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Arbeitsbericht NAB 19-01

Quaternary Borehole QBO Untersiggenthal (QUST)

Data Report

April 2019

National Cooperative
for the Disposal of
Radioactive Waste

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1 Introduction

In the context of the sectoral plan "Sachplan geologische Tiefenlager" (SGT) Nagra is currently investigating three sites in northern Switzerland to potentially host repositories for radioactive waste. The field exploration project "Quartäruntersuchungen" (QAU) is dedicated to the characterisation of Quaternary deposits within and around these siting regions to further constrain scenarios of their geological long-term evolution. The investigations support the reconstruction of Quaternary landscape evolution.

The borehole (Quartärbohrung, QBO) at Untersiggenthal (QBO Untersiggenthal / QUST) is part of this Quaternary investigation program (QAU; compare Nagra 2017). The drill site in Untersiggenthal is located close to the northern end of the Gebenstorf-Stilli Trough. It was chosen to characterize the geometry and infill of this glacially overdeepened section of the Lower Aare Valley. Today, the study area is characterized by the confluence of Aare, Reuss and Limmat, and the transition between the Folded and Tabular Jura (Fig. 1, Fig. 2; Bitterli-Dreher et al. 2007, Graf 2009). The drilling was conducted between 22.05. and 21.06.2018 by combination of pile-drive coring using a Düsterloh Hammer and wire-line drilling with a triple-tube core-barrel, i.e. with a plastic core liner.

This report covers the request for a documentation of the authorized works on-site (UVEK 2018, Dispositiv 5.20) and documents also the first results of the lab analyses (UVEK 2018, Dispositiv 5.21). The works on-site described in the work program ("Arbeitsprogramm", Nagra 2018) have been carried out. This report corresponds to the data report that was announced in this work program.

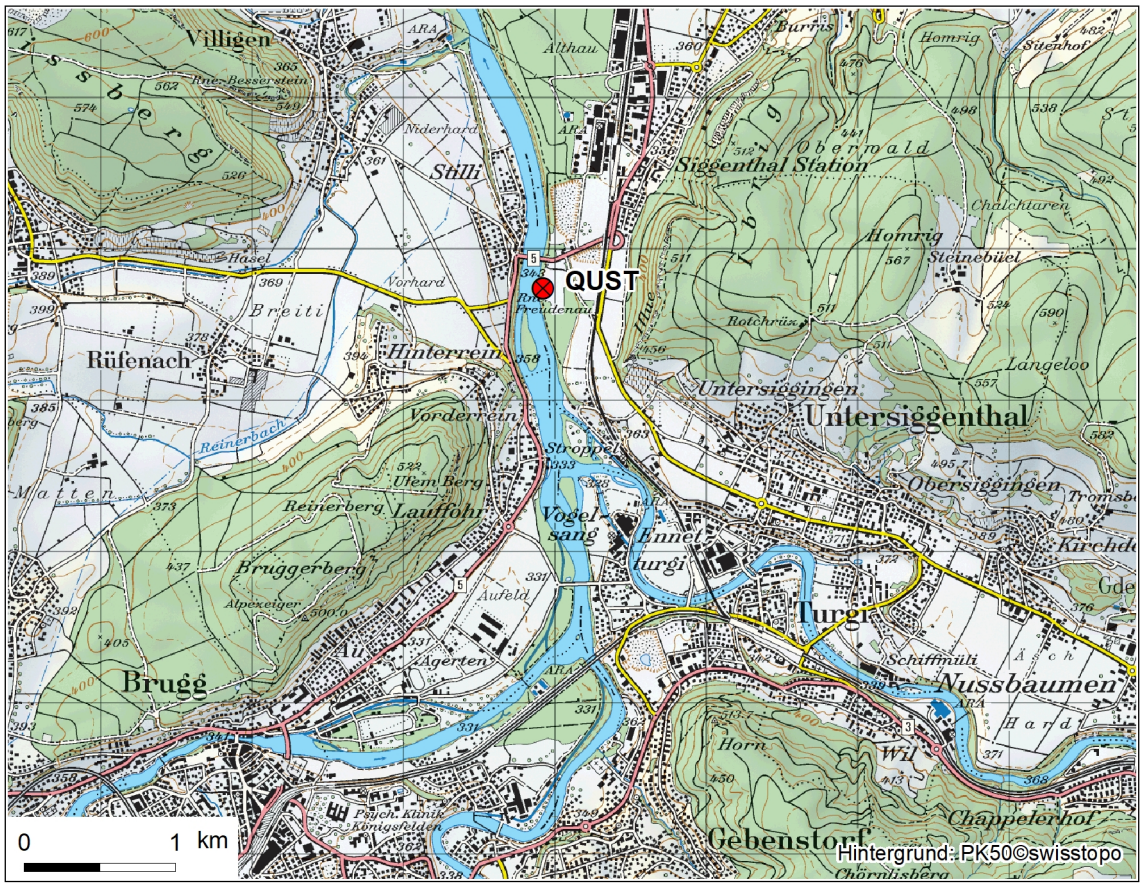


Fig. 1: Location of the Quaternary borehole Untersiggenthal (QUST).

In this report, we present core images, sedimentological descriptions, and geophysical measurements of the cores, all of which were acquired at the University of Bern. Additionally, a borehole geophysical report of BLM Gesellschaft für Bohrlochmessung mbH and R. Garrard (Nagra) and a technical drilling report of Fretus AG and P. Hinterholzer-Reisegger (Nagra) are presented in appendices H and I, respectively. This report is the basis for planning further core analysis and later interpretation in the larger geological context.

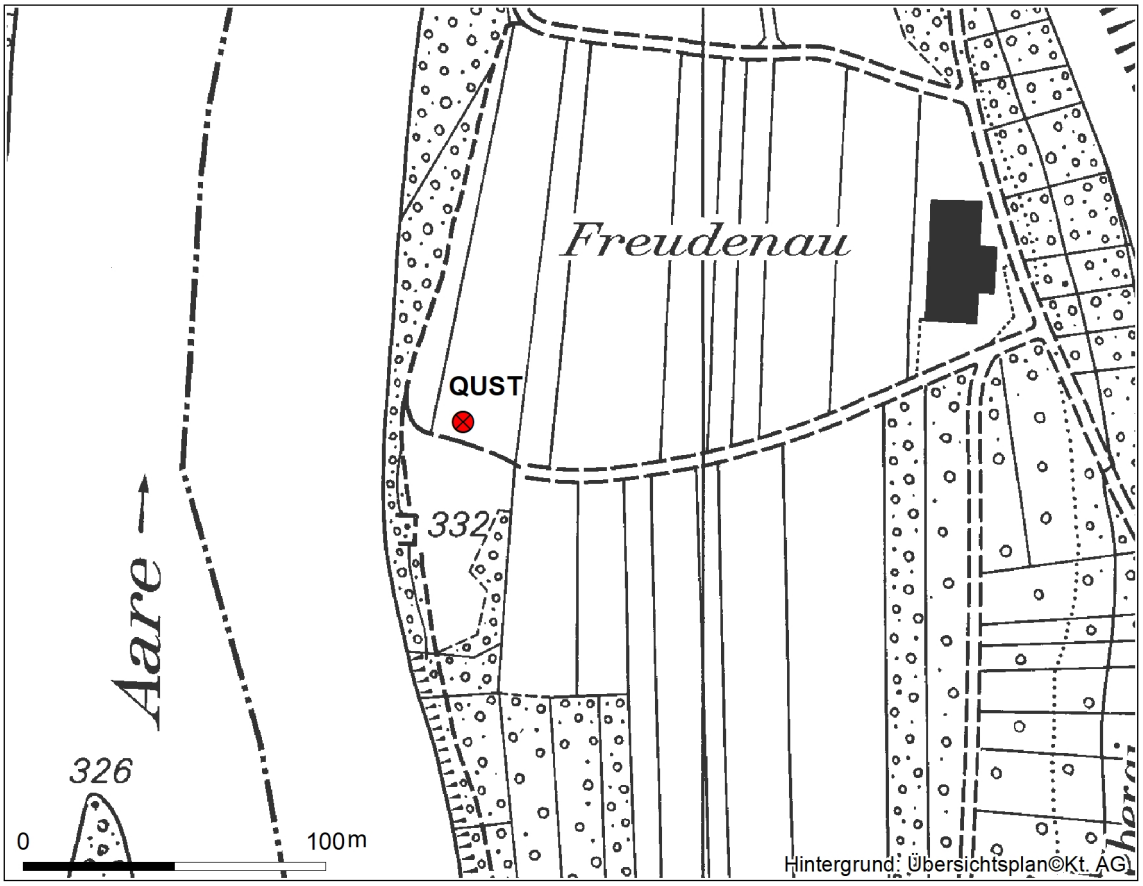


Fig. 2: Detailed location of the Quaternary borehole Untersiggenthal (QUST).

Tab. 1: Coordinates of the Quaternary borehole Untersiggenthal (QUST).

Coordinates (CH1903+)	2'659'921.00, 1'262'740.99
Elevation (m a.s.l.)	331.20
Depth (m b. ground)	86.4

2 Methods

2.1 Drill site core handling

After pull-out, the cores in liners (in plastic liners with 10.4 cm (orange liners, 0.0 – 77.1 m) and 10.6 cm (black liners, 77.1 – 86.4 m) inner diameter, usually in 1 m-core runs) were taken out of the core barrel, closed with plastic caps, sealed with tape and labeled with the core name ("UST-1" plus driller's depth). The core direction was labeled on the end caps ("O" for "oben" or "U" for "unten"), on the plastic liner itself ("Kopf" at the top, "Krone" (drill bit) at the bottom), and also on the wooden boxes used for storage of the individual cores. Labeling was performed by drilling supervisor, who also weighed the individual core pieces for a first assessment of core recovery.

The cores were stored on-site until the next transport to the cool storage facility in Bern, which typically occurred within two to three working days. At the drill site, the cores were protected from excessive heating and extended exposure to daylight.

2.2 Core lab workflow

2.2.1 Petrophysical logging

The whole cores were first analyzed with a Geotek multi-sensor core logger (MSCL) within one to few days after drilling. The MSCL recorded bulk density (by gamma attenuation), p-wave velocity and magnetic susceptibility in a 5 mm depth-resolution (Geotek 2016, Schultheiss and Weaver 1992). The results of these measurements are given in appendix F. Data points related to strongly disturbed core material or gaps within the core, as indicated on the individual section logs, were discarded. Apart from that, the data were not revised (e.g. no smoothing of the curves at core ends). The remaining data points were vertically positioned according to chapter 2.3.2 (composite depth).

Note also:

- During some MSCL runs, a technical problem resulted in erroneous core diameter measurements. Therefore, it was decided to re-process the affected data assuming a constant core diameter (10.4 cm for intervals 0.0 – 41.0 m).
- Low p-wave velocity values (below the value for water of ~1500 m/s) are measurement artifacts and result of missing mechanical coupling due to a gap between the plastic liner and the core material.
- Exceptionally high peaks in magnetic susceptibility may be the result of metal shards broken off the core catcher or drill bit (as observed e.g. in QUST 73.0 – 74.0).

2.2.2 Core opening and description

Core opening was then performed in two steps: After labelling the plastic liner on both sides, the length of it was sliced with a buzz-saw on opposite sides. Secondly, the core was split into half. As the material was generally gravelly, the sections had to be split by levering with a spatula. Immediately after splitting, one half (B-half) of the respective core was covered with an opaque tubular foil, to allow for later luminescence dating (see section 2.5) and packed into two layers of stretch foil to prevent it from drying out.

The freshly opened surface of the other core half (A-half) was then prepared for core imaging and sedimentological logging. This included evening out the surface and cleaning some surficial

clasts. High-resolution core photos were recorded with a line-scan camera mounted on the MSCL. Following this, the sedimentology was logged for each core section (ref. appendix E). Additionally, smear slides were prepared from intervals of suitable (cohesive fine-grained) lithology, and shear strength measurements were taken using an Eijkelkamp pocket vane tester suited for max. 250 kPa (Eijkelkamp 2012) (see appendix G). For storage, the A-half was also sealed with two layers of stretch foil and wrapped in tubular foil.

For description of the bedrock cores, a different approach was used. After splitting the liners, one liner half was lifted off the core, and the photos and descriptions were made based on the whole core. For detailed description and classification, the bedrock cores were examined together with H. Bläsi (Geo-Consulting), M. Filipponi (Nagra) and S. Wohlwend (ETH Zürich). An inventory of structural geological features (faults, joints, etc.) within the bedrock cores was established by A. Ebert and L. Gregorczyk (Geo Explorers) and integrated into this report.

2.2.3 Material storage

At the time of completion of this report, all processed core material is stored in the core repository of Nagra in Mellingen, with the interval QUST 62.0-76.0 m being kept refrigerated.

2.3 Preliminary data integration

2.3.1 Core recovery

After an initial estimation at the borehole site via core weight (see appendix I), the recovery was determined based on the description of the cores including the MSCL data. Recovery is defined here as the ratio between the length of recovered core and length of the drilled interval. Sediment that could be clearly identified as strongly disturbed (i.e., original sedimentary context could not be reconstructed) or infall/caving material was excluded and does not add to the recovered core length. In addition, feedback on the coring process from the drill crew was included. The core-lab recovery is plotted in appendix D.

Recovery was generally very high, between 90 and 100 %, although major disturbance of the material, e.g. internal mixing of the core, could not always be excluded (see appendices D and E).

During widening of the drill hole, clasts exceeding the coring diameter were recovered at 23 m depth. These are documented in the section logs but do not contribute to the core recovery.

2.3.2 Composite depth

To construct a composite depth:

- The top of the recovered cores was aligned with the top depth of the driller's depth. All other core material including the core catchers was placed below that top. The non-recovered intervals were placed at the bottom of the cored interval (IODP 2011). As mentioned above, material that could be clearly identified as caving material or strongly disturbed was excluded and does not add to the recovered core depth.
- The length of recovered cores may slightly exceed the cored length. In this case, the cores were scaled to match the drilled length.

2.3.3 Overview and condensed core profiles

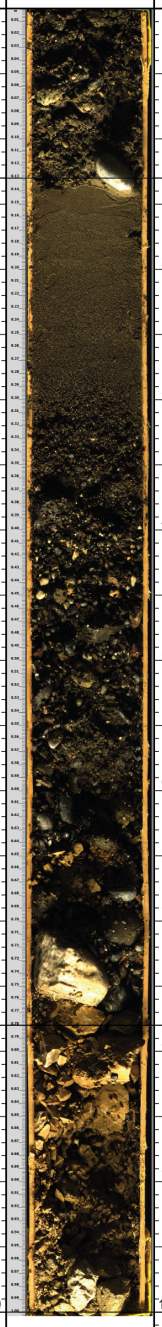
Individual core logs were summarized and preliminarily interpreted in geological profiles for the borehole Untersiggenthal (appendix B). An additional profile plots the petrophysical MSCL measurements together with borehole geophysical data (natural gamma and caliper, see appendix C).

2.4 Core section documentation

All relevant observations were summarized on raw section logs (Fig. 3). These are specifically:

- **Composite depth**: see section 2.3.2
- **Core image**
- **Section depth**
- **Lithology:** General core lithology represented by graphic patterns (legend provided in appendix A)
- **Structures and sampling**: Sedimentary structures (legend provided in appendix A) and sampling points. Note: All samples taken during the initial core description phase are indicated (see also appendix G). Not all the samples taken will necessarily be analyzed. During the upcoming detailed analysis, additional samples may be taken.
- **Description** of the respective unit: Grain size and composition (principal and secondary fractions), sedimentary structures, color (using a Munsell Rock Color Book, 2014 production, munsell.com), clast properties, additional free comments

Drill site	**QBO Untersiggenthal QUST**	
Core name	UST1-13.0-14.0	Logged by: Lukas Gegg
Driller's depth	13.0-14.0 m b. ground	Date: 15.06.2018
General remarks:	100 % recovery	



Compos. depth	Sect. Depth	Lithology	Recovery	Structures & sampling	Description
13.00	10			13	Gravel, sandy; clast-supported; moderately-poorly sorted; massive; dark gray; loose- medium dense; Clasts: A-R, ~P, Alpine lithologies; sharp base contact
13.13					
	20			LUM 17-27: DM-UST-001	Sand (top) - coarse Gravel (base); clast-supported; well (top) - moderately (base) sorted; massive, fining upwards; light gray (top) - gray (middle) - beige-gray (base); Clasts: A-R, ~P, colorful Alpine lithology spectrum; sharp base contact
	30				
	40			normal grading (very clean)	
	50			53-58: fine sandy matrix	
	60				
	70			78	
13.78					
	80				Boulder; shattered block of light beige limestone, probably local origin
	90				
14.00	100			100	

Fig. 3: Example for section log.

2.5 Provisions for luminescence dating

In anticipation of later luminescence dating, the drill cores were protected against exposure to daylight with the following measures:

- **Opaque liners**: For QUST the drilling operator chose to switch for the Quaternary section (interval 0.0 – 76.0 m) the liner type to better cope with the coarse-grained sediments (more flexible plastic) and thermal expansion in the hot summer weather (reducing the risk of liner stuck in the core barrel). This new liner type, however, turned out to be less opaque than the tested liner used at the previous drillings (QRIN1, QRIN2). The outside rim of the QUST cores must thus be considered to have experienced dimmed sunlight exposure. To reduce the exposure, the cores were wrapped in opaque plastic bags after retrieval as preliminary work-around (effective from 50 m onwards).
- **Core opening**: During core opening, the lighting in the core lab was dimmed (blinds closed, fluorescent lamps over the core opening table shut off). The B-half was covered and then wrapped in opaque tubular foil within seconds after splitting. The split core surfaces must thus be expected to have experienced a short light exposure. Deeper light penetration into core should, however, be excluded.
  To enable the possibility to apply luminescence dating to gravel clasts, the cores QUST 53.0 – 54.0 m, QUST 63.0 – 64.0 m, QUST 73.0 – 74.0 m were opened in the OSL Laboratory at the University of Bern under subdued red-light conditions.
- **Core storage**: The B-halves were wrapped in two layers of stretch foil and opaque tubular foil and stored in wooden storage boxes. This setup ensures protection against light and rapid desiccation

2.6 Porewater and geotechnical sampling

From the borehole in Untersiggenthal no porewater or geotechnical samples were taken due to a lack of larger intervals of suitably fine-grained material.

3 Geological overview

With the QBO Untersiggenthal the external part of the glacially overdeepened Gebenstorf-Stilli Trough was investigated. At the drill site, the valley fill above Mesozoic limestone is 76 m thick and coarsens in general upwards from sand and gravel towards coarse gravel and cobbles. Below ~300 m a.s.l.[1] these sediments are probably emplaced in overdeepened position in a delta or subglacial setting. Above this level, they may also be of (glacio-) fluvial origin. Finally, the succession is capped by silt and sand with colluvial influence and soil formation.

Detailed core documentation and supplementary data are organized in the appendices as listed on page II.

[1] This corresponds to the approximate elevation of the bedrock (Pietsch & Jordan 2014) beyond the Gebenstorf-Stilli trough, in the area between Würenlingen and Döttingen (i.e. the lowest base level).

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