alaska peninsulas, southern one-half of the Susitna-Matanuska valleys, and Copper River Basin provinces. Larvae burrow through the cambium tissue and when their tunnels overlap, they effectively girdle the tree. Since not all trees are attacked (some *Picea* and hardwoods are not infested), the impact is only partially stand replacing and thus a multicohort stand develops. *D. simplex*, another bark beetle, and *Pristiphora erichsonii*, a defoliator, have acted in concert to kill *L. laricina* in the Tanana Valley. Mortality caused by these two insects effectively removes *Larix* from stands before they reach large size and hastens succession to the more tolerant *P. mariana*. *Choristoneura fumiferana*, a budworm and defoliator, is also active in Alaska; to date, it has not caused significant mortality.

Most pathogens do not cause mortality to Northern Forest tree species in Alaska. *Inonotus tomentosus*, the stand thinning disease, is a serious root rot that contributes to windthrow of *P. glauca* and is found throughout the Northern Forest in Alaska. The brooms that are common on *Picea* are not due to *Arceuthobium*; the causal agent is a rust fungus, *Chrysomyxa arctostaphyli*, which requires an alternate host, *Arctostaphylos uva-ursi*. The brooms provide shelter for *Tamiasciurus hudsonicus* during periods of extreme cold. Most important hardwood pathogenic fungi cause heart rot and contribute to individual tree breakage.

Alces alces, the moose (elk in Europe), utilizes both the *Betula* and *Populus* tree species in addition to the preferred species of *Salix* for winter and early spring browse. Oftentimes, browsing is so heavy year after year that the trees are killed outright or have height growth severely reduced. This type of browsing has been observed to go on for 15 years. The effect of such damage is to hasten succession to the more tolerant *Picea*. *Castor canadensis*, the beaver, cuts or attempt to cut the *Populus* for both food and structures. *Castor* activity commonly encourages stump sprouting and root suckering and thus creates multi-cohort stands.

Appendix C:
Bedrock and Glacial Geology of Tour Route

C.A. Stiles, Associate Professor of Soil Science, University of Wisconsin-Madison

Introduction

Under the thick tundra mats and taiga forests along the road north from Fairbanks lies the complicated skeleton of Alaska, a bedrock patchwork quilt that is just as fascinating to look at (and more reliably present) as the wildlife. Along this route, we will cross seven physiographic provinces oriented in east-west trends that are roughly equivalent to several provinces that span the greater part of continental North America (Figures 1A & B). We will traverse lands that have been heavily scoured by Quaternary glaciations and those untouched by the direct effects of glaciers, but still carrying evidence of the periglacial legacy. Our trip takes us through two major river drainages (Yukon and Koyukuk), across Brooks Range—the northernmost range in the Rocky Mountain chain, and finally down onto the broad Arctic Coastal Plain, where oil exploration progresses alongside subsistence lifestyles in the great "Serengeti of North America." Here lies something for every earthwatcher to enjoy. For the rock hound, the most spectacular vistas are the stark outcrops of the Brooks Range, where vegetation scarcely covers the lower elevation toeslopes because of the high latitude location. Glacial aficionados will appreciate the deeply incised U-shaped valleys and morainal topography of the Brooks Foothills that reflect the direct influence of valley glaciers during the last 1.2 million years. Finally, the subtle ice-dominated topography of the Arctic Coastal Plain displays rare landforms that are not found anywhere else in the United States of America. The following is a brief review of geology and geomorphology concepts as they apply to this field trip.

The Essentials of Alaskan Geology and Geomorphology for Pedologists

Terranes

Alaska is located at the very end of the spine of the two American continents. The spine of mountains that follows the general alignment of North and South America runs from its southernmost point in Tierra del Fuego as the Andes Mountains, up through Central America as the Cordillera Central, and then through North America as the Rocky Mountain chain. The Brooks Range is the northernmost expression of this spine and its east-west trend has forced the accretion of no less than 26 fault-bounded subcontinental-size chunks or terranes of differing stratigraphy and age that have accumulated along a continental suture zones.

Fairbanks and its surrounding mining areas are located on the Proterozoic age (2.5 – 0.6 Ma) Yukon-Tanana terrane containing the Birch Creek Schist and associated gold-bearing members. We traverse several terranes and subterranes on the trip north to Deadhorse, especially as we cross the Brooks Range. The major terranes are, from south to north: the Wickersham, Manley, White Mountain, Totzina, Ruby, and Angayucham terranes, the Coldfoot, Hammond, and Endicott Mountains subterranes, and finally the Arctic-Alaska terrane. Each is characterized by different stacked and sometimes disordered and overprinted rock layers that were initially laid down by the earth-building process at the time and place of their formation. The age of the terranes varies within the units, but by and large, are getting younger as we head north out of the Yukon-Tanana River Basin. The southern face of the Brooks Range tends to have a more accretionary architecture, which simply means that the time sequence isn't always very easy to follow. However, once over the Atigun Pass and coming onto the North Slope, the time series of rocks is easy to follow, progressing from Devonian (410 Ma) to undifferentiated Paleogene (23-65 Ma) sediments overlaid by a thickening to the north veneer of Quaternary alluvial and glacial sediments.

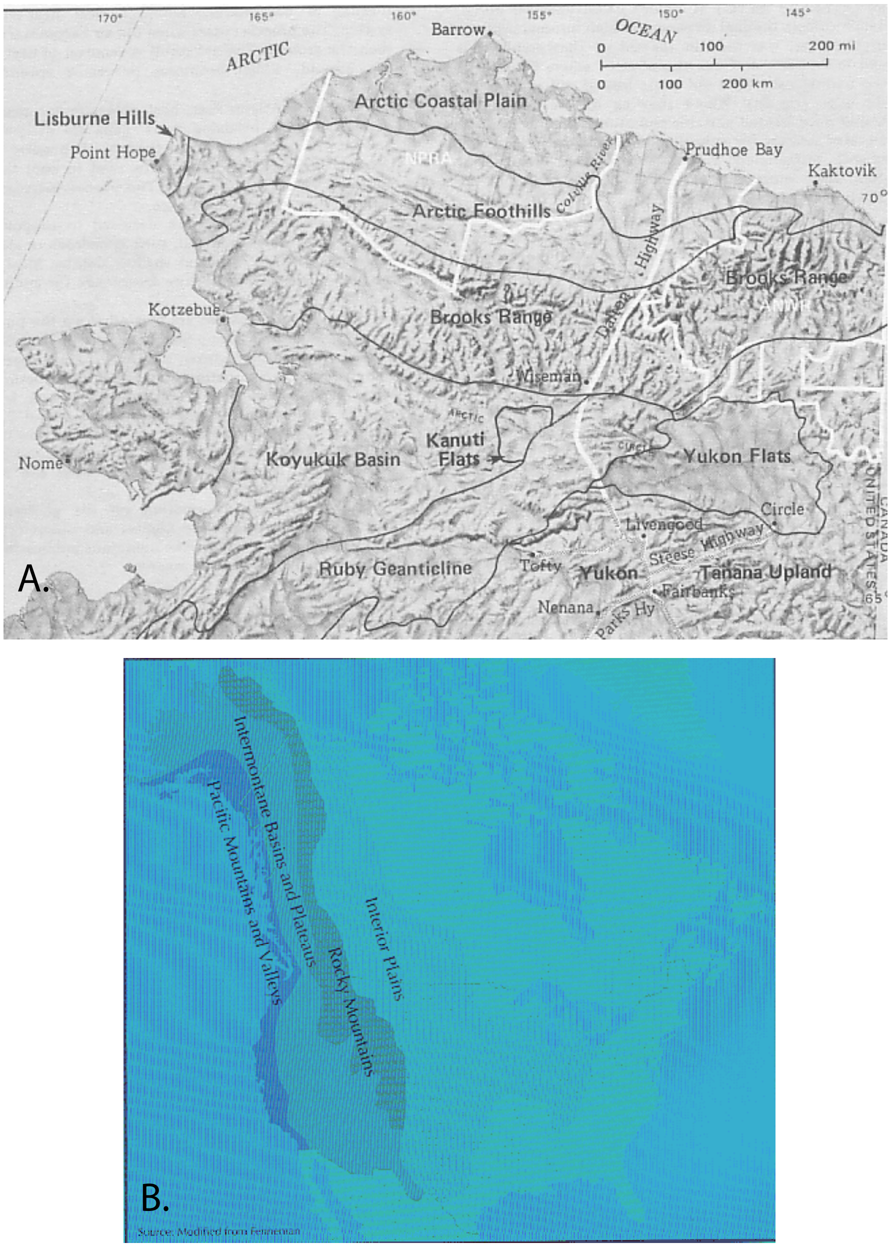


Figure 1: A) Physiographic provinces of northern Alaska (Mull and Adams, 1989); B) Physiographic regions of western North America (Pearson and Hermans, 2003)

Formation sequences and their rocks

The passage through different terranes does not mean that we pass simply from one rock type to another, although in some cases, such as the Angayucham terrane, the geochemical composition of the rock is different from the country rock because of its origin in deep oceanic spreading zones. In each physiographic/terrane province we pass through, you will notice predominance of some particular rock types related to past depositional settings and tectonic activities.

Sequences are time-progressive depositional entities that give a strong indication of local geological conditions that prevailed during the time the rocks were deposited. There are three major sequences that each encompasses several formations as we move from south to north along the highway from Fairbanks to Deadhorse. These sequences present a picture of the evolution of this portion of North America through the rock types and morphologies in the formations, from the early accretion of sediments onto the ancient proto-continental Canadian Shield far to the east, to the most recent shedding of colluvium off the uplifted Brooks Range and development of the hydrocarbon enriched Arctic Slope/Colville Basin.

The southernmost sequence is the Franklinian Sequence, which is composed of Proterozoic to mid-Devonian strata of argillites, limestone/dolostone, volcanic rocks, phyllites and shales. This sequence represents early mountain-building events that initiated in western Canada and built out the core of the Alaskan “thumb” that allowed for later terrane accretion. In the southern Brooks Range, the Franklinian Sequence is often metamorphosed to upper greenschist to amphibolite facies, meaning the rocks are schists and gneiss (often banded with graphite), marble, and felsic intrusive rocks. The most spectacular expression of the Franklinian Sequence is the Skajit Limestone that makes up the massive cliffs encountered along the Dalton Highway from miles 203-224, starting with the monumental Sukakpak Mountain, the marker of the Gates of the Arctic National Park and the Arctic National Wildlife Refuge.

The next chronostratigraphic sequence is the Ellesmerian Sequence that ranges in age roughly from late Devonian to early Cretaceous (Figure 2). These rocks are derived from sediments, again from a northern source but deposited on a stable platform during a time of relative quiet with only three major sea level changes.

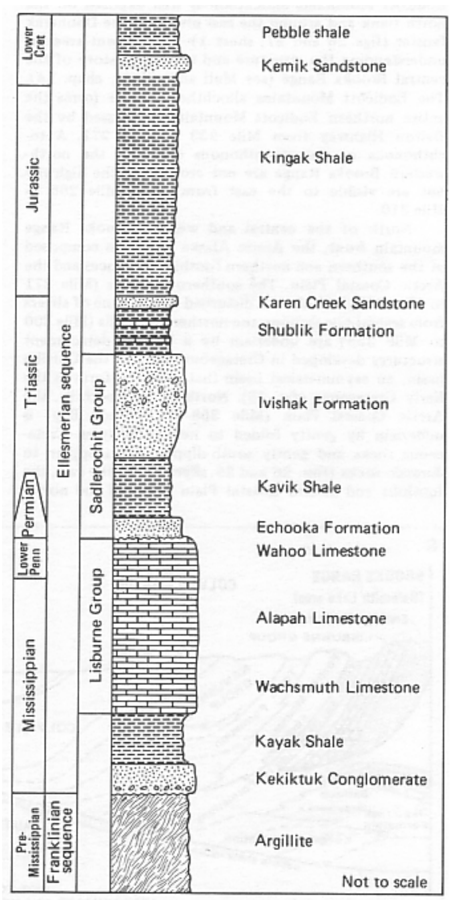


Figure 2: Generalized stratigraphic column showing upper Frankinian and complete Ellesmerian Sequence in the northeastern Brooks Range (Mull and Adams, 1989).

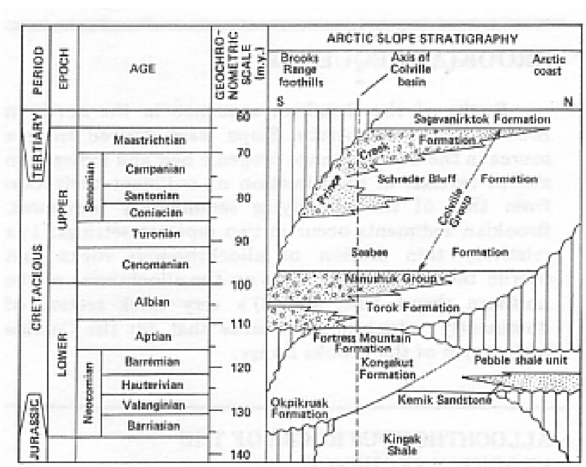


Figure 3: Generalized stratigraphic relationships in the Brookian Sequence of the Colville Basin on the North Slope. Note: Kingak Shale, Kemik Sandstone and pebble shale are Ellesmerian members (Mull and Adams, 1989).

They are primarily shales, conglomerates, and sandstones, with one prominent limestone formation, the Lisburne Formation, a significant ridge former in this relatively dry climate. On the south face of the Brooks Range, the Ellesmerian rocks are metamorphosed and comprise the foreboding dark rocks of the Atigun Pass. Rocks from this sequence extend from miles 224-271, ending near Galbraith Lake and bounded by the Atigun River Valley, where an extensive unconformity occurs.

The dramatic Atigun River Valley, trending east-west from the Dalton Highway at milepost 271, is where the final and youngest sequence commences. The Brookian Sequence represents a time interval from the Cretaceous to and unspecified time within the early to mid Tertiary. The end outcrop of the Ellesmerian Sequence along the Dalton Highway is the high rampart of Mt. Hultèn, with its spectacular 600 m rise above the deep U-shaped valleys in which the highway runs. This mountain is part of an overturned sequence that was emplaced by extensive thrust faulting when the Brooks Range was forced upward. Brittle failure of the carbonate-rich Lisburne created the deep valley through which the Atigun River was directed. Evidence of this folding is found at the toeslope of the mountain between milemarkers 270-271.

Brookian Sequence rocks are less metamorphosed and represent the sediments shed from the south to the north during the Brooks Range uplift, an abrupt shift from the underlying sequences. The rocks here are shales, sandstones, and conglomerates (Figure 3). There are very few calcareous rocks in this sequence, as most of the strata represent shedding off of pre-existing siliciclastic material from the south. Coals and fossils at the surface attest to the lack of metamorphosis and also hint at subterranean hydrocarbon occurrences that are being found in the Colville Basin and the Arctic Ocean Coastline. The most significant feature in the Brookian Sequence is the relatively regular stratigraphy, the silicate-dominated mineralogy, and the K-T Boundary. This occurs between mile markers 352 and 354, underlying the Sagwon bluffs near the Sagavanirktok River, where the upper Cretaceous Prince Creek Formation underlies the lower Paleogene Sagavanirktok Formation. The badlands-like Franklin Bluffs between mile markers 381 and 395 are the last surficial exposure of lithified sediments and may represent yet another significant paleoclimatic boundary, the Initial Eocene Thermal Maximum. This interval is notable in that crocodilians and sub-tropical flora occurred in this part of the world, despite the continents being in pretty much the same locations they are today. Think of it, crocodiles in Alaska, and not in some hothouse or zoo! It is hard to believe

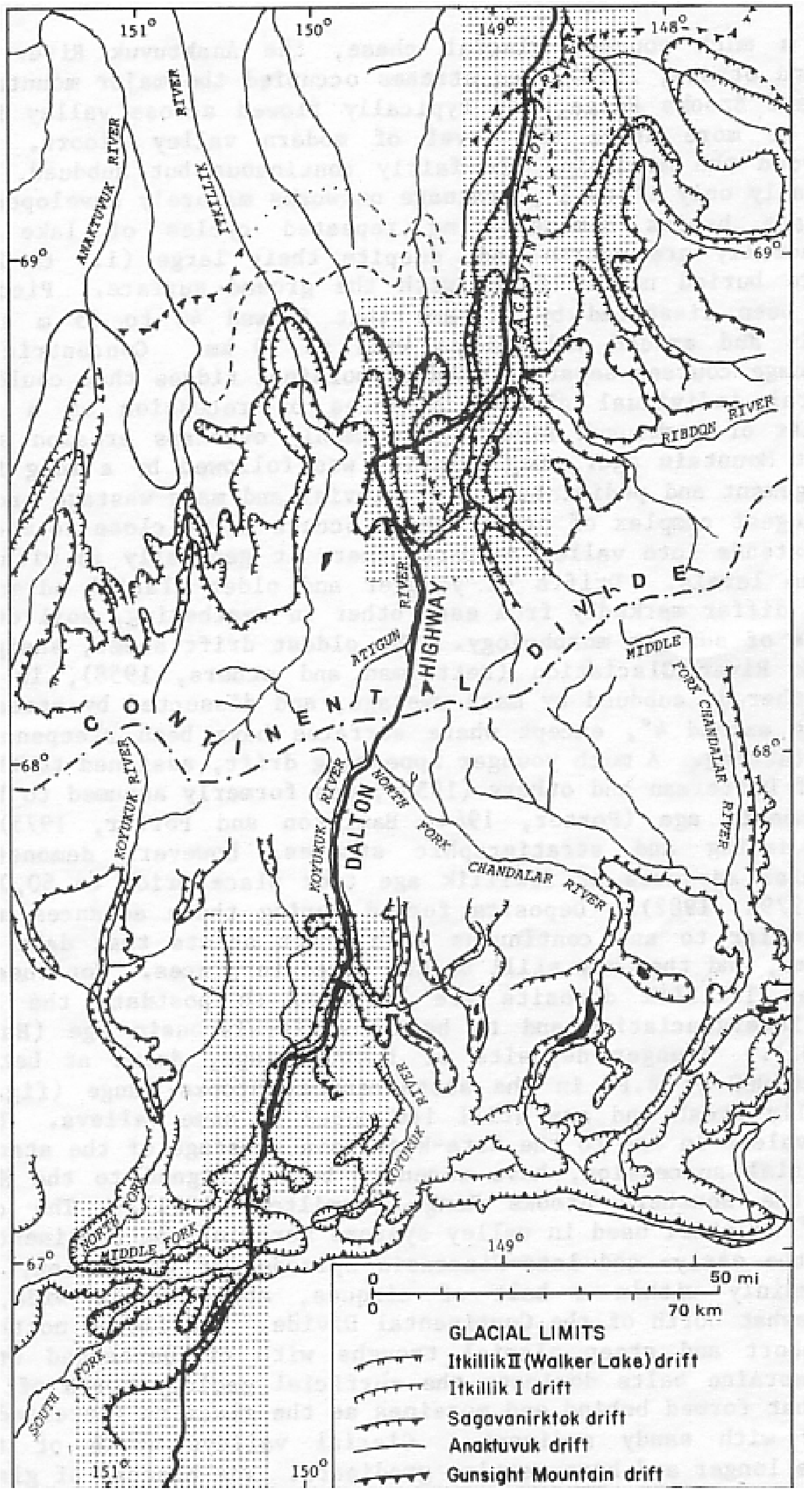


Figure 4: Extent of glacial deposits along the Dalton Highway. Map by Hamilton (1978, 1979, 1982) from Brown and Krieg (1983).

with all this permafrost underfoot and the boggy nature of the land.

Now that the sequences have been set out, what does that mean for soils and plants? Probably one of the most notable features about these rock formations is the balance of silicates and carbonates between east and west North Slope of the Brooks Range. To the west, the rocks are primarily siliceous and material derived from those rocks is rich in silicon (Si), aluminum (Al), and iron (Fe). The carbonaceous rocks to the east of the Alaska Pipeline extend closer to the Arctic Coast and are enriched in alkaline earth elements (calcium [Ca], magnesium [Mg], sodium [Na], and potassium [K]) as well as having some isolate outcrops of rock formations bearing phosphorus (P). This makes a difference in the native fertility of the soil, although cryoturbation processes often dominate soil formation.

Glacial processes and characteristic morphologies

Glaciers have played an important role in shaping the Brooks Range. Glacial advances were confined to deep valleys and flowed out as fingers in the Interior and onto the Arctic Coastal Plain (Figure 4). Glacial advances occurred from the late Pliocene to as recently as 8-9 kyr BP. Table 1 gives the various glacial advance ages and the time of deposition.

Patterns of drift deposits on in the mountains become younger as elevation increases and approaching the continental divide. The oldest surfaces, Gunsight Mountain, are delineated by erratics of

Table 1: The names and chronology of general glacial deposits in the Brooks range vicinity

Name of glacial deposit	Age	Time before present (ka)
Fan Mountain or Itkillik III	Late Holocene	8-9
Itkillik II or Walker Lake	Late Wisconsin	12-25
Itkillik I	Early Wisconsin	40-60
Sagavanirktok Drift	Middle Pleistocene	430-470
Anaktuvuk River Drift	Early Pleistocene	1100
Gunsight Mountain erratics	Late Pliocene	>1900

Table 2. Simplified classification of patterned ground features (Washburn, 1970)

Types	Subtypes	Processes
Circles	Sorted Non-sorted	Features subdivided on basis of necessity of cracking (frost cracking, permafrost cracking, dilation, joint control). Where cracking is not important, heave and mass displacement are prevalent.
Polygons	Sorted Non-sorted	Includes ice and sand wedges. Cracking of all types. Heave, mass displacement, and thaw processes important in non-cracked types.
Nets	Sorted Non-sorted	Includes earth hummocks. Cracking of all types except joint controlled types. Heave and mass displacement in non-cracked types. Thaw also important in sorted varieties.
Steps	Sorted Non-sorted	Cracking unimportant. Heave, mass wasting, and displacement in nonsorted. Frost sorting and thaw also important in sorted varieties. Terracette (sheep-step) form.
Stripes	Sorted Non-sorted	All types of cracking important. Heaving, mass wasting, and displacement in nonsorted. Frost sorting and thaw also important in sorted types.

Kanayut Conglomerate and usually restricted to elevated terraces and piedmont zones. More recent glacial advances have obliterated and reworked these deposits. The Anaktuvuk River drift is more defined and commonly overlaps Gunsight Mountain surfaces.

The youngest complex of drift sheets occurs most frequently on the valley bottoms in well-defined moraines. The Sagavanirktok Drift is subdued by later dissection, erosion and mass wastage. The Itkillik Drift series have clearer moraines that will be indicated in the road log following. Soils that form on the different age materials range from quite ice-rich in the oldest drifts to mineral-rich clast-supported ice bodies in the more recent deposits.

Presently, the only glaciers in the Brooks Range are cirque glaciers that are usually located in the higher elevations (above 1500 m). Expansion and contraction of the cirques depends upon their altitude and relative orientation. Northeast-facing cirque glaciers on the North Slope are dynamic entities and often experience year-by-year shifts in snow field size and glacial movement.

General geomorphology along the route

The traverse from Fairbanks to Coldfoot, through the Brooks Range and out to the Coastal Plain, provides comprehensive viewing of many examples of geomorphologic agents and features. Periglacial processes have shaped (and continue to influence) the landscapes of the Interior and the North Slope. Glacial processes are evident as both active features and as relict landforms close to and extending from the Brooks Range. Mass wastage and fluvial processes dictate the slope morphologies within the confines of the valleys.

Up to the south foothills of the Brooks Range, the landscape morphology is broadly convex hill slopes initially caused by volcanic intrusions bulging up under the surface and rounded by solifluction (downhill movement of saturated soils and sediments). In this area, there is a strong contrast between permafrost presence and depths between north to east facing slopes ("cool" slopes) and south to west facing slopes ("warm" slopes). Thus, in some cases, dominant slope morphology changes according to slope aspect. This difference is also noted in the vegetation mosaics that blanket the hillslopes.

Tors are present on cryoplanation surfaces in the large flats. In many cases, local loess has blanketed the slopes and occurs in varying thicknesses depending on the prevailing wind and proximity to source. Approaching the mountain, the most notable features to be seen are glacial moraines, outwash terraces, and lacustrine sediments from the various ice advances described above. Slope morphology tends to be more linear where the glaciers have cleared out older colluvium. Shallow depth to bedrock prohibits deep permafrost and sideslope soils are often eroded through frost heave and nivation (sub-snow cover frost shattering and entrainment).

The North Slope landscape, devoid of trees and tall brush, provides an excellent view of many geomorphic processes induced by intensely cold and harsh environments. The side-slopes of the steep U-shaped valleys are steeply graded, carved out by the numerous glacial advances, and have dramatic colluvial/alluvial fans and talus slopes skirting them. Rock falls and/or slushflows sometime trail from the very peak of the summit to the footslope position of the surrounding hills, as much as 500 m elevation difference. The streams and rivers often host aufeis (flood overflow buildup) that accumulates through the winter and often persists into the late summer, abandoned in the stream beds. Braided flow is normal here, and rock flour is actively produced by gelifraction and grinding in active cirque basin glaciers.

The hydrology of the Brooks Range and North Slope is greatly influenced by the presence of permafrost. You will see outstanding examples of periglacial drainage patterns that once dominated the northern United States during the Pleistocene glaciations. In the uplands and foothills, "Horsetail Drainage" carves out trellised patterns that funnel into concavities in the hillslopes. On the toeslopes and onto the floodplains, "paternoster" or beaded drainage is common, where the stream flow through a series of melted-out ice polygons. In the late summer, melt- and runoff water essentially sheetflows under the organic mats down slopes. On the Coastal Plain, thaw lakes prevail and as the depth to permafrost becomes shallower, the wetter the landscape becomes, even though the North Slope only receives <350 mm of total precipitation.

Patterned ground features and their formation mechanism will be reviewed at the soil pit stops along the way. The classification of these features are presented in Table 2. These features are particularly noticeable on the open ground of Little Kanuti Flats, the Chandalar Shelf, and the Arctic Foothills and Coastal Plain.

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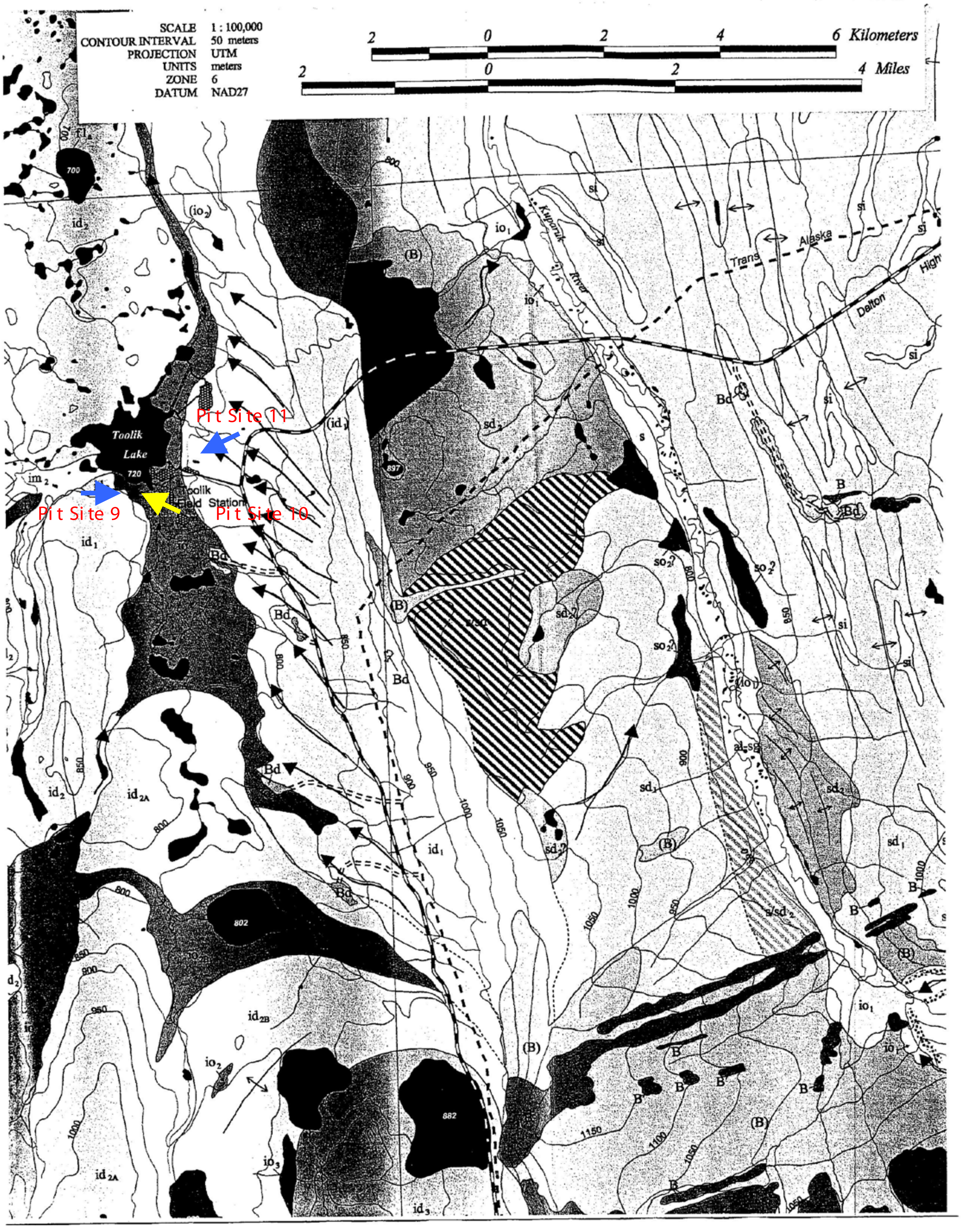
Appendix D:
Glacial geology of the Toolik Lake area



GLACIAL GEOLOGY OF THE UPPER KUPARUK RIVER REGION

Thomas D. Hamilton

This map is based on a previous map of the region at 1 : 250,000 scale (Hamilton, 1978) and field reconnaissance in 1996. It was mapped from color-infrared aerial photographs taken in 1982 and enlarged to 1 : 25,000 scale. Some parts are subject to revision. Areas that are most uncertain are tagged with a "?".

Cartography by A. W. Balser, D.A. Walker, and J.A. Anderson
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Last updated September, 2001.

GLACIAL DEPOSITS

Note: ( ) represents thin and discontinuous drift overlying bedrock

Itkillik Glaciation

13-11 Ka BP — id_3 Drift of latest Itkillik readvance
25-11 Ka BP — id_2 Drift of Itkillik Phase II
id_{2B} Drift of Itkillik Phase II (younger advance)
25-17 Ka BP — id_{2A} Drift of Itkillik Phase II (older advance)
120-50 Ka B P — id_1 Drift of Itkillik Phase I
id_{1B} Drift of Itkillik Phase I (younger advance)
id_{1A} Drift of Itkillik Phase I (older advance)
id Undifferentiated Itkillik drift

Sagavanirktok River Glaciation

Drift of Sagavanirktok River age
sd Drift of younger Sagavanirktok River age
sd_1 Drift of Older Sagavanirktok River age

GLACIAL OUTWASH DEPOSITS

Note: ( ) represents thin and discontinuous drift overlying bedrock

Itkillik Outwash Deposits

Outwash of latest Itkillik readvance
Outwash of Itkillik Phase II
Outwash of Itkillik Phase II (younger advance)
Outwash of Itkillik Phase II (older advance)
io_1 Outwash of Itkillik Phase I
io_{1B} Outwash of Itkillik Phase I (younger advance)

Sagavanirktok River Outwash Deposits

Outwash of Sagavanirktok River age
Outwash of younger Sagavanirktok River age

Ice Stagnation Deposits

im_3 Subglacial meltwater deposits of latest Itkillik reac
im_2 Subglacial meltwater deposits of Itkillik Phase II
ii_3 Inwash deposits of latest Itkillik readvance

Colored diagonal stripes designate the two elements of each compound unit.

SYMBOLS

Narrow moraine crest
Broad moraine crest (arrows point to flanking slop
Glacial divide crossing
Glacial drainage channel
Contact between units (dashed where inferred)
Pond or lake
Rivers
Gravel Pad
Gravel Road

RIVER DEPOSITS

al Undifferentiated alluvium
al_3 Modern alluvium
al_2 Low floodplain deposits
al_1 Higher floodplain deposits
al-sg Silty alluvium overlying channel deposits ranging from gravel to sandy gravel
al-s Silty alluvium overlying channel deposits ranging from silt with sparse sand to fine gravel
tg Undifferentiated alluvial terrace deposits
tg_2 Low alluvial terrace deposits
tg_1 Higher alluvial terrace deposits

FAN DEPOSITS

f_3 Modern fan deposits
f_2 Older fan deposits
f_1 Oldest fan deposits
fd Fan-delta deposits

LACUSTRINE DEPOSITS

l_2 Lacustrine deposits (younger)
l_1 Lacustrine deposits (older)
b Beach deposits

COLLUVIAL DEPOSITS

s Solifluction deposits *
si Ice-rich silt deposits
Talus rubble
Active tundra earthflow
Inactive (vegetated) tundra earthflow

* "s/" Represents areas where generally thin solifluctio sheets overlie glacial deposits of various ages.

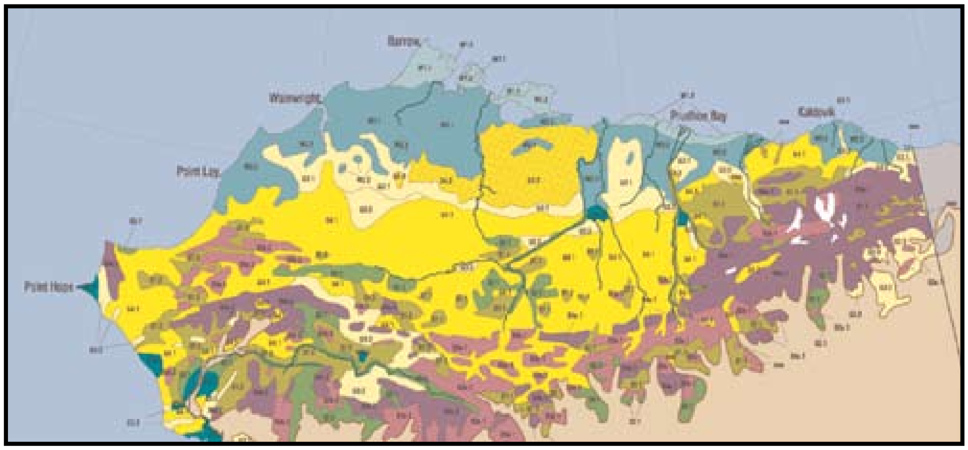
BEDROCK

Bedrock
(B) Near-surface bedrock
Bd Bedrock exposed by human disturbance

Appendix E: Vegetation communities of arctic Alaska

By Raynolds, M.K., D.A. Walker, and H.A. Maier. 2006. Alaska Arctic Tundra Vegetation Map. Scale 1:4,000,000. Conservation of Arctic Flora and Fauna Map No. 2.

NORTHERN ALASKA ARCTIC TUNDRA VEGETATION



Barrens

B3e Acidic mountain complexes in Subzone E

B3e.1 Prostrate dwarf-shrub, graminoid communities on acidic slopes, in complex with snowbeds, talus slopes and meadow communities. Brooks Range, Subzone E.

B3e.2 Prostrate dwarf-shrub, lichen communities on dry granitic slopes, in complex with snowbeds, talus slopes and meadow communities. NW Alaska, Subzone E.

B4e Non-acidic mountain complexes in Subzone E

B4e.1 Prostrate dwarf-shrub, sedge communities in complex with snowbeds, talus slopes and meadow communities, on dry limestoneslopes. Brooks Range, Subzone E.

B4e.2 Prostrate dwarf-shrub, forb, lichen communities in complex with snowbeds, talus slopes and meadow communities, on dry limestone slopes. NW Alaska, Subzone E.

Graminoid tundras

G3 Non-tussock graminoid tundras

G3.1 Non-tussock sedge, dwarf-shrub, moss communities on mesic non-acidic loess. Northern Arctic Coastal Plain, Subzone D.

G3.3 Non-tussock sedge, dwarf-shrub, forb, moss communities on mesic non-acidic loess. Arctic Foothills of the Brooks Range, Subzone E.

G4 Tussock graminoid tundras on non-sandy substrates

G4.1 Tussock-sedge, dwarf-shrub, moss communities on mesic, acidic loess. Foothills of the Brooks Range, Subzone E.

G4 Tussock graminoid tundras on sandy substrates

G4.3 Tussock-sedge, dwarf-shrub, moss communities on sands, in complex with lakes and wet tundra. Northern Arctic Coastal Plain, Subzone D.

Erect-shrub tundras

S1 Erect dwarf-shrub tundras

S1.1 Erect dwarf-shrub communities on mesic sites. Foothills of the eastern Brooks Range, Northern Alaska floristic province, Subzone E.

S1.2 Erect dwarf-shrub, lichen communities on mesic sites. Foothills of the western Brooks Range, Beringian Alaska floristic province, Subzone E.

S2 Low-shrub tundras

S2.1 Low-shrub communities with open to closed canopies of willows or shrub birch, or open alder. Foothills of the Brooks Range, Subzone E.

S2.2 Low-shrub communities with closed alder canopies in drainages and valleys, and at treeline. Foothills of the southern Brooks Range, Subzone E.

Wetlands

W1 Wetlands in Subzone C

W1.1 Wet graminoid, moss communities on wet acidic coastal areas, with moist communities on higher microsites. Northern Arctic Coastal Plain, Subzone C.

W1.2 Wet graminoid, moss communities on wet non-acidic coastal areas, with moist communities on higher microsites. Northern Arctic Coastal Plain, Subzone C.

W2 Wetlands in Subzone D

W2.1 Wet sedge, moss communities on wet acidic sites, with moist tussock-sedge, dwarf-shrub communities on higher microsites. Northern Arctic Coastal Plain, Subzone D.

W2.2 Wet sedge, moss communities on wet nonacidic sites, with moist communities (G3.1) on higher microsites. Northern Arctic Coastal Plain, Subzone D.

W3 Wetlands in Subzone E

W3.6 Wet sedge, moss communities on nonacidic sites, with moist communities (G3.3) on higher microsites. NW Alaska, Subzone E.

Water **Treeline** **Riparian corridor** **Glacier**