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Oedometer tests on frozen cores from Qaanaaq, Greenland

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Cover image: Example of test specimen installed in oedometer cell.

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1 Introduction

This report summarizes incremental loading oedometer tests conducted on specimens of frozen fine grained sediments from the Qaanaaq area. As part of the site investigations conducted in Qaanaaq in the summer of 2017, 23 boreholes were drilled using a Nordmeyer DSB 3 drill rig. As the area is affected by continuous permafrost, the boreholes were drilled using a special hollow stem auger (ice auger) for coring of fine grained frozen sediments, while coarser sediments and rock were drilled using down-the-hole (DTH) hammer. Intact permafrost cores were described and photo-documented on-site. They were then packed in Tubolit foam tubes for insulation and placed in core boxes in a temperature controlled container at a temperature of -10 °C for shipment to Denmark, where they were classified and tested in the Permafrost Laboratory of the Technical University of Denmark.

1.1 Sample preparation and selection

Most formations encountered during drilling operations in Qaanaaq were relatively coarse grained and unsuitable for consolidation testing in the small-ring (35 mm diameter) setup available in the temperature controlled DTU permafrost laboratory. Samples were thus selected from the few available intact frozen cores of silty and clayey soils retrieved from boreholes QAA2017-14 (airport), QAA2017-18 (beach east of town) and QAA2017-22 (by power plant). The locations of these boreholes are illustrated on the map in figure 1.1, and borehole profiles are available in appendix A. The cores and final samples selected are listed in tables 1.1 and 1.2.

Sample classification was conducted according to the Danish practice for engineering geological sample description (Larsen et al., 1995), and ice contents were classified according to the visual/manual procedure (ASTM-D4083-89, 2007).

Table 1.1: Cores selected for oedometer testing and the requested load in the thaw branch for each test. References to reports where data were first reported are given in the last column.

	Borehole	**Lab no.**	**Depth [m b g s]**	**Location in core**	**thaw branch σ' [kPa]**	Reference
1	QAA2017-14	06B	2.50-2.78	Bottom	114 kPa	[2]
2	QAA2017-14	09A2	4.46-4.66	Bottom	149 kPa	[2]
3	QAA2017-14	09B	4.73-4.77	-	160 kPa	[1]
4	QAA2017-14	23A	10.98-11.01	-	280 kPa	[1]
5	QAA2017-18	03C	1.25-1.35	Top	32 kPa	[3]
6	QAA2017-22	27B	12.67-12.77	Bottom	309 kPa	[3]
7	QAA2017-22	27A	12.63-12.67	-	200 kPa	n.a.

[1] Experiment reported in Vakulenko (2018a)
[2] Experiment reported in Vakulenko (2018b)
[3] Experiment reported in Kristensen (2019)
[n.a.] Experiment is not reported elsewhere

According to the borehole logs, all cores were classified as CLAY with varying components of silt and sand. All core material was classified as "well bonded" with no visible ice (Nbn or Nbe) or visible ice in the form of distinctly oriented ice formations (Vs) or individual inclusions (Vx). No separate classification has been carried out of the samples selected for oedometer tests. Cores and specific material for the consolidation tests were selected to avoid segments with larger grains (gravel), as such grains would dominate the experimental results in the small specimens used. Segments with high excess ice contents were also avoided, as the presence of excess ice significantly complicates the preparation of a reqular shaped test specimen.

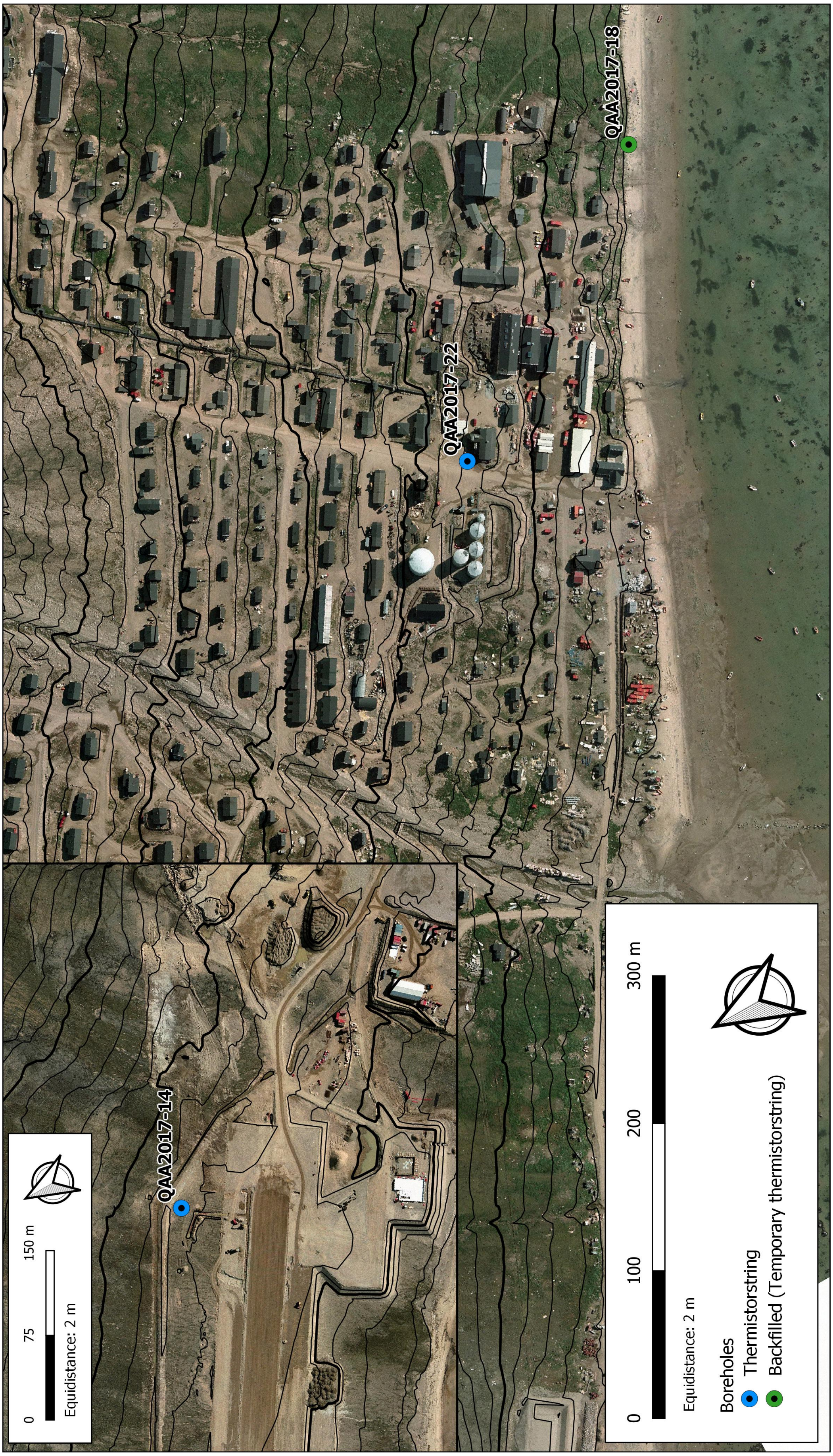


Figure 1.1: Map showing the location of the boreholes from which specimens were selected for the oedometric tests. Orthophoto and Isohypses from Asiaq, Greenland Survey.

Table 1.2: Final samples prepared for oedometer tests. Soil classification and description of ice contents relate to the full core runs from which the samples were selected, and were obtained from the borehole logs.

	Borehole	**Lab**	**Depth**	**Description**
1	QAA2017-14	06B	2.77 m	CLAY, silty, shell fragments, black, saline. ICE: Nbe, Vs at the bottom of core
2	QAA2017-14	09A2	4.65 m	CLAY, black, ICE: Nbn
3	QAA2017-14	09B	4.75 m	CLAY, black, ICE: Nbn
4	QAA2017-14	23A	11.00 m	CLAY, silty, Very dark gray, ICE: Nbn
5	QAA2017-18	03C	1.26 m	CLAY, v. silty, saline, ICE: Nbn
6	QAA2017-22	27B	12.76 m	CLAY, silty, sandy to v. sandy, very dark gray to black, saline. ICE: Nbn/Vs
7	QAA2017-22	27A	12.65 m	CLAY, silty, sandy to v. sandy, very dark gray to black, saline. ICE: Nbn/Vs

Originally cores were drilled with ice augers of 70 mm inner diameter. Sub-sampling of the frozen core material was performed using a core drill mounted in an upright drilling machine at $-10\,°C$. Subsequently the samples were manually adapted to the test ring using a Stanley knife.

2 Oedometer testing

2.1 Test method

The test specimens were trimmed to an initial height of approximately 20 mm and a ring inner diameter of approximately 35.7 mm and installed in a liquid free standard geotechnical oedometer apparatus as illustrated in figure 2.1. Except for sample dimensions, the test procedure follows DS/CEN ISO/TS 17892-5 with necessary modifications to allow for testing at sub-zero temperatures.

The oedometers were placed in a temperature-controlled environment, with continuous temperature measurements by PT100 sensors installed in the drainage channel below the filter stone. Furthermore, the temperature of the climate chamber and the computer room (where loggers and signal conditioners were located) was continuously monitored using thermistors.

The consolidation process has been divided in a frozen branch (loading), a thawing branch (constant load), and an unfrozen branch (unloading and reloading). In the frozen branch, the samples were initially loaded incrementally at constant temperature to the load levels given listed in table 1.1 as [Thaw branch σ']. This selected thaw branch loads were typically selected based on the in-situ stress levels experienced by the samples. In the thawing branch, the sample temperature was gradually increased at constant load, to allow thawing to occur and to register the effects of increasing unfrozen water content. In the unfrozen branch, the samples were incrementally unloaded and reloaded to a maximum load of 2400 kPa in order to determine the unfrozen deformation properties. The load and temperature scheme is shown in table 2.1 for two of the samples. The duration of each load step was individually adjusted to ensure primary consolidation had completed and the creep phase was well described. For thaw branch temperature steps, the duration was adjusted to ensure stabilization at the new temperature level. The remaining samples were tested with similar programs, adjusted for the relevant thaw branch loads.

The sample deformation was logged at a one second interval for the first hour of each new step and with an interval of 30 s for the remainder of the step. Temperatures of sample, climate chamber and computer room were continuously logged at an interval of 30 s.

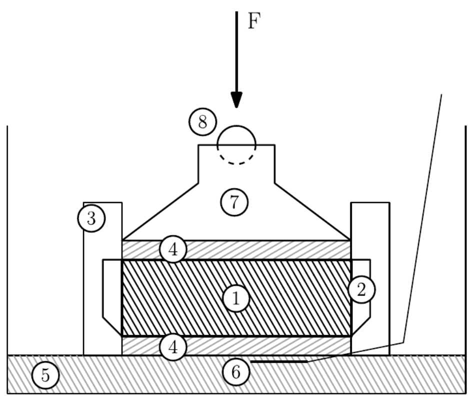


Figure 2.1: Sketch of the oedometer cell. 1) Specimen, 2) specimen ring, 3) constraining steel ring, 4) top and bottom filter stone, 5) steel base, 6) PT-100 sensor for sample temperature monitoring, 7) pressure head and 8) LVDT for strain readings is mounted here. F indicates direction of load application (Agergaard, 2017)

.

Table 2.1: Two examples of the program for load and temperature steps for temperature controlled consolidation tests with the initial frozen loading branch extending to either 114 kPa or 149 kPa. The other tests followed similar programs, with the load in the thaw branch adjusted accordingly.

Thaw branch load 114 kPa			**Thaw branch load** 149 kPa		
Stress level	**Temperature**	**Duration**	**Stress level**	**Temperature**	**Duration**
1.5 kPa	−9.0 °C	2 h	1.5 kPa	−9.3 °C	2 h
12 kPa	−10.0 °C	3 h	12 kPa	−10.2 °C	3 h
22 kPa	−10.9 °C	16 h	22 kPa	−11.0 °C	16 h
42 kPa	−11.0 °C	25 h	42 kPa	−11.1 °C	25 h
73 kPa	−11.0 °C	25 h	80 kPa	−11.1 °C	25 h
114 kPa	−11.0 °C	21 h	149 kPa	−11.1 °C	21 h
114 kPa	−11.6 °C	48 h	149 kPa	−9.3 °C	48 h
114 kPa	−7.5 °C	24 h	149 kPa	−7.6 °C	24 h
114 kPa	−6.2 °C	54 h	149 kPa	−6.3 °C	54 h
114 kPa	−5.2 °C	42 h	149 kPa	−5.3 °C	42 h
114 kPa	−4.2 °C	33 h	149 kPa	−4.3 °C	33 h
114 kPa	−3.3 °C	39 h	149 kPa	−3.5 °C	39 h
114 kPa	−2.4 °C	24 h	149 kPa	−2.5 °C	24 h
114 kPa	−1.2 °C	45 h	149 kPa	−1.4 °C	45 h
114 kPa	4.0 °C	26 h	149 kPa	3.9 °C	26 h
73 kPa	4.7 °C	1 h	83 kPa	4.6 °C	1 h
27 kPa	4.8 °C	1 h	22 kPa	4.6 °C	1 h
1.5 kPa	4.7 °C	14 h	1.5 kPa	4.5 °C	14 h
155 kPa	4.8 °C	14 h	155 kPa	4.8 °C	14 h
308 kPa	6.8 °C	17 h	308 kPa	6.7 °C	17 h
614 kPa	6.2 °C	24 h	614 kPa	5.7 °C	24 h
1226 kPa	5.4 °C	22 h	1226 kPa	5.1 °C	22 h
2451 kPa	5.2 °C	41 h	2451 kPa	5.0 °C	41 h
1226 kPa	5.2 °C	1 h	1226 kPa	5.0 °C	1 h
614 kPa	5.2 °C	1 h	614 kPa	5.1 °C	1 h
308 kPa	5.3 °C	1 h	308 kPa	5.1 °C	1 h
155 kPa	5.3 °C	1 h	155 kPa	5.1 °C	1 h
1.5 kPa	5.3 °C	3 h	1.5 kPa	5.1 °C	3 h

2.2 Results

The result of the oedometer tests are fully documented in appendices C to I. For each sample the appendices present the following:

- the final stress-strain curve
- the full table of classification parameters for the tested sample
- an overview table of the applied load and temperature steps and the corresponding interpreted results
- an overview graph of the complete timeseries of strains throughout the experiment

2.2.1 Classification parameters for test specimens

Classification properties of the test specimens were determined by weighing and measuring dimensions of each sample before and after the oedometer tests. The post-testing sample height (used for volume and density calculation) was calculated from the LVDT strain (ε_f) at the end of the final unloading step. One exception is the sample QAA2017-14 S23A, which experienced an unreasonably large rebound during the unloading. In this case the sample was physically measured after disassembling the setup. A summary of the results is presented in Table 2.2, and full details are available in appendices C to I. Table 2.2 summarize all classification data available for the samples; the referenced tests were conducted on material from the same frozen core samples, but not necessarilry on the actual test specimens.

Void ratios (e) and ice and water saturations ($S_{r,i}$ before test, $S_{r,w}$ after test) are calculated based on grain densities (ρ_s) measured on the sample material. For samples 1, 2 and 7, grain densities were not measured, so the nearest available measurement from the same borehole was used in the calculations.

The void ratios before test typically range from 0.4 to 0.91, and the ice saturations ($S_{r,i}$) are close to unity. As the unfrozen water characteristics of the samples are unknown, parameters were calculated with the assumption that all water exist as ice in the frozen sample. Similarly, after testing, in the unloaded, thawed state, the water saturation is typically close to unity. Sub-saturation is expected to some extent, as the tests were conducted without water in the chamber around the sample, and thus the samples will not necessarily take in water during unloading. A few samples show apparent water super-saturation after testing ($S_{r,i} > 1$) which is not physically possible, and must be ascribed to measurement uncertainties (typically geometries or grain density).

All samples tested were saline, with Practical Salinities (S_p, unitless) ranging from 29.5 to 41.8. For comparison, standard seawater has a Practical Salinity of 35.0 by definition (IOC et al., 2010). All samples were relatively fine grained, with grain sizes in the clay and silt fractions constituting between 16 and 89 %. Samples classify as Lean Clays (CL) to Silty/Clayey Sands (SC/SM) according to the Unified Soil Classification System (ASTM-D2487-11, 2011). Surprisingly, the two specimens (sample 6 and 7, specimen 27A and 27B) from borehole QAA2017-22 have very different fines content, despite the fact that the specimens are adjacent subsamples of the same core.

2.2.2 Oedometer results

The main results of the oedometer tests are shown in figures 2.3a to 2.3g in the form of stress-strain curves for each tested specimen. During the first two load steps (1.5 kPa and 10 kPa) the system is readjusting to the sample, and thus intial zero strain is typically defined at the end of the 10 kPa load step.

Most samples show limited deformation upon thawing, with thaw branch strains in the range from 2 to 4 %. Exceptiona are samples 1 and 4 (QAA2017-14 S06B and QAA2017-14 S23A) which experience 7 % to 8 % deformation during the thaw branch.

Due to multiple climate chamber malfunction events, a well described thaw branch with several complete temperature steps are only available for samples 1 and 2 (QAA2017-S06B and QAA2017-14 S09A2). These tests document that most of the thaw related strain occurs at temperatures lower than -1.5 °C, which is consistent with the high Practical Salinities of the samples causing a freezing point depression of the porewater. For the remaining samples, the climate chamber malfunction events and resulting uncontrolled (in some cases partial) thaw of the specimens, mean that the thaw branch can be mainly used to estimate the total thaw related strain of the samples. More details of the loading, strain and temperature history of the tests is available in appendices C to I.

In the reloading branch after thawing, where time curves are well-behaved, these have been interpreted using the squareroot-of-time method as described in DS/CEN ISO/TS 17892-5 (2004). The deformation at end of primary consolidation (ε_{100}) and the final deformation (ε_f) at each step is indicated on the stress-strain curves in figure 2.3.

Based on the interpreted 90 % consolidation time, t_{90} [s], the coefficient of consolidation, c_v [m^2/s], was calculated as:

$$c_v = \frac{0.848 \cdot L^2}{t_{90}} ,$$

where L [m] is the drainage path, which equals half of the sample height at 50 % consolidation.The coefficient of secondary compression, C_α [%/lct], is taken as the slope of the linear portion (in a

Table 2.2: Characterization parameters of samples used for oedometer testing, before and after test. See full details in appendices C to I.

Parameter		Unit	Before test	After test
Sample 1: QAA2017-14 S06B				
Water content	w	[%]	21.15	16.88
Bulk density	ρ_b	[g/cm^3]	1.96	2.18
Dry density	ρ_d	[g/cm^3]	1.62	1.87
Void ratio	e	[-]	0.62	0.40
Ice saturation	$S_{r,i}$	[-]	0.98	–
Water saturation	$S_{r,w}$	[-]	–	1.09
Sample 2: QAA2017-14 S09A2 Top				
Water content	w	[%]	16.45	15.08
Bulk density	ρ_b	[g/cm^3]	2.07	2.17
Dry density	ρ_d	[g/cm^3]	1.78	1.89
Void ratio	e	[-]	0.51	0.42
Ice saturation	$S_{r,i}$	[-]	0.95	–
Water saturation	$S_{r,w}$	[-]	–	0.97
Sample 3: QAA2017-14 S09B Top				
Water content	w	[%]	14.54	11.82
Bulk density	ρ_b	[g/cm^3]	2.19	2.27
Dry density	ρ_d	[g/cm^3]	1.91	2.03
Void ratio	e	[-]	0.40	0.32
Ice saturation	$S_{r,i}$	[-]	1.06	–
Water saturation	$S_{r,w}$	[-]	–	1.00
Sample 4: QAA2017-14 S23A				
Water content	w	[%]	18.43	12.96
Bulk density	ρ_b	[g/cm^3]	1.97	2.19
Dry density	ρ_d	[g/cm^3]	1.66	1.94
Void ratio	e	[-]	0.61	0.38
Ice saturation	$S_{r,i}$	[-]	0.88	–
Water saturation	$S_{r,w}$	[-]	–	0.91
Sample 5: QAA2017-18 S03C				
Water content	w	[%]	26.43	20.72
Bulk density	ρ_b	[g/cm^3]	1.96	2.17
Dry density	ρ_d	[g/cm^3]	1.55	1.80
Void ratio	e	[-]	0.77	0.53
Ice saturation	$S_{r,i}$	[-]	1.03	–
Water saturation	$S_{r,w}$	[-]	–	1.08
Sample 6: QAA2017-22 S27B				
Water content	w	[%]	14.47	12.22
Bulk density	ρ_b	[g/cm^3]	2.04	2.21
Dry density	ρ_d	[g/cm^3]	1.79	1.97
Void ratio	e	[-]	0.54	0.40
Ice saturation	$S_{r,i}$	[-]	0.80	–
Water saturation	$S_{r,w}$	[-]	–	0.84
Sample 7: QAA2017-22 S27A				
Water content	w	[%]	30.38	22.44
Bulk density	ρ_b	[g/cm^3]	1.88	1.90
Dry density	ρ_d	[g/cm^3]	1.44	1.55
Void ratio	e	[-]	0.91	0.77
Ice saturation	$S_{r,i}$	[-]	1.00	–
Water saturation	$S_{r,w}$	[-]	–	0.80

Figure 2.2: Classification properties of the test specimens.

	Borehole	Lab no	depth [m.b.g.s.]	w_{tot} [%]	S_p [-]	ρ_s [g/cm3]	ρ_b [g/cm3]	ρ_d [g/cm3]	e [-]	$S_{r,i}$ [-]	LOI [%]	Reference -
1	QAA2017-14	06B	2.50-2.78	17.3 ± 1.9	37.8 ± 2.17	n.d.	1.96	1.62	0.62	0.98	n.d.	[2]
2	QAA2017-14	09A2	4.46-4.66	18.4 ± 6.7	37.0 ± 0.98	n.d.	2.07	1.78	0.51	0.95	n.d.	[2]
3	QAA2017-14	09B	4.73-4.77	16.4 ± 0.8	51.1 ± 1.85	2.68	2.19	1.91	0.40	1.06	1.85	[1]
4	QAA2017-14	23A	10.98-11.01	15.1 ± 2.1	29.6 ± 1.06	2.68	1.97	1.66	0.61	0.88	1.41	[1]
5	QAA2017-18	03C	1.25-1.35	19.7 ± 0.9	27.0 ± 2.59[a)]	2.74	1.96	1.55	0.77	1.03	1.43	[3]
6	QAA2017-22	27B	12.67-12.77	10.9 ± 2.59[a)]	41.8 ± 2.59[a)]	2.75	2.04	1.79	0.54	0.80	1.40	[3]
7	QAA2017-22	27A	12.63-12.67	14.4	n.d.	n.d.	1.88	1.44	0.91	1.00[b)]	1.48	n.a.

	Borehole	Lab no	depth [m.b.g.s.]	w_{tot} [%]	w_L [%]	w_P [%]	I_P [%]	I_c [-]	$< 63\mu m$ [%]	C_u [-]	C_c [-]	USCS [-]	Reference -
1	QAA2017-14	06B	2.50-2.78	17.3 ± 1.9	n.d.	n.d.	n.d.	n.d.	89.1	d.a.	d.a.	n.d.	[2]
2	QAA2017-14	09A2	4.46-4.66	18.4 ± 6.7	n.d.	n.d.	n.d.	n.d.	68.2	d.a.	d.a.	n.d.	[2]
3	QAA2017-14	09B	4.73-4.77	16.4 ± 0.8	25.1	17.6	7.5	0.49	88.2	d.a.	d.a.	CL	[1]
4	QAA2017-14	23A	10.98-11.01	15.1 ± 2.1	26.1	14.4	11.6	0.76	70.6	d.a.	d.a.	CL	[1]
5	QAA2017-18	03C	1.25-1.35	19.7 ± 0.9	n.d.	n.d.	n.d.	n.d.	16.7	d.a.	d.a.	n.d.	[3]
6	QAA2017-22	27B	12.67-12.77	10.9[a)]	29.6	16.1	13.5	1.38	17.6	d.a.	d.a.	SC/SM	[3]
7	QAA2017-22	27A	12.63-12.67	14.4	n.d.	n.d.	n.d.	n.d.	75.9	d.a.	d.a.	n.d.	n.a.

[a] No documentation available for measurements. However, values correspond to measurements on adjacent samples.
[b] Ice saturation assumed unity, ρ_b is derived based on this assumption.
n.d.: Measurement was not conducted, no data available.
d.a.: Data is available but not yet processed.
For references see table 1.1. The classification of sample 7 is not reported elsewhere.

log(time) transformation) of the creep part of the time curve. The consolidation modulus, K [kPa], is calculated as the ratio of the change in effective stress to the change in strain:

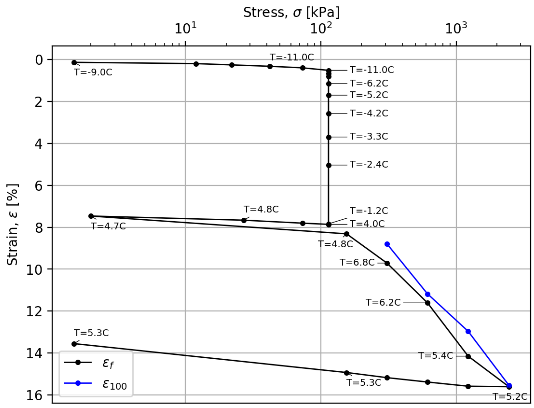
$$K = \frac{\Delta\sigma'}{\varepsilon_{100} - \varepsilon_0} \quad .$$

Finally, the coefficient of permeability, k_0 [m/s], is calculated as:

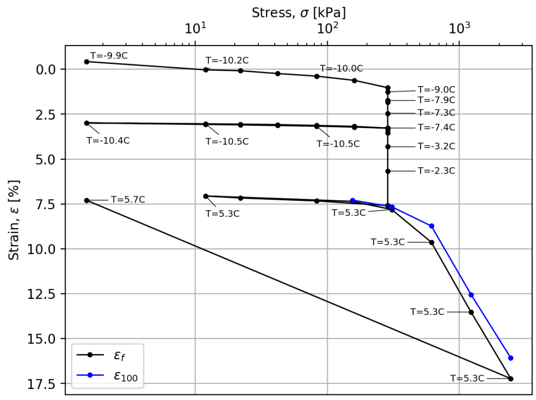
$$k_0 = c_v \cdot \frac{\gamma_w}{K} \quad ,$$

where γ_w [kN/m^3] is the specific weight of water, here defined as 10 kN/m^3.

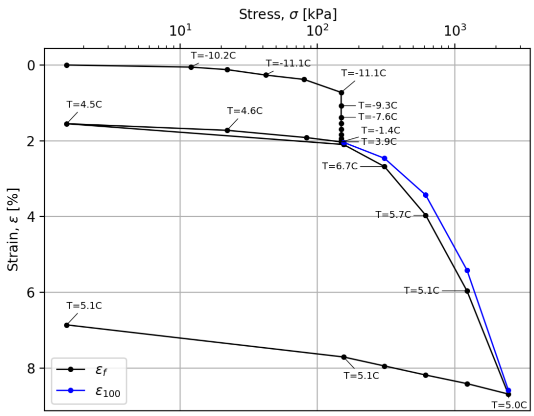
The interpreted values of c_v, C_α, K and k_0 are tabelized for each test specimen in the respective appendix C to I. The full data sets of strain and temperature time series for each test specimen are available in digital form for further processing and interpretation.



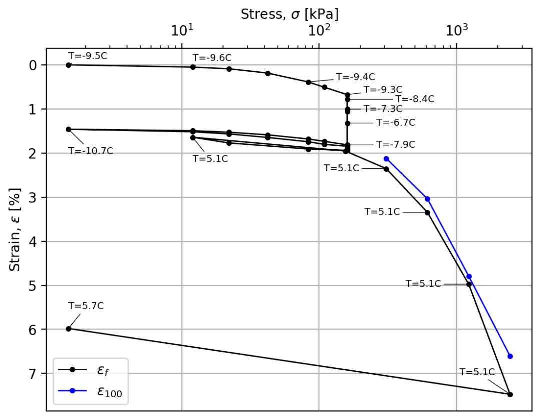
(a) Sample 1 - QAA2017-14 S06B



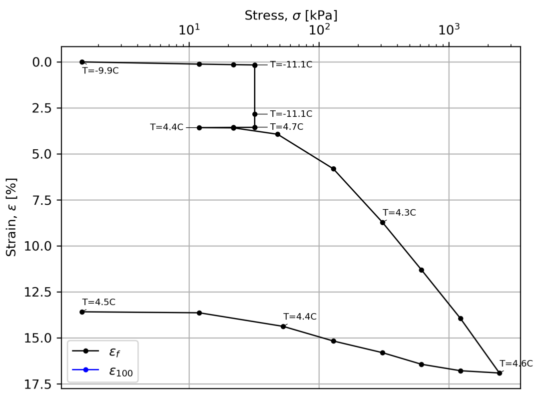
(b) Sample 4 - QAA2017-14 S23A



(c) Sample 2 - QAA2017-14 S09A2

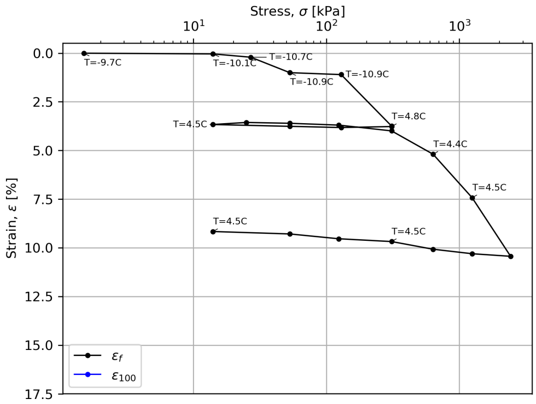


(d) Sample 3 - QAA2017-14 S09B

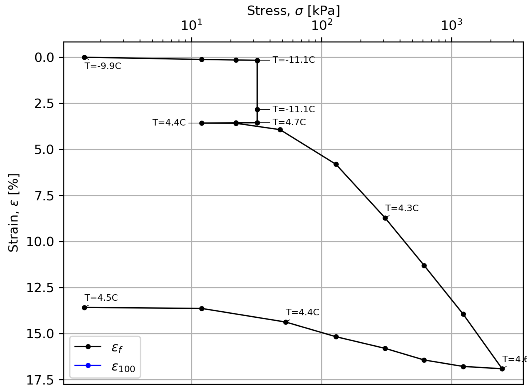


(e) Sample 5 - QAA2017-18 S03C

Figure 2.3: Final Stress-strain curves for each oedometer test. Larger versions are included in appendix C to I.



(f) Sample 6 - QAA2017-22 S27B



(g) Sample 7 - QAA2017-22 S27A

Figure 2.3: Final Stress-strain curves for each oedometer test. Larger versions are included in appendix C to I.

3 Summary

Under temperature controlled conditions, temperature controlled incremental loading oedometer tests have been conducted on 7 samples from the Qaanaaq area. The sample material is classified as CLAY with varying components of silt and sand (or in some cases in the USCS as silty/clayey sand, SC/SM). The samples were collected, transported and prepared in frozen condition for installation in the test setup. The conducted test procedure consisted of an initial frozen loading branch, where samples were loaded to stess levels in the range 32 kPa to 309 kPa, depending on the sampling depth and target test application. The samples where then allowed to thaw under constant load and using specified temperature steps from −10 °C to 5 °C (thawing branch). The following unloading/reloading sequence, where samples were loaded to a final stress level of 2400 kPa, was conducted in unfrozen state (unfrozen branch). Finally, the samples were unloaded and removed from the setup.

Stress-strain curves are presented for the 7 tests and show thaw strains varying from around 2 % to 4 % during the thawing branch, with one sample experiencing 8 % deformation. The samples experience the largest thaw strains at temperatures below −1.5 °C due to pore water of high salinities causing a freezing point depression. All samples are slightly pre-consolidated, most likely a result of the natural freezing process. Based on the test results we interpret these sediments as post-glacial deposits, as their pre-consolidation stresses are much lower than would be expected, had they experienced the load of an ice cap.

The tested specimens all had relatively low excess ice contents. Core segments with high excess ice contents were avoided where possible, as the presence of excess ice makes it very difficult (impossible with the tools available) to prepare a regularly shaped test specimen. For segments where gravimetric water contents or bulk densities indicate the presence of excess ice, the excess ice should be specifically considered when estimating the deformation properties.

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A Borehole logs

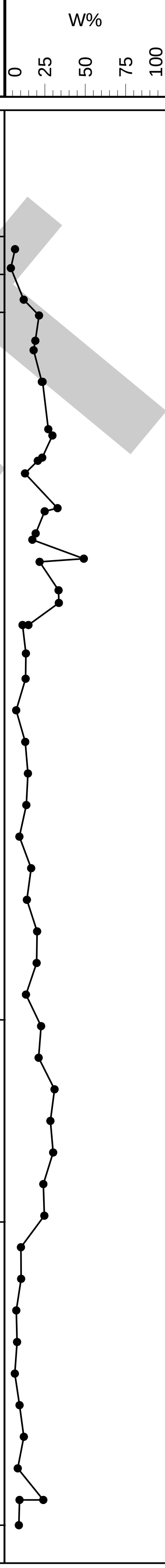
Borehole name

QAA2017-14

Borehole location

Qaanaaq, Airport, North of runway

Depth (m)	Sample No.	Soil description / Observations	Drilling tool
18		Water table: 2017-08-19, 0.77 m.b.g.s.	
		Frost table: 2017-08-19, 1.64 m.b.g.s.	
17		16.5 m	
	1	GRAVEL, sl. silty, v. sandy, w. boulders, dark grayish brown	AUG
16	2	SAND, clayey, silty, gravelly, graysih brown	
	3		
15	4	CLAY, silty, v. sandy, sl. gravelly, gray to black	ICE
		(Coarse boulder)	CUT
	5		
14	6		
	7		
13	8	(Becoming grey)	
12	9		ICE
	10		
11	11		
	12		
10	13	(Large boulder)	
		CLAY, silty, v. sandy, sl. gravelly, reddish brown	
	14		
9	15	(Large boulder)	
	16		
8	17	(becomes v. sandy, v. gravelly)	DTH
	18	(Visible ice crystals)	
7	19	(Large boulder)	
	20	(Visible ice crystals)	
6	21	(Visible ice crystals)	
	22	(Visible ice crystals)	ICE
5	23		
	24		
	25	(Large boulder)	
4	26	CLAY, silty, sandy, gravelly, w. boulders, dark brwonish gray	
		(Visible ice crystals)	
	27		
3	28	(Many visible ice crystals)	
	29	(Visible ice crystals)	
2	30	(Visible ice crystals)	
	31	(Visible ice crystals)	
1	32	SAND, sl. silty, v. gravelly, w. boulders, grayish brown	DTH
	33		
0	34	(Visible ice crystals)	
	35	(few visible ice crystals)	
1	36	(no visible ice)	
	37		
2	38		
	39		
3	40	(Large boulder)	
	41		ICE
4	42	(Drilling terminated at 20.40 m.b.g.s.)	



Coordinates:

x: 491004.7 m y: 8601163.3 m z: 16.5 m

Ref sys: UTM Zone 19N / GR96

Height ref: Mean sea level

Drilling information:

Drilled by: GEO / TBH

Completed: 2017-08-07

Logged by: CSL

Drilling method: 6" dry rotation / DTH / Coring

Drilling rig: Nordmeyer DSB-3

Sampling method: Bag / Core

Project: Qaanaaq site investigations

Drawn by: TIN

QC by: NF

Status: Draft: Field log

Borehole name
QAA2017-18

Borehole location
Qaanaaq, East town, beach, possible pier location

Depth (m)	Sample No.	Soil description / Observations	Drilling tool
2		Water table: Not identified.	
		Frost table: 2017-08-11, 0.59 m.b.g.s.	
1		0.9 m	
	1	SAND, fine to medium, sorted, light yellowish brown	AUG
	2	CLAY, silty, sandy, gravelly, dark gray	
0	3	(Frost table possibly at 0.5 m.b.g.s.?)	
		(becoming less sandy and gravelly)	ICE
1	4		
	5		
2		(becoming more sandy, darker gray/black	CUT
	6	(Large boulder)	ICE
		(Large boulder)	CUT
3	7	GRAVEL, sl. silty, v. sandy, brownish gray	ICE
4	8		
	9		
5	10	(Large boulder)	
	11	GRAVEL, sl. silty, v. sandy, grayish brown	
6	12		
	13		
7	14	(Large boulder)	
	15		
8	16	(Many visible ice crystals, ice layer at 8.40 m.b.g.s.)	
	17	(Few visible ice crystals)	
9	18	(Few visible ice crystals)	
	19	(Large boulder)	
		(Few visible ice crystals)	
10	20	(Large boulder)	
	21	SANDSTONE, quartz, pale	
11	22		DTH
	23		
12	24		
	25		
13	26	(w. shale layers ~13.4-13.6 m.b.g.s.)	
	27		
14	28	(w. shale layers ~14.5 m.b.g.s.)	
	29	(w. shale layers ~15.0-15.4 m.b.g.s.)	
15	30		
	31		
16	32	(w. shale layers ~16.5-16.8 m.b.g.s.)	
	33		
17	34		
	35		
18	36	(w. shale layers ~18.7-18.8 m.b.g.s.)	
	37		
19	38		
	39	(Drilling terminated at 20 m.b.g.s.)	
20			

Column headers: Depth (m) | Lithology | Sample color | Water/frost | Sample | Sample No. | Soil description / Observations | W% (0, 25, 50, 75, 100) | Construction | Drilling tool | SPT results | Depth (m)

Coordinates:
x: 494647.9 m y: 8598560.7 m z: 0.9 m
Ref sys: UTM Zone 19N / GR96
Height ref: Mean sea level

Drilling information:
Drilled by: GEO / TBH
Completed: 2017-08-12
Logged by: CSL
Drilling method: 6" dry rotation / DTH / Coring
Drilling rig: Nordmeyer DSB-3
Sampling method: Bag / Core

Project: Qaanaaq site investigations
Drawn by: TIN
QC by: NF
Status: Draft: Field log

Borehole name	Borehole location
QAA2017-22	**Qaanaaq, East town, next to power plant**

Depth (m)	Lithology	Sample color	Water/frost	Sample	Sample No.	Soil description / Observations	W% (0 25 50 75 100)	Construction	Drilling tool	SPT results	Depth (m)

Water table: 2017-08-15, 0.18 m.b.g.s.
Frost table: 2017-08-20, 1.30 m.b.g.s.

15.3 m

Sample No.	Soil description / Observations
1	FILL?, SAND, sl. silty, gravelly, brown
2	FILL?, GRAVEL, sandy, w. stones, brown
3	FILL?, SAND, gravelly, w. stones, brown
4	FILL?, GRAVEL, sandy, dark yellowish brown. ICE: Nbn
5	FILL?, SAND, medium to coarse, silty, brown
6	SAND, fine, silty, shell fragments, olive gray
7	SILT, sandy, gravelly, shell fragments, black. ICE: Nf
8	SILT, sandy, gravelly, shell fragments, black. ICE: Nf to Nbn
9	
10	GRAVEL, v. sandy, w. stones, light olive brown to dark grayish brown
11	
12	
13	(Large boulder, 5.4m to 6.2m)
14	
15	
16	
17	
18	SAND, fine to medium, silty, gravelly, dark olive gray
19	GRAVEL, sandy, light olive brown
20	SAND, fine, silty, very dark grayish brown
21	(Large boulder ~9.5-9.7 m.b.g.s.)
22	
23	SILT, sandy, v. gravelly, black. ICE: Nbn
24	CLAY, sandy, black. ICE: Nbn
	GRAVEL, sl. silty, v. sandy, olive gray
25	CLAY, silty, sl. sandy, saline, very dark gray
26	
27	CLAY, silty, sandy to v. sandy, very dark gray to black, saline. ICE: Nbn/Vs
28	CLAY, silty, sandy, shell fragments, saline, dark olive gray
29	(Few visible ice crystals)
	SAND, sl. silty, v. gravelly, w. stones, grayish brown
30	
31	SAND, gravelly, light brownish gray
32	
33	SAND, sl. gravelly, olive brown
34	
35	SAND, sl. silty, sl. gravelly, olive brown
36	
37	SANDSTONE, dark gray
38	(Weathered zone, 17.6 to 18.8 m)
39	
40	SANDSTONE, white
41	
42	(Drilling terminated at 20.0 m.b.g.s.)

Drilling tool (top to bottom): AUG, CUT, DTH, ICE, CUT, ICE, DTH, ICE, DTH, ICE, DTH

Depth scale (m): 2, 1, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21

Coordinates:		Drilling information:				Project:
x: 494516.6 m	y: 8598762.7 m z: 15.3 m	Drilled by:	GEO / TBH	Drilling method:	6" dry rotation / DTH / Coring	Qaanaaq site investigations
Ref sys:	UTM Zone 19N / GR96	Completed:	2017-08-18	Drilling rig:	Nordmeyer DSB-3	Drawn by: TIN — QC by: NF
Height ref:	Mean sea level	Logged by:	CSL	Sampling method:	Bag / Core	Status: Final borehole log

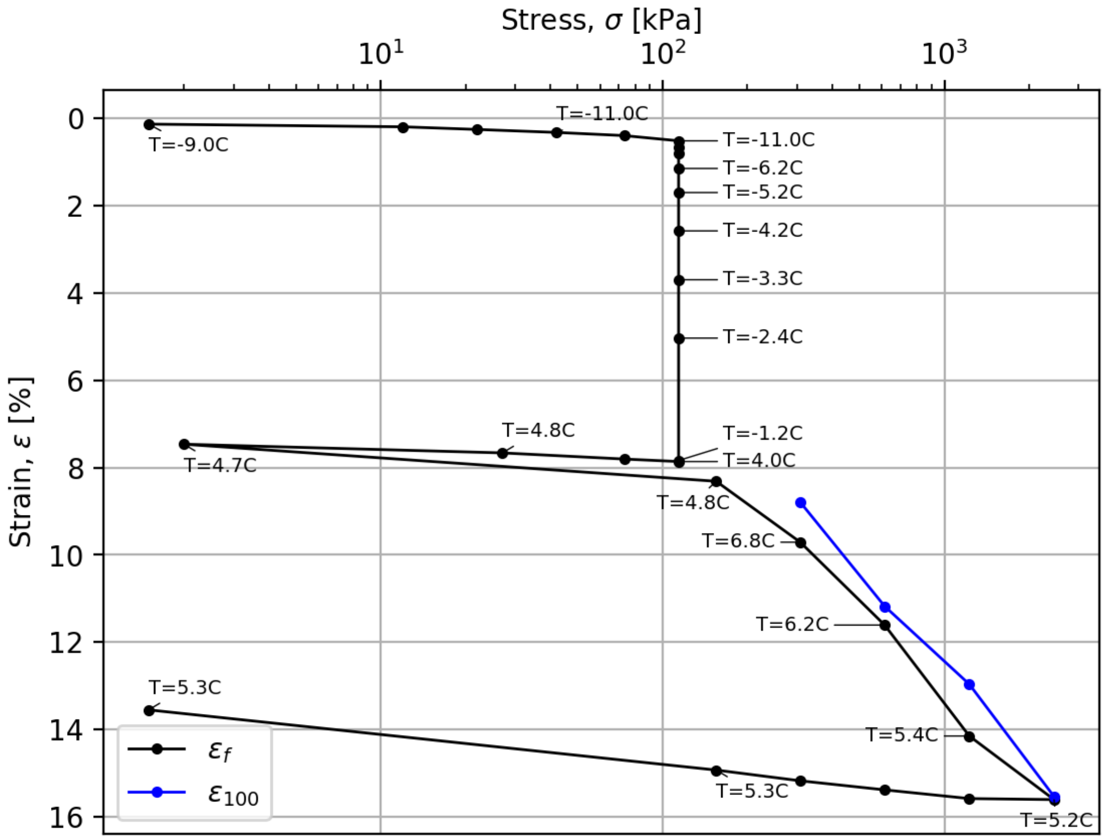
B Data anomalies

Table B.1: Description of observed data anomalies and events during the oedometer tests.

Step	Approx. time	Description
Sample 1: QAA2017-14 S06B, and		
Sample 2: QAA2017-14 S09A2 Top		
Step 7	2018-11-13 01:15	Cold room malfunction, temperature dropped to $-25\,°C$.
Step 7	2018-11-13 09:00	Cold room control system reset.
Step 7	2018-11-13 11:00	Cold room temperature reached set point at $-10\,°C$
Step 12	2018-11-22 08:05	LVDTs register slight drop due to vibration from activity in adjacent room.
Steps 16-24	2018-11-26 to 2018-11-29	Vibrations from construction works outside building.
Sample 3: QAA2017-14 S09B Top, and		
Sample 4: QAA2017-14 S23A		
Step 9-10	2018-09-17 14:07	Datalogger was reset due to installation of voltage divider.
Step 11-12	2018-09-19 13:40	Cold room was opened to replace cables. Sample 2 shows high increase of strain in this period.
Step 12-13	2018-09-20 10:00	New LVDT were installed, defrost cycle was set to 8 hours, heating system enabled.
Sample 5: QAA2017-18 S03C, and		
Sample 6: QAA2017-22 S27B		
Step 1	2019-01-16 22:00	Cold room malfunction for about 2 hours, little impact on sample.
Step 5	2019-01-21 6:00	Cold room malfunction. Severe thawing of samples. Samples refroze upon cold room restart, but the thaw phase had progressed too far for additional meaningful T-steps, so samples were eventually thawed out.
Sample 7: QAA2017-22 S27A		
-	-	Noanomalies encountered.

C Sample "QAA2017-14 S06B"

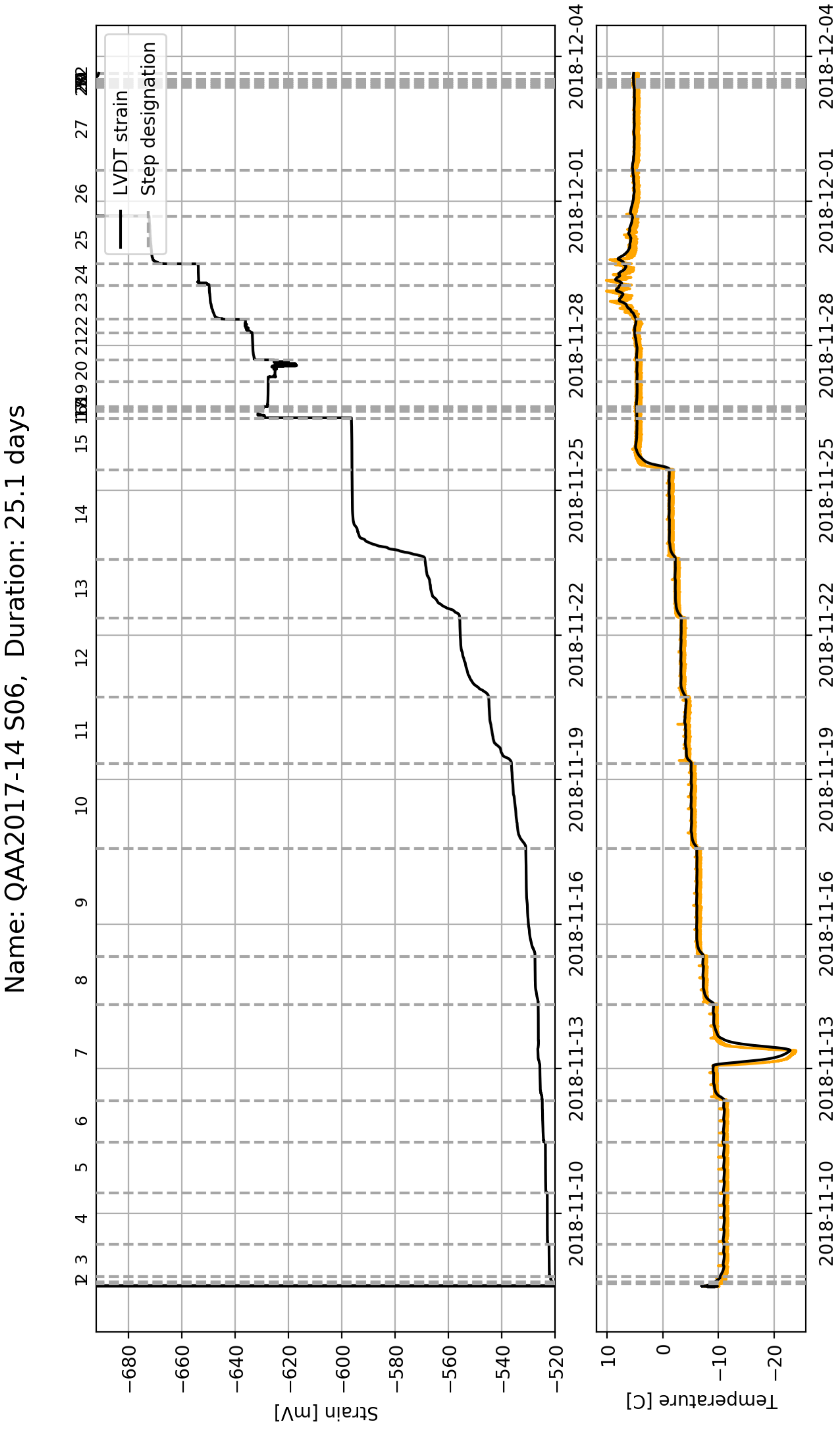
C.1 Consolidation curve



Parameter	Value
Name	QAA2017-14 S06B
Depth	2.71-2.75 m
Start date	2018-11-08
End date	2018-12-03

C.2 Overview of load steps and interpreted results

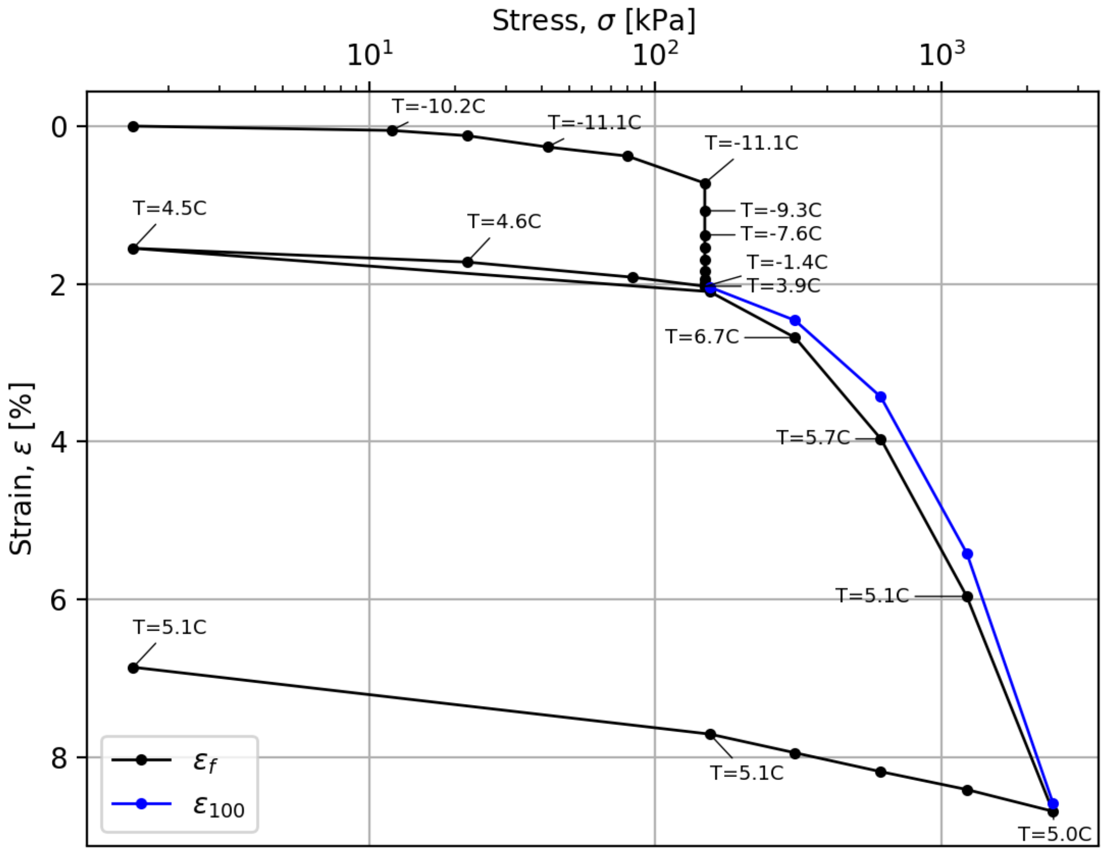
Step	σ [kPa]	T [°C]	ε_0 [%]	ε_{50} [%]	ε_{100} [%]	ε_f [%]	C_α [%/lct]	c_v [m^2/s]	K [kPa]	k_0 [m/s]
1	1.5	-9.0				0.129				
2	12.0	-10.0				0.191				
3	22.0	-10.9				0.251				
4	42.0	-11.0				0.319				
5	73.0	-11.0				0.392				
6	114.0	-11.0				0.512				
7	114.0	-11.6				0.670				
8	114.0	-7.5				0.793				
9	114.0	-6.2				1.145				
10	114.0	-5.2				1.697				
11	114.0	-4.2				2.576				
12	114.0	-3.3				3.694				
13	114.0	-2.4				5.032				
14	114.0	-1.2				7.838				
15	114.0	4.0				7.862				
16	73.0	4.7				7.804				
17	27.0	4.8				7.663				
18	1.5	4.7				7.464				
19	155.0	4.8				8.314				
20	308.0	6.8	7.913	8.352	8.792	9.709	0.217	1.530×10^{-5}	17397	8.796×10^{-9}
21	614.0	6.2	9.606	10.392	11.178	11.609	0.146	3.688×10^{-7}	19475	1.894×10^{-10}
22	1226.0	5.4	10.570	11.767	12.964	14.151	0.221	1.247×10^{-5}	25566	4.876×10^{-9}
23	2451.0	5.2	12.906	14.222	15.538	15.608	0.024	1.356×10^{-5}	46537	2.913×10^{-9}
24	1226.0	5.2				15.585				
25	614.0	5.2				15.385				
26	308.0	5.3				15.177				
27	155.0	5.3				14.932				
28	1.5	5.3				13.552				



Name: QAA2017-14 S06, Duration: 25.1 days
LVDT strain
Step designation
Strain [mV]
Temperature [C]
2018-11-10
2018-11-13
2018-11-16
2018-11-19
2018-11-22
2018-11-25
2018-11-28
2018-12-01
2018-12-04

D Sample "QAA2017-14 S09A2"

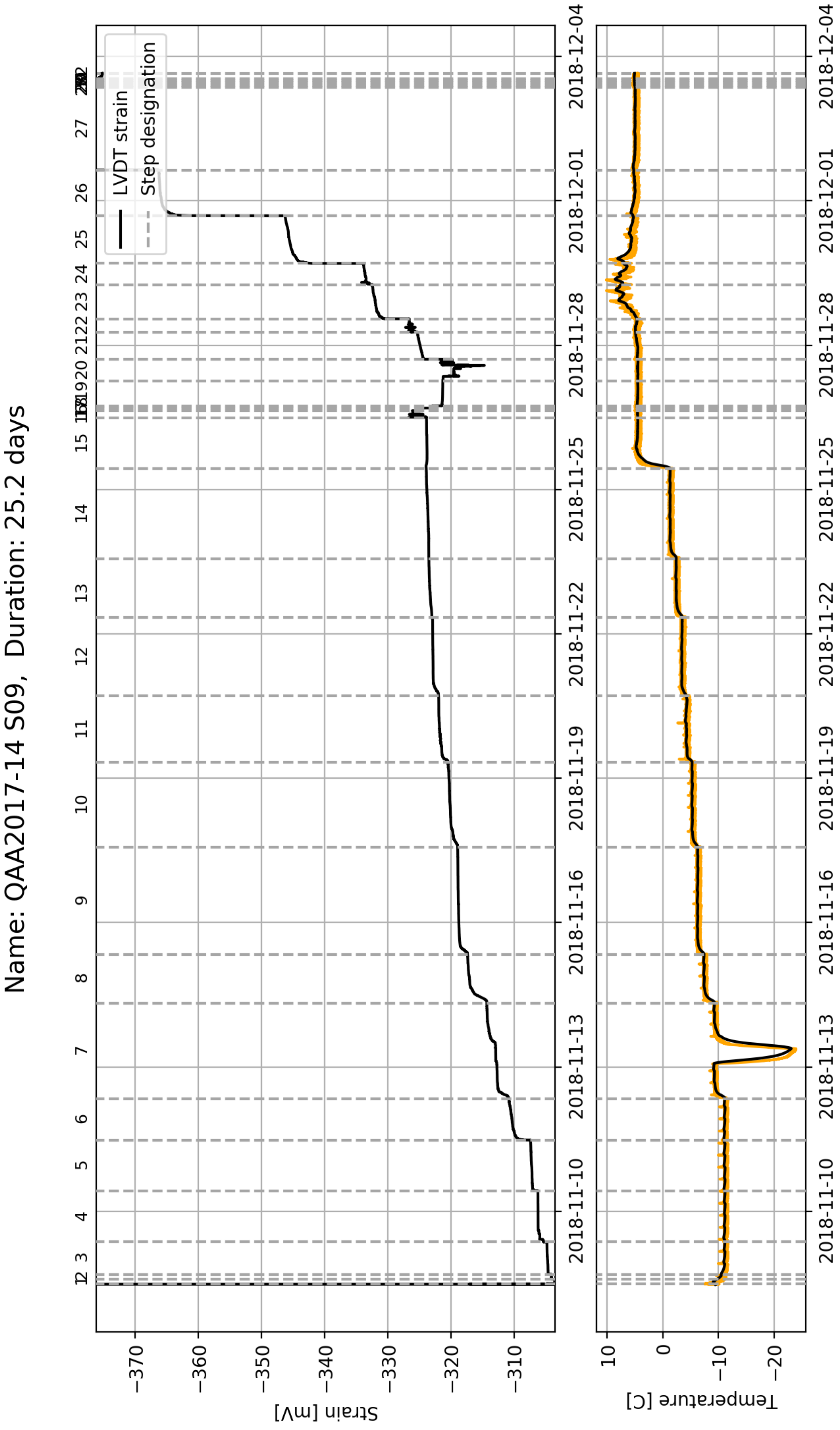
D.1 Consolidation curve



Parameter	Value
Name	QAA2017-14 S09A2
Depth	4.46-4.66 m
Start date	2018-11-08
End date	2018-12-03

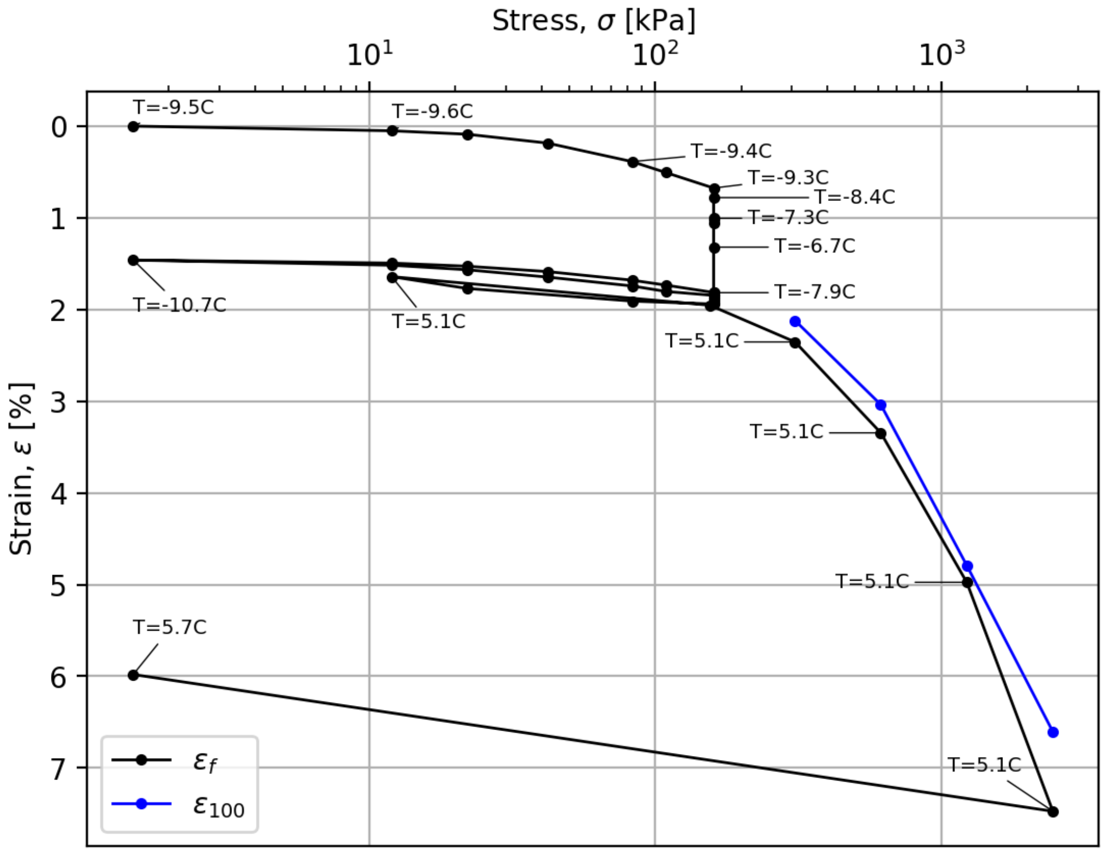
D.2 Overview of load steps and interpreted results

Step	σ [kPa]	T [°C]	ε_0 [%]	ε_{50} [%]	ε_{100} [%]	ε_f [%]	C_α [%/lct]	c_v [m^2/s]	K [kPa]	k_0 [m/s]
1	2.0	-9.3				0.001				
2	12.0	-10.3				0.056				
3	22.0	-11.0				0.123				
4	42.0	-11.1				0.266				
5	80.0	-11.1				0.381				
6	149.0	-11.1				0.725				
7	149.0	-9.3				1.075				
8	149.0	-7.6				1.380				
9	149.0	-6.3				1.537				
10	149.0	-5.3				1.690				
11	149.0	-4.3				1.839				
12	149.0	-3.5				1.934				
13	149.0	-2.5				1.989				
14	149.0	-1.4				2.034				
15	149.0	3.9				2.031				
16	83.0	4.6				1.917				
17	22.0	4.6				1.725				
18	2.0	4.5				1.551				
19	155.0	4.8	1.267	1.655	2.042	2.100	0.036	1.086×10^{-5}	19752	5.499×10^{-9}
20	308.0	6.7	1.902	2.183	2.465	2.683	0.072	1.053×10^{-5}	27194	3.873×10^{-9}
21	614.0	5.7	2.332	2.883	3.434	3.966	0.141	1.009×10^{-5}	27760	3.634×10^{-9}
22	1226.0	5.1	3.317	4.366	5.414	5.963	0.183	9.452×10^{-6}	29185	3.239×10^{-9}
23	2451.0	5.0	5.942	7.261	8.580	8.687	0.256	9.402×10^{-9}	46436	2.025×10^{-12}
24	1226.0	5.0				8.411				
25	614.0	5.1				8.185				
26	308.0	5.1				7.946				
27	155.0	5.1				7.708				
28	2.0	5.1				6.861				


Name: QAA2017-14 S09, Duration: 25.2 days
LVDT strain
Step designation
Strain [mV]
Temperature [C]
2018-11-10
2018-11-13
2018-11-16
2018-11-19
2018-11-22
2018-11-25
2018-11-28
2018-12-01
2018-12-04

E Sample "QAA2017-14 S09B"

E.1 Consolidation curve



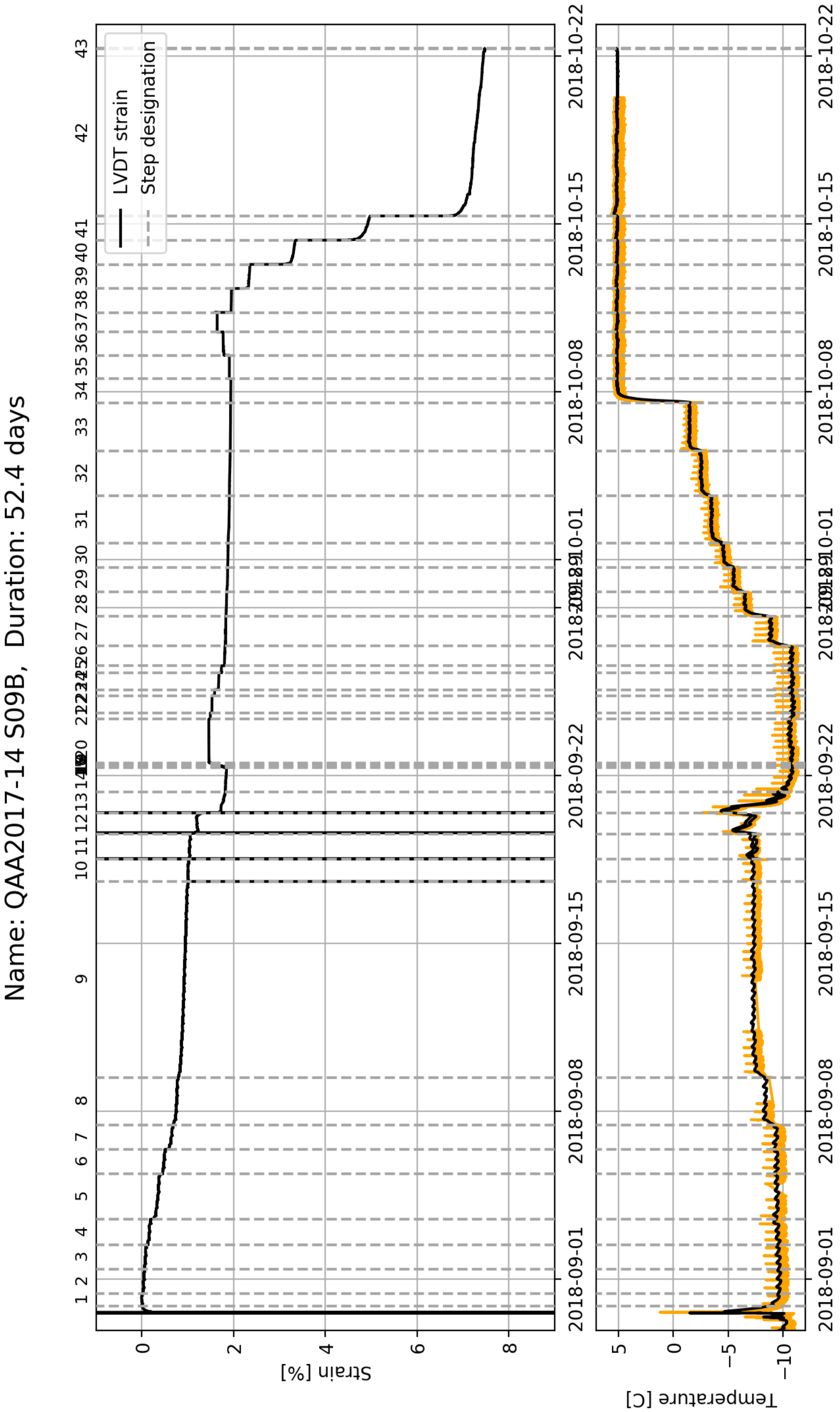
Parameter	Value
Name	QAA2017-14 S09B
Depth	4.73-4.77 m
Start date	2018-08-30
End date	2018-10-22

E.2 Overview of load steps and interpreted results

Step	σ [kPa]	T [°C]	ε_0 [%]	ε_{50} [%]	ε_{100} [%]	ε_f [%]	C_α [%/lct]	c_v [m^2/s]	K [kPa]	k_0 [m/s]
1	1.5	-9.5				0.000				
2	12.0	-9.6				0.051				
3	22.0	-9.5				0.089				
4	42.0					0.186				
5	83.0	-9.4				0.388				
6	109.0	-9.4				0.507				
7	160.0	-9.3				0.676				
8	160.0	-8.4				0.780				
9	160.0	-7.3				1.006				
10	160.0	-7.3				1.018				
11	160.0	-7.1				1.058				
12	160.0	-6.7				1.320				
13	160.0	-7.9				1.817				
14	160.0	-10.5				1.847				
15	109.0	-10.8				1.804				
16	83.0	-10.8				1.744				
17	42.0	-10.7				1.647				
18	22.0	-10.6				1.567				
19	12.0	-10.6				1.518				
20	1.5	-10.7				1.461				
21	12.0	-10.8				1.494				
22	22.0	-10.9				1.528				
23	42.0	-10.8				1.587				
24	83.0	-10.8				1.681				
25	109.0	-10.7				1.735				
26	160.0	-10.8				1.815				

Table continues on next page...

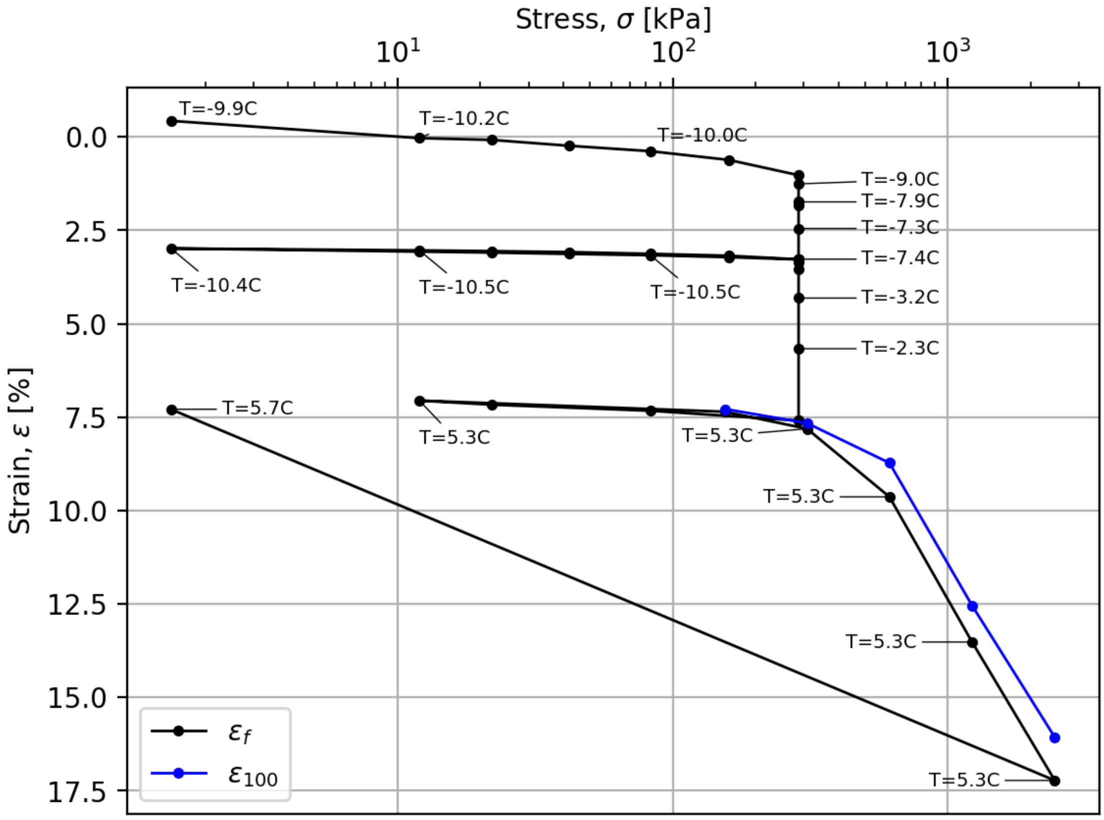
Step	σ [kPa]	T [°C]	ε_0 [%]	ε_{50} [%]	ε_{100} [%]	ε_f [%]	C_α [%/lct]	c_v [m^2/s]	K [kPa]	k_0 [m/s]
27	160.0	-8.9				1.831				
28	160.0	-6.5				1.850				
29	160.0	-5.5				1.870				
30	160.0	-4.6				1.881				
31	160.0	-3.5				1.908				
32	160.0	-2.5				1.926				
33	160.0	-1.5				1.934				
34	160.0	5.1				1.941				
35	83.0	5.1				1.909				
36	22.0	5.1				1.771				
37	12.0	5.1				1.642				
38	155.0	5.1				1.954				
39	308.0	5.1	1.869	1.995	2.121	2.354	0.032	9.338×10^{-6}	60832	1.535×10^{-9}
40	614.0	5.1	2.131	2.585	3.038	3.345	0.101	4.562×10^{-6}	33746	1.352×10^{-9}
41	1226.0	5.1	4.426	4.608	4.791	4.975	0.224	7.022×10^{-9}	167388	4.195×10^{-13}
42	2451.0	5.1	4.564	5.584	6.605	7.472	0.199	3.977×10^{-6}	60008	6.628×10^{-10}
43	1.5	5.7				5.981				



Name: QAA2017-14 S09B, Duration: 52.4 days
LVDT strain
Step designation
Strain [%]
Temperature [C]
2018-09-01
2018-09-08
2018-09-15
2018-09-22
2018-10-01
2018-10-08
2018-10-15
2018-10-22

F Sample "QAA2017-14 S23A"

F.1 Consolidation curve



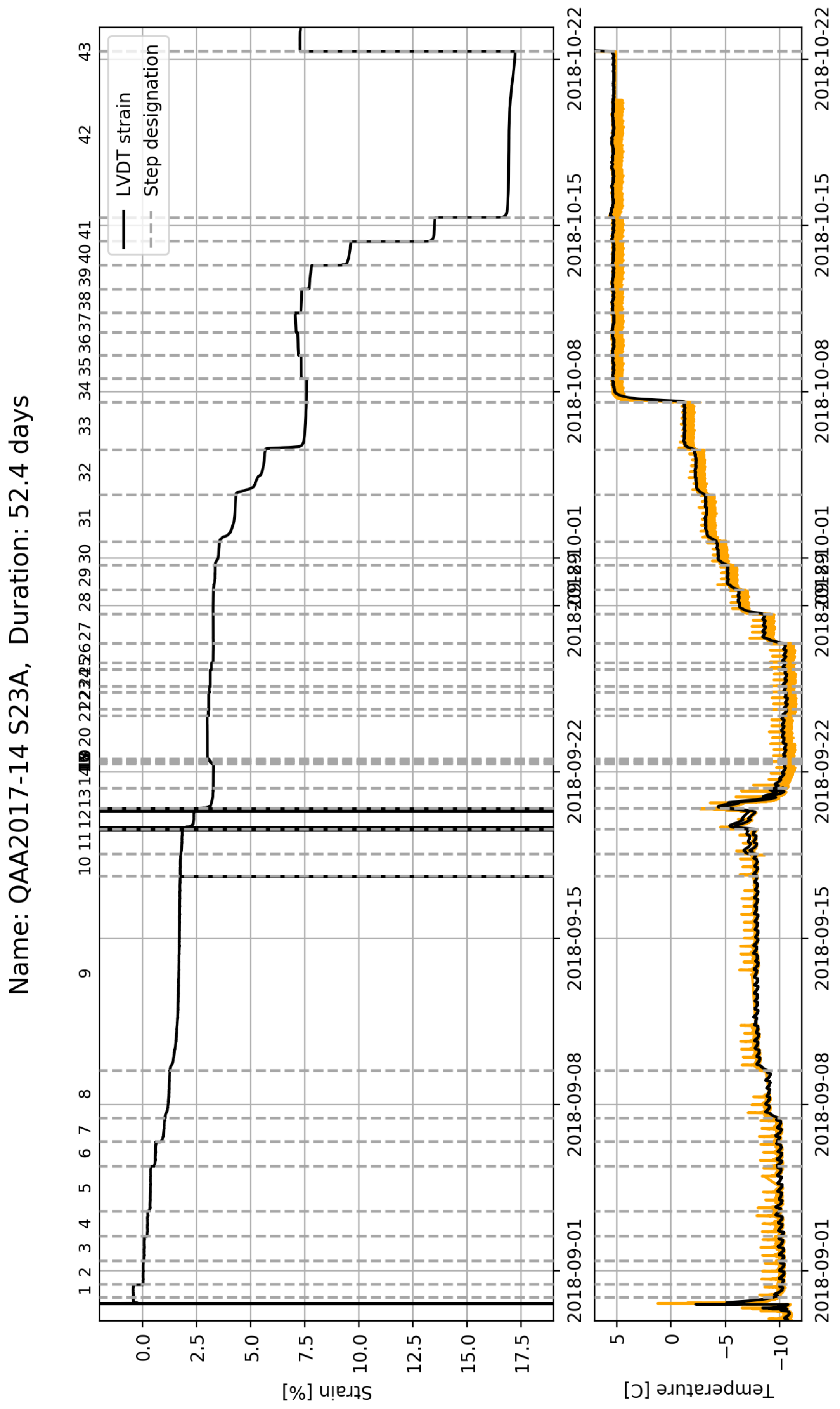
Parameter	Value
Name	QAA2017-14 S23A
Depth	10.97-11.01 m
Start date	2018-08-30
End date	2018-10-22

F.2 Overview of load steps and interpreted results

Step	σ [kPa]	T [°C]	ε_0 [%]	ε_{50} [%]	ε_{100} [%]	ε_f [%]	C_α [%/lct]	c_v [m^2/s]	K [kPa]	k_0 [m/s]
1	1.5	-9.9				-0.430				
2	12.0	-10.2				0.032				
3	22.0	-10.2				0.080				
4	42.0	-10.1				0.237				
5	83.0	-10.0				0.382				
6	160.0	-10.0				0.615				
7	287.0	-9.9				1.025				
8	287.0	-9.0				1.258				
9	287.0	-7.9				1.740				
10	287.0	-7.8				1.753				
11	287.0	-7.7				1.834				
12	287.0	-7.3				2.450				
13	287.0	-7.4				3.271				
14	287.0	-10.1				3.280				
15	160.0	-10.5				3.218				
16	83.0	-10.5				3.166				
17	42.0	-10.4				3.131				
18	22.0	-10.3				3.096				
19	12.0	-10.3				3.071				
20	1.5	-10.4				2.986				
21	12.0	-10.5				3.037				
22	22.0	-10.6				3.057				
23	42.0	-10.5				3.083				
24	83.0	-10.5				3.129				
25	160.0	-10.4				3.180				
26	287.0	-10.4				3.276				

Table continues on next page...

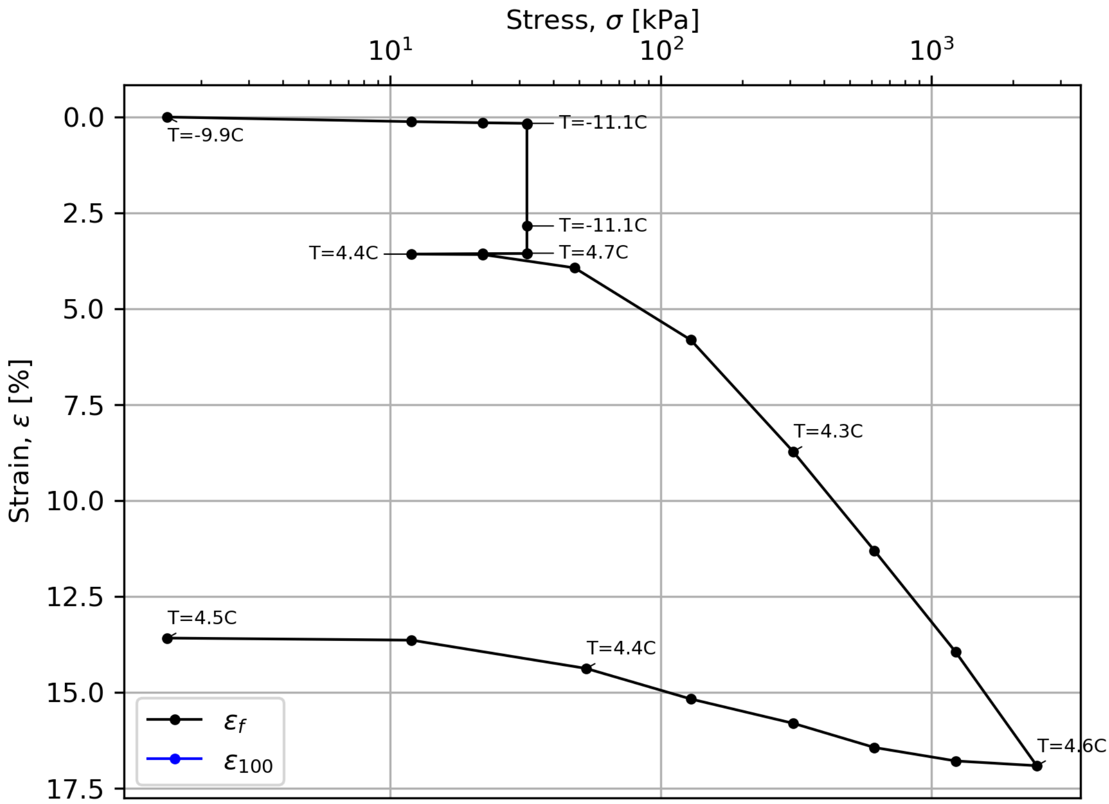
Step	σ [kPa]	T [°C]	ε_0 [%]	ε_{50} [%]	ε_{100} [%]	ε_f [%]	C_α [%/lct]	c_v [m^2/s]	K [kPa]	k_0 [m/s]
27	287.0	-8.6				3.271				
28	287.0	-6.3				3.279				
29	287.0	-5.2				3.357				
30	287.0	-4.3				3.549				
31	287.0	-3.2				4.314				
32	287.0	-2.3				5.670				
33	287.0	-1.2				7.575				
34	287.0	5.3				7.592				
35	83.0	5.4				7.329				
36	22.0	5.3				7.167				
37	12.0	5.3				7.057				
38	155.0	5.3	7.236	7.260	7.284	7.355	0.033	1.768×10^{-6}	296529	5.962×10^{-11}
39	308.0	5.3	7.326	7.493	7.660	7.811	0.075	1.240×10^{-6}	45814	2.706×10^{-10}
40	614.0	5.3	6.938	7.833	8.727	9.633	0.173	1.746×10^{-5}	17110	1.020×10^{-8}
41	1226.0	5.3	6.944	9.743	12.541	13.518	0.123	1.630×10^{-5}	10934	1.490×10^{-8}
42	2451.0	5.3	12.719	14.394	16.069	17.224	0.123	1.511×10^{-5}	36574	4.131×10^{-9}
43	1.5	5.7				7.290				



Name: QAA2017-14 S23A, Duration: 52.4 days
LVDT strain
Step designation
Strain [%]
Temperature [C]

G Sample "QAA2017-18 S03C"

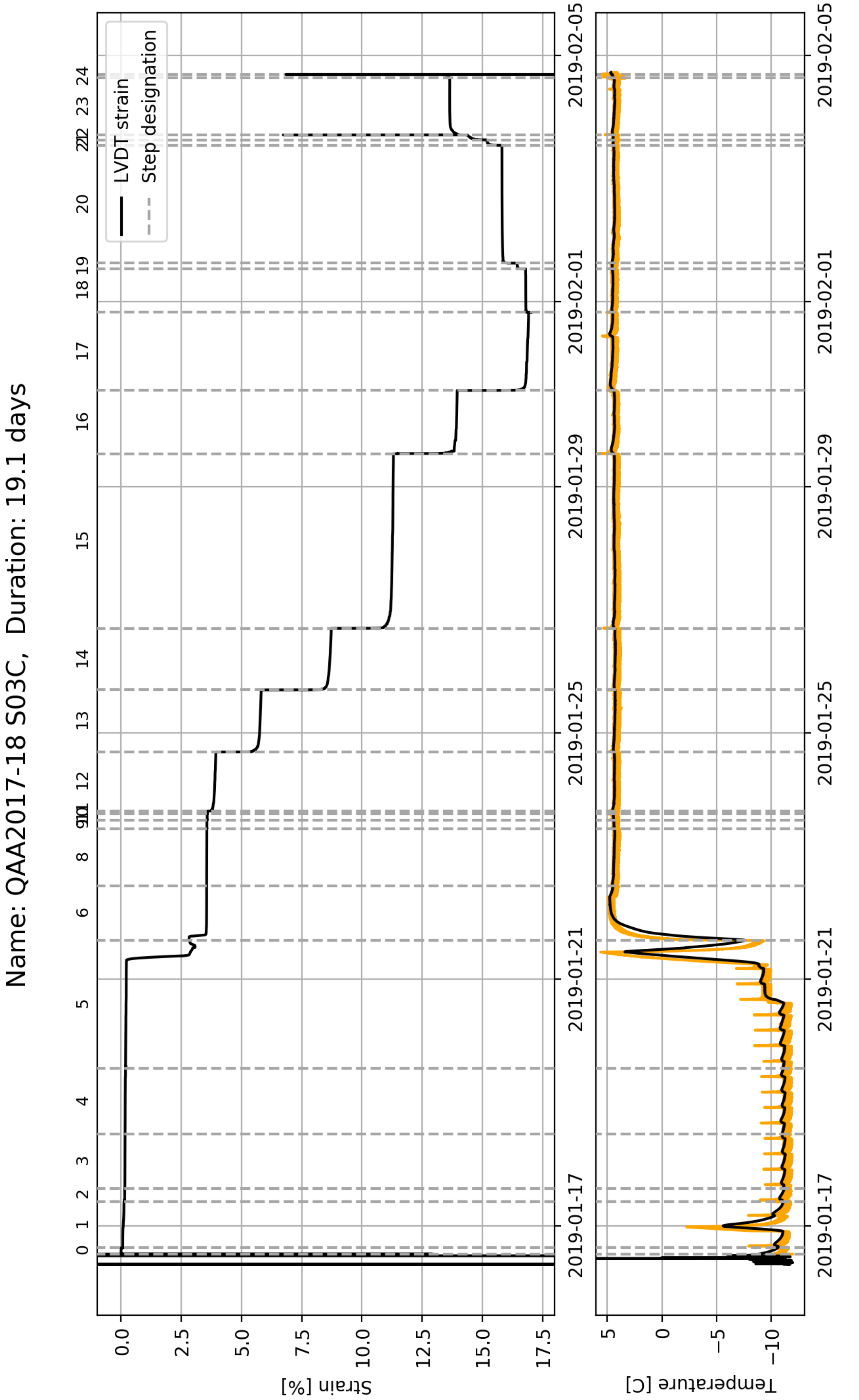
G.1 Consolidation curve



Parameter	Value
Name	QAA2017-18 S03C
Depth	1.25-1.35 m
Start date	2019-01-16
End date	2019-02-04

G.2 Overview of load steps and interpreted results

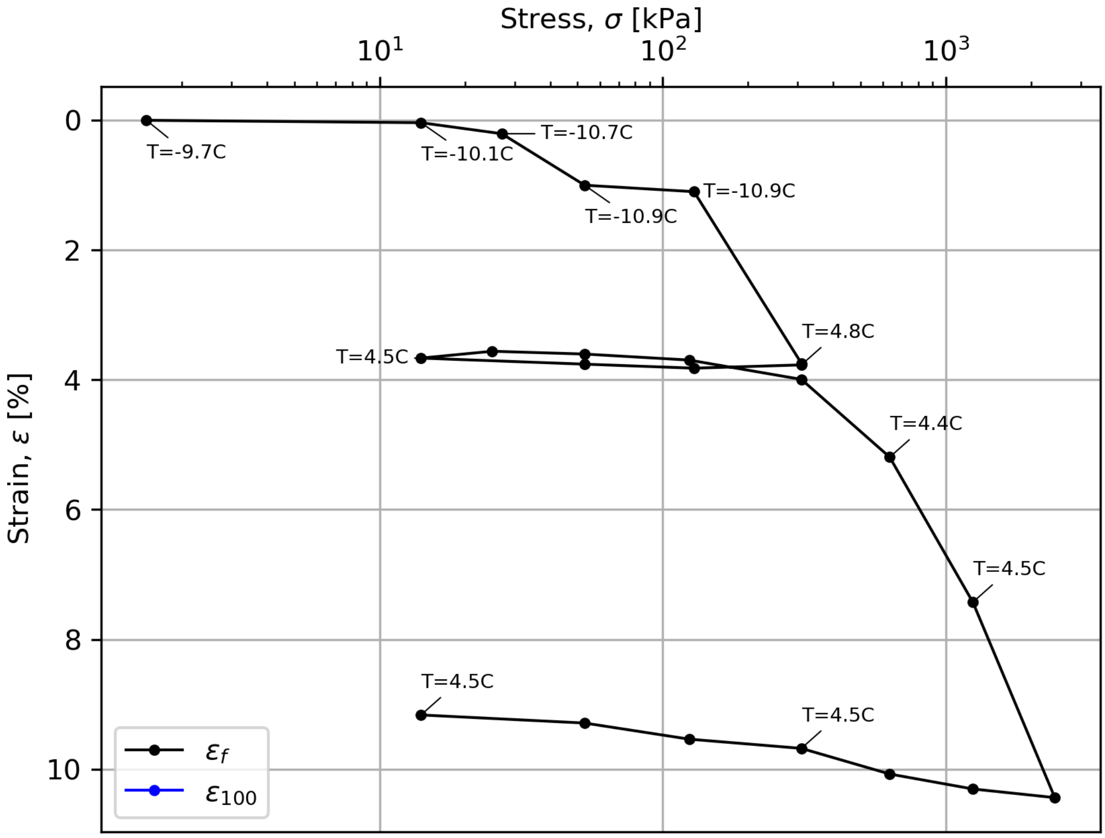
Step	σ [kPa]	T [°C]	ε_f [%]
0	1.5	-9.9	0.003
1	12.0	-10.7	0.123
2	22.0	-11.0	0.152
3	32.0	-11.1	0.168
4	32.0	-11.1	0.186
5	32.0	-11.1	2.844
6	32.0	4.7	3.554
8	32.0	4.4	3.562
9	22.0	4.4	3.565
10	12.0	4.4	3.578
11	22.0	4.5	3.591
12	48.0	4.4	3.936
13	129.0	4.3	5.817
14	308.0	4.3	8.726
15	615.0	4.3	11.310
16	1228.0	4.4	13.955
17	2448.0	4.6	16.920
18	1228.0	4.5	16.796
19	615.0	4.5	16.445
20	308.0	4.4	15.814
21	129.0	4.4	15.180
22	53.0	4.4	14.384
23	12.0	4.4	13.646
24	1.5	4.5	13.591



Name: QAA2017-18 S03C, Duration: 19.1 days
LVDT strain
Step designation
Strain [%]
Temperature [C]
0 1 2 3 4 5 6 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
2019-01-17
2019-01-21
2019-01-25
2019-01-29
2019-02-01
2019-02-05
0.0 2.5 5.0 7.5 10.0 12.5 15.0 17.5
5 0 −5 −10

H Sample "QAA2017-22 S27B"

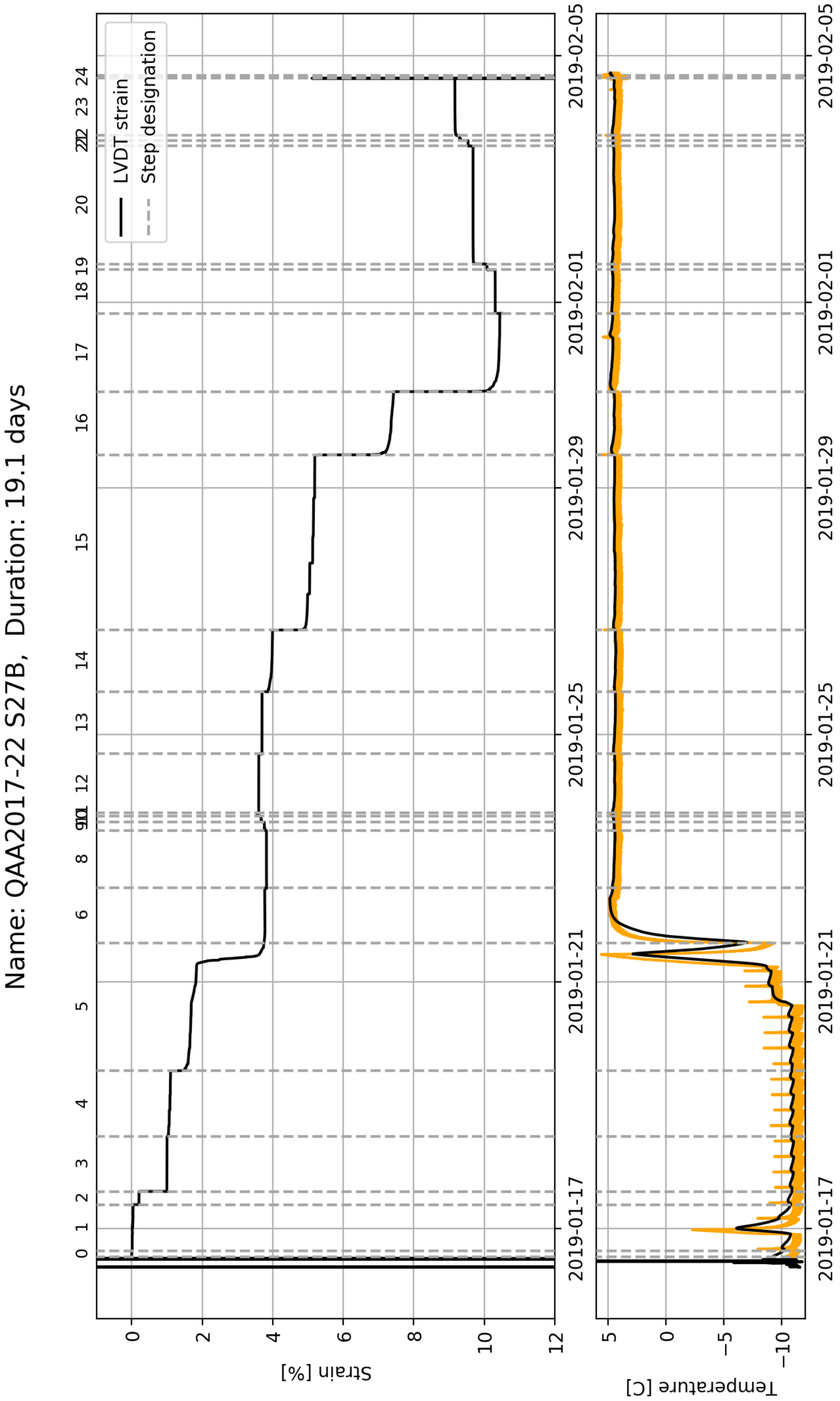
H.1 Consolidation curve



Parameter	Value
Name	QAA2017-22 S27B
Depth	12.57-12.63 m
Start date	2019-01-16
End date	2019-02-04

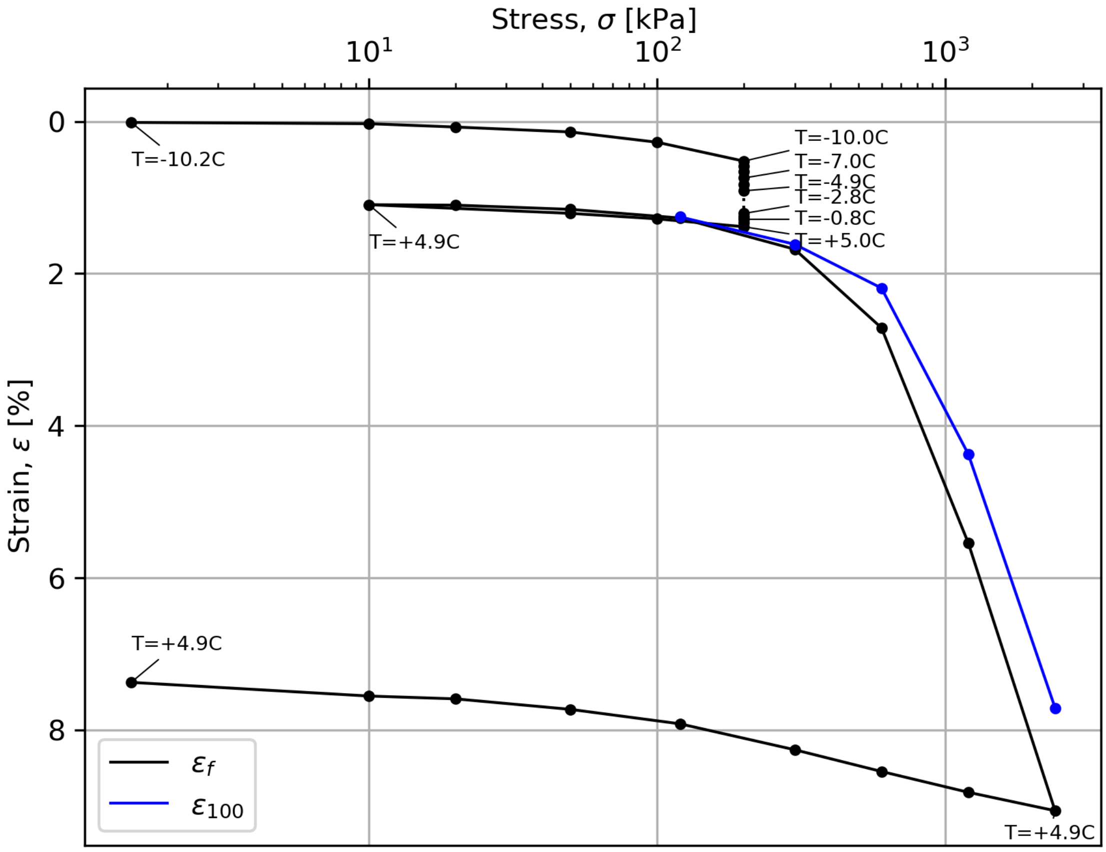
H.2 Overview of load steps and interpreted results

Step	σ [kPa]	T [°C]	ε_0 [%]	ε_{50} [%]	ε_{100} [%]	ε_f [%]	C_α [%/lct]	c_v [m^2/s]	K [kPa]	k_0 [m/s]
0	1.5	-9.7				0.004				
1	14.0	-10.1				0.041				
2	27.0	-10.7	0.205	0.206	0.207	0.211	0.005	2.436×10^{-7}	1203231	2.025×10^{-12}
3	53.0	-10.9	0.994	0.997	1.001	1.004	0.003	2.872×10^{-8}	384375	7.471×10^{-13}
4	129.0	-10.9	1.029	1.029	1.029	1.103	0.043	9.849×10^{-6}	-45097863	-2.184×10^{-12}
5	309.0	-10.8	1.453	1.453	1.454	3.747	0.121	1.153×10^{-5}	26785679	4.305×10^{-12}
6	309.0	4.8				3.772				
8	129.0	4.5				3.823				
9	53.0	4.5	3.770	3.770	3.771	3.761	-0.003	9.726×10^{-6}	-12023911	-8.089×10^{-12}
10	14.0	4.5	3.698	3.697	3.695	3.668	-0.024	2.162×10^{-6}	1364492	1.585×10^{-11}
11	25.0	4.6	3.557	3.559	3.562	3.562	0.001	1.575×10^{-7}	254100	6.197×10^{-12}
12	53.0		3.601	3.602	3.602	3.605	0.001	7.778×10^{-7}	2876272	2.704×10^{-12}
13	124.0	4.4	3.696	3.696	3.696	3.698	0.001	6.103×10^{-6}	68163900	8.953×10^{-13}
14	309.0	4.4	3.872	3.871	3.870	3.995	0.091	4.148×10^{-6}	-10478299	-3.959×10^{-12}
15	634.0	4.4	4.764	4.883	5.001	5.193	0.059	3.071×10^{-9}	137159	2.239×10^{-13}
16	1247.0	4.5	5.874	6.165	6.455	7.428	0.201	6.955×10^{-6}	105605	6.586×10^{-10}
17	2429.0	4.7	9.642	9.643	9.644	10.439	0.198	1.699×10^{-5}	74746120	2.273×10^{-12}
18	1247.0	4.6	10.319	10.314	10.309	10.305	-0.001	7.714×10^{-7}	11501232	6.707×10^{-13}
19	634.0	4.7	10.088	10.087	10.085	10.075	-0.008	5.024×10^{-6}	21446542	2.342×10^{-12}
20	309.0	4.5	9.713	9.700	9.687	9.680	-0.007	2.112×10^{-8}	1223415	1.726×10^{-13}
21	124.0	4.6	9.540	9.541	9.541	9.538	-0.003	7.743×10^{-6}	-25557691	-3.029×10^{-12}
22	53.0	4.6	9.337	9.332	9.328	9.290	-0.047	7.696×10^{-8}	841058	9.150×10^{-13}
23	14.0	4.5	9.220	9.220	9.220	9.165	-0.015	2.482×10^{-6}	-27443810229288960	-9.045×10^{-23}


Name: QAA2017-22 S27B, Duration: 19.1 days
LVDT strain
Step designation
Strain [%]
Temperature [C]
2019-01-17
2019-01-21
2019-01-25
2019-01-29
2019-02-01
2019-02-05
0 1 2 3 4 5 6 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

I Sample "QAA2017-22 S27A"

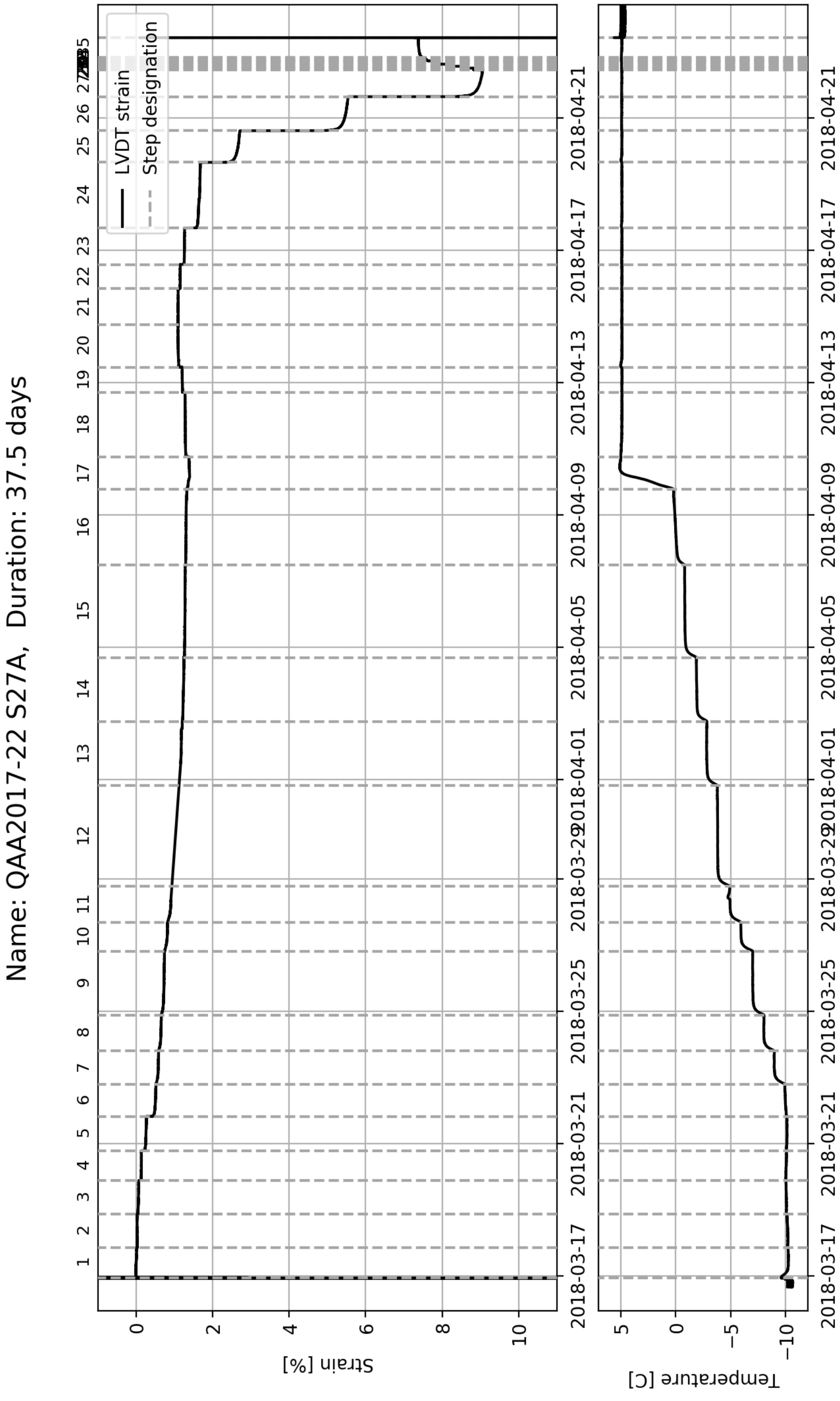
I.1 Consolidation curve



Parameter	Value
Name	QAA2017-22 S27A
Depth	12.63-12.67 m
Start date	2018-03-16
End date	2018-04-23

I.2 Overview of load steps and interpreted results

Step	σ [kPa]	T [°C]	ε_0 [%]	ε_{50} [%]	ε_{100} [%]	ε_f [%]	C_α [%/lct]	c_v [m^2/s]	K [kPa]	k_0 [m/s]
1	1.5	-10.2				0.014				
2	10.0	-10.2				0.030				
3	20.0	-10.1				0.074				
4	50.0	-10.1				0.139				
5	100.0	-10.1				0.274				
6	200.0	-10.0				0.522				
7	200.0	-9.0				0.591				
8	200.0	-8.0				0.661				
9	200.0	-7.0				0.744				
10	200.0	-5.9				0.826				
11	200.0	-4.9				0.913				
12	200.0	-3.9								
13	200.0	-2.8				1.209				
14	200.0	-1.9				1.251				
15	200.0	-0.8				1.286				
16	200.0	0.2				1.329				
17	200.0	5.0				1.384				
18	100.0	4.9				1.281				
19	50.0	4.9				1.208				
20	10.0	4.9				1.094				
21	20.0	4.9				1.101				
22	50.0	4.9				1.156				
23	120.0	4.9	1.250	1.253	1.255	1.269	0.005	2.630×10^{-6}	1497784	1.756×10^{-11}
24	300.0	4.9	0.965	1.290	1.615	1.680	0.036	2.095×10^{-5}	27700	7.562×10^{-9}
25	600.0	4.9	1.888	2.039	2.190	2.713	0.151	1.664×10^{-5}	99202	1.678×10^{-9}
26	1200.0	4.9	3.692	4.032	4.372	5.540	0.228	1.455×10^{-5}	88277	1.649×10^{-9}
27	2400.0	4.9	6.678	7.192	7.706	9.057	0.278	1.458×10^{-5}	116700	1.250×10^{-9}
28	1200.0	4.9				8.815				
29	600.0	4.9				8.542				
30	300.0	4.9				8.256				
31	120.0	4.9				7.916				
32	50.0	4.9				7.726				
33	20.0	4.9				7.588				
34	10.0	4.9				7.550				
35	1.5	4.9				7.371				



Name: QAA2017-22 S27A, Duration: 37.5 days
LVDT strain
Step designation
Strain [%]
Temperature [C]

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Department of Civil Engineering

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