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The IsoPerm Project: Expedition to the Klondike (Yukon, Canada) in 2023

Edited by
Thomas Opel

with contributions of the participants

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*Titel: Permafrostaufschluss am Whitman Gulch im Klondike, Yukon (Kanada)
(Foto: Thomas Opel, AWI))*

*Cover: Permafrost exposure at Whitman Gulch in the Klondike, Yukon (Canada)
(Photo: Thomas Opel, AWI))*

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The IsoPerm Project: The Expedition CA-Land_2023_Klondike

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1. ÜBERBLICK

Thomas Opel

DE.AWI

Dieser Bericht gibt einen Überblick über die deutsch-kanadische Expedition in den Klondike im Jahr 2023. Seitens des AWI wurde sie als gemeinsame Expedition der Sektionen Polare Terrestrische Umweltsysteme und Permafrostforschung durchgeführt wurde. Diese Expedition fand im Rahmen des durch den Leverhulme Trust geförderte Projekt IsoPerm statt. Sie knüpfte an viele AWI-Expeditionen in den vergangenen 25 Jahren an, die sich mit dem Permafrost von Beringia, der im letzten Glazial unvergletscherten Landfläche, die sich vom heutigen Ostsibirien bis nach Alaska und Nordwestkanada erstreckte. Die Klondike-Region (Yukon, Kanada) stellt dabei den östlichsten Bereich von Beringia nahe der amerikanischen Inlandeisschilde dar.

Ziel dieser Expedition war die Untersuchung des in den Goldminen des Klondike aufgeschlossenen alten Permafrosts. Die Analyse von Sedimenten und Grundeis trägt zu einem besseren Verständnis der folgenden Themen bei:

- Entstehungsbedingungen des Permafrosts (z.B. Klima, Ökosystem, Sedimentdynamik),
- Klima-Permafrost-Interaktionen in vergangen Glazialen und Interglazialen,
- Die damit einhergehenden Paläolandschaftsdynamik,
- Charakterisierung des Permafrostinventars (z.B. Kohlenstoff, Stickstoff).

Die Durchführung dieser Expedition war auf war nur durch die unverzichtbare Unterstützung durch die organisierenden Institutionen und lokale Partner möglich, denen wir herzlich danken.

SUMMARY

This report provides an overview of the German-Canadian expedition to the Klondike in 2023. On the part of the AWI, it was carried out as a joint expedition of the Polar Terrestrial Environmental Systems and Permafrost Research sections. This expedition took place as part of the IsoPerm project funded by the Leverhulme Trust. It followed on from many AWI expeditions over the past 25 years that have focused on the permafrost of Beringia, the land area that remained ice-free during the last glacial period, stretching from present-day eastern Siberia to Alaska and northwestern Canada. The Klondike region (Yukon, Canada) represents the easternmost part of Beringia, close to the American ice sheets.

The main objective of this expedition was to investigate the ancient permafrost exposed in the Klondike gold mines. The analysis of sediments and ground ice contributes to a better understanding of the following topics:

- Conditions of permafrost formation (e.g., climate, ecosystem, sediment dynamics)
- Climate-permafrost interactions in past glacial and interglacial periods
- The associated paleolandscape dynamics
- Characterization of the permafrost inventory (e.g., carbon, nitrogen)

This expedition was only possible thanks to the indispensable support of the organizing institutions and local partners, to whom we extend our heartfelt thanks.

2. INTRODUCTION

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2.1 Objectives

In East Beringia, Canadian scientists have spent the last 25 years studying the permafrost environmental archives in the Klondike Goldfields south of Dawson City (Fig. 2.1). In 2023, a small German-Canadian team visited this area to sample goldmine exposures in the Klondike area, the easternmost part of former Beringia.



Fig. 2.1: Overview map of Beringia showing the location of the Klondike
(source: <https://www.nps.gov/subjects/beringia/about.htm>)

The objective of this expedition was to study the permafrost exposed in the Klondike Goldfields. More detailed, it was aimed to sample ground ice (ice wedges and pore ice) and frozen sediments in order to (1) reconstruct seasonal climate conditions as well as past landscape and permafrost conditions of an extremely continental region close to the former Laurentide and Cordilleran ice sheet margins and to (2) assess the paleoecology of an ice-age refugium using ancient organic matter characteristics and fossil bioindicators. These permafrost archives contain discontinuous records of middle and late Pleistocene, including some deposits dating back to more than 740 ka (Froese et al., 2008). In order to constrain the existing knowledge on stratigraphy and chronology in Beringia's eastern edge of the Yedoma domain, we took specific samples to employ a suite of dating techniques (^{14}C , tephra chronology, luminescence dating, $^{36}\text{Cl}/\text{Cl}$).

2.2 Geomorphological, geological, and environmental background

The study area of the Klondike Goldfields, located in the Canadian Yukon Territory near the boundary to Alaska, is bordered to the N and NE by the Klondike River and to the S and SE by the Stewart River. The Yukon River borders the area to the west. The Klondike is a low mountain region with the King Solomon Dome as the highest elevation (1234 m NN). The entire area is drained in a ring by numerous small rivers and streams starting from the King Solomon Dome. During the Cenozoic, this drainage system released gold from bedrock and, coupled with slow rates of uplift, produced prominent terraces in major valleys dating to the Pliocene and early Pleistocene. In the valley bottoms, local creek gravels are covered by Yedoma Ice Complex, or “muck” deposits (Froese et al., 2009). Nearly all drainages of King Solomon Dome have produced gold, with a total of about 15 million ounces. Today, more than 50,000 ounces are produced annually in active mining, mostly from small, independent mines.

The bedrock in the Klondike Goldfields consists of Paleozoic quartz-chlorite schist, quartz-muscovite schist, micaceous quartzite, graphitic quartzite, quartz-feldspar-augen schist, amphibolite, orthogneiss, greenstone, and serpentinite (Lowey, 2006).

According to the maps shown in Froese & Hein (1996), the western parts of the Klondike Goldfields were probably covered by pre-Reid glacial deposits.

The area is the easternmost part of the Beringia landmass, a continuous Arctic and sub-Arctic region from Eastern Siberia to the Yukon area that was unglaciated during the late Pleistocene. The study area belongs to the discontinuous permafrost zone. Permafrost deposits in the Klondike Goldfields are locally more than 750 ka old (Froese et al., 2009). The permafrost thickness varies and extends to 60 m near Dawson City. The active layer in alluvial sediments is up to 1.5 m thick and up to 2 m in dry sand. In locations with ice-rich organic soils, the active layer is 0.3 to 0.4 m thick (Calmels et al., 2012). Since the discovery of placer gold in 1896, mining has produced tremendous exposures of surficial sediments within the Klondike goldfields, along with the recognition of abundant Pleistocene fossil bones (Zazula et al., 2003, 2005, 2006, 2007). According to Froese et al. (2009), the Quaternary chronostratigraphy is mainly constrained by tephra chronology. The most prominent tephra layers are Gold Run tephra (740 ± 60 ka), Old Crow tephra (131 ± 11 ka), Dominion Creek tephra (82 ± 9 ka), Sheep Creek-K tephra (ca. 80 ka), the frequently represented Dawson tephra (25.3 ^{14}C ka BP), and White River Ash tephra (1.2 and 1.7 ka).

Dawson City and the Klondike area have a subarctic, subalpine continental climate. According to the Weather and Climate, CA website (<https://weatherandclimate.com/canada/yukon-territory/klondike>), the mean annual temperature is approximately -1.7°C with a summer (June to August) mean of 20.0°C and a winter (December to February) mean of -25.4°C . The mean annual precipitation is reported to be 146 mm.

According to the Canadian National Vegetation Classification (CNVC <http://cnvc-cnvc.ca>), the Klondike Goldfields belong to the Alaskan-Yukon North American Boreal Forest and Woodland (M 156). Dominant tree species are white spruce (*Picea glauca*), black spruce (*P. mariana*), trembling aspen (*Populus tremuloides*), lodgepole pine (*Pinus contorta* var. *latifolia*), and, at higher elevations, subalpine fir (*Abies lasiocarpa*). Common understory species include willows (*Salix* spp.), shrub birches (*Betula nana* and/or *B. glandulosa*), black crowberry (*Empetrum nigrum*), common Labrador tea (*Rhododendron groenlandicum*), fireweed (*Chamerion angustifolium*), lingonberry (*Vaccinium vitis-idaea*), twinflower (*Linnaea borealis*), Arctic lupine (*Lupinus arcticus*), Altai fescue (*Festuca altaica*), common bearberry (*Arctostaphylos uva-ursi*), northern comandra (*Geocaulon lividum*), reindeer (*Cladonia* spp.) and clad (*Cladonia* spp.) lichens, and stairstep moss (*Hylocomium splendens*).

2.3 Expedition itinerary

The three-week expedition was divided into a preparation and post-expedition period in Whitehorse and Dawson City and the main fieldwork in the Klondike Goldfields (Tab. 2.1).

Tab. 2.1: Expedition schedule of CA-Land_2023_Klondike

Date	Location and activities
19.07.2023	Flight Berlin-Frankfurt-Vancouver-Whitehorse
20.-21.07.2023	Expedition preparation in Whitehorse
22.07.2023	Drive from Whitehorse to Dawson City
23.-25.07.2023	Overview visits and reconnaissance in the Klondike Goldfields area
25.-29.07.2023	Fieldwork at Little Blanche (LB)
30.07.2023	Sample organization, visit of the floating excavator "Dredge No. 4"
31.07.-02.08.2023	Fieldwork at Whitman Gulch (WG) and Dominion Creek (DC)
03.08.2023	Fieldwork at Bear Creek and "Land Research Confluence" meeting with Tr'ondëk Hwëch'in citizens and Dawson City community
04.-05.08.2023	Concluding field site visits and final sorting and packing of samples and equipment for shipping to Potsdam
06.-07.08.2023	Return drive from Dawson City to Whitehorse
07.-09.08.2023	Follow-up work and freight preparation in Whitehorse
10.-11.08.2023	Return flight Whitehorse-Vancouver-Frankfurt-Berlin

After a two-day overview survey of the area with reconnaissance visits to several sites (e.g., Independence Creek, Hester Creek, Eureka, Paradise Hill), detailed fieldwork with sediment and ice sampling was carried out at three sites: Little Blanche Creek, Whitman Gulch, and Bear Creek (Fig. 2.2, Tab. 2.2), while at Dominion Creek, only one ice wedge was sampled.

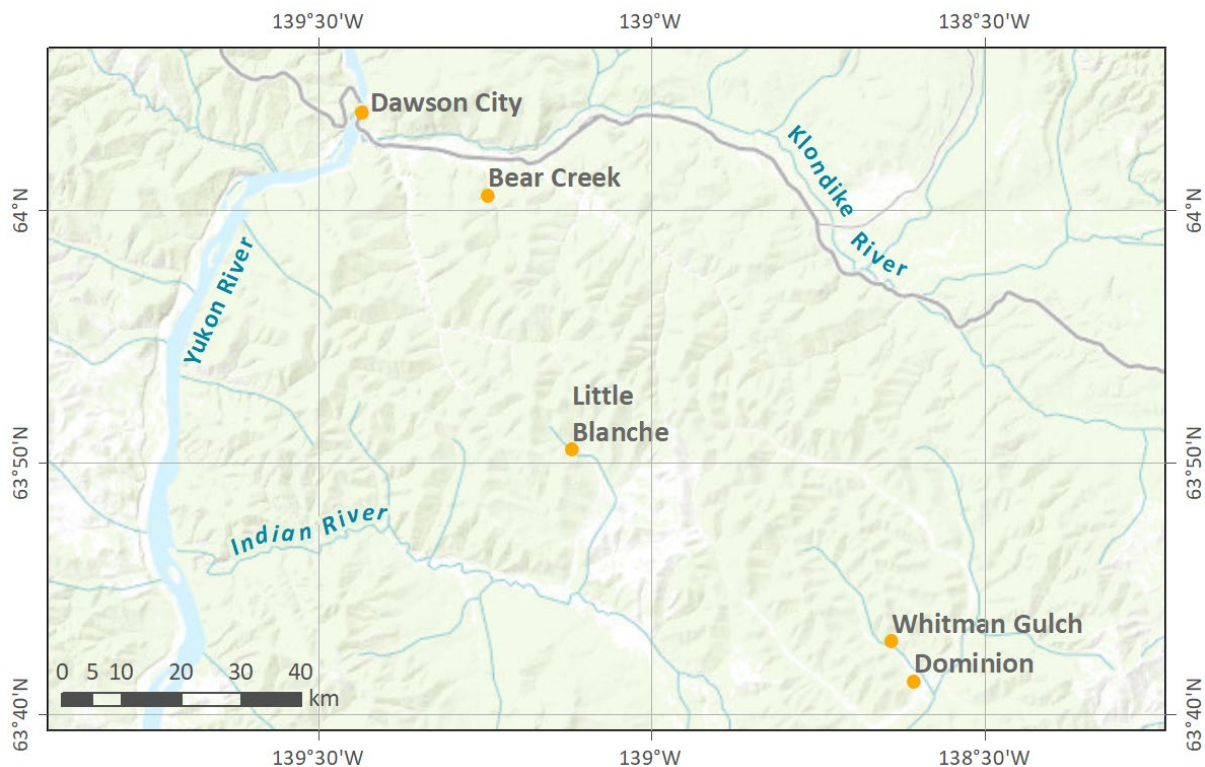


Fig. 2.2: Overview map of the Klondike gold fields with the main study sites as well as Dawson City

Tab. 2.2: Overview of main field sites in the Klondike Goldfields. More detailed coordinates for specific sites at Little Blanche site as well as other samples are presented in the sample list (Tab. A.3.1 in the Appendix).

Site	field ID	AWI ID	Lat	Lon
Little Blanche	LB	EN23801	63.842016°N	139.114993°W
Whitman Gulch	WG	EN23802	63.715365°N	138.639611°W
Dominion Creek	DC	EN23803	63.688542°N,	138.606239°W
Bear Creek	BC	EN23804	64.009263°N	139.245661°W

2.4 Field methods

For gold mining, miners thaw ice-rich permafrost overlying gold-bearing gravel with water cannons and collect the gravels with excavators. This process gives the short-term opportunity to examine fresh, nearly vertical permafrost walls. These exposures were described with regard to cryostratigraphy and suitable sampling points were determined.

The frozen sediment was cleaned, and ice and sediment structures were described, followed by sediment sampling with an axe and hammer. From thawed subsamples, we calculated the absolute ice content (mass of water / mass of wet sample x 100). At every other sampling point, 3-4 cm long frozen cores for biomarker analyses were taken with a Makita cordless drill. These samples were taken using nitrile laboratory gloves and the material was stored in glass jars to avoid contamination. For luminescence dating (OSL and IRSL), approx. 10-15 cm long sediment cores were drilled with a Makita cordless drill and stored frozen in black tubes protected from light. In addition, samples for Gamma spectrometry measurement were taken from the same sample site with hammer and axe. Sediment layers interpreted as tephra layers in outcrops were carefully sampled by spatula or knife for geochemical characterization. All samples were kept frozen.

Ice wedges were cleaned and described in terms of their size, the color of ice, internal structure, and the existence and form of gas bubbles. They were sampled as blocks with a chainsaw. Plant macro remains in the immediate vicinity of the ice wedge were sampled, as well as pore ice adjacent to ice wedges. All samples were kept frozen.

At several locations, we sampled stream water and precipitation for stable isotope analysis using narrow-mouth PE bottles. Samples were stored cool.

Modern vegetation was sampled at an undisturbed forest site. These samples serve as references for the biomarker patterns of functional vegetation classes (e.g., grasses, shrubs) and were frozen.

For microplastic investigations, two samples were collected at each of the three sites. On the one hand, surface vegetation was sampled (0-5 cm deep). On the other hand, the underlying active layer was sampled (5-10 cm).

2.5 Data management

Expedition data will be archived, published and disseminated according to international standards by the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (<https://www.pangaea.de>) within three years after the end of the expedition at the latest. By default, the CC-BY license will be applied.

These expeditions were supported by the Helmholtz Research Programme “Changing Earth – Sustaining our Future” under the following Topics and Subtopics:

- Topic 5: Landscapes of the Future: Securing terrestrial ecosystems and freshwaterresources under natural dynamics and global change
- Subtopic 5.3: Determining natural functions and sensitivities of the Earth surfacsystem

3. LITTLE BLANCHE (LB)

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The first location was **Little Blanche Creek** (63.842016°N, 139.114993°W). Along a valley of about 1 km total length, four sediment profiles (LB-S1 to LB-S4) were sampled from the valley floor (Fig. 3.1 and 3.2) to the upper edge of the valley (up to 25 m above the valley floor), complemented by five ice wedges in the immediate vicinity of the sediment profiles. The bedrock varies between blocky competent quartzite and highly fractured muscovite schist (van Loon and Bond, 2021, p. 83).

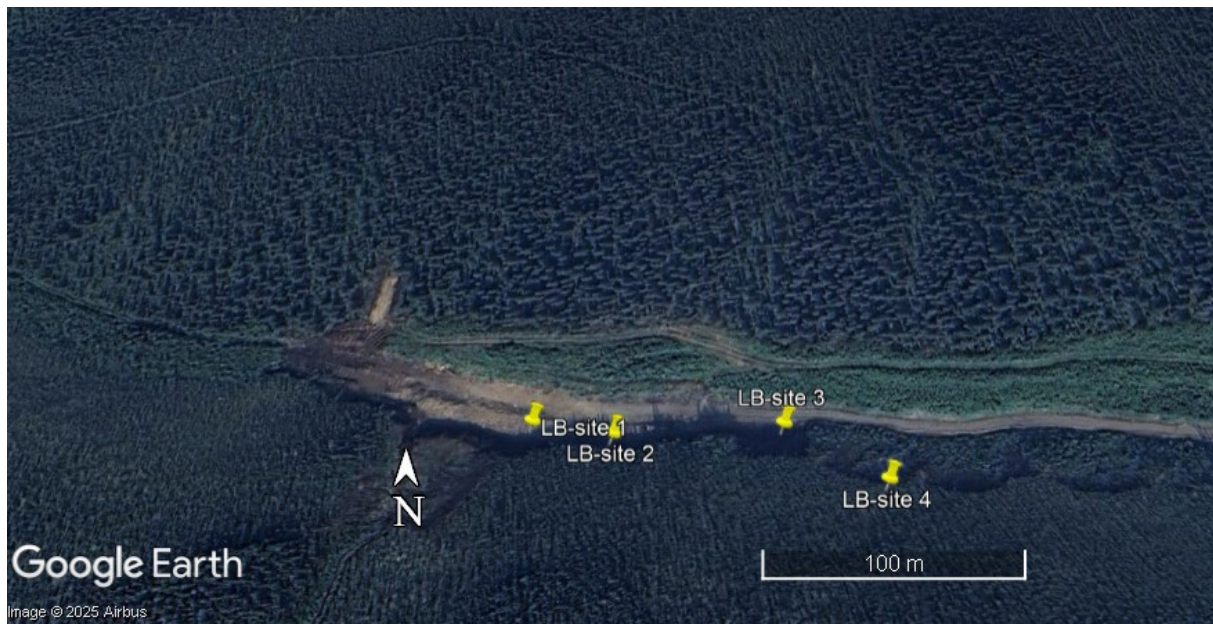


Fig. 3.1: Location of the studied sites with sediment profiles and ice wedges in the Little Blanche valley

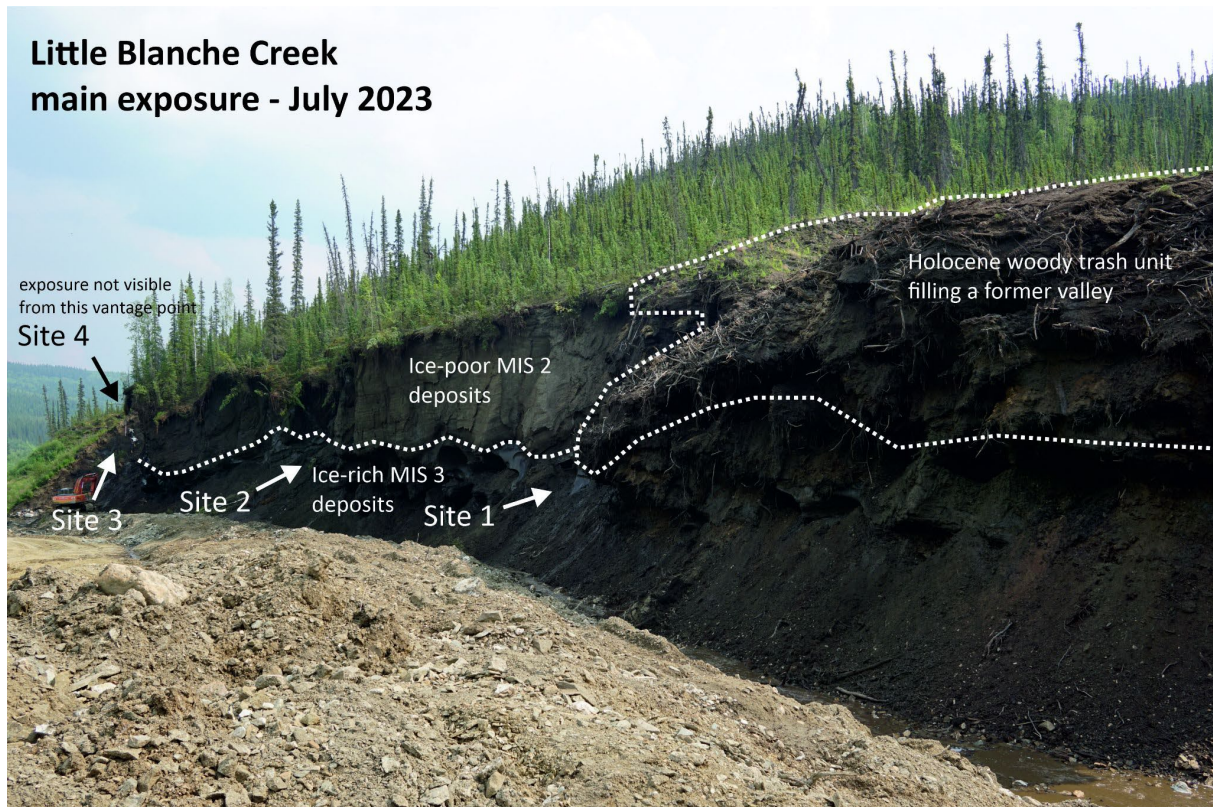


Fig. 3.2: Overview of the Little Blanche main exposure (photograph: Trevor Porter)

At the bottom of the valley, the bedrock is still present. This is followed by approx. 2 m of frozen yellowish coarse sand with gravel and pebbles (up to 10 cm in size), which contains no plant remains. The cryostructure is massive, and absolute ice contents are around 10 wt%.

The general profile continues with frozen brownish-gray silty fine sand containing individual gravel grains, larger unrounded pebbles (1-10 cm), and numerous plant remains (Figures 3.4, 3.7, and 3.10). The cryostructure in this horizon is massive in the lower part (up to 4 m) and banded and lenticular in the upper section. The absolute ice contents are between 32 and 82 wt%.

The Dawson Tephra is found in this horizon at 13 to 15 m above the valley floor (Figures 3.3, 3.6, and 3.12). This tephra is dated at about 25.3 ^{14}C ka BP (ca. 30 cal ka BP, Froese et al., 2006) and separates ice-rich MIS 3 and ice-poor MIS 2 horizons.

The MIS 3 horizon contains large ice wedges of 1 to 3 m width and up to 10 m length. Ice wedges LB-IW-01 to LB-IW-04 were sampled in horizontal profiles in close vicinity to the respective sediment profiles (Figures 3.5, 3.8, 3.11, 3.14).

The MIS 2 horizon contains only small ice wedges. The uppermost part, consisting of peaty sand, likely representing the Holocene, could not be sampled except for one ice wedge (LB-IW-05).

Sampling for luminescence dating (code Lumi) focused on the lower sandy sections sequence (LB-S1-03-Lumi, LB-S2-04-Lumi, LB-S3-02-Lumi, LB-S3-10-Lumi), which may be too old for radiocarbon dating or may not contain visible organic matter. In addition, luminescence samples were taken in LB-S4 above and below the Dawson Tephra (LB-S4-06-Lumi, LB-S4-07-Lumi). The Dawson Tephra was also sampled specifically (LB-IW3-tephra, LB-S4-DT, LB-IW4-tephra).

The detailed sample list and descriptions are presented in Tab. A.3.1.

3.1 Site 1 - Profile 1 and IW 1 (63.841918°N, 139.119479°W)

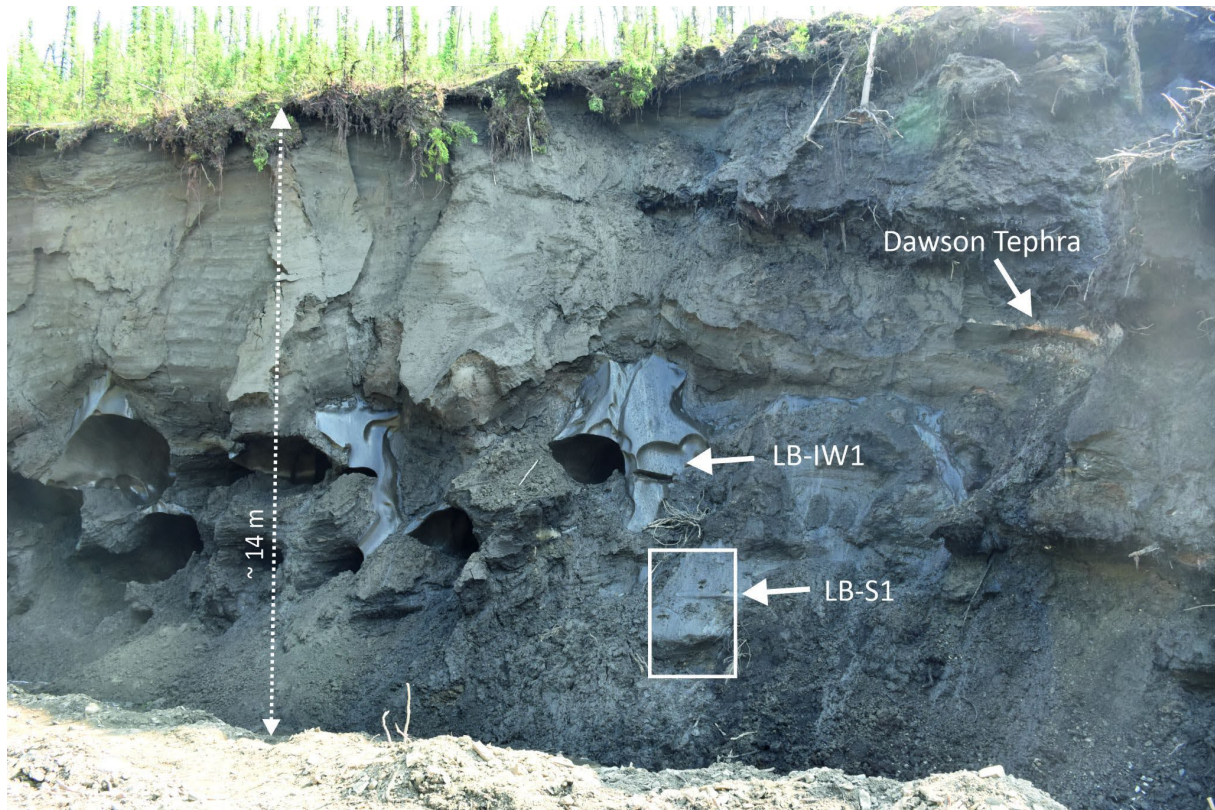


Fig. 3.3: Overview of site 1 at Little Blanche (photograph: Thomas Opel)



Fig. 3.4 (left): Sediment profile LB-S1 at Little Blanche (gray: sediment sample, orange: biomarker sample, yellow: luminescence dating sample, photograph: Lutz Schirrmeister)

Fig. 3.5 (right): Ice wedge LB-IW1 at Little Blanche with sampling positions (photograph: Thomas Opel)

The ice wedge LB-IW1 (Fig. 3.5) was 3-4 m wide, but only part of it could be sampled (in three blocks) at about 5 m above stream level next to a cavity formed by a water cannon. Wedge ice was gray with many elongated bubbles and partly visible ice veins. Also, a few sediment veins occurred. The surface of the ice wedge was cut at an angle of about 45° to its cracking direction. The ice wedge showed 3 raised tops.

3.2 Site 2 - Profile 2 and IW 2 (63.841830°N, 139.118722°W)



Fig. 3.6: Overview of site 2 at Little Blanche (photograph: Thomas Opel)



Fig. 3.7 (left): Sediment profile LB-S2 at Little Blanche (gray: sediment sample, orange: biomarker sample, yellow: luminescence dating sample, photograph: Fabian Seemann)

Fig. 3.8 (right): Ice wedge LB-IW2 at Little Blanche with sampling positions (photograph: Thomas Opel). Shovel for scale

Ice wedge LB-IW2 (Fig. 3.8) represents the lowest level of ice wedges sampled at the Little Blanche site and was located about shortly above bedrock and gravel at the base of the exposure. We sampled 3 blocks in a cavity formed by a water cannon about 5.5 m above stream level. The ice wedge was 67 cm wide, and its surface was cut at an angle of about 45° to its cracking direction. The wedge ice was gray with clearly visible foliations, spherical bubbles, and few sediment veins.

3.3 Site 3 - Profile 3 and IW 3 (63.841901°N, 139.117230°W)

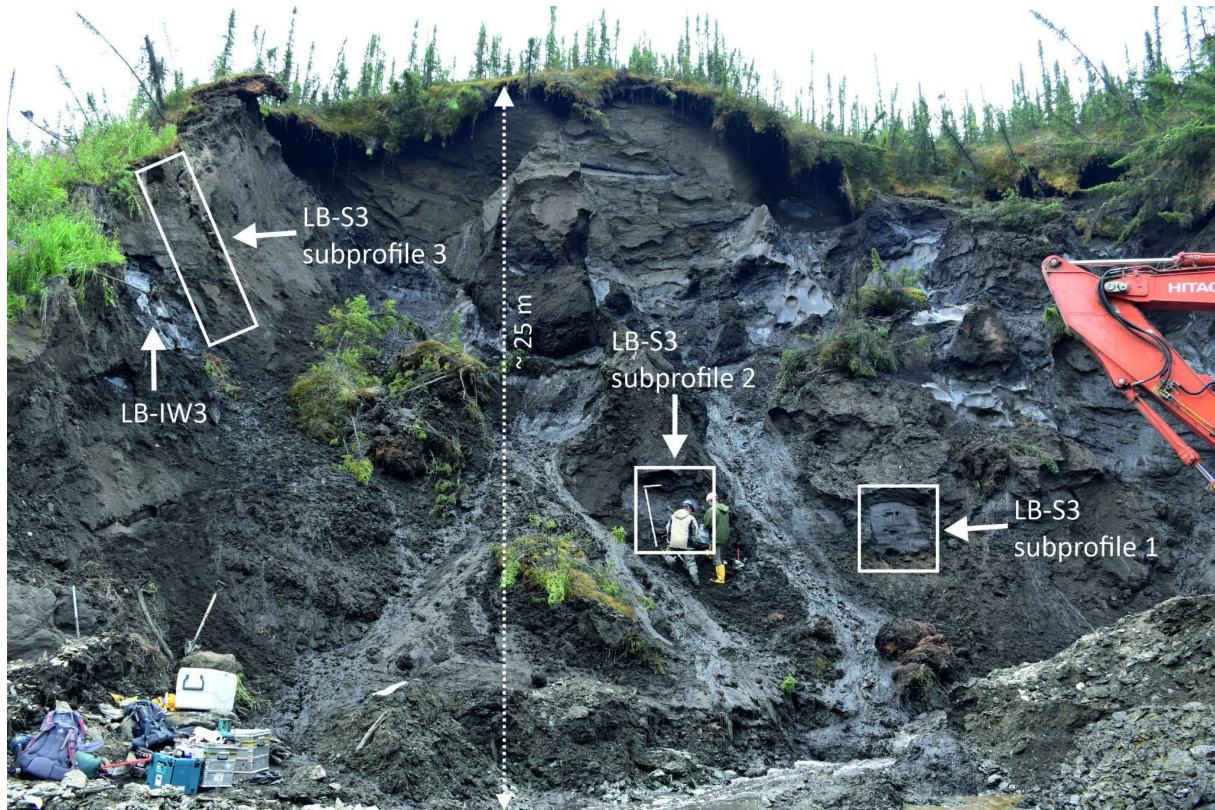


Fig. 3.9: Overview of site 3 at Little Blanche (photograph: Thomas Opel)

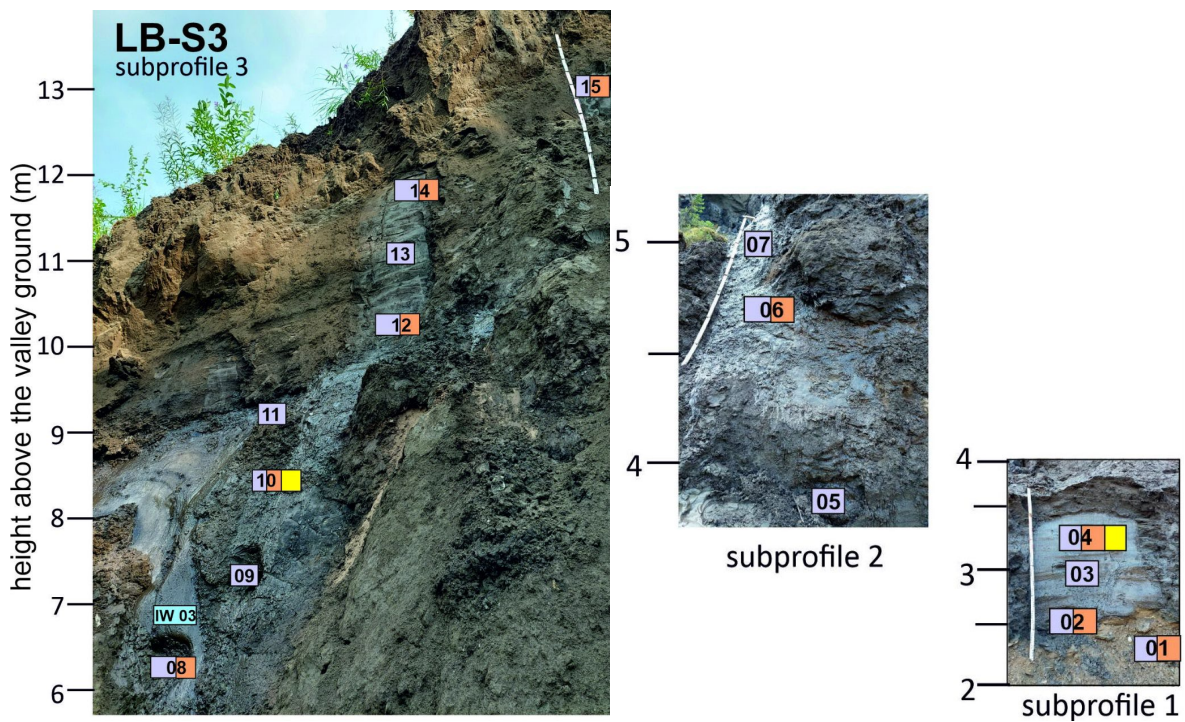


Fig. 3.10: Sediment profile LB-S3 at Little Blanche (gray: sediment sample, orange: biomarker sample, yellow: luminescence dating sample, photographs: Lutz Schirrmeister and Fabian Seemann)

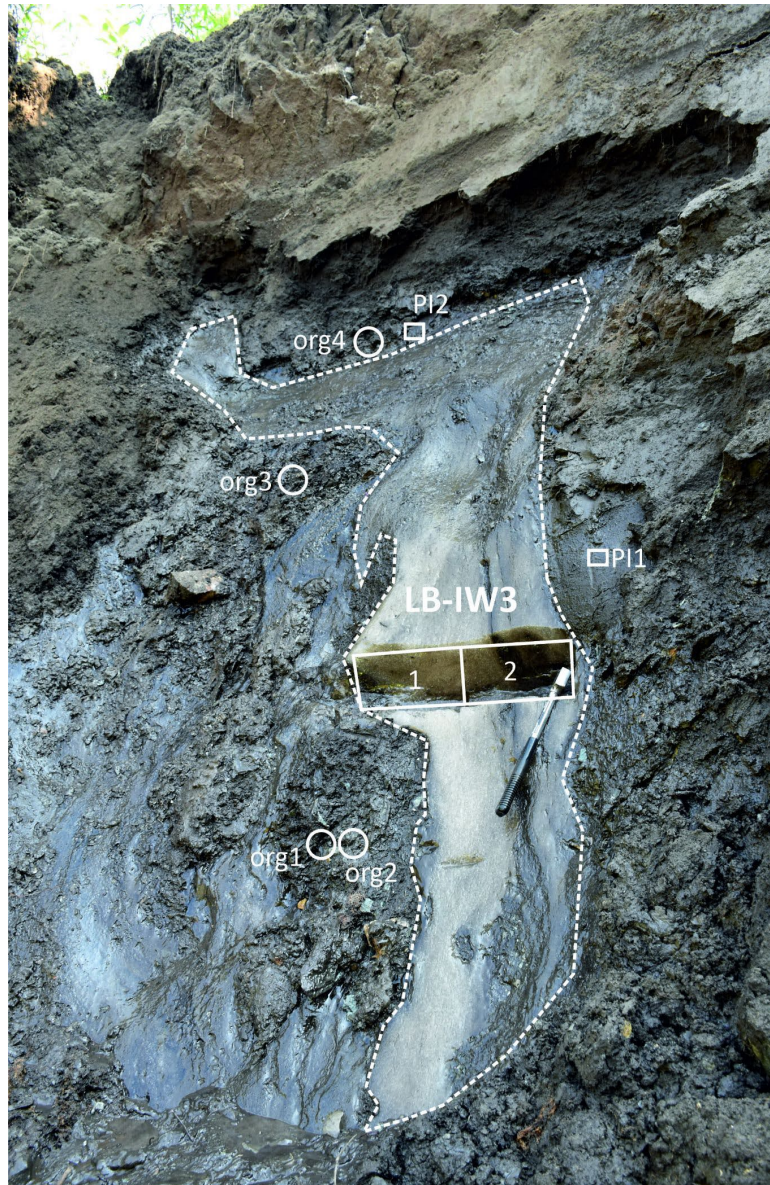


Fig. 3.11: Ice wedge LB-IW3 at Little Blanche with sampling positions (photograph: Thomas Opel)

Ice wedge LB-IW3 (Fig. 3.11) was sampled in a 52 cm wide profile (2 blocks) about 8 m above stream level. The visible length of the wedge was about 3 m. The wedge ice was white (in the center) to grey with mostly spherical but also elongated bubbles and only partially visible foliations. A few sediment veins and even gravel could be found in the ice wedge. Additionally, we sampled pore ice (-PI) and plant macro remains (-org) above and beside the ice wedge as well as the Dawson tephra about 2 m above the top of the ice wedge (LB-IW3-tephra).

3.4 Site 4 - Profile 4 and IW 4+5 (63.841487°N, 139.116285°W)

The uppermost profile section was studied below and above the Dawson Tephra at site 4 (Figures 3.12 and 3.13). The frozen sediment here consists of gray to graybrown, silty fine sand with plant remains and massive cryostructure.

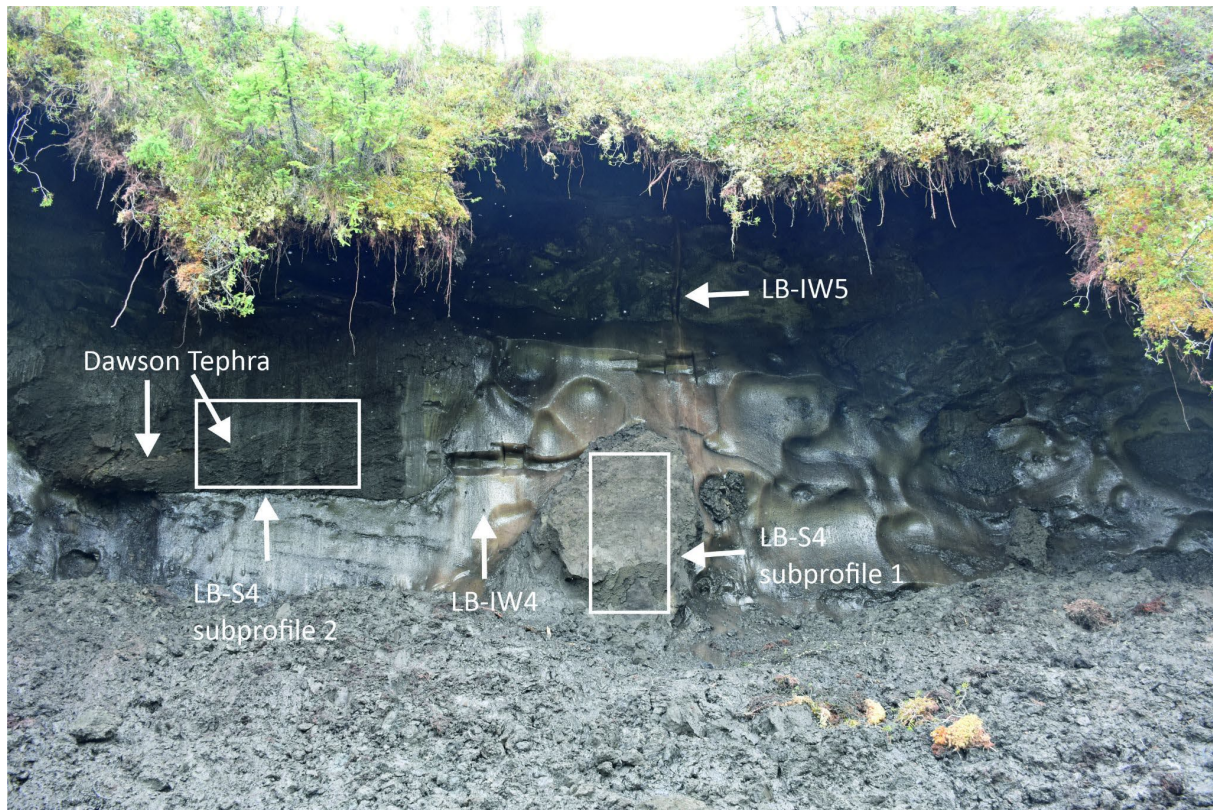


Fig. 3.12: Overview of site 4 at Little Blanche (photograph: Thomas Opel)

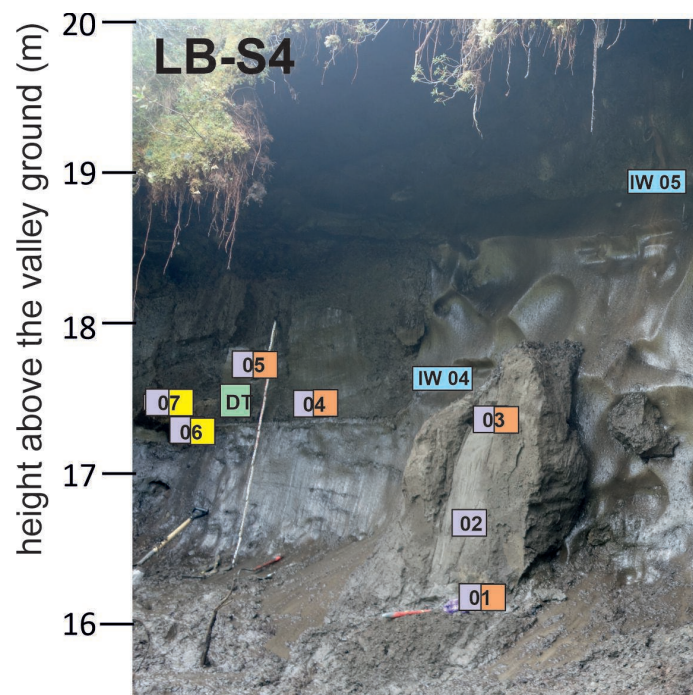


Fig. 3.13: Sediment profile LB-S4 at Little Blanche (gray: sediment sample, orange: biomarker sample, yellow: luminescence dating sample, green: Dawson Tephra, photograph: Lutz Schirrmeister)

Two surface sediment samples (0-0.05 and 0.05-0.1 m depth) were taken for microplastic analysis (LB-S5-01-MP and -02-MP, respectively).

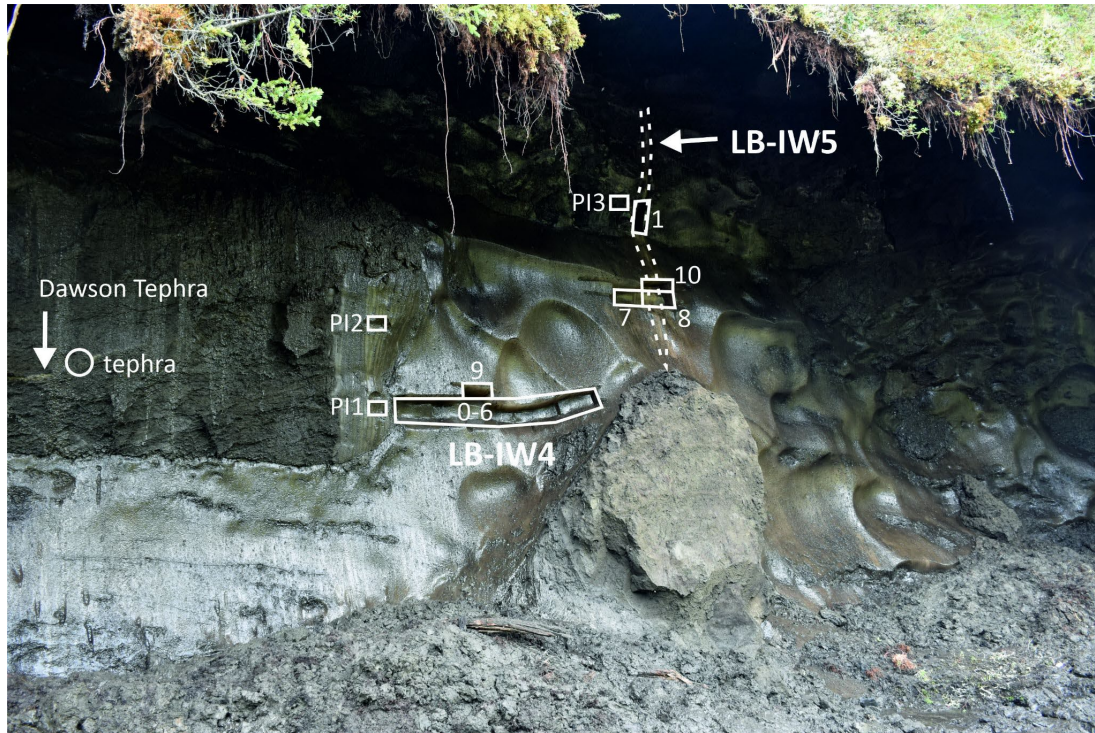


Fig. 3.14: Ice wedges LB-IW4 and LB-IW5 at Little Blanche with sampling positions (photograph: Thomas Opel)

Ice wedge LB-IW4 (Fig. 3.14) was about 1.45 m wide and its visible length was about 2.5 m. We sampled a profile of seven blocks (0-6) across the ice wedge. About 80 cm above the first profile, we sampled a second profile of 2 blocks (7-8). This profile contained the lower part of a younger ice wedge penetrating from the Holocene cover into the older MIS 3 ice wedge. From samples 3 and 8, we took replicate samples (9 and 10, respectively). About 70 cm above the second profile, we took a block of the Holocene ice wedge (LB-IW5). The MIS 3 wedge ice was gray with spherical bubbles and no clearly visible ice veins. In contrast, the Holocene ice of LB-IW5 appeared white with clearly visible veins and smaller elongated bubbles. Additionally, we took three samples of pore ice beside LB-IW4 and LB-IW5, respectively, and a sample of the supposed Dawson tephra (LB-IW4-tephra).

4. WHITMAN GULCH (WG)

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² CA.UTM

The second location was Whitman Gulch (63.715365°N, 138.639611°W). Figure 4.1 shows the exposure on 31 July 2023. The bedrock here consists of quartz-mica schist (van Loon and Bond, 2021, p. 113).

Several large blocks that had just been broken off were sampled at this site (WG-S1, WG-S2, WG-S6), as well as two shorter profiles (WG-S3, WG-S4) directly on the outcrop wall (Figures 4.3, 4.4, 4.5, 4.6). Active water monitoring changed the exposure in the days that followed. Additional samples from newly fallen blocks were taken during a further visit on 02.08.2023.

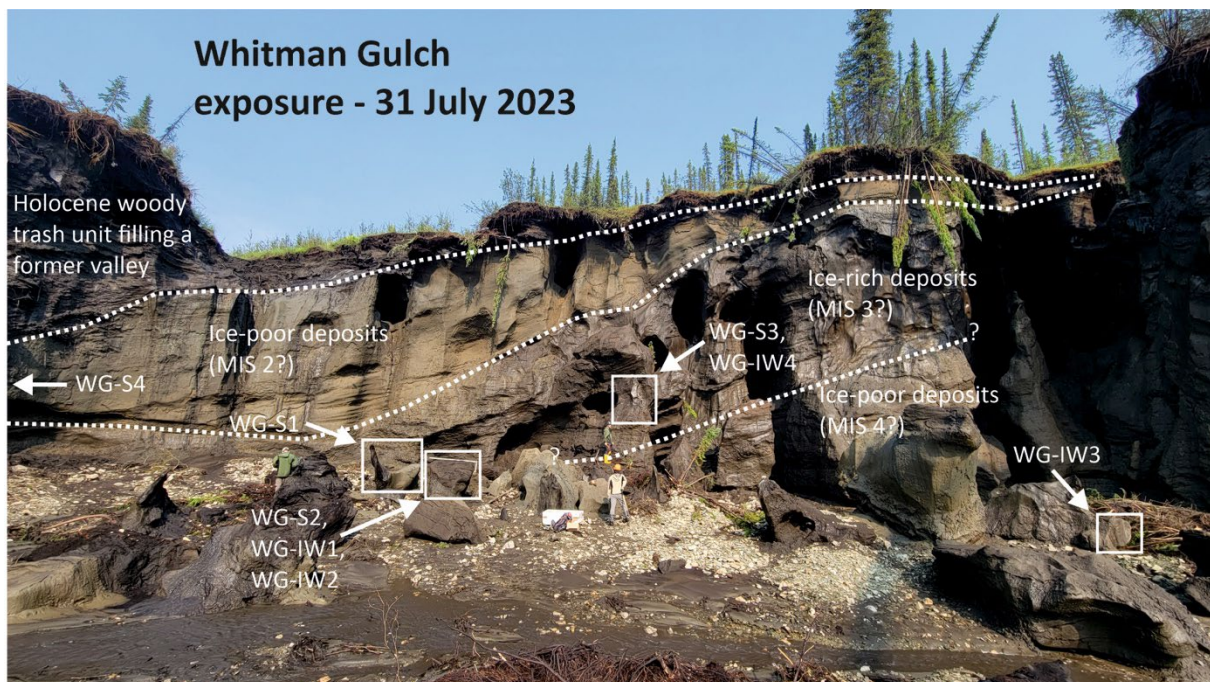


Fig. 4.1: Overview picture of the Whitman Gulch exposure (photograph Trevor Porter) and location of the studied sediment profiles and ice wedges

While WG-S1 represents the upper part of the sequence (supposed MIS 2 and Holocene cover), WG-S2 and WG-S3 represent the upper and middle part of the darker sediments with ice wedges (supposed MIS 3). Most of the sediments studied consisted of frozen brownish-gray silty fine sand with numerous plant remains and individual Arctic ground squirrel nests (AGSN). Two of these were also sampled, one at WG-S2 (i.e., samples WG-S2-3 and WG-AGSN-1, Fig. 4.2) and one at the headwall (WG-AGSN-2) in presumably MIS 2 deposits above the basal gravel layer. The studied sediment also contained some 1-5 cm thick brownish plant layers. The cryostructure is massive. The absolute ice contents were 24.2 to 47.4 wt%.



Fig. 4.2: Arctic ground squirrel nest at profile WG-S2, photograph: Fabian Seemann

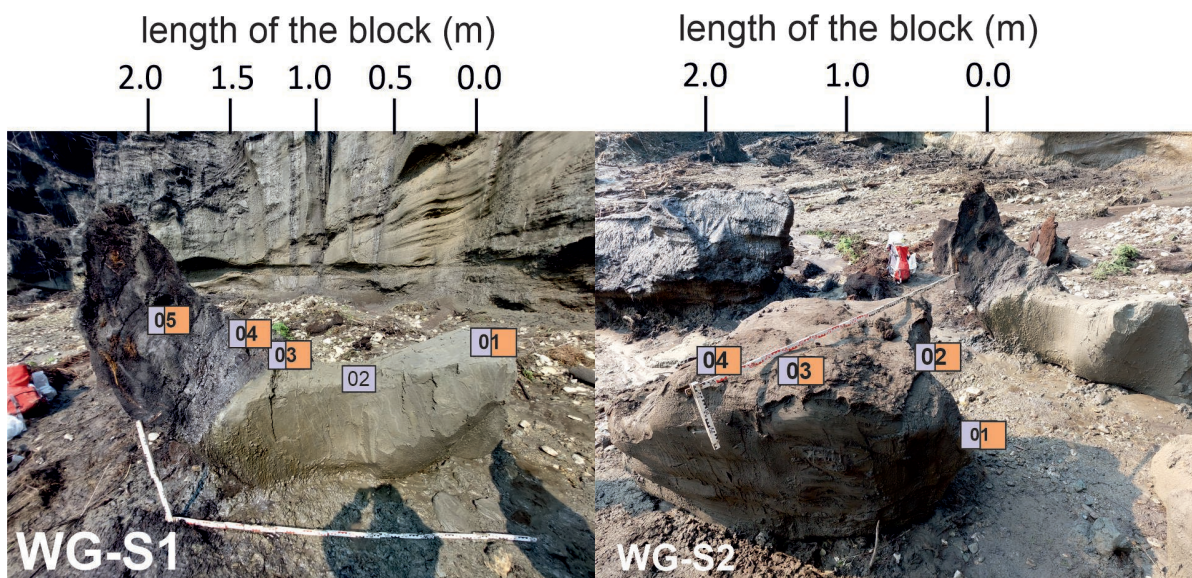


Fig. 4.3 (left): Sediment profile WG-S1 at Whitman Gulch (gray: sediment sample, orange biomarker sample, photograph: Fabian Seemann)

Fig. 4.4 (right): Sediment profile WG-S2 at Whitman Gulch (gray: sediment sample, orange biomarker sample, photograph: Fabian Seemann)

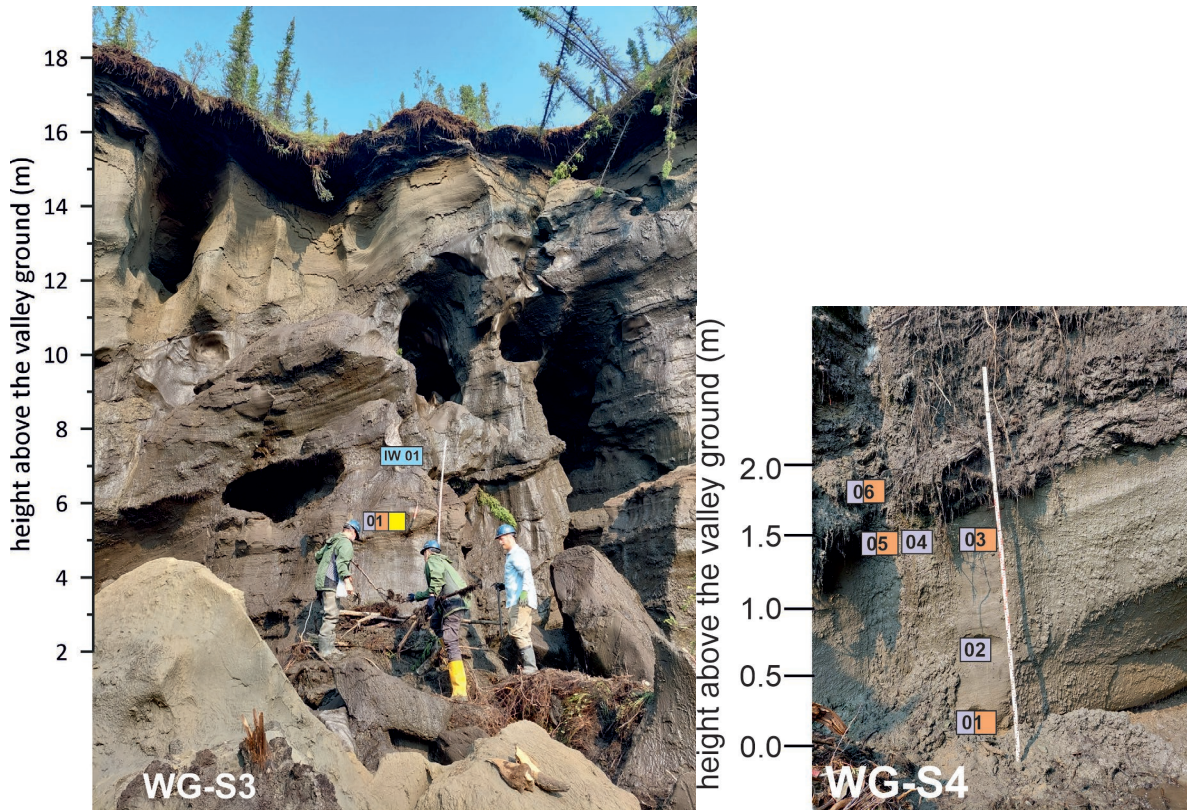


Fig. 4.5 (left): Sediment profile WG-S3 at Whitman Gulch (gray: sediment sample, orange: biomarker sample, yellow: luminescence dating sample, photograph: Fabian Seemann)

Fig. 4.6 (right): Sediment profile WG-S4 at Whitman Gulch (gray: sediment sample, orange biomarker sample, photograph: Fabian Seemann)

At the fallen blocks and at the headwall, a total of five ice wedges were sampled (WG-IW-01 to WG-IW-05, Figures 4.7, 4.8, 4.9, 4.10). The detailed sample list and descriptions are shown in Tab. A.3.1. The upper grayish horizon of the headwall did not contain any large ice wedges. This could indicate that these are MIS-2 deposits. However, large parts of this horizon were not accessible to us, only the uppermost part could be sampled in profiles WG-S1 and WG-S4.

Presumably Late Glacial to Holocene deposits were found in a small lateral valley fill (WG-S4). In the lower 2 m, they consist of an irregular alternation of gray-brown silty fine sand layers and dark brown organic-rich layers, partly with woody roots and twigs. The uppermost sample contains single non-rounded clasts. The cryostructure is massive. The absolute ice contents were 27 to 44 wt%.

For luminescence dating, we took a sample in profile WG-S3 (WG-S3-01-Lumi). Additionally, we took two samples of supposed tephra for detailed analyses (WG-IW1-tephra, WG-IW4-tephra).

In addition, two near-surface samples (WG-S5-01-MP, WG-S5-02-MP) were taken for microplastic analyses in 0-5 cm and 5-10 cm depth.

The orientation of WG-IW1 and -IW2 at the huge fallen block (Fig. 4.7) was not entirely clear, but one block was sampled from each ice wedge. The ice was rather gray with low to medium sediment content and medium to many spherical bubbles about 3 mm in diameter. Ice veins were only partially visible. Also the orientation of WG-IW3 (Fig. 4.8) was not entirely clear. One block was sampled, and the wedge ice was gray with medium sediment content, medium to many small spherical bubbles, and visible ice veins. From ice wedge WG-IW4 we took one block (Fig. 4.9). The ice was gray with low sediment content, many small to medium spherical bubbles, and clearly visible veins. Ice wedge WG-IW5 was accessible only on 02.08.2023 at a block that had just fallen from the wall due to active water monitoring (Fig. 4.10). We took two samples, one for stable isotope analysis (WG-IW5-1) and one for ^{36}Cl dating (WG-IW5-

36Cl). The wedge ice was gray, with medium to many spherical bubbles and clearly visible ice veins. Adjacent to WG-IW5, a sediment sample was taken as reference (WG-S6-01).

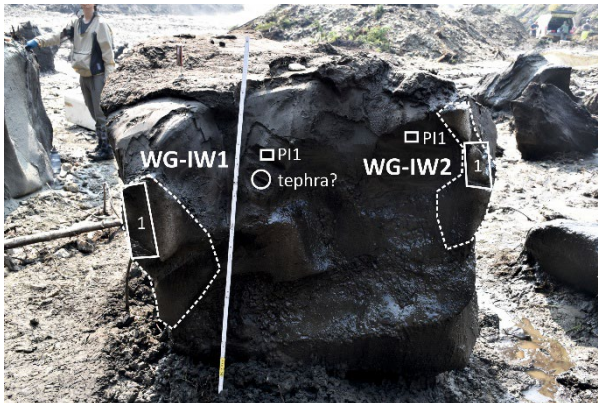


Fig. 4.7 (left): Ice wedges WG-IW1 and WG-IW2 at Whitman Gulch with sampling positions (same block as WG-S2) (photograph: Thomas Opel)



Fig. 4.8 (right): Ice wedge WG-IW3 at Whitman Gulch with sampling position (photograph: Thomas Opel)

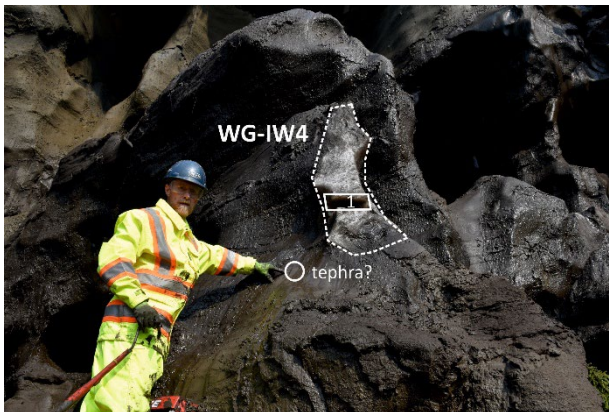


Fig. 4.9 (left): Ice wedge WG-IW4 at Whitman Gulch with sampling position (photograph: Thomas Opel)



Fig. 4.10 (right): Ice wedge WG-IW5 at Whitman Gulch with sampling position (photograph: Thomas Opel)

5. BEAR CREEK (BC)

Thomas Opel¹, Lutz Schirrmeister¹, Fabian Seemann¹; Trevor Porter², Mickey Chen²

¹ DE.AWI

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The third site was located in **Bear Creek Valley** (64.009263°N, 139.245661°W), where the lower part of an approx. 8 m high outcrop wall was studied (Fig. 5.1). The bedrock here consists of slabby to decayed schist (van Loon and Bond, 2021, p. 41).



Fig. 5.1: Overview photograph of the Bear Creek exposure (Photograph Jordan Ross, Tr'ondëk Hwëch'in government)

The layered frozen sediment consists of gray to graybrown, silty fine sand with single non-rounded clasts, dark brown organic layers, and plant remains (Fig. 5.2). The cryostructure is massive. The absolute ice content is 40 to 60 wt%. The layers descend into the valley. The ice wedges are relatively thin (about 0.5 meters). A tephra layer just above the base of the outcrop wall and the gravel horizon was preliminary identified as Sheep Creek tephra (ca. 80 ka old, Demuro et al., 2013).

Two samples (BC-S2-01-MP, BC-S2-02-MP) were also taken from the surface at this exposure for microplastic analysis at depths of 0-5 and 5-10 cm.

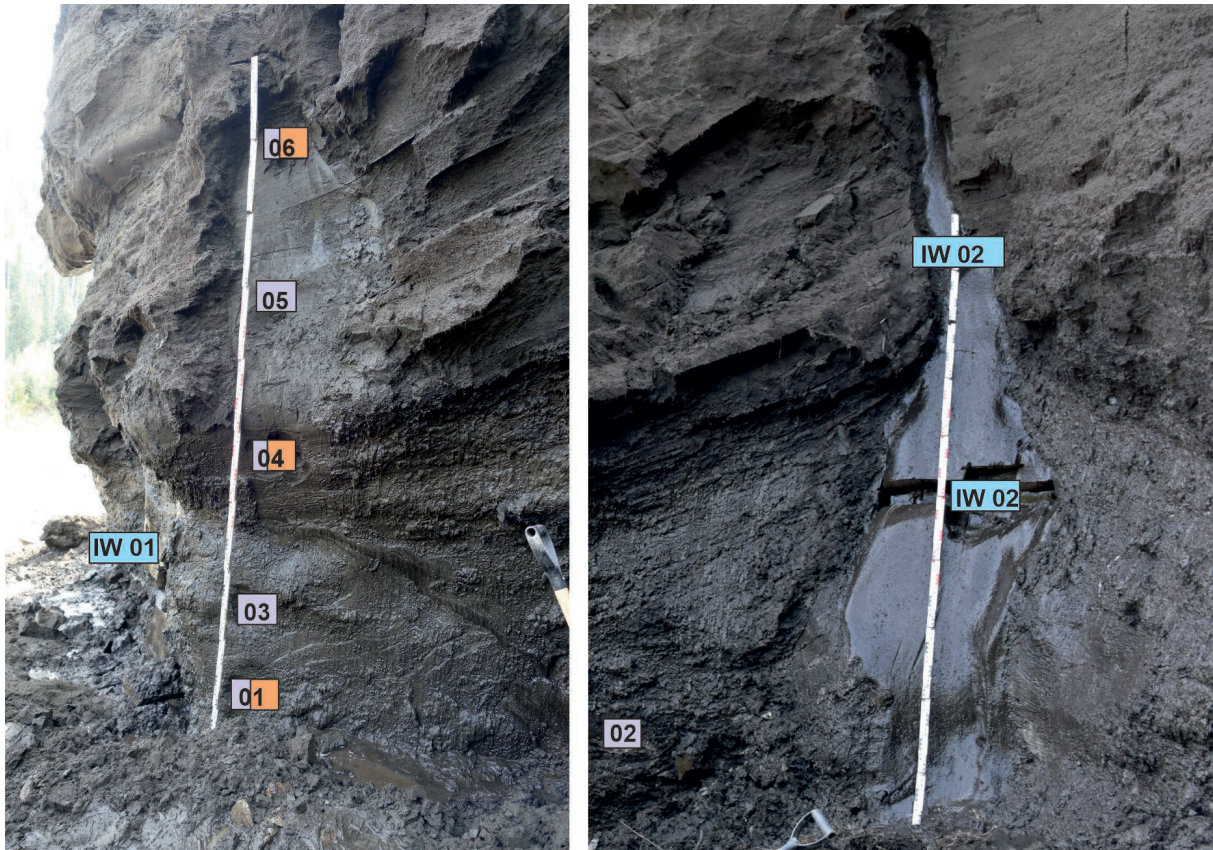


Fig. 5.2: Schematic profile and detailed sample points of the Bear Creek (BC) profile (gray: sediment sample, orange biomarker sample, photographer: Lutz Schirrmeister, Thomas Opel)

Ice wedge BC-IW1 (Fig. 5.3) was about 50 cm wide and its visible length was about 1.5 m. The ice wedge was inclined downslope, probably due to slope processes. The wedge ice was grey with spherical bubbles between 0.5 and 4 mm in diameter. The sediment content was low and no ice veins were visible. We sampled a horizontal profile consisting of 3 blocks and took 2 additional samples above the middle block. Additionally, close to the ice wedge, we sampled pore ice, organic material, and the tephra layer into which the ice wedge penetrated.

Ice wedge BC-IW2 (Fig. 5.4) was up to 60 cm wide, becoming narrower towards the top, and its visible length was about 4 m. We sampled one profile with 4 blocks in the widest part of the ice wedge about 1.5 m above the base of the outcrop. This profile was supplemented by 2 blocks above the third block. At a height of about 2.8 m, we sampled another block. The wedge ice was grey with a medium number of spherical bubbles (1-3 mm in diameter) and a few larger (up to 8 mm) elongated bubbles. The sediment content was low, and ice veins were only partly visible. Additionally, we sampled organic material and pore ice close to the ice wedge at about 2.8 m height.

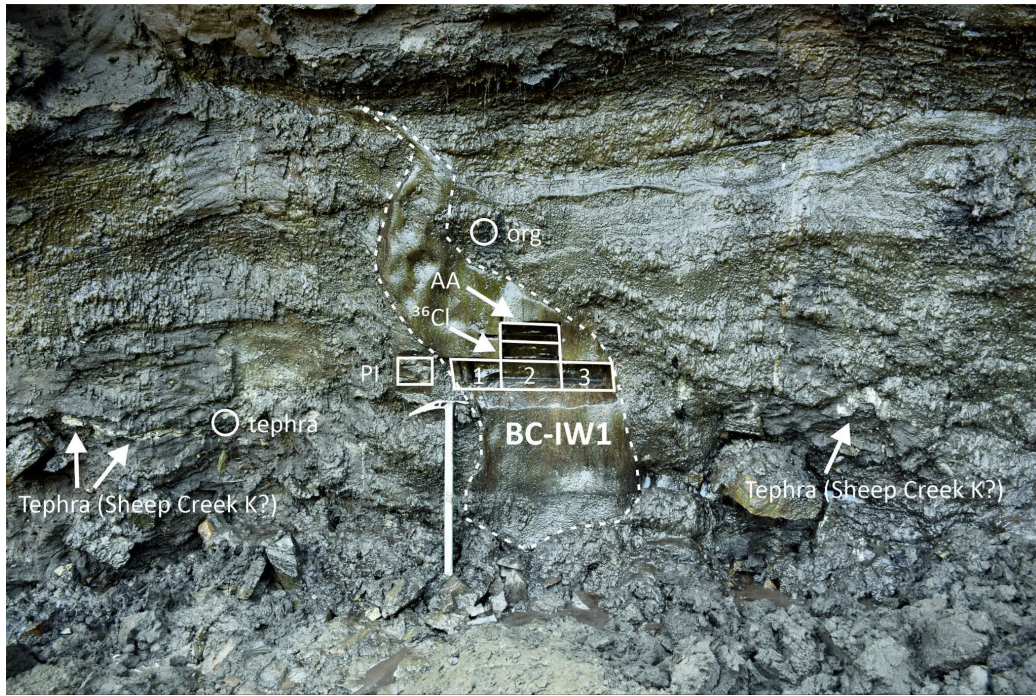


Fig. 5.3: Ice wedge BC-IW1 at Bear Creek with sampling positions (photograph: Thomas Opel)

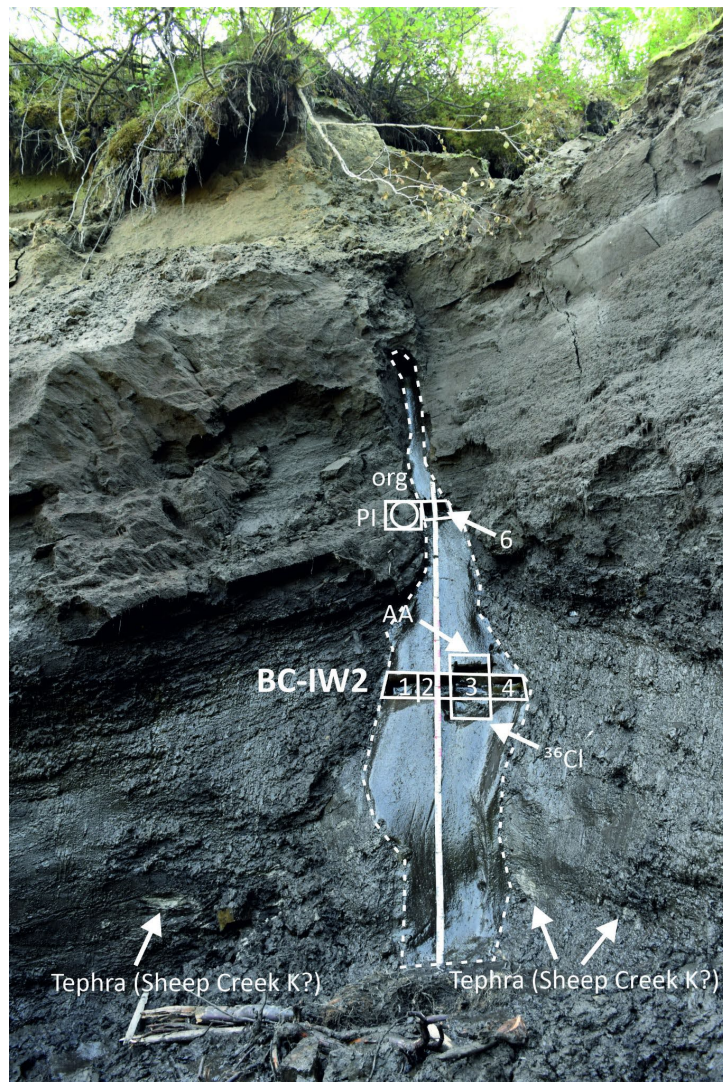


Fig. 5.4: Ice wedge BC-IW2 at Bear Creek with sampling positions (photograph: Thomas Opel)

In the forest behind the Bear Creek exposure, vegetation samples were taken for the determination of biomarker patterns in modern vegetation (Fig. 5.5). These samples serve as reference samples to the chemotaxonomy of functional vegetation classes: lichens, mosses, grasses, herbs, shrubs, deciduous, and coniferous plants. In total, 15 plant samples typical for this forest site were taken. Plant parts such as leaves and needles were sampled using nitrile laboratory gloves and glass jars for transportation and storage. The samples are stored frozen at AWI Potsdam.

The detailed sample list and descriptions are shown in Tab. A.3.1.



Fig 5.5: (a, left) Forest floor with site-typical vegetation in Bear Creek Valley, (b, middle) *Geocaulon lividum* (bastard toadflax, northern comandra), (c, right) *Petasites frigidus* var. *sagittatus* (arrowleaf coltsfoot). (b, c) These are examples of shrubs from the forest floor (Photographs Fabian Seemann).

6. DOMINION CREEK (DC)

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The fourth site was located at **Dominion Creek** (63.688542°N, 138.606239°W). Here, the oldest directly dated ancient permafrost was found (Froese et al., 2008). In a slope position, an ice wedge (DC-IW1) could be dug out and sampled (Fig. 6.1). We sampled an about 80 cm wide profile of four blocks. The wedge ice was grey with many small (< 1 mm) spherical and a few larger (up to 6 mm) elongated bubbles. Additionally, we took a sample of supposed tephra from directly above the ice wedge for detailed analysis (DC-IW1-tephra). The sediment content was low and ice veins were hardly visible. Due to heavy slumping of thawed material and later heavy rain, we could not reach frozen sediments to sample a sediment profile.

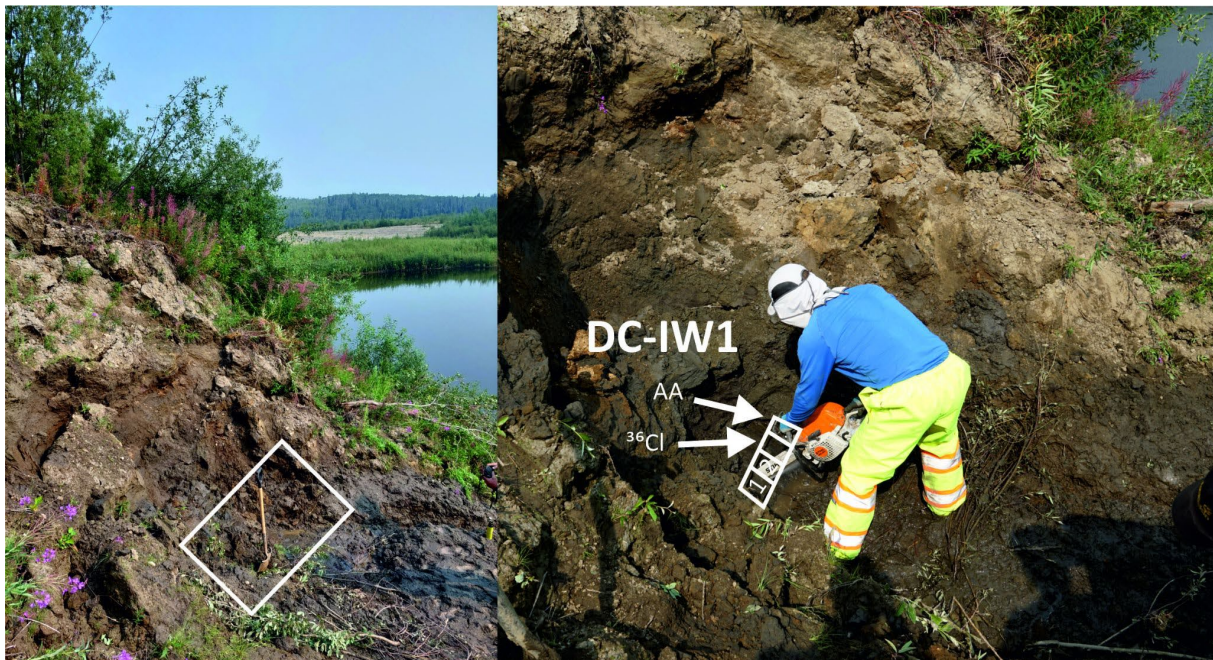


Fig. 6.1: Overview photograph of the studied sequence (left) and position of the sampled ice-wedge profile (Photographs: Thomas Opel)

7. PRELIMINARY RESULTS

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Based on our field observations, three schematic stratigraphic profiles have been developed for our study sites Little Blanche, Whitman Gulch, and Bear Creek (Figure 7.1).

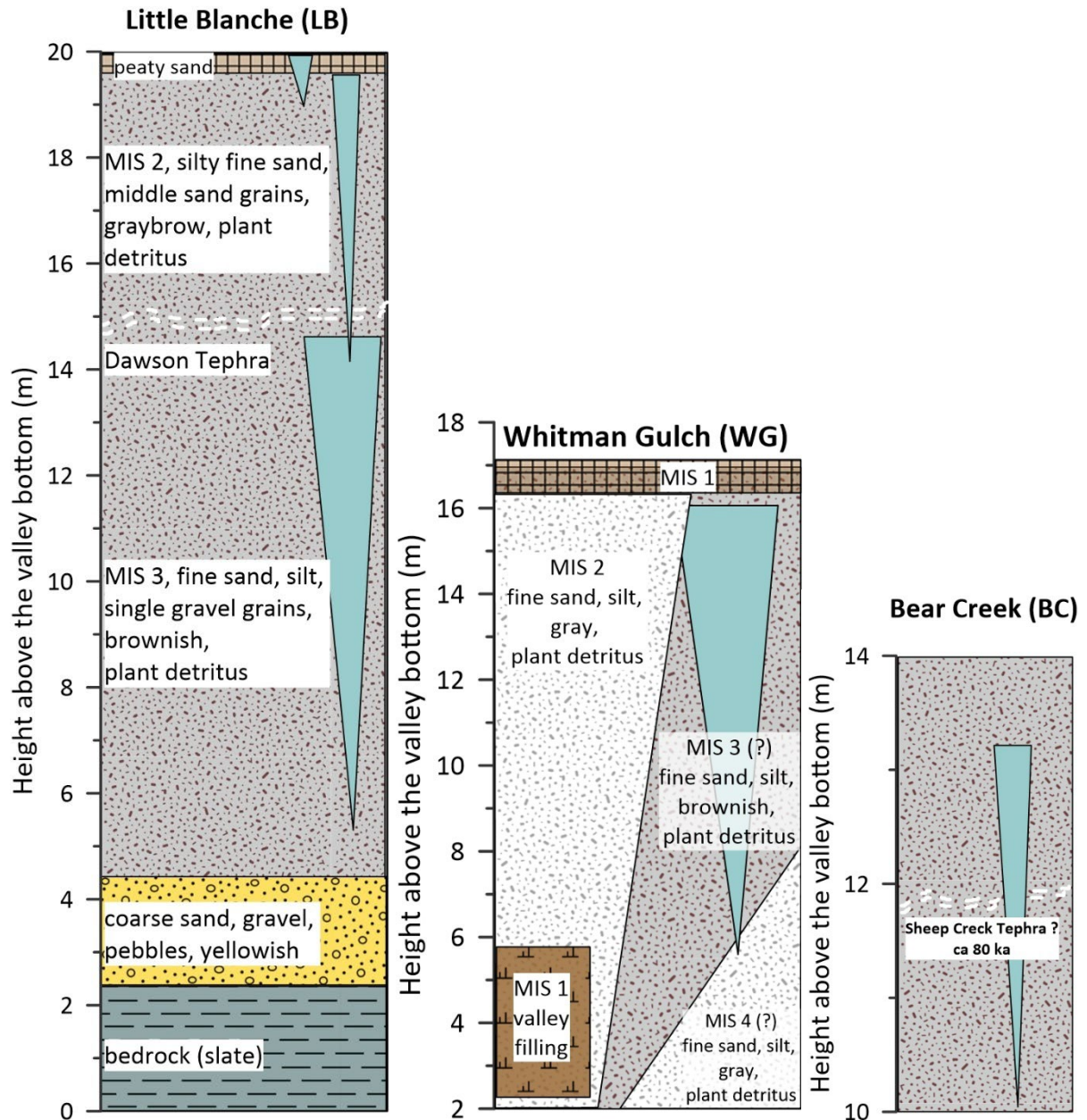


Fig. 7.1: Schematic profiles of the Little Blanche (left), Whitman Gulch (middle), and Bear creek (right) exposures (Lutz Schirrmeister)

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We would like to thank Duane Forese (University of Alberta) for his advice on suitable research locations.

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APPENDIX

A.1 TEILNEHMENDE INSTITUTE / PARTICIPATING INSTITUTES

A.2 EXPEDITIONSTEILNEHMER:INNEN / EXPEDITION PARTICIPANTS

A.3. SUPPLEMENTARY MATERIAL

A.1 TEILNEHMENDE INSTITUTE / PARTICIPATING INSTITUTES

Affiliation	Address
In the field	
DE.AWI	Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung Postfach 120161 27515 Bremerhaven Germany
CA.UTM	University of Toronto Mississauga Department of Geography, Geomatics and Environment 3359 Mississauga Road Mississauga, ON, L5L 1C6 Canada
Not in the field	
CA.UA	University of Alberta Department of Earth and Atmospheric Sciences 116 St and 85 Ave Edmonton, Alberta T6G 2R3 Canada

A.2 EXPEDITIONSTEILNEHMER:INNEN / EXPEDITION PARTICIPANTS

Name/ Last name	Vorname/ First name	Institut/ Institute	Beruf/ Profession	Fachrichtung/ Discipline
Opel	Thomas	DE.AWI	Scientist	Geography
Schirrmeister	Lutz	DE.AWI	Senior scientist	Geology
Fabian	Seemann	DE.AWI	PhD student	Geography
Trevor	Porter	CA.UTM	Professor	Geography
Mickey	Chen	CA.UTM	PhD student	Geography
Not in the field				
Hanno	Meyer	DE.AWI	Senior scientist	Geology
Jens	Strauss	DE.AWI	Senior scientist	Geoecology
Duane	Froese	CA.UA	Professor	Geography

A.3 SUPPLEMENTARY MATERIAL

Tab. A.3.1: List of all sediment, ice, water and plant samples (sediment and vegetation samples for biomarker analysis are marked in orange, samples for luminescence dating are marked in yellow, samples for microplastics analysis are marked in green)

Date	Field ID	AWI ID	Latitude	Longitude	height (m)	Sample type	Description	Ice content (wt%)
25.07.2023	LB-SW-1	EN23801-SW-1	N63.841918	W139.119479	0.0	water	stream water	-
25.07.2023	LB-IW1-01	EN23801-IW1-01	N63.841918	W139.119479		wedge ice		-
25.07.2023	LB-IW1-02	EN23801-IW1-02	N63.841918	W139.119479		wedge ice		-
25.07.2023	LB-IW1-03	EN23801-IW1-03	N63.841918	W139.119479		wedge ice		-
25.07.2023	LB-S1-01	EN23801-S1-01	N63.841918	W139.119479	0.5	sediment	coarse sand, gravel, pebbles (10 cm), no organic, yellowish, massive CS	10.5
25.07.2023	LB-S1-01-BM	EN23801-S1-01-BM	N63.841918	W139.119479	0.5	sediment		
25.07.2023	LB-S1-02	EN23801-S1-02	N63.841918	W139.119479	0.9	sediment	fine sand, silt, single coarser grains, gray to darkgray, brownish patches, massive CS	38.5
25.07.2023	LB-S1-02-BM	EN23801-S1-02-BM	N63.841918	W139.119479	0.9	sediment		-
25.07.2023	LB-S1-03	EN23801-S1-03	N63.841918	W139.119479	1.4	sediment	fine sand, silt, single coarser grains, gray to darkgray, brownish patches, massive CS	40.7
26.07.2023	LB-S1-03-Lumi	EN23801-S1-03-Lumi	N63.841918	W139.119479	1.4	sediment		40.8
26.07.2023	LB-S1-03-Gamma	EN23801-S1-03-Gamma	N63.841918	W139.119479	1.4	sediment		40.8

Date	Field ID	AWI ID	Latitude	Longitude	height (m)	Sample type	Description	Ice content (wt%)
25.07.2023	LB-S1-04	EN23801-S1-04	N63.841918	W139.119479	2.0	sediment	fine sand, silt, single coarser grains, gray to darkgray, brownish patches, massive CS	57.8
25.07.2023	LB-S1-04-BM	EN23801-S1-04-BM	N63.841918	W139.119479	2.0	sediment		-
25.07.2023	LB-S1-05	EN23801-S1-05	N63.841918	W139.119479	1.8	ice band	horizontal, very small bubbles, clear ice	-
26.07.2023	LB-IW2-01	EN23801-IW2-01	N63.841830	W139.118722		wedge ice		-
26.07.2023	LB-IW2-02	EN23801-IW2-02	N63.841830	W139.118722		wedge ice		-
26.07.2023	LB-IW2-03	EN23801-IW2-03	N63.841830	W139.118722		wedge ice		-
26.07.2023	LB-IW2-03-org	EN23801-IW2-03	N63.841830	W139.118722		wedge ice		
26.07.2023	LB-S2-01	EN23801-S2-01	N63.841830	W139.118722	2.5	bedrock	green slate	-
26.07.2023	LB-S2-02	EN23801-S2-02	N63.841830	W139.118722	4.2	sediment	coarse sand, gravel, pebbles (10 cm), no organic, yellowish, massive CS	8.3
26.07.2023	LB-S2-02-BM	EN23801-S2-02-BM	N63.841830	W139.118722	4.2	sediment		-
26.07.2023	LB-S2-03	EN23801-S2-03	N63.841830	W139.118722	4.9	sediment	fine sand, silt, single coarser grains, browngray, brownish patches, root remains, massive CS	35.8
26.07.2023	LB-S2-04	EN23801-S2-04	N63.841830	W139.118722	5.5	sediment	fine sand, silt, single coarser grains, browngray, brownish patches, root remains, massive CS	35.1
26.07.2023	LB-S2-04-BM	EN23801-S2-04-BM	N63.841830	W139.118722	5.5	sediment		-

Date	Field ID	AWI ID	Latitude	Longitude	height (m)	Sample type	Description	Ice content (wt%)
26.07.2023	LB-S2-04-Lumi	EN23801-S2-04-Lumi	N63.841830	W139.118722	5.5	sediment	fine sand, silt, single coarser grains, browngray, brownish patches, root remains, massive CS	35.1
26.07.2023	LB-S2-04-Gamma	EN23801-S2-04-Gamma	N63.841830	W139.118722	5.5	sediment	fine sand, silt, single coarser grains, browngray, brownish patches, root remains, massive CS	35.1
26.07.2023	LB-S2-05	EN23801-S2-05	N63.841830	W139.118722	6.5	sediment	fine sand, silt, single coarser grains, browngray, brownish patches, root remains, massive CS	35.6
26.07.2023	LB-S2-06	EN23801-S2-06	N63.841830	W139.118722	7.2	sediment	fine sand, silt, single coarser grains, browngray, brownish patches, root remains, massive CS	32.1
27.07.2023	LB-IW3-01	EN23801-IW3-01	N63.841901	W139.117230		wedge ice		-
27.07.2023	LB-IW3-02	EN23801-IW3-02	N63.841901	W139.117230		wedge ice		-
27.07.2023	LB-IW3-0rg1	EN23801-IW3-0rg1	N63.841901	W139.117230		organics	wood below IW profile	-
27.07.2023	LB-IW3-0rg2	EN23801-IW3-0rg2	N63.841901	W139.117230		organics	peat below IW profile	-
27.07.2023	LB-IW3-0rg3	EN23801-IW3-0rg3	N63.841901	W139.117230		organics	wood+peat above profile	-
27.07.2023	LB-IW3-0rg4	EN23801-IW3-0rg4	N63.841901	W139.117230		organics	roots above IW top	-
27.07.2023	LB-IW3-PI1	EN23801-IW3-PI1	N63.841901	W139.117230		pore ice	pore ice right of profile	-
27.07.2023	LB-IW3-PI2	EN23801-IW3-PI2	N63.841901	W139.117230		pore ice	pore ice above top IW	-
27.07.2023	LB-IW3-tephra	EN23801-IW3-DT	N63.841901	W139.117230		tephra	presumably Dawson tephra	

Date	Field ID	AWI ID	Latitude	Longitude	height (m)	Sample type	Description	Ice content (wt%)
27.07.2023	LB-S3-01	EN23801-S3-01	N63.841901	W139.117230	2.4	sediment	coarse sand, gravel, pebbles (10 cm), no organic, yellowish, massive CS	18.8
27.07.2023	LB-S3-01-BM	EN23801-S3-01-BM	N63.841901	W139.117230	2.4	sediment		-
27.07.2023	LB-S3-02	EN23801-S3-02	N63.841901	W139.117230	2.6	sediment	fine sand, silt, single coarser grains, browngray, brownish patches, root remains, massive CS	43.4
27.07.2023	LB-S3-02-BM	EN23801-S3-02-BM	N63.841901	W139.117230	2.6	sediment		-
27.07.2023	LB-S3-02-Lumi	EN23801-S3-04-Lumi	N63.841901	W139.117230	3.6	sediment		-
27.07.2023	LB-S3-02-Gamma	EN23801-S3-04-Gamma	N63.841901	W139.117230	3.6	sediment		-
27.07.2023	LB-S3-03	EN23801-S3-03	N63.841901	W139.117230	3.1	sediment	fine sand, silt, single coarser grains, browngray, brownish patches, root remains, massive CS	34.2
27.07.2023	LB-S3-04	EN23801-S3-04	N63.841901	W139.117230	3.6	sediment	fine sand, silt, single coarser grains, browngray, brownish patches, root remains, massive CS	42.0
27.07.2023	LB-S3-04-BM	EN23801-S3-04-BM	N63.841901	W139.117230	3.6	sediment		-
27.07.2023	LB-S3-05	EN23801-S3-05	N63.841901	W139.117230	3.6	sediment	fine sand, silt, single coarser grains, browngray, brownish patches, root remains, massive CS	81.8
27.07.2023	LB-S3-06	EN23801-S3-06	N63.841901	W139.117230	4.2	sediment	fine sand, silt, single coarser grains, browngray, brownish patches, root remains, massive CS	40.7

Date	Field ID	AWI ID	Latitude	Longitude	height (m)	Sample type	Description	Ice content (wt%)
27.07.2023	LB-S3-06-BM	EN23801-S3-06-BM	N63.841901	W139.117230	4.2	sediment		-
28.07.2023	LB-S3-07	EN23801-S3-07	N63.841901	W139.117230	4.9	sediment	gray to graybrown, silty fine sand, plant remains, partly lenslike reticulated CS, ice lenses up to 1 cm thick	45.1
28.07.2023	LB-S3-08	EN23801-S3-08	N63.841901	W139.117230	5.8	sediment	gray to graybrown, silty fine sand, plant remains, partly lenslike reticulated CS, ice lenses up to 1 cm thick, single nonrounded clasts (1-10 cm)	44.1
28.07.2023	LB-S3-08-BM	EN23801-S3-08-BM	N63.841901	W139.117230	5.8	sediment		-
28.07.2023	LB-S3-09	EN23801-S3-09	N63.841901	W139.117230	8.0	sediment	gray to graybrown, silty fine sand, plant remains, single ice bands, single nonrounded clasts (1-10 cm)	52.8
28.07.2023	LB-S3-10	EN23801-S3-10	N63.841901	W139.117230	8.7	sediment	gray to graybrown, silty fine sand, plant remains, single ice band (10 mm), single nonrounded clasts (1-10 cm)	43.9
28.07.2023	LB-S3-10-BM	EN23801-S3-10-BM	N63.841901	W139.117230	8.7	sediment		-
28.07.2023	LB-S3-10-Lumi	EN23801-S3-10-Lumi	N63.841901	W139.117230	8.7	sediment		-
28.07.2023	LB-S3-10-Gamma	EN23801-S3-10-Gamma	N63.841901	W139.117230	8.7	sediment		-
28.07.2023	LB-S3-11	EN23801-S3-11	N63.841901	W139.117230	9.5	sediment	gray to graybrown, silty fine sand, plant remains, single ice band (10 mm), single nonrounded clasts (1-10 cm)	39.4

Date	Field ID	AWI ID	Latitude	Longitude	height (m)	Sample type	Description	Ice content (wt%)
28.07.2023	LB-S3-12	EN23801-S3-12	N63.841901	W139.117230	10.4	sediment	gray to graybrown, silty fine sand, plant remains, no clasts	43.0
28.07.2023	LB-S3-12-BM	EN23801-S3-12-BM	N63.841901	W139.117230	10.4	sediment		-
28.07.2023	LB-S3-13	EN23801-S3-13	N63.841901	W139.117230	11.1	sediment	gray to graybrown, silty fine sand, plant remains, no clasts, massive CS	39.7
28.07.2023	LB-S3-14	EN23801-S3-14	N63.841901	W139.117230	11.8	sediment	gray to graybrown, silty fine sand, plant remains, no clasts, massive CS	40.6
28.07.2023	LB-S3-14-BM	EN23801-S3-14-BM	N63.841901	W139.117230	11.8	sediment		-
28.07.2023	LB-S3-15	EN23801-S3-15	N63.841901	W139.117230	13.0	sediment	with Dawson Tephra, otherwise gray to graybrown, silty fine sand, plant remains, no clasts, massive CS	41.0
28.07.2023	LB-S3-15-BM	EN23801-S3-15-BM	N63.841901	W139.117230	13.0	sediment		-
28.07.2023	LB-IW4-0	EN23801-IW4-0	N63.841487	W139.116285		wedge ice		-
28.07.2023	LB-IW4-1	EN23801-IW4-1	N63.841487	W139.116285		wedge ice		-
28.07.2023	LB-IW4-2	EN23801-IW4-2	N63.841487	W139.116285		wedge ice		-
28.07.2023	LB-IW4-3	EN23801-IW4-3	N63.841487	W139.116285		wedge ice		-
28.07.2023	LB-IW4-4	EN23801-IW4-4	N63.841487	W139.116285		wedge ice		-
28.07.2023	LB-IW4-5	EN23801-IW4-5	N63.841487	W139.116285		wedge ice		-
28.07.2023	LB-IW4-6	EN23801-IW4-6	N63.841487	W139.116285		wedge ice		-
28.07.2023	LB-IW4-7	EN23801-IW4-7	N63.841487	W139.116285		wedge ice		-
28.07.2023	LB-IW4-8	EN23801-IW4-8	N63.841487	W139.116285		wedge ice		-
28.07.2023	LB-IW4-9AA	EN23801-IW4-9AA	N63.841487	W139.116285		wedge ice		-
28.07.2023	LB-IW4-10AA	EN23801-IW4-10AA	N63.841487	W139.116285		wedge ice		-
28.07.2023	LB-IW5-1	EN23801-IW5-1	N63.841487	W139.116285		wedge ice		-

Date	Field ID	AWI ID	Latitude	Longitude	height (m)	Sample type	Description	Ice content (wt%)
28.07.2023	LB-IW4-PI1	EN23801-PI1	N63.841487	W139.116285		pore ice	left of profile	-
28.07.2023	LB-IW4-PI2	EN23801-PI2	N63.841487	W139.116285		pore ice	at Dawson Tephra	-
28.07.2023	LB-IW4-PI3	EN23801-PI3	N63.841487	W139.116285		pore ice	above IW, close to IW5	-
28.07.2023	LB-IW4-tephra	EN23801-IW4-DT	N63.841487	W139.116285		tephra	Presumably Dawson Tephra	
30.07.2023	LB-S4-01	EN23801-S4-01	N63.841487	W139.116285	0.0	sediment	gray to graybrown, silty fine sand, plant remains, massive CS	35.7
30.07.2023	LB-S4-01-BM	EN23801-S4-01-BM	N63.841487	W139.116285	0.0	sediment		-
30.07.2023	LB-S4-02	EN23801-S4-02	N63.841487	W139.116285	0.7	sediment	gray to graybrown, silty fine sand, plant remains, massive CS	34.1
30.07.2023	LB-S4-03	EN23801-S4-03	N63.841487	W139.116285	1.4	sediment	gray to graybrown, silty fine sand, plant remains, massive CS	36.1
30.07.2023	LB-S4-03-BM	EN23801-S4-03-BM	N63.841487	W139.116285	1.4	sediment		-
30.07.2023	LB-S4-04	EN23801-S4-04	N63.841487	W139.116285	1.9	sediment	gray to graybrown, silty fine sand, plant remains, massive CS	35.6
30.07.2023	LB-S4-04-BM	EN23801-S4-04-BM	N63.841487	W139.116285	1.9	sediment		-
30.07.2024	LB-S4-DT	EN23801-S4-DT	N63.841487	W139.116285	1.8	sediment	Dawson Tephra, 5-15 mm thick	-
30.07.2023	LB-S4-05	EN23801-S4-05	N63.841487	W139.116285	2.3	sediment	gray to graybrown, silty fine sand, middle sand grains, plant remains, massive CS	36.6
30.07.2023	LB-S4-05-BM	EN23801-S4-05-BM	N63.841487	W139.116285	2.3	sediment		-
30.07.2023	LB-S4-06-Lumi	EN23801-S4-06-Lumi	N63.841487	W139.116285		sediment	gray to graybrown, silty fine sand, plant remains, massive CS	-
30.07.2023	LB-S4-06-Gamma	EN23801-S4-06-Gamma	N63.841487	W139.116285		sediment		-

Date	Field ID	AWI ID	Latitude	Longitude	height (m)	Sample type	Description	Ice content (wt%)
30.07.2023	LB-S4-07-Lumi	EN23801-S4-07-Lumi	N63.841487	W139.116285		sediment	gray to graybrown, silty fine sand, middle sand grains, plant remains, massive CS	-
30.07.2023	LB-S4-07-Gamma	EN23801-S4-07-Gamma	N63.841487	W139.116285		sediment		-
30.07.2024	LB-S5-01-MP	EN23801-S5-01-MP	N63.841487	W139.116285		vegetation	surface vegetation, moss, small shrubs	-
30.07.2025	LB-S5-02-MP	EN23801-S5-02-MP	N63.841487	W139.116285		vegetation	brown moss	-
31.07.2023	WG-S1-01	EN23802-S1-01	N63.715365	W138.639611	0.0	sediment	gray to graybrown, silty fine sand, plant remains, very small mica plates, massive CS	25.6
31.07.2023	WG-S1-01-BM	EN23802-S1-01-BM	N63.715365	W138.639611	0.0	sediment		-
31.07.2023	WG-S1-02	EN23802-S1-02	N63.715365	W138.639611	0.6	sediment	gray to graybrown, silty fine sand, plant remains, very small mica plates, massive CS	24.2
31.07.2023	WG-S1-03	EN23802-S1-03	N63.715365	W138.639611	1.2	sediment	gray to graybrown, silty fine sand, plant remains, very small mica plates, massive CS	25.9
31.07.2023	WG-S1-03-BM	EN23802-S1-03-BM	N63.715365	W138.639611	1.2	sediment		-
31.07.2023	WG-S1-04	EN23802-S1-04	N63.715365	W138.639611	1.4	sediment	Holocene cover, brown peaty layer (3-5 cm thick), alternate with graybrown silty fine sand layers, massive CS	39.4
31.07.2023	WG-S1-04-BM	EN23802-S1-04-BM	N63.715365	W138.639611	1.4	sediment		-
31.07.2023	WG-S1-05	EN23802-S1-05	N63.715365	W138.639611	1.9	sediment	Holocene cover, brown peaty layer (3-5 cm thick), alternate with graybrown silty fine sand layers, massive CS	47.4

Date	Field ID	AWI ID	Latitude	Longitude	height (m)	Sample type	Description	Ice content (wt%)
31.07.2023	WG-S1-05-BM	EN23802-S1-05-BM	N63.715365	W138.639611	1.9	sediment		-
			N63.715365	W138.639611				
31.07.2023	WG-S2-01	EN23802-S2-01	N63.715365	W138.639611	0.0	sediment	gray to graybrown, silty fine sand, plant remains, massive CS	34.6
31.07.2023	WG-S2-01-BM	EN23802-S2-01-BM	N63.715365	W138.639611	0.0	sediment		-
31.07.2023	WG-S2-02	EN23802-S2-02	N63.715365	W138.639611	0.9	sediment	gray to graybrown, silty fine sand, light tephra inclusions, plant remains, black patches	36.1
31.07.2023	WG-S2-02-BM	EN23802-S2-02-BM	N63.715365	W138.639611	0.9	sediment		-
31.07.2023	WG-S2-03	EN23802-S2-03	N63.715365	W138.639611	1.8	AGSN	ground squirrel nest	37.9
31.07.2023	WG-S2-03-BM	EN23802-S2-03-BM	N63.715365	W138.639611	1.8	AGSN	ground squirrel nest	-
31.07.2023	WG-S2-04	EN23802-S2-04	N63.715365	W138.639611	2.0	sediment	gray to graybrown, silty fine sand, plant remains, massive CS	
31.07.2023	WG-S2-04-BM	EN23802-S2-04-BM	N63.715365	W138.639611	2.0	sediment		-
31.07.2023	WG-S3-01	EN23802-S3-01	N63.715365	W138.639611	1.2	sediment	gray to graybrown, silty fine sand, middle sand grains, ice bands (1-2 mm), brownish plant layers (1-5 cm), massive CS	29.5
31.07.2023	WG-S3-01-BM	EN23802-S3-01-BM	N63.715365	W138.639611	1.2	sediment		-
31.07.2023	WG-S3-01-Lumi	EN23802-S3-01-Lumi	N63.715365	W138.639611	1.2	sediment	gray to graybrown, silty fine sand, middle sand grains, ice bands (1-2 mm), brownish plant layers (1-5 cm), massive CS	-

Date	Field ID	AWI ID	Latitude	Longitude	height (m)	Sample type	Description	Ice content (wt%)
31.07.2023	WG-S3-01-Gamma	EN23802-S3-01-Gamma	N63.715365	W138.639611	1.2	sediment		-
31.07.2023	WG-SW-1	EN23802-SW-1	N63.715365	W138.639611		stream water		-
31.07.2023	WG-IW1-tephra	EN23802-IW1-tephra	N63.715365	W138.639611		tephra	Presumably tephra	-
31.07.2023	WG-IW1-1	EN23802-IW1-1	N63.715365	W138.639611		wedge ice		-
31.07.2023	WG-IW2-1	EN23802-IW2-1	N63.715365	W138.639611		wedge ice		-
31.07.2023	WG-IW1-PI	EN23802-IW1-PI	N63.715365	W138.639611		pore ice		-
31.07.2023	WG-IW2-PI	EN23802-IW2-PI	N63.715365	W138.639611		pore ice		-
31.07.2023	WG-AGSN-1	EN23802-AGSN-1	N63.715365	W138.639611		AGSN, pore ice		-
31.07.2023	WG-IW3-1	EN23802-IW3-1	N63.715365	W138.639611		wedge ice		-
31.07.2023	WG-IW4-1	EN23802-IW4-1	N63.715365	W138.639611		wedge ice		-
31.07.2023	WG-IW4-tephra	EN23802-IW4-tephra	N63.715365	W138.639611		tephra	Presumably tephra	-
31.07.2023	WG-AGSN-2	EN23802-AGSN-2	N63.715365	W138.639611		AGSN, pore ice		-
01.08.2023	DC-RW1	EN23803-RW1	N63.688541	W138.606238		rain water		-
01.08.2023	DC-IW1-1	EN23803-IW1-1	N63.688541	W138.606238		wedge ice		-
01.08.2023	DC-IW1-2	EN23803-IW1-2	N63.688541	W138.606238		wedge ice		-
01.08.2023	DC-IW1-36CI	EN23803-IW1-36CI	N63.688541	W138.606238		wedge ice		-
01.08.2023	DC-IW1-AA	EN23803-IW1-AA	N63.688541	W138.606238		wedge ice		-
01.08.2023	DC-IW1-tephra	EN23803-RW1	N63.688541	W138.606238		tephra	Presumably tephra	-
02.08.2023	WG-S4-01	EN23802-S4-01	N63.715365	W138.639611	0.2	sediment	graybrown silty fine sand, plant remains, gravels below were co sampled, massive CS	26.2
02.08.2023	WG-S4-01-BM	EN23802-S4-01-BM	N63.715365	W138.639611	0.2	sediment		-

Date	Field ID	AWI ID	Latitude	Longitude	height (m)	Sample type	Description	Ice content (wt%)
02.08.2023	WG-S4-02	EN23802-S4-02	N63.715365	W138.639611	1.0	sediment	graybrown silty fine sand, plant remains, single slate clasts, massive CS	24.0
02.08.2023	WG-S4-02-MP	EN23802-S4-02-MP	N63.715365	W138.639611	1.0	sediment		24.1
02.08.2023	WG-S4-03	EN23802-S4-03	N63.715365	W138.639611	1.8	sediment	graybrown silty fine sand, plant remains, single slate clasts, massive CS	27.0
02.08.2023	WG-S4-03-BM	EN23802-S4-03-BM	N63.715365	W138.639611	1.8	sediment		-
02.08.2023	WG-S4-04-IW	EN23802-S4-04-IW	N63.715365	W138.639611	1.4	ice	small vertical ice band	-
02.08.2023	WG-S4-05	EN23802-S4-05	N63.715365	W138.639611	1.7	sediment	middle to coarse sand, fine gravel, larger nonrounded clasts (15-20 cm), 15 cm thick layer	17.3
02.08.2023	WG-S4-05-BM	EN23802-S4-05-BM	N63.715365	W138.639611	1.7	sediment		-
02.08.2023	WG-S4-06	EN23802-S4-06	N63.715365	W138.639611	1.9	sediment	Holocene, nonregular alternation of graybrown silty fine sand layers and darkbrown organicrich layers, partly with woody roots and twigs, massive CS	43.8
02.08.2023	WG-S4-06-BM	EN23802-S4-06-BM	N63.715365	W138.639611	1.9	sediment		-
02.08.2023	WG-S5-01-MP	EN23802-S5-01-MP	N63.715365	W138.639611		vegetation	vegetation cover	
02.08.2023	WG-S5-02-MP	EN23802-S5-02-MP	N63.715365	W138.639611		vegetation	roots, soil	
02.08.2023	WG-IW5-1	EN23802-IW5-1	N63.715365	W138.639611		wedge ice		-
02.08.2023	WG-IW5-36CI	EN23802-IW5-36CI	N63.715365	W138.639611		wedge ice		-
02.08.2023	WG-S6-01	EN23802-S6-01	N63.715365	W138.639611		sediment		-
02.08.2023	WG-Bedrock	EN23802-Bedrock	N63.715365	W138.639611	0.0	bedrock		-
03.08.2023	BC-SW-1	EN23804-SW-1	N64.009263	W139.245661		stream water		-

Date	Field ID	AWI ID	Latitude	Longitude	height (m)	Sample type	Description	Ice content (wt%)
03.08.2023	BC-IW1-01	EN23804-IW1-1	N64.009263	W139.245661		wedge ice		-
03.08.2023	BC-IW1-02	EN23804-IW1-2	N64.009263	W139.245661		wedge ice		-
03.08.2023	BC-IW1-03	EN23804-IW1-3	N64.009263	W139.245661		wedge ice		-
03.08.2023	BC-IW1-36CI	EN23804-IW1-36CI	N64.009263	W139.245661		wedge ice		-
03.08.2023	BC-IW1-AA	EN23804-IW1-AA	N64.009263	W139.245661		wedge ice		-
03.08.2023	BC-IW1-org	EN23804-IW1-org	N64.009263	W139.245661		organics		-
03.08.2023	BC-IW1-PI	EN23804-IW1-PI	N64.009263	W139.245661		pore ice		-
03.08.2023	BC-IW1-tephra	EN23804-IW1-tephra	N64.009263	W139.245661		tephra	Presumably Sheep Creek tephra Klondike	-
03.08.2023	BC-IW2-01	EN23804-IW2-1	N64.009263	W139.245661		wedge ice		-
03.08.2023	BC-IW2-02	EN23804-IW2-2	N64.009263	W139.245661		wedge ice		-
03.08.2023	BC-IW2-03	EN23804-IW2-3	N64.009263	W139.245661		wedge ice		-
03.08.2023	BC-IW2-04	EN23804-IW2-4	N64.009263	W139.245661		wedge ice		-
03.08.2023	BC-IW2-36CI	EN23804-IW2-36CI	N64.009263	W139.245661		wedge ice		-
03.08.2023	BC-IW2-05AA	EN23804-IW2-5AA	N64.009263	W139.245661		wedge ice		-
03.08.2023	BC-IW2-06	EN23804-IW2-6	N64.009263	W139.245661		wedge ice		-
03.08.2023	BC-IW2-org	EN23804-IW2-org	N64.009263	W139.245661		organics		-
03.08.2023	BC-IW2-PI	EN23804-IW2-PI	N64.009263	W139.245661		pore ice		-
03.08.2023	BC-S1-01	EN23804-S1-01	N64.009263	W139.245661	0.3	sediment	gray to graybrown, silty fine sand, plant remains, massive CS	58.1
03.08.2023	BC-S1-01-BM	EN23804-S1-01-BM	N64.009263	W139.245661	0.3	sediment		-
03.08.2023	BC-S1-02	EN23804-S1-02	N64.009263	W139.245661	0.7	sediment	Presumably Sheep Creek tephra Klondike, light gray	50.6
03.08.2023	BC-S1-03	EN23804-S1-03	N64.009263	W139.245661	0.75	sediment	gray to graybrown, silty fine sand, darkbrown organic layers, plant remains, massive CS	59.9

Date	Field ID	AWI ID	Latitude	Longitude	height (m)	Sample type	Description	Ice content (wt%)
03.08.2023	BC-S1-04	EN23804-S1-04	N64.009263	W139.245661	1.4	sediment	gray to graybrown, silty fine sand, single non rounded clasts, darkbrown organic layers, plant remains, massive CS	47.4
03.08.2023	BC-S1-04-BM	EN23804-S1-04-BM	N64.009263	W139.245661	1.4	sediment	-	-
03.08.2023	BC-S1-04-MP	EN23804-S1-04-MP	N64.009263	W139.245661	1.4	sediment	gray to graybrown, silty fine sand, single non rounded clasts, darkbrown organic patches, plant remains, massive CS	47.4
03.08.2023	BC-S1-05	EN23804-S1-05	N64.009263	W139.245661	2.0	sediment	gray to graybrown, silty fine sand, darkbrown organic patches, plant remains, small ice bands (< 1mm), massive CS	39.6
03.08.2023	BC-S1-06	EN23804-S1-06	N64.009263	W139.245661	2.6	sediment	gray to graybrown, silty fine sand, single non rounded clasts, darkbrown organic patches, plant remains, massive CS	53.2
03.08.2023	BC-S1-06-BM	EN23804-S1-06-BM	N64.009263	W139.245661	2.6	sediment	-	-
03.08.2023	BC-S2-01-MP	EN23804-S2-01-MP	N64.008232	W139.244556		vegetation	fresh moss	-
03.08.2023	BC-S2-02-MP	EN23804-S2-02-MP	N64.008232	W139.244556		vegetation	slightly decomposed moss	-
03.08.2023	BC-Bedrock	EN23804-Bedrock	N64.009263	W139.245661	0.0	rock	-	-
04.08.2023	BC-(Reindeer)lichen	EN23804-(Reindeer)lichen	N64.009263	W139.245661		vegetation	lichen	
04.08.2023	BC-Aspen	EN23804-Aspen	N64.009263	W139.245661		vegetation	deciduous tree	
04.08.2023	BC-White-Spruce	EN23804-White-Spruce	N64.009263	W139.245661		vegetation	conifer	
04.08.2023	BC-Fern	EN23804-Fern	N64.009263	W139.245661		vegetation	fern	
04.08.2023	BC-Crowberry	EN23804-Crowberry	N64.009263	W139.245661		vegetation	herb	

Date	Field ID	AWI ID	Latitude	Longitude	height (m)	Sample type	Description	Ice content (wt%)
04.08.2023	BC-Labrador-tea	EN23804-Labrador-tea	N64.009263	W139.245661		vegetation	shrub	
04.08.2023	BC-Gramnoids	EN23804-Gramnoids	N64.009263	W139.245661		vegetation	grass	
04.08.2023	BC-Horsetail	EN23804-Horsetail	N64.009263	W139.245661		vegetation	herb	
04.08.2023	BC-Black-Spruce	EN23804-Black-Spruce	N64.009263	W139.245661		vegetation	conifer	
04.08.2023	BC-Sphagnum-moss	EN23804-Sphagnum-moss	N64.009263	W139.245661		vegetation	moss	
04.08.2023	BC-Betula	EN23804-Betula	N64.009263	W139.245661		vegetation	deciduous tree	
04.08.2023	BC-Willow-shrub	EN23804-Willow-shrub	N64.009263	W139.245661		vegetation	shrub	
04.08.2023	BC-Shrub-alder	EN23804-Shrub-alder	N64.009263	W139.245661		vegetation	shrub	
04.08.2023	BC-herb1	EN23804-herb1	N64.009263	W139.245661		vegetation	herb	
04.08.2023	BC-herb2	EN23804-herb2	N64.009263	W139.245661		vegetation	herb	
04.08.2023	PH-tephra	EN23805-tephra	N63.988842	W139.067627		tephra	Presumably tephra	
04.08.2023	DA-RW1	EN23806-RW1	N64.069092	W139.424736		rain water	20:40 at Whitehouse Cabins	
04.08.2023	DA-SW1	EN23806-SW1	N64.068199	W139.428389		river water	Yukon river at ferry	
06.08.2023	DA-SW2	EN23806-SW2	N64.069824	W139.435654		river water	Yukon river at ferry - other side	
06.08.2023	DA-SW3	EN23806-SW3	N64.058732	W139.440362		river water	Klondike river water (close to Mammoth)	
08.08.2023	WH-RW1	EN23807-RW1	N60.778469	W135.113442		rain water	12:45 at AirBnB (24 Gleaner Avenue)	
08.08.2023	WH-RW2	EN23807-RW2	N60.778469	W135.113442		rain water	18:15 at AirBnB (24 Gleaner Avenue)	
09.08.2023	WH-SW1	EN23808-SW1	N60.725142	W135.051867		river water	Yukon river in Whitehorse, 15:00	

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