

LV-2016-106



Landsvirkjun



# Þeistareykir – Well ÞG-10

Drilling of Phases 0 and 1 down to 193 m



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Drilling of Phases 0 and 1 down to 193 m



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**Abstract:** Well ÞG-10 was drilled to become a production well for the Peistareykir power plant. It is sited on the same drill pad as wells ÞG-1, ÞG-4 and ÞG-5. The well is located approximately 300 m north of Mt. Bæjarfjall and the aim of the drilling was to penetrate a purported fracture system north of Mt. Bæjarfjall. This report addresses the drilling history and data acquisition of the 0<sup>th</sup> and 1<sup>st</sup> phases. Which includes subsurface mapping of the lithologies and alteration in the well based on drill-cuttings and results of the wireline logging. ÞG-10 was pre-drilled with 21" drill bit for 18 $\frac{3}{8}$ " surface casing to 110 m. Drilling continued with a 17 $\frac{1}{2}$ " drill bit for a 13 $\frac{3}{8}$ " anchor casing. Due to over-pressurized feed zone at 184 m the drilling had to be stopped at 193 m depth. Several days were spent on controlling the over-pressure without success and finally the drill-string was cemented in the well down to 170 m and the well abandoned. The stratigraphy of phases 0 and 1 in well ÞG-10 is composed of basaltic lava flows, in the uppermost part, and hyaloclastite formations, mostly basaltic breccia and tuff. In the uppermost 70 m of the stratigraphic section alteration is minor, with zeolites and clays, but below that it increases and becomes moderate to high. Quartz was found at 72 m depth.

### Key words:

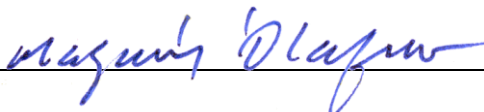
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# 1 Introduction

Drilling of well ÞG-10 in the Þeistareykir geothermal field was conducted by Iceland Drilling (Jarðboranir) for Landsvirkjun.

ÞG-10 was drilled from the same well pad as wells ÞG-1, ÞG-4 and ÞG-5 (well pad A) (Figure 1). The wells are located approximately 300 m north of Bæjarfjall (Table 1), at 349 m a.s.l. The planned depth of well ÞG-10 was 2000–2500 m. The well should be directionally drilled towards east, with the aim of intersecting the permeability and heat anomaly related to the fracture system north of Mt. Bæjarfjall (Thordarson, 2016; Khodayar et al., 2016; Mortensen, 2012).

**Table 1.** Geographical position of well ÞG-10. Coordinates are in ISNET93.

Well name	Well ID	East (X) (m)	North (Y) (m)	Elevation (m a.s.l.)	Planned depth (m)
ÞG-10	60410	593011.9	599073.6	349.1	2500

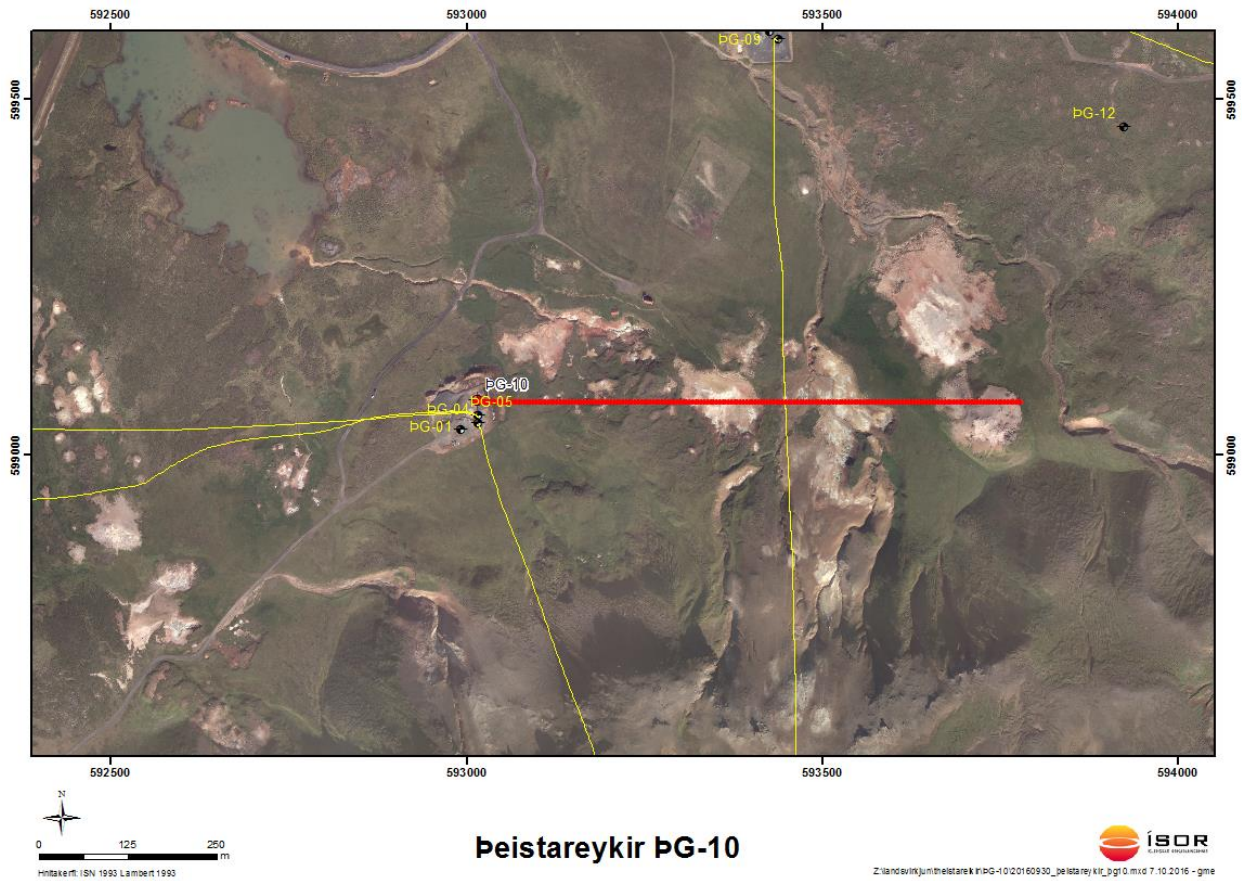
The planned design of well ÞG-10 (Figure 2) was as follows:

- Phase 0: Pre-drilling for the surface casing with 21" drill bit to approximately 100 m depth. Cased with 18 $\frac{5}{8}$ ".
- Phase 1: Drilling for the anchor casing with 17 $\frac{1}{2}$ " drill bit down to ~ 300 m depth. Cased with 13 $\frac{5}{8}$ ".
- Phase 2: Drilling for the production casing with 12" drill bit down to ~ 800 m depth. Cased with 9 $\frac{5}{8}$ ".
- Phase 3: Drilling of the production part with 8 $\frac{1}{2}$ " drill bit to 2000–2500 m depth, cased with 7" perforated liner.

To reach the target zones the direction of the well was set at 90° ±5° relative to true North, with an inclination 25° ±3° from the vertical within the depth range 500 m to 1600 m (MD). Below 1600 m (MD) greater deviations in direction and inclination are tolerated i.e. ±15° for direction and ±12° for inclination (Figure 3). The kick-off was planned at 500 m depth. The angle build-up rate was planned to be 2°/30m with the final inclination of 25° from the vertical, to be completed before 875 m (MD).

Phases 0 and 1 were drilled by the drill-rig Sleipnir. Depths in this report refer to measured depth (MD) relative to Sleipnir's rig floor (5.72 m above ground level), except otherwise stated.

The drilling contractor, Iceland Drilling (Jarðboranir), carried out the drilling operations with Landsvirkjun monitoring the work. Iceland GeoSurvey (ÍSOR) managed cutting inspection, geophysical logging, and geothermal consulting.



**Figure 1.** Aerial photograph of well pad A north of Mt. Bæjarfjall. Well PG-10 is located close to PG-1, PG-4 and PG-5. The planned path of PG-10, towards east, is shown (red line).

This report presents drilling history of the well and the drilling problems encountered during phases 0 and 1. It also describes the geological units drilled through, including lithology, alteration and feed points, as well as the wireline logging of the well. The report is divided into the following chapters: the *first chapter* gives an introduction. The *second chapter* reports on the drilling operations during drilling of phases 0 and 1. The *third chapter* describes the geological strata and alteration, observed by the on-site geologist. The *fourth chapter* includes the wireline loggings of phases 0 and 1, carried out by ÍSOR's logging engineers.

The aim of this report is to document the geological- and geophysical part from the drilling of phases 0 and 1 in PG-10, and present all the data collected and provide data interpretations. Appendix A contains daily reports written by the borehole geologist during drilling operations, presenting preliminary results.

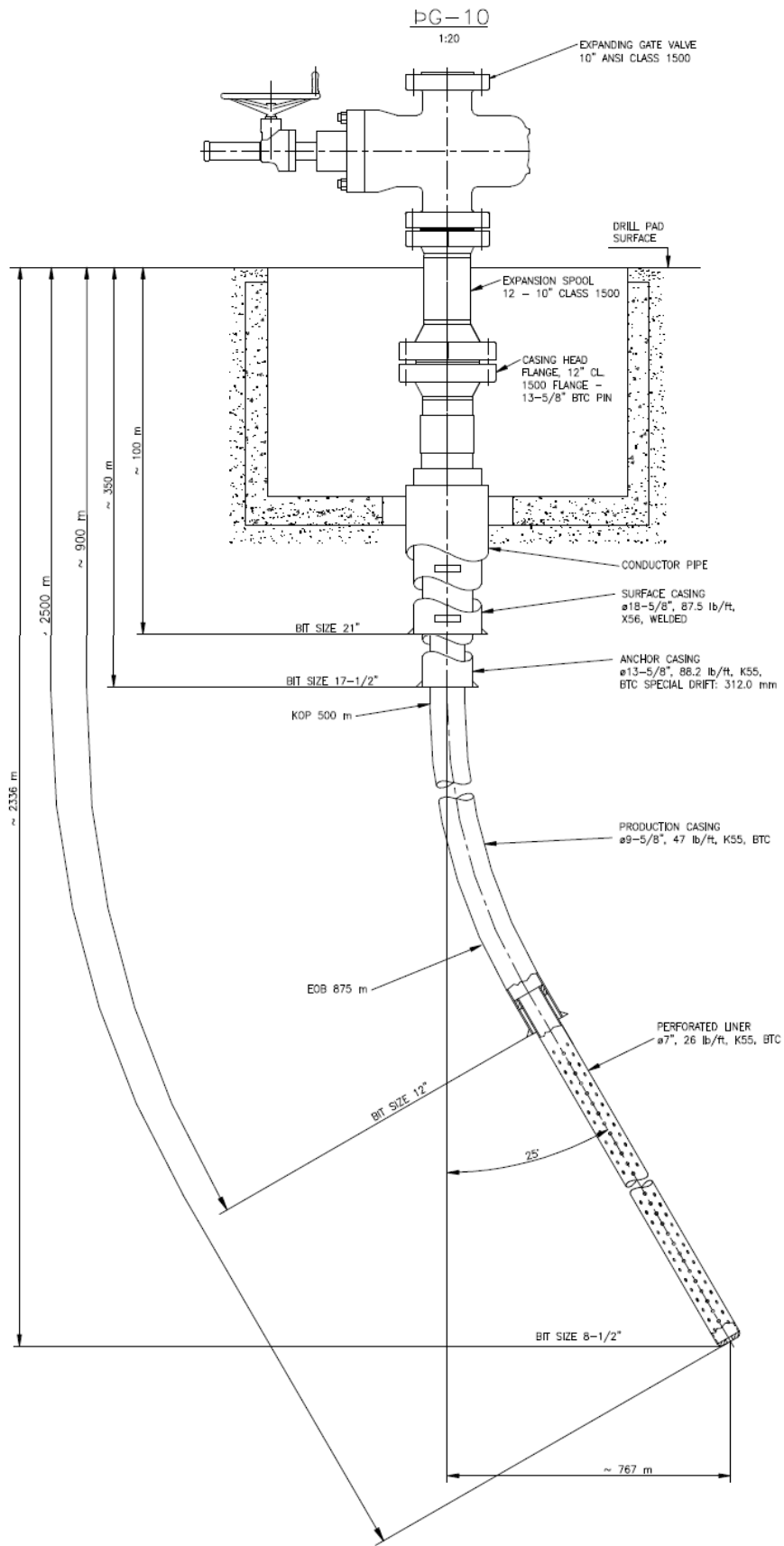
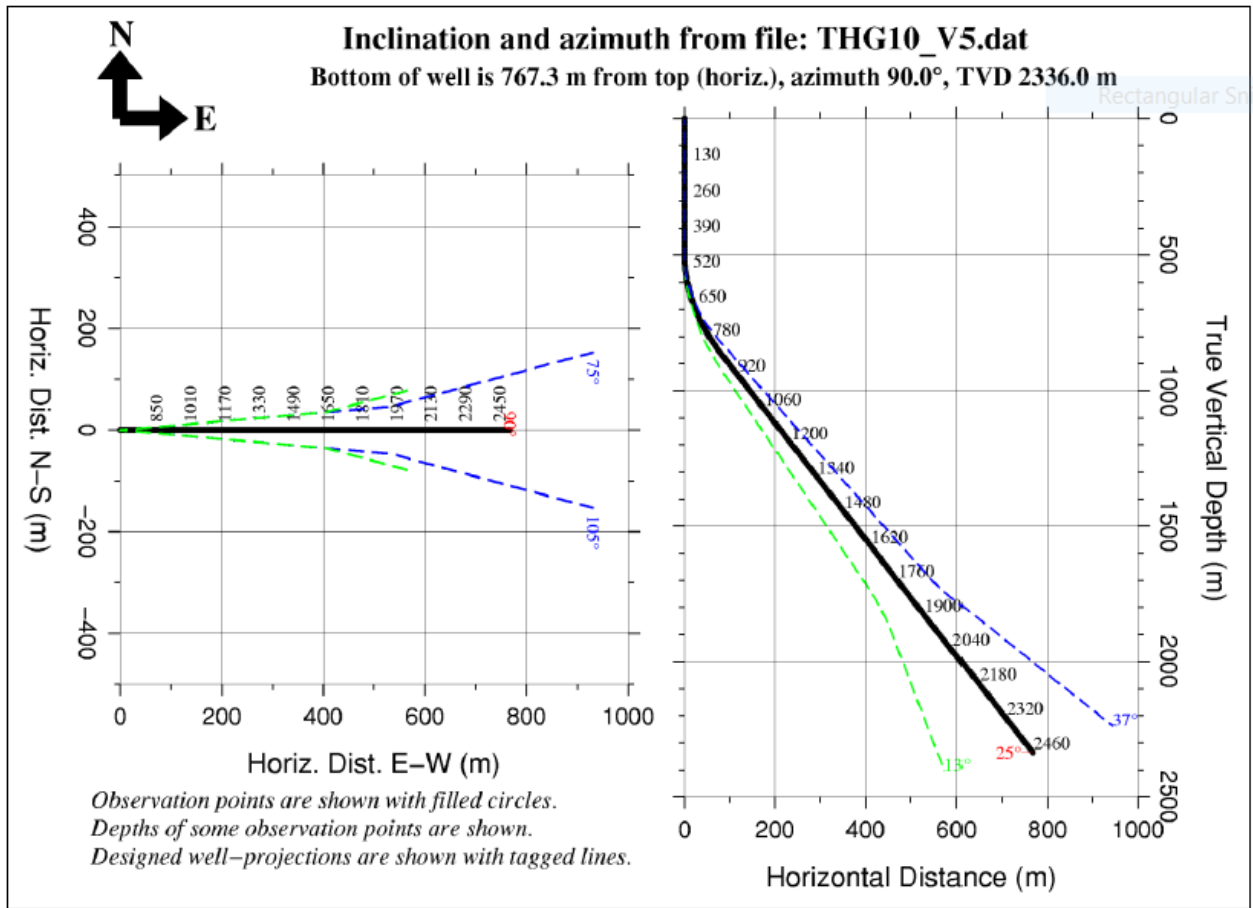


Figure 2. Well design of DG-10.



**Figure 3.** Design of well PG-10 shown in a horizontal and vertical plane, along with maximum allowed deviation (Thordarson, 2016).

## 2 Drilling operations

### 2.1 Overview

Drill rig Sleipnir was ready for commencing drilling on the 23<sup>rd</sup> of June 2016. Drilling with a 21" drill bit started the same day at 14.2 m depth. Drilling progressed slowly but firmly during the entire phase. Two cement jobs were required due to circulation losses. Drilling, casing, cementing and logging of phase 0 was completed on the 30<sup>th</sup> of June 2016, workday 11 of Sleipnir. At this point the well was 110 m deep relative to the drilling platform of Sleipnir (5.72 m above ground). The 18 $\frac{5}{8}$ " surface casing was set at 106.9 m depth.

Preparations for the drilling of phase 1 started on the 30<sup>th</sup> of June 2016 with testing of the blow-out preventers (BOP). Drilling into formation with a 17 $\frac{1}{2}$ " drill bit started on the 1<sup>st</sup> of July, at 110 m. Drilling was almost continuous down to 184 m when an over-pressurized zone was intersected and the temperature of the circulation fluid started to rise rapidly. Drilling was continued down to 193 m on the 2<sup>nd</sup> of July when it was decided to POOH and run cement string into the well and cement the over pressurized feed zone. A blow-out occurred while the cementing string was being lowered into the well and the blow-out preventers had to be shut to stop the blow-out. During the next days the well was cemented repeatedly in order to control the overpressurized feed zone but each time after drilling out the cement plugs the well built up pressure and blowout was eminent. Drilling operations in PG-10 were finally terminated on the 8<sup>th</sup> of July and the well abandoned due to the blow-out hazard. This was the 19<sup>th</sup> workday on the well.

An overview of the two drilling phases and details of the surface casing depth is shown in Table 2. Figure 4 shows the drilling progress of well PG-10 during drilling of phases 0 and the unsuccessful phase 1.

**Table 2.** *Drilling and casing depth in well PG-10.*

Drill-rig	Phase	Drill bit	Depth (m)	Depth Reference	Casing Type	Casing Depth
Sleipnir	0	21"	110	Sleipnir RF*	18 $\frac{5}{8}$ "	106.9
Sleipnir	1	17 $\frac{1}{2}$ "	193	Sleipnir RF*	-	-

\* RF = rig floor. Sleipnir's rig floor is 5.72 m above ground level.

# PG-10 - Drilling Progress

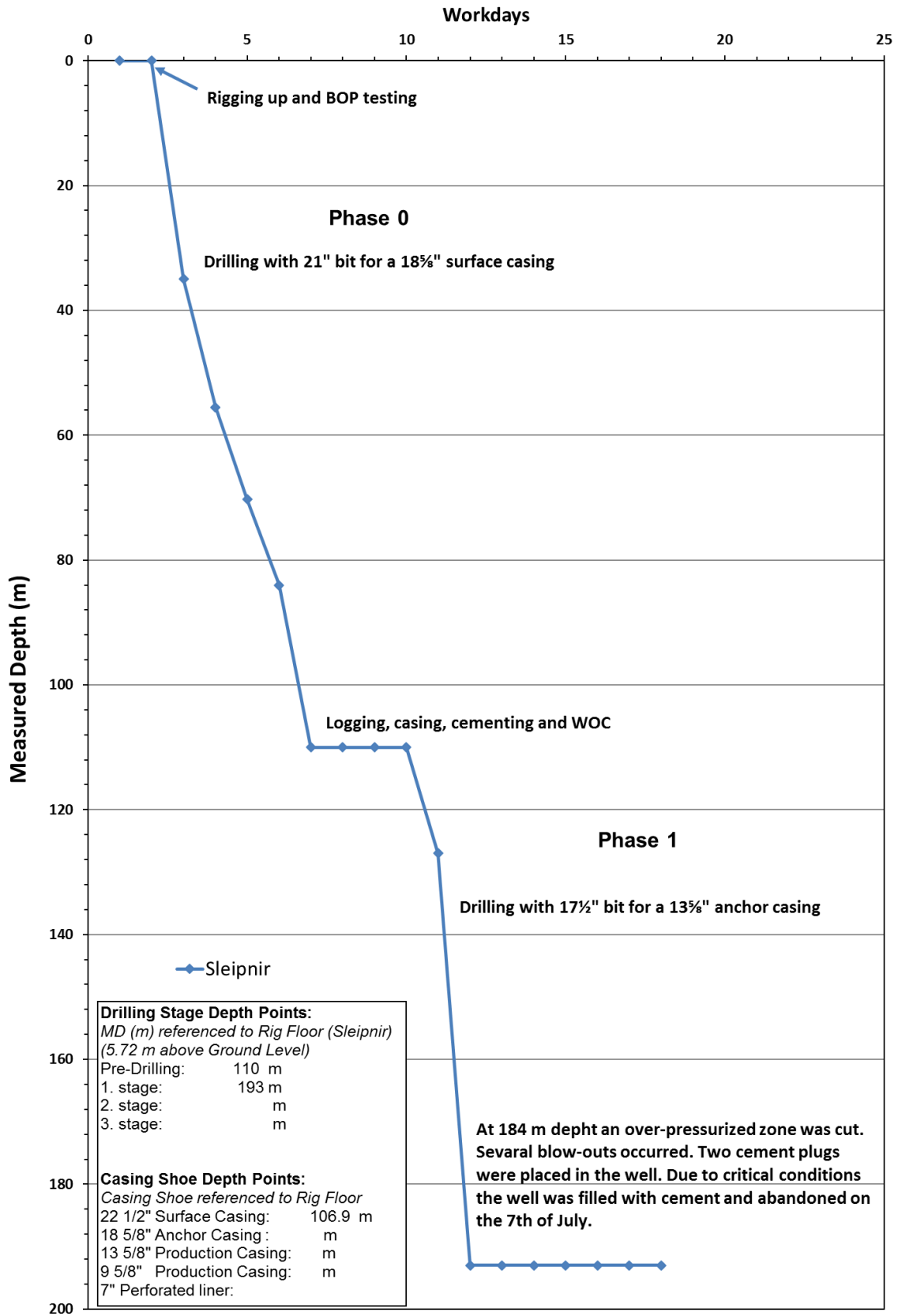


Figure 4. Drilling progress of well PG-10.

## 2.2 Pre-drilling for the surface casing (18<sup>5</sup>/<sub>8</sub>") - Phase 0

Transportation of the Sleipnir drill rig, from well PG-11 on drill pad B, to well PG-10 on drill pad A, was completed on the 18<sup>th</sup> of June. After rigging-up of the drill rig, pre-drilling of well PG-10, with 21" drill bit, commenced in the morning of June 23<sup>rd</sup>. Drilling of phase 0 was completed the 30<sup>th</sup> of June, workday 11. Drilling started slowly but firmly, with an average rate of penetration (ROP) of 1.1 m/hr. One cement job was carried out due to circulation loss at 14 m. Cement was drilled from 13.5 m to 14.2 m, and drilling into formation was continued from 14.2 m.

Wells PG-1, PG-4 and PG-5 are located on the same drill pad (A) as PG-10. Table 3 gives an overview of the recorded circulation losses in those wells during drilling at shallow depths.

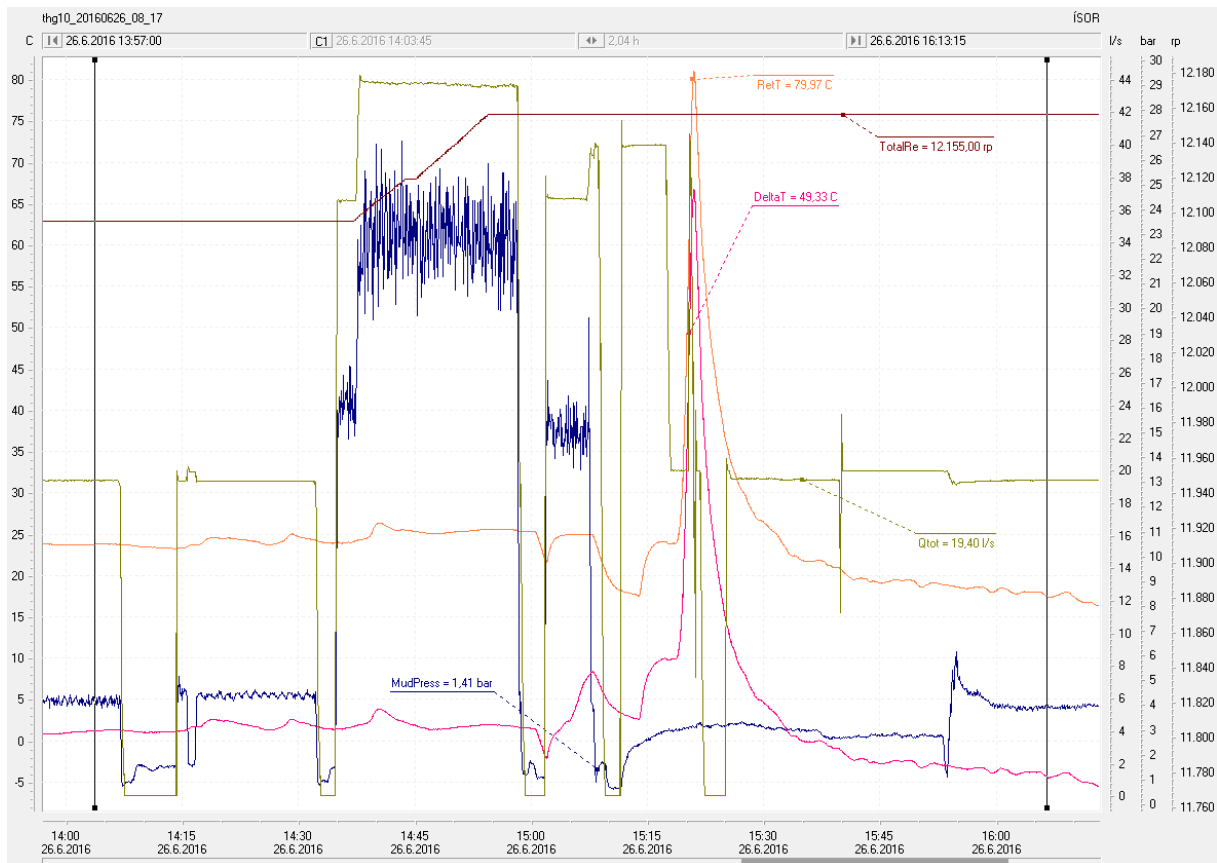
**Table 3.** Information on shallow loss zones in wells PG-1, PG-4, PG-5 and PG-10.

Well	phase	Depth (m)	Circ.loss (l/s)	Remarks
PG-1	0	48.5	TLC	Loss zone cemented with 4 m <sup>3</sup> of cement. Minor losses at 58 m.
PG-4	1	92	TLC	Very open loss zone in a basaltic breccia formation. Cemented with 91.2 m <sup>3</sup> slurry in nine attempts.
PG-5	0	110	0	No losses measured
PG-10	0	74	20	A drop of the water-table occurred followed by a blow-out

Drilling was ongoing the whole day and night of June 25<sup>th</sup>, down to 70.3 m. The rate of penetration was very slow, around 0.6 m/h. On June 26<sup>th</sup> drilling was ongoing from midnight to 10:00 in the morning, down to 74 m. As the formation seemed to be very hard it was decided to pull the string out of the hole to check the condition of the drill bit. The drill bit appeared to be in good condition and was run in the hole again, but when drilling had just started the water-table fell and a minor blow-out occurred. The annular BOP was closed. About 2.5 hours later the annular BOP was opened and a pumping of 43 l/s applied. Loss of circulation was measured 20 l/s. Figure 5 shows drilling data from the 26<sup>th</sup> of June, at 14:00–16:00 hrs., at the time of the blow-out. From the figure it can be seen how the differential temperature rose and how the mud pressure drops, indicating a subsidence of the water-level in the well.

Drilling continued down to 84 m. At 80 m (at 21:00 hours) the circulation losses were measured 14 l/s, and 12 l/s at 84 m depth. At noon on June 27<sup>th</sup> the 84 m depth was reached. Then the well was rinsed and prepared for a cement job. In total 6 m<sup>3</sup> of cement was used for plugging (Figure 6). Top of cement was found at 69 m depth.





**Figure 5.** Drilling data from 14:00 to 16:00 on June 26<sup>th</sup> 2016.

As no losses of circulation were observed after the plugging operation the drilling was continued until casing depth was reached, at 110 m, 2 am on the 28<sup>th</sup> of June, on workday 9. After casing depth was reached for the surface casing, the well was circulated with water and polymer. At 4 am pulling out of the string was started and a wiper trip was carried out. No bottom hole deposit was found. Inclination was measured at 96 m and showed 0.3°. Next, the well was cooled for an hour and then the string was pulled out. At 15:30 on the 28<sup>th</sup> of June, ÍSOR's logging engineers carried out temperature and caliper logs. At 17:00 the crew started to run in the 18<sup>5</sup>/<sub>8</sub>" casing. The surface casing was set at 106.9 depth relative to the Sleipnir's rig floor (Figures 7 and 8). Afterwards, the cement string was run in hole and the well cooled. In total 15 m<sup>3</sup> of cement slurry were used in the cementing procedure with returns (Figure 9). Based on the caliper log the estimated volume of cement was ~10 m<sup>3</sup>. The cement sank approximately 1.3 m. The cement string was pulled out and waiting on cement was carried out until 22:00 on the 29<sup>th</sup> of June, when the casing was cut to a desired height. This marks the end of drilling phase 0 on the 10<sup>th</sup> workday of Sleipnir on the well. Figure 4 and Table 3 show the drilling progress of phase 0.




 <b>Cementing Report</b> Rig: Sleipnir Job No: DG-10		<b>Iceland Drilling</b> Rig No: 28000 Job Name: DG10	
Cement Job Information			
Start Date/Time:	27-jún.-16 04:00	Well Bore:	Original Well Bore
Job Type:	PLUG	Cementing Engineer:	Andrés
Cementing Co:	JARDB		
Plug Job Detail			
Plug Type:	Sandsteypa		
Plug: Top (m):	69,0	Bottom (m):	84,0
		Length (m):	15,0
Calc. Displacement Vol (cu m):	Hole Size at Plug (cm):		53,34
	Volume (cu m)	Pump Time	Rate (cu.m./min)
	Volume (bar)		
Conditioning Data:			
Cement Data:			
Displacement Data:			
Slurry Information			
Type	Density	Yield	Sacks
			Volume
			Rate
			Additives
No Slurry Information Data			
Post Job Information			
Actual Top of Cmt (m):	69,0	Job Success?	No
Misc. Comments:	Dæling á holi var stöðvuð í 11 mín Dælt með steypudælu 6 m <sup>3</sup> af sandsteypu niður þáð tók 6 mín dælt síðan 2000 L/sek vatni á eftir og blíndioka lokað		

Figure 6. Cementing report for a cement job performed on the 27<sup>th</sup> of June.


 <b>Casing Information Report</b> Rig: Sleipnir Job No: DG-10		<b>Iceland Drilling</b> Rig No: 28000 Job Name: DG10	
Casing Information			
Run Date/Time:	28-jún.-16 16:00	Leak Off Test (kg/cu m):	
Well Section:	INT1	String Type:	FULL
String Top MD (m):	0,0	String Top TVD (m):	106,9
Casing Shoe MD (m):	93,5	Casing Shoe TVD (m):	93,5
String Nominal OD (cm):	47,31	String Nominal ID (cm):	44,45
Bit Diameter (cm):	53,34	Avg. Open Hole Diam. (cm):	54,50
Centralizers: No:		Manufacturer/Type:	
Depths:			
Hanger Type:		Manufacturer:	
Comments:			
String Component Details			
Joins	Item	Length (m)	OD(cm)
			ID (cm)
			Weight (kg)
			Grade
			Connection
			Torque
No String Component Data			

Figure 7. Casing Information Report for the 18<sup>5/8</sup>" surface casing.

ICELAND DRILLING		<b>Casing Tally Run Report</b>				Jarðboranir			
		Rig: Sleipnir				Rig No: 28000			
		Job No: ÞG-10				Job Name: ÞG-10			
String Nominal OD (cm):		47,31		String Type:		FULL			
Items Run:	11	Length Run:	107,710	Top Depth:	0,000				
Items Excluded:	0	Length Excluded:	0,000	Bottom Depth:	106,870				
Items Talled:	11	Length All Items:	107,710	Cut Off Length:	0,840				
Run No.	Joint No	Item	Length	Top	Bottom	Description	Comments	Cnt	Scr
1	1	JOINT	0,510	106,360	106,870	0,00 x 0,00 X-56 WELD	Flotskór		
2	2	JOINT	12,210	94,150	106,360	0,00 x 0,00 X-56 WELD			
3	3	JOINT	0,680	93,470	94,150	0,00 x 0,00 X-56 WELD	Flotkolli		
4	4	JOINT	12,180	81,290	93,470	0,00 x 0,00 X-56 WELD			
5	5	JOINT	12,160	69,130	81,290	0,00 x 0,00 X-56 WELD			
6	6	JOINT	11,790	57,340	69,130	0,00 x 0,00 X-56 WELD			
7	7	JOINT	11,270	46,070	57,340	0,00 x 0,00 X-56 WELD			
8	8	JOINT	11,720	34,350	46,070	0,00 x 0,00 X-56 WELD			
9	9	JOINT	11,750	22,600	34,350	0,00 x 0,00 X-56 WELD			
10	10	JOINT	11,690	10,910	22,600	0,00 x 0,00 X-56 WELD			
11	11	JOINT	11,750	-0,840	10,910	0,00 x 0,00 X-56 WELD			

Figure 8. Casing Tally Run Report for the 18<sup>5</sup>/<sub>8</sub>" surface casing.

ICELAND DRILLING		<b>Cementing Report</b>				Iceland Drilling	
		Rig: Sleipnir				Rig No: 28000	
		Job No: ÞG-10				Job Name: ÞG10	
Cement Job Information							
Start Date/Time:	29-jún.-16 09:30		Well Bore:	Original Well Bore			
Job Type:	PRIMARY		String OD (cm):	47,31			
Well Section:	INT1		String Type:	FULL			
Cementing Co:	JARDB		Cementing Engineer:	Sveinbjörn Bjarnason			
Primary Job Detail							
	Volume (cu m)	Pump Time	Rate (cu.m./min)	Pressure (bar)			
Conditioning Data:							
Cement Data:	15,0	30	0,5	2			
Displacement Data:							
Calc. Displacement Vol:	0,4						
	<input type="checkbox"/> Batch Mix?	<input type="checkbox"/> Bump Plug?	Bump Pressure:				
Returns to Surface:	FULL	<input type="checkbox"/> Reciprocate Pipe?	<input checked="" type="checkbox"/> Cement at Surface?				
Calc Top of Cement (m):	93,5	Excess (%):	100,00%	Avg. Hole Size (cm):	53,34		
Slurry Information							
Type	Density	Yield	Sacks	Volume	Rate	Additives	
LEAD	15				0,5		
DISPLACE	0				0,4		
Post Job Information							
Liner Top Test (kg/cu m):				Job Success?	Yes		
Actual Top of Cmt (m):				CBL Bond Quality:	GOOD		
Misc. Comments:							

Figure 9. Cementing report for the 18<sup>5</sup>/<sub>8</sub>" surface casing.

**Table 4.** *Drilling progress of the pre-drilling phase carried out by Sleipnir. Depths are relative to the rig-floor of Sleipnir (5.72 m above the ground).*

Day	Workday of Sleipnir	Drilled Section (m)	Drill Time (hrs.)	ROP (m/hr.)	Total Depth at 24:00 (m)
24.06.2016	5	20.5	22.5	0.9	55.5
25.06.2016	6	14.8	24	0.6	70.3
26.06.2016	7	14	16	0.9	84
27.06.2016	8	23	13	1.8	107
28.06.2016	9	3	1.8	1.7	110
<b>Total</b>		<b>72.3</b>	<b>75.5</b>	<b>1.2 (average)</b>	

### 2.3 Drilling for the anchor casing (13<sup>5</sup>/<sub>8</sub>") - Phase 1

Drilling operations of phase 1 started on June 30<sup>th</sup>, on workday 11, with setting up and testing the blow-out preventers by applying 30 bars for 15 minutes. They passed the test and drilling with 17½" bit into cement at 94.5 m started early morning on the 1<sup>st</sup> of July. Few hours later drilling into a formation started at 110 m.

Drilling was almost continuous down to 184 m on the 2<sup>nd</sup> of July when the temperature of the circulation fluid started to rise rapidly from 39°C to 91°C in a short time. In order to avoid a blow-out, the drilling was stopped. The well head pressure measured 32 bar when pumping of 50 l/s was applied. Clearly an over-pressurized zone had been cut. At 5 pm, the temperature of the outflow fluid rose to 67°C. When the pumping was stopped for a short time, fluid immediately started to flow from the well into the tanks. Pumping was started again and drilling was continued down to 193 m. The plan was to place a cement plug in the well and squeeze cement into the overpressured feed zone at 184 m. The well was therefore cleaned and cooled before the string was pulled out. At 11 pm the crew started to strip the drill string out of the well. At 4 am on the 3<sup>rd</sup> of July a cementing string was RIH. The lowermost three singles were composed of glass fiber, in total 27 m in length. At about 5:45 am, when running a cement string into the well a blow-out occurred, at that time the depth of the string was 104 m (see Figure 10). Mud and debris was thrown high in the air and carried several hundred meters towards south from the rig. The control room of the rig was filled with mud. Three members of the crew were in there and suffered injuries. One person was taken to a hospital at Húsavík, with second degree burn on hands and feet. The annular BOP and the pipe-ram were shut in immediately after the blow-out occurred.



**Figure 10.** *Mud and debris at well pad A after a blow-out from PG-10 at 5:45 am on July 3<sup>rd</sup>.*

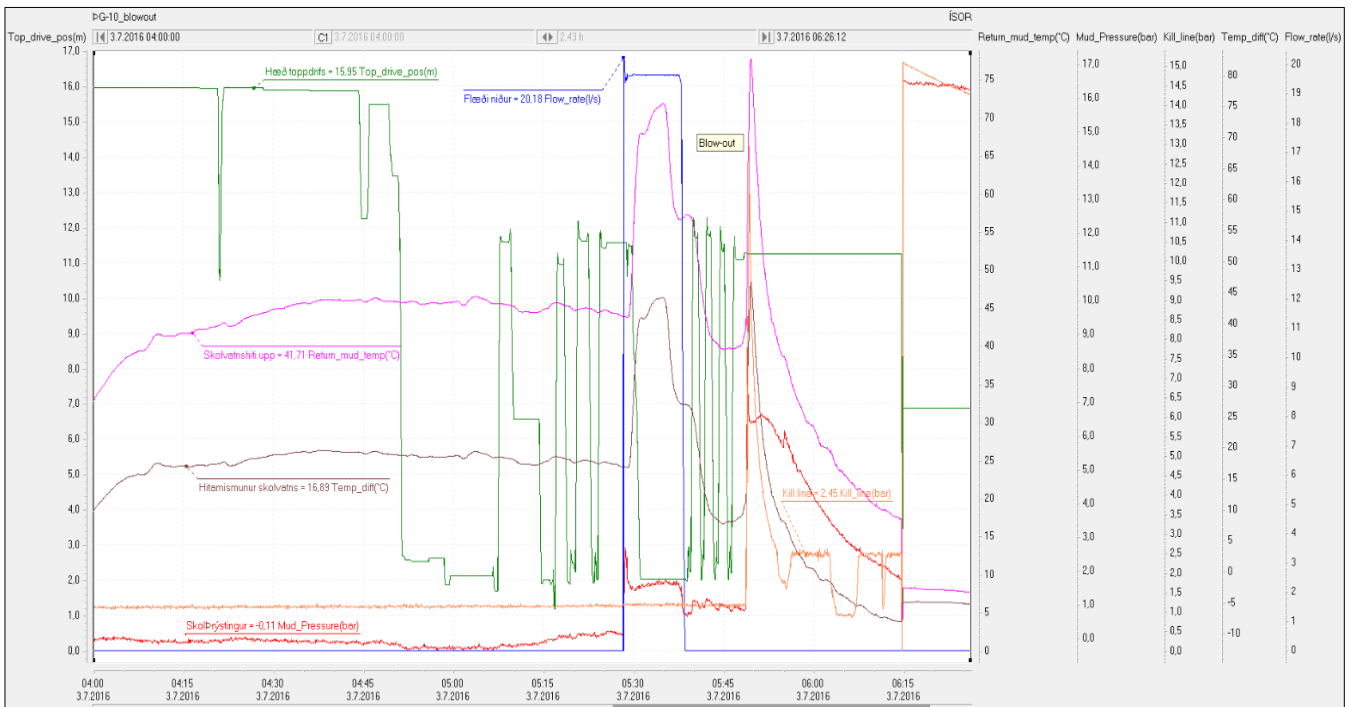
Immediately after the shut-in the wellhead pressure measured 13 bar but soon lowered to 2 bar. At 10 am on July 3<sup>rd</sup> the wellhead pressure measured 18 bar and two hours later it was 16 bar. At noon a pumping of 3 l/s into the well was applied by using the cementing equipment. Then the pressure rose up to 30 bar. Pumping was stopped. When opening the kill-line the pressure dropped down to zero bar. No pressure build-up was measured after this. Most probably the well had got clogged when the BOP were shut in.

Figures 11 and 12 show some selected drilling parameters from Sleipnir when a rise in the return mud temperature occurred on the 2<sup>nd</sup> of July, when drilling at 184 m and when the blow-out that occurred on July 3<sup>rd</sup>.





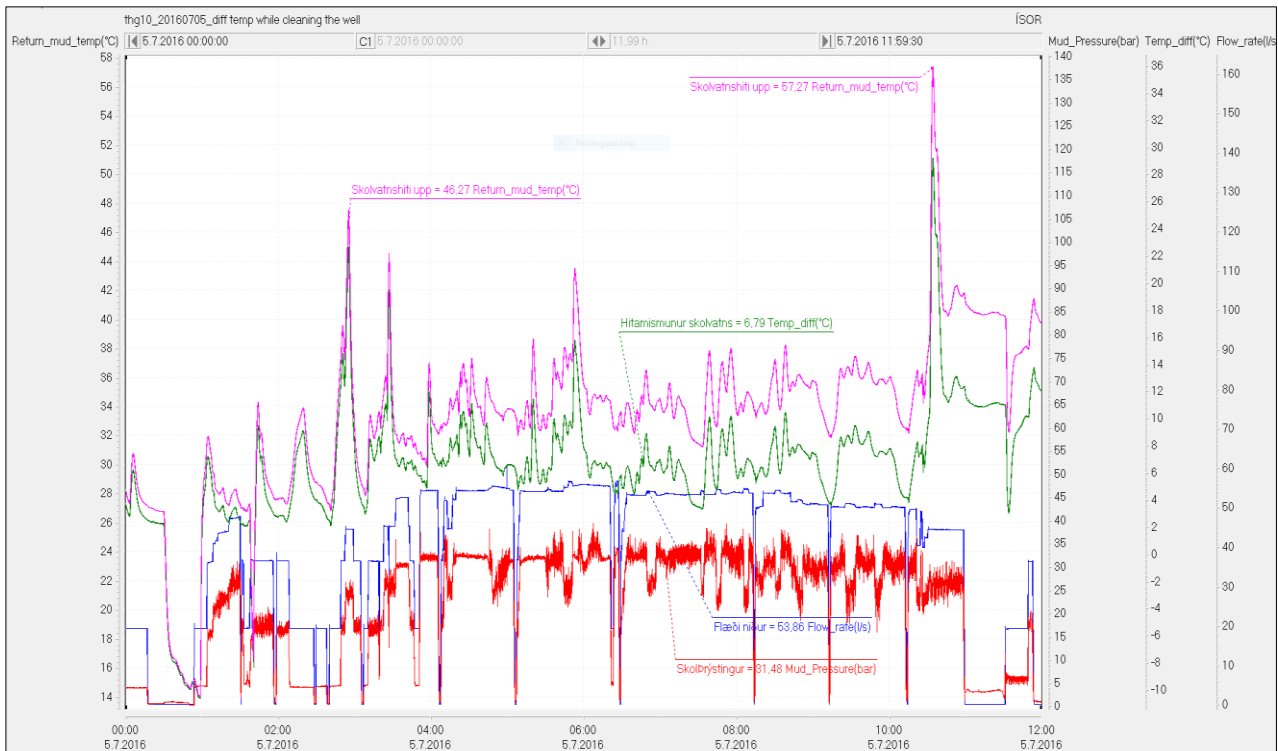
**Figure 11.** Increased return mud temperature (pink curve) at 3:30 pm on the 2<sup>nd</sup> of July.



**Figure 12.** Blow-out from the bG-10 at 5:45 am on the 3<sup>rd</sup> of July, occurring while running a cementing string into the well.

Until 2 am on July 4<sup>th</sup> the crew worked on cleaning the rig which became covered by gray mud after the blow-out the day before. Pieces of rock (mostly tuff), up to 7 cm in diameter, were found scattered around the well pad. At 2 to 3:30 am the cementing string was stripped out of the well, about 86m in length. Two fiber pipes from the lowermost part of the string were left in the well (9 m long each). Until 7 am the crew worked on maintenance of the rig, including the pumps, flow-line and the top-drive. An inspection of the power tong revealed that some of the hydraulic pipes had to be replaced. During the rest of the 4<sup>th</sup> of July most of the time was spent on repairing the power tong and also reinforcing the control room located on the drill floor. Finally, at 8:45 pm everything was ready for RIH of a string with a bit in order to clean the well. A circulation of 50 l/s of water was applied. Debris was found at shallow depth inside the surface casing. Obstacles were found at 75–83 m depth. Pulses of gas and fluid was emitted from the well while drilling in that interval. A total loss of circulation occurred for five minutes at 83 m depth. At 83–118 m the well was clean but at 118–140 m and again at 158–172 m depth a lot of cuttings was retrieved to surface. At about 11 am a total loss of circulation occurred at 172 for few minutes.

During the cleaning process in the morning on July 5<sup>th</sup> the return temperature of the circulation fluid started to rise rapidly for a while (Figure 13). Between 11 and 12 am the gas sensors on Sleipnir indicated several times that some H<sub>2</sub>S escaped from the well. Values in range of 10–20 ppm were measured. Each time the alarm started everyone stopped working and ran to the assembly point. At noon, with the bit at 172 m, the cleaning process was stopped. Pumping was cut off and the pressure released on the kill-line valve. The pressure measured in range of 13–31 bar (at kill-line). At 4 pm a pumping of 17 l/s was applied with pressure at kill-line of 19.3 bar. This was the minimum flow rate on the pump but as the wellhead valve was throttled, some 4–5 l/s flowed to the water tank but the rest 13–14 l/s flowed down the well and into the formation. At 6 pm one single was broken out from the string and preparations for a temperature logging started.



**Figure 13.** Some selected drilling parameters from Sleipnir from July 5<sup>th</sup> while cleaning the well. At 10:30 the return mud temperature rose suddenly as indicated by the temperature spike on the diagram.

At 9 pm on July 5<sup>th</sup> a temperature logging was carried out by the ÍSOR loggers. The results showed that the cooling was effective down to approximately 153 m depth, where the injected water flowed out of the well. Below 153 m the temperature rose from ~30°C to ~100°C at the float valve at 167 m. Based on the log it was decided to place a cement plug in the well in order to plug up the feed zone at 153 m. At 1:00 am in the morning of July 6<sup>th</sup> a 13 m<sup>3</sup> of cement slurry was pumped into the well. There was a wait on cement until 6:00 am in the morning when the kill-line was opened. At 7:30 am a pumping of 2 l/s on kill-line was applied by using the cementing equipment. Then at 8:10 am a circulation of 19 l/s is applied. Temperature of the return fluid measured 44°C. At 8:30 am a string with a bit is RIH. Top of cement was tagged at 124 m depth. Drilling in cement continued down to 166 m where a blow-out occurred. The BOP valves were shut immediately (pressure on kill-line was 11.3 bar). At 4:30 pm the pressure was throttled off the well through kill-line and the string stripped down to 178 m depth. At 7–9 pm the logging engineers from ÍSOR carried out a temperature logging in the well with 13 l/s injection on killline. The log showed cooling down to ~150 m as in the log day before. Below 150 m the temperature rose from 40°C to 185°C, i.e. at 165 m, and to 187°C at the float valve at 176 m depth. The log showed that the water in the drill-string was at boiling conditions indicating a very hot upflow from bottom region of the well, probably originating in the over-pressurized feed zone at 184 m. At 8 pm seven singles were stripped out before placing a cement plug in the well in order to plug the feed zones and stop the underground blow-out. At 9 pm 10 m<sup>3</sup> of cement slurry was pumped into the well. From 9:15 pm until 8:00 am on the 7<sup>th</sup> of July the crew waited on cement, followed by the opening of the well and RIH with a drill-string, tagging the top of the cement at 125 m depth. Cement was drilled from 125 m to

140 m, with notably softer cement being drilled from 137–140 m. Drilling of cement continued down to 155 m and temperature of the return fluid was about 30°C. The crew waited on orders from 13:00 to 14:45 and the well was circulated. Further drilling of cement was decided and at 170 m depth the well kicked and blew off steam. Pipe-ram was closed and kill-line pressure was found to be around 8 bar. Pump-pressure was 9.5 bar with 18.5 l/s pumping during the quenching of the well, decreasing to 7 bar and then rising to about 23 bar. At 17:30 pumping was stopped and the kill-line closed. Cement-pump was connected to the kill-line and pumping resumed at the rate of 2 l/s with 5.5 bar pressure. Pumping was increased to 6.5 l/s and the pressure remained 5.5 bar. Pressure then rose to 15.7 bar and when pumping was stopped the pressure dropped to 5 bar. Pumping resumed on the kill-line at the rate of 2 l/s until the evening, changing rubber-seal in the diverter. At 22:00 it was decided to try to drill further against the over-pressure. Pumping on kill-line was stopped and pressure was throttled on the kill-line. Pipe-ram was kept closed and the upper annular preventer was also closed. The flow-line valve was throttled to a half-opening and the BOP was slowly opened. Immediately the well blew out with immense force. Pipe-ram and upper and lower annular preventers were closed but the well was not shut-in and gas and steam continued to emerge through the flow-line. When gas and steam started to appear on the outside of the surface casing it was evident that the situation was slowly beginning to become out of control and a decision was made to leave the drill-string in the well and cement the well-off through the kill-line to prevent further escalation of the blow-out and to prevent further damage and unmanageable situation on the drill-pad. The cementing was finished just after midnight on the 7<sup>th</sup> of July and well thereby abandoned.

A sinker-bar was run in the drill string at 14:00 on Friday the 8<sup>th</sup> of July. The outside of the upper part of the drill-string, above the BOP stack was considerably hot, or 85–90°C. After breaking out the uppermost joint, freeing the top-drive and installing a poor-boy on the end, it periodically emitted small puffs of steam. The sinker-bar ran freely down to the float-valve at 167 m and when the sinker bar was out of the hole temperature and pressure logs were carried out down to the float valve. The logs showed intensive boiling of the water in lower part of the drill-string where the measured temperature was close to 180°C, indicating very hot conditions outside the drill-string below ~150 m. The temperature and pressure in the string was very unstable due to the boiling and the water level which was near 50 m depth in the drill-string was fluctuating several meters. The drillers filled up the drill-pipe with water and on the 9<sup>th</sup> of July a temperature and pressure were measured showing similar boiling conditions as the day before. The pulling of the logging tool out of the well on July 9<sup>th</sup> marks the end of the unsuccessful drilling of well PG-10.

**Table 5.** *Drilling progress of phase 1 carried out by Sleipnir. Depths are relative to the rig-floor of Sleipnir (5.72 m above the ground).*

Day	Drilled Section (m)	Drill Time (hrs.)	ROP (m/hr.)	Total Depth at 24:00 (m)
01.07.2016	17	5	3.4	127
02.07.2016	66	14	4.7	193
<b>Total</b>	<b>83</b>	<b>19</b>	<b>4.1 (average)</b>	



### 3 Lithology, alteration, intrusions and circulation losses

The crew of Sleipnir collected cutting samples at two metres interval during the drilling of phases 0 and 1 in well ÞG-10. Depth values of the samples refer to the rig floor of Sleipnir (5.72 m above ground level). The samples were collected in 150 ml plastic containers. During the drilling the ÍSOR's borehole geologist inspected the cutting samples and determined the lithology and the alteration mineral assemblage with the aid of a binocular microscope.

Additionally, data from the drill-rig data acquisition system, including the main drilling parameters, were collected systematically and also information on losses of circulation. The description of the lithology down to 192 m is below and graphical presentation of the lithology is shown in Figure 15. Figure 16 shows a comparison of the lithologies of wells ÞG-10 with the neighbouring well ÞG-1 and Figure 17 shows the distribution of alteration minerals in the well. Legend for the graphs is shown in Figure 14.

0–18 m: NO CUTTINGS

18–20 m: FINE-MEDIUM GRAINED BASALT

A little altered dark-brownish medium-grained basalt lava. Grains of glassy basalt are mixed within the cuttings.

20–26 m: NO CUTTINGS

26–28 m: FINE-MEDIUM GRAINED BASALT

Same as at 18–20 m, less glassy basalt.

28–42 m: BASALTIC BRECCIA

Basalt breccia. Glassy basalt and tuff. Some of the cutting-grains are rather pyrite rich. Greenish tuff very prominent at 34–36 m.

42–44 m: NO CUTTINGS

44–70 m: BASALTIC BRECCIA

Tuff-rich basaltic breccia with few plagioclases rich partly crystallised grains mixed in. Pyrite, calcite, clay and zeolites fill up voids in the grains. the tuff grains are altered and some even totally altered with white and green appearances.

70–72 m: GLASSY BASALT

Less tuff grains. Mostly partly crystallized plagioclase rich grains light in colour.

72–73.6: m BASALTIC TUFF

Pyrite-rich partially altered basalt tuff, considerably fractured and filled with alteration minerals.

73.6–82 m: BASALTIC BRECCIA

Increase in green and white altered basalt tuff. The cuttings consist of tuff, glassy basalt, fine-medium grained basalt and brown-black glass. The appearance of quartz is noted at around 80 m.

82–84 m: NO CUTTINGS

84–86 m: BASALTIC BRECCIA

Pyrite-rich breccia, same as above, but fine-medium grained basalt is more prominent than above.

86–88 m: NO CUTTINGS

88–100 m: BASALTIC BRECCIA

Same as 86 m.

100–102 m: NO CUTTINGS

102–138 m: BASALTIC BRECCIA

Mostly crystalline basalt, grey and brownish. Highly altered. Non porphyritic. Quartz is rather prominent as a secondary mineral. Pyrite and calcite are abundant.

138–152 m: FINE-MEDIUM GRAINED BASALT

Highly altered crystalline basalt, non-porphyritic. Whitish in colour. Traces of epidote seem to be present at 138–142 m. Quartz is common. Most possibly lava flows rather than pillow lava.

152–184 m: REWORKED TUFF

Very fine grained sedimentary tuff, light greenish and grey. Few grains of crystalline basalt are present. Fine grained clay is seen in the tuff.

184–188 m: BASALTIC BRECCIA



















More crystalline basalt mixed with tuff and glass. Dark and light brown fine-grained basalt.

188–192 m: BASALTIC BRECCIA



Dark green and brownish plagioclase rich basalt mixed with precipitations and some glass. Possibly an intrusion.

A comparison with PG-1 and PG-4 shows that the lithologies of these wells are similar in all main aspects (Figure 16). Below lava flows in the uppermost part of the wells, i.e. 20–30 m, the formation is composed of hyaloclastite, mostly breccia. At 132 m in PG-1, 138 m in PG-4 and at 152 m in PG-10 a thick layer of basaltic tuff is encountered, most probably the same formation. In PG-5 a top of 70 m thick tuff layer is found at 140 m depth (Gautason et al., 2007).





### Rock Types

	Scoria
	Basaltic Tuff
	Basaltic Breccia
	Glassy Basalt
	Fine-medium crystalline Basalt
	Medium-coarse crystalline Basalt
	Coarse crystalline Basalt
	Intermediate (andesitic) Tuff
	Intermediate (andesitic) Breccia
	Intermediate fine-medium crystalline Formation (e.g. Andesite)
	Intermediate coarse crystalline Formation (e.g. Diorite)
	Acidic Tuff
	Acidic Breccia
	Acidic fine-medium crystalline Formation (e.g. Rhyolite)
	Acidic coarse crystalline Formation (e.g. Granite)
	Sedimentary Tuff
	Glacial Deposits (Tillite)
	Clay- / Siltstone
	Sandstone
	Gravel Deposit
	No Cuttings




### Intrusion

	Intrusion
	Possible Intrusion

### Degree of Alteration

	Unaltered
	Low alteration
	Medium alteration
	High alteration

### Feed Point

	Small Feed Point
	Medium Feed Point
	Large Feed Point

### Alteration Minerals



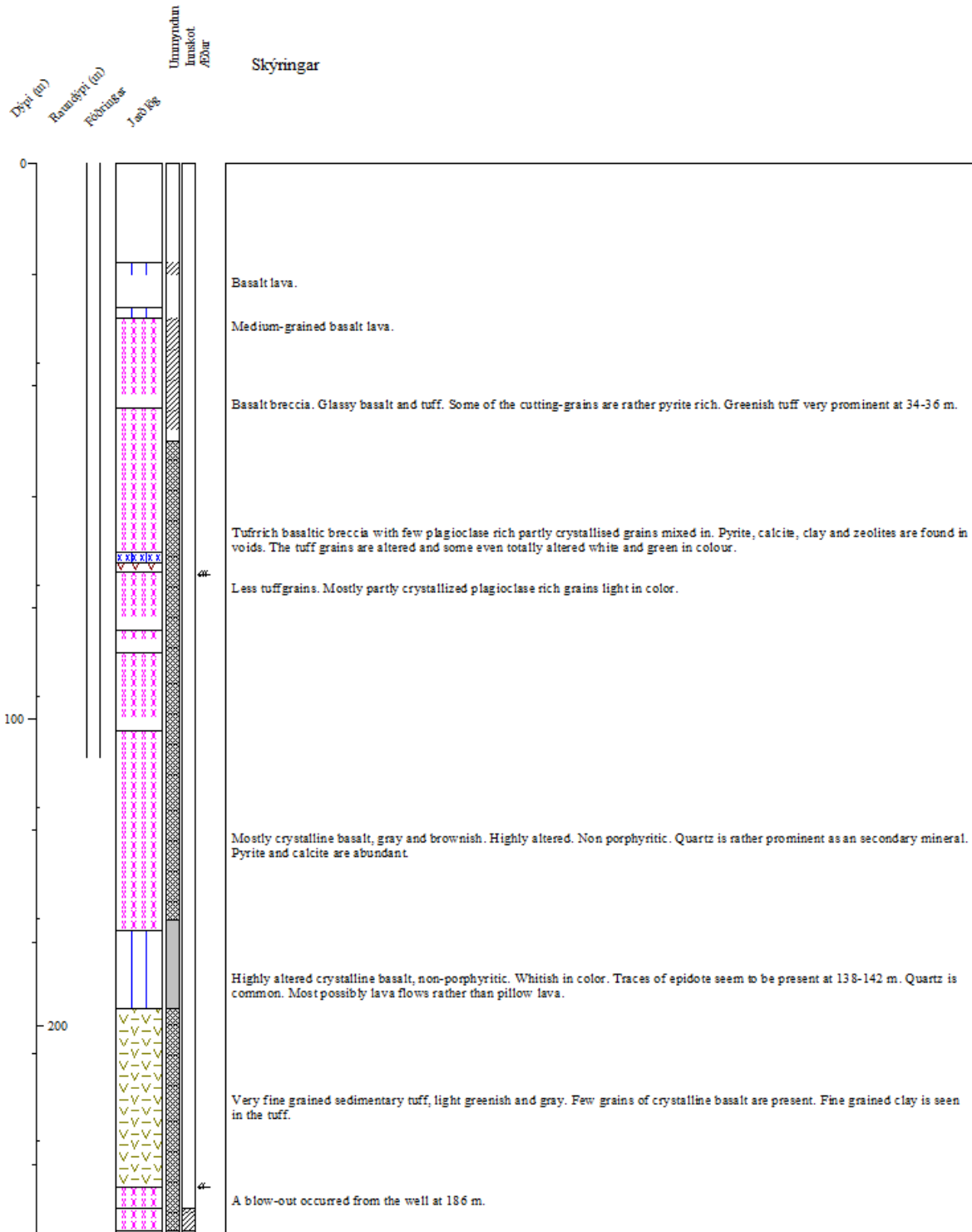
	Positive Identification
	Uncertain Identification

Figure 14. Lithology legend for Figures 15–17.

Staður: Þeistareykir  
 Holunafn: ÞG-10

 Bor: Sleipnir  
 Dýptarbil: 0-193 m

 Skolvökvi: Mud  
 Verkhlut: Phase 0-1

 Staðarnúmer: 60410  
 Starfsmenn: MÁŠ, RSÁ, SRG, SÁ


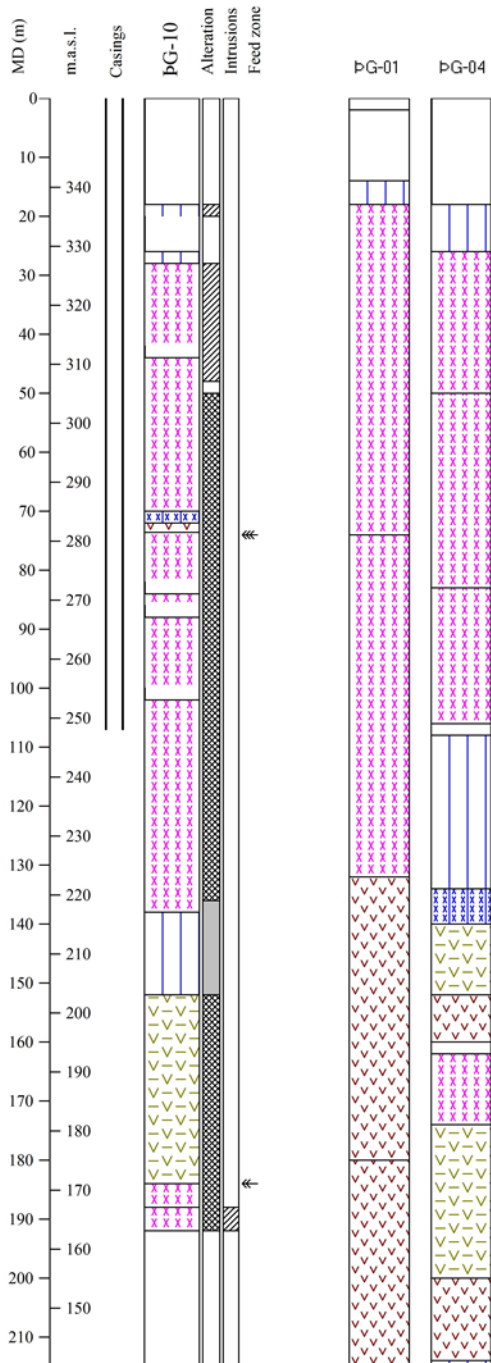
**Figure 15.** Lithology and lithology descriptions from surface down to 192 m in ÞG-10.

Location: Peistareykir  
Well: ÞG-10

Drill rig: Sleipnir  
Depth interval: 0-193 m

Drilling fluid: Mud  
Work phase: Phase 0-1

UWI: 60410  
Geologists: MÁŠ, RSÁ, SRG, SÁ



**Figure 16.** Comparison of the lithology in wells ÞG-10, ÞG-1 and ÞG-4, from surface to 215 m (Guðmundsson et al., 2002; Guðmundsson et al., 2007).

### 3.1 Intrusions

A possible intrusion was intersected at 188–192 m depth. Fragments of dark green and brownish plagioclase rich basalt are common in the cuttings at this depth.

### 3.2 Alteration

Figure 16 shows the main alteration mineral distribution in well PG-10 from surface down to 192 m depth. In the uppermost 72 m the alteration mineral assembly describes low temperature alteration where fine grained clay and zeolites like scolecite and heulandite are common. Below 72 m Quartz was identified in almost every sample, indicating formation temperature of 180°C or higher. Laumontite was found at 86 to 98 m depth. Laumontite forms at 120–180°C. Possible epidote, with formation temperature of 230°C, was found at a narrow depth interval from 138–142 m. No signs of retrograde alteration were noticed. In general, the grade of alteration was high. In the neighbouring wells PG-1, PG-4 and PG-5 quartz was first seen at 48, 86 and 120 m, respectively (Guðmundsson et al., 2002; Gautason et al., 2007).

Area/field: Peistareykir  
Well name: bG-10

Rig: Sleipnir  
Depth interval: 0-193 m

Drilling fluid: Mud  
Drill-stage: Phase 0-1

Well id.: 60410  
Geologist: MÁŠ, RSÁ, SRG, SÁ

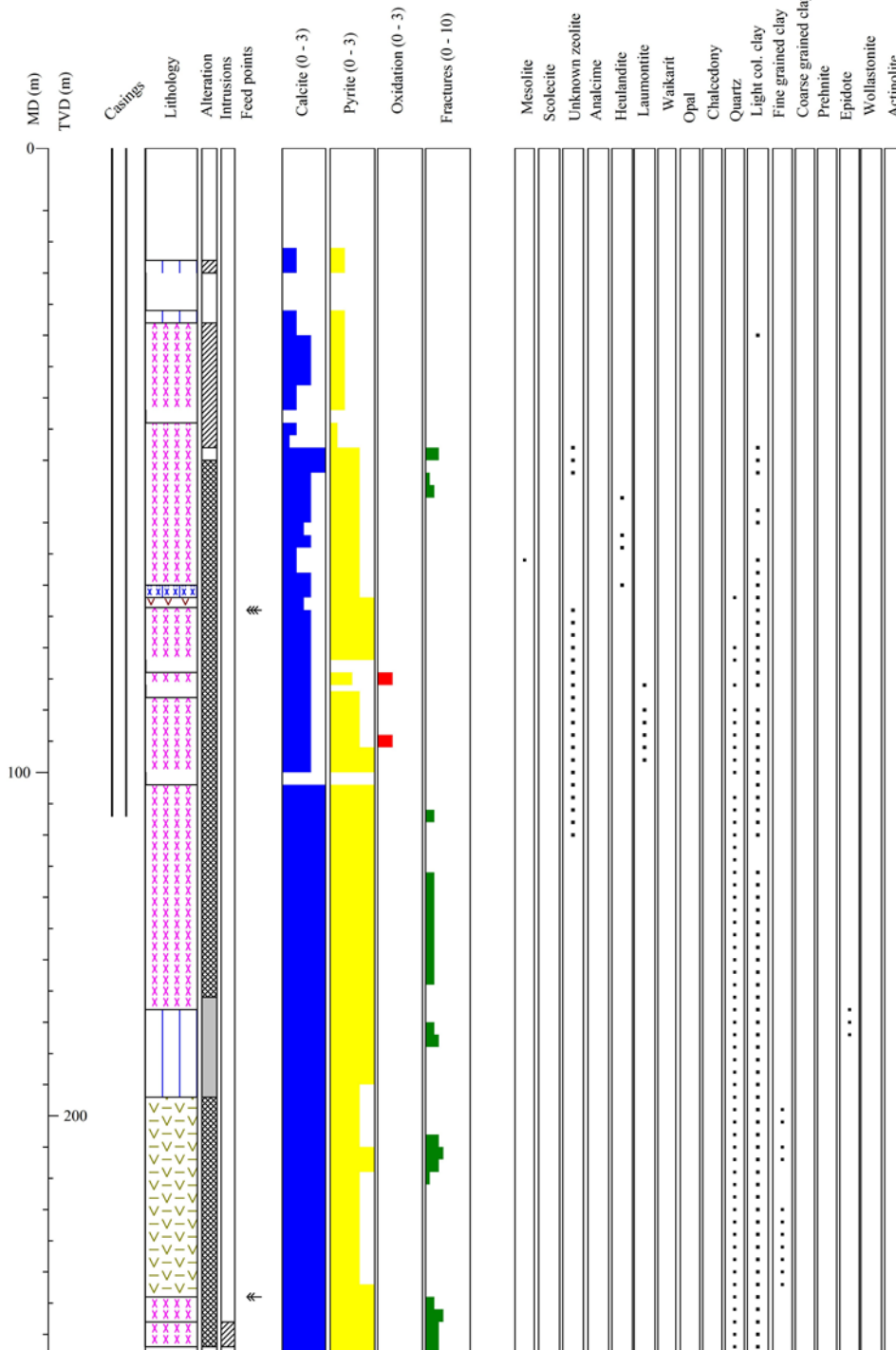


Figure 17. Lithology and alteration minerals in well bG-10 from 0–192 m depth.

### 3.3 Circulation losses during drilling of phases 0 and 1

Circulation losses encountered while drilling of phases 0 and 1 are listed in Table 6.

**Table 6.** *Circulation losses during drilling of phases 0-1 in PG-10.*

Date	Depth (m)	LOC (L/s)	Remarks
26.06.2016	74	20	Losses measured when starting drilling after a change of bit. A plug was placed in the well at 84 m depth.

## 4 Wireline logging

Wireline logging in drilling phases 0 and 1 may be categorized as follow:

- Temperature log prior to cementing in order to check the thermal state of the well and to locate loss zones if they occur.
- Caliper log prior to cementing in order to map the well's diameter, i.e. cavities and possible obstacles inside the well that might require further reaming. In addition, the caliper log gives the minimum volume behind the casing needed to be filled with cement.
- Sinker-bar run to explore possible obstacles in the drill string.
- Pressure log to evaluate conditions in the well.

In this chapter the logging activity and the logging results in phases 0 and 1 in PG-10 are introduced and discussed. Overview of the wireline loggings is shown in Table 7.

**Table 7.** *Overview of wireline logging in drilling phases 0 for the surface casing and drilling phase 1 for the surface casing.*

Date	Time	Log type	Depth (m)	Purpose	Q [l/s]	Remarks
28.6.2016	16:12-16:19	Temperature	6-110	Temperature	0	Logged in open hole
28.6.2016	16:42-16:53	Caliper	110-5	Well diameter, wash-outs, obstacles	0	
5.7.2016	21:17-21:21	Temperature	5-167	Temperature, flow zones	-10	Logged inside drill-string
6.7.2016	17:33-17:40	Temperature	5-155	Temperature, flow zones	-13	Logged inside drill-string. Temperature limit reached at 155m depth
6.7.2016	18:30-18:47	T&P	0-176	Temperature, flow zones	-13	Logged inside drill-string
8.7.2016	13:10-14:08	Sinker-bar	0-167	Obstacles / Clearance	0	Logged inside drill-string
8.7.2016	14:48-14:59	T&P	0-167	Well conditions	0	Logged inside drill-string
9.7.2016	23:20-23:35	T&P	0-162	Well conditions	0	Logged inside drill-string. Depth reference point at cellar edge.

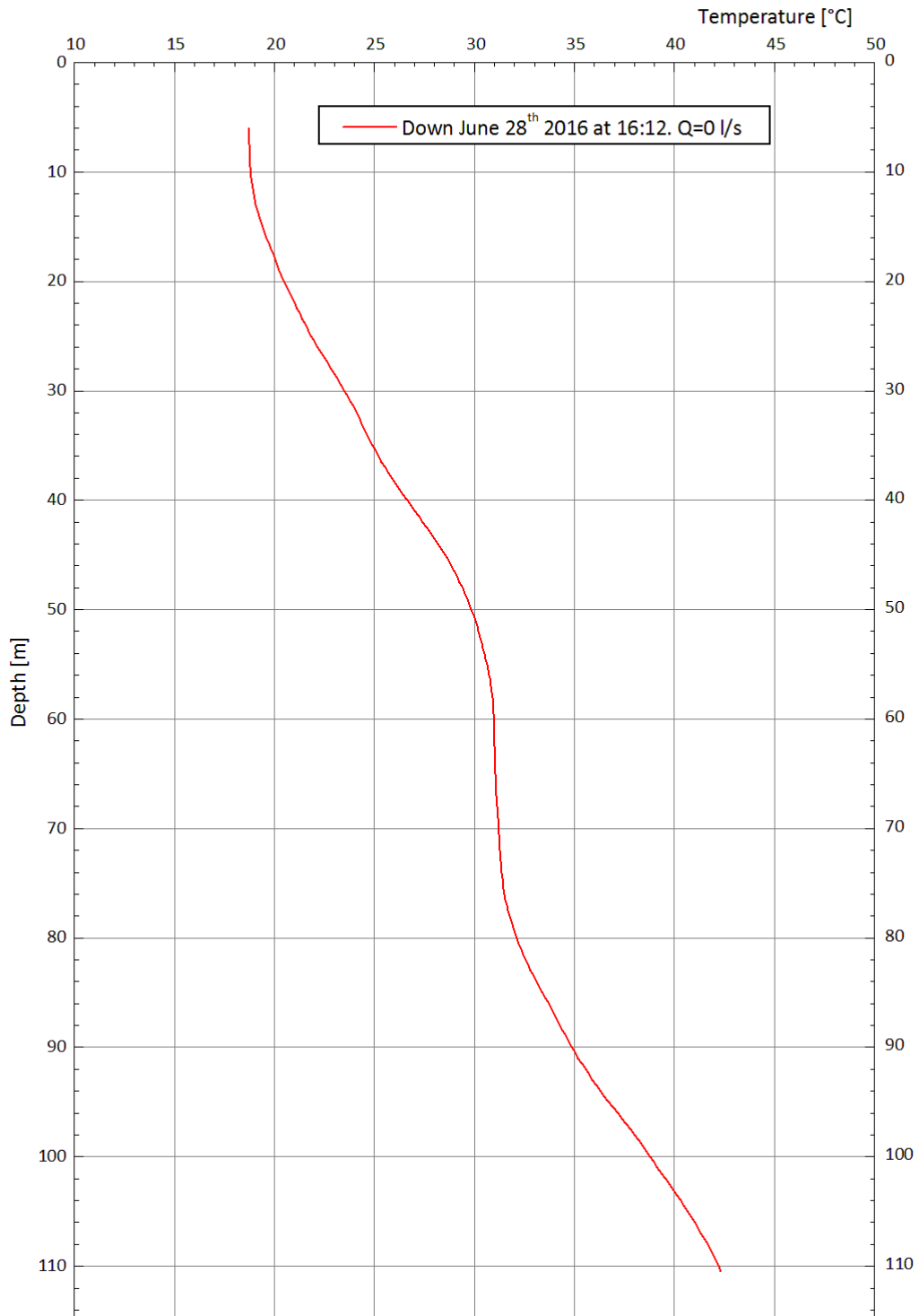


## 4.1 Logging in phase 0

After casing depth was reached, for the 18<sup>5</sup>/<sub>8</sub>" surface casing, at 110 m depth on June 28<sup>th</sup> the well was circulated clean with water and polymer. At 4:00 in the morning POOH was started and a wiper trip was carried out from 7:00–9:45. No bottom hole deposits were found. Next, the well was cooled for an hour and then POOH. At 15:30 on June 28<sup>th</sup> ÍSOR's logging engineers performed temperature and caliper measurements. Figure 18 shows the temperature profile measured in open hole. No water loss was in the well at this point and no indications of feed zones are seen in the smooth temperature profile indicating that the cementing of the loss zone at 73 m had been very successful.

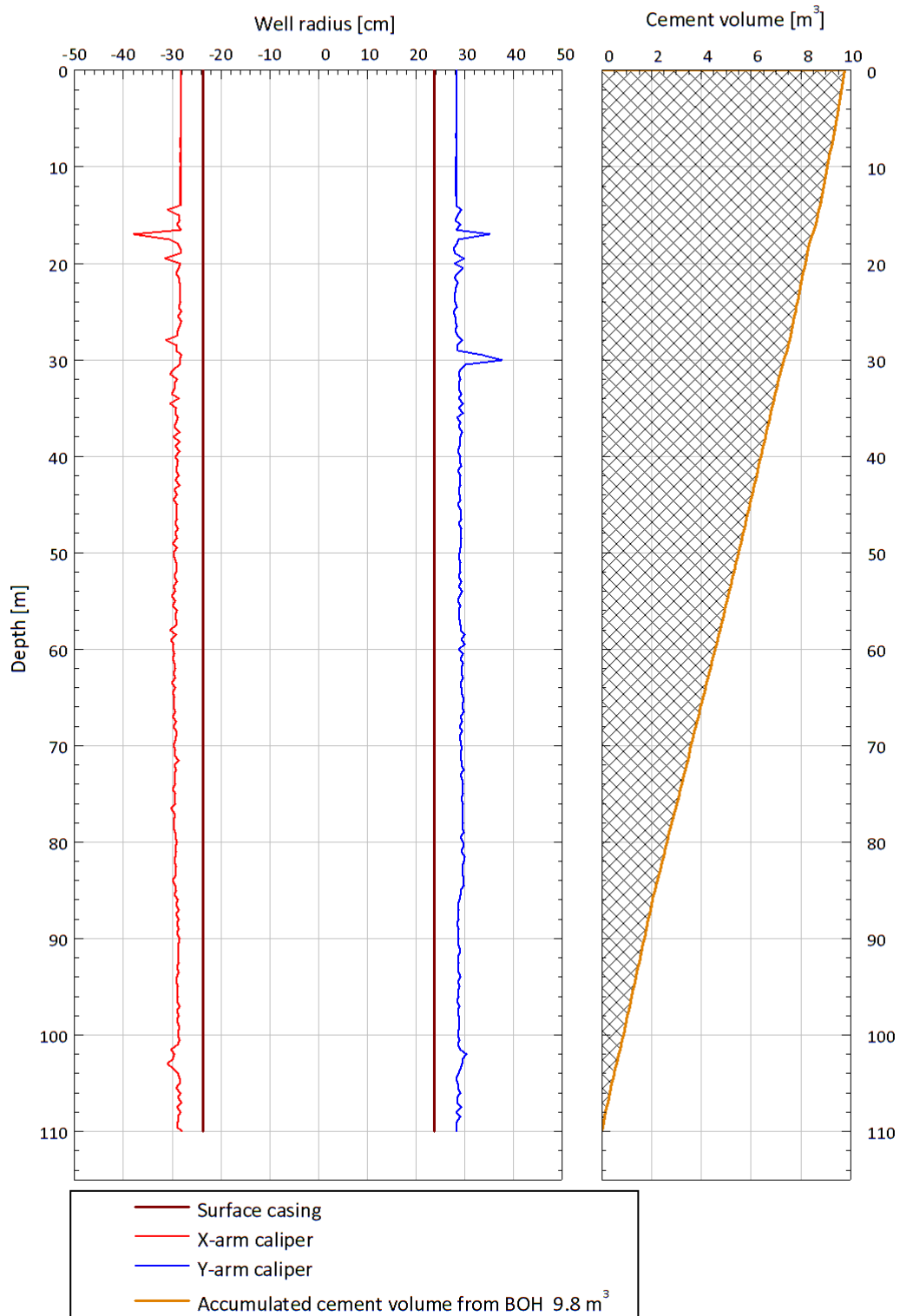
In order to obtain information on the well's diameter and possible obstacles and/or washouts, a caliper log was run. The caliper tool went without problems down to 110 m. The caliper log is shown in Figure 19. At 17 m there was a 20–25 cm wide cavity over only ~1 m, i.e. 3 m below the shoe of the conductor pipe. At 30 m depth there was a 25 cm anomaly on one of the caliper pair (X-arm) which indicates drilling induced fracture or borehole break-out (Tingay et al., 2008). From 30 m depth the caliper log showed rather even well diameter of 580–590 mm down to 84 m where the diameter decreased to about 560–575 mm with an exception of 50 mm increase at the 101–104 m depth interval. Figure 19 shows the caliper log put in context with the wellbore radius and the planned 18<sup>5</sup>/<sub>8</sub>" surface casing. The figure also shows the accumulated volume (calculated from the caliper data starting at BOH) to be cemented between the annulus and the surface casing. The calculated volume was 9,8 m<sup>3</sup>, based on truncated cone shapes between data points of the caliper log. The actual amount of cement used was, however, 50% more or 15 m<sup>3</sup>.

**Well ÞG-10**



**Figure 18.** Temperature log in open hole before installing the surface casing to 107 m.

## Well ÞG-10



**Figure 19.** Caliper log put in context of casing programs so far and estimated volume to be cemented between the annulus and the surface casing.

## 4.2 Logging in phase 1

Drilling of phase 1 (drilling for the anchor casing) commenced on July 1<sup>st</sup>. Drilling stopped at 193 m depth on July 3<sup>rd</sup> after an over-pressurized zone had been intersected at 184 m depth. The next days 48 hours were spent on fighting the over-pressure as described in chapter 2.3. After drilling through a cement plug to about 170 m on July 5<sup>th</sup> the ÍSOR's logging engineers ran temperature log. The log started at 21:17. At that time, some 13 L/s were injected on kill-line. The temperature log is shown in Figure 20 (red curve). It shows that the cooling was effective down to approximately 153 m depth, where the injected water exits. The temperature rose rapidly below 153 m and was 103°C at the float valve at 167 m.

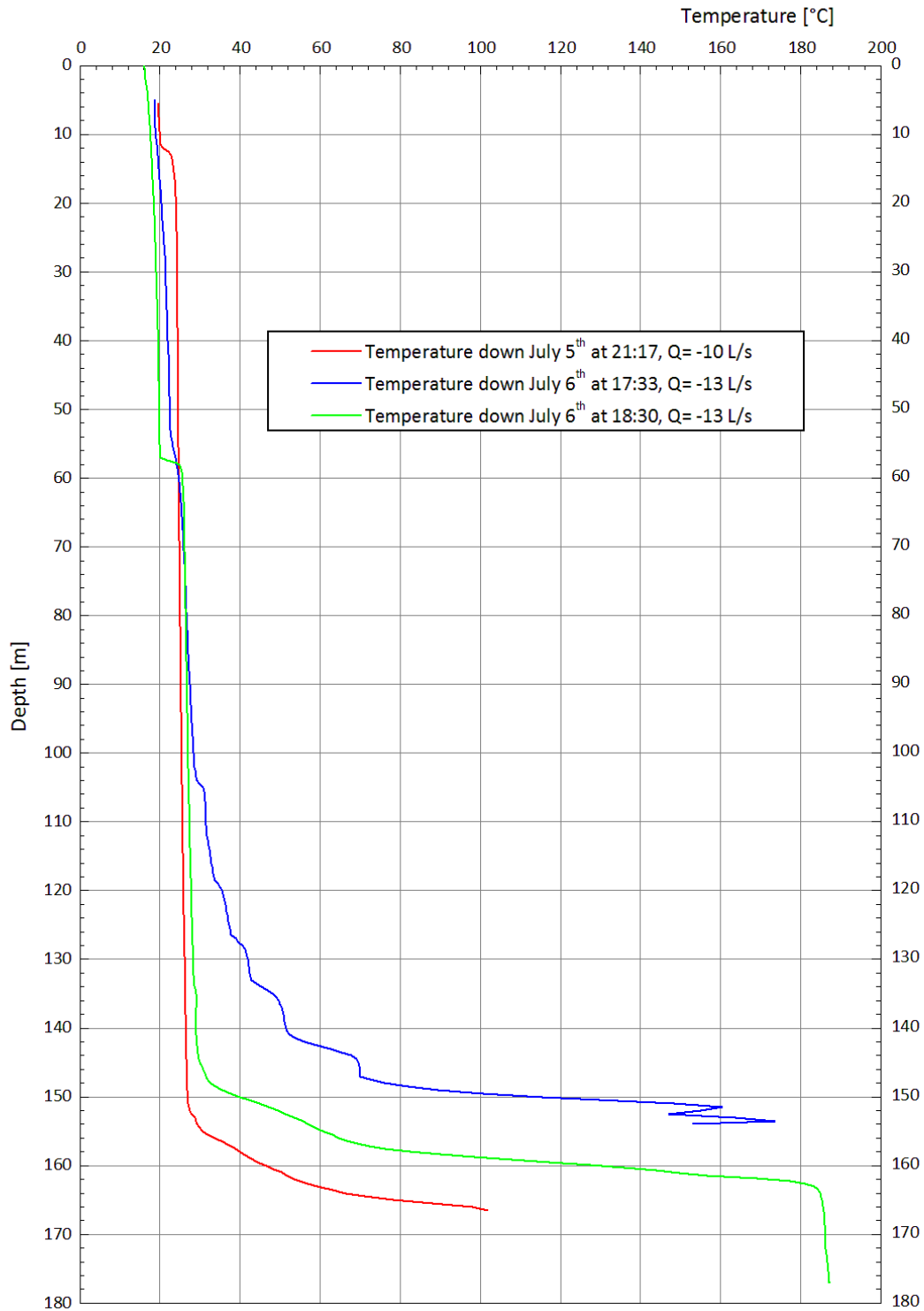
At 01:00 in the morning of July 6<sup>th</sup> a cement slurry was pumped into the well. Drilling in cement started at 124 m depth and continued down to 166 m where the drill bit went through the cement plug and the well came immediately under pressure at 15:35 on July 6<sup>th</sup>. At 16:30, after releasing some pressure from the well, the drill string was stripped down to 178 m depth. Logging engineers arrived to the drillsite at 17:00 to carry out temperature log inside drill-string, with pumping of about 13 L/s on kill-line. The log started 17:33 and is shown in Figure 20 (blue curve). Temperature limit of the logging tool (150°C) was reached at 155 m. Then it was decided to log the well with a high temperature, combined pressure/temperature tool (K10) to get to the bottom. The log started at 18:33 July 6<sup>th</sup> and temperature log is shown in Figure 20 (green curve) and the pressure log in Figure 21. The temperature logs show as before that the injection cooled the well down to 153 m depth, where the temperature rose rapidly to more than 185°C at 165 m but near isothermal from there down to the bottom of the drill-string at 176 m. The pressure log in Figure 21 show that in the deepest 10 m the fluid inside the drill-string is a boiling mixture of water and steam. The temperature profile shows that an underground blow out has started in the well (outside the drill-string) with probably over 200°C hot fluid (water and/or steam) flowing from the bottom region up to 153 m, where it exits the well with the cold water injected on top.

When logging was finished seven singles were stripped out before placing a cement plug in the well. On July 7<sup>th</sup> drilling in cement continued but overpressure occurred again as soon as the bit drilled through the cement plug at ~165 m. Later it was evident that the situation was slowly beginning to become out of control and decision was made to leave the drill-string in the well and cement the well-off through the kill-line to prevent further escalation of the blow-out and to prevent further damage and unmanageable situation on the drill-pad. The cementing was finished just after midnight on the 7<sup>th</sup> of July and well thereby abandoned.

Shortly after lunch on July 8<sup>th</sup> logging engineers ran a sinker bar in the drill string to explore possible obstacles. The sinker bar ran freely down to the float valve at 167 m. After pulling out the sinker bar a combined pressure/temperature tool (K10) was RIH (Figures 22 and 23). The logs show vigorous boiling in the water column in the drill-string, indicating very hot conditions outside the drill-string below 150 m or so.

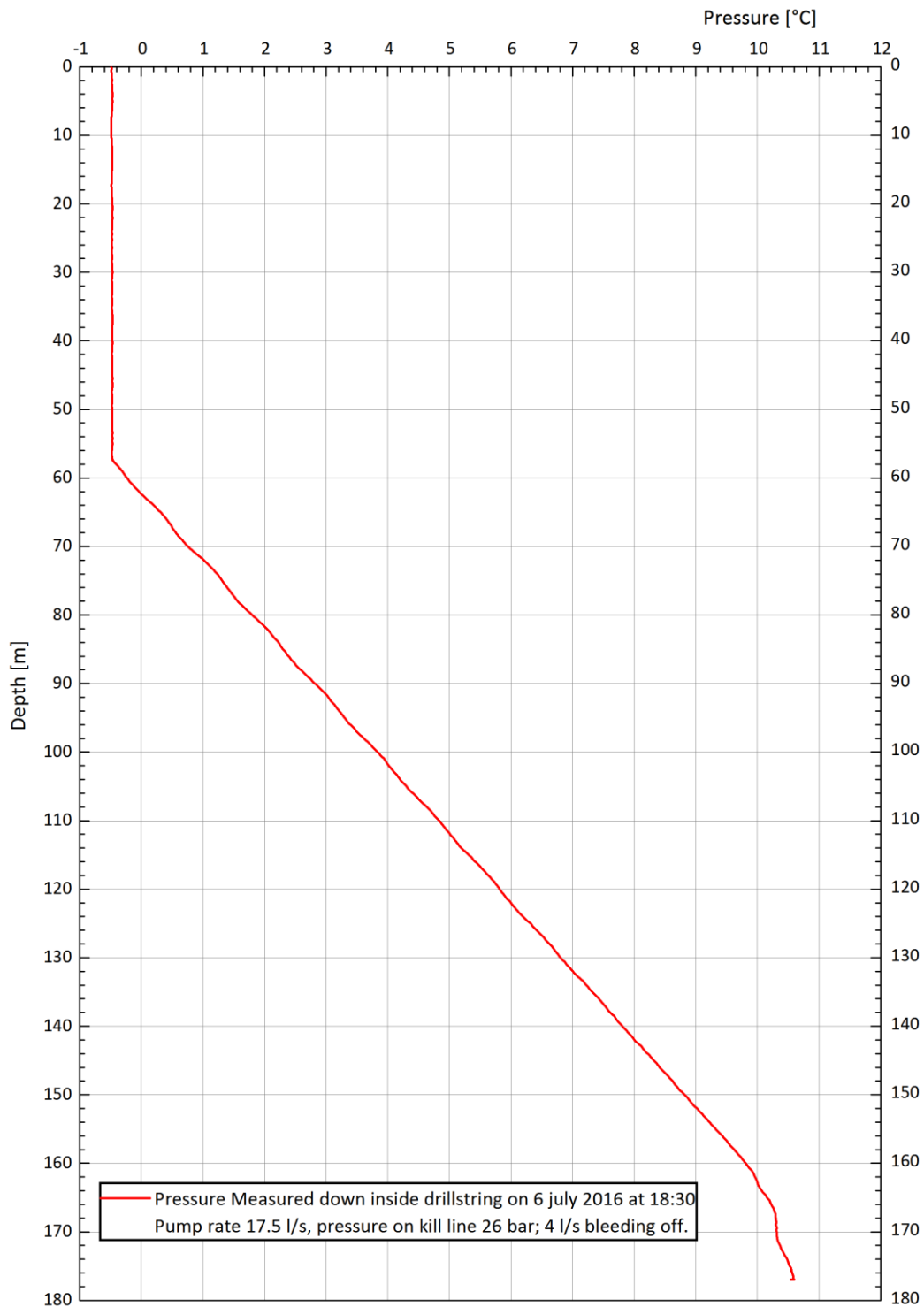
The last logs carried out in well ÞG-10 were temperature/pressure logs (Figures 24 and 25) in late evening on July 9<sup>th</sup>. The results are comparable to the logs from July 8<sup>th</sup> and show boiling conditions inside the drill-pipes.

**Well ÞG-10**



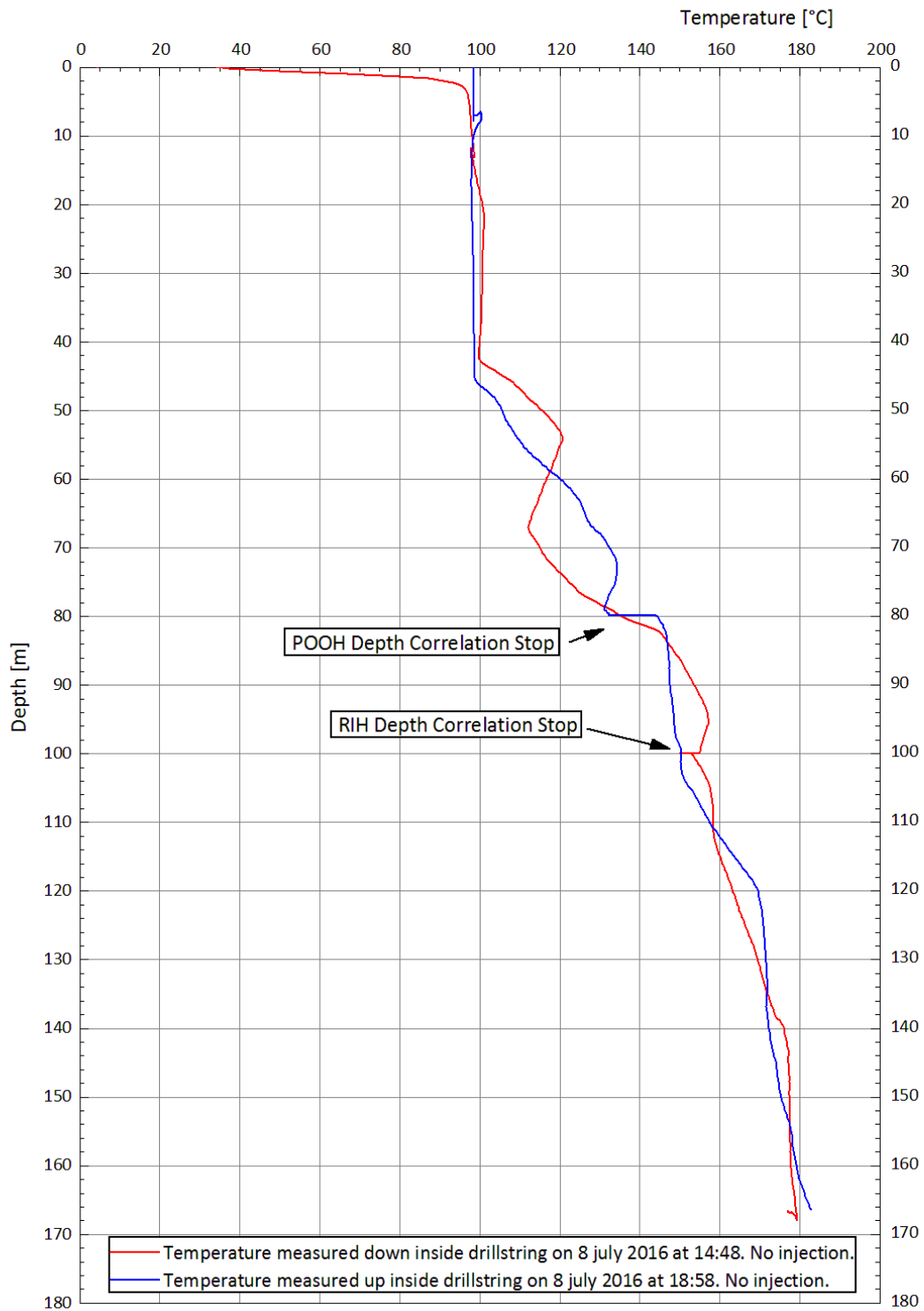
**Figure 20.** Temperature logs in ÞG-10 from 5<sup>th</sup> and 6<sup>th</sup> of July.

**Well ÞG-10**



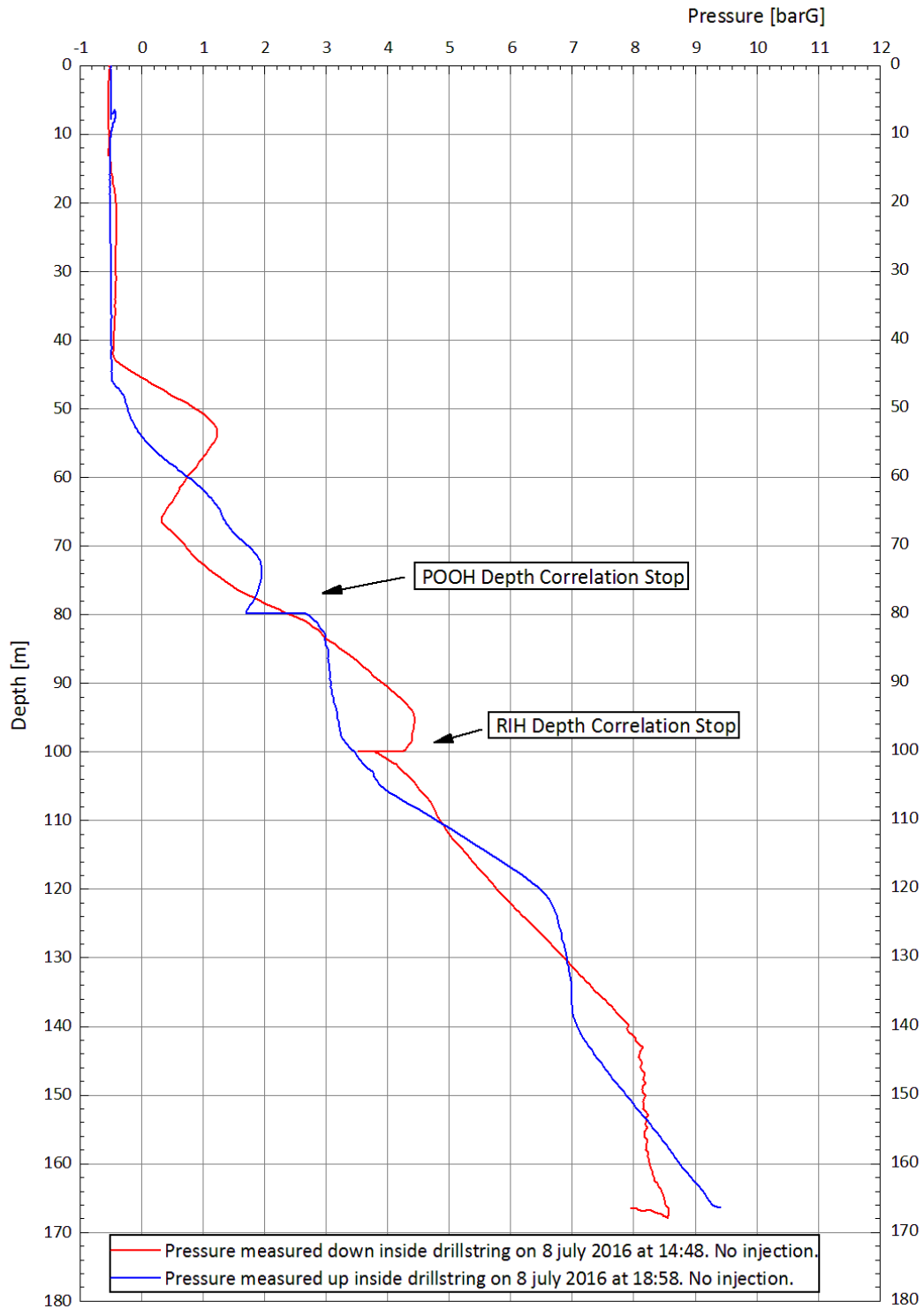
**Figure 21.** Pressure log in ÞG-10 on the 6<sup>th</sup> of July.

**Well PG-10**



**Figure 22.** Temperature logs in PG-10 on the 8<sup>th</sup> of July.

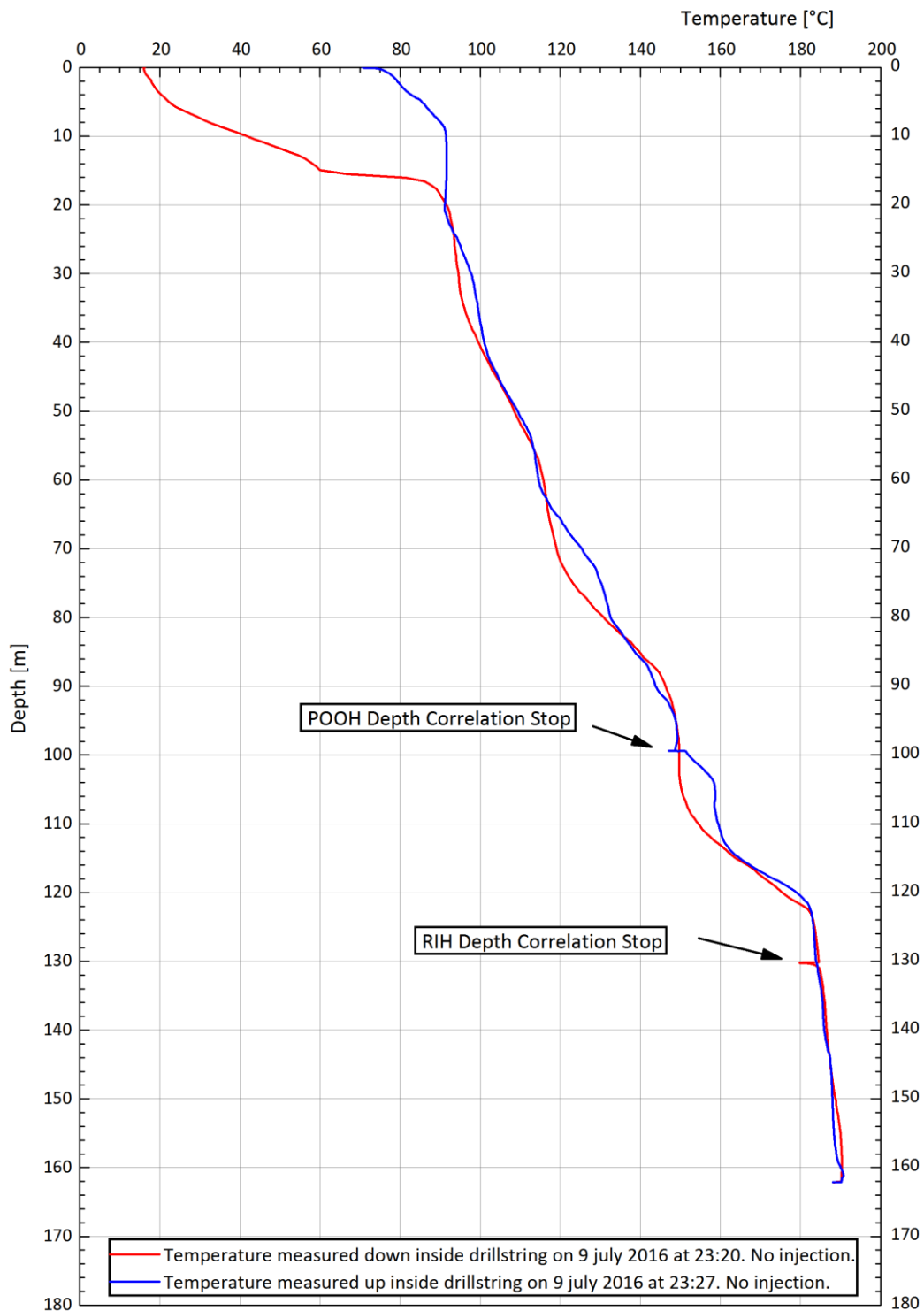
**Well ÞG-10**



**Figure 23.** Pressure logs in ÞG-10 on the 8<sup>th</sup> of July.

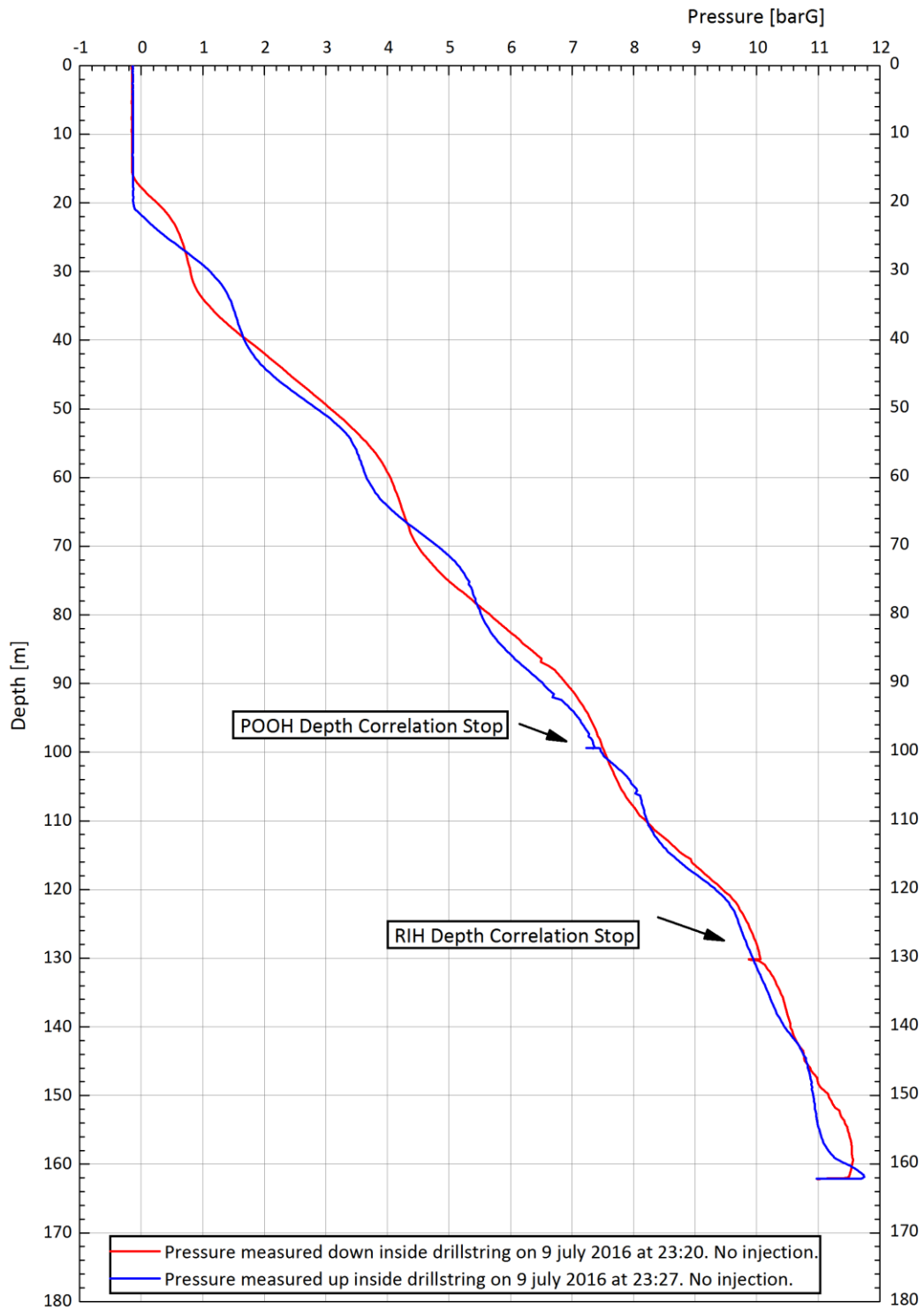


**Well ÞG-10**



**Figure 24.** Temperature logs in ÞG-10 on the 9<sup>th</sup> of July.

**Well ÞG-10**



**Figure 25.** Pressure logs in ÞG-10 on the 9<sup>th</sup> of July.

## 5 References

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**Appendix:**  
**Daily reports**

<b>Peistareykir</b>	<b>Report #01</b> Preliminary results	<b>Pre-Drilling</b> (surface casing)
<i>Operator:</i> <b>Landsvirkjun</b>	<i>Drilling Company:</i> <b>Iceland Drilling Company</b>	
<i>Well Name:</i> <b>PG-10</b>	<i>Drill-Rig:</i> <b>Sleipnir</b>	
<i>Well-Id:</i> <b>60410</b>	<i>Geologist/Geophysicist:</i> <b>SÁ</b> (E-mail: sigurveig.arnadottir@isor.is)	
<i>Last casing size:</i> -	<i>Depth at 24 hrs.</i> <b>35,7 m</b>	<i>Hole made last 24 hrs. :</i> <b>22 m</b>
<i>Last casing depth:</i> -	<i>Depth at 8 hrs.</i> <b>44,3 m</b>	<i>Drilling time:</i> <b>16,25 hrs.</b>
<i>Drilling fluid:</i> <b>Mud</b>	<i>Circulation losses at 8 hrs.</i> <b>0 l/s</b>	<i>Average ROP:</i> <b>1,4 m/hr</b>

### Drilling

Transportation of the Sleipnir drill rig, from well PG-11 on drill pad B to well PG-10 on drill pad A, was completed on the 18th of June. After the drill rig had been made ready, pre-drilling of well PG-10, with 21" drill bit, commenced yesterday morning. Cement was drilled from 13,5 m to 14,2 m at 7-8 am, and drilling into formation at 14,2 m started at 8 am. Drilling has been going well, with an average ROP of 1,4 m/hr.

### Geology

Drill cuttings have been collected since 18 m. Cuttings from 18, 20 and 28 m (no cuttings were collected at 22-26 m) consist of basalt lava, and cuttings from 30 to 42 m consist of basalt breccia. Pyrite and calcite are recorded in all samples.

## Peistareykir

## Report #02 Preliminary results

## Pre-Drilling (surface casing)

*Operator:* **Landsvirkjun**

*Drilling Company:* **Iceland Drilling Company**

*Well Name:* **ÞG-10**

*Drill-Rig:* **Sleipnir**

*Well-Id:* **60410**

*Geologist/Geophysicist:* **SRG**  
(E-mail: srg@isor.is)

Last casing size: -	Depth at 24 hrs. <b>55.5 m</b>	Hole made last 24 hrs. : <b>20.5 m</b>
Last casing depth: -	Depth at 8 hrs. <b>60.5 m</b>	Drilling time: <b>22.5 hrs.</b>
Drilling fluid: <b>Mud</b>	Circulation losses at 8 hrs. <b>0 l/s</b>	Average ROP: <b>0.9 m/hr</b>

### Drilling

Drilling was almost continuous yesterday with drillig from 35-55.5 m depth. Drilling ROP has somewhat slowed down with average ROP of 0.9 m/hr. Currently at 09:00 the 25<sup>th</sup> of June drilling is ongoing, at 61 m depth and ROP around 1. No circulation losses have been measured. Wells ÞG-1, 4 and 5 are located on the same drill pad (A) as ÞG-10. Table 1 gives an overview of recorded circulation losses in those wells in comparison to what may be expected in well ÞG-10 during drilling of phase 0. Since no losses have been measured within ÞG-10 so far it is safe to state that the loss zone seen in ÞG-1 at 48.5 m is now tight, especially since no losses have been measured at that depth in the later drilled wells. No losses were measured in ÞG-5 in phase 0 down to 110 m, and it will be interesting to see wheather that will also be the case in ÞG-10.

**Table 1.** Informations on loss zones in wells ÞG-1, 4 and 5.

Well	phase	Depth (m)	Circ.loss (l/s)	Remarks
ÞG-1	0	48.5	TLC	Loss zone cemented with 4m <sup>3</sup> of cement. Minor losses at 58 m.
ÞG-4	1	92	TLC	Very open loss zone in a basaltic breccia formation. Cemented with 91.2 m <sup>3</sup> slurry in nine attempts.
ÞG-5	0	110	0	No losses measured

### Geology

The lithology in wells ÞG-1, 4 and 5 have mostly consisted of basaltic breccia the first 100 m. That is consistent to what is seen in the drill cuttings so far in ÞG-10. Cuttings down to 48 m have been analysed. The breccia is highly tuff rich and consists of grains with glassy ground-mass with white and clear pore fillings and fine grained clay.

## Peistareykir

## Report #03 Preliminary results

## Pre-Drilling (surface casing)

*Operator:* **Landsvirkjun**

*Drilling Company:* **Iceland Drilling Company**

*Well Name:* **ÞG-10**

*Drill-Rig:* **Sleipnir**

*Well-Id:* **60410**

*Geologist/Geophysicist:* **SRG**  
(E-mail: srg@isor.is)

Last casing size: -                      Depth at 24 hrs. **70.3 m**                      Hole made last 24 hrs. : **14.8 m**

Last casing depth: -                      Depth at 8 hrs. **73 m**                      Drilling time: **24 hrs.**

Drilling fluid: **Mud**                      Circulation losses at 8 hrs. **0 l/s**                      Average ROP: **0.6 m/hr**

### Drilling

Drilling was ongoing the whole day and night of June 25<sup>th</sup>. The ROP was very slow, around 0.6 m/h. Compared to the other wells from the same drill pad (ÞG-1, 4 and 5), the ROP during the pre-drilling phase is the slowest in well ÞG-10 (table 1). The drilled formations however, resemble to what was seen in the other wells, medium altered and tuff-rich basaltic breccia. No circulation losses have been measured so far.

**Table 1.** Average ROP in wells ÞG-1, 4, 5 and 10 during pre-drilling

Well	Depth interval (m)	Average ROP (m/h)
ÞG-10	14.5-70.3	0.9
ÞG-5	15-110	1.8
ÞG-4	17-98	4.1
ÞG-1	74-116 (phase 1)	1.9

Figure 1 shows the drilling progress of ÞG-10 the first 5 workdays.

## PG-10 - Drilling Progress

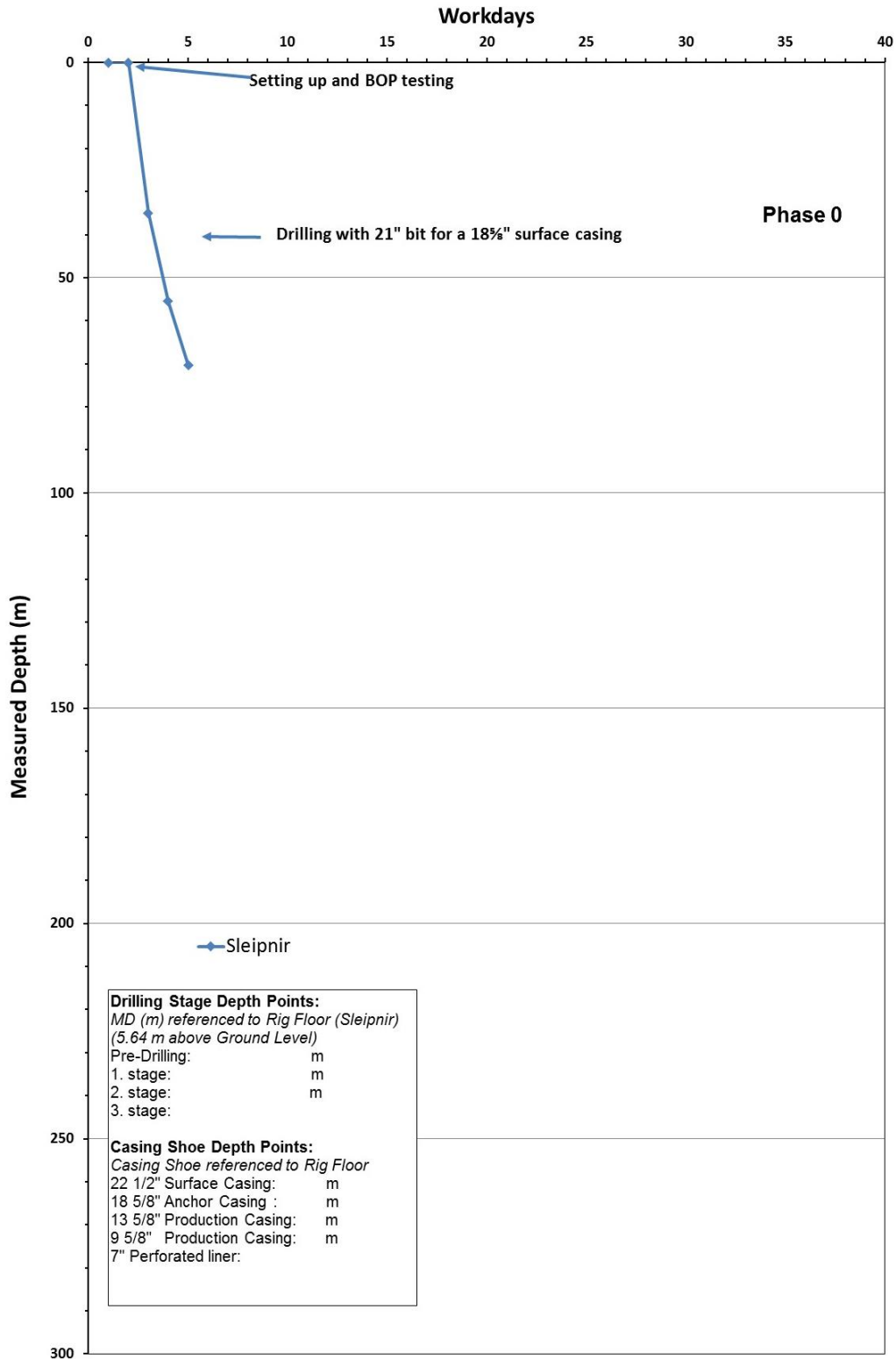


Figure 1. Drilling progress of PG-10.



## Geology

Description of analyzed samples from 0-74 m in well PG-10:

0-18 m NO CUTTINGS

18-20 m FINE-MEDIUM GRAINED BASALT

Basalt lava.

20-26 m: NO CUTTINGS

26-28 m: FINE-MEDIUM GRAINED BASALT

Medium-grained basalt lava.

28-42 m: BASALTIC BRECCIA

Basalt breccia. Glassy basalt and tuff. Some of the cutting-grains are rather pyrite rich. Greenish tuff very prominent at 34-36 m.

42-44 m: NO CUTTINGS

44-70 m: BASALTIC BRECCIA

Tuff-rich basaltic breccia with few plagioclase rich partly crystallized grains mixed in. Pyrite, calcite, clay and zeolites fill up voids in the grains. the tuff grains are altered and some even totally altered with white and green appearances.

70-72 m: GLASSY BASALT

Less tuff grains. Mostly partly crystallized plagioclase rich grains, light in color. Euhedral quartz cluster as a pore filling.

Figure 2 shows the alteration mineral assembly and alteration from surface down to 74 m in well PG-10. From the Figure it can be seen that low temperature zeolites are the main alteration minerals at that depth interval (e.g. thompsonite, analcime and heulandite). The first appearance of Quartz in the cutting in well PG-1 was at 48 m, in PG-4 at 84 m and PG-5 at 120 m. A very small cluster of Quartz was noticed in one sample at 72 as a pore filling in PG-10.

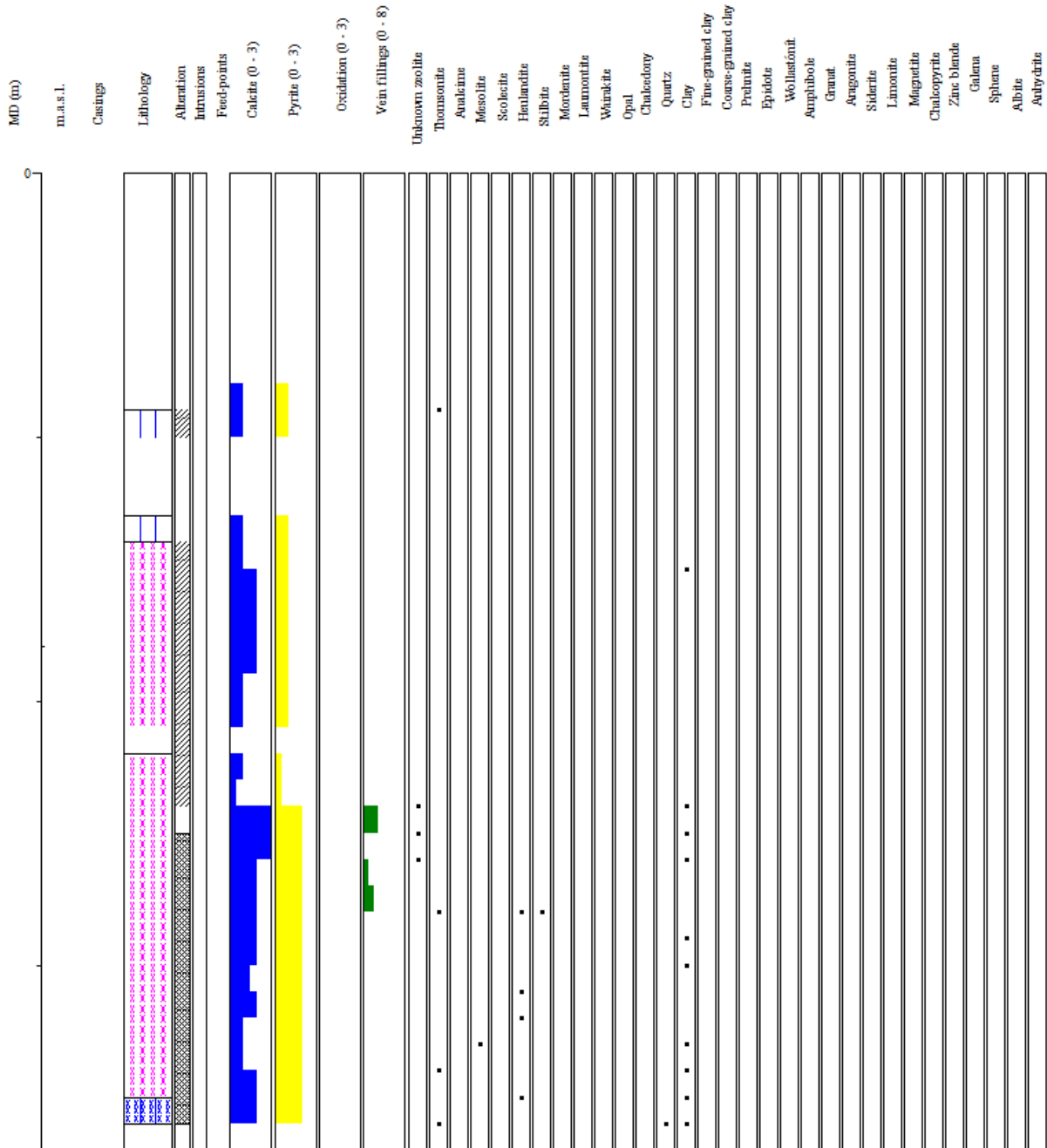


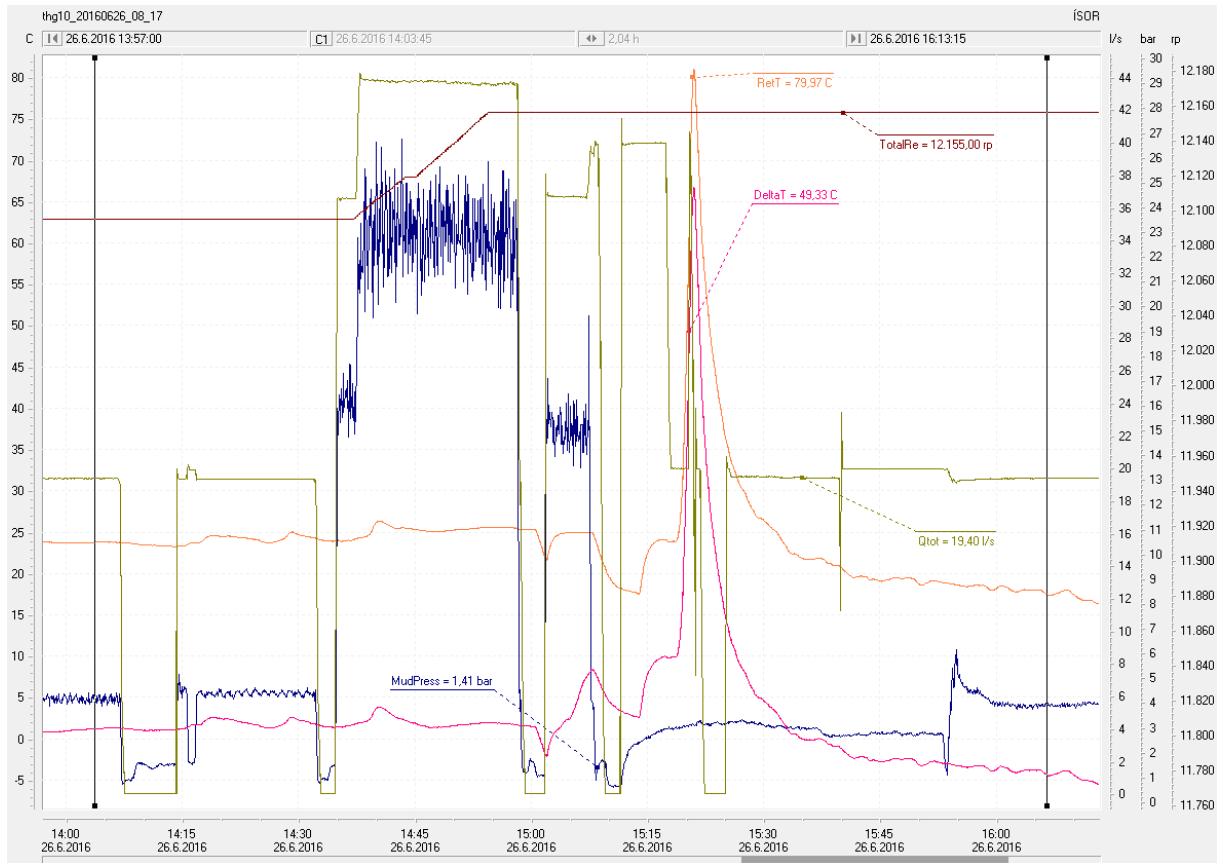
Figure 2. Alteration in well ÞG-10 from surface down to 74 m.

**Peistareykir**
**Report #04**  
**Preliminary results**
**Pre-Drilling**  
**(surface casing)**

<i>Operator:</i>	<b>Landsvirkjun</b>	<i>Drilling Company:</i>	<b>Iceland Drilling Company</b>
<i>Well Name:</i>	<b>ÞG-10</b>	<i>Drill-Rig:</i>	<b>Sleipnir</b>
<i>Well-Id:</i>	<b>60410</b>	<i>Geologist/Geophysicist:</i>	<b>SRG</b> (E-mail: srg@isor.is)
<i>Last casing size:</i>	-	<i>Depth at 24 hrs.</i>	<b>84 m</b>
<i>Last casing depth:</i>	-	<i>Depth at 8 hrs.</i>	<b>84 m</b>
<i>Drilling fluid:</i>	<b>Mud</b>	<i>Circulation losses at 8 hrs.</i>	<b>6 l/s</b>
		<i>Hole made last 24 hrs. :</i>	<b>13.7 m</b>
		<i>Drilling time:</i>	<b>16 hrs.</b>
		<i>Average ROP:</i>	<b>0.9 m/hr</b>

**Drilling**

Drilling was ongoing from midnight to 10:00 the 26<sup>th</sup> of June. The drilled formation was very hard and therefore it was decided to pull the string out of the hole to see the condition of the drill bit. The drill bit was in good condition and was not totally covered in mud, that could have been a factor in the slow ROP. The string with the bit was RIH, but when drilling had just started the well belched mud and the water table fell. The well was cooled with pumping of 43 l/s and circulation losses were measured 20 l/s. It was decided to carry on drilling. At 21:00 the circulation losses were 14 l/s, and 12 l/s at 23:30. The next thing to do was to rinse the well for a cement job. Currently at 09:00 the cement job has been completed and WOC as well. Next thing to do is drill into the cement plug. Figure 1 shows the drilling data from yesterday (14:00-16:00) at the time of the eruption. From the figure it can be seen how the differential temperature rises along with the returning temperature and the mud pressure decreases, indicating that the water level in the well has dropped.



## Geology

No loss zones were found at 73 m in the other wells (PG-1, 4 and 5) located on the same drill pad. It is however not possible to rule out that the circulation losses have started at shallower levels within the well, but were only first noticed when the well belched at around 15:20 yesterday. The analyzed drill cuttings at 72 m showed pillow basalt formation, where tuff grains were not as common as in the breccia formation above 72 m. The sample analyzed at 73.6 m (that came up when the well belched) showed only medium altered tuff grains, rich in pyrite and white fillings in fractures and pores.

<b>Peistareykir</b>		<b>Report #05</b>		<b>Pre-Drilling</b>	
		<b>Preliminary results</b>		<b>(surface casing)</b>	
<i>Operator:</i>	<b>Landsvirkjun</b>	<i>Drilling Company:</i>	<b>Iceland Drilling Company</b>		
<i>Well Name:</i>	<b>PG-10</b>	<i>Drill-Rig:</i>	<b>Sleipnir</b>		
<i>Well-Id:</i>	<b>60410</b>	<i>Geologist/Geophysicist:</i>	<b>SÁ</b> (E-mail: sigurveig.arnadottir@isor.is)		
<i>Last casing size:</i>	-	<i>Depth at 24 hrs.</i>	<b>107 m</b>	<i>Hole made last 24 hrs.:</i>	<b>23 m</b>
<i>Last casing depth:</i>	-	<i>Depth at 8 hrs.</i>	<b>110 m</b>	<i>Drilling time:</i>	<b>13 hrs.</b>
<i>Drilling fluid:</i>	<b>Mud</b>	<i>Circulation losses at 8 hrs.</i>	<b>0 l/s</b>	<i>Average ROP:</i>	<b>1,8 m/hr</b>

## Drilling

Drilling into the cement plug started yesterday morning, and formation at 84 m was reached by ca. 13:30. It seemed that the cement had not quite succeeded, as mostly sand came up. Nevertheless, the cement appears to have served its purpose, as no circulation losses have been noted.

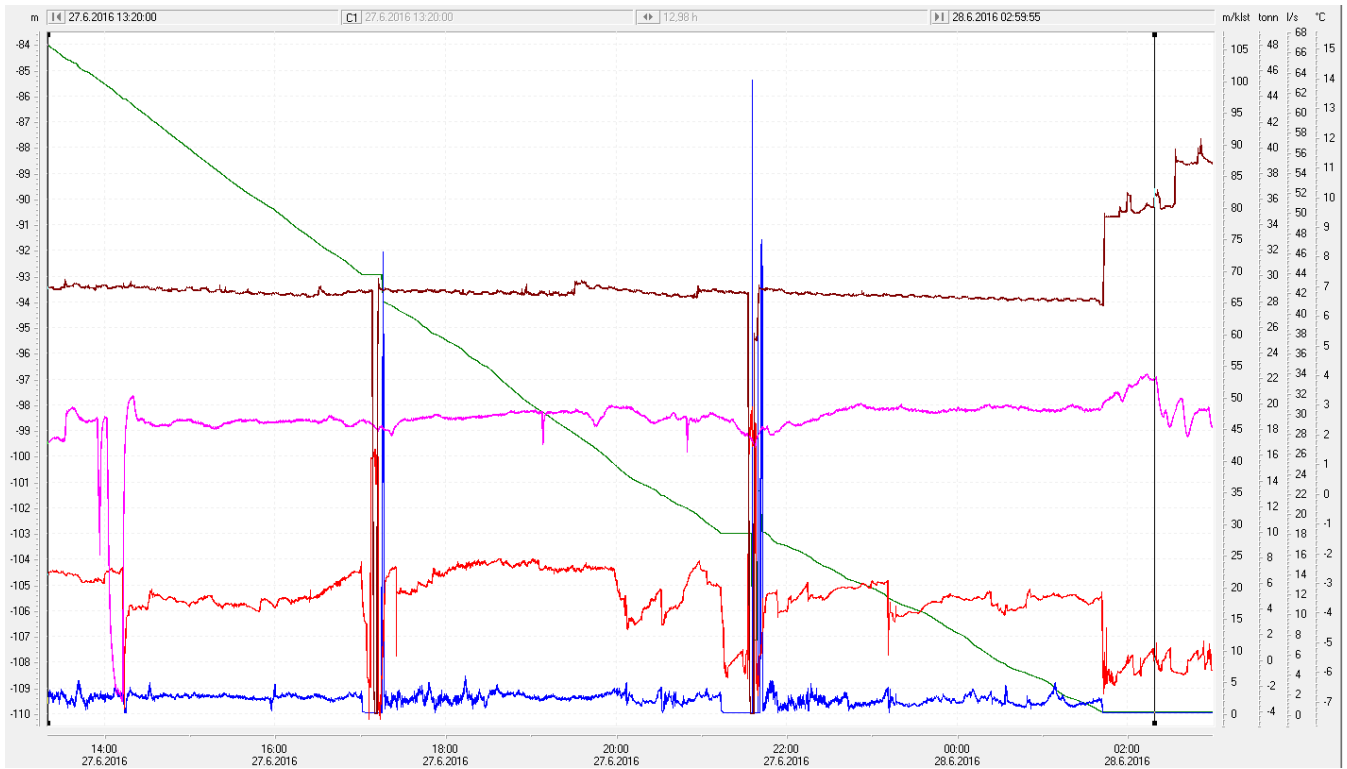
Drilling was continuous until casing depth was reached, at 110 m, 2 am last night. A wiper-trip is currently ongoing. After that, temperature and caliper logging will be carried out.

Figure 1 shows selected drilling parameters from yesterday and last night, during drilling from 84 to 110 m.

## Geology

Cuttings from 72-110 m consist of pyrite-rich breccia and are a mixture of tuff, glassy basalt, fine-medium grained basalt and brown/black glass fragments. Increase in fine-medium grained basalt is observed at 84 m, and increase in glassy basalt at 102 m. Quartz is observed at 106 m. Quartz was also analyzed, but with low confidence, at 72 m.

Drill cutting analysis during pre-drilling is shown in Figures 2 and 3.



Legend:

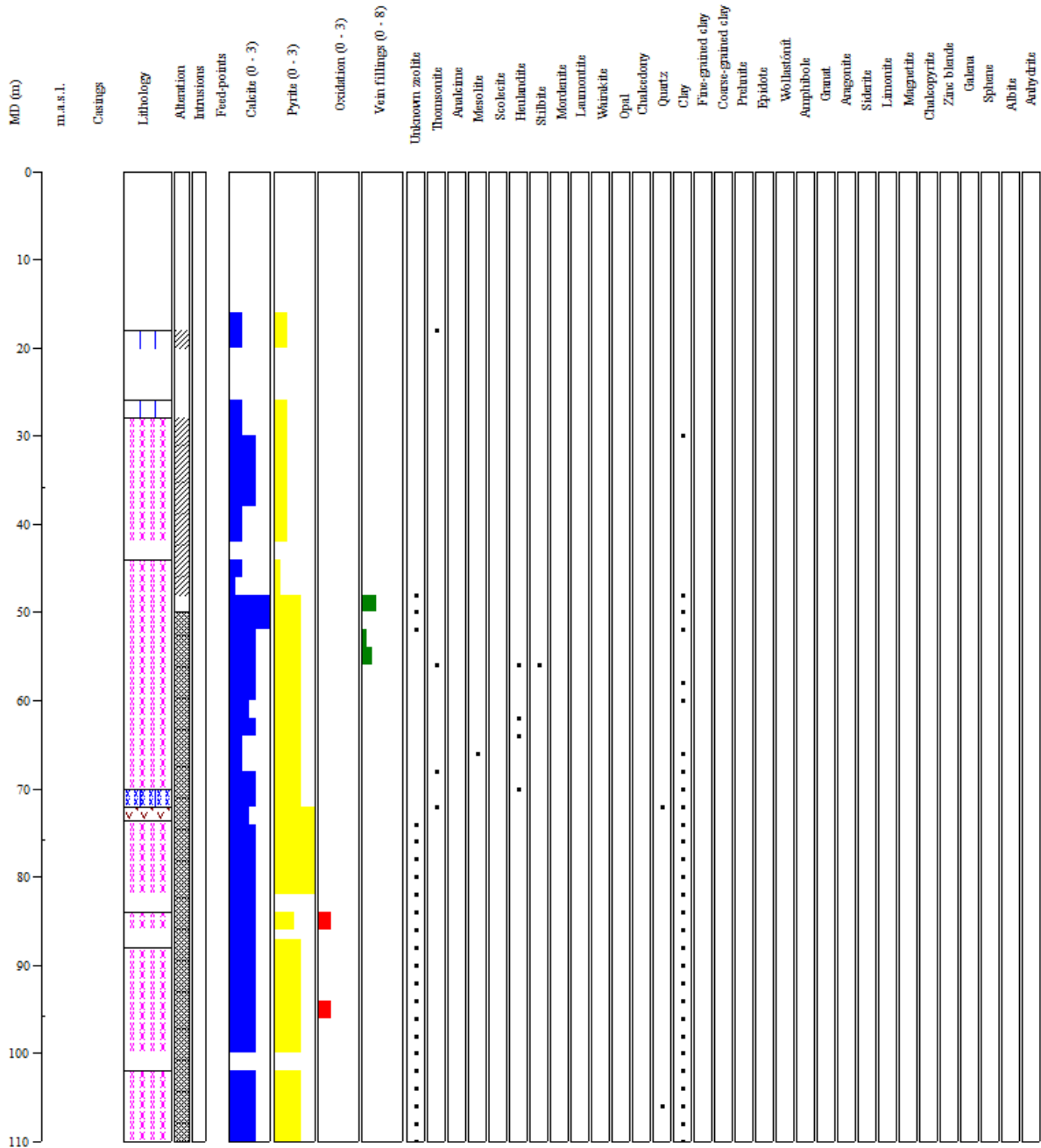
m	Dýpi_borholu	(MD)
m/klst	Borunarhraði	(ROP)
tonn	Alag_á_krónu	(WOB)
°C	Mismunahiti	(WOB)
l/s	Heildardæling	(DeltaT)
		(Qtot)

**Figure 1.** Selected drilling parameters from yesterday and last night, during drilling from 84 m to 110 m.

Area/field: Peistareykir  
 Well name: ÞG-10

 Rig: Sleipnir  
 Depth interval: 0-110 m

 Drilling fluid: Mud  
 Drill-stage: Phase 0

 Well id: 60410  
 Geologists: SRG, SÁ


**Figure 2.** Drill cutting analysis in well ÞG-10 at 0-110 m.

Location: Peistareykir  
Well: ÞG-10

Drill rig: Sleipnir  
Depth interval: 0-110 m

Drilling fluid: Mud  
Work phase: Phase 0

UWT: 60410  
Geologists: SRG, SÁ

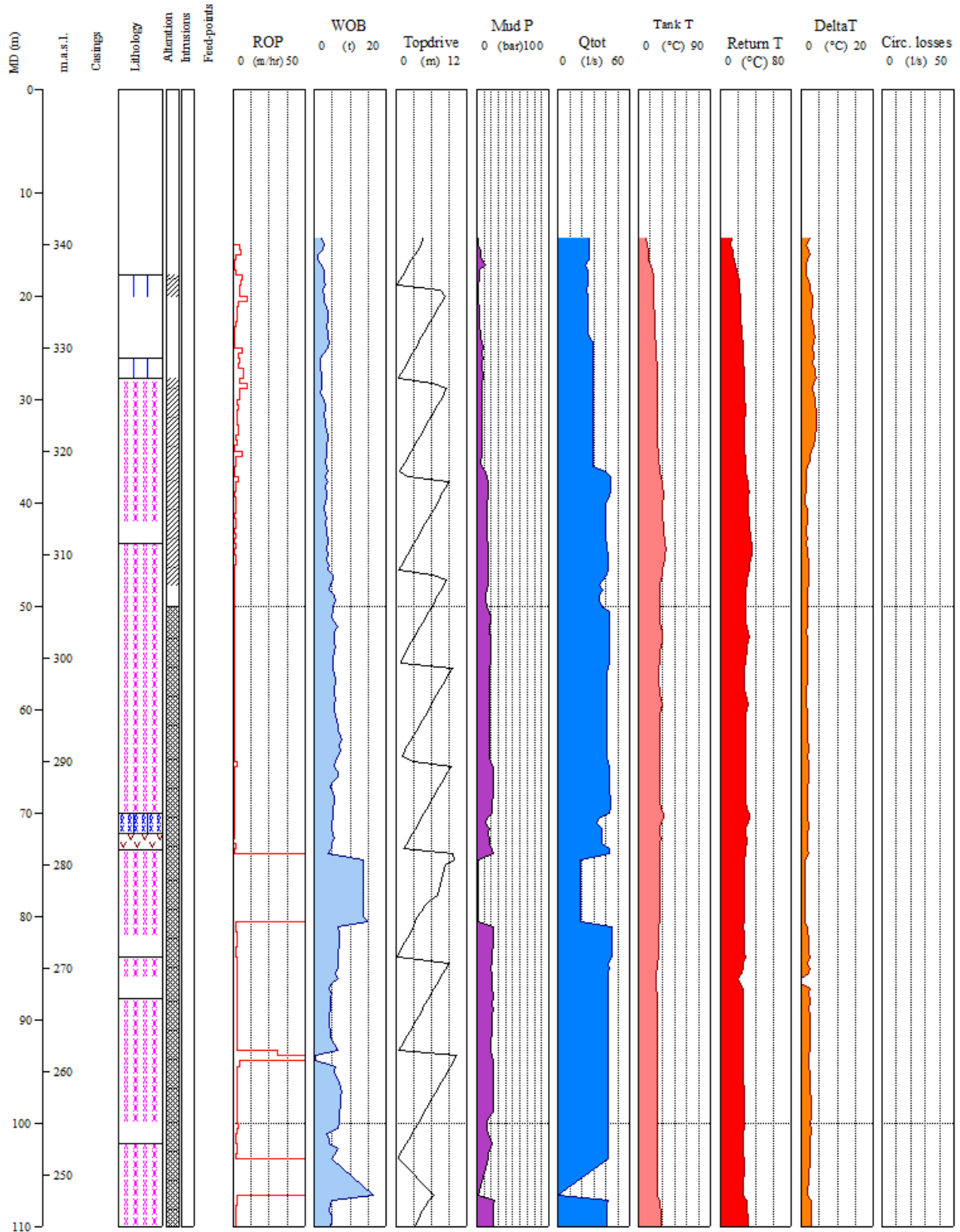


Figure 3. Drill cutting analysis in comparison with drill data.



<b>Peistareykir</b>		<b>Report #06</b>		<b>Pre-Drilling</b>	
		<b>Preliminary results</b>		<b>(surface casing)</b>	
<i>Operator:</i>	<b>Landsvirkjun</b>	<i>Drilling Company:</i>	<b>Iceland Drilling Company</b>		
<i>Well Name:</i>	<b>ÞG-10</b>	<i>Drill-Rig:</i>	<b>Sleipnir</b>		
<i>Well-Id:</i>	<b>60410</b>	<i>Geologist/Geophysicist:</i>	<b>SRG/ÞEg,FP</b> (E-mail: srg@isor.is)		
<i>Last casing size:</i>	<b>18 5/8"</b>	<i>Depth at 24 hrs.</i>	<b>110 m</b>	<i>Hole made last 24 hrs. :</i>	<b>m</b>
<i>Last casing depth:</i>	<b>110 m</b>	<i>Depth at 8 hrs.</i>	<b>110 m</b>	<i>Drilling time:</i>	<b>hrs.</b>
<i>Drilling fluid:</i>	<b>Mud</b>	<i>Circulation losses at 8 hrs.</i>	<b>0 l/s</b>	<i>Average ROP:</i>	<b>m/hr</b>

### Drilling

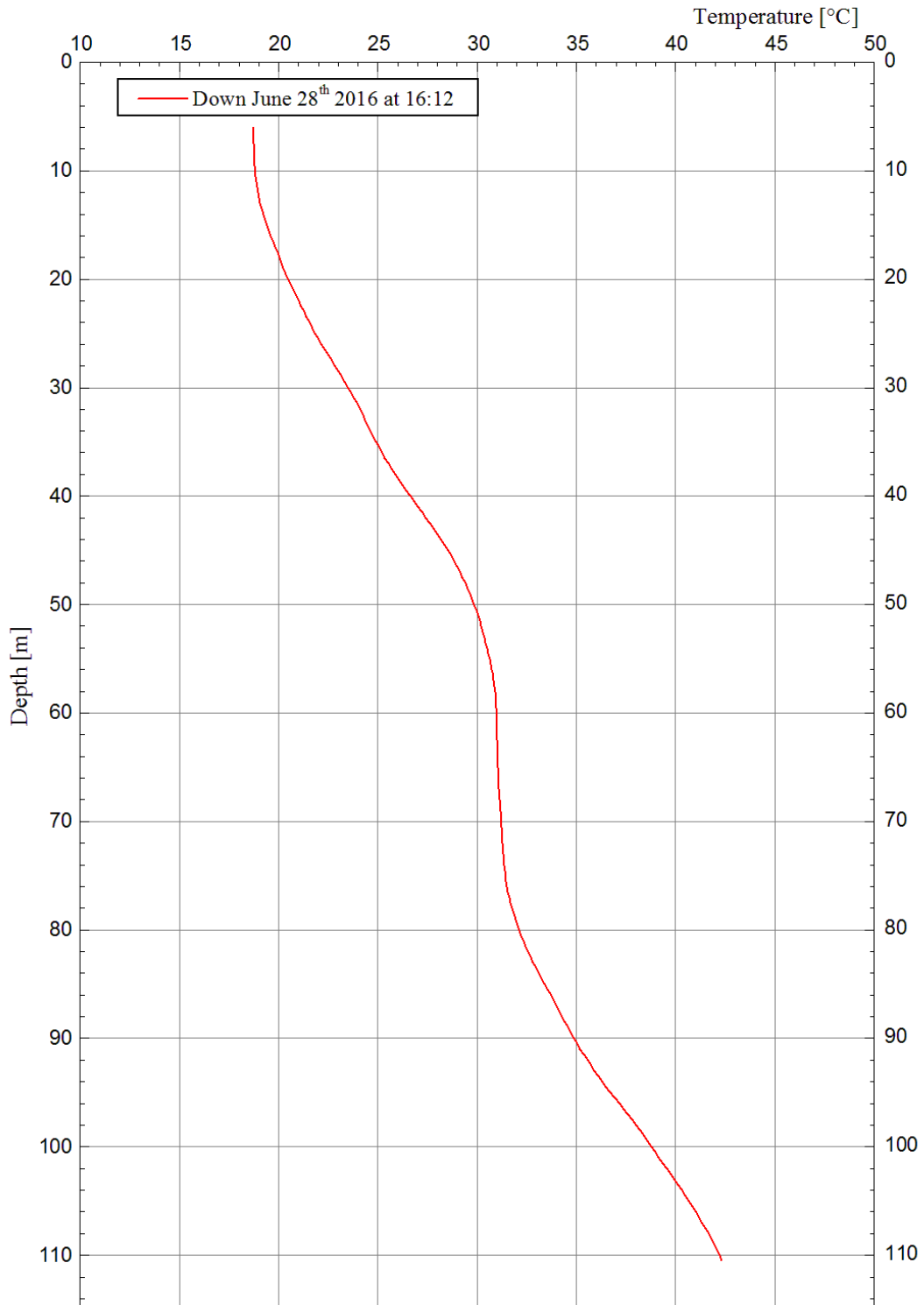
After casing depth was reached, for the 18<sup>5/8"</sup> surface casing, at 110 m the well was circulated clean with water and polymer. At 04:00 POOH was started and a wiper trip was carried out from 07:00-09:45. No bottom hole deposit was found. Inclination was measured at 96 m and showed 0.3°. Next, the well was cooled for an hour and then POOH. At 15:30 ÍSOR's logging engineers performed temperature and caliper measurements. The 18<sup>5/8"</sup> casing was RIH at 17:00. Currently at 09:00 the 29<sup>th</sup> of June, preparations for the cement job is in action.

### Wireline logging

Figure 1 shows the temperature profile measured in open hole after the BHA had been POOH. The well is moderately cooled down to BOH and no sign of leakage is observed.

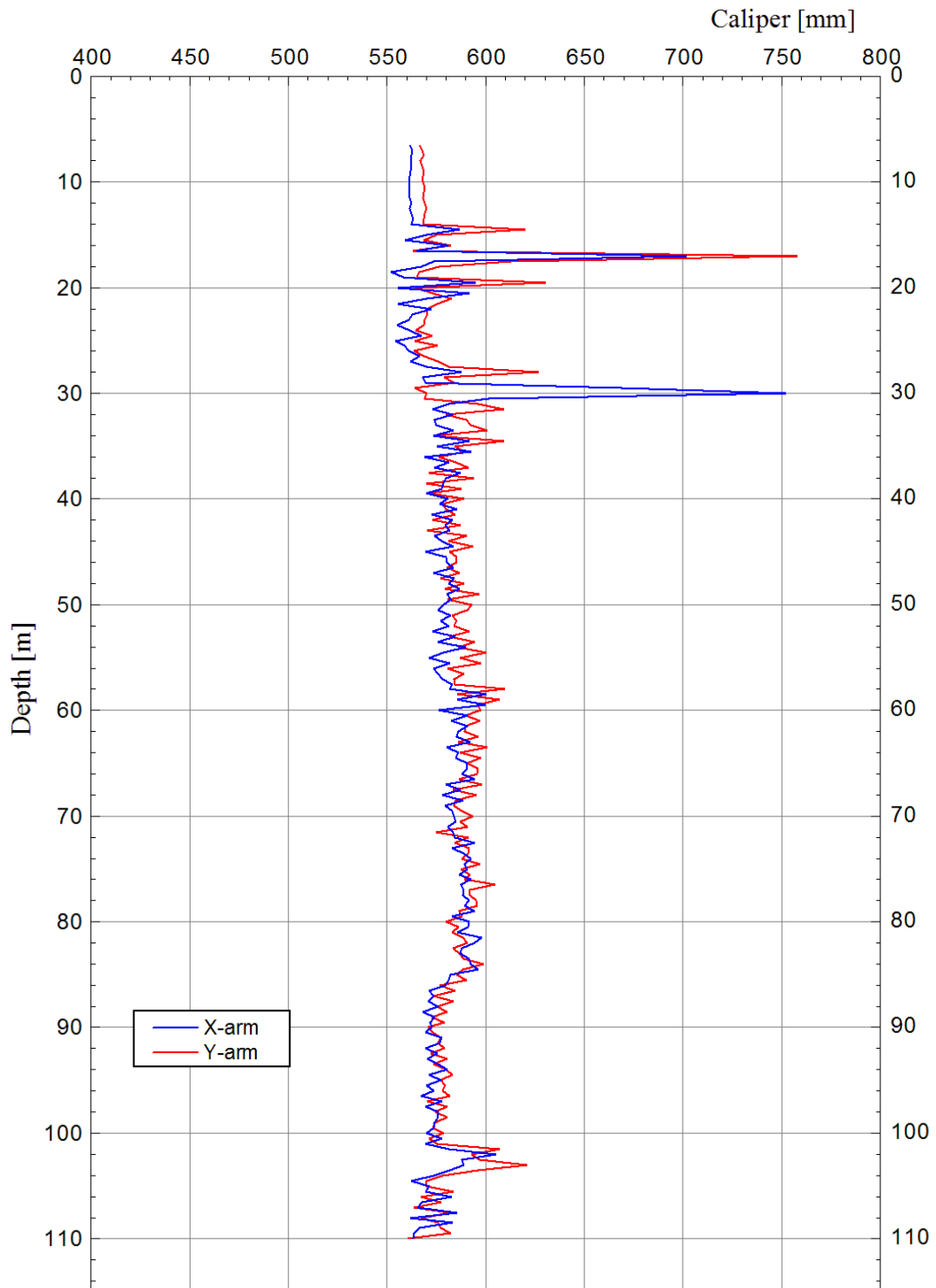
Figure 2 shows the measured diameter of the well. It shows that no major washouts occur in the well, a small one is at 16 m depth, i.e. 2 m below the conductor casing. The deviation seen at 30 m depth only appears on one of the arm pairs (X-arm) which might indicate a small fracture. Besides, a small cavity is recorded at the 112 m-114 m depth interval. Figure 3 shows the caliper log put in context with the wellbore radius and the planned 18<sup>5/8"</sup> surface casing. The figure also shows the accumulated volume (calculated from the caliper data starting at BOH) to be cemented between the annulus and the surface casing. The calculated value of this volume is about 10 m<sup>3</sup>, based on truncated cone shapes between data points of the caliper log.

Þeistareykir, Þeistareykjagundur  
Well ÞG-10



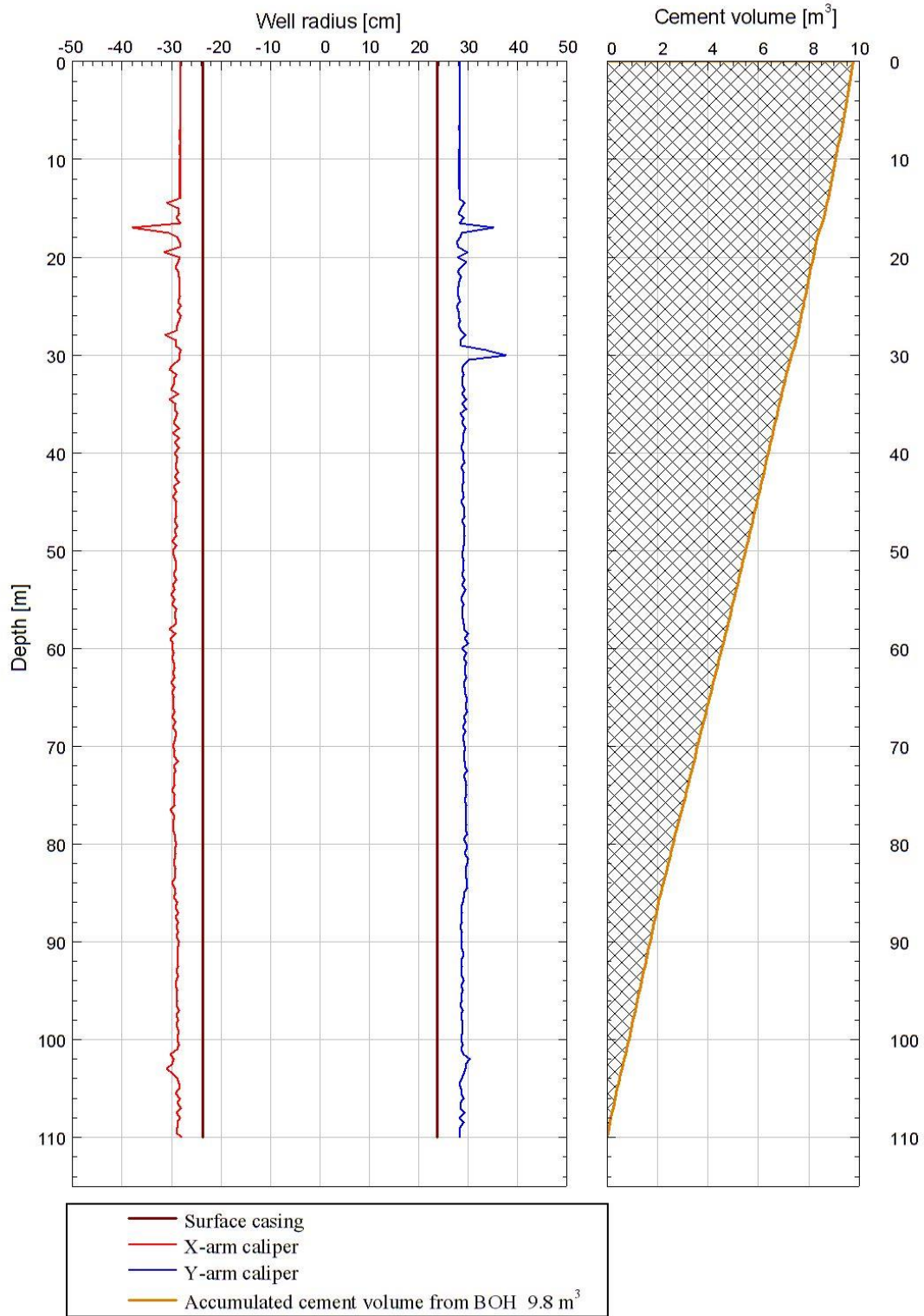
**Figure 26.** Temperature log in open hole after the BHA had been POOH.

Þeistareykir, Þeistareykjagrundir  
Well ÞG-10



**Figure 27.** The caliper log shows no major washouts in the well.

## Þeistareykir, Þeistareykjagrundir Well ÞG-11



**Figure 28.** The caliper log put in context with the wellbore radius and accumulated volume to be cemented between the annulus and the surface casing.

**Peistareykir**
**Report #07**  
**Preliminary results**
**Pre-Drilling**  
**(surface casing)**

<i>Operator:</i> <b>Landsvirkjun</b>	<i>Drilling Company:</i> <b>Iceland Drilling Company</b>	
<i>Well Name:</i> <b>ÞG-10</b>	<i>Drill-Rig:</i> <b>Sleipnir</b>	
<i>Well-Id:</i> <b>60410</b>	<i>Geologist/Geophysicist:</i> <b>SRG/ÞEg,FP</b> (E-mail: srg@isor.is)	
<b>Last casing size: 18 5/8"</b>	<b>Depth at 24 hrs. 110 m</b>	<b>Hole made last 24 hrs. : m</b>
<b>Last casing depth: 106.9 m</b>	<b>Depth at 8 hrs. 110 m</b>	<b>Drilling time: hrs.</b>
<b>Drilling fluid: Mud</b>	<b>Circulation losses at 8 hrs. 0 l/s</b>	<b>Average ROP: m/hr</b>

**Drilling**

The 18 5/8" surface casing was run down to 106.9 from the Sleipnir rig floor. The float-collar was set at 93.5 m. Afterwards, the cement string was RIH and the well cooled. 15m<sup>3</sup> of cement slurry were used in the cementing procedure with returns. The caliper log estimated volume of ~ 10 m<sup>3</sup>. The cement sank approximately 1.3 m. The cement string was POOH and WOC was carried out until 22:00 when the casing was cut and BOP's taken down. Figure 1 shows the drilling progress of phase 0 in ÞG-10. Figure 2 shows the drill crew working on the BOP's this morning. Figures 3-5 show the casing and cementing in well ÞG-10.

# PG-10 - Drilling Progress

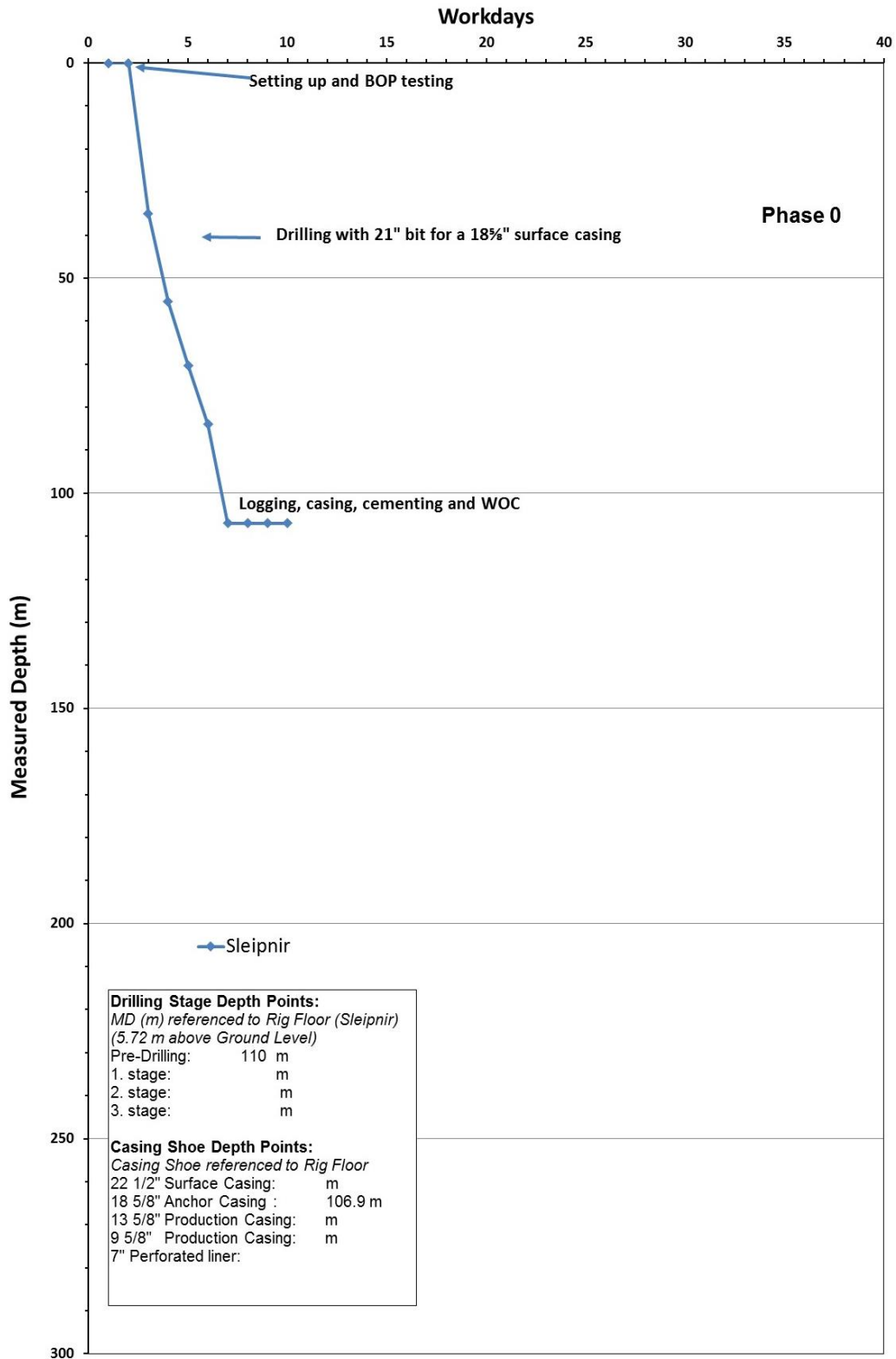


Figure 1. Drilling progress of PG-10.



Figure 2. The drill crew at work this morning.


 <b>Casing Information Report</b> Rig: Sleipnir Job No: DG-10		<b>Iceland Drilling</b> Rig No: 28000 Job Name: DG10						
Casing Information								
Run Date/Time:	28-Jun.-16 16:00	Leak Off Test (kg/cu m):						
Well Section:	INT1	String Type:	FULL					
String Top MD (m):	0,0	String Top TVD (m):	106,9					
Casing Shoe MD (m):	93,5	Casing Shoe TVD (m):	93,5					
String Nominal OD (cm):	47,31	String Nominal ID (cm):	44,45					
Bit Diameter (cm):	53,34	Avg. Open Hole Diam. (cm):	54,50					
Centralizers: No:		Manufacturer/Type:						
Depths:								
Hanger Type:		Manufacturer:						
Comments:								
String Component Details								
Joints	Item	Length (m)	OD(cm)	ID (cm)	Weight (kg)	Grade	Connection	Torque
No String Component Data								

Figure 3. Casing report for the 18<sup>5</sup>/<sub>8</sub>" surface casing.



Iceland Drilling		Cementing Report		Iceland Drilling		
Rig: Sleipnir		Job No: ÞG-10		Rig No: 28000		
Job Name: ÞG10						
Cement Job Information						
Start Date/Time:	29-jún.-16 09:30	Well Bore:	Original Well Bore			
Job Type:	PRIMARY	String OD (cm):	47,31			
Well Section:	INT1	String Type:	FULL			
Cementing Co:	JARDB	Cementing Engineer:	Sveinbjörn Bjarnason			
Primary Job Detail						
	Volume (cu m)	Pump Time	Rate (cu.m./min)	Pressure (bar)		
Conditioning Data:						
Cement Data:	15,0	30	0,5	2		
Displacement Data:						
Calc. Displacement Vol:	0,4					
<input type="checkbox"/> Batch Mix? <input type="checkbox"/> Bump Plug?    Bump Pressure:						
Returns to Surface:	FULL	<input type="checkbox"/> Reciprocate Pipe?	<input checked="" type="checkbox"/> Cement at Surface?			
Calc Top of Cement (m):	93,5	Excess (%):	100,00%	Avg. Hole Size (cm):	53,34	
Slurry Information						
Type	Density	Yield	Sacks	Volume	Rate	Additives
LEAD	15				0,5	
DISPLACE	0				0,4	
Post Job Information						
Liner Top Test (kg/cu m):		Job Success?	Yes			
Actual Top of Cmt (m):		CBL Bond Quality:	GOOD			
Misc. Comments:						

Figure 4. Cementing report for the 18 $\frac{5}{8}$ " surface casing.

Iceland Drilling		Cementing Report		Iceland Drilling		
Rig: Sleipnir		Job No: ÞG-10		Rig No: 28000		
Job Name: ÞG10						
Cement Job Information						
Start Date/Time:	27-jún.-16 04:00	Well Bore:	Original Well Bore			
Job Type:	PLUG	Cementing Engineer:	Andrés			
Cementing Co:	JARDB					
Plug Job Detail						
Plug Type:	Sandsteypa					
Plug: Top (m):	69,0	Bottom (m):	84,0	Length (m):	15,0	
Calc. Displacement Vol (cu m):	Hole Size at Plug (cm):		53,34			
	Volume (cu m)	Pump Time	Rate (cu.m./min)	Volume (bar)		
Conditioning Data:						
Cement Data:						
Displacement Data:						
Slurry Information						
Type	Density	Yield	Sacks	Volume	Rate	Additives
No Slurry Information Data						
Post Job Information						
Actual Top of Cmt (m):	69,0	Job Success?	No			
Misc. Comments:	Deiling á holu var stöðvuð í 11 mín Deilt með steypuðælu 6 m <sup>3</sup> af sandsteypu niður það tók 6 mín deilt síðan 2000 L/sek vatni á eftir og blíndloka lokað					

Figure 5. Cementing report for the cement job performed the 27<sup>th</sup> of June.

## Geology

Figure 6 shows the comparison of the lithology in wells ÞG-10 and ÞG-01, who are drilled from the same drill pad. Very good agreement is seen in these two wells, where basaltic breccia is dominant in the uppermost 110 m. Fine to medium grained basalt is seen on top of the breccia in both the wells.



Location: Þeistareykir  
Well Name: ÞG-10

Drill Rig: Sleipnir  
Depth Interval: 0-110 m

Circulation fluid: Mud  
Drill-stage: Phase 0

Geologist: SRG, SÁ

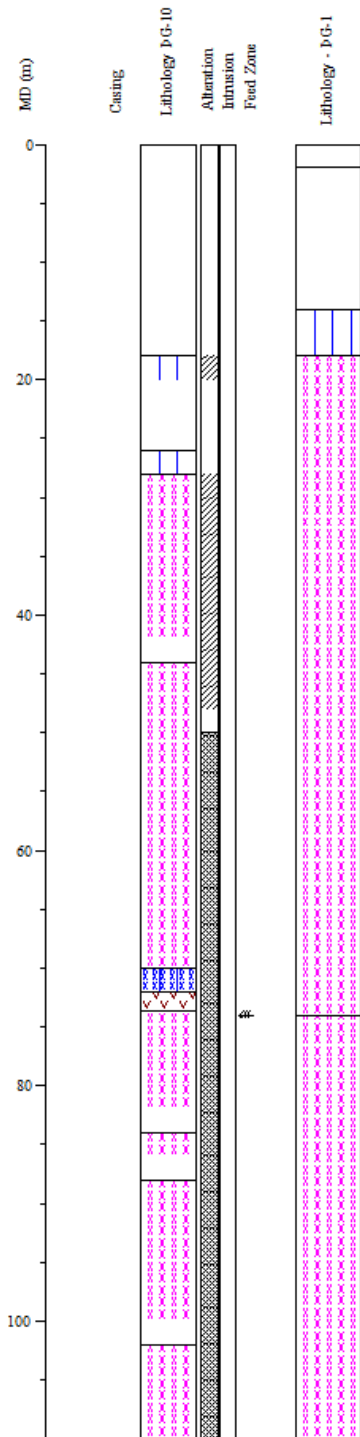


Figure 6. Comparison of the lithology in wells ÞG-10 (left) and ÞG-01 (right).



# ÞG-10

Friday  
1<sup>st</sup> of July 2016  
Workday #11

**Peistareykir**

**Report #08**  
Preliminary results

**Phase 1**  
(anchor casing)

<i>Operator:</i> <b>Landsvirkjun</b>	<i>Drilling Company:</i> <b>Iceland Drilling Company</b>	
<i>Well Name:</i> <b>ÞG-10</b>	<i>Drill-Rig:</i> <b>Sleipnir</b>	
<i>Well-Id:</i> <b>60410</b>	<i>Geologist/Geophysicist:</i> <b>SRG/ÞEg,FP</b> (E-mail: srg@isor.is)	
<i>Last casing size:</i> <b>18 5/8"</b>	<i>Depth at 24 hrs.</i> <b>110 m</b>	<i>Hole made last 24 hrs. :</i> <b>m</b>
<i>Last casing depth:</i> <b>106.9 m</b>	<i>Depth at 8 hrs.</i> <b>110 m</b>	<i>Drilling time:</i> <b>hrs.</b>
<i>Drilling fluid:</i> <b>Mud</b>	<i>Circulation losses at 8 hrs.</i> <b>0 l/s</b>	<i>Average ROP:</i> <b>m/hr</b>

## Drilling

Between 00:00 and 03:00 the 18<sup>5/8</sup>" surface casing was cut and the BOP's removed from well head. The 21<sup>1/4</sup>" flange was then cut and welded. The BOP's were re-installed and kill-line and flow-line connected. The rest of the day was spent on pressure testing the BOP's with 30 bars for 15 minutes. They passed the test and currently at 08:00 the 1<sup>st</sup> of July the drill string is at 77 m depth and drilling will start soon.



**PG-10**

Saturday  
2<sup>nd</sup> of July 2016  
Workday #12

**Peistareykir**

**Report #09**  
Preliminary results

**Phase 1**  
(anchor casing)

<i>Operator:</i> <b>Landsvirkjun</b>	<i>Drilling Company:</i> <b>Iceland Drilling Company</b>	
<i>Well Name:</i> <b>PG-10</b>	<i>Drill-Rig:</i> <b>Sleipnir</b>	
<i>Well-Id:</i> <b>60410</b>	<i>Geologist/Geophysicist:</i> <b>MÁS, RSÁ</b> (E-mail: mas@isor.is)	
<i>Last casing size:</i> <b>18 5/8"</b>	<i>Depth at 24 hrs.</i> <b>127 m</b>	<i>Hole made last 24 hrs. :</i> <b>17 m</b>
<i>Last casing depth:</i> <b>106.9 m</b>	<i>Depth at 8 hrs.</i> <b>164.6 m</b>	<i>Drilling time:</i> <b>5 hrs.</b>
<i>Drilling fluid:</i> <b>Mud</b>	<i>Circulation losses at 8 hrs.</i> <b>0 l/s</b>	<i>Average ROP:</i> <b>3.4 m/hr</b>

### Drilling

Yesterday morning at 4 am a BHA with a 17½" bit was RIH. At noon drilling in cement started at 94.5 m and some five hours later drilling in formation started at 110 m. Drilling was then paused at 5 pm at 117.5 m depth while mixing drilling mud for using for further drilling of phase 1. Drilling then continued few hours later. No loss of circulation has been noted so far. ROP has been in range of 3-5 m/hr.

This morning one the mud pumps needed a maintenance. At present, 9 am, drilling is ongoing.

### Geology

The cuttings collected last night and this morning are being inspected now. Preliminary inspection indicates that at 162-164 m we are drilling in a basaltic breccia. The grade of alteration is moderate. The rock seems to be considerably fractured, with quartz and pyrite as vein-fillings. Other alteration minerals are fine grained green clay and calcite.

<b>Peistareykir</b>		<b>Report #10</b>		<b>Phase 1</b>	
		<b>Preliminary results</b>		<b>(anchor casing)</b>	
<i>Operator:</i>	<b>Landsvirkjun</b>	<i>Drilling Company:</i>	<b>Iceland Drilling Company</b>		
<i>Well Name:</i>	<b>ÞG-10</b>	<i>Drill-Rig:</i>	<b>Sleipnir</b>		
<i>Well-Id:</i>	<b>60410</b>	<i>Geologist/Geophysicist:</i>	<b>MÁS, RSÁ</b> (E-mail: mas@isor.is)		
<i>Last casing size:</i>	<b>18 5/8"</b>	<i>Depth at 24 hrs.</i>	<b>127 m</b>	<i>Hole made last 24 hrs. :</i>	<b>66 m</b>
<i>Last casing depth:</i>	<b>106.9 m</b>	<i>Depth at 8 hrs.</i>	<b>193 m</b>	<i>Drilling time:</i>	<b>13 hrs.</b>
<i>Drilling fluid:</i>	<b>Mud</b>	<i>Circulation losses at 8 hrs.</i>	<b>0 l/s</b>	<i>Average ROP:</i>	<b>5.1 m/hr</b>

## Drilling

Yesterday drilling was going fine until 3 pm when the temperature of the circulation fluid started to rise rapidly from 39°C to 91°C in a short time. At that time the depth of the well was 184 m. In order to avoid a blow-out, the drilling was stopped. Clearly an over-pressurized zone had been cut. A pumping of 50 l/s was applied for two hours. At 5 pm when pumping was stopped for a short time fluid immediately started to flow from the well into the tanks. The temperature of the outflow fluid was 67°C at that time. Pumping was started again. At 6 until 10:30 pm last night drilling was continued down to 193 m. The plan was to place a cement plug in the well. Then the well was cleaned and cooled before POOH. At 11 pm the crew started to strip the drill string out of the well. Early this morning, at about 5:30 am, when running a cement string into the well a blow-out occurred. Mud and debris was thrown from it several hundred meters towards South (Figure 1). The control room of the rig was filled with mud. Three members of the crew were in there but did not get seriously injured. One person was taken to a hospital at Húsavík. The well was shut in. At present no pumping is applied. The wellhead pressure measures about 50 bar this morning.

Further drilling operations will be paused until the condition of the rig is known in details. Drilling data from Sleipnir from yesterday afternoon and this morning cannot be retrieved at present.

For comparison, over-pressurized zones were cut at 212 m in ÞG-1 and at 192 m in ÞG-4.



**Figure 1.** *Mud and debris at well pad A after a blow-out from PG-10 at 5:30 am this morning.*

## **Geology**

Cuttings from 110-172 m have been inspected at present (Figure 2).

110-138 m: BASALTIC BRECCIA

Mostly crystalline basalt, gray and brownish. Highly altered. Non porphyritic. Quartz is rather prominent as a secondary mineral. Pyrite and calcite are abundant.

138-152 m: FINE-MEDIUM GRAINED BASALT

Highly altered fine grained crystalline basalt, non-porphyritic. Whitish in color. Traces of epidote seem to be present at 138-142 m. Quartz is common. Most possibly lava flows rather than pillow lava.

152-172 m: REWORKED TUFF

Very fine grained sedimentary tuff, light greenish and gray. Few grains of crystalline basalt are present. Fine grained clay is seen in the tuff. Grade of alteration is rather high. The main alteration minerals are calcite, pyrite, quartz and fine grained green clay.

Location: Þeistareykir  
Well Name: ÞG-10

Drill Rig: Sleipnir  
Depth Interval: 0-186 m

Circulation fluid: Mud  
Drill-stage: Phase 0-1

Geologist: SRG, SÁ, MÁŠ

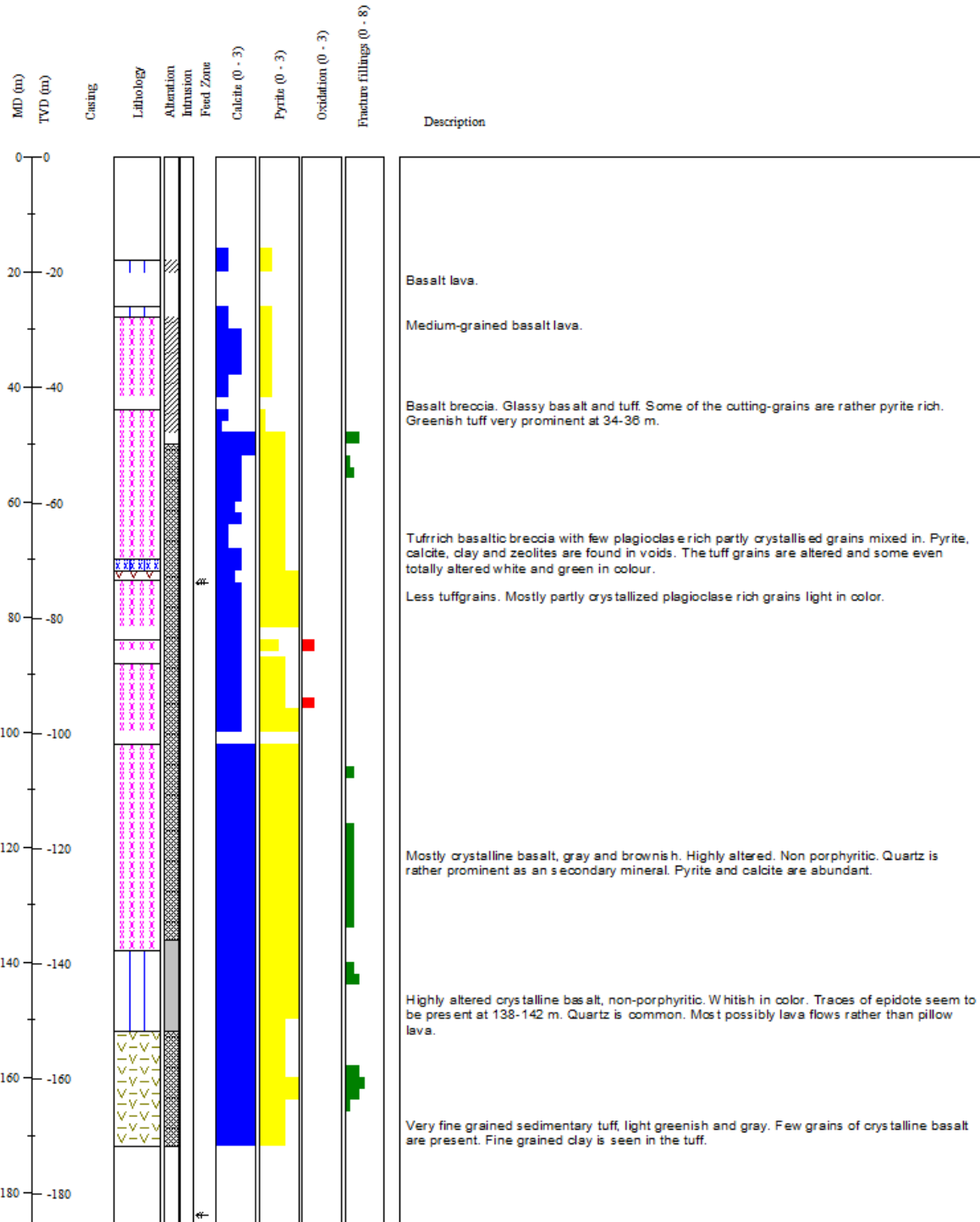


Figure 2. Lithology of ÞG-10 down to 172 m depth.

**Peistareykir**
**Report #11**  
 Preliminary results

**Phase 1**  
 (anchor casing)

<i>Operator:</i> <b>Landsvirkjun</b>	<i>Drilling Company:</i> <b>Iceland Drilling Company</b>
<i>Well Name:</i> <b>PG-10</b>	<i>Drill-Rig:</i> <b>Sleipnir</b>
<i>Well-Id:</i> <b>60410</b>	<i>Geologist/Geophysicist:</i> <b>MÁS, RSÁ</b> (E-mail: mas@isor.is)
<i>Last casing size:</i> <b>18 5/8"</b>	<i>Depth at 24 hrs.</i> <b>193 m</b>
<i>Last casing depth:</i> <b>106.9 m</b>	<i>Depth at 8 hrs.</i> <b>193 m</b>
<i>Drilling fluid:</i> <b>Mud</b>	<i>Circulation losses at 8 hrs.</i> <b>0 l/s</b>
	<i>Hole made last 24 hrs. :</i> <b>0 m</b>
	<i>Drilling time:</i> <b>0 hrs.</b>
	<i>Average ROP:</i> <b>- m/hr</b>

### Drilling

Yesterday morning at about 5:45 am a blow-out occurred from the well while running in the cementing string. At that time the depth of the string was 104 m. The annular BOP and the pipe-ram were shut in. In the beginning the wellhead pressure measured 50 bar but soon lowered to 40 bar. At 10 am the wellhead pressure measured 18 bar and two times later it was 16 bar. At noon a pumping of 3 l/s into the well was applied by using the cementing equipment. Then the pressure rose up to 30 bar. Pumping was stopped. When opening the kill-line the pressure dropped down to zero bar. No pressure build-up was measured after this. Most probably the well got clogged.

Yesterday the crew spent most of their time in cleaning and repairing of the rig. No major damages were found. This morning the condition of the rig seems to be fine. Now preparations for running in a drill-string with a bit is underway. Before the cementing operation can be continued all loose material must be cleaned from the well.

Figures 1 and 2 show some selected drilling parameters from Sleipnir when a rise in the return mud temperature occurred on the 2<sup>nd</sup> of July and when the blow-out occurred yesterday.

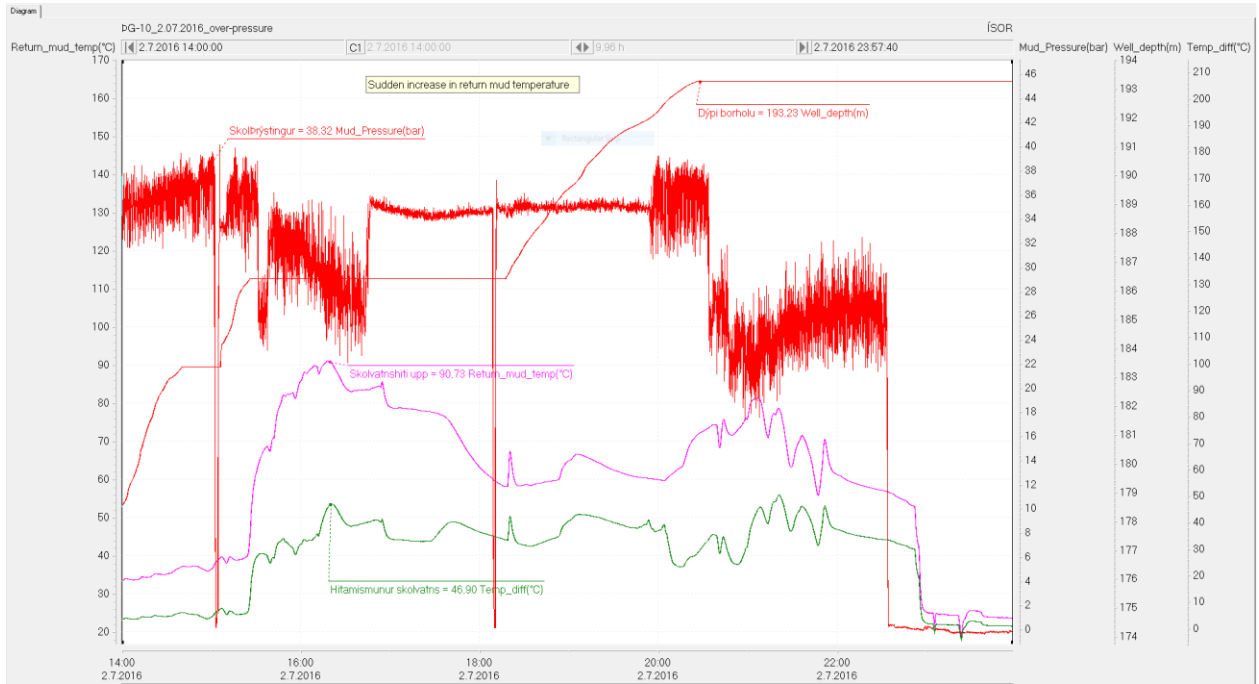


Figure 1. Increased return mud temperature at 3:30 pm on the 2<sup>nd</sup> of July.

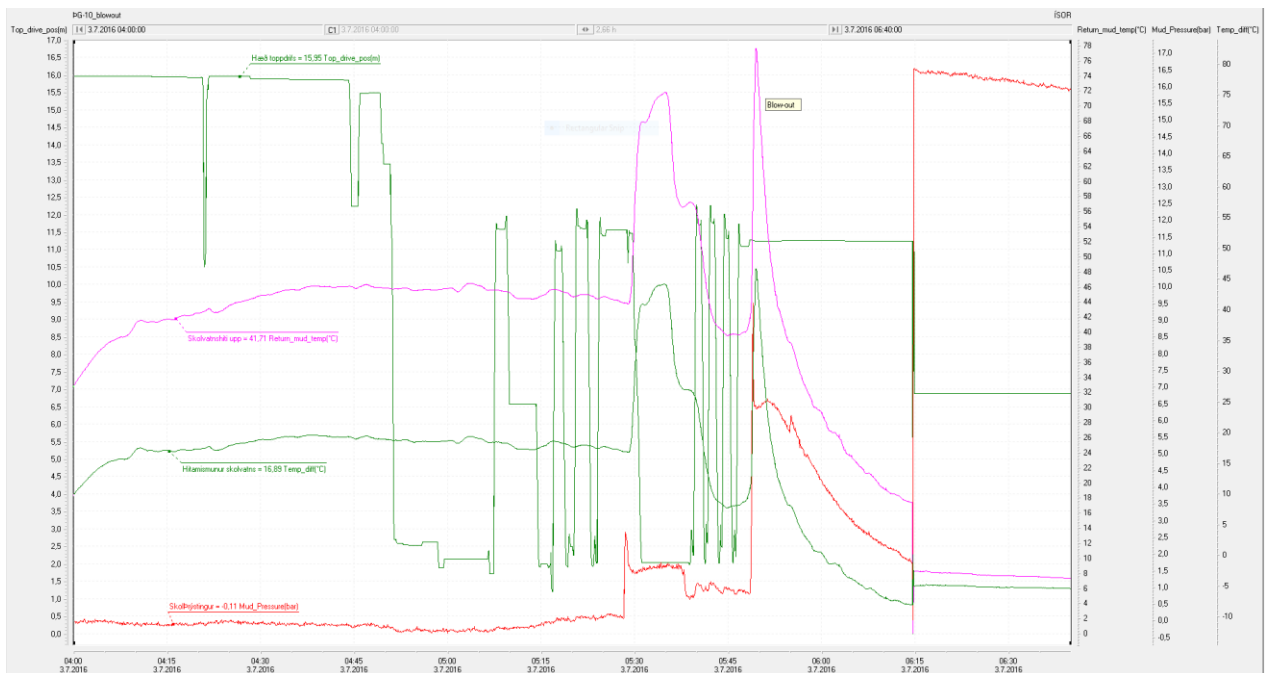


Figure 2. Blow-out from the PG-10 at 5:45 am on the 3<sup>rd</sup> of July, occurring while running a cementing string into the well.



## **Geology**

Cuttings from 110-193 m have been inspected at present (Figure 3).

### **110-138 m: BASALTIC BRECCIA**

Mostly crystalline basalt, gray and brownish. Highly altered. Non porphyritic. Quartz is rather prominent as a secondary mineral. Pyrite and calcite are abundant.

### **138-152 m: FINE-MEDIUM GRAINED BASALT**

Highly altered fine grained crystalline basalt, non-porphyritic. Whitish in color. Traces of epidote seem to be present at 138-142 m. Quartz is common. Most possibly lava flows rather than pillow lava.

### **152-184 m: REWORKED TUFF**

Very fine grained sedimentary tuff, light greenish and gray. Few grains of crystalline basalt are present. Fine grained clay is seen in the tuff. Grade of alteration is rather high. The main alteration minerals are calcite, pyrite, quartz and fine grained green clay.

### **184-188 m: BASALTIC BRECCIA**

More crystalline basalt mixed with tuff and glass. Dark and light brown fine grained basalt. An over-pressurized zone was entered at 186 m resulting in a blow-out (eruption) from the well. In the neighbor well PG-1, a similar over-pressurized zone was cut at 212 m.

### **188-192 m: BASALTIC BRECCIA**

Dark green and brown plagioclase rich basalt mixed with white precipitations and some minor glass. Possibly intrusive rock. The upper boundary seems to be rather sharp.

Location: Peistareykir  
Well: ÞG-10

Drill rig: Sleipnir  
Depth interval: 0-193 m

Drilling fluid: Mud  
Work phase: Phase 0-1

UWI: 60410  
Geologists: MÁŠ, RSÁ, SRG, SÁ

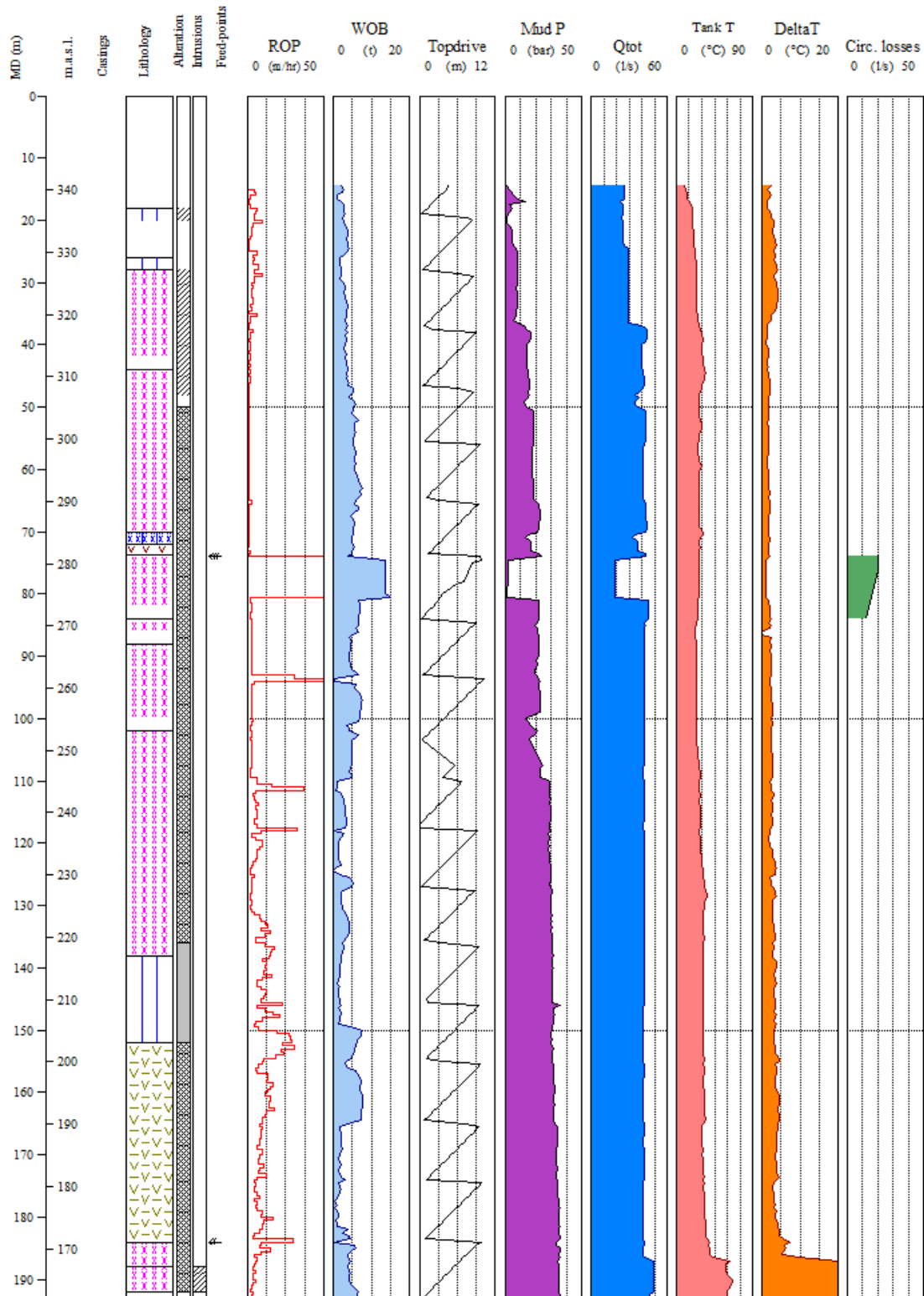


Figure 3. Lithology and some selected drilling parameters from ÞG-10.

<b>Peistareykir</b>		<b>Report #12</b>		<b>Phase 1</b>	
		<b>Preliminary results</b>		<b>(anchor casing)</b>	
<i>Operator:</i>	<b>Landsvirkjun</b>	<i>Drilling Company:</i>	<b>Iceland Drilling Company</b>		
<i>Well Name:</i>	<b>ÞG-10</b>	<i>Drill-Rig:</i>	<b>Sleipnir</b>		
<i>Well-Id:</i>	<b>60410</b>	<i>Geologist/Geophysicist:</i>	<b>MÁS, RSÁ</b> (E-mail: mas@isor.is)		
<i>Last casing size:</i>	<b>18 5/8"</b>	<i>Depth at 24 hrs.</i>	<b>193 m</b>	<i>Hole made last 24 hrs. :</i>	<b>0 m</b>
<i>Last casing depth:</i>	<b>106.9 m</b>	<i>Depth at 8 hrs.</i>	<b>193 m</b>	<i>Drilling time:</i>	<b>0 hrs.</b>
<i>Drilling fluid:</i>	<b>Mud</b>	<i>Circulation losses at 8 hrs.</i>	<b>0 l/s</b>	<i>Average ROP:</i>	<b>- m/hr</b>

### Drilling

Yesterday morning until 2 am the crew worked on cleaning the rig which became covered by gray mud after the blow-out on the 2<sup>nd</sup> of July. Pieces of rock (mostly tuff), up to 7 cm in diameter, are found scattered around the well pad. At 2 to 3:30 am the cementing string was stripped out of the well, about 104 m in length. Two fiber pipes from the lowermost part of the string were left in the well (2x9 m). Until 7 am the crew worked on maintenance of the rig, including the pumps, flow-line and the top-drive. An inspection of the power tong revealed that some of the hydraulic pipes had to be replaced. Yesterday, most of the time was spent in repairing the power tong and also reinforcing the control room located on the drill floor. Finally, at 8:45 pm everything was ready for RIH of a string with a bit in order to clean the well. Debris was found at shallow depth inside the surface casing. A pumping of 50 l/s of water was applied. This morning the depth of the bit is about 162 m, slowly approaching the over-pressurized zone at 185-186 m. Temperature of the return fluid has been rather constant for a while about 36°C.

### Geology

No cuttings have been retrieved since the 2<sup>nd</sup> of July from 193 m depth.

A comparison of wells ÞG-10 and ÞG-01 is shown in Figure 1 below. In both wells postglacial lavas are found in the uppermost 20-25 m and below that thick layer of breccia appears, down to 130-135 m. In ÞG-10 a 15 m thick pile of basaltic lavas, highly altered, is found below the breccia but not in ÞG-01. Below the lavas the formation is composed of basaltic tuff. In ÞG-10 there seems to be a boundary between the tuff, above, and a breccia below at 184-186 m where the blow-out from the well occurred.

Location: Beistareykir  
Well: ÞG-10

Drill rig: Sleipnir  
Depth interval: 0-193 m

Drilling fluid: Mud  
Work phase: Phase 0-1

UWI: 60410  
Geologists: MÁŠ, RSÁ, SRG, SÁ

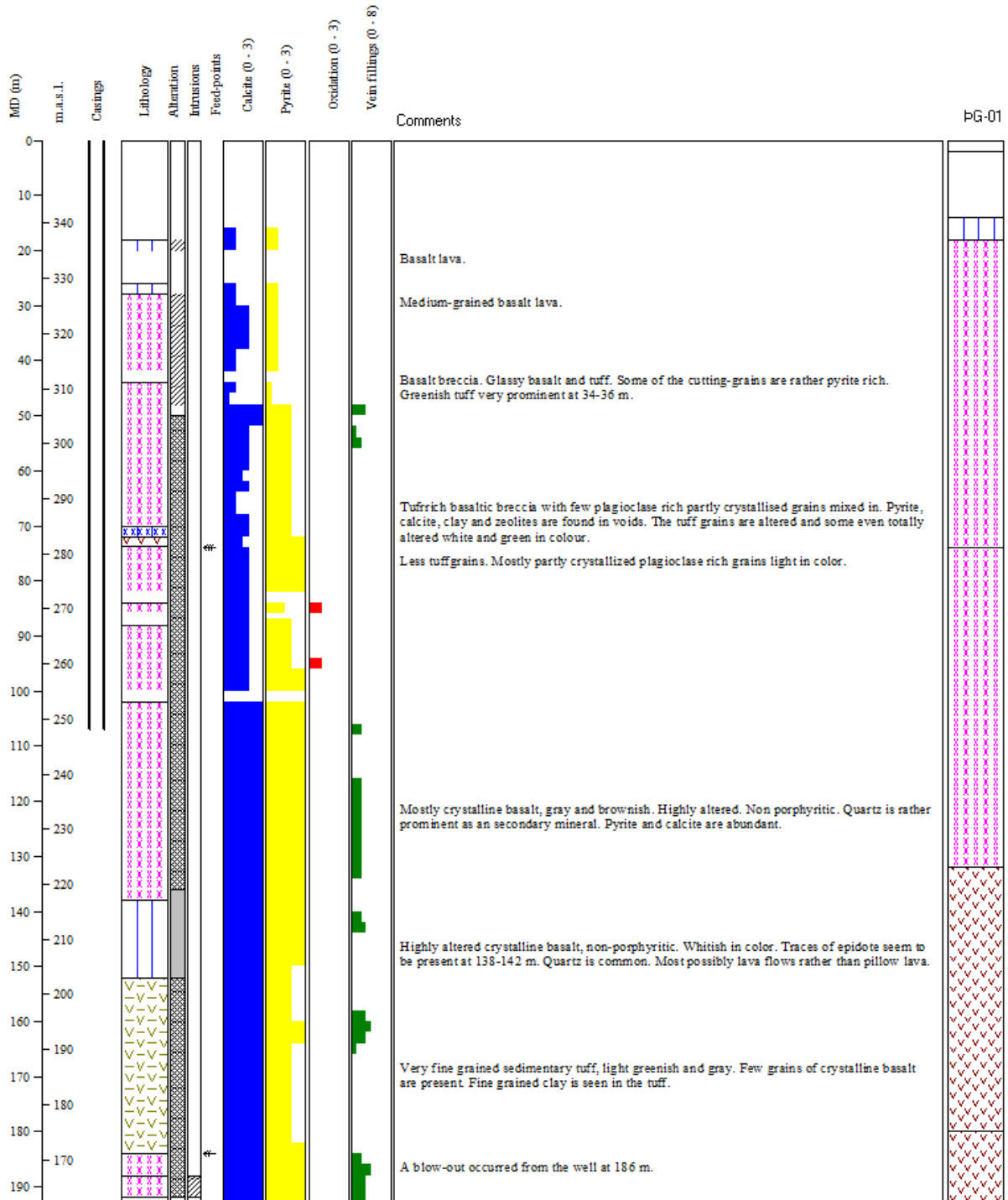


Figure 1. Comparison of wells ÞG-10 and ÞG-01.

<b>Peistareykir</b>		<b>Report #13</b>		<b>Phase 1</b>	
		<b>Preliminary results</b>		<b>(anchor casing)</b>	
<i>Operator:</i>	<b>Landsvirkjun</b>	<i>Drilling Company:</i>	<b>Iceland Drilling Company</b>		
<i>Well Name:</i>	<b>ÞG-10</b>	<i>Drill-Rig:</i>	<b>Sleipnir</b>		
<i>Well-Id:</i>	<b>60410</b>	<i>Geologist/Geophysicist:</i>	<b>MÁS, RSÁ</b> (E-mail: mas@isor.is)		
<i>Last casing size:</i>	<b>18 5/8"</b>	<i>Depth at 24 hrs.</i>	<b>193 m</b>	<i>Hole made last 24 hrs. :</i>	<b>0 m</b>
<i>Last casing depth:</i>	<b>106.9 m</b>	<i>Depth at 8 hrs.</i>	<b>193 m</b>	<i>Drilling time:</i>	<b>0 hrs.</b>
<i>Drilling fluid:</i>	<b>Mud</b>	<i>Circulation losses at 8 hrs.</i>	<b>0 l/s</b>	<i>Average ROP:</i>	<b>- m/hr</b>

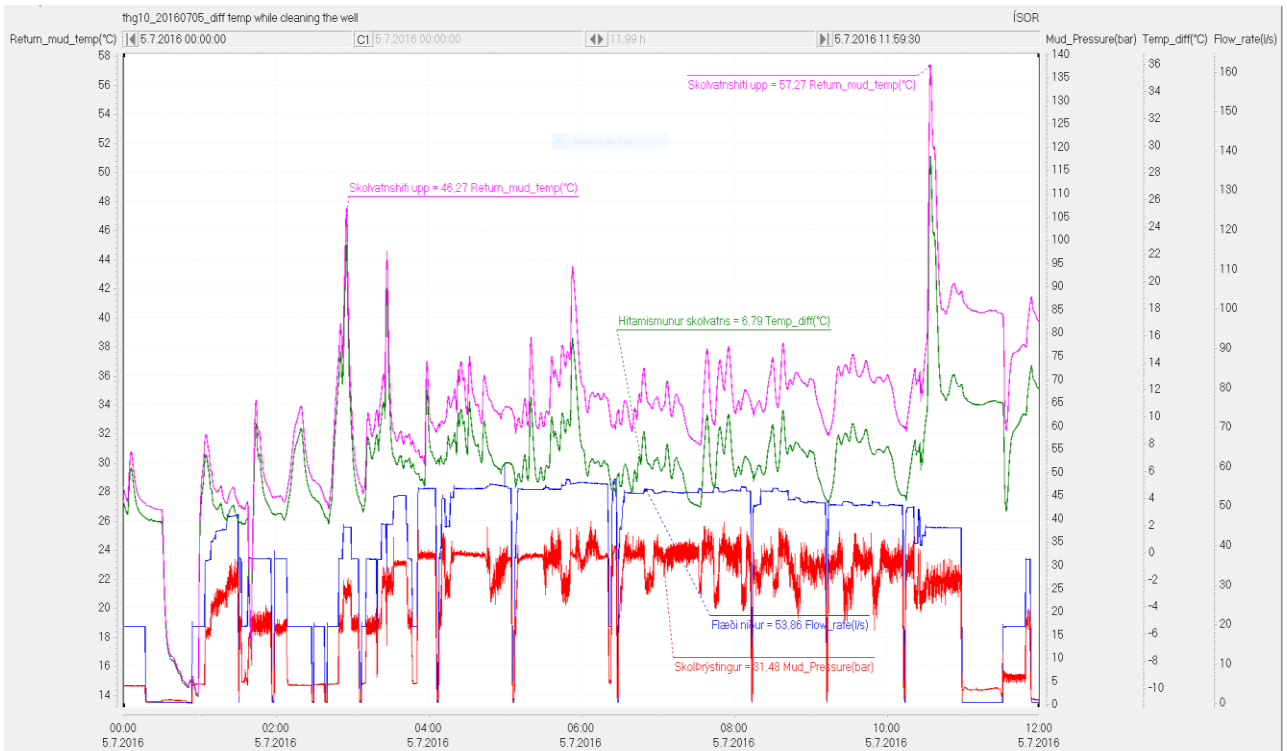
## Drilling

Yesterday morning a string for cleaning the well was RIH. Everything was going fine until the bit approached the over-pressurized zone. At about 170 m depth the return temperature of the circulation fluid started to rise rapidly for a while (Figure 1). Between 11 and 12 am gas sensors on Sleipnir indicated several times that some H<sub>2</sub>S escaped from the well. Values in range of 10-20 ppm were shown by the sensor. Each time the alarm started everyone stopped working and ran to the assembly point. At noon the cleaning process was stopped. Pumping was cut off and the pressure released on the kill-line valve. The pressure measured in range of 13-31 bar (at kill-line). At 4 pm a pumping of 17 l/s was applied (pressure at kill-line measured 19.3 bar). The return flow was estimated 4-5 l/s. At 6 pm one single was broken out from the string and preparations for a temperature logging started.

At 9 pm a temperature logging was carried out by the ISOR loggers. The results are shown in Figure 2 below. It shows that the cooling is effective down to approximately 153 m depth, where a loss of circulation occurred, estimated about 10 l/s. Based on the log it was decided to place a cement plug in the well in order to fill up the loss zone. At 1:00 am this morning a 13 m<sup>3</sup> of cement slurry was pumped into the well. At 8 am TOC was tagged at 124 m depth. The cement appeared to be too soft so WOC will continue until noon today.

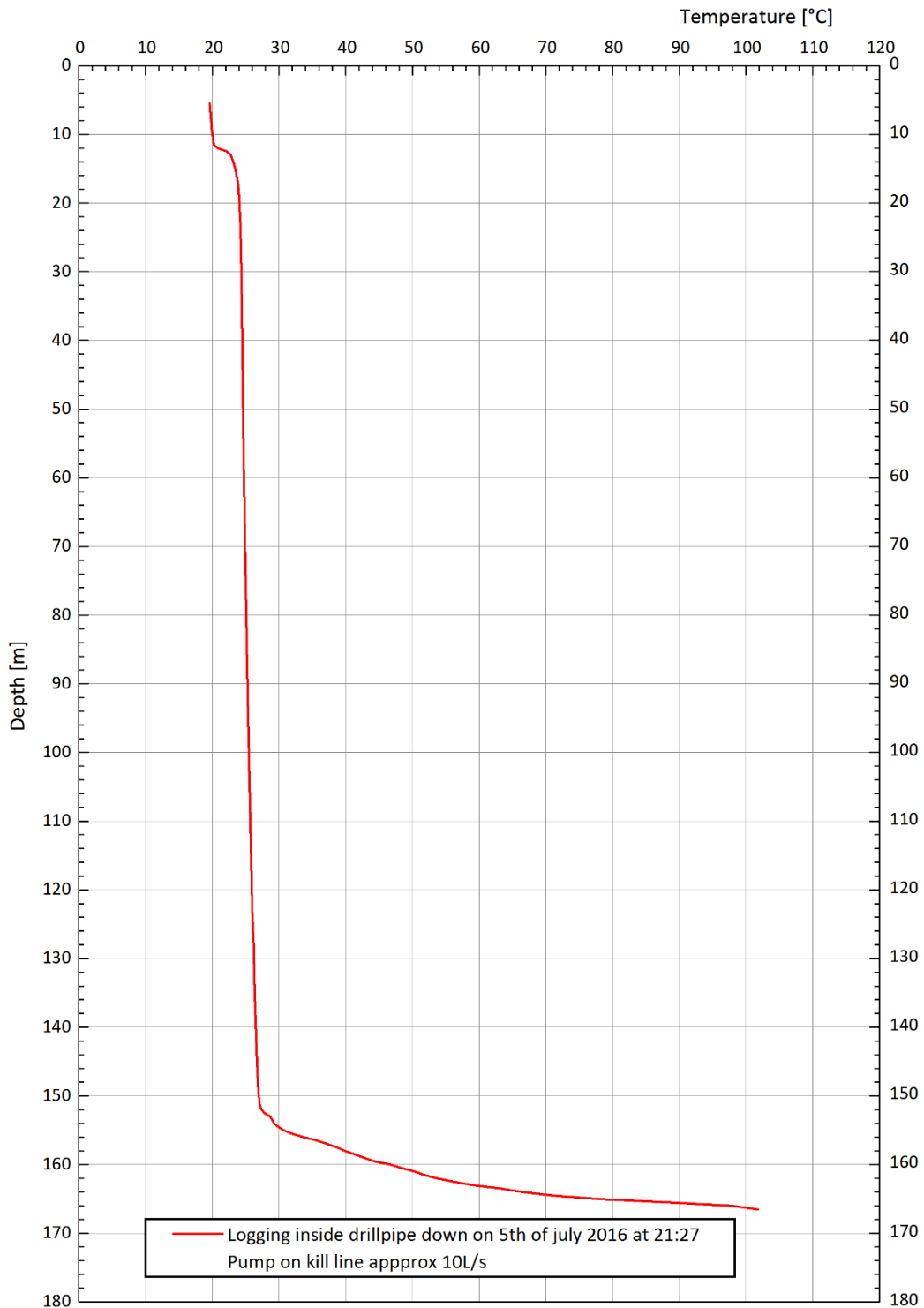
## Geology

No cuttings have been retrieved since the 2<sup>nd</sup> of July from 193 m depth. The loss zone at about 153 m most likely is related to a boundary between crystalline basalt and a tuff below at 152 m depth.



**Figure 1.** Some selected drilling parameters from Sleipnir from yesterday while cleaning the well. At 10:30 the return mud temperature rose suddenly as indicated on the diagram.

## Well ÞG-10



**Figure 2.** Temperature logging from ÞG-10, on the 5<sup>th</sup> of July 2016.

**Peistareykir**
**Report #14**  
**Preliminary results**
**Phase 1**  
**(anchor casing)**

<i>Operator:</i> <b>Landsvirkjun</b>	<i>Drilling Company:</i> <b>Iceland Drilling Company</b>	
<i>Well Name:</i> <b>PG-10</b>	<i>Drill-Rig:</i> <b>Sleipnir</b>	
<i>Well-Id:</i> <b>60410</b>	<i>Geologist/Geophysicist:</i> <b>MÁS, RSÁ/SSv, FP, HeI</b> (E-mail: mas@isor.is)	
<i>Last casing size:</i> <b>18 5/8"</b>	<i>Depth at 24 hrs.</i> <b>193 m</b>	<i>Hole made last 24 hrs. :</i> <b>0 m</b>
<i>Last casing depth:</i> <b>106.9 m</b>	<i>Depth at 8 hrs.</i> <b>193 m</b>	<i>Drilling time:</i> <b>0 hrs.</b>
<i>Drilling fluid:</i> <b>Mud</b>	<i>Circulation losses at 8 hrs.</i> <b>0 l/s</b>	<i>Average ROP:</i> <b>- m/hr</b>

## Drilling

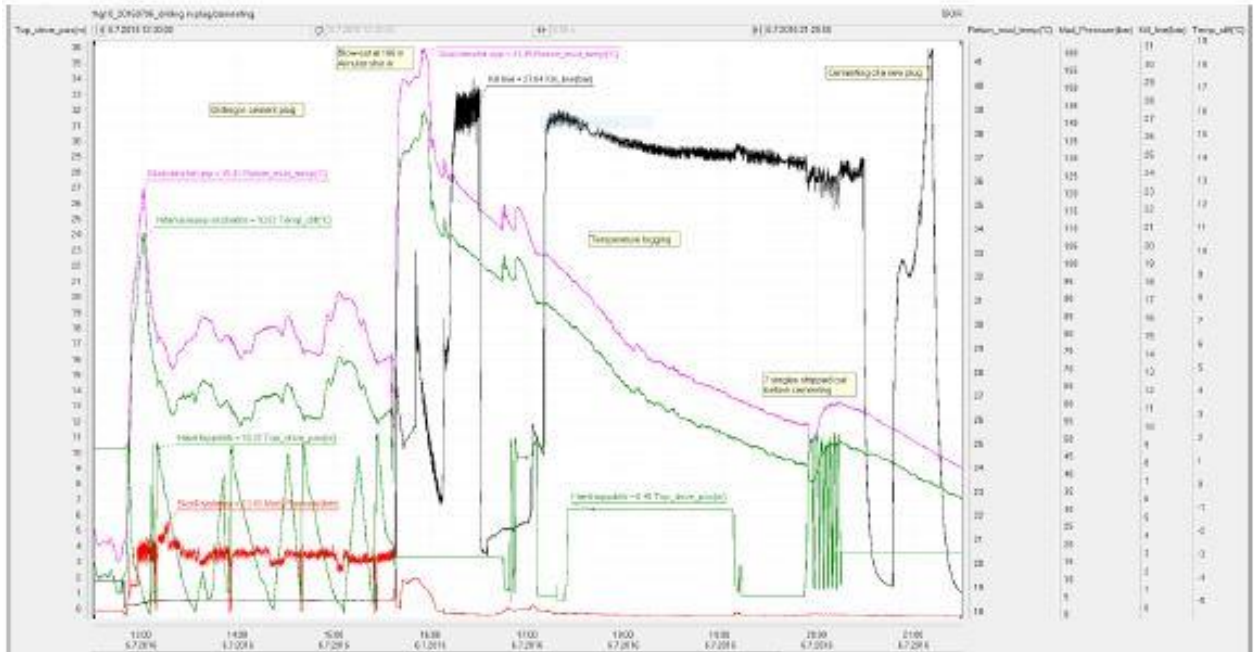
Yesterday morning after cementing of a plug in the well, which finished at 00:40 am, the cement was allowed to cure until 8 am. Then the pipe-ram was closed and a pumping applied in order to estimate if the cementing was successful. A pressure of 8 bar was measured at the well-head in the beginning which slowly dropped to 3 bar. Indicating some leakage in the well. At 8:30 am the drill-string was lowered into the well. TOC was tagged at 124 m depth. After 3 m of drilling it was stopped as the cement was still very soft. The annular was shut in and a pumping on kill-line applied. At noon drilling in cement resumed. At 3:35 pm, when drilling at 166 m depth, a blow-out occurred (see Figures 1 and 2). The string was lifted and the well shut-in. Pumping was also stopped for a while but soon a pumping of 18 l/s was applied. At 4:30 pm, after releasing some pressure from the well, the drill string was stripped down to 178 m depth.

Between 5 and 7 pm a temperature and pressure logging was carried out by the ISOR logging team. The results indicate that there are still some openings at around 150 m depth (Figures 3 and 4). On the basis of the logs preparations for cementing a plug in the well started. At 9 to 10 pm the cementing process was carried out. A plug of 10 m<sup>3</sup> of cement slurry with a density of 1.75 g/cm<sup>3</sup> was placed in the well. Since then until 8 am this morning there was a WOC. At present, at 9:30 am, drilling into the plug is ongoing. The base of the plug should be at 176 m.

## Geology

No cuttings have been retrieved from the well since the 2<sup>nd</sup> of July.





**Figure 1.** Some selected drilling parameters from Sleipnir while drilling through the cement plug yesterday. A blow-out occurred 3:35 pm at 166 m depth. A cement plug was placed in the well at 9-9:30 pm.



**Figure 2.** A blow-out from DG-10 at 3:35 pm yesterday.

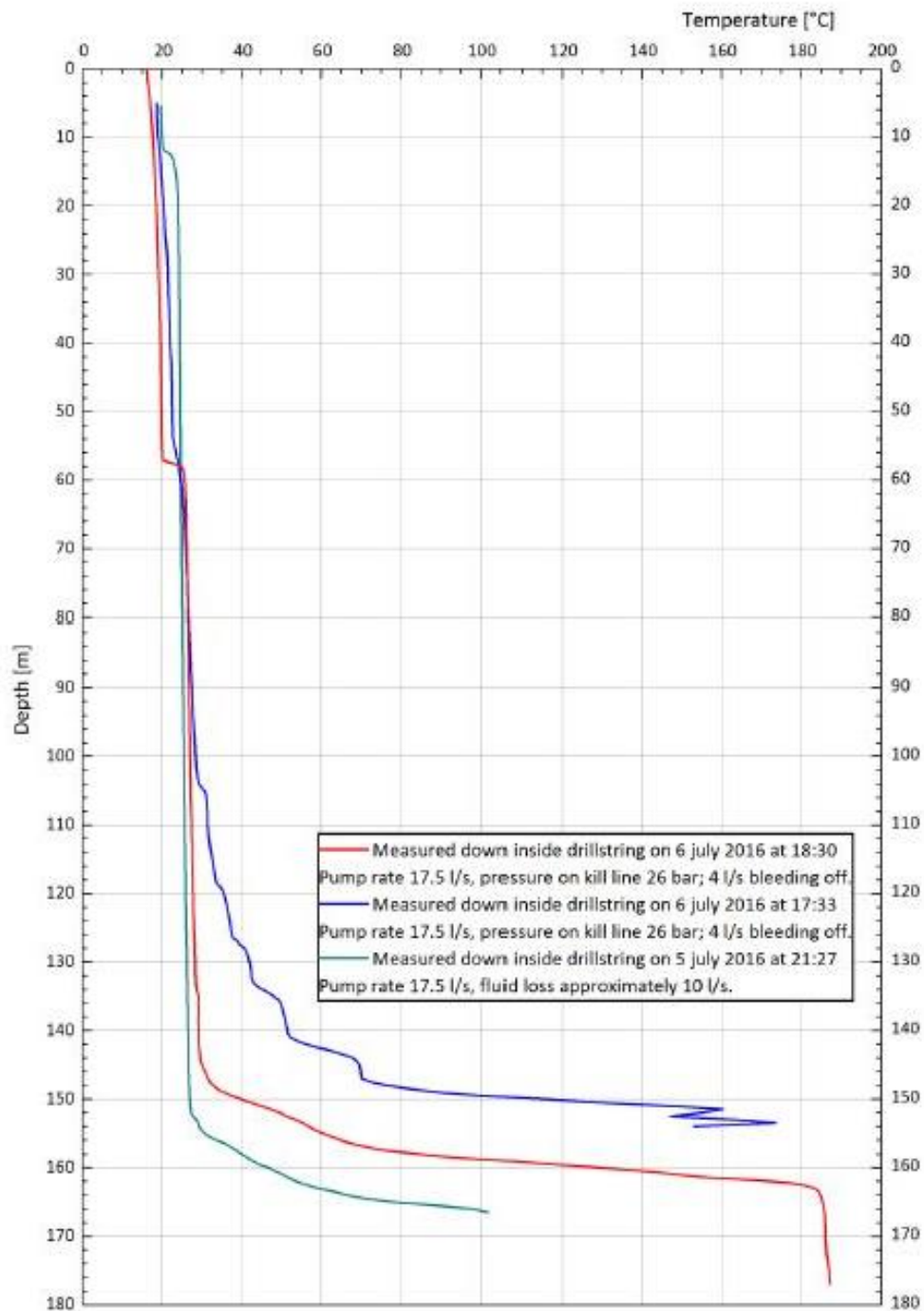


Figure 3. Temperature logs from ÞG-10 carried out on the 5<sup>th</sup> and 6<sup>th</sup> of July 2016.

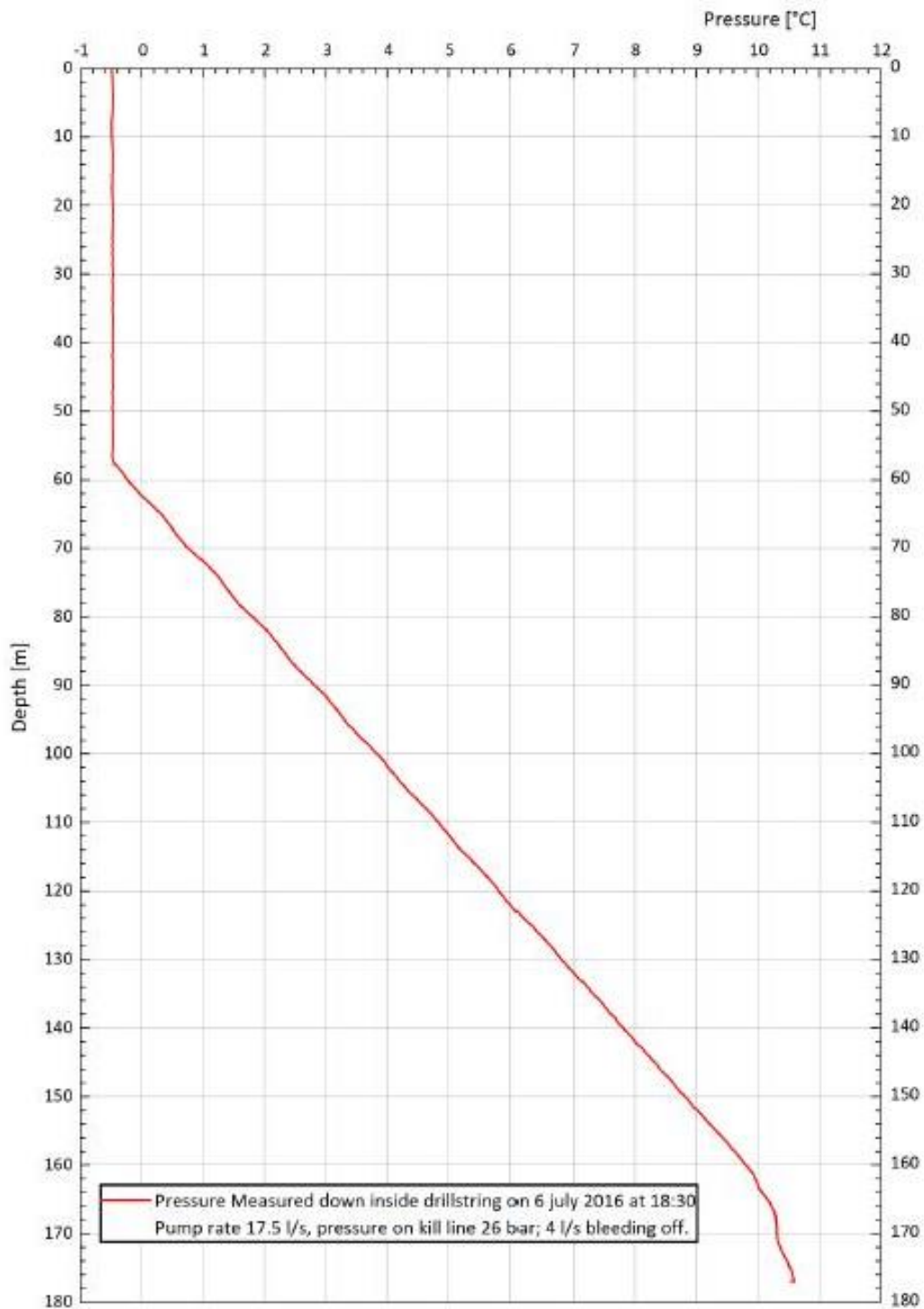


Figure 4. Pressure log from ÞG-10, on the 6<sup>th</sup> of July 2016.

<b>Peistareykir</b>		<b>Report #15</b>		<b>Phase 1</b>	
		<b>Preliminary results</b>		<b>(anchor casing)</b>	
<i>Operator:</i>	<b>Landsvirkjun</b>	<i>Drilling Company:</i>	<b>Iceland Drilling Company</b>		
<i>Well Name:</i>	<b>PG-10</b>	<i>Drill-Rig:</i>	<b>Sleipnir</b>		
<i>Well-Id:</i>	<b>60410</b>	<i>Geologist/Geophysicist:</i>	<b>SSjo-SRG</b> (E-mail: ssjo@isor.is)		
<i>Last casing size:</i>	<b>18 5/8"</b>	<i>Depth at 24 hrs.</i>	<b>193 m</b>	<i>Hole made last 24 hrs. :</i>	<b>0 m</b>
<i>Last casing depth:</i>	<b>106.9 m</b>	<i>Depth at 8 hrs.</i>	<b>193 m</b>	<i>Drilling time:</i>	<b>0 hrs.</b>
<i>Drilling fluid:</i>	<b>--</b>	<i>Circulation losses at 8 hrs.</i>	<b>0 l/s</b>	<i>Average ROP:</i>	<b>- m/hr</b>

## Drilling

From midnight on the 7<sup>th</sup> of July the crew waited on cement, followed by the opening of the well and RIH with a drill-string, tagging the top of the cement at 125 m depth. Cement was drilled from 125 m to 140 m, with notably softer cement being drilled from 137-140 m. Cement drilling continued down to 155 m and temperature of the return fluid was about 30°C. The crew waited on orders from 13:00 to 14:45 and the well was circulated. Further drilling of cement was decided and at 170 m depth the well kicked and blew off steam. Pipe-ram was closed and kill-line pressure was found to be around 8 bar. Pump-pressure was 9.5 bar with 18.5 l/s pumping during the quenching of the well, decreasing to 7 bar and then rising to about 23 bar. At 17:30 pumping was stopped and the kill-line closed. Cement-pump was connected to the kill-line and pumping resumed at the rate of 2 l/s with 5.5 bar pressure. Pumping was increased to 6.5 l/s and the pressure remained 5.5 bar. Pressure rose to 15.7 bar and when pumping was stopped the pressure dropped 5 bar. Pumping resumed on the kill-line at the rate of 2 l/s until the evening, changing rubber-seal in the diverter. At 22:00 it was decided to try to drill further against the over-pressure. Pumping on kill-line was stopped and pressure was reduced on the kill-line. Pipe-ram was kept closed and the upper annular preventer was also closed. The flow-line valve was throttled to a half-opening and the BOP was slowly opened. Immediately the well blew out with immense force. Pipe-ram and upper and lower annular preventers were closed but the well was not shut-in and gas and steam continued to emerge through the flow-line. When gas and steam started to appear on the outside of the surface casing it was evident that the situation was slowly beginning to become out of control and a decision was made to leave the drill-string in and cement the well off to prevent further escalation of the blow-out and to prevent further damage and unmanageable situation on the drill-pad. The cementing was finished just after midnight on the 8<sup>th</sup> of July and well thereby abandoned.

A sinker-bar was run in the drill string at 14:00 on Friday the 8<sup>th</sup> of July. The outside of the upper part of the drill-string, above the BOP stack was considerably hot, or 85-90°C. After breaking out the uppermost joint, freeing the top-drive and installing a poor-boy on the end, it periodically emitted small puffs of steam. The sinker-bar ran freely down to the float-valve. A Kuster K-10 P/T memory tool will be run in the drill-string to evaluate conditions.



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