

REPORT

# Norwegian GeoTest Sites (NGTS)

GEOTECHNICAL SITE INVESTIGATION, SVALBARD  
FIELD REPORT – PERMAFROST SITES – ADVENDTDALEN/UNIS EAST

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## Summary

The NORWEGIAN GEOTEST SITES research infrastructure, with funding from The Research Council of Norway, creates national research test sites facility for geotechnical research.

This report covers the field work on the NGTS Permafrost site performed by SINTEF during the time period April-May 2018 at the Adventtdalen and Unis East site, located in the Longyearbyen area.

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## Review and reference page

## 1 Introduction

The NORWEGIAN GEOTEST SITES research infrastructure, with funding from The Research Council of Norway, creates national research test sites facility for geotechnical research. Five national test sites are located in Norway and on Svalbard. The research consortium consists of NGI, NTNU, SINTEF/UNIS and NPRA (Norwegian Public Roads Administration). The research project will develop the five sites as field laboratories for the testing and verification of innovative soil investigation and testing methods, and foundation solutions. These sites cover the soil conditions of soft clay, quick clay, silt, sand and permafrost.

This report covers the field work on the Permafrost site performed by SINTEF during the time period April-May 2018 at the Adventdalen and UNIS East sites, located in the Longyearbyen area.

## 2 Background

The field work performed on Svalbard is covered by the subcontract signed by UNIS and SINTEF. The work comprises:

- i) Site supervision
- ii) Drilling and sampling
- iii) Installation of field instrumentation

Responsible for site supervision: Anatoly Sinitsyn

Drilling and sampling crew: Trond Larsen and Kjartan Følke

Installation of casings: Trond Larsen and Kjartan Følke

## 3 Field location

The national test site for permafrost is located in the Svalbard Archipelago in the surroundings of Longyearbyen (see *Figure 1*). Four proposed sites comprise the NGTS Permafrost site. An overview of the proposed sites for NGTS Permafrost site is presented in *Figure 2*, these sites are:

- *Adventdalen (1)*
- *Endalen (2)*
- *UNIS East (3)*
- *Longyearbyen Slope (4)*

This report covers field works in the Adventdalen and UNIS East sites in April/May 2018. Detailed map of borehole locations is presented in *Figure 3* and *Figure 4*.



Figure 1 Overview map of the Svalbard Archipelago.

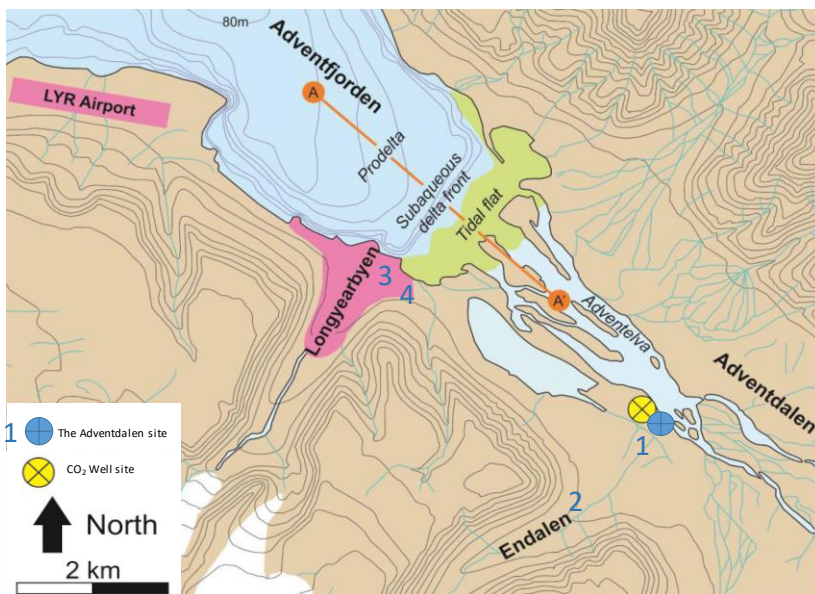


Figure 2 Overview of the Longyearbyen area and proposed sites for NGTS Permafrost site (after / 1/ and / 2/).



Figure 3 Detailed map of borehole locations at the NGTS site in Adventdalen.

Anleggsdrift AS had set a casing in borehole A4-2 down to 20m depth.

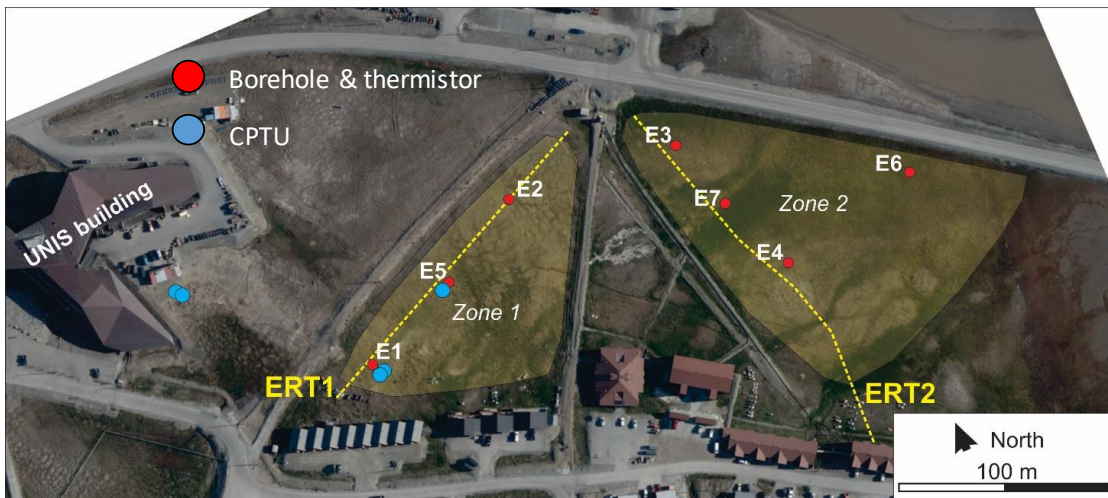


Figure 4 Overview of planned field activity at UNIS East. (This report covers boreholes E5, E6 and E7).

#### Specification of the field work:

- Sampling from active layer:
  - Collection of bag samples with normal auger drilling.
- Sampling of permafrost:
  - SINTEF-modified CRREL coring auger (45mm core diameter).
  - Sampling with auger was performed in challenging ground conditions.
- Installation of plastic casing in boreholes for installation of thermistor strings: the boreholes made after coring or augering were used for this purpose.

No sampling was performed from the bedrock. Samples was delivered in cold storage facility at UNIS.

## 4 Methods and equipment

### 4.1 Drilling rig

Field work is performed with SINTEF's custom built Geotech 504. The drilling rig can be disassembled to make it easy to transport in parts with helicopter if necessary. The drilling rig is equipped for different types of drilling and sounding, cone penetration testing (CPTU), permafrost coring and conventional piston sampling. The drilling rig in operation in Adventdalen is shown in Figure 5.

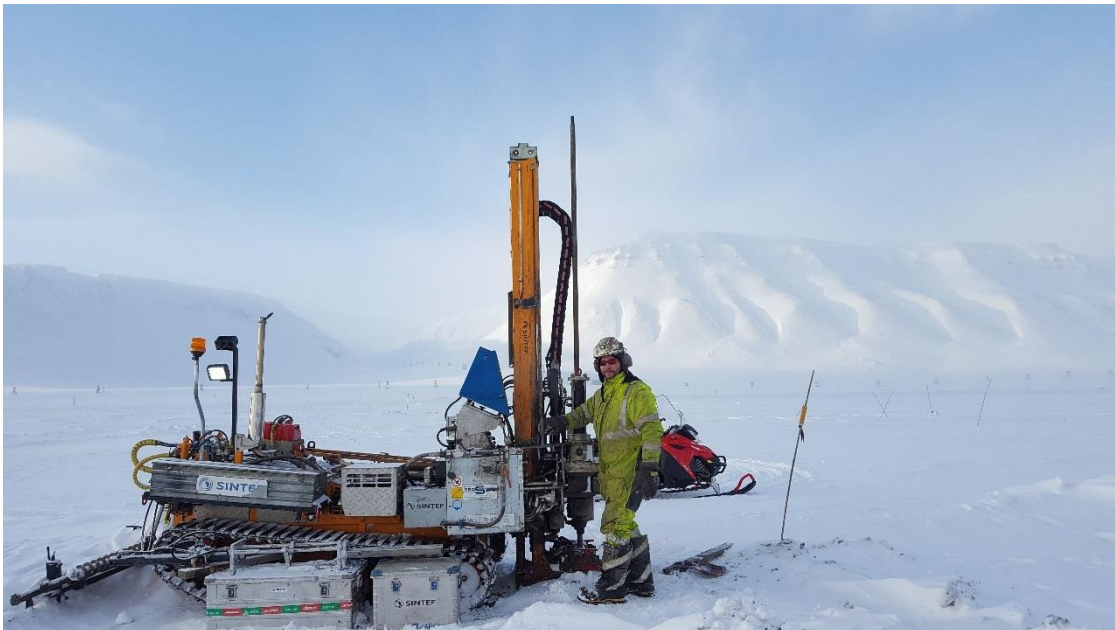


Figure 5 The SINTEF drilling rig in operation in Adventdalen.

### 4.2 Permafrost coring

The SINTEF-modified CRREL coring auger for permafrost is presented in Figure 6. The corer consists of a cutting bit attached to a thick walled hollow core collecting auger. This type of corer has proven to be efficient in collecting cores in fine grained frozen soils. The inner diameter of the corer is 45mm. The corer cut samples of 40 cm length.

The SINTEF permafrost corer ensures penetration in most materials due to the use of poly-crystalline diamond composite (PCD) bit inserts. These inserts are very durable and can even cut cores in rock. This coring barrel is used without drilling fluids. This is a big advantage when operating in cold climate where environmentally unfriendly additives have to be used in order to prevent the liquids from freezing.



Figure 6 The SINTEF permafrost corer; drill piece (top left), PCD inserts (top right), frost corer assembled (lower left) and sampling in Adventdalen (bottom right).

## 5 Event log

The event log is presented in Table 1.

Table 1 Event log.

Day	Date	Activity
Thursday	2018-04-12	Travel to Svalbard
Friday	2018-04-13	Project meeting and HSE. Preparation and checking equipment for field work. Two holes drilled for CPT-rig at A6, UNIS East. Transport of rig to Adventtdalen.
Saturday	2018-04-14	CRREL coring and auger sampling at A4-2.
Sunday	2018-04-15	CRREL coring and auger sampling at A4-2.
Monday	2018-04-16	Auger the last 2m down to 30m depth. Installation of plastic casing. Rig transported to borehole E5 at UNIS East.
Tuesday	2018-04-17	Auger sampling at E5 to 2m depth. CRREL coring down to 10m depth.
Wednesday	2018-04-18	CRREL coring at E5 from 10m to 15m depth at E5.
Thursday	2018-04-19	CRREL coring at E5 from 15m to 20m depth. One auger sample below.
Friday	2018-04-20	CRREL coring and auger sampling at E5 from 22m to 26m depth at E5.
Saturday	2018-04-21	Cleaning E5 with auger and installed casing down to 27m depth.
Sunday	2018-04-22	Moved rig to E6. CRREL coring and auger sampling to 11m depth.
Monday	2018-04-23	Auger down to 12m depth in E6. Difficult to keep hole open. Plastic casing installed to 12m depth. Moved to E7.
Tuesday	2018-04-24	CRREL coring and auger sampling at E7 to almost 12m depth. Change of cutters on the sampler.
Wednesday	2018-04-25	Auger sampling at E7 to almost 16m depth. Installation of plastic casing. Rig maintenance and storage of equipment.
Thursday	2018-04-26	Travel from Svalbard

Note: A4-2, E5-E7– borehole locations.

## 6 Weather conditions

The field work was performed in air temperatures down to -12 °C during daytime, and with windchill effect the temperatures were down to -25 °C during fieldwork as seen in *Figure 7*. The weather did not jeopardize or delay the work for this field trip.

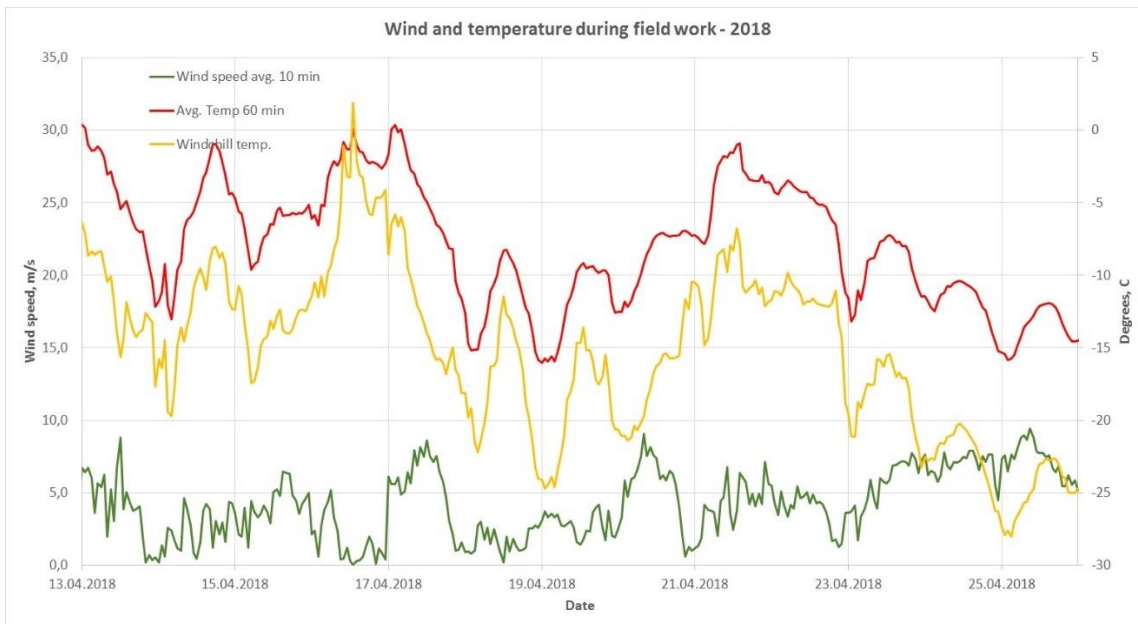


Figure 7 Overview of temperature and wind during the field campaign.

## 7 Coordinates

The coordinates for the geotechnical boreholes in the Adventdalen and UNIS East sites are shown in Table 2. The geodetic measurements have been performed with DGPS.

Table 2 Location and elevation of geotechnical boreholes in the Adventdalen and UNIS East sites.

Place	Borehole	Easting	Northing	Elevation surface, NN2000
Adventdalen site	A4-2	519149	8680830	4,0
UNIS East site	E5	515037	8683205	6,0
UNIS East site	E6	515174	8683180	2,0
UNIS East site	E7	515251	8683162	1,0

## 8 Sampling

Samples were collected with auger or with permafrost corer. All samples were properly named, packed (wrapped on plastic and packed in plastic bags) and brought to cold storage at UNIS. Each core sample was marked with borehole number, core number and depth (e.g. A4-2 Prøve 5 21,8-22,2 m). Details regarding samples from the different boreholes are shown in Table 3–**Error! Reference source not found.** Totally 82 samples of very good quality were taken using the permafrost corer, and pictures of these samples are shown in Appendix A. Totally 21 samples taken with auger were put in plastic bags.

*Table 3 Samples collected in borehole A4-2. (Pre-installed steel casing in depths 0-20m).*

Depth top	Depth bottom	Sampling method		Sample wrap	Picture
20,2	20,6	Permafrost corer	Pr.1	Bag	Yes
20,6	21,0	Permafrost corer	Pr.2	Bag	Yes
21,0	21,4	Permafrost corer	Pr.3	Bag	Yes
21,4	21,8	Permafrost corer	Pr.4	Bag	Yes
21,8	22,2	Permafrost corer	Pr.5	Bag	Yes
22,2	22,6	Permafrost corer	Pr.6	Bag	Yes
24,0	24,2	Auger		Bag	No
24,2	24,6	Permafrost corer	Pr.7	Bag	Yes
24,6	25,0	Permafrost corer	Pr.8	Bag	Yes
25,0	25,4	Permafrost corer	Pr.9	Bag	Yes
27,2	27,6	Permafrost corer	Pr.10	Bag	Yes
27,6	28,0	Permafrost corer	Pr.11	Bag	Yes
28,0	29,0	Auger		Bag	No
29,0	30,0	Auger		Bag	No

Note: Augering in depths 22,6-24,2m, some ice detected.

*Table 4 Samples collected in borehole E5.*

Depth top	Depth bottom	Sampling method		Sample wrap	Picture
0,5	1,0	Auger		Bag	No
1,5	1,9	Auger		Bag	No
1,9	2,3	Permafrost corer	Pr.1	Bag	Yes
2,3	2,7	Permafrost corer	Pr.2	Bag	Yes
2,7	3,1	Permafrost corer	Pr.3	Bag	Yes
3,1	3,5	Permafrost corer	Pr.4	Bag	Yes
3,5	3,9	Permafrost corer	Pr.5	Bag	Yes
3,9	4,3	Permafrost corer	Pr.6	Bag	Yes
4,3	4,7	Permafrost corer	Pr.7	Bag	Yes
4,7	5,1	Permafrost corer	Pr.8	Bag	Yes
5,1	5,5	Permafrost corer	Pr.9	Bag	Yes
5,5	5,9	Permafrost corer	Pr.10	Bag	Yes
5,9	6,3	Permafrost corer	Pr.11	Bag	Yes
6,3	6,7	Permafrost corer	Pr.12	Bag	Yes
6,7	7,1	Permafrost corer	Pr.13	Bag	Yes
7,1	7,5	Permafrost corer	Pr.14	Bag	Yes
7,5	7,9	Permafrost corer	Pr.15	Bag	Yes
7,9	8,3	Permafrost corer	Pr.16	Bag	Yes
8,3	8,7	Permafrost corer	Pr.17	Bag	Yes
8,7	9,1	Permafrost corer	Pr.18	Bag	Yes
9,1	9,5	Permafrost corer	Pr.19	Bag	Yes
9,5	9,9	Permafrost corer	Pr.20	Bag	Yes

9,9	10,3	Permafrost corer	Pr.21	Bag	Yes
10,3	10,7	Permafrost corer	Pr.22	Bag	Yes
10,7	11,1	Permafrost corer	Pr.23	Bag	Yes
11,1	11,5	Permafrost corer	Pr.24	Bag	Yes
11,5	11,9	Permafrost corer	Pr.25	Bag	Yes
11,9	12,3	Permafrost corer	Pr.26	Bag	Yes
12,3	12,7	Permafrost corer	Pr.27	Bag	Yes
12,9	13,3	Permafrost corer	Pr.28	Bag	Yes
13,3	13,7	Permafrost corer	Pr.29	Bag	Yes
13,7	14,1	Permafrost corer	Pr.30	Bag	Yes
14,1	14,5	Permafrost corer	Pr.31	Bag	Yes
14,5	14,9	Permafrost corer	Pr.32	Bag	Yes
14,9	15,3	Permafrost corer	Pr.33	Bag	Yes
15,3	15,7	Permafrost corer	Pr.34	Bag	Yes
17,7	18,1	Permafrost corer	Pr.35	Bag	Yes
18,1	18,5	Permafrost corer	Pr.36	Bag	Yes
18,5	18,9	Permafrost corer	Pr.37	Bag	Yes
18,9	19,3	Permafrost corer	Pr.38	Bag	Yes
19,3	19,7	Permafrost corer	Pr.39	Bag	Yes
19,7	20,1	Permafrost corer	Pr.40	Bag	Yes
21,5	21,7	Auger		Bag	No
21,7	22,1	Permafrost corer	Pr.41	Bag	Yes
22,1	22,5	Permafrost corer	Pr.42	Bag	Yes
22,5	22,9	Permafrost corer	Pr.43	Bag	Yes
23,5	23,7	Auger		Bag	No
25,0	25,3	Auger		Bag	No
25,7	26,1	Permafrost corer	Pr.44	Bag	Yes

Note: Augering in depths 15,7-17,7m, 20,1-21,7m and 26,1-27,0m.

*Table 5 Samples collected in borehole E6.*

Depth top	Depth bottom	Sampling method	Sample name	Sample wrap	Picture
0,5	1,0	Auger		Bag	No
1,0	1,5	Auger		Bag	No
2,0	2,4	Permafrost corer	Pr.1	Bag	Yes
2,4	2,8	Permafrost corer	Pr.2	Bag	Yes
2,8	3,2	Permafrost corer	Pr.3	Bag	Yes
3,2	3,6	Permafrost corer	Pr.4	Bag	Yes
5,4	5,7	Auger		Bag	No
5,7	6,1	Permafrost corer	Pr.5	Bag	Yes
6,1	6,5	Permafrost corer	Pr.6	Bag	Yes
6,5	6,9	Permafrost corer	Pr.7	Bag	Yes
6,9	7,3	Permafrost corer	Pr.8	Bag	Yes
7,3	7,7	Permafrost corer	Pr.9	Bag	Yes
9,3	9,7	Auger		Bag	No

9,7	10,1	Permafrost corer	Pr.10	Bag	Yes
10,1	10,3	Permafrost corer	Pr.11	Bag	Yes
10,3	10,7	Permafrost corer	Pr.12	Bag	Yes
10,7	11,1	Permafrost corer	Pr.13	Bag	Yes

Not: Augering in depths 3,6-5,7m, 7,7-9,7m and 11,1-12,0m.

*Table 6 Samples collected in borehole E7.*

Depth top	Depth bottom	Sampling method	Sample name	Sample wrap	Picture
0,3	0,7	Auger		Bag	No
1,1	1,4	Auger		Bag	No
1,7	2,0	Auger		Bag	No
2,0	2,4	Permafrost corer	Pr.1	Bag	Yes
2,4	2,8	Permafrost corer	Pr.2	Bag	Yes
2,8	3,2	Permafrost corer	Pr.3	Bag	Yes
3,2	3,6	Permafrost corer	Pr.4	Bag	Yes
3,6	4,0	Permafrost corer	Pr.5	Bag	Yes
5,5	6,0	Auger		Bag	No
6,0	6,4	Permafrost corer	Pr.6	Bag	Yes
6,4	6,8	Permafrost corer	Pr.7	Bag	Yes
6,8	7,2	Permafrost corer	Pr.8	Bag (not frozen)	Yes
7,2	7,6	Permafrost corer	Pr.9	Bag (not frozen)	Yes
7,6	8,0	Permafrost corer	Pr.10	Bag	Yes
8,5	9,0	Auger		Bag	No
9,5	10,0	Auger		Bag	No
10,1	10,5	Permafrost corer	Pr.11	Bag	Yes
10,5	10,9	Permafrost corer	Pr.12	Bag	Yes
10,9	11,3	Permafrost corer	Pr.13	Bag	Yes
11,3	11,7	Permafrost corer	Pr.14	Bag	Yes
13,5	14,0	Auger		Bag	No
14,5	15,0	Auger		Bag	No
15,0	15,7	Auger		Bag	No

Note: Augering in depths 4,0-5,5m, 8,0-10,0m and 11,7-16,0m.

## 9 Installation of casings

In this project thermistors for measuring ground temperature in depth shall be installed in casings. The casings consisted of 2m sections of Ø50mm PEHD (poly ethylene high density) pipes satisfying DS2119 (Danish standard) (/ 6/) and KIWA certified. Tape were used in the threaded coupling between casing sections to avoid water entering the casing. The casings were pushed down in the open holes A4-2, E5, E6 and E7. Sand was filled around the casings after installation.

*It can, in general, be recommended to equip boreholes for thermal measurements in permafrost zones with casing due to the following reasons: i) practical experience shows that casings were used in most of the cases*

*/ 7/ for temperature measurements in permafrost zones due to a number of practical reasons; ii) in particular, casings protect the wire of the thermistor string from rupture if frost heave occur at the site; iii) casing protects the borehole from collapsing if cryopegs are encountered; iv) casing provides an opportunity to change the thermistor string if some of sensors are malfunctioning during exploitation.*

Coring with CRREL permafrost corer had been performed in these holes previously, and the holes were cleaned by auger prior to installation of casings. The installed casing depths in the boreholes are shown in *Table 7*.

*Table 7 Casing depths in Adventdalen.*

Place	Borehole	Installation depth (m)	Remarks
Adventdalen site	A4-2	29,7	Steel casing installed to 20m depth
UNIS East site	E5	27,0	
UNIS East site	E6	12,0	
UNIS East site	E7	16,0	

Thermistor strings will be installed by UNIS-personnel.

## 10 General soil description

The active layer at the site in Adventtdalen and UNIS East is assumed to have a thickness of 1 m. This layer was frozen during the field campaign. Due to problems with encountered cryopegs in Adventtdalen at depths 13-16m in the 2017 field campaign steel casing has been installed in A4-2 down to 20m depth. No cryopegs were detected in this field campaign.

### Borehole A4-2

The sediments below 20 m depth in A4-2 are generally fine-grained, however ice lenses can be observed on photos of samples at depths 27,4m and 27,9m. During augering in depths 22,6-24,2m some ice was reported to occur.

### UNIS East E5

Photos of samples show silty, sandy material down to 2,4m depth. Below this depth the material seem to be fine-grained, except for a coarse-grained layer of 8-10 cm thickness at 8,4m depth and interbedded layers of fine to coarse-grained sediments at depths 12,9-13,3m. Some ice seems to occur at 3,1m depth.

### UNIS East E6

Coarse-grained soil can be observed from photos of samples down to 2,7m, at depths 9,7-9,9m and at depths 10,7-11,1m. The remaining soil seems to be fine-grained.

#### UNIS East E7

Coarse-grained soil can be observed from photos of samples down to 2,6m. A thin coarse-grained layer can be observed at 6,95m depth. The remaining soil seems to be fine-grained. A thin ice layer can be seen on 2,8 m depth.

## 11 Comments to field investigation

The field investigations in Adventdalen were performed during spring with snow cover and low temperatures. This time was selected to prevent damage to the vulnerable tundra. Drilling at this time of the year will increase the amount of time to perform the geotechnical investigations.

It would have been useful to perform geophysical investigations/analyze existing geophysical data in Adventdalen prior to the geotechnical investigation campaign.

Obtained core samples had a very good quality and are, in particular, suitable for mechanical testing. Mechanical testing will be suggested. Values of mechanical parameters obtained from mechanical tests can be more suitable than the ones obtained by index properties if one considers analysis of new foundation solutions on the site in the future.

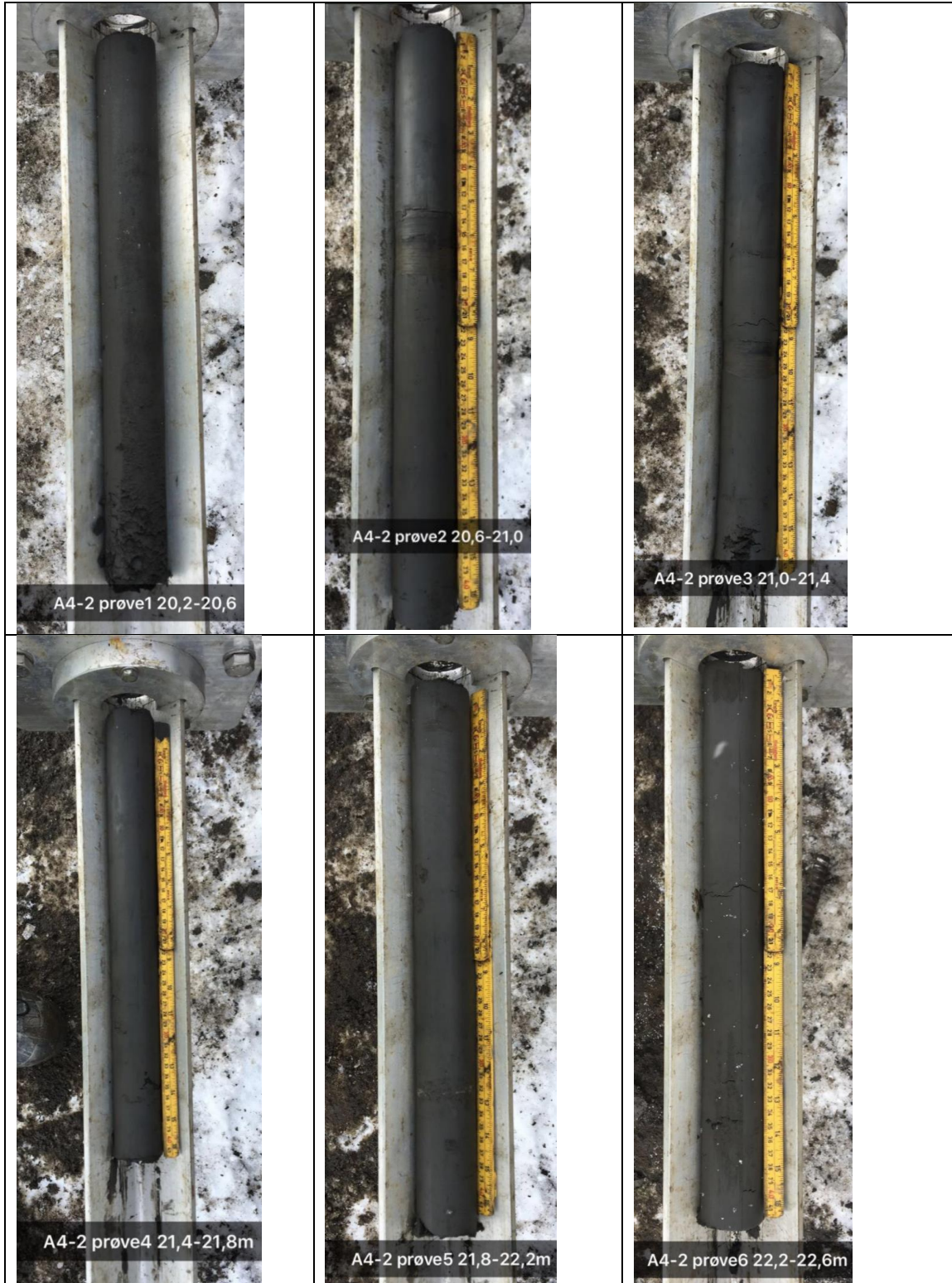
## 12 References

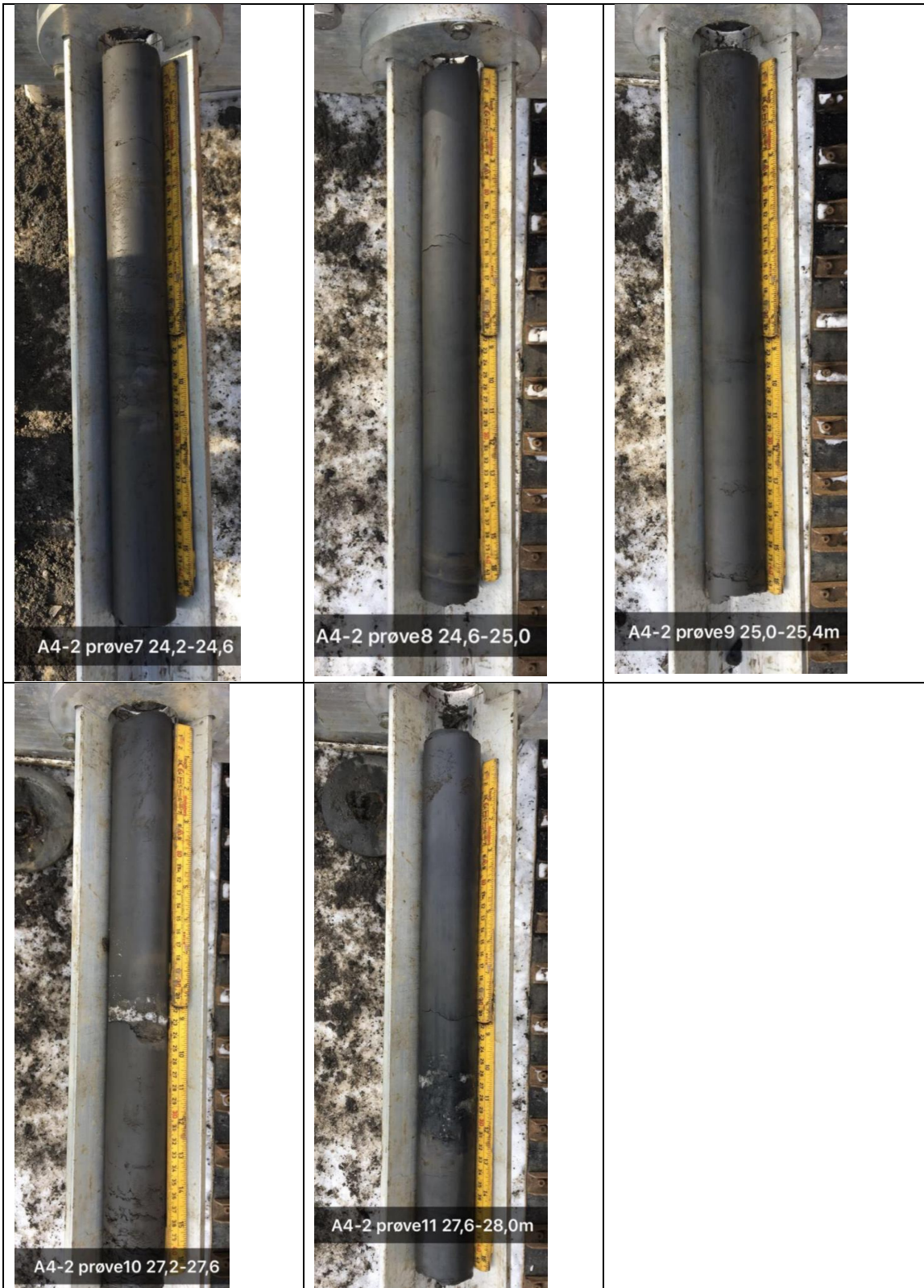
- / 1/ Gilbert, G.L., *Sedimentology and geocryology of an Arctic fjord head delta (Adventdalen, Svalbard)*, in Department of Geosciences, Faculty of Mathematics and Natural Sciences. 2014, University of Oslo. p. 133.
- / 2/ Arne Instanes, UNIS, *Norwegian GeoTest Sites (Nasjonale geoforsøksfelt)*, Technical Note 2016-1 Selection of sites, dated September 13, 2016. 8 pages + 4 enclosures.
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- / 7/ Balmand, E., *State of the art: thermal measurement techniques in permafrost. SAMCoT-report SBF 2012 A0134, February 2012.*

# Appendix A

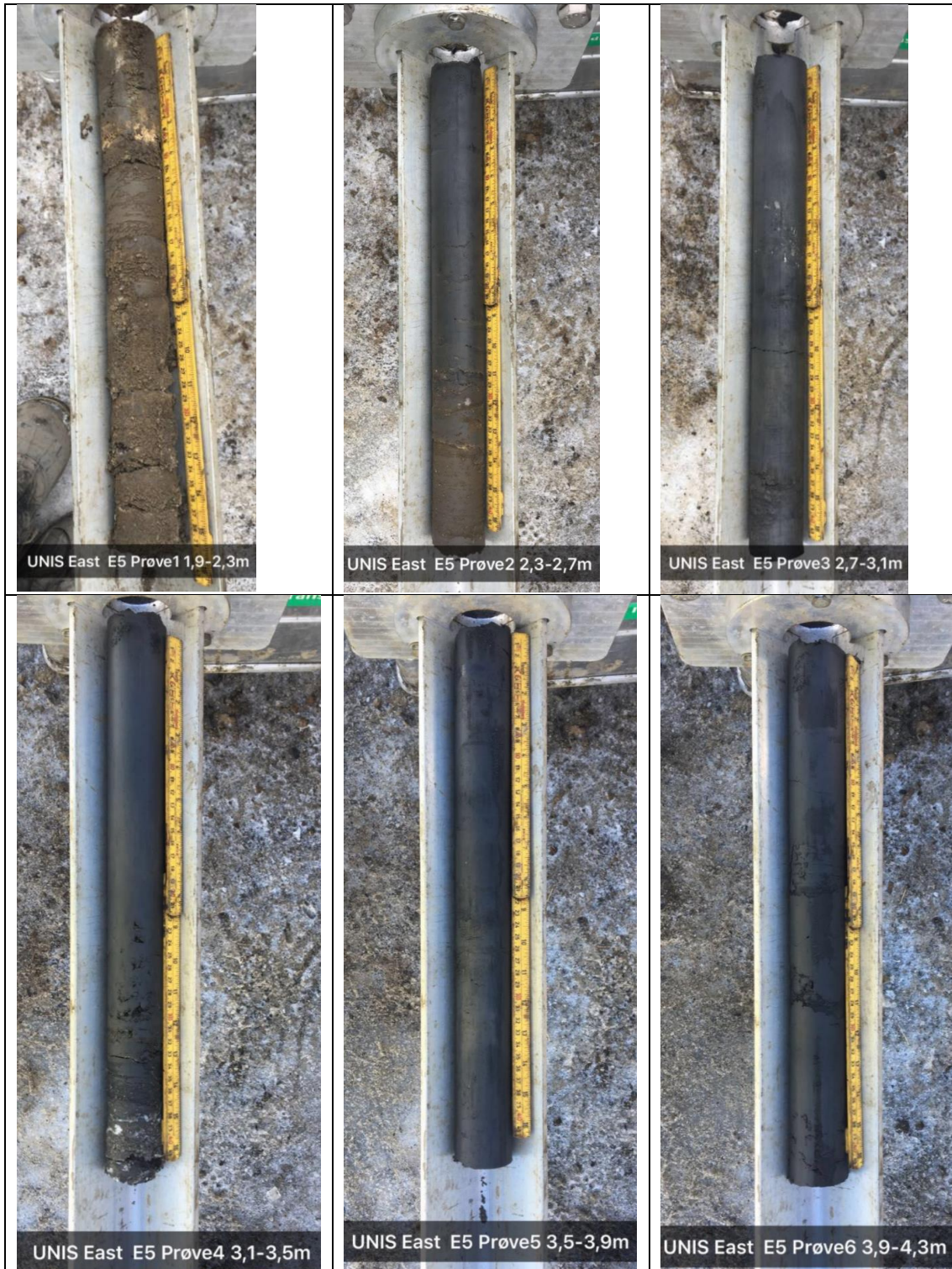
## SAMPLE PICTURES

## A1 Pictures of samples – Borehole A4-2 Adventtdalen





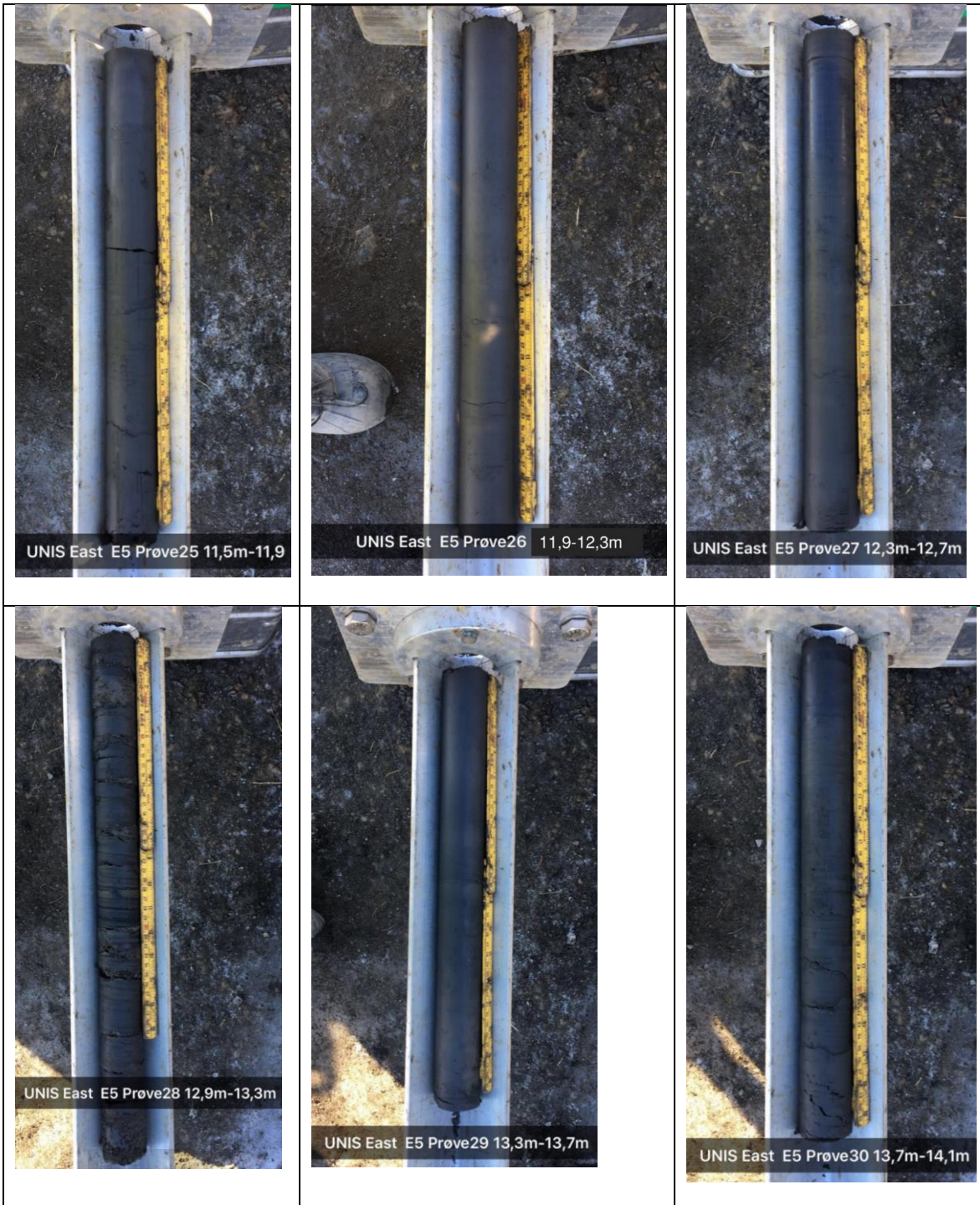
## A2 Picture of samples – Borehole E5 UNIS East



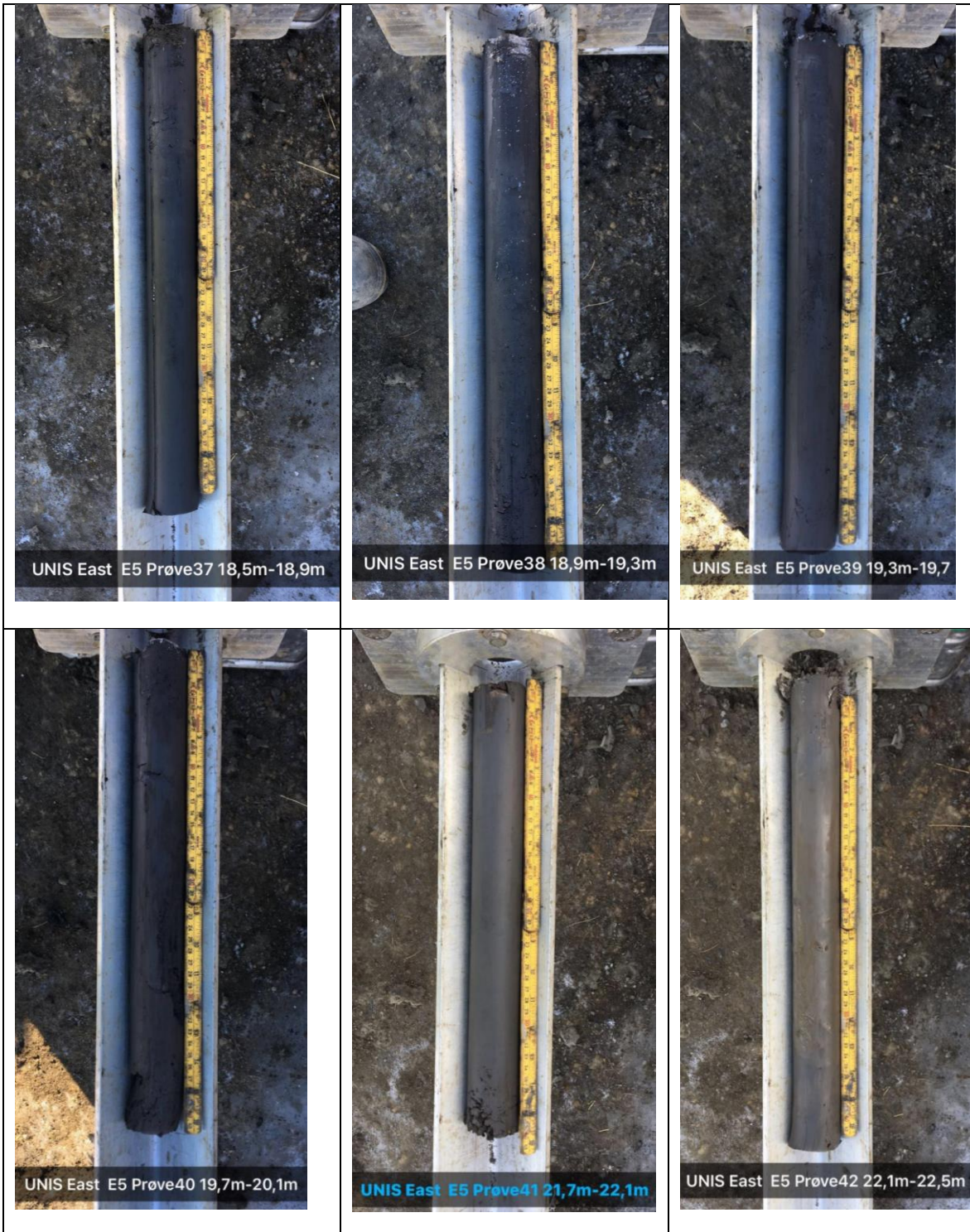














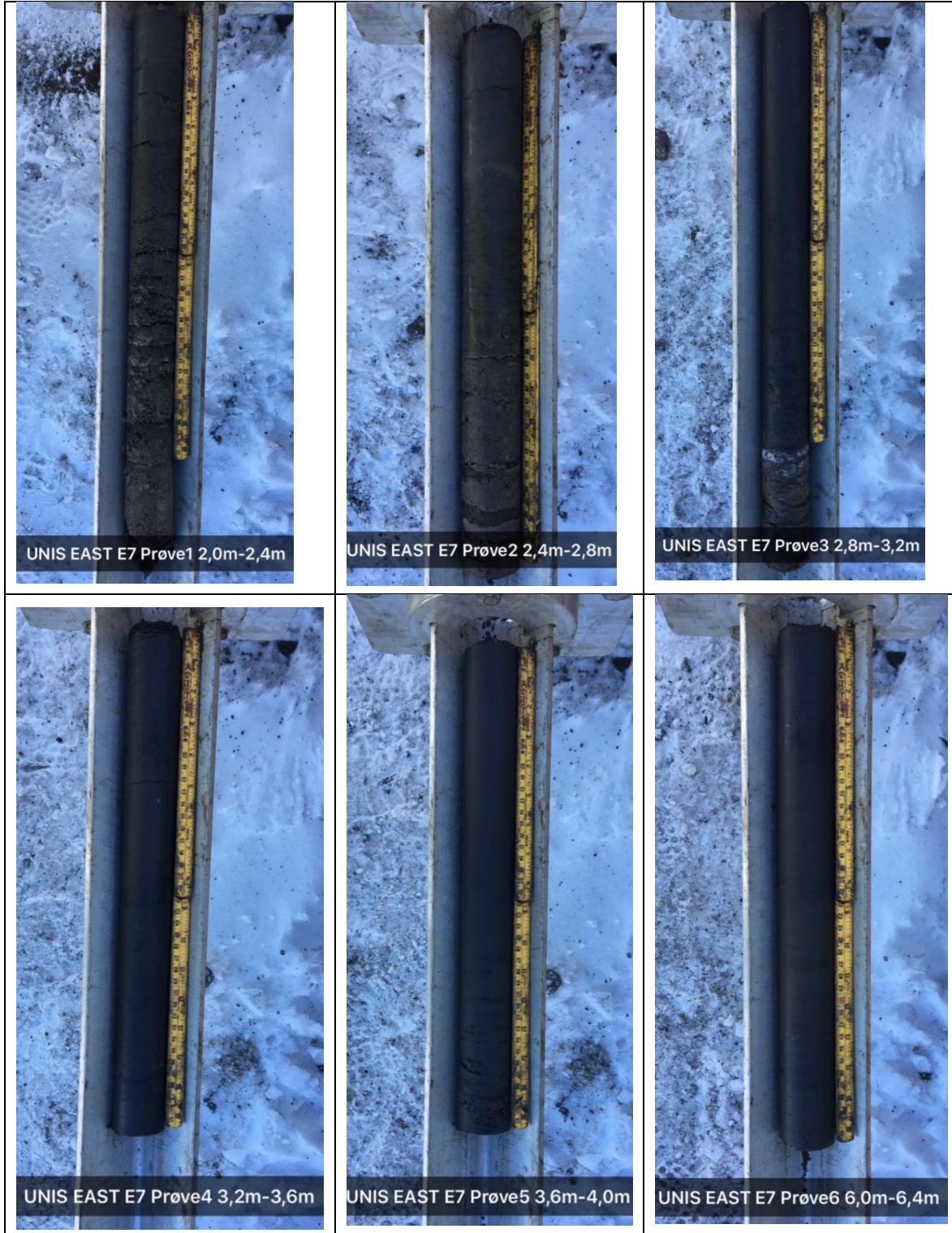
### A3 Pictures of samples - Borehole E6 UNIS East

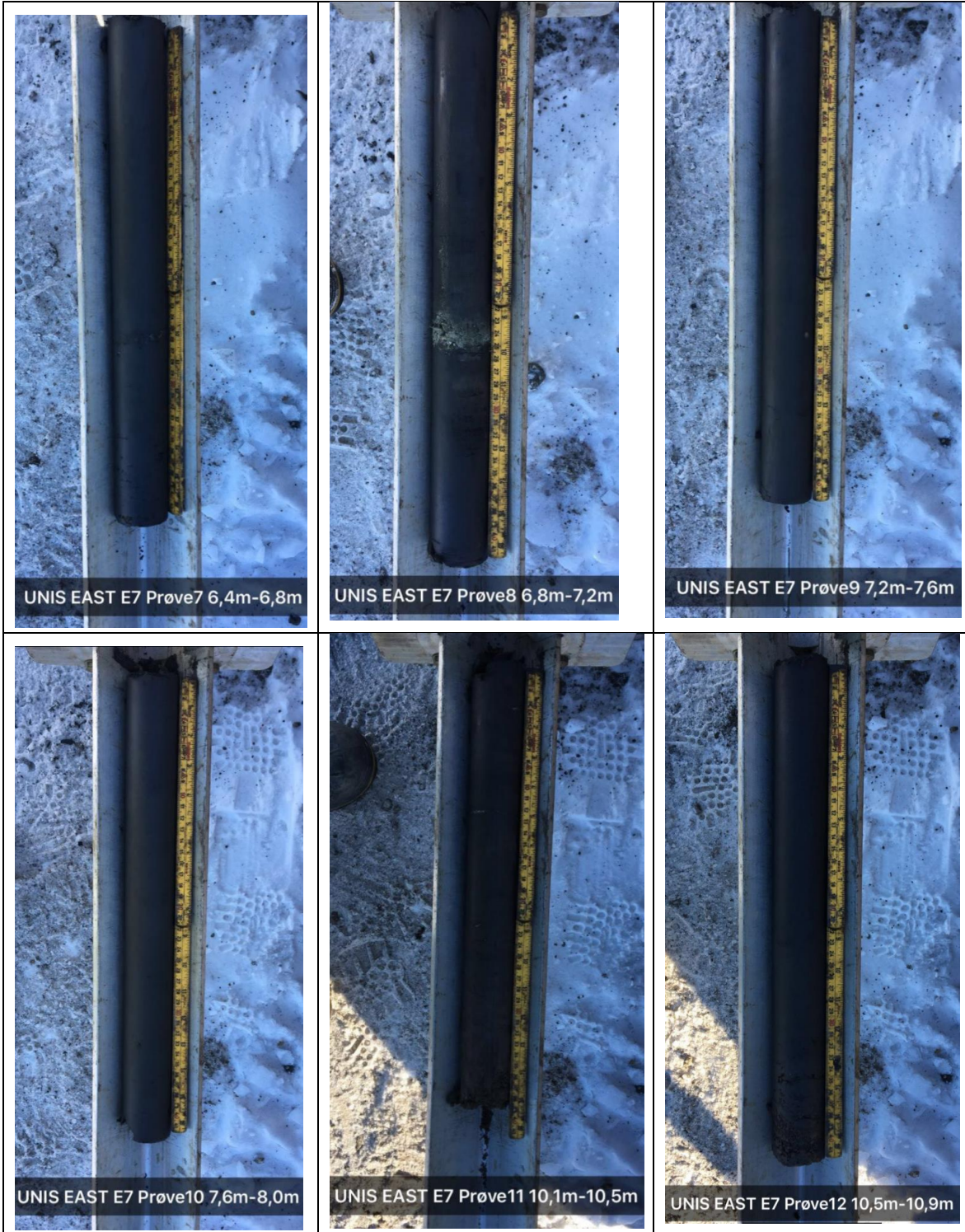






### A3 Picture of samples – Borehole E7 UNIS East











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<b>Stedfesting/Geographical information</b>	
<b>Land, fylke/Country</b> bmCountry	<b>Havområde/Offshore area</b> bmOffshoreArea
<b>Kommune/Municipality</b> bmMunicipality	<b>Felt navn/Field name</b> bmFieldName
<b>Sted/Location</b> bmSted	<b>Sted/Location</b> bmLocation
<b>Kartblad/Map</b> bmMap	<b>Felt, blokknr./Field, Block No.</b> bmFieldBlockNo
<b>UTM-koordinater/UTM-coordinates</b> <b>Zone:</b> bmUTMzone <b>East:</b> bmUTMeast <b>North:</b> bmUTMnorth	<b>Koordinater/Coordinates</b> <b>Projection, datum:</b> bmProjeksjon <b>East:</b> bmEast <b>North:</b> bmNorth

<b>Dokumentkontroll/Document control</b>					
<b>Kvalitetssikring i henhold til/Quality assurance according to NS-EN ISO9001</b>					
Rev/ Rev.	Revisjonsgrunnlag/Reason for revision	Egenkontroll av/ Self review by:	Sidemanns- kontroll av/ Colleague review by:	Uavhengig kontroll av/ Independent review by:	Tverrfaglig kontroll av/ Interdisciplinary review by:
0	Original document	Select control date Type your name	Select control date Type your name	Select control date Type your name	Select control date Type your name

<b>Dokument godkjent for utsendelse/ Document approved for release</b>	<b>Dato/Date</b> <i>Select date</i>	<b>Prosjektleder/Project Manager</b> Jean-Sebastien L'Heureux
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