Permafrost boreholes, Prudhoe Bay study area, August 2022

In August 2022, Shur and Kanevskiy studied cryostratigraphy and ground-ice content of the upper permafrost in the Prudhoe Bay study area; Alexandra Veremeeva also participated in the fieldwork. This study was performed in cooperation with the NSF-funded project "NNA TRACK 1: Landscape evolution and adapting to change in Ice-Rich Permafrost Systems" (NNA-IRPS, PI Skip Walker). During this study, a total of 31 permafrost boreholes were drilled during 26–30 August 2022 to examine the status of permafrost and protective layers (TL and IL) above ice wedges in: (1) NIRPO thermokarst ponds along Transect T6; (2) Jorgenson Transect thermokarst ponds; (3) ice-wedge troughs along NIRPO Transect T7; and (4) road-related disturbed sites along Colleen site Transect T2.

Ten boreholes were drilled at the NIRPO site in thermokarst ponds where the vegetation was sampled by Emily Watson-Cook in 2021 (**Figure 1, Table 1**).

Nine boreholes were drilled at the Jorgenson Site in thermokarst ponds where the vegetation was sampled by Emily Watson-Cook in 2021. Shown here are all boreholes drilled in 2019, 2021, and 2022 in ponds sampled by Emily Watson-Cook at the Jorgenson site in 2021 (**Figure 2, Table 2**).

Three permafrost boreholes were drilled at the NIRPO site in three ice-wedge troughs along the Transect T7 near permanent vegetation plots 21-35, 21-32, and 21-31 (**Figure 3, Table 3**).

Nine ice wedges that were sampled in 2014 at the road-disturbed Colleen site Transect T2, were redrilled to assess the current status of ice-wedge degradation/stabilization (**Table 4**).

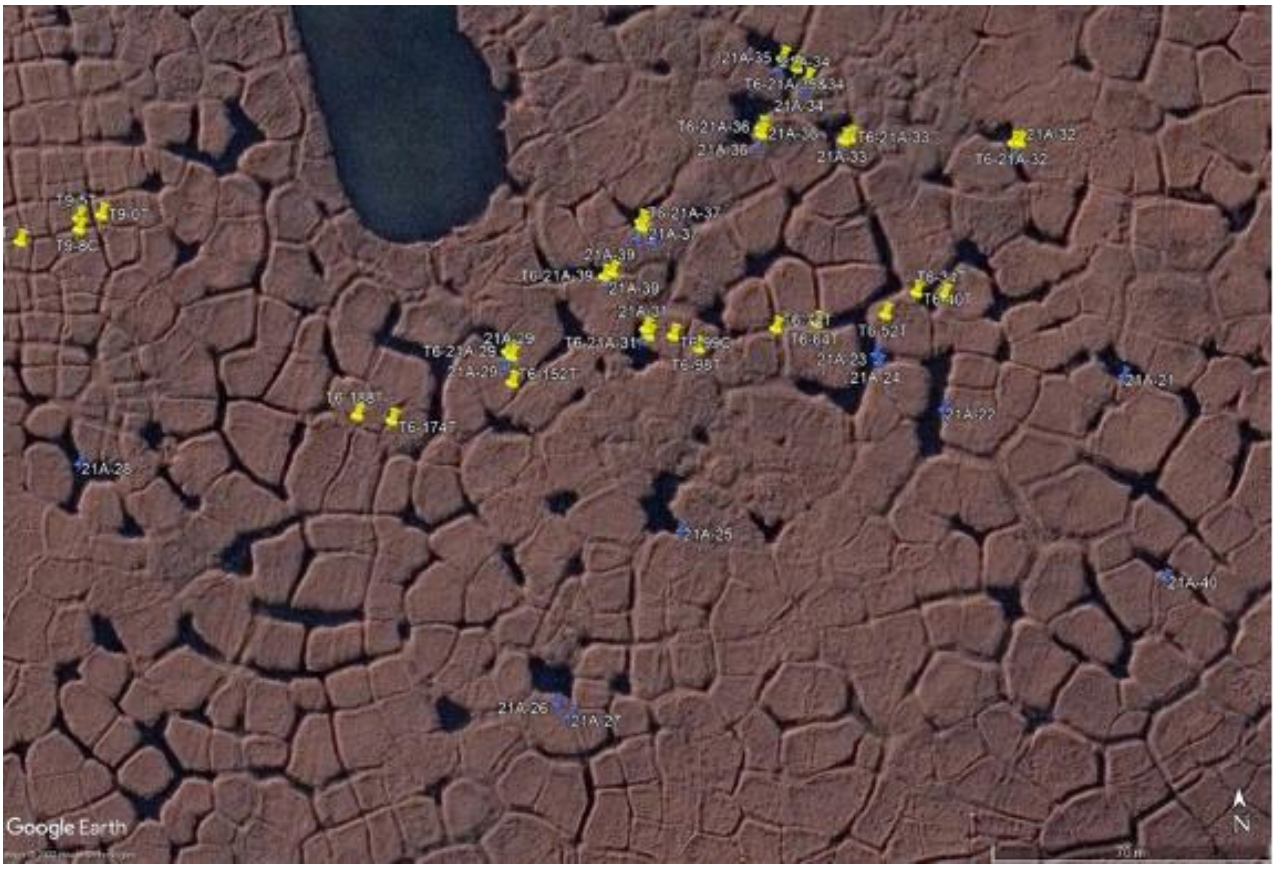

Figure 1. Boreholes at NIRPO Transect T6 in 2021 (yellow markers) and 2022 (thermokarst ponds, blue markers).

Table 1. Results of coring in thermokarst ponds, NIRPO Transect T6 in 2021 and 2022. Pond numbers correspond to Watson-Cook's vegetation plot numbers.

Borehole	Pond (veget. plot)	Date	Bore-hole depth, cm	Water depth, cm	Thaw depth (ALT), cm	TL, cm	IL, cm	Depth to massive ice, cm	TL+IL (PL2), cm	Notes
T6-21A-31	21A-31	8/31/2021	99	45	49	5	7	61	12	1.8 m S of 21A-31
T6-21A-29	21A-29	8/31/2021	95	46	50	6	0	56	6	1.5 m NW of 21A-29
T6-21A-39	21A-39	8/31/2021	82	39	46	6	0	52	6	1.6 m W of 21A-39
T6-21A-37	21A-37	8/31/2021	97	46	48	0	4	52	4	1.5 m N of 21A-37
T6-21A-36	21A-36	8/31/2021	79	45	41	6	9	56	15	1.6 m N of 21A-36
T6-21A-35&34	21A-35, 21A-34	9/1/2021	90	55	42	8	13	63	21	Between 21A-35 and 21A-34
T6-21A-33	21A-33	9/1/2021	89	35	41	0	0	41	0	1.6 m E of 21A-33; actively degrading ice wedge; fresh cracks around the pond
T6-21A-32	21A-32	9/1/2021	77	30	45	6	7	58	13	1.6 m W of 21A-32
Average T6 2021, n=8			88.5	42.6	45.3	4.6	5.0	54.9	9.6	Only one ice wedge (T6-21A-33) was degrading in 2021
T6-21A-26&27	21A-26, 21A-27	8/26/2022	69	55	41	8	7	56	15	Between 21A-26 and 21A-27, aquatic moss
T6-21A-25	21A-25	8/26/2022	71	57	45	8	3	56	11	1.2 m W of 21A-25; aquatic moss; 45-56 – destroyed and/or lost core
T6-21A-25A	21A-25	8/26/2022	77	56	47	7	3	57	10	0.3 m W of 21A-25 borehole; aquatic moss; 57-65 - IW boundary, soil from 65
T6-21A-22	21A-22	8/26/2022	80	47	53	7	3	63	10	1.2 m S of 21A-22; aquatic moss
T6-21A-23&24	21A-23, 21A-24	8/26/2022	66	61	39	12	3	54	15	Between 21A-23 and 21A-24, some aquatic moss
T6-21A-28	21A-28	8/26/2022	71	41	41	6	11	58	17	1.0 m E of 21A-28; aquatic moss; 41-43 destroyed
T6-21A-30	21A-30	8/26/2022	83	55	48	8	0	56	8	1.2 m W of 21A-30; no aquatic moss; (21A-29 - in the same pond - see above)
T6-21A-38	21A-38	8/26/2022	74	51	47	3	0	50	3	1.3 m E of 21A-38; no aquatic moss;
T6-21A-21	21A-21	8/27/2022	73	35	41	7	13	61	20	1.2 m E of 21A-21; very thick aquatic moss; 41-44 destroyed;
T6-21A-40	21A-40	8/27/2022	73	52	46	9	0	55	9	1.2 m E of 21A-40; some aquatic moss; 46-54 destroyed (gravel);
Average T6 2022, n=9			73.3	50.4	44.6	7.6	4.4	56.6	12.0	No degrading ice wedges in 2022; T6-21A-25A was excluded
Average T6 2021-22, n=17			80.5	46.8	44.9	6.2	4.7	55.8	10.9	One ice wedge was degrading in 2021; six ice wedges were vulnerable in 2021-2022 (PL2<10 cm)

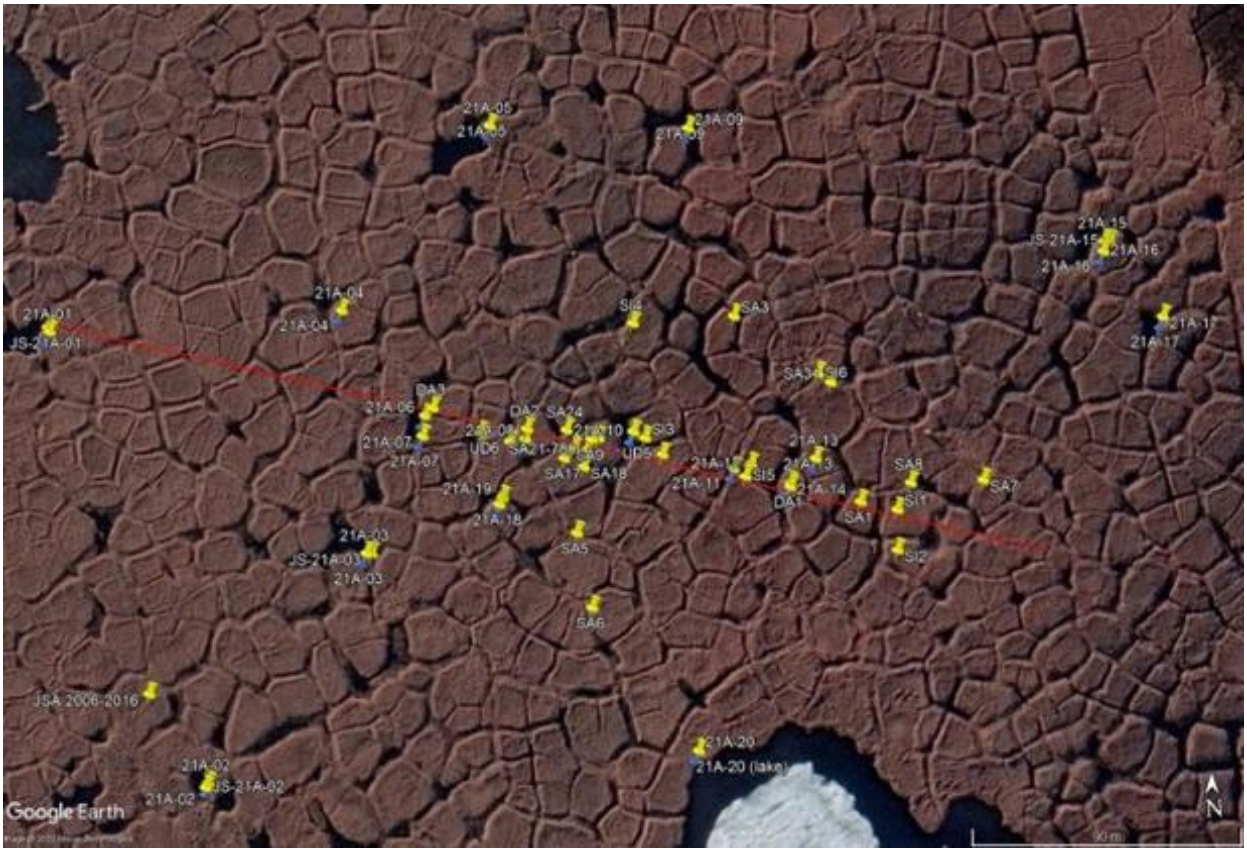

Figure 2. Boreholes along the Jorgenson Transect (red line). Yellow markers are 2011, 2012, 2019, 2021, and 2022 boreholes. Blue markers are ponds sampled by Emily Watson-Cook in 2021.

Table 2. Results of coring in thermokarst ponds, Jorgenson site, 2021 and 2022. Pond numbers correspond to Watson-Cook's vegetation plot numbers.

Borehole	Pond	Date	Bore-hole depth, cm	Water depth, cm	Thaw depth (ALT), cm	TL, cm	IL, cm	Depth to massive ice, cm	TL+IL (PL2), cm	Notes
T6-21A-31	21A-31	8/31/2021	99	45	49	5	7	61	12	1.8 m S of 21A-31
T6-21A-29	21A-29	8/31/2021	95	46	50	6	0	56	6	1.5 m NW of 21A-29
T6-21A-39	21A-39	8/31/2021	82	39	46	6	0	52	6	1.6 m W of 21A-39
T6-21A-37	21A-37	8/31/2021	97	46	48	0	4	52	4	1.5 m N of 21A-37
T6-21A-36	21A-36	8/31/2021	79	45	41	6	9	56	15	1.6 m N of 21A-36
T6-21A-35&34	21A-35, 21A-34	9/1/2021	90	55	42	8	13	63	21	Between 21A-35 and 21A-34
T6-21A-33	21A-33	9/1/2021	89	35	41	0	0	41	0	1.6 m E of 21A-33; actively degrading ice wedge; fresh cracks around the pond
T6-21A-32	21A-32	9/1/2021	77	30	45	6	7	58	13	1.6 m W of 21A-32
Average T6 2021, n=8			88.5	42.6	45.3	4.6	5.0	54.9	9.6	Only one ice wedge (T6-21A-33) was degrading in 2021
T6-21A-26&27	21A-26, 21A-27	8/26/2022	69	55	41	8	7	56	15	Between 21A-26 and 21A-27, aquatic moss
T6-21A-25	21A-25	8/26/2022	71	57	45	8	3	56	11	1.2 m W of 21A-25; aquatic moss; 45-56 – destroyed and/or lost core
T6-21A-25A	21A-25	8/26/2022	77	56	47	7	3	57	10	0.3 m W of 21A-25 borehole; aquatic moss; 57-65 - IW boundary, soil from 65
T6-21A-22	21A-22	8/26/2022	80	47	53	7	3	63	10	1.2 m S of 21A-22; aquatic moss
T6-21A-23&24	21A-23, 21A-24	8/26/2022	66	61	39	12	3	54	15	Between 21A-23 and 21A-24, some aquatic moss
T6-21A-28	21A-28	8/26/2022	71	41	41	6	11	58	17	1.0 m E of 21A-28; aquatic moss; 41-43 destroyed
T6-21A-30	21A-30	8/26/2022	83	55	48	8	0	56	8	1.2 m W of 21A-30; no aquatic moss; (21A-29 - in the same pond - see above)
T6-21A-38	21A-38	8/26/2022	74	51	47	3	0	50	3	1.3 m E of 21A-38; no aquatic moss;
T6-21A-21	21A-21	8/27/2022	73	35	41	7	13	61	20	1.2 m E of 21A-21; very thick aquatic moss; 41-44 destroyed;
T6-21A-40	21A-40	8/27/2022	73	52	46	9	0	55	9	1.2 m E of 21A-40; some aquatic moss; 46-54 destroyed (gravel);
Average T6 2022, n=9			73.3	50.4	44.6	7.6	4.4	56.6	12.0	No degrading ice wedges in 2022; T6-21A-25A was excluded
Average T6 2021-22, n=17			**80.5**	**46.8**	**44.9**	**6.2**	**4.7**	**55.8**	**10.9**	One ice wedge was degrading in 2021; six ice wedges were vulnerable in 2021-2022 (PL2<10 cm)

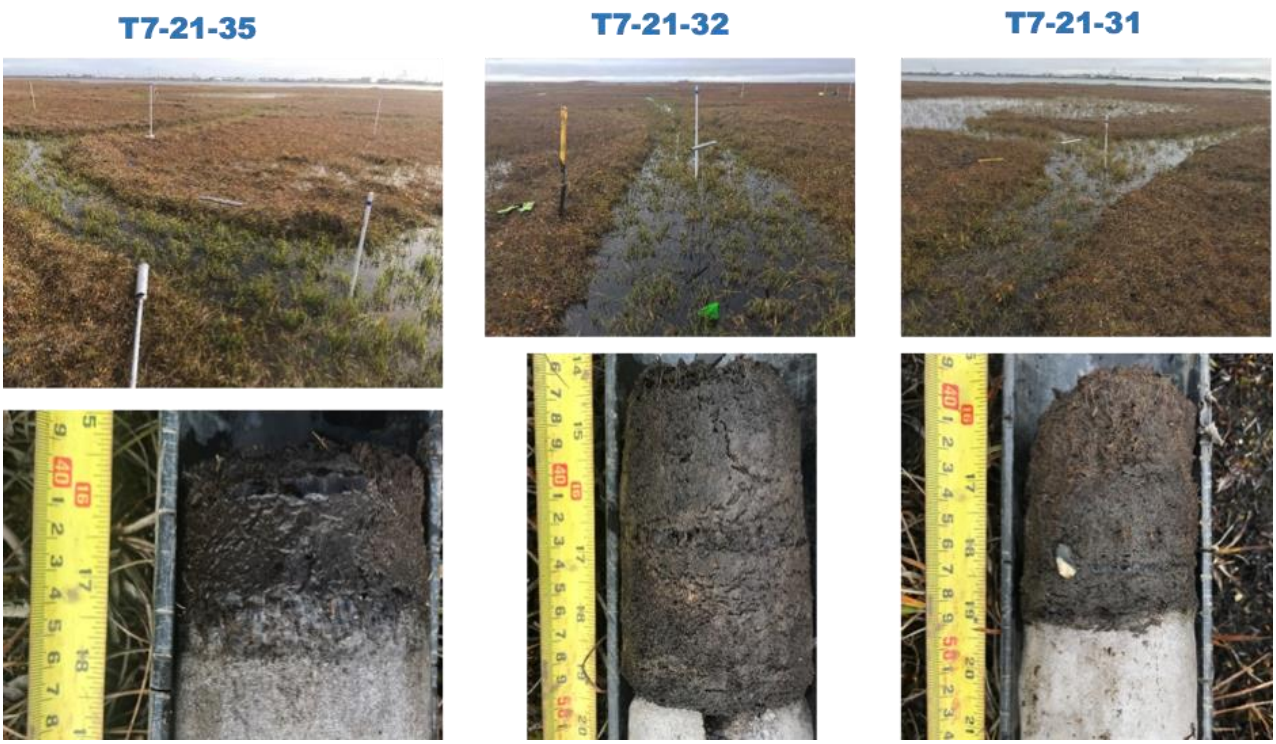

Figure 3. Coring sites and frozen cores obtained from boreholes T7-21-35, T7-21-32, and T7-21-31. Borehole locations in central parts of ice-wedge troughs are marked with the permafrost probe (upper photographs).

Table 3. Results of coring at T7-21-35, T7-21-32, and T7-21-31.

Borehole	Date	Borehole depth, cm	Water depth, cm	Thaw depth, cm	TL, cm	IL (PL3), cm	Depth to massive ice, cm	TL+IL (PL2), cm	Notes
T7-21-35	8/27/2022	58	28	39	1	4	44	5	1.2 m N of 21-35, belt at 40
T7-21-32	8/27/2022	71	20	36	6	6	48	12	1.2 m N of 21-32, belt at 42
T7-21-31	8/27/2022	55	22	38	8	2	48	10	1.2 m NW of 21-31, belt at 46
Average T7 2022, n=3		61.3	23.3	37.7	5.0	4.0	46.7	9.0	No degrading ice wedges

Table 4. Results from redrilling of ice-wedge boreholes originally sampled in 2014 at the Colleen site, Transect T2.

Borehole	Date	Bore-hole depth, cm	Water depth, cm	Thaw depth (ALT), cm	TL, cm	IL (PL3), cm	Depth to massive ice, cm	TL+IL (PL2), cm	Notes
T2-10T-1	8/10/2014	89	0	53	6	7	66	13	
T2-10T-1/22	8/29/2022	73	18	55	6	4	65	10	1.0 m W of T2-10T-1, no significant changes since 2914, no clear TL/IL boundary
T2-25T-1	8/10/2014	102	35	45	0	19	64	19	
T2-25T-1/22	8/29/2022	67	43	52	4	11	>67	>15	0.6 m N of T2-25T-1, Refusal at 67 (gravel), no significant changes
T2-50T-1	8/11/2014	77		48	10	1	59	11	
T2-50T-1/22	8/29/2022	64	0	51	0	13	>64	>13	0.6 m N of T2-50T-1, Refusal at 64 (gravel), some stabilization
T2-50T-3	8/11/2014	68	35	46	8	2	56	10	
T2-50T-3/22	8/29/2022	73	33	50	8	8	66	16	1.0 m W of T2-50T-3, no clear TL/IL boundary, aquatic vegetation, some stabilization since 2014
T2-100T-1	8/11/2014	65	8	43	8	6	57	14	
T2-100T-1/22	8/29/2022	71	19	42	11	5	58	16	0.6 m N of T2-100T-1, no clear TL/IL boundary, no significant changes
T2-200T-1	8/12/2014	49	70	28	8	0	36	8	
T2-200T-1/22	8/30/2022	75	60	48	7	7	62	14	0.6 m W of T2-200T-1, aquatic vegetation, some stabilization since 2014
T2-200T-3	8/12/2014	98		68	0	5	73	5	
T2-200T-3/22	8/30/2022	71		54	8	8	>71	16	0.6 m S of T2-200T-3, Refusal at 71 (gravel), some stabilization since 2014, no clear TL/IL boundary
T2-200T-4	8/12/2014	92		55	0	5	60	5	
T2-200T-4/22	8/30/2022	71		45	5	11	61	16	0.6 m S of T2-200T-4, some stabilization since 2014, no clear TL/IL boundary
T2-200T-8	8/13/2014	75	27	44	5	0	49	5	
T2-200T-8/22	8/30/2022	71	44	45	4	9	58	13	0.6 m N of T2-200T-8, aquatic vegetation, some degradation since 2014, then stabilization
Average T2 2014, n=9	August 2014	79.4	29.2	47.8	5.0	5.0	57.8	10.0	No degrading ice wedges in 2014; four wedges were vulnerable (PL1<10 cm)
Average T2 2022, n=9	August 2022	70.7	31.0	49.1	5.9	8.4	63.6	14.3	No degrading or vulnerable ice wedges in 2022; PL2>10 cm for all the ice wedges