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Arbeitsbericht NAB 21-21

TBO Bözberg-1-1: Data Report

Dossier I Drilling

February 2022

National Cooperative
for the Disposal of
Radioactive Waste

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M. Ammen, P.-J. Palten, J. Vliek, K. Gollob & K. Hilgendorf

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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:
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Abbreviations

AKO	Adjustable kick-off sub
API	American Petroleum Institute
APS	Accelerator porosity sonde
ASME	American Society of Mechanical Engineers
ATEX	EU directives describing the minimum safety requirements of the workplace and equipment used in explosive atmosphere (Appareils destinés à être utilisés en ATmosphères EXplosives)
BGL	Below ground level
BHA	Bottom hole assembly
BOP	Blow-out preventer
BTC	Buttress connection
CBL	Cement bond log
CE	CE marking certification, "*Conformité Européen"* = "European Conformity"
CHH	Casing head housing
CSG	Casing
DDR	Daily drilling reports
DETEC	Federal Department of the Environment, Transport, Energy and Communications (German abbreviation UVEK)
DF	Drilling fluid
DIN	German national organisation for standardisation (Deutsches Institut für Normung e.V.)
DLS	Dog leg severity
DM	Drilling manager
DMT	Deutsche Montan Technologie
DP	Drill pipe
DSV	Drilling supervisor
EDTC	Enhanced digital telemetry cartridge
EGT	Expert Group on Nuclear Waste Disposal
EMS	Electronic multishot system
ENSI	Swiss Federal Nuclear Safety Inspectorate (Eidgenössisches Nuklearsicherheitsinspektorat)
EOWR	End of well report
EMW	Equivalent mud weight
FAC	First aid cases
FEM	European materials handling federation

FIT	Formation integrity test
FL	Fluid loss
FMI	Formation micro imager tool
GPIT	General purpose inclinometer tool
GR	Gamma ray
GR-INC	Gamma ray – inclination
GR-INC / AZ	Gamma ray – inclination / azimuth
GTPT	Gas threshold pressure test
HiVis	High viscosity
HLW	High-level waste
HNGS	Hostile gamma ray neutron sonde
HRLT	High resolution laterolog array tool
HSE	Health, safety and environment
HWDP	Heavyweight drill pipe
IADC	International Association of Drilling Contractors
ID	Inner diameter
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
KOP	Kick-off point
L/ILW	Low- and intermediate-level waste
LCM	Lost circulation material
LEH.QT	Logging equipment head with tension
LIH	Left in hole
LSRV	Low shear rate viscosity
LTI	Lost time injuries
LTIF	Lost time injuries frequency
M/U	Make up
MAASP	Maximum allowable annulus surface pressure
MBT	Methylene blue test
MCFL	Micro-cylindrically focused log
MD	Measured depth
MDT	Multiple dynamic tester
MHF	Micro hydraulic fracturing
MSIP	Modular sonic imaging platform
MTC	Medical treatment cases

MTCF	Medical treatment cases frequency
MW	Mud weight
NOV	National Oilwell Varco
NPT	Non-productive time
NSC	Federal Nuclear Safety Commission
NSG	Application for exploration permits (Nagra Sondiergesuch)
OD	Outer diameter
OPS	Operations
Opa	Opalinus Clay
PAC	Polyanionic cellulosic polymer
PAEI	Proactive effort indicator
PDC	Polycrystalline diamond compact bit
PED	Pressure equipment directive
PJSM	Pre-job safety meetings
POOH	Pull out of hole
PPC	Powered positioning device and caliper
PPE	Personal protective equipment
PT	Pressure test
P/U	Pick up
RIH	Run in hole
RM	Rig manager
ROP	Rate of penetration
RPM	Revolutions per minute
RS	Rohrschuh (casing / liner shoe)
RW	Pumping test with constant flowrate ('rate withdrawal test')
RWC	Restricted work cases
RWCF	Restricted work cases frequency
RWS	Pressure recovery after pumping test with constant flowrate (shut-in)
S/N	Serial number
SFOE	Swiss Federal Office of Energy
SG	Specific gravity
SGT	Sectoral Plan for Deep Geological Repositories
SHO	Staged hole opener
SLB	Schlumberger N. V.
SPP	Standpipe pressure

TBO	Tiefbohrungen
TC	Tungsten carbide
TCI	Tungsten carbide inset
TD	Target depth of section or hole / total depth
TLD	Three-detector lithology detector
TOC	Top of cement
TP	Tool-pusher
TRC	Total recordable cases
TRS	Tubular running service
TT	Transit time
TVD	True vertical depth
UBI	Ultrasonic borehole imager
USIT	Ultrasonic imager tool
UVEK	Eidgenössisches Departement für Umwelt, Verkehr, Energie und Kommunikation
VA	Annular velocity
VDL	Variable density log
VS	Vertical section
VSP	Vertical seismic profile
WEP	Well Engineering Partners BV
WEUS	Weatherford directional drilling service and fishing service (Langenhagen, Germany)
WL	Wireline
WOB	Weight on bit
WOC	Waiting on cement
XO	Crossover
YP	Yield point

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 Bözberg-1-1 borehole.

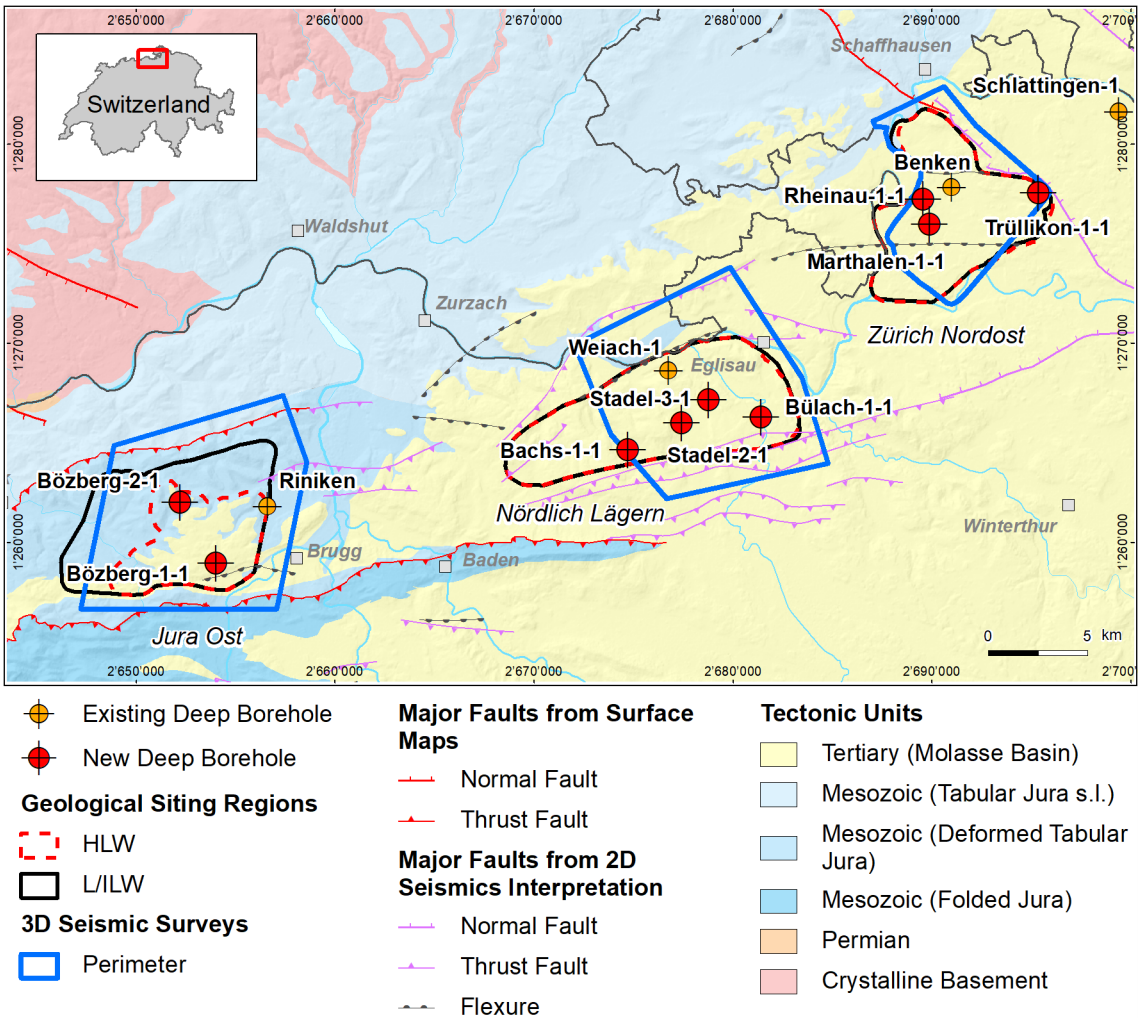


Fig. 1-1: Tectonic overview map with the three siting regions under investigation

1.2 Location and specifications of the borehole

The Bözberg-1-1 (BOZ1-1) exploratory borehole is the fourth borehole drilled within the framework of the TBO project. The drill site is located in the southern part of the Jura Ost siting region (Fig. 1-2). The borehole specifications are provided in Tab. 1-1.

Due to a lost packer system, the borehole was cemented up to 682 m MD[1] (*cf.* Section 3.8). Resuming coring operations, a sidetrack was initiated with a kickoff point (KOP) at 709 m MD. This sidetrack was labelled Bözberg-1-1B (BOZ1-1B). BOZ1-1B reached a final depth of 1'037.39 m MD. For easier communication and labelling, the name BOZ1-1 is generally used for this borehole, including the sidetrack, unless stated otherwise.

Tab. 1-1: General information about the BOZ1-1 borehole

Siting region	Jura Ost
Municipality	Bözberg (Canton Aargau / AG), Switzerland
Drill site	Bözberg-1 (BOZ1)
Borehole	Bözberg-1-1 (BOZ1-1) including sidetrack Bözberg-1-1B (BOZ1-1B)
Coordinates	LV95: 2'653'995.815 / 1'258'925.446
Elevation	Ground level = top of rig cellar: 513.29 m above sea level (asl)
Borehole depth	1'037.39 m measured depth (MD) below ground level (bgl) for BOZ1-1B
Drilling period	27th April 2020 – 2nd December 2020 (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 – 250 m: Polymers 250 – 882 m: Potassium silicate & polymers 882 – 1'037.39 m: Sodium chloride & polymers

The lithostratigraphic profile and the casing scheme are shown in Fig. 1-3. The comparison of the core versus log depth[3] of the main lithostratigraphic boundaries in the BOZ1-1 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.

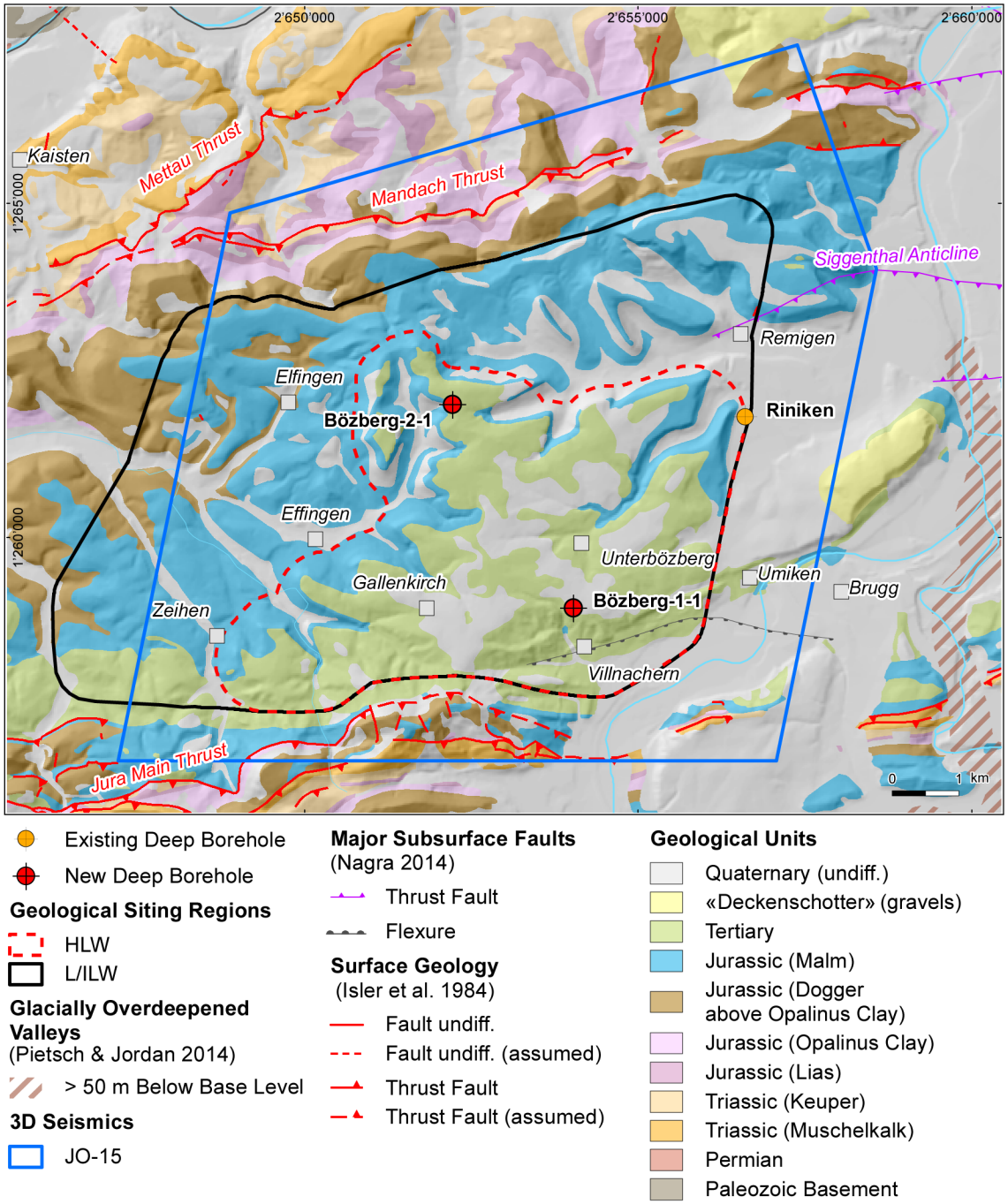


Fig. 1-2: Overview map of the investigation area in the Jura Ost siting region with the location of the BOZ1-1 borehole in relation to the boreholes Riniken and BOZ2-1

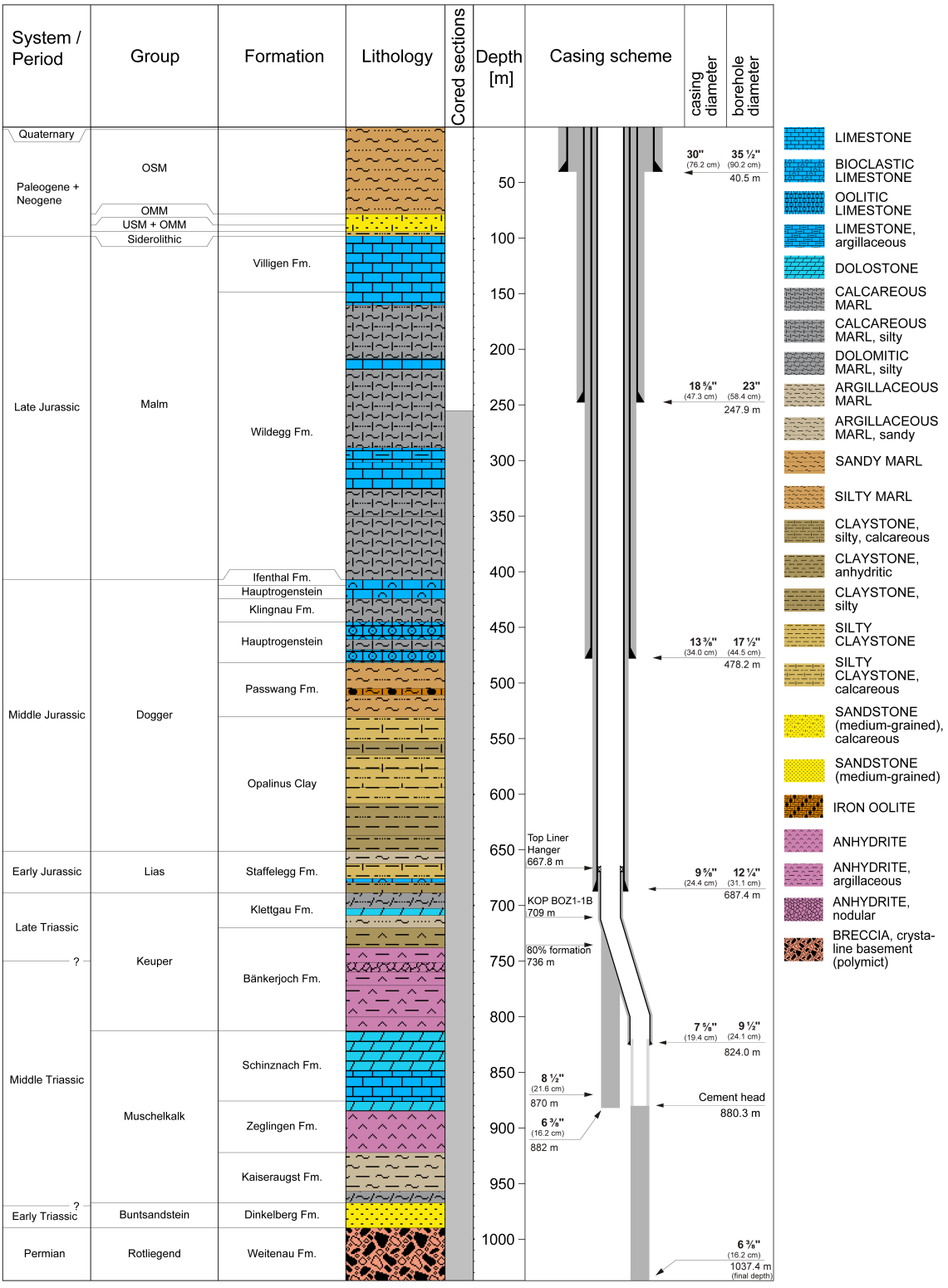


Fig. 1-3: Lithostratigraphic profile and casing scheme for the BOZ1-1 borehole[4]

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

Tab. 1-2: Core and log depth for the main lithostratigraphic boundaries in the BOZ1-1 borehole[5]

System / Period	Group	Formation	Core depth in m	Log depth in m (MD)	
Quaternary			**2**		—
Paleogene + Neogene	OSM		78		—
	OMM		88		—
	USM / OMM		94		—
	Siderolithic		**98**		—
Jurassic	Malm	Villigen Formation	148		—
		Wildegg Formation	406.67	406.72	—
	Dogger	Ifenthal Formation	411.91	411.94	—
		Hauptrogenstein	424.11	424.13	—
		Klingnau Formation	444.85	444.93	—
		Hauptrogenstein	481.50	481.55	—
		Passwang Formation	530.28	530.32	—
		Opalinus Clay	651.39	651.46	—
	Lias	Staffelegg Formation	**688.72**	**688.76**	—
Triassic	Keuper	Klettgau Formation	720.03	720.21	—
		Bänkerjoch Formation	812.62	812.45	—
	Muschelkalk	Schinznach Formation	875.89	876.05	—
		Zeglingen Formation	922.22	922.30	—
		Kaiseraugst Formation	967.38	967.70	—
	Buntsandstein	Dinkelberg Formation	**989.89**	**989.83**	—
Permian	Rotliegend	Weitenau Formation	1037.39 final depth		

[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 BOZ1-1 borehole

NAB 21-21 documents the majority of the investigations carried out in the BOZ1-1 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 BOZ1-1 borehole. It includes most of the data available approximately one year after completion of the borehole. Some analyses are still ongoing (e.g. diffusion experiments, analysis of veins, hydrochemical interpretation of water samples) 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 21-21

Black indicates the dossier at hand.

Dossier	Title	Authors
I	TBO Bözberg-1-1: Drilling	M. Ammen, P.-J. Palten, J. Vliek, K. Gollob & K. Hilgendorf
II	TBO Bözberg-1-1: Core Photography	D. Kaehr & M. Gysi
III	TBO Bözberg-1-1: Lithostratigraphy	M. Schwarz, P. Schürch, H. Naef, P. Jordan, R. Felber, T. Ibele & M. Gysi
IV	TBO Bözberg-1-1: Microfacies, Bio- and Chemostratigraphic Analyses	S. Wohlwend, H.R. Bläsi, S. Feist-Burkhardt, B. Hostettler, U. Menkveld-Gfeller, V. Dietze & G. Deplazes
V	TBO Bözberg-1-1: Structural Geology	A. Ebert, L. Gregorczyk, S. Cioldi, E. Hägerstedt, & M. Gysi
VI	TBO Bözberg-1-1: Wireline Logging, Micro-hydraulic Fracturing and Pressure-meter Testing	J. Gonus, E. Bailey, J. Desroches & R. Garrard
VII	TBO Bözberg-1-1: Hydraulic Packer Testing	R. Schwarz, R. Beauheim, S.M.L. Hardie, M. Voß & A. Pechstein
VIII	TBO Bözberg-1-1: Rock Properties, Porewater Characterisation and Natural Tracer Profiles	P. Wersin, L. Aschwanden, L. Camesi, E.C. Gaucher, T. Gimmi, A. Jenni, M. Kiczka, U. Mäder, M. Mazurek, D. Rufer, H.N. Waber, C. Zwahlen & D. Traber
IX	TBO Bözberg-1-1: Rock-mechanical and Geomechanical Laboratory Testing	E. Crisci, L. Laloui & S. Giger
X	TBO Bözberg-1-1: Petrophysical Log Analysis	S. Marnat & J.K. Becker
	TBO Bözberg-1-1: Summary Plot	Nagra

1.4 Scope and objectives of this dossier

The objective of this report is to provide a summary of the drilling operations, including rig site construction, casing tallies, cement bond quality, coring parameter and recovery.

The report is organised as follows:

- Chapter 1 presents the general overview of the drilling campaign and the vertical borehole BOZ1-1 and BOZ1-1B.
- 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 BOZ1-1 / BOZ1-1B 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
  - Health safety & environment (HSE) manager
- Well Engineering Partners BV (WEP)
  - Drilling engineer: technical drilling supervision, coring, casing running, cementing, logging and testing operations performed in the borehole
- PR Marriott Drilling Ltd: drilling contractor
- Sirius-ES HandelsGmbH (subcontractor Marriott): mud engineering
- Fangmann Energy Services GmbH & Co. KG (subcontractor Marriott): cementing service
- National Oilwell Varco (NOV) (subcontractor Marriott): liner hanger / packer systems
- GEO-data GmbH: mud logging and core handling
- Schlumberger (SLB) and SEMM logging: wireline logging and testing
- Solexperts and Intera: hydraulic and gas testing
- Deutsche Montan Technologie (DMT) GmbH & Co KG and SLB: seismic service
- Weatherford (WEUS): directional drilling service Langenhagen / Germany
- Weatherford (WEUS): fishing service Langenhagen / Germany
- National Service Company (NSC): fishing service Potenza / Italy
- Well Engineering Partners BV (WEP): night and day drilling supervisors and HSE specialist
- Hartmann Valves GmbH: wellhead installation service

2 Drilling technology

2.1 Overview

The drilling operation combined wireline coring operations with rotary drilling operations.

The drilling rig of the contractor Marriott was a Drillmec HH102 (102 t operational hook load) semi-trailer with telescopic mast. 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 D.

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.

The wireline coring string was driven from surface by the topdrive. 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. 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.

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
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"

Tab. 2-1: continued

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

2.2 Drilling / coring tools

2.2.1 Drill string and wireline coring string

Two different drill strings were used for the BOZ1-1 borehole, the same as for the TRU1-1 borehole. A 5½" wireline coring string (SK 5½" B, N80) from the manufacturer MICON-Drilling GmbH (MICON-Drilling 2021) was mainly used for coring operations 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 BOZ1-1 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. Two different types of core bits (see Fig. 2-1) were used in the BOZ1-1 borehole:

- Thermally stable diamond (TSD) core bit, also called 'synset' core bit:
- 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 behaviour.
- 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.

In Appendix F all bit and core bits are listed, which were run in borehole BOZ1-1. A detailed table with coring runs and drilling parameters is available in Appendix I.



Fig. 2-1: Synset core bit (left) and impregnated core bit (right)

2.2.3 Tricone bits

The tricone bit is by far the most common bit type used in rotary drilling operations. They are available with a large variety of tooth designs, bearing types and nozzle designs. They have three roller cutter cones with a series of teeth that crush the rock on the rock face as they roll across their face. Because of the bearings used for every cone, the revolutions for such a bit are limited. There are different types available with either longer or shorter teeth, and wider or closer placement of teeth for different levels of hardness of the drilled formation. Furthermore, the teeth can have milled teeth for softer formations or tungsten carbide insert teeth for harder formations. The teeth are cleaned by hydraulic nozzles.

The 23" section of BOZ1-1 was drilled with two tricone bits.

The hard formations drilled in the upper borehole section of BOZ1-1 required short teeth, which needed sufficient weight to crush the rock. Because of the short drill string length below the rotary table, the weight exerted onto the drill bit by the drill collar was limited. In the beginning, the drilling ROP (rate of penetration) was thus restricted by the available WOB (weight on bit).

The first bit had to be pulled at 229 m because of low ROP, was found balled up, cleaned and re-run. After 194 hours, the lifetime of the bearings had already been reached and the bit was pulled.

The second 23" bit managed to drill to the end of the section.

After cementing the different casings (18⅝", 13⅜" and 9⅝"), the float valve and cement in the casing had to be drilled out. This was done with 17½", 12¼" and 8½" tricone bits.

To enlarge the hole from 6⅜" coring diameter to a size suitable to run the casing, the borehole was opened with hole openers guided by tricone bits to prevent a new wellbore path being cut when running the hole opener.

The last section of BOZ1-1 was drilled with rotary BHA and tricone bits. Because 6⅜" is not a standard drilling size, the stabilisers had to be grinded down and were not under-gauged causing the bit to hang up, creating cutting with the stabiliser, so that identification of the formation was not easy getting red cuttings from Rotliegend with stabiliser offset from bit on the shakers. The

open hole section from 824 m to 1'037.39 m was drilled with three tricone bits. For the last two runs, a mud motor from MICON was picked up because without motor the string stalled out and with more than 60 rpm from surface stick slip occurred. With two runs the section was drilled to TD.

2.2.4 Hole opening tools

Staged hole openers (SHOs) were used to enlarge the existing borehole to the required diameter for casing running and cementing, mostly in steps from 6⅜" to 8½" and from 8½" to 12¼". These SHOs run with a bullnose or a pilot bit of the same size as the existing borehole at the bottom, which serves as guidance for the enlarged hole. The pilot section of the SHO itself (lower part of the SHO) consists of one or two rows of cuttings structures to recondition the pilot hole and remove any swelling clays or loose material. Gauge pads provide initial stabilisation as the SHO begins the staged reaming process to reduce stick/slip, whirling or off-centre tendencies. The lower cutters of the SHO are designed to minimise work rates on each cutter position for maximum durability. By relieving stress from the formation with this intermediate stage, larger-hole drilling can be done at a more aggressive ROP. This part of the SHO recentralises the SHO on the given vertical borehole trajectory. The main body of the SHO completes the final hole diameter. With the formation being already stress-relieved, the reaming section remains aggressive, even in more competent formations. Gauge trimmers and spiralled gauge pads ensure good hole quality.

Besides the drilling and hole opening bits, a well-stocked supply of various stabilisers, drill collars, heavy weight drill pipes and other BHA (bottom hole assembly) components was kept onsite to be able to arrange suitable BHA setups for the planned work steps. Appropriate BHA designs are of great importance in drilling operations to effectively load and control the drill bit (for bit list, see Appendix F).

3 Drilling operation

3.1 Overview

Drilling began on 27.04.2020 at 11:00 a.m. and, including the scientific investigations carried out in the borehole, continued until 02.12.2020, 12:00 (Appendix A). With a final depth of 1'037.39 m MD, the borehole was terminated 47.5 m into the Rotliegend formation. The Opalinus Clay was encountered between 530.28 m and 651.39 m MD (121.11 m in thickness).

To protect the groundwater, a 30" outer diameter (OD) standpipe was run to 40.5 m and cemented during drill site construction.

The borehole was drilled with a 23" tricone bit (TCI bit) for the uppermost 250 m and the 18⅝" casing was run to 247.90 m MD; the remaining four sections (17½" at 480 m MD with 13⅜" casing at 478.20 m MD, 12¼" at 690 m MD with 9⅝" casing at 687.40 m MD, 9½" to 825.00 m MD with 7⅝" liner shoe at 824.00 m MD and liner top at 667.8 m MD) were continuously cored with 6⅜" core bits using wireline technique. Afterwards the coring hole was opened to run the casing / liner.

For the cored sections, triple core barrels with synthetic liners were used almost exclusively and core recovery was 99.43% for BOZ1-1 and 99.86% for BOZ1-1B. The diameter drilled with the core bit was 6⅜" (161.9 mm). The cores have a diameter of 95 mm.

A total of three permanent casings (18⅝", 13⅜", 9⅝"), the anchor casing (30") and a 7⅝" liner were installed in the borehole. All casings were cemented up to ground level. No losses were experienced during the cement jobs because cement density was selected from fracture pressures measured with SLB MHF (micro-hydraulic fracturing) tests. For the liner, the plug was bumped with 45 bar and pressured up to 100 bar. All cement bond logs (CBL) / ultrasonic imager tool logs (USIT) showed a very good cement bond.

The first two sections of the borehole down to the top of the Opalinus Clay were drilled using a mixture of clay and fresh water as drilling fluid with a density between 1.18 SG (specific gravity) and 1.20 SG (pure bore mud system). The Opalinus Clay was drilled in Section III with silicate mud with a density from 1.20 SG to 1.25 SG. Silicate mud was also used in Section IV and creating problems in the Bänkerjoch Formation because the silicate crystallised on the BHA and the bit and plugged the flow channels in the annulus. In the Muschelkalk, losses started at a mud density greater than 1.14 SG. Approximately 119 m^3 of mud were lost in the fractures of the Muschelkalk. Because of these losses, a hydraulic test string was RIH before reaching section TD (total depth). The section was cored ahead to section TD with losses while drilling. Because the losses were even higher than before, the hydraulic test was repeated. While pulling out of hole the string got stuck in the auxiliary casing with the packer and could no longer be moved in any direction. Therefore, overpull was applied and the safety joint above the packer was disconnected. The auxiliary casing was pulled without any signs of scratches on the metal. Several fishing BHAs and one WEUS washover pipe were run. In the end, a short piece of the test string, from the safety joint to the weakest point above the packer, was retrieved by pulling with 80% of available rig overpull. It was decided to cement back and to sidetrack the borehole. Because of the loss zone in the bottom of the hole, two cement plugs were pumped. The first and second plug were pumped with a density of 1.36 SG and 1.75 SG, respectively, to create a compressive strength of the cement higher than that of the formation, and to enable the directional BHA to cut a new borehole path (sidetrack BOZ1-1B).

The sidetrack from the cement plug in open hole with an 8½" bit of Section IV and coring with 6⅜" bits in Section V were drilled using a saturated brine (density: 1.15 SG to 1.23 SG) for drilling through the salt horizon in the Muschelkalk. In the Dinkelberg Formation losses occurred again. Approximately 278 m^3 of brine were lost.

After the active borehole investigations were completed, the borehole was backfilled with cement below the Schinznach Formation. The mud left in the borehole is brine with a density of 1.15 SG. Before the rig was moved, the wellhead was removed and a new wellhead was installed.

Work was completed in 219 working days (continuous 24 h operation) after spud-in, excluding days for rig up (515 h) and rig down (400 h). The time spent on scientific investigations in the borehole amounted to 59% and drilling activities including casing runs and cementation accounted for 61% of the total time mentioned. The difference between the planned and actual time was 73.25 d.

While drilling the borehole, a total of 397.4 m^3 of losses were recorded, 119.4 m^3 in the Muschelkalk and 278 m^3 in the Dinkelberg Formation (Buntsandstein).

Regarding HSE, one first aid case was reported. An employee injured his finger at the door of the doghouse. The door handle was replaced immediately.

3.2 Drill site construction and standpipe

Start of execution

Before the start of construction, a technical investigation was carried out for the drill site. Investigations of the soil at the site and a technical examination were carried out simultaneously. Due to poor stability, the soil had to be reinforced with cement and gravel. The ground level of the site was increased by 30 cm instead of excavating it to reduce costs. An individual drilling cellar with a rectangular shape was built in accordance with the Nagra specification for BOZ1-1.

The approvals were given in two stages:

- Stage 1 included approvals for the earthworks and
- Stage 2 included approvals for the in situ concrete construction of the drilling cellar.

Work preparation

The temporary use of the property and the rights of passage for the supply lines along the cantonal road were regulated and compensated with the landowners. Following Nagra's instructions, the street towards the drill site was covered with a layer of rolled asphalt granulate thinner than 7 cm, reinforced and equipped with a traffic sign. The hiking trail was redirected, and a 1 m wide new trail was created 1 m from the access road. No further hiking trail was created at the drill site parking spaces.

Construction engineering of the drill site and standpipe

The construction of the drill site started on 09.09.2019 (ERNE construction company, Kleinandelfingen). Fig. 3-1 shows the drill site during construction. More pictures and a drawing of the rigsite are given in Appendix C.

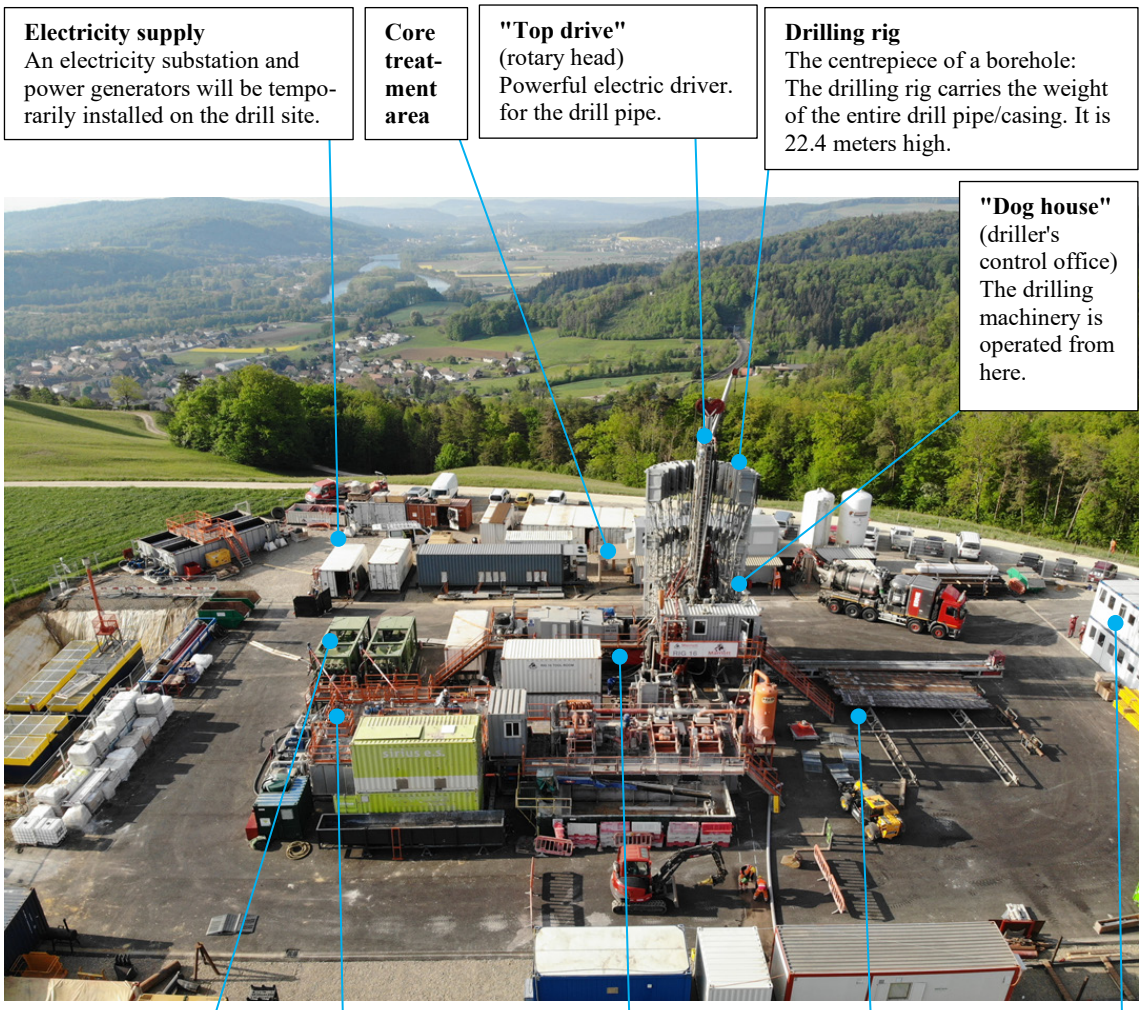


Fig. 3-1: Drill site

Crossing beneath the cantonal road was carried out trenchless with a 600 mm tube. For better traffic management, the access road towards the drill site from Bözbergstrasse was extended with a short second lane to allow cars and trucks to bypass. The standpipe borehole and mousehole were done by the special foundation engineering company Bauer. The work was carried out directly on the gravel ground at an early stage. In autumn, the soil removal was complicated due to the soil moisture. The cellar was stiffened with a steel structure for post-operation and covered with steel plates and gratings. Two sprouted cable ducts were created instead of the empty pipes for the power cables running from the VFD (variable frequency drive) room to the drilling rig; the cable ducts were covered with steel plates and additionally with asphalt. A construction site fence was set up for drilling operations.

Environment

Water collected on the site was fed into the sewage system via a sludge collector, mineral oil separator and settling basin. The wastewater was fed directly into the wastewater sewer. The removal of soil started end of August 2019 with damp soil conditions. The arrangement of the floor depots was optimised.

3.3 Chronology of the BOZ1-1 and BOZ1-1B borehole

Below is a chronology of all working steps of the BOZ1-1 and BOZ1-1B borehole. Details can be found in the daily drilling reports (DDR) in Appendix J.

6.04.2020 – 20.04.2020

- preparations for erecting the rig
- laid cable trays and pulled cable, installed electric lines
- completed mud tank and mud pump

21.04.2020 – 04.05.2020

- rigged up all equipment on BOZ1-1
- rig audit by ENSI (Swiss Federal Nuclear Safety Inspectorate)
- drilled out cement from 34.5 m to 40 m MD
- "drilled 23" section from 40 m to 250 m MD with rotary BHA
- Performed a survey at 108 m MD – 0.4° and 210 m MD – 1.24°

05.05.2020 – 18.05.2020

- performed a survey at 250 m MD – 1.05°
- circulated and POOH 23" drill string, L / out stabs and bit
- cut and removed 30" conductor pipe
- rigged up and RIH 18⅝" casing until 247.85 m MD
- cement 18⅝" casing, POOH stinger, rigged down cementing service

- drilled out shoe track and 1 m of new formation, POOH 17½" drill string
- RIH 8½" drill string, drilled 4 m of formation as guide for auxiliary casing
- changed current mud to potassium silicate mud; density 1.18 SG
- technical logging B (CBL and VDL)
- RIH 7⅝" auxiliary casing and RIH coring string
- cored from 255 m to 375.8 m MD

19.05.2020 – 01.06.2020

- cored from 375.8 m to 480 m MD
- petrophysical logging (Schlumberger) performed in six runs
- changed from mud to fresh water
- fluid logging A (Intera)
- changed from fresh water to mud
- technical logging A, main run and repeated caliper log (Terratec)
- petrophysical logging
- hydraulic test, dual packer

02.06.2020 – 15.06.2020

- hydraulic test, dual packer
- hole opening to 8½" from 255 m to 480 m MD incl. circulating hole clean
- MHF
- hole opening to 12¼" from 252 m to 255 m MD
- continue MHF
- logging after MHF
- POOH 13⅜" auxiliary casing
- hole opening to 12¼" from 255 m to 480 m MD incl. circulating hole clean
- hole opening to 17½" from 255 m to 323.80 m MD

16.06.2020 – 29.06.2020

- hole opening to 17½"to 480 m "D
- RIH 13⅜" casing and cement casing section
- USIT – CBL logging
- RIH 8½" drill string and drilled 2 m of new formation to 483 m MD
- cored 6⅜" from 483 m to 498 m MD

30.06.2020 – 13.07.2020

- cored 6⅜" from 498 m to 564 m MD (target 30 m below Top Opalinus Clay)
- hydraulic testing of the Opalinus Clay
- petrophysical logging (caliper and FMI)
- hydraulic testing of the Opalinus Clay

14.07.2020 – 27.07.2020

- hydraulic testing of the Opalinus Clay
- hydraulic testing of «Brauner Dogger» (1+2); downhole tool failure
- BOP pressure test
- wiper trip and conditioning of mud system
- RIH double packer test equipment with new downhole tool
- hydraulic testing of «Brauner Dogger» (2)
- cored 6⅜" from 564 m to 663 m MD

28.07.2020 – 10.08.2020

- cored 6⅜" from 663 m to 690 m MD
- petrophysical logging (7 runs with SLB)
- hydraulic testing of the Opalinus Clay to Lias
- hydraulic testing of the Opalinus Clay
- hydraulic testing of Opalinus Clay to Lias
- gas threshold pressure test (GTPT)

11.08.2020 – 24.08.2020

- GTPT
- hole opening to 8½" from 483 m to 690 m
- EMS + UBI
- MHF (7 tests)
- logging after MHF
- hole opening to 12¼" from 481 m to 660 m MD

25.08.2020 – 07.09.2020

- hole opening to 12¼" from 660 m to 689.1 m MD
- pressure test BOP

- technical logging A incl. Caliper
- VSP
- RIH 9⅝" casing till 687.4 m MD
- cemented 9⅝" casing with 29 m^3 cement slurry 1.65 SG
- cored 6⅜" from 692 m to 758.4 m MD; POOH

08.09.2020 – 21.09.2020

- continued coring 6⅜" from 758.4 m to 816 m MD
- technical logging (caliper only) Terratec main and repeated run
- hydraulic testing of the Klettgau Formation (KEU1 PW1, PW2)
- continued coring 6⅜" from 816 m to 867 m MD
- BOP pressure test
- technical logging (caliper only) Terratec main and repeated run
- hydraulic testing of the Schinznach Formation MUK1

22.09.2020 – 05.10.2020

- hydraulic testing of the Schinznach Formation MUK1
- cored from 867 m to 882 m MD
- hydraulic testing of the Schinznach Formation MUK2
- fishing operation (packer from hydraulic test string)

06.10.2020 – 19.10.2020

- fishing operation (no success, packer from hydraulic test string left in hole, length: 10.19 m)
- hole opening to 8½" from 690 m to 870 m½"POOH 8½" drill string
- pressure test BOP
- petrophysical logging in 8½ hole
- MHF
- logging after MHF
- RIH 2⅞" cement tubing
- changed current mud to salt saturated mud; density 1.14 SG
- cementation in two stages back to the shoe (light cement 1.36 SG with fibres to prevent losses) and 1.75 SG cement slurry; first plug 853 m to 777.2 m MD, second plug 769 m to 682 m MD
- dressed cement from 682.5 m to 691.5 m MD
- circulated hole clean

20.10.2020 – 02.11.2020

- circulated hole clean and flow check of well, static
- POOH drill string
- waited for Weatherford equipment

03.11.2020 – 16.11.2020

- scraped 9⅝" casing
- RIH 6⅜" drill string
- drilled out shoe track and new formation until 828 m MD and circulated (due to low ROP while drilling the landing collar needed to be changed; inserted bit to milled tooth bit)
- FIT 1.70 SG EMW "POOH 6⅜" drill string
- RIH 6⅜" coring string
- cored from 828 m to 945.5 m MD

17.11.2020 – 30.11.2020

- cored from 945.5 m to 1'037.4 m MD
- petrophysical logging
- MHF (6)
- logging after MHF
- VSP
- cemented first plug from 1'037.39 m up to 933 m MD
- tagged top of cement at 933.47 m MD
- cemented second plug from 933 m up to 880.25 m MD
- Waiting on cement (WOC)
- tagged top of cement to 880.25 m MD
- changed drilling mud to fresh brine

1.12.2020 – 14.12.2020

- installed final wellhead and did pressure test; test was ok
- rig released on 02.12.2020 at 12:00 a.m.
- rigged down drilling rig
- last truck load sent off site on 09.12.2020 at 2:00 p.m.

3.4 Time analysis

Work was completed in 219 working days (continuous 24 h operation) after spud-in, excluding days for rig up (515 h) and rig down (400 h). The time spent on scientific investigations in the borehole amounted to 59% and drilling activities including casing runs and cementation accounted for 61% of the total time mentioned. The difference between the planned and actual schedule is 73.25 d.

The total NPT time recorded for BOZ1-1 and BOZ1-1B was 889 h, which equals 17.1% of the total operations time (5'214 h). With 472.75 h, the majority of the NPT time was collected while testing the lower part of the BHA lost in hole.

3.5 Drilling process

The first section was drilled with a 23" bit and the other sections were initially cored. After coring the hole was opened to the requested diameter to run the casing.

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

From [m MD]	**To** [m MD]	**Diameter** [in]	**Drilling method**
0	40	35½	Pile drilling
40	250	23	Rotary
250	251	17½	Rotary / bit
251	255	8½	Rotary / bit
255	570	6⅜	Rotary core bit
255	480	8½	Rotary / hole opening
255	480	12¼	Rotary / hole opening
255	478.5	17½	Rotary / hole opening
480	481	12¼	Rotary / hole opening
481	483	8½	Rotary / hole opening
483	690	6⅜	Rotary / core bit
483	689.5	8½	Rotary / hole opening
481	689.1	12¼	Rotary / hole opening
690	732.5	6⅜	Rotary / core bit
732.5	732.7	6⅜	Rotary / bit
732.7	882	6⅜	Rotary / bit
690	870	8½	Rotary / hole opening
682.5	691.5	8½	Rotary / dress cement plug
691.5	825	8½	Rotary / bit
690	825	9½	Rotary / hole opening
825	828	6⅜	Rotary / bit
828	1'037.39	6⅜	Rotary / core bit

3.5.1 30" Conductor to 40.50 m MD

A subcontractor (Strabag) was hired to run the conductor pipe. The drilling of the conductor pipe is not described in detail in this report.

3.5.2 Section I: 23" drilling to 250 m and 18⅝" anchor casing to 247.85 m

Before drilling started, a 30" diverter and a connecting line to a 40 m^3 tank were installed. The setup was tested and approved by the Nagra drilling supervisor (DSV).

The 23" hole was drilled with BHA #1 using a roller cone tooth bit (International Association of Drilling Contractors, IADC: 415, type: T43 from NOV) from 40.5 m to 250 m MD. ROP was between 0.8 m/h and 4 m/h. The borehole was circulated bottoms up and a wiper trip was performed to 23 m MD. After pumping the high viscosity (HiVis) pill, a lot of cuttings came over the shakers and a second pill was pumped. The BHA was pulled out of hole (POOH) without problems.

The section down to 250.0 m MD was drilled into the Wildegg Formation at which the 18⅝" casing was set and cemented up to the surface.

The mud system used was pure bore water-based with a mud density between 1.01 kg/l and 1.10 kg/l. In total 227 m^3 of fluid were used to drill this section. The inclination was measured every 50 m with single shots; all inclination measurements were below 1.24°.

The 18⅝" casing (87.5 pounds per foot [lbs/ft], grade K55, buttress connection) was RIH without problems. The last joint was run to 247.85 m MD.

A 20¾" diverter and the casing head housing were installed, tested and approved.

3.5.3 Section II: 250 m to 480 m

The cement and float equipment were drilled out with a 17½" roller cone tooth bit (IADC 1-1-5, S/N D188410). Additional formation was drilled from 250.0 m to 251.0 m MD. A new BHA with 8½" bit was RIH to centre-punch the hole down to 255 m MD for the auxiliary casing.

The borehole was circulated clean. Then an FIT (formation integrity test) was performed at an equivalent mud weight (EMW) of 1.65 kg/l (mud density of 1.18 kg/l and additional pressure at the surface of 200 psi). The current mud was changed to potassium silicate with 1.19 SG. The 7⅝" auxiliary casing (29.7 lbs/ft, grade J55, connection BTC) was RIH until 252 m MD, then washed down to 255 m MD and finally set to 253.20 m MD to enable coring. It was set into the wellhead with a tubing hanger. A wireline gyro survey was run for the top-hole casing, before the 5½" coring string (SK 5½" B) was tested (make up test with dope). Nagra geologists cored a maximum of 3 m before pulling the liner out again and using a plastic liner only. Coring was performed with an impregnated core head to 257.55 m MD before the BHA was POOH and another impregnated core bit was RIH to core to 480 m MD. At 426 m MD coring was stopped to repair the crown block of the rig. After wireline logging, the auxiliary casing was pulled and a coring BHA was RIH to exchange the mud system with water for the hydraulic test. After fluid logging, the mud was exchanged to potassium silicate with 1.19 SG. A caliper log was run to identify the depth setting of the packer for the following hydrotest.

The auxiliary casing was pulled and an 8½" hole opener BHA #12 with a 6⅛" bit below was run from 255 m to 479.80 m MD (rathole 0.2 m). Unfortunately, the MHF tools could not pass 251 m MD and the hole was opened to 12¼" from 252 m to 255 m MD. Because the tool string could not pass again, a 13⅜" auxiliary casing was RIH to 247.20 m MD without success. After running the auxiliary casing to 250.61 m MD, the MHF tools passed and MHF tests were performed. The auxiliary casing was pulled and the hole was opened to 12¼" from 255 m to 479.80 m MD. The next BHA was run from 554.7 m to 480 m MD with a 12¼" tricone bit below the 17½" hole opener (cutter position 6 m above bit). At 256.60 m MD the hole opener was pulled because of low ROP. Opening the hole to 17½" took 196.5 h instead of the planned 60 h because the design of the available hole opener was not according to the NOV specifications and a backup tool was not available (Fig. 3-2).



Fig. 3-2: 17½" hole opener – modified on the rig floor to prevent it from getting stuck

The tubular running service (TRS) was rigged up to run the 13⅜" casing to 478.17 m MD. From 466 m MD the casing was run with circulation. The stinger cement job was performed as planned.

3.5.4 Section III: 480 m to 690 m

The cement and float equipment as well as 1 m of new formation were drilled with a 12¼" tooth bit down to 481 m MD. After CBL and USIT log, a BHA with 8½" bit was RIH and drilled from 481 m to 483 m MD. The FIT was performed to EMW 1.75 SG, applying 26 bar on actual potassium silicate mud with a density of 1.20 SG. The 7⅝" auxiliary casing was RIH to 482.5 m MD and the first core bit drilled from 483.00 m to 498.00 m MD (aluminium was found in the flow channels). The next bit was a Ballas gold and cored in the Opalinus Clay from 498.0 m to 564.00 m MD. After more than 300 h of hydraulic testing, the test string was POOH and a coring BHA was run. Unfortunately, the inner core barrel could not be pulled with slick line, because a tape from the hydrotest BHA blocked it. This caused 8 h of NPT for the additional roundtrip. The BHA had to be washed down from 510 m to 521 m MD and reamed to 564 m MD. The impregnated core bit cored till 657.50 m MD. At the surface a broken matrix was found wedged into the mud channel. Another impregnated core bit was run and cored to 690.0 m MD. After petrophysical logging a single packer and a dual packer hydraulic test were performed. A wiper trip was executed before running the gas threshold pressure test (GTPT) with 4½" tubings on 2⅞" tubing in the Opalinus Clay. The BHA had to wash and ream from 470 m to 690.00 m MD and mud was

conditioned at the bottom. The 7⅝" auxiliary casing was POOH and the hole opened to 8½" from 480 m to 690 m MD. To calibrate SLB MHF logging tools, 66 m were run with the 9⅞" auxiliary casing. After logging, the auxiliary casing was pulled and the hole opened to 12¼" from 481 m to 690 m MD. Wireline technical logging was run and a vertical seismic profile (VSP) was carried out as per programme. Before the 9⅝" casing was run, a wiper trip was run with the 12¼" hole opener. The BHA had to be washed down from 653 m to 690 m MD.

The 9⅝" casing was run to 687.40 m MD and cementation was carried out through stinger.

3.5.5 Section IV: 690 m to 882 m MD

The cement and the float equipment, as well as 2 m new formation were drilled down to 692.0 m with an 8½" tungsten carbide inset bit. The FIT was performed with a stable pressure of 450 psi with potassium silicate mud with a density of 1.23 SG in the hole (EMW 1.70 SG). The 7⅝" auxiliary casing was RIH and cored with an impregnated core crown from 692 m to 693.22 m MD. Due to low ROP, the bit was pulled to surface and junk was found (Fig. 3-3). A Ballas bit was RIH and drilled to 729.00 m MD where the BHA was pulled again because of low ROP. The PDC (polycrystalline diamond compact) core bit was RIH, only drilled 60 cm and was POOH because of low ROP. At the surface four small pieces of junk were retrieved from the PDC bit. The junk consisted of magnetic metal in the shape of a nail and a helical form around the PDC cutter. There was no wear on the cutters because the junk prevented the cutter from cutting fresh formation. A Ballas core bit was RIH and drilled from 729.60 m to 732.50 m MD. Two small pieces of junk were once again recovered from the bit. A TCI tricone bit was run and drilled to 732.70 m MD followed by four runs with a magnet fishing tool on slick line creating 34.5 h of NPT. The Ballas core bit was drilled from 83.3 m to 816.0 m MD with an average ROP of 1.21 m/h.



Fig. 3-3: Junk collected during runs below the 9⅝" casing

When drilling into the Bänkerjoch Formation (top at 720 m MD), the silicate mud reacted with the formation. Fig. 3-4 shows pictures of a silicate layer on the body of the collars creating an increase in pressure due to a smaller flow area in the annulus.



Fig. 3-4: Crystallised silicate on the BHA

Coring was continued after a hydraulic test. The Ballas core bit was re-run and cored from 816.0 m to 867.0 m MD.

At approximately 863 m MD in the Muschelkalk, 8 m^3/h of dynamic losses with 400 l/min flow-rate and static losses with 240 l/h were recorded. The fractures in the Muschelkalk were closed by cuttings and no static losses were recorded at 867.0 m MD. After another hydraulic test, coring continued from 867.0 m to 862.0 m MD by re-running the last core bit. Because 60 l/h of losses were recorded during the flow check, it was decided to run the hydraulic test BHA again. During POOH the BHA got stuck with the upper packer in the auxiliary casing (Fig. 3-5). An overpull of 7.2 t was used but attempts to free it downwards were unsuccessful. Inflating and deflating the packer twice did not help and the communication with the packer was lost. Reversing the flow direction and increasing the pressure from 70 bar to 250 bar did not help. The overpull was increased in steps of 5 mt, 10 mt, 15 mt and 18 mt, but holding pull for 30 min did not work the string free. Finally, it was decided to shear off the screws of the safety joint (Fig. 3-6). The screws were sheared off with 20 mt overpull as per data sheet and 10.61 m of the test BHA were left in hole below the upper part of the safety joint.

Fishing during the hydraulic test BHA

A magnet was run to 688 m MD on a slick line down without any noticeable tag. The auxiliary casing was POOH with the shoe at 691.20 m MD. No damages or scratches of any kind could be observed on and in the casing. For BHA #51 the inner core barrel was modified to accommodate 101.4 mm.

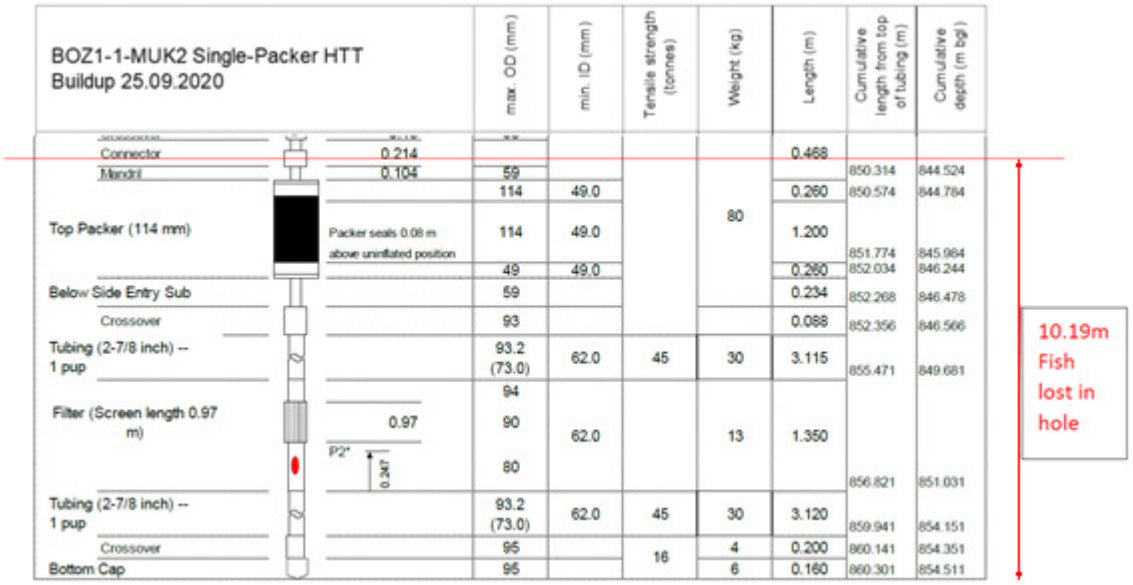


Fig. 3-5: Final diagram of fish lost in hole

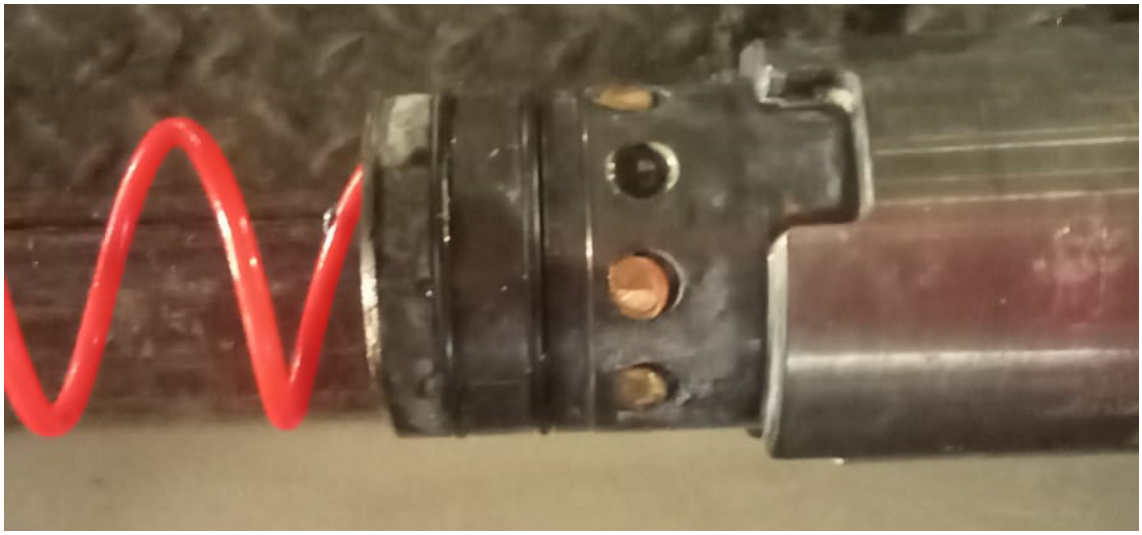


Fig. 3-6: Upper part of the safety joint with sheared screws

A special core crown with a special core catcher was RIH and the top of the fish was tagged with 1 t at 870.20 m MD. During wash down with 400 l/min, losses started at 833 m MD (total 3.2 m^3). It was possible to latch the core catcher across the safety joint and pull on it. The core catcher was released and BHA was POOH to run the overshot from NSC, Italy. The measured outer diameter (OD) of the retrieved end of the safety joint did not match the reported diameter, but the grapple available on the overshot was still able to grab it – this was checked in situ on the safety joint (Figs. 3-7 and 3-8). The top of the fish was tagged at 870.40 m MD and the grapple on the overshot tried to engage without any clear indication. At the surface, it was found that the grapple had not been activated.



Fig. 3-7: Grappel on the overshot sitting on the recovered safety joint

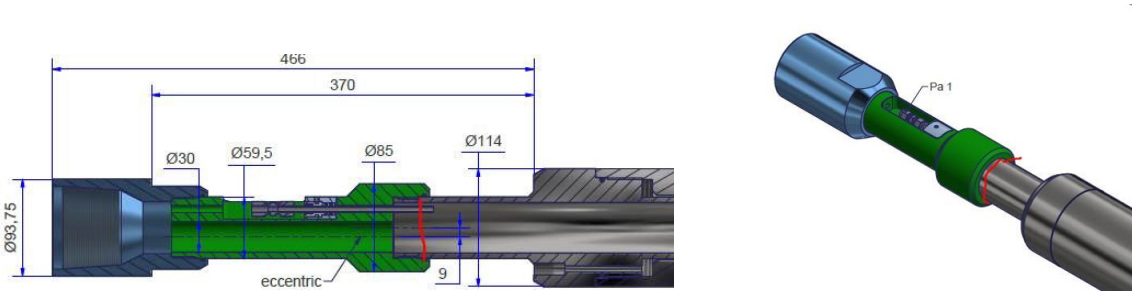


Fig. 3-8: Eccentricity below safety joint

The coring BHA with a special catcher (Fig. 3-9) was RIH, tagged the top of the fish at 870.76 m MD and connected to the fish. Overpull was increased to 24 t, but the fish did not move. Because the maximum pull on the catcher was 25.5 t, the BHA was disengaged and POOH.

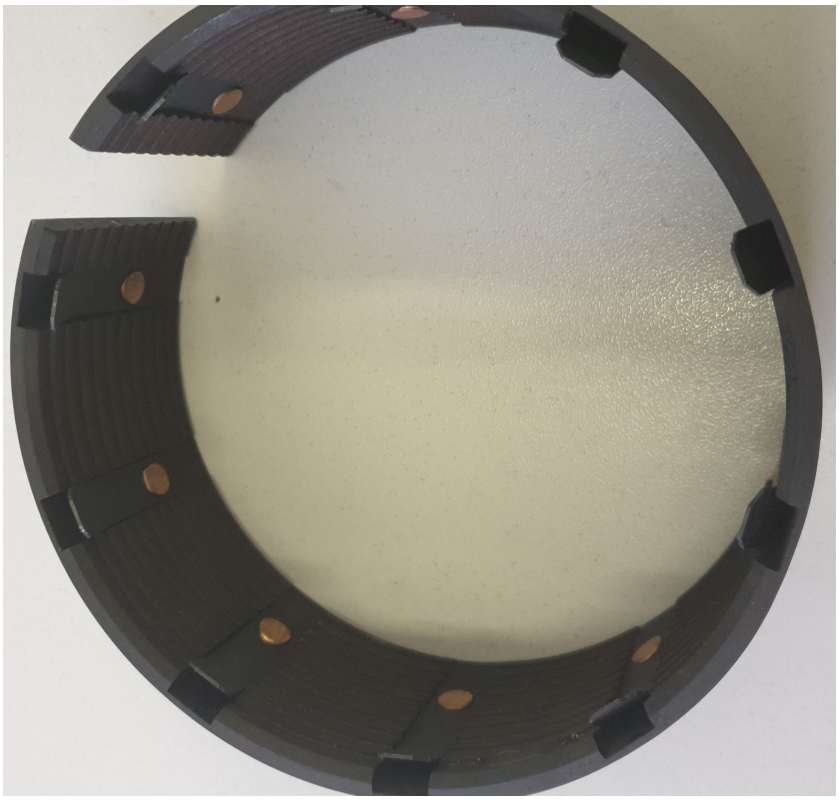


Fig. 3-9: Core catcher with special springs used to connect and pull the fish

Marriott welded blades on a special core head which had enough ID to wash over the packer element with 114.0 mm OD (Fig. 3-10).



Fig. 3-10: Self-made washover crown welded by Marriott

The top of the fish was tagged at 871.40 m MD and washed over to 875.60 m MD with 500 l/min and 3 klb/ft to 5 klb/ft torque and 260 psi standpipe pressure (SPP). The rig pulled with a maximum of 10 t overpull when pulling the modified core bit over the packer. At surface, the bit was worn down within 0.5 mm. When running in again, the top of the fish was tagged at a different

depth (874.2 m MD) and the core catcher successfully connected below the safety joint. Overpull was applied in steps of 5 t until reaching 36 t overpull (hook-load 64 t with 28 t neutral weight). At surface nothing was found in the core barrel and the finger core spring was lost in hole on the fish, similar to the springs used before. Next try with a washover pipe from Weatherford was RIH and washed down to 876.81 m MD. With a 101 mm core bit and finger core spring the fish was tagged at 874.20 m MD and overpull was applied step by step from 5 mt to 49 t without success. By applying additional torque of 170 daNm with 22 t overpull and increasing overpull to 49 t, the fish was freed and could be pulled. At surface 42 cm of fish were retrieved. The hydraulic testing BHA had a weak connection between the safety joint and the upper packer, which sheared on packer threads. The fishing operations were stopped, the borehole was cemented back and it was decided to continue with a sidetrack.

A 8½" hole opener was RIH and drilled from 692 m to 870 m MD with flowrates from 800 l/min to 1'000 l/min, 80 rpm to 85 rpm, 16 bar to 21 bar and 1 mt to 4 t weight on bit (WOB). Average ROP for the hole opening was 4.21 m/h. To prevent losses, fine $CaCO_3$ was successfully added to the mud system. Petrophysical wireline logging and USIT were run by SLB. Due to caliper restrictions at 715 m MD, a wiper trip with an 8½" BHA was RIH. At 717.8 m MD the BHA found 0.5 t resistance. A wireline caliper was run followed by MHF tests and a final image log.

Cementing back and sidetrack from 825 m to 709 m MD – interval IV BOZ1-1B

Because losses were recorded, the cement job was planned with two plugs. A lightweight cement was used on top of the fish, while high strength cement was used in the upper part to enable sidetracking. A 2⅞" tubing string with stinger was RIH to 853 m MD and the silicate mud with a density of 1.15 SG was changed to NaCl mud with a density of 1.14 SG.

Sidetrack operation started at KOP 709 m. The motor was equipped with a dump sub to prevent being pulled out wet. The theoretical build-up rate of the motor with AKO 1.15° was 6°/30 m dogleg severity (DLS). The coring equipment was limited to 3.5°/30 m in DLS. For larger DLS, the inner core barrel could not be pulled to surface. The borehole plan was created for 2.0°/30 m. The toolface received from the tool was magnetic, but not due to gravity because the inclination at KOP was smaller than 4°. The first surveys were flagged red from magnetic interference of the 9⅝" shoe at 687.4 m MD. The first unflagged survey was seen at 729 m MD. Unfortunately, drilling took several days and at 732.3 m only 50% of the formation were seen on the shakers, but the bit revolutions reached the limit of the bit (800'000 revolutions).

The BHA was pulled to change the bit. Because the drilled DLS was below theoretical values the AKO of the motor was set to 1.15°and drilled to section TD at 825.0 m MD. The hole was opened up to $9^1/_2$" (Fig. 3-11) before, the 9⅝" casing was scraped from 660 m to 680 m MD.



Fig. 3-11: Titan Tools underreamer DTU 7500, opening up the hole to 9½"

7⅝" liner 667.80 m to 824.00 m MD

The 7⅝" liner was RIH dry to 817 m MD and then washed down to 824.00 m MD. The liner was set as per NOV instructions and cemented with 6.1 m^3 of cement with a density of 1.67 SG. The float sub was holding back pressure and the liner packer was set before the running tool was released and POOH.

3.5.6 Section V: 824 m to 1'037.39 m

The cement, dart and landing collar were drilled out with a 6⅜" bit from TOC at 794.0 m MD down to 828.0 m MD (3 m new formation). Unfortunately, two runs were required because the first bit was pulled with a low penetration rate and bearing cones 1 and 3 failed. The NaCl based mud system was conditioned and circulated (density 1.16 SG) before the FIT was performed with EMW 1.7 SG. An impregnated diamond matrix core bit was RIH but could not start coring because excessive torque-up stalled out the top drive. At surface, the core head was plugged by aluminium in four crown channels and had one chipped as well as one broken segment. The core bit was exchanged for a surface set diamond bit but only drilled for 90 cm before the bit was pulled again. The impregnated bit cored from 828.90 m to 925.00 m MD. During this run two bearings of the rig crown block were changed causing 8.5 h of NPT. The mud weight was increased step by step during this BHA run from 1.15 SG to 1.23 SG. At 938.60 m MD the pressure increased, the bit was POOH and nine plugged channels were found. Another gold and red impregnated core bit was RIH and had to be pulled after coring for 2.90 m. A gold core bit cored from 941.5 m to 988.47 m MD, until the final core bit cored from 988.47 m to 1'037.0 m MD. At 1'000.0 m MD mud losses of up to 19 m^3/h were recorded. Resolving the losses by pumping lost circulation material (LCM) was without success. The borehole was drilled with losses down to 1'037.39 m MD until it was decided to stop drilling and borehole TD was declared. The BHA had to be reamed back and 5.1 m^3 of $CaCO_3$ LCM were pumped before petrophysical logs and MHF tests were run. A 2⅞" tubing string was RIH to set a cement plug from the bottom of the hole to the bottom of the Schinznach Formation. Because of the loss zone, two cement plugs were set. The cement was tagged at 880.25 m MD. The borehole was displaced to NaCl brine with a density of 1.15 SG.

3.6 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 by 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 over the course of day- or week-long tests
- 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.

The borehole consists of five sections. Sections II – V were cored completely. In Section I the polymer drilling fluids (DF) system was used, while Sections II, III and IV were completed using a highly inhibitive K-silicate system. Section V was drilled with NaCl polymer DF. Performance of the system met the expectations and operations were completed successfully, avoiding numerous issues encountered in the offset borehole.

3.6.1 Section I: Pure bore mud

Tab. 3-2 shows the composition and Tab. 3-3 the properties of the drilling fluid used for Section I.

Tab. 3-2: Fluid ingredients for Section I

Section No.	**Ingredients**
Section I	Pure bore, soda ash, sodium bicarbonate, citric acid, defoamer, calcium carbonate, polyanionic cellulosic polymer (PAC), xanthan gum

Section I was drilled rotary using pure bore mud. The borehole was drilled to a depth of 250 m MD (TD) in one bit run and without any technical problems. The polymer DF system performed as predicted and provided a stable viscosity, good hole cleaning and borehole stability. The 18⅝" casing was set without any issues.

The rig was equipped with three shale shakers. One was additionally fitted with a desander / desilter unit. Three shakers were processing the active mud system. All shakers were equipped with screens from API 80 to API 200. 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 if required to maintain the proposed mud parameters. Flocculation was not necessarily due to the geology and the usage of fine mesh screens.

Tab. 3-3: Fluid properties for Section I

Parameter	**Unit**	**Min.**	**Max.**	**Average**
Mud weight	[SG]	1.00	1.10	1.08
Plastic viscosity	[cP]	14	26	19
Yield point	[lb/100 ft^2]	16	27	20
Gel strength (10 s)	[lb/100 ft^2]	4	6	5
Gel strength (10 min)	[lb/100 ft^2]	5	12	9
Fluid loss	[ml]	5.60	18.00	7.44
Cake	[mm]	0.10	0.30	0.23
Solids	[vol.-%]	0	5	4
Sand content	[vol.-%]	0.00	0.50	0.21
Methylene blue test (MBT)	[kg/m^3]	0	24	17
pH		9.2	11.3	10.0

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 Sirius data management system with the corresponding weighing slip. The coordination of the drilling waste transportation was performed in a timely accurate and safe way.

3.6.2 Section II, III and IV: Silicate mud

Tab. 3-4 shows the composition of the drilling fluid used for Sections II, III and IV.

Tab. 3-4: Fluid ingredients for Sections II, III and IV

Section No.	**Ingredients**
Sections II, III and IV	Silicate mud, K-silicate, soda ash, defoamer, Flowzan, citric acid, PAC, sodium bicarb, Sirius ES-Pac LV

Section II

This section was drilled with 6⅜" core bits from 250 m to 480 m MD through Jurassic limestones (Malm), marlstones and claystones (Dogger) and the hole was opened up to 17½". The fluid properties for Section II are represented in Tab. 3-5.

Section II was drilled with K-silicate polymer DF. The polymer DF was treated with sodium bicarbonate and citric acid while drilling cement and new formation to a depth of 255 m with 17½" and 8½" BHA. A total of 68 m^3 new K-silicate DF was built up before drilling this interval. The displacement was performed without any problems. The ROP ranged between 0.8 m/h and 1.5 m/h with a flowrate of 400 l/min. The K-Silicate DF provided proper hole stability and hole cleaning. The mud weight (MW) of 1.19 SG was obtained by adding 43% silicate and was maintained at an MW of 1.19 SG by running one centrifuge while drilling. The rheology was slowly reduced because the active mud was heated up while drilling. The yield point (YP) dropped from

15 lb/100 ft^2 to 11 lb/100 ft^2. The API fluid loss (FL) was maintained at 4 ml/30 min to 5 ml/30 min by treating the active DF with Sirius ES-Pac LV. The silicate concentration was maintained all the time while coring and assured excellent DF inhibition and hole stability.

Tab. 3-5: Fluid properties for Section II

Parameter	**Unit**	**Min.**	**Max.**	**Average**
Mud weight	[SG]	1.15	1.20	1.18
Plastic viscosity	[cP]	9	16	12
Yield point	[lb/100 ft^2]	10	19	14
Gel strength (10 s)	[lb/100 ft^2]	2	5	3
Gel strength (10 min)	[lb/100 ft^2]	3	6	4
FL	[ml]	3.20	6.40	4.98
Cake	[mm]	0.10	0.10	0.10
Solids	[vol.-%]	1	3	2
Sand content	[vol.-%]	0.00	0.10	0.09
Methylene blue test (MBT)	[kg/m^3]	0	5	2
pH		12.7	13.3	13.0

The K-silicate DF was displaced with tap water for fluid logging. Tap water was in the open hole for approximately one day for the fluid logging operation. Afterwards the water was changed back to K-silicate DF and 4 d of logging operations were performed before the 6⅜" cored interval was opened to 8½" (12¼" and 17½").

The 8½" hole opening from 250 m to 480 m MD was performed without problems. The low shear rate viscosity (LSRV) was increased to a YP of ~ 15 lb/100 ft^2 with Flowzan and maintained the fluid loss with Sirius-ES Pac LV. During hole opening one centrifuge was run to remove fine drill solids. After opening the hole to 8½", 7 m^3 of HiVis pill (Flowzan) were pumped through the hole to sweep for POOH. After the second period of testing, the next operational step was opening the hole to 12¼" and finally 17½". Typical drilling parameters for the hole opening to 12¼" were: ROP ranging from 6 m/h to 9 m/h and a flowrate of 2'100 l/min; for the hole opening to 17½", ROP ranged from 1.5 m/h to 2.5 m/h with a flowrate of 2'700 l/min.

The drilling fluid was conditioned and treated by blending freshly mixed K-silicate premix with Flowzan to achieve the desired viscosity and mud properties. The K-silicate DF also ensured good hole cleaning and hole stability while opening the hole. No additional sweep was pumped through the hole. The MW of 1.19 SG was obtained by adding silicate and was maintained at MW = 1.19 SG by running one centrifuge while drilling. The drilling fluids' rheology was increased to 17 lb/100 ft^2 to 18 lb/100 ft^2. The API fluid loss was maintained at 4 ml/30 min to 5 ml/30 min by using Sirius ES-Pac LV. The silicate concentration was maintained all the time, while hole opening assured excellent DF inhibition and hole stability. No losses occurred during hole opening and this operation was completed without any problems.

In total 107 m^3 of K-silicate drilling fluid from this interval was kept to drill the next section.

Solids control: Shaker screens on shakers were partially replaced with finer screens (API 200 and API 270) during coring operations. These worked successfully and the sand content remained < 0.1%. Shaker #3 was completely fitted with very fine mesh screens of API 200. Two centrifuges were available, but only one was used. The same setup was partly used during hole opening.

Section III

Section III was drilled with K-silicate polymer DF from the previous section. The fluid properties for Section III are represented in Tab. 3-6.

The K-silicate DF was treated with silicate to increase the MW in steps from 1.19 SG to 1.25 SG to assure proper hole stability for the testing periods and better coring. The API FL decreased with Sirius ES Pac LV to FL < 4 ml/30 min to improve core stability. Most of the time only one shaker dressed with API 270 screens and one centrifuge run while coring to keep the solids content as low as possible. Hole opening to 8½" was conducted without any major problems, while removing the auxiliary casing required additional K-silicate in the mud to achieve a uniform MW of 1.25 SG.

Solids control: During coring shakers were dressed with API 270 screens. In addition, mud was further processed by the centrifuge. This ensured that even very fine particles were separated from the drilling fluids and the drill solids content remained very low

Tab. 3-6: Fluid properties for Section III

Parameter	Unit	Min.	Max.	Average
Mud weight	[SG]	1.19	1.25	1.22
Plastic viscosity	[cP]	10	17	14
Yield point	[lb/100 ft^2]	10	18	14
Gel strength (10 s)	[lb/100 ft^2]	2	4	3
Gel strength (10 min)	[lb/100 ft^2]	3	5	4
FL	[ml]	3.10	5.90	4.20
Cake	[mm]	0.10	0.20	0.10
Solids	[vol.-%]	3	6	4
Sand content	[vol.-%]	0.10	0.10	0.10
Methylene blue test (MBT)	[kg/m^3]	0	0	0
pH		12.2	13.1	12.7

Section IV

Section IV was drilled with K-silicate polymer DF from the previous section. The fluid properties for Section IV are represented in Tab. 3-7. A total of 95 m^3 K-silicate DF at MW 1.23 SG was used. Due to the displacement with water at the end of the cement job and heavy rain during the following days, the mud weight was reduced by two points from 1.25 SG before the cement job to 1.23 SG starting with Section IV. When drilling out the cement, a CSG (casing) pressure test was performed at 680 m MD, followed by a formation integrity test at 692 m MD. During these

drilling and circulation operations, the mud was conditioned with the remaining K-silicate and S-ES PAC-LV to improve fluid loss and rheology. With the confirmation of the slightly reduced mud weight of 1.23 SG the core operations began. The 6⅜" coring from 690 m to 816 m MD was completed without major problems. A series of tests that followed were also completed successfully. Coring the underlying formation of clay-anhydrite was slightly difficult, as the BHA was balling with mud and the formation of crystals and SPP increased. This required an additional trip to clean the BHA. The active K-silicate polymer DF had to be diluted with additional K-silicate and water to keep the viscosity as low as possible and YP at ca. 15 lb/100 ft^2. Five days of logging and hydraulic testing of the Klettgau Formation were completed without any issues. Coring was then continued from 816 m to 862 m MD. Partial formation losses were observed at a depth of 862 m MD (4 m^3/h at a flowrate of 400 l/min) but no static losses. MW of active mud was reduced from 1.24 SG. to 1.18 SG with 13.5 m^3 of water and coring was continued to a depth of 867 m MD; partial formation losses (~ 2.5 m^3/h) continued while coring at a flowrate of 300 l/min.

Tab. 3-7: Fluid properties for Section IV

Parameter	**Unit**	**Min.**	**Max.**	**Average**
Mud weight	[SG]	1.14	1.24	1.18
Plastic viscosity	[cP]	6	24	14
Yield point	[lb/100 ft^2]	9	25	15
Gel strength (10 s)	[lb/100 ft^2]	1	13	3
Gel strength (10 min)	[lb/100 ft^2]	2	16	5
FL	[ml]	3.70	6.60	5.03
Cake	[mm]	0.10	0.20	0.14
Solids	[vol.-%]	0	6.0	3
Sand content	[vol.-%]	0.05	0.25	0.10
Methylene blue test (MBT)	[kg/m^3]	0	0	0
pH		11.1	13.2	12.5

A total of 19.2 m^3 of drilling fluids was lost while coring. The mud was treated with Flowzan and S-ES PAC LV to maintain fluid properties. Coring was continued after the hydraulic testing from 867 m MD to the final section depth of 882 m MD. The SG of the mud was reduced to 1.15 SG by mixing the new muds with reduced SG. From the beginning of coring, mud losses of 4 m^3/h to 7 m^3/h occurred at a flowrate of 300 l/min; after entering the chalk formation the mud losses ranged from 2.0 m^3/h to 2.5 m^3/h. In the interval from 867 m to 882 m MD, mud losses amounted to a total of 61 m^3. After reaching the final depth of the section at 882 m MD, it was decided to repeat the hydraulic test. During hole opening from 6⅜" to 8½" mud losses decreased slowly from 6 m^3/d to 1 m^3/d. Before POOH, a 2.5 m^3 pill with SG of 1.19 was positioned at a depth of 870 m MD (top of fish; see Section 3.5.5) and the losses declined to zero. The pill was mixed with 300 kg/m^3 of different sizes of calcium carbonate (carb 10, 40, 65, 130); borehole logging and testing followed. As a next step, preparations were made to abandon: silicate mud was displaced with simple saltwater polymer mud that was additionally treated with calcium carbonate to ensure that no losses would occur. No problems occurred during the following cement jobs. The cement was then dressed to 691.5 m MD and drilling commenced for BOZ1-1B.

Solids control: Shakers were dressed with API 270 screens. One centrifuge was used continuously during coring operations to keep the content of fine solids at a minimum. As the silicate mud was replaced with a saltwater mud system, the shakers were initially dressed with API 120 and API 100 screens that were later screened up to API 140 and API 120.

3.6.3 Section IVB and V: Brine

Tab. 3-8 shows the composition of the drilling fluid used for Sections IVB and V.

Tab. 3-8: Fluid ingredients for Sections IVB and V

Section No.	**Ingredients**
Section IVB sidetrack, V	NaCl brine, pure bore ULV, soda ash

Section IVB

This section was drilled with NaCl polymer DF. To initiate the sidetrack, a lengthy drilling phase was required. During this operation mud was treated with citric acid and sodium bicarbonate if neccessary. The fluid properties for Section IVB are represented in Tab. 3-9.

Tab. 3-9: Fluid properties for Section IVB

Parameter	**Unit**	**Min.**	**Max.**	**Average**
Mud weight	[SG]	1.13	1.16	1.15
Plastic viscosity	[cP]	14	31	26
Yield point	[lb/100 ft^2]	14	23	18
Gel strength (10 s)	[lb/100 ft^2]	1	1	1
Gel strength (10 min)	[lb/100 ft^2]	2	2	2
FL	[ml]	0	6.00	4.79
Cake	[mm]	0.10	0.10	0.10
Solids	[vol.-%]	5	6.5	6
Sand content	[vol.-%]	0.10	0.15	0.10
Methylene blue test (MBT)	[kg/m^3]	0	0	0
pH		9.4	11.2	10.2

Section IVB was drilled ahead without any problems to the section's TD of 825 m MD. Underreaming followed from 8½" to 9½". On the bottom at a depth of 825 m MD, 6 m^3 of high viscosity pills were pumped to clean the hole. In addition to 6 kg/m^3 of biopolymer and 35 kg/m^3 of fine calcium carbonate, the pill was mixed with mud from the active system. The pill did not result in additional cuttings on the shakers.

Solids control: Shakers were dressed with API 140 and 120 screens. The centrifuge was continuously used during drilling phase to remove fine solids and control the mud weight.

Section V

Section V was drilled with NaCl polymer DF from the previous section with an initial specific weight of 1.16 SG and salt concentration of 180 kg/m^3. The fluid properties for this section are represented in Tab. 3-10. The 7⅝" float equipment and liner shoe and 3 m of new formation (depth 828.0 m MD) were drilled out without any problems. Cored with 6⅜" from 828.0 m to 996.5 m MD. At 888 m MD, the salt concentration and mud density were increased to 280 kg/m^3 to 310 kg/m^3 and 1.23 kg/l, respectively, to prevent washouts in salt layers. Salt formation was encountered from 914.06 m to 917.50 m MD. Dynamic losses during coring started at a depth of 996.5 m MD with 3.5 m^3/h to 4 m^3/h. Coring was continued step by step with the core extraction down to 1'001.5 m MD with increasing losses of up to max 19 m^3/h (90% losses, 10% returns). The core was extracted and a 5 m^3 LCM pill with SG 1.24 kg/l and 12 m^3 of mud with 1.21 kg/l displacement were pumped without returns. The pill was mixed with 75 kg/m^3 of salt, 5 kg/m^3 of Flowzan biopolymer and 320 kg/m^3 of different sizes of calcium carbonate (80 kg/m^3 of carb 10, 80 kg/m^3 of carb 40, 80 kg/m^3 of carb 65 and 80 kg/m^3 of carb 130). A second 5 m^3 LCM pill with SG 1.24 kg/l was mixed with similar chemical concentrations as the first pill and pumped with 20% returns and 80% losses. The active mud density was reduced from 1.21 kg/l to 1.15 kg/l by dilution (the salt concentration was reduced from 300 kg/m^3 to 130 kg/m^3). Coring was continued step by step with dynamic losses of 8 m^3/h to 10 m^3/h without problems until the final depth of 1'037.39 m MD. At the bottom, the hole was cleaned by circulating 213 l/min at 14 bar, with losses decreasing from 4 m^3/h to 5 m^3/h. Circulated bottoms up twice, POOH to 858 m MD (loss zone at ± 860 m MD in sand formation) and pumped a third 5.5 m^3 LCM pill with SG of 1.15 kg/l with 10.3 m^3 of displacement. The losses were stopped. A pill was mixed with 5 kg/m^3 of Flowzan biopolymer and 275 kg/m^3 of calcium carbonate of different sizes (150 kg/m^3 of carb fine and 125 kg/m^3 of carb 130). 278 m^3 of total losses were recorded during the following logging. POOH during flow check; the inflow (ballooning effect) from the borehole (formation) at the time of logging was 2 m^3/h and decreased to 0.1 m^3/h to 0.0 m^3/h. The cementation of the 6⅜" hole with the first plug (1'037.39 m to 933 m MD) proceeded without any problems and no losses were recorded. Salt polymer mud with 1.13 kg/l was displaced with a NaCl brine with 1.15 kg/l. First a 5 m^3 HiVis pill 1.15 kg/l (5 m^3 brine 1.15 kg/l + 25 kg Flowzan) and then 35 m^3 of NaCl brine 1.15 kg/l were pumped. No losses were recorded.

Tab. 3-10: Fluid properties for Section V

Parameter	**Unit**	**Min.**	**Max.**	**Average**
Mud weight	[SG]	1.14	1.23	1.17
Plastic viscosity	[cP]	14	27	20
Yield point	[lb/100 ft^2]	8	17	13
Gel strength (10 s)	[lb/100 ft^2]	1	1	1
Gel strength (10 min)	[lb/100 ft^2]	2	2	2
FL	[ml]	3.50	5.20	4.27
Cake	[mm]	0.10	0.10	0.10
Solids	[vol.-%]	6	14	10
Sand content	[vol.-%]	0.05	0.15	0.09
Methylene blue test (MBT)	[kg/m^3]	0	0	0
pH		9.0	10.3	9.4

Solids control: While drilling the 6⅜" section, shakers were dressed with the following screens: 2 × API 270 / 2 × API 200 on shaker #1, 4 × API 270 on shaker #2 and shaker #3 was used occasionally. The centrifuge was continuously used during coring to remove fine solids and control the mud weight.

3.7 Borehole measurements

Borehole measurements planned as per work programme (WP) are described in Appendix B.

Technical logging operations were carried out in all sections. Petrophysical logging operations and VSP were carried out by Schlumberger with the assistance of the drilling contractor. Details on petrophysical logging and VSP can be found in Dossier VI.

In situ stress testing (micro-hydraulic fracturing MHF) with the modular formation dynamic tester (MDT) was carried by Schlumberger with the assistance of the drilling contractor. Details on MHF can be found in Dossier VI.

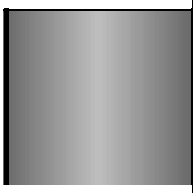
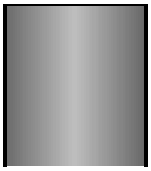
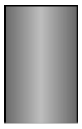
Hydraulic packer tests were carried out by Intera with the assistance of the drilling contractor. Fluid logging was carried out by Terratec. Details on hydraulic testing and fluid logging can be found in Dossier VII.

3.8 Borehole diameters and casing

An overview of the borehole diameters and the emplaced casings is given in Tab. 3-11.

Various tally lists with positions of centraliser and connections and individual joint descriptions are givenin Appendix L.

Tab. 3-11: Borehole diameters and casing overview

Hole size [in]	**Casing size** [in] **Depth** [m MD]	**Casing programme**	**Planned depth** [m MD] [m TVD]	**Actual depth** [m MD] [m TVD]	**Length drilled** [m]	**Incl.** [°]	**Steel Quality**
23	18⅝ 247.86		220	250	250	Vertical	18⅝" surface casing, K55, 94.5 lbs/ft, BTC
17½	13⅜ 478.2		405	480	230	-	13⅜" intermediate casing, J55, 68 lbs/ft, BTC
12½	9⅝ 687.4		625	690	210	-	9⅝" intermediate casing, K55, 40 lbs/ft, BTC
8½	7⅝ 667.8 – 824.0 m		825	825	135	1.5	7⅝" liner, K55, 29.7 lbs/ft, BTC
6⅜			1005	1037.39	212	-	-

3.9 Cementation

The casing diameter, grade of the steel, weight per ft, type of connection and depth along hole are listed in Section 3.8. Tab. 3-12 displays the cement volume and cement specifications.

Tab. 3-12: Cementation

From [m MD]	**To** [m MD]	**Amount** [m^3]	**Specification**
0	40	32	CEM III 32.5HRS
0	247.85	43	CEM III/B 32.5 N-LH/HS/NA 1.70 SG
0	478.08	36	CEM III/B 32.5 N-LH/HS/NA 1.65 SG
0	687.4	29	CEM III/B 32.5 N-LH/HS/NA 1.64 SG
853	777.2	6	CEM III/B 32.5 N-LH/HS/NAlite cement 1.36 SG
769	682	4.4	Class C API cement 1.75 SG
824	667.8	6.1	CEM III/B 32.5 N-LH/HS/NA, 1.67 SG
1'037.39	933.47	2.2	CEM III/B with fibers 1.65 SG
933.47	880.25	1.5	CEM III/B 1.65 SG

3.9.1 30" conductor casing

0 m to 40 m MD 30" conductor pipe, S355, --, structural steel, welded.

3.9.2 18⅝" cementation

The 18⅝" casing with 94.5 lbs/ft and an ID of 17.655" was cemented to surface. Cement volume was 43 m^3 with a density of 1.70 SG. For the cementing charts and the cementing programme, see Appendix L.

A CBL was acquired in the BOZ1-1 borehole to evaluate the integrity of the cement and control the casing collar locations. A description is also given in Appendix L.

Overall, the cementation job was classified as medium across the interval from 0 m to 247.2 m MD, with one poor cement zone from 15.6 m to 62 m MD. Below a depth of 62 m MD, the zonal isolation gradually improves and finally reaches an excellent cement bond starting at 232 m MD. No free-pipe section was observed close to surface, implying that the 18⅝" casing was cemented to surface. Log readings were attenuated above 15.6 m MD, therefore TOC cannot be confirmed in the CBL / VDL logs.

3.9.3 13⅜" cementation

The 13⅜" casing with 68 lbs/ft and an ID of 12.415" was cemented to surface. A cement volume of 47.8 m^3 with a density of 1.65 SG was pumped. For cementing chart and the cementing programme see Appendix L.

A CBL was acquired in Section II of the BOZ1-1 borehole to evaluate the integrity of the cement and identify the locations of the TOC and the lead-tail interface. The main conclusion of this report is that a small region with poor bonding and potentially poor zonal isolation was located just below the previous casing shoe (248 – 254 m), where the hole is enlarged (washouts). Medium bond could be seen from 5.1 to 156 m with large casing. Based on the USIT, there are few areas with weaker bond, some narrow liquid channels and de-bonded patches present, which may be caused by limited mud removal at "restricted flow" areas near the casing collars, but this is not affecting overall zonal isolation. Medium bond was found from 387 to 395.5 m. All other regions had an excellent bond.

3.9.4 9⅝" cementation

A cement volume of 29.4 m^3 was planned to cement the 9⅝" casing from TD to surface (687.40 m to 0 m MD):

For the cementing chart and the cementing programme, see Appendix L.

Overall, the cementing job was classified as medium to good across the interval from 10.5 m to 688 m MD. The TOC was identified at the surface based on log readings, the pressure chart in the cement report and because cement returns were observed at the surface during the cement job. In the double casing section (in particular from 414 m to 437 m MD), the USIT readings were affected by the dual-steel casing and there was less bonding. Below the casing shoe of the previous 13⅜" casing (478.08 m MD to TD) the bond was excellent.

3.9.5 Cement plugs below the 9⅝" casing to sidetrack the well

The first cement plug was set from 853 m to 757 m MD; 6 m^3 of water spacer, 6 m^3 of cement with fibres (1.36 SG), 1.8 m^3 of water spacer and 0.5 m^3 of mud (1.15 SG brine) were pumped. The second cement plug was set from 775 m to 680 m MD; 6 m^3 of water spacer, 4.4 m^3 of cement (1.75 SG), 0.5 m^3 of water spacer and 1.9 m^3 of mud (1.15 SG brine) were pumped. An 8½" bit was run and dressed the cement from 682.5 m to 691.5 m MD because the rig was waiting for Weatherford's directional equipment.

3.9.6 7⅝" liner and cement job

A cement volume of 6.1 m^3 with a density of 1.67 SG was planned to cement the 7⅝" liner from 667.80 m to 824.00 m MD. 10 m^3 of spacer with a density of 1.40 SG were pumped before the cement. The cement was displaced with 4.7 m^3 of water and 3.5 m^3 of mud with a density of 1.16 SG. The plug bumped and pressure was increased from 45 bar to 100 bar; floats were holding. With reverse circulation 2 m^3 of cement and 20.3 m^3 of spacer and mix zone were dumped.

The cement bond was checked with CBL / VDL acquired during run 5.1.3. The acoustic impedance logs were acquired by the USIT in run 5.1.4. In the CBL / VDL logs the TOC was identified at the top of the 7⅝" liner (at 667.2 m MD). This contradicts the cement report, which places the TOC at 638 m MD. Good to excellent bonding was observed throughout most of the cemented interval from 667.2 m to 824 m MD, with the exception of two poor zones around 709 m MD and below 816 m MD. Logs show poor zonal isolation in a short interval (from 709 m to 712.1 m MD) around the KOP of the sidetrack, parallel borehole (BOZ1-1B). At the bottom of the 7⅝" liner (below 816 m MD), the bond appeared to be partially absent from the annulus, meaning that zonal

isolation was not achieved. A possible explanation could be that the cement bond was damaged while drilling out the collar and liner show track, which took much longer than usual (ca. 26 h) based on the drilling forecast.

3.9.7 Cement plugs below 7⅝" liner

The first cement plug was set from 1'037.39 m to 937 m MD; 3.5 m^3 of water spacer, 2.7 m^3 of cement with fibres (1.65 SG) and 2.2 m^3 of water spacer and mud (1.15 SG brine) were pumped. TOC was tagged at 933.47 m MD. The second cement plug was set from 933 m to 876 m MD – 7⅝" and shoe at 824.0 m MD; 3.5 m^3 of water spacer, 1.5 m^3 of cement (1.65 SG) and 2.2 m^3 of water spacer and mud (1.15 SG brine) were pumped. Reverse circulation was done at 822 m MD and cement was tagged at 880.25 m MD.

3.10 Borehole deviation

The borehole is almost vertical. The maximum inclination measured is 3.12° of inclination at 709 m. Maximum dogleg severity (DLS) is 7.5°/30 m at 518.31 m MD caused by a big turn.

The final survey report was created by combining different survey sections from SLB general purpose inclinometer tool (GPIT) measurements, Gyro run from surveys. Plan view and section view show the deviation from the origin with a maximum of -5.42 m towards east-west and 2.63 m towards north for the sidetrack, and 5.22 m towards north and -5.19 m towards east for the original borehole.

A plot from the directional drilling service, plan view, section view and survey stations for BOZ1-1 and BOZ1-1B is given in Appendix E.

4 HSE

4.1 Health and safety

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

The site was fenced to protect workers from external influences and to define a clear boundary 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 carry 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 changes of shifts 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 who was visiting or working at the drill site had to follow. These rules set 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.

Throughout the drilling phase of BOZ 1-1, one restricted work case and three first-aid cases were reported. The restricted work case happened on 26.01.2020: RWC and was a foot injury. The first-aid cases happened on 25.08.2019: with bruised thumb of the left hand, on 14.12.2019 with chemical burn to eye from silica mud and on 25.02.2020 with chemical burns on body due to exposure to potassium silicate.

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 correctly
- 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
- to check the storage of hazardous substances
- 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 water collected on the drill site within the asphalted area was originally collected over a roof pitch, passed through a scum collector, an oil separator, decantation pits and finally seeped away in a seepage pit. The collected solids in the decantation pits were disposed of on a regular basis by suction trucks. The collected water from the rig site was discharged into the nearest public wastewater system via the rainwater sewer system instead of being moved to a wastewater facility by truck.

4.2.3 Noise

During the entire drilling phase, the legal limits of the Noise Abatement Ordinance had to be complied with at the nearest residential properties to the drill site. Because drilling operations were carried out without any interruptions, it was important to stay within the legal limits for day and night. The limit during daytime was 60 dB(A) and 50 dB(A) during the night. For the BOZ1-1 borehole, several noise measurements were performed by a specialised company at the nearest house to evaluate the average noise emissions of the work carried out. Noise measurements showed no excess of noise, so that no additional noise protection walls were built.

4.2.4 Lighting

Besides noise emissions, light emissions were also relevant for the drill site, especially during the night. 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.

4.2.5 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. For each analysis two samples were taken: first to determine the texture and mechanical modularity and second for eluate investigations.

4.2.6 Mud losses

At the BOZ1-1 and BOZ1-1B borehole some mud quantities were lost into the formations in Sections IV, IVB and V. The losses occurred between 867 m MD and 1'001.5 m MD because of high mud weight of over 1.20 SG. The mud losses stopped when the weight was equal or lower than 1.20 SG. Quantities are reported in Chapter 3.

5 References

Isler, A., Pasquier, F. & Huber, M. (1984): Geologische Karte der zentralen Nordschweiz 1:100'000. Herausgegeben von der Nagra und der Schweiz. Geol. Komm.

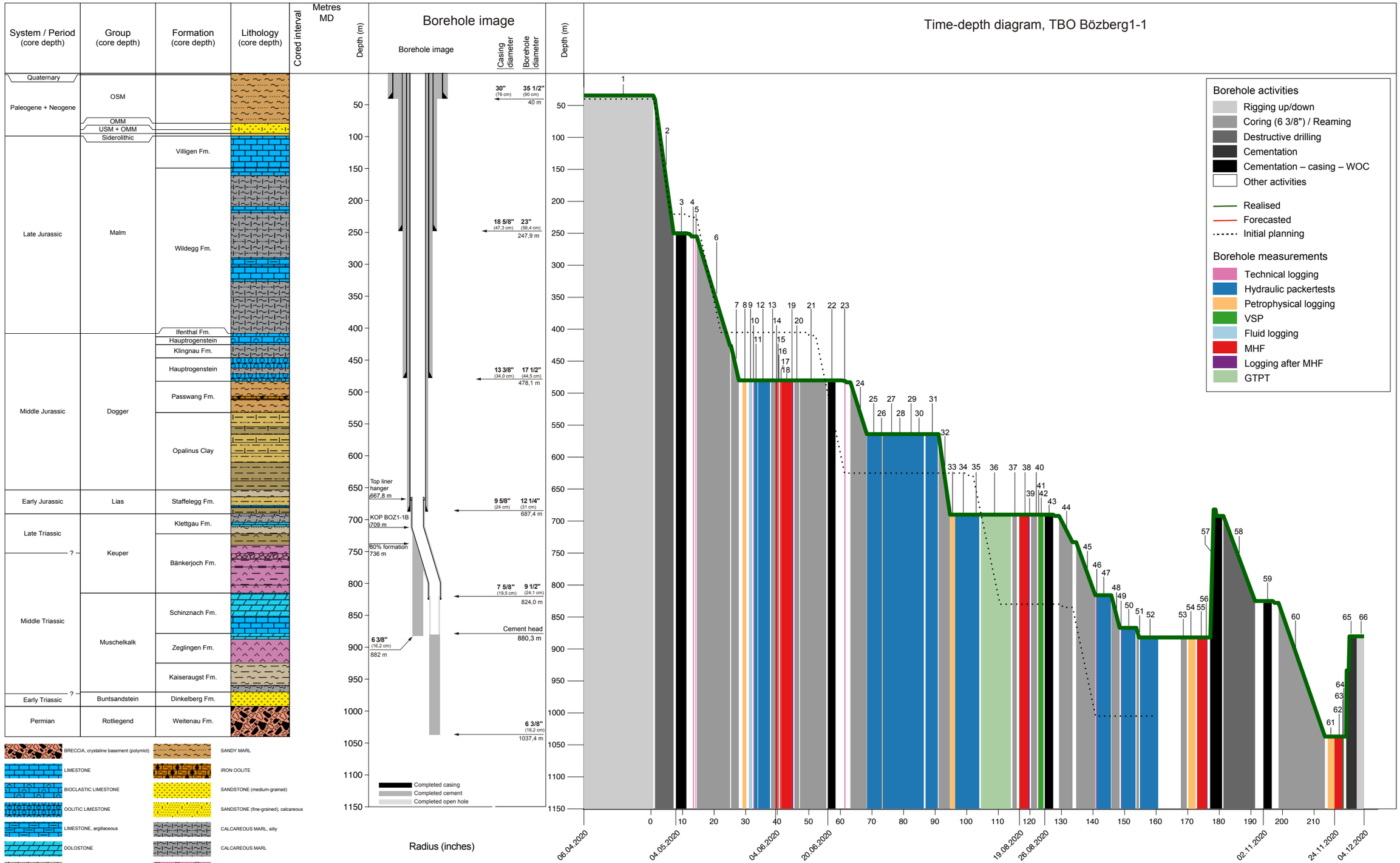
MICON-Drilling (2021): Rotary Vertical Drilling System RVDS. MICON-Drilling GmbH. https://www.micon-drilling.de/Download/Catalog_RVDS_EN_210720.pdf

Nagra (2014): SGT Etappe 2: Vorschlag weiter zu untersuchender geologischer Standortgebiete mit zugehörigen Standortarealen für die Oberflächenanlage. Geologische Grundlagen. Dossier II: Sedimentologische und tektonische Verhältnisse. Nagra Technischer Bericht NTB 14-02.

Nagra (2018a): 2 AP1, Arbeitsprogramm für Tiefbohrungen:Spezifisches Untersuchungsprogramm der Tiefbohrung Bözberg1-1. Nagra Sondiergesuch NSG 16-06.

Pietsch, J. & Jordan, P. (2014): Digitales Höhenmodell Basis Quartär der Nordschweiz – Version 2013 (SGT E2) und ausgewählte Auswertungen. Nagra Arbeitsbericht NAB 14-02.

Appendix A: Executed Work Programme



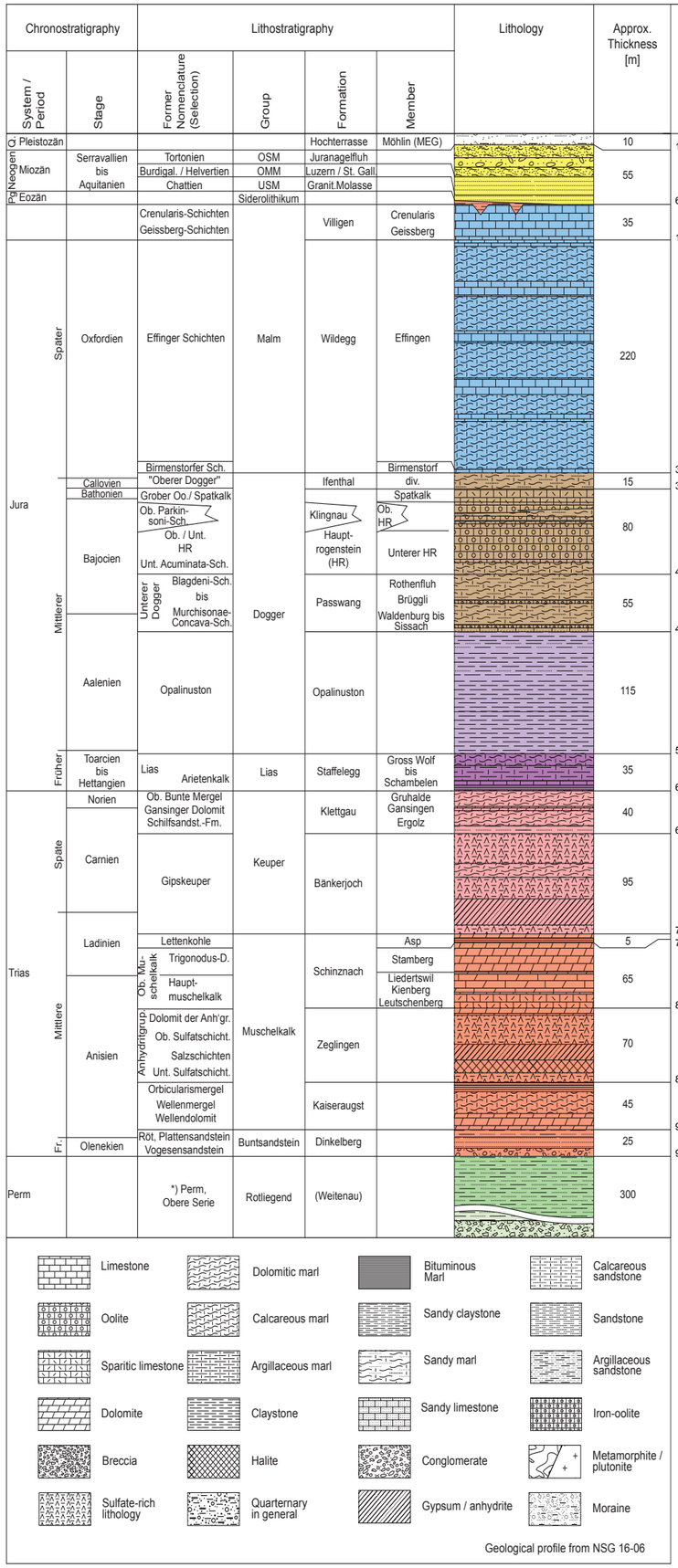
BRECCIA, crystaline basement (polymict)
LIMESTONE
BIOCLASTIC LIMESTONE
OOLITIC LIMESTONE
LIMESTONE, argillaceous
DOLOSTONE
DOLOMITIC MARL, silty
ARGILLACEOUS MARL
SILTY CLAYSTONE, calcareous
SILTY CLAYSTONE
ANHYDRITE, nodular
ANHYDRITE
SANDY MARL
IRON OOLITE
SANDSTONE (medium-grained)
SANDSTONE (fine-grained), calcareous
CALCAREOUS MARL, silty
CALCAREOUS MARL
ANHYDRITE, argillaceous
CLAYSTONE, silty, calcareous
CLAYSTONE, anhydritic
CLAYSTONE, silty

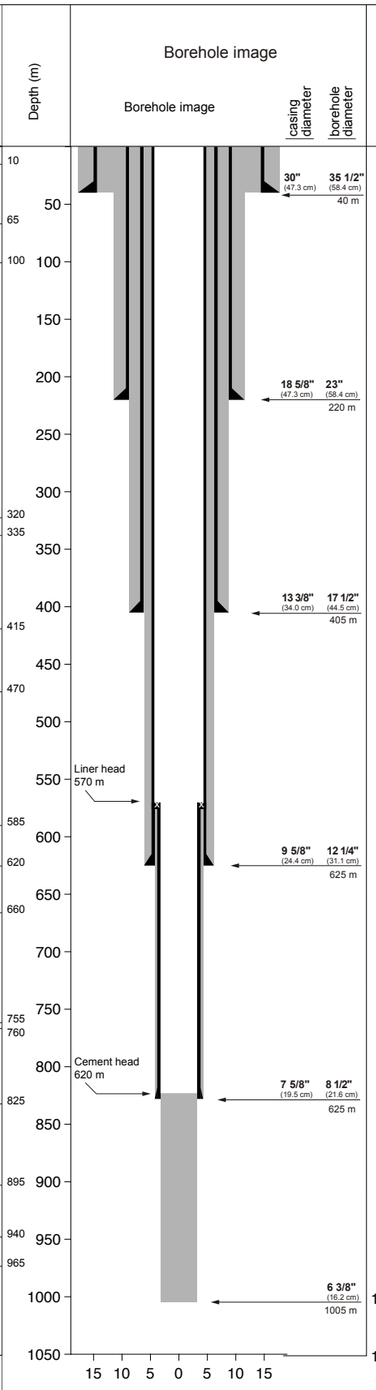
Numbering of the main operational steps (numbering in brackets corresponds to complete list of operational steps, cf. Table 6-1)

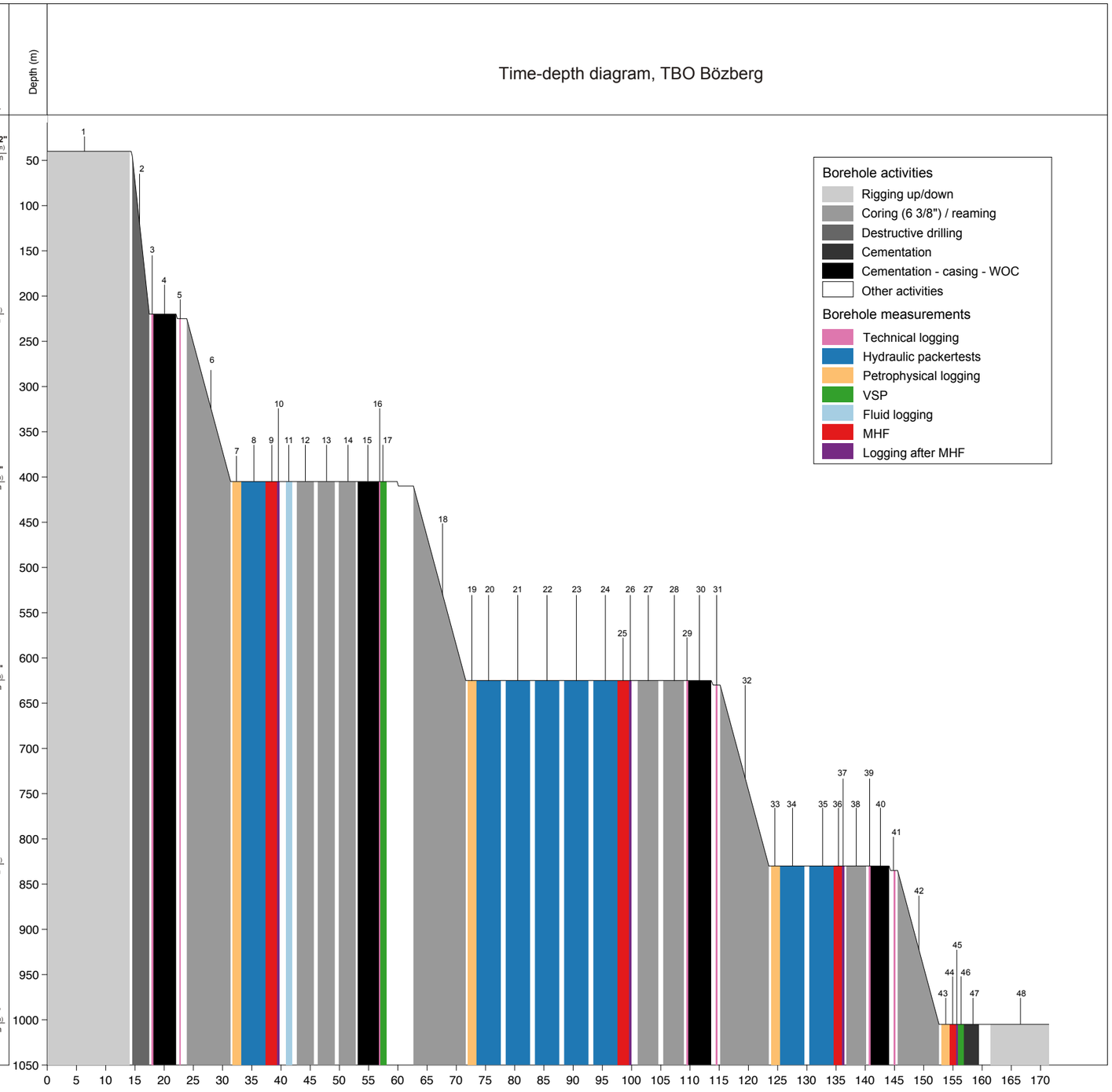
1 (1): Rigging up drilling rig, workshops, containers; preparing mud & BHA, ENSI audit
2 (4): Drilling 23" from 40 m till 250 m
3 (8-15): Cementation, Casing & WOC
4 (21): Technical Logging B (incl. assembly & disassembly) (CBL)
5 (23): Technical Logging B (incl. assembly & disassembly) (Gyro)
6 (25): Coring 6 3/8" from 255 m till 426 m
7 (27): Coring 6 3/8" from 426 m till 480 m
8 (29): Petrophysical Logging
9 (32): Fluid-Logging A
10 (34): Technical Logging A (incl. assembly & disassembly) (Caliber)
11 (35): Hydraulic Testing A+B (incl. assembly & disassembly). Mid BD
12 (37): Hydraulic Testing A+B (incl. assembly & disassembly). Mid BD
13 (40): Hole opening 8 1/2" from 255-480 m incl. circulate hole clean
14 (42): MHF (6-7 Tests)
15 (43): Hole opening 12 1/4" from 252-255 m incl. circulate hole clean
16 (44): Continue MHF (6-7 Tests)
17 (46): Continue MHF (6-7 Tests)
18 (48): Continue MHF (6-7 Tests)
19 (49): Logging after MHF
20 (52): Hole opening 12 1/4" from 255-480m incl. circulate hole clean
21 (55): Hole opening 17 1/2" from 255 - 480 m (478.5m cutter depth)
22 (59-65): Cementation, Casing & WOC
23 (71): Technical Logging B (incl. assembly & disassembly)
24 (77): Coring 6 3/8" from 483 - 564 m (taget 30m below top Opa) incl. RT f. CH (6hrs)
25 (79): Hydraulic Testing Opalinuston (incl. assembly & disassembly)
26 (80): Petrophysical Logging (Caliper and FMI)
27 (81): Hydraulic Testing Opalinuston (2) (incl. assembly & disassembly)
28 (82): Hydraulic Testing Opalinuston (3) (incl. assembly & disassembly)
29 (83): Hydraulic Testing Brauner Dogger (1) (incl. assembly & disassembly)
30 (84): Hydraulic Testing Brauner Dogger (2) (incl. assembly & disassembly)
31 (87): Hydraulic Testing Brauner Dogger (2) (incl. assembly & disassembly)
32 (89): Coring 6 3/8" from 564 - 690m
33 (91): Petrophysical Logging (full suite)
34 (92): Hydraulic Testing Opa -Lias (1) (incl. assembly & disassembly)
35 (93): Hydraulic Testing Lias (2) (incl. assembly & disassembly)
36 (95): Gas Threshold Pressure test GTPT - OPA 3 (incl. assembly & disassembly)
37 (98): Hole opening 8 1/2" from 483 - 690m and circulate Hole clean
38 (102): MHF (6-7 tests incl 1 x PMT in Opa)
39 (103): Logging after MHF
40 (106): Hole opening 12 1/4" from 481- 690m and circulate clean (2hrs)
41 (108): Technical Logging A (incl. assembly & disassembly) (Cal)
42 (109): VSP
43 (112-119): Cementation, Casing & WOC
44 (124): Coring 6 3/8" from 692 - 732.5m
45 (129): Coring 6 3/8" from 732.5m to 816m
46 (131): Technical Logging (caliper only)
47 (132): Hydraulic Testing Klettgau (incl. assembly & disassembly) incl. Water sampling
48 (134): Coring 6 3/8" from 816 - 867 m (Top Zeglingen)
49 (137): Technical Logging (caliper only)
50 (138): Hydraulic Testing Schinznach (incl. assembly & disassembly)
51 (140): Coring 6 3/8" from 867 - 882 m
52 (143): Hydraulic Testing Schinznach (incl. assembly & disassembly)
53 (153): Hole opening 8 1/2" from 692 - 870 m (ensure no losses => use approved LCM)
54 (156): Petrophysical Logging (full suite) + USIT
55 (158): Calliper log and MHF (7-8 Tests)
56 (159): Logging after MHF
57 (163-168): Cementation, Casing & WOC
58 (170): Directional drilling 8 1/2" below shoe to 825m TVD (time drilling to kick off)
59 (175-183): Cementation, Casing & WOC
60 (190): Coring 6 3/8" from 828 - 1030m (current depth) BOP test done during 4. core bit change out trip
61 (193): Petrophysical Logging (full suite) + USIT
62 (194): MHF (6-8)
63 (195): Logging after MHF
64 (196): VSP
65 (198-207): Cementing from end of hole up to 925 m
66 (208): Rigging down drilling rig, workshops, containers etc. / Rig up STA3-1

nagra	NAB 21-21
Time-depth diagram - Bözberg-1-1: programme as performed	
Dossier I	DAT.: Feb. 2022 — Appendix A

Appendix B: Original Work Programme







Numbering of the main operational steps (numbering in brackets corresponds to complete list of operational steps, cf. Table 6-1)

1 (1): Rigging up drilling rig, workshops, containers; preparing mud, rig inspection & technical approval (3 days)
2 (4): Drilling 23" from 45 m till 220 m
3 (6): Technical Logging A
4 (7-14): Cementation, Casing & WOC
5 (18): Technical Logging B
6 (21): Coring 6 3/8" from 225 m till 405 m
7 (23): Petrophysical Logging
8 (24): Hydraulic Testing A+B. Mid BD
9 (25): MHF (7-8 Tests), including fluid sampling
10 (26): Logging after MHF
11 (29): Fluid-Logging A
12 (32): Hole opening 8 1/2" from 225-405 m
13 (35): Hole opening 12 1/4" from 225-405 m
14 (38): Hole opening 17 1/2" from 225-405 m
15 (40-47): Cementation, Casing & WOC
16 (48): Technical Logging B
17 (49): VSP
18 (61): Coring 6 3/8" from 410 - 625 m
19 (63): Petrophysical Logging (full suite)
20 (64): Hydraulic Testing Brauner Dogger - OPA
21 (66): Hydraulic Testing Brauner Dogger
22 (68): Hydraulic Testing Brauner OPA
23 (70): Hydraulic Testing Brauner OPA -Lias
24 (72): Hydraulic Testing Brauner Lias
25 (73): MHF (7-8 Tests)
26 (74): Logging after MHF
27 (77): Hole opening 8 1/2" from 410 - 625 m
28 (80): Hole opening 12 1/4" from 410 - 625 m
29 (82): Technical Logging A
30 (83-92): Cementation, Casing & WOC
31 (96): Technical Logging B
32 (98): Coring 6 3/8" from 630 - 830 m
33 (100): Petrophysical Logging (full suite)
34 (101): Hydraulic Testing Muschelkalk
35 (103): Hydraulic Testing Klettgau
36 (104): MHF (7-8 Tests)
37 (105): Logging after MHF
38 (107): Hole opening 8 1/2" from 630-830 m
39 (109): Technical Logging A
40 (110-118): Cementation, Casing & WOC
41 (122): Technical Logging B
42 (124): Coring 6 3/8" from 835 - 1005 m final depth
43 (126): Petrophysical Logging (3 runs)
44 (127): MHF (4 tests)
45 (128): Logging after MHF
46 (129): VSP
47 (130-136): Cementing from end of hole up to 7 5/8" liner
48 (138): Rigging down drilling rig, workshops, containers etc.

Diese Figur wird bei relevanten neuen Erkenntnissen vor Beginn der Arbeiten noch angepasst. Die Resultate der 3D-Seismik mit Stand vom 11.04.2018 wurden konsultiert.

nagra	NAB 21-21
Time-depth diagram - Bözberg-1-1: programme as planned	
Dossier I	DAT.: Feb. 2022 — Appendix B

Appendix C: Drill site pictures and drawing

Drone flight Bözberg-1-1:
https://youtu.be/ob-eM-S4s7c



Fig. C-1: Drill site underground construction



Fig. C-2: Drill site underground construction progress



Fig. C-3: Pile drilling machine for standpipe hole drilling and RIH standpipe with 2 cranes



Fig. C-4: Drill site covered with asphalt



Fig. C-5: Drill site asphalt construction



Fig. C-6: Drill site in operations with Marriott's rig 16



Fig. C-7: Drill site in operations with Marriott's rig 16



Fig. C-8: Drill site in operations with Marriott's rig 16



Fig. C-9: Drill site in operations with Marriott's rig 16



Fig. C-10: DMT Vibrotruck on Bözberg location





Fig. C-11: Hydrotesting on Bözberg location

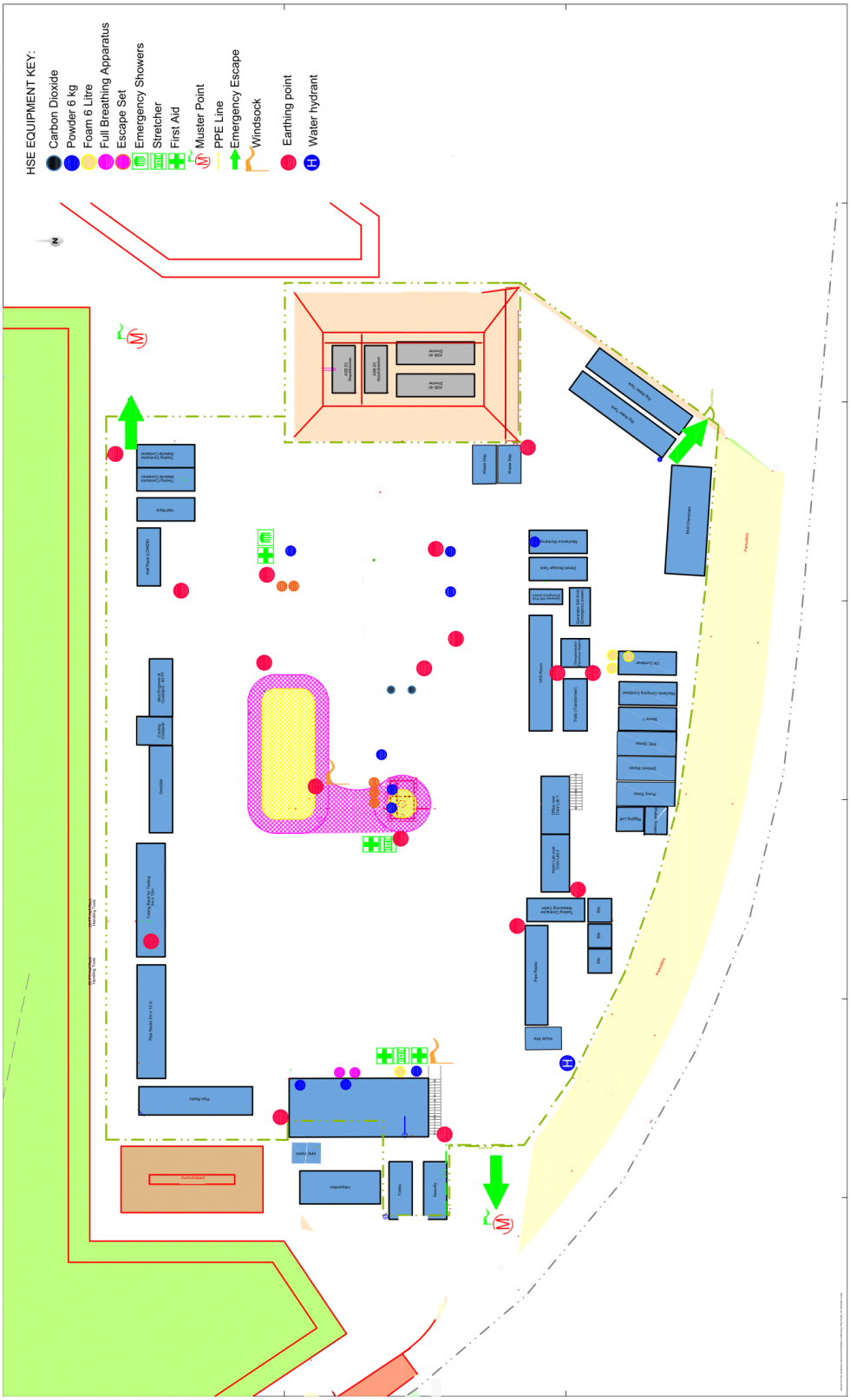


Fig. C-12: Drawing for Bözberg location with muster point

Appendix D: Technical data of the rig

Tab. D-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 (top drive stroke)
	Min.imum nominal gross capacity (with 2 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
	Casing stabbing board	Yes / no	Not applicable
	Derrickman windbreaks height	m	Not applicable
	Derrick camera system	Yes / no	Not applicable
A 2	Substructure		
	Manufacturer		Drillmec
	Type		
	Year of construction		
	Width	m	2.9
	Clear height below rotary table beams up to	m	4.316
	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	N/A
	Drainage system		Yes

Tab. D-1: continued

A 2.1 (continued)	Kelly hole Mousehole	Yes / no Yes / no	Not applicable /Mud hose 3½" ID, 5'000psi Yes / with hydraulic clamp
A 3	Draw works Manufacturer Type Year of construction Number of electric motors Drive system power Max. cable tension, 2nd layer Auxiliary brake Automatic feed system Manufacturer Type	 kW kN 	 Drillmec Hydraulic RAM 2012 1 447 Not applicable Drillmec hydraulic Drillmec Pipe handler
A 4	Drilling and coring lines		
A 4.1	Drilling line Diameter Type Min.imum breaking load	 mm kN	 34 Diepa AF 2371C 652
A 4.2	Coring wireline Diameter Length	 mm m	Millenium wireline 8 2'000
A 5	Dead line anchor Manufacturer Type		 Drillmec Yoke pinned
A 6	Crown block and hook		
A 6.1	Crown block Manufacturer Type Year of construction Capacity Crown block safety device	 kN 	 Drillmec Fixed to mast telescopic section 2012 978.16 Drillmec kinetic

Tab. D-1: continued

A 6.2	Hook		
	Manufacturer		Drillmec
	Type		Ouble hook
	Year of construction		2012
	Capacity	kN	978.61
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		Independent hydraulic Driven
	Maximum opening	in	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. D-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 flowrate	l/min (140 spm)	2'484 × 2
	with liner		
	Size	in	6¾"
	Stroke length	in	10"
C 2	Standpipe(s)		
	Number		1
	ID	in	30"
	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 1502	
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. D-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	.23

Tab. D-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)		Electric 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)		Electric driven
	Power rating	kW	75
	Rotary speed control	Yes / no	No

Tab. D-1: continued

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

Tab. D-1: continued

E 4	Torque converter		
	(only for diesel-mechanical rigs)		
	Number		Not applicable
	Power rating	kW	
E 5	Generators		
	(only for diesel-electric rigs)		
	Number		5
	Manufacturer		Caterpillar
	Power rating	kVA	500 each
E 6	SCR system		
	(only for diesel-electric rigs)		
	Manufacturer		Bauer
E 7	Auxiliary power supply (400 V / 50 Hz)		
	Number		2
	Manufacturer		Caterpillar
	Power rating	kVA	180
E 8	Fuel tanks		
	Number		1
	Capacity	m^3	20.892
	With EX-protection	Yes / no	Yes
	Leak detection	CMR electrical	Type: ODS2-2
E 9	Rig service air system		
	Number		2
	Volume	m^3/min	3.6
	Working pressure	bar	10.34
	Storage capacity	l	Yes
	Air dryer unit		Yes
F 1	Diverter system		
	Manufacturer		Drilltech
	Type		R73
	Size	in	21¼"
	Side outlets quantity		2
	Side outlets size	in	9"
	H_2S rating	Yes / no	No
	Diverter lines		
	Length	m	57

Tab. D-1: continued

F 1 (continued)	Nominal ID		10"
	Manual valves		
	Number		2
	Working pressure	psi / bar	580 / 40
	Hydraulically actuated valves		
	Number		1
	Working pressure	psi / bar	Max. 2'000 / 140
F 2	Annular preventer		
	Number		1
	Manufacturer		
	Type		Shanghai Shenhai
	Size	in	13⅝"
	Pressure rating	psi	5'000
	H_2S rating	Yes / no	yes
F 3	Ram type preventer		
	Number		1
	Manufacturer		Shanghai Shenkai
	Type		Double gate
	Size	in	13⅝"
	Pressure rating	psi	5'000
	H_2S rating	Yes / no	yes
	Side outlets quantity		2
	Side outlets size	in	$4^{1}/_{16}$"
F 4	Ram types		
F 4.1	Pipe rams		
	Number	sets	2
	Size	in	4½" to 7" VBR
F 4.2	Blind/shear rams	sets	1 (kit) each
F 4.3	Variable bore rams		
	Number	sets	2 (depending on the borehole control programme)
	Size (from – to)	in	2⅞" to 5"
F 5	Drilling spools		
	Side outlets quantity		2
	Side outlets size		4 1/16"
	Spacer spools		2 × 13⅝"

Tab. D-1: continued

F 6	BOP control system		
	Manufacturer		Shaffer
	Type		5 stage T20120-35
	Total capacity	l	1059
	Bottle working pressure	psi / bar	3000 / 210
	Annular pressure control valve	Yes / no	Yes
	Electric pumps		
	Number		1
	Capacity	l/min	15.52
	Air pumps		
	Number		3
	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	No
F 7.2	Choke lines		1
	Number		
	Type		
	Nominal ID	in	3
	Length	m	10
	Working pressure	psi	5'000

Tab. D-1: continued

F 7.2 (continued)	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	8 – 10
	Working pressure	psi / bar	
F 7.6	Flare		
	Height	m	On demand
	OD	in	
	Ignition system		remote
F 8	BOP test equipment		
F 8.1	Test unit / test pump		
	Working pressure	psi / bar	High pressure pump 10'000 / 700
	Pressure recorder	Yes / no	Yes
F 8.2	Cup type tester		
	As per casing programme	Yes / no	Yes

Tab. D-1: continued

F 9	Kelly cocks		
	Number		3
	Connection type		NC50
	Working pressure	psi / bar	5'000 / 350
	H_2S rating	Yes / no	Yes
F 10	Drop-in valves		
	Number		1
	OD	in	Depending on drill pipe size
	ID	in	See above
	Working pressure	psi / bar	5'000 / 350
	Landing nipple		
	OD	in	Depending on drill pipe size
	ID	in	See above
	Connection type		Depending on drill pipe connection
F 11	IBOP / gray valve		
	Number		1
	Connection type		Connected to the topdrive
	Working pressure	psi / bar	5'000 / 350
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

Tab. D-1: continued

G 1.1	Coring string		
	OD	in	5½ SK»
	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		SK
	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	× 2 m
	Number / length	m	× 3 m
			Other lengths available on request
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	

Tab. D-1: continued

G 4	Drill collars		
	Number		12 × 6½ and 12 × 8"
	OD	in	8 – 6½
	ID	in	13/16"
	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	
H	Handling tools		
	Elevator links		
	Elevators		
	Rotary tongs	In sufficient quantities to perform the scope of work for all strings (DP, casing, stinger, etc.)	
	Slips		
	DC safety clamps		
	Drill pipe wipers		
	Bit breakers		
	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

Tab. D-1: continued

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 Drive	Yes / no Hydraulic / pneumatic	Not applicable
J	Fishing equipment Over shots Junk basket Overshot Spear	In sufficient quantities to handle all strings in the scope of work	
K 1	Drilling control console with Weight indicator Hook position Standpipe pressure gauges Choke manifold pressure gauges Rotary speed tachometer Rotary torque indicator Pump pressure indicators Pump stroke counters Flowrate Pit volume Trip tank level	 Yes / no Yes / no Yes / no Yes / no Yes / no Yes / no Yes / no Yes / no Yes / no Yes / no Yes / no	 Yes Yes Yes Yes Yes Yes Yes Yes Yes Yes Yes
K 2	Drilling recorder Manufacturer Type Recording all parameters as shown at drilling console as minimum	 Yes / no	 Drillmec Data Aquisition System (DAS)s No
K 3	Pit volume totaliser Number of sensors Loss / gain indicators and alarm	 Yes / no	 7 Yes
K 4	Trip tank Capacity	 m^3	 5

Tab. D-1: continued

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		
	Ring gauges		
	DP / DC drifts		
	Casing drifts	In adequate quantities for contractor's string and drilling programme	
	Bit calipers / gauges		
	Internal / external calipers		
	Derrick tapes (steel)		
K 7	Pressure gauges		
	Standpipe manifold	Number	3
	Choke manifold	Number	3
K 8	Flowline gas sensor		
	Total gas	Yes / no	Yes
	H_2S sensor	Yes / no	Yes
	Measurement range (C1-Cx)		
	Alarm	Yes / no	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	Surehot 0° to 7°
L 1	General personnel safety equipment		
	Fire fighting equipment		In adequate quantities
	Personal protective equipment		In adequate quantities
	First aid equipment		In adequate quantities
	Eye washing stations		In adequate quantities
	Emergency lights		In adequate quantities

Tab. D-1: continued

L 2	Derrick safety equipment		
	Derrick escape line		In adequate quantities
	Manufacturer		
	Type		
	Derrick safety belts		In adequate quantities
	Derrick safety devices		In adequate quantities
	Derrick climbing assistant		In adequate quantities
L 3	Gas / fire / smoke detection		
	H_2S monitoring system	Yes / no	Yes, on request
	H_2S / CO_2 detectors (portable)	Yes / no	Yes, on request
	Explosimeters	Yes / no	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
N 5	Cellar pump		
	Manufacturer		KSB
	Type		ATEX
	Power	kW	1.5
N 6	Forklift		
	Capacity	kN	120 and 25

Bözberg-1-1
Switzerland

Drilling-Engineering-Plot, 1:500

Mudlogging:

Client:
Client: Nagra
Operator: Nagra

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

Location:
Country: Switzerland
Region or oilfield: Kanton Aargau
Location: Bözberg

Coordinates:
Longitude / Latitude: E 8° 9' 17.90" N 47° 28' 43.98"
Elev. Ground level (MSL) 513.29 m
Elev. Rig Floor (GL) 4.90 m
Depth datum: Groundlevel

Well Type:
Shallow stratigraphic/structure test

Duration:
Spud: 27.04.2020
Last day drilled: 25.09.2020
Start depth (Tie-in) 0.00 m
Total depth: 882.24 m

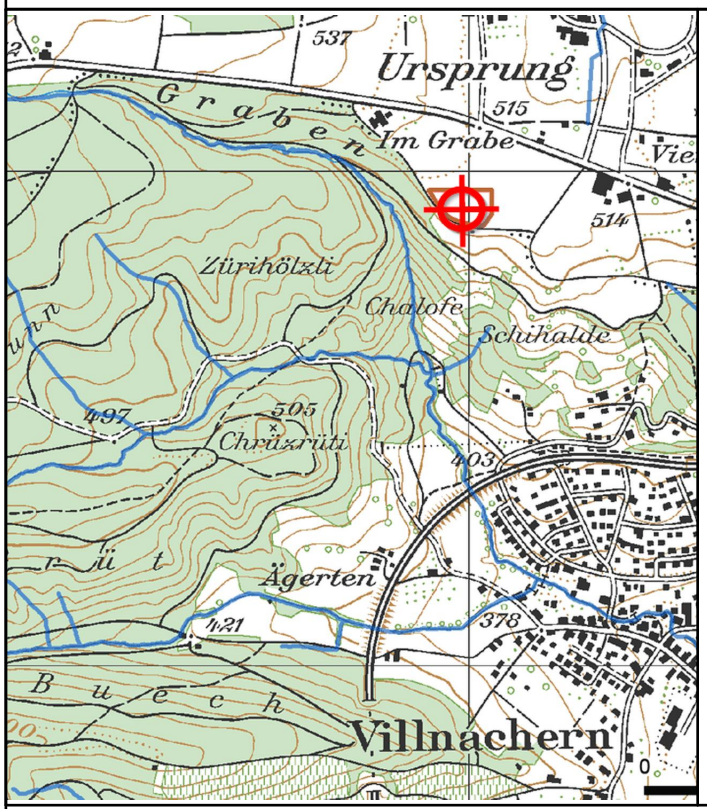
Rig:
Marriott Rig 16
Marriott Drilling Ltd

Team:
Company Man: M. Ammen
Toolpusher: T. Bernston, D. Blackband, D. Brock, M. Shillito
Supervisor: K. Hilgendorf, K. Gollob
Project- and operations geologist: M. Gysi
Wellsite geologist: M. Gysi, M. Stockhecke, HP. Weber

Mudlogging:
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Germany
info@geo-data.de
Mudloggers: C. Anders, H.-J. Weirich, S. Schlak, M. O. Baxmann, J. Hartwig, F. Huter, R. Hofmann, H. Höpner

Service:
Fluid Services: SIRIUS-ES
Mud Engineers: M. Artym, M. Dieckmann, R. Eggenweber, R. Podivinsky, M. Samrozik, P. Sowinski

Remarks:
Bottom Rig Cellar: 511.39 m; Top Rig Cellar: 513.29 m; Rig Floor: 518.19 m
Print Date: 19.03.2021 13:34



Measured depth referenced to Top Rig Cellar at 513.29 m.

Other Services

Wireline: Schlumberger
Casing: General Tubular Services
Cementing: Fangmann Evaporites Artificial

Evaporites
Anhydrite

Clastic sediments
Sandstone, Claystone

Carbonates and Biogenic sediments
Limestone, Limestone, marly, Oolite, Marl (-stone), Marl, argillaceous, Marlstone, calcareous, Dolomite, Dolomite, calcareous

Artificial
Cement, No sample

Accessories
Anhydritic, Argillaceous, Bituminous, Calcareous, Dolomitic, Ferruginous, Glauconite, Iron Ooids, Ironstone, Laminated, Marly, Mica (unspec.), Ooids, Pyrite, Sandy, Silty

Fossils
Brachiopods, Cephalopods, Crinoids, Fossiliferous, Gastropods

Molluscs, Shell fragments, Sponges

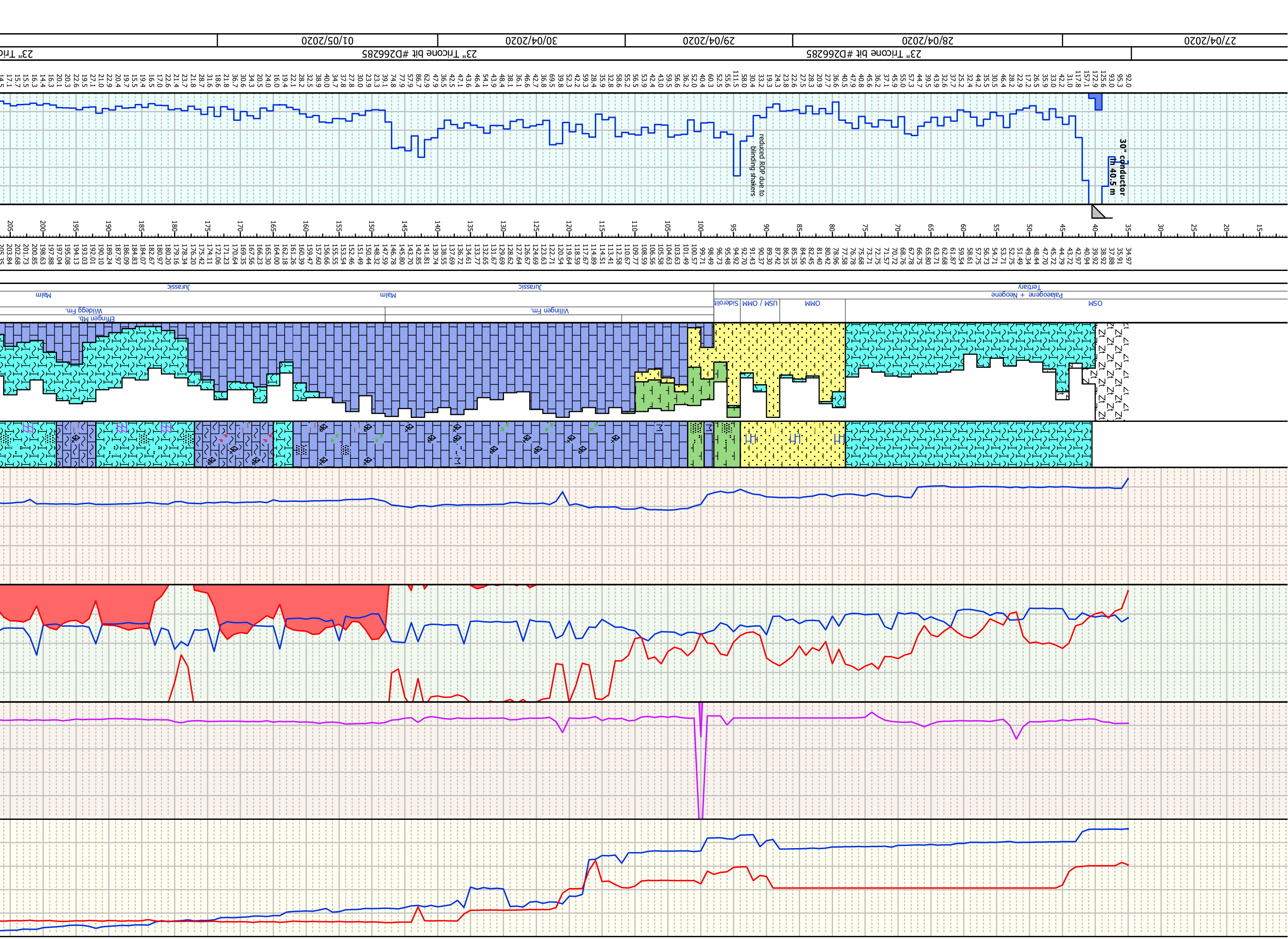
Framework
Lime-Mudstone, Lime-Wackestone, Cryptocrystalline, Fine crystalline, Microcrystalline, Crystalline

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

Vertical axis is measured depth.

GEO data GeoWellPower

Date (dd/mm/yy)	Bit	R.O.P. min/m	R.O.P. R.O.P. [min/m] 25 50 75 100 125	Depth Driller's depth in m from Groundlevel 1:500	Lagged depth m	Cored Intervals	Litho-Stratigraphy	Lithological Composition (fine fraction) 20 40 60 80	Lithology and accessories	Torque @ Surface [daN.m] 500 1000 1500 2000 2500	Hookload and W.O.B. W.O.B. [tf] 2.5 5 7.5 10 12.5 Hookload [tf] 20 40 60	R.P.M. RPM Bit [rpm] 50 100 150 200	Mud Flowrate and SPP SPP (bar) Flow In (Lpm) Flow IN [L/min] 500 1000 1500 2000 2500 3000 Pump Pressure (SPP) [bar] 20 40 60 80
		0.0 0.0		0 5 10			Quat						


27/04/2020
28/04/2020
29/04/2020
30/04/2020
01/05/2020
23" Tricone bit #D266285
23" Tricone bit #D266285
30" conductor @ 40.5 m
reduced ROP due to blinding shakers
OSM
OMM
USM / OMM
Sideroli
Palaeogene + Neogene
Tertiary
Jurassic
Malm
Villingen Fm.
Effingen Mb.
Wildegg Fm.

one bit #D266285

02/05/2020

8 1/2 6 3

08/05 11/05

12/05/2020

6 3/8" core bit #67769 Large Ballas

14/05/2020

15/05/2020

16/05/2020

17/05/2020

18/05/2020

19/05/2020

17 5/8" CS
in 247.85 m

Jurassic

Malm

Jurassic

Malm

Jurassic

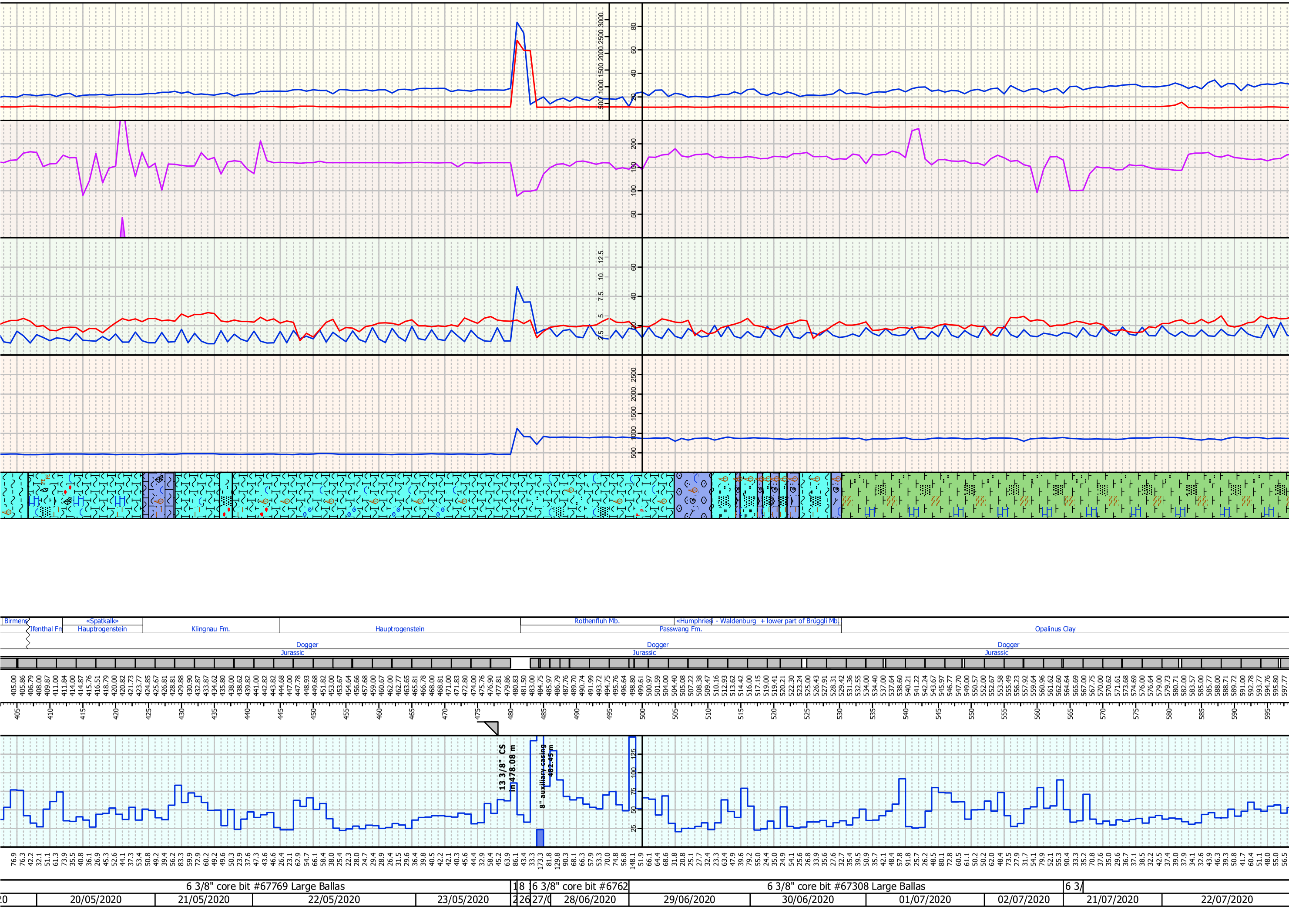
Malm

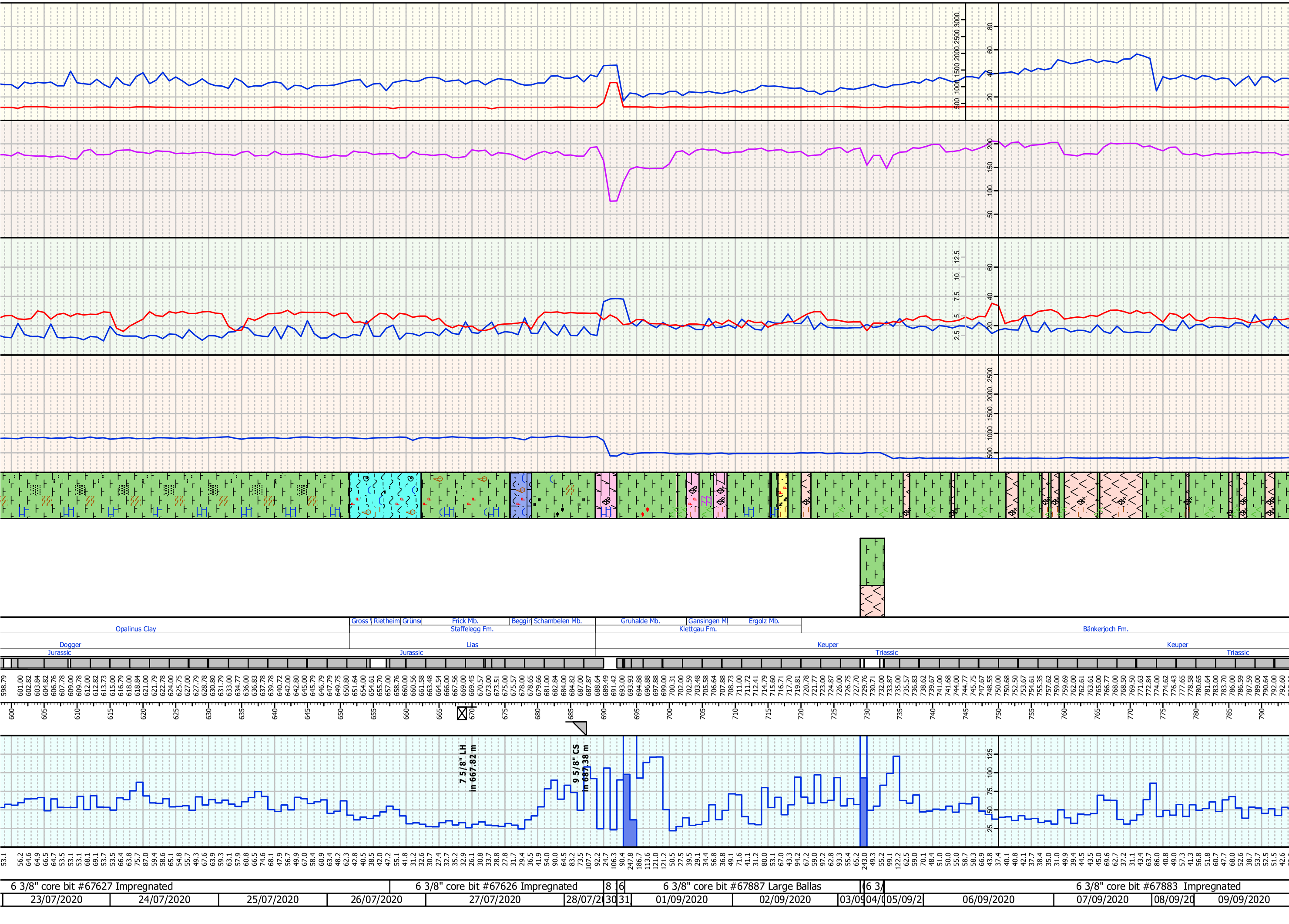
Jurassic

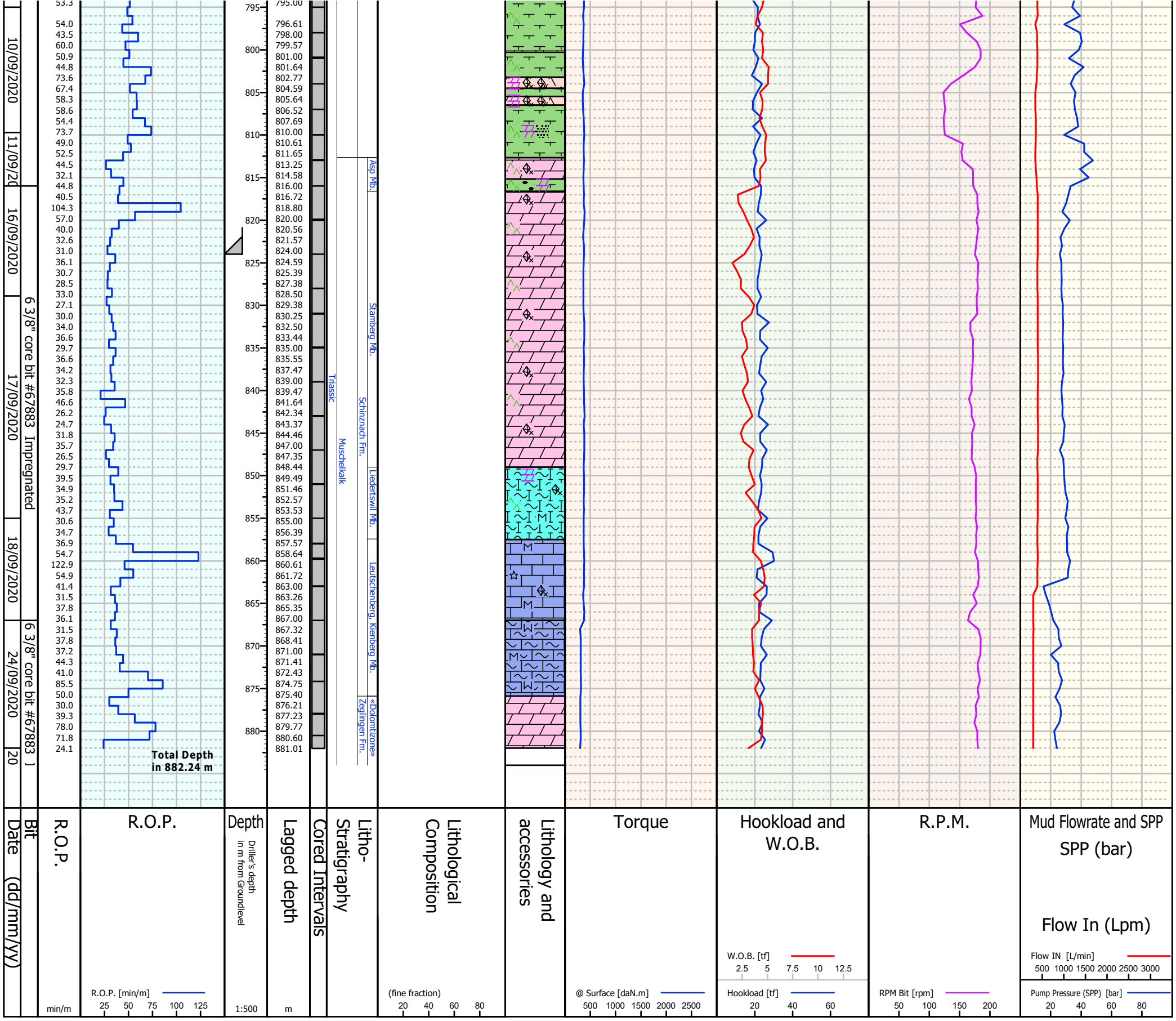
Effingen Mb.
Wildegg Fm.

Effingen Mb.
Wildegg Fm.

Effingen Mb.
Wildegg Fm.


Birmens
Ifenthal Fm
«Spatkalk»
Hauptrogenstein
Klingnau Fm.
Hauptrogenstein
Rothenfluh Mb.
«Humphriesi - Waldenburg + lower part of Brüggli Mb
Passwang Fm.
Opalinus Clay
Dogger
Jurassic
Dogger
Jurassic
Dogger
Jurassic
13 3/8" CS
m478.08 m
8" auxiliary casing
482.45 m
6 3/8" core bit #67769 Large Ballas
6 3/8" core bit #6762
6 3/8" core bit #67308 Large Ballas
6 3/
20/05/2020
21/05/2020
22/05/2020
23/05/2020
28/06/2020
29/06/2020
30/06/2020
01/07/2020
02/07/2020
21/07/2020
22/07/2020


500 1000 1500 2000 2500 3000
20 40 60 80
50 100 150 200
2.5 5 7.5 10 12.5
20 40 60
500 1000 1500 2000 2500
Opalinus Clay
Gross
Rietheim
Grüns
Frick Mb.
Beggin
Schambelen Mb.
Staffelegg Fm.
Gruhalde Mb.
Gansingen M
Ergolz Mb.
Klettgau Fm.
Bänkerjoch Fm.
Dogger
Jurassic
Lias
Keuper
Triassic
7 5/8" LH
in 667.82 m
9 5/8" CS
in 687.38 m
25 50 75 100 125
6 3/8" core bit #67627 Impregnated
6 3/8" core bit #67626 Impregnated
6 3/8" core bit #67887 Large Ballas
6 3/8" core bit #67883 Impregnated
23/07/2020
24/07/2020
25/07/2020
26/07/2020
27/07/2020
28/07/2020
01/09/2020
02/09/2020
03/09/2020
04/09/2020
05/09/2020
06/09/2020
07/09/2020
08/09/2020
09/09/2020



nagra **NAB 21-21**

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

Dossier I | DAT.: Feb . 2022 | **Appendix E**

nagra.

Bözberg-1-1B

Switzerland

Drilling-Engineering-Plot, 1:500

Mudlogging:

GEO data

Client:

Client: Nagra
Operator: Nagra

Project:

Borehole Section: Bözberg-1-1B
Well Name: Bözberg-1-1

Location:

Country: Switzerland
Region or oilfield: Kanton Aargau
Location: Bözberg

Coordinates:

Longitude / Latitude: E 8° 9' 17.90" N 47° 28' 43.98"
Elev. Ground level (MSL) 513.29 m
Elev. Rig Floor (GL) 4.90 m
Depth datum: Groundlevel

Well Type:

Shallow stratigraphic/structure test

Duration:

Spud: 27.04.2020
First day drilled: 21.10.2020
Last day drilled: 21.11.2020
Start depth (Tie-in) 709.00 m
Total depth: 1037.39 m

Rig:

Marriott Rig 16
Marriott Drilling Ltd

Team:

Company Man: M. Ammen
Toolpusher: T. Bernston, D. Blackband, D. Brock, M. Shillito
Supervisor: K. Hilgendorf, K. Gollob
Project- and operations geologist: M. Gysi
Wellsite geologist: M. Gysi, M. Stockhecke, HP. Weber

Mudlogging:

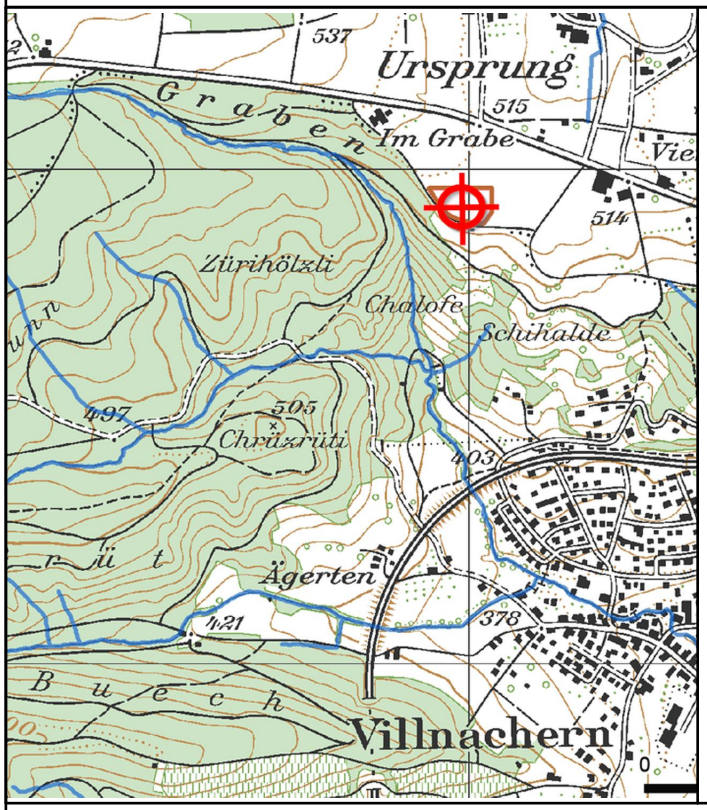
GEO-data, Gesellschaft für Logging-Service mbH
Leinestraße 33
D-30827 Garbsen
Germany
info@geo-data.de
Mudloggers: C. Anders, H.-J. Weirich, S. Schlak, M. O. Baxmann, J. Hartwig, F. Huter, R. Hofmann, H. Höpner

Service:

Fluid Services: SIRIUS-ES
Mud Engineers: M. Artym, M. Dieckmann, R. Eggenweber, R. Podivinsky, M. Samrozik, P. Sowinski, M.Obreja

Remarks:

Bottom Rig Cellar: 511.39 m; Top Rig Cellar: 513.29 m; Rig Floor: 518.19 m
Print Date: 19.03.2021 13:33



Measured depth referenced to Top Rig Cellar at 513.29 m.

Other Services

Wireline: Schlumberger
Casing: General Tubular Services
Cementing: Fangmann Evaporites Artificial
Directional Drilling: Weatherford

Evaporites

Anhydrite
Rock Salt

Artificial

Cement
No sample

Fossils

Shell fragments

Clastic sediments

Sandstone
Siltstone
Claystone

Accessories

Anhydritic
Argillaceous
Calcareous
Calcite
Dolomitic
Ferruginous
Laminated
Marly
Mica (unspec.)
Pyrite

Framework

Lime-Mudstone
Lime-Wackestone
Cryptocrystalline
Fine crystalline
Microcrystalline

Carbonates and Biogenic sediments

Limestone
Limestone, dolomitic
Marl (-stone)
Marl, argillaceous
Marlstone, dolomitic
Dolomite
Dolomite, calcareous
Quartzitic
Sandy
Silty

Technical symbols

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

Vertical axis is measured depth.

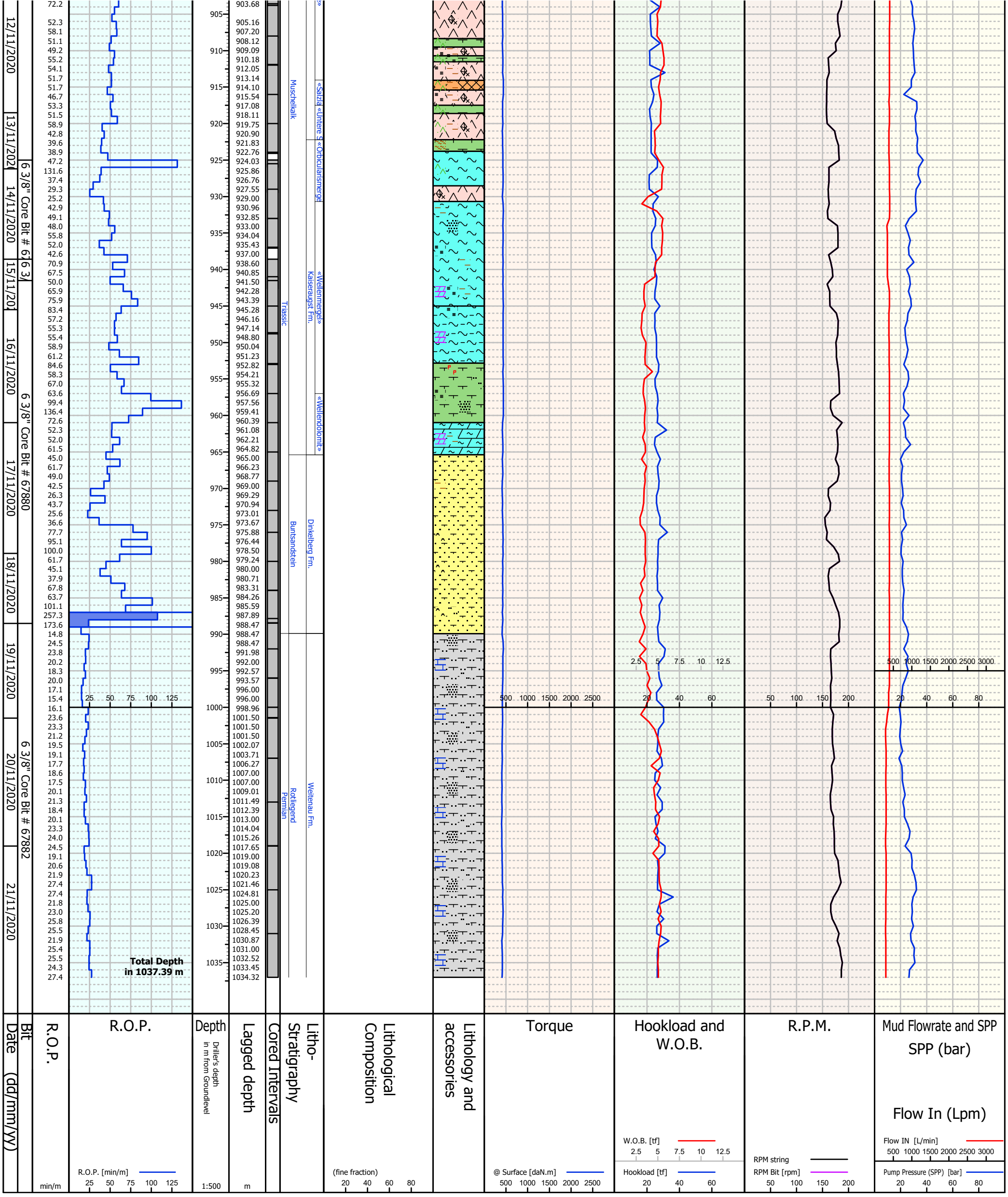
GEO data
GeoWellPower

22/10/2020	23/10/2020	24/10/2020	25/10/2020	27/10/2020	28/10/2020	29/10/2020	30/10/2020	05/11/2020	08/11/2020	09/11/2020	10/11/2020	11/11/2020
8.5" Tricone Bit #1253685						8.5" Tricone Bit #2389		6 3/4"	6 3/8" Core Bit # 67627			

KOP: 709.0 m

7 5/8" Liner
LH @ 667.82 m
LS @ 824.00 m

Keuper
Triassic
Ergolz Mb.
Bänkerjoch Fm.
Keuper
Triassic
Asp Mb.
Stamberg Mb.
Schinznach Fm.
Liedertswil Mb.
Leutschenberg, Kienberg Mb.
«Dolomitzone»
Muschelkalk
Triassic
«Obere Sulfatzone»
Zeglingen Fm.



nagra **NAB 21-21**

Drilling engineering plot
Bözberg-1-1B: programme as performed

Dossier I | DAT.: Sep . 2021 | **Appendix E2**

Appendix F: Bit list

Well	Bit №	Bit № BHA	Hole Opener	Date Run	Date Out	Size	Bit type	Manufacturer	Type	IADC code	Serial №	Jets	TFA	Depth In	Depth Out	Total Footage	Drilling Hours	ROP	WOB min	WOB max	RPM at bit	RPM at surface	SPP	Flow rate	MW	Visc	Formation in	Formation out	Drive system	I	O	D	Loc	B	G	O	R	Total Revs on bit	Remarks
			Y/N	RIH	POOH								[in²]	[m]	[m]	[m]	[hr]	[m/hr]	[tons]	[tons]	total	total	[bar]	[lpm]	[kg/dm³]													
BOZ 1-1	1	1	N	27/04/20	05/04/20	23.000	TCI Tungsten Carbide Insert	NOV	T43	435	D266285	3x20	0.920	34.50	250	216	134	0.8-4	1.00	20.00	30-60	30-60	`10-108	1500-3600	1.01-1.09	61	Tertiär - Obere Meeresmolasse	Malm - Wildegg Fm.	Rotary	1	1	WT	A	E	I	NO	TD	316492	looks like new
BOZ 1-1	2	2	N	05/07/20	05/08/20	17.500	Milled Tooth	Reed Hycalog	n/a	115	D188410	3x22 1x18	1.363	250.00	251.00	1.00	0.50	2.00	4.00	6.00	30-50	30-50	10-14	1000 -1200	1.10	55	Malm - Wildegg Fm.	Malm - Wildegg Fm.	Rotary	1	1	WT	A	E	I	No	TD	24000	looks like new
BOZ 1-1	3	3	N	05/08/20	05/09/20	8.500	Milled Tooth	Reed Hycalog	84E37	437	32357	3x16	0.920	251.00	255.00	4.00	3.50	1.14	1.00	3.00	75	75	10-16	1000 -1300	1.10	55	Malm - Wildegg Fm.	Malm - Wildegg Fm.	Rotary	1	1	WT	A	E	I	No	TD	8800	looks like new
BOZ 1-1	4	5	N	05/10/20	05/11/20	6.375	Coring Diamond impregnated Matrix	Micon	CSK146	n/a	67621	n/a	n/a	255.00	257.50	2.50	10.50	0.24	1.00	2.00	60	70	3-4	300	1.18	63	Malm - Wildegg Fm.	Malm - Wildegg Fm.	Rotary	2	2	WT	A	E	I	No	TD	37800	small damages visuable still okay for RR
BOZ 1-1	5	6	N	05/11/20	25/05/20	6.375	Coring Diamond impregnated Matrix	Micon	CSK146 TSD	n/a	67769	n/a	n/a	257.50	480	223	187.00	1.19	1.00	5.00	160	160	20-24	400	1.19	52	Malm - Wildegg Fm.	Dogger - Klingnau/Hauptrogenstein	Rotary	6	6	WT	A	X	I	CT	TD	176990	scrap
BOZ 1-1	6	12	Y	03/06/20	04/06/20	8.500		NOV	PDC	n/a	266713	3x14	n/a	255.00	480	225	29.75	7.56	1.00	6.00	50	70	56	2100	1.18	52	Malm - Wildegg Fm.	Dogger - Klingnau/Hauptrogenstein	Rotary	2	2	WT	A	E	I	No	TD	89250	small damages visuable still okay for RR
BOZ 1-1	7	13	Y	06/09/220		12.250		NOV	PDC	n/a	266794	5x14	n/a	255.00	480	225	33.00	6.82	1.00	6.00	50	70	58	2800	1.18	52	Malm - Wildegg Fm.	Dogger - Klingnau/Hauptrogenstein	Rotary	2	2	WT	A	E	I	No	TD	99000	small damages visuable still okay for RR
BOZ 1-1	8	14	Y	06/11/20	20/06/20	17.500		NOV	PDC	n/a	IBH-19-175-2	3x20	n/a	255.00	479	223.50	139.50	1.60	1.00	6.00	90 -125	90	58	2800	1.18	52	Malm - Wildegg Fm.	Dogger - Klingnau/Hauptrogenstein	Rotary	6	6	WT	A	X	I	CT	TD	920700	scrap can`t be used anymore
BOZ 1-1	9	19	n	25/06/20	26/06/21	12.250	Milled Tooth	NOV	TC		D266286	3x20	0.920	480.00	481	1.00	10	0.10	1.00	8.00	80-120	100	58	2800	1.20	55	Malm - Wildegg Fm.	Dogger - Klingnau/Hauptrogenstein	Rotary	1	1	WT	A	E	I	NO	TD	55185	Like new
BOZ 1-1	10	20	n	26/06/20	26/06/2020	8.500	Milled Tooth	NOV	TC		8939	3x20	0.920	481.00	483	2.00	1.25	1.60	1.00	6.00	80-120	180	58	2700	1.20	54	Malm - Wildegg Fm.	Dogger - Klingnau/Hauptrogenstein	Rotary	2	2	WT	A	E	I	NO	TD		
BOZ 1-1	11	21	n	27/06/20	29/06/20	6.375	Impregnated	Micon	TSD	n/a	67623	n/a	n/a	483.00	498	15.00	21	0.71	1.00	5.00	140-170	180	20	400	1.20	54	Malm - Wildegg Fm.	Dogger - Klingnau/Hauptrogenstein	Rotary	2	2	WT	A	X	I	PN	BHA		Alu und metall in Spülungskanälen, kann weiter benutzt werden nach Shoe aufbohren
BOZ 1-1	12	22	n	29/06/20	21/07/20	6.375	Ballast	Micon	CSK 146 Gold	n/a	67309	n/a	n/a	498.00	567	69.00	47	1.48	1.00	4.00	140-190	180	24	400	1.20	54	Malm - Wildegg Fm.	Dogger - Passwang	Rotary	2	2	WT	A	X	I	PN	TD		kann weiter benutz werden
BOZ 1-1	13	27 / 28	n	21/07/20	26/07/20	6.375	Impregnated	Micon	TSD	n/a	67627	n/a	n/a	567.00	657.50	98.00	83	1.18	1.00	4.00	140-191	180	32	390	1.23	54	Dogger - Opalinus Clay	Dogger - Opalinus Clay	Rotary	3	3	WT	A	X	I	CT	BHA		kann weiter benutz werden
BOZ 1-1	14	29	n	26/07/20	28/07/20	6.375	Impregnated	Micon	TSD	n/a	67626	n/a	n/a	657.50	690.00	32.50	35	0.93	1.00	4.00	140-192	180	34	390	1.25	54	Lias - Staffelegg. Fm.	Lias - Staffelegg. Fm.	Rotary	2	2	WT	A	X	I	PN	TD		kann weiter benutz werden
BOZ 1-1	15		Y	16/08/20	18/08/20	8.500		NOV	PDC	n/a	266713	3x12	n/a	481.00	689.50	208.50	28.75	7.25	1.00	6.00	50	70	56	2100	1.18	52	Lias - Staffelegg. Fm.	Lias - Staffelegg. Fm.	Rotary	3	3	WT	A	E	I	No	TD	124050	small damages visuable still okay for RR
BOZ 1-1	16	35	Y	22/08/20	27/08/20	12.250		NOV	PDC	n/a	266794	5x14	n/a	481.00	689.50	208.50	40.00	5.21	1.00	6.00	50	70	58	2800	1.18	52	Lias - Staffelegg. Fm.	Lias - Staffelegg. Fm.	Rotary	3	3	WT	A	E	I	No	TD	219000	small damages visuable still okay for RR
BOZ 1-1	17	37	n	28/08/20	30/08/20	8.500	TCI Tungsten Carbide Insert	GLINIK	TC	537	Q5-20x-SN43	3x12	0.331	690.00	692.00	2.00	1.25	1.60	1.00	6.00	80-120	80-120	58	2700	1.23	54	Malm - Wildegg Fm.	Dogger - Klingnau/Hauptrogenstein	Rotary	2	2	WT	A	E	1/16	NO	TD		
BOZ 1-1	18	38	n	30/08/20	31/08/20	6.375	Impregnated	Micon	TSD	n/a	67626	n/a	n/a	692.00	693.20	1.20	2.75	0.44	3.00	6.00	140	140	30	400	1.23	56	Malm - Wildegg Fm.	Dogger - Klingnau/Hauptrogenstein	Rotary	3	3	BT	G	X	I	NO	TD		junk found in bore hole
BOZ 1-1	19	39	n	31/08/20	03/09/20	6.375	Ballast	Micon	CSK 146 Gold	n/a	67887	n/a	n/a	693.20	729.00	35.80	43.50	0.82	3.00	6.00	180	180	30	400	1.23	56	Malm - Wildegg Fm.	Dogger - Klingnau/Hauptrogenstein	Rotary	6	7	BT	A	X	I	WT	PR		junk found in bore hole
BOZ 1-1	20	40	n	03/09/20	04/09/20	6.375	Coring PDC	Micon	PDC	n/a	67451	n/a	n/a	729.00	729.60	0.60	3.50	0.17	3.00	6.00	180	180	30	400	1.23	56	Malm - Wildegg Fm.	Dogger - Klingnau/Hauptrogenstein	Rotary	0	0	NO	A	X	I	NO	PR		junk found in bore hole
BOZ 1-1	21	41	n	04/09/20	04/09/20	6.375	Ballast	Micon	CSK 146 Gold	n/a	67888	n/a	n/a	729.60	732.50	2.90	3.00	0.97	3.00	6.00	180	180	30	400	1.23	56	Malm - Wildegg Fm.	Dogger - Klingnau/Hauptrogenstein		0	0	BT	A	X	I	NO	PR		
BOZ 1-1	21	42	n	04/09/20	05/09/20	6.375	TCI Tungsten Carbide Insert	GLINIK	TC	637	7-1-0307	3x14	0.331	729.00	732.70	3.70	1.25	1.60	1.00	6.00	80-120	80-120	34	400	1.23	56	Malm - Wildegg Fm.	Dogger - Klingnau/Hauptrogenstein	Rotary	0	0	NO	A	X	I	NO	PR		
BOZ 1-1	22	43+44	n	05/09/20	11/09/20	6.375	Ballast	Micon	IMP	n/a	67883	n/a	n/a	732.70	816.00	83.30	68.75	1.21	3.00	6.00	180	180	45	400	1.24	56	Malm - Wildegg Fm.	Dogger - Klingnau/Hauptrogenstein	Rotary	3	1	BT	T	X	I	WT	TD	1169081	
BOZ 1-1	22	46	n	16/09/20	19/09/20	6.375	Ballast	Micon	IMP	n/a	67883	n/a	n/a	816.00	867.00	51.00	35.00	1.46	3.00	6.00	180	180	45	400	1.18	52	Malm - Wildegg Fm.	Dogger - Klingnau/Hauptrogenstein	Rotary	3	1	BT	T	X	I	WT	TD	1510750	
BOZ 1-1	22	49	n	24/09/20	25/09/20	6.375	Ballast	Micon	IMP	n/a	67883	n/a	n/a	867.00	882.00	15.00	12.00	1.25	3.00	6.00	180	180	45	400	1.18	50	Malm - Wildegg Fm.	Dogger - Klingnau/Hauptrogenstein	Rotary	4	2	LT	A	X	I	WT	TD	1643338	
BOZ 1-1	23	58	Y	10/07/20	10/10/20	8.500		NOV	PDC	n/a	266713	3x12	n/a	690.00	870.00	180.00	42.25	4.26	1.00	4.00	70-80	70-80	20	1000-800	1.15	67	Lias - Staffelegg. Fm.	Lias - Staffelegg. Fm.	Rotary	3	3	WT	A	E	I	No	TD	184045	small damages visuable still okay for RR
BOZ 1-1	24	62	n	18/10/20	19/10/20	8.500	TCI Tungsten Carbide Insert	Varel	HE14 MRSV	437	266713	3x12	0.451	682.50	691.50	9.00	2.50	3.60	1.00	3.00	70-80	70-80	34	500	1.15	67	Keuper - Klettgau Fm.	Keuper - Klettgau Fm.	Rotary	0	0	NO	A	E	I	No	BHA	11166	Like new

Well	Bit	Nº BHA	Nº Hole Opener	Date Run	Date Out	Size	Bit type	Manufacture	Type	IADC code	Serial Nº	Jets	TFA	Depth In	Depth Out	Total Footag	Drilling Hours	ROP	WOB min	WOB max	RPM at bit	RPM at surface	SPP	Flow rate	MW	Visc	Formation in	Formation out	Drive system	I	O	D	Loc	B	G	O	R	Total Krevs on bit	Remarks
			Y/N	RIH	POOH								[in²]	[m]	[m]	[m]	[hr]	[m/hr]	[tons]	[tons]	total	total	[bar]	[lpm]	[kg/dm³]													
BOZ 1-1B	25	63	n	20/10/20	26/10/20	8.500	TCI Tungsten Carbide Insert	Varel	HE14 MRSV	437	266713	3x12	0.451	691.50	732.30	40.80	109.75	0.37	0.50	1.00	110	0	65	1500	1.15	67	Keuper - Klettgau Fm.	Keuper - Klettgau Fm.	Rotary	2	2	WT	A	E	I	No	HR	795045	one cone bearing easier to move
BOZ 1-1B	26	64	n	26/10/20	31/10/20	8.500	TCI Tungsten Carbide Insert	Varel	HE14 MRSV	447	2389	3x12	0.528	732.30	825.00	92.70	107.50	0.86	0.50	4.00	110	45	65	1500	1.15	67	Keuper - Klettgau Fm.	Dogger - Klingnau/Hauptrogenstein	Rotary	1	1	WT	A	E	I	No	TD	731322	
BOZ 1-1B	27	65	y	31/10/20	01/11/20	9.500			underreamer		DTV-13-8-2			690.25	825.00	134.75	17.75	7.59	0.50	2.00	70-90	70-90	73	1200	1.15	67	Keuper - Klettgau Fm.	Dogger - Klingnau/Hauptrogenstein	Rotary								TD	45875	
BOZ 1-1B	28	68	n	04/11/20	05/11/20	6.375	Impregnated	GLINIK	IMP	637	3	3x12		794.00	799.60	5.60	13.00	0.43	0.50	9.00	60	60	25	600	1.16	65			Rotary	1	1	WT	A	F	I	NO	PR	35177	Scrap can`t be used anymore seals failed
BOZ 1-1B	29	69	n	05/11/20	05/11/20	6.375	Milled Tooth	NOV		325	SX0630	3x16		799.60	828.00	28.40	12.00	2.37	1.00	9.00	60-90	60-90	25	600	1.16	65	Muschelkalk - Schinznach Fm	Muschelkalk - Schinznach Fm	Rotary	8	8	CT	A	E	I	BT	BHA	83717	scrap
BOZ 1-1B	30	70	n	06/11/20	06/11/20	6.375	Coring Diamond impregnated Matrix	Hughes Christensen	Impr.Gold soft		67957			828.00	828.03	0.03	4.25	0.01	0.50	2.00	60-90	60-90	20	400	1.16	60	Muschelkalk - Schinznach Fm	Muschelkalk - Schinznach Fm	Rotary	3	3	CT	A	X	I	LT	PR	42	lost matrix scrap
BOZ 1-1B	31	71	n	07/11/20	07/11/20	6.375	Coring Surface set diamond	Hughes Christensen			67693			828.00	828.90	0.90	2.75	0.33	0.50	4.00	60-100	60-100	20	400	1.16	60	Muschelkalk - Schinznach Fm	Muschelkalk - Schinznach Fm	Rotary	3	3	WT	A	X	I	NO	PR	19800	
BOZ 1-1B	32	72	n	08/11/20	13/11/20	6.375	Coring Diamond impregnated Matrix	Hughes Christensen	gold red impreg		67627			828.90	925.00	96.10	75.64	1.27	0.50	5.00	100-185	100-185	20-35	400	1.23-1.21	93-82	Muschelkalk - Zeglingen Fm.	Muschelkalk - Kaiseraugust Fm.	Rotary	4	4	BT	A	X	I	WT	PR	739686	
BOZ 1-1B	33	73	n	13/11/20	14/11/20	6.375	Coring Diamond impregnated Matrix	Hughes Christensen	gold red impreg		67626			925.00	938.60	32.35	11.50	2.81	4.00	5.00	160-185	160-185	20-35	400	1.21	82	Muschelkalk - Kaiseraugust Fm.	Muschelkalk - Kaiseraugust Fm.	Rotary	3	3	BT	A	X	I	NO	BHA	111248	
BOZ 1-1B	34	74	n	15/11/20	15/11/20	6.375	Coring Diamond impregnated Matrix	Hughes Christensen	gold red impreg		67882			938.60	941.50	2.90	2.90	1.00	4.00	5.00	160-170	160-170	17-22	350	1.21+	75	Muschelkalk - Kaiseraugust Fm.	Muschelkalk - Kaiseraugust Fm.	Rotary	1	1	NO	A	X	I	NO	BHA	29980	
BOZ 1-1B	35	75	n	15/11/20	19/11/21	6.375	Ballast	Micon	CSK 146 Gold		67890			941.50	988.47	46.97	54.75	0.86	3.00	4.00	160-180	160-180	25	400	120+	65	Muschelkalk - Kaiseraugust Fm.	Permium / Rotliegend Fm.	Rotary	8	8	WT	A	X	`0.0625	BT	PR	565041	
BOZ 1-1B	37	76	n	19/11/20	19/11/21	6.375	Coring Diamond impregnated Matrix	Hughes Christensen	gold red impreg		67882			988.47	1037.00	48.53	19.25	2.52	4.00	5.00	160-185	160-185	25	300	1.15	65	Permium / Rotliegend Fm.	Permium / Rotliegend Fm.	Rotary	3	3	WT	A	X	I	BT	TD	178033	

Appendix G: Bottom Hole Assembly (BHA) reports

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

Appendix H: Survey report

The borehole is almost vertical. Maximum inclination measured is 3.12° at 709 m MD. Maximum DLS is 7.5°/30 m at 518.31 m MD caused by a big turn.

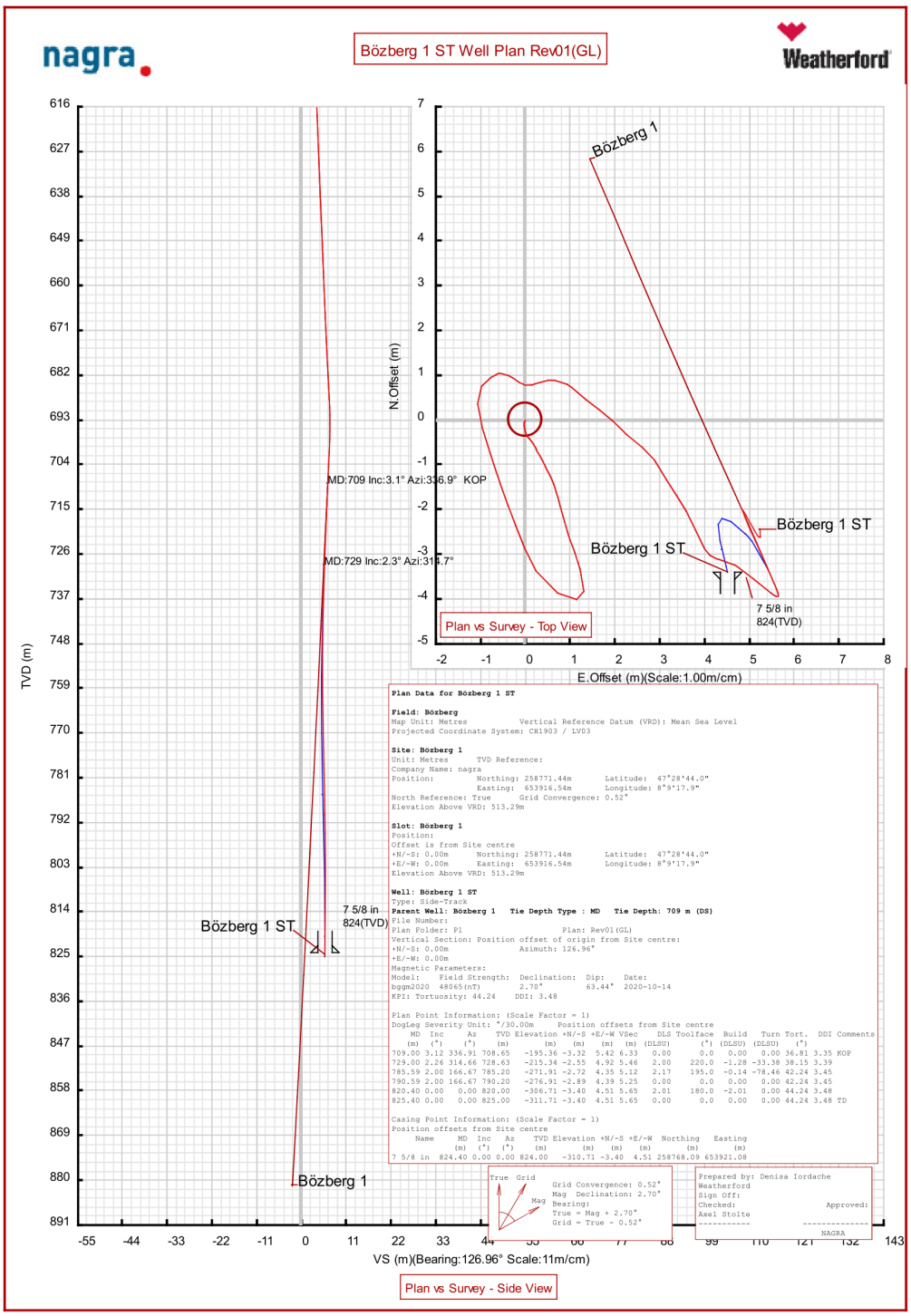


Fig. H-1: Weatherford plot after finishing the 8½" sidetrack

Tab. H-1: Deviation of the BOZ1-1 borehole

Along hole depth; MD [m]	**Inclination** [°]	**Azimuth** [°]	**TVD** [m]	**East (X)** [m]	**North (Y)** [m]	**Vertical section** [m]	**Departure** [m]	**DLS** [°/30 m]
5.00	0.26	214.10	5.00	-0.01	-0.01	-0.01	0.01	1.58
10.00	0.32	202.15	10.00	-0.02	-0.03	-0.02	0.04	0.49
15.00	0.33	195.50	15.00	-0.03	-0.06	-0.04	0.06	0.23
20.00	0.28	176.92	20.00	-0.03	-0.08	-0.06	0.09	0.65
25.00	0.31	177.06	25.00	-0.03	-0.11	-0.09	0.11	0.16
30.00	0.42	164.07	30.00	-0.02	-0.14	-0.12	0.14	0.86
35.00	0.45	173.15	35.00	-0.02	-0.18	-0.16	0.18	0.45
40.00	0.49	167.00	40.00	-0.01	-0.22	-0.20	0.22	0.36
45.00	0.43	170.37	45.00	0.00	-0.26	-0.24	0.26	0.37
50.00	0.43	155.47	50.00	0.01	-0.29	-0.27	0.29	0.67
55.00	0.42	153.50	55.00	0.03	-0.33	-0.31	0.33	0.09
60.00	0.42	144.31	60.00	0.04	-0.36	-0.35	0.36	0.41
65.00	0.44	141.38	65.00	0.07	-0.39	-0.38	0.39	0.18
70.00	0.44	133.69	70.00	0.09	-0.42	-0.42	0.43	0.35
75.00	0.43	146.43	75.00	0.12	-0.45	-0.45	0.46	0.58
80.00	0.50	142.70	80.00	0.14	-0.48	-0.49	0.50	0.41
85.00	0.47	145.05	85.00	0.17	-0.51	-0.54	0.54	0.18
90.00	0.53	148.29	90.00	0.19	-0.55	-0.58	0.58	0.39
95.00	0.59	146.75	95.00	0.22	-0.59	-0.63	0.63	0.38
100.00	0.51	161.53	100.00	0.24	-0.63	-0.68	0.68	0.99
105.00	0.49	160.24	105.00	0.25	-0.67	-0.72	0.72	0.11
110.00	0.75	144.22	110.00	0.28	-0.72	-0.77	0.77	1.87
115.00	0.67	150.92	115.00	0.31	-0.77	-0.83	0.83	0.70
120.00	0.69	151.64	120.00	0.34	-0.83	-0.89	0.89	0.13
125.00	0.70	149.85	125.00	0.37	-0.88	-0.95	0.95	0.16
130.00	0.79	156.13	130.00	0.40	-0.94	-1.02	1.02	0.70
135.00	0.61	148.95	134.99	0.43	-0.99	-1.08	1.08	1.19
140.00	0.65	160.10	139.99	0.45	-1.04	-1.13	1.13	0.77
145.00	0.77	152.11	144.99	0.48	-1.10	-1.19	1.19	0.91
150.00	0.86	152.17	149.99	0.51	-1.16	-1.27	1.27	0.59
155.00	0.80	152.49	154.99	0.54	-1.22	-1.34	1.34	0.42
160.00	0.80	155.51	159.99	0.57	-1.29	-1.41	1.41	0.25
165.00	0.89	156.79	164.99	0.60	-1.35	-1.48	1.48	0.54
170.00	0.98	159.25	169.99	0.63	-1.43	-1.56	1.56	0.60
175.00	1.03	163.76	174.99	0.66	-1.51	-1.65	1.65	0.56
180.00	1.18	162.85	179.99	0.69	-1.60	-1.75	1.75	0.89
185.00	1.27	163.40	184.99	0.72	-1.71	-1.85	1.85	0.56
190.00	1.26	165.70	189.99	0.75	-1.81	-1.96	1.96	0.31

Tab. H-1: continued

Along hole depth; MD [m]	**Inclination** [°]	**Azimuth** [°]	**TVD** [m]	**East (X)** [m]	**North (Y)** [m]	**Vertical section** [m]	**Departure** [m]	**DLS** [°/30 m]
195.00	1.29	164.40	194.99	0.78	-1.92	-2.07	2.07	0.25
200.00	1.42	165.45	199.98	0.81	-2.03	-2.19	2.19	0.78
205.00	1.43	162.46	204.98	0.84	-2.15	-2.31	2.31	0.45
210.00	1.48	165.07	209.98	0.88	-2.27	-2.44	2.44	0.49
215.00	1.65	162.67	214.98	0.92	-2.41	-2.57	2.57	1.13
220.00	1.69	165.84	219.98	0.96	-2.55	-2.71	2.72	0.60
225.00	1.71	157.66	224.98	1.00	-2.69	-2.86	2.87	1.46
230.00	1.62	159.06	229.97	1.06	-2.82	-3.01	3.01	0.58
235.00	1.47	161.71	234.97	1.10	-2.95	-3.14	3.15	1.03
240.00	1.45	164.77	239.97	1.14	-3.07	-3.27	3.27	0.48
245.00	1.50	159.84	244.97	1.18	-3.19	-3.40	3.40	0.82
250.00	1.72	162.65	249.97	1.22	-3.33	-3.53	3.54	1.41
320.00	1.56	300.00	319.95	0.71	-3.85	-3.81	3.92	1.31
356.16	2.57	338.12	356.09	-0.02	-2.85	-2.60	2.85	1.37
357.07	2.57	338.12	357.00	-0.03	-2.81	-2.56	2.81	0.00
358.14	2.59	338.31	358.07	-0.05	-2.77	-2.51	2.77	0.57
368.20	2.61	338.92	368.12	-0.22	-2.34	-2.05	2.35	0.10
378.10	2.62	339.59	378.01	-0.38	-1.92	-1.60	1.96	0.10
388.16	2.62	340.67	388.06	-0.54	-1.49	-1.14	1.58	0.15
398.07	2.63	341.62	397.96	-0.68	-1.06	-0.69	1.26	0.14
408.13	2.63	342.78	408.00	-0.82	-0.62	-0.23	1.03	0.16
418.19	2.67	342.60	418.05	-0.96	-0.18	0.23	0.98	0.11
458.27	1.50	62.47	458.11	-0.77	0.96	1.19	1.23	2.11
468.02	0.36	56.97	467.87	-0.64	1.03	1.20	1.21	3.51
478.23	0.22	72.06	478.08	-0.59	1.06	1.20	1.21	0.46
488.14	0.87	105.88	487.98	-0.50	1.04	1.15	1.15	2.11
498.04	0.66	108.78	497.89	-0.37	1.00	1.07	1.07	0.65
508.41	2.44	126.31	508.25	-0.14	0.85	0.83	0.86	5.29
518.31	2.56	63.91	518.14	0.23	0.82	0.66	0.86	7.85
528.37	2.58	96.95	528.19	0.66	0.90	0.55	1.11	4.36
538.12	2.44	129.42	537.94	1.04	0.74	0.25	1.27	4.34
548.18	2.25	131.35	547.99	1.35	0.47	-0.12	1.43	0.62
558.24	2.21	123.54	558.04	1.66	0.23	-0.46	1.68	0.91
568.30	2.32	135.81	568.09	1.96	-0.02	-0.82	1.96	1.48
578.51	2.47	133.70	578.29	2.27	-0.32	-1.21	2.29	0.52
588.26	2.64	124.98	588.03	2.60	-0.59	-1.60	2.67	1.31
598.17	2.75	149.53	597.93	2.91	-0.93	-2.03	3.05	3.48
608.23	2.53	147.35	607.98	3.15	-1.33	-2.49	3.42	0.71

Tab. H-1: continued

Along hole depth; MD [m]	**Inclination** [°]	**Azimuth** [°]	**TVD** [m]	**East (X)** [m]	**North (Y)** [m]	**Vertical section** [m]	**Departure** [m]	**DLS** [°/30 m]
618.29	2.33	147.72	618.03	3.38	-1.68	-2.91	3.78	0.61
628.19	2.43	149.10	627.92	3.60	-2.04	-3.32	4.13	0.37
638.25	2.72	158.21	637.97	3.79	-2.44	-3.77	4.51	1.49
638.40	2.73	159.71	638.12	3.80	-2.45	-3.78	4.52	14.06
648.31	2.77	150.36	648.02	4.00	-2.88	-4.25	4.93	1.37
658.22	2.48	98.18	657.92	4.33	-3.12	-4.61	5.33	7.04
668.27	2.45	124.95	667.97	4.72	-3.27	-4.91	5.74	3.40
678.18	2.74	128.90	677.86	5.08	-3.54	-5.30	6.19	1.03
688.09	2.53	199.61	687.76	5.19	-3.89	-5.67	6.49	9.24
689.61	3.00	197.28	689.28	5.17	-3.96	-5.72	6.51	9.65
699.21	3.15	339.66	698.88	5.00	-3.96	-5.65	6.38	18.21
708.51	3.17	340.06	708.16	4.82	-3.47	-5.14	5.94	0.10
718.41	3.16	339.85	718.05	4.63	-2.96	-4.59	5.50	0.07
728.17	3.14	339.31	727.79	4.45	-2.46	-4.06	5.08	0.10
738.53	3.18	338.64	738.14	4.24	-1.92	-3.48	4.66	0.16
748.44	3.20	338.41	748.03	4.04	-1.41	-2.93	4.28	0.08
758.19	3.21	338.45	757.77	3.84	-0.90	-2.39	3.94	0.03
768.40	3.24	338.22	767.96	3.63	-0.37	-1.81	3.65	0.08
778.46	3.26	338.23	778.00	3.42	0.16	-1.24	3.42	0.05
788.52	3.27	338.65	788.04	3.21	0.69	-0.67	3.28	0.09
798.27	3.33	338.90	797.78	3.00	1.21	-0.11	3.24	0.17
808.63	3.39	338.59	808.13	2.78	1.78	0.49	3.30	0.19
818.54	3.44	338.62	818.02	2.57	2.33	1.08	3.47	0.15
828.45	3.46	338.43	827.90	2.35	2.88	1.68	3.72	0.09
838.50	3.49	338.60	837.94	2.13	3.45	2.29	4.05	0.09
848.41	3.50	338.81	847.83	1.91	4.01	2.89	4.44	0.05
858.32	3.49	337.73	857.72	1.68	4.58	3.50	4.88	0.20
868.53	3.58	336.61	867.91	1.44	5.16	4.12	5.35	0.33
868.68	3.63	336.42	868.06	1.44	5.16	4.13	5.36	10.38
868.83	3.63	336.19	868.21	1.43	5.17	4.14	5.37	2.99
868.98	3.64	336.50	868.37	1.43	5.18	4.15	5.37	3.92
869.14	3.64	336.26	868.52	1.42	5.19	4.16	5.38	2.92
869.29	3.64	336.18	868.67	1.42	5.20	4.17	5.39	1.70
869.44	3.72	336.08	868.82	1.42	5.21	4.18	5.40	13.99
869.59	3.71	336.10	868.98	1.41	5.22	4.19	5.41	1.31

Tab. H-2: Borehole deviation of the BOZ1-1B borehole

Along hole depth; MD [m]	**Inclination** [°]	**Azimuth** [°]	**TVD** [m]	**East (X)** [m]	**North (Y)** [m]	**Vertical section** [m]	**Departure** [m]	**DLS** [°/30 m]
5	0.26	214.1	5.00	-0.01	-0.01	-0.01	0.01	1.56
10	0.32	202.15	10.00	-0.02	-0.03	-0.02	0.04	0.51
15	0.33	195.5	15.00	-0.03	-0.06	-0.04	0.06	0.23
20	0.28	176.92	20.00	-0.03	-0.08	-0.06	0.09	0.66
25	0.31	177.06	25.00	-0.03	-0.11	-0.09	0.11	0.18
30	0.42	164.07	30.00	-0.02	-0.14	-0.12	0.14	0.82
35	0.45	173.15	35.00	-0.02	-0.18	-0.16	0.18	0.45
40	0.49	167	40.00	-0.01	-0.22	-0.20	0.22	0.39
45	0.43	170.37	45.00	0.00	-0.26	-0.24	0.26	0.39
50	0.43	155.47	50.00	0.01	-0.29	-0.27	0.29	0.67
55	0.42	153.5	55.00	0.03	-0.33	-0.31	0.33	0.11
60	0.42	144.31	60.00	0.05	-0.36	-0.35	0.36	0.40
65	0.44	141.38	65.00	0.07	-0.39	-0.38	0.39	0.18
70	0.44	133.69	70.00	0.09	-0.42	-0.42	0.43	0.35
75	0.43	146.43	75.00	0.12	-0.45	-0.45	0.46	0.58
80	0.5	142.7	80.00	0.14	-0.48	-0.49	0.50	0.46
85	0.47	145.05	85.00	0.17	-0.51	-0.54	0.54	0.22
90	0.53	148.29	90.00	0.19	-0.55	-0.58	0.58	0.40
95	0.59	146.75	95.00	0.22	-0.59	-0.63	0.63	0.37
100	0.51	161.53	100.00	0.24	-0.63	-0.68	0.68	0.97
105	0.49	160.24	105.00	0.25	-0.67	-0.72	0.72	0.14
110	0.75	144.22	110.00	0.28	-0.72	-0.77	0.77	1.86
115	0.67	150.92	115.00	0.31	-0.77	-0.83	0.83	0.69
120	0.69	151.64	120.00	0.34	-0.83	-0.89	0.89	0.13
125	0.7	149.85	125.00	0.37	-0.88	-0.95	0.95	0.14
130	0.79	156.13	130.00	0.40	-0.94	-1.02	1.02	0.73
135	0.61	148.95	134.99	0.43	-0.99	-1.08	1.08	1.20
140	0.65	160.1	139.99	0.45	-1.04	-1.13	1.13	0.77
145	0.77	152.11	144.99	0.48	-1.10	-1.19	1.19	0.93
150	0.86	152.17	149.99	0.51	-1.16	-1.27	1.27	0.54
155	0.8	152.49	154.99	0.54	-1.22	-1.34	1.34	0.36
160	0.8	155.51	159.99	0.57	-1.29	-1.41	1.41	0.25
165	0.89	156.79	164.99	0.60	-1.35	-1.48	1.48	0.55
170	0.98	159.25	169.99	0.63	-1.43	-1.56	1.56	0.59
175	1.03	163.76	174.99	0.66	-1.51	-1.65	1.65	0.56
180	1.18	162.85	179.99	0.69	-1.60	-1.75	1.75	0.91
185	1.27	163.4	184.99	0.72	-1.71	-1.85	1.85	0.54
190	1.26	165.7	189.99	0.75	-1.81	-1.96	1.96	0.31

Tab. H-2: continued

Along hole depth; MD [m]	**Inclination** [°]	**Azimuth** [°]	**TVD** [m]	**East (X)** [m]	**North (Y)** [m]	**Vertical section** [m]	**Departure** [m]	**DLS** [°/30 m]
195	1.29	164.4	194.99	0.78	-1.92	-2.07	2.07	0.25
200	1.42	165.45	199.98	0.81	-2.03	-2.19	2.19	0.79
205	1.43	162.46	204.98	0.84	-2.15	-2.31	2.31	0.45
210	1.48	165.07	209.98	0.88	-2.28	-2.44	2.44	0.50
215	1.65	162.67	214.98	0.92	-2.41	-2.57	2.58	1.09
220	1.69	165.84	219.98	0.96	-2.55	-2.72	2.72	0.60
225	1.71	157.66	224.98	1.00	-2.69	-2.86	2.87	1.46
230	1.62	159.06	229.97	1.06	-2.82	-3.01	3.01	0.59
235	1.47	161.71	234.97	1.10	-2.95	-3.14	3.15	1.00
240	1.45	164.77	239.97	1.14	-3.07	-3.27	3.28	0.48
245	1.5	159.84	244.97	1.18	-3.19	-3.40	3.40	0.82
250	1.72	162.65	249.97	1.22	-3.33	-3.54	3.54	1.40
320	1.56	300	319.95	0.71	-3.85	-3.81	3.92	1.31
356.2	2.57	338.12	356.13	-0.02	-2.85	-2.60	2.85	1.37
357.1	2.57	338.12	357.03	-0.03	-2.82	-2.56	2.82	0.00
358.1	2.59	338.31	358.03	-0.05	-2.77	-2.51	2.78	0.65
368.2	2.61	338.92	368.12	-0.22	-2.35	-2.06	2.36	0.10
378.1	2.62	339.59	378.01	-0.38	-1.93	-1.61	1.96	0.10
388.2	2.62	340.67	388.10	-0.53	-1.49	-1.15	1.58	0.15
398.1	2.63	341.62	397.99	-0.68	-1.06	-0.69	1.26	0.14
408.1	2.63	342.78	407.98	-0.82	-0.63	-0.24	1.03	0.16
418.2	2.67	342.6	418.07	-0.96	-0.18	0.23	0.98	0.12
458.3	1.5	62.47	458.15	-0.77	0.95	1.19	1.23	2.11
468	0.36	56.97	467.84	-0.64	1.03	1.20	1.21	3.53
478.2	0.22	72.06	478.04	-0.59	1.05	1.20	1.21	0.47
488.1	0.87	105.88	487.94	-0.50	1.04	1.15	1.15	2.12
498	0.66	108.78	497.84	-0.37	1.00	1.07	1.07	0.65
508.4	2.44	126.31	508.24	-0.14	0.85	0.83	0.86	5.25
518.3	2.56	63.91	518.13	0.23	0.82	0.66	0.85	7.85
528.4	2.58	96.95	528.22	0.66	0.89	0.55	1.11	4.34
538.1	2.44	129.42	537.91	1.03	0.74	0.25	1.27	4.36
548.2	2.25	131.35	548.00	1.35	0.47	-0.12	1.43	0.61
558.2	2.21	123.54	558.00	1.66	0.23	-0.46	1.67	0.92
568.3	2.32	135.81	568.09	1.96	-0.02	-0.82	1.96	1.47
578.5	2.47	133.7	578.28	2.26	-0.32	-1.22	2.29	0.51
588.3	2.64	124.98	588.07	2.60	-0.60	-1.60	2.67	1.30
598.2	2.75	149.53	597.96	2.91	-0.93	-2.04	3.06	3.49
608.2	2.53	147.35	607.95	3.15	-1.33	-2.49	3.42	0.73

Tab. H-2: continued

Along hole depth; MD [m]	**Inclination** [°]	**Azimuth** [°]	**TVD** [m]	**East (X)** [m]	**North (Y)** [m]	**Vertical section** [m]	**Departure** [m]	**DLS** [°/30 m]
618.3	2.33	147.72	618.04	3.38	-1.69	-2.92	3.78	0.60
628.2	2.43	149.1	627.93	3.60	-2.04	-3.32	4.13	0.35
638.3	2.72	158.21	638.02	3.79	-2.44	-3.78	4.51	1.49
648.3	2.77	150.36	648.01	4.00	-2.87	-4.25	4.93	1.14
658.2	2.48	98.18	657.90	4.33	-3.11	-4.61	5.33	7.04
668.3	2.45	124.95	667.99	4.73	-3.27	-4.91	5.74	3.39
678.2	2.74	128.9	677.88	5.08	-3.54	-5.30	6.19	1.03
688.2	3.11	128.9	687.87	5.48	-3.86	-5.75	6.70	1.11
Bözberg-1-1 B KOP								
709	3.12	336.91	708.65	5.42	-3.32	-5.24	6.35	0.11
711	2.67	336.13	710.65	5.38	-3.23	-5.14	6.27	6.78
723	2.52	335.74	722.63	5.15	-2.73	-4.59	5.83	0.38
732	2.19	334.39	731.63	5.00	-2.40	-4.22	5.54	1.12
741	1.33	342.96	740.62	4.89	-2.14	-3.95	5.34	2.99
751	0.3	332.03	750.62	4.85	-2.01	-3.81	5.25	3.11
760	0.49	140.16	759.62	4.86	-2.02	-3.82	5.26	2.62
769	1.06	152.38	768.62	4.92	-2.12	-3.94	5.36	1.97
778	1.44	150.05	777.62	5.02	-2.29	-4.14	5.52	1.28
787	1.32	150.34	786.62	5.13	-2.48	-4.35	5.70	0.40
795	0.7	141	794.61	5.20	-2.60	-4.49	5.82	2.40
804	0.35	11.4	803.61	5.24	-2.62	-4.52	5.86	3.21
806	0.45	4.71	805.61	5.25	-2.60	-4.51	5.86	1.65
816.10	1.19	109.98	815.72	5.35	-2.60	-4.55	5.94	4.08
826.01	1.40	348.53	825.62	5.42	-2.51	-4.50	5.97	6.84
836.07	1.49	348.67	835.68	5.37	-2.27	-4.25	5.83	0.26
845.97	1.40	349.27	845.58	5.32	-2.02	-4.01	5.69	0.27
856.03	1.41	348.55	855.63	5.27	-1.78	-3.77	5.57	0.06
866.09	1.44	347.45	865.69	5.22	-1.53	-3.53	5.44	0.13
876.00	1.40	347.67	875.59	5.17	-1.29	-3.28	5.33	0.13
886.05	1.36	348.03	885.65	5.12	-1.06	-3.05	5.23	0.13
895.96	1.32	348.37	895.55	5.07	-0.83	-2.82	5.14	0.11
906.02	1.35	349.12	905.61	5.02	-0.60	-2.59	5.06	0.09
916.08	1.41	348.73	915.66	4.98	-0.36	-2.36	4.99	0.20
925.98	1.39	352.89	925.56	4.94	-0.13	-2.12	4.94	0.32
936.04	1.43	351.97	935.62	4.91	0.12	-1.89	4.91	0.15
946.10	1.46	351.03	945.68	4.87	0.37	-1.64	4.88	0.11
956.01	1.43	350.81	955.58	4.83	0.62	-1.40	4.87	0.08
966.06	1.41	351.08	965.63	4.79	0.86	-1.16	4.87	0.06

Tab. H-2: continued

Along hole depth; MD [m]	**Inclination** [°]	**Azimuth** [°]	**TVD** [m]	**East (X)** [m]	**North (Y)** [m]	**Vertical section** [m]	**Departure** [m]	**DLS** [°/30 m]
975.97	1.41	350.77	975.54	4.75	1.10	-0.92	4.88	0.03
986.03	1.41	350.13	985.59	4.71	1.35	-0.68	4.90	0.05
996.09	1.41	351.82	995.65	4.67	1.59	-0.45	4.94	0.12
1'005.99	1.43	351.03	1'005.55	4.64	1.84	-0.21	4.99	0.09
1'016.05	1.44	350.76	1'015.61	4.60	2.08	0.03	5.05	0.04
1'025.96	1.49	350.44	1'025.51	4.55	2.33	0.28	5.12	0.15
1'036.93	1.67	345.90	1'036.48	4.49	2.63	0.58	5.21	0.60

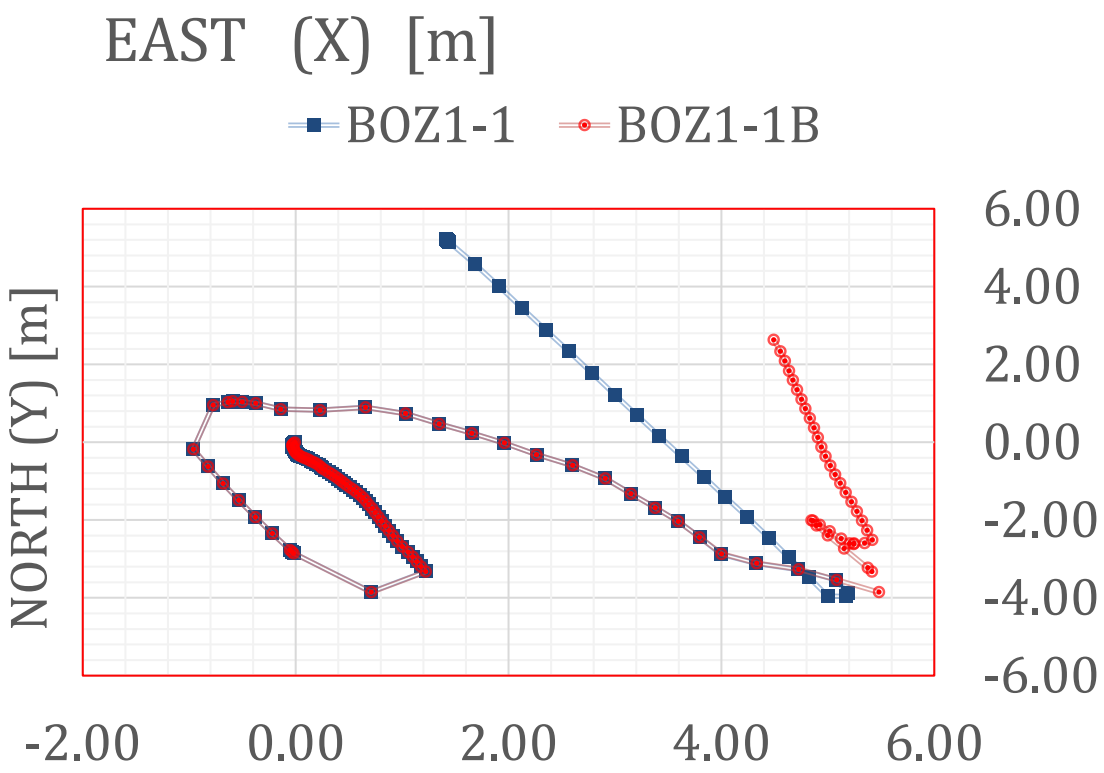


Fig. H-2: Plan view BOZ1-1 and BOZ1-1B

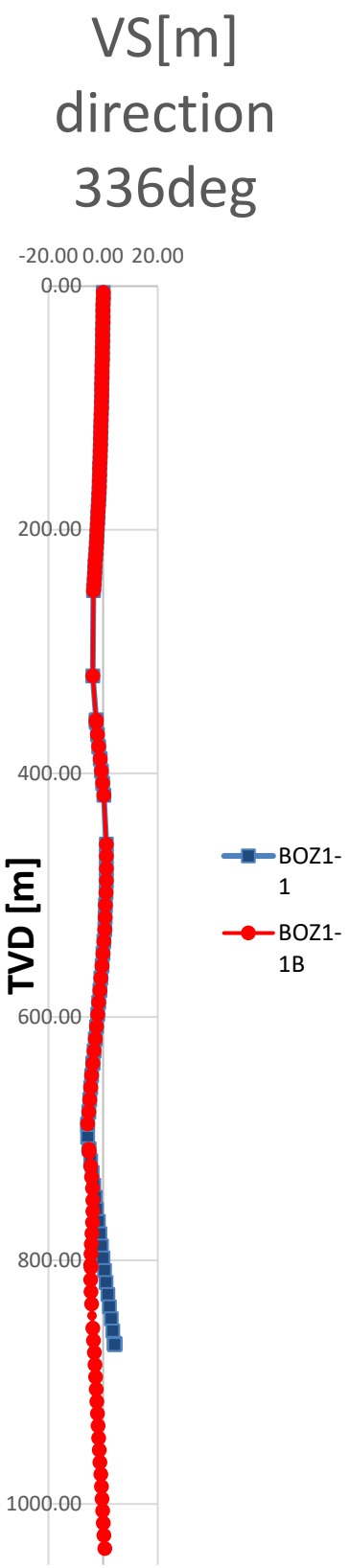


Fig. H-3: Section view BOZ1-1 and BOZ1-1B

Appendix I: Coring parameters

The core recovery was 99.43% for the Bözberg-1-1 borehole (coring from 255 m to 867.22 m MD).

Tab. I-1: Coring parameters of BOZ1-1

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	95	255.00	256.00	255.00	256.00	1.00	1.00	100%	10/05/2020	04:25	04:30	00:05	04:30	04:37	00:07	00:00	03:55	03:55	0.25	90	2 - 3	6-8	300	1.18	0	0
2	95	256.00	257.50	256.00	257.44	1.50	1.44	96%	10/05/2020	05:05	06:43	01:38	13:17	13:31	00:14	06:43	13:17	06:34	0.23	262	3.0	11	331	1.18	0	0
3	95	257.50	260.91	257.44	260.91	3.41	3.47	102%	11/05/2020	16:45	19:45	03:00	06:08	06:44	00:36	01:50	06:08	04:18	0.79	130	2-4	6-16	376	1.18	0	0
4	95	260.91	264.00	260.91	264.01	3.10	3.10	100%	12/05/2020	06:44	07:22	00:44	10:03	10:30	00:27	07:22	10:03	02:41	1.16	130	3.0	12-15	380	1.18	0	0
5	95	264.00	267.00	264.01	267.00	3.00	2.99	99%	12/05/2020	10:30	11:08	00:38	13:22	13:50	00:28	11:08	13:22	02:14	1.34	130	3.0	13-14	380	1.18	0	0
6	95	267.00	270.00	267.00	270.03	3.00	3.03	101%	12/05/2020	13:50	14:26	00:36	16:24	16:48	00:24	14:26	16:24	01:58	1.53	150	3.5	12-14	390	1.18	0	0
7	95	270.00	273.00	270.03	273.03	3.00	3.00	100%	12/05/2020	16:48	17:17	00:29	19:30	20:00	00:30	17:17	19:30	02:13	1.35	150	3-4	12-15	380	1.18	0	0
8	95	273.00	276.00	273.03	276.02	3.00	2.99	100%	12/05/2020	20:00	20:35	00:35	23:28	00:05	00:37	20:35	23:28	02:53	1.04	115	3-4	12-14	375	1.18	0	0
9	95	276.00	279.00	276.02	279.04	3.00	3.02	101%	12/05/2020	00:05	00:33	00:28	03:18	03:55	00:37	00:33	03:18	02:45	1.09	130	3-4	12-14	385	1.18	0	0
10	95	279.00	282.00	279.04	282.12	3.00	3.08	103%	12/05/2020	03:55	04:18	00:23	06:41	07:11	00:30	04:18	05:41	01:23	2.17	140	3-4	12-15	368	1.18	0	0
11	95	282.00	285.00	282.12	284.98	3.00	2.86	95%	13/05/2020	07:11	07:53	00:42	11:06	11:36	00:30	07:53	11:06	03:13	0.93	120	3-4	16-17	440	1.18	0	0
12	95	285.00	288.00	284.98	288.02	3.00	3.04	101%	13/05/2020	11:36	12:10	00:34	13:48	14:15	00:27	12:10	12:48	00:38	4.74	130	4.0	18	430	1.18	0	0
13	95	288.00	291.00	288.02	291.13	3.00	3.11	104%	13/05/2020	14:15	14:52	00:37	15:54	16:24	00:30	14:52	15:54	01:02	2.90	140	4.0	15	400	1.18	0	0
14	95	291.00	294.00	291.13	294.02	3.00	2.89	96%	13/05/2020	16:24	17:10	00:46	18:55	19:30	00:35	17:10	18:55	01:45	1.71	150	4.0	15	400	1.18	0	0
15	95	294.00	297.00	294.02	297.12	3.00	3.10	103%	13/05/2020	19:30	20:04	00:34	21:41	22:23	00:42	20:04	21:41	01:37	1.86	150	5.0	14	400	1.18	0	0
16	95	297.00	300.00	297.12	299.93	3.00	2.81	94%	13/05/2020	22:23	22:48	00:25	00:39	01:11	00:32	22:48	00:39	01:51	1.62	150	4.0	14	410	1.18	0	0
17	95	300.00	303.00	299.93	302.91	3.00	2.98	99%	13/05/2020	01:11	01:44	00:33	03:25	04:06	00:41	01:44	03:25	01:41	1.78	150	3.8	14	412	1.18	0	0
18	95	303.00	306.00	302.91	305.97	3.00	3.06	102%	13/05/2020	04:06	04:32	00:26	06:20	07:00	00:40	04:32	06:20	01:48	1.67	160	4.4	14	418	1.19	0	0
19	95	306.00	309.00	305.97	308.98	3.00	3.01	100%	14/05/2020	07:00	07:42	00:42	09:01	09:40	00:39	07:42	09:01	01:19	2.28	165	2-4	13	400	1.19	0	0
20	95	309.00	312.00	308.98	312.05	3.00	3.07	102%	14/05/2020	09:40	10:16	00:36	11:25	11:57	00:32	10:16	11:25	01:09	2.61	140	3.0	13	400	1.19	0	0
21	95	312.00	315.00	312.05	315.02	3.00	2.97	99%	14/05/2020	11:57	12:29	00:32	13:44	14:14	00:30	12:29	13:44	01:15	2.40	140	3.0	13	400	1.19	0	0
22	95	315.00	318.00	315.02	318.07	3.00	3.05	102%	14/05/2020	14:14	14:58	00:44	16:25	17:05	00:40	14:58	16:25	01:27	2.07	100	3-4	15	400	1.19	0	0
23	95	318.00	321.00	318.07	320.98	3.00	2.91	97%	14/05/2020	17:05	17:32	00:27	19:01	19:33	00:32	17:32	19:01	01:29	2.02	150	3.5	15	400	1.19	0	0
24	95	321.00	324.00	320.98	323.99	3.00	3.01	100%	14/05/2020	19:33	20:00	00:27	22:35	23:09	00:34	20:00	22:35	02:35	1.16	160	3.5	16	413	1.19	0	0
25	95	324.00	327.00	323.99	327.08	3.00	3.09	103%	14/05/2020	23:09	23:40	00:31	02:37	03:12	00:35	23:40	02:37	02:57	1.02	150	4.0	16	400	1.19	0	0
26	95	327.00	330.00	327.08	329.96	3.00	2.88	96%	14/05/2020	03:12	03:45	00:33	05:31	06:07	00:36	03:45	05:31	01:46	1.70	160	4.0	18	438	1.19	0	0
27	95	330.00	333.00	329.96	332.99	3.00	3.03	101%	14/05/2020	06:07	06:34	00:27	09:05	09:42	00:37	06:34	09:05	02:31	1.19	160-180	4.0	17	400	1.20	0	0
28	95	333.00	336.00	332.99	336.00	3.00	3.01	100%	15/05/2020	09:42	10:17	00:35	13:04	14:00	00:56	10:17	13:04	02:47	1.08	170	3-4	18	398	1.20	0	0
29	95	336.00	339.00	336.00	338.99	3.00	2.99	100%	15/05/2020	14:00	15:09	01:09	19:33	20:10	00:37	15:09	19:33	04:24	0.68	170	3-4	18	390	1.20	0	0
30	95	339.00	342.00	338.99	342.02	3.00	3.03	101%	15/05/2020	20:10	20:33	00:23	00:51	01:26	00:35	20:33	00:51	02:38	1.14	150	4.0	19	407	1.20	0	0
31	95	342.00	345.00	342.02	345.12	3.00	3.10	103%	15/05/2020	01:26	01:51	00:25	05:57	06:39	00:42	01:51	05:57	04:06	0.73	155	3.5	17	415	1.20	0	0
32	95	345.00	348.00	345.12	348.08	3.00	2.96	99%	15/05/2020	06:39	07:05	00:26	11:36	12:12	00:36	07:05	11:36	04:31	0.66	160	3-4	18	405	1.19	0	0
33	95	348.00	351.00	348.08	351.02	3.00	2.94	98%	16/05/2020	12:12	12:41	00:29	15:20	15:55	00:35	12:41	15:20	02:39	1.13	165	4.0	18	400	1.19	0	0
34	95	351.00	354.00	351.02	354.13	3.00	3.11	104%	16/05/2020	15:55	16:24	00:29	19:05	19:38	00:33	16:24	19:05	02:41	1.12	160	4.0	18	394	1.19	0	0
35	95	354.00	357.00	354.13	357.03	3.00	2.90	97%	16/05/2020	19:38	20:09	00:31	23:01	23:39	00:38	20:09	23:01	02:52	1.05	160	4.5	17	402	1.19	0	0
36	95	357.00	360.00	357.03	360.04	3.00	3.01	100%	16/05/2020	23:39	00:10	00:31	05:13	05:49	00:36	00:10	05:13	05:03	0.59	160	4.0	24	400	1.19	0	0
37	95	360.00	363.00	360.04	363.07	3.00	3.03	101%	16/05/2020	05:49	06:17	00:28	09:48	10:20	00:32	06:17	09:48	03:31	0.85	160	4.0	24	400	1.19	0	0
38	95	363.00	366.00	363.07	366.05	3.00	2.98	99%	17/05/2020	10:20	10:52	00:32	13:08	13:43	00:35	10:52	13:08	02:16	1.32	160	4.0	23	400	1.19	0	0
39	95	366.00	369.00	366.05	369.06	3.00	3.01	100%	17/05/2020	17:00	18:36	01:36	21:09	21:42	00:33	18:36	21:09	02:33	1.18	160	4.5	23	406	1.19	0	0
40	95	369.00	372.00	369.06	372.06	3.00	3.00	100%	17/05/2020	21:42	22:04	00:22	00:24	00:59	00:35	22:04	00:24	02:20	1.29	160	4.8	22	400	1.19	0	0
41	95	372.00	375.00	372.06	375.02	3.00	2.96	99%	17/05/2020	00:59	01:25	00:26	05:10	05:41	00:31	01:25	05:10	03:45	0.80	160	5.0	23	400	1.19	0	0
42	95	375.00	378.00	375.02	378.03	3.00	3.01	100%	17/05/2020	05:41	06:03	00:22	09:35	10:07	00:32	06:03	09:35	03:32	0.85	160	4-5	25	405	1.19	0	0
43	95	378.00	381.00	378.03	381.07	3.00	3.04	101%	18/05/2020	10:31	10:47	00:16	15:06	15:45	00:39	10:47	15:06	04:19	0.69	160	4.0	24	412	1.19	0	0
44	95	381.00	384.00	381.07	384.07	3.00	3.00	100%	18/05/2020	15:45	16:13	00:28	19:23	19:57	00:34	16:13	19:23	03:10	0.95	160	4.2	22	407	1.19	0	0
45	95	384.00	387.00	384.07	387.02	3.00	2.95	98%	18/05/2020	19:57	20:40	00:43	00:49	01:31	00:42	20:40	00:49	04:09	0.72	100	4.5	20	400	1.19	0	0
46	95	387.00	390.00	387.02	390.15	3.00	3.13	104%	18/05/2020	01:31	02:11	00:40	05:11	05:49	00:38	02:11	05:11	03:00	1.00	160	4.5	20	400	1.19	0	0
47	95	390.00	393.00	390.15	393.01	3.00	2.86	95%	18/05/2020	05:49	06:19	00:30	08:04	08:43	00:39	06:19	08:04	01:45	1.71	160	4-5	22	400	1.19	0	0
48	95	393.00	396.00	393.01	396.03	3.00	3.02	101%	19/05/2020	08:43	09:05	00:22	11:51	12:27	00:36	09:05	11:51	02:46	1.08	160	4.0	22	405	1.19	0	0
49	95	396.00	399.00	396.03	399.15	3.00	3.12	104%	19/05/2020	13:00	13:17	00:17	16:52	17:30	00:38	13:17	16:52	03:35	0.84	160	3-4	22	408	1.19	0	0
50	95	399.00	402.00	399.15	402.09	3.00	2.94	98%	19/05/2020	17:56	18:16	00:20	22:26	22:58	00:32	18:16	22:26	04:10	0.72	160	4.0	22	410	1.19	0	0

Tab. I-1: continued

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]
51	95	402.00	405.00	402.09	405.07	3.00	2.98	99%	19/05/2020	22:58	23:29	00:31	02:16	02:50	00:34	23:29	02:16	02:47	1.08	160	4.5	22	400	1.19	0	0
52	95	405.00	405.14	405.07	405.07	0.14	0.00	0%	19/05/2020	02:50	03:14	00:24	03:50	04:17	00:27	03:14	03:50	00:36	0.23	160	5.5	20	400	1.19	0	0
53	95	405.14	408.00	405.07	408.05	2.86	2.98	104%	19/05/2020	04:17	04:51	00:34	06:46	07:23	00:37	04:51	06:46	01:55	1.49	180	4.6	22	416	1.19	0	0
54	95	408.00	411.00	408.05	411.08	3.00	3.03	101%	20/05/2020	07:38	07:55	00:17	10:13	10:46	00:33	07:55	10:13	02:18	1.30	160	3.0	22	405	1.19	0	0
55	95	411.00	414.00	411.08	414.10	3.00	3.02	101%	20/05/2020	10:46	11:14	00:28	13:37	14:10	00:33	11:14	13:37	02:23	1.26	160	3-4	23	405	1.19	0	0
56	95	414.00	417.00	414.10	417.08	3.00	2.98	99%	20/05/2020	14:10	14:36	00:26	16:19	16:57	00:38	14:36	16:19	01:43	1.75	160	4.0	22	405	1.19	0	0
57	95	417.00	420.00	417.08	420.05	3.00	2.97	99%	20/05/2020	17:19	17:37	00:18	19:52	20:32	00:40	17:37	19:52	02:15	1.33	157	4.0	21	393	1.19	0	0
58	95	420.00	423.00	420.05	423.05	3.00	3.00	100%	20/05/2020	20:32	20:57	00:25	23:02	23:40	00:38	20:57	23:02	02:05	1.44	170	4.7	22	405	1.19	0	0
59	95	423.00	426.00	423.05	426.09	3.00	3.04	101%	20/05/2020	23:40	00:08	00:28	02:27	03:01	00:34	00:08	02:27	02:19	1.29	160	4.5	22	400	1.19	0	0
60	95	426.00	429.00	426.09	429.03	3.00	2.94	98%	21/05/2020	11:39	14:13	02:34	16:26	16:59	00:33	14:13	16:26	02:13	1.35	160	4.5	25	404	1.19	0	0
61	95	429.00	432.00	429.03	431.99	3.00	2.96	99%	21/05/2020	16:59	17:30	00:31	21:05	21:40	00:35	17:30	21:05	03:35	0.84	156	5.1	23	402	1.19	0	0
62	95	432.00	435.00	431.99	435.10	3.00	3.11	104%	21/05/2020	21:30	22:10	00:40	01:05	01:40	00:35	22:10	01:05	02:55	1.03	175	5.0	23	398	1.19	0	0
63	95	435.00	438.00	435.10	438.01	3.00	2.91	97%	21/05/2020	01:40	02:14	00:34	04:20	04:55	00:35	02:14	04:20	02:06	1.43	160	4.0	23	407	1.19	0	0
64	95	438.00	441.00	438.01	441.01	3.00	3.00	100%	21/05/2020	04:55	05:19	00:24	07:07	07:39	00:32	05:19	07:07	01:48	1.67	180	4.5	22	398	1.19	0	0
65	95	441.00	444.00	441.01	444.04	3.00	3.03	101%	22/05/2020	07:39	08:04	00:25	10:15	10:50	00:35	08:04	10:15	02:11	1.37	160	4.5	24	410	1.19	0	0
66	95	444.00	447.00	444.04	447.00	3.00	2.96	99%	22/05/2020	10:50	11:20	00:30	12:32	13:05	00:33	11:20	12:32	01:12	2.50	160	4.5	25	400	1.19	0	0
67	95	447.00	450.00	447.00	450.04	3.00	3.04	101%	22/05/2020	13:05	13:44	00:39	16:41	17:17	00:36	13:44	16:41	02:57	1.02	160	2.3	26	422	1.19	0	0
68	95	450.00	453.00	450.04	453.14	3.00	3.10	103%	22/05/2020	17:17	17:44	00:27	20:10	20:44	00:34	17:44	20:10	02:26	1.23	160	4.4	25	406	1.19	0	0
69	95	453.00	456.00	453.14	456.04	3.00	2.90	97%	22/05/2020	20:44	21:23	00:39	22:35	23:05	00:30	21:23	22:35	01:12	2.50	160	3.3	26	396	1.19	0	0
70	95	456.00	459.00	456.04	459.11	3.00	3.07	102%	22/05/2020	23:05	23:32	00:27	00:54	01:30	00:36	23:32	00:54	01:22	2.20	160	3.5	25	402	1.19	0	0
71	95	459.00	462.00	459.11	462.08	3.00	2.97	99%	22/05/2020	01:30	01:53	00:23	03:12	03:45	00:33	01:53	03:12	01:19	2.28	160	4.6	26	407	1.19	0	0
72	95	462.00	465.00	462.08	465.07	3.00	2.99	100%	22/05/2020	03:45	04:18	00:33	05:45	06:20	00:35	04:18	05:45	01:27	2.07	160	4.5	26	402	1.19	0	0
73	95	465.00	468.00	465.07	468.06	3.00	2.99	100%	23/05/2020	06:20	06:41	00:21	08:38	09:13	00:35	06:41	08:38	01:57	1.54	160	3.5	28	402	1.19	0	0
74	95	468.00	471.00	468.06	471.13	3.00	3.07	102%	23/05/2020	09:13	09:40	00:27	11:45	12:19	00:34	09:40	11:45	02:05	1.44	160	3.5	27	403	1.19	0	0
75	95	471.00	474.00	471.13	474.08	3.00	2.95	98%	23/05/2020	12:19	12:52	00:33	15:01	15:37	00:36	12:52	15:01	02:09	1.40	160	4.5	26	402	1.19	0	0
76	95	474.00	477.00	474.08	477.01	3.00	2.93	98%	23/05/2020	15:37	16:20	00:43	18:22	18:52	00:30	16:20	18:22	02:02	1.48	160	4.5	26	399	1.19	0	0
77	95	477.00	480.00	477.01	480.02	3.00	3.01	100%	23/05/2020	18:52	19:26	00:34	22:17	22:55	00:38	19:26	22:17	02:51	1.05	160	4.8	26	400	1.19	0	0
78	95	483.00	484.50	483.00	484.29	1.50	1.29	86%	27/06/2020	15:50	21:28	05:38	01:33	02:10	00:37	21:28	01:33	04:05	0.37	107	2.5	17	390	1.2	0	0
79	95	484.50	486.00	484.29	485.70	1.50	1.41	94%	28/06/2020	02:10	02:40	00:30	05:10	05:40	00:30	02:40	05:10	02:30	0.60	155	3.0	20	392	1.2	0	0
80	95	486.00	487.50	485.70	487.29	1.50	1.59	106%	28/06/2020	05:40	06:15	00:35	09:21	10:00	00:39	06:15	08:21	02:06	0.71	161	3.4	19	398	1.2	0	0
81	95	487.50	489.00	487.29	488.70	1.50	1.41	94%	28/06/2020	10:00	10:41	00:41	12:25	13:00	00:35	10:41	12:25	01:44	0.87	153	3.6	21	394	1.2	0	0
82	95	489.00	492.00	488.70	491.72	3.00	3.02	101%	28/06/2020	13:00	13:44	00:44	16:52	17:27	00:35	13:44	16:52	03:08	0.96	171	3.5	19	397	1.2	0	0
83	95	492.00	495.00	491.72	494.80	3.00	3.08	103%	28/06/2020	17:27	18:00	00:33	20:55	21:23	00:28	18:00	20:55	02:55	1.03	160	4.2	21	396	1.2	0	0
84	95	495.00	498.00	494.80	497.80	3.00	3.00	100%	28/06/2020	21:23	21:58	00:35	00:55	01:30	00:35	21:58	00:55	02:57	1.02	150	4.2	18	400	1.2	0	0
85	95	498.00	498.80	497.80	498.58	0.80	0.78	97%	29/06/2020	04:30	07:24	02:54	09:40	10:14	00:34	07:24	09:40	02:16	0.35	180	3.6	21	394	1.2	0	0
86	95	498.80	501.00	498.58	500.68	2.20	2.10	95%	29/06/2020	10:14	11:05	00:51	13:16	13:51	00:35	11:05	13:16	02:11	1.01	178	3.6	22	394	1.2	0	0
87	95	501.00	504.00	500.68	503.77	3.00	3.09	103%	29/06/2020	13:51	14:23	00:32	17:19	17:55	00:36	14:23	17:19	02:56	1.02	175	4.0	23	394	1.2	0	0
88	95	504.00	507.00	503.77	506.73	3.00	2.96	99%	29/06/2020	17:55	18:30	00:35	19:45	20:15	00:30	18:30	19:45	01:15	2.40	170	4.2	22	398	1.2	0	0
89	95	507.00	510.00	506.73	509.70	3.00	2.97	99%	29/06/2020	20:15	20:57	00:42	22:24	23:00	00:36	20:57	22:24	01:27	2.07	175	3.4	21	393	1.2	0	0
90	95	510.00	513.00	509.70	512.65	3.00	2.95	98%	29/06/2020	23:00	23:28	00:28	01:27	01:55	00:28	23:28	01:27	01:59	1.51	175	4.0	24	398	1.2	0	0
91	95	513.00	516.00	512.65	515.82	3.00	3.17	106%	29/06/2020	01:55	02:36	00:41	05:25	05:55	00:30	02:36	05:25	02:49	1.07	172	4.1	23	399	1.2	0	0
92	95	516.00	519.00	515.82	518.82	3.00	3.00	100%	30/06/2020	05:55	06:37	00:42	08:20	09:03	00:43	06:37	08:20	01:43	1.75	170	3.9	23	399	1.2	0	0
93	95	519.00	521.00	518.82	520.81	2.00	1.99	99%	30/06/2020	09:03	09:35	00:32	10:36	18:12	07:36	09:35	10:36	01:01	1.97	172	4.0	22	397	1.2	0	0
94	95	521.00	525.00	520.81	524.03	4.00	3.22	81%	30/06/2020	18:12	18:49	00:37	21:02	21:36	00:34	18:49	21:02	02:13	1.80	180	4.1	20	408	1.2	0	0
95	95	525.00	528.00	524.03	527.75	3.00	3.72	124%	30/06/2020	21:36	22:28	00:52	00:11	00:55	00:44	22:28	00:11	01:43	1.75	170	4.0	22	408	1.2	0	0
96	95	528.00	531.00	527.75	530.82	3.00	3.07	102%	30/06/2020	00:55	01:25	00:30	03:00	03:36	00:36	01:25	03:00	01:35	1.89	160	3.9	22	403	1.2	0	0
97	95	531.00	534.00	530.82	533.79	3.00	2.97	99%	01/07/2020	03:36	04:11	00:35	06:05	06:50	00:45	04:11	06:05	01:54	1.58	179	4.1	23	408	1.2	0	0
98	95	534.00	537.00	533.79	536.40	3.00	2.61	87%	01/07/2020	06:50	07:32	00:42	09:26	10:02	00:36	07:32	09:26	01:54	1.58	176	3.2	24	393	1.2	0	0
99	95	537.00	540.00	536.40	539.74	3.00	3.34	111%	01/07/2020	10:02	11:48	01:46	15:07	15:43	00:36	11:48	15:07	03:19	0.90	160	3.6	27	400	1.2	0	0
100	95	540.00	543.00	539.74	542.65	3.00	2.91	97%	01/07/2020	15:43	16:34	00:51	17:53	18:30	00:37	16:34	17:53	01:19	2.28	165	3.3	25	405	1.2	0	0

Tab. I-1: continued

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]
101	95	543.00	546.00	542.65	545.88	3.00	3.23	108%	01/07/2020	18:30	19:20	00:50	22:47	23:25	00:38	19:20	22:47	03:27	0.87	170	3.8	26	397	1.2	0	0
102	95	546.00	549.00	545.88	548.50	3.00	2.62	87%	01/07/2020	23:25	23:57	00:32	03:14	03:54	00:40	23:57	03:14	03:17	0.91	160	4.0	26	400	1.2	0	0
103	95	549.00	552.00	548.50	551.80	3.00	3.30	110%	02/07/2020	03:54	04:30	00:36	06:45	07:24	00:39	04:30	06:45	02:15	1.33	166	3.9	26	399	1.2	0	0
104	95	552.00	555.00	551.80	554.90	3.00	3.10	103%	02/07/2020	07:24	08:05	00:41	11:07	12:17	01:10	08:05	11:07	03:02	0.99	165	3.6	28	400	1.2	0	0
105	95	555.00	558.00	554.90	557.80	3.00	2.90	97%	02/07/2020	11:43	12:17	00:34	13:55	14:30	00:35	12:17	13:55	01:38	1.84	170	4.8	27	403	1.2	0	0
106	95	558.00	561.00	557.80	560.83	3.00	3.03	101%	02/07/2020	14:30	15:05	00:35	18:13	18:53	00:40	15:05	18:13	03:08	0.96	150	4.5	26	406	1.2	0	0
107	95	561.00	564.00	560.83	563.62	3.00	2.79	93%	02/07/2020	18:53	19:36	00:43	22:55	23:36	00:41	19:36	22:55	03:19	0.90	170	3.9	27	393	1.2	0	0
108	95	564.00	567.00	563.62	566.69	3.00	3.07	102%	21/07/2020	03:05	08:25	05:20	10:19	13:55	03:36	08:25	10:19	01:54	1.58	100	4.3	29	416	1.19	0	0
109	95	567.00	570.00	566.69	569.91	3.00	3.22	107%	21/07/2020	15:00	19:12	04:12	21:32	22:15	00:43	19:12	21:32	02:20	1.29	150	4.2	30	408	1.19	0	0
110	95	570.00	573.00	569.91	572.81	3.00	2.90	97%	21/07/2020	22:15	22:54	00:39	00:35	01:15	00:40	22:54	00:35	01:41	1.78	150	3.1	29	414	1.19	0	0
111	95	573.00	576.00	572.81	575.81	3.00	3.00	100%	21/07/2020	01:15	01:48	00:33	03:39	04:20	00:41	01:48	03:39	01:51	1.62	156	3.2	30	412	1.19	0	0
112	95	576.00	579.00	575.81	578.83	3.00	3.02	101%	21/07/2020	04:20	04:50	00:30	06:45	07:29	00:44	04:50	06:45	01:55	1.57	150	3.5	29	415	1.19	0	0
113	95	579.00	582.00	578.83	581.37	3.00	2.54	85%	22/07/2020	07:29	08:12	00:43	10:05	10:54	00:49	08:12	10:05	01:53	1.59	180	4.0	30	427	1.19	0	0
114	95	582.00	585.00	581.37	584.82	3.00	3.45	115%	22/07/2020	10:54	11:36	00:42	13:13	13:55	00:42	11:36	13:13	01:37	1.86	180	4.5	31	378	1.19	0	0
115	95	585.00	588.00	584.82	587.93	3.00	3.11	104%	22/07/2020	13:55	14:30	00:35	16:39	17:22	00:43	14:30	16:39	02:09	1.40	180	4.2	30	373	1.19	0	0
116	95	588.00	591.00	587.93	590.93	3.00	3.00	100%	22/07/2020	17:22	18:06	00:44	20:18	20:57	00:39	18:06	20:18	02:12	1.36	180	3.5	30	390	1.19	0	0
117	95	591.00	594.00	590.93	593.93	3.00	3.00	100%	22/07/2020	20:57	21:34	00:37	00:15	00:50	00:35	21:34	00:15	02:41	1.12	175	4.3	30	390	1.19	0	0
118	95	594.00	597.00	593.93	596.59	3.00	2.66	89%	22/07/2020	00:50	01:25	00:35	04:05	04:47	00:42	01:25	04:05	02:40	1.13	180	4.3	30	390	1.19	0	0
119	93	597.00	600.00	596.59	598.43	3.00	1.84	61%	23/07/2020	04:47	05:36	00:49	08:13	09:05	00:52	05:36	08:13	02:37	1.15	177	4.5	31	388	1.21	0	0
120	95	600.00	601.00	598.43	600.92	1.00	2.49	249%	23/07/2020	09:05	10:11	01:06	11:04	11:50	00:46	10:11	11:04	00:53	1.13	178	4.4	30	360	1.21	0	0
121	95	601.00	605.00	600.92	604.95	4.00	4.03	101%	23/07/2020	11:50	12:19	00:29	16:35	17:10	00:35	12:19	16:35	04:16	0.94	180	4.5	29	398	1.21	0	0
122	95	605.00	609.00	604.95	608.56	4.00	3.61	90%	23/07/2020	17:10	17:57	00:47	21:37	22:16	00:39	17:57	21:37	03:40	1.09	177	5.3	27	389	1.21	0	0
123	95	609.00	612.00	608.56	611.74	3.00	3.18	106%	23/07/2020	22:16	23:11	00:55	02:03	02:40	00:37	23:11	02:03	02:52	1.05	170	4.9	35	389	1.21	0	0
124	95	612.00	615.00	611.74	614.72	3.00	2.98	99%	23/07/2020	02:40	03:18	00:38	06:14	06:56	00:42	03:18	06:14	02:56	1.02	180	4.8	38	390	1.21	0	0
125	95	615.00	618.00	614.72	617.78	3.00	3.06	102%	24/07/2020	06:56	07:37	00:41	10:37	11:19	00:42	07:37	10:37	03:00	1.00	180	4.1	31	389	1.23	0	0
126	95	618.00	621.00	617.78	620.78	3.00	3.00	100%	24/07/2020	11:19	11:50	00:31	15:42	16:22	00:40	11:50	15:42	03:52	0.78	186	5.5	30	398	1.23	0	0
127	95	621.00	624.00	620.78	623.90	3.00	3.12	104%	24/07/2020	16:22	16:57	00:35	20:00	20:37	00:37	16:57	20:00	03:03	0.98	185	5.4	34	389	1.23	0	0
128	95	624.00	627.00	623.90	626.79	3.00	2.89	96%	24/07/2020	20:37	21:18	00:41	00:02	00:40	00:38	21:18	00:02	02:44	1.10	180	5.5	42	389	1.23	0	0
129	95	627.00	630.00	626.79	629.66	3.00	2.87	96%	24/07/2020	00:40	01:15	00:35	04:09	04:50	00:41	01:15	04:09	02:54	1.03	178	5.6	42	388	1.23	0	0
130	95	630.00	633.00	629.66	632.83	3.00	3.17	106%	24/07/2020	04:50	05:22	00:32	08:30	09:15	00:45	05:22	08:30	03:08	0.96	175	5.4	35	388	1.25	0	0
131	95	633.00	636.00	632.83	635.89	3.00	3.06	102%	25/07/2020	09:15	09:50	00:35	12:44	13:24	00:40	09:50	12:44	02:54	1.03	189	5.0	38	389	1.25	0	0
132	95	636.00	639.00	635.89	638.85	3.00	2.96	99%	25/07/2020	13:24	13:58	00:34	17:27	18:19	00:52	13:58	17:27	03:29	0.86	178	4.6	28	384	1.25	0	0
133	95	639.00	642.00	638.85	641.90	3.00	3.05	102%	25/07/2020	18:19	18:40	00:21	21:14	21:52	00:38	18:40	21:14	02:34	1.17	182	5.4	35	389	1.25	0	0
134	95	642.00	645.00	641.90	644.80	3.00	2.90	97%	25/07/2020	21:52	22:30	00:38	01:30	02:10	00:40	22:30	01:30	03:00	1.00	180	5.4	42	382	1.25	0	0
135	95	645.00	648.00	644.80	647.85	3.00	3.05	102%	25/07/2020	02:10	02:45	00:35	05:48	06:30	00:42	02:45	05:48	03:03	0.98	177	5.4	31	388	1.25	0	0
136	95	648.00	651.00	647.85	650.86	3.00	3.01	100%	26/07/2020	06:30	06:59	00:29	09:35	10:18	00:43	06:59	09:35	02:36	1.15	176	5.2	29	386	1.25	0	0
137	95	651.00	654.00	650.86	653.85	3.00	2.99	100%	26/07/2020	10:18	10:58	00:40	12:57	13:39	00:42	10:58	12:57	01:59	1.51	182	4.2	34	389	1.25	0	0
138	95	654.00	657.00	653.85	654.38	3.00	0.53	18%	26/07/2020	13:39	14:08	00:29	16:16	16:58	00:42	14:08	16:16	02:08	1.41	180	4.6	31	389	1.25	0	0
139	93	657.00	657.50	654.38	657.44	0.50	3.06	612%	26/07/2020	16:58	17:34	00:36	18:00	18:42	00:42	17:34	18:00	00:26	1.15	173	4.3	24	310	1.25	0	0
140	95	657.50	660.00	657.44	659.84	2.50	2.40	96%	26/07/2020	22:55	00:43	01:48	02:46	03:28	00:42	00:43	02:46	02:03	1.22	175	4.4	42	382	1.25	0	0
141	95	660.00	663.00	659.84	662.93	3.00	3.09	103%	26/07/2020	03:28	04:14	00:46	05:49	06:32	00:43	04:14	05:49	01:35	1.89	180	4.9	32	387	1.25	0	0
142	95	663.00	666.00	662.93	665.93	3.00	3.00	100%	27/07/2020	06:32	07:09	00:37	08:36	09:18	00:42	07:09	08:36	01:27	2.07	177	4.6	37	384	1.25	0	0
143	93	666.00	669.00	665.93	668.96	3.00	3.03	101%	27/07/2020	09:18	09:56	00:38	11:33	12:15	00:42	09:56	11:33	01:37	1.86	170	3.6	34	386	1.25	0	0
144	93	669.00	672.00	668.96	671.76	3.00	2.80	93%	27/07/2020	12:15	12:52	00:37	14:23	15:36	01:13	12:52	14:23	01:31	1.98	187	3.6	33	386	1.25	0	0
145	95	672.00	673.00	671.76	672.86	1.00	1.10	110%	27/07/2020	15:36	16:17	00:41	16:48	17:30	00:42	16:17	16:48	00:31	1.94	181	3.6	30	343	1.25	0	0
146	95	673.00	675.00	672.86	674.86	2.00	2.00	100%	27/07/2020	17:30	18:01	00:31	18:58	19:38	00:40	18:01	18:58	00:57	2.11	179	3.7	36	385	1.25	0	0
147	95	675.00	678.00	674.86	677.88	3.00	3.02	101%	27/07/2020	19:38	20:12	00:34	21:37	22:20	00:43	20:12	21:37	01:25	2.12	180	4.0	35	386	1.25	0	0
148	95	678.00	681.00	677.88	680.84	3.00	2.96	99%	27/07/2020	22:20	22:56	00:36	01:12	01:50	00:38	22:56	01:12	02:16	1.32	170	3.5	31	384	1.25	0	0
149	95	681.00	684.00	680.84	683.97	3.00	3.13	104%	27/07/2020	01:50	02:28	00:38	06:22	07:04	00:42	02:28	06:22	03:54	0.77	178	5.5	39	388	1.25	0	0
150	95	684.00	687.00	683.97	687.01	3.00	3.04	101%	28/07/2020	07:04	07:40	00:36	11:07	11:50	00:43	07:40	11:07	03:27	0.87	174	5.5	38	389	1.25	0	0

Tab. I-1: continued

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]
151	95	687.00	690.00	687.01	690.01	3.00	3.00	100%	28/07/2020	11:50	12:27	00:37	16:35	17:15	00:40	12:27	16:35	04:08	0.73	180	5.4	39	385	1.25	0	0
152	95	692.00	693.00	692.00	692.93	1.00	0.93	93%	31/08/2020	07:00	12:40	05:40	14:14	14:46	00:32	12:40	14:14	01:34	0.64	135	4.0	21	400	1.23	0	0
153	95	693.00	693.20	692.93	692.93	0.20	0.00	0%	31/08/2020	14:46	15:36	00:50	16:45	17:39	00:54	15:36	16:45	01:09	0.17	138	5.0	17	392	1.23	0	0
154	95	693.20	694.20	692.93	693.99	1.00	1.06	106%	31/08/2020	21:45	01:15	03:30	04:59	05:55	00:56	01:15	04:59	03:44	0.27	161	4.0	19	402	1.23	0	0
155	95	694.20	696.00	693.99	695.88	1.80	1.89	105%	01/09/2020	05:55	06:11	00:16	10:32	11:16	00:44	06:11	10:32	04:21	0.41	147	4.5	21	395	1.23	0	0
156	95	696.00	699.00	695.88	698.77	3.00	2.89	96%	01/09/2020	11:16	12:00	00:44	18:02	18:45	00:43	12:00	18:02	06:02	0.50	145	4.0	22	397	1.23	0	0
157	95	699.00	702.00	698.77	701.86	3.00	3.09	103%	01/09/2020	18:45	19:32	00:47	21:12	21:55	00:43	19:32	21:12	01:40	1.80	180	4.0	23	400	1.23	0	0
158	95	702.00	705.00	701.86	704.81	3.00	2.95	98%	01/09/2020	21:55	22:37	00:42	00:17	01:07	00:50	22:37	00:17	01:40	1.80	177	4.0	23	392	1.23	0	0
159	95	705.00	708.00	704.81	707.78	3.00	2.97	99%	01/09/2020	01:07	01:51	00:44	03:59	04:45	00:46	01:51	03:59	02:08	1.41	190	4.0	25	405	1.23	0	0
160	95	708.00	711.00	707.78	710.78	3.00	3.00	100%	02/09/2020	04:45	05:31	00:46	08:42	09:32	00:50	05:31	08:42	03:11	0.94	180	4.0	24	408	1.23	0	0
161	95	711.00	714.00	710.78	713.77	3.00	2.99	100%	02/09/2020	09:32	10:13	00:41	11:55	12:43	00:48	10:13	11:55	01:42	1.76	187	4.0	26	397	1.23	0	0
162	95	714.00	717.00	713.77	716.77	3.00	3.00	100%	02/09/2020	12:43	13:24	00:41	16:43	17:27	00:44	13:24	16:43	03:19	0.90	185	4.7	29	399	1.23	0	0
163	95	717.00	720.00	716.77	719.75	3.00	2.98	99%	02/09/2020	17:27	18:03	00:36	21:17	22:14	00:57	18:03	21:17	03:14	0.93	184	4.7	27	402	1.23	0	0
164	95	720.00	723.00	719.75	722.83	3.00	3.08	103%	02/09/2020	22:14	22:49	00:35	02:31	03:21	00:50	22:49	02:31	03:42	0.81	176	5.5	24	404	1.23	0	0
165	95	723.00	726.00	722.83	725.83	3.00	3.00	100%	02/09/2020	03:21	04:01	00:40	07:37	08:25	00:48	04:01	07:37	03:36	0.83	190	4.7	25	410	1.23	0	0
166	95	726.00	729.00	725.83	728.83	3.00	3.00	100%	03/09/2020	08:25	09:01	00:36	12:00	12:46	00:46	09:01	12:00	02:59	1.01	190	4.4	27	404	1.23	0	0
167	95	729.00	729.60	728.83	728.83	0.60	0.00	0%	03/09/2020	17:30	22:15	04:45	01:43	05:08	03:25	22:15	01:43	03:28	0.17	144	2.8	29	371	1.23	0	0
168	95	729.60	732.00	728.83	728.83	2.40	0.00	0%	04/09/2020	05:08	09:15	04:07	11:35	14:00	02:25	09:15	11:35	02:20	1.03	175	4.1	29	388	1.23	0	0
169	95	732.00	732.50	728.83	728.83	0.50	0.00	0%	04/09/2020	14:00	14:35	00:35	14:58	21:47	06:49	14:35	14:58	00:23	1.30	180	4.3	32	416	1.23	0	0
170	95	732.70	735.00	732.70	734.99	2.30	2.29	100%	05/09/2020	15:15	20:08	04:53	00:18	01:04	00:46	20:08	00:18	04:10	0.55	183	4.3	29	401	1.23	0	0
171	95	735.00	738.00	734.99	737.91	3.00	2.92	97%	05/09/2020	01:04	01:48	00:44	05:00	05:48	00:48	01:48	05:00	03:12	0.94	194	4.8	30	392	1.23	0	0
172	95	738.00	741.00	737.91	740.95	3.00	3.04	101%	05/09/2020	05:48	06:27	00:39	08:54	09:45	00:51	06:27	08:54	02:27	1.22	199	4.4	34	400	1.23	0	0
173	95	741.00	744.00	740.95	744.02	3.00	3.07	102%	06/09/2020	09:45	10:31	00:46	13:04	13:50	00:46	10:31	13:04	02:33	1.18	184	4.7	37	399	1.23	0	0
174	95	744.00	747.00	744.02	746.97	3.00	2.95	98%	06/09/2020	13:50	14:32	00:42	17:37	18:20	00:43	14:32	17:37	03:05	0.97	187	4.5	37	405	1.23	0	0
175	95	747.00	750.00	746.97	750.05	3.00	3.08	103%	06/09/2020	18:20	19:02	00:42	21:12	22:03	00:51	19:02	21:12	02:10	1.38	205	6.5	40	409	1.23	0	0
176	95	750.00	753.00	750.05	753.00	3.00	2.95	98%	06/09/2020	22:03	22:50	00:47	00:49	01:35	00:46	22:50	00:49	01:59	1.51	202	4.6	41	408	1.23	0	0
177	95	753.00	756.00	753.00	756.08	3.00	3.08	103%	06/09/2020	01:35	02:13	00:38	04:09	04:56	00:47	02:13	04:09	01:56	1.55	198	5.3	44	407	1.23	0	0
178	95	756.00	759.00	756.08	759.06	3.00	2.98	99%	06/09/2020	04:56	05:39	00:43	07:18	08:10	00:52	05:39	07:18	01:39	1.82	204	5.0	44	406	1.23	0	0
179	95	759.00	762.00	759.06	762.03	3.00	2.97	99%	07/09/2020	11:00	11:40	00:40	13:41	16:10	02:29	11:40	13:41	02:01	1.49	175	5.1	50	399	1.23	0	0
180	95	762.00	765.00	762.03	765.07	3.00	3.04	101%	07/09/2020	16:10	16:46	00:36	18:59	19:51	00:52	16:46	18:59	02:13	1.35	180	5.0	51	399	1.23	0	0
181	95	765.00	768.00	765.07	768.10	3.00	3.03	101%	07/09/2020	19:51	20:31	00:40	23:47	00:47	01:00	20:31	23:47	03:16	0.92	202	5.6	51	394	1.23	0	0
182	95	768.00	771.00	768.10	770.93	3.00	2.83	94%	07/09/2020	00:47	01:24	00:37	03:07	03:55	00:48	01:24	03:07	01:43	1.75	201	5.6	52	408	1.23	0	0
183	95	771.00	774.00	770.93	774.09	3.00	3.16	105%	07/09/2020	03:55	04:46	00:51	07:59	08:50	00:51	04:46	07:59	03:13	0.93	195	5.6	55	405	1.23	0	0
184	95	774.00	777.00	774.09	777.06	3.00	2.97	99%	08/09/2020	15:20	00:00	06:40	02:11	03:08	00:57	00:00	02:11	02:11	1.37	195	5.5	37	392	1.23	0	0
185	95	777.00	780.00	777.06	780.12	3.00	3.06	102%	08/09/2020	03:08	04:42	01:34	07:18	08:15	00:57	04:42	07:18	02:36	1.15	180	5.1	37	395	1.23	0	0
186	95	780.00	783.00	780.12	783.13	3.00	3.01	100%	09/09/2020	08:15	10:49	02:34	13:31	14:30	00:59	10:49	13:31	02:42	1.11	175	4.6	38	399	1.23	0	0
187	95	783.00	786.00	783.13	786.18	3.00	3.05	102%	09/09/2020	14:30	15:19	00:49	18:19	19:16	00:57	15:19	18:19	03:00	1.00	180	4.8	36	397	1.23	0	0
188	95	786.00	789.00	786.18	786.16	3.00	2.98	99%	09/09/2020	19:16	19:58	00:42	22:22	23:11	00:49	19:58	22:22	02:24	1.25	186	4.5	37	396	1.23	0	0
189	95	789.00	792.00	786.16	792.00	3.00	2.84	95%	09/09/2020	23:11	23:52	00:41	02:21	03:16	00:55	23:52	02:21	02:29	1.21	180	4.7	36	400	1.23	0	0
190	95	792.00	795.00	792.00	795.04	3.00	3.04	101%	09/09/2020	03:16	03:54	00:38	06:21	09:34	03:13	03:54	06:21	02:27	1.22	177	4.5	35	392	1.24	0	0
191	95	795.00	798.00	795.04	798.05	3.00	3.01	100%	10/09/2020	09:34	10:30	00:56	13:06	14:00	00:54	10:30	13:06	02:36	1.15	190	4.5	40	402	1.24	0	0
192	95	798.00	801.00	798.05	800.93	3.00	2.88	96%	10/09/2020	14:00	14:53	00:53	17:31	18:32	01:01	14:53	17:31	02:38	1.14	186	4.6	43	392	1.24	0	0
193	95	801.00	804.00	800.93	804.07	3.00	3.14	105%	10/09/2020	18:32	19:16	00:44	22:22	23:09	00:47	19:16	22:22	03:06	0.97	143	4.9	35	364	1.24	0	0
194	95	804.00	807.00	804.07	807.23	3.00	3.16	105%	10/09/2020	23:09	23:52	00:43	02:38	03:27	00:49	23:52	02:38	02:46	1.08	137	4.8	36	347	1.24	0	0
195	95	807.00	810.00	807.23	810.23	3.00	3.00	100%	10/09/2020	03:27	04:10	00:43	07:24	08:24	01:00	04:10	07:24	03:14	0.93	124	4.7	38	358	1.24	0	0
196	95	810.00	813.00	810.23	813.16	3.00	2.93	98%	11/09/2020	08:24	09:16	00:52	11:42	12:40	00:58	09:16	11:42	02:26	1.23	156	4.6	42	342	1.24	0	0
197	95	813.00	816.00	813.16	816.21	3.00	3.05	102%	11/09/2020	12:40	13:31	00:51	15:14	16:27	01:13	13:31	15:14	01:43	1.75	176	4.3	40	381	1.24	0	0
198	95	816.00	820.00	816.21	820.11	4.00	3.90	97%	16/09/2020	11:45	17:15	05:30	21:15	22:10	00:55	17:15	21:15	04:00	1.00	179	3.2	28	398	1.24	0	0
199	95	820.00	824.00	820.11	824.21	4.00	4.10	103%	16/09/2020	22:10	22:53	00:43	01:13	02:10	00:57	22:53	01:13	02:20	1.71	180	3.4	29	403	1.24	0	0
200	95	824.00	828.00	824.21	828.24	4.00	4.03	101%	16/09/2020	02:10	02:50	00:40	04:57	05:50	00:53	02:50	04:57	02:07	1.89	179	2.7	27	394	1.24	0	0

Tab. I-1: continued

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]
201	95	828.00	831.00	828.24	831.18	3.00	2.94	98%	16/09/2020	05:50	06:30	00:40	08:03	08:54	00:51	06:30	08:03	01:33	1.94	176	4.0	28	397	1.24	0	0
202	95	831.00	835.00	831.18	835.12	4.00	3.94	99%	17/09/2020	08:54	09:36	00:42	11:51	12:41	00:50	09:36	11:51	02:15	1.78	172	3.1	28	400	1.24	0	0
203	95	835.00	839.00	835.12	839.29	4.00	4.17	104%	17/09/2020	12:41	13:19	00:38	15:34	16:24	00:50	13:19	15:34	02:15	1.78	171	3.1	28	405	1.24	0	0
204	95	839.00	843.00	839.29	843.26	4.00	3.97	99%	17/09/2020	16:24	17:03	00:39	19:21	20:12	00:51	17:03	19:21	02:18	1.74	170	3.0	27	398	1.24	0	0
205	95	843.00	847.00	843.26	847.35	4.00	4.09	102%	17/09/2020	20:12	20:50	00:38	22:58	23:55	00:57	20:50	22:58	02:08	1.88	175	3.0	29	409	1.24	0	0
206	95	847.00	851.00	847.35	851.32	4.00	3.97	99%	17/09/2020	23:55	00:32	00:37	02:46	03:41	00:55	00:32	02:46	02:14	1.79	179	3.0	28	399	1.23	0	0
207	95	851.00	855.00	851.32	855.32	4.00	4.00	100%	17/09/2020	03:41	04:24	00:43	06:49	07:41	00:52	04:24	06:49	02:25	1.66	176	3.0	29	399	1.23	0	0
208	95	855.00	858.00	855.32	858.29	3.00	2.97	99%	18/09/2020	07:41	08:23	00:42	10:05	10:56	00:51	08:23	10:05	01:42	1.76	178	3.6	31	395	1.23	0	0
209	95	858.00	859.80	858.29	859.98	1.80	1.69	94%	18/09/2020	10:56	11:46	00:50	14:38	15:28	00:50	11:46	14:38	02:52	0.63	179	4.0	30	397	1.23	0	0
210	95	859.80	863.00	859.98	863.14	3.20	3.16	99%	18/09/2020	15:28	17:48	02:20	20:18	22:30	02:12	17:48	20:18	02:30	1.28	175	4.5	31-26	398	1.23	7.3	48.67
211	95	863.00	867.00	863.14	867.22	4.00	4.08	102%	18/09/2020	22:30	03:09	04:39	05:30	06:28	00:58	03:09	05:30	02:21	1.70	176	3.1	17	292	1.18	9.6	68.09

The core recovery was 99.86% for the Bözberg-1-1B borehole (coring from 828 m to 1'037.39 m MD).

Tab. I-2: Coring parameters of BOZ1-1B

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]
1B	94	828.00	828.40	828.00	828.31	0.40	0.31	78%	07/11/2020	02:50	11:40	08:50	13:25	14:35	01:10	11:40	13:25	01:45	0.23	100	5.0	19.0	378	1.16	0	
2B	94	828.40	828.90	828.31	828.83	0.50	0.52	104%	07/11/2020	14:35	15:16	00:41	16:51	18:02	01:11	15:16	16:51	01:35	0.32	133	6.0	23.0	402	1.16	0	
3B	84	828.90	831.00	828.83	830.91	2.10	2.08	99%	07/11/2020	23:40	05:22	05:42	09:30	10:30	01:00	05:22	09:30	04:08	0.51	131	4.8	17.0	393	1.16	0	
4B	94	831.00	835.00	830.91	834.95	4.00	4.04	101%	08/11/2020	10:30	11:21	00:51	14:18	15:12	00:54	11:21	14:18	02:57	1.36	130	4.6	21.0	446	1.16	0	
5B	94	835.00	840.00	834.95	839.92	5.00	4.97	99%	08/11/2020	15:12	16:05	00:53	18:27	19:22	00:55	16:05	18:27	02:22	2.11	150	4.6	21.0	404	1.16	0	
6B	94	840.00	844.50	839.92	844.46	4.50	4.54	101%	08/11/2020	19:30	20:10	00:40	22:09	22:55	00:46	20:10	22:09	01:59	2.27	152	4.5	23.0	395	1.16	0	
7B	94	844.50	849.00	844.46	849.02	4.50	4.56	101%	08/11/2020	22:55	23:34	00:39	01:50	02:41	00:51	23:34	01:50	02:16	1.99	157	4.5	23.0	400	1.16	0	
8B	94	849.00	854.00	849.02	853.94	5.00	4.92	98%	08/11/2020	02:50	03:25	00:35	06:03	06:55	00:52	03:25	06:03	02:38	1.90	150	4.0	21.0	396	1.16	0	
9B	94	854.00	858.00	853.94	857.31	4.00	3.37	84%	09/11/2020	06:55	07:37	00:42	10:03	18:15	08:12	07:37	10:03	02:26	1.64	160	3.0	21.0	397	1.15	0	
10B	94	858.00	862.50	858.00	862.59	4.50	4.59	102%	09/11/2020	18:20	19:06	00:46	22:04	22:50	00:46	19:06	22:04	02:58	1.52	155	4.0	22.0	400	1.15	0	
11B	94	862.50	867.00	862.59	867.11	4.50	4.52	100%	09/11/2020	23:00	23:33	00:33	02:51	03:40	00:49	23:33	02:51	03:18	1.36	150	4.5	20.0	390	1.15	0	
12B	94	867.00	871.50	867.11	871.53	4.50	4.42	98%	09/11/2020	03:45	04:24	00:39	07:33	08:30	00:57	04:24	07:33	03:09	1.43	153	4.0	21.0	397	1.15	0	
13B	94	871.50	876.00	871.53	876.18	4.50	4.65	103%	10/11/2020	08:30	09:10	00:40	12:06	13:05	00:59	09:10	12:06	02:56	1.53	150	3.5	21.0	390	1.15	0	
14B	94	876.00	880.00	876.18	880.10	4.00	3.92	98%	10/11/2020	13:05	13:49	00:44	16:03	17:05	01:02	13:49	16:03	02:14	1.79	164	3.5	21.0	390	1.15	0	
15B	94	880.00	884.00	880.10	884.03	4.00	3.93	98%	10/11/2020	17:05	17:40	00:35	04:40	05:31	00:51	02:07	04:40	02:33	1.57	157	4.0	22.0	383	1.15	0	
16B	94	884.00	888.00	884.03	887.72	4.00	3.69	92%	11/11/2020	05:38	06:15	00:37	10:34	11:26	00:52	06:15	10:34	04:19	0.93	180	3.6	25.0	396	1.15	0	
17B	94	888.00	892.00	887.72	892.18	4.00	4.46	112%	11/11/2020	11:26	12:08	00:42	16:05	16:56	00:51	12:08	16:05	03:57	1.01	184	5.1	25.0	404	1.17	0	
18B	95	892.00	896.00	892.18	896.16	4.00	3.98	100%	11/11/2020	16:56	17:55	00:59	22:51	23:48	00:57	17:55	22:51	04:56	0.81	180	5.0	28.0	409	1.19	0	
19B	95	896.00	900.00	896.16	900.07	4.00	3.91	98%	11/11/2020	23:48	00:49	01:01	05:28	06:30	01:02	00:49	05:28	04:39	0.86	181	5.8	28.0	399	1.20	0	
20B	95	900.00	903.80	900.07	903.66	3.80	3.59	94%	12/11/2020	06:40	07:13	00:33	11:32	12:20	00:48	07:13	11:32	04:19	0.88	185	5.4	27.0	404	1.20	0	
21B	95	903.80	908.00	903.66	908.10	4.20	4.44	106%	12/11/2020	12:25	13:11	00:46	16:57	17:45	00:48	13:11	16:57	03:46	1.12	180	4.9	29.0	406	1.20	0	
22B	95	908.00	912.00	908.10	912.01	4.00	3.91	98%	12/11/2020	17:50	18:28	00:38	21:58	22:52	00:54	18:28	21:58	03:30	1.14	163	5.8	30.0	401	1.23	0	
23B	95	912.00	916.00	912.01	916.04	4.00	4.03	101%	12/11/2020	22:52	23:44	00:52	03:03	04:02	00:59	23:44	03:03	03:19	1.21	156	5.5	30.0	400	1.23	0	
24B	94	916.00	920.00	916.04	920.10	4.00	4.06	102%	12/11/2020	04:02	04:49	00:47	08:22	09:15	00:53	04:49	08:22	03:33	1.13	160	5.3	32.0	395	1.23	0	
25B	94	920.00	924.00	920.10	924.03	4.00	3.93	98%	13/11/2020	09:15	10:01	00:46	12:42	13:38	00:56	10:01	12:42	02:41	1.49	175	4.6	31.0	390	1.23	0	
26B	94	924.00	925.00	924.03	924.11	1.00	0.08	8%	13/11/2020	13:40	14:24	00:44	15:11	20:51	05:40	14:24	15:09	00:45	1.33	180	5.2	37.0	393	1.22	0	
27B	94	925.00	925.50	924.11	925.11	0.50	1.00	200%	13/11/2020	20:51	02:57	06:06	04:35	05:26	00:51	02:57	04:35	01:38	0.31	160	6.0	33.0	401	1.21	0	
28B	65-94	925.50	929.00	925.11	929.07	3.50	3.96	113%	13/11/2020	05:26	06:12	00:46	08:33	09:28	00:55	06:12	08:33	02:21	1.49	160	5.5	27-36	400	1.21	0	
29B	91-94	929.00	933.00	929.07	933.08	4.00	4.01	100%	14/11/2020	09:30	10:22	00:52	13:01	13:55	00:54	10:22	13:01	02:39	1.51	162	4.0	31	403	1.21	0	
30B	90-94	933.00	937.00	933.08	937.03	4.00	3.95	99%	14/11/2020	14:31	15:06	00:35	18:18	19:18	01:00	15:06	18:18	03:12	1.25	180	5.6	22-31	332	1.21	0	
31B	94	937.00	938.60	937.03	937.09	1.60	0.06	4%	14/11/2020	19:18	20:09	00:51	21:31	02:31	05:00	20:09	21:31	01:22	1.17	162	5.5	27	348	1.21	0	
32B	91-94	938.60	941.00	937.09	939.84	2.40	2.75	115%	14/11/2020	02:31	07:29	04:58	10:05	11:17	01:12	07:29	10:05	02:36	0.92	170	4.3	25	345	1.21	0	
33B	80-94	941.00	941.50	939.84	941.49	0.50	1.65	330%	15/11/2020	11:40	12:16	00:36	12:38	18:00	05:22	12:16	12:38	00:22	1.36	160	3.8	25	336	1.21	0	
34B	90-92	941.50	945.00	941.49	945.07	3.50	3.58	102%	15/11/2020	18:00	00:33	06:33	04:46	05:42	00:56	00:33	04:46	04:13	0.83	164	3.7	26	401	1.21	0	
35B	92-94	945.00	948.80	945.07	948.74	3.80	3.67	97%	15/11/2020	05:42	06:29	00:47	10:08	10:59	00:51	06:29	10:08	03:39	1.04	180	3.0	25	390	1.20	0	
36B	93-94	948.80	953.00	948.74	952.84	4.20	4.10	98%	16/11/2020	11:00	12:02	01:02	16:29	17:25	00:56	12:02	16:29	04:27	0.94	180	3.5	23	390	1.20	0	
37B	93-94	953.00	957.00	952.84	956.90	4.00	4.06	102%	16/11/2020	17:30	18:14	00:44	22:13	23:06	00:53	18:14	22:13	03:59	1.00	183	3.3	26	398	1.21	0	
38B	94	957.00	961.00	956.90	960.92	4.00	4.02	101%	16/11/2020	23:06	00:04	00:58	06:42	07:35	00:53	00:04	06:42	06:38	0.60	166	3.5	22	397	1.21	0	
39B	94	961.00	965.00	960.92	964.95	4.00	4.03	101%	17/11/2020	07:40	08:13	00:33	11:52	12:47	00:55	08:13	11:52	03:39	1.10	177	3.5	27	401	1.21	0	
40B	94	965.00	969.00	964.95	969.00	4.00	4.05	101%	17/11/2020	12:50	13:41	00:51	17:05	18:00	00:55	13:41	17:05	03:24	1.18	180	3.5	23	392	1.21	0	
41B	92-94	969.00	973.00	969.00	973.04	4.00	4.04	101%	17/11/2020	18:00	18:44	00:44	21:02	21:59	00:57	18:44	21:02	02:18	1.74	166	3.3	22	399	1.21	0	
42B	93-94	973.00	976.00	973.04	976.12	3.00	3.08	103%	17/11/2020	21:59	22:45	00:46	01:07	02:00	00:53	22:45	01:07	02:22	1.27	160	3.6	21	402	1.21	0	
43B	94	976.00	980.00	976.12	980.22	4.00	4.10	103%	17/11/2020	02:00	02:45	00:45	08:06	09:08	01:02	02:45	08:06	05:21	0.75	183	3.7	22	401	1.21	0	
44B	93-94	980.00	984.00	980.22	984.18	4.00	3.96	99%	18/11/2020	09:08	09:50	00:42	13:11	14:06	00:55	09:50	13:11	03:21	1.19	165	3.4	23	396	1.21	0	
45B	88-94	984.00	987.84	984.18	988.15	3.84	3.97	103%	18/11/2020	14:06	14:58	00:52	22:17	23:20	01:03	14:58	22:17	07:19	0.53	186	3.4	22	397	1.21	0	
46B	94	987.84	988.47	988.15	988.75	0.63	0.60	95%	18/11/2020	23:20	00:02	00:42	03:44	09:20	05:36	00:02	03:44	03:42	0.17	191	3.8	22	402	1.21	0	
47B	95	988.47	992.00	988.75	992.33	3.53	3.58	101%	19/11/2020	11:30	18:18	06:48	19:24	20:24	01:00	18:18	19:24	01:06	3.21	167	3.5	25	396	1.21	0	

Tab. J-2: continued

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]
48B	95	992.00	996.00	992.33	996.31	4.00	3.98	100%	19/11/2020	20:24	21:16	00:52	22:34	23:35	01:01	21:16	22:34	01:18	3.08	167	3.5	25	397	1.21	0	0.00
49B	95	996.00	1000.00	996.31	1000.33	4.00	4.02	101%	19/11/2020	23:35	23:35	00:00	01:25	02:23	00:58	23:35	01:25	01:02	3.87	168	3.8	20	376	1.21	5.5	88.71
50B	95	1000.00	1001.50	1000.33	1001.74	1.50	1.41	94%	19/11/2020	02:23	03:15	00:52	03:47	04:47	01:00	03:15	03:47	00:32	2.81	169	3.7	20	346	1.21	2.5	78.13
51B	95	1001.50	1007.00	1001.74	1007.22	5.50	5.48	100%	20/11/2020	16:55	19:55	03:00	21:48	22:51	01:03	19:55	21:48	01:53	2.92	170	4.2	20	307	1.15	11.6	102.65
52B	95	1007.00	1013.00	1007.22	1013.33	6.00	6.11	102%	20/11/2020	22:51	23:37	00:46	01:41	02:53	01:12	23:37	01:41	02:03	2.93	171	5.0	24	311	1.15	16	130.08
53B	95	1013.00	1019.00	1013.33	1019.30	6.00	5.97	100%	20/11/2020	02:53	03:43	00:50	05:52	07:08	01:16	03:43	05:52	02:09	2.79	172	5.2	23	307	1.15	19.0	147.29
54B	95	1019.00	1025.00	1019.30	1025.35	6.00	6.05	101%	21/11/2020	07:08	08:20	01:12	10:37	11:57	01:20	08:20	10:37	02:17	2.63	176	5.3	32	312	1.15	23.3	170.07
55B	95	1025.00	1031.00	1025.35	1031.38	6.00	6.03	101%	21/11/2020	11:57	12:59	01:02	15:24	16:37	01:13	12:59	15:24	02:25	2.48	175	5.4	30	297	1.15	28.2	194.48
56B	95	1031.00	1037.00	1031.38	1037.39	6.00	6.01	100%	21/11/2020	16:37	17:50	01:13	20:18	21:40	01:22	17:50	20:18	02:28	2.43	185	5.0	30	302	1.15	20	135.14

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: Casing / liner tally lists

Tab. K-1: 18⅝" tally list

Date: 04/05/2020		Marriott Rig # 16						
				Nagra Well: Bözberg 1-1				
Casing Tally List		17.755" ID	451mm		Centralizer			
Casing: 18 5/8"		torque	7940 ft/lbs		Bow Centrailzer	Ridgid Centralizer		
Joint #	Length	Total Length @ RT	GL depth	Drifted			UP/Dwn WT	Remarks
Shoe	0.765	0.77	-4.15					welded
1	13.110	13.88	8.97	x				
Float	0.415	14.29	9.38					baker locked/welded
2	13.110	27.40	22.49	x		x		
3	13.043	40.44	35.53	x		x	32/29	
4	13.112	53.56	48.65	x		x	35/31	
5	13.115	66.67	61.76	x				
6	13.119	79.79	74.88	x		x	38/35	
7	13.116	92.91	88.00	x				
8	13.720	106.63	101.72	x			45/40	
9	13.115	119.74	114.83	x				
10	13.103	132.84	127.93	x			53/46	
11	13.107	145.95	141.04	x				
12	13.110	159.06	154.15	x			60/55	
13	13.107	172.17	167.26	x				
14	13.110	185.28	180.37	x		x	65/60	
15	12.979	198.26	193.35	x		x		
16	13.118	211.37	206.46	x			74/67	
17	13.107	224.48	219.57	x		x		
18	13.108	237.59	232.68	x			86/73	
A	2.915	240.50	235.59	x				
19	13.115	253.62	247.86	x			95/85	85cm Stickup

Tab. K-2: 13⅜" tally list

Date: 20/6/2020 **Marriott Rig # 16**
Casing: 13 3/8" , 68 lb/ft K 55 BTC
Make up: 7000ft/lbs, Cap:0.01497bbl/ft
Metal disp:0.247bbls/ft **Nagra Well: Bözberg 1-1**
Casing Tally List
Casing: 13 3/8" , 68 lb/ft K 55 BTC

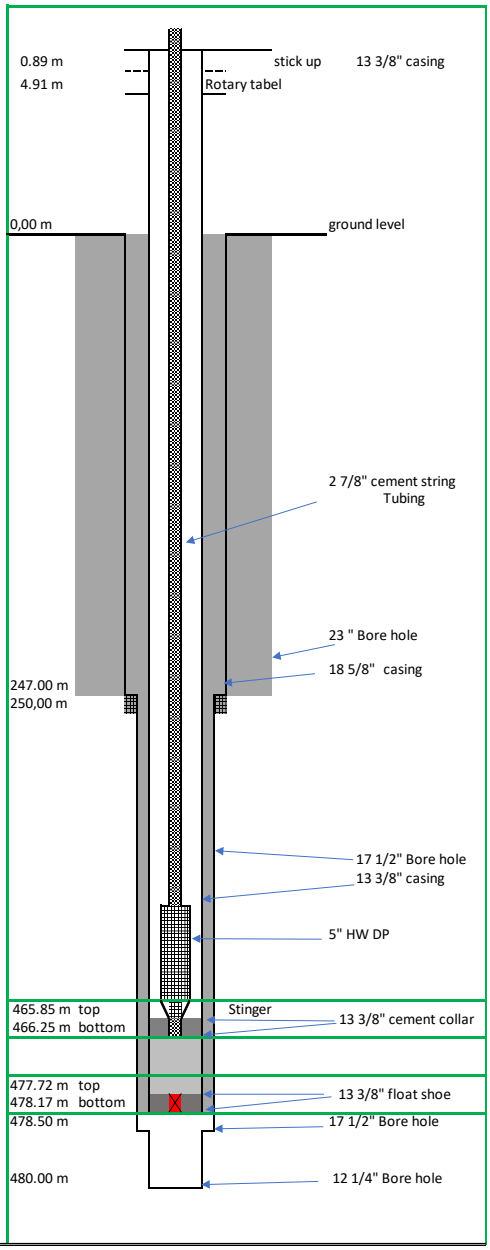
	ID	
	12.415"	**315.34mm**
GL to RT	4.91 m	

Centralizer
Bow Centrailzer **Ridgid Centralizer**

Joint #	Length	Total	Below GL	17 1/2" x 13 3/8"	18 5/8" 13 3/8"	Remarks
Shoe	**0.45**	0.45	-4.46			tack welding
1	11.47	11.92	7.01	1		tack welding
Float	0.40	12.32	7.41			tack welding
2	11.60	23.92	19.01	2		tack welding
3	11.59	35.51	30.60			tack welding
4	11.60	47.11	42.20	3		
5	11.47	58.58	53.67			
46	11.43	70.01	65.10	4		
44	11.33	81.34	76.43			
8	11.47	92.81	87.90	5		
9	11.59	104.40	99.49			
10	11.49	115.89	110.98	6		
11	11.60	127.49	122.58			
12	11.59	139.08	134.17	7		
13	11.45	150.53	145.62			
14	11.26	161.79	156.88	8		
15	11.60	173.39	168.48			
16	11.59	184.98	180.07	9		
17	11.47	196.45	191.54			
18	11.58	208.03	203.12	10		
19	11.57	219.60	214.69			
20	11.50	231.10	226.19	11		
21	11.57	242.67	237.76			
22	11.56	254.23	249.32	12		
23	11.47	265.70	260.79			
24	11.46	277.16	272.25	13		
25	11.57	288.73	283.82			
26	11.33	300.06	295.15	14		
27	11.57	311.63	306.72			
28	11.59	323.22	318.31	15		
29	11.57	334.79	329.88			
30	11.60	346.39	341.48	16		
31	10.76	357.15	352.24			
32	11.55	368.70	363.79	17		
33	11.58	380.28	375.37			
34	11.44	391.72	386.81	18		
35	11.57	403.29	398.38			
36	11.50	414.79	409.88	19		
37	11.57	426.36	421.45			
38	11.43	437.79	432.88	20		
39	11.58	449.37	444.46			
40	11.58	460.95	456.04	21		
41	11.57	472.52	467.61			
42	11.45	483.97	478.17	22		
	Stick up RT	0.89 m				

Stay out of hole

Pup jnt 1	9.00	10.89	x			
Pup jnt 2	6.00	11.70	X			
Pup jnt 3	6.00	11.73	X			
43	11.59					
7	11.61					
45	11.59					
6	11.60					



Tab. K-3: 9⅝" tally list

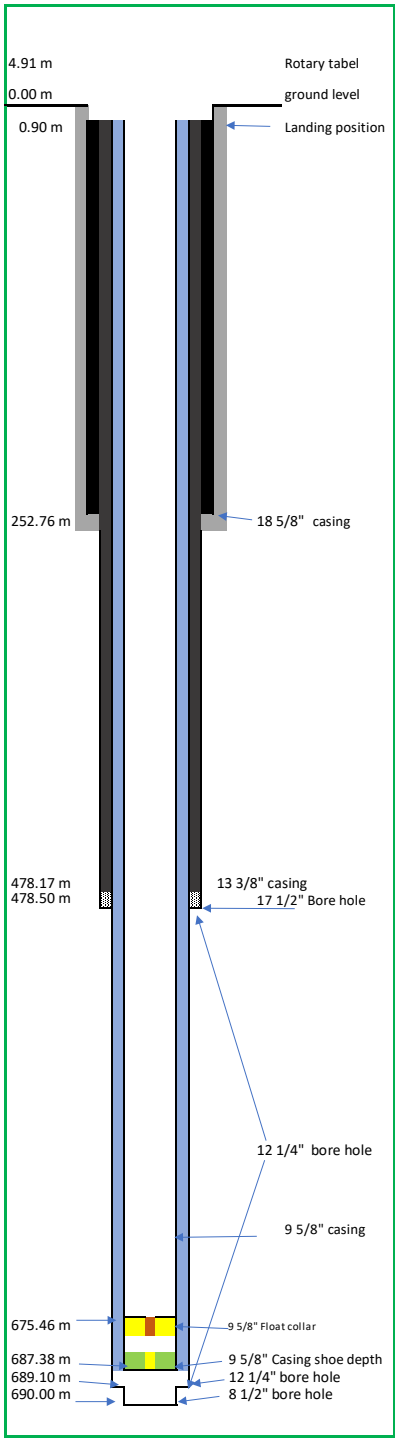
Date: 26/08/20 **Marriott Rig # 16**

Casing Tally List **hole depth** 690 metres

Casing: 9 5/8" 40 lb/ft **12 1/4" depth** 689.10 metres **Nagra Well: Bözberg 1**

Shoe depth 687.38 metres

				Final position in hole BGL			
Joint #		**Length**	**Total**	**from**	**to**	**Centralizer**	Remarks
Float Shoe		**0.5**	**0.5**				tack weld
1		11.06	11.56			x,x	
Float collar		0.35	11.91				tack weld
2		10.92	22.83			x,x	tack weld
3		11.43	34.26			x	tack weld
4		10.98	45.24				
5		11.45	56.69			x	
6		11.14	67.83				
7		11.21	79.04			x	
8		11.27	90.31				
9		11.34	101.65			x	
10		11.31	112.96				
11		11.23	124.19			x	
12		11.60	135.79				
13		11.29	147.08			x	
14		10.97	158.05				
15		11.35	169.40			x	
16		11.42	180.82				
17		11.43	192.25			x	
18		10.99	203.24				
19		11.01	214.25			x	
20		11.10	225.35				
21		11.41	236.76			x	
22		11.33	248.09				
23		11.21	259.30				
24		11.38	270.68			x	
25		11.07	281.75				
26		11.65	293.40				
27		11.33	304.73			x	
28		11.64	316.37				
29		11.40	327.77				
30		11.47	339.24			x	
31		11.39	350.63				
32		11.42	362.05				
33		11.39	373.44			x	
34		11.28	384.72				
35		11.24	395.96				
36		11.17	407.13			x	
37		11.18	418.31				
38		11.07	429.38				
39		11.08	440.46			x	
40		11.15	451.61				
41		11.65	463.26				
42		11.60	474.86			x	
43		11.65	486.51				
44		11.15	497.66				
45		11.30	508.96			x	
46		11.29	520.25				
47		11.21	531.46				
48		10.89	542.35			x	
49		11.26	553.61				
50		11.17	564.78				
51		11.00	575.78			x	
52		11.17	586.95				
53		11.20	598.15				
54		11.41	609.56			x	
55		11.45	621.01				
56		11.41	632.42				
57		11.46	643.88			Rigid	
58		11.40	655.28				
59		11.45	666.73			Rigid	
PJ	1	5.88	672.61				
PJ	3	2.87	675.48				
60		11.00	686.48	687.38 m BGL		Rigid	
Stay out of hole							
61		11.67					
62		11.65					
63		11.67					
64		11.60					
65		11.68					
66		11.43					
Pup joint 2		5.87					
Pup joint 4		2.88					



Tab. K-4: 7⅝" tally list

Marriott DRILLING GROUP

Date	01/11/2020
BHA #	7 5/8" Liner Hanger
Rig #	16
Well #	Nagra Bozberg B1

Item	Description	Length	Acc Length	Total Depth-BGL	Remarks
1	Casing Shoe	0.67	0.67	-4.33	
2	7 5/8 Casing	11.47	12.14	7.14	
3	Float Collar	0.43	12.57	7.57	
4	7 5/8 Casing	11.51	24.08	19.08	
5	Landing Collar	0.39	24.47	19.47	
6	7 5/8 Casing	10.84	35.31	30.31	
7	7 5/8 Casing	11.55	46.86	41.86	
8	7 5/8 Casing	11.16	58.02	53.02	
9	7 5/8 Casing	11.55	69.57	64.57	
10	7 5/8 Casing	11.24	80.81	75.81	
11	7 5/8 Casing	11.64	92.45	87.45	
12	7 5/8 Casing	11.08	103.53	98.53	
13	7 5/8 Casing	11.42	114.95	109.95	
14	7 5/8 Casing	11.65	126.60	121.60	
15	7 5/8 Casing	11.55	138.15	133.15	
16	7 5/8 Casing	11.55	149.70	144.70	Top of liner = 667.80
17	Liner Hanger	6.50	156.20	151.20	
18	Running tool	2.96	159.16	154.16	
19	X/O	0.60	159.76	154.76	
20	6 1/2" DC	9.34	169.10	164.10	
21	6 1/2" DC	9.23	178.33	173.33	
22	6 1/2" DC	9.32	187.65	182.65	
23	6 1/2" DC	9.29	196.94	191.94	
24	6 1/2" DC	9.28	206.22	201.22	
25	6 1/2" DC	9.21	215.43	210.43	
26	6 1/2" DC	9.24	224.67	219.67	
27	6 1/2" DC	9.35	234.02	229.02	
28	6 1/2" DC	9.27	243.29	238.29	
29	6 1/2" DC	9.26	252.55	247.55	
30	6 1/2" DC	9.36	261.91	256.91	
31	6 1/2"DC	9.24	271.15	266.15	
32	X/O	0.45	271.60	266.60	
33	HWDP	9.36	280.96	275.96	
34	HWDP	9.36	290.32	285.32	
35	HWDP	9.36	299.68	294.68	
36	HWDP	9.36	309.04	304.04	
37	HWDP	9.36	318.40	313.40	
38	HWDP	9.28	327.68	322.68	
39	HWDP	9.36	337.04	332.04	
40					

Comments:

Appendix L: Cementation data and cement bond

Figs. L-1 to L-2 show the cement charts, cementing programmes and cement plugs for the different casings. In Tabs. L-1 – L-4 data of the cement bonds are included.

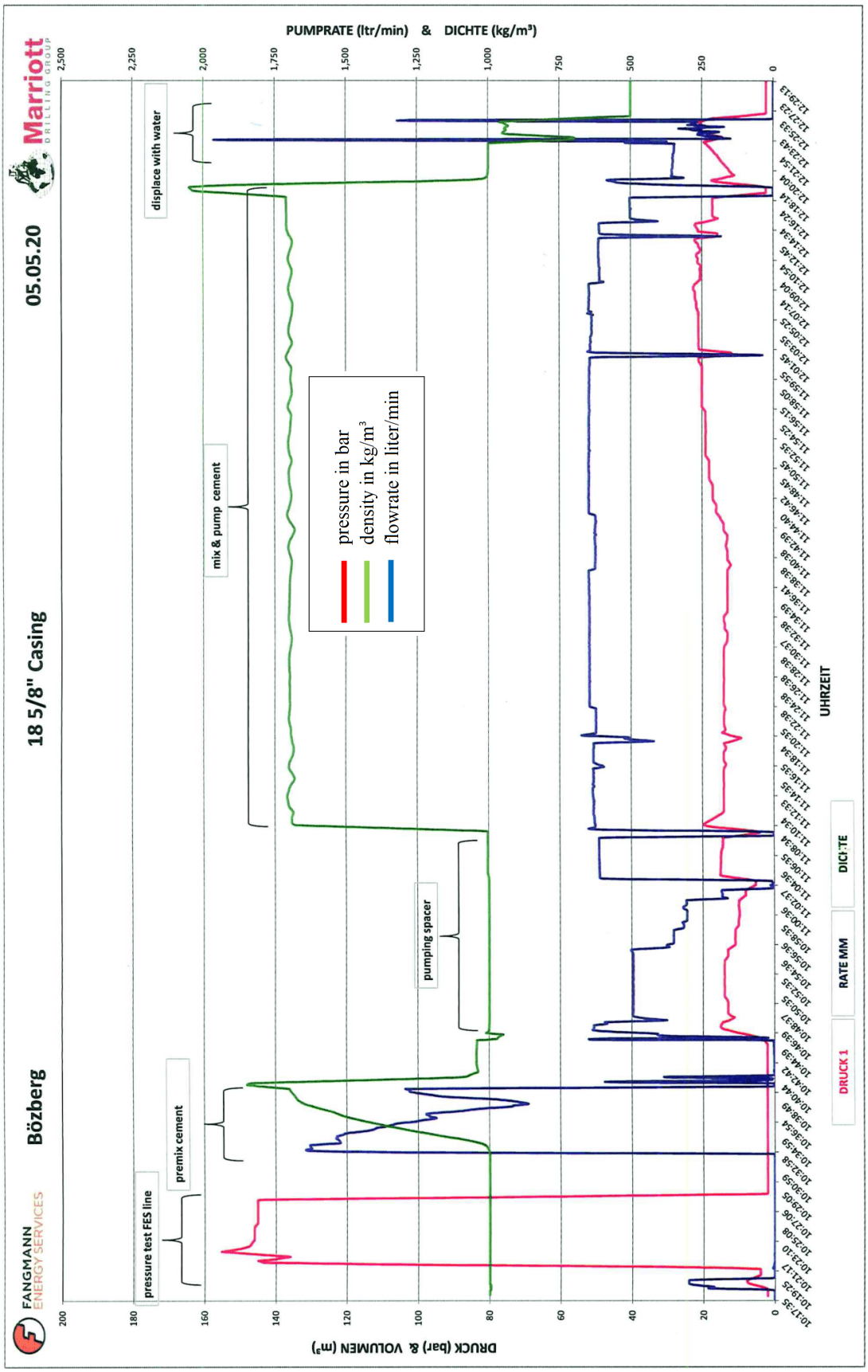


Fig. L-1: 18⅝" cementing chart

FANGMANN ENERGY SERVICES

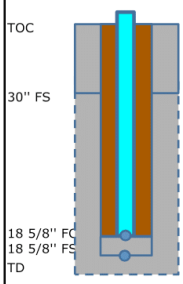
Client: Marriott Drilling
Well: Bözberg
Cementing: 18 5/8" Casing

MD 220,0 m
TVD 220,0 m
Max. Dev 0°

BHST 25°C
Test Temp. 22°C

Marriott DRILLING GROUP

Volume Calculation



	OD	Description	Length	Capacity		Comment	Volume
Previous casing	**30 "**	**157,7 ppf**	40m	**426,80l/m**		Total cap.	+ 17,07 m³
			0m	0,00l/m			+ 0,0 m³
Open hole	**23 "**	35% OH XS	180m	**268,20l/m**		OH without XS	+ 48,28 m³
	26,67 "	**100% annular XS**		184,86l/m in annulus		OH XS	+ 16,66 m³
					Displacement		
Casing to be cemented	**18 5/8 "**	**94,5 ppf**	220m	**158,19l/m**	175,87l/m	Total displ.	- 38,69m³
			0m	0,00l/m	0,00l/m		- 0,00m³
			0m	0,00l/m	0,00l/m		- 0,00m³
			12m			Shoetrack	+ 1,9 m³
						Cement volume	**48,40m³**
Drill pipe	**2 7/8 "**	**6,5 ppf**	217m	**3,02l/m**		Total cap.	0,66m³
			0m	0,00l/m			0,00m³
			0m	0,00l/m			0,00m³
						Displacement volume	**0,66m³**

End pressure **24 bar**

Fluid Design

Spacer	**1,00kg/l**	dead vol. 0,2 m³ per m³	**10,2m³** total		**Cement**	**1,70kg/l**	dead vol. 0,5 m³ per ton cmt.	per m³	**48,9m³** total
Fresh water	lt	1000,0	10200,0		Fresh water	lt	610,8	642,1	31398,4
					CAF-902	lt	**1,0**	1,1	51,4
					CXT-621	kg	**1,5**	1,6	77,1
					CMT-003	tonne	**1,0**	1,1	51,4
					CLC-602	kg	5,7	**6,0**	293,0
Yield	lt	1000,0			Yield	lt	951,3		

Logistics

Personnel		**Equipment**		**Material**		Quantity	Comments
Supervisor:	1	Pumptruck	1x	CMT-003	CEM III B Cement	51,40 tonne	
Operator:	Pump	incl. Data recording		CAF-902	Antifoam	51,40 lt	
Operator:	Mixtank	Mixtank	1x	CXT-621	Bentonite	77,11 kg	adds. to cmt. E-modulus
Operator:	Bulk	Generator, Compressor	2x	CLC-602	CemFibers	200,00 kg	adds to cmt. tensile str.
		Bulktruck	1x	SK80	Wiperball 80	1,00 EA	DP cleaning
		incl. Compressor					
		27 t Cement silo	2x				
		30 m³ Vertical tank	1x				
		From client:		From client:			
		Suction truck	1x	Fresh water for spacer		11,16 m³	
		(fluids disposal)		Fresh water for cement		31,40 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 first 7 m³ of cement					20
	Pump fresh water spacer	54 m	10,00	1,00	1000	10
	Mix & pump cement		48,40	1,00	800	61
	(after the first 7 m³ pumped, start adding fibers 6 kg./m³)					
	when 2,5 m³ of cement to surface, switch to displacement					
	Pump fresh water		0,36	1,00	800	0
	Pump fresh water (surface lines)		0,30	1,00	300	1
	Flow Check, Sting-out, Circulate DP clean + Sponge ball, WOC (check with surface sample)					15
					Pumping time:	**107min**

Recommendations / Comments
- OH XS, tubular capacities & mud weight to be confirmed
- **casing to be chained down to avoind any lifting while pumping**
- fibers and bentonite are used to add in cement flexibility @ FIT against the weak formation

Document info
Prepared: T. Precup
Client: Marriott Drilling
Version #: 2
Status: Draft
Date: 29.04.2020

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. L-2: 18⅝" cementing programme

Tab. L-1: 18⅝" cement bond

From	To	Lithostratigraphic units	Zone description
(m MD)			
Surface		***Top of cement***	
0	15.6	Quaternary, OSM	Readings attenuated
40.5		30" conductor pipe	
15.6	62	OSM	High CBL amplitude, with strong casing arrivals and mud arrivals evident on the VDL; strong chevron patterns are also present on the VDL and cement is weakly bonded to the casing, possibly due to the presence of a micro-annulus – poor bond
62	112	OSM, OMM, USM / OMM, Siderolithikum Villigen Fm.	Medium to high CBL amplitude, with medium casing arrivals and visible formation arrivals on the VDL, but the cement bond is weak as indicated by the casing signals and chevron patterns – medium bond
112	180.7	Villigen Fm. Wildegg Fm.	Medium CBL amplitude, with weak and 'wavy' casing arrivals on the VDL affected by the fast limestone arrivals across the interval; collar rings are dampened indicating a better bond – medium bond
180.7	232	Wildegg Fm.	Medium to low CBL amplitude, weak casing arrivals and stronger formation arrivals on the VDL, improved bond in this interval – medium bond
232	247.2	Wildegg Fm.	CBL amplitude indicates full bond, with strong formation arrivals and no casing arrivals on the VDL, chevron patterns are fully dampened and barely visible, excellent zonal isolation around the casing shoe – good bond
247.85		18⅝" casing shoe (not logged)	

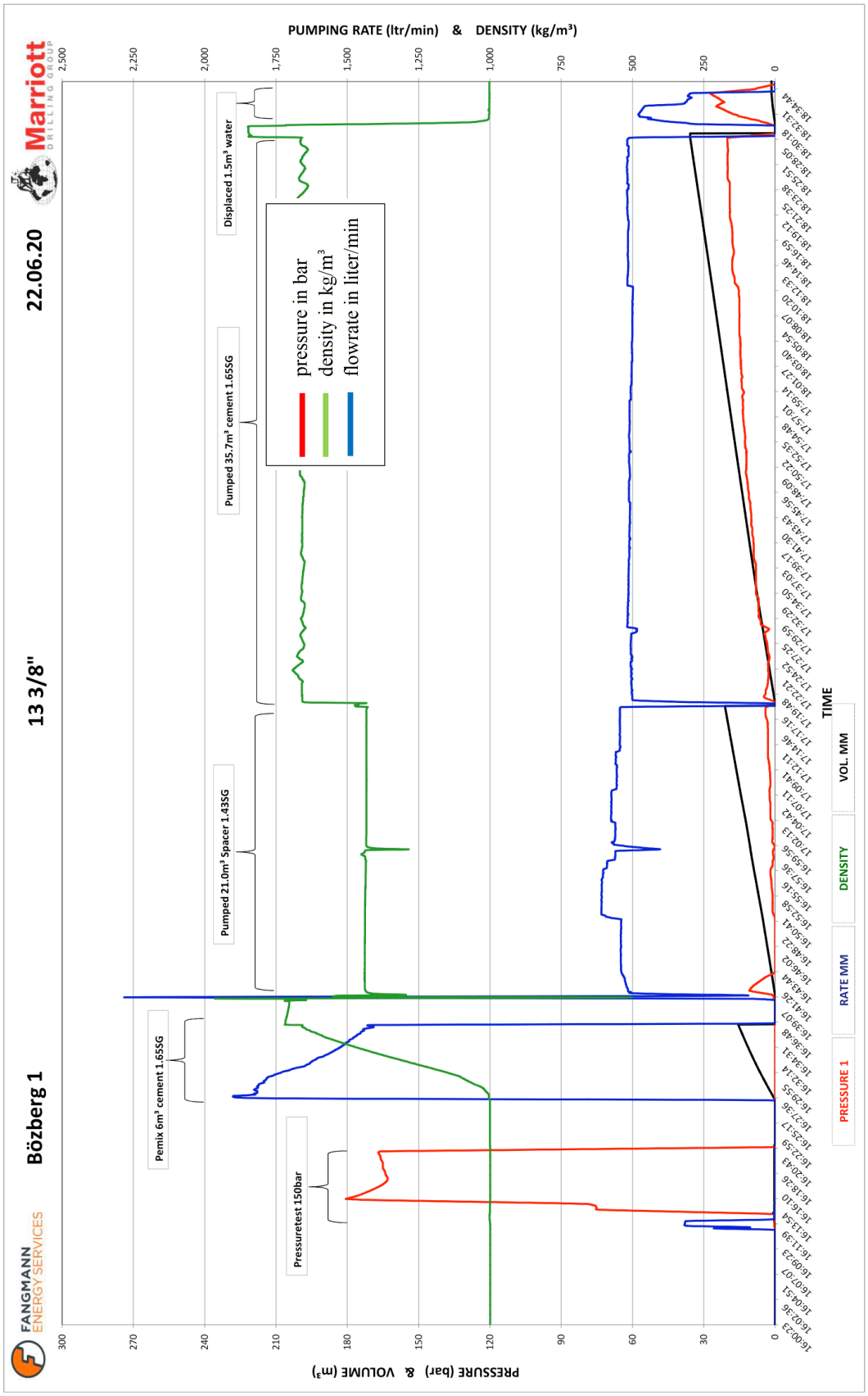
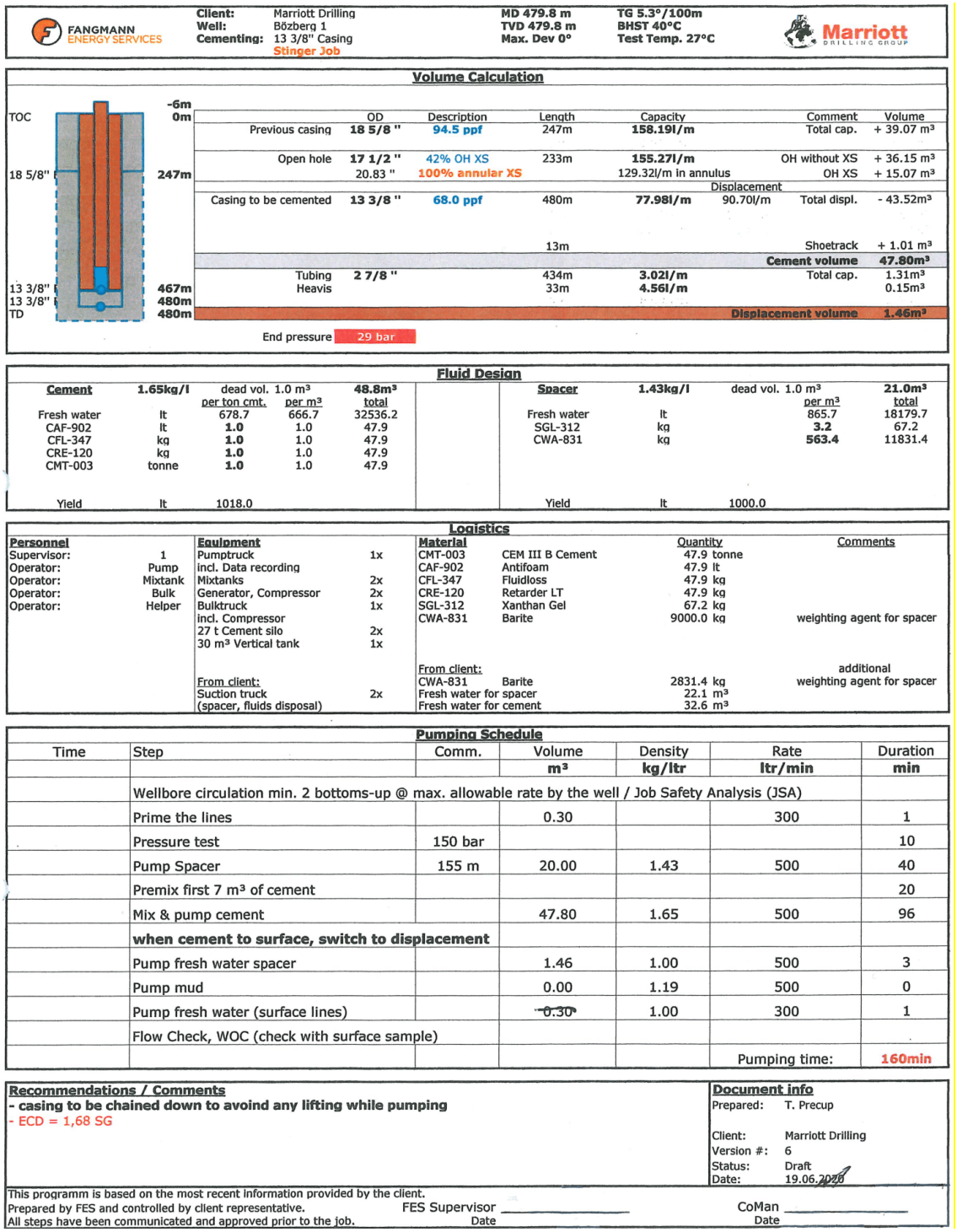


Fig. L-3: 13⅜" cement chart



FANGMANN ENERGY SERVICES

Client: Marriott Drilling
Well: Bözberg 1
Cementing: 13 3/8" Casing
Stinger Job

MD 479.8 m **TVD 479.8 m** **Max. Dev 0°**
TG 5.3°/100m **BHST 40°C** **Test Temp. 27°C**

Marriott DRILLING GROUP

Volume Calculation

		OD	Description	Length	Capacity		Comment	Volume
	Previous casing	**18 5/8 "**	**94.5 ppf**	247m	**158.19l/m**		Total cap.	+ 39.07 m³
	Open hole	**17 1/2 "**	42% OH XS	233m	**155.27l/m**		OH without XS	+ 36.15 m³
		20.83 "	**100% annular XS**		129.32l/m in annulus		OH XS	+ 15.07 m³
						Displacement		
	Casing to be cemented	**13 3/8 "**	**68.0 ppf**	480m	**77.98l/m**	90.70l/m	Total displ.	- 43.52m³
				13m			Shoetrack	+ 1.01 m³
							Cement volume	**47.80m³**
	Tubing	**2 7/8 "**		434m	**3.02l/m**		Total cap.	1.31m³
	Heavis			33m	**4.56l/m**			0.15m³
							Displacement volume	**1.46m³**

End pressure 29 bar

Fluid Design

Cement	**1.65kg/l**	dead vol. 1.0 m³ per ton cmt.	per m³	**48.8m³** total
Fresh water	lt	678.7	666.7	32536.2
CAF-902	lt	**1.0**	1.0	47.9
CFL-347	kg	**1.0**	1.0	47.9
CRE-120	kg	**1.0**	1.0	47.9
CMT-003	tonne	**1.0**	1.0	47.9
Yield	lt	1018.0		

Spacer	**1.43kg/l**	dead vol. 1.0 m³ per m³	**21.0m³** total
Fresh water	lt	865.7	18179.7
SGL-312	kg	**3.2**	67.2
CWA-831	kg	**563.4**	11831.4
Yield	lt	1000.0	

Logistics

Personnel	
Supervisor:	1
Operator:	Pump
Operator:	Mixtank
Operator:	Bulk
Operator:	Helper

Equipment	
Pumptruck incl. Data recording	1x
Mixtanks	2x
Generator, Compressor	2x
Bulktruck incl. Compressor	1x
27 t Cement silo	2x
30 m³ Vertical tank	1x
From client:	
Suction truck (spacer, fluids disposal)	2x

Material		Quantity	Comments
CMT-003	CEM III B Cement	47.9 tonne	
CAF-902	Antifoam	47.9 lt	
CFL-347	Fluidloss	47.9 kg	
CRE-120	Retarder LT	47.9 kg	
SGL-312	Xanthan Gel	67.2 kg	
CWA-831	Barite	9000.0 kg	weighting agent for spacer
From client:			additional
CWA-831	Barite	2831.4 kg	weighting agent for spacer
Fresh water for spacer		22.1 m³	
Fresh water for cement		32.6 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				10
	Pump Spacer	155 m	20.00	1.43	500	40
	Premix first 7 m³ of cement					20
	Mix & pump cement		47.80	1.65	500	96
	when cement to surface, switch to displacement					
	Pump fresh water spacer		1.46	1.00	500	3
	Pump mud		0.00	1.19	500	0
	Pump fresh water (surface lines)		~~0.30~~	1.00	300	1
	Flow Check, WOC (check with surface sample)					
					Pumping time:	**160min**

Recommendations / Comments
- casing to be chained down to avoind any lifting while pumping
- ECD = 1,68 SG

Document info
Prepared: T. Precup
Client: Marriott Drilling
Version #: 6
Status: Draft
Date: 19.06.2020

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. L-4: 13⅜" cement programme

Tab. L-2: 13⅜" cement bond

From	To	Lithostratigraphic units	Zone description
(m MD)			
Surface		***Top of cement***	
0	5.1	Quaternary, OSM	Readings attenuated
40.5		30" conductor pipe	
5.1	156	OSM, OMM, USM / OMM, Siderolithikum Villigen Fm. Wildegg Fm.	Low CBL amplitude (10 mV) given the large casing and casing-in-casing scenario, with visible casing arrivals and strong formation arrivals on the VDL; Based on the USIT, there are few areas with weaker bond, some narrow liquid channels and de-bonded patches are present, which may be caused by limited mud removal at areas of restricted flow near the casing collars, but this does not affect overall zonal isolation – medium bond
156	246	Wildegg Fm.	Low CBL amplitude, with visible formation and casing arrivals on the VDL; USIT shows overall darker colour on the cement map than in the previous section, with a few pockets of liquid and some channels – good bond
247.85		18⅝" casing shoe	
246	252	Wildegg Fm.	Around the 18 5/8" casing shoe the amplitude is very low and strong casing arrivals are present on the VDL; the bond index shows pockets of liquid and gas but no cement, with the acoustic impedance reaching a very high value; this area could either be affected by channelling or poor cementing due to the larger hole size (compared to the rathole in the previous section) – poor bond
252	302	Wildegg Fm.	Low CBL amplitude and strong formation arrivals on the VDL; USIT indicates good cement with high acoustic impedance – good bond
302	318	Wildegg Fm.	CBL amplitude indicates full bond, with no casing arrivals and fast formation arrivals on the VDL; USIT shows strong acoustic impedance and darker colours on the cement map, indicating excellent zonal isolation in this formation, which provides the cemented annulus with extra shear bond support and enhances bonding – good bond
318	387	Wildegg Fm.	Low CBL amplitude, with strong formation arrivals on the VDL, the changes in bond correlate to formation effects; USIT shows clear indications of many formation effects and full circumferential coverage (no channelling) on the acoustic impedance map confirms that excellent zonal isolation was achieved – good bond

Tab. L-2: continued

From	To	Lithostratigraphic units	Zone description
(m MD)			
387	395.5	Wildegg Fm.	Medium CBL amplitude and visible casing arrivals on the VDL; bond index shows liquid channelling in this area; a formation breakout seems to affect the cement bonding behind the casing – medium bond
395.5	478	Wildegg Fm. Ifenthal Fm. Hauptrogenstein Klingnau Fm. Hauptrogenstein	Very low CBL amplitude, with strong formation arrivals on the VDL and no channelling visible on the USIT, indicating good quality cement – good bond
478.08		13⅜" casing shoe (not logged)	

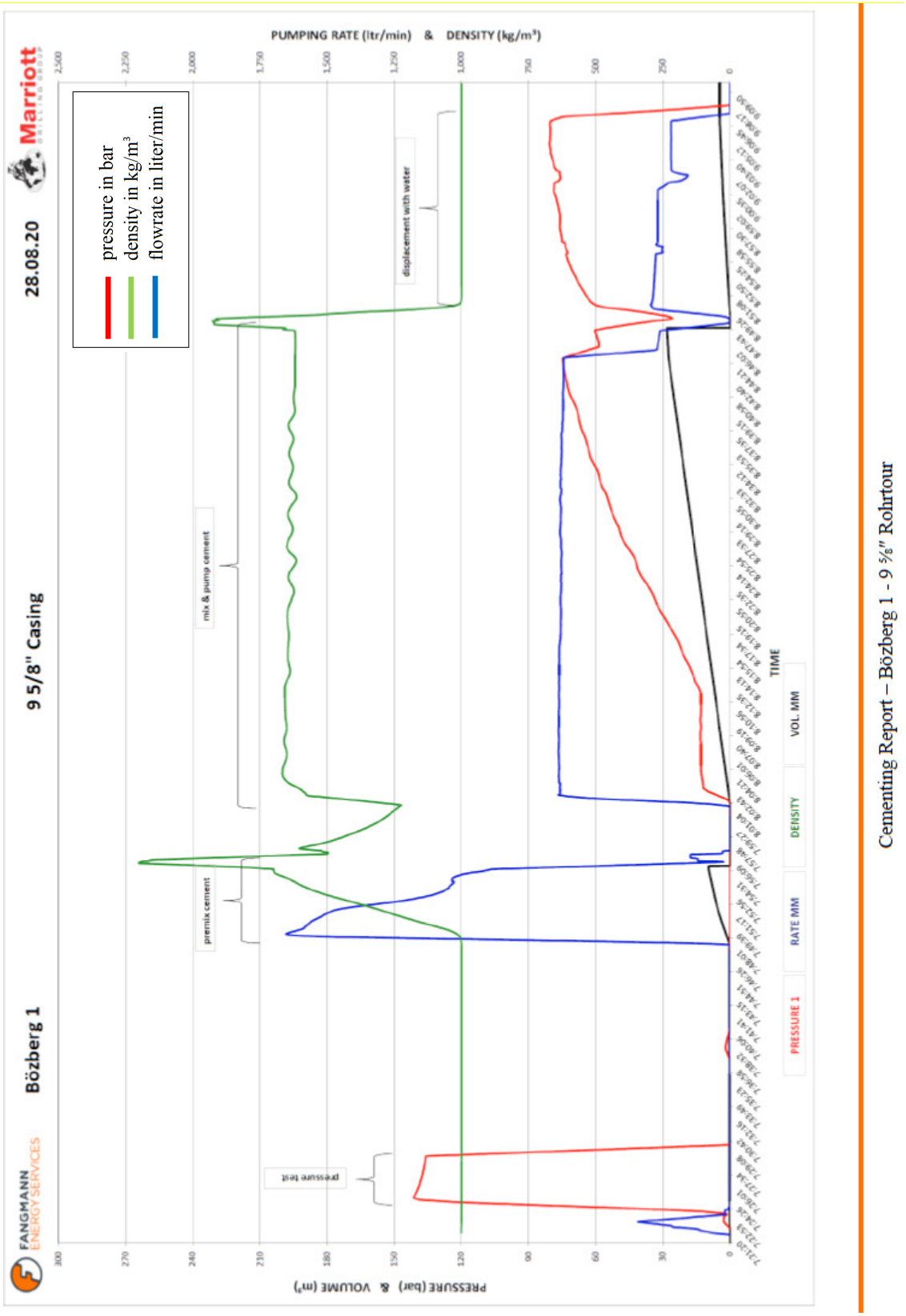
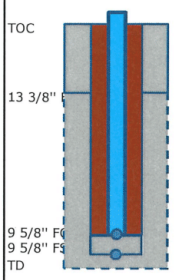


Fig. L-5: 9⅝" cement chart

FANGMANN ENERGY SERVICES

Client:	Marriott Drilling	**MD 690,0 m**	**TG 3,9°/100m**	Marriott DRILLING GROUP	
Well:	Bözberg 1	**TVD 690,0 m**	**BHST 42°C**		
Cementing:	9 5/8" Casing	**Max. Dev 0°**	**Test Temp. 35°C**		

Volume Calculation



-9m								
0m		OD	Description	Length	Capacity		Comment	Volume
	Previous casing	**13 3/8 "**	**68,0 ppf**	478m	**77,98l/m**		Total cap.	+ 37,27 m³
				0m	0,00l/m			+ 0,0 m³
	Open hole	**12 1/4 "**	10% OH XS	212m	**76,08l/m**		OH without XS	+ 16,13 m³
478m		12,85 "	**26% annular XS**		36,72l/m in annulus		OH XS	+ 1,61 m³
						Displacement		
	Casing to be cemented	**9 5/8 "**	**40,0 ppf**	688m	**39,49l/m**	46,97l/m	Total displ.	- 32,33m³
				0m	0,00l/m	0,00l/m		- 0,00m³
				0m	0,00l/m	0,00l/m		- 0,00m³
				12m			Shoetrack	+ 0,47 m³
							Cement volume	**29,40m³**
	Drill pipe	**5 "**		685m	**9,05l/m**		Total cap.	6,20m³
676m				0m	0,00l/m			0,00m³
688m				0m	0,00l/m			0,00m³
690m							Displacement volume	6,20m³

End pressure **49 bar** ECD **1,71 SG** Formation grad. **1,82 SG**

Fluid Design

Spacer	**1,40kg/l**	dead vol. 0,5 m³	**20,5m³**		**Cement**	**1,65kg/l**	dead vol. 0,5 m³		**29,9m³**
		per m³	total				per ton cmt.	per m³	total
Fresh water	lt	875,1	17939,6		Fresh water	lt	670,2	660,9	19760,7
SGL-312	kg	**3,0**	61,5		CAF-902	lt	**2,0**	2,0	59,0
CWA-831	kg	**524,5**	10752,3		CXT-621	kg	**1,5**	1,5	44,2
					CRE-120	kg	**1,3**	1,3	38,3
					CMT-003	tonne	**1,0**	1,0	29,5
Yield	lt	1000,0			Yield	lt	1014,1		

Logistics

Personnel		**Equipment**		**Material**		Quantity	Comments
Supervisor:	1	Pumptruck	1x	CMT-003	CEM III B Cement	29,5 tonne	**Bulktruck & Silo 19**
Operator:	Pump	incl. Data recording		CAF-902	Antifoam	59,0 lt	
Operator:	Mixtank	Mixtank	1x	CXT-621	Bentonite	44,2 kg	
Operator:	Bulk	incl. Power source		CRE-120	Retarder LT	38,3 kg	Lot.-Nr. MM11K-06S3
		Bulktruck	1x	SGL-312	Xanthan Gel	61,5 kg	
		incl. Compressor		CWA-831	Barite	10752,3 kg	
		30 m³ Vertical tank	1x				
		From client:		From client:			
		Suction truck	1x	Fresh water for spacer		26,5 m³	
		(spacer, fluids disposal)		Fresh water for cement		37,8 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 first 6 m³ of cement					20
	Pump Spacer	545 m	20,00	1,40	600	33
	Mix & pump cement		29,40	1,65	600	49
	when cement to surface, switch to displacement					
	Pump fresh water		5,90	1,00	500	12
	Pump fresh water (surface lines)		0,30	1,00	300	1
	Flow Check, Sting-out, Circulate DP clean, WOC (check with surface sample)					15
					Pumping time:	**130min**

Recommendations / Comments
- tubular capacities to be confirmed
- casing to be chained down to avoind any lifting while pumping
- OH-vol. as per caliper 16,2 m³

Document info
Prepared: T. Precup
Client: Marriott Drilling
Version #: 3
Status: Draft
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Fig. L-6: 9⅝" cement programme

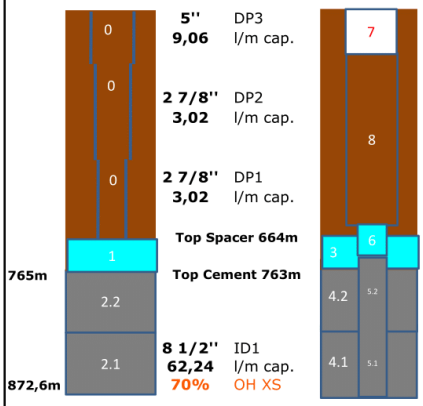
Tab. L-3: 9⅝" cement bond

From	To	Lithostratigraphic units	Zone description
(m MD)			
Surface		***Top of cement***	
0	10.5	Quaternary, OSM	Readings attenuated
40.50		30" conductor pipe	
10.5	52	OSM	Medium CBL amplitude (10 mV – 25 mV), with strong casing and formation arrivals on the VDL; bond index along with low acoustic impedance (mean 0.6 MRayl) indicate very little to no cement; the dampened casing collars on the VDL indicate the presence of some cement; bond is possibly lower here due to the leading-edge of cement intermixing with the spacer – medium bond
52	145	OSM, OMM, USM / OMM, Siderolithikum Villigen Fm.	CBL amplitude lower than above, with strong formation arrivals on the VDL and medium to low (1 – 5 MRayl) acoustic impedance, darker colours on cement map indicate improved cement in this interval – medium bond
145	205	Villigen Fm. Wildegg Fm.	Low to medium CBL amplitude (5 mV – 20 mV), with stronger casing arrivals on the VDL; the acoustic impedance is low and the cement map indicates little cement – medium bond
247.85		18⅝" casing shoe	
205	478	Wildegg Fm. Ifenthal Fm. Hauptrogenstein Klingnau Fm. Hauptrogenstein	Low CBL amplitude, with visible casing arrivals, strong formation arrivals and dampened casing collars on the VDL; although strongly dampened by the cement, in the casing-in-casing interval, can also see the 13 3/8" casing collars suggesting that they are strongly bonded to the 9 5/8" casing; CBL / VDL results are not consistent with the USIT, which show low acoustic impedance (1.6 MRayl) and little cement on the bond index; USIT is affected by the dual-steel casing in this interval – medium bond
478.08		13⅜" casing shoe	
478	688	Hauptrogenstein Passwang Fm. Opalinus Clay Staffelegg Fm.	CBL amplitude indicates full bond, with strong formation arrivals and no casing arrivals on the VDL; USIT indicates very good cement, high acoustic impedance and excellent zonal isolation; the cement map shows strong cement and no channelling – good bond
687.4		9⅝" casing shoe (not logged)	

FANGMANN ENERGY SERVICES

Client	Marriott Drilling	**MD 872,6 m**	**TG 4,0°/100m**	Marriott DRILLING GROUP
Well	Bözberg 1	**TVD 872,6 m**	**BHST 50°C**	
Cementing	Plug 1	**Max. Dev 3,5°**	**Test Temp. 36°C**	

Wellbore schematic without and with drill pipes



Volume Calculation

0	Surface lines				0,30m³
		5'' DP3	0m	9,06l/m	0,00m³
	Total DP 873 m	2 7/8'' DP2	**87m**	3,02l/m	0,26m³
		2 7/8'' DP1	**786m**	3,02l/m	2,37m³
1	**Total Spacer**	Top 664m	101m	62,24l/m	6,30m³
2	**Cement plug**	2.2	54m	62,24l/m	3,35m³
		2.1	54m	62,24l/m	3,35m³
					6,70m³
3	**Spacer ahead**		103m	58,05l/m	**6,00m³**
4	**Cement in Annular**	4.2	56m	58,05l/m	3,25m³
		4.1	54m	58,05l/m	3,12m³
5	**Cement in DP**	5.2	56m	3,02l/m	0,17m³
		5.1	54m	3,02l/m	0,16m³
6	**Spacer behind**		103m		0,30m³
	Cement to be circulated depth		**780m**		
7	**Underdisplacement**				0,30m³
8	**Mud displacement**				2,00m³

Fluid Design

Spacer	**1,00kg/l**	dead vol. 0,2 m³	**6,5m³**
		per m³	total
Fresh water	lt	1000,0	6500,0
Yield	lt	1000,0	

Cement	**1,35kg/l**	dead vol. 0,5 m³		**7,2m³**
		per ton cmt.	per m³	total
Fresh water	lt	1007,9	616,3	4437,2
CAF-902	lt	**2,0**	1,2	8,8
CXT-621	kg	**4,0**	2,4	17,6
CFL-347	kg	**0,5**	0,3	2,2
BLN-007	tonne	**1,2**	0,7	5,3
CLC-602	kg	6,5	**4,0**	28,6
Yield	lt	1635,5		

Logistics

Personnel		**Equipment**		**Material**		Quantity	Comments
Supervisor:	1	Pumptruck	1x	BLN-007	HOZlite	5,27 tonne	
Operator:	Pump	incl. Data recording		CAF-902	Antifoam	8,80 lt	
Operator:	Mixtank	7 m³ Mixtank	1x	CXT-621	Wyoming API Bentonite	17,61 kg	
Operator:	Bulk	incl. Power source		CFL-347	Fluidloss	2,20 kg	
		Bulktruck	1x	CLC-602	CemFibers	26,80 kg	LCM, 4 kg./m³
		incl. Compressor					
		From client:		From client:			
		Suction truck	1x	Fresh water for spacer, prime & displ.		6,90 m³	
		(fluids disposal)		Fresh water for cement		4,50 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 fresh water spacer ahead		6,00	1,00	450	13
	Pump cement slurry		6,70	1,35	450	15
	Total displacement volume	2,30m³				
	Pump fresh water spacer behind		0,30	1,00	450	1
	Pump mud		1,70	1,15	450	4
	Pump fresh water (surface lines)		0,30	1,00	300	1
	Flow check, POOH, Reverse circulate @	780m				30
					Pumping time:	**84min**

Recommendations / Comments

- in case of pressure increase during displacement, stop pumping to avoid overdisplacement (continue with flow check, POOH & reverse circulate)

Document info

Prepared: T. Precup
Client: Marriott Drilling
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Status: Field Version
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This programm is based on the most recent information provided by the client.
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All steps have been communicated and approved prior to the job.

FES Supervisor _____ Date

CoMan _____ Date

Fig. L-7: Cement plug below 9⅝" casing; cementing programme plug 1

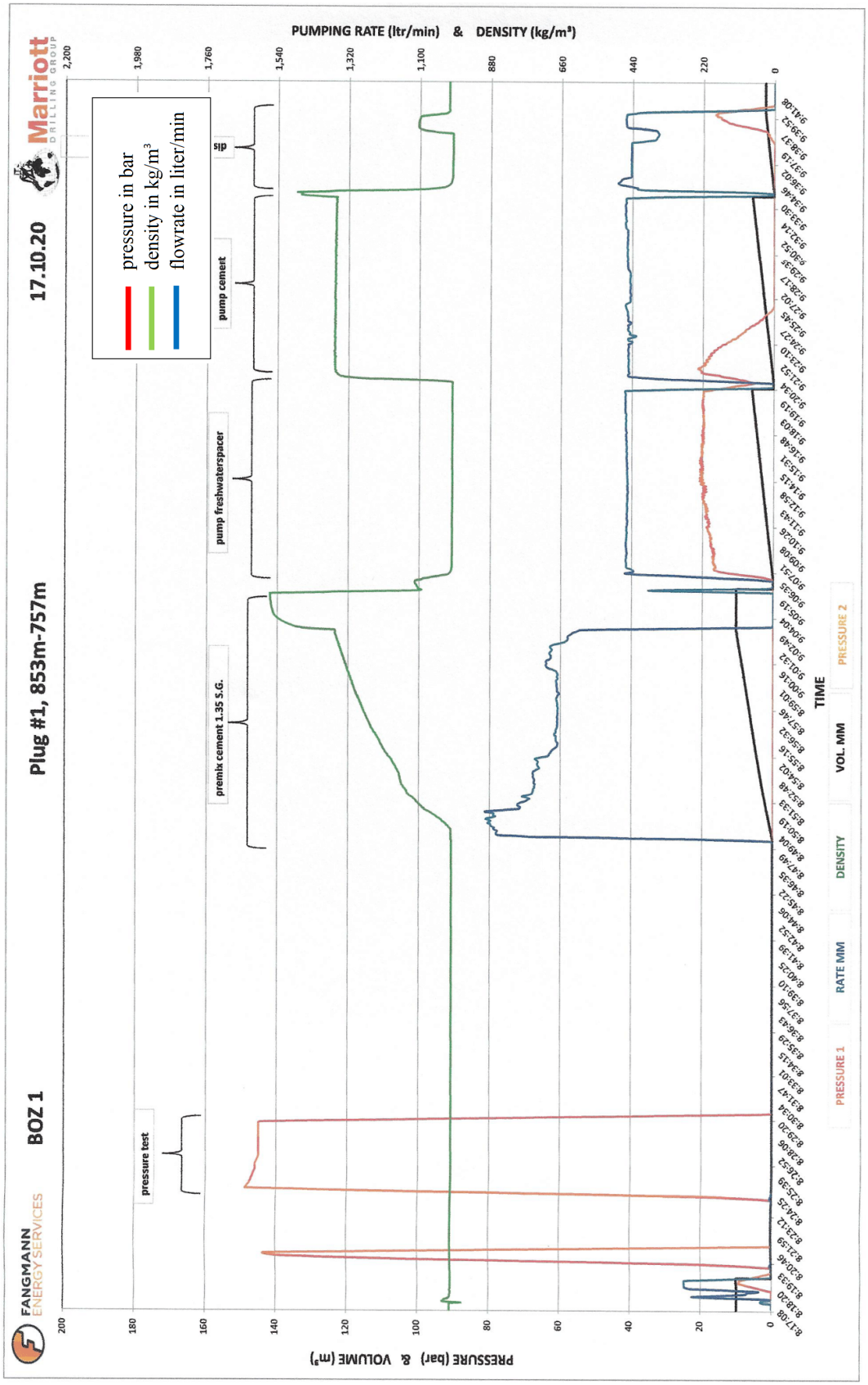
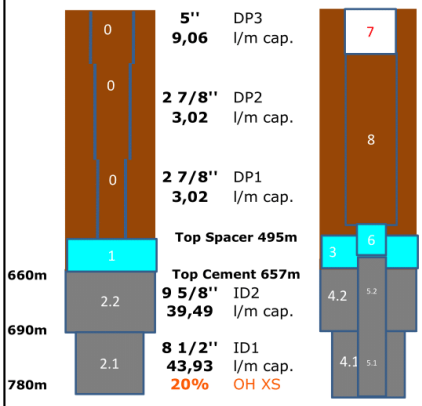


Fig. L-8: Cement plug below 9⅝" casing; cementing chart plug No. 1

FANGMANN ENERGY SERVICES

Client	Marriott Drilling	**MD 780,0 m**	**TG 4,0°/100m**	Marriott DRILLING GROUP
Well	Bözberg 1	**TVD 780,0 m**	**BHST 46°C**	
Cementing	Plug 2	**Max. Dev 3,5°**	**Test Temp. 31°C**	

Wellbore schematic without and with drill pipes



Volume Calculation

0	Surface lines				0,30m³
		5'' DP3	0m	9,06l/m	0,00m³
	Total DP 780 m	2 7/8'' DP2	**87m**	3,02l/m	0,26m³
		2 7/8'' DP1	**693m**	3,02l/m	2,09m³
1	**Total Spacer**	Top 495m	165m	39,49l/m	6,50m³
2	**Cement plug**	2.2	30m	39,49l/m	1,18m³
		2.1	90m	43,93l/m	3,95m³
					5,10m³
3	**Spacer ahead**		170m	39,74l/m	**6,00m³**
4	**Cement in Annular**	4.2	33m	35,30l/m	1,15m³
		4.1	90m	39,74l/m	3,58m³
5	**Cement in DP**	5.2	33m	3,02l/m	0,10m³
		5.1	90m	3,02l/m	0,27m³
6	**Spacer behind**		170m		0,50m³
	Cement to be circulated depth		**680m**		
7	**Underdisplacement**				0,30m³
8	**Mud displacement**				1,50m³

Fluid Design

Spacer	**1,00kg/l**	dead vol. 0,2 m³	per m³	**6,7m³** total
Fresh water	lt		1000,0	6700,0
Yield	lt	1000,0		

Cement	**1,75kg/l**	dead vol. 0,5 m³	per ton cmt.	per m³	**5,6m³** total
Fresh water	lt		581,5	633,4	3547,0
CAF-902	lt		**2,0**	2,2	12,2
CSL-944	kg		**23,2**	25,3	141,5
CRE-345	kg		**1,7**	1,9	10,4
CMT-001	tonne		**1,0**	1,1	6,1
Yield	lt		918,1		

Logistics

Personnel		**Equipment**		**Material**		Quantity	Comments
Supervisor:	1	Pumptruck	1x	CMT-001	Class C API cement	6,10 tonne	
Operator:	Pump	incl. Data recording		CAF-902	Antifoam	12,20 lt	
Operator:	Mixtank	7 m³ Mixtank	1x	CRE-345	Retarder	10,37 kg	
Operator:	Bulk	incl. Power source					
		Bulktruck	1x				
		incl. Compressor					
				From client:			
		From client:		CSL-944	Salz NaCl	141,45 kg	
		Suction truck	1x	Fresh water for spacer, prime & displ.		7,10 m³	
		(fluids disposal)		Fresh water for cement		3,60 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 fresh water spacer ahead		6,00	1,00	450	13
	Pump cement slurry		5,10	1,75	450	11
	Total displacement volume	2,00m³				
	Pump fresh water spacer behind		0,50	1,00	450	1
	Pump mud		1,20	1,15	450	3
	Pump fresh water (surface lines)		0,30	1,00	300	1
	Flow check, POOH, Reverse circulate @	680m				30
					Pumping time:	**79min**

Recommendations / Comments

- in case of pressure increase during displacement, stop pumping to avoid overdisplacement (continue with flow check, POOH & reverse circulate)

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All steps have been communicated and approved prior to the job.

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CoMan _____ Date

Fig. L-9: Cement plug below 9⅝" casing; cementing programme plug No. 2

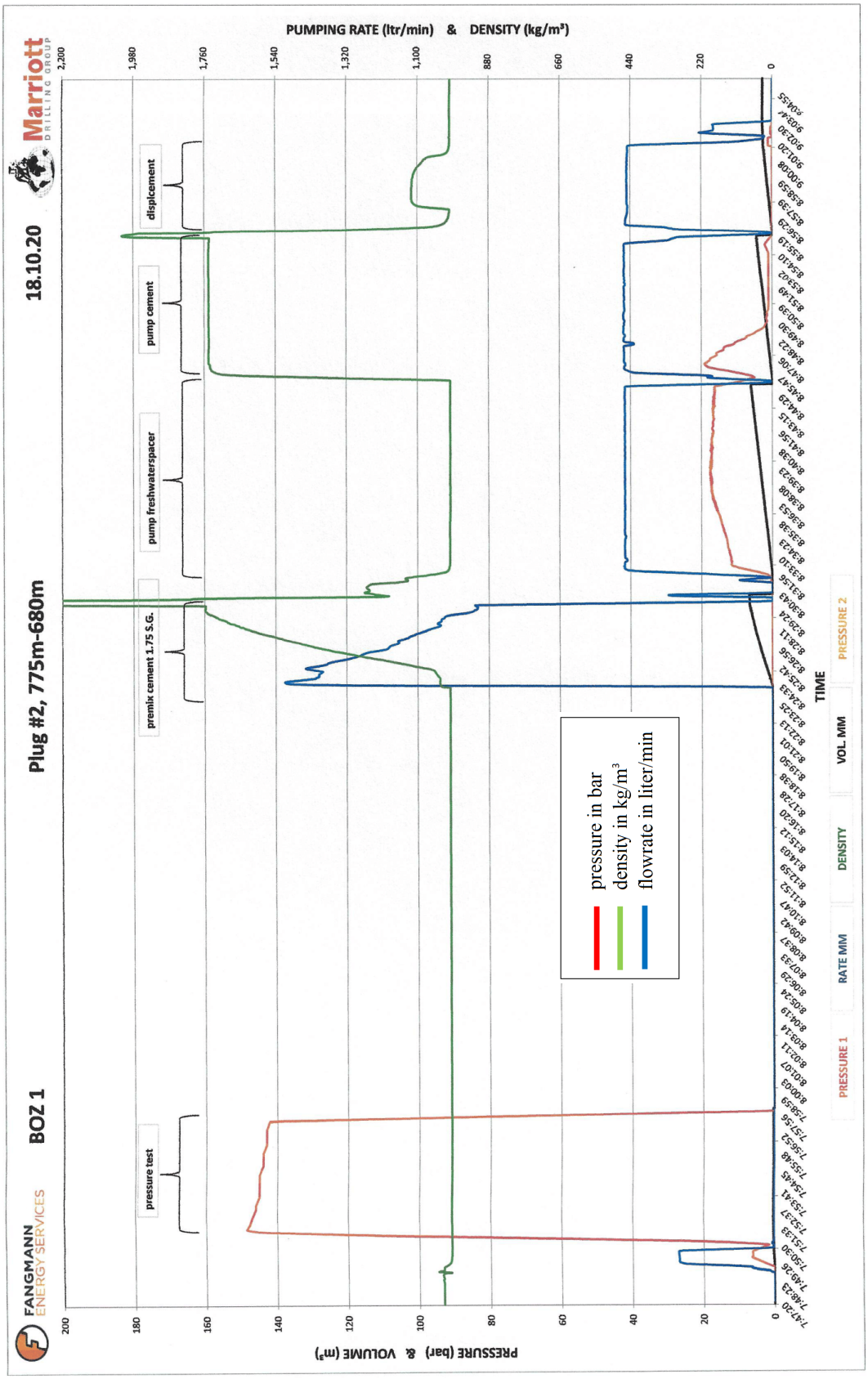


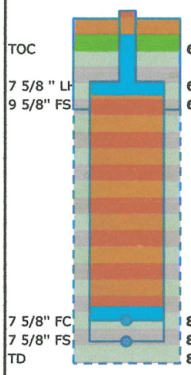
Fig. L-10: Cement plug below 9⅝" casing; cementing chart plug No. 2

FANGMANN ENERGY SERVICES

Client	Marriott Drilling		**MD 825.0 m**	**TG 4.3°/100m**	
Well	Bözberg 1		**TVD 825.0 m**	**BHST 48°C**	
Cementing	7 5/8" Liner		**Max. Dev 0°**	**Test Temp. 36°C**	

Marriott DRILLING GROUP

Volume Calculation



	OD	Description	Length	Capacity	Comment	Volume
Previous casing	**9 5/8 "**	**40.0 ppf**	50m	**39.55l/m**	Total cap.	+ 2.0 m³
Open hole	**9 1/2 "**	36% OH XS	137m	**45.73l/m**	OH without XS	+ 6.25 m³
	11.06 "	**100% annular XS**		32.49l/m in annulus	OH XS	+ 2.22 m³
				Displacement		
Liner to be cemented	**7 5/8 "**	**29.7 ppf**	156m	29.48l/m	Total displ.	- 4.60m³
			24m		Shoetrack	+ 0.57 m³
					Cement volume	**6.10m³**
				Capacity		
Drill pipe	**5 "**	**19.5 ppf**	495m	**9.05l/m**	Total cap.	4.48m³
	5" HWDP		**65m**	4.61l/m		0.30m³
	6 1/2" DC		**111m**	4.01l/m		0.45m³
Liner to be cemented	**7 5/8 "**	**29.7 ppf**	131m	**23.95l/m**	Total cap.	3.14m³
					Displacement volume	**8.40m³**

End pressure 24 bar ECD 1.41 SG

Fluid Design

Spacer	**1.40kg/l**	dead vol. 0.5 m³	**10.5m³**
		per m³	total
Fresh water	lt	881.2	9252.6
SGL-312	kg	**3.0**	31.5
CWA-831	kg	**498.4**	5233.2
Yield	lt	1000.0	

Cement	**1.65kg/l**	dead vol. 0.5 m³		**6.6m³**
		per ton cmt.	per m³	total
Fresh water	lt	646.6	655.0	4322.7
CAF-902	lt	**2.0**	2.0	13.4
CFL-347	kg	**2.0**	2.0	13.4
CRE-120	kg	**1.0**	1.0	6.7
CMT-003	tonne	**1.0**	1.0	6.7
Yield	lt	987.2		

Logistics

Personnel	
Supervisor:	1
Operator:	Pump
Operator:	Mixtank
Operator:	Bulk

Equipment	
Pumptruck	1x
incl. Data recording	
Mixtank	2x
Generator, Compressor	2x
Cement silo	1x
From client:	
Suction truck (fluids disposal)	1x

Material		Quantity	Comments
CMT-003	CEM III B cement	6.7 tonne	Silo 19
CAF-902	Antifoam	13.4 lt	
CFL-347	Fluidloss LT/MT	13.4 kg	
CRE-120	Retarder LT	6.7 kg	Lot.-Nr. MM11K-06S3
SGL-312	Polymer	31.5 kg	
CWA-831	Barite	5233.2 kg	
From client:			
Fresh water for spacer		15.1 m³	
Fresh water for cement		4.3 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 (confirm with LH Specialist) / JSA					
	Prime the lines		0.30		300	1
	Pressure test	150 bar				10
	Premix cement					20
	Pump spacer	308 m	10.00	1.40	500	20
	Pump CEM III B cement		6.10	1.65	500	12
	Release dart (LH Supervisor)					5
	Total displacement volume	8.4 m³				
	Pump fresh water spacer		1.50	1.00	500	3
	Pump mud		0.20	1.20	500	0
	Pump fresh water spacer	LH area	3.00	1.00	500	6
	Pump mud		3.40	1.20	500	7
	Pump fresh water (surface lines)		0.30	1.00	300	1
	Flow check, Set LH packer, Release, Circulate out extra cement					30
					Pumping time:	104min

Recommendations / Comments
- OH XS, tubular capacities & mud weight to be confirmed
- max. 1/2 shoetrack extra displacement volume
- Wiper-Plug shear pressure to be confirmed by LH Supervisor

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FES Supervisor Date 03.11.2020

CoMan Date 03.11.2020

Fig. L-11: 7⅝" cement programme

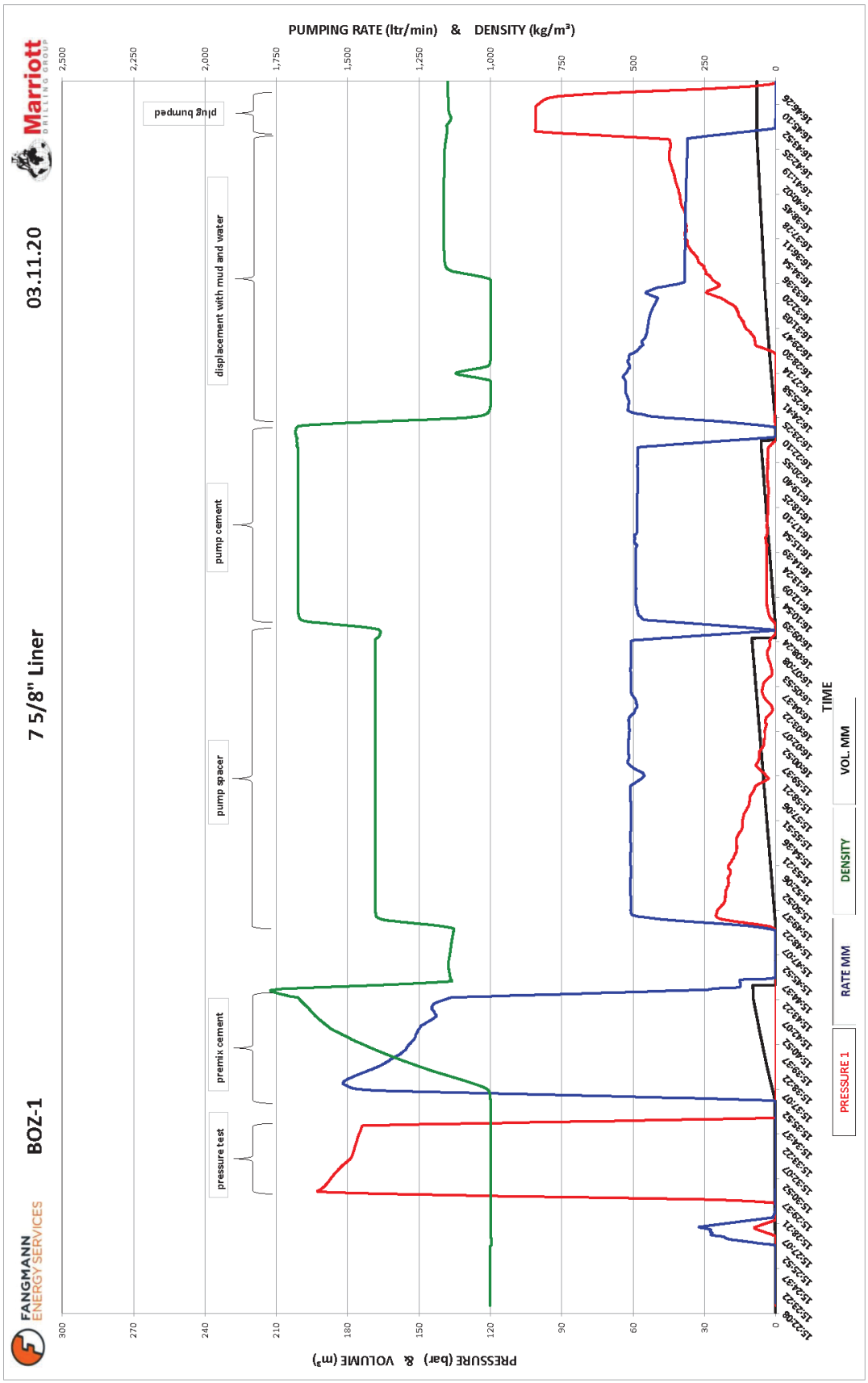


Fig. L-12: 7⅝" cement chart

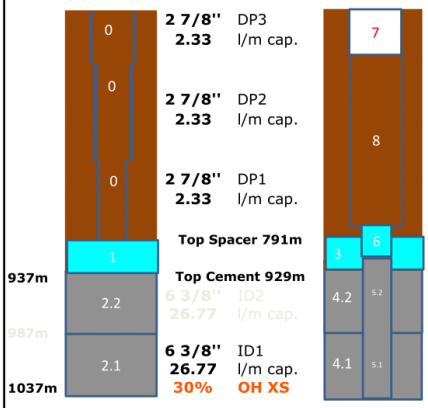
Tab. L-4: 7⅝" cement bond

From	To	Lithostratigraphic units	Zone description
(m MD)			
667.2 (top of liner)		***Top of cement***	
667.2	687.4	Staffelegg Fm.	Low CBL amplitude, with weak casing arrivals and strong formation arrivals on the VDL; the presence of a fast formation zone generates galaxy patterns on the USIT; bond index shows almost complete cement coverage, apart from a few small liquid pockets – good bond
687.4		9⅝" casing shoe	
687.4	709	Staffelegg Fm. Klettgau Fm.	CBL amplitude indicates full bond, with strong formation arrivals and no casing arrivals on the VDL; the cement map shows almost 100% cement coverage and the acoustic impedance is high (5 – 7 MRayl) – good bond
709		KOP of sidetrack BOZ1-1B	
709	712.1	Klettgau Fm.	High CBL amplitude, with strong casing and formation arrivals on the VDL; bond index shows liquid channelling and low acoustic impedance on the cement map; poor bonding at KOP probably due to washout – poor bond
712.1	786.8	Klettgau Fm. Bänkerjoch Fm.	CBL amplitude indicates full bond, with strong formation arrivals and no casing arrivals on the VDL; high acoustic impedance, dark colours on the cement map and bond index indicate almost 100% cement coverage – good bond
786.8	799	Bänkerjoch Fm.	Medium CBL amplitude and medium casing and formation arrivals on the VDL suggest poor bonding; this does not match the bond index which shows excellent cement coverage; galaxy patterns on the cement map indicate a thin cement sheath, which combined with the fact that this is in a interval of slow formation (claystones of the Bänkerjoch Fm.) would explain the discrepancy between logs. – good bond
799	816	Bänkerjoch Fm. Schinznach Fm.	Erratic CBL amplitude, no casing arrivals and fast formation arrivals on the VDL indicate good shear bond and zonal isolation – good bond
816	824	Schinznach Fm.	High CBL amplitude, with strong casing and formation arrivals on the VDL; bond index shows gas along with micro-annulus, cement map has a very light colour and acoustic impedance is low, indicating that zonal isolation is not achieved around the bottom joint of the liner; strong formation arrivals indicate that cement is present but detached from the casing; much better bond across the dolostones of the Upper Schinznach Formation would be expected – poor bond
824		Bottom of 7⅝" liner	

FANGMANN ENERGY SERVICES

Client	Marriott Drilling	**MD 1037.0 m**	**TG 3.2°/100m**	Marriott DRILLING GROUP
Well	Bözberg 1	**TVD 1037.0 m**	**BHST 43.3°C**	
Cementing	OH Plug-Back	**Max. Dev 3.5°**	**Test Temp. 36°C**	

Wellbore schematic without and with drill pipes



Volume Calculation

0	Surface lines				0.30m³
	Total DP 1037 m	2 7/8" DP3	0m	2.33l/m	0.00m³
		2 7/8" DP2	0m	2.33l/m	0.00m³
		2 7/8" DP1	**1037m**	2.33l/m	2.42m³
1	**Total Spacer**	Top 791m	146m	26.77l/m	3.90m³
2	**Cement plug**	2.2	50m	26.77l/m	1.34m³
		2.1	50m	26.77l/m	1.34m³
					2.70m³
3	**Spacer ahead**		155m	22.58l/m	**3.50m³**
4	**Cement in Annular**	4.2	58m	22.58l/m	1.32m³
		4.1	50m	22.58l/m	1.13m³
5	**Cement in DP**	5.2	58m	2.33l/m	0.14m³
		5.1	50m	2.33l/m	0.12m³
6	**Spacer behind**		155m		0.40m³
	Cement to be circulated depth		**937m**		
7	**Underdisplacement**				0.15m³
8	**Mud displacement**				1.90m³

Fluid Design

Spacer	**1.00kg/l**	dead vol. 0.2 m³	per m³	**4.7m³** total
Fresh water	lt		1000.0	4700.0
Yield	lt	1000.0		

Cement	**1.65kg/l**	dead vol. 0.3 m³ per ton cmt.	per m³	**3.0m³** total
Fresh water	lt	646.6	655.0	1965.0
CAF-902	lt	**1.0**	1.0	3.0
CFL-347	kg	**2.0**	2.0	6.1
CRE-120	kg	**1.0**	1.0	3.0
CMT-003	tonne	**1.0**	1.0	3.0
CLC-602	kg	2.0	**2.0**	6.1
Yield	lt	987.2		

Logistics

Personnel		**Equipment**		**Material**		Quantity	Comments
Supervisor:	1	Pumptruck	1x	CMT-003	CEM III B (BFS cmt.)	3.0 tonne	**Silo 19 + Bulk-Kammer 1**
Operator:	Pump	incl. Data recording		CAF-902	Antifoam	3.0 lt	
Operator:	Mixtank	Mixtank	2x	CFL-347	Fluidloss LT/MT	6.1 kg	
Operator:	Bulk	Generator	1x	CRE-120	Retarder LT/MT	3.0 kg	Lot.-Nr. MM11K-06S3
		Bulktruck	1x	CLC-602	CemFibers	6.1 kg	LCM, 2 kg./m³
		incl. Compressor					
		From client:		From client:			
		Suction truck	1x	Fresh water for spacer		4.7 m³	
		(fluids disposal)		Fresh water for cement		2.0 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		3.50	1.00	400	9
	Pump Cement		2.70	1.65	400	7
	Total displacement volume	2.30m³				
	Pump Spacer behind		0.40	1.00	400	1
	Pump mud		1.60	1.14	400	4
	Pump fresh water (surface lines)		0.30	1.00	300	1
	Flow check, POOH, Circulate out extra cement @ 937 m					45
					Pumping time:	**87min**

Recommendations / Comments

- in case of pressure increase during displacement, stop pumping to avoid overdisplacement (continue with flow check, POOH, circulate out extra cement)

Document info

Prepared: T. Precup
Client: Marriott Drilling
Version #: 5
Status: Field Version
Date: 27.11.2020

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. L-13: Cement plug below 7⅝" casing; cementing programme plug No. 1

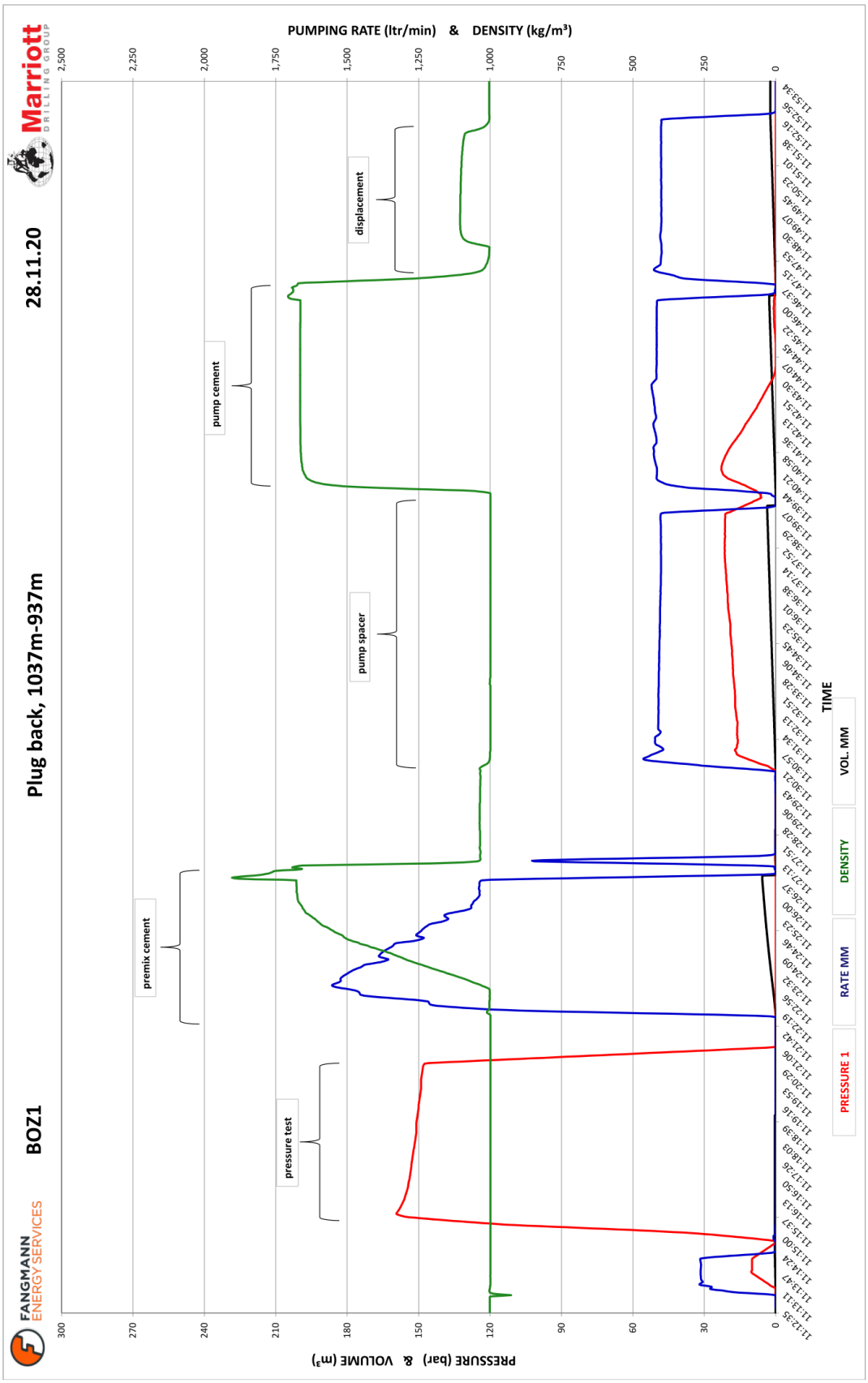


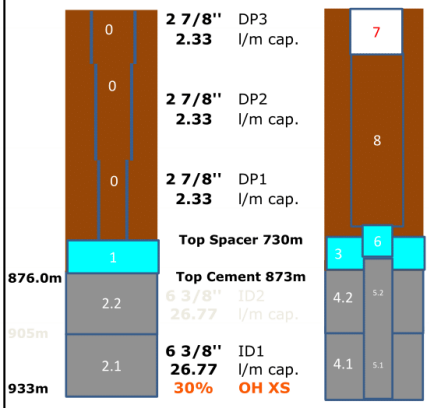
Fig. L-14: Cement plug below 7⅝" casing; cementing chart plug No. 1

FANGMANN ENERGY SERVICES

Client	Marriott Drilling		**MD 933.0 m**	**TG 3.2°/100m**	
Well	Bözberg 1		**TVD 933.0 m**	**BHST 39.9°C**	
Cementing	OH Plug-Back		**Max. Dev 3.5°**	**Test Temp. 36°C**	

Marriott DRILLING GROUP

Wellbore schematic without and with drill pipes



Volume Calculation

0	Surface lines				0.30m³
	Total DP 933 m	2 7/8" DP3	0m	2.33l/m	0.00m³
		2 7/8" DP2	0m	2.33l/m	0.00m³
		2 7/8" DP1	**933m**	2.33l/m	2.17m³
1	**Total Spacer**	Top 730m	146m	26.77l/m	3.90m³
2	**Cement plug**	2.2	29m	26.77l/m	0.76m³
		2.1	29m	26.77l/m	0.76m³
					1.50m³
3	**Spacer ahead**		155m	22.58l/m	**3.50m³**
4	**Cement in Annular**	4.2	32m	22.58l/m	0.72m³
		4.1	29m	22.58l/m	0.64m³
5	**Cement in DP**	5.2	32m	2.33l/m	0.07m³
		5.1	29m	2.33l/m	0.07m³
6	**Spacer behind**		155m		0.40m³
	Cement to be circulated depth		**876.0m**		
7	**Underdisplacement**				0.15m³
8	**Mud displacement**				1.80m³

Fluid Design

Spacer	**1.00kg/l**	dead vol. 0.2 m³	per m³	**4.7m³** total
Fresh water	lt		1000.0	4700.0
Yield	lt	1000.0		

Cement	**1.65kg/l**	dead vol. 1.3 m³	per ton cmt.	per m³	**2.8m³** total
Fresh water	lt		646.6	655.0	1834.0
CAF-902	lt		**1.0**	1.0	2.8
CFL-347	kg		**2.0**	2.0	5.7
CRE-120	kg		**1.0**	1.0	2.8
CMT-003	tonne		**1.0**	1.0	2.8
Yield	lt		987.2		

Logistics

Personnel		**Equipment**		**Material**		Quantity	Comments
Supervisor:	1	Pumptruck	1x	CMT-003	CEM III B (BFS cmt.)	2.8 tonne	**Silo 19 + Bulk-Kammer 1**
Operator:	Pump	incl. Data recording		CAF-902	Antifoam	2.8 lt	
Operator:	Mixtank	Mixtank	2x	CFL-347	Fluidloss LT/MT	5.7 kg	
Operator:	Bulk	Generator	1x	CRE-120	Retarder LT/MT	2.8 kg	Lot.-Nr. MM11K-06S3
		Bulktruck	1x				
		incl. Compressor					
		From client:		From client:			
		Suction truck (fluids disposal)	1x	Fresh water for spacer		4.7 m³	
				Fresh water for cement		1.8 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		3.50	1.00	400	9
	Pump Cement		1.50	1.65	400	4
	Total displacement volume	2.20m³				
	Pump Spacer behind		0.40	1.00	400	1
	Pump mud		1.50	1.14	400	4
	Pump fresh water (surface lines)		0.30	1.00	300	1
	Flow check, POOH, Circulate out extra cement @ 875,9 m					45
					Pumping time:	**83min**

Recommendations / Comments

- in case of pressure increase during displacement, stop pumping to avoid overdisplacement (continue with flow check, POOH, circulate out extra cement)

Document info

Prepared:	T. Precup
Client:	Marriott Drilling
Version #:	5
Status:	Field Version
Date:	27.11.2020

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. L-15: Cement plug below 7⅝" casing; cementing programme plug No. 2

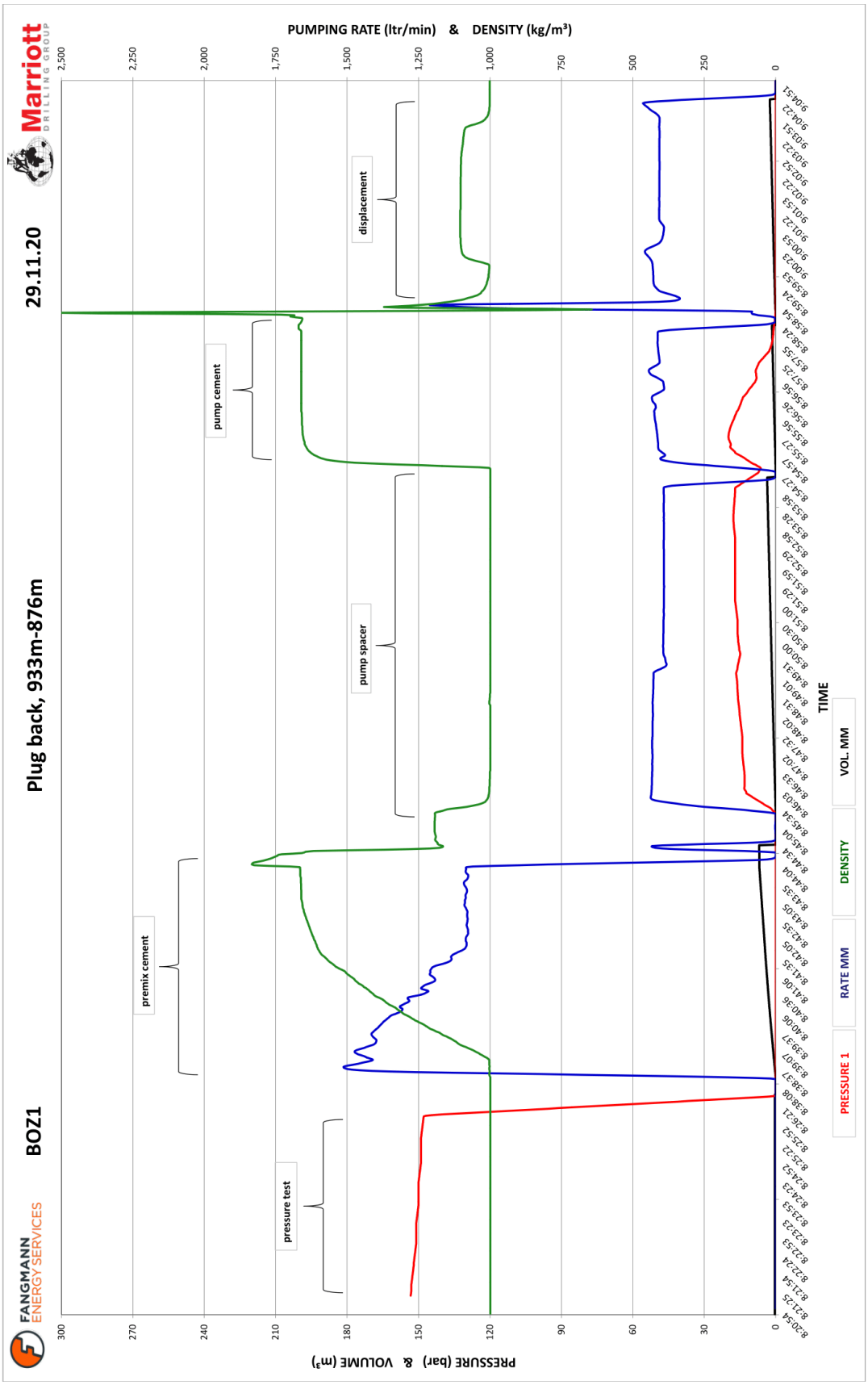
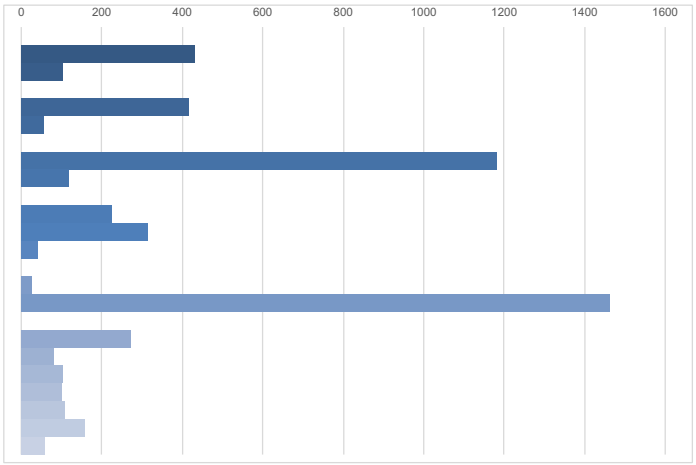
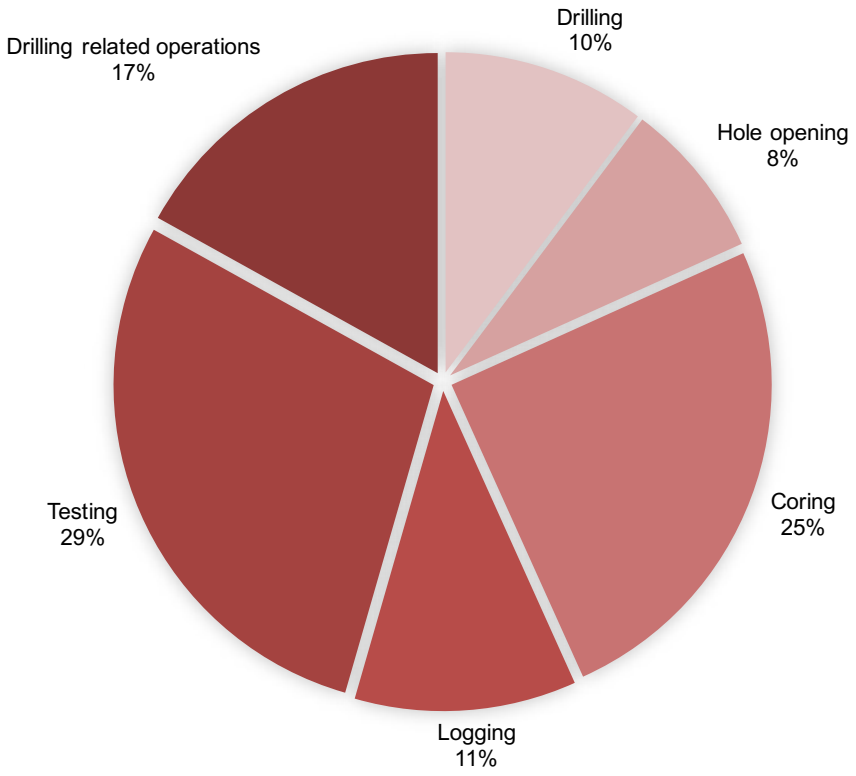


Fig. L-16: Cement plug below 7⅝" casing; cementing chart plug No. 2

Exploration borehole Bözberg-1-1
(27.04.2020 – 02.12.2020)

Activity	%	Hrs
Drilling		
Drilling	8,2%	430
Tripping (drilling)	2,0%	103
Hole opening		
Hole opening	7,9%	416
Tripping (hole opening)	1,1%	57
Coring		
Coring	22,5%	1181
Tripping (Coring)	2,3%	119
Logging		
Petrophysical & Technical Logging	4,3%	226
MHF	6,0%	315
VSP	0,8%	42
Testing		
Fluid Logging	0,5%	25
Hydrotest & GTPT	27,8%	1463
Drilling related operations		
Casing & Cementing & WOC	5,2%	273
BOP & Well Control & Wellhead	1,5%	80
Drill out shoe & FIT	2,0%	103
Run auxiliary casing	1,9%	102
Mud exchange & borehole conditioning	2,1%	108
Fishing operations	3,0%	157
Various operations (magnet run etc.)	1,1%	58
	100,0%	5257





nagra	NAB 21-21
Time analysis - Bözberg-1-1	
Dossier I	DAT.: Feb. 2022 **Appendix M**