Arbeitsbericht NAB 22-03

TBO Rheinau-1-1: Data Report

Dossier I Drilling

June 2023

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Keywords:
RHE1-1, Zürich Nordost, TBO, deep drilling campaign, end-of-well report, drilling, drill site, drilling technology, drilling tools, sections, casing, cementing, drilling fluid, mud system, mud losses, coring system, hole opening, potassium silicate, HSE, non-productive time

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Nagra Arbeitsberichte ("Working Reports") present the results of work in progress that have not necessarily been subject to a comprehensive review. They are intended to provide rapid dissemination of current information.

This NAB aims at reporting drilling results at an early stage. Additional borehole-specific data will be published elsewhere.

In the event of inconsistencies between dossiers of this NAB, the dossier addressing the specific topic takes priority. In the event of discrepancies between Nagra reports, the chronologically later report is generally considered to be correct. Data sets and interpretations laid out in this NAB may be revised in subsequent reports. The reasoning leading to these revisions will be detailed there.

This Dossier was prepared by a project team consisting of:
P. Hinterholzer-Reisegger (project management, writing)
F. Casanova (QC)

Editorial work: Geomecon, P. Blaser and M. Unger

The Dossier has greatly benefitted from technical discussions with, and reviews by, external and internal experts. Their input and work are very much appreciated.

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Abbreviations

API	American Petroleum Institute
ATEX	EU directives describing the minimum safety requirements of the workplace and equipment used in an explosive atmosphere (Appareils destinés à être utilisés en ATmosphères EXplosives)
BGL	Below ground level
BHA	Bottom hole assembly
BOP	Blowout preventer
BTC	Buttress thread connection
CBL	Cement bond log
DCS	Drill collar slip
DDR	Daily drilling report
DLS	Dogleg severity
DMT	Deutsche Montan Technologie
DP	Drill pipe
EMS	Electronic multishot system
EMW	Equivalent mud weight
ENSI	Swiss Federal Nuclear Safety Inspectorate (Eidgenössisches Nuklearsicherheitsinspektorat)
FIT	Formation integrity test
Fm.	Formation
FOEN	Federal Office for the Environment
GPIT	General purpose inclinometer tool
GR	Gamma ray
GTPT	Gas threshold pressure test
HLW	High-level waste
HSE	Health safety environment
HV	High viscosity
HWDP	Heavy weight drill pipe
KOP	Kick-off point
K-silicate	Potassium silicate (drilling fluid)
LTI	Lost time incidents
L/ILW	Low- and intermediate-level waste
LV95	National survey 95 (Landesvermessung 95)
L/ILW	Low- and intermediate-level waste
Mb.	Member
MBT	Methylene blue test

MD	Measured depth
MW	Mud weight
MWD	Measurement while drilling
NB	Near bit
NPT	Non-productive time
NSG	Application for exploration permits (Nagra Sondiergesuch)
N/A	Nor applicable
OD	Outer diameter
PAC	Polyanionic cellulosic polymer
PDC	Polycrystalline diamond compact
POOH	Pulling out of hole
PPE	Personal protective equipment
P/U	Pick up
RIH	Run in hole
ROP	Rate of penetration
RPM	Revolutions per minute
RSS	Rotary steerable system
RT	Rotary table
SG	Specific gravity
SGT	Sectoral Plan for Deep Geological Repositories
SLB	Schlumberger N. V.
SPM	Strokes per minute
TBO	Tiefbohrungen
TD	Target depth of section or hole / total depth
TOC	Top of cement
TSD	Thermally stable diamond
TVD	True vertical depth
USIT	Ultrasonic imager tool
USM	Untere Süsswassermolasse
VDL	Variable density log
VSP	Vertical seismic profile
WEP	Well Engineering Partners BV
WL	Wireline
WOB	Weight on bit
WOC	Waiting on cement
ZNO	Zürich Nordost

1 Introduction

1.1 Context

To provide input for site selection and the safety case for deep geological repositories for radioactive waste, Nagra has drilled a series of deep boreholes ("Tiefbohrungen", TBO) in Northern Switzerland. The aim of the drilling campaign is to characterise the deep underground of the three remaining siting regions located at the edge of the Northern Alpine Molasse Basin (Fig. 1-1).

In this report, we present the results from the Rheinau-1-1 borehole located in the siting region Zürich Nordost (Fig. 1-2). In the following, the unique exploration objective of this specific borehole is further outlined.

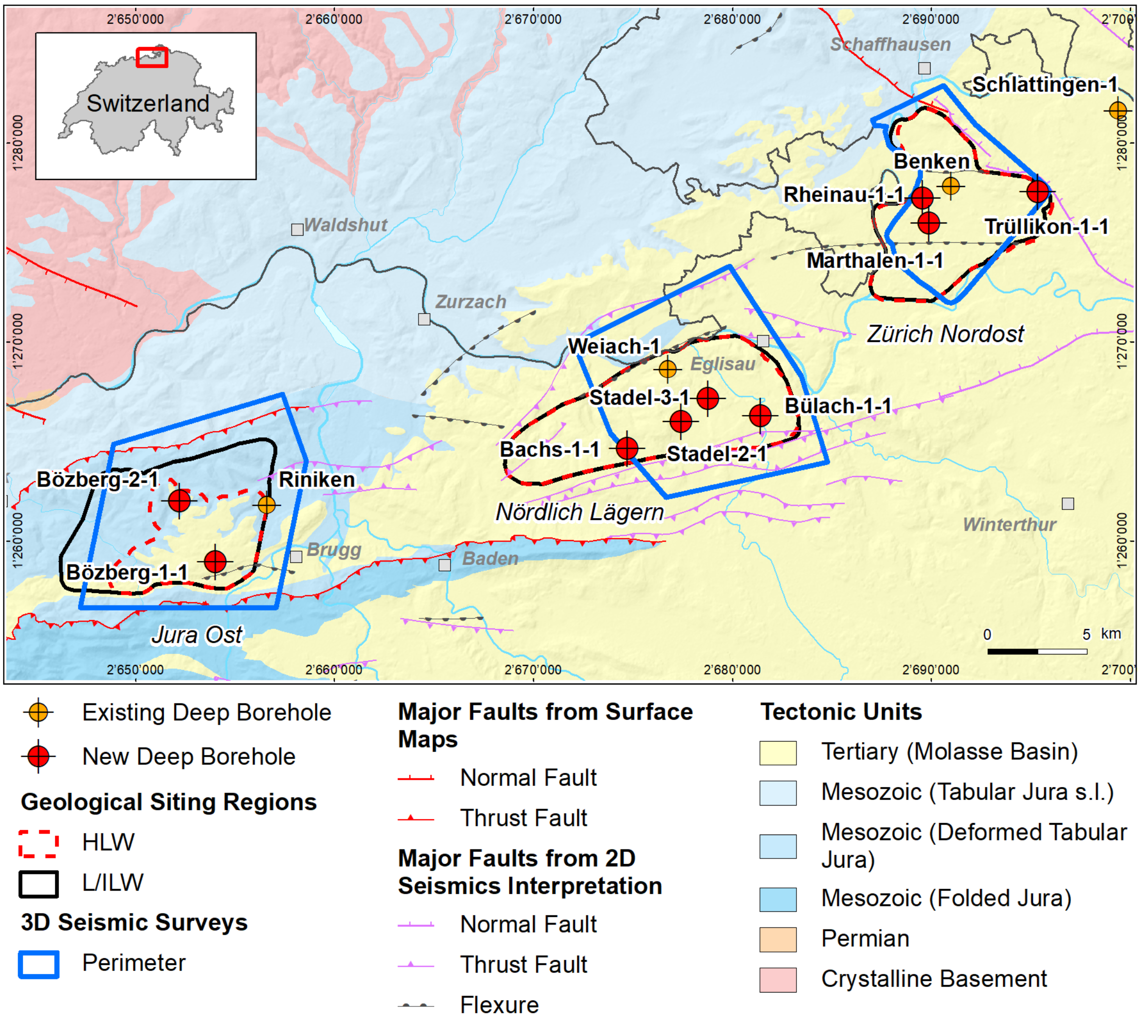


Fig. 1-1: Tectonic overview map with the three siting regions under investigation

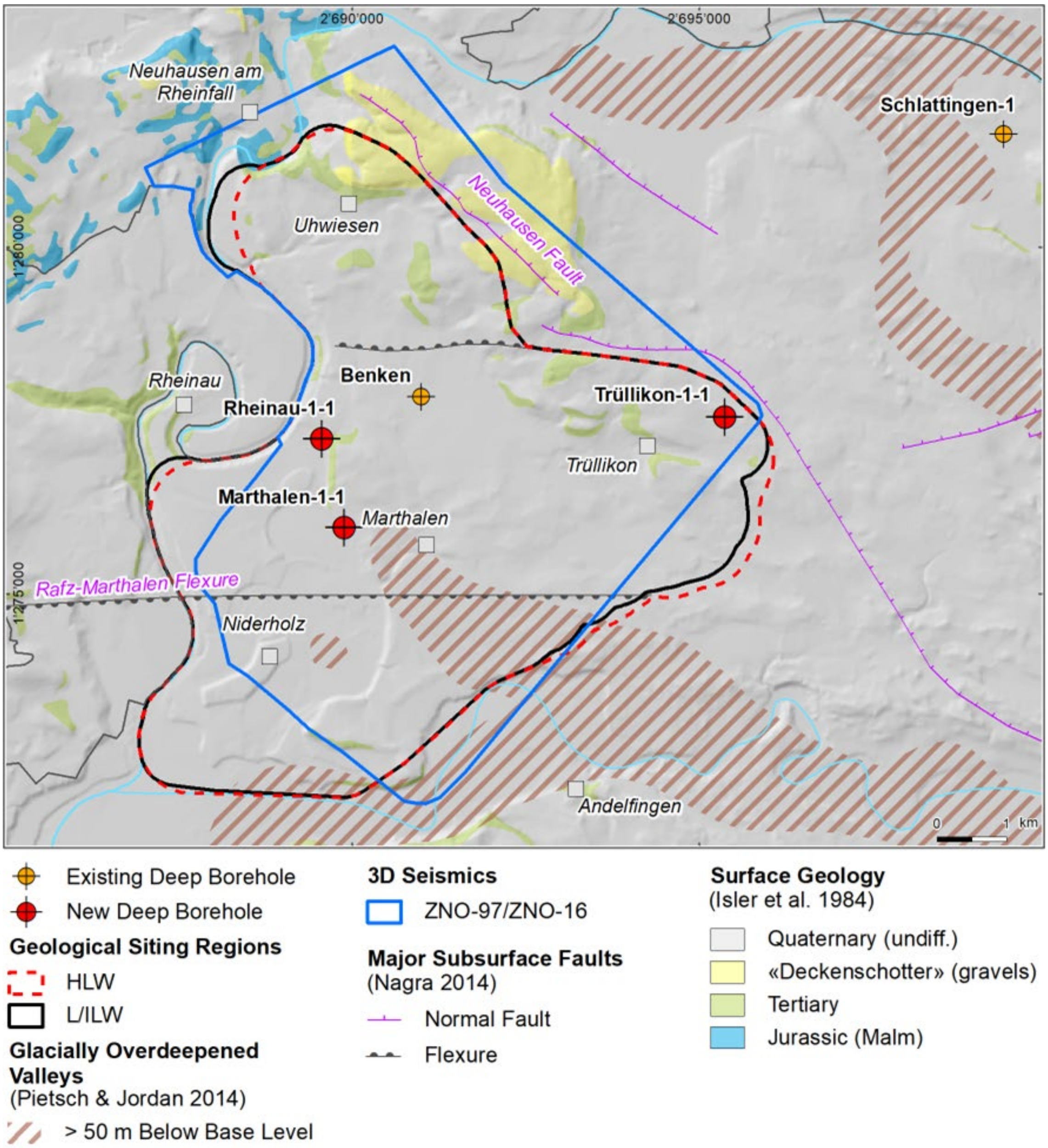


Fig. 1-2: Overview map of the investigation area in the Zürich Nordost siting region with the location of the RHE1-1 borehole in relation to the Benken, TRU1-1 and MAR1-1 boreholes

Exploration objective of the Rheinau-1-1 borehole

In the context of Nagra's TBO project, the Rheinau-1-1 (RHE1-1) borehole is the only deviated borehole. It was planned as a case study with the primary objective of characterising the structural geology of the Opalinus Clay in the area of a steeply dipping fault. Furthermore, dedicated hydrological packer testing and investigations of natural tracers in porewater were conducted to investigate the self-sealing capacity of the Opalinus Clay. More specifically, a stepped constant head injection test was performed in addition to the standard hydraulic packer test to investigate the evolution of transmissivity as a function of effective stress in a fractured interval (*cf.* Dossier VII, Hydraulic Packer Testing for details).

To enable hydraulic testing in the Opalinus Clay with its relatively low strength and high swelling capacity, the maximum borehole deviation (with respect to vertical) was limited to approximately 35° (borehole plunge of 55°). Hence, for the absolute deviation, a trade-off had to be made between maximising the lateral coverage for fracture frequency statistics (large deviation desired) and robust in-situ testing (small deviation desired).

Given the above-outlined scientific goals and related technical requirements, the Rheinau Fault, located immediately east of the Rheinau-1 drill site, was selected for this case study. It is an NNE-SSW trending, steeply dipping fault showing only very minor indications of vertical offsets in seismic amplitude sections. Nevertheless, it was already identified in seismic attribute horizon slices during initial interpretation of Nagra's 3D seismic campaign in the Zürich Nordost siting region (Birkhäuser et al. 2001) and later confirmed during the analysis of follow-up seismic processing products (e.g. Nagra 2019). Fig. 1-3 shows that this fault has a clear seismic attribute expression along the boundaries of the formations below the Opalinus Clay and also along some of the more brittle units above (see horizon slices of the Top Bänkerjoch and Top Villigen Formations shown in Fig. 1-3). However, within the Opalinus Clay, no clear seismic expression is observed. Fig. 1-4 shows the 3D-seismic interpretation considered for trajectory planning of the RHE1-1 borehole together with the discussed and executed borehole trajectories.

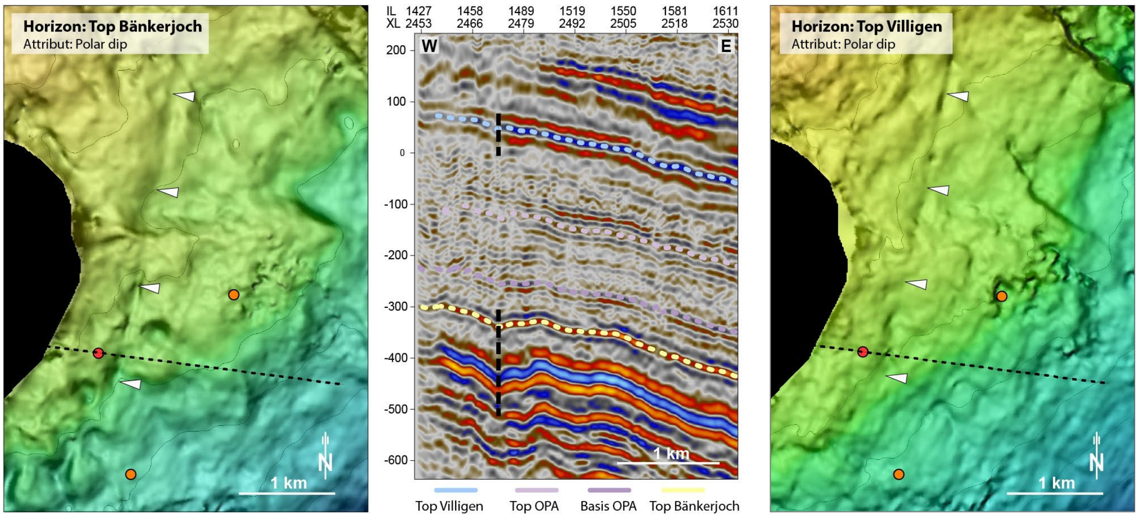


Fig. 1-3: Seismic amplitude cross-section and seismic attribute maps showing the Rheinau Fault

Left and right panels: Seismic attribute maps (polar dip) of a depth-migrated seismic cube (PSDM-A) overlain with depth values (yellowish and blueish colors indicate shallower and larger depths, respectively). The dashed black line indicates the position of the seismic section shown in the central panel. Red and orange dots show the position of the RHE1-1 borehole and neighouring boreholes, respectively. White trianlges mark the lineament representing the Rheinau Fault.

Central panel: Corresponding seismic amplitude section crossing the Rheinau Fault. The vertical axis indicates depth above sea level, and the horizontal axis shows the inline and crossline positions. The approximate trace of the Rheinau Fault above and below the Opalinus Clay is indicated by dashed black lines.

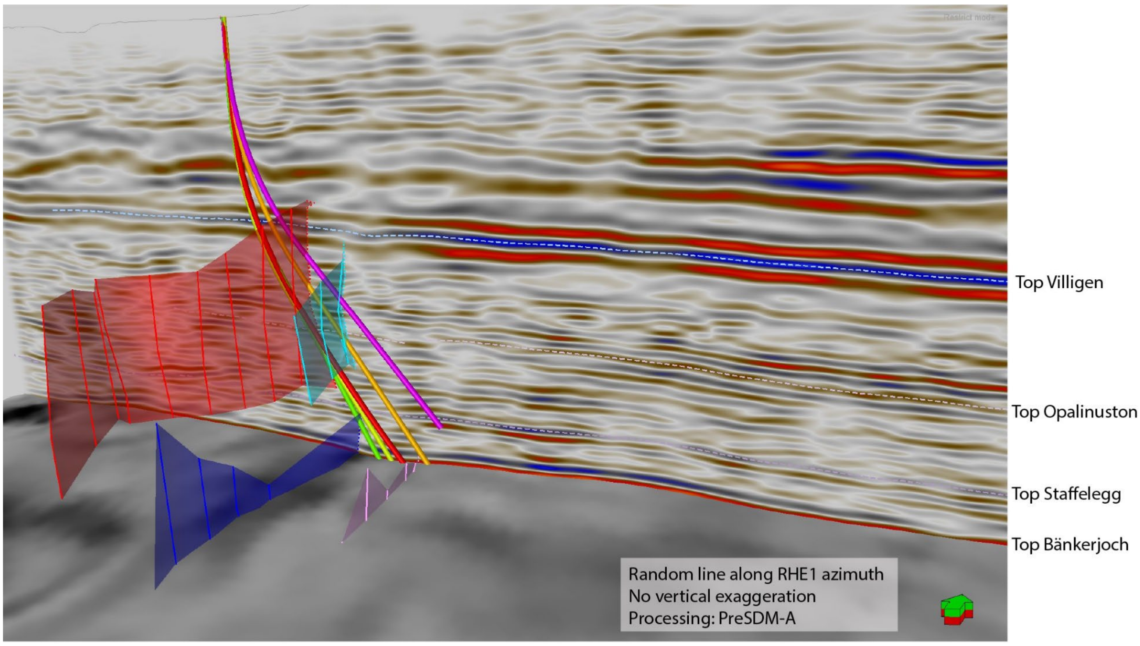


Fig. 1-4: Detailed seismic fault interpretation available for trajectory planning and discussed/ executed well trajectories

Cross-section shows seismic amplitude (seismic processing: pre-stack depth migration PDSM-A). The north direction is indicated by a green-and-red arrow. The vertical distance between the Top Opalinus Clay and Top Staffelegg is ~ 120 m and shows no vertical exaggeration. The horizon slice shows polar dip attribute. Semitransparent subvertical surfaces indicate intepreted faults. The final planned and the drilled trajectories are shown in light green and red, respectively. Other discussed trajectories are shown in yellow, orange and red.

Fig. 1-5 shows a conceptual structural model for the Rheinau Fault incorporating both 3D-seismic interpretations and observations from other exploration boreholes as well as from outcrop studies. This conceptual model shows a pronounced mechanical stratigraphy of Northern Switzerland's Mesozoic sedimentary sequence with more focused deformation in the competent units, and distributed deformation in the incompetent units (Roche et al. 2020). Prior to drilling, three hypotheses were formulated on what the RHE1-1 borehole is likely to encounter in the Opalinus Clay. These hypotheses ranged from 1) absence of a distinct fault zone, likely due to a strong degree of strain partitioning within the rheologically weak Opalinus Clay, 2) one or several prominent fault zones, for example revealing cataclastic fault rock or scaly clay as it has been described to occur along larger faults within the Opalinus Clay (Jäggi et al. 2017) and 3) the former, but including the occurrence of secondary mineralisations.

As this report represents a data documentation, it deliberately avoids engaging in a synthesis of the observations and test results. Nevertheless, the following results can already be highlighted:

- The drilled trajectory was within close limits compared to the planned well path (see Dossier I for a detailed comparison).
- The borehole did not yield any evidence of a larger-scale fault zone within the Opalinus Clay. However, a number of fault planes have been encountered (*cf.* Dossier V).
- In-situ hydraulic packer tests across these features (*cf.* Dossier VII) yielded hydraulic conductivities similar to undisturbed Opalinus Clay.

- The stepped constant head test demonstrated that a significant enhancement of the flow rate can only be achieved in existing fractures if the fluid pressure is raised considerably and the magnitude of elevated fluid pressure can be maintained (*cf.* Dossier VII).
- Excursions in the profiles of natural tracers can indicate past fluid flow. No such irregularities are seen for the RHE1-1 borehole in the Opalinus Clay (*cf.* Dossier VIII). The stable isotope porewater profiles show characteristics similar to the neighbouring vertical boreholes MAR1-1 and Benken.

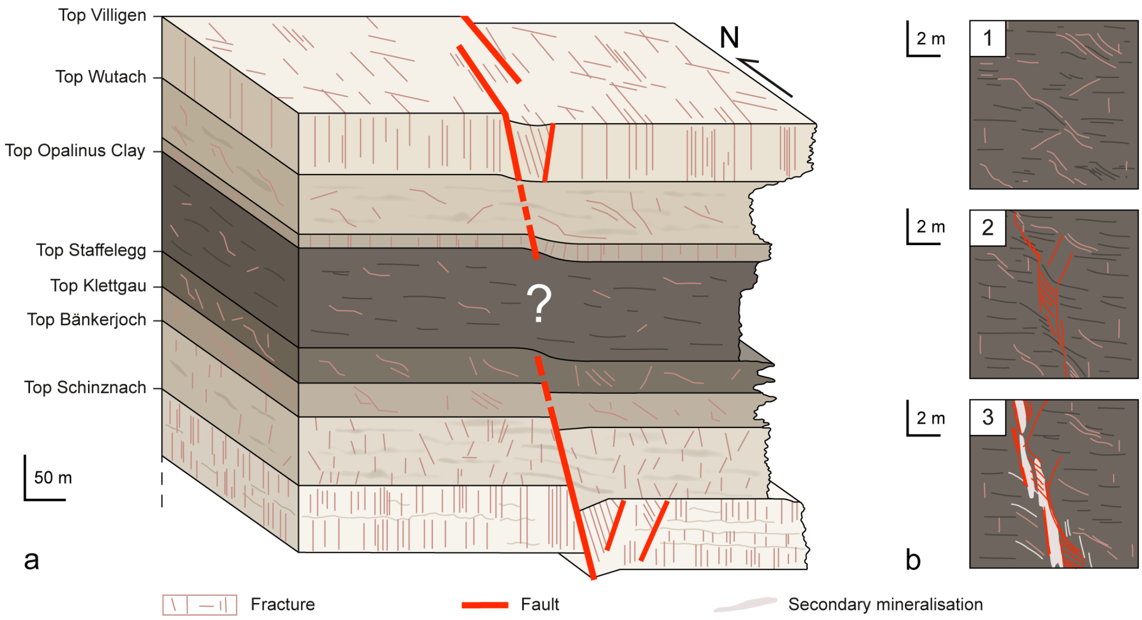


Fig. 1-5: Conceptual structural model of the Rheinau Fault

(a) Conceptual block model. The pronounced mechanical stratigraphy of the Mesozoic sequence in the area is stressed via a schematic weathering profile. The RHE1-1 borehole aimed at characterising the deformation style in the Opalinus Clay constituting a mechanically weak layer in between rheologically stiffer units (e.g. under- and overlying Schinznach/ Bänkerjoch and Villigen/Wutach Formations). According to outcrop records and previous borehole results, these units show a significantly higher frequency of fault planes compared to the Opalinus Clay. In 3D seismics, the Rheinau Fault is also only clearly recognisable at the horizons related to stiffer formations.

(b) Hypothetic deformation characteristics of the Opalinus Clay to be encountered in the RHE1-1 borehole: 1) No exceptional deformation features besides small-scale fault planes as previously observed in vertical boreholes outside of seismically recognised faults. 2) One or several localised zones associated with cataclastic fault rock (e.g. scaly clay) as described for larger fault zones elsewhere (e.g. Jäggi et al. 2017). 3) The above, but also including secondary mineralisation (not to scale on picture).

1.2 Location and specifications of the borehole

The Rheinau-1-1 (RHE1-1) exploratory borehole is the eighth borehole drilled within the framework of the TBO project. The drill site is located in the western part of the Zürich Nordost siting region (Fig. 1-2). The deviated borehole reached a final depth of 827.99 m MD = 745.33 m TVD (true vertical depth)[1]. The borehole specifications are provided in Tab. 1-1.

Tab. 1-1: General information about the RHE1-1 borehole

Siting region	Zürich Nordost
Municipality	Rheinau (Canton Zürich / ZH), Switzerland
Drill site	Rheinau-1 (RHE1)
Borehole	Rheinau-1-1 (RHE1-1)
Coordinates	LV95: 2'689'563.92 / 1'277'235.06
Elevation	Ground level = top of rig cellar: 387.23 m above sea level (asl)
Borehole depth	827.99 m measured depth (MD) = 745.33 m true vertical depth (TVD) below ground level (bgl)
Borehole deviation at total depth (TD)	Inclination from vertical: 38.93° Azimuth from North: 76.25°
Drilling period	19th July – 10th October 2021 (spud date to end of rig release)
Drilling company	PR Marriott Drilling Ltd
Drilling rig	Rig-16 Drillmec HH102
Drilling fluid	Water-based mud with various amounts of different components such as[2]: …0 – 497 m: Polymers 497 – 828 m: Potassium silicate & polymers

The lithostratigraphic profile and the casing scheme are shown in Fig. 1-6. The comparison of the core versus log depth[3] of the main lithostratigraphic boundaries in the RHE1-1 borehole is shown in Tab. 1-2.

[1] Measured depth (MD) refers to the position along the borehole trajectory, starting at ground level, which for this borehole is the top of the rig cellar. For a perfectly vertical borehole, MD below ground level (bgl) and true vertical depth (TVD) are the same. In all Dossiers depth refers to MD unless stated otherwise.

[2] For detailed information see Chapter 3.

[3] Core depth refers to the depth marked on the drill cores. Log depth results from the depth observed during geophysical wireline logging. Note that the petrophysical logs have not been shifted to core depth, hence log depth differs from core depth.

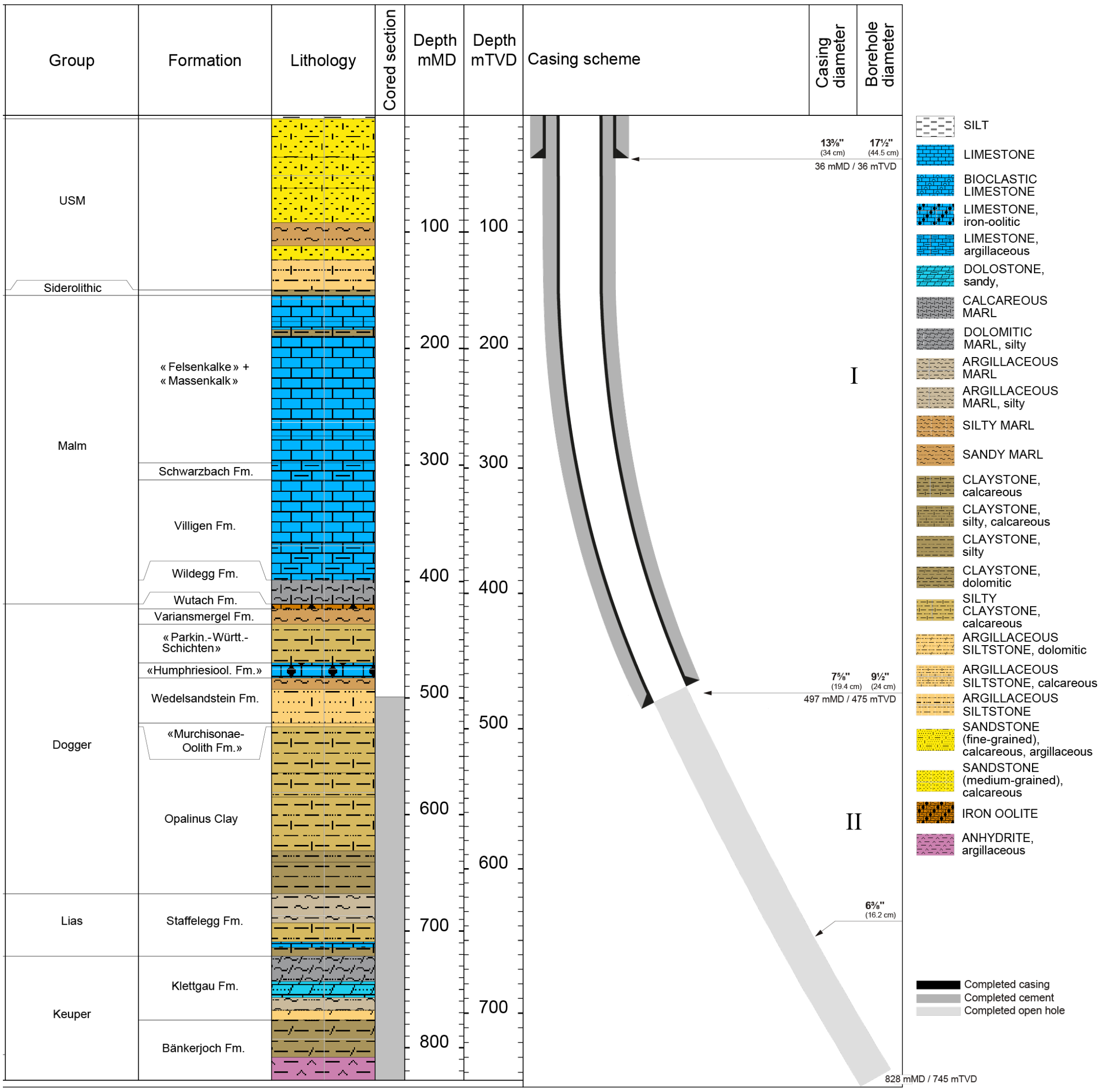


Fig. 1-6: Lithostratigraphic profile and casing scheme for the RHE1-1 borehole[4]

[4] For detailed information see Chapter 3 and Dossier III.

Tab. 1-2: Core and log depth for the main lithostratigraphic boundaries in the RHE1-1 borehole[5]

System / Period	Group	Formation	Core top depth in m (MD)	Log top depth in m (MD)	Core top depth in m (TVD)	Log top depth in m (TVD)
Quaternary						
Paleogene + Neogene	USM		**3**		**3**	
	Siderolithic		149.90		149.88	
Jurassic	Malm	«Felsenkalke» + «Massenkalk»	**154.40**		**154.37**	
		Schwarzbach Formation	298.10		295.71	
		Villigen Formation	312.70		309.70	
		Wildegg Formation	398.80		389.75	
	Dogger	Wutach Formation	419.20		408.04	
		Variansmergel Formation	423.40		411.78	
		«Parkinsoni-Württembergica-Sch.»	436.60		423.47	
		«Humphriesioolith Formation»	469.80		452.23	
		Wedelsandstein Formation	482.80		463.20	
		«Murchisonae-Oolith Formation»	521.43	521.21	495.83	495.64
		Opalinus Clay	524.61	524.33	498.51	498.27
	Lias	Staffelegg Formation	668.07	668.19	617.65	617.75
Triassic	Keuper	Klettgau Formation	**721.46**	**721.50**	**660.95**	**660.98**
		Bänkerjoch Formation	776.42	776.79	704.82	705.11
		final depth	827.99	828.24	745.33	745.52

[5] For details regarding lithostratigraphic boundaries see Dossier III and IV; for details about depth shifts (core goniometry) see Dossier V.

1.3 Documentation structure for the RHE1-1 borehole

NAB 22-03 documents the majority of the investigations carried out in the RHE1-1 borehole, including laboratory investigations on core material. The NAB comprises a series of stand-alone dossiers addressing individual topics and a final dossier with a summary composite plot (Tab. 1-3).

This documentation aims at early publication of the data collected in the RHE1-1 borehole. It includes most of the data available approximately one year after completion of the borehole. Some analyses are still ongoing and results will be published in separate reports.

The current borehole report will provide an important basis for the integration of datasets from different boreholes. The integration and interpretation of the results in the wider geological context will be documented later in separate geoscientific reports.

Tab. 1-3: List of dossiers included in NAB 22-03

Black indicates the dossier at hand.

Dossier	Title	Authors
I	TBO Rheinau-1-1: Drilling	M. Ammen & P.-J. Palten
II	TBO Rheinau-1-1: Core Photography	D. Kaehr & M. Gysi
III	TBO Rheinau-1-1: Lithostratigraphy	M. Schwarz, P. Schürch, P. Jordan, H. Naef, R. Felber, T. Ibele & F. Casanova
IV	TBO Rheinau-1-1: Microfacies, Bio- and Chemostratigraphic Analysis	S. Wohlwend, H.R. Bläsi, S. Feist-Burkhardt, B. Hostettler, U. Menkveld-Gfeller, V. Dietze & G. Deplazes
V	TBO Rheinau-1-1: Structural Geology	A. Ebert, S. Cioldi, E. Hägerstedt, L. Gregorczyk & F. Casanova
VI	TBO Rheinau-1-1: Wireline Logging and Micro-hydraulic Fracturing	J. Gonus, E. Bailey, J. Desroches & R. Garrard
VII	TBO Rheinau-1-1: Hydraulic Packer Testing	R. Schwarz, M. Willmann, P. Schulte, H. Fisch, S. Reinhardt, L. Schlickenrieder, M. Voß & A. Pechstein
VIII	TBO Rheinau-1-1: Rock Properties and Natural Tracer Profiles	J. Iannotta, F. Eichinger, L. Aschwanden & D. Traber
IX		
X	TBO Rheinau-1-1: Petrophysical Log Analysis	S. Marnat & J.K. Becker
	TBO Rheinau-1-1: Summary Plot	Nagra

1.4 Scope and objectives of this dossier

The dossier at hand provides a summary of the drilling operations, including rig site construction, casing tallies, cement bond quality, coring parameters and recovery.

The report is organised as follows:

- Chapter 1 presents the general overview of the drilling campaign and the deviated borehole RHE1-1
- Chapter 2 is dedicated to the drilling technology
- Chapter 3 describes the construction phase, drilling operations and their chronology
- Chapter 4 discusses the health, safety and environmental topic
- Finally, this report includes a set of appendices, which present relevant general project information and further investigation details

1.5 Involved companies

The following companies were involved in the drilling activities of the RHE1-1 borehole:

- Nagra
  - Drilling manager: project management, coordination and organisation of the drilling of the borehole, definition of test aims, quality control, technical drilling supervision, coring, casing running, cementing, logging and testing operations performed in the borehole
  - Drilling engineer: technical drilling supervision, coring, casing running, cementing, logging and testing operations performed in the borehole
  - Health safety & environment (HSE) manager
- PR Marriott Drilling Ltd: drilling contractor
- GEO-data GmbH: mud logging and core handling
- Sirius-Austria: mud engineering
- Fangmann Energy Services: cementing service
- Deutsche Montan Technologie (DMT) GmbH & Co KG and SLB: seismic service
- Schlumberger (SLB) Ltd.: wireline logging and testing, directional drilling
- Monitron AG Polimetra: Gyro survey
- Terratec geophysical services GmbH & Co. KG: wireline logging
- Solexperts AG: hydraulic and gas testing
- Well Engineering Partners BV (WEP): night and day drilling supervisors and HSE specialist
- MICON-Drilling GmbH: wireline coring string

2 Drilling technology

Drilling operation combined wireline coring operations with rotary drilling operations.

The wireline coring string was driven from surface by the top drive. To pull the core to surface, the drill string was kept in the hole and the inner core tube was pulled to surface with a catcher connected to a slick line. Compared with conventional coring, this is much faster and the hole experiences less stress. With this method, short core sections (3 m) can be obtained in better quality without losing much time. Also, the handling of the cores is easier in terms of weight and time required at the surface. In difficult sections of the borehole individual core runs of less than one metre were drilled to increase the core gain and core quality.

For ecological reasons, this system was operated electrically by providing a separate electro-hydraulic main drive unit. The mud pumps were operated by electric frequency adjustable motors.

2.1 Technical data of the drilling rig

The drilling rig of the contractor Marriott was a Drillmec HH102 (102 t operational hook load) semi-trailer with telescopic mast (Fig. 2-1). The draw works had a power of 447 kW. The hydraulic Drillmec topdrive was equipped with 447 kW drive system power (22.5 kNm torque with 140 rpm); mud pumps were two triplex pumps BAMCO F-1000 with a 735 kW power rating for each pump. Three shakers were used. One centrifuge and one flocculation unit were provided by the mud service company. An overview of the general drilling rig data can be found in Tab. 2-1 and a detailed description of the equipment in Appendix C.

Tab. 2-1: General drilling rig data

Rig	Type	Drillmec HH102
	Year of construction	2012
	Owner	Marriott
Mast	Type	Telescopic in compliance with API 4F
	Mast height from ground level (GL)	26.80 m
	Drill floor elevation from GL	4.9 m (false rotary table 5.0 m)
	Max. pull up weight	100 t
	Sheaves of crown block	4
Drilling floor	Height	4.90 m
	Dimensions	4.40 m × 2.10 m
	Clear height under rotary beams	4.39 m

Tab. 2-1: (continued)

Topdrive	Type	Drillmec
	Torque 1, 2, 3	22'500 Nm, 14'500 Nm, 9'000 Nm
	Speed 1, 2, 3	140 rpm, 225 rpm, 360 rpm
	Max. pull up	100 t
	Max. pull down	20 t
	Stroke	16"
Rotary table	Type	Drillmec
	Opening	20½"
	Max. torque	1'000 kgm
	Max. speed	60 rpm
Mud pump	Mud pump 1	6¾ × 10" F-1000 BAMCO
	Power input	1'000 HP
	Pressure max.	176 bar with 6½" piston, 345 bar with 4" piston
	Pump rate max.	1'760 l/min with 6½" piston, 783 l/min with 4" piston
	Stroke	10"
	Stroke per minute max.	150
	Mud pump 2	6¾ × 10" F-1000 BAMCO
	Power input	1'000 HP
	Pressure max.	176 bar with 6½" piston, 345 bar with 4" piston
	Pump rate max.	1'760 l/min with 6½" piston, 783 l/min with 4" piston
	Stroke	7"
	Stroke per minute max.	150
Drill pipe	DP wireline coring	97 × 5½" SK N80/P110 29 kg/m Nagra, 82 × 5" G105 premium G105 19.5 ppf, 55 jts 3½" DP, 15 × 5" HWDP 73.4 kg/m, 9 × 3½" HWDPs 37.7 kg/m
	DC	12 × 8", 12 × 6¾", 10 × 4¾"
Diesel consumption		80 – 120 €/1'000 HP/hr dependent upon drilling activities

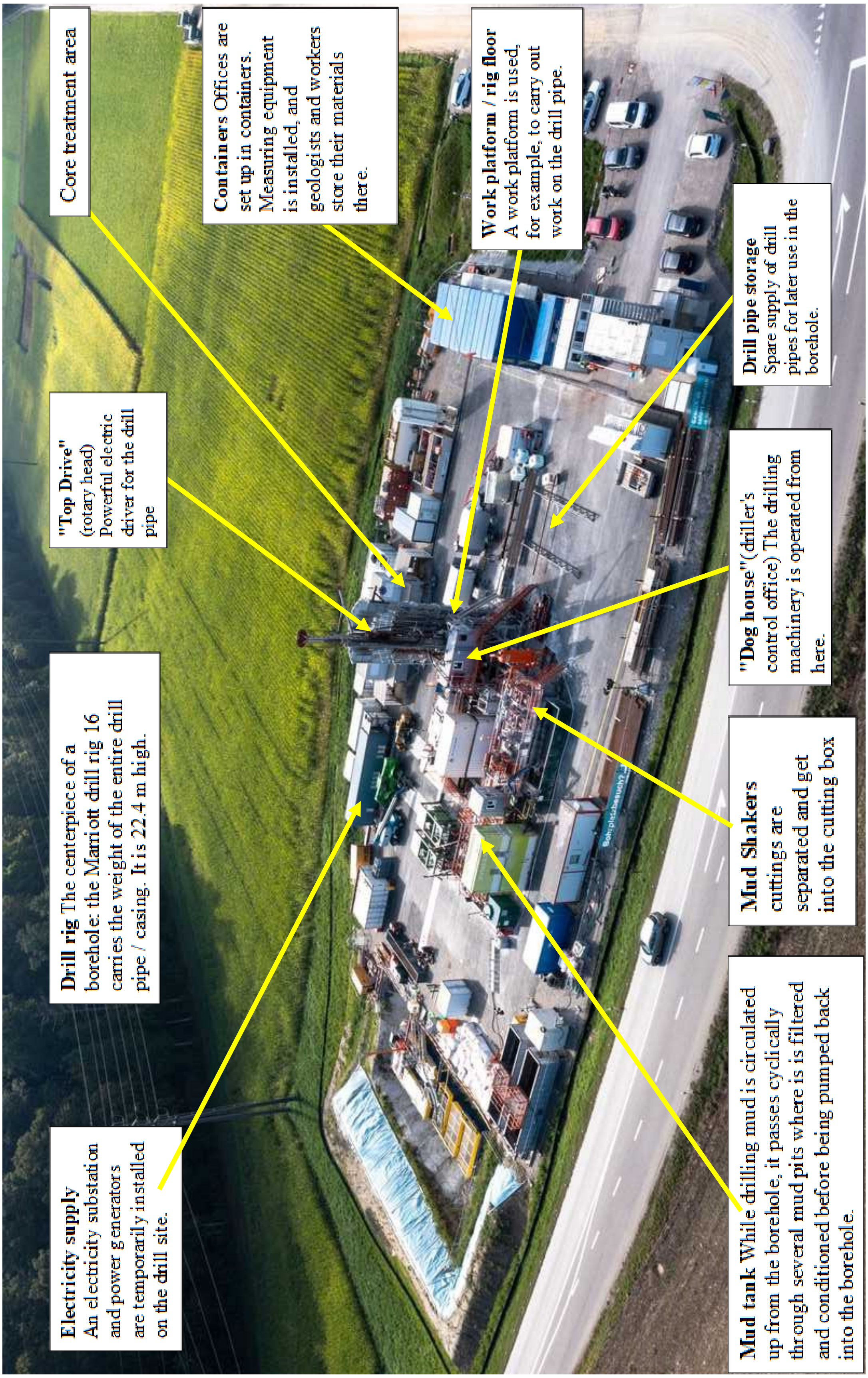


Fig. 2-1: Drilling rig and site

2.2 Drilling tools

2.2.1 Drill string and wireline coring string

Two different drill strings were used for the RHE 1-1 borehole. A 5½" wireline coring string (SK 5½" B, N80) from the manufacturer MICON-Drilling GmbH (MICON-Drilling 2016) was mainly used for coring operations (see Appendix H) and a 5" drill string (G105, #19.5) was mainly used for destructive drilling, hole opening and drilling out cement and float equipment.

Wireline core barrels were used to ensure complete recovery of the cores without pulling out the drill string. This technique speeds up core retrieval, reduces time-consuming drill rod handling and helps to maximise coring efficiency. The catching assembly is attached to a wireline winch system and lowered into the wireline drill string. The overshot securely interlocks with the latching head. Subsequently, the core-filled inner tube system can be hoisted out through the wireline drill string.

The wireline coring system used for the RHE 1-1 borehole consisted of a core bit, inner and outer core barrels, core catcher, core pipes, stabilisers as well as crossovers and other spare parts and consumables. The drilling diameter was 6⅜" (161.9 mm) resulting in a core diameter of 95 mm. All cores were drilled with plastic liners for protection and higher quality of the cores. These plastic liners allowed simplified handling of the cores, eliminating mechanical impacts such as hammering or pumping out the core from the inner core barrel. It enabled transport of the cores to the core handling table in one piece. The core was then removed from the plastic liner by pushing it out by hand or cutting the liner along the longitudinal axis. Core lengths up to 6 m could be reached with the wireline coring system, but to decrease the exposure time of the core in the drilling fluid and during sampling, the core length was set to 3 m.

Compared to conventional drill pipes, the wireline coring pipes with an average length of 9 m have slick tool joints, which means that the outer diameter of the pipe body and the tool joint are identical. Tool joints have no shoulders and the diameter of 5½" is the same along the entire drill string. This prevents flow restrictions and improves hole cleaning during coring within the small annulus between the formation and the coring string.

For drilling operations other than coring, conventional 5" drill pipes were used as they have standard connections which makes assembling the BHA much easier compared to the coring string, which has non-standard connections. The outer diameter of the tool joint is larger (168 mm) than the body of the 5" drill pipe to accommodate the threads. Furthermore, these shoulders provide stiffness to prevent bending and breaking. Due to the large diameter at the tool joint, the 5" drill pipes with an average length of 9.6 m did not fit into the 6⅜" borehole.

2.2.2 Core bits

The 5½" wireline coring string allows to use 6⅜" (161.9 mm) core bits; the core barrel OD (outer diameter) is 152.4 mm with a core diameter of 95 mm. Three different types of core bits (see Fig. 2-2) were used in the RHE1-1 borehole:

- Thermally stable diamond (TSD) core bit, also called "Synset":

  This type of core bit is designed for medium hard to hard and medium abrasive formations. TSD cutters consist of multiple layers of synthetic diamond fragments. This feature gives TSD cutters a self-sharpening property.

- Diamond-impregnated matrix core bit:

  This type of core bit is designed for medium hard to extremely hard formations, but also for less abrasive to very abrasive rocks. Multiple layers of synthetic diamond fragments are sintered into a hard metal matrix. This compound has self-sharpening properties during progressive abrasion. Worn diamonds are released and replaced by new ones until the matrix compound is completely eroded. This core bit is available with different types of matrix.

- Polycrystalline diamond compact bit (PDC)

  This bit is a drilling tool that uses polycrystalline diamond compact (PDC) cutters to shear rock with a continuous scraping motion. The cutters are synthetic diamond disks and are designed for high-speed drilling in shale, limestone and sandstone formations.

Fig. 2-2: Synset core bit (left) and impregnated core bit (right)

Fig. 2-3 shows different core bit options for soft formations on the left to hard formations on the right.

Fig. 2-3: Different types of available core bits

From left to right: impregnated, PDC, synset/ballas set, surface set.

A bit summary including bit grading, coring runs and drilling parameters for RHE1-1 is available in Appendix F.

The 9½" directional section was drilled with a rotary steerable system (RSS) using a PDC bit.

3 Drilling operations

3.1 Overview

Drilling began on 19.07.2021 at 06:30 p.m. and, including the scientific investigations carried out in the borehole, continued until 18.08.2021 at 11:30 a.m. With a final depth of 828 m MD (drilling) and 827.99 m MD (coring), 14 m deeper than planned. The Opalinus Clay was encountered between 524.61 m MD (498.51 m TVD, total vertical depth) and 668.07 m MD (617.65 m TVD), resulting in a thickness along hole of 143.46 m and a true vertical thickness of 119.14 m, with a drilling inclination between 32.5° and 35°.

To protect the groundwater, an 18⅝" outer diameter (OD) standpipe was run to 35.8 m and cemented before the drill site construction started.

The first section was drilled with a 9½" Smith polycrystalline diamond compact (PDC) bit, a matrix body, directional bit with 7 blades and a PDC cutter with a diameter of 16 mm. The first bottom hole assembly (BHA) was a rotary BHA with near bit (NB) stabiliser and string stabiliser that was used to drill to 50 m and pick up (P/U) the SLB rotary steerable system (RSS) PowerDrive Xceed. The mud used was a water / polymer system with a density of 1.01 SG (specific gravity) to 1.07 SG.

The PDC bit was pulled after 53 h at 497 m MD. The bit drilled with an average rate of penetration (ROP) of 8.43 m/h. The borehole was kicked off at 102 m MD and inclination was built from vertical to 32.4° to the east. Deviation surveys were taken every 20 m and the maximum dogleg severity (DLS) measured was 3.44°/30 m. The BHA measured inclination, azimuth, gamma ray, resistivity and sonic while drilling. Petrophysical logging was run on a SLB wireline (WL) tool-string including a general purpose inclinometer tool (GPIT) survey. The 7⅝" casing was run to 496.10 m MD and cemented as per programme with 14.8 m^3 of cement with a density of 1.65 SG.

The remaining section from 497 m to 828 m MD was continuously cored with two impregnated 6⅜" core bits using WL technique. Triple core barrels with synthetic liners were used and core recovery was 100% (328.89 m recovered from 328.90 m). The water-based mud was exchanged to K-silicate mud.

To keep the drilling inclination without directional control, the coring BHA was designed with three fully-gauged stabilisers at 0.52 m, 7.79 m and 17.49 m from the bit. As contingency, in case the borehole would run off target direction, 3½" drill pipes (DP), heavy weight drill pipes (HWDP), 4¾" DCS 4¾" measurement while drilling (MWD) tools and motor were on standby from SLB. The inclination and direction of the well were checked with electronic multi shots (EMS) performed by MICON-Drilling GmbH.

Petrophysical logging including Ultrasonic imager tool (USIT) and cement bond log (CBL) was run before the hydraulic testing started. Unfortunately, the gas threshold pressure test (GTPT) in the Opalinus Clay was stopped after 46 h due to a leaking packer. At surface the packer and flatpack lines appeared damaged because the centraliser and steel straps did not prevent a contact point on the low side of the string. Because time was needed to replace the packer, the hydraulic test BHA for the Lias was RIH for 113 h. The GTPT BHA was RIH with several modifications and remained 261 h below the RT. The BOP was tested before the final test BHA in the Opalinus Clay was RIH for 445 h. The borehole investigations were completed with a VSP and the borehole was backfilled with four cement plugs to surface. To prevent contact of the K-silicate mud with the cement, the mud was replaced by NaCl brine with 1.20 SG and a spacer was pumped before the cement.

Work was completed in 83 working days (continuous 24 h operation) after spud-in until finishing with cement back to surface and rigging down the BOP. The RHE1-1 borehole was initially planned to be completed in 55 d, meaning the actual time was 28 d longer than planned. A detailed analysis of the reasons the actual job duration was longer than planned is documented in Appendix O.

Scientific investigations in the borehole add up to 51% of the total time, specifically 28% for hydraulic tests, 15.1% for GTPT and 7.9% for logging. The drilling activities including casing runs and cement jobs add up to 41% of the total time.

While drilling the borehole, no losses were recorded.

Regarding HSE, no first-aid case was reported. There were no lost-time incidents and no spills.

3.2 Drill site construction and standpipe

Start of execution

Prior to the work preparation, a technical investigation was carried out for the drill site. Based on the soil tests, the subsoil was found to have a varying thickness of 0.30 cm to 0.90 cm. With the large areas under stress, the removal of subsoil and topsoil was considered unpractical, particularly because the available landfill area was too small. Therefore, a layer of gravel was placed on the existing soil. An exception was the drainage pit.

Nagra decided to build the drill site with two drill cellars in order to have sufficient opportunities to achieve the defined aims. The cellars were built at a distance of 5 m directly behind each other. In the end, the goals could be achieved with the use of one cellar (one well) only.

The water supply as well as the electrical supply could be managed by the nearby networks of local providers. Based on the experience with the previous TBO drill sites, the available parking spaces were expected to be limited. Therefore, it was decided to build a gravel strip along the existing road to generate additional parking spaces.

During construction, the diverter line was still in use at Stadel-3-1 with the rig on top. To use the same line, specially manufactured concrete covers were placed to ensure that trucks could drive over them and to enable later installation.

Construction engineering of the drill site and standpipe

The construction of the drill site started in September 2020 (LANDOLT + Co. AG construction company, Kleinandelfingen) and after a break continued in May 2021. Figs. 3-1 and 3-2 show the rig site during construction (see also Appendix E).

The standpipe hole and mousehole installation was carried out by a special construction company (Birchmeier Spezialtiefbau AG) in April 2021. The work was carried out in an early stage directly on the gravel ground. Oilfield casings with a diameter of 13⅜" were used for the standpipe hole and the mousehole. The cellar was stiffened with a steel structure for post-operation and covered with steel plates and gratings.

During the installation of the drilling rig, the drill site had to be slightly adjusted in the area of the doghouse and the mud tanks because the slope of the site (2%) did not allow the placement. Likewise, the height of the drilling cellar walls had to be adjusted. A concrete curb was constructed around the tanks to separate the rainwater from the drilling water.

Fig. 3-1: Picture of the drill site

Fig. 3-2: Drilling the hole for the 13⅜" standpipe

3.3 Drilling chronology of the RHE1-1 borehole

Below is a chronology of all working steps of the RHE1-1 borehole. Details can be found in the daily drilling reports (DDR) in Appendix J.

Sept 2020 – July 2021	• Drill site construction
19.07.2021 – 01.08.2021	• Rig – accepted by ENSI on 19.7.21 and spud. • RIH 9½" BHA, drilled to ca. 50 m MD • Drilled with 9½" bit from 50 m to 497 m MD; drilled directionally with RSS with ring resistivity, gamma ray and sonic logging while drilling (LWD) tools; planned inclination of 3°/30 m, final inclination of 32.4° 20 m hold section • Petrophysical logging full suite: 8 runs in total • Casing to 496.13 m MD • Cemented 7⅝" casing, cement dumped at surface with 1.64 SG, float held • Drilled out float, shoe and 2 m new formation and changed mud from water based to K-silicate • Cored from 499.10 m to 549 m MD
02.08.2021 – 15.08.2021	• Cored from 549 m to 792 m MD
16.08.2021 – 29.08.2021	• Cored from 792 m to 828 m MD • Petrophysical logging (including USIT and CBL) • Hydraulic test OPA1 with BHA #07; GTPT cancelled because of packer damage • Hydraulic test LIA1 with BHA #8; LIAS double packer hydraulic test cancelled because connection to packer was damaged when RIH • Hydraulic tests LIA1 with BHA #9
30.08.2021 – 12.09.2021	• Hydraulic tests LIA1 with BHA #9 • Hydraulic test OPA1 (GTPT) • Hydraulic tests OPA2a, OPA2b, OPA2c and OPA2d (including fluid exchange, step head injection and self-sealing); ongoing
13.09.2021 – 26.09.2021	• Hydraulic tests OPA2a, OPA2b, OPA2c and OPA2d (including fluid exchange, step head injection) with BHA #13 with redressed dual packer system; ongoing
72.09.2021 – 11.10.2021	• Hydraulic tests OPA2a, OPA2b, OPA2c and OPA2d (including fluid exchange, step head injection) with BHA #13 with redressed dual packer system • VSP run • Changed silicate mud to NaCl brine and rigged up cementing service • Set four cement plugs to surface

3.4 Time analysis

Work was completed in 82.92 working days (continuous 24 h operation) after spud-in until finishing with cement back to surface and rig down of the BOP. The RHE1-1 borehole was initially planned to be completed in 54.67 d, meaning the actual time was 28 d longer than planned.

The time analysis in Appendix O shows, that scientific investigations in the borehole add up to 51% of the total time: 28% for hydraulic tests, 15.1% for GTPT and 7.9% for logging. The drilling activities, including casing runs and cement jobs, add up to 41% of the total time.

Out of the 28 d difference between actual and planned schedule, logging accounts for 4.9 d, hydraulic testing for 14.9 d, drilling (Marriott) for 4.2 d while 6.8 d were NPT. Cementing was 2.1 d shorter than planned and the Gyro run took 0.1 d less than planned.

3.5 Casing scheme

The casing diameter, grade of the steel, weight per ft, type of connection and depth along hole are:

0 m to 35.8 m MD   13⅜" conductor casing, K55, 68 lbs/ft, buttress thread connection (BTC)

0 m to 496.1 m MD   7⅝" casing, K55, 29.7 lbs/ft, BTC

The tally list of the casing with the positions of centraliser and connections and individual joint descriptions is given in Appendix H.

3.6 Drilling process

The drilling operations combined wireline coring and rotary drilling techniques (Tab. 3-1). To ensure the planned drilling trajectory, a rotary steerable system (RSS) from SLB (PowerDrive Xceed) was applied.

Tab. 3-1: Hole diameter drilled from top to bottom

From [m MD]	**To** [m MD]	**Hole diameter** [in]	**Drilling method**
0	35.8	34.64 (880 mm)	Rotary with support casing
34.5	497.0	9½"	Rotary
497	828	6⅜"	Coring

3.6.1 13⅜" conductor / standpipe to 35.8 m MD

A subcontractor (Birchmeier Spezialtiefbau AG) was hired to install the standpipe. A Gyro measurement and a cement evaluation log were run.

3.6.2 Section I: 35.8 m to 497.0 m MD

Before drilling started, a diverter line and a connecting line to a 40 m^3 tank were installed. The setup was tested and approved by the Nagra DSV (drilling supervisor).

The 9½" hole was drilled with BHA #1 using a PDC bit from Smith from 36.40 m to 50.00 m MD, with 7 × 11/32" nozzles. Average ROP was 6.89 m/h. The BHA was POOH to P/U the RSS BHA with PowerDrive Xceed. The BHA was POOH without problems. The condition of the bit was excellent at surface and was graded 0-0.

The second BHA was RIH with the same bit, and drilled from 50.00 m to section TD at 497.0 m MD. The condition of the bit was excellent at surface and was graded 0-0 again.

The section was drilled into the Wedelsandstein Formation where the 7⅝" casing was set 90 cm above the bottom and cemented up to surface.

The mud system used was Pure-Bore® water-based with a mud density between 1.01 SG and 1.07 SG. The inclination was measured every 20 m with MWD tools and the well was built from kick-off point (KOP) at 112 m MD to 32.4° inclination with 098.00° azimuth. The BHA was POOH without problems and eight wireline runs were performed by SLB. Before the casing was RIH, a check-trip was performed with a 9½" roller cone bit from Smith.

The 7⅝" casing (29.7 pounds per foot [lbs/ft], grade K55, BTC) was RIH without problems. The last joint was run to 496.10 m MD.

The casing was cemented through a stinger with 14.8 m^3 of cement (1.65 SG). The cement was seen at surface and had a density of 1.64 SG. A total of 6 m^3 of cement and mud contaminated with cement were dumped. No losses occurred during the cement job. The top of cement (TOC) was later found to be at 13 m.

3.6.3 Section II: 497 m to 828 m MD

The cement and float equipment were drilled out with a 6⅜" Glinik roller cone tooth bit. Before the float collar was drilled, the casing was pressure tested with 50 bar and MW of 1.08 SG – good result. Additional formation was drilled from 497.0 m to 499.1 m. The borehole was circulated clean and then a FIT was performed to an EMW of 1.75 SG (mud density of 1.08 SG, 490 psi (34 bar) on surface). A coring BHA was RIH to 496.0 m MD, a Gyro survey was run by Polymetra and the BHA cored to 501.0 m MD, where the mud was changed out to K-silicate with 1.20 SG.

Coring was performed with an impregnated core head until 543.0 m MD before the BHA was POOH because the core had gotten stuck, and ROP was low. An impregnated core bit was RIH and cored to section TD at 828.0 m MD in one run. To check the trajectory of the borehole, an EMS was run by MICON-Drilling GmbH, initially every 18 m and later every 36 m. The EMS was initially run on a MICON winch, then on a Marriott core winch and later again on the repaired MICON winch. In general, the borehole kept the azimuth and built a slight upward inclination with the stiff rotary coring BHA. To reduce built, the BHA was turned faster from surface and weight on bit (WOB) was decreased. The EMS were quality checked by a Polymetra Gyro run in and out from 450 m to 590 m MD. The coring BHA was POOH and ten WL runs (including USIT and CBL) were performed by SLB before the GTPT BHA was RIH to 603.11 m MD. After 62 h the BHA was POOH because one of the packers was not sealing. At surface it was observed that the packer and parts of the flatpack were damaged. The double packer hydraulic testing BHA was

RIH to have time to replace the damaged packer and the Lias formation was tested for 156.5 h. Afterwards, a check trip was run with the core bit before the GTPT BHA was RIH again for 262 h. Before the last hydraulic test in the Opalinus Clay was performed, the BOP was tested and a check trip with the core bit was performed without problems.

Because the hydraulic test was extended, the VSP had to be postponed and the rig had to wait for 73.5 h for the new scheduled VSP. SLB ran a calliper log before the geophones were RIH and the seismic measurements were performed.

3.6.4 Cementing back to surface

To prevent flush set of the cement when it gets in contact with K-silicate mud, this mud was exchanged to NaCl brine with a mud density of 1.20 SG. Four plugs were pumped to reduce the time and pressure on the formation. For the first plug (from 828 m to 611.4 m MD), Fangmann Energy Services pumped 4 m^3 of spacer, 4.9 m^3 of cement with a density of 1.65 SG, 0.6 m^3 of spacer and 1.1 m^3 of mud without recorded losses. A volume of 7 m^3 of contaminated spacer, cement and brine was disposed of from the cellar. When the cement head was disconnected, the cement plug was blowing for all four plugs, meaning that the level of the cement was higher in the annulus than in the 2⅞" tubing string, as planned. The BOP was closed and reverse-circulated for the first three plugs. The first reverse circulation was performed at 617 m MD and the string was pulled back to 598.0 m MD. After waiting on cement (WOC) for 20 h TOC was tagged at 611.4 m MD.

For the second plug, Fangmann pumped 4 m^3 of spacer, 4.8 m^3 of cement with a density of 1.65 SG, 0.6 m^3 of spacer and 0.5 m^3 of mud without recorded losses. Reverse circulation was performed at 411.0 m MD and 1 m^3 of cement with a density of 1.56 SG and 6 m^3 of contaminated spacer and brine were returned to the cellar. After WOC for 20 h TOC was tagged at 410.11 m MD.

For the third plug, Fangmann pumped 4 m^3 of spacer, 4.9 m^3 of cement with a density of 1.65 SG, 0.6 m^3 of spacer and 0.2 m^3 of mud without recorded losses. Reverse circulation was performed at 195.0 m MD and 13 m^3 of contaminated cement / spacer / brine were returned to the cellar and disposed of.

For the last plug, Fangmann pumped 4 m^3 of spacer, 4.6 m^3 of cement with a density of 1.65 SG and 0.3 m^3 of mud without recorded losses. After the 2⅞" tubing string was pulled, the mule shoe was cemented. TOC was tagged at 17 m below the cellar.

3.7 Drilling fluids

The scope of this project was to obtain detailed geological information concerning formation properties and behaviour in the area of interest. This was achieved through coring and a series of measurements and tests conducted downhole.

Regarding the drilling fluids, the following priorities were set:

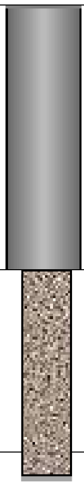
- guarantee that cores are of good quality
- maintain the formation stability during tests lasting days or weeks
- minimise fluid interaction with the formation and keep the content of drill solids as low as possible

- drilling fluid should not cause any problems or impediments to operations at the drill site
- ensure that all activities are conducted in safe and responsible manner, with the target being zero incidents

All goals were fulfilled. Recovered cores were of good quality, tests were conducted without any problems and drilling fluid did not impede the operations. Good collaboration with drilling contractor's HSE personnel ensured no accidents.

The borehole consists of two sections. Section II was cored completely. In Section I, a water-based polymer drilling fluid (DF) system was used, while Section II was completed using a highly inhibitive K-silicate system. To prevent flush set of the cement, the mud was replaced to NaCl brine with 1.20 SG before the borehole was cemented back to surface. The performance of the system met the expectations and operations were completed successfully, avoiding numerous issues encountered in the offset borehole. The drilling fluid parameters for both sections are given in Tabs. 3-2 to 3-5.

Tab. 3-2: Sections drilled and fluid properties

Hole size [in]	**Casing size** [in] **Depth** [m MD]	**Casing programme**	**Planned depth MD** [TVD]	**Actual depth MD** [TVD]	**Length drilled** [m]	**Incl.** [°]	**Mud system / density** [SG]	**Planned days** [d]	**Actual days** [d]
9½	7⅝ 496.1		400	497 (475.70)	497	32.40	Polymer DF (1.04 to 1.08)	30	10
6⅜			814	828 (745.05)	331	38.93	K-silicate DF polymer / NaCl (1.20) Polymer (1.02 to 1.22)	26	72

3.7.1 Pure-Bore® mud, Section I

The drilling fluid ingredients and the fluid properties for Section I are given in Tabs. 3-3 and 3-4.

Tab. 3-3: Fluid ingredients for Section I

Section no.	**Ingredients**
Section I	Polymer drilling fluid, soda ash, sodium bicarbonate, defoamer, polyanionic cellulosic polymer (PAC), Flowzan

The polymer DF system performed as expected and provided stable viscosity, good hole cleaning and borehole stability. The 7⅝" casing was set at 496.10 m MD without any issues. In total 97.9 m³ of fluid were used to drill this section.

Tab. 3-4: Fluid properties for Section I

See also Appendix L.

Parameter	Unit	Min	Max	Average
Mud weight	[SG]	1.04	1.08	1.07
Plastic viscosity	[cP]	9	16	11
Yield point	[lb/100 ft^2]	10	19	13
Solids	[vol.-%]	3	4.0	3
Sand	[vol.-%]	0.2	0.5	0.23
Methylene blue test (MBT)	[kg/m^3]	0	14	10
pH	-	9.8	10.6	10.1

The rig was equipped with three shale shakers. One was additionally fitted with a desander / desilter unit. The three shakers were processing the active mud system. All shakers were equipped with API 100 and API 120 screens. The mud cleaner was also equipped with an API 200 screen. In addition to this equipment, two Sirius-ES high performance centrifuges (type Flottweg Z3E and Z4E) with a floc unit were processing the drilling fluid system and were applied as required to maintain the proposed mud parameters. Flocculation was not necessarily due to geology and usage of fine mesh screens.

Solids control: cuttings were loaded in specially constructed skips that were hauled off from the location for further treatment. Each transport / loading was documented in the data management system with the corresponding weighing slip. The coordination of the drilling waste transportation could be performed in a timely accurate and safe way. During the entire drilling phase, it was possible to recover 4 m^3 of mud from the cuttings box, thereby reducing the need for waste disposal and the amount of freshly mixed mud.

3.7.2 Silica mud, Section II

The drilling fluid ingredients for Section II are presented in Tab. 3-5, and the fluid properties of the K-silicate mud for this section are listed in Tab. 3-6.

Tab. 3-5: Fluid ingredients for Section II

Section no.	**Ingredients**
Section II	Silica mud, K-silicate, sodium bicarbonate, soda ash, defoamer, Flowzan, citric acid, PAC

Section II (497.0 m to 828.0 m MD) was drilled from 29.07.2021 to 09.10.2021 in 72 days. The first part of Section II was drilled with the mud from the previous interval. After drilling out the cement and an additional 2 m of new formation the polymer mud was displaced with K-silicate mud (1.12 SG) from the previous project in Stadel-2-1. During circulation and before starting to core, the density of the mud was increased to 1.20 SG. The borehole was cored with a 6⅜" bit to a depth of 828 m MD without any problems. Some increase in viscosity and contamination with calcium ions occurred during coring of anhydrite close to TD, but these issues were not serious enough to influence operations in any way. They were monitored but sufficient material was available on location to conduct treatment. An additional sweep with a high viscosity (HV) pill was performed at TD, but no further cuttings were observed in the returns, proving adequate hole cleaning.

Check trips were conducted periodically during the tests. During each trip the condition of the mud was checked and a bottom up (B/U) sample was taken and stored as a reference. No mud treatment was necessary and hole conditions were acceptable. The final operations related to testing were a VSP and a caliper run, which were also successful. In total, 11.7 m^3 of fresh mud were mixed during drilling of the second section, while 31 m^3 of mud were stored after Stadel-3-1 and were available to begin drilling the section. The total volume of silicate mud used in Section II was 42.7 m^3. To avoid the reaction of the K-silicate mud with the cement, it was decided to displace K-silicate mud with saltwater-polymer mud with 1.20 SG. In total, 41 m^3 of the NaCl mud were mixed, which was the minimum volume needed for circulation, including 5 m^3 of the HV spacer needed for displacement. The borehole was abandoned by setting four cement plugs from the bottom to the surface in a four-stage cement job.

Solids control: only one of the three shakers available was routinely used and was equipped with API 270 screens (the finest available). When the amount of material in returns became difficult to handle for one shaker, or the mud with increased viscosity was circulated, other shakers (API 230 screens and API 120 screens) were temporarily used as required. One centrifuge was running continuously during coring.

Tab. 3-5: K-silicate fluid properties for Section II

Parameter	Unit	Min	Max	Average
Mud weight	[SG]	1.12	1.20	1.19
Plastic Viscosity	[cP]	9	21	12
Yield point	[lb/100 ft²]	6	21	13
Solids	[vol.-%]	2	5.1	3
Sand	[vol.-%]	0.0	0.2	0.02
Methylene blue test (MBT)	[kg/m³]	0	0	0
pH	-	11.2	12.8	12.6

3.8 Cementation

The casing diameter, grade of steel, weight per ft, type of connection and depth along hole are listed in Section 3.5. Tab. 3-6 displays the cement volume and cement specifications.

Tab. 3-6: Cementation

From [m MD]	**To** [m MD]	**Amount** [m³]	**Specification**
0	35.8	16	CEM III 42.5HRS (1.88 SG)
12.2	497	14.8	CEM III 32.5HRS (1.65 SG)
828	611.4	4.9	CEM III 32.5HRS (1.65 SG)
611.4	410.11	4.8	CEM III 32.5HRS (1.65 SG)
410.1	195	4.9	CEM III 32.5HRS (1.65 SG)
195	surface	4.6	CEM III 32.5HRS (1.65 SG)

3.8.1 13⅜" conductor casing

The conductor hole was drilled, run and cemented by Birchmeier Spezialtiefbau AG. Standard oil filed 13⅜" casings were used for the conductor and the mousehole:

0 m to 35.8 m MD 13⅜" surface casing, K55, 68 lbs/ft, BTC

3.8.2 7⅝" anchor casing

0 m to 497.0 m 7⅝" casing, K55, 29.7 lbs/ft, BTC

A tally list with positions of centraliser and connections as well as individual joint descriptions is given in Appendix H.

The 7⅝" casing with 29.7 lbs/ft was cemented to surface. Cement volume was 14.8 m^3 with a density of 1.65 SG. For cementing chart and programme see Appendix N.

A CBL and USIT were acquired to evaluate the integrity of the cement and control the casing collar locations (Appendix N). From 3 m to 12.2 m MD the cement has poor bond with a free pipe at the top of the borehole. The bond log shows strong casing signals. From 12.2 m to 500 m MD the cement has medium to good bond. The TOC is located at 12.2 m MD.

3.8.3 Well abandonment

Well abandonment was performed in four stages:

First stage from 828 m to 620 m MD: A total of 4 m^3 of spacer with 1.33 SG, 5.1 m^3 of cement with 1.65 SG and 1.3 m^3 of displacement fluid was pumped. After a flow check it was POOH to 615 m MD, reverse-circulated and a volume of 7 m^3 of spacer, cement and interface with a maximum measured density of 1.58 SG was dumped.

Second stage from 611 m to 411 m MD: A total of 4 m^3 of spacer with 1.33 SG, 5.0 m^3 of cement with 1.65 SG and 1.0 m^3 of displacement fluid were pumped. After a flow check it was POOH to 410 m MD, reverse-circulated and a volume of 7 m^3 of spacer, cement and interface with a maximum measured density of 1.56 SG was dumped.

Third stage from 401 m to 195 m MD: A total of 4.0 m^3 of spacer, (freshwater), 5.1 m^3 of cement with 1.65 SG and 0.4 m^3 of displacement fluid was pumped. After a flow check it was POOH to 213 m MD, reverse-circulated and a volume of 13 m^3 of spacer, cement and interface with a maximum measured density of1.33 SG was dumped.

Fourth stage from 195 m to 0 m MD: A total of 4.0 m^3 of spacer (freshwater), 5.1 m^3 of cement with 1.65 SG and 0.3 m^3 of displacement fluid was pumped. After a flow check, 4 m^3 of spacer and cement were dumped.

3.9 Borehole deviation

The borehole was drilled approximately as planned. The RHE1-1 borehole is almost vertical from 0 m to 122 m MD (log depth). From 122 m to 500 m MD (log depth), the inclination increases linearly until it reaches 32° (deviation as measured from the vertical) in an easterly direction. From 500 m MD (log depth) until the final depth, the inclination continues to increase linearly from 32° to 38.93°, still towards the east. The maximum DLS measured is 3.52°/30 m at 639.0 m MD and it is caused by a big turn. The rotary coring BHA built up inclination and deviated to the left. This deviation allowed additional distance to the east to be checked for the presence of the fault plane, so it was no longer necessary to drill a second borehole. The final survey report was created combining different survey sections from standpipe Gyro, SLB MWD surveys and from MICON EMS surveys. Plan view and section view show the departure from origin at 827.99 m MD with 296.03 m to the east and 29.97 m to the south.

Plan view, section view and survey stations for the RHE1-1 borehole are given in Appendix E and in Fig. 3-3 below.

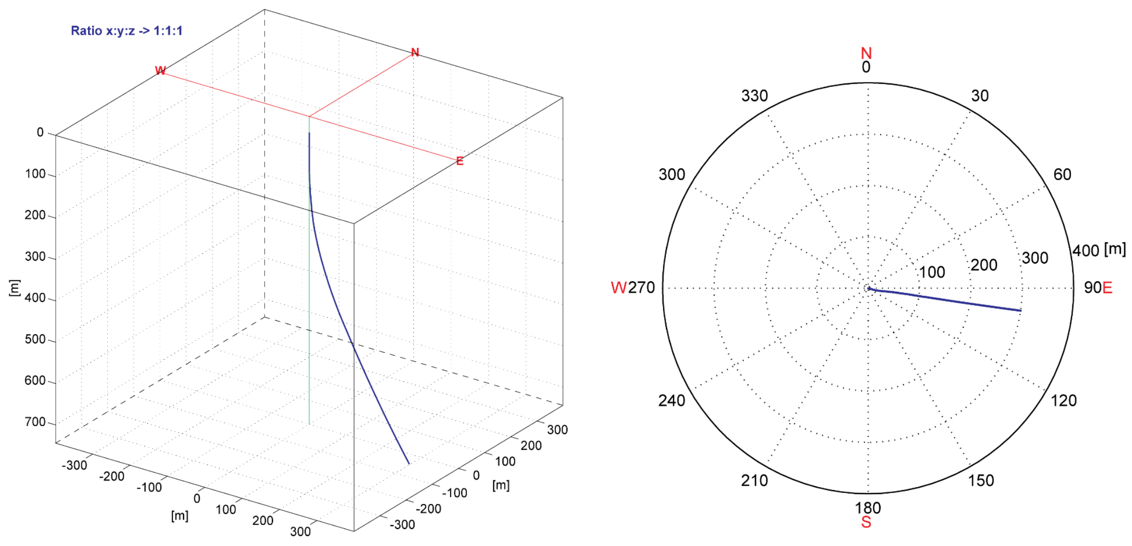


Fig. 3-3: Borehole deviation within the cored section

The left image visualises the borehole path in 3D with a compressed z-axis. The borehole azimuth is shown on the right.

4 Health, safety and environment

4.1 Health and safety

The health and safety of employees, contractors and subcontractors of Nagra are of vital importance. Therefore, several measures were taken during planning and performance of the drilling campaign to reduce hazards to a minimum and to create safe working conditions.

All drill sites were fenced to protect workers from external influences and to define a clear barrier for people and animals which are not allowed to access the drill site. Additionally, the drill site was permanently guarded by a security service during the entire drilling phase. The security guards were also responsible for performing detailed access controls.

To respect the different ATEX zones around the drilling rig, the drill site was divided into a restricted area and a non-restricted area. Access to the restricted area was allowed only with the correct personal protective equipment (PPE), consisting of:

- Overall / Jacket
  - anti-flammable
  - anti-static
  - high visibility
- Safety shoes
  - S3
  - mid height
- Safety helmet
- Safety glasses
- Safety gloves

Within the restricted area, it was not permitted to have any non-explosion-proof electrical devices to prevent hazardous sparks within the ATEX zone.

A firefighting and rescue plan with specific procedures for emergency situations was in place for the drill site. Furthermore, the drill site was equipped with emergency exits, muster points, fire-extinguishers, first aid kits and alarm signals. Evacuation drills and trainings were carried out with the onsite personnel on a weekly basis to practice correct behaviour in emergency situations.

Daily shift changes always started with pre-job safety meetings to make the rig crew aware of potential hazards on location. Special jobs such as cementing required additional safety meetings together with subcontractors to address all planned work steps and further safety instructions.

Life-saving rules were implemented which everyone visiting or working at the drill site had to follow. These rules set out the minimum requirements for controlling the risk of serious injury from common activities.

The drilling contractor had a STOP card system in place that allowed all persons onsite to address positive and/or negative observations at the drill site related to HSE. These STOP cards were collected and analysed to pinpoint problems that needed to be addressed and improved for the future. Good cards served as feedback and motivation on excellent performance.

During the entire duration of the drilling phase in RHE1-1, no restricted work cases and only 4 minor first-aid cases were reported. Having zero lost time incidents (LTI) proved that the regular emergency training of the personnel onsite was successful.

As for previous boreholes, additional safety rules were implemented due to the COVID-19 pandemic. No infections were recorded on the drill site during the entire project.

4.2 Environment

4.2.1 Environmental supervision and monitoring

Due to official regulations, the entire project had to be accompanied by an environmental supervisor. This supervisor was responsible for advising and informing Nagra on environmental aspects and for consulting external experts if necessary.

The tasks of the environmental supervisor during the drilling phase were:

- to communicate transport routes
- to verify whether environmental requirements and protective measures were respected for transporting and drilling activities
- to check if the drainage concept was respected and working properly
- to check if the lighting concept was respected and whether further measures were necessary
- to check the machinery list and particle filters of all vehicles and machines
- checking the storage of hazardous substances
- to check the emergency power generator and its leakage detection system
- the conduction of leakage tests of wastewater and sewage pipes
- to check the storage, separation and disposal of waste at the drill site
- to check if legal noise limits were complied with

The drill site was inspected on a regular basis. No major findings were identified, and official regulations were all fulfilled.

4.2.2 Wastewater

A dewatering concept was prepared according to official regulations and approved by the cantonal authorities. The drill site water was led into a settling basin via a sand trap, an oil separator and a pump shaft. The settling basin was emptied and disposed of from time to time by a specialised company. In case of heavy rainfall, the water in the settling basin overflew and was then discharged via the seepage gallery and the pump shaft for infiltrations.

The wastewater and septic water were led into a separate tank, sucked out and disposed of also by a specialised company.

4.2.3 Pedological site support

The drill site was constructed in an agricultural zone. Several official regulations thus had to be fulfilled during the construction and drilling phase. The project was accompanied by a pedological site support, and a soil protection concept was developed to define the pending work steps.

The removal of soil at parts of the site was carried out in September 2020 and May 2021 during dry weather. Intermediate soil storage was accomplished directly on the topsoil in accordance with the requirements of the Canton of Zürich. A fence for the protection of amphibians was installed around the drilling location.

The pedological site support was responsible for maintaining and checking the quality of the soil on a regular basis. No findings were reported during the entire duration of the project.

4.2.4 Noise

The noise limits for immissions at nearby properties were during daytime 60 dB(A) and 50 dB(A) at night. As there were no inhabited buildings in the vicinity, these values could be complied with without any problems.

4.2.5 Lighting

Beside noise emissions, light emissions were also relevant for the drill site. Proper lighting at the workspace is indispensable in terms of safety for the crew but must not affect the surrounding environment. Therefore, warm-white LED lamps were installed at the site to reduce the harmful blue content in the emitted spectrum, being more environmentally friendly for wildlife and people.

4.2.6 Waste management

Waste material from the drilling process was categorised and disposed of according to the regulations of the Federal Office for the Environment (FOEN).

In every section of the borehole, a detailed analysis of the cuttings and drilling fluid was performed at a specified laboratory to classify the waste materials.

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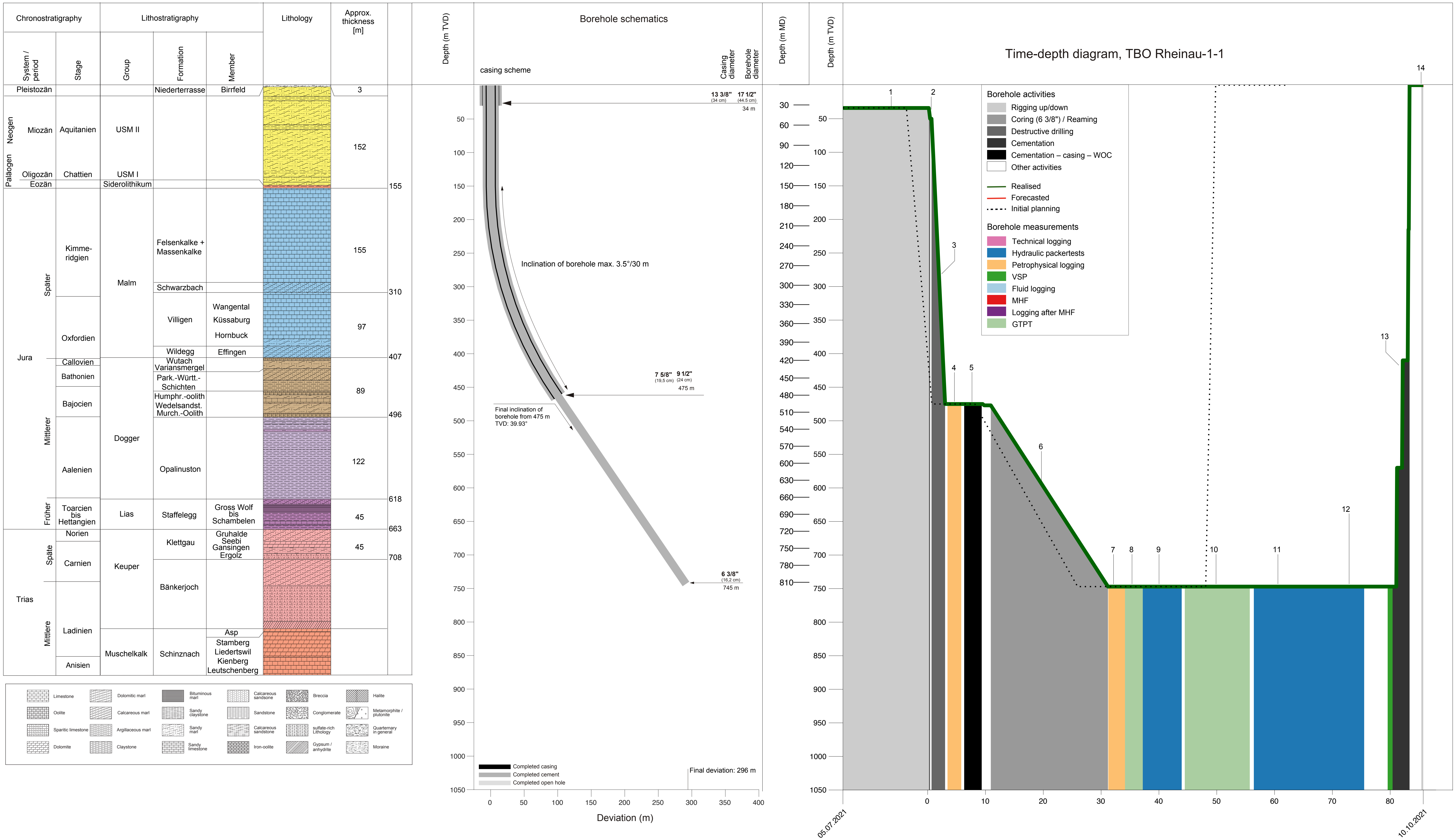

Numbering of the main operational steps

1: Rig up Marriott`s rig 16, 13 3/8" conductor already installed
2: RIH 9 1/2" BHA, WBM SG 1.1 and drill to +/- 50m
3: Drill 9 1/2" from 50 - 497 m. Directional with RSS, plan 3°/30m, 32.5° final Inclination, 20m Hold
4: Petrophysical Logging full suite
5: Cementation, Casing & WOC
6: Coring with 6 3/8" core bit. Check well path with Survey single shots
7: Petrophysical Logging (including USIT and CBL)
8: Hydraulic Test Opa 1 - GTPT
9: Hydraulic Test LIA 1
10: Hydraulic Test Opa 1 - GTPT
11: Hydraulic Test Opa 2 a,b,c,d (incl. Fluidexchange, step head injection, "self sealing") / parallel Mini Vibro Seismic on 27th of September
12: Caliper run & VSP
13: Cementation back to surface
14): Rig down Mariott`s rig 16

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Time-depth diagram - Rheinau-1-1: programme as performed

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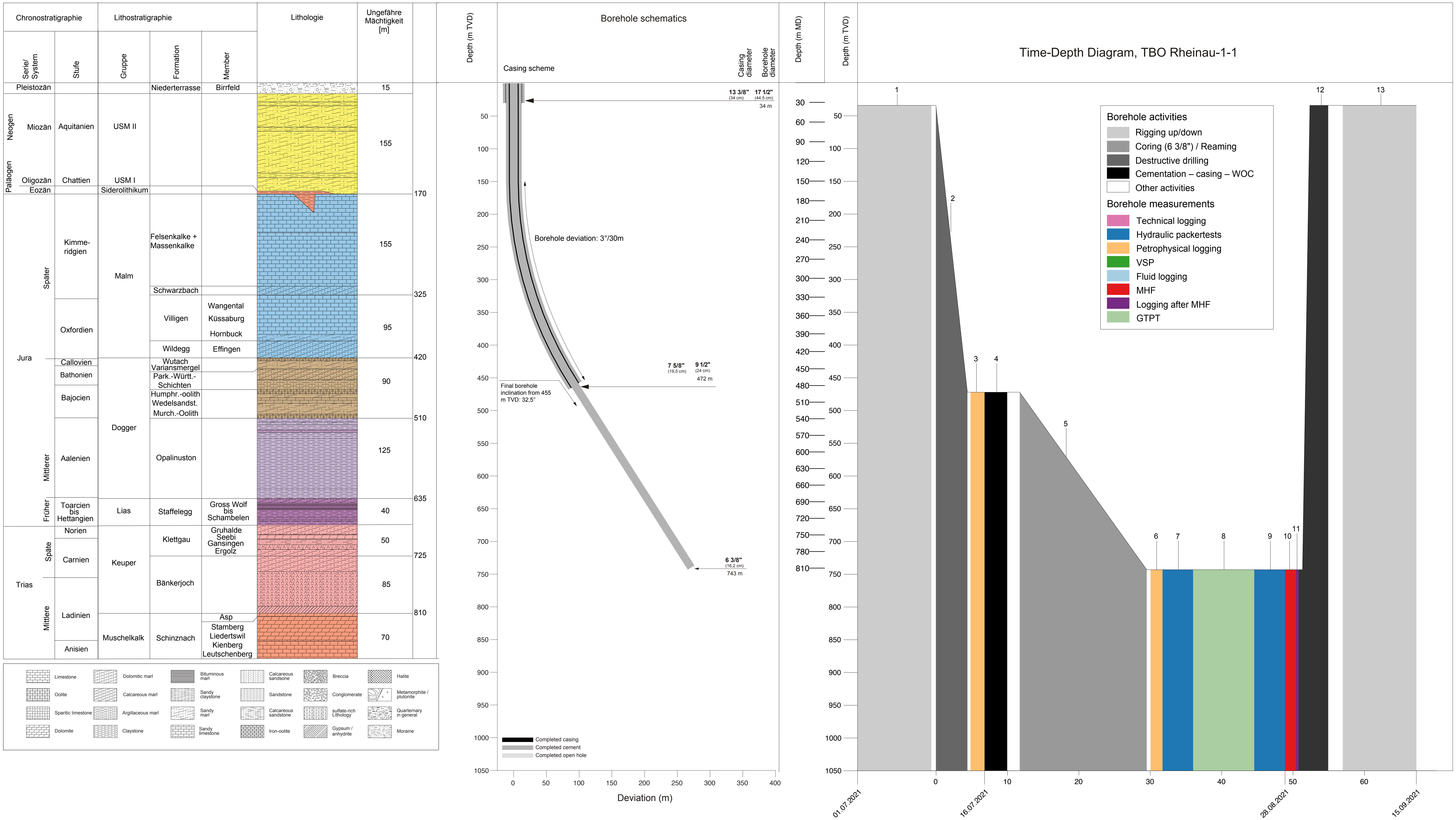


Numbering of the main operational steps

1: Rigging up drill rig (Marriott Rig 16), 13 3/8" conductor already installed, optional diverter line
2: Drilling 9 1/2" from 33.8 to 492 m. Downhole Motor and Oriented (RSS). Planned 3°/30m, 32.5° final deviation, 20 m Hold
3: Petrophysical logging incl. survey log, if Gyro by SLB available
4: Cementation, casing & WOC
5: Coring 6 3/8" from 492 to ca. 814 m. Check trajectory with survey single shots
6: Petrophysical logging
7): Hydraulic test Opa (incl. rigging up)
8: Hydraulic test GTPT
9 : Hydraulic test Opa (incl. rigging down)
10: MHF
11: Logging after MHF
12: Cementation to surface
13: Rigging down drill rig (Marriott rig 16)

nagra	NAB 22-03
Time-depth diagram - Rheinau-1-1: programme as planned	
Dossier I	DAT.: Jun. 2023 — Appendix B

Appendix C: Technical data of the rig

Tab. C-1: Derrick / mast, substructure, draw works and associated equipment

A 1	Derrick / mast		
	Manufacturer		Drillmec
	Type		Telescopic HH102
	Year of construction		2012
	Free height	m	16 (topdrive stroke)
	Minimum nominal gross capacity (with 8 lines)	kN	978.61 (100 MT)
	Nominal hook load (with 8 lines)	kN	Not applicable
	Crown block		
	Gross capacity	kN	978.61
	Nominal capacity	kN	978.61
	Racking capacity		
	5" string incl. DC	m	1'767
	3½" string incl. DC	m	2'356
A 2	Substructure		
	Manufacturer		Drillmec
	Type		
	Year of construction		
	Width	m	2.9
	Clear height below rotary table beams up to	m	4.87
	Setback capacity up to	kN	978.61
	Casing / rotary capacity	kN	978.61
	Setback capacity at max. rotary capacity	kN	978.61
	BOP installation equipment		Yes
A 2.1	Drillfloor		
	Size	m^2	35
	Height of windbreaks on rig floor	m	2.5
	Drainage system		Yes
	Kelly hole	Yes / no	Not applicable
	Mousehole	Yes / no	Yes / with hydraulic clamp

Tab. C-1: continued

A 3	Draw works		
	Manufacturer		Drillmec
	Type		Hydraulic RAM
	Year of construction		2012
	Number of electric motors		1
	Drive system power	kW	447
	Maximum cable tension, 2nd layer	kN	Not applicable
	Auxiliary brake		Drillmec hydraulic
	Automatic feed system		
	Manufacturer		Drillmec
	Type		Pipe handler
A 4	Drilling and coring lines		
A 4.1	Drilling line		
	Diameter	mm	34
	Type		Diepa AF 2371C
	Minimum breaking load	kN	652
A 4.2	Coring wireline		Millenium wireline
	Diameter	mm	8
	Length	m	2'000
A 5	Dead line anchor		
	Manufacturer		Drillmec
	Type		Yoke pinned
A 6	Crown block and hook		
A 6.1	Crown block		
	Manufacturer		Drillmec
	Type		Fixed to mast telescopic section
	Year of construction		2012
	Capacity	kN	978.16
	Crown block safety device		Drillmec kinetic
A 6.2	Hook		
	Manufacturer		Drillmec
	Type		Double hook
	Year of construction		2012
	Capacity	kN	978.61

Tab. C-1: continued

A 7	Swivel		
	Manufacturer		Drillmec
	Type		
	Year of construction		2012
	Static capacity	kN	978.61
	Pressure rating	bar	344.7
A 8	Auxiliary winches		
	Number		1
	Type		Hydraulic
	Maximum cable load, 1st layer	kN	49.82
B 1	Rotary table		
	Manufacturer		Drillmec
	Type		Independently hydraulically driven
	Maximum opening	inch	20.5
	Static capacity	kN	978.61
	Number of electric motors		2 × hydraulic motors
	Drive system power	kW	447
	Maximum rotary speed	min^{-1}	60
B 2	Topdrive		
	(Electric / hydraulic)		Hydraulic
	Manufacturer		Drillmec
	Model		HH 102
	Drive system power	kW	447
	Static capacity	kN	978.61
	Dynamic capacity	kN	
	Maximum torque	Nm	32'330
	Continuous torque	Nm	1'129
	Maximum rotary speed	min^{-1}	154
	Rotary speed at continuous torque	min^{-1}	53

Tab. C-1: continued

C 1	Mud pumps		
	Number		2
	Manufacturer		Baoji
	Model		MP-1000
	Drive system (electric)		Motor
	Power rating	kW	746
	Maximum pressure	psi / bar	5'000 / 350
	with liner		
	Size	in	4"
	Maximum flow rate	l/min (140 spm)	2'484 × 2
	with liner		
	Size	in	6¾"
	Stroke length	in	10"
C 2	Standpipe(s)		
	Number		1
	ID	in	18⅝
	Working pressure	psi / bar	5'000 / 350
C 3	Rotary hose		
	Number		1
	ID	in	3½"
	Working pressure	psi / bar	7'500 / 517
C 4	Circulation head	4½" IF × Fig 1'502	
C 5	Wash lines		Not applicable
	ID	in	
D 1	Active tanks		
	Total capacity	m^3	82.83
D 1.1	Shaker tank		
	Capacity	m^3	46
	Number of chambers		4
	Sand trap	m^3	11.5
	Agitators		
	Number		4
	Power	kW	14.91
	Mud guns		
	Number		

Tab. C-1: continued

D 1.2	Intermediate tank		
	Number		1
	Capacity	m^3	51
	Number of chambers		3 (22 m^3, 15 m^3)
	Agitators		
	Number		2
	Power	kW	14.91
	Mud guns		
	Number		4
D 1.3	Suction tank		
	Number		1
	Capacity	m^3	37.36
	Number of chambers		2
	Agitators		
	Number		2
	Power	kW	14.91
	Mud guns		
	Number		2
D 2	Mixing system		
D 2.1	Mix tank		
	Capacity	m^3	45.47
	Pill tank capacity	m^3	3.97
	Agitators		
	Number		2
	Power	kW	14.91
D 2.2	Mix funnels		
	Number		1
D 2.3	Mix pumps		
	Number		21
	Manufacturer		Baker
	Type		Electric
	Power rating	kW	75
D 3	Chemical mixing tank		
	Capacity	m^3	0.23

Tab. C-1: continued

D 4	Mud treatment equipment		
D 4.1	Shale shakers		
	Number		3
	Manufacturer		Swaco
	Type		Mongoose
	Drive system		Electric motors
	Power rating	kW	
	Screen area	m^2	4.065
D 4.2	Desander		
	Number		1
	Manufacturer		Swaco
	Type		2-12T 6T4
	Number of cyclones		2
	Diameter of cyclones	in	12"
	Cyclone capacity	l/min	3'785
	Feed pump		
	Number		1
	Manufacturer		Forum
	Type		8" × 6" × 14"
	Drive system (electric)		Electrically driven
	Power rating	kW	75
	Rotary speed control	Yes / no	No
D 4.3	Desilter		
	Number		1
	Manufacturer		Swaco
	Type		2-12T 6T4
	Number of cyclones		12
	Diameter of cyclones	in	4"
	Cyclone capacity	l/min	3'406
	Feed pump		
	Number		1
	Manufacturer		Forum
	Type#		8" × 6" × 14"
	Drive system (electric)		Electrically driven
	Power rating	kW	75
	Rotary speed control	Yes / no	No

Tab. C-1: continued

D 4.4	(Vacuum) degasser Number Manufacturer Type Capacity	 l/min	 1/atm MISwaco Mechanical 3'785
D 4.5	Flowline magnets Number		
D 5	Additional tanks and silos		
D 5.1	Reserve tanks Number Type Total capacity Agitators Number Power	 m^3 kW	 1 Bulk tank 47 2 14.91
D 5.2	Drinking-water tanks Number Total capacity	 m^3	 Not applicable
D 5.3	Drilling water tanks Number Total capacity	 m^3	 1 (or as needed) max. 3 45
D 5.4	Dry material silos Number Total capacity	 m^3	 2 100
E 1	Drive system (electric)		Hydraulically electrically driven
E 2	Power requirement	kVA	447
E 3	Diesel engines Number Manufacturer Type Power rating At revs	 kW min^{-1}	 Not applicable, see E 5

Tab. C-1: continued

E 4	Torque converter (only for diesel-mechanical rigs) Number Power rating	 kW	 Not applicable
E 5	Generators (only for diesel-electric rigs) Number Manufacturer Power rating	 kVA	 5 Caterpillar 500 each
E 6	SCR system (only for diesel-electric rigs) Manufacturer		 Bauer, Schrobenhausen
E 7	Auxiliary power supply (400 V / 50 Hz) Number Manufacturer Power rating	 kVA	 2 Caterpillar 180
E 8	Fuel tanks Number Capacity With EX-protection Leak detection	 m^3 Yes / no CMR electrical	 1 20.892 Yes Type: ODS2-2
E 9	Rig service air system Number Volume Working pressure Storage capacity Air dryer unit	 m^3/min bar l 	 2 3.6 10.34 Yes Yes
F 1	Diverter system Manufacturer Type Size Side outlets quantity Side outlets size H_2S rating	 in in Yes / no	Drilltech R73 21¼" 2 9" No

Tab. C-1: continued

F 1 (continued)	Diverter lines Length Nominal ID Manual valves Number Working pressure Hydraulically actuated valves Number Working pressure	 m psi / bar psi / bar	 57 10" 2 580 / 40 1 Max. 2'000 / 140
F 2	Annular preventer Number Manufacturer Type Size Pressure rating H_2S rating	 in psi Yes / no	 1 Hydril 13⅝" 5'000 Yes
F 3	Ram type preventer Number Manufacturer Type Size Pressure rating H_2S rating Side outlets quantity Side outlets size	 inch psi Yes / no in	 1 Shanghai Shenkai Double gate 13⅝" 5'000 Yes 2 4¹⁄₁₆"
F 4	Ram types		
F 4.1	Pipe rams Number Size	 sets in	 2 3½" to 5" (variable)
F 4.2	Blind / shear rams	sets	1 (kit) each
F 4.3	Variable bore rams Number Size (from – to)	 sets in	 2 (depending on the borehole control programme) 2⅞" to 5"

Tab. C-1: continued

F 5	Drilling spools		
	Side outlets quantity		2
	Side outlets size		4¹⁄₁₆"
	Spacer spools		2 × 13⅝"
F 6	BOP control system		
	Manufacturer		Shaffer
	Type		5 stage T20120-35
	Total capacity	l	1'059
	Bottle working pressure	psi / bar	3'000 / 210
	Annular pressure control valve	Yes / no	Yes
	Electric pumps		
	Number		1
	Capacity	l/min	15.52
	Air pumps		
	Number		2
	Capacity	l/min	227
	Remote control panels		
	Number		2
	Locations	(driller / toolpusher etc.)	Drill floor
F 7	Choke / kill lines		
	H_2S rating	Yes / no	Yes
F 7.1	Choke manifold		
	Nominal ID	in	3⅛"
	Working pressure inlet	psi / bar	5'000 / 350
	Working pressure oulet	psi / bar	5'000 / 350
	Flanges with wear plugs	Yes / no	No
	Manual choke		
	Number		1
	Nominal ID	in	2"
	Remote choke		
	Number		1
	Nominal ID	in	2"
	Automatic control	Yes / no	Yes

Tab. C-1: continued

F 7.2	Choke lines		
	Number		1
	Type		
	Nominal ID	in	3
	Length	m	10
	Working pressure	psi	5000
	Manual valves		
	Number		10
	Working pressure	psi / bar	5'000 / 350
	Hydraulically actuated valves		
	Number		
	Working pressure	psi / bar	5'000 / 350
F 7.3	Kill lines		
	Number		1
	Type		
	Nominal ID	in	3
	Length	m	
	Working pressure check valve	psi / bar	5'000 / 350
	Manual valves		
	Number		
	Working pressure	psi / bar	5'000 / 350
	Hydraulically actuated valves		
	Number		
	Working pressure	psi / bar	5'000 / 350
F 7.4	Poor boy degasser / mud gas separator		
	Capacity	m^3/min	3.78
	Volume	l	3'418
F 7.5	Flare line		
	Length	m	On demand / as needed
	Nominal ID	in	
	Working pressure	psi / bar	8 - 10
F 7.6	Flare		
	Height	m	On demand
	OD	in	
	Ignition system		remote

Tab. C-1: continued

F 8	BOP test equipment		
F 8.1	Test unit / test pump Working pressure Pressure recorder	 psi / bar Yes / no	 High pressure pump 10'000 / 700 Yes
F 8.2	Cup type tester As per casing programme	 Yes / no	 Yes
F 9	Kelly cocks Number Connection type Working pressure H_2S rating	 psi / bar Yes / no	 1 Drill pipe fitted 5'000 / 350 Yes
F 10	Drop-in valves Number OD ID Working pressure Landing nipple OD ID Connection type	 in in psi / bar in in 	 1 Depending on drill pipe size See above 5'000 / 350 Depending on drill pipe size See above Depending on drill pipe connection
F 11	IBOP / gray valve Number Connection type Working pressure	 psi / bar	 1 Connected to the topdrive 5'000 / 350

Tab. C-1: continued

G 1	Drill string		
	OD	in	5" to 3½"
	Total length	m	3'000
	Nominal weight	lbs/ft	19.5/15.5 and/or 13.3
	Range		R 2
	Grade		G105
	Class		Premium
	Connection type		NC 50 / NC 38
	Tool joint OD	in	6½" – 5 IEU
	Tool joint ID	in	3" – 2⅛"
	Hard facing	Yes / no / type	Yes
	Internal coating	Yes / no / type	No
G 1.1	Coring string		
	OD	in	5⅝"
	Inner barrel OD	in	4⅝"
	Total length	m	1'500
	Nominal weight	lbs/ft	13.5
	Joint length	m	9
	Grade		
	Class		N/P
	Connection type		CSK / NSK
	Tool joint OD	in	5½"
	Tool joint ID	in	4⅞"
	Hard facing	Yes / no / type	No
	Internal coating	Yes / no / type	No
G 2	Pup joints		
	Number / length	m	3 × 1 m
	Number / length	m	3 × 2 m
	Number / length	m	3 × 3 m
			Other lengths available on request

Tab. C-1: continued

G 3	HW drill pipe		
	Number		12
	OD	in	5
	Nominal weight	lbs/ft	49
	Range		2
	Grade class		
	Connection type		NC50
	Tool joint OD	in	
	Tool joint ID	in	
	Hard facing	Yes / no / type	Yes
	Internal coating	Yes / no / type	
G 4	Drill collars		
	Number		On demand
	OD	in	8¼" – 6¾"
	Nominal weight	lbs/ft	150 – 99
	Range		R2
	Connection type		6⅝" reg / NC-46
	Spiral	Yes / no	Yes
	Handling / slip reces	Yes / no	On demand
G 5	Bit and string stabilisers		As required for the drilling programme
G 6	Drilling jar		As required for the drilling programme
G 7	Drilling accelerator		As required for the drilling programme
G 8	Bumper sub		As required for the drilling programme
G 9	Crossovers		As required for the drilling programme
G 10	Bits		Drilling: as required for the drilling programme Coring: as required for the drilling programme

Tab. C-1: continued

H	Handling tools		
	Elevator links Elevators Rotary tongs Slips DC safety clamps Drill pipe wipers Bit breakers	In sufficient quantities to perform the scope of work for all strings (DP, casing, stinger etc.)	
	Automatic slips	Yes / no	Yes, hydraulically operated
I 1	Catheads Number	Yes / no	All functions by power swivel
I 2	Easy torque (or similar)	Yes / no	All functions by power swivel
I 3	Spinning wrench (or similar)	Yes / no	All functions by power swivel
I 4	Torque wrench (or similar)	Yes / no	Yes
I 5	Iron roughneck (or similar)	Yes / no	Yes - Drillmec Iron Roughneck
I 6	Kelly spinner	Yes / no	Not applicable
	Drive	Hydraulic / pneumatic	
J	Fishing equipment Over shots Junk basket Overshot Spear	In sufficient quantities to handle all strings in the scope of work	

Tab. C-1: continued

K 1	Drilling control console with		
	Weight indicator	Yes / no	Yes
	Hook position	Yes / no	Yes
	Standpipe pressure gauges	Yes / no	Yes
	Choke manifold pressure gauges	Yes / no	Yes
	Rotary speed tachometer	Yes / no	Yes
	Rotary torque indicator	Yes / no	Yes
	Pump pressure indicators	Yes / no	Yes
	Pump stroke counters	Yes / no	Yes
	Flow rate	Yes / no	Yes
	Pit volume	Yes / no	Yes
	Trip tank level	Yes / no	Yes
K 2	Drilling recorder		
	Manufacturer		Drillmec
	Type		Advanced drillers
	Recording all parameters as shown at drilling console as minimum	Yes / no	No
K 3	Pit volume totaliser		
	Number of sensors		7
	Loss / gain indicators and alarm	Yes / no	Yes
K 4	Trip tank		
	Capacity	m^3	5
K 5	Tong torque / line pull indicators		
	Line pull range (maximum)	kN	40.67
	Line pull range (maximum)	kN	40.67
K 6	General measuring equipment	In adequate quantities for contractor's string and drilling programme	
	Ring gauges		
	DP / DC drifts		
	Casing drifts		
	Bit calipers / gauges		
	Internal / external calipers		
	Derrick tapes (steel)		
K 7	Pressure gauges		
	Standpipe manifold	Number	3
	Choke manifold	Number	3

Tab. C-1: continued

K 8	Flowline gas sensor Total gas H_2S sensor Measurement range (C1 – Cx) Alarm	 Yes / no Yes / no Yes / no	 Yes Yes Yes
K 9	Soft torque drilling system	Yes / no	Yes
K 10	Internal telephone system	Yes / no	No
K 11	Mud laboratory Fully equipped mud laboratory as required to keep mud within programme parameters		
K 12	Direction measuring system	Totco / Gyro available	Sureshot 0° to7°
L 1	General personnel safety equipment Fire fighting equipment Personal protective equipment First aid equipment Eye washing stations Emergency lights		 In adequate quantities In adequate quantities In adequate quantities In adequate quantities In adequate quantities
L 2	Derrick safety equipment Derrick escape line Manufacturer Type Derrick safety belts Derrick safety devices Derrick climbing assistant		 In adequate quantities In adequate quantities In adequate quantities In adequate quantities
L 3	Gas / fire / smoke detection H_2S monitoring system H_2S / CO_2 detectors (portable) Explosimeters	 Yes / no Yes / no Yes / no	 Yes, on request Yes, on request Yes, on request
N 1	Phone and internet connection	Yes / no	No
N 2	Pipe racks Capacity	 m	 3'000
N 3	Cutting and welding equipment	Yes / no	Yes
N 4	High pressure cleaner	Yes / no	Yes

Tab. C-1: continued

N 5	Cellar pump		
	Manufacturer		KSB
	Type		ATEX
	Power	kW	1.5
N 6	Forklift		
	Capacity	kN	120 and 25

nagra.

Rheinau-1-1
Switzerland

Drilling-Engineering-Plot, 1:500

Mudlogging:

GEO data

Client:
Client: Nagra
Operator: Nagra

Project:
Borehole Section: Rheinau-1-1
Well Name: Rheinau-1

Location:
Country: Switzerland
Region or oilfield: Kanton Zürich
Location: Bachs

Coordinates:
Longitude / Latitude: E 8° 37' 49.71" N 47° 38' 22.75"
Elev. Ground level (MSL) 386.34 m
Elev. Rig Floor (GL) 4.93 m
Depth datum: Groundlevel

Well Type:
Production/exploitation well

Duration:
Spud: 19.07.2021
Last day drilled: 18.09.2021
Start depth (Tie-in) 0.00 m
Total depth: 827.99 m

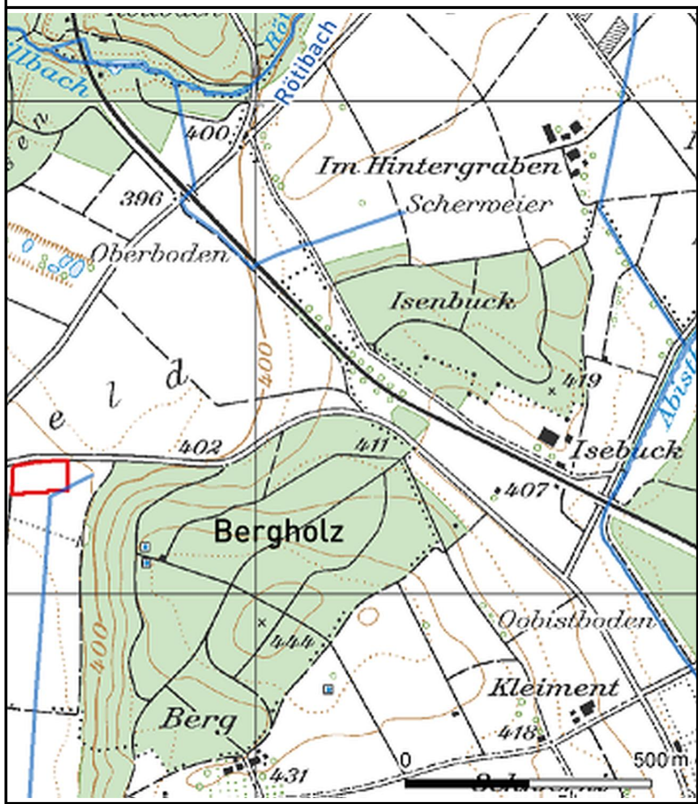
Rig:
Marriott Rig 16
Marriott Drilling Ltd

Team:
Company Man: M. Ammen
Toolpusher: T. Bernston, D. O'Connor
Supervisor: K. Hilgendorf, P.-J. Palten
Project- and operations geologist: M. Gysi
Wellsite geologist: M. Gysi, M. Stockhecke, HP. Weber

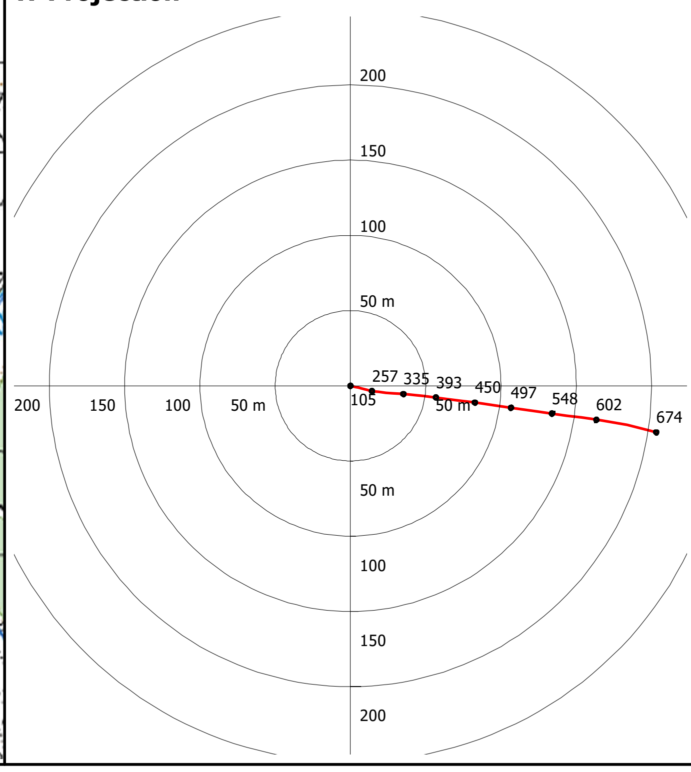
Mudlogging:
GEO-data, Gesellschaft für Logging-Service mbH
Leinestraße 33
D-30827 Garbsen
Germany
info@geo-data.de
Mudloggers: C. Anders, F. Steppat, H. Höpner, M. O. Baxmann, S. Schlak, B. Germerott, R. Hofmann, A. Toczko

Service:
Fluid Services: sirius e.s.
Mud Engineers: P. Sowinsky, R. Eggenweber, M. Artym, M. Samrozik, M. Dieckmann

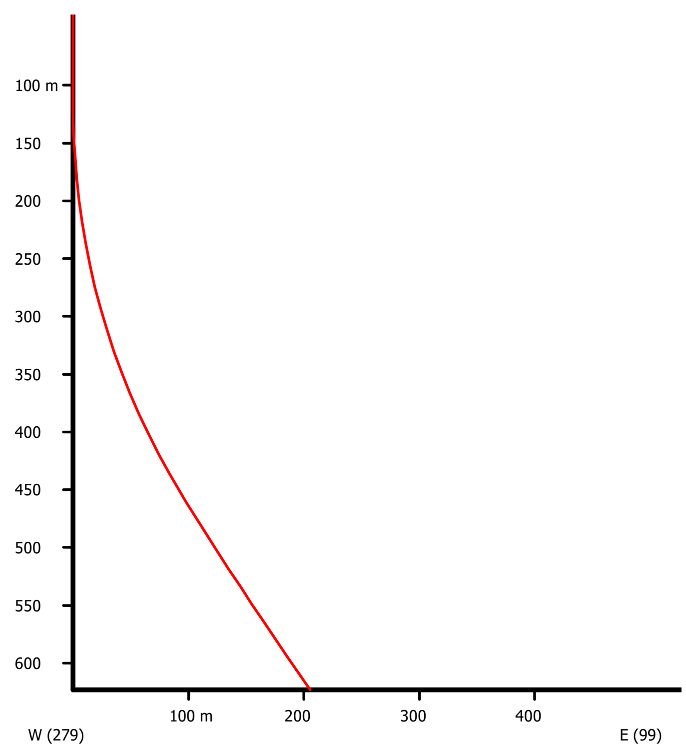
Remarks:
Top Rig Cellar: 387.23 m; Rig Floor: 392.16 m
Print Date: 10.01.2022 14:13



H-Projection



V-Projection



Measured depth referenced to Top Rig Cellar at 387.23 m.

Other Services

Wireline: Schlumberger
Directional Drilling: Schlumberger
Casing: General Tubular Services
Cementing: Fangmann

(map source: www.nagra.ch)

Evaporites
Anhydrite

Clastic sediments
Breccia, Gravel, Sand, Sandstone, Siltstone, Claystone

Carbonates and Biogenic sediments
Limestone, Limestone, marly, Marl (-stone), Marl, argillaceous

Artificial
No sample

Accessories
Anhydritic, Argillaceous, Calcareous, Calcite, Carbonaceous, Dolomitic, Ferruginous, Glauconite, Iron Ooids, Laminated, Marly, Mica (unspec.), Ooids, Pyrite, Rock Fragments, Sandy, Silty, Tourmaline

Fossils
Cephalopods, Fossiliferous, Molluscs, Pellets, Shell fragments

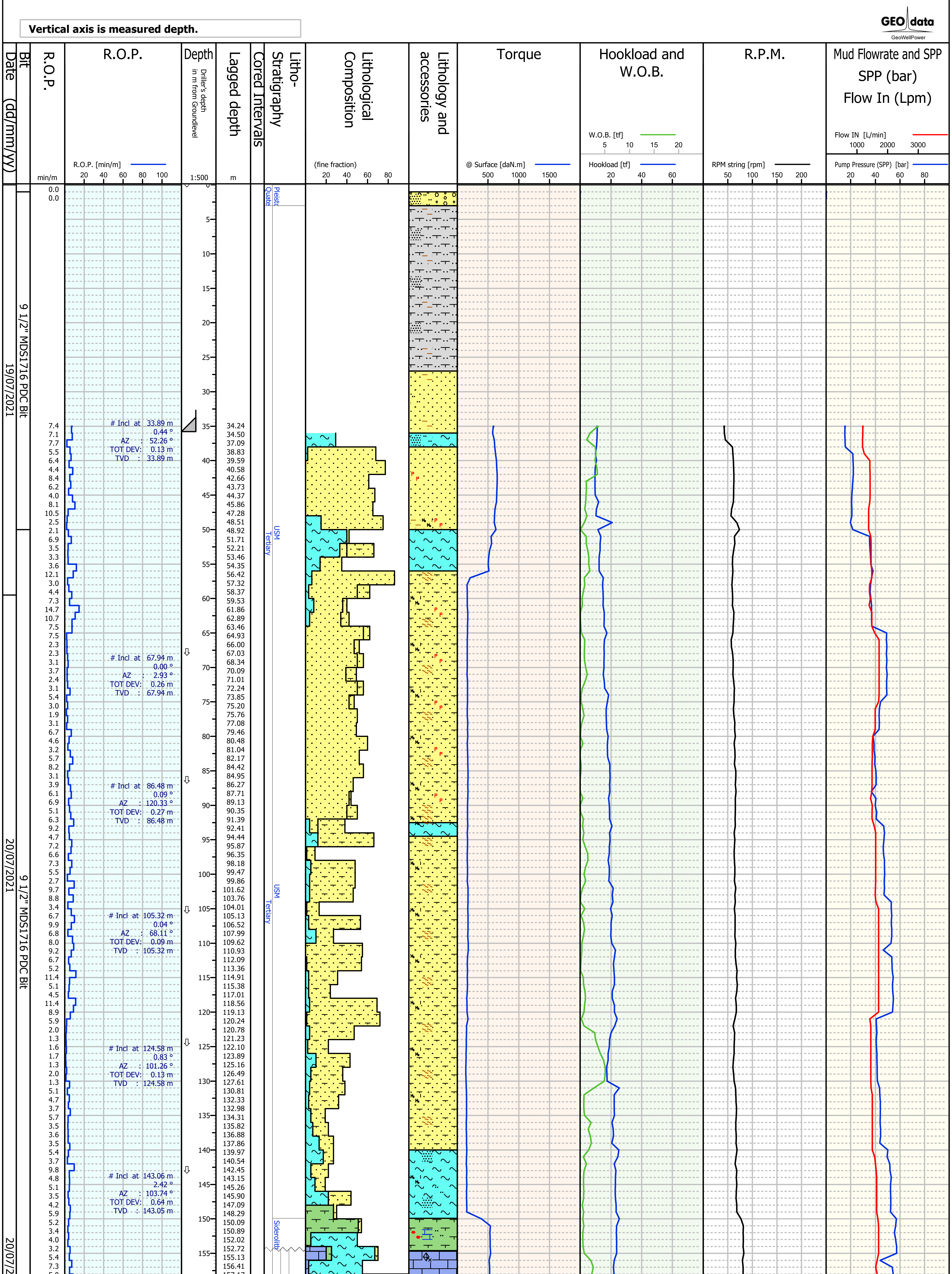
Framework
Lime-Mudstone, Cryptocrystalline, Microcrystalline

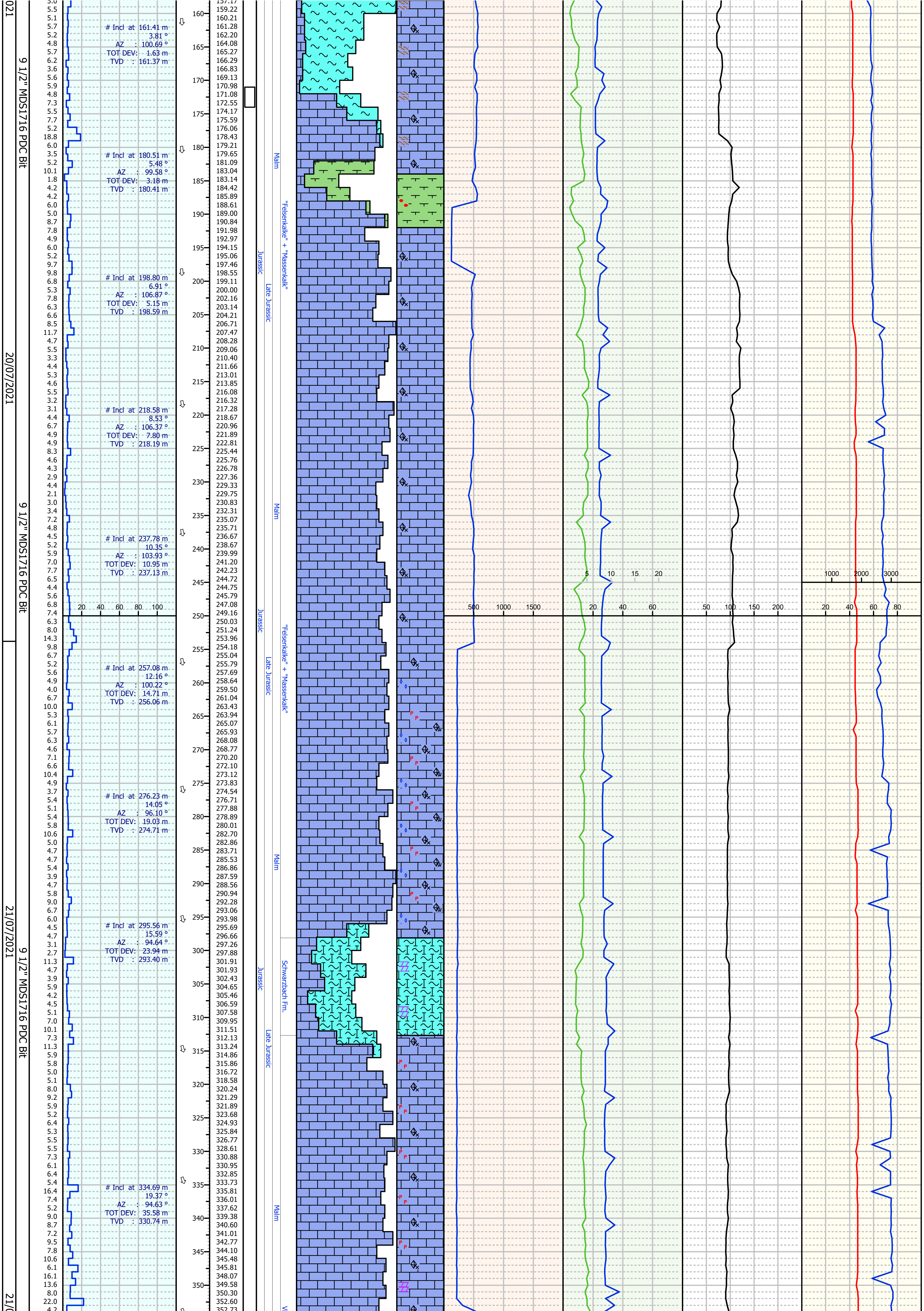
Technical symbols
Casing shoe, Liner head, Sidewall core, (unrecovered), Hydrocarbon show, Gains, Losses, FIT or leakoff test, Directional drilling

Marlstone, calcareous

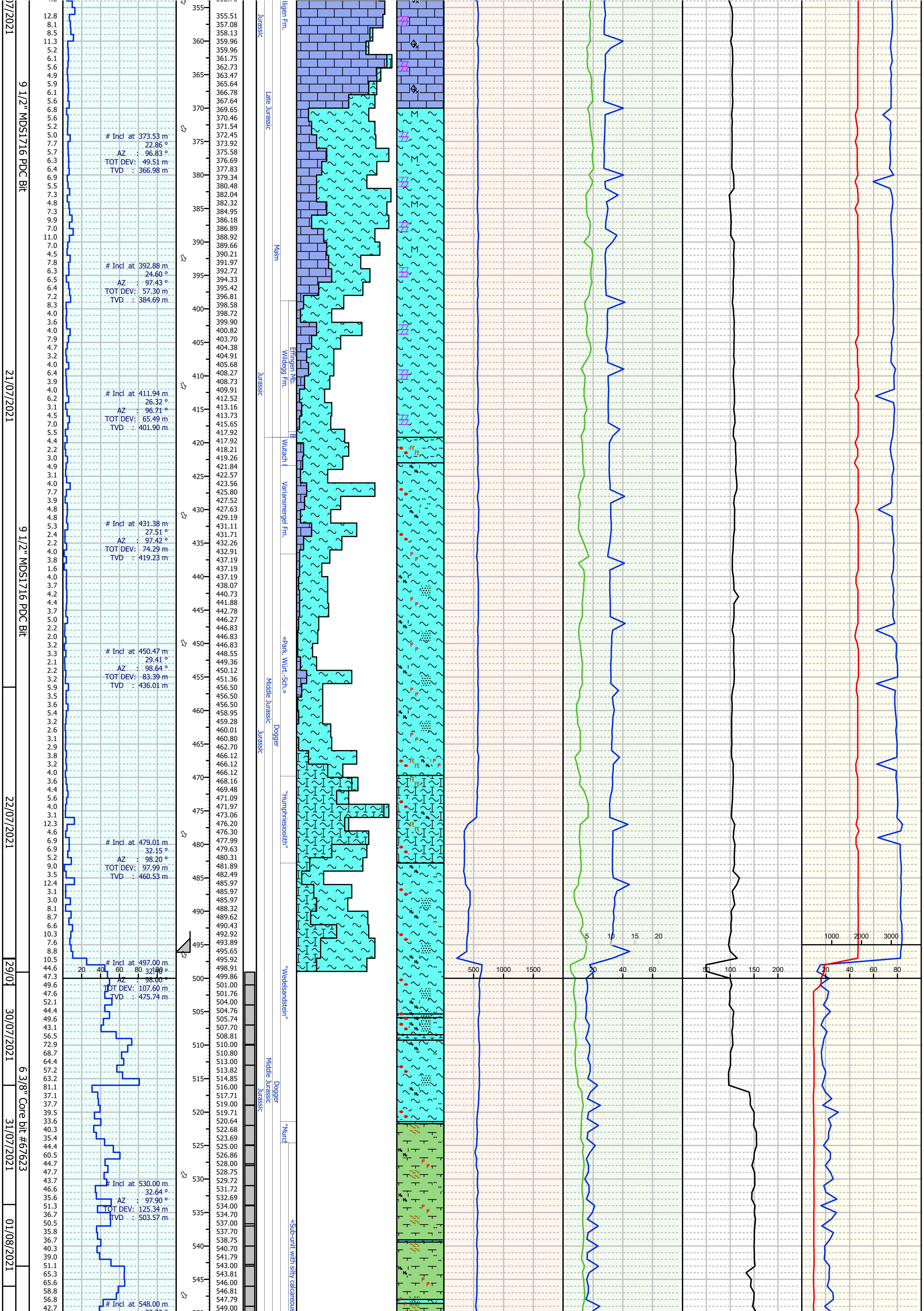
Dolomite

Vertical axis is measured depth.





9 1/2" MDS1716 PDC Bit
20/07/2021
21/07/2021
Incl at 161.41 m 3.81 ° AZ : 100.69 ° TOT DEV: 1.63 m TVD : 161.37 m
Incl at 180.51 m 5.48 ° AZ : 99.58 ° TOT DEV: 3.18 m TVD : 180.41 m
Incl at 198.80 m 6.91 ° AZ : 106.87 ° TOT DEV: 5.15 m TVD : 198.59 m
Incl at 218.58 m 8.53 ° AZ : 106.37 ° TOT DEV: 7.80 m TVD : 218.19 m
Incl at 237.78 m 10.35 ° AZ : 103.93 ° TOT DEV: 10.95 m TVD : 237.13 m
Incl at 257.08 m 12.16 ° AZ : 100.22 ° TOT DEV: 14.71 m TVD : 256.06 m
Incl at 276.23 m 14.05 ° AZ : 96.10 ° TOT DEV: 19.03 m TVD : 274.71 m
Incl at 295.56 m 15.59 ° AZ : 94.64 ° TOT DEV: 23.94 m TVD : 293.40 m
Incl at 334.69 m 19.37 ° AZ : 94.63 ° TOT DEV: 35.58 m TVD : 330.74 m
Jurassic
Late Jurassic
Malm
"Felsenkalke" + "Massenkalk"
Schwarzbach Fm.
20 40 60 80 100
500 1000 1500
5 10 15 20
20 40 60
50 100 150 200
1000 2000 3000
20 40 60 80



21/07/2021
22/07/2021
29/07
30/07/2021
31/07/2021
01/08/2021
9 1/2" MDS1716 PDC Bit
9 1/2" MDS1716 PDC Bit
6 3/8" Core bit #67623
Incl at 373.53 m
22.86 °
AZ : 96.83 °
TOT DEV: 49.51 m
TVD : 366.98 m
Incl at 392.88 m
24.60 °
AZ : 97.43 °
TOT DEV: 57.30 m
TVD : 384.69 m
Incl at 411.94 m
26.32 °
AZ : 96.71 °
TOT DEV: 65.49 m
TVD : 401.90 m
Incl at 431.38 m
27.51 °
AZ : 97.42 °
TOT DEV: 74.29 m
TVD : 419.23 m
Incl at 450.47 m
29.41 °
AZ : 98.64 °
TOT DEV: 83.39 m
TVD : 436.01 m
Incl at 479.01 m
32.15 °
AZ : 98.20 °
TOT DEV: 97.99 m
TVD : 460.53 m
Incl at 497.00 m
AZ : 98.00 °
TOT DEV: 107.60 m
TVD : 475.74 m
Incl at 530.00 m
32.64 °
AZ : 97.90 °
TOT DEV: 125.34 m
TVD : 503.57 m
Incl at 548.00 m
Jurassic
Late Jurassic
Malm
Effingen Mb.
Wildegg Fm.
Wutach
Variansmergel Fm.
«Park.-Würt.-Sch.»
Middle Jurassic
Dogger
"Humphriesioolith"
"Wedelsandstein"
"Murch
«Sub-unit with silty calcareous
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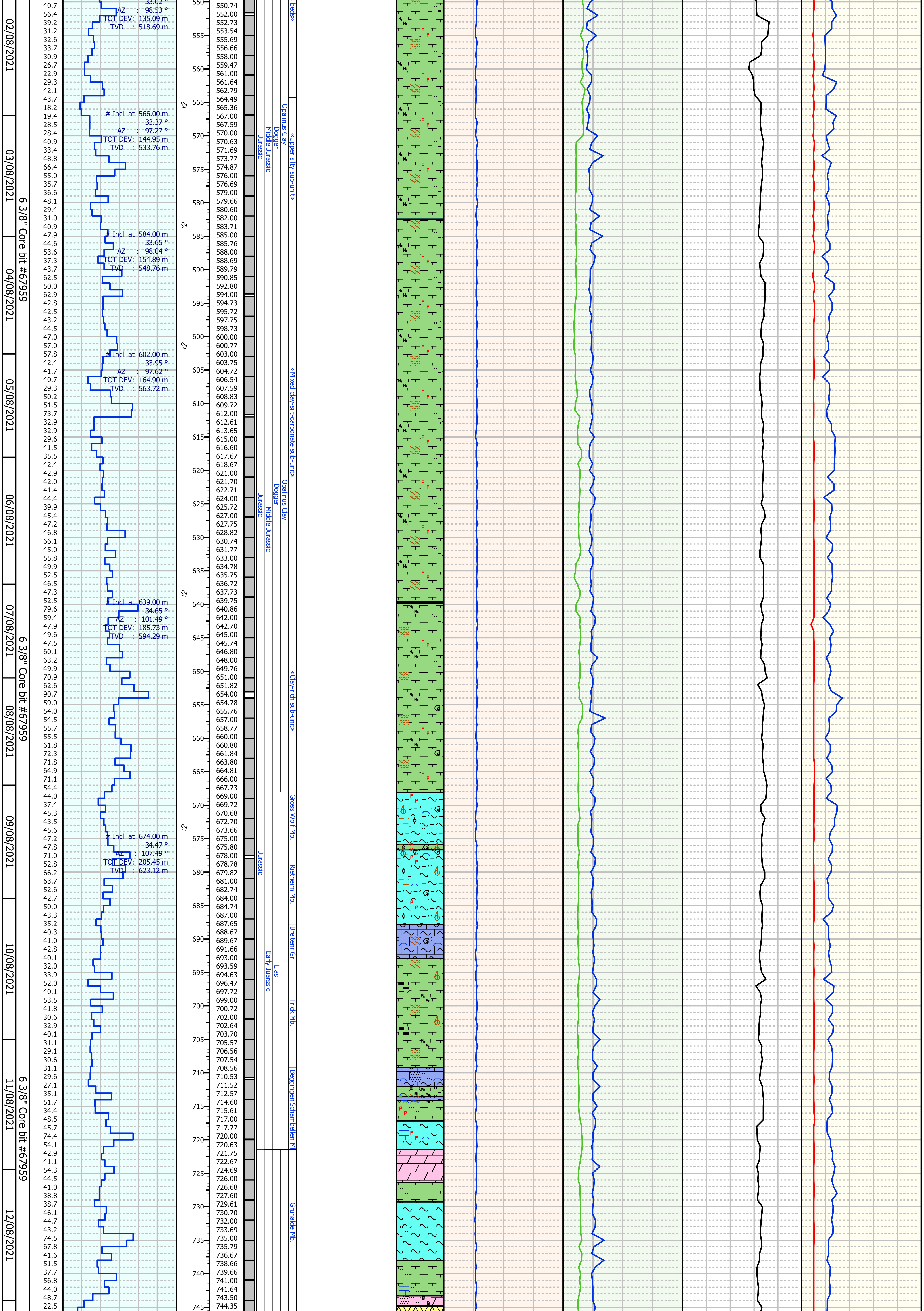
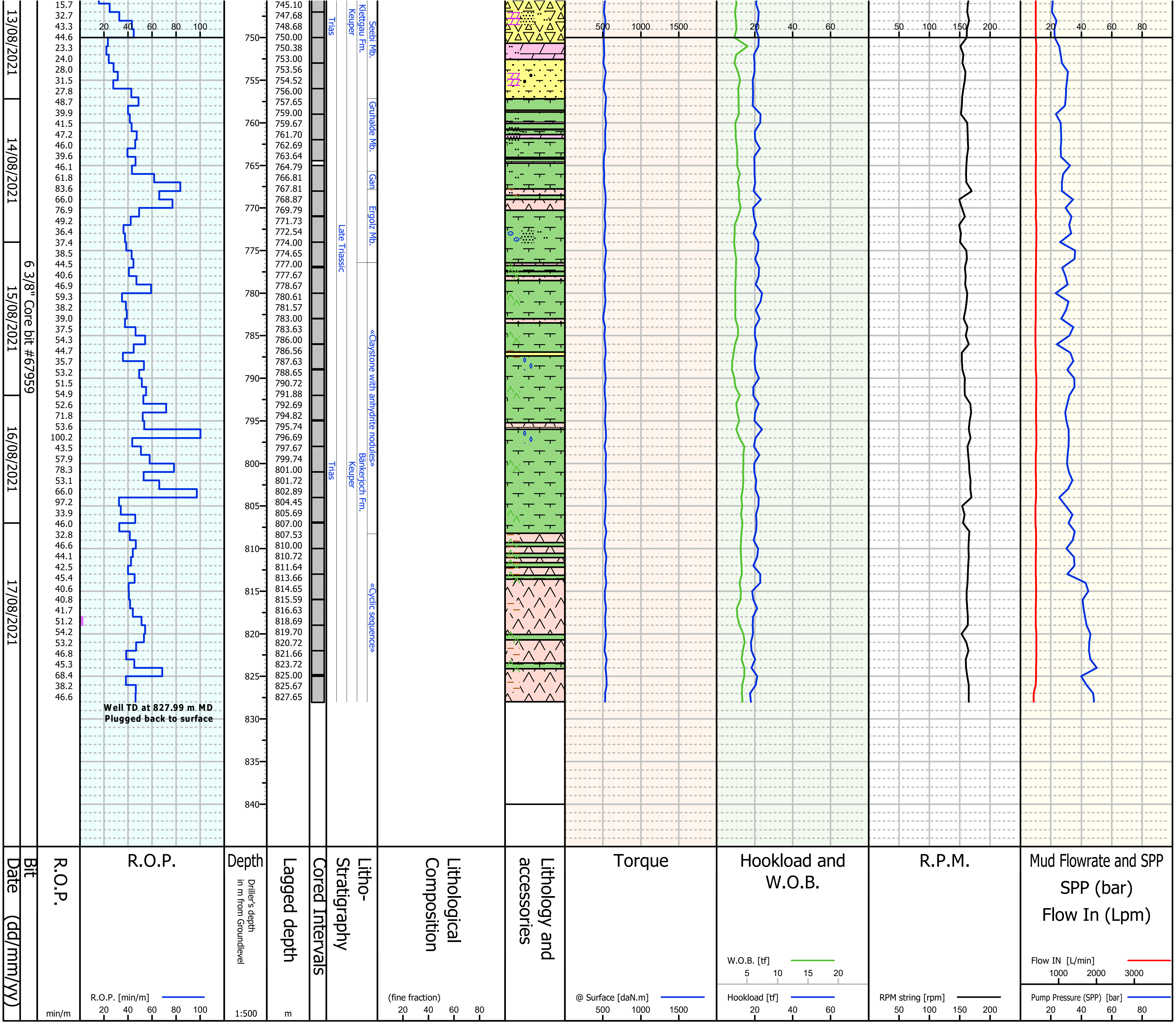
500 1000 1500
5 10 15 20
20 40 60
50 100 150 200
1000 2000 3000
20 40 60 80



02/08/2021
03/08/2021
04/08/2021
05/08/2021
06/08/2021
07/08/2021
08/08/2021
09/08/2021
10/08/2021
11/08/2021
12/08/2021
6 3/8" Core bit #67959
6 3/8" Core bit #67959
6 3/8" Core bit #67959
AZ : 98.53 °
TOT DEV: 135.09 m
TVD : 518.69 m
Incl at 566.00 m
33.37 °
AZ : 97.27 °
TOT DEV: 144.95 m
TVD : 533.76 m
Incl at 584.00 m
33.65 °
AZ : 98.04 °
TOT DEV: 154.89 m
TVD : 548.76 m
Incl at 602.00 m
33.95 °
AZ : 97.62 °
TOT DEV: 164.90 m
TVD : 563.72 m
Incl at 639.00 m
34.65 °
AZ : 101.49 °
TOT DEV: 185.73 m
TVD : 594.29 m
Incl at 674.00 m
34.47 °
AZ : 107.49 °
TOT DEV: 205.45 m
TVD : 623.12 m
beds»
«Upper silty sub-unit»
Opalinus Clay
Dogger
Middle Jurassic
Jurassic
«Mixed clay-silt-carbonate sub-unit»
Opalinus Clay
Dogger
Middle Jurassic
Jurassic
«Clay-rich sub-unit»
Gross Wolf Mb.
Rietheim Mb.
Breitenr Gr.
Frick Mb.
Beggingen Schambelen Mb
Gruhalde Mb.
Lias
Early Jurassic
Jurassic



nagra **NAB 22-03**

Drilling engineering plot
Rheinau-1-1: programme as performed

Dossier I | DAT.: Jun. 2023 | **Appendix D**

Appendix E: Drill site scheme and pictures

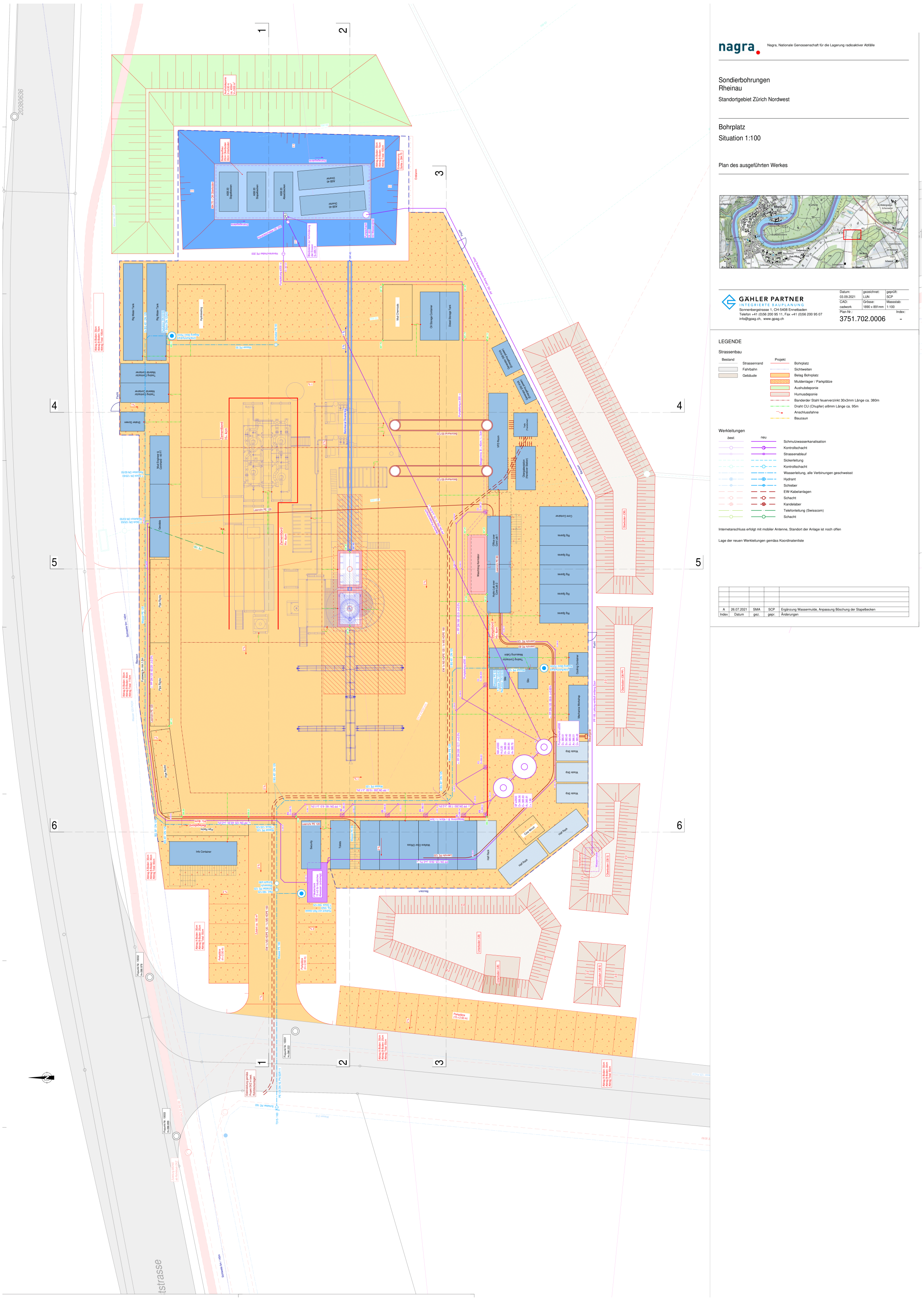


Fig. E-1: Overview plan of the drill site

Fig. E-2: Trench excavation (above) and piping (below)

Fig. E-3: Gravel layer on soil

Fig. E-4: Construction of well cellar

Fig. E-5: Paving the site

Appendix F: Bit list

Bit Runs Rheinau 1-1

Bit №	BHA №	Hole Opener	Date Run	Date Out	Size	Bit type	Manufacturer	Type	IADC code	Serial №	Jets	TFA [in²]	Depth In [m]	Depth Out [m]	Total Footage [m]	Drilling Hours	ROP [m/h]	WOB min [to]	WOB max [to]	RPM at bit	RPM at surface	SPP [bar]	Flow rate [l/min]	MW [SG]	Visc	Formation in	Formation out	Drive system	I	O	D	Loc	B	G	O	R	Total Krevs on bit	Remarks
1	1	n	19/07/21	20/07/21	9.500	PDC	Smith	MDSi716		JE6157	7 x 11	0.65	34.50	50.00	15.50	2.25	6.89	1.00	2.00	60	60	38	1500	1.01	80	Tertiär - Obere Meeresmolasse	Tertiär - Obere Meeresmolasse	Rotary	0	0	NO	A	X	I	NO	BHA	10.392	Like new no wear at all
2 (RR)	2	n	20/07/21	22/07/21	9.500	PDC	Smith	MDSi716		JE6157	7 x 11	0.65	50.00	497.00	447.00	53.00	8.43	1.00	5.00	60-115	60-115	86	1880	1.08	63	Tertiär - Obere Meeresmolasse	Dogger - Passwang	Rotary	0	0	NO	A	X	I	BU	TD	258.700	Like new no viewable wear at all, drilled with PD Xceed
3	3	n	25/07/21	25/07/21	9.500	Milled Tooth	Smith	XR+CR	117	RJ4719	4 x 20	1.227	497.00	497.00	0.00	0.00		0.00	0.00				1400	1..07	63	Dogger - Passwang	Dogger - Passwang	Rotary	0	0	NO	A	X	I	NO	BHA		
4	4	n	28/07/21	28/07/21	6.375	Milled Tooth	Glinik	537	537	7	3 x 13	0.389	497.00	499.10	2.10	1.50	1.40	2.00	2.50	85	85	15	750	1..07	63	Dogger - Passwang	Dogger - Passwang	Rotary	0	0	NO	A	X	I	NO	BHA	7.650	
5	5	n	29/07/2021	08/01/21	6.375	Coring Diamond impregnated Matrix	Micon	impregnated		67623	N/A	N/A	499.10	543.00	43.90	35.25	1.25	3.00	4.50	80-150	80-150	26.00	400	1.20	10	Dogger - Opalinus Clay	Dogger - Opalinus Clay	Rotary	5	5	NO	A	X	I	NO	PR		
6	6	n	08/01/21	18/8/2021	6.375	Coring Diamond impregnated Matrix	Micon	impregnated		67959	N/A	N/A	543.00	828.00	285.00	216.50	1.32	3.00	4.50	150-170	150-170	26-50	350-400	1.20	60	Dogger - Opalinus Clay	Keuper - Baenkerjoch Fm.	Rotary	1	1	WT	A	X	I	PN	TD		Like new after cleaning
`7/8	`10/12	n	31/08/21 12/09-21	31/08/21 13/09/21	6.375	Coring Diamond impregnated Matrix	Micon	impregnated		67959	N/A	N/A	828.00	828.00	0.00	0.00		0.00	4.50	15-40	15-40	14-34	550	1.18	60			Rotary	1	1	WT	A	X	I	PN	TD		Checktrip

Appendix G: Survey report

The borehole was drilled almost as planned. The maximum inclination measured is 38.93° at 827.0 m MD. The maximum DLS is 3.52°/30 m at 639.0 m MD caused by a big turn.

Tab. G-1: Deviation of the Rheinau-1-1 borehole (VS angle 98°)

MD [m]	**Inclination** [°]	**Azimuth (TRUE)** [°]	**TVD** [m]	**North (Y)** [m]	**East (X)** [m]	**PHD (V/S)** [m]	**DLS** [°/30 m]
0.00	0.00	0.00	0.00	0.00	0.00	0.00	N/A
2.20	0.39	66.74	2.20	0.00	0.01	0.01	0.32
4.20	0.36	69.77	4.20	0.01	0.02	0.02	0.54
6.20	0.30	71.28	6.20	0.01	0.03	0.03	0.91
8.20	0.28	75.46	8.20	0.01	0.04	0.04	0.44
10.20	0.33	76.64	10.20	0.02	0.05	0.05	0.76
12.20	0.33	70.40	12.20	0.02	0.06	0.06	0.54
14.20	0.31	64.11	14.20	0.02	0.07	0.07	0.61
16.20	0.26	56.16	16.20	0.03	0.08	0.07	0.95
18.20	0.25	46.31	18.20	0.04	0.09	0.08	0.67
20.20	0.24	54.19	20.20	0.04	0.09	0.09	0.53
22.20	0.23	55.77	22.20	0.05	0.10	0.09	0.18
24.20	0.27	53.43	24.20	0.05	0.11	0.10	0.62
26.20	0.32	50.68	26.20	0.06	0.12	0.11	0.78
28.20	0.36	49.23	28.20	0.06	0.12	0.11	0.61
30.20	0.42	50.30	30.20	0.07	0.13	0.12	0.91
30.79	0.44	52.26	30.79	0.08	0.14	0.13	1.26
34.20	*0.19*	*51.23*	*34.20*	*0.09*	*0.15*	*0.14*	*2.21*
39.08	0.17	235.05	39.08	0.09	0.15	0.14	2.21
67.94	0.00	2.93	67.94	0.06	0.12	0.11	0.18
86.48	0.09	120.33	86.48	0.06	0.13	0.12	0.15
105.32	0.04	68.11	105.32	0.05	0.15	0.14	0.12
124.58	0.83	101.26	124.58	0.03	0.29	0.29	1.24
143.06	2.42	103.74	143.05	-0.09	0.80	0.81	2.58
161.41	3.81	100.69	161.37	-0.30	1.78	1.80	2.29
180.51	5.48	99.58	180.41	-0.57	3.30	3.35	2.63
198.80	6.91	106.87	198.59	-1.03	5.22	5.31	2.67
218.58	8.53	106.37	218.19	-1.79	7.76	7.94	2.46
237.78	10.35	103.93	237.13	-2.61	10.80	11.06	2.91

Tab. G-1: continued

MD [m]	**Inclination** [°]	**Azimuth (TRUE)** [°]	**TVD** [m]	**North (Y)** [m]	**East (X)** [m]	**PHD (V/S)** [m]	**DLS** [°/30 m]
257.08	12.16	100.22	256.06	-3.38	14.49	14.82	3.03
276.23	14.05	96.10	274.71	-3.99	18.78	19.16	3.30
295.56	15.59	94.64	293.40	-4.45	23.71	24.09	2.46
314.97	17.25	94.38	312.02	-4.88	29.17	29.57	2.57
334.69	19.37	94.63	330.74	-5.37	35.35	35.75	3.23
354.34	21.03	95.18	349.18	-5.95	42.11	42.53	2.55
373.53	22.86	96.83	366.98	-6.70	49.24	49.69	3.02
392.88	24.60	97.43	384.69	-7.67	56.97	57.48	2.72
411.94	26.32	96.71	401.90	-8.68	65.10	65.67	2.75
431.38	27.51	97.42	419.23	-9.76	73.83	74.47	1.90
450.47	29.41	98.64	436.01	-11.03	82.84	83.57	3.12
469.58	31.60	98.54	452.48	-12.48	92.43	93.27	3.44
479.01	32.15	98.20	460.49	-13.21	97.36	98.25	1.84
497.00	32.40	98.00	475.70	-14.56	106.87	107.85	0.45
530.00	32.64	97.90	503.54	-17.03	124.40	125.56	0.30
548.00	33.02	98.53	518.67	-18.43	134.06	135.32	0.85
566.00	33.37	97.27	533.73	-19.78	143.82	145.18	1.30
584.00	33.65	98.04	548.74	-21.11	153.67	155.11	0.85
602.00	33.95	97.62	563.69	-22.47	163.59	165.13	0.63
639.00	34.73	90.05	594.26	-23.85	184.38	185.91	3.52
674.00	35.30	95.61	622.93	-24.85	204.42	205.89	2.78
710.00	36.26	96.74	652.14	-27.11	225.35	226.93	0.97
746.00	37.05	95.47	681.02	-29.39	246.72	248.41	0.91
782.00	37.70	94.42	709.63	-31.28	268.49	270.23	0.76
827.00	38.93	76.25	745.05	-28.97	296.03	297.18	7.54

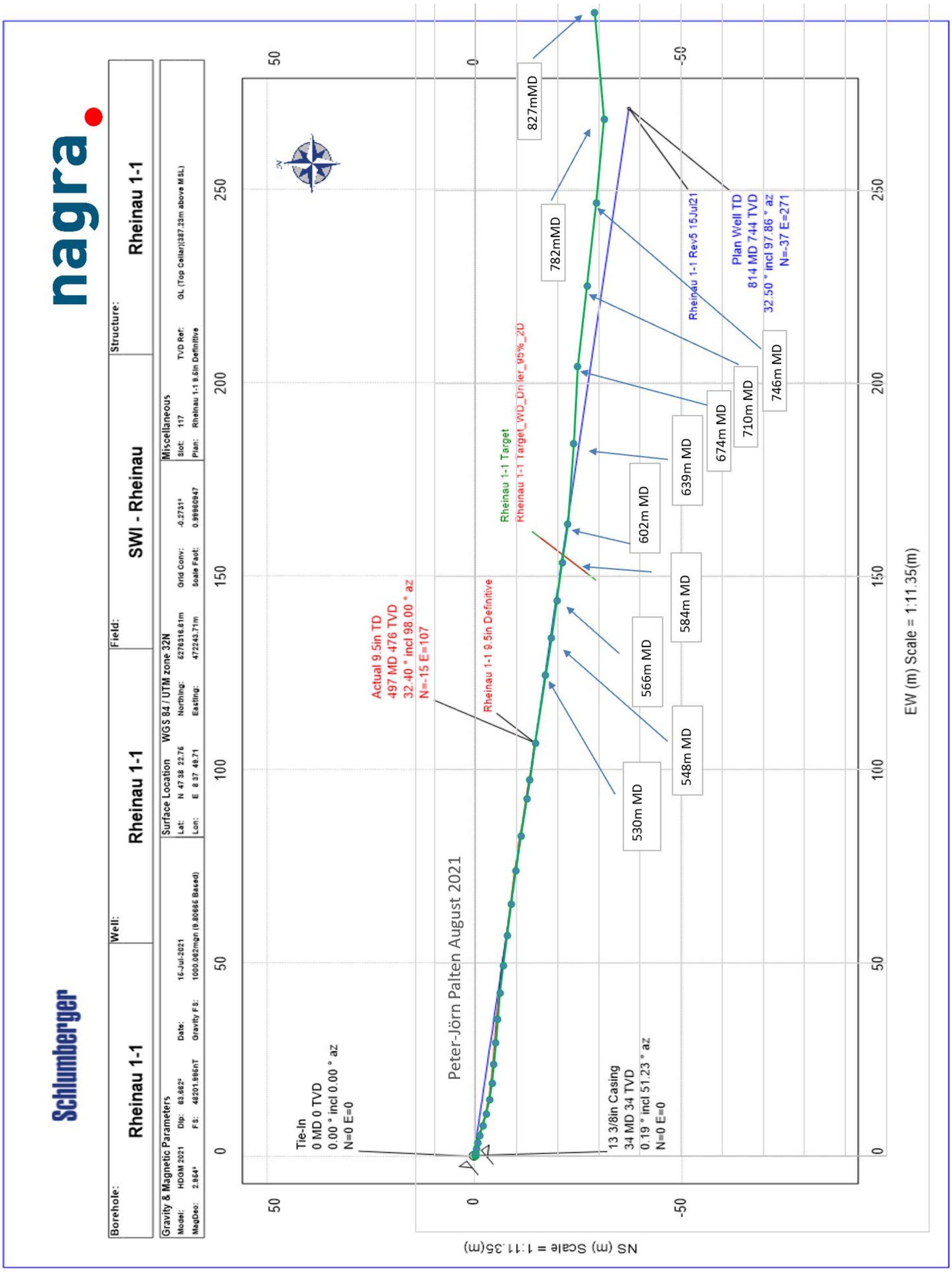


Fig. G-1: Plan view of the RHE1-1 borehole

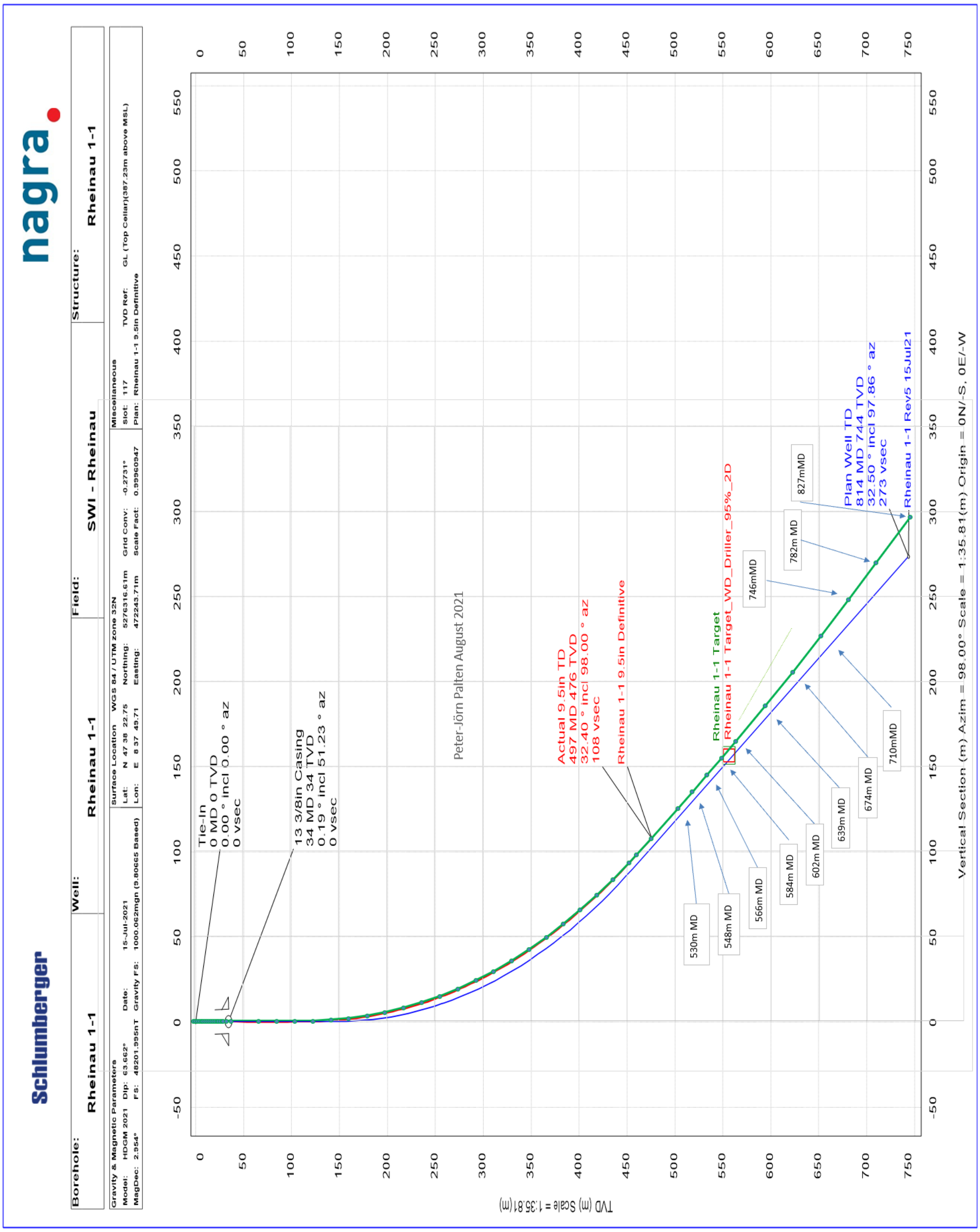


Fig. G-2: Section view of the RHE1-1 borehole

Appendix H: Casing / liner tally lists

Date: 25/07/2021 **Marriott Rig # 16**

NAGRA **Hole Depth 497.0m** **Nagra Well: Rheinau 1-1**

Casing Tally List **9 5/8" Depth 35.5 m**

Casing: 7 5/8" lb/ft

Joint #	Length	Total	BGL	Drifted	Bow Centralizer	BGL	Remarks
Shoe	**0.47**	**0.47**				496.33	tack weld
1	11.55	12.02	7.09	x	x	495.86	tack weld
2	11.51	23.53	18.60	x	x	484.31	tack weld
Float	**0.67**	24.20	19.27		x	472.80	tack weld
3	11.26	35.46	30.53	x	x	472.13	
4	11.56	47.02	42.09	x	x	460.87	
5	11.51	58.53	53.60	x	x	449.31	
6	11.55	70.08	65.15	x	x	437.80	
7	11.58	81.66	76.73	x	x	426.25	
8	11.57	93.23	88.30	x	x	414.67	
9	11.43	104.66	99.73	x	x	403.10	
10	11.55	116.21	111.28	x	x	391.67	
11	11.51	127.72	122.79	x	x	380.12	
12	11.51	139.23	134.30	x	x	368.61	
13	11.56	150.79	145.86	x	x	357.10	
14	11.31	162.10	157.17	x	x	345.54	
15	11.57	173.67	168.74	x	x	334.23	
16	11.51	185.18	180.25	x	x	322.66	
17	11.59	196.77	191.84	x	x	311.15	
18	11.55	208.32	203.39	x	x	299.56	
19	11.57	219.89	214.96	x	x	288.01	
20	11.51	231.40	226.47	x	x	276.44	
21	11.55	242.95	238.02	x	x	264.93	
22	11.43	254.38	249.45	x	x	253.38	
23	11.52	265.90	260.97	x	x	241.95	
24	11.46	277.36	272.43	x	x	230.43	
25	11.58	288.94	284.01	x	x	218.97	
26	11.35	300.29	295.36	x	x	207.39	
27	11.43	311.72	306.79	x	x	196.04	
28	11.51	323.23	318.30	x	x	184.61	
29	11.56	334.79	329.86	x	x	173.10	
30	10.59	345.38	340.45	x	x	161.54	
31	11.55	356.93	352.00	x	x	150.95	
32	11.51	368.44	363.51	x		139.40	
33	11.51	379.95	375.02	x	x	127.89	
34	11.56	391.51	386.58	x		116.38	
35	11.51	403.02	398.09	x	x	104.82	
36	11.37	414.39	409.46	x		93.31	
37	11.41	425.80	420.87	x	x	81.94	
38	11.51	437.31	432.38	x		70.53	
39	11.51	448.82	443.89	x	x	59.02	
40	11.51	460.33	455.40	x		47.51	
41	10.89	471.22	466.29	x		36.00	
42	11.36	482.58	477.65	x	x	25.11	
43	11.52	494.10	489.17	x		13.75	
Pup Joint 3	1.92	496.02	491.09	x		2.23	
Pup Joint 1	3.10	499.12	494.19	x		0.31	
Pup Joint 4	2.94	502.06	497.13	x		0.00	Casing landed off on timber,
							1.0m stickup above R/T
							Final shoe depth 496.33 B GL
TOTAL		502.06	497.13				**9 1/2" hole to 497m**
pup joints and extras							
Pup Jnt 1	3.10		44	11.51			
Pup jnt 2	1.96		45	11.6			
Pup jnt 3	1.92		46	11.59			
Pup jnt 4	2.94		47	11.18			
Pup jnt 5	3.93		48	11.52			
Pup jnt6	1.94						

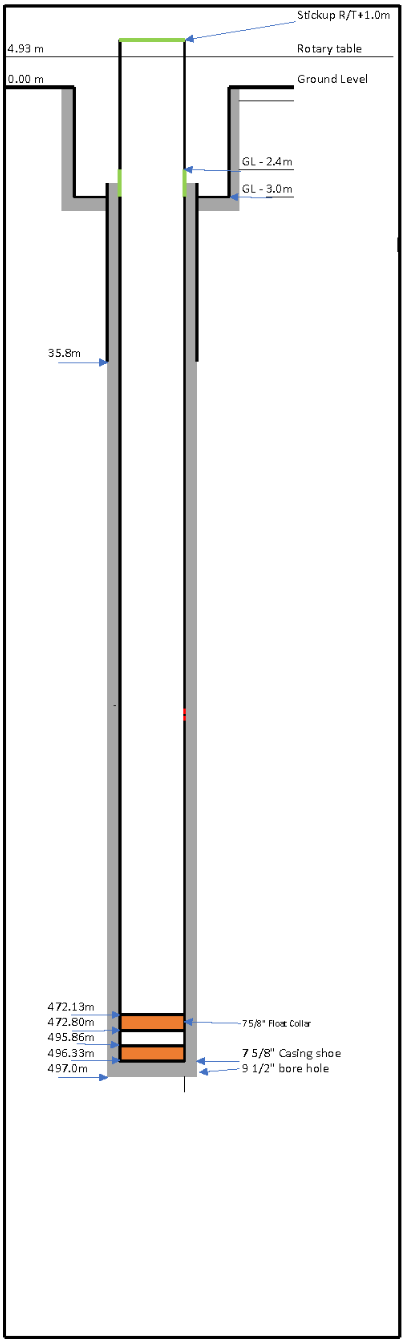


Fig. H-1: Casing tally list

Appendix I: Coring parameters

The core recovery was 99.83% for the RHE1-1 borehole (coring from 499.1 m to 827.99 m MD).

CS-Nr.	Ø core	depth MD		depth MD core´		core section			date	time RIH			time POOH			drilling duration				RpM	WoB	pump		dens.	mudloss	
		from	to	from	to	target	actual	rcy		from	to	Δ	from	to	Δ	from	to	Δ	ROP			p	Flow in		vol	v
	[mm]	[m]	[m]	[m]	[m]	[m]	[m]	[%]											[m/h]	[min-1]	[t]	[bar]	[l/min]	[g/cm3]	[m3]	[l/min]
1	94-95	499.10	501.00	499.10	501.15	1.90	2.05	108%	7/29/2021	02:10	05:00	02:50	06:33	07:33	01:00	05:00	06:33	01:33	1.23	105	2.1	22	398	1.20	0	0
2	95	501.00	504.00	501.15	504.16	3.00	3.01	100%	7/30/2021	07:33	08:15	00:42	10:40	11:16	00:36	08:15	10:40	02:25	1.24	99	2.3	21	395	1.20	0	0
3	95	504.00	507.00	504.16	507.16	3.00	3.00	100%	7/30/2021	11:16	11:54	00:38	14:11	14:50	00:39	11:54	14:11	02:17	1.31	107	2.2	18	400	1.20	0	0
4	95	507.00	510.00	507.16	510.05	3.00	2.89	96%	7/30/2021	14:50	15:41	00:51	18:33	19:20	00:47	15:41	18:33	02:52	1.05	106	2.9	18	391	1.20	0	0
5	95	510.00	513.00	510.05	513.20	3.00	3.15	105%	7/30/2021	19:20	19:55	00:35	23:11	00:00	00:49	19:55	23:11	03:16	0.92	101	2.3	16	408	1.20	0	0
6	95	513.00	516.00	513.20	516.20	3.00	3.00	100%	7/31/2021	00:00	00:35	00:35	04:00	05:05	01:05	00:35	04:00	03:25	0.88	98	2.2	017	408	1.20	0	0
7	95	516.00	519.00	516.20	519.15	3.00	2.95	98%	7/31/2021	05:05	09:45	04:40	11:27	12:16	00:49	09:45	11:27	01:42	1.76	142	4.2	20	395	1.20	0	0
8	95	519.00	522.00	519.15	522.16	3.00	3.01	100%	7/31/2021	12:16	12:51	00:35	14:45	15:28	00:43	12:51	14:45	01:54	1.58	148	3.9	21	402	1.20	0	0
9	95	522.00	525.00	522.16	525.07	3.0	2.91	97%	7/31/2021	15:28	16:05	00:37	17:58	18:50	00:52	16:05	17:58	01:53	1.6	154	3.6	22	410	1.2	0	0
10	95	525.00	528.00	525.07	527.80	3.0	2.73	91%	7/31/2021	18:50	19:35	00:45	22:12	22:58	00:46	19:35	22:12	02:37	1.1	150	4.6	25	405	1.2	0	0
11	95	528.00	531.00	527.80	531.18	3.0	3.38	113%	7/31/2021	22:58	23:35	00:37	01:53	02:40	00:47	23:35	01:53	02:48	1.1	154	4.0	29	398	1.2	0	0
12	95	531.00	534.00	531.18	534.09	3.00	2.91	97%	7/31/2021	02:40	05:05	02:25	07:07	07:52	00:45	05:05	07:07	02:02	1.48	147	4.0	20	407	1.20	0	0
13	95	534.00	537.00	534.09	536.80	3.00	2.71	90%	8/1/2021	07:52	08:25	00:33	10:43	11:28	00:45	08:25	10:43	02:18	1.30	154	4.0	28	398	1.20	0	0
14	95	537.00	540.00	536.80	540.07	3.00	3.27	109%	8/1/2021	11:28	11:58	00:30	13:49	14:33	00:44	11:58	13:49	01:51	1.62	148	4.3	25	400	1.20	0	0
15	95	540.00	543.00	540.07	542.84	3.00	2.77	92%	8/1/2021	14:33	15:10	00:37	17:15	22:00	04:45	15:10	17:15	02:05	1.44	152	4.5	19	407	1.20	0	0
16	95	543.00	546.00	542.84	546.03	3.00	3.19	106%	8/1/2021	22:00	02:54	04:54	06:10	07:00	00:50	02:54	06:10	03:16	0.92	108	4.0	25	398	1.20	0	0
17	95	546.00	549.00	546.03	549.04	3.00	3.01	100%	8/2/2021	07:00	07:30	00:30	10:10	10:52	00:42	07:30	10:10	02:40	1.13	148	4.2	21	411	1.20	0	0
18	95	549.00	552.00	549.04	551.67	3.00	2.63	88%	8/2/2021	10:52	12:34	01:42	14:50	15:34	00:44	12:34	14:50	02:16	1.32	157	4.2	26	412	1.20	0	0
19	95	552.00	555.00	551.67	554.88	3.00	3.21	107%	8/2/2021	15:34	16:11	00:37	17:49	18:36	00:47	16:11	17:49	01:38	1.84	178	3.7	25	397	1.20	0	0
20	95	555.00	558.00	554.88	557.99	3.00	3.11	104%	8/2/2021	18:36	19:08	00:32	20:45	21:35	00:50	19:08	20:45	01:37	1.86	165	4.5	20	403	1.20	0	0
21	95	558.00	561.00	557.99	560.90	3.00	2.91	97%	8/2/2021	21:35	22:12	00:37	23:24	01:35	02:11	22:12	23:24	01:12	2.50	142	3.8	20	408	1.20	0	0
22	95	561.00	564.00	560.90	564.02	3.00	3.12	104%	8/2/2021	01:35	02:15	00:40	04:10	04:55	00:45	02:15	04:10	01:55	1.57	150	4.5	27	405	1.20	0	0
23	93-95	564.00	567.00	564.02	566.93	3.00	2.91	97%	8/2/2021	04:55	05:35	00:40	06:35	07:30	00:55	05:35	06:35	01:00	3.00	160	3.8	20	406	1.20	0	0
24	95	567.00	570.00	566.93	569.90	3.00	2.97	99%	8/3/2021	07:30	10:54	03:24	12:18	13:08	00:50	10:54	12:18	01:24	2.14	169	4.3	27	403	1.20	0	0
25	95	570.00	573.00	569.90	573.02	3.00	3.12	104%	8/3/2021	13:08	13:50	00:42	15:41	16:29	00:48	13:50	15:41	01:51	1.62	166	2.8	24	413	1.20	0	0
26	95	573.00	576.00	573.02	576.03	3.00	3.01	100%	8/3/2021	16:29	17:01	00:32	19:50	20:38	00:48	17:01	19:50	02:49	1.07	168	2.7	26	409	1.20	0	0
27	95	576.00	579.00	576.03	578.94	3.00	2.91	97%	8/3/2021	20:38	21:08	00:30	22:57	23:46	00:49	21:08	22:57	01:49	1.65	165	2.6	23	408	1.20	0	0
28	95	579.00	582.00	578.94	581.95	3.00	3.01	100%	8/3/2021	23:46	00:25	00:37	02:16	03:00	00:44	00:25	02:16	01:51	1.62	165	2.9	22	410	1.20	0	0
29	95	582.00	585.00	581.95	584.95	3.00	3.00	100%	8/3/2021	03:00	03:40	00:40	05:50	06:38	00:48	03:40	05:50	02:10	1.38	160	2.9	22	410	1.20	0	0
30	95	585.00	588.00	584.95	588.02	3.00	3.07	102%	8/4/2021	06:38	08:35	01:57	10:57	12:17	01:20	08:35	10:57	02:22	1.27	167	2.7	20	362	1.20	0	0
31	95	588.00	591.00	588.02	591.04	3.00	3.02	101%	8/4/2021	12:17	12:52	00:35	15:15	16:05	00:50	12:52	15:15	02:23	1.26	163	2.5	22	391	1.20	0	0
32	95	591.00	594.00	591.04	593.67	3.00	2.63	88%	8/4/2021	16:05	16:45	00:40	19:19	20:12	00:53	16:45	19:19	02:34	1.17	177	2.8	21	354	1.20	0	0
33	95	594.00	597.00	593.67	596.61	3.00	2.94	98%	8/4/2021	20:12	20:57	00:45	23:04	23:51	00:47	20:57	23:04	02:07	1.42	171	2.6	26	416	1.20	0	0
34	95	597.00	600.00	596.61	600.08	3.00	3.47	116%	8/4/2021	23:51	00:47	00:58	03:02	03:48	00:46	00:47	03:02	02:15	1.33	166	2.1	23	403	1.20	0	0
35	95	600.00	603.00	600.08	603.10	3.00	3.02	101%	8/4/2021	03:48	04:33	00:45	07:18	08:04	00:46	04:33	07:18	02:45	1.09	169	2.2	22	403	1.20	0	0
36	95	603.00	606.00	603.10	606.07	3.00	2.97	99%	8/5/2021	08:04	09:54	01:50	11:58	12:47	00:49	09:54	11:58	02:04	1.45	163	2.5	23	410	1.20	0	0
37	95	606.00	609.00	606.07	609.11	3.00	3.04	101%	8/5/2021	12:47	15:07	02:20	16:53	17:40	00:47	15:07	16:53	01:46	1.70	164	2.8	23	391	1.20	0	0
38	95	609.00	612.00	609.11	611.79	3.00	2.68	89%	8/5/2021	17:40	18:13	00:33	21:31	22:17	00:46	18:13	21:31	03:18	0.91	165	2.6	23	397	1.20	0	0
39	95	612.00	615.00	611.79	614.98	3.00	3.19	106%	8/5/2021	22:17	23:02	00:45	00:36	03:19	02:43	23:02	00:36	01:34	1.91	170	3.2	23	395	1.20	0	0
40	95	615.00	618.00	614.98	618.03	3.00	3.05	102%	8/5/2021	03:19	04:05	00:46	05:52	06:40	00:48	04:05	05:52	01:47	1.68	169	3.2	29	408	1.20	0	0
41	95	618.00	621.00	618.03	621.02	3.00	2.99	100%	8/6/2021	06:40	07:17	00:37	09:22	10:10	00:48	07:17	09:22	02:05	1.44	172	3.6	27	402	1.20	0	0
42	95	621.00	624.00	621.02	624.08	3.00	3.06	102%	8/6/2021	10:10	10:44	00:34	12:51	13:40	00:49	10:44	12:51	02:07	1.42	167	3.4	27	398	1.20	0	0
43	95	624.00	627.00	624.08	626.96	3.00	2.88	96%	8/6/2021	13:40	14:36	00:56	16:35	17:32	00:57	14:36	16:35	01:59	1.51	172	3.4	25.0	408	1.20	0	0
44	95	627.00	630.00	626.96	630.11	3.00	3.15	105%	8/6/2021	17:32	18:10	00:38	20:50	21:39	00:49	18:10	20:50	02:40	1.13	165	2.7	24	402	1.20	0	0
45	95	630.00	633.00	630.11	633.09	3.00	2.98	99%	8/6/2021	21:39	22:19	00:40	00:47	01:34	00:47	22:19	00:47	02:28	1.22	163	3.5	26	407	1.20	0	0
46	95	633.00	636.00	633.09	636.02	3.00	2.93	98%	8/6/2021	01:34	02:19	00:45	04:46	05:31	00:45	02:19	04:46	02:27	1.22	170	2.5	25	406	1.20	0	0
47	95	636.00	639.00	636.02	638.93	3.00	2.91	97%	8/6/2021	05:31	06:09	00:38	08:35	09:24	00:49	06:09	08:35	02:26	1.23	169	3.6	25	412	1.20	0	0
48	94-95	639.00	642.00	638.93	642.12	3.00	3.19	106%	8/7/2021	09:24	13:04	03:40	16:13	17:07	00:54	13:04	16:13	03:09	0.95	164	3.8	24	410	1.20	0	0
49	95	642.00	645.00	642.12	645.12	3.00	3.00	100%	8/7/2021	17:07	17:43	00:36	20:05	20:56	00:51	17:43	20:05	02:22	1.27	164	3,8	26	403	1.20	0	0
50	95	645.00	648.00	645.12	648.13	3.00	3.01	100%	8/7/2021	20:56	21:36	00:40	00:27	01:18	00:51	21:36	00:27	02:51	1.05	165	3.5	23	409	1.20	0	0
51	95	648.00	651.00	648.13	651.12	3.00	2.99	100%	8/7/2021	01:18	01:59	00:41	04:46	05:32	00:46	01:59	04:46	02:47	1.08	173	3.5	23	409	1.20	0	0
52	95	651.00	654.00	651.12	653.19	3.00	2.07	69%	8/7/2021	05:32	06:19	00:47	10:06	10:52	00:46	06:19	10:06	03:47	0.79	165	3.4	22.0	400	1.20	0	0
53	95	654.00	657.00	653.19	657.13	3.00	3.94	131%	8/8/2021	10:52	11:50	00:58	14:39	15:25	00:46	11:50	14:39	02:49	1.07	165	4.0	30.0	405	1.20	0	0
54	95	657.00	660.00	657.13	660.13	3.00	3.00	100%	8/8/2021	15:25	16:11	00:46	18:51	19:43	00:52	16:11	18:51	02:40	1.13	168	3.2	23.0	402	1.20	0	0
55	95	660.00	663.00	660.13	663.14	3.00	3.01	100%	8/8/2021	19:43	20:28	00:45	23:52	00:38	00:46	20:28	23:52	03:24	0.88	171	3.2	24.0	401	1.20	0	0

CS-Nr.	Ø core	depth MD		depth MD core´		core section			date	time RIH			time POOH			drilling duration				RpM	WoB	pump		dens.	mudloss	
		from	to	from	to	target	actual	rcy		from	to	Δ	from	to	Δ	from	to	Δ	ROP			p	Flow in		vol	v
	[mm]	[m]	[m]	[m]	[m]	[m]	[m]	[%]											[m/h]	[min-1]	[t]	[bar]	[l/min]	[g/cm3]	[m3]	[l/min]
56	95	663.00	666.00	663.14	666.16	3.00	3.02	101%	8/8/2021	00:38	01:20	00:42	04:31	05:22	00:51	01:20	04:31	03:11	0.94	168	3.3	24.0	425	1.20	0	0
57	95	666.00	669.00	666.16	669.14	3.00	2.98	99%	8/8/2021	05:22	06:04	00:42	08:34	09:20	00:46	06:04	08:34	02:30	1.20	175	3.0	25.0	407	1.20	0	0
58	93-95	669.00	672.00	669.14	672.15	3.00	3.01	100%	8/9/2021	09:20	10:02	00:42	12:05	12:55	00:50	10:02	12:05	02:03	1.46	165	3.5	30.0	410	1.20	0	0
59	95	672.00	675.00	672.15	675.17	3.00	3.02	101%	8/9/2021	12:55	13:30	00:35	15:46	16:40	00:54	13:30	15:46	02:16	1.32	165	2.8	24.0	407	1.20	0	0
60	95	675.00	678.00	675.17	677.72	3.00	2.55	85%	8/9/2021	16:40	18:22	01:42	21:16	22:01	00:45	18:22	21:16	02:54	1.03	166	3.0	23.0	395	1.20	0	0
61	95	678.00	681.00	677.72	681.09	3.00	3.37	112%	8/9/2021	22:01	22:45	00:44	01:46	02:33	00:47	22:45	01:46	01:46	1.70	167	3.1	25.0	403	1.20	0	0
62	95	681.00	684.00	681.09	684.20	3.00	3.11	104%	8/9/2021	02:33	03:15	00:42	05:34	06:30	00:56	03:15	05:34	02:19	1.29	161	3.2	22.0	412	1.20	0	0
63	95	684.00	687.00	684.20	687.20	3.00	3.00	100%	8/10/2021	06:30	07:05	00:35	09:18	10:10	00:52	07:05	09:18	02:13	1.35	170	3.0	27.0	410	1.20	0	0
64	95	687.00	690.00	687.20	690.21	3.00	3.01	100%	8/10/2021	10:10	10:48	00:38	12:44	13:35	00:51	10:48	12:44	01:56	1.55	165	3.7	23.0	395	1.20	0	0
65	95	690.00	693.00	690.21	693.23	3.00	3.02	101%	8/10/2021	13:35	14:16	00:41	16:20	17:10	00:50	14:16	16:20	02:04	1.45	161	3.2	23.0	400	1.20	0	0
66	95	693.00	696.00	693.23	696.23	3.00	3.00	100%	8/10/2021	17:10	17:55	00:45	19:53	20:41	00:48	17:55	19:53	01:58	1.53	164	3.3	24.0	404	1.20	0	0
67	95	696.00	699.00	696.23	699.26	3.00	3.03	101%	8/10/2021	20:41	21:23	00:42	23:23	00:12	00:49	21:23	23:23	02:00	1.50	161	3.1	27.0	405	1.20	0	0
68	95	699.00	702.00	699.26	702.17	3.00	2.91	97%	8/10/2021	00:12	00:48	00:36	02:29	03:22	00:53	00:48	02:29	01:41	1.78	163	3.2	26.0	410	1.20	0	0
69	95	702.00	705.00	702.17	705.17	3.00	3.00	100%	8/10/2021	03:22	04:01	00:39	05:44	06:40	00:56	04:01	05:44	01:43	1.75	162	3.0	26.0	409	1.20	0	0
70	95	705.00	708.00	705.17	708.21	3.00	3.04	101%	8/11/2021	06:40	07:20	00:40	08:50	09:40	00:50	07:20	08:50	01:30	2.00	168	3.1	24.0	405	1.20	0	0
71	95	708.00	711.00	708.21	710.91	3.00	2.70	90%	8/11/2021	09:40	10:13	00:33	11:44	12:40	00:56	10:13	11:44	01:31	1.98	165	3.2	23.0	405	1.20	0	0
72	95	711.00	714.00	710.91	714.15	3.00	3.24	108%	8/11/2021	12:40	14:50	02:10	16:45	17:43	00:58	14:50	16:45	01:55	1.57	170	3.3	24.0	400	1.20	0	0
73	95	714.00	717.00	714.15	717.19	3.00	3.04	101%	8/11/2021	17:43	18:24	00:41	20:20	21:15	00:55	18:24	20:20	01:56	1.55	170	3.3	24.0	409	1.20	0	0
74	95	717.00	720.00	717.19	720.07	3.00	2.88	96%	8/11/2021	21:15	21:49	00:34	00:39	01:32	00:53	21:49	00:39	02:50	1.06	156	3.4	22.0	400	1.20	0	0
75	95	720.00	723.00	720.07	723.12	3.00	3.05	102%	8/11/2021	01:32	02:05	00:33	04:05	04:58	00:53	02:05	04:05	02:00	1.50	161	4.0	26.0	408	1.20	0	0
76	95	723.00	726.00	723.12	726.14	3.00	3.02	101%	8/12/2021	04:58	05:37	00:39	08:03	08:57	00:54	05:37	08:03	02:26	1.23	159	3.6	28.0	404	1.20	0	0
77	95	726.00	729.00	726.14	729.18	3.00	3.04	101%	8/12/2021	08:57	09:38	00:41	11:36	12:23	00:47	09:38	11:36	01:58	1.53	160	3.4	30.0	404	1.20	0	0
78	95	729.00	732.00	729.18	732.16	3.00	2.98	99%	8/12/2021	12:23	13:00	00:37	15:04	15:56	00:52	13:00	15:04	02:04	1.45	165	3.6	26.0	298	1.20	0	0
79	95-94	732.00	735.00	732.16	735.19	3.00	3.03	101%	8/12/2021	15:56	16:43	00:47	19:19	20:04	00:45	16:43	19:19	02:36	1.15	165	3.7	26.0	407	1.20	0	0
80	95	735.00	738.00	735.19	738.21	3.00	3.02	101%	8/12/2021	20:04	21:41	01:37	23:21	00:13	00:52	21:41	23:21	01:40	1.80	163	4.1	22.0	403	1.20	0	0
81	95	738.00	741.00	738.21	741.14	3.00	2.93	98%	8/12/2021	00:13	00:47	00:34	03:00	03:55	00:55	00:47	03:00	02:13	1.35	158	3.1	24.0	404	1.20	0	0
82	95	741.00	743.00	741.14	744.14	3.00	3.00	100%	8/13/2021	03:55	04:36	00:41	06:40	07:36	00:56	04:36	06:40	02:04	1.45	162	3.4	24.0	403	1.20	0	0
83	95	743.00	747.00	744.14	747.24	3.00	3.10	103%	8/13/2021	07:36	08:16	00:40	09:18	10:19	01:01	08:16	09:18	01:02	2.90	169	3.2	22.0	401	1.20	0	0
84	95+	747.00	750.00	747.24	750.28	3.00	3.04	101%	8/13/2021	10:19	12:02	01:43	14:03	20:43	06:40	12:02	14:03	02:01	1.49	165	3.2	21.0	403	1.20	0	0
85	95	750.00	753.00	750.28	753.25	3.00	2.97	99%	8/13/2021	20:43	00:13	03:30	01:25	02:28	01:03	00:13	01:25	01:12	2.50	155	3.0	26.0	412	1.20	0	0
86	95	753.00	756.00	753.25	756.29	3.00	3.04	101%	8/13/2021	02:28	02:58	00:30	04:26	05:22	00:56	02:58	04:26	01:28	2.05	157	3.7	28.0	409	1.20	0	0
87	95	756.00	759.00	756.29	759.30	3.00	3.01	100%	8/14/2021	05:22	06:01	00:39	08:09	09:14	01:05	06:01	08:09	02:08	1.41	158	3.4	29.0	404	1.20	0	0
88	95	759.00	762.00	759.30	762.32	3.00	3.02	101%	8/14/2021	09:14	10:00	00:46	12:12	13:18	01:06	10:00	12:12	02:12	1.36	161	3.3	27.0	404	1.20	0	0
89	95	762.00	765.00	762.32	764.77	3.00	2.45	82%	8/14/2021	13:18	14:02	00:44	16:14	17:16	01:02	14:02	16:14	02:12	1.36	165	3.5	36.0	404	1.20	0	0
90	95	765.00	768.00	764.77	768.00	3.00	3.23	108%	8/14/2021	17:16	18:11	00:55	21:18	22:10	00:52	18:11	21:18	03:07	0.96	161	3.6	27.0	398	1.20	0	0
91	95	768.00	771.00	768.00	770.93	3.00	2.93	98%	8/14/2021	22:10	22:55	00:45	02:07	03:06	00:59	22:55	02:07	03:12	0.94	153	3.7	33.0	408	1.20	0	0
92	92-95	771.00	774.00	770.93	774.07	3.00	3.14	105%	8/15/2021	03:06	03:40	00:34	05:34	06:45	01:11	03:40	05:34	01:54	1.58	152	2.9	31.0	414	1.20	0	0
93	95	774.00	777.00	774.07	776.95	3.00	2.88	96%	8/15/2021	06:45	07:29	00:44	09:35	10:34	00:59	07:29	09:35	02:06	1.43	162	3.0	34.0	409	1.20	0	0
94	95	777.00	780.00	776.95	780.13	3.00	3.18	106%	8/15/2021	10:34	11:16	00:42	13:43	14:41	00:58	11:16	13:43	02:27	1.22	161	3.1	30.0	403	1.20	0	0
95	95	780.00	783.00	780.13	780.13	3.00	0.00	0%	8/15/2021	14:41	15:21	00:40	17:13	18:12	00:59	15:21	17:13	01:52	1.61	163	3.3	29.0	401	1.20	0	0
96	95	783.00	786.00	780.13	783.10	3.00	2.97	99%	8/15/2021	18:12	20:18	02:06	22:41	23:30	00:49	20:18	22:41	02:23	1.26	160	3.8	35.0	395	1.20	0	0
97	95	786.00	789.00	783.10	786.07	3.00	2.97	99%	8/15/2021	23:30	00:15	00:45	02:36	03:25	00:49	00:15	02:36	02:21	1.28	154	2.5	33.0	399	1.20	0	0
98	95	789.00	792.00	786.07	788.98	3.00	2.91	97%	8/16/2021	03:25	04:00	00:35	06:36	07:34	00:58	04:00	06:36	02:36	1.15	158	2.8	35.0	416	1.20	0	0
99	95	792.00	795.00	788.98	792.12	3.00	3.14	105%	8/16/2021	07:34	08:11	00:37	11:07	12:01	00:54	08:11	11:07	02:56	1.02	172	3.4	31.0	406	1.20	0	0
100	95	795.00	798.00	792.12	795.01	3.00	2.89	96%	8/16/2021	12:01	12:47	00:46	16:03	16:57	00:54	12:47	16:03	03:16	0.92	168	4.6	31.0	414	1.20	0	0
101	95	798.00	801.00	795.01	798.02	3.00	3.01	100%	8/16/2021	16:57	17:36	00:39	20:44	21:37	00:53	17:36	20:44	03:08	0.96	163	4.6	31.0	400	1.20	0	0
102	95	801.00	804.00	798.02	804.10	3.00	6.08	203%	8/16/2021	21:37	22:14	00:37	01:48	02:40	00:52	22:14	01:48	03:34	0.84	168	4.9	37.0	405	1.20	0	0
103	95	804.00	807.00	804.10	806.99	3.00	2.89	96%	8/16/2021	02:40	03:20	00:40	05:12	06:23	01:11	03:20	05:12	01:52	1.61	168	4.9	37.0	405	1.20	0	0
104	95	807.00	810.00	806.99	809.97	3.00	2.98	99%	8/17/2021	06:23	07:04	00:41	09:04	10:04	01:00	07:04	09:04	02:00	1.50	165	4.3	35.0	407	1.20	0	0
105	95	810.00	813.00	809.97	813.14	3.00	3.17	106%	8/17/2021	10:04	10:45	00:41	12:52	13:49	00:57	10:45	12:52	02:07	1.42	164	4.2	36.0	402	1.20	0	0
106	95	813.00	816.00	813.14	816.09	3.00	2.95	98%	8/17/2021	13:49	14:33	00:44	16:41	17:40	00:59	14:33	16:41	02:08	1.41	166	3.7	39.0	405	1.20	0	0
107	95	816.00	819.00	816.09	819.10	3.00	3.01	100%	8/17/2021	17:40	18:17	00:37	20:32	21:27	00:55	18:17	20:32	02:15	1.33	162	3.5	43.0	403	1.20	0	0
108	95	819.00	822.00	819.10	822.13	3.00	3.03	101%	8/17/2021	21:27	23:20	01:53	01:55	02:54	00:59	23:20	01:55	02:35	1.16	161	3.5	45.0	417	1.20	0	0
109	95	822.00	825.00	822.13	824.93	3.00	2.80	93%	8/18/2021	02:54	02:54	00:00	07:13	08:14	01:01	02:54	07:13	04:19	0.69	161	4.7	50.1	408	1.20	0	0
110	95	825.00	828.00	824.93	827.99	3.00	3.06	102%	8/18/2021	08:14	08:55	00:41	11:07	12:05	00:58	08:55	11:07	02:12	1.36	165	4.2	48.0	405	1.20	0	0

Appendix J: Daily drilling reports

Note: Only in the digital version of this report (PDF) is Appendix J attached and can be found under the paper clip symbol.

Appendix K: Bottom hole assembly reports

Note: Only in the digital version of this report (PDF) is Appendix K attached and can be found under the paper clip symbol.

Appendix L: Mud service report (Sirius)

Note: Only in the digital version of this report (PDF) is Appendix L attached and can be found under the paper clip symbol.

Appendix M: Cementation data

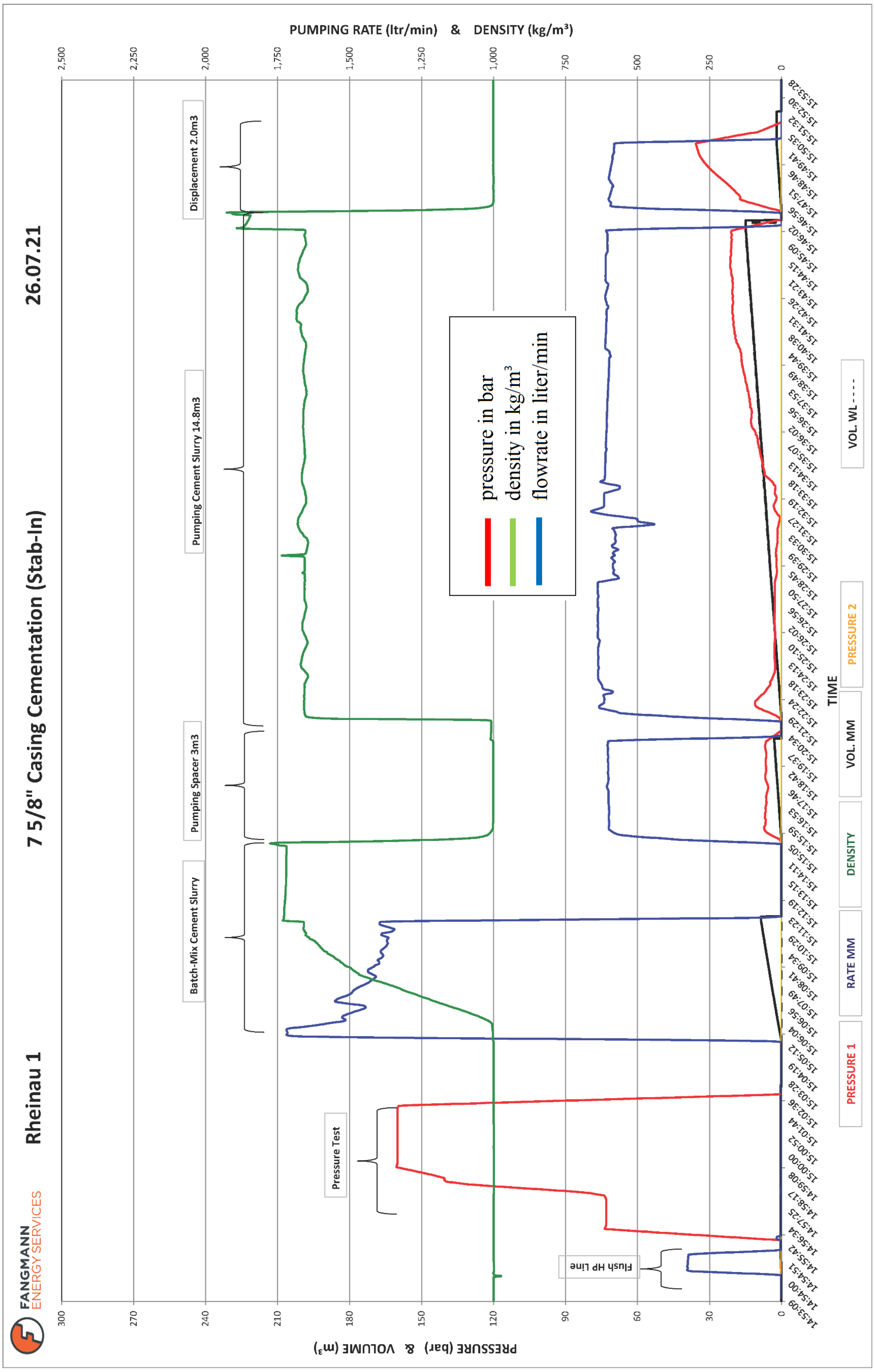
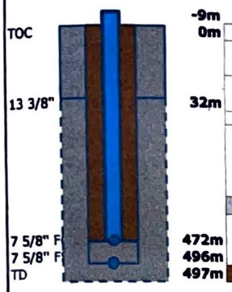


Fig. M-1: 7⅝" cementing chart

FANGMANN ENERGY SERVICES

Client: Marriott Drilling	**MD 497.0 m**	**TG 3.0°/100m**	Marriott DRILLING GROUP
Well: Rheinau 1	**TVD 497.0 m**	**BHST 30°C**	
Cementing: 7 5/8" Casing	**Max. Dev 32.5°**	**Test Temp. 27°C**	

Volume Calculation



	OD	Description	Length	Capacity	Displacement	Comment	Volume
Previous casing	13 3/8 "	68.0 ppf	32m	77.84l/m		Total cap.	+ 2.49 m³
Open hole	9 1/2 " 9.62 "	2.5% OH XS 7% annular XS	465m	45.76l/m 17.42l/m in annulus		OH without XS OH XS	+ 21.28 m³ + 0.53 m³
Casing to be cemented	7 5/8 "	29.7 ppf	496m	23.92l/m	29.48l/m	Total displ.	+ 14.62 m³
			24m			Shoetrack	+ 0.57 m³
						Cement volume	**12.30m³**
Drill pipe	2 7/8 "	10.4 ppf	397m	2.73l/m		Total cap.	1.08m³
SK	5 1/2 "	19.5 ppf					0.98m³
						Displacement volume	**2.06m³**

End pressure **29 bar** Casing lift **-11 To** @ Pump pres. **65 bar**

Fluid Design

Spacer	1.00kg/l	dead vol. 0.2 m³ per m³	3.2m³ total
Fresh water	lt	997.0	3190.4
SGL-312	kg	3.0	9.6
Yield	lt	1000.0	

Cement	1.65kg/l	dead vol. 0.5 m³ per to. cmt.	per m³	12.8m³ total
Fresh water	lt	673.6	663.9	8498.3
CAF-902	lt	1.0	1.0	12.6
CFL-347	kg	1.0	1.0	12.6
CRE-120	kg	0.5	0.5	6.3
CMT-003	tonne	1.0	1.0	12.6
Yield	lt	1014.6		

Logistics

Personnel		**Equipment**	
Supervisor:	1	Pumptruck	1x
Operator:	Pump	Incl. Data recording	
Operator:	Mixtank	7 m³ Mixtank	1x
Operator:	Bulk	Generator	1x
		Bulktruck	1x
		Incl. Compressor	
		30 m³ Vertical tank	1x
		From client:	
		Suction truck (fluids disposal)	1x

Material		**Quantity**	**Comments**
CMT-003	CEM III B cement	12.6 tonne	
CAF-902	Antifoam	12.6 lt	
CFL-347	Fluidloss	12.6 kg	
CRE-120	Retarder LT	6.3 kg	Lot.-Nr. MM11K-06S3
SGL-312	Polymer	9.6 kg	
CLC-602	CemFibers (LCM)	60.0 kg	4 Kg./m³, at request
From client:			
FRWA for spacer + cementing line		5.6 m³	
FRWA for cement		8.5 m³	

Pumping Schedule

Time	Step	Comm.	Volume m³	Density kg/ltr	Rate ltr/min	Duration min
	Wellbore circulation min. 2 bottoms-up @ max. allowable rate by the well / Job Safety Analysis (JSA)					
	Prime the lines		0.30		300	1
	Pressure test	150 bar				5
	Premix first 6 m³ of cement					20
	Pump spacer	172 m	3.00	1.00	600	5
	Mix & pump cement		12.30	1.65	600	21
	when cement to surface, switch to displacement					
	Displace with fresh water		2.06	1.00	300	7
	Flow Check, Sting-out, Reverse Circulate DP clean					15
					Pumping time:	**67min**

Recommendations / Comments
- tubular capacities to be confirmed
- Casing to be chained down to avoid any lifting while pumping.

Document info
Prepared: T. Precup
Client: Marriott Drilling
Version #: 3
Status: Field Version
Date: 23.07.2021

This programm is based on the most recent information provided by the client.
Prepared by FES and controlled by client representative.
All steps have been communicated and approved prior to the job.

FES Supervisor ____ Date 26/July/2021

CoMan ____ Date 26.07.21

Fig. M-2: 7⅝" cementing programme

Cement plugs back to surface

Four cement plugs were set to cement the well to surface.

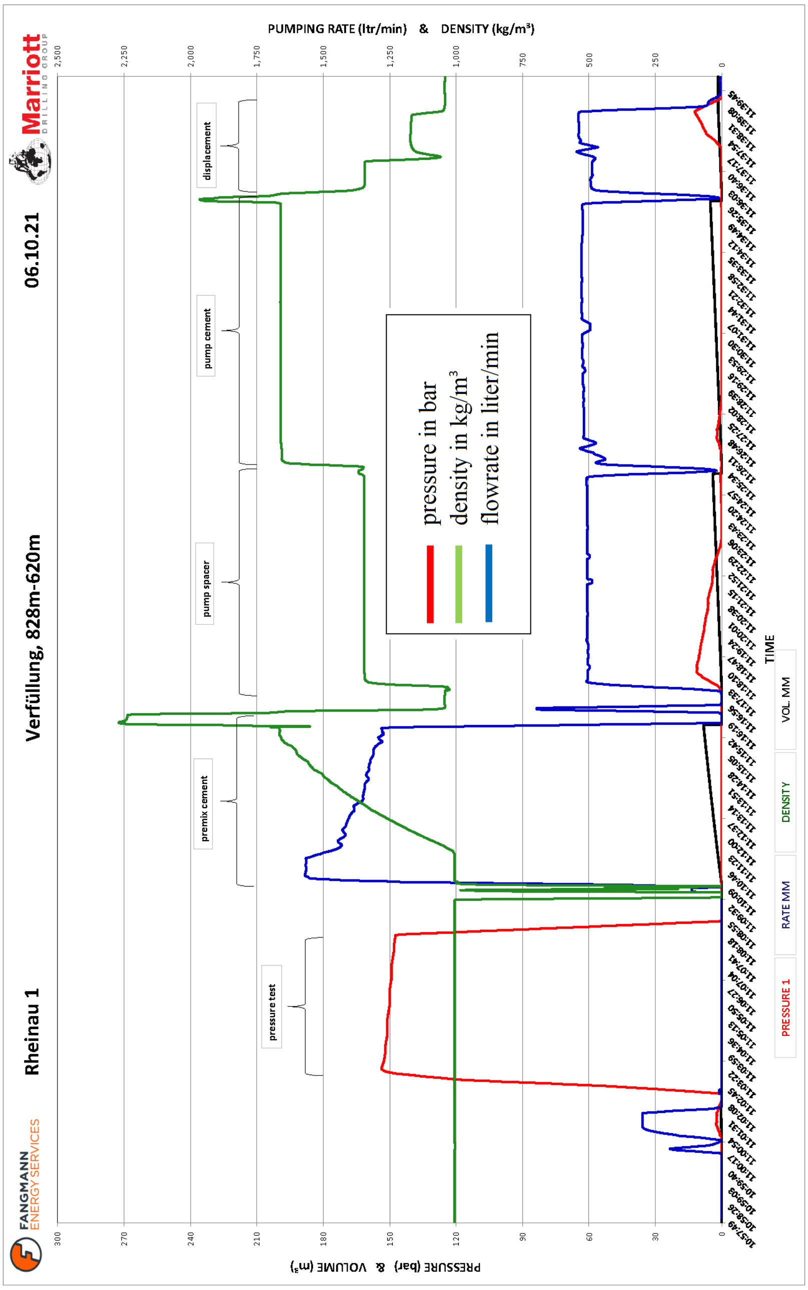
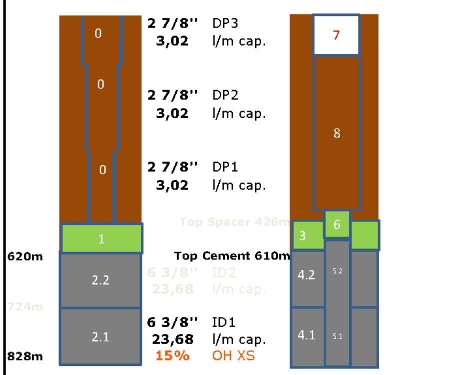


Fig. M-3: First cement plug (from 828 m to 611.4 m MD) cementing chart

FANGMANN ENERGY SERVICES	**Client** Marriott Drilling	**MD 828,0 m**	**TG 3,2°/100m**	Marriott DRILLING GROUP
	Well Rheinau 1	**TVD 710,0 m**	**BHST 38°C**	
	Cementing P&A_Step 1	**Max. Dev 39°**	**Test Temp. 30°C**	

Wellbore schematic without and with drill pipes



Volume Calculation

0	Surface lines				0,15m³
		2 7/8" DP3	0m	3,02l/m	0,00m³
	Total DP 828 m	2 7/8" DP2	0m	3,02l/m	0,00m³
		2 7/8" DP1	**828m**	3,02l/m	2,50m³
1	**Total Spacer**	Top 426m	194m	23,68l/m	4,60m³
2	**Cement plug**	2.2	104m	23,68l/m	2,46m³
		2.1	104m	23,68l/m	2,46m³
					4,90m³
3	**Spacer ahead**		205m	19,49l/m	**4,00m³**
4	**Cement in Annular**	4.2	114m	19,49l/m	2,22m³
		4.1	104m	19,49l/m	2,03m³
5	**Cement in DP**	5.2	114m	3,02l/m	0,34m³
		5.1	104m	3,02l/m	0,31m³
6	**Spacer behind**		205m		0,60m³
	Cement to be circulated depth		**620m**		
7	**Underdisplacement**				0,30m³
8	**Mud displacement**				1,10m³

Fluid Design

Spacer	**1,33kg/l**	dead vol. 0,25 m³	**4,9m³**
		per m³	total
Fresh water	lt	803,5	3897,0
SGL-312	kg	**2,0**	9,7
CRE-120	kg	**1,0**	4,9
CWA-705	kg	**525,9**	2550,6
Yield	lt	1000,0	

Cement	**1,65kg/l**	dead vol. 0,5 m³		**5,4m³**
		per ton cmt.	per m³	total
Fresh water	lt	670,3	662,0	3574,6
CAF-902	lt	**1,0**	1,0	5,3
CFL-347	kg	**0,5**	0,5	2,7
CRE-120	kg	**1,0**	1,0	5,3
CMT-003	tonne	**1,0**	1,0	5,3
Yield	lt	1012,6		

Logistics

Personnel		**Equipment**	
Supervisor:	1	Pumptruck	1x
Operator:	Pump	incl. Data recording	
Operator:	Mixtank	Mixtank	2x
Operator:	Bulk	Generator	1x
		Bulktruck	1x
		incl. Compressor	
		From client:	
		Suction truck (fluids disposal)	1x

Material		Quantity	Comments
CMT-003	CEM III B cement	5,3 tonne	
CAF-902	Antifoam	5,3 lt	
CFL-347	Fluidloss	2,7 kg	
CRE-120	Retarder LT	10,2 kg	MM11K-06S3
SGL-312	Polymer	9,7 kg	
CWA-705	Fine chalk	2550,6 kg	weighting agent for spacer
From client:			
FRWA for spacer + cementing line		5,5 m³	
FRWA for cement		3,6 m³	

Pumping Schedule

Time	Step	Comm.	Volume	Density	Rate	Duration
			m³	**kg/ltr**	**ltr/min**	**min**
	Wellbore circulation min. 2 bottoms-up @ max. allowable rate by the well / Job Safety Analysis (JSA)					
	Prime the lines		0,30		300	1
	Pressure test	150 bar				5
	Premix cement					20
	Pump Spacer ahead		4,00	1,33	500	8
	Pump cement		4,90	1,65	500	10
	Total displacement volume	1,70m³				
	Pump Spacer behind		0,60	1,33	500	1
	Pump mud		0,80	1,20	500	2
	Pump fresh water (surface lines)		0,30	1,00	300	1
	Flow check, POOH, Reverse circulate @	620m				60
					Pumping time:	**102min**

Recommendations / Comments
- tubular capacities to be confirmed
- in case of pressure increase during displacement, stop pumping to avoid overdisplacement

Document info
Prepared: T. Precup
Client: Marriott Drilling
Version #: 4
Status: Field Version
Date: 05.10.2021

This programm is based on the most recent information provided by the client.
Prepared by FES and controlled by client representative.
All steps have been communicated and approved prior to the job.

FES Supervisor ________________ Date
CoMan ________________ Date

Fig. M-4: First cement plug (from 828 m to 611.4 m MD) cementing programme

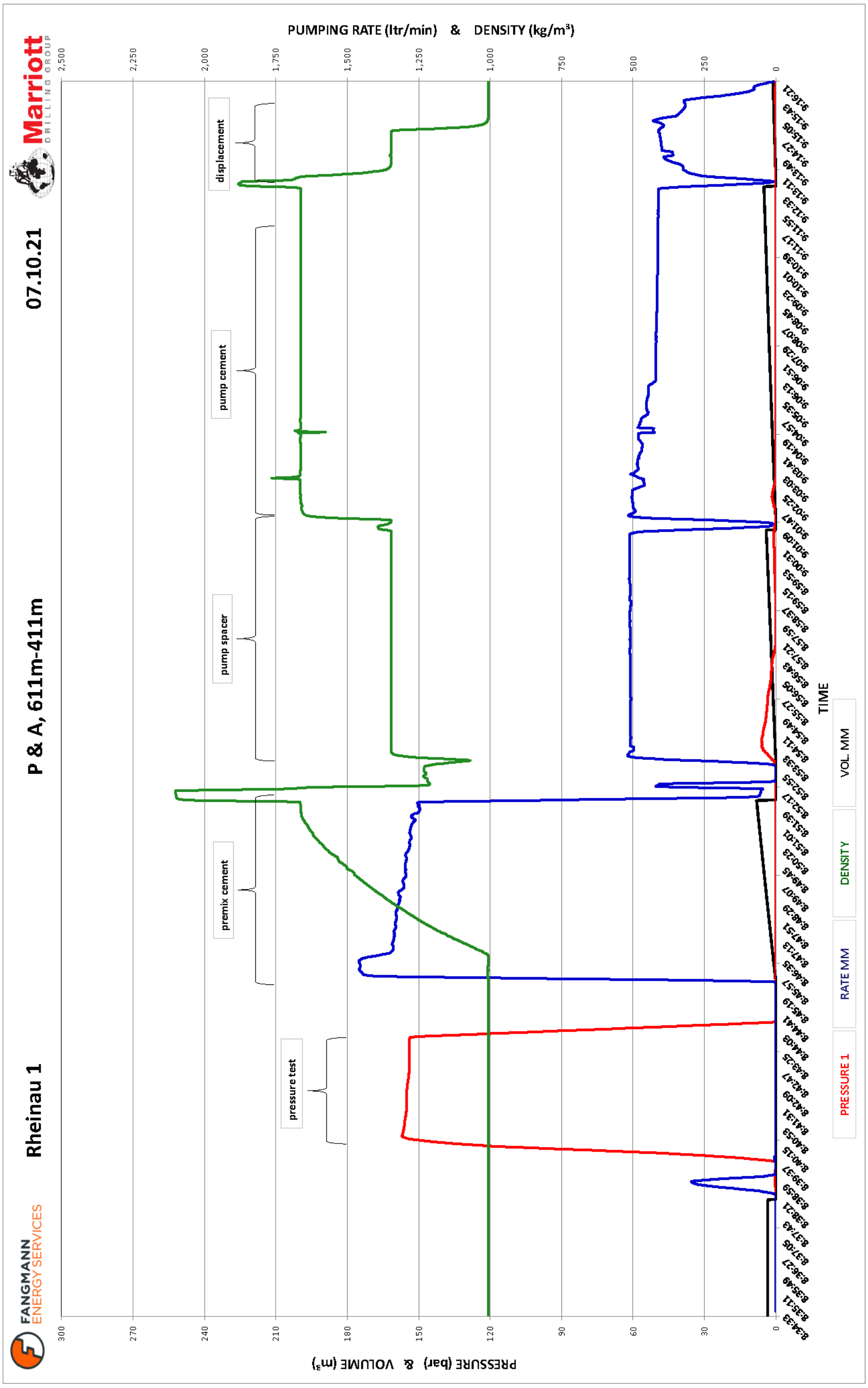
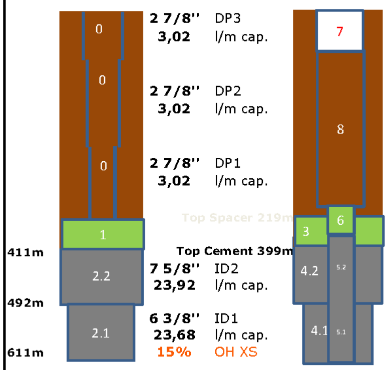


Fig. M-5: Second cement plug (from 611.4 m to 410.11 m MD) cementing chart

FANGMANN ENERGY SERVICES	**Client**	Marriott Drilling	**MD 611,0 m**	**TG 3,0°/100m**	Marriott DRILLING GROUP
	Well	Rheinau 1	**TVD 549,2 m**	**BHST 31°C**	
	Cementing	P&A_Step 2	**Max. Dev 39°**	**Test Temp. 30°C**	

Wellbore schematic without and with drill pipes



Volume Calculation

0	Surface lines				0,15m³
		2 7/8" DP3	0m	3,02l/m	0,00m³
	Total DP 611 m	2 7/8" DP2	0m	3,02l/m	0,00m³
		2 7/8" DP1	**611m**	3,02l/m	1,85m³
1	**Total Spacer**	Top 219m	192m	23,92l/m	4,60m³
2	**Cement plug**	2.2	81m	23,92l/m	1,94m³
		2.1	119m	23,68l/m	2,82m³
					4,80m³
3	**Spacer ahead**		203m	19,49l/m	**4,00m³**
4	**Cement in Annular**	4.2	93m	19,73l/m	1,84m³
		4.1	119m	19,49l/m	2,32m³
5	**Cement in DP**	5.2	93m	3,02l/m	0,28m³
		5.1	119m	3,02l/m	0,36m³
6	**Spacer behind**		203m		0,60m³
	Cement to be circulated depth		**420m**		
7	**Underdisplacement**				0,30m³
8	**Mud displacement**				0,50m³

Fluid Design

Spacer	**1,33kg/l**	dead vol. 0,25 m³	**4,9m³**
		per m³	total
Fresh water	lt	803,5	3897,0
SGL-312	kg	**2,0**	9,7
CRE-120	kg	**1,0**	4,9
CWA-705	kg	**525,9**	2550,6
Yield	lt	1000,0	

Cement	**1,65kg/l**	dead vol. 0,5 m³		**5,3m³**
		per ton cmt.	per m³	total
Fresh water	lt	670,3	662,0	3508,4
CAF-902	lt	**1,0**	1,0	5,2
CFL-347	kg	**0,5**	0,5	2,6
CRE-120	kg	**1,0**	1,0	5,2
CMT-003	tonne	**1,0**	1,0	5,2
Yield	lt	1012,6		

Logistics

Personnel		**Equipment**	
Supervisor:	1	Pumptruck	1x
Operator:	Pump	incl. Data recording	
Operator:	Mixtank	Mixtank	2x
Operator:	Bulk	Generator	1x
		Bulktruck	1x
		incl. Compressor	
		From client:	
		Suction truck (fluids disposal)	1x

Material		Quantity	Comments
CMT-003	CEM III B cement	5,2 tonne	
CAF-902	Antifoam	5,2 lt	
CFL-347	Fluidloss	2,6 kg	
CRE-120	Retarder LT	10,1 kg	MM11K-06S3
SGL-312	Polymer	9,7 kg	
CWA-705	Fine chalk	2550,6 kg	weighting agent for spacer
From client:			
FRWA for spacer + cementing line		5,2 m³	
FRWA for cement		3,5 m³	

Pumping Schedule

Time	Step	Comm.	Volume	Density	Rate	Duration
			m³	**kg/ltr**	**ltr/min**	**min**
	Premix cement					20
	Pump Spacer ahead		4,00	1,33	500	8
	Pump cement		4,80	1,65	500	10
	Total displacement volume	1,10m³				
	Pump Spacer behind		0,60	1,33	500	1
	Pump fresh water (surface lines)		0,30	1,00	300	1
	Flow check, POOH, Reverse circulate @	420m				60
					Pumping time:	**100min**

Recommendations / Comments
- tubular capacities to be confirmed
- in case of pressure increase during displacement, stop pumping to avoid overdisplacement

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CoMan ________________ Date

Fig. M-6: Second cement plug (from 611.4 m to 410.11 m MD) cementing programme

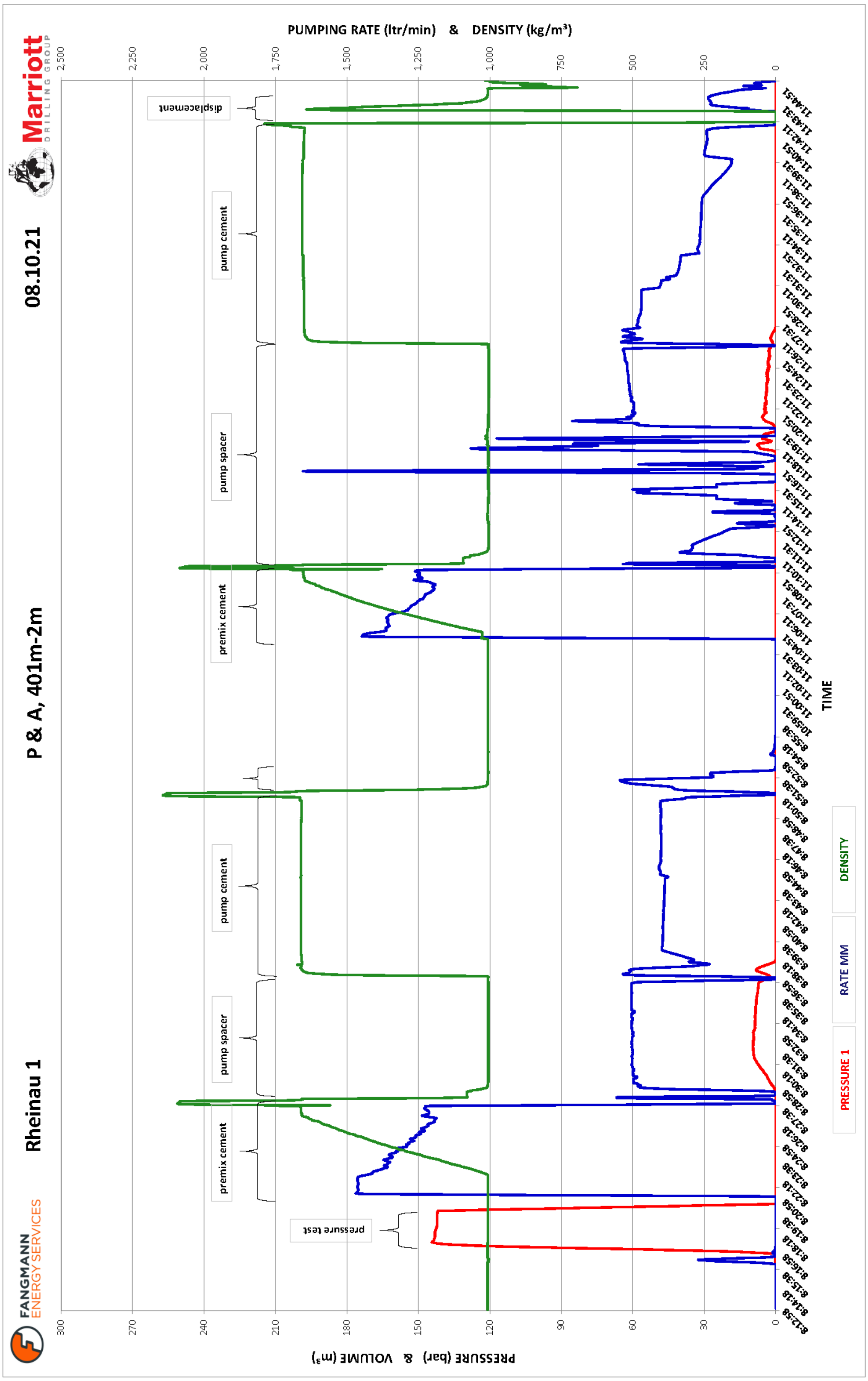
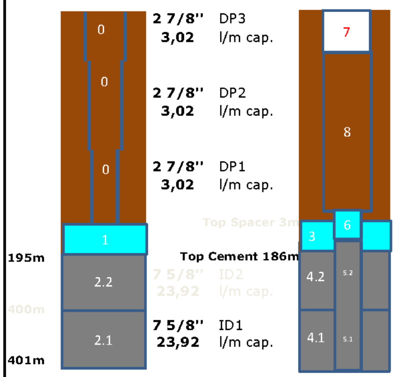


Fig. M-7: Third and fourth cement plug (from 410.11 m MD to 195 m MD) cementing chart

FANGMANN ENERGY SERVICES	Client	Marriott Drilling	MD 401,0 m	TG 3,0°/100m	Marriott DRILLING GROUP
	Well	Rheinau 1	TVD 401,0 m	BHST 27°C	
	Cementing	P&A_Step 3	Max. Dev 0,0°	Test Temp. 22°C	

Wellbore schematic without and with drill pipes



Volume Calculation

0	Surface lines				0,15m³
		2 7/8'' DP3	0m	3,02l/m	0,00m³
	Total DP 401 m	2 7/8'' DP2	0m	3,02l/m	0,00m³
		2 7/8'' DP1	**401m**	3,02l/m	1,21m³
1	**Total Spacer**	Top 3m	192m	23,92l/m	4,60m³
2	**Cement plug**	2.2	205m	23,92l/m	4,90m³
		2.1	1m	23,92l/m	0,02m³
					4,90m³
3	**Spacer ahead**		203m	19,73l/m	**4,00m³**
4	**Cement in Annular**	4.2	214m	19,73l/m	4,23m³
		4.1	1m	19,73l/m	0,02m³
5	**Cement in DP**	5.2	214m	3,02l/m	0,65m³
		5.1	1m	3,02l/m	0,00m³
6	**Spacer behind**		203m		0,60m³
	Cement to be circulated depth		**195m**		
7	**Underdisplacement**				0,30m³
8	**Mud displacement**				-0,20m³

Fluid Design

Spacer	**1,00kg/l**	dead vol. 0,2 m³	**4,8m³**
		per m³	total
Fresh water	lt	1000,0	4800,0
Yield	lt	1000,0	

Cement	**1,65kg/l**	dead vol. 0,5 m³		**5,4m³**
		per ton cmt.	per m³	total
Fresh water	lt	715,7	688,4	3717,2
CAF-902	lt	**1,0**	1,0	5,2
CRE-120	kg	**1,0**	1,0	5,2
CMT-003	tonne	**1,0**	1,0	5,2
Yield	lt	1039,7		

Logistics

Personnel		Equipment		Material		Quantity	Comments
Supervisor:	1	Pumptruck	1x	CMT-003	CEM III B cement	5,2 tonne	
Operator:	Pump	incl. Data recording		CAF-902	Antifoam	5,2 lt	
Operator:	Mixtank	Mixtank	1x	CRE-120	Retarder LT	5,2 kg	MM11K-06S3
Operator:	Bulk	Generator	1x				
		Bulktruck	1x				
		incl. Compressor					
		From client:		From client:			
		Suction truck	1x	FRWA for spacer + cementing line		4,9 m³	
		(fluids disposal)		FRWA for cement		3,7 m³	

Pumping Schedule

Time	Step	Comm.	Volume	Density	Rate	Duration
			m³	**kg/ltr**	**ltr/min**	**min**
	Wellbore circulation min. 2 bottoms-up @ max. allowable rate by the well / Job Safety Analysis (JSA)					
	Prime the lines		0,30		300	1
	Pressure test	150 bar				5
	Premix cement					20
	Pump Spacer ahead		4,00	1,00	500	8
	Pump cement		4,90	1,65	500	10
	Total displacement volume	0,40m³				
	Pump Spacer behind		0,40	1,00	500	1
	Flow check, POOH, Reverse circulate @	195m				60
					Pumping time:	**98min**

Recommendations / Comments
- tubular capacities to be confirmed
- in case of pressure increase during displacement, stop pumping to avoid overdisplacement

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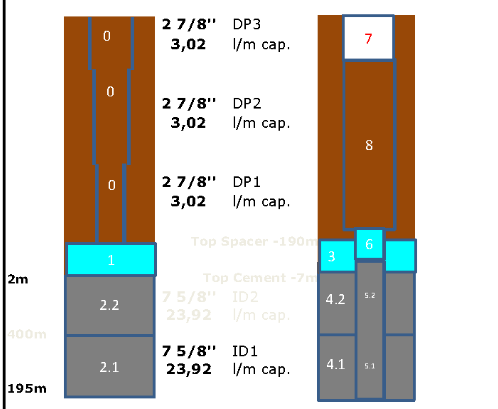
Fig. M-8: Third cement plug (from 410.11 m to 195 m MD) cementing programme

FANGMANN ENERGY SERVICES	Client: Marriott Drilling	MD 195,0 m	TG 3,0°/100m	Marriott DRILLING GROUP
	Well: Rheinau 1	TVD 195,0 m		
	Cementing: P&A_Step 4	Max. Dev 0,0°	Test Temp. 22°C	

Wellbore schematic without and with drill pipes



Volume Calculation

0	Surface lines				0,30m³
	Total DP 195 m	2 7/8'' DP3	0m	3,02l/m	0,00m³
		2 7/8'' DP2	0m	3,02l/m	0,00m³
		2 7/8'' DP1	**195m**	3,02l/m	0,59m³
1	**Total Spacer**	-Top 190m	192m	23,92l/m	4,60m³
2	**Cement plug**	2.2	398m	23,92l/m	9,52m³
		2.1	-205m	23,92l/m	-4,90m³
					4,60m³
3	**Spacer ahead**		203m	19,73l/m	**4,00m³**
4	**Cement in Annular**	4.2	407m	19,73l/m	8,03m³
		4.1	-205m	19,73l/m	-4,04m³
5	**Cement in DP**	5.2	407m	3,02l/m	1,23m³
		5.1	-205m	3,02l/m	-0,62m³
6	**Spacer behind**		203m		0,60m³
	Cement to be circulated depth		**2m**		
7	**Underdisplacement**				0,30m³
8	**Mud displacement**				-0,60m³

Fluid Design

Spacer	**1,00kg/l**	dead vol. 0,2 m³	**4,2m³**
		per m³	total
Fresh water	lt	1000,0	4200,0
Yield	lt	1000,0	

Cement	**1,65kg/l**	dead vol. 0,5 m³		**5,1m³**
		per ton cmt.	per m³	total
Fresh water	lt	708,5	684,7	3492,0
CAF-902	lt	**1,0**	1,0	4,9
CMT-003	tonne	**1,0**	1,0	4,9
Yield	lt	1034,8		

Logistics

Personnel		Equipment		Material		Quantity	Comments
Supervisor:	1	Pumptruck	1x	CMT-003	CEM III B cement	4,9 tonne	
Operator:	Pump	incl. Data recording		CAF-902	Antifoam	4,9 lt	
Operator:	Mixtank	Mixtank	1x				
Operator:	Bulk	Generator	1x				
		Bulktruck	1x				
		incl. Compressor					
		From client:		From client:			
		Suction truck	1x	FRWA for spacer + cementing line		4,5 m³	
		(fluids disposal)		FRWA for cement		3,5 m³	

Pumping Schedule

Time	Step	Comm.	Volume	Density	Rate	Duration
			m³	**kg/ltr**	**ltr/min**	**min**
	Premix cement					20
	Pump Spacer ahead		4,00	1,00	500	8
	Pump cement		4,60	1,65	500	9
	Pump fresh water (surface lines)		0,30	1,00	300	1
	Flow check, POOH, Fill up to	2m				60
					Pumping time:	**97min**

Recommendations / Comments

- tubular capacities to be confirmed
- in case of pressure increase during displacement, stop pumping to avoid overdisplacement

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Fig. M-9: Fourth cement plug (from 195 m MD to surface) cementing programme

Appendix N: Cement bond

A CBL and USIT were acquired in the RHE1-1 borehole to evaluate the integrity of the cement and control the casing collar locations.

From 3 m to 13 m MD the cement has poor bond with a free pipe at the top of the borehole. The bond log shows strong casing signals. From 12.2 m to 500 m MD the cement has medium – good bond. The TOC is located at 12.2 m MD. The attenuation rate is 25 dB/m and the casing signals and casing collars are damped. A micro annulus is indicated on the acoustic impedance map.

Tab. N-1: Cement zone descriptions for Section I (based on runs 2.2.3 and 2.2.10)

From	**To**	**Lithostratigraphic unit**	**Zone description**
[m MD]			
0	3	Quaternary, USM	Readings attenuated or invalid
3	12.2	USM	CBL amplitude at free-pipe value (60 mV), strong casing arrivals on the VDL. Attenuation rate is 2 dB/m. Bond index show liquid is present and low accoustic impendence – Poor Bond
12.2		TOC	
12.2	53.8	USM	CBL amplitude is low, weak casing and formation arrivals on the VDL. The casing collars are dampened indicating the presence of cement. Attenuation rate is 25 dB/m. The acoustic impedance map indicates a microannulus is present in this casing in casing section – Medium Bond
53.8	120.2	USM	CBL/VDL indicates some areas of low attenuation likely due to a thin cement sheath on the narrow side of the annulus. Bond index shows 100% cement coverage – Good Bond
120.2	124.7	USM	CBL amplitude is medium, medium casing and formation arrivals on the VDL. Bond index shows an isolated pocket of liquid – Medium Bond
124.7	322.6	USM, Siderolithikim, «Felsenkalke» + «Massenkalk», Schwarzbach Fm., Villigen Fm.	Casing signals and casing collars are damped with strong formation arrivals on the VDL. Galaxy patterns on the accoustic impedence map are due to reflections from the fast formation interfering with the acoustic signal. Fast formation intervals register medium to high on the CBL. Bond index is 100% on the acoustic impedance map – Good bond
322.6	326.6	Villigen Fm.	Isolated channel of liquid evident on the acoustic impedence map – Medium bond
326.3	345.7	Villigen Fm.	Strong formation arrivals on the VDL, which arrive before the casing signals indicating fast formation. Bond index indicates 100% cement coverage – Good bond
345.7	350.8	Villigen Fm.	Isolated pocket of liquid evident on the acoustic impedence map – Medium bond

From	**To**	**Lithostratigraphic unit**	**Zone description**
[m MD]			
350.8	380.2	Villigen Fm.	Strong formation arrivals on the VDL, which arrive before the casing signals indicating fast formation. Bond index indicates 100% cement coverage – Good bond
380.2	381.3	Villigen Fm.	Isolated pocket of liquid evident on the acoustic impedence map – Medium bond
381.3	488.2	Villigen Fm., Wildegg Fm., Wutach Fm., Variansmergel Fm., «Park.-Württ.-Sch.», « Humphriesioolith»	CBL amplitude is low, weak casing signals and strong formation arrivals on the VDL. Accoustic impedance map shows full cement coverage around the casing. Narrow side feature from 475.9 m to 485.3 m MD in the impedance map is due to reflections in the formation – Good bond
488.2	496.13	«Wedelsandstein»	CBL amplitude is low, weak casing signals and strong formation arrivals on the VDL. Acoustic impedence map shows a few isolated pockets. Zonal isolation is achieved around the 7⅝" casing shoe – Medium bond
496.13		7⅝" casing shoe	

Exploration borehole Rheinau-1-1
(19.07.2021 – 10.10.2021)

Activity	%	Hrs
Drilling		
Drilling	2,8%	55
Tripping (drilling)	1,5%	30
Hole opening		
Hole opening	0,0%	0
Tripping (hole opening)	0,0%	0
Coring		
Coring	23,5%	467
Tripping (Coring)	0,4%	9
Logging		
Petrophysical & Technical Logging	6,5%	129
VSP	4,7%	94
Testing		
Hydrotest & GTPT	47,0%	936
Drilling related operations		
Casing & Cementing & WOC	5,2%	103
BOP & Well Control & Wellhead	4,5%	90
Drill out shoe & FIT	0,7%	14
Mud exchange & borehole conditioning	3,2%	64
Various operations (magnet run etc.)	0,1%	2
	100,0%	1990