3.5 Studies on recent cryogenesis

Hanno Meyer and Waldemar Schneider

The main aim of studying recent cryogenesis processes is to establish a stable isotope thermometer for ice wedges. The recent ice veins are attributed to the discrete year of their formation by means of tracer experiments. A tracer (coloured lycopodium spores) is applied to a polygon with recent cryogenesis, which allows identifying all types of ground ice, which were formed in the considered year.

Studies on recent ice wedge growth were carried out for a polygon at the 1st Lena River terrace of Samoylov Island. For a detailed description of the site and the experimental set-up of the first year, see Meyer (2003). 10 different recent frost cracking experiments were carried out, for which 22 steel poles were used, two of them for survey purposes (11 and 12). The general set-up of every single experiment consists of two about 1 m long steel poles (e. g. 1A and 1B) inserted to the permafrost on both sides of a frost crack. Between two steel poles, a breaking cable was installed. Six (out of ten) experiments in 2003 were equipped with voltage data loggers (type ESIS Minidan Volt) connected to the cables, which should break at the moment of frost cracking. It is expected that the experimental set-up shows a.) if frost cracking took place and b.) the precise moment of frost cracking. The loggers measure every 20 minutes from the moment of installation until the moment of frost cracking.

Only for 5 out of 10 experiments broken cables were observed between 2002 and 2003. These were: 3A-3B, 4A-4B, 6A-6B, 9A-9B, 10A-10B. For the five other experiments, the breaking cables remained in place without cracking. Only three of the five loggers, where frost cracking occurred were equipped with a data logger (4A-4B (Volt 1), 6A-6B (Volt 3), 9A-9B (Volt 6)). Volt 3 cracked on December 9th, 2002, but had contact again on January, 8th, 2003. Volt 1 cracked on November, 27, but had contact again after that. Volt 6 did not show a clear moment of cracking. There was no clear indication which type of wire was the most suitable for the experiments: 2 out of 4 wires (Cu two-wire braid) cracked as well as 1 out of 3 wires (Cu single-wire braid) and 2 out of 3 wires (Cu wire 0.5 mm). For 2003, all experiments were equipped with two-wire braid.

The distance to two fix points (poles 11 and 5b) was measured and compared to the data of 2002 (Table 3.5-1).

Table 3.5-1: Characteristics of 22 steel poles: length, height above surface, distance to fix points (poles 11 and 5b) and depth in permafrost as well as the active layer depth.

	steel pole	2002	2003	Difference 2002-2003	2002 (09.08.)	2003 (21.07)	2003 (30.08.)	Difference 2002-2003
Steel pole	length	distance to M11	distance to M11	distance to M11	distance to 5b	distance to 5b	distance to 5b	distance to 5b
Nr.	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)
1a	95	957,4	959,3	-1,9	-	-	-	
1b	100	930,5	932,2	-1,7	1171,8	1172	1172,4	-0,2
2a	100	866,7	869	-2,3	-	-	-	
2b	100	818,8	819,5	-0,7	944	944	945	0
3a	92	921,4	924,5	-3,1	-	-	-	
3b	100	887,2	888,4	-1,2	763,2	763,8	764,5	-0,6
4a	100	846,5	849	-2,5	-	-	-	
4b	100	806,7	807,6	-0,9	552,3	552,7	553,2	-0,4
5a	93	681,6	682,5	-0,9	-	-	-	
5b	100	660,2	660,3	-0,1	0	0	0	0
6a	92	635,4	635,6	-0,2	-	-	-	
6b	100	589,3	589,8	-0,5	465	466	464,9	-1
7a	100	977	978,5	-1,5	-	-	-	
7b	100	965	966,2	-1,2	991,1	992	992,6	-0,9
8a	92	727,5	727,7	-0,2	-	-	-	
8b	100	679,3	680,5	-1,2	977,2	979	979,6	-1,8
9a	98	531,8	532,4	-0,6	-	-	-	
9b	100	492	492,5	-0,5	1030,4	1031,3	1032,4	-0,9
10a	99,5	581,1	581,6	-0,5	-	-	-	
10b	100	555,6	557,5	-1,9	1217,3	1218	1217,4	-0,7
11	100	0	0		660,2	660	660	0,2
12	100	339,3	339,8	-0,5	472,8	474	-	-1,2

For the new installation of the experiments, the tension of the wires (Cu two-wire braid, HO3VH-H, 2x0.75) was increased by counting the turnarounds of the nut (type M5) on the thread rods (Table 3.5-2, compare Meyer, 2003).

Table 3.5-2. Ten stretching experiments with applied cables and voltmeters, the lengths of the breaking cables between the poles A and B before spanning the cable (1) and after the cables were stretched (2). The tension of the wires was increased by counting the revs (or turnarounds) of a nut (type M5) on the thread rod. In some cases, the tension was raised on August, 30th. For every cable type, maximum revs were calculated according to its length by means of the breaking experiments.

Marker	**Volt-meter**	**Cable length**		**Diff.**	**Control**	**Cable length**		**Diff.**	**Turn-arounds**	**Turn-arounds**	**Max.**	**Tension in**
		(21.7)			**(30.8)**	**(30.8)**						**%**
		1	**2**			**1**	**2**		**(21.7)**	**(30.8)**		
1A-1B	1	238	244	-6	new	211	219	-8	40	36	55	66
2A-2B	2	258	265	-7	tension control	268	271	-3	44	70	68	103
3A-3B	3	204	206	-2	new	178	186	-8	36	42	47	90

4A-4B	4	280	285	-5	tension control	288	288	0	46	58	72	81
5A-5B	5	150	152	-2	new	125	126	-1	40	20	32	63
6A-6B	6	290	294	-4	new	302	305	-3	52	39	76	51
7A-7B	7	280	283	-3	tension control	284	284	0	41	48	71	68
8A-8B	8	340	345	-5	new	340	341	-1	44	74	85	87
9A-9B	9	322	326	-4	tension control	328	328	0	39	50	82	61
10A-10B	10	175	178	-3	tension control	178	178	0	37	37	45	83

Additionally, the distances between the two poles of each experiment (e.g. 1A and 1B) was determined again in 2003 and compared to the results of 2002 (see Table 3.5-3). The poles were much (up to 152 mm !) closer to each other than in 2002.

Table 3.5-3: Ten stretching experiments with the respective distances (in mm) between the poles A and B measured from the a.) top to the top, b.) tape mark to the tape mark and c.) bottom to the bottom, after the cables were stretched .

Marker	**Distance Top-Top**		**Diff**	**Distance Tape-Tape**		**Diff**	**Distance Bottom-Bottom**		**Diff**
	2002	2003		2002	2003		2002	2003	
1A-1B	358	306	52	372	315	57	386	345	41
2A-2B	465	383	82	457	392	65	454	402	52
3A-3B	351	262	89	361	266	95	343	288	55
4A-4B	406	379	27	415	388	27	407	386	21
5A-5B	231	169	62	240	174	66	236	180	56
6A-6B	435	356	79	429	361	68	411	354	57
7A-7B	351	332	19	349	334	15	348	338	10
8A-8B	503	351	152	509	396	113	498	411	87
9A-9B	380	359	21	392	374	18	404	397	7
10A-10B	259	230	29	264	232	32	289	264	25

To understand how the low temperatures in winter penetrate the active layer and the permafrost, temperature loggers were introduced to the permafrost to derive the temperature gradients necessary for frost cracking activity. The loggers were inserted every 15 cm in depths of 0.05 m, 0.2 m, 0.35 m and 0.5 m. In this place the active layer is 0.4 m thick.

In order to attribute an ice vein to the discrete year of its formation, tracer experiments were carried out. In late summer, 1 kg of **malachite green** coloured *lycopodium* spores was applied to the polygon walls, especially to the apexes above the frost crack to avoid drifting of the spores by wind. After application, the spores were expected to be covered by the first snow as soon as possible. In winter, when frost cracking takes place, some of the spores should fall into the frost crack. In spring, when the snow cover melts, more spores are washed into the crack. Since the melt water freezes immediately, the spores are conserved in the newly formed ice vein, which can clearly be attributed to the year of its formation.