

Arbeitsbericht NAB 18-40

**Quaternary Boreholes
QBO Riniken-1 & -2
(QRIN1 & QRIN2)
Data Report**

December 2018

**National Cooperative
for the Disposal of
Radioactive Waste**

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KEYWORDS

Quartärbohrung, Quaternary Drilling, QBO, Riniken,
Rinikerfeld, Lower Aare Valley, Quaternary, Geology

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(Annotation: The appendices E to J can be found in the digital version of this report (PDF).)

1 Introduction

The boreholes (Quartärbohrung, QBO) at Riniken (QBO Riniken-1 / QRIN1, QBO Riniken-2 / QRIN2) were the first drilling operations within Nagra's Quaternary investigation program ("Quartäruntersuchungen" QAU; compare Nagra 2017) project. The drill site in Riniken was chosen to characterize the geometry and infill of the Rinikerfeld channel, which is an elevated paleo-channel detached from the modern Lower Aare valley (Fig.1 and 2; Bitterli-Dreher et al. 2007, Graf 2009). Originally, only one borehole was foreseen. Due to loss of core material in the first borehole (QRIN1) over geological key intervals (roughly between 4.5-18.0 m and 31.1-41.2 m) it was decided to carry out a second borehole (QRIN2) within a few meters nearby to close the recovery gaps. The first borehole QRIN1 was conducted from 06.-21.03.2018 using a combination of Düsterloh hammer drilling and wire-line drilling (triple-tube core-barrel, i.e. with a plastic core liner). The second borehole QRIN2 was conducted from 22.03.-11.04.2018 only using the Düsterloh hammer throughout and succeeded in coring the missing intervals. The two drillings were combined into a composite profile (ref. section 2.3.2), which is called QBO Riniken composite (QRIN).

This report covers the request for a documentation of the authorized works on-site (BFE 2017, Dispositiv 5.6) and documents also the first results of the lab analyses (BFE 2017, Dispositiv 5.7). 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.

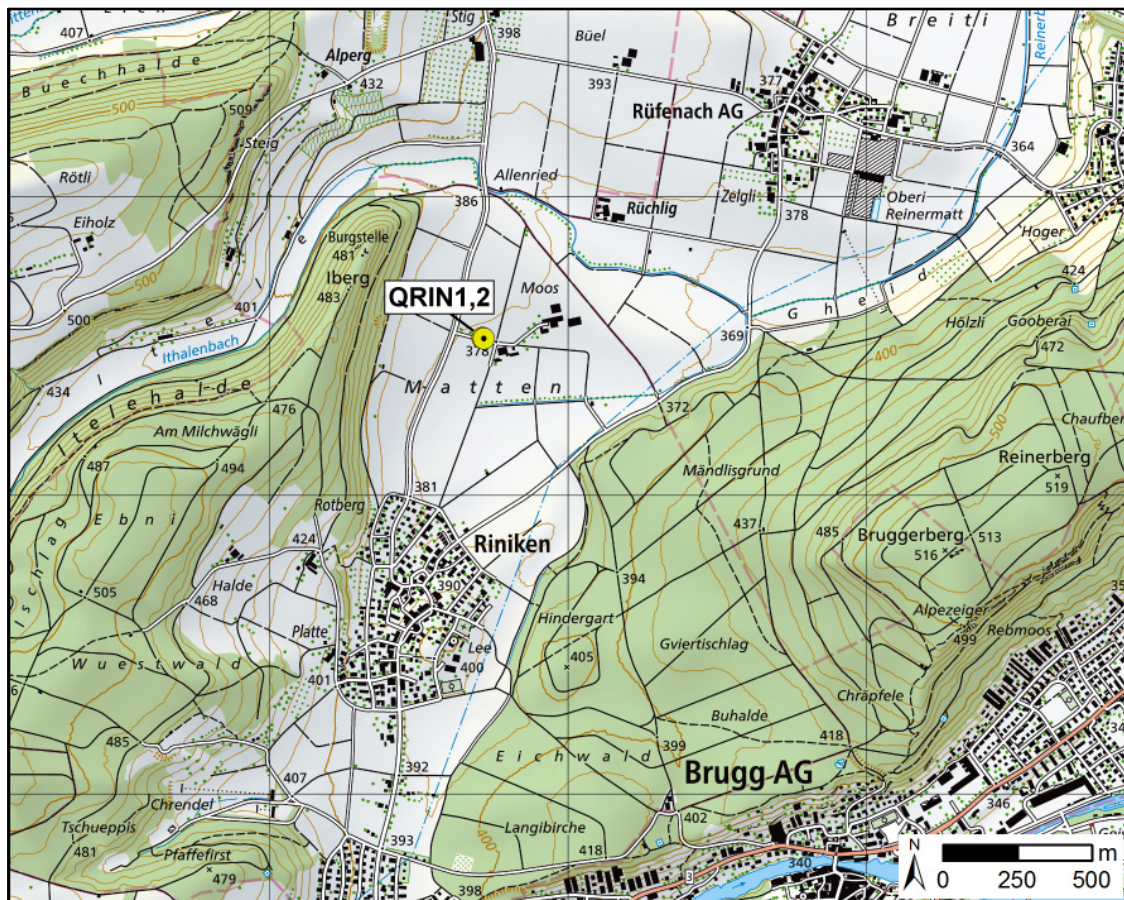


Fig. 1: Location of the boreholes.

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, borehole geophysical reports of BLM Gesellschaft für Bohrlochmessung mbH and technical reports of Fretus AG and Nagra are presented in appendices I and J, respectively. This report is the basis for planning further core analysis and later interpretation in the larger geological context.

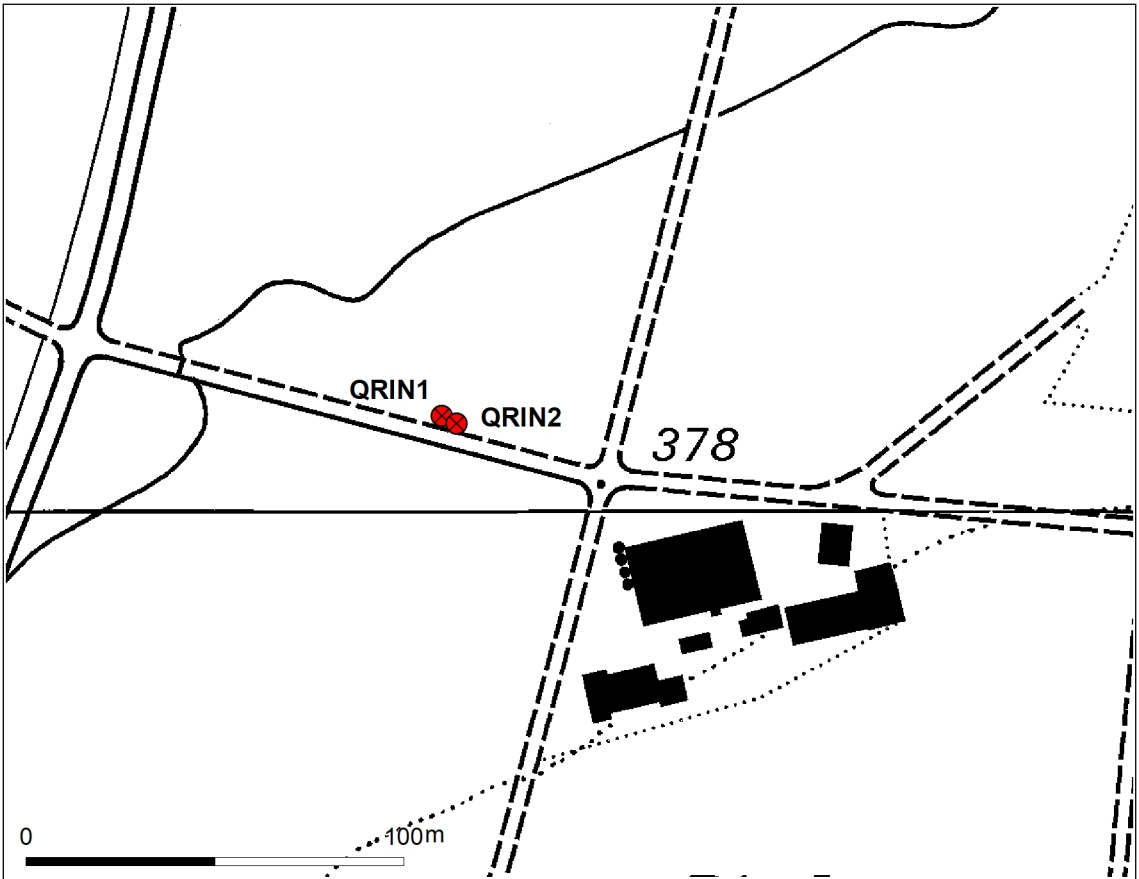


Fig. 2: Detailed location of QRIN1 and QRIN2.

Tab. 1: Coordinates of the boreholes QRIN1 and QRIN2.

	QRIN1	QRIN2
Coordinates	2'656'712.53 E, 1'261'525.42 N	2'656'716.77 E, 1'261'523.14 N
Elevation (m a.s.l.)	378.79	378.76
Depth (m b. ground)	52.7	41.2

2 Methods

2.1 Drill-site core handling

After pull-out, the cores (in plastic liners with 10.4 cm (orange liners) and 10.6 cm (black liners) 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 preliminary core name (RIN1 and RIN2 plus driller's depth and "CC" for core-catchers). The core direction was labeled on the end caps ("O" for "oben" or "U" for "unten") and on the liner itself. Labeling generally was performed by the drilling crew. The individual core pieces were then weighted for a first assessment of core recovery and placed in labeled wooden boxes for further storage and transport.

The cores were stored on-site until the next transport to the cool storage facility in Bern, which typically occurred within two working days. To protect the cores against freezing, extended exposure to sunlight and heating during on-site storage, the nearby barn was used.

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 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. by 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 QRIN1 1.0-10.0 m and QRIN2 4.5-18.0 m, 10.6 cm for QRIN1 10.0-52.7 m), with exception of the lower part of QRIN2, where actual core diameter measurements could be used again.
- 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 drillbit (as observed in RIN2 38.8-39.1 m).

2.2.2 Core opening and description

Core opening was 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. In case of sand, silt or clay, this was done by pushing two pieces of sheet metal in the slit between the liner halves. Gravelly 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 interest, and shear strength measurements were taken using an Eijkelkamp pocket vane tester suited for max. 250 kPa (Eijkelkamp 2012) (see appendices G and H). 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.

2.2.3 Material storage

At the time of completion of this report, all processed core material is being kept refrigerated, either at the university of Bern or the cold storage of Emmi in Ostermundigen. Longer-term archiving for selected intervals is foreseen at core facilities of Nagra in Mellingen.

2.3 Preliminary data integration

2.3.1 Core recovery

After an initial estimation at the borehole site via core weight, 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 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 assessment is plotted in appendix D.

Very low recovery values occurred in QRIN1 in certain sections. The observed core loss is related to the flush out of incohesive core material by the drilling fluid. In several sections, it was observed that the nominal recovery is above 100%, i.e. the length of the recovered cores exceeds that of the drilled interval (by typically less than 20 %). The reason cannot be specified in detail. It is assumed to be due to drilling inaccuracies, loosening and vertical stretching of the cores, non-identified re-cored or caving material. The driller's depth of core QRIN1 27.3-27.7 could have been mislabeled but was included as given from the driller.

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. An exception was made in the interval QRIN1 35.4-41.3, which is generally strongly disturbed (fine material being flushed out) but was accepted for the composite section.

- The length of recovered cores including core catcher may exceed the cored length. This was mostly observed in the wireline drilling setup (see section 2.3.1). In an overlength case, the cores were scaled linearly to match the drilled length.
- QRIN1-QRIN2 cross-hole correlation was performed using the driller's depth, where major lithological transitions recognizable in both cores agreed well, i.e. with deviations usually below 0.5 m. These deviations are explained by the geological setting of the boreholes (see section 3 and appendix B), in which sedimentation has likely been laterally highly variable. Where available (5.0-18.0 and 31.1-41.2 m below ground), the composite profile was based on data from QRIN2, as recovery and core quality were generally better than in QRIN1.

2.3.3 Overview and condensed core profiles

Individual core logs were summarized and preliminarily interpreted in overview profiles for the two boreholes (appendix B). A second set of profiles plots the petrophysical MSCL measurements together with borehole geophysical data (natural gamma and caliber, see appendix C).

2.4 Core section documentation

All relevant observations were summarized on 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 until the date of this report are indicated (see also appendix H). 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, clast properties, additional free comments

Drill site QBO Riniken QRIN1 Core name RIN1-3.0-4.0 Logged by: Lukas Gegg Driller's depth 3.0-4.0 m b. ground Date: 21.03.2018 General remarks: 93 % recovery					
Compos. depth	Core image	Sect. Depth	Lithology	Recovery	Description
				Infall	
3.00		10		---	6 Silt, slightly gravelly, clayey; matrix-supported; poorly sorted; massive; grey-brown; soft; Clasts: SA-SR, sl.P gradational base contact
10		20			Gravel, slightly silty, sandy; clast-supported; poorly sorted, massive, reddish ocher-beige; medium dense - dense; Clasts: SA-R, sl.P-E, Alpine and local origin; gradational base contact
20		30			
30		40			
40		50		---	49
3.43		60		 Δ normal grading	78 Sand, gravelly, with isolated cobbles; matrix-supported; moderately (top) - poorly (base) sorted; crudely bedded, fining upwards; greyish-beige; medium dense; Clasts: A-R, B-sl.P, Alpine and local origin; sharp and inclined base contact
50		70			
60		80		 Δ normal grading	93 Sand, silty; matrix-supported; well (top) - moderately (bottom) sorted; bedded, fining upwards; beige with reddish oxidized bands; soft to firm; gradational base contact
70		90		---	
3.72		100			99 Sand, gravelly; matrix-supported; poorly sorted; crudely bedded; reddish-beige; loose; Clasts: SA-R, sl.P-E of Alpine and local origin
80					
90					
3.87					
3.93					

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:** The cores were drilled in opaque liners.
- **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.
- **Core storage:** The B-halves were wrapped in two layers of stretch foil and opaque tubular foil and afterwards stored in wooden storage boxes. This setup ensures protection against light and rapid desiccation.

2.6 Porewater and geotechnical samples

Porewater sampling required squeezing of fresh and unopened full cores (Tomonaga et al. 2011, 2014). It was performed after MSCL scanning in the lab (4 samples from QRIN1) or on the drill site without prior MSCL scanning (1 sample from QRIN1). The samples were ~25 cm long and taken from the bottom ends of the respective cores. The squeezed samples were later split open and described as all other core material; squeezing apparently caused only minor disturbance of the core material. Note: In case of on-site sampling, the MSCL data were recorded from the squeezed and potentially disturbed core piece.

Undisturbed samples for geotechnical analysis were taken after MSCL scanning but prior to core opening (gap in the core image and without description in this report). Any residuals after geotechnical analysis will be imaged, described and placed in the core boxes.

3 Geological overview

The filling of the Rinikerfeld channel at the borehole sites consists of some 40 m of Quaternary sediments on top of Jurassic marls and limestones of the Effingen Member (Wildegge Formation). The Mesozoic is overlain by ~4 m of diamicts probably emplaced in a glacial setting and ~2 m of (glacio-)fluvial sands and gravels (37.6-35.7 m depth). The latter transition (over ~2 m) into lacustrine silts and clays with a total thickness of 24 m (33.5-9.3 m depth). The top of these lake sediments is again characterized by a gradual transition (~2 m) into 5 m of sands, gravels and diamicts (7.4-2.8 m depth). Finally, the succession is capped by gravels and diamicts with colluvial influence and soil formation.

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

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