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LV-2016-087

Landsvirkjun

Þeistareykir – Well ÞG-11

Phases 0 and 1: Drilling for Surface Casing down to 94 m and Anchor Casing down to 304 m Depth

ÍSOR

ÍSLENSKAR ORKURANNSÓKNIR

ÍSOR-2016/040

Project no.: 16-0110

June 2016

Key page

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Title: Þeistareykir – Well ÞG-11. Phases 0 and 1: Drilling for Surface Casing down to 94 m and Anchor Casing down to 304 m Depth.

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Prepared for: Landsvirkjun

Co operators:

Abstract: Well ÞG-11 is a directionally drilled production well for the Þeistareykir power plant. It is sited on the same drill pad as well ÞG-9. The well is located approximately 600 m north of Mt. Bæjarfjall and the aim of the drilling was to penetrate a purported fracture systems north of, and under, Mt. Bæjarfjall. This report addresses the drilling history and data acquisition of the 0th and 1st phase. This includes subsurface mapping of the lithologies and alteration in the well based on drill-cuttings, estimating subsurface temperatures from key alteration minerals, and relating drill-data and geophysical logs to lithology to constrain formation boundaries and identify potential aquifers. ÞG-11 was pre-drilled with 21" drill bit for 18⅝" surface casing to 94.3 m. Drilling continued with a 17½" drill bit for a 13⅜" anchor casing, down to 304 m. The stratigraphy of phases 0 and 1 in well ÞG-11 is composed of basaltic lava flows and hyaloclastite formations, including basaltic breccias, tuffs and pillow basalts. The uppermost part of the stratigraphic section is unaltered. Zeolites and clay first appear around 30 m depth and alteration of the drilled formations increases modestly below 45 m depth. Alteration increase further below 200 m where quartz and wairakite commonly occur.

Key words:

Þeistareykir, well ÞG-11, geothermal area, high temperature, wellbore, steam mining, geological strata, feed zones, wireline logging, Sleipnir, Landsvirkjun, ÍSOR

ISBN no:

UWI (Unique Well Id): B60411

Approved by Landsvirkjun's project manager

Project manager's signature	Reviewed by
magnús Ólafsson	Sigvaldi Thordarson

Ágrip

Hola ÞG-11 er stefnuboruð vinnsluhola. Tilgangur borunarinnar er að afla viðbótargufu fyrir Þeistareykjavirkjun sem nú er í byggingu. Holan er staðsett á borplani B sem er um 600 m norðan Bæjarfjalls. Á sama plani er holan ÞG-9. Í skýrslunni eru lagðar fram upplýsingar um jarðlög og ummyndun sem byggjast á svarfgreiningu á borstað. Gefið er yfirlit um borgögn úr sjálfvirku skráningarkerfi Sleipnis og ennfremur er greint frá borholumælingum sem gerðar voru á meðan borverkinu stóð. Hola ÞG-11 var forboruð (áfangi 0) með 21" krónu fyrir 18⅝" yfirborðsfóðringu á 94,3 m dýpi og svo með með 17½" krónu fyrir 13⅝" öryggisfóðringu á 304 m dýpi (áfangi 1). Í efstu 93 m eru millikorna basalthraunlög ráðandi en þar fyrir neðan, í 304 m, er um móbergsmyndun að ræða. Móbergið er ýmist breksía, túff eða bóstrabergsmyndun. Vægrar ummyndunar verður fyrst vart á 30 m dýpi þar sem leir og zeólítar koma fram. Ummyndun eykst síðan smám saman niður holuna en á um 200 m dýpi sést fyrst til kvars og wairakíts. Skoltap var óverulegt á meðan borun stóð. Yfirþrýstar æðar voru skornar á 110 og 180 m dýpi.

Table of contents

Tables

Figures

1 Introduction

Drilling of well ÞG-11 in the Þeistareykir geothermal field was conducted by Iceland Drilling (Jarðboranir) for Landsvirkjun. ÞG-11 was drilled from the same well pad as the vertical, 2194 m deep well ÞG-9 (well pad B), drilled in 2013 (Figure 1). The wells are located approximately 600 m north of Bæjarfjall (Table 1), at 350 m a.s.l. (Mortensen et al., 2013b). The planned depth of well ÞG-11 is 2000–2500 m. The well will be directionally drilled towards south, with the aim of intersecting the permeability and heat anomaly related to the fracture system north of, and under, Mt. Bæjarfjall (see Khodayar et al., 2016; Mortensen, 2012).

Table 1. *Geographical position of well ÞG-11. Coordinates are in ISNET93.*

Well name	Well ID	East (X) (m)	North (Y) (m)	Elevation (m a.s.l.)	Planned depth (m)
ÞG-11	60411	593436	599582	350	2500

The planned design of well ÞG-11 (Figure 2) is as follows:

- Phase 0: Pre-drilling for the surface casing with 21" drill bit to approximately 100 m depth. Cased with 18⅝".
- Phase 1: Drilling for the anchor casing with 17½" drill bit down to ~ 300 m depth. Cased with 13⅜".
- Phase 2: Drilling for the production casing with 12" drill bit down to ~ 800 m depth. Cased with 9⅝".
- Phase 3: Drilling of the production part with 8½" 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 180° ±5°relative to true North, with an inclination 40° ±3° from the vertical within the depth range 320 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 20 m below the anchor casing, at 320 m depth. The angle build-up rate was planned to be 3°/30m with the final inclination of 40° from the vertical, to be completed before 800 m (MD).

Phases 0 and 1 were drilled by the drill-rig Sleipnir. Originally the plan was that another rig (Óðinn) would complete both the 2nd and 3rd phases in well ÞG-11. However, near the end of the 1st phase a decision was made to have Sleipnir also complete drilling for the production casing (2nd phase), in well ÞG-11, before moving to ÞG-10. Depths in this report refer to measured depth (MD) relative to Sleipnir´s rig floor (5.72 m above ground level, measured before setting the anchor casing), except if otherwise is 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, gyro surveying and geothermal consulting.

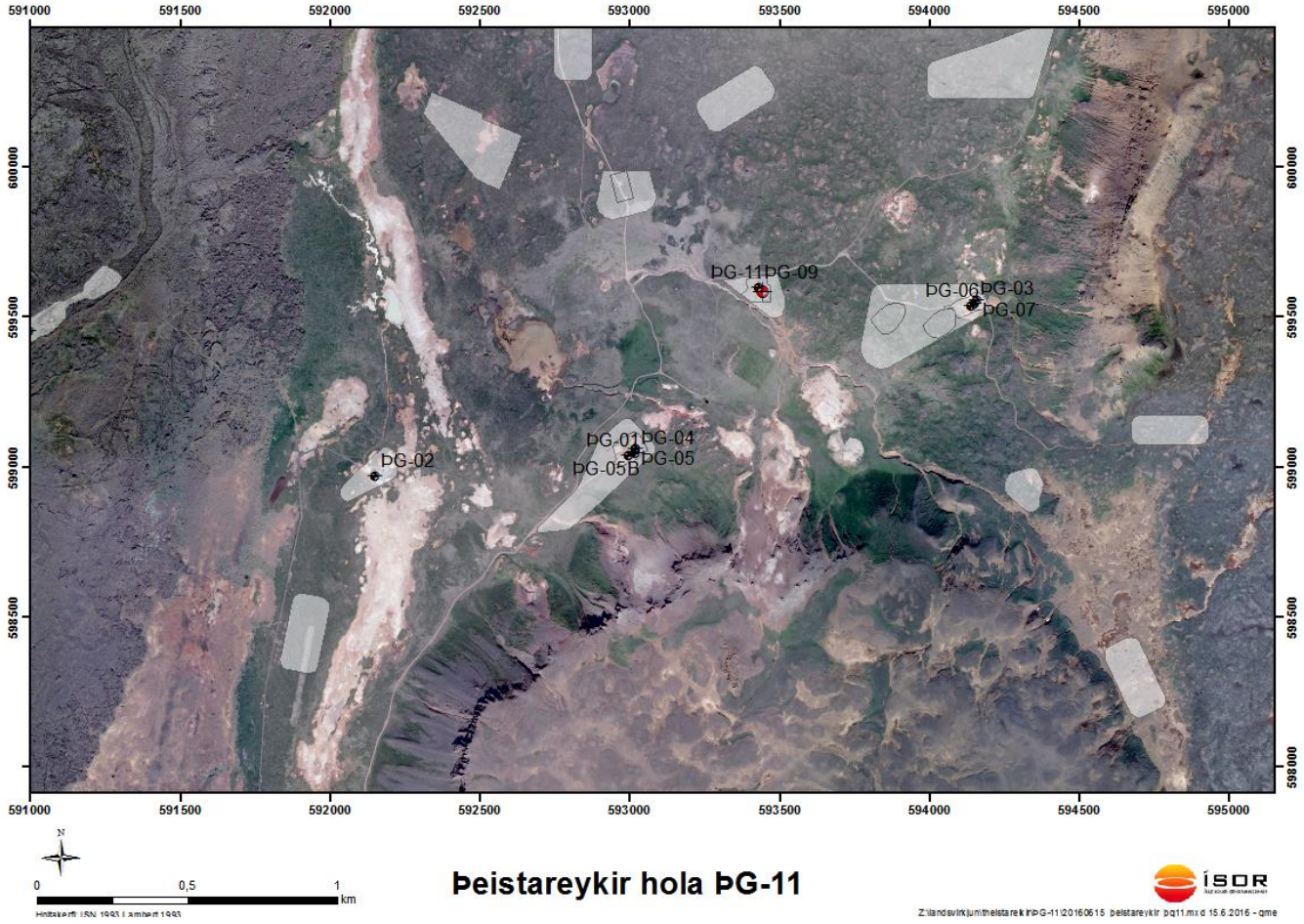


Figure 1. *Aerial photograph of Þeistareykir. Location of current and proposed drillpads indicated by light green areas. Location of well ÞG-11 beside well ÞG-9 on well pad B is shown. Wells ÞG-1, ÞG-4 and ÞG-5 (A and B) in Þeistareykir.*

This report presents the geological part of the drilling, including e.g. lithology, alteration and feed points, as well as the geophysical logging of the well. The report is structured 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, and potential aquifers in the well. *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 ÞG-11, and present all the data collected and provide data interpretations. Appendix B contains all daily reports written by the borehole geologist during drilling operations, presenting preliminary results.

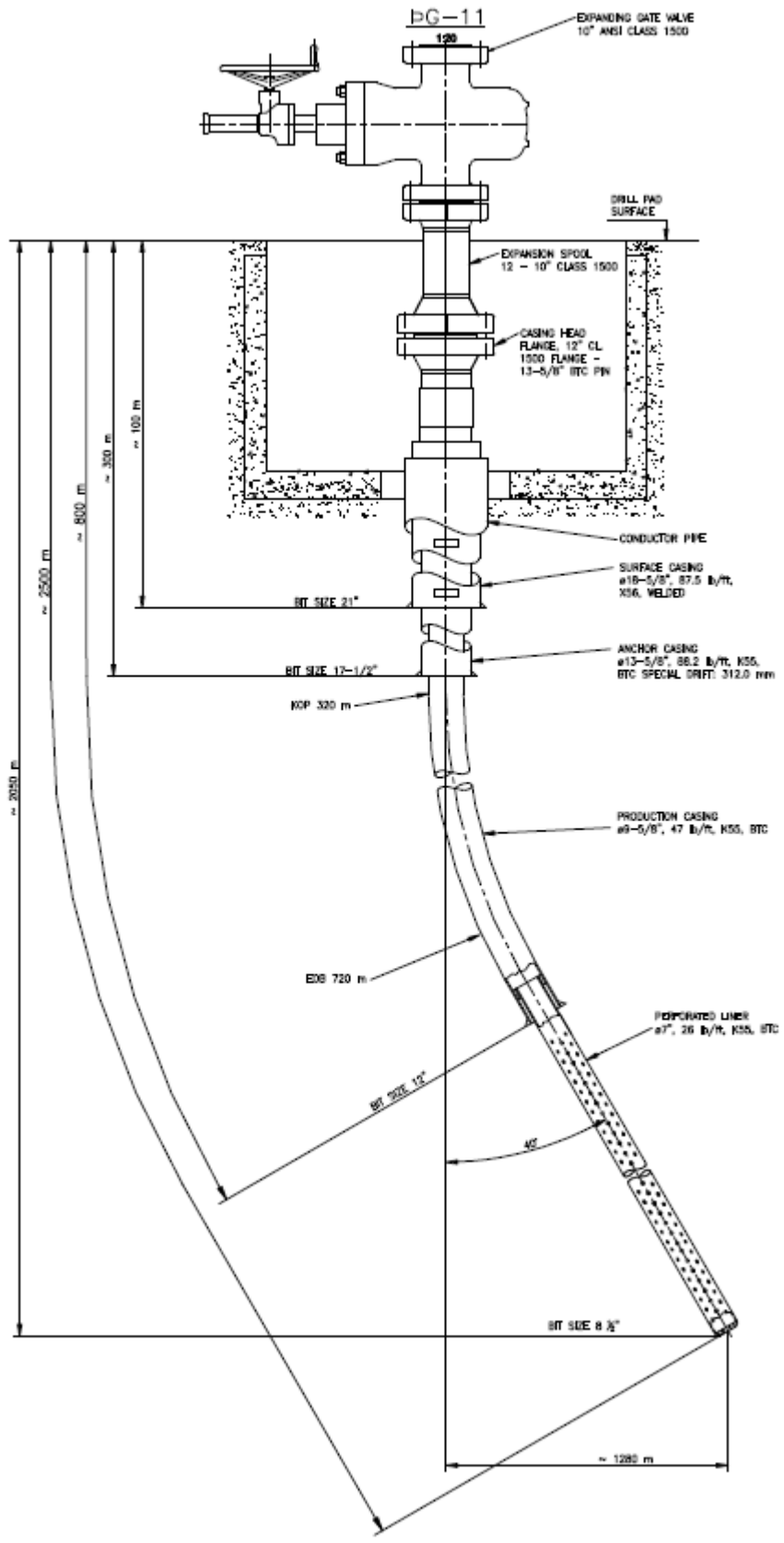


Figure 2. *Well design of ÞG-11.*

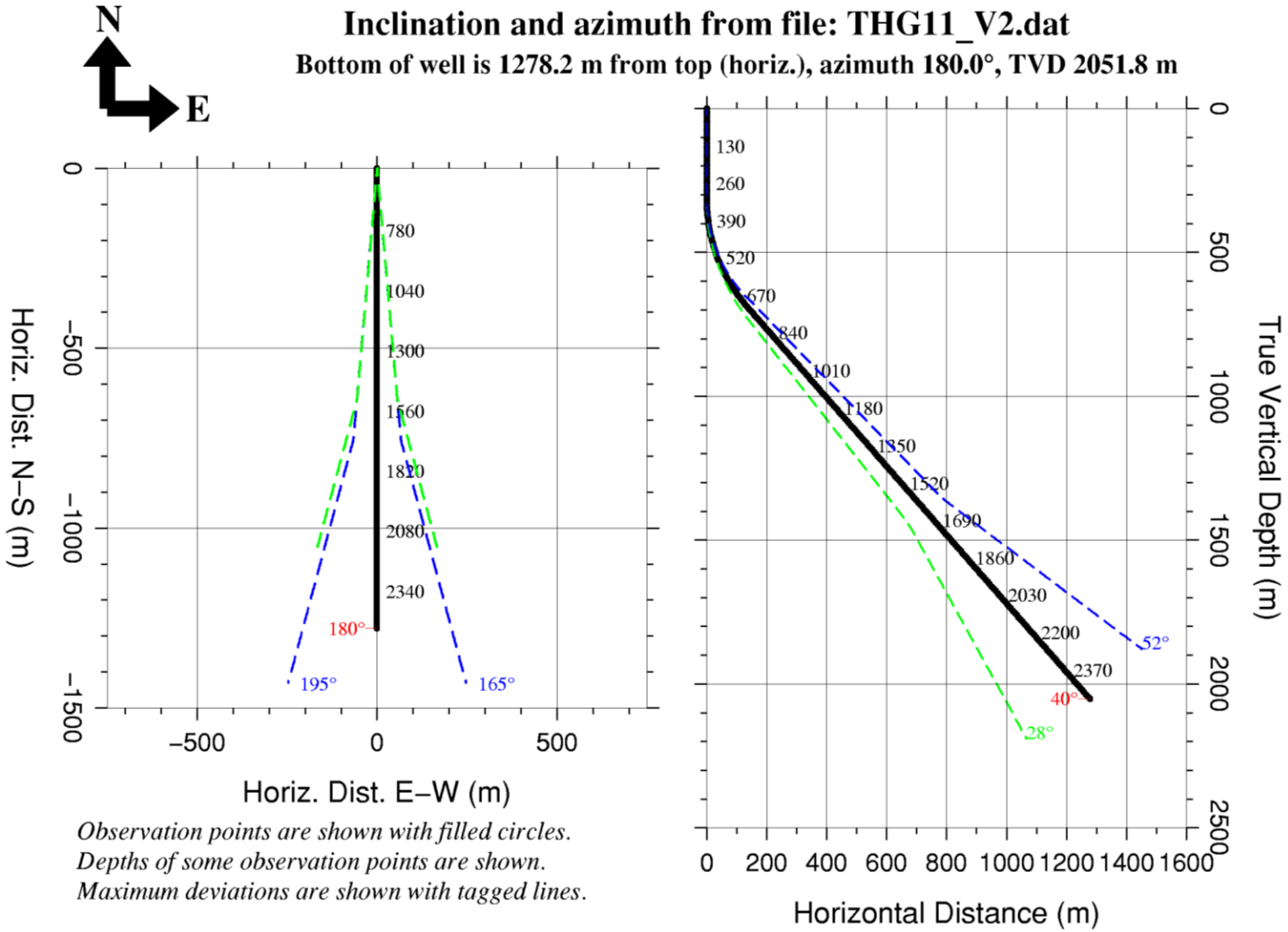


Figure 3. *Cross section and birds-eye-view of the planned trajectory of well ÞG-11 with allowable deviation indicated (Thordarson, 2016).*

2 Drilling operations

2.1 Overview

Drill rig Sleipnir was ready for commencing drilling on the 11th of May 2016. Drilling with a 21" drill bit started the same day at 11.4 m. Drilling progressed slowly but surely during the entire phase. Drilling, casing, cementing and logging of phase 0 was completed on the 20th of May 2016, workday 11. At this point the well was 94.3 m deep relative to the drilling platform of Sleipnir (5.72 m above ground). The 18⅝" surface casing was set at 91.5 m depth.

Preparations for the drilling of phase 1 started on the 20th of May 2016 with testing of the blow-out preventers (BOP). Problems with leaking of the BOP's caused delays of drilling operations. Drilling into formation with a 17½" drill bit started at noon the 24th of May, at 94 m. Phase 1 was complete 3rd of June 2016 (workday 25). A 13⅝" anchor casing was run to 302.5 m depth.

An overview of the drilling phases and details of the casing depths are shown in Table 2. Figure 4 shows the drilling progress of well ÞG-11 during drilling of phases 0 and 1.

Table 2. *Drilling and casing depths in well ÞG-11:*

Drill-Rig	Phase	Drill bit	Depth (m)	Depth Reference	Casing Type	Casing Depth
Sleipnir	0	21"	94.3	Sleipnir RF*	18⅝"	91.5
Sleipnir	1	17½"	304	Sleipnir RF*	13⅜"	302.5

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

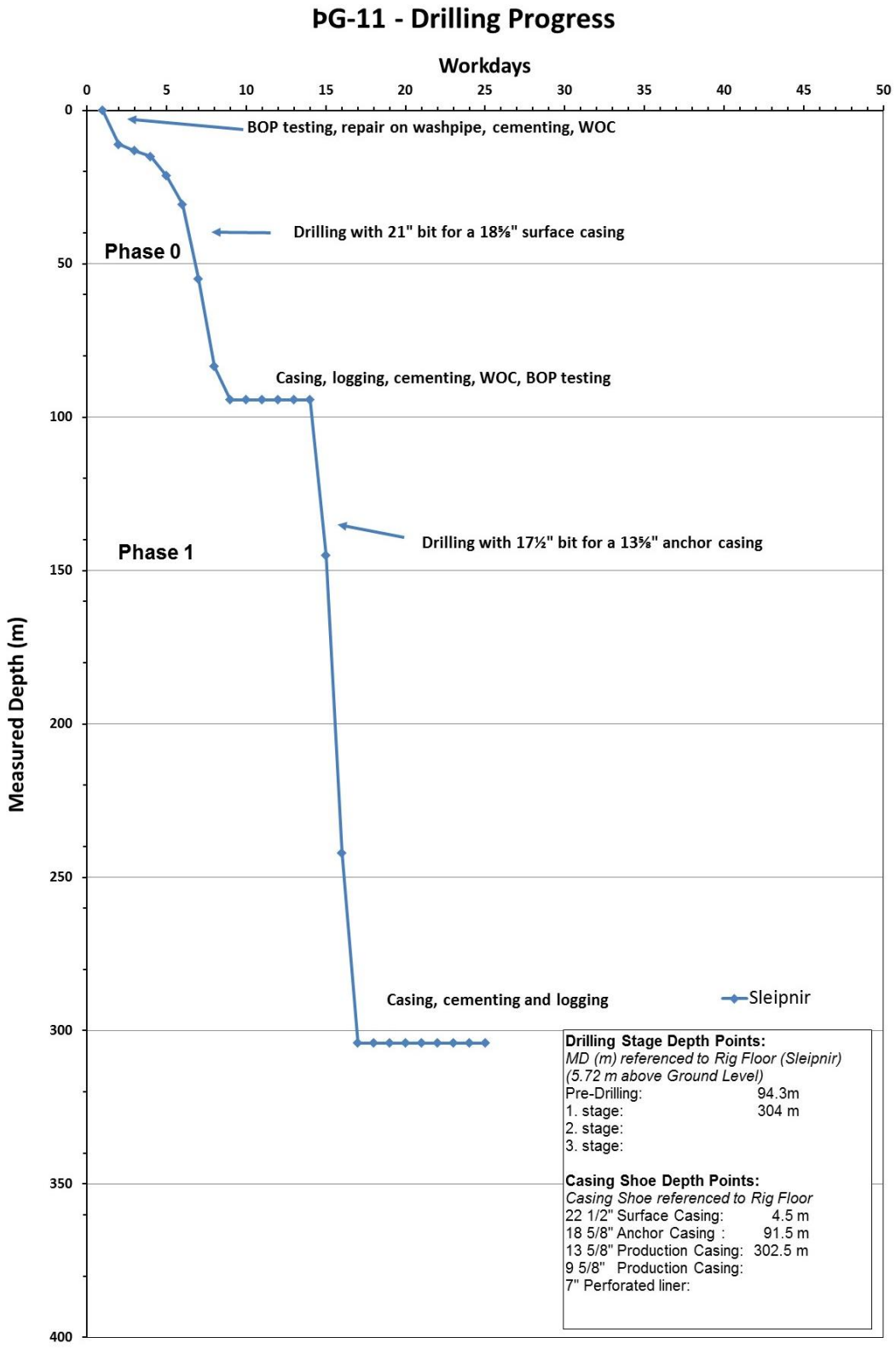


Figure 4. *Drilling progress of well ÞG-11.*

2.2 Pre-drilling for the surface casing (18⅝") - Phase 0

The drill rig Sleipnir was transported to drill pad B in Þeistareykir at the end of April 2016. The drill pad (B) is located approximately 600 m north of Bæjarfjall, at 350 m a.s.l (Figure 1). After rigging up, the drillers worked on preparations for drilling of ÞG-11. Some maintenance work and repairing had to be carried out before drilling could be started, causing a delay of the project for a few days. Drilling of well ÞG-11 started 11th of May, with a 21" drill bit, and phase 0 (pre-drilling) was completed the 20th of May (workday 11). Drilling was almost continuous down to the final depth of 94.3 m, which was reached on the 17th of May, without any significant problems.

Total circulation losses at 32.5 m and 50 m during drilling of ÞG-9 had been problematic and required cementing to tighten the well (Mortensen et al., 2013a). Such problems were also expected at similar depths in ÞG-11, and thus as a precaution, ÍSOR's geologists and loggers were onsite during the pre-drilling, monitoring the cuttings and prepared to log the well in case problems arose. Total losses were, however, not a problem during the pre-drilling of ÞG-11. It has been speculated that the reason for this is that cementing from ÞG-9 extended beyond the well and even into ÞG-11, as cement was encountered in the cuttings from ÞG-11 at 44 m to 46 m depth.

Early morning on the 11th of May, the blow out preventers were pressure tested by applying 6 bar for 15 minutes. They passed the test but a leakage from the wash-pipe was noted and needed repairing. In the afternoon, when pumping into the well, a circulation loss of 8 l/s was noticed. It was decided to drill a few metres and to place a cement plug in the well before further drilling. Drilling was carried out from 11.4–13.3 m and afterwards, 0.5 m of bottom hole deposit was circulated out of the well. In the evening, 3 m^3 of sandy cement was pumped into the well. After cementing, the surface of the plug was found at 8 m depth (from the rig floor). It appeared that the wash-pipe was not working properly and required some more maintenance before further drilling. Waiting on cement (WOC) lasted until 18:00 the 12th of May, when drilling with 21" drill bit into cement started. A hard formation was reached at 13.1 m with no recorded circulation losses. Drilling was stopped at 19.5 m, in the morning of May 13th and the well was rinsed for half an hour and the drilling fluid was changed from water to mud. Drilling started again in the afternoon with no recorded circulation losses.

Minor circulation losses (1.25 l/s) were recorded at 28 m depth on May 14th. Consequently, mica was added to the drilling fluid, and about half an hour later the well was tight again. Circulation losses of 4 l/s were recorded in the evening, and mica was added to the drilling fluid again. Drilling was continuous with no major problems and no recorded circulation losses until the 17th of May when casing depth (94.3 m) was reached. The plan was to set the casing within the basalt lavas, above the hyaloclastie tuff formation (beginning at 96 m in ÞG-9). At 91 m, disturbances were noticed in weight on bit (WOB) and torque, and was considered to indicate fractured rock (Figure 5). Thus, it was decided to drill until it became stable. Circulation losses were checked frequently, but no losses were noticed. At 94.3 m depth, the torque had been stable for a while, and even though some tuff had appeared in the cuttings, it was decided to stop drilling there. Results of the observation of the 21" drill bit after phase 0 showed that the bit was in good condition (Figure 6).

The well was rinsed and then the string was pulled out of the well. A tilt measurement was carried out at 78 m, confirming a vertical well (0°). After measuring the tilt and pulling out of

hole, a wiper trip was completed. No obstacles were noticed during the wiper trip. Some 1.5 m of bottom hole deposits were found in the well which were circulated clean. In the evening of May 17th, ÍSOR's logging engineers started logging the temperature and caliper of the well. Afterwards, the drilling crew prepared the casing work.

Casing job for 18⅝" surface casing started at 03:30 the 18th of May and was completed at 10 pm the same day. Casing shoe was set at 91.5 m, measured from the rig floor. Next, preparations were made for cementing of the surface casing. After running in the cement string, the cement job was carried out between 4:30 and 04:50 on the 19th of May. At first, 8.6 m^3 of cement-sludge (with density of 1.72 g/cm^3) was pumped down the string. Afterwards, some 0.8 m^3 of water were pumped down to clean the string. Finally, 0.33 m^3 of cement were cemented on top for a fill-up in the annulus. Welding the flange of the 18 ⅝" surface casing was finished around 13:30 on the 20th of May and that marks the end of drilling phase 0.

The progress of drilling during the pre-drilling (phase 0) is shown in Table 3. Casing and cement reports from the drilling contractor (Iceland Drilling) are shown in Table 4, Table 5 and Figure 7.

Table 3. *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	Drilled Section (m)	Drill Time (h)	ROP (m/h)	Total Depth at 24:00 (m)
11.05.2016	1.7	2.0	0.9	13.1
12.05.2016	1.9	5.0	0.4	15
13.05.2016	7.9	16	0.5	22.9
14.05.2016	7.7	22.5	0.3	30.6
15.05.2016	24.4	22.0	1.1	54.9
16.05.2016	28.6	24.0	1.2	83.6
17.05.2016	10.7	10	1.1	94.3
Total	**82.9**	**101.5**	**0.8**	

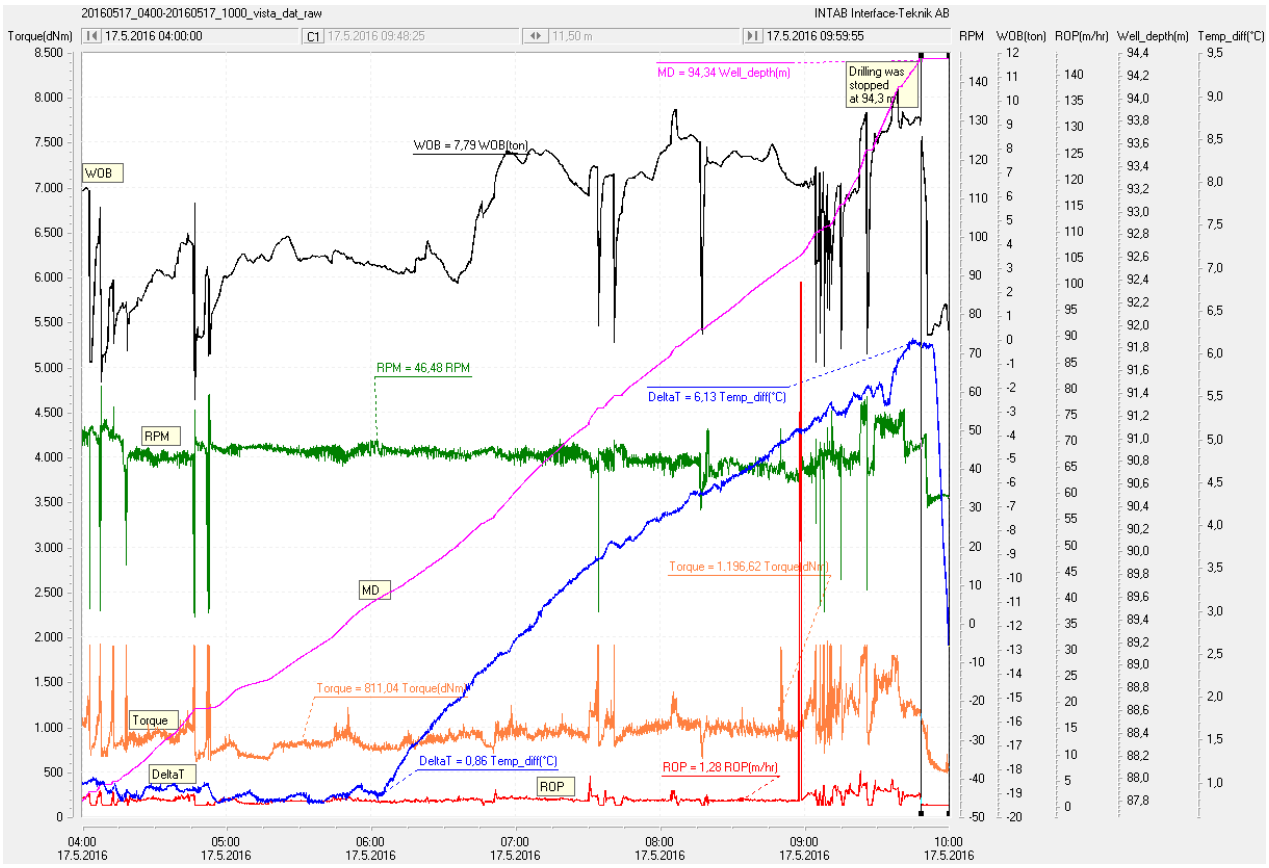


Figure 5. *Drilling data from 4–10 in the morning of the 17th of May. Torque began to be unstable around the proposed casing depth, which is considered to indicate fractured rock. (Note that deltaT started to increase a 6 am, at ~89 m depth.)*

Figure 6. *The 21" drill bit, after pre-drilling of ÞG-11.*

Table 4. *Casing report for surface casing in ÞG-11.*

Casing Information Report — **Iceland Drilling**
Rig: Sleipnir — **Rig No: 28000**
Job No: 28176 — Job Name: ÞG-11

Casing Information

Run Date/Time:	18-maí-16 05:00		
		Leak Off Test (kg/cu m):	
Well Section:	SURF	String Type:	FULL
String Top MD (m):	0,0	String Top TVD (m):	
Casing Shoe MD (m):	91,5	Casing Shoe TVD (m):	
String Nominal OD (cm):	47,31	String Nominal ID (cm):	45,10
Bit Diameter (cm):	53,34	Avg. Open Hole Diam. (cm):	53,34
Centralizers: No:		Manufacturer/Type:	
Depths:			
Hanger Type:		Manufacturer:	
Comments:	Transferred from Casing Tally Detail on 19-maí-16 12:41		

String Component Details

Joints	Item	Length (m)	OD(cm)	ID (cm)	Weight (kg)	Grade	Connection	Torque
1	SHOE	0,520	47,31	45,10		X-56	WELD	
1	JOINT	12,220	47,31	45,10		X-56	WELD	
1	FLOAT	0,690	47,31	45,10		X-56	WELD	
7	JOINT	85,560	47,31	45,10		X-56	WELD	
Totals: 10		98,990						

Table 5. *Cementing report for surface casing in ÞG-11.*

Cementing Report — **Iceland Drilling**
Rig: Sleipnir — **Rig No: 28000**
Job No: 28176 — Job Name: ÞG-11

Cement Job Information

Start Date/Time:	19-maí-16 04:20	Well Bore:	Original Well Bore
Job Type:	PRIMARY	String OD (cm):	47,31
Well Section:	SURF	String Type:	FULL
Cementing Co:	JARDB	Cementing Engineer:	Sveinbjörn Bjarnasson

Primary Job Detail

	Volume (cu m)	Pump Time	Rate (cu.m./min)	Pressure (bar)
Conditioning Data:				
Cement Data:	8,6	0,86	10,0	0
Displacement Data:	0,8	1	0,8	
Calc. Displacement Vol:	0,8			

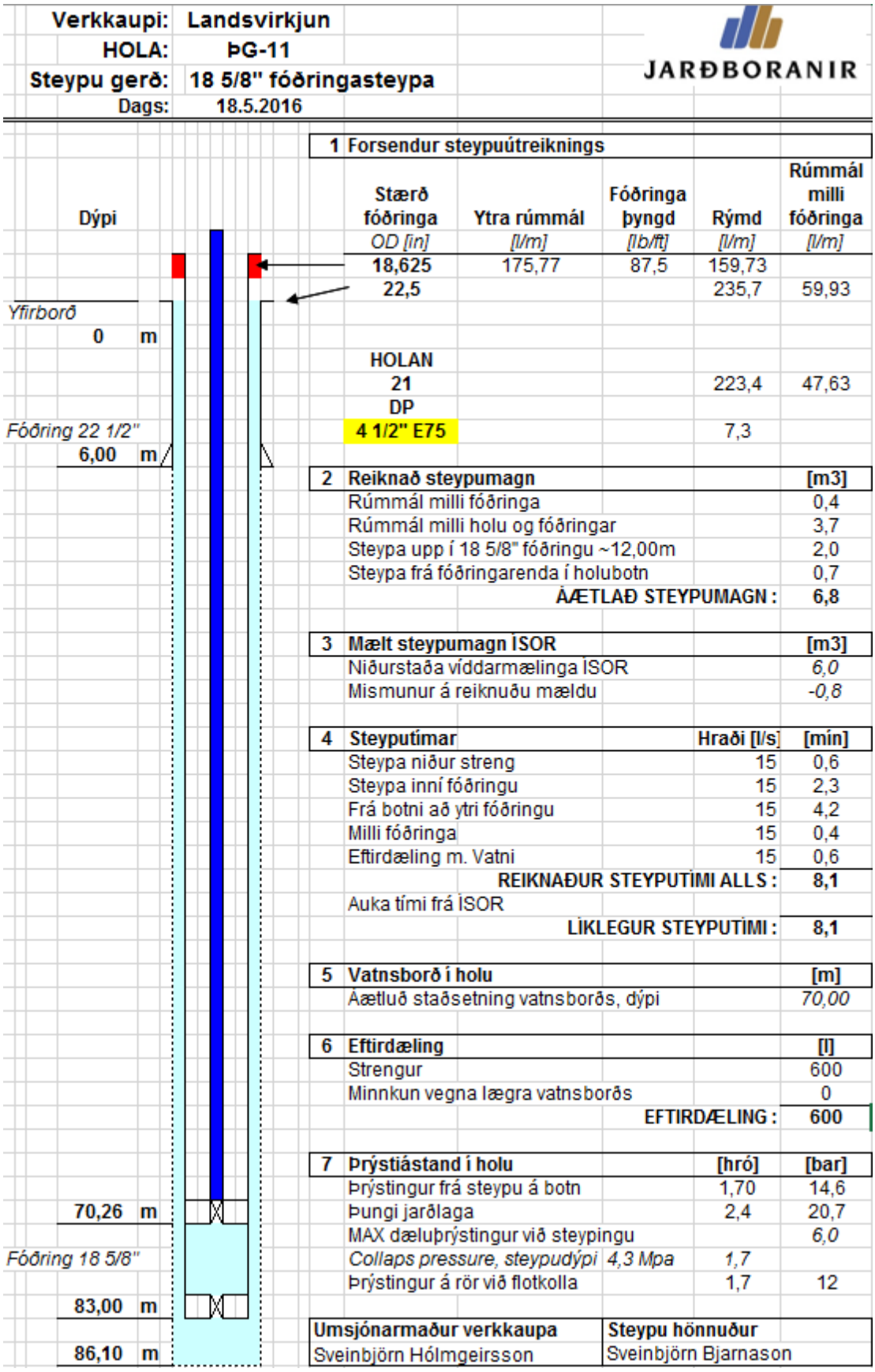
☐ Batch Mix? ☐ Bump Plug? Bump Pressure:
Returns to Surface: ☐ Reciprocate Pipe? ☐ Cement at Surface?
Calc Top of Cement (m): Excess (%): Avg. Hole Size (cm): 53,34

Slurry Information

Type	Density	Yield	Sacks	Volume	Rate	Additives
DISPLACE	1					
LEAD	9					
TAIL	0					

Post Job Information

Liner Top Test (kg/cu m):		Job Success?	No
Actual Top of Cmt (m):		CBL Bond Quality:	
Misc. Comments:	Engin leki í holu steypt í gegnum streng 8,6 m3 g blöndu eðlisþyngd 1,72 steypt ofaná 0,33m3 sem gera 10,000 kg þurefni		



Verkkaupi:	Landsvirkjun
HOLA:	ÞG-11
Steypu gerð:	18 5/8" fóðringasteypa
Dags:	18.5.2016

JARÐBORANIR

1 Forsendur steypuútreiknings

Dýpi	Stærð fóðringa OD [in]	Ytra rúmmál [l/m]	Fóðringa þyngd [lb/ft]	Rými [l/m]	Rúmmál milli fóðringa [l/m]
	18,625	175,77	87,5	159,73	
	22,5			235,7	59,93
Yfirborð 0 m					
	HOLAN 21 DP			223,4	47,63
Fóðring 22 1/2" 6,00 m	4 1/2" E75			7,3	

2	Reiknað steypumagn	[m3]
	Rúmmál milli fóðringa	0,4
	Rúmmál milli holu og fóðringar	3,7
	Steypa upp í 18 5/8" fóðringu ~12,00m	2,0
	Steypa frá fóðringarenda í holubotn	0,7
	ÁÆTLAÐ STEYPUMAGN :	6,8

3	Mælt steypumagn ÍSOR	[m3]
	Niðurstaða víddarmælinga ÍSOR	*6,0*
	Mismunur á reiknuðu mældu	*-0,8*

4	Steyputímar	Hraði [l/s]	[mín]
	Steypa niður streng	15	0,6
	Steypa inní fóðringu	15	2,3
	Frá botni að ytri fóðringu	15	4,2
	Milli fóðringa	15	0,4
	Eftirdæling m. Vatni	15	0,6
	REIKNAÐUR STEYPUTÍMI ALLS :		8,1
	Auka tími frá ÍSOR		
	LÍKLEGUR STEYPUTÍMI :		8,1

5	Vatnsborð í holu	[m]
	Áætluð staðsetning vatnsborðs, dýpi	*70,00*

6	Eftirdæling	[l]
	Strengur	600
	Minnkun vegna lægra vatnsborðs	0
	EFTIRDÆLING :	600

7	Þrýstiástand í holu	[hró]	[bar]
	Þrýstingur frá steypu á botn	1,70	14,6
	Þungi jarðlaga	2,4	20,7
	MAX dæluþrýstingur við steypingu		*6,0*
	Collaps pressure, steypudýpi 4,3 Mpa	*1,7*	
	Þrýstingur á rör við flotkolla	1,7	12

Umsjónarmaður verkkaupa	Steypu hönnuður
Sveinbjörn Hólmgeirsson	Sveinbjörn Bjarnason

70,26 m

Fóðring 18 5/8"

83,00 m

86,10 m

Figure 7. *Cementing report for surface casing of ÞG-11.*

2.3 Drilling for the anchor casing (13⅝") - Phase 1

Drilling operations of phase 1 were conducted from May 20th (workday 11) to June 3rd (workday 25).

In the afternoon of May 20th, when the drill crew was working on the blow out preventers, it turned out that the pipe ram leaked and needed repairing. A specialist from the Netherlands was called out, and arrived to the drill site at 21:00 the next day, and replaced an O-ring in the pipe-ram. During pressure testing of the preventers stack on the 22nd of May it turned out that the lower annular preventer was leaking and needed repairing (Figure 8). It was reinstalled and successfully pressure tested with 20 bar for 10 minutes on the 23rd of May. Drilling into formation with a 17½" bit started at noon on the 24th of May, at 94 m. Drilling was almost continuous down to anchor casing depth, except for a few and short maintenance breaks, with no recorded circulation losses.

The rate of penetration (ROP) was generally low during drilling of phase 1, ranging from 3–7 m/h. Figure 9 shows chosen drilling parameter from the drill rig Sleipnir during drilling on the 25th of May, while drilling from 145 to 242 m. From the figure it can be seen how the differential temperature (DeltaT) rises from approximately 5.5°C to 8.5°C at around 16:00 o´clock, which is at a similar depth (~ 190 m) as an influx seen on the temperature log carried out the 27th of May (Figure 23). Figure 9 also shows fluctuations in the rate of penetration from approximately 194–236 m MD, where the drill bit was penetrating through hyaloclastite formations. It then decreased and stabilized when fine grained basalt formation replaced the hyaloclastite at 236 m.

After drilling was stopped at 304 m on the 26th of May, the well was circulated with water for a few hours. Bottom hole deposits were 1.5 m thick so the well was circulated further. At 22:30, ÍSOR´s logging engineers prepared for an inclination, temperature and warm up log, and started logging in the string with no pumping just before midnight. The inclination at 288 m was 2.5° from the vertical. The results of the temperature logging can be seen in Figure 23.

The string was pulled out of the well early in morning of the 27th of May. At 09:00, when pulling out the first collar, the well erupted a considerable amount of mud. The pressure at the well head rose up to 13.2 bar. At this time, the bit was at approximately 90 m depth. The top part of the well was then cooled down by circulating mud, gradually diluted with water. Pulling the string out of the hole was completed at 18:30 the same day. Next, preparations for running in the anchor casing commenced. Running in the casing was delayed for approximately 30 hours due to the fact that the elevator that was delivered to site could not be used on this rig. The casing work got further delayed on the 29th of May, when it became clear that the upper annular preventer was not functioning properly and the rubber "donut" had to be replaced.

When the drill crew was starting running in the 13 ⅝" anchor casing early in the morning of May 30th, a problem with threading on the second casing tube caused minor delays. Several attempts were made to rectify the problem, but to no avail. The casing tube was subsequently replaced and the joint welded together. Running in the casing continued shortly after lunch. At 22:00 H_2S concentration was measured 30–50 ppm at the tanks, but H_2S had been streaming out of the well since 17:30. When the casing job was almost complete at 23:00 in the evening of May 30th, a bottom hole deposit was found at 289 m and the well was circulated clean. The casing was flushed down from 294 m to the final casing depth of 302.5 m. Running in the

casing was completed in the early morning of May 31st. The well was rinsed clean and polymer pills injected. Next, the drill crew prepared for the cementing of the casing.

The cement string was run in hole and cementing of the casing started shortly after dinner on the 31st of May. A total of 31.5 m^3 of cement slurry were used for the job. The first 30 m^3 of cement slurry, with density of 1.7 g/cm^3, were pumped down the string, filling up the annulus. Cement-slurry was returned to the surface after 30 minutes. After the slurry had settled, 1.5 m^3 of cement slurry was added on top between the casings.

Two cement bond logs (CBL) and temperature logs were performed, by ÍSOR´s logging engineers. The first one was carried out early morning on June 1st, after 5 hours of WOC. The cement between the surface casing and the anchor casing showed no sign of hardening but below 90 m the cement already showed clear sign of bonding.

In order to estimate the heat-up rate inside the casing, a roughly one-hour heat-up log was measured.

The second temperature and CBL-logs were run in the well shortly after noon on the 1st of June (17.5 hours after cementing).

The second CBL log showed a good overall bonding between the casing and the formation. Also, the cement between the surface casing and the anchor casing was forming a good bond. Casing-and cement reports from Iceland drilling is shown in tables Table 7 and Table 7Table 8, respectively. Further information on the CBL and temperature log can be found in chapter 4.

The landing joint was detached and the flange was attached to the 13 ⅝" anchor casing just before noon on the 3rd of June, workday 25. That marks the end of drilling phase 1.

Drilling progress during drilling of phase 1 is shown in Table 6.

Table 6. *Drilling progress during drilling of phase 1 in ÞG-11.*

Day	Drilled Section (m)	Drill Time (h)	ROP (m/h)	Total Depth at 24:00 (m)
24.05.2016	51	11.0	4.6	145
25.05.2016	97	20.5	4.7	242
26.05.2016	62	17.0	3.6	304
Total	**210**	**48.5**	**4.3**	

Figure 8. *The drill crew at ÞG-11 working on repairing the lower annular BOP.*

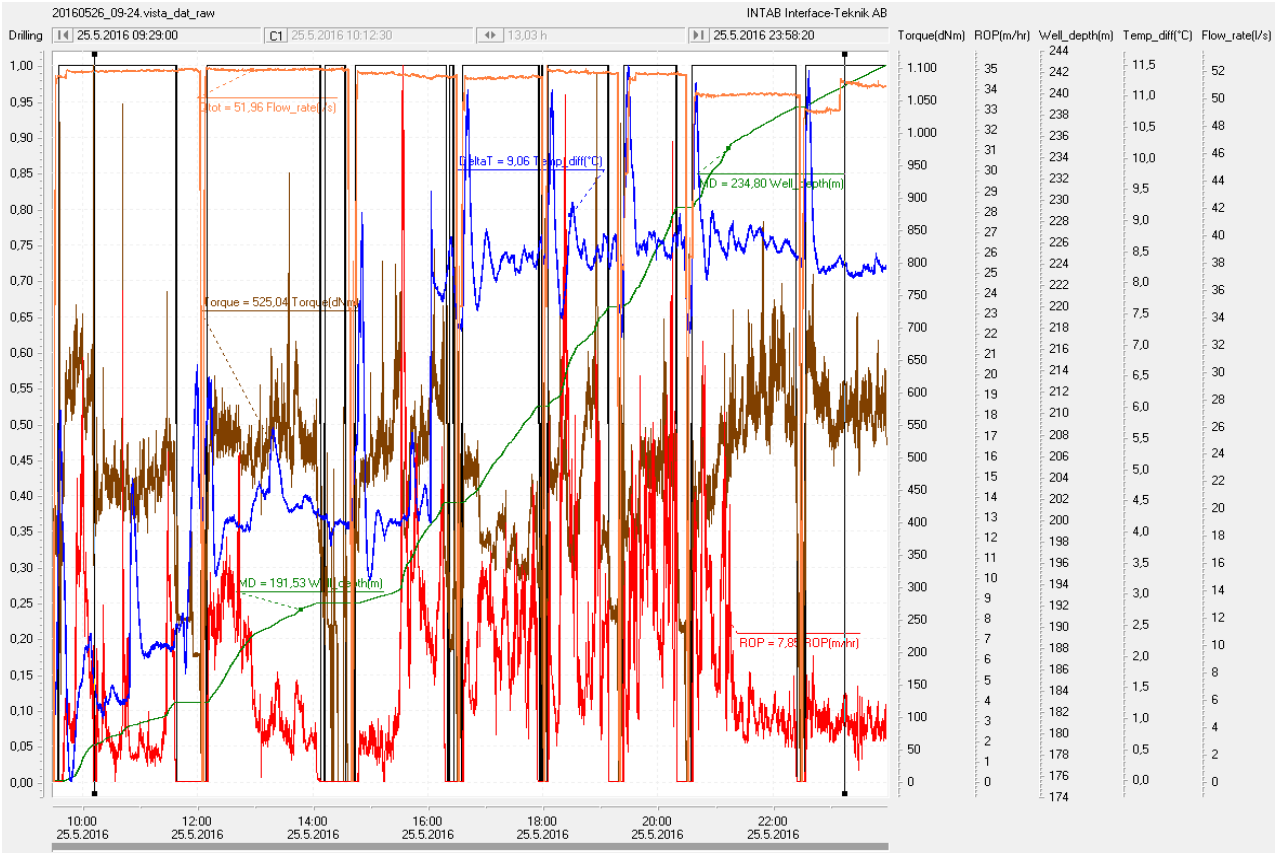


Figure 9. *Drilling data (Qtot-orange, Torque-brown, ROP-red, DeltaT-blue, Well depth-green) the 25th of May.*

Table 7. *Casing report for the 13⅝" anchor casing.*

Casing Information Report		Iceland Drilling
Rig: Sleipnir		Rig No: 28000
Job No: 28176		Job Name: ÞG-11

Casing Information

Run Date/Time:	30-maí-16 07:00		
		Leak Off Test (kg/cu m):	
Well Section:	INT1	String Type:	FULL
String Top MD (m):	-1,0	String Top TVD (m):	1,0
Casing Shoe MD (m):	302,5	Casing Shoe TVD (m):	302,5
String Nominal OD (cm):	34,61	String Nominal ID (cm):	
Bit Diameter (cm):	44,45	Avg. Open Hole Diam. (cm):	
Centralizers: No:	9	Manufacturer/Type:	
Depths:			
Hanger Type:		Manufacturer:	
Comments:	Transferred from Casing Tally Detail on 31-maí-16 06:42		

String Component Details

Joints	Item	Length (m)	OD(cm)	ID (cm)	Weight (kg)	Grade	Connection	Torque
1	SHOE	0,850					BUTT	1600
2	JOINT	22,820	34,61		131,3	K-55	BUTT	2400
1	FLOAT	0,480					BUTT	1600
24	JOINT	271,530	34,61		131,3	K-55	BUTT	2400
Totals: 28		295,680						

Table 8. *Cement report for the anchor casing.*

Cementing Report		Iceland Drilling
Rig: Sleipnir		Rig No: 28000
Job No: 28176		Job Name: ÞG-11

Cement Job Information

Start Date/Time:	31-maí-16 20:25	Well Bore:	Original Well Bore
Job Type:	PRIMARY	String OD (cm):	34,61
Well Section:	INT1	String Type:	FULL
Cementing Co:	JARDB	Cementing Engineer:	Einar Sólberg

Primary Job Detail

	Volume (cu m)	Pump Time	Rate (cu.m./min)	Pressure (bar)
Conditioning Data:				
Cement Data:	30,0	35	0,9	3
Displacement Data:	2,5			
Calc. Displacement Vol:	2,5			

	☐ Batch Mix?	☐ Bump Plug?	Bump Pressure:		
Returns to Surface:	FULL	☐ Reciprocate Pipe?	☑ Cement at Surface?		
Calc Top of Cement (m):		Excess (%):	100,00%	Avg. Hole Size (cm):	47,31

Slurry Information

Type	Density	Yield	Sacks	Volume	Rate	Additives
DISPLACE	3					
LEAD	30					
TAIL	2					

Post Job Information

Liner Top Test (kg/cu m):		Job Success?	Yes
Actual Top of Cmt (m):		CBL Bond Quality:	
Misc. Comments:	Engin leki í holu steypt í gegnum streng 30 m3 g blöndu eðlisþyngd 1,7 steypt ofaná 1,5m3 eðlisþyngd 1,75		

3 Lithology, alteration, intrusions and circulation losses

The drilling crew collected cutting samples at two metres interval during the drilling of phases 0 and 1 in well ÞG-11. Depth values of the samples are in reference to the rig floor of Sleipnir (5,72 m above ground level). The samples were collected in 150 ml plastic containers. ÍSOR's borehole geologists analyzed the cutting samples onsite during drilling and determined the lithology and the alteration mineral assemblage through the aid of a binocular microscope. Additional data on the main drilling parameters from the drill rig data system were collected, wire-line logs as well as measured circulation losses were compared with the lithological units drilled trough.

3.1 Lithology of phases 0 and 1

The lithology of phases 0 and 1 in well ÞG-11 corresponds well to what was seen in the top 300 m in well ÞG-9 (Mortensen et al., 2013a). Both wells are drilled from well pad B, so strong similarities were expected. A detailed lithological log for well ÞG-11 from surface to 304 m depth is compiled in Figure 11-13, where different units are described. In Figure 16 the lithology of well ÞG-11 is compared to the lithology of well ÞG-9.

A recap of the drilling history during the drilling for the preliminary casing, surface casing and anchor casing is shown in Figure 14–15. A cursory inspection of the figures reveals that the tuffs and glassy basalts are in general easier to drill through (higher ROP's for a given WOB) than the crystallized basalts, either fine- or medium grained.

The description of the drill cuttings sampled from well ÞG-11 is as follows:

Phase 0 (0–94 m)

The lithology of drilling phase 0 mainly consists of medium-coarse grained olivine and plagioclase rich basaltic lava formations. A difference in the recorded depth values in the two wells corresponds at some levels to the difference in the height of the rig floor of Sleipnir (5.72 m above ground) in comparison with the rig floor of Geysir (6.8 m above ground), which drilled well ÞG-9. The uppermost lavas are fresh and oxidization appears below 26 m. One clear scoria interbed between lava units is noticed at 32–37 m. Slight alteration is seen below 47 m in the form of alteration of the primary minerals (olivine and plagioclase) and the apperance of zeolites and fine grained clay in the cuttings.

0–11 m. No cuttings:

11–18 m. Medium-coarse grained basalt:

Mostly medium grained olivine rich basalt. No alteration is noted. Minor oxidation at intervals. Based on the regional geology the formation is composed of compound lava belonging to the postglacial Stóravíti lava shield (c. 12 ka old).

18–26 m. Medium-coarse grained basalt:

Fresh, unaltered, medium grained basalt lava (olivine-tholeiite). Oxidized, especially at the top.

26–28 m. No cuttings (1.25 and 4 l/s circulation losses)

28–32 m. Medium-coarse grained basalt:

Same as 18–26 m.

32–37 m. Scoria:

Oxidized scoria with zeolites and clay. Fresh, black glass is prominent.

37–43 m. Medium-coarse grained basalt:

Similar to the cuttings above; medium-coarse grained, oxidized basalt lava (olivine-tholeiite).

43–44 m. Cement:

Cement from well ÞG-9.

44–87 m. Medium-coarse grained basalt:

Medium-coarse grained, oxidized basalt lava, with large plagioclase phenocrysts. Slightly altered. Cement grains from ÞG-9 noticed.

87–88 m. Basaltic breccia:

Light-coloured, pyrite-rich glassy basalt (with plagioclase phenocrysts) is mixed within the medium-coarse grained basalt.

88–93 m. Medium-coarse grained basalt:

Oxidized, medium-coarse grained basalt (with plagioclase phenocrysts).

93–94,3 m. Basaltic tuff:

Greyish, rather pyrite-rich tuff.

Phase 1 (94–304 m)

Below 100 m, hyaloclastite formations are dominant, including basaltic tuff, basaltic breccia and glassy basalt. At 186 m, in both well ÞG-11 and ÞG-9, a possible thin (< 10 m) basaltic lava intrusion is intersected. Below 240 m the succession is characterized by fine grained basalts.

94.3–104. Reworked tuff:

White/greyish and even green tuff. Medium/highly altered. Grains rather dense, but often very fractured with white/clear fillings (calcite). Zeolites and clay often in pores. Occasional grain has plagioclase micro-phenocrysts. Grains slightly less altered down the formation and become more porous.

104–114 m. Basaltic breccia:

Clinopyroxen and plagioclase rich. Less fractured than above. Very coarse grained cuttings. Occasional sediment grain with very fine groundmass. Clay is seen in pores.

114–116. Basaltic tuff:

Brownish tuff. Pores filled with white deposits. Likely zeolites since no calcite seems to be present in the sample.

116–124. Reworked tuff:

Very dense and fractured tuff (sedimentary?). Greyish and very fine grained. Slightly phyric with plagioclase and altered olivine. Chalcedony found in pores as well as zeolites and calcite.

124–126 m. Basaltic tuff:

Mostly green and quite altered basaltic tuff grains. Calcite and zeolites in pores.

126–128 m. Basaltic breccia:

A few plagioclase and olivine (altered) rich grains, but mostly tuff grains.

128–142 m. Basaltic tuff:

Highly altered, coarse grained green tuff. Pores up to 50% filled with chalcedony, pyrites and zeolites. Mixed in are partly crystallized grains with plagioclase needles. Alteration increases downward.

142–150 m. Reworked tuff:

Dense and tuff-rich sediment. Highly fractured with white/clear fillings. Mixed in are basaltic tuff grains. Cuttings gets more mixed downward where crystalline basaltic grains are mixed in with clay in pores.

150–166 m. Basaltic breccia:

Quite mixed with tuff and partly crystalline grains. Calcite and zeolites in pores. Generally very tuff-rich. Euhedral quartz crystals were found at 166 m.

166–186 m. Glassy basalt:

Tuff grains are less abundant than above. Porous with zeolites, clay and calcite in pores. Pyrite lumps in the middle of the formation. Lower in the formation more crystalline basaltic grains are mixed in.

186–194 m. Fine-medium grained basalt:

Mixed with tuff and glassy grains, but still mostly fine grained basalt grains not much altered. Clay in pores, but still rather dense formation, possible intrusion.

194–204 m. Basaltic breccia:

Tuff becomes more abundant in the cuttings. Pyrite is commonly associated with the tuff grains. Crystalline and denser and less altered grains mixed in with the porous and filled hyaloclastite grains.

204–236 m. Basaltic tuff:

Almost completely pyrite covered and white tuff grains. Pyrite is common as vein-fillings. White pore fillings are also seen. Still some crystalline basaltic grains mixed in. Occasional partly crystalline basaltic grains with plagioclase needles are seen.

236–246. Fine-medium grained basalt:

Mostly little/moderately altered basalt with some minor tuff admixed. Mostly dark coloured grains, few with greenish.

246–258 m. Basaltic breccia:

White and fractured tuff grains with high amount of pyrite mixed with basalt grains. The cuttings show various grades of alteration. Down the formation the amounts of tuff increases with coarse grained clay and quartz in pores. Minor amount of calcite in pores as well.

258–262. Basaltic tuff:

Totally altered white tuff grains with abundant pyrite.

262–266 m. Basaltic breccia:

The amount of dark crystallized basaltic grains increase, less altered with plagioclase needles.

266–296 m: Fine-medium grained basalt:

Very altered greenish basalt with plagioclase needles. Mixed with white pyrite rich tuff. Quite hard to distinguish the lithology, could as well be a hyaloclastite formation, at least the upper parts. Pores are filled with clay and pyrite is found in fissures. Slight increase in calcite downward. Alteration decreases around 282 m where grains become darker (partly crystalline) with plagioclase needles. The formation becomes more homogenous, well crystallized and less altered at around 290 m.

296–298: No cuttings.

298–304: Basaltic breccia:

White/green tuff grains with abundant pyrite. Tuff grains are fractured with white/-clear fillings. Mixed in are crystallized and much less altered dark coloured basaltic grains.

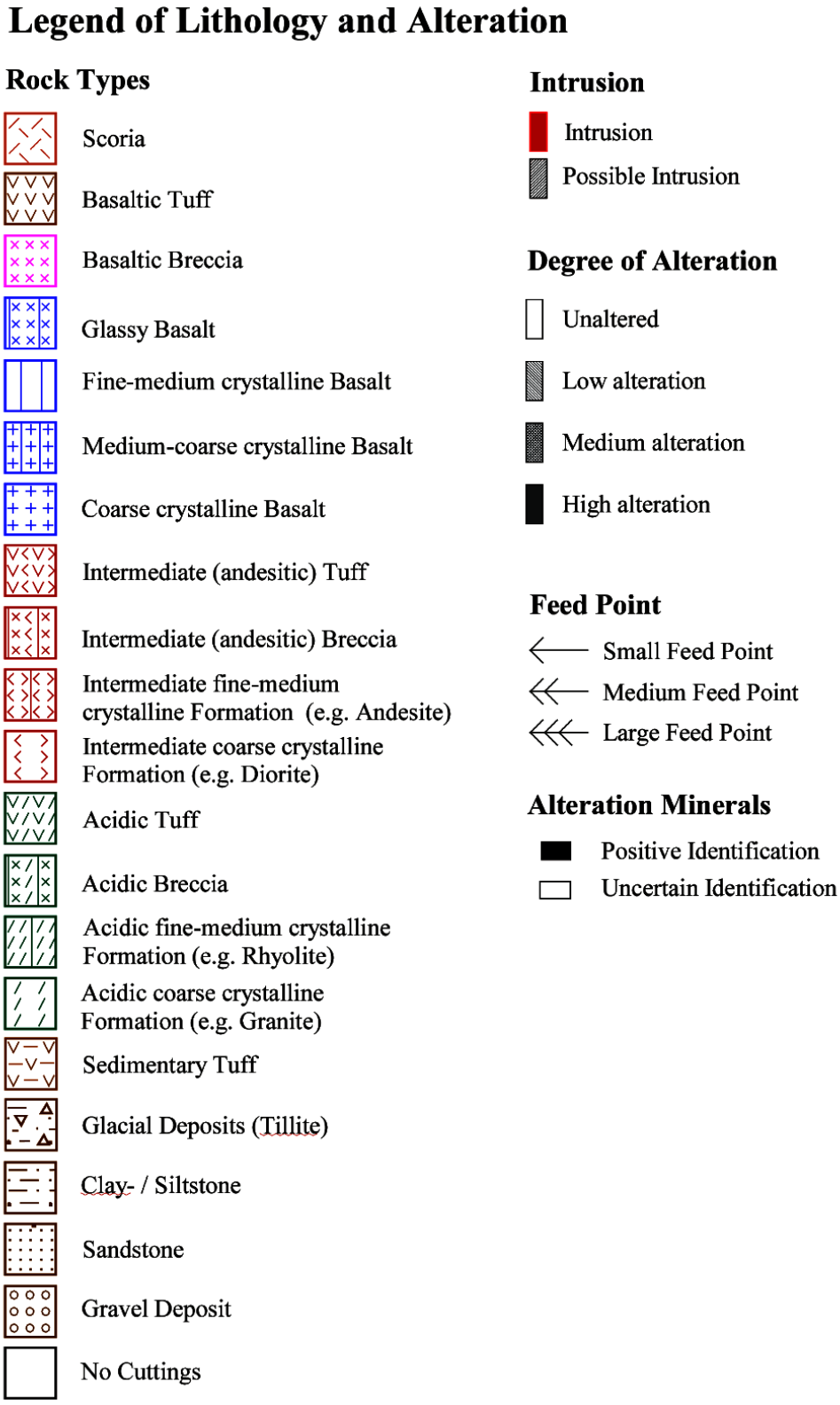


Figure 10. *Lithology legend for Figures 11–16.*

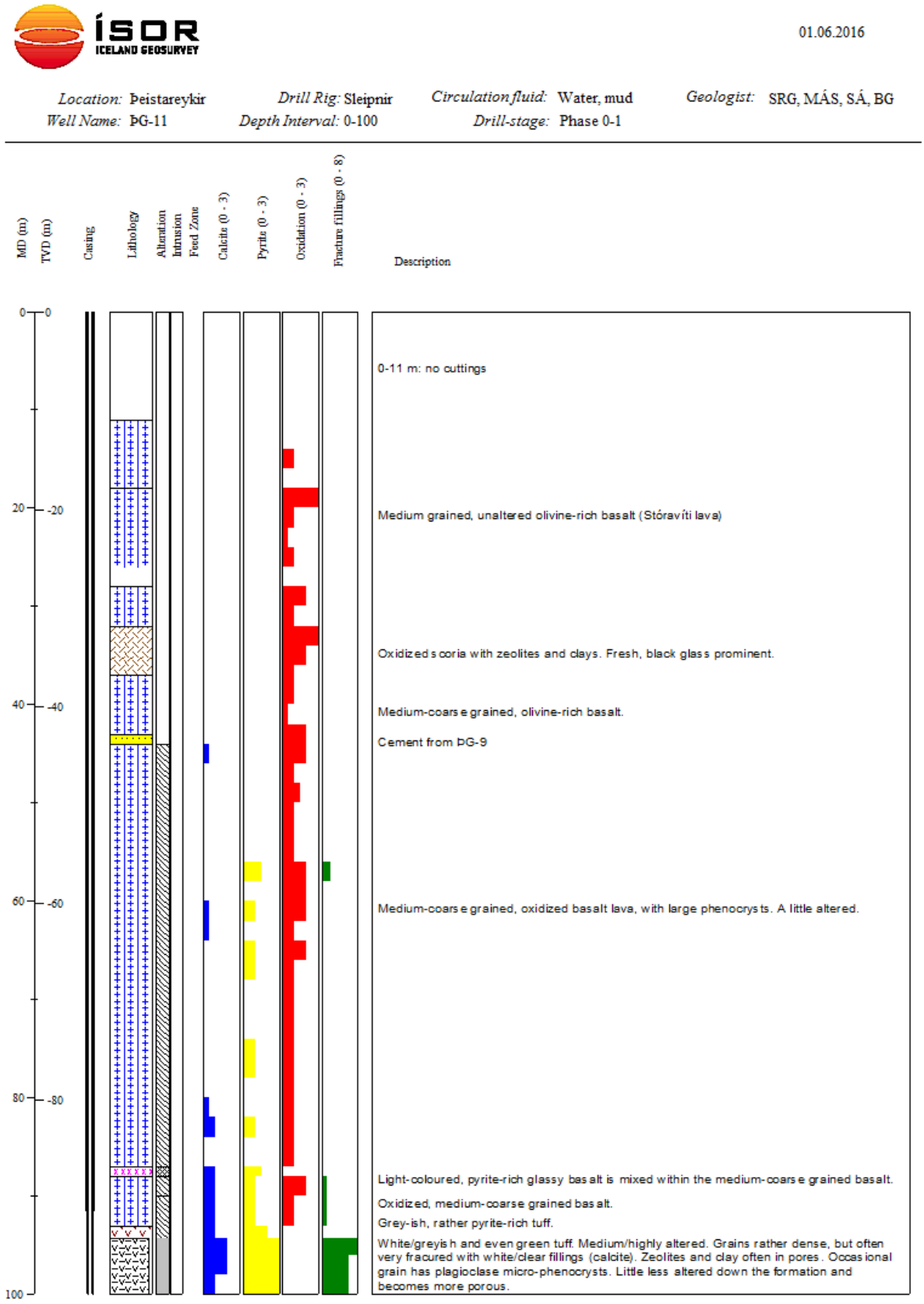


Figure 11. *Lithology, alteration and description of lithology at 0–100 m in ÞG-11.*

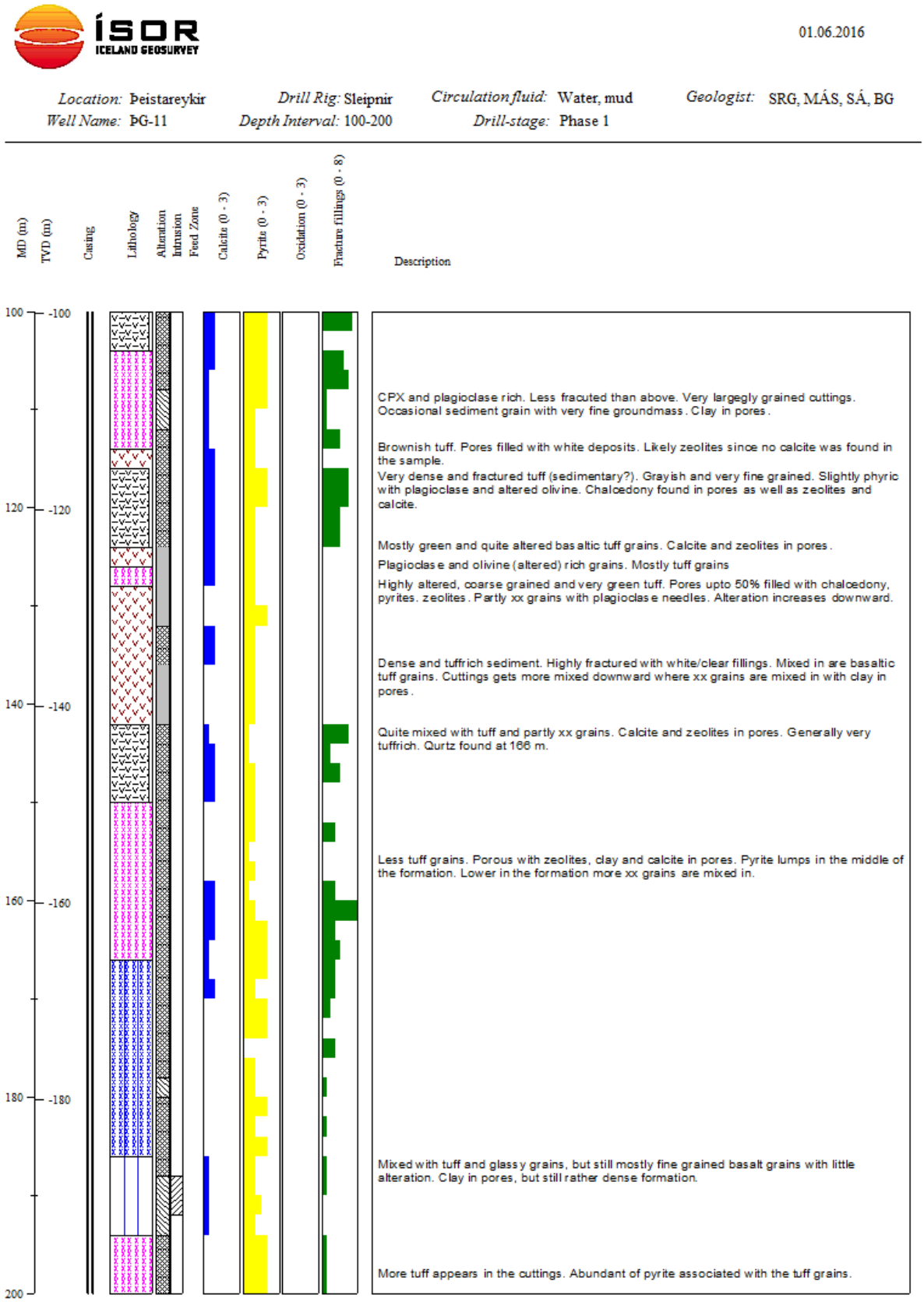


Figure 12. *Lithology, alteration and description of lithology at 100–200 m in ÞG-11.*

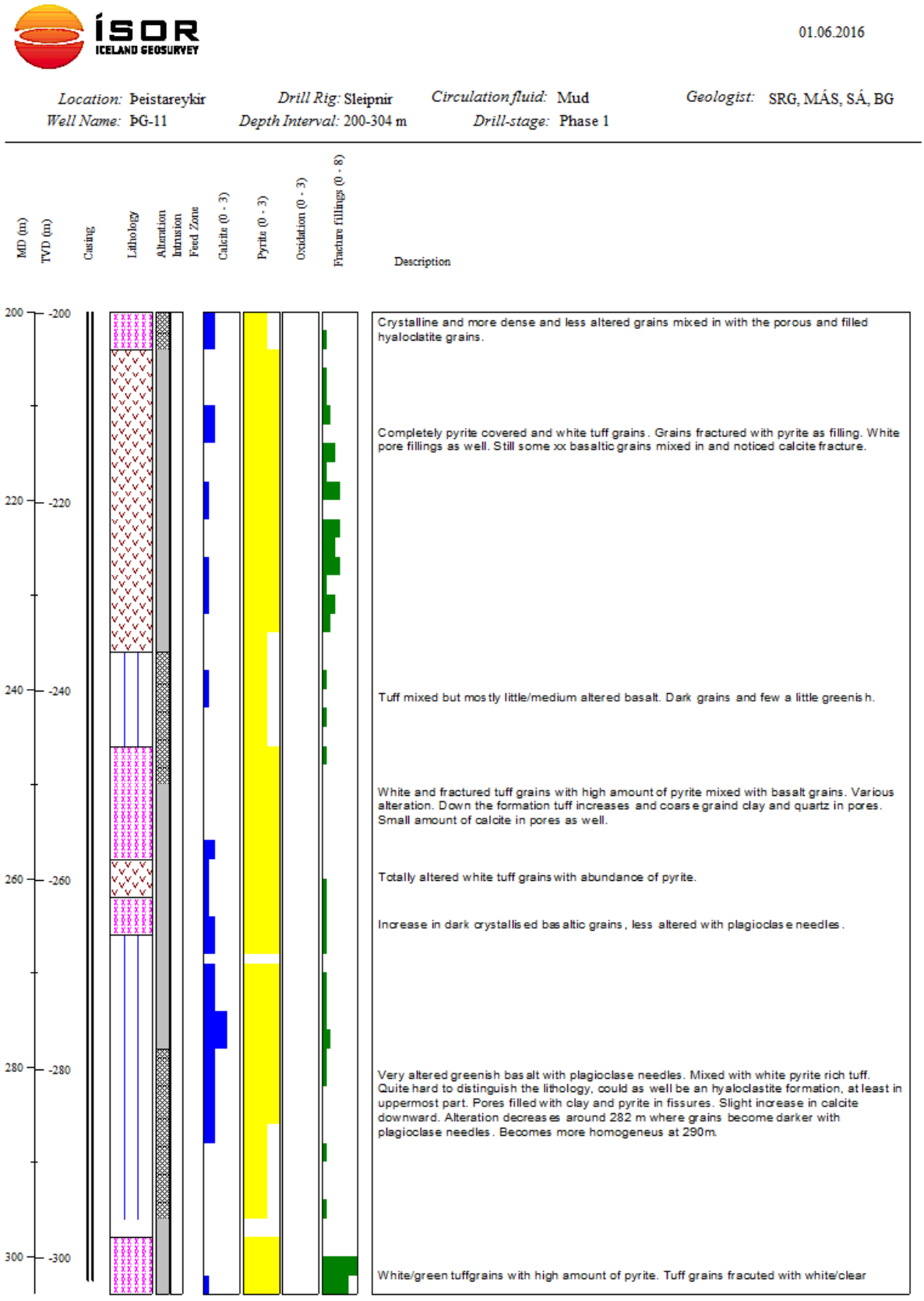


Figure 13. *Lithology, alteration and description of lithology at 200–304 m in well ÞG-11.*

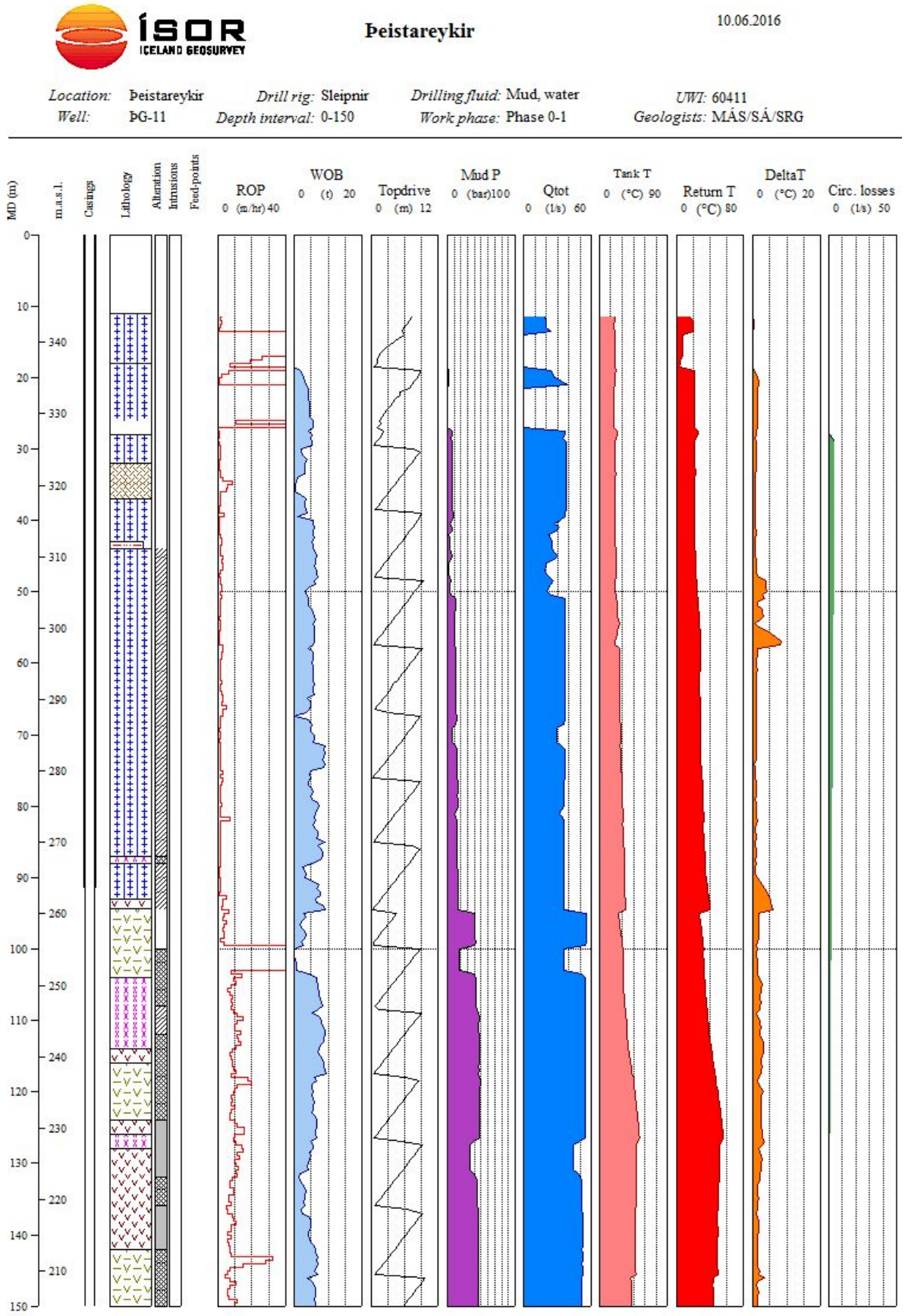


Figure 14. *Comparison of lithology and drilling data from 0–150 m in ÞG-11.*

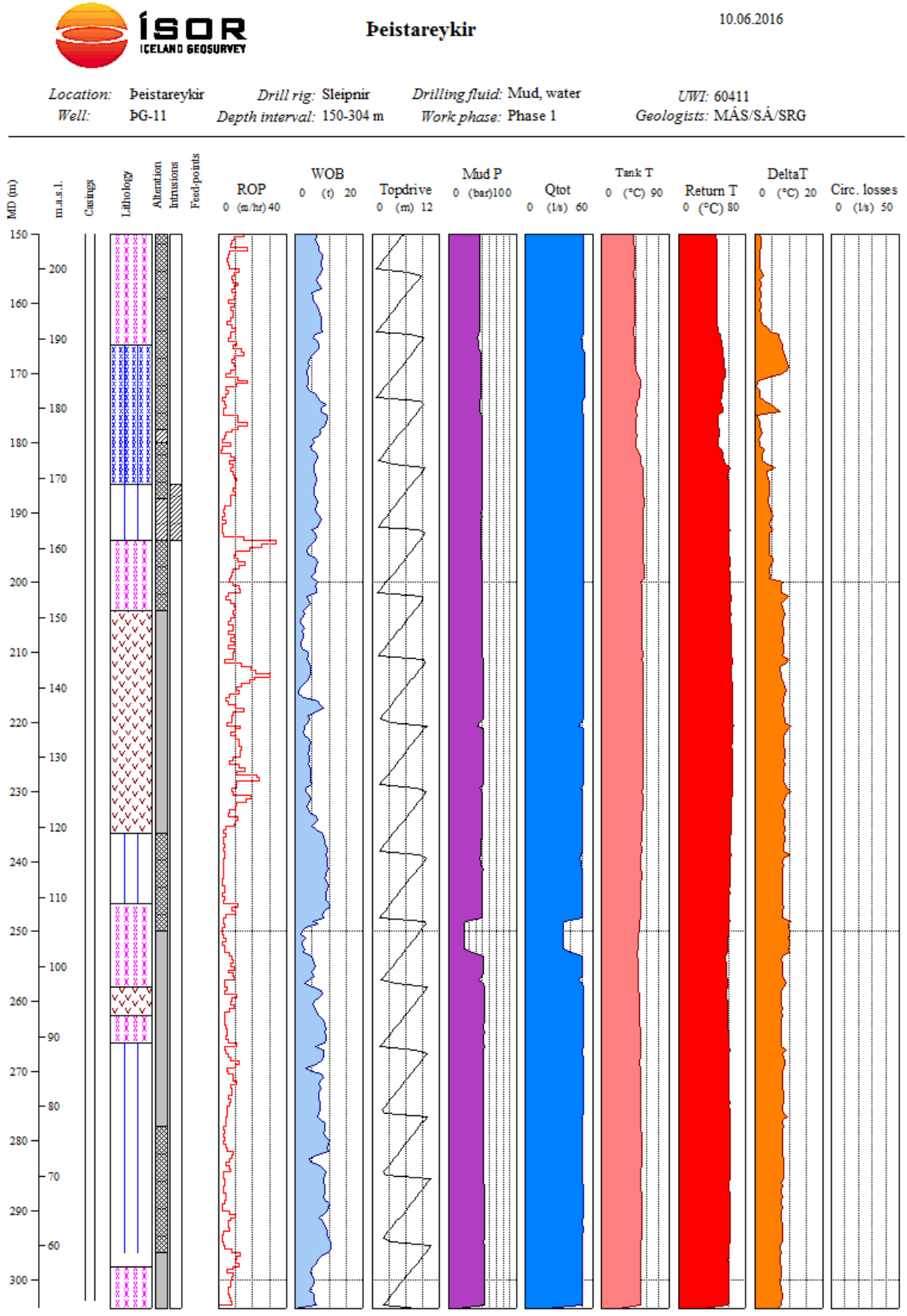


Figure 15. *Comparison of lithology and drilling data from 150–304 m in ÞG-11.*

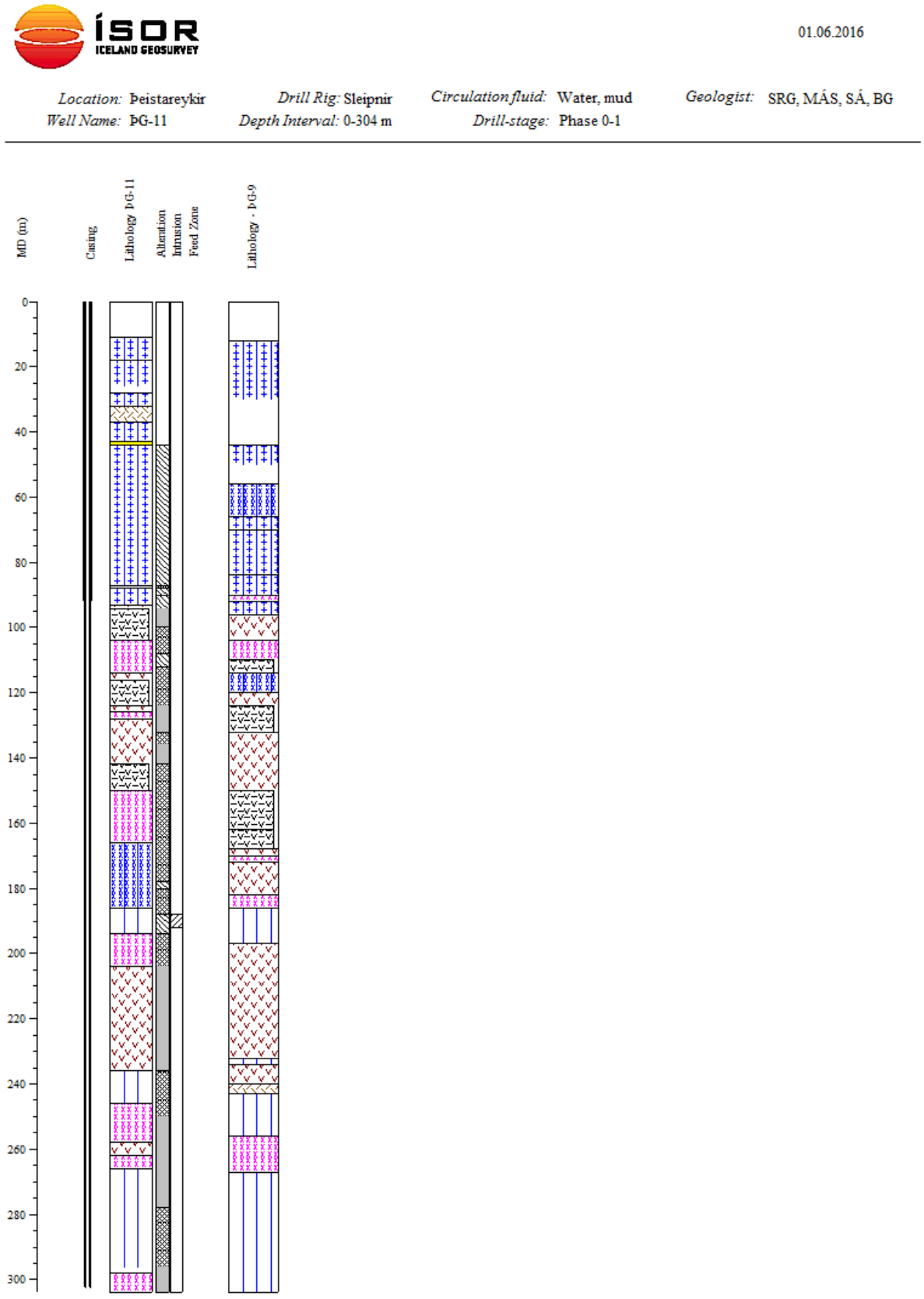


Figure 16. *Comparison of the lithology in wells ÞG-11 (left column) and ÞG-9 (right column), from 0–304 m.*

3.2 Intrusions

No intrusions were detected in the drill cuttings down to 186 m, where a possible thin (6 m) intrusion was penetrated. Based on the cutting analysis from well ÞG-9, an intrusion is known at this depth interval. The description of the unit from section 3.1 was a fine-medium grained basalt with low alteration of primary minerals (plagioclase and clinopyroxen).

A spike in the ROP can be seen at the lower boundary of the intrusion in Figure 15, where soft basaltic breccia was penetrated.

3.3 Alteration

The distribution of alteration minerals in well ÞG-11 is presented in Figure 17. A regular progressive increase in hydrothermal alteration with increasing depth was noticed from the alteration mineral assemblage in the well. No alteration of primary minerals in the formations was observed in the uppermost 45 m of the well. The first low temperature zeolites (mostly unidentified zeolites, as well as scolecite and mesolite) were noticed at 26 m depth and the first apperance of a fine grained clay was at 34 m. At deeper levels in the well the clay becomes coarser grained and quartz and wairakite appear. Quartz is first noticed at 166 m in one sample (hyaloclastite), as a cluster of euhedral crystals. The zeolites disappear at around 190 m and quartz is found more regularly, along with wairakite, below ~ 200 m. At that depth the grade of alteration rapidly increases from medium to high.

The first signs of pyrite were at 55 m, and then it generally increased down the well. It was found in a high abundance in the last 100 m of drilling, both within the lava and hyaloclastite formations. Calcite was found occasionally below 45 m. Oxidation was limited to the uppermost medium grained lava formations, but fractures with fillings like calcite, pyrite and zeolites, were mostly associated with the lower hyaloclastite formations.

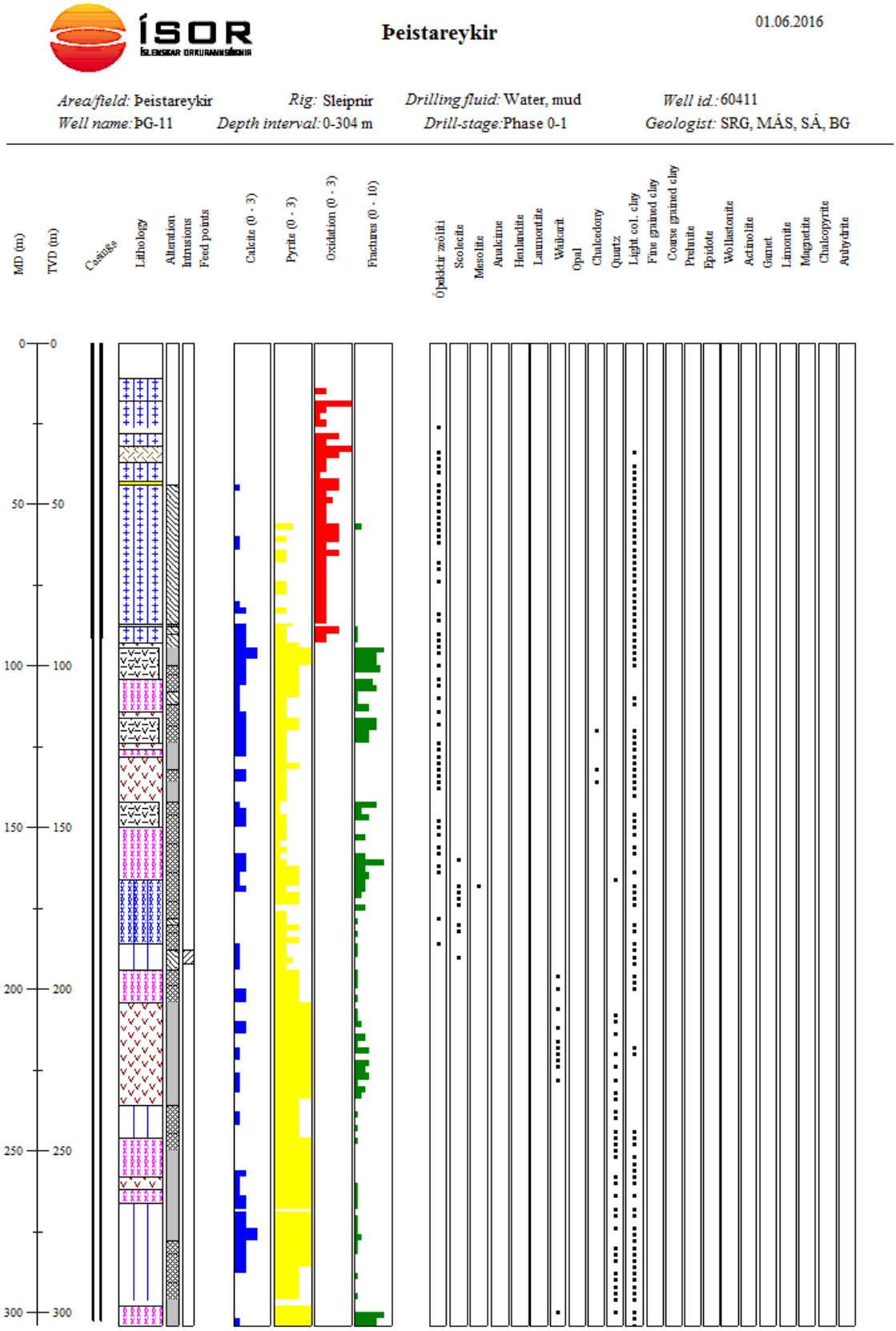


Figure 17. *A summary of the alteration minerals found in ÞG-11 during drilling of phases 0 and 1.*

3.4 Circulation losses during drilling of phases 0 and 1

Circulation losses were closely monitored during drilling of phases 0 and 1 in ÞG-11, especially due to previously measured total circulation losses at basaltic lava boundaries at 32.5 m and 50 m during drilling of ÞG-9 (Mortensen et al., 2013a). Major circulation losses were, however, not encountered during drilling of either phase 0 or phase 1 in well ÞG-11. As stated in section 2.2, it is considered likely that the cement job performed in the loss zones at 32.5 and 50 m in ÞG-9 managed to plug the expected loss zones in ÞG-11, since cement-like cuttings were encountered at similar depths (43 and 46 m) in ÞG-11 (see section 3.1). The record of circulation losses from drilling phases 0 and 1 is found in Table 9.

Table 9. *Measurements of circulation losses during drilling of phases 0 and 1 in ÞG-11.*

Phase	Date	Depth (m)	Circ. Loss (L/s)	Remarks
0	11.05.2016	11.4	8	Drilled from 11.4–13.3 and cement job carried out.
0	14.05.2016	28	1.25	Mica added to the drilling fluid.
0	14.05.2016	29.6	4	Mica added to the drilling fluid.

4 Wireline logging

The wireline logging planned after drilling for the surface casing were temperature and caliper logs. However, a logging truck and logging engineers were ready at site during the entire drilling of this section in case over pressurized feed zones were encountered.

After drilling for the anchor casing, temperature and caliper logs were planned prior to running in hole and cementing of the 13⅝" casing. Following the cementing of the anchor casing, temperature and cement bond logs (CBL) were scheduled in order to map the actual bonding of the casing, both to the surface casing and to the formation surrounding the anchor casing.

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

- Temperature log prior to cementing in order to check the warm-up rate inside 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 require further reaming. In addition, the caliper log gives the minimum volume behind the casing needed to be filled with cement.
- Temperature log and CBL-log after cementing in order to check the hardening- and the binding process of the cement that is exoergic and heats up the stagnant water inside the casing.

When well ÞG-9, which also is at platform B, was drilled, lithological logs consisting of resistivity log, induced dual neutron log and natural gamma ray emission were scheduled in

phase 1 but since the well was over pressurized they were all cancelled (Mortensen et al., 2013b).

In this chapter the logging activity and the logging results in phases 0 and 1 in ÞG-11 are introduced and discussed. Overview of the wireline loggings is shown in Table 10.

Table 10. *Overview of wireline logging in drilling phases 0 for the surface casing and drilling phase 1 for the anchor casing.*

Date	Time	Log type	Depth (m)	Purpose	Q [l/s]	Remarks
17.5.2016	22:44-22:53	Temperature	0-94	Temperature, flow zones	0	Logged in open hole
17.5.2016	22:54-00:04	Temperature	94	Temperature, heat-up	0	Heat-up log for formation temperature estimate
18.5.2016	00:34-00:52	Caliper	93-11	Well diameter, obstacles, washouts, cement volume	0	
26.5.2016	23:01-23:19	Temperature	15-288	Temperature	0	Measured in Drill-Pipe. 18 l/s pumped in the drill string
26.5.2016	23:19-00:06	Temperature	288-288	Temperature	0	Measured in Drill-Pipe. No pumping
27.5.2016	00:06-00:21	Temperature	80-288	Temperature	0	Measured in Drill-Pipe. No pumping
27.5.2016	00:25-00:34	Temperature	155-155	Temperature	0	Measured in Drill-Pipe. 18 l/s pumping started @ 00:34
27.5.2016	03:00-03:26	Inclination	0-288	Inclination	0	
27.5.2016	20:57-21:09	Temperature	3-223	Temperature, flow zones	0	Logged in open hole. Instrument stopped in mud at 223 m depth.
1.6.2016	00:57-01:11	Temperature	0-279	Temperature	0	Logged before CBL
1.6.2016	02:27-02:39	Temperature	75-279	Temperature	0	Logged before CBL
1.6.2016	03:44-04:07	CBL	3-282	Cement Bond	0	About 6 hours after last cementing
1.6.2016	13:32-13:46	Temperature	0-279	Temperature	0	Logged before CBL
1.6.2016	14:36-14:55	CBL	0-279	Cement Bond	0	About 18 hours after last cementing

Drilling for the surface casing started on May 7th and finished at 09:45 m on May 17th. After one-hour circulation the drill string was POOH and after that a wiper-trip was run. ISOR's logging engineers got access to the well at about 22:30 and the temperature tool was run in hole (RIH) at 22:44. The measured temperature is shown in Figure 18. The well was full of the thick and heavy mud that was used in the drilling process. When the temperature sensor is run in such mud the sensor house fills up and builds up an isolating layer around the sensor, which causes a delayed response to temperature changes in the well. Therefore, the temperature tool was run slowly in hole in order to minimize this effect. The temperature log shows that no fluid carrying zones are connected to the well. When at BOH a 70 minutes heat-up was measured and the result is shown in Figure 19. A Horner interpretation of the heating process indicates formation temperature at 94 m to be around 100°C (see Figure 20).

In order to obtain information on the well's diameter and possible obstacles and/or washouts, a caliper log was run. Besides, the caliper log is used to calculate the annulus volume. The caliper log (Figure 21) shows that there were no obstacles in the well after the drilling and the following wiper trip. A 10 cm anomaly at 35 m depth, measured with both arms, is the biggest

one and besides that two 5 cm anomalies are measured with the Y-arm and one 4 cm anomaly with the X-arm. In Figure 22 the caliper log is put in context of the current casing program and the volume between the anchor casing used to cement it with the outside formation and the 4.5 m long conductor casing. This volume is estimated about 6 m^3.

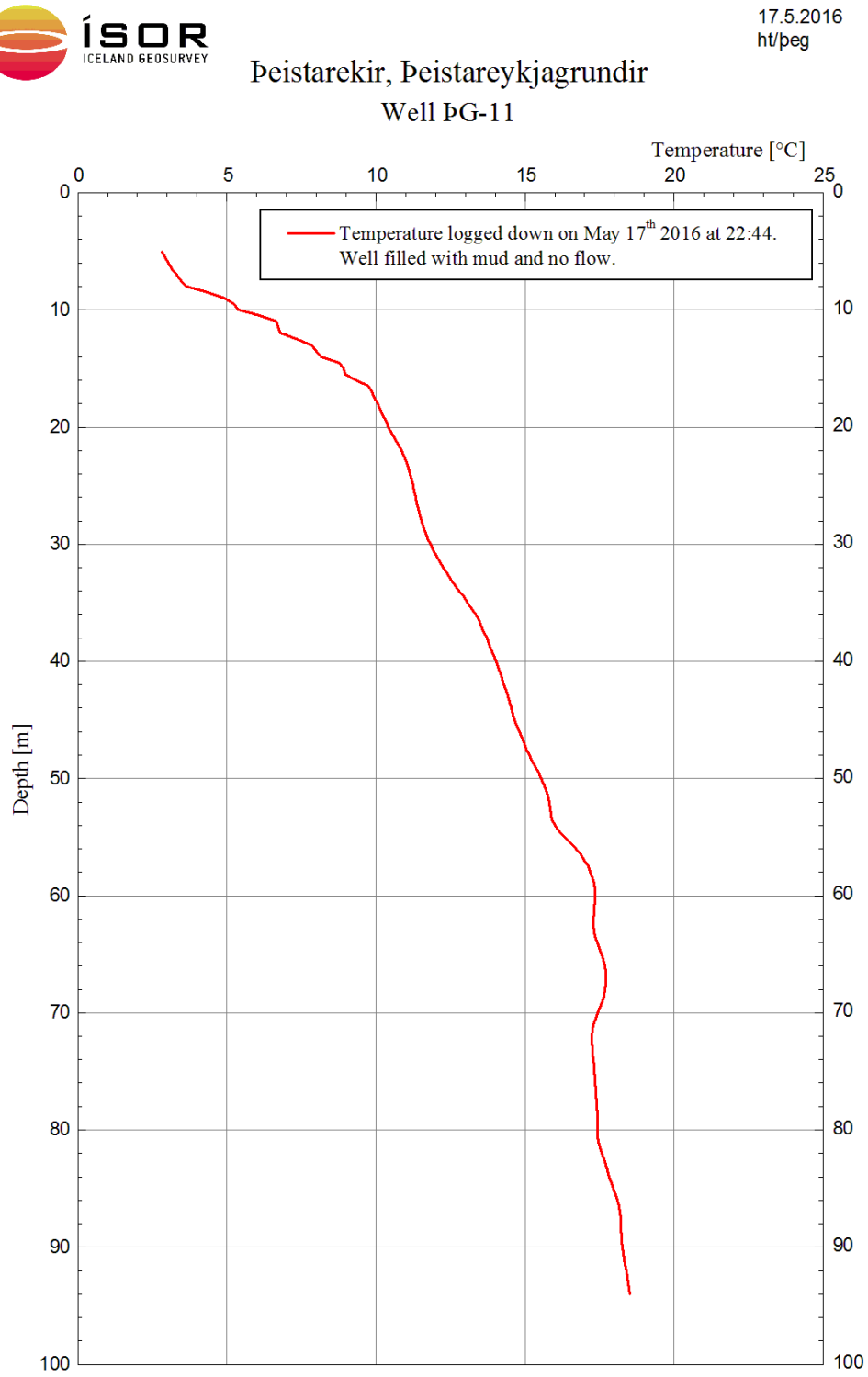


Figure 18. *Temperature in open hole before installing the surface casing to 94 m.*

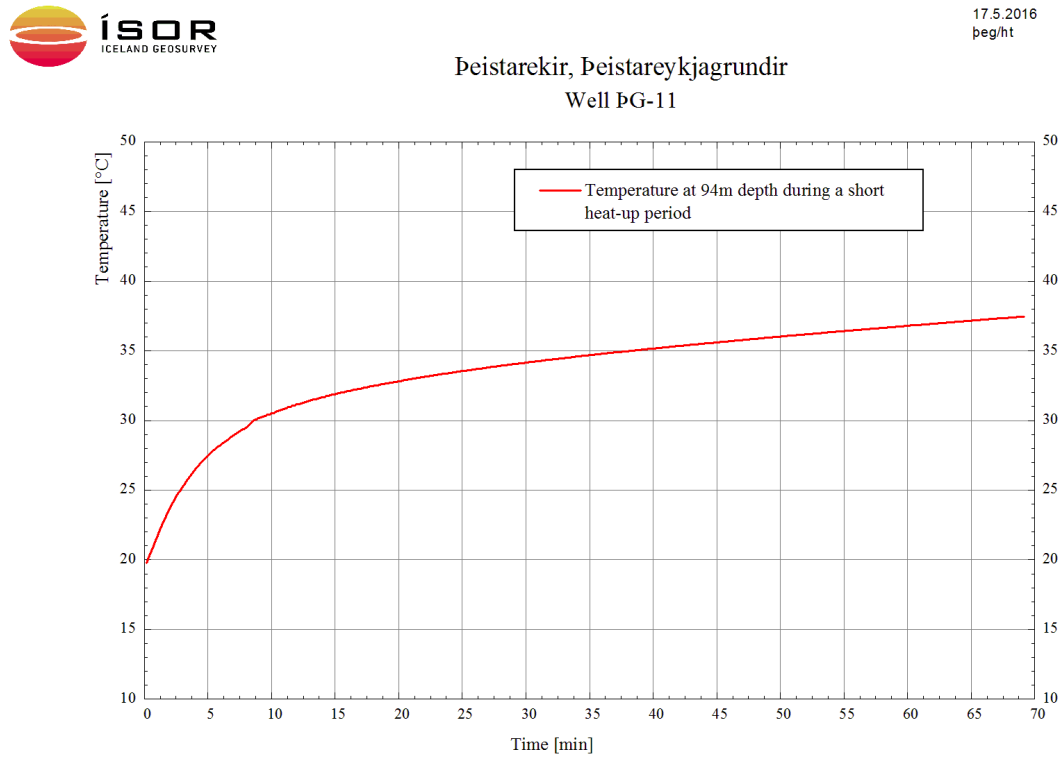


Figure 19. *The heat-up process at 94 m (BOH) depth in well ÞG-11 after the predrilling finished.*

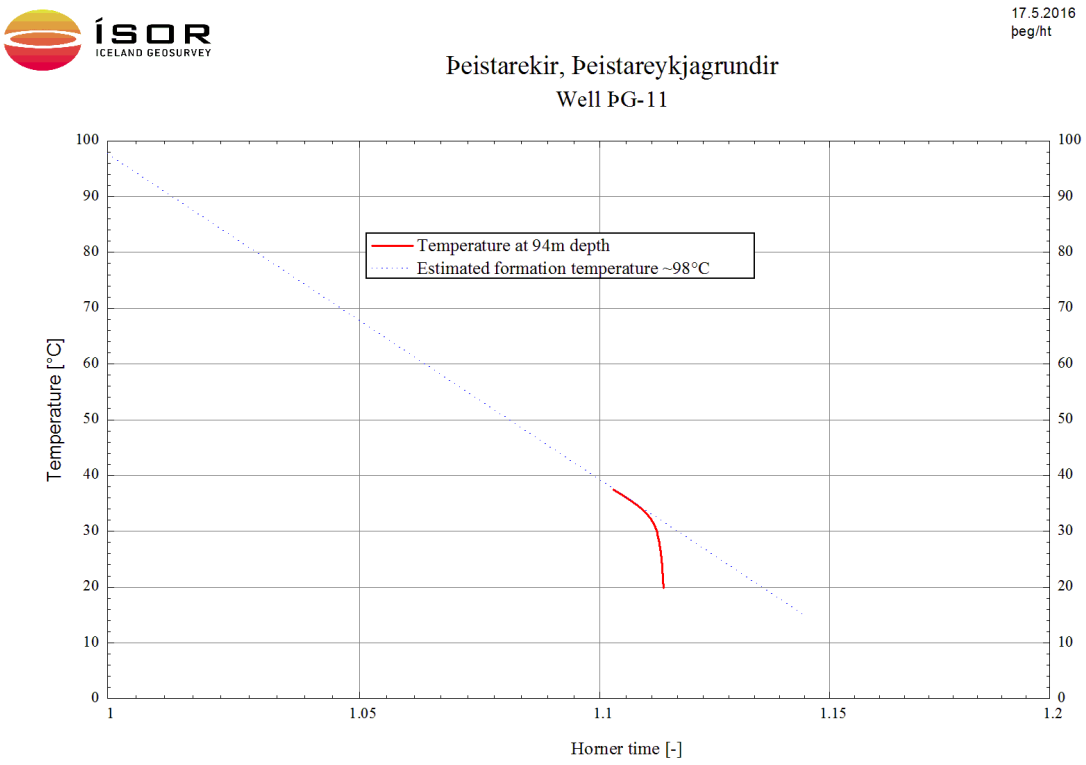


Figure 20. *Horner interpretation of the measured heating process at BOH after the predrilling indicates ~100°C formation temperature.*

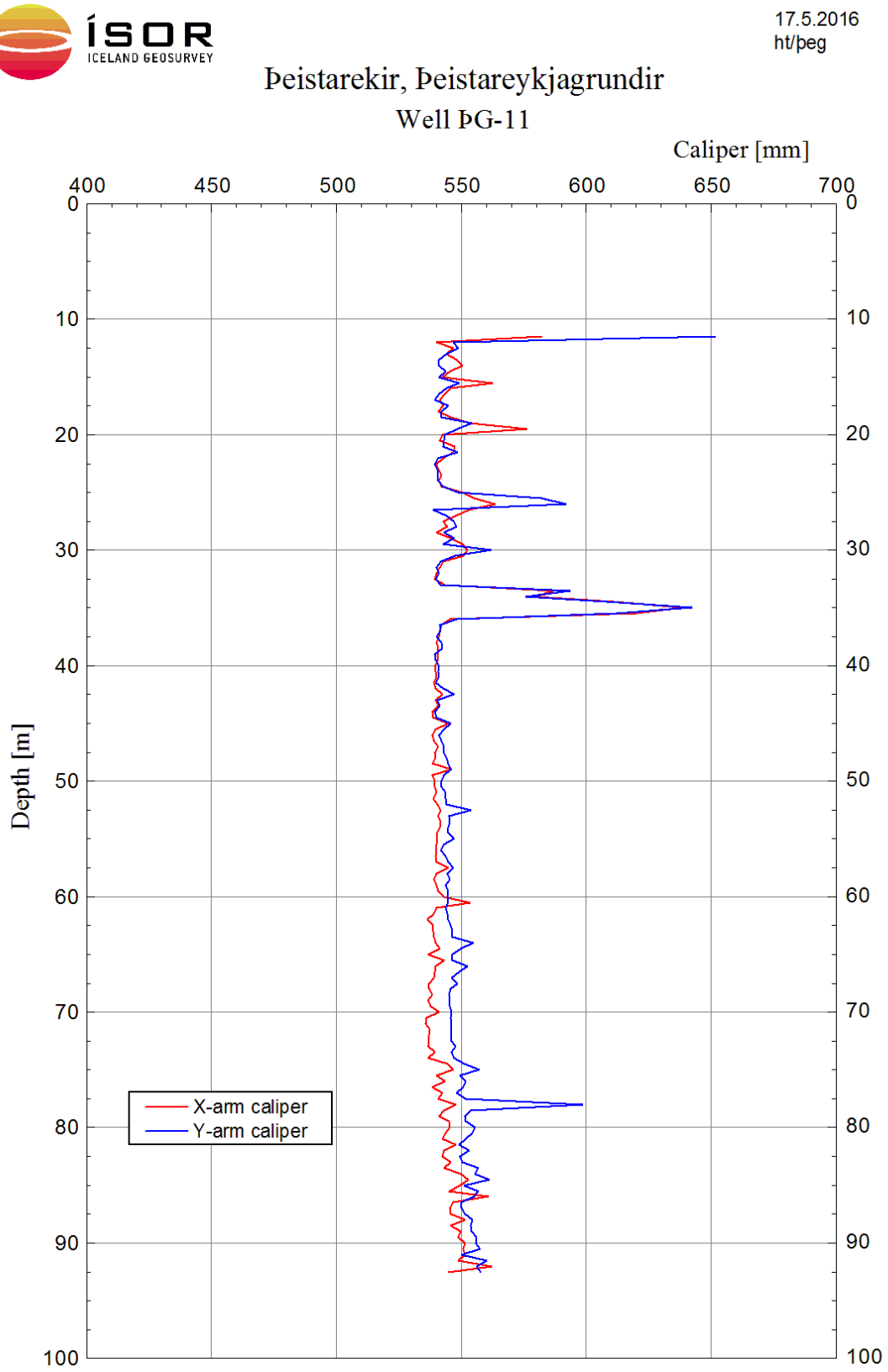


Figure 21. *The caliper log at the end of the predrilling process.*

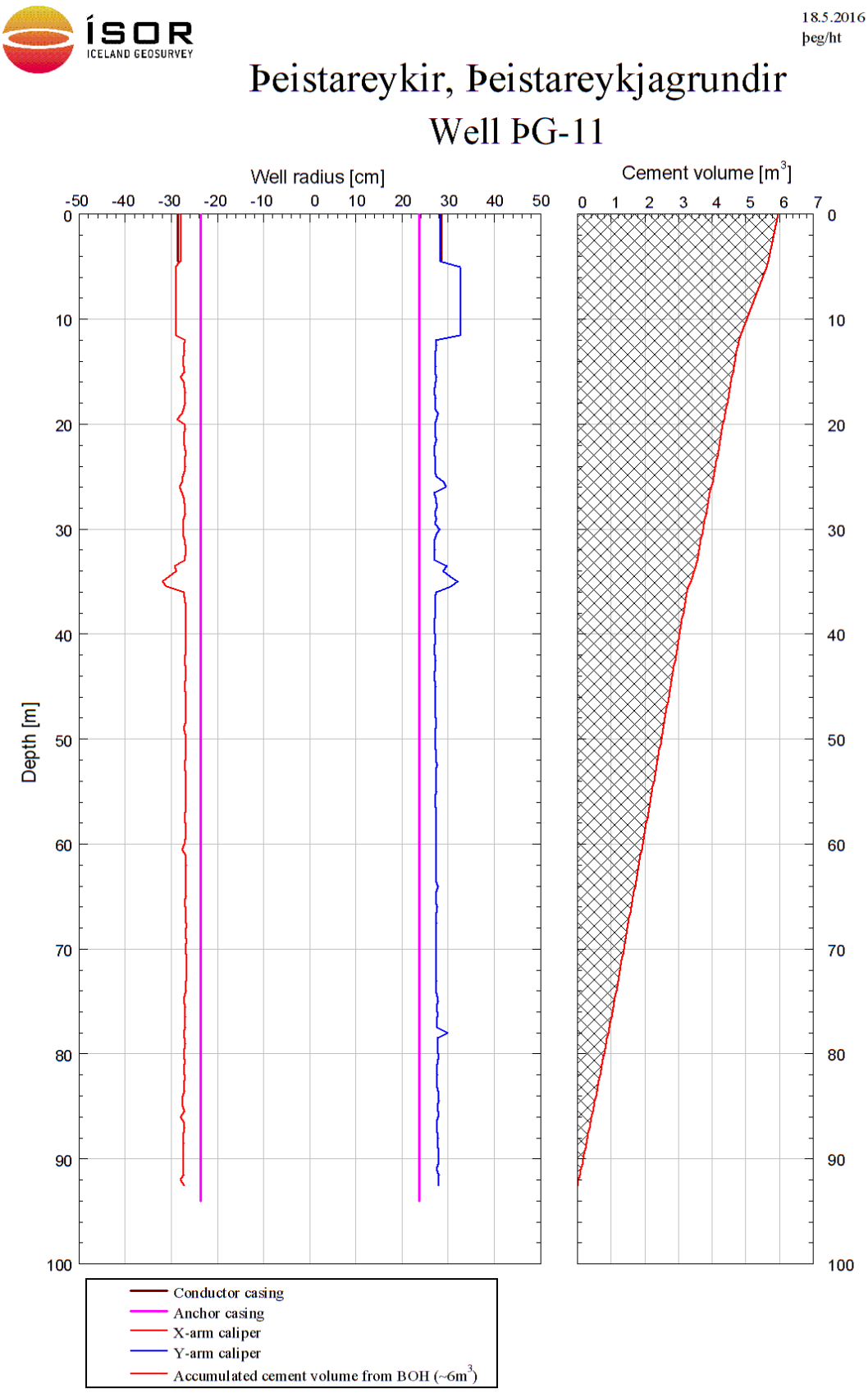


Figure 22. *Caliper log put in context of casing programs so far and estimated volume to be cemented between the annulus and the anchor casing.*

Drilling of phase 1 (drilling for the anchor casing) commenced on May 24th and finished at 304 m on May 26th. No logging was performed during the drilling down to 304 m but after the drilling was finished and before the bottom hole assembly (BHA) was pulled out of hole (POOH) a temperature log was measured, i.e. inside the drill string. During drilling of the 1st stage no circulation loss was detected. The measured profiles are shown in Figure 23. Unfortunately, IDC could not provide less circulation rate than 18 l/s and under that situation no anomalies are seen in the temperature log. The temperature profile measured up with no circulation shows slow heating below 180 m depth where there is a sharp increase in temperature. The reason for this temperature peak is that a tiny amount of fluid/gas is seeping into the well at the same location as a fracture/fissure appeared as a loss zone in the neighbouring well ÞG-9 (Mortensen, et al., 2013b). At about 9 o'clock on Friday the 26th of May the well threw off about all the mud above 180 m as the gas expanded. It should be noted that when the temperature tool is run in the mud fluid used for drilling the 1st stage the mud thickens and fills up the sensor house and forms an insulating layer around the temperature sensor itself. This causes delays in the measured temperature from the actual well temperature. The broad temperature anomaly from 180 m to 110 m in the up-measured temperature profile (blue) in Figure 23 was, therefore, probably narrower in the well at the time it was logged. That profile reaches up to 88 m and after that the tool was run down to 155 m depth in order to measure the heat-up rate. A ten minutes log was measured and the result is shown in Figure 24. In these ten minutes, the temperature increased from 77°C to 105°C but the applied time interval is too short for a reliable estimate of the formation temperature and the mud-filled sensor house also has its effect on that.

With a situation of in-seeping hot fluid/gas at 180 m the open-hole temperature logging was planned in light of estimated formation temperature and system pressure for well ÞG-9 (Egilson, 2013). The estimated temperature at 180 m depth is about 207°C and the corresponding reservoir pressure is about 18 bar-a. Also, the estimated overpressure in this part of the reservoir is about 0.5 bar. It was therefore decided to log the temperature with 1.3 bar well head pressure and the measured temperature profile is shown in Figure 25. The temperature log was run in the well starting around 21:00. It was carried out with a pup-joint with a poor-boy that was put on the top of the drill string with the pipe-ram and an annular blow out prevention valve (BOP) closed. Also, the temperature tool was mounted with the blind ram closed and the 1.3 bar requested kill-line pressure (KLP) was obtained by circulating water through the pup-joint and out on the kill line valve with the required resistance. The gas-seep (or aquifer) at 180 m is clearly visible and in addition some gas is probably seeping into the well at ~110 m depth which was not visible in earlier runs.

After the temperature log was run a decision was made to abandon further logging in this section. Even though no circulation losses were detected, the well was regarded unstable because of gas rich zone(s) connected to it. No chances of stimulating it further were taken and the plan for casing the well was activated.

The cementing of the 13⅜" anchor casing was finished in the evening of May 31st. About 4 hours after the completion of the cement job, ÍSOR's logging engineers arrived at the drill site for temperature and CBL logging. The temperature log was performed first and the results are shown in Figure 25.

Figure 26 shows the CBL-log measured inside the casing six hours after the cement job finished. The cement between the surface casing and the anchor casing showed little signs of hardening but below 90 m the cement already showed clear signs of bonding.

Second temperature and CBL logs were run shortly after lunch on June 1st. The temperature log was measured first and the result is shown in Figure 25. During the 12.5 hours between the first and last temperature logs after the cementing the well heated up approximately 45°C and the highest temperature measured was 107°C at the bottom.

The second CBL log was measured 17.5 hours after the cement job and the result is shown in Figure 27. A good overall bonding between the casing and the formation was achieved. Also, the cement between the surface casing and the anchor casing was forming a good bond according to this log.

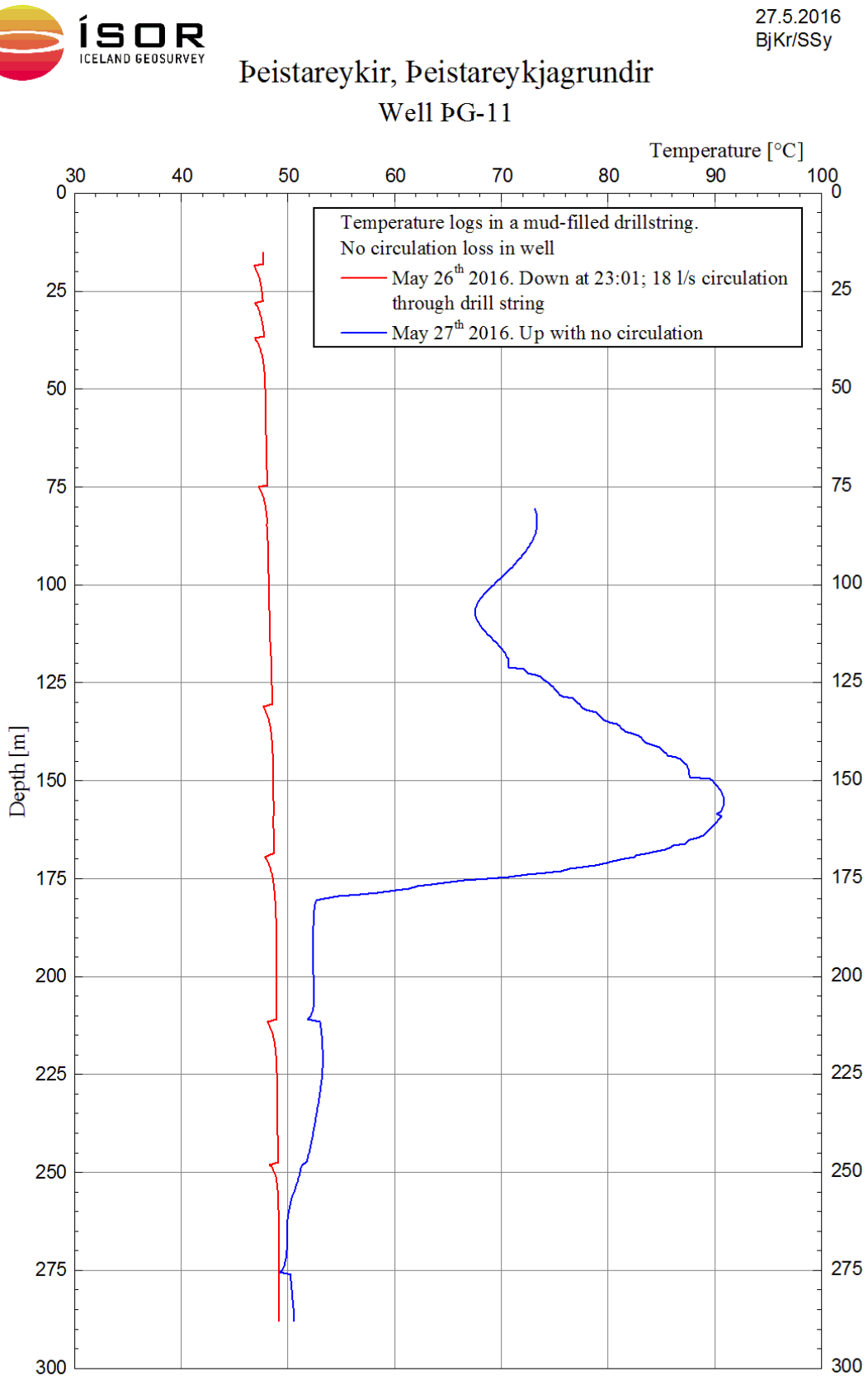


Figure 23. *Temperature profiles inside the drillstring with and without circulation through it. The sharp change in temperature at 180 m indicates slight seeping of fluid/gas into the well.*

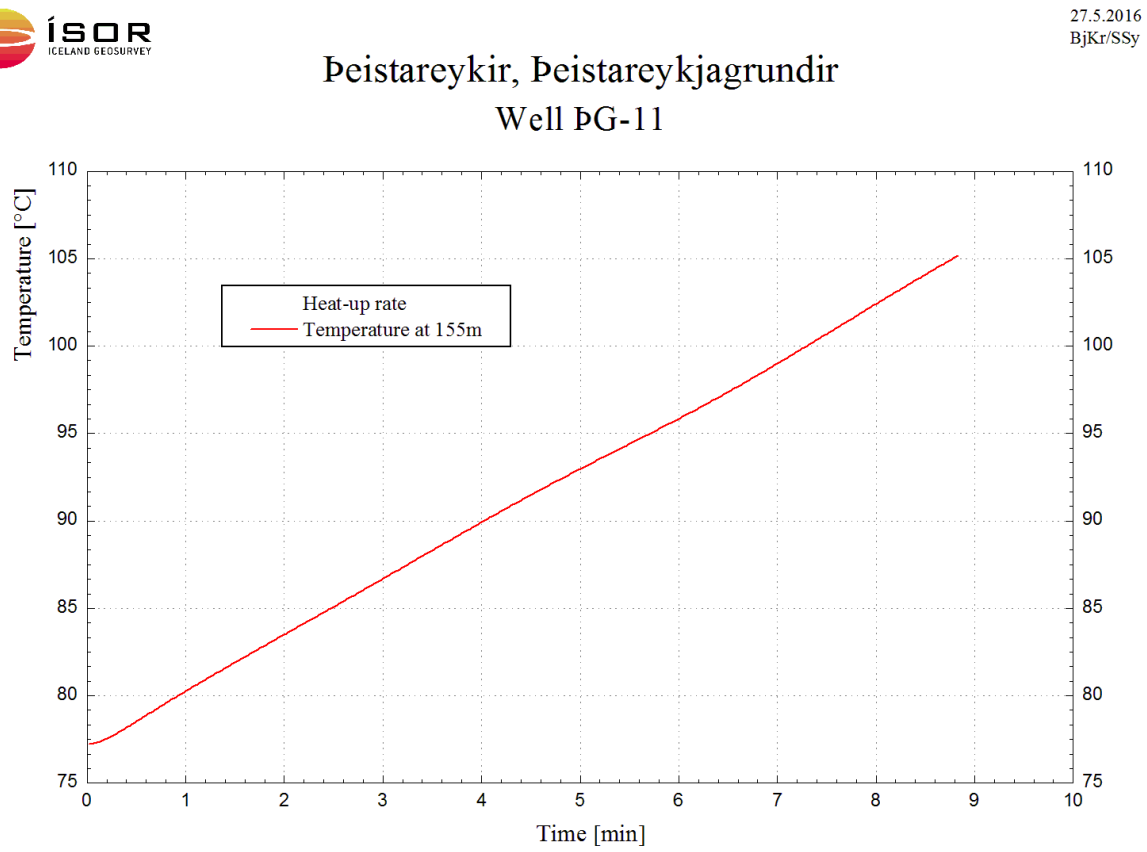


Figure 24. *The measured heat-up rate at 155 m depth inside the drill string before the POOH of the BHA when drilling phase 1 for the anchor casing*.

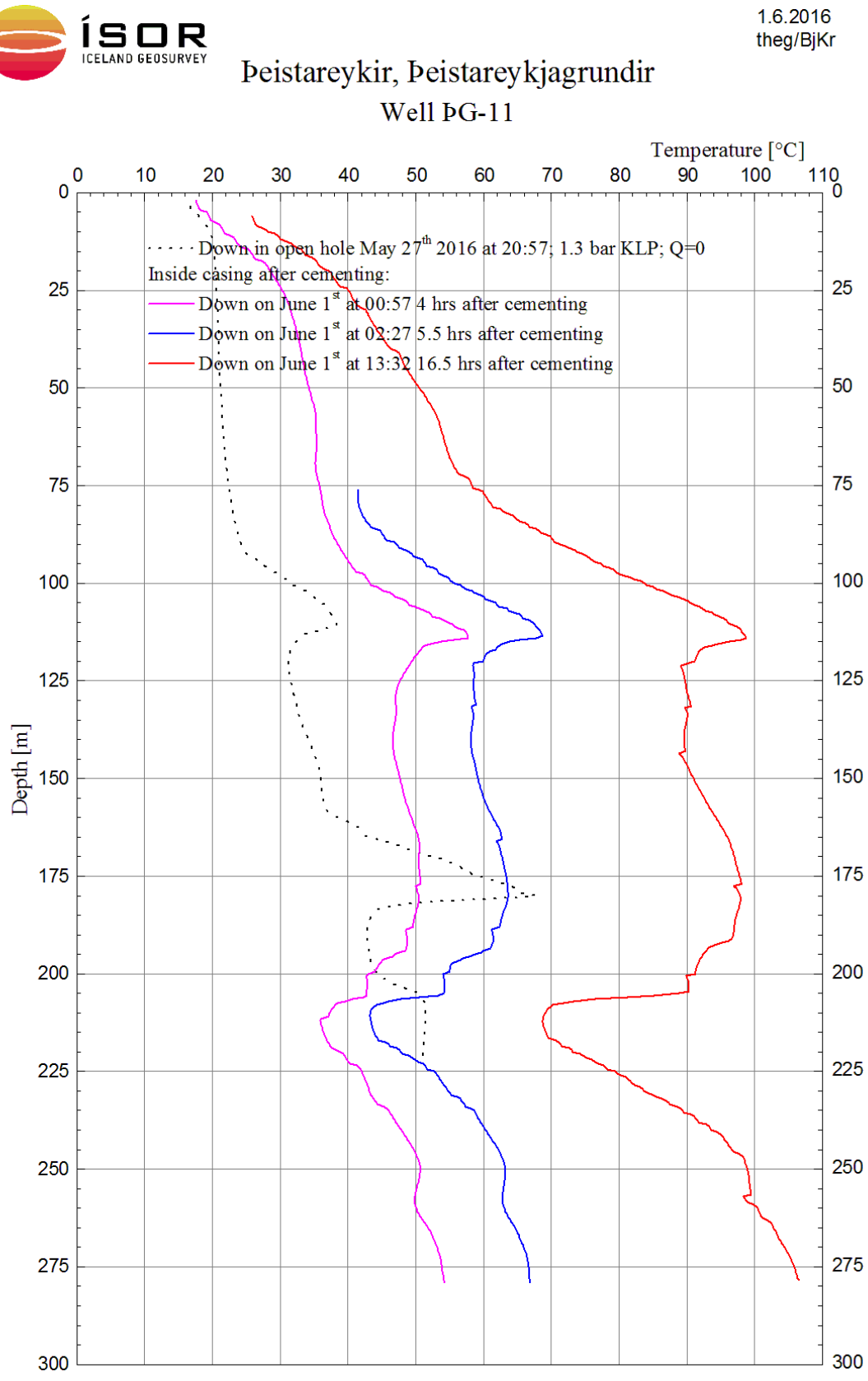


Figure 25. *Temperature profiles inside the anchor casing after it had been cemented together with the temperature profile run in open hole before the cement job.*

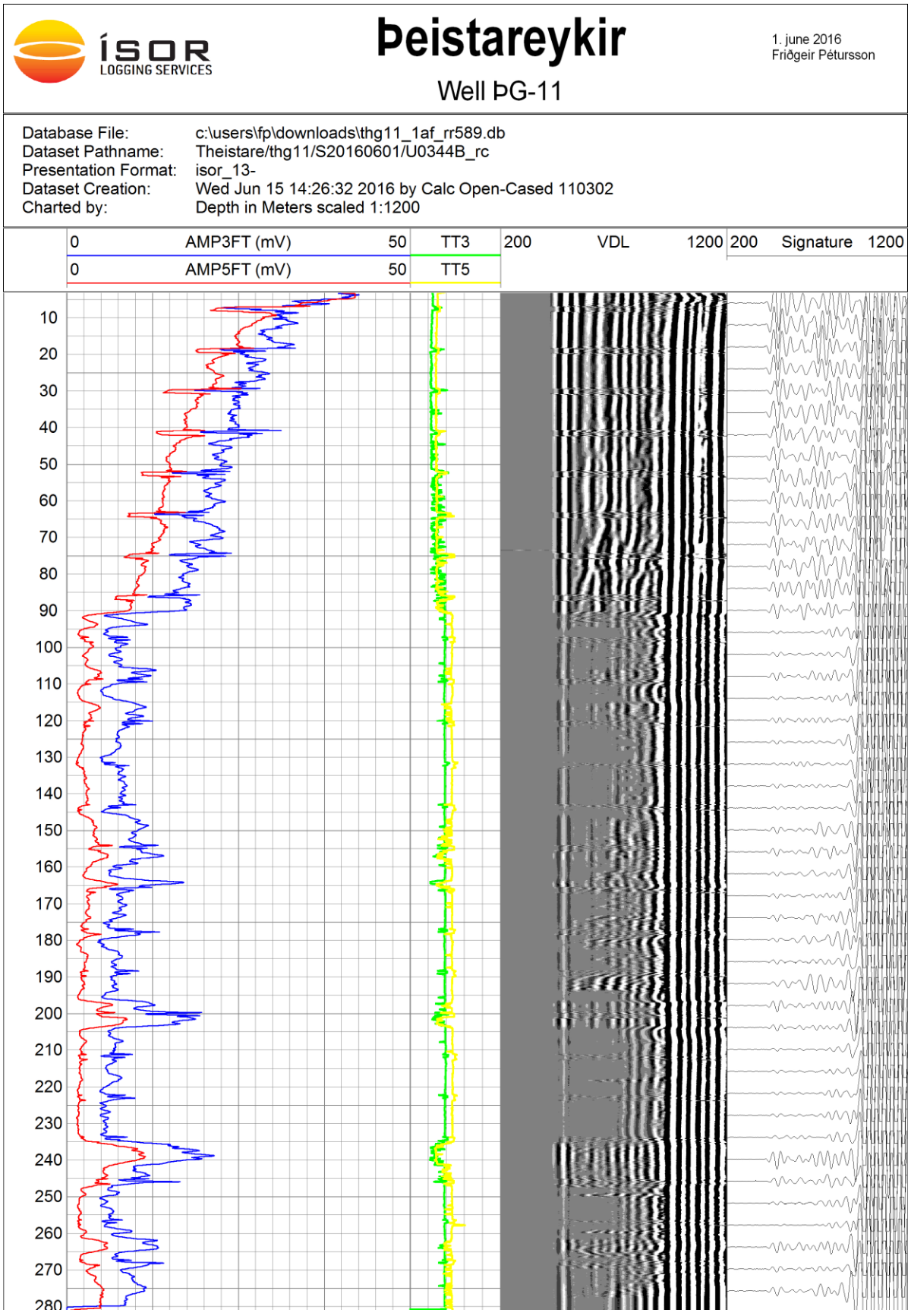


Figure 26. *CBL log from June 1st @ 03:44 in well ÞG-11.*

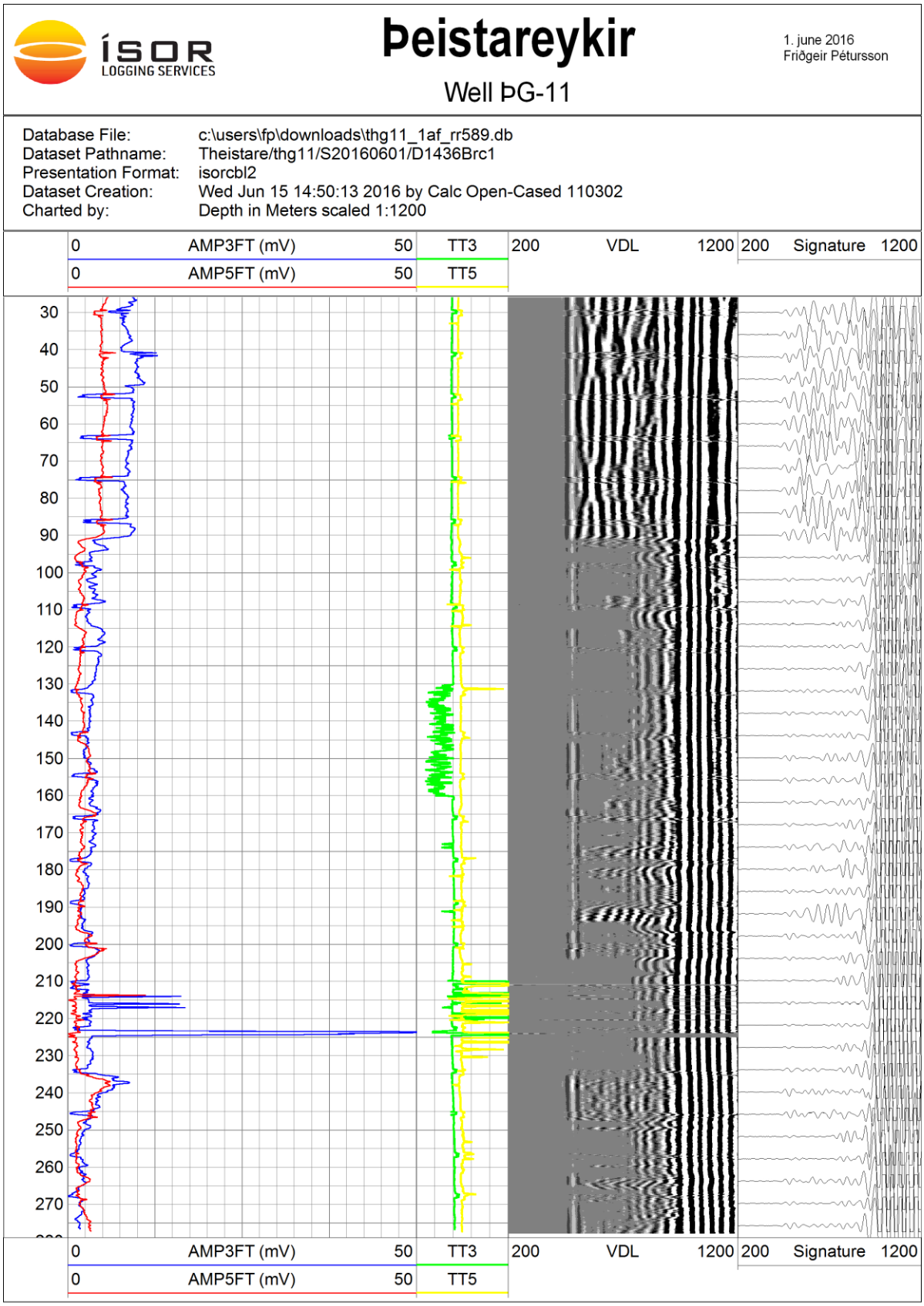


Figure 27. *CBL log from June 1st @ 14:36 in well ÞG-11.*

5 References

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Appendix A: Casing report

Surface casing

ICELAND DRILLING

Casing Tally Run Report
Rig: Sleipnir
Job No: 28176

Jarðboranir
Rig No: 28000
Job Name: ÞG-11

String Nominal OD (cm): 47,31 **String Type: FULL**

Items Run:	**10**	**Length Run:**	**98,990**	**Top Depth:**	**0,000**
Items Excluded:	**0**	**Length Excluded:**	**0,000**	**Bottom Depth:**	**91,500**
Items Tallied:	**10**	**Length All Items:**	**98,990**	**Cut Off Length:**	**7,490**

Run No.	Joint No	Item	Length	Top	Bottom	Description	Comments	Cnt	Scr
1	10	SHOE	0,520	90,980	91,500	47,31 x 45,10 X-56 WELD			
2	9	JOINT	12,220	78,760	90,980	47,31 x 45,10 X-56 WELD			
3	8	FLOAT	0,690	78,070	78,760	47,31 x 45,10 X-56 WELD			
4	7	JOINT	12,220	65,850	78,070	47,31 x 45,10 X-56 WELD			
5	6	JOINT	12,230	53,620	65,850	47,31 x 45,10 X-56 WELD			
6	5	JOINT	12,220	41,400	53,620	47,31 x 45,10 X-56 WELD			
7	4	JOINT	12,220	29,180	41,400	47,31 x 45,10 X-56 WELD			
8	3	JOINT	12,230	16,950	29,180	47,31 x 45,10 X-56 WELD			
9	2	JOINT	12,220	4,730	16,950	47,31 x 45,10 X-56 WELD			
10	1	JOINT	12,220	-7,490	4,730	47,31 x 45,10 X-56 WELD			

Printed: 21:19 29-sep.-16 *RIMDrill 6.0.4.65* *Page: 1 of 1*

Anchor casing

ICELAND DRILLING

Casing Tally Run Report
Rig: Sleipnir
Job No: 28176

Jarðboranir
Rig No: 28000
Job Name: ÞG-11

String Nominal OD (cm): 34,61 **String Type: FULL**

Items Run:	**28**	**Length Run:**	**295,680**	**Top Depth:**	**-1,036**
Items Excluded:	**0**	**Length Excluded:**	**0,000**	**Bottom Depth:**	**302,490**
Items Tallied:	**28**	**Length All Items:**	**295,680**	**Cut Off Length:**	**-7,846**

Run No.	Joint No	Item	Length	Top	Bottom	Description	Comments	Cnt	Scr
1		SHOE	0,850	301,640	302,490	0,00 x 0,00 BUTT	023396		
2	26	JOINT	11,400	290,240	301,640	34,61 x 0,00 K-55 BUTT	311425-111-0005-C6		
3	25	JOINT	11,420	278,820	290,240	34,61 x 0,00 K-55 BUTT	311426-111-0018-C6	1	
4		FLOAT	0,480	278,340	278,820	0,00 x 0,00 BUTT	023397		
5	24	JOINT	11,250	267,090	278,340	34,61 x 0,00 K-55 BUTT	311427-111-0011-B6		
6	23	JOINT	11,000	256,090	267,090	34,61 x 0,00 K-55 BUTT	311427-111-0015-B6	1	
7	22	JOINT	11,170	244,920	256,090	34,61 x 0,00 K-55 BUTT	311427-111-0019-B6		
8	21	JOINT	11,430	233,490	244,920	34,61 x 0,00 K-55 BUTT	311425-111-0028-B6	1	
9	20	JOINT	11,430	222,060	233,490	34,61 x 0,00 K-55 BUTT	311425-111-0031-B6		
10	19	JOINT	11,140	210,920	222,060	34,61 x 0,00 K-55 BUTT	311425-111-0011-C6	1	
11	18	JOINT	11,400	199,520	210,920	34,61 x 0,00 K-55 BUTT	113273-111-0008-B6		
12	17	JOINT	11,410	188,110	199,520	34,61 x 0,00 K-55 BUTT	311426-111-0047-C6		
13	16	JOINT	11,410	176,700	188,110	34,61 x 0,00 K-55 BUTT	311426-111-021-C6	1	
14	15	JOINT	11,420	165,280	176,700	34,61 x 0,00 K-55 BUTT	311427-111-0022-B6		
15	14	JOINT	11,440	153,840	165,280	34,61 x 0,00 K-55 BUTT	311426-111-020-C6		
16	13	JOINT	11,140	142,700	153,840	34,61 x 0,00 K-55 BUTT	311425-111-0001-C6		
17	12	JOINT	11,430	131,270	142,700	34,61 x 0,00 K-55 BUTT	311425-111-0055-B6		
18	11	JOINT	11,420	119,850	131,270	34,61 x 0,00 K-55 BUTT	311425-111-0036-B6	1	
19	10	JOINT	11,440	108,410	119,850	34,61 x 0,00 K-55 BUTT	311426-111-0002-C6		
20	9	JOINT	11,430	96,980	108,410	34,61 x 0,00 K-55 BUTT	311426-111-0036-C6		
21	8	JOINT	11,430	85,550	96,980	34,61 x 0,00 K-55 BUTT	311425-111-0027-B6	1	
22	7	JOINT	11,430	74,120	85,550	34,61 x 0,00 K-55 BUTT	113273-111-0005-B6		
23	6	JOINT	11,170	62,950	74,120	34,61 x 0,00 K-55 BUTT	311426-111-030-C6		
24	5	JOINT	11,180	51,770	62,950	34,61 x 0,00 K-55 BUTT	311425-111-0035-B6		
25	4	JOINT	11,170	40,600	51,770	34,61 x 0,00 K-55 BUTT	311425-111-0020-C6	1	
26	3	JOINT	11,440	29,160	40,600	34,61 x 0,00 K-55 BUTT	113273-111-0013-B6		
27	2	JOINT	11,050	18,110	29,160	34,61 x 0,00 K-55 BUTT	113273-111-0011- B6	1	
28	1	JOINT	11,300	6,810	18,110	34,61 x 0,00 K-55 BUTT	113273-111-0026-B6		

Printed: 21:15 29-sep.-16 *RIMDrill 6.0.4.65* *Page: 1 of 1*

Appendix B

Daily reports

ÍSOR ICELAND GEOSURVEY	**ÞG-11**	**Thursday** **12th of May 2016** Workday #3

Þeistareykir	**Report #01** **Preliminary results**	**Pre-Drilling** **(surface casing)**

Operator:	**Landsvirkjun**	*Drilling Company:*	**Iceland Drilling Company**
Well Name:	**ÞG-11**	*Drill-Rig:*	**Sleipnir**
Well-Id:	**60411**	*Geologist/Geophysicist:*	**MÁS** **(E-mail: mas@isor.is)**

Last casing size:	**22½″** **(conductor casing)**	**Depth at 24 hrs.**	**13.1 m**	**Hole made last 24 hrs. :**	**1.7 m**
Last casing depth:	**5.8 m**	**Depth at 8 hrs.**	**13.1 m**	**Drilling time:**	**2 hrs.**
Drilling fluid:	**Mud**	**Circulation losses at 8 hrs.**	**8 l/s**	**Average ROP:**	**0.9 m/hr**

Drilling

The drill rig Sleipnir was transported to pad B at Þeistareykir in the end of April 2016. The well pad (B) is located approximately 600 m north of Bæjarfjall, at 355 m a.s.l. After rigging up, which finished last week, the drillers worked on preparations for drilling of ÞG-11. Some maintenance work and repairing had to be carried out before drilling could be started, causing a delay of the project for a few days. In the morning on May 11th the BHA with a 21″ **bit** was made ready for drilling of the first section.

Early yesterday morning the BOP's were pressure tested by applying 6 bar for 15 min. The BOP´s passed the test but a leakage from the wash-pipe was noted. It had to be dismantled and repaired. A part of it was moved to Akureyri for a further treatment. The repairing of the wash-pipe finished at 4 pm in the afternoon.

At 5 pm when pumping into the well a circulation loss of 8 l/s was noted. Then it was decided to place cement plug in the well before further drilling actions. Prior to cementing two meters were drilled in formation, from 11.4-13.1 m depth. About 0.5 m of bottom hole debris was removed from the well. At 8 to 9 pm a 3 m^3 of sandy cement was pumped into the well from a cement truck. After cementing, the surface of the plug was found at 8 m depth (from the rig floor, which is 5.64 m above ground level). From 9 pm to midnight there was a WOC. At 6 am this morning the condition of the cement was checked but appeared not to be cured yet. So, this morning there is still a WOC. Unfortunately, it appeared that the wash-pipe was not working properly and will require some more maintenance before further drilling.
Drilling of the well is expected to resume in the afternoon.

ÍSOR ICELAND GEOSURVEY	**ÞG-11**	**Friday** **13th of May 2016** Workday #4

Þeistareykir	**Report #02** **Preliminary results**	**Pre-Drilling** **(18⅝" surface casing)**

Operator:	**Landsvirkjun**	*Drilling Company:*	**Iceland Drilling Company**
Well Name:	**ÞG-11**	*Drill-Rig:*	**Sleipnir**
Well-Id:	**60411**	*Geologist/Geophysicist:*	**MÁS** **(E-mail: mas@isor.is)**

Last casing size:	**22½"** **(conductor casing)**	**Depth at 24 hrs.**	**15 m**	**Hole made last 24 hrs. :**	**1.9 m**
Last casing depth:	**5.8 m**	**Depth at 8 hrs.**	**18 m**	**Drilling time:**	**5 hrs.**
Drilling fluid:	**Water/mud**	**Circulation losses at 8 hrs.**	**0 l/s**	**Average ROP:**	**0.4 m/hr**

Drilling

Yesterday morning there was a WOC until 9 am. As mentioned yesterday al leakage appeared in the wash-pipe, similar as earlier. At 6 pm in the afternoon, after repairing of the wash-pipe, the rig was ready for action again. Then drilling in cement started at 8 m depth and at 13.1 m drilling in formation started. No loss of circulation was noted. According to the drillers the formation is hard. So far, water has been used as a drilling fluid. Polymer pills are pumped into the well every 6 hours. Soon, this morning, the drilling fluid will be changed over to drilling mud.

Geology

Cuttings from 8 to 18 m depth have been inspected. At that depth interval the formation is composed of fresh, unaltered basaltic lavas. The rock is medium grained, gray-brownish in colour with abundant olivine. The lavas belong to the postglacial Stóravíti lava shield, c. 12 ka old.

ÍSOR ICELAND GEOSURVEY	**ÞG-11**	**Saturday** **14th of May 2016** Workday #5

Þeistareykir	**Report #03** **Preliminary results**	**Pre-Drilling** **(18⅝" surface casing)**

Operator:	**Landsvirkjun**	*Drilling Company:*	**Iceland Drilling Company**
Well Name:	**ÞG-11**	*Drill-Rig:*	**Sleipnir**
Well-Id:	**60411**	*Geologist/Geophysicist:*	**SÁ** **(E-mail: sigurveig.arnadottir@isor.is)**

Last casing size:	**22½"** **(conductor casing)**	**Depth at 24 hrs.**	**21,3 m**	**Hole made last 24 hrs. :**	**7,9 m**
Last casing depth:	**5.8 m**	**Depth at 8 hrs.**	**24,3 m**	**Drilling time:**	**15,8 hrs.**
Drilling fluid:	**mud**	**Circulation losses at 8 hrs.**	**0 l/s**	**Average ROP:**	**0.5 m/hr**

Drilling

Drilling was stopped at 19,5 m yesterday morning at 9:30, and the well was rinsed for approximately half hour. After checking and calibrating of the data acquisition system had been carried out, and the drilling fluid had been changed from water to mud, drilling started again at 16:30. Drilling was paused for ca. half hour yesterday at 20:45 for adjustments of level gauge. No circulation losses have been recorded. Assembly of the drill string is as follows: sub1, sub2, 21" drill bit, stabilizer, shock absorber, stabilizer, collar (9x).

Geology

Cuttings from 20-24 m are similar to the cuttings described in yesterday's report, and consist of fresh, unaltered medium-grained basalt lavas. The cuttings at 20 m are rather oxidized, while less oxidation is seen at 22 and 24 m.

ÍSOR ICELAND GEOSURVEY	**ÞG-11**	**Sunday (Whitsunday)** **15th of May 2016** Workday #6

Þeistareykir	**Report #04** **Preliminary results**	**Pre-Drilling** **(18⅝" surface casing)**

Operator:	**Landsvirkjun**	*Drilling Company:*	**Iceland Drilling Company**
Well Name:	**ÞG-11**	*Drill-Rig:*	**Sleipnir**
Well-Id:	**60411**	*Geologist/Geophysicist:*	**SÁ** **(E-mail: sigurveig.arnadottir@isor.is)**

Last casing size:	**22½"** **(conductor casing)**	**Depth at 24 hrs.**	**30,6 m**	**Hole made last 24 hrs. :**	**7,7 m**
Last casing depth:	**5.8 m**	**Depth at 8 hrs.**	**39,1 m**	**Drilling time:**	**22,5 hrs.**
Drilling fluid:	**mud**	**Circulation losses at 8 hrs.**	**0 l/s**	**Average ROP:**	**0,3 m/hr**

Drilling

Drilling has been ongoing since yesterday with an average ROP of 0,3 m/hrs. Drilling was stopped once, at ca. 3:30 am, when the collars from Thor drill rig, which had turned out to have too large OD, were replaced with collars with smaller OD. After that, drilling started again at ca. 5 am. Some circulation losses (1,25 l/s) were recorded at 28 m depth. Consequently, mica was added to the drilling fluid, and about half hour later the well was tight again. Ca 4 l/s circulation losses were recorded at 7-8 pm, and mica was added to the drilling fluid again. Since around 7 pm yesterday, clogging in the silo made the gel mixing troublesome, but after cleaning of the silo last night, the mixing has been going well. Drilling parameters (ROP, WOB, Delta T and total Q) from 8 am yesterday to 8 am today are shown in Figure 1.

Geology

The drill cuttings from 26-38 m depth still consist of unaltered, oxidized basalt lavas. At 34-37 m, oxidized scoria with clay and zeolites is observed.

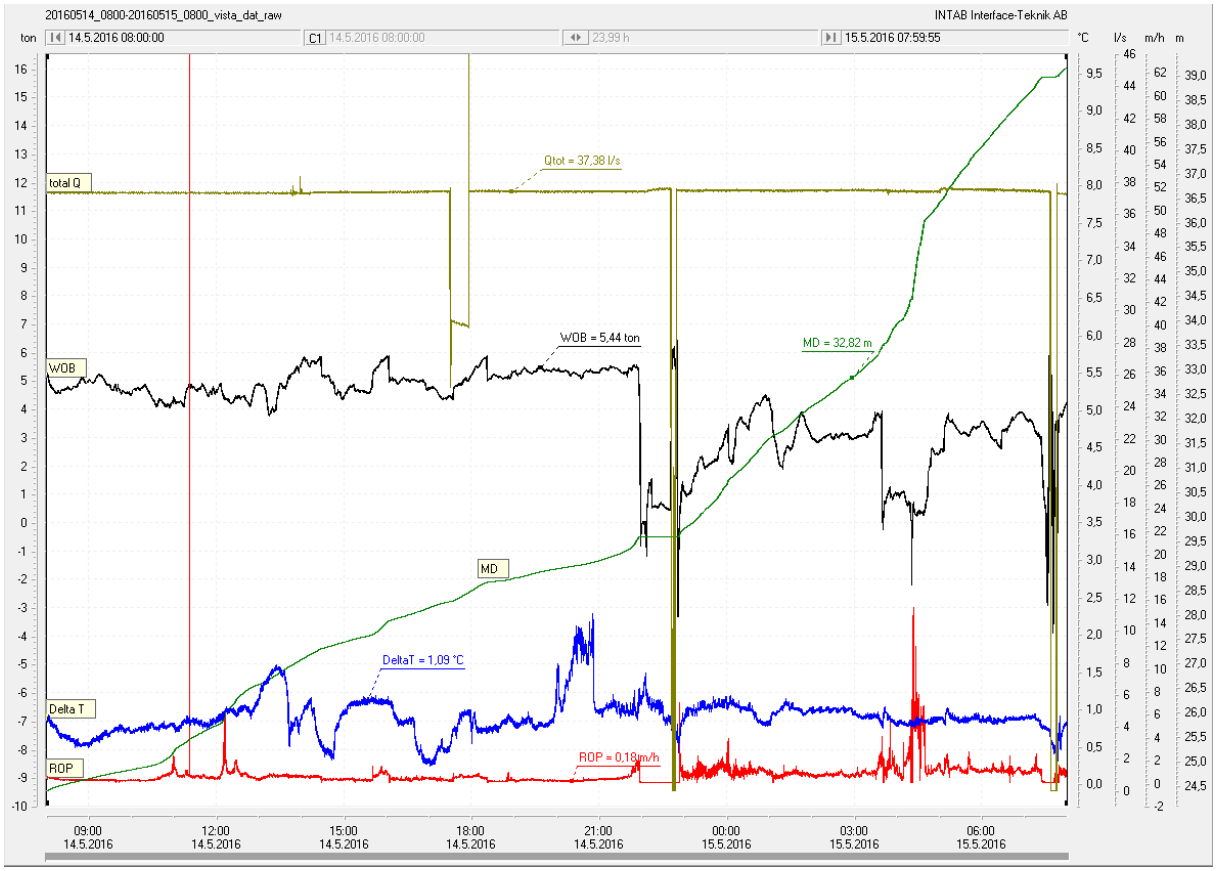


Figure 1. *Drilling parameters from 8 am yesterday to 8 am today.*

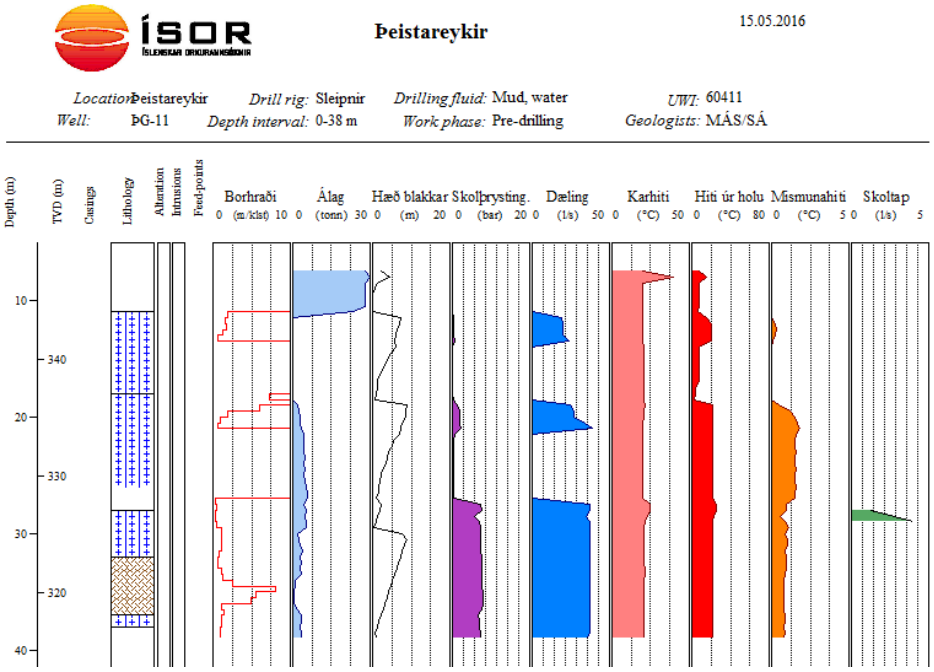


Figure 2: *Lithology and drilling parameters in ÞG-11 down to 38 m. The drilling parameters are, from left to right: ROP, WOB, top drive position, mud pressure (stand-pipe pressure), mud pump, mud tank temperature, return mud temperature, temperature difference, and circulation losses. Please note that errors are in the ROP at 6-11, 14-19 and 21-27 m.*

ÍSOR ICELAND GEOSURVEY	**ÞG-11**	**Monday (Whitmonday)** **16th of May 2016** Workday #7

Þeistareykir	**Report #05** **Preliminary results**	**Pre-Drilling** **(18⅝" surface casing)**

Operator:	**Landsvirkjun**	*Drilling Company:*	**Iceland Drilling Company**
Well Name:	**ÞG-11**	*Drill-Rig:*	**Sleipnir**
Well-Id:	**60411**	*Geologist/Geophysicist:*	**SÁ** **(E-mail: sigurveig.arnadottir@isor.is)**

Last casing size:	**22½"** **(conductor casing)**	**Depth at 24 hrs.**	**54,9 m**	**Hole made last 24 hrs. :**	**27,4 m**
Last casing depth:	**5.8 m**	**Depth at 8 hrs.**	**63 m**	**Drilling time:**	**22 hrs.**
Drilling fluid:	**mud**	**Circulation losses at 8 hrs.**	**0 l/s**	**Average ROP:**	**1,1 m/hr**

Drilling

Drilling continued yesterday with an average ROP of 1,1 m/hr. Drilling was stopped for 2 hours in the afternoon (at 4-6 pm), when it appeared that hydraulic fluid was leaking along a hose nipple. The hose nipple broke when it was tightened, and consequently new hose nipples were picked up at Húsavík.

Circulation losses were expected around 50 m, as a total loss had occurred in ÞG-9 at that depth, but however no losses have been recorded since at around 28 m depth.

The BOPs and collar arrived yesterday afternoon, and preparations for casing operations have begun.

Drilling parameters (ROP, WOB, DeltaT and Qtot) from 8 am yesterday to 8 am this morning are shown in Figure 1.

Geology

Drill cutting from 11-46 m are shown in Figure 2. A very quick look at the drill cuttings from last night and this morning shows that the cuttings still consist of medium-coarse grained basalt lavas.

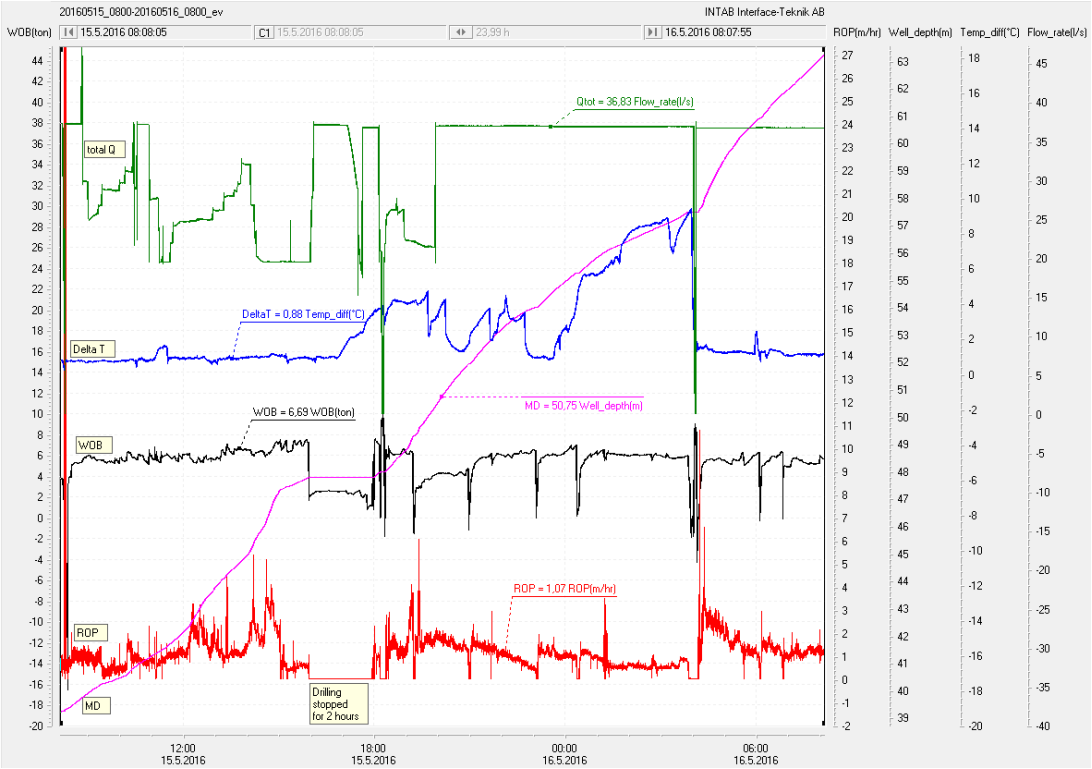


Figure 1. *Drilling data from 8 am yesterday to 8 am this morning.*

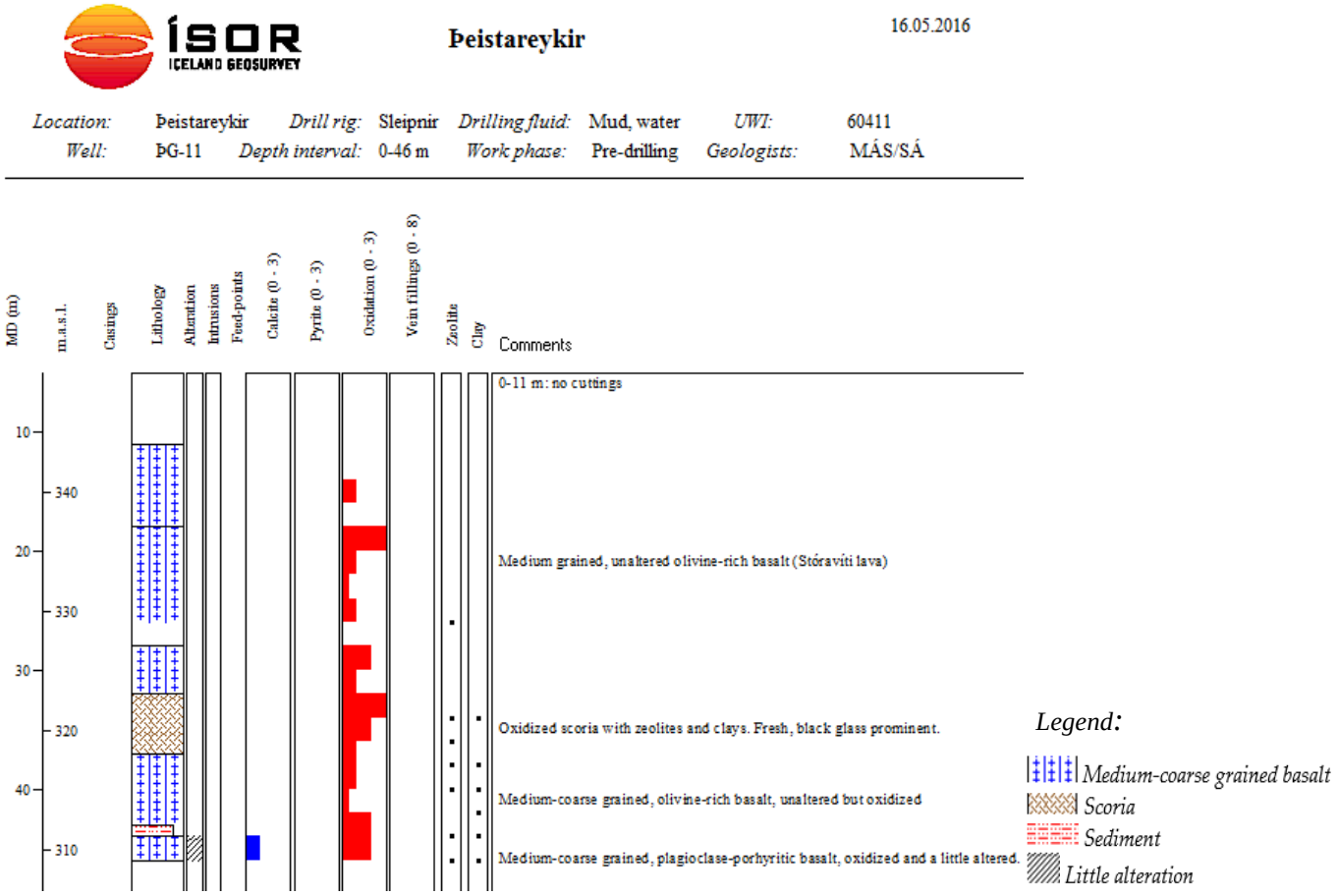


Figure 2. *Drill cuttings from 11-46 m.*

Figure 3. *After night-frost and snowfall, the water-hose to ISOR's container required some amendments.*

Þeistareykir

Report #06
Preliminary results

Pre-Drilling
(18⅝" surface casing)

Operator:	**Landsvirkjun**	*Drilling Company:*	**Iceland Drilling Company**
Well Name:	**ÞG-11**	*Drill-Rig:*	**Sleipnir**
Well-Id:	**60411**	*Geologist/Geophysicist:*	**SÁ** (E-mail: sigurveig.arnadottir@isor.is)

Last casing size:	22½" (conductor casing)	Depth at 24 hrs.	83,5 m	Hole made last 24 hrs. :	28 m
Last casing depth:	5.8 m	Depth at 8 hrs.	91,6 m	Drilling time:	24 hrs.
Drilling fluid:	mud	Circulation losses at 8 hrs.	0 l/s	Average ROP:	1,2 m/hr

Drilling

Sleipnir drilled continuously yesterday and until ~9:45 this morning. It had been decided that the casing depth should be within the basalt lavas, before the tuff (beginning at 96 m in ÞG-9) was reached. However, at little more than 91 m, disturbances were noted in WOB and torque; this happened several times, and was considered to indicate fractures. Thus, it was decided to drill 1 m further, but when the torque went unstable again at 92,5 m, it was decided to drill further, until it became stable. Circulation losses were checked frequently, but no losses were noted. At 94,3 m depth, the torque had been stable for some time, and even though some tuff had appeared in the cuttings, it was decided that this was a good casing depth. Drilling was thus stopped ca. 9:45 am, at 94,3 m depth.

Drilling parameters (ROP, WOB, DeltaT and Qtot) from 8 am yesterday to 8 am this morning are shown in Figure 1. Parameters from 4 am last night to 10 am this morning are shown in Figure 2.

Geology

Yesterday's drill cuttings from 11-74 m are shown in Figures 2 and 3.

Drill cuttings down to 86 m consist of medium-coarse grained basalt lavas. At 88 m, several grains of light-colored, pyrite-rich glassy basalt are mixed within the medium-coarse grained basalt. A cutting sample was collected at 88,6 m, which contains more of the glassy grains. This is most likely the thin breccia observed in ÞG-9 at 90-92 m. At 90 m, the glassy basalt grains have almost disappeared, and the cuttings consist mostly of medium-coarse grained basalt. Several tuff grains appear in the sample from 94 m, and in the last cutting sample, collected at 94,3 m, tuff grains are predominant although the medium-coarse grained basalt is still seen.

Pyrite is first clearly observed at 58 m. Very slight reaction with HCL is observed in amygdules at 46. A more prominent reaction is then observed at 84 m.

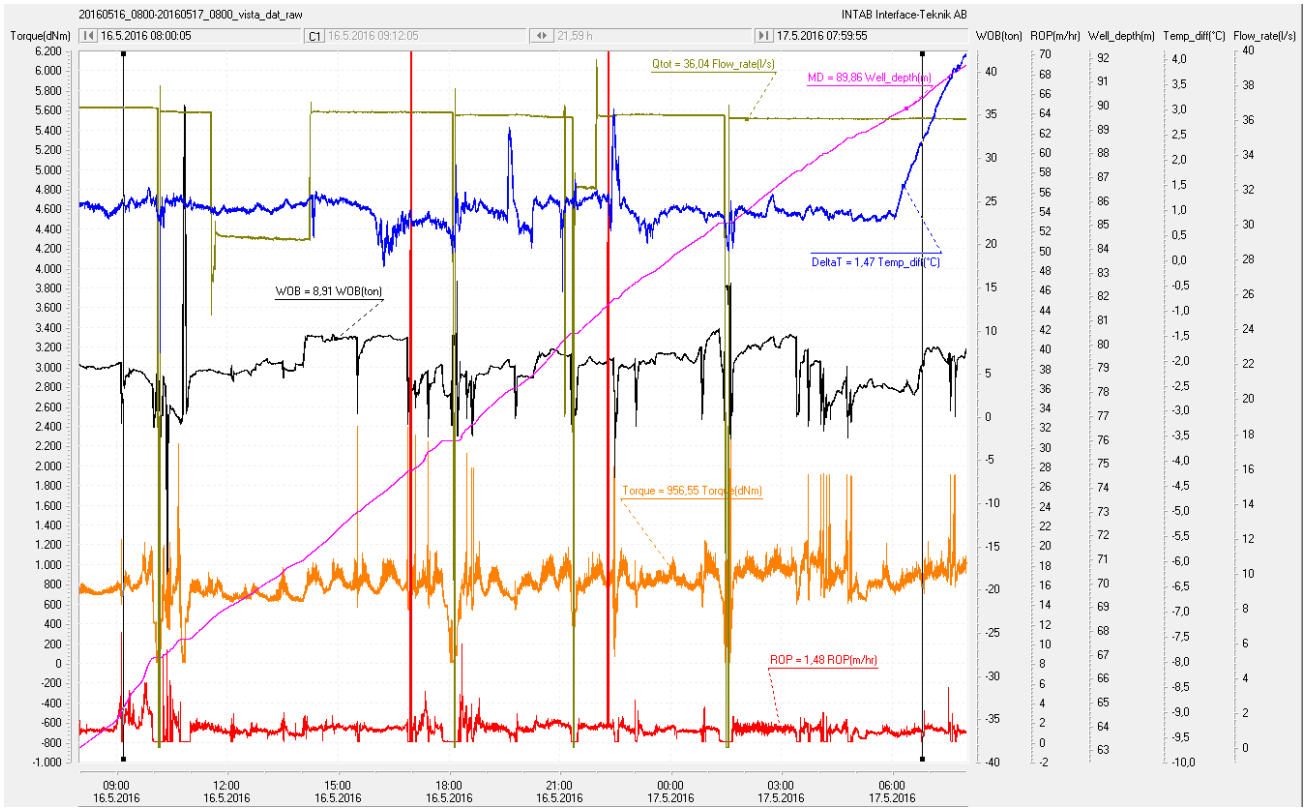


Figure 1. *Drilling data from 8 am yesterday to 8 am this morning.*

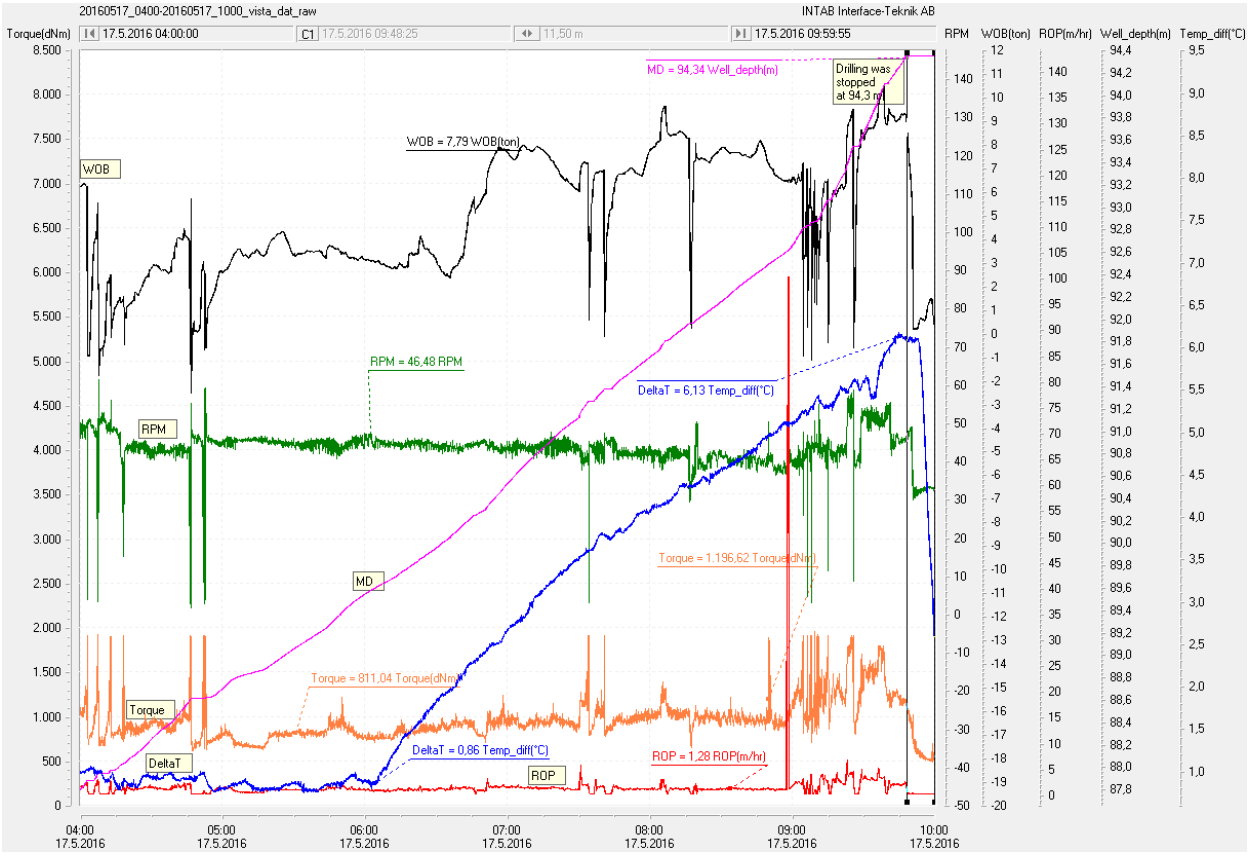


Figure 2. *Drilling data from 4 am last night to 10 am this morning. Torque began to be unstable around the proposed casing depth. (Note that deltaT has been increasing since ca 6 am, at ~89 m depth).*

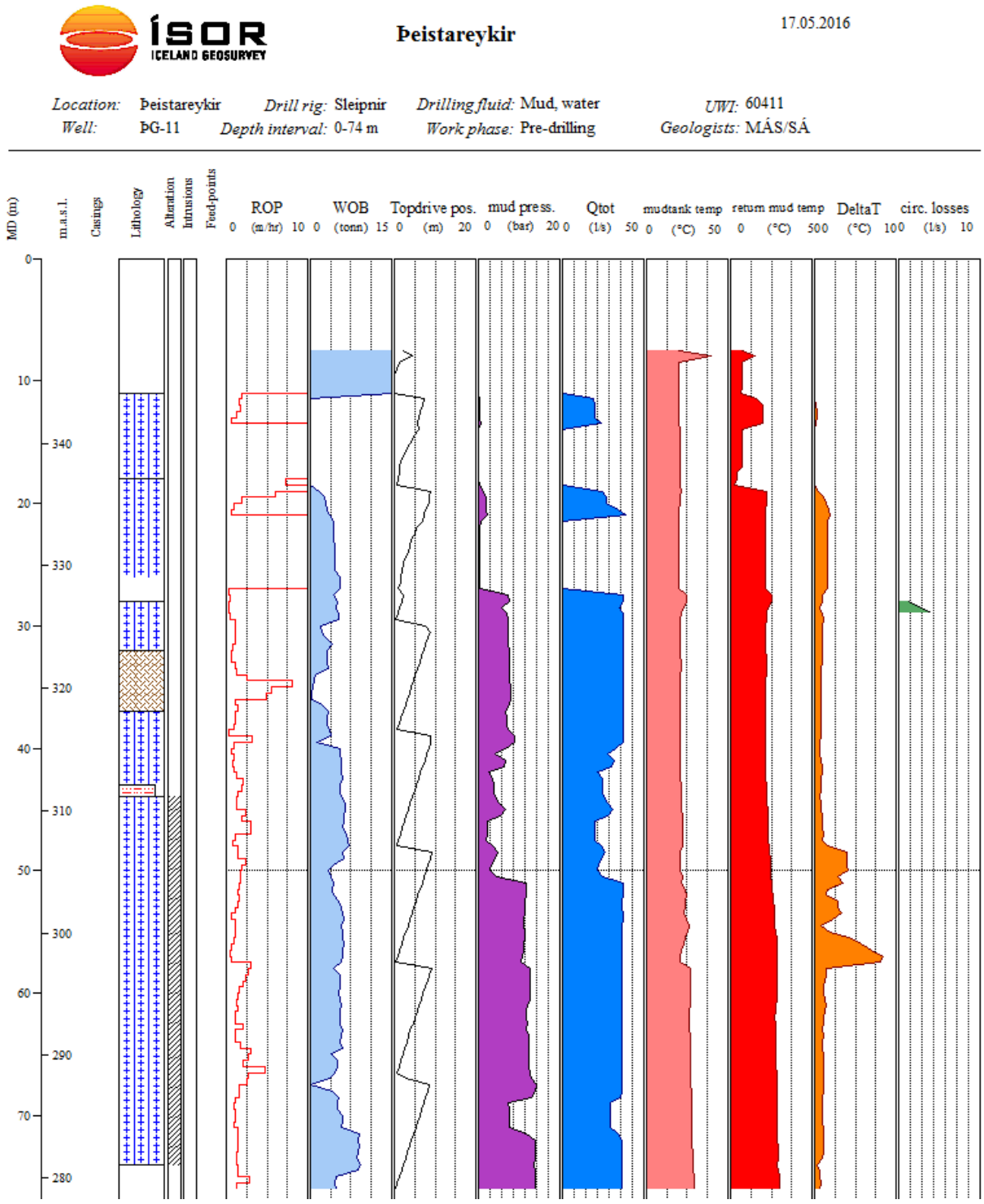


Figure 3. *Drill cuttings from 11-74 m in comparison with drilling parameters (note: errors are in the ROP at 6-11, 14-19 and 21-27 m).*

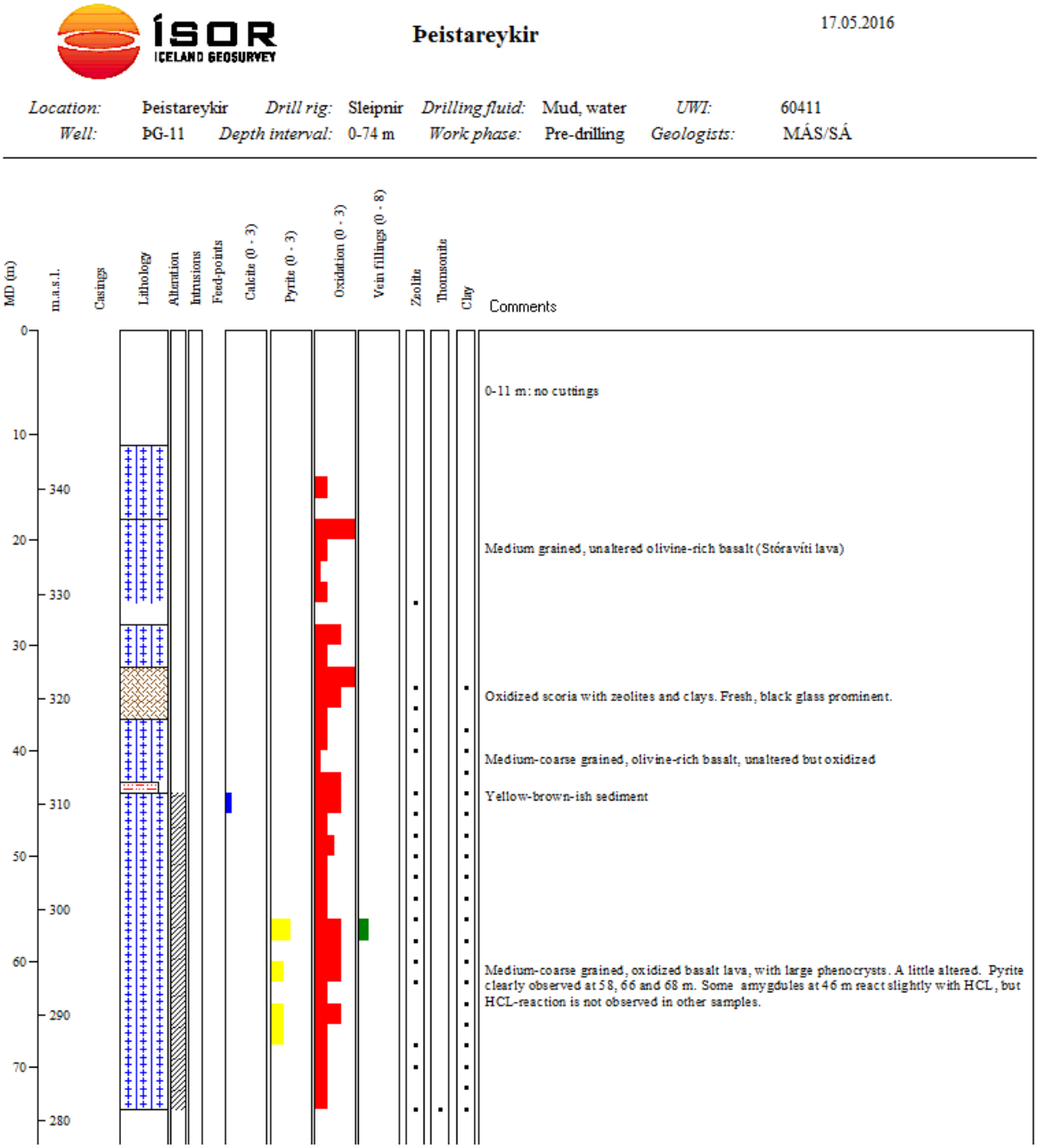


Figure 4. *Drill cuttings from 11-74 m.*

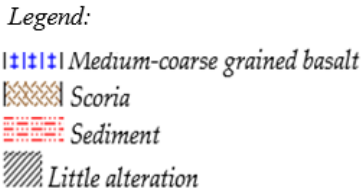


Figure 5. *Legend for Figures 3 and 4.*

Þeistareykir

Report #07
Preliminary results

Pre-Drilling
(18⅝" surface casing)

Operator:	**Landsvirkjun**	*Drilling Company:*	**Iceland Drilling Company**
Well Name:	**ÞG-11**	*Drill-Rig:*	**Sleipnir**
Well-Id:	**60411**	*Geologist/Geophysicist:*	**SÁ/ÞEg/HHT** (E-mail: sigurveig.arnadottir@isor.is)

Last casing size:	22½" (conductor casing)	Depth at 24 hrs.	94,3 m	Hole made last 24 hrs. :	10,7 m
Last casing depth:	5.8 m	Depth at 8 hrs.	94,3 m	Drilling time:	10 hrs.
Drilling fluid:	-	Circulation losses at 8 hrs.	0 l/s	Average ROP:	1,07 m/hr

Drilling

After casing depth was reached at 94,3 m yesterday morning, the well was rinsed and the string POOH. One collar was then removed from the drill string before a tilt measurement was carried out. The results showed that the well tilts 0°. After measuring the tilt and pulling out of hole, a wiper trip was carried out. No obstacles were noted during the wiper trip. 1,5 m of deposits were in the well. The well was then rinsed and after POOH at 22:30 last night, ISOR's loggers started logging the temperature and caliper of the well. The results are presented in Figures 1-5 and discussed hereunder. After logging, the drilling crew prepared the casing work. Casing started at 03:30 last night and is expected to be finished tonight.

Analysis of drill cuttings collected during the pre-drilling are presented in Figures 6 and 7. After reconsidering the sediment recorded at 44 m, it is now suspected to be cement from ÞG-9. Further analysis is however required for final decision (e.g. thin sections and XRD).

The 21" drill bit, after drilling the pre-drilling phase is shown in Figure 8. Observation of the drill bit's condition will be carried out today.

Logging

As scheduled, temperature- and caliper log were measured in open hole after POOH the BHA. The specific safety tool pipe was put in place for mounting the logging tool at the rig floor. The temperature log started at 22:44 in the evening and the result is shown in Figure 1. The well was full of the thick and heavy mud that was used in the drilling process. When the temperature sensor in run in such mud the sensor house fills up and builds up isolating layer around the sensor, which causes late response to temperature changes. Therefore, the temperature tool was run slowly in hole in order to minimize this effect. The temperature log shows that no fluid carrying zones are connected to the well. When at BOH a 70 minutes heat-up was measured and the result is shown in Figure 4 and a Horner interpretation of the heating process indicates formation temperature at 94 m to be around 100°C, see Figure 5.

The caliper log (see Figure 2) shows that there were no obstacles in the well after the predrilling and the following wiper trip. One 10 cm anomaly at 35 m depth is measured with both arms

is the biggest one and besides that two 5 cm anomalies are measured with the Y-arm and one 4 cm anomaly with the X-arm.

In Figure 3 the caliper log is put in context with the current casing program and the volume between the anchor casing used to cement it with the outside formation and the 4.5 m long conductor casing. This volume is estimated about 6 m^3.

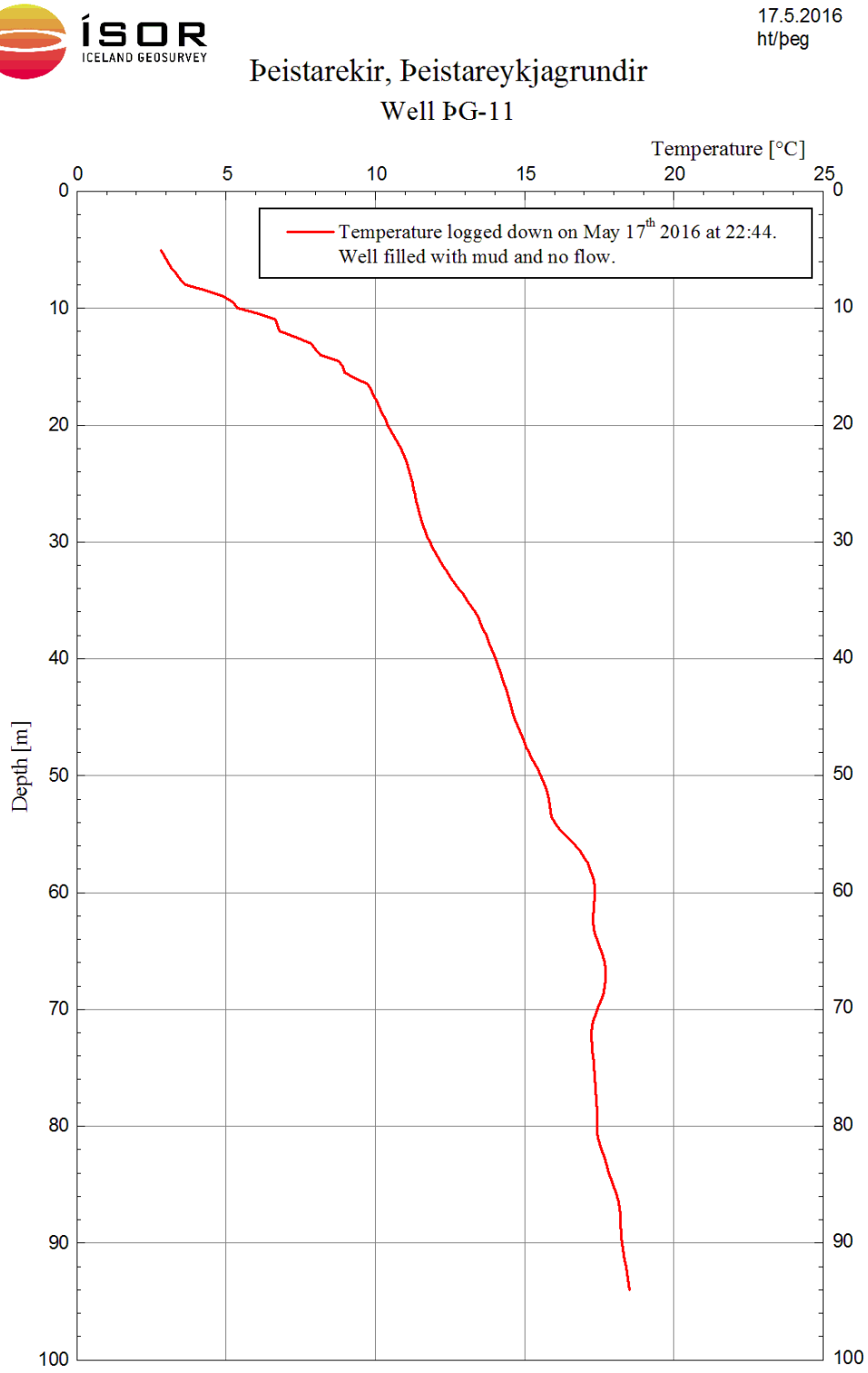


Figure 1. *Temperature log in well ÞG-11 after the predrilling down to 94 m finished.*

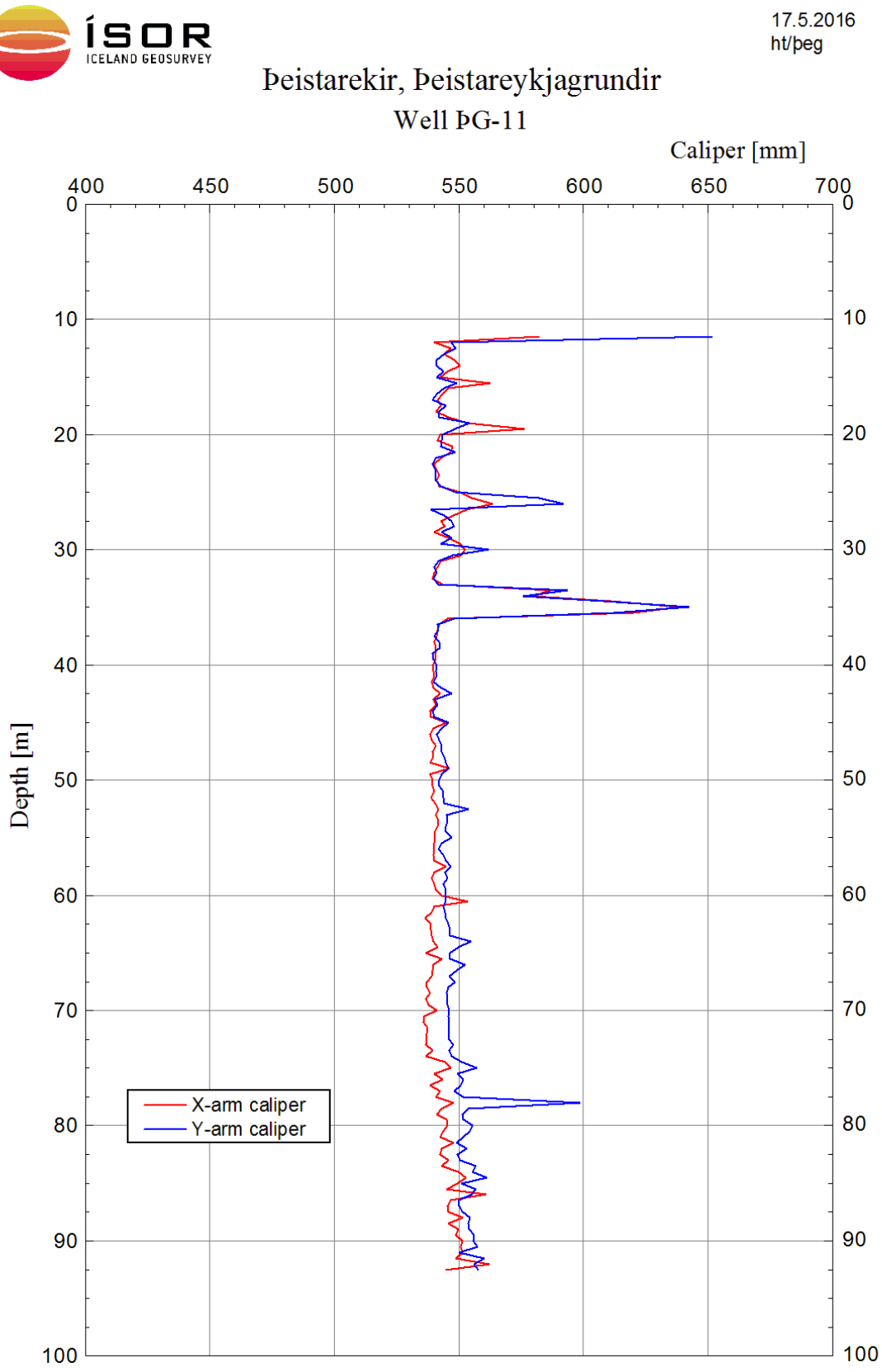


Figure 2. *The caliper log at the end of the predrilling process.*

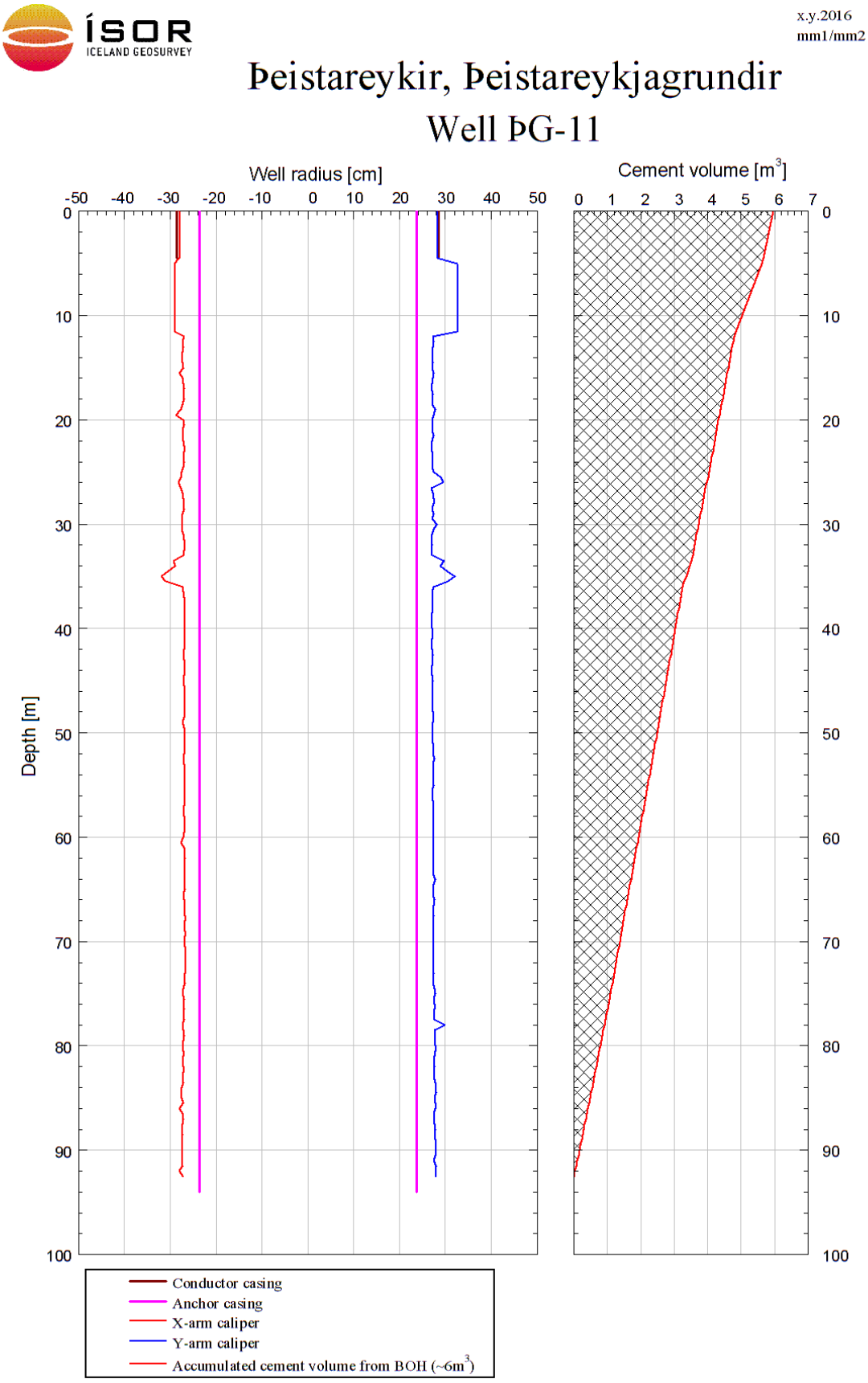


Figure 3. *Caliper log put in context of casing programs so far and estimated volume to be cemented between the annulus and the anchor casing.*

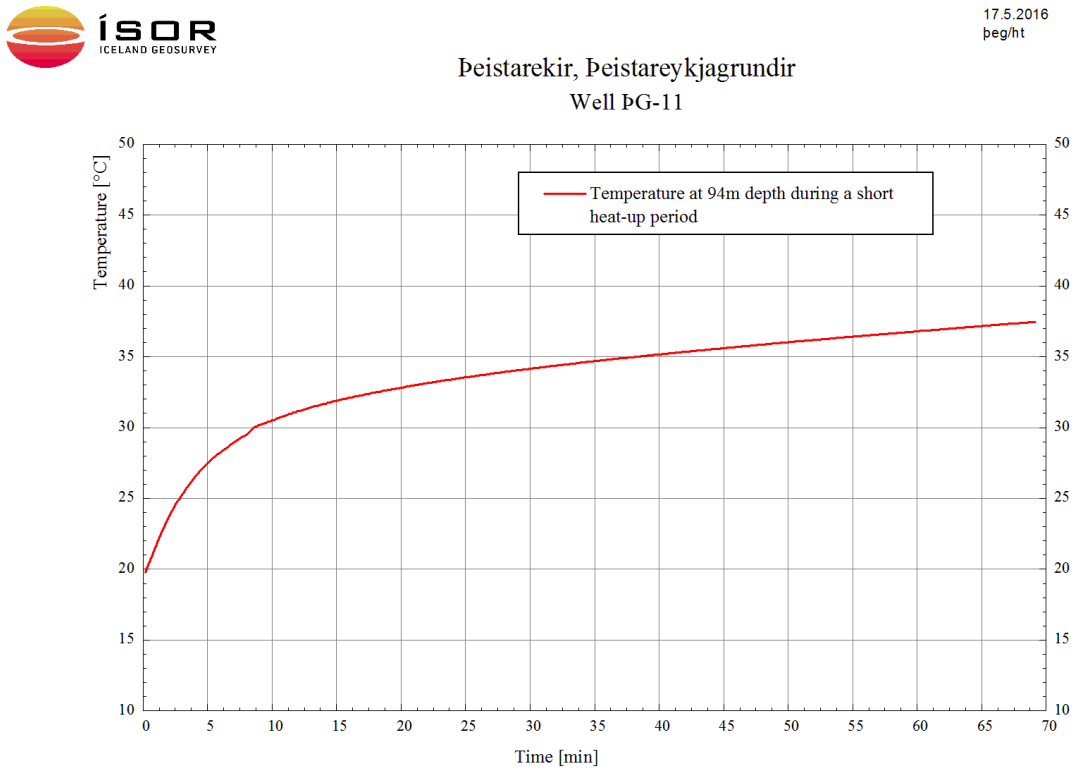


Figure 4. *The heat-up process at 94 m (BOH) depth in well ÞG-11 after the predrilling finished.*

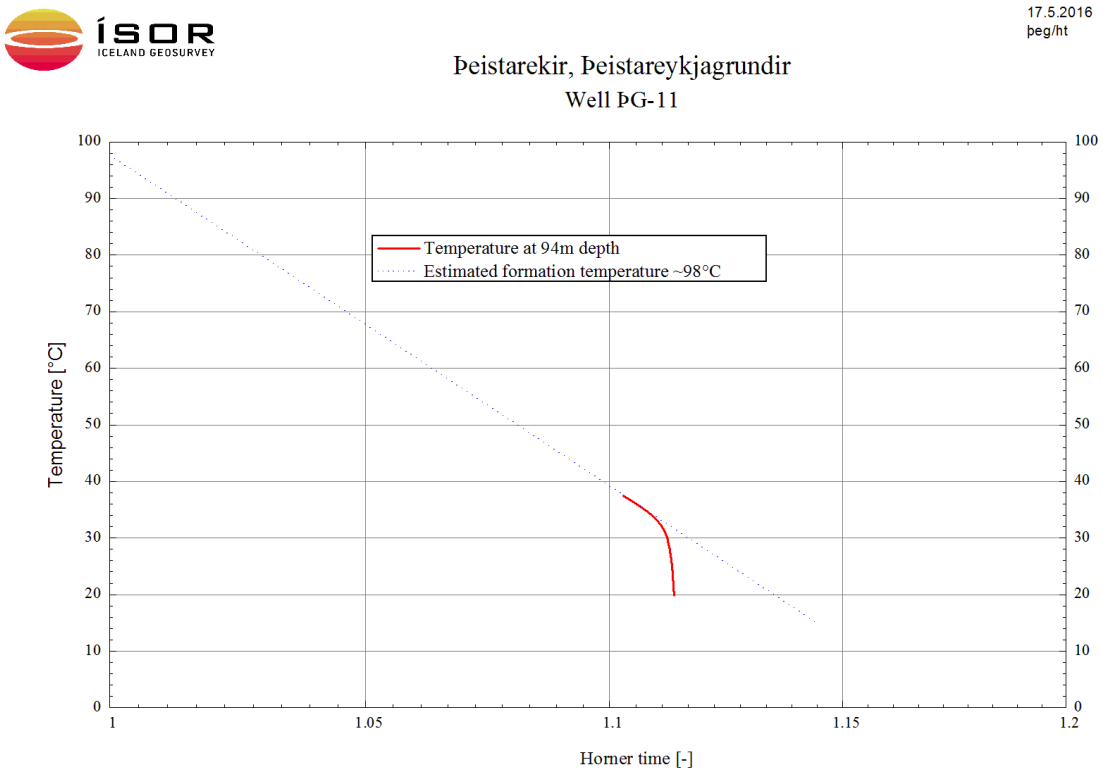


Figure 5. *Horner interpretation of the measured heating process at BOH after the predrilling indicates ~100°C formation temperature.*

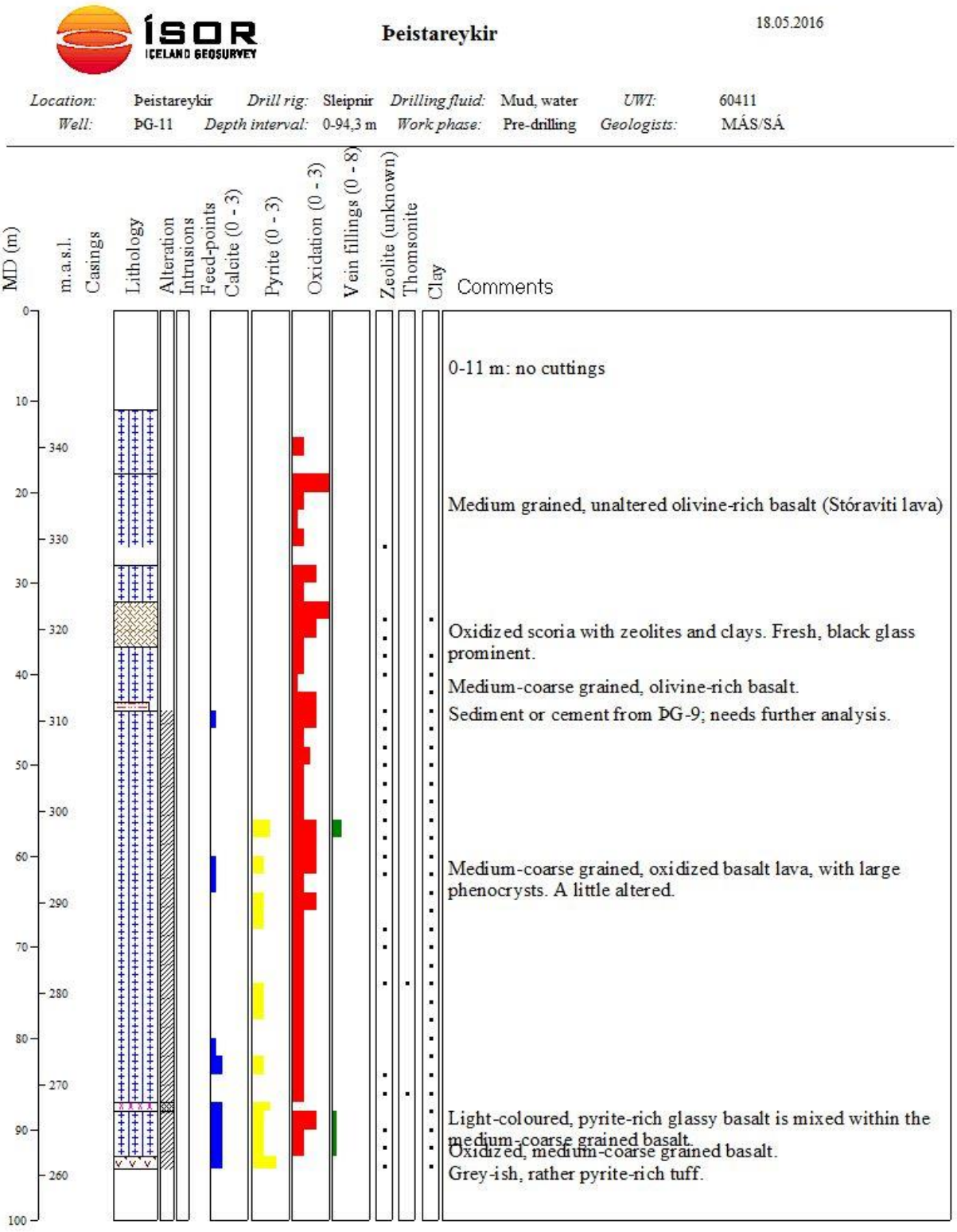


Figure 6. *Drill-cutting analysis from 11 to casing depth, 94,3 m.*

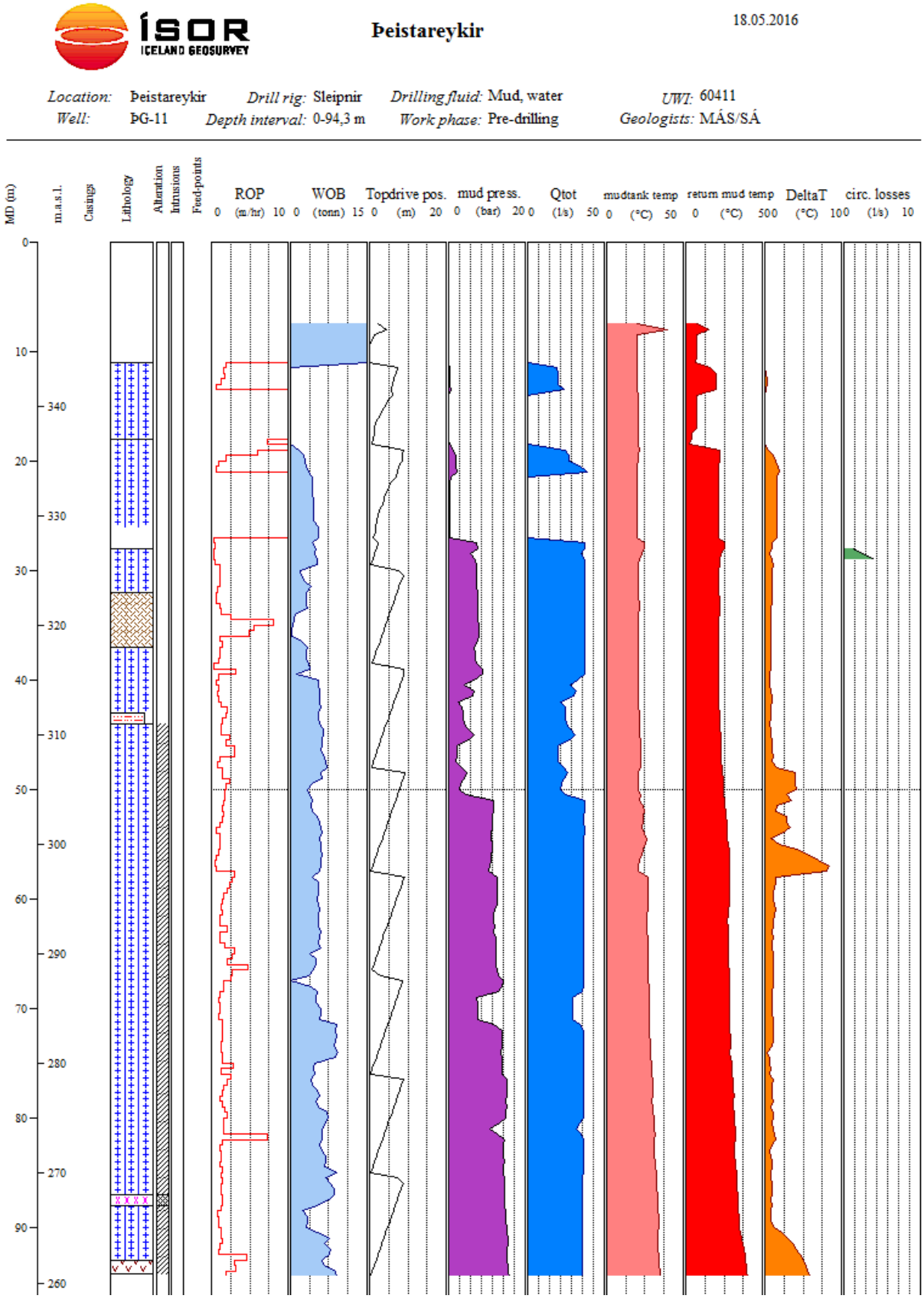


Figure 7. *Lithology at 11-94,3 m depth, in comparison with drilling parameters (note: errors are in the ROP at 6-11, 14-19 and 21-27 m).*

Figure 8. *The 21" drill bit, after the pre-drilling.*

Þeistareykir

Report #08
Preliminary results

Pre-Drilling
(18⅝" surface casing)

Operator:	**Landsvirkjun**	*Drilling Company:*	**Iceland Drilling Company**
Well Name:	**ÞG-11**	*Drill-Rig:*	**Sleipnir**
Well-Id:	**60411**	*Geologist/Geophysicist:*	**SÁ** (E-mail: sigurveig.arnadottir@isor.is)

Last casing size:	**18 5/8"** (surface casing)	**Depth at 24 hrs.**	**94.3 m**	**Hole made last 24 hrs. :**	**0 m**
Last casing depth:	**91.5 m**	**Depth at 8 hrs.**	**94.3 m**	**Drilling time:**	**0 hrs.**
Drilling fluid:	**-**	**Circulation losses at 8 hrs.**	**0 l/s**	**Average ROP:**	**0 m/hr**

Casing

Casing job for 18 5/8" casing was completed at 10 pm last night. Casing shoe is at 91.5 m, measured from the drill floor (which is 5.64 m above ground). After that, preparations were made for cementing of the surface casing, and after running in the cement string, the cement job started at 4:30 last night. At first 8.6 m^3 of cement (with density of 1.72 g/cm^3) were pumped down. Afterwards, some 0.8 m^3 of water were pumped down to clean the string. Finally, 0.33 m^3 of cement were cemented on top. The cement job was finished at 04:50. WOC is estimated to take 24 hours, and will thus be finished early tomorrow morning.
Casing- and cementing reports are presented hereunder.

Casing Information Report

Rig: Sleipnir
Job No: 28176

Iceland Drilling
Rig No: 28000
Job Name: ÞG-11

Casing Information

Run Date/Time:	18-maí-16 05:00		
		Leak Off Test (kg/cu m):	
Well Section:	SURF	String Type:	FULL
String Top MD (m):	0,0	String Top TVD (m):	
Casing Shoe MD (m):	91,5	Casing Shoe TVD (m):	
String Nominal OD (cm):	47,31	String Nominal ID (cm):	45,10
Bit Diameter (cm):	53,34	Avg. Open Hole Diam. (cm):	53,34
Centralizers: No:		Manufacturer/Type:	
Depths:			
Hanger Type:		Manufacturer:	
Comments:	Transferred from Casing Tally Detail on 19-maí-16 12:41		

String Component Details

Joints	Item	Length (m)	OD(cm)	ID (cm)	Weight (kg)	Grade	Connection	Torque
1	SHOE	0,520	47,31	45,10		X-56	WELD	
1	JOINT	12,220	47,31	45,10		X-56	WELD	
1	FLOAT	0,690	47,31	45,10		X-56	WELD	
7	JOINT	85,560	47,31	45,10		X-56	WELD	
Totals: 10		98,990						

Cementing Report

Rig: Sleipnir
Job No: 28176

Iceland Drilling
Rig No: 28000
Job Name: ÞG-11

Cement Job Information

Start Date/Time:	19-maí-16 04:20	Well Bore:	Original Well Bore
Job Type:	PRIMARY	String OD (cm):	47,31
Well Section:	SURF	String Type:	FULL
Cementing Co:	JARDB	Cementing Engineer:	Sveinbjörn Bjarnasson

Primary Job Detail

	Volume (cu m)	Pump Time	Rate (cu.m./min)	Pressure (bar)
Conditioning Data:				
Cement Data:	8,6	0,86	10,0	0
Displacement Data:	0,8	1	0,8	
Calc. Displacement Vol:	0,8			

☐ Batch Mix? ☐ Bump Plug? Bump Pressure:

Returns to Surface: ☐ Reciprocate Pipe? ☐ Cement at Surface?

Calc Top of Cement (m): Excess (%): Avg. Hole Size (cm): 53,34

Slurry Information

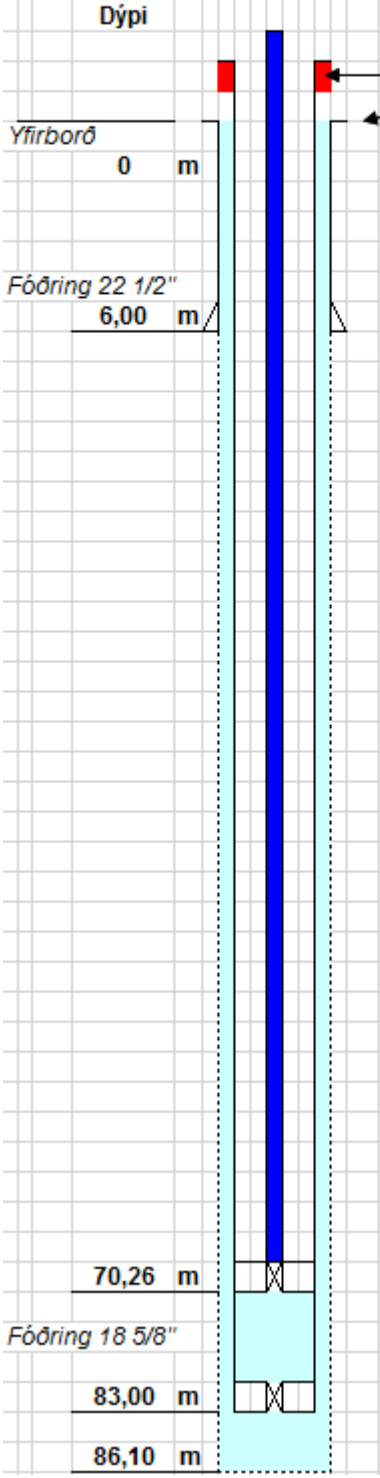
Type	Density	Yield	Sacks	Volume	Rate	Additives
DISPLACE	1					
LEAD	9					
TAIL	0					

Post Job Information

Liner Top Test (kg/cu m):		Job Success?	No
Actual Top of Cmt (m):		CBL Bond Quality:	
Misc. Comments:	Engin leki í holu steypt í gegnum streng 8,6 m3 g blöndu eðlisþyngd 1,72 steypt ofaná 0,33m3 sem gera 10,000 kg þurefni		

Verkkaupi:	**Landsvirkjun**
HOLA:	**ÞG-11**
Steypu gerð:	**18 5/8" fóðringasteypa**
Dags:	**18.5.2016**

JARÐBORANIR



1 Forsendur steypuútreiknings

	Stærð fóðringa OD [in]	Ytra rúmmál [l/m]	Fóðringa þyngd [lb/ft]	Rými [l/m]	Rúmmál milli fóðringa [l/m]
	18,625	175,77	87,5	159,73	
	22,5			235,7	59,93
	HOLAN				
	21			223,4	47,63
	DP				
	4 1/2" E75			7,3	

2	Reiknað steypumagn	[m3]
	Rúmmál milli fóðringa	0,4
	Rúmmál milli holu og fóðringar	3,7
	Steypa upp í 18 5/8" fóðringu ~12,00m	2,0
	Steypa frá fóðringarenda í holubotn	0,7
	ÁÆTLAÐ STEYPUMAGN :	**6,8**

3	Mælt steypumagn ÍSOR	[m3]
	Niðurstaða víddarmælinga ÍSOR	*6,0*
	Mismunur á reiknuðu mældu	*-0,8*

4	Steyputímar	Hraði [l/s]	[mín]
	Steypa niður streng	15	0,6
	Steypa inní fóðringu	15	2,3
	Frá botni að ytri fóðringu	15	4,2
	Milli fóðringa	15	0,4
	Eftirdæling m. Vatni	15	0,6
	REIKNAÐUR STEYPUTÍMI ALLS :		**8,1**
	Auka tími frá ÍSOR		
	LÍKLEGUR STEYPUTÍMI :		**8,1**

5	Vatnsborð í holu	[m]
	Áætluð staðsetning vatnsborðs, dýpi	*70,00*

6	Eftirdæling	[l]
	Strengur	600
	Minnkun vegna lægra vatnsborðs	0
	EFTIRDÆLING :	**600**

7	Þrýstiástand í holu	[hró]	[bar]
	Þrýstingur frá steypu á botn	1,70	14,6
	Þungi jarðlaga	2,4	20,7
	MAX dæluþrýstingur við steypingu		*6,0*
	Collaps pressure, steypudýpi 4,3 Mpa	*1,7*	
	Þrýstingur á rör við flotkolla	1,7	12

Umsjónarmaður verkkaupa	Steypu hönnuður
Sveinbjörn Hólmgeirsson	Sveinbjörn Bjarnason

ÍSOR ICELAND GEOSURVEY	**ÞG-11**	**Friday** **20th of May 2016** Workday #11

Þeistareykir	**Report #09** **Preliminary results**	**Pre-Drilling** **(18⅝" surface casing)**

Operator:	**Landsvirkjun**	*Drilling Company:*	**Iceland Drilling Company**
Well Name:	**ÞG-11**	*Drill-Rig:*	**Sleipnir**
Well-Id:	**60411**	*Geologist/Geophysicist:*	**SÁ** **(E-mail: sigurveig.arnadottir@isor.is)**

Last casing size:	**18 5/8"** **(surface casing)**	**Depth at 24 hrs.**	**94.3 m**	**Hole made last 24 hrs. :**	**0 m**
Last casing depth:	**91.5 m**	**Depth at 8 hrs.**	**94.3 m**	**Drilling time:**	**0 hrs.**
Drilling fluid:	**-**	**Circulation losses at 8 hrs.**	**0 l/s**	**Average ROP:**	**0 m/hr**

Drilling operations

The cement had solidified by 7 pm yesterday, earlier than had been estimated. Consequently, the drilling crew started taking down the BOP. After cutting the casing, the casing end was sanded, at 4-6 am this morning. Welding of the flange then started, at 6 am this morning, and is currently ongoing.

When welding of the flange will be finished, the new BOPs will be put in place, and the flow-line will be reconstructed.

Results of the observation of the 21" drill bit after pre-drilling the well showed that the bit is in good condition, and that all areas/rows are even.

ÍSOR ICELAND GEOSURVEY	**ÞG-11**	**Saturday** **21st of May 2016** Workday #12

Þeistareykir	**Report #10** **Preliminary results**	**Pre-Drilling** **(18⅝" surface casing)**

Operator:	**Landsvirkjun**	*Drilling Company:*	**Iceland Drilling Company**
Well Name:	**ÞG-11**	*Drill-Rig:*	**Sleipnir**
Well-Id:	**60411**	*Geologist/Geophysicist:*	**SRG** **(E-mail: srg@isor.is)**

Last casing size:	**18 5/8"** **(surface casing)**	**Depth at 24 hrs.**	**94.3 m**	**Hole made last 24 hrs. :**	**0 m**
Last casing depth:	**91.5 m**	**Depth at 8 hrs.**	**94.3 m**	**Drilling time:**	**0 hrs.**
Drilling fluid:	**-**	**Circulation losses at 8 hrs.**	**0 l/s**	**Average ROP:**	**0 m/hr**

Drilling operations

Welding of the 18 5/8" surface casing was finished around 13:30 the 20th of May. The flow-line was reconstructed between 13:30-16:30 and afterwards the annular preventer was put in place. When working on the pipe ram, it turned out that it leaked and currently (at 09:00 the 21st of May) the drill crew is waiting for spare parts and a specialist from the Netherlands, arriving around 21:00 this evening. Figure 1 shows the drilling progress of ÞG-11.

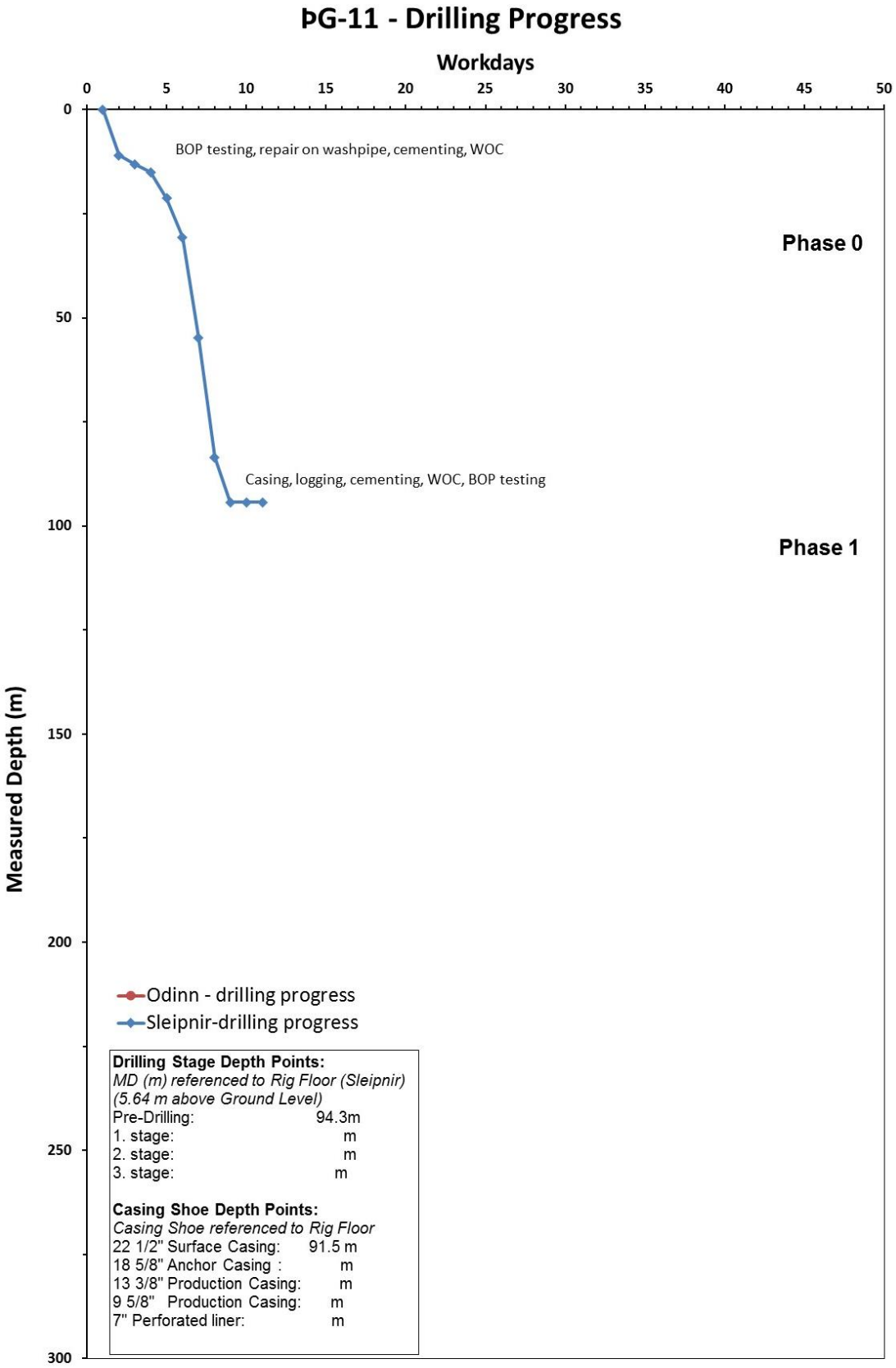


Figure 1. Drilling progress of ÞG-11 during drilling of phase 0.

Þeistareykir

Report #11
Preliminary results

Pre-Drilling
(18⅝" surface casing)

Operator:	**Landsvirkjun**	*Drilling Company:*	**Iceland Drilling Company**
Well Name:	**ÞG-11**	*Drill-Rig:*	**Sleipnir**
Well-Id:	**60411**	*Geologist/Geophysicist:*	**SRG** (E-mail: srg@isor.is)

Last casing size:	18 5/8" (surface casing)	Depth at 24 hrs.	94.3 m	Hole made last 24 hrs. :	0 m
Last casing depth:	91.5 m	Depth at 8 hrs.	94.3 m	Drilling time:	0 hrs.
Drilling fluid:	-	Circulation losses at 8 hrs.	0 l/s	Average ROP:	0 m/hr

Drilling operations

The specialist from the Netherlands arrived at the drill site around 21:00 last evening. He replaced an O-ring in the pipe-ram since the original one was too small, causing the leakage. At 23:00 the drill crew was working on building the BOP. Currently at 09:00 the 22nd of May, the BOP is ready and the next thing to do is to work on connecting the flow-line. The toolpusher expects that drilling may be conducted later today/evening, after the BOP has been pressure tested.

Figures 1-3 show the drill crew working on connecting the flow-line.

Figures 1-3. The drill crew working on connecting the flow-line.

ÍSOR ICELAND GEOSURVEY	**ÞG-11**	**Monday** **23rd of May 2016** Workday #14

Þeistareykir	**Report #12** **Preliminary results**	**Pre-Drilling** **(18⅝″ surface casing)**

Operator:	**Landsvirkjun**	*Drilling Company:*	**Iceland Drilling Company**
Well Name:	**ÞG-11**	*Drill-Rig:*	**Sleipnir**
Well-Id:	**60411**	*Geologist/Geophysicist:*	**SRG** **(E-mail: srg@isor.is)**

Last casing size:	**18 5/8"** **(surface casing)**	**Depth at 24 hrs.**	**94.3 m**	**Hole made last 24 hrs. :**	**0 m**
Last casing depth:	**91.5 m**	**Depth at 8 hrs.**	**94.3 m**	**Drilling time:**	**0 hrs.**
Drilling fluid:	**-**	**Circulation losses at 8 hrs.**	**0 l/s**	**Average ROP:**	**0 m/hr**

Drilling operations

During pressure testing of the BOP the 22nd of May it turned out that the lower annular preventer was leaking. At 20:10 it was decided to take down the BOP and repair the annular preventer. Currently at 10:00 the 23rd of May, the drill crew is working on repairing the BOP, and hopefully it will be successfully pressure tested later today/evening.

Figures 1-3 show the drill crew working on taking down the BOP.

Figures 1-3. The drill crew working taking down the BOP.

ÍSOR ICELAND GEOSURVEY	**ÞG-11**	**Tuesday** **24th of May 2016** Workday #15

Þeistareykir	**Report #13** **Preliminary results**	**Pre-Drilling** **(18⅝" surface casing)**

Operator:	**Landsvirkjun**	*Drilling Company:*	**Iceland Drilling Company**
Well Name:	**ÞG-11**	*Drill-Rig:*	**Sleipnir**
Well-Id:	**60411**	*Geologist/Geophysicist:*	**SRG** **(E-mail: srg@isor.is)**

Last casing size:	**18 5/8"** **(surface casing)**	**Depth at 24 hrs.**	**94.3 m**	**Hole made last 24 hrs. :**	**0 m**
Last casing depth:	**91.5 m**	**Depth at 8 hrs.**	**94.3 m**	**Drilling time:**	**0 hrs.**
Drilling fluid:	**-**	**Circulation losses at 8 hrs.**	**0 l/s**	**Average ROP:**	**0 m/hr**

Drilling operations

The BOP was reinstalled at 15:00 the 23rd of May. The flow-line was connected and following the lower annular preventer was pressure tested with 20 bar for 10 minutes, and passed. Next, the upper annular preventer was successfully pressure tested with 20 bar for 10 minutes. Between 20:00-23:00 the drill crew worked on putting together the BHA, and it was lowered into the well just before midnight. Currently, at 08:30 the 24th of May, drilling into cement is carried out, drilling into formation is expected to be conducted around noon.

ÍSOR ICELAND GEOSURVEY	**ÞG-11**	**Wednesday** **25th of May 2016** Workday #16

Þeistareykir	**Report #14** **Preliminary results**	**Phase 1** **(13 ⅝" anchor casing)**

Operator:	**Landsvirkjun**	*Drilling Company:*	**Iceland Drilling Company**
Well Name:	**ÞG-11**	*Drill-Rig:*	**Sleipnir**
Well-Id:	**60411**	*Geologist/Geophysicist:*	**SRG** **(E-mail: srg@isor.is)**

Last casing size:	**18 ⅝"** **(surface casing)**	**Depth at 24 hrs.**	**145 m**	**Hole made last 24 hrs. :**	**51 m**
Last casing depth:	**91.5 m**	**Depth at 8 hrs.**	**175 m**	**Drilling time:**	**11 hrs.**
Drilling fluid:	**Mud**	**Circulation losses at 8 hrs.**	**0 l/s**	**Average ROP:**	**4.6 m/hr**

Drilling operations

Drilling into formation at 94 m started at noon the 24th of May. Drilling was continuous until 23:00 at depth of 145 m with no circulation losses. Between 23:00 and 00:00 drilling was stopped for rinsing and replacing the Washington. 09:30 the 25th of May, the well depth is 175 m and drilling has not been in operation for few hours due to maintance in the engine of the drill. Drilling is now (10:00) back in action with ROP around 6 m/h. Figure 1 shows the drilling progress of well ÞG-11.

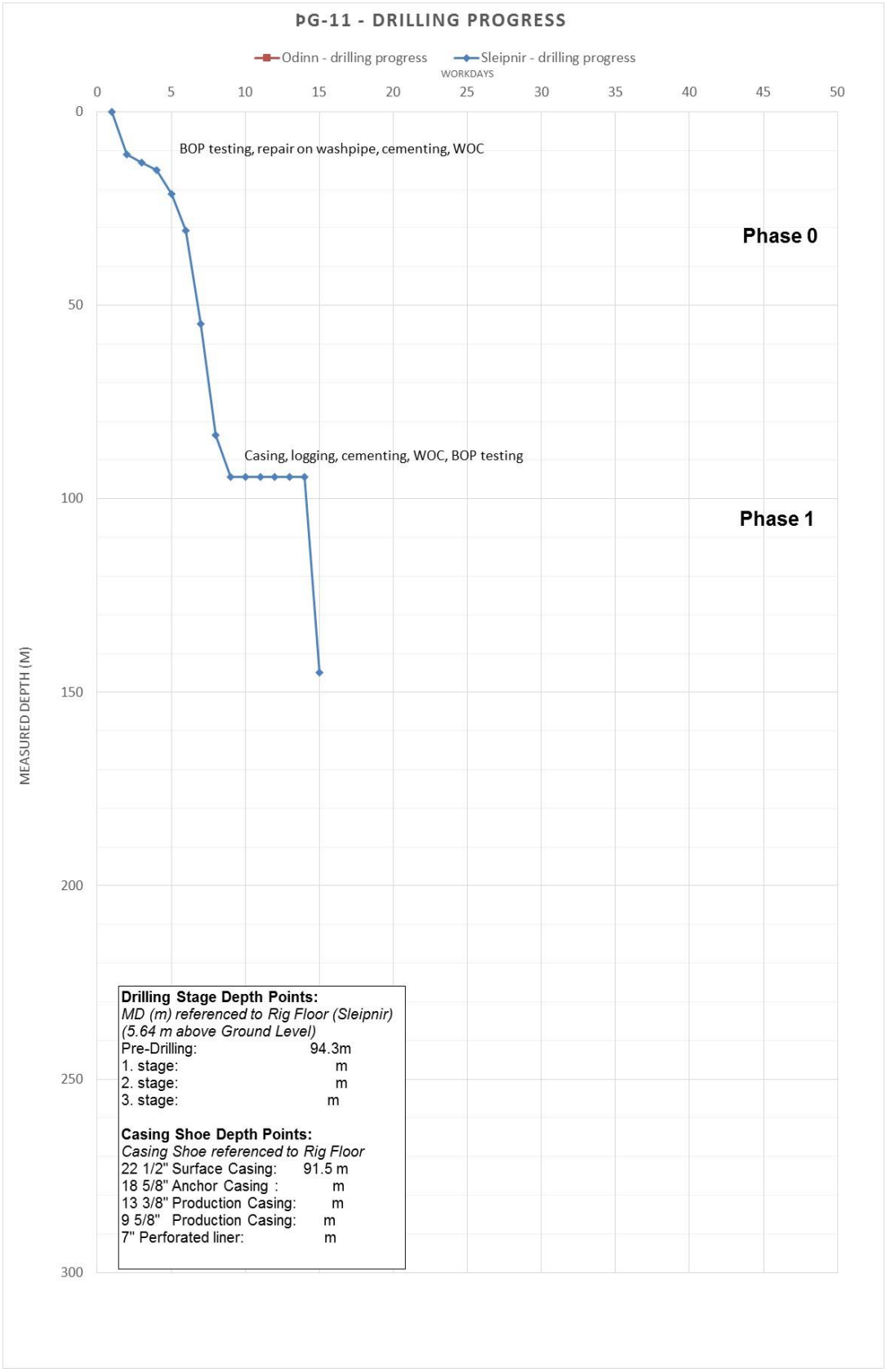


Figure 1. Drilling progress of well ÞG-11

Geology
The lithology from 93-124 m in well ÞG-11 is as follows:

93-94,3 BASALTIC TUFF
Grey-ish, rather pyrite-rich tuff.

94,3-104 REWORKED TUFF
white/greyish and even green tuff. Medium/highly altered. Grains rather dense, but often very fracured with white/clear fillings (calcite). Zeolites and clay often in pores. Occasional grain has plagioclase micro-phenocrysts. Little less altered down the formation and becomes more porous.

104-114 m BASALTIC BRECCIA
CPX and plagioclase rich. Less fracuted than above. Very largegly grained cuttings. Occasional sediment grain with very fine groundmass. cCay in pores.

114-116 m BASALTIC TUFF
Brownish tuff. Pores filled with white deposits. likely zeolites since no calcite was found in the sample.

116-124 m REWORKED TUFF
very dense and fractured tuff (sedimentary?). Grayish and very fine grained. Slightly phyric with plagioclase and altered olivine. Chalcedony found in pores as well as zeolites and calcite.

The lithology of well ÞG-11 is in good agreement with the lithology from ÞG-09 as may be seen on Figure 2. From the figure it is clear that below ~100 m depth, hyaloclastite formation are dominant and based on the drill cuttings from ÞG-9 those formations can be expected to reach down to approximately 240 m, where basaltic lava formations take over.

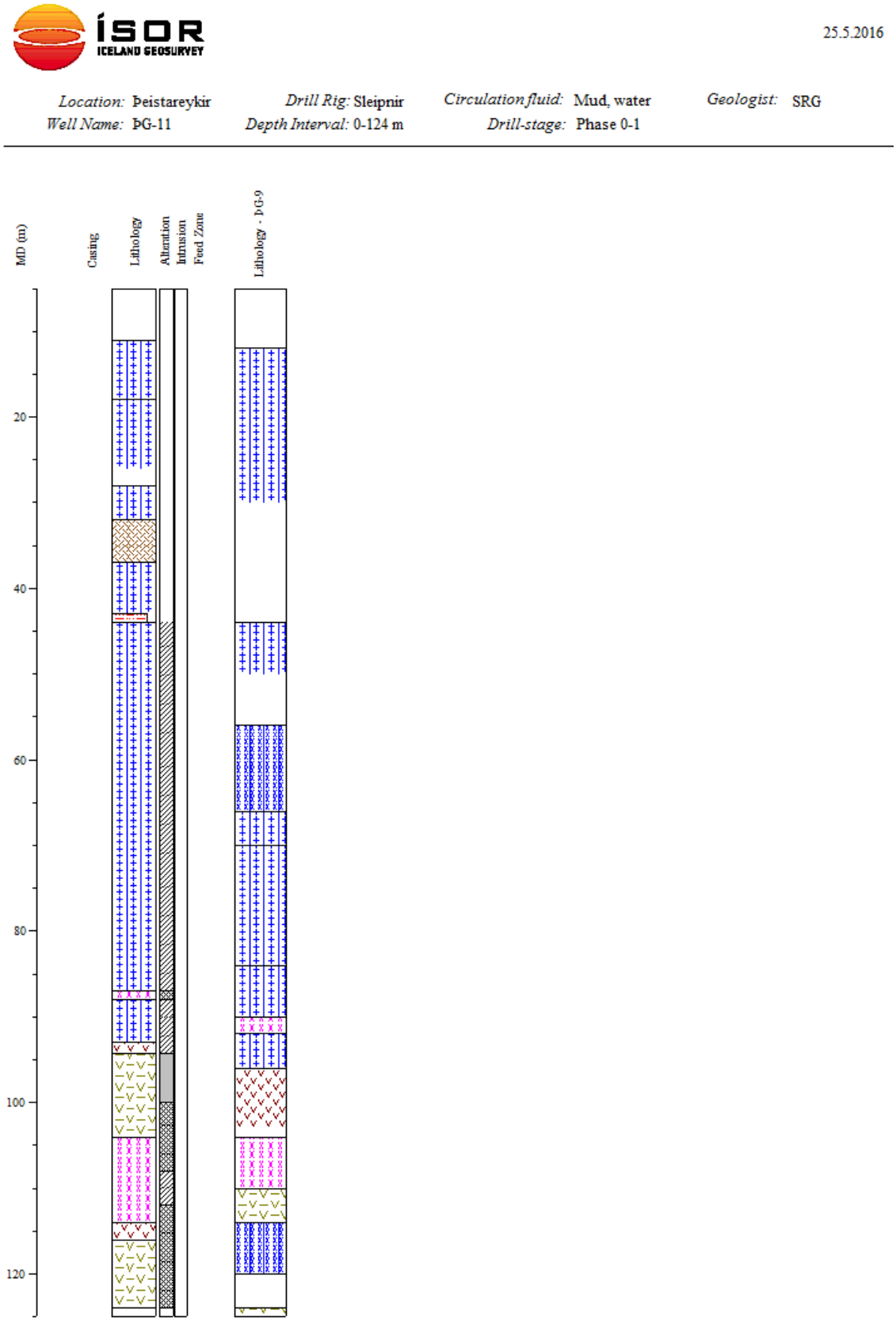


Figure 2. Comparison of the lithology in wells ÞG-11 and ÞG-09 from wellpad B.

Figure 3 shows the lithology of ÞG-11 with descriptions for individual formations, along with the amount of calcite, pyrite and oxidation noticed in the drill cuttings.

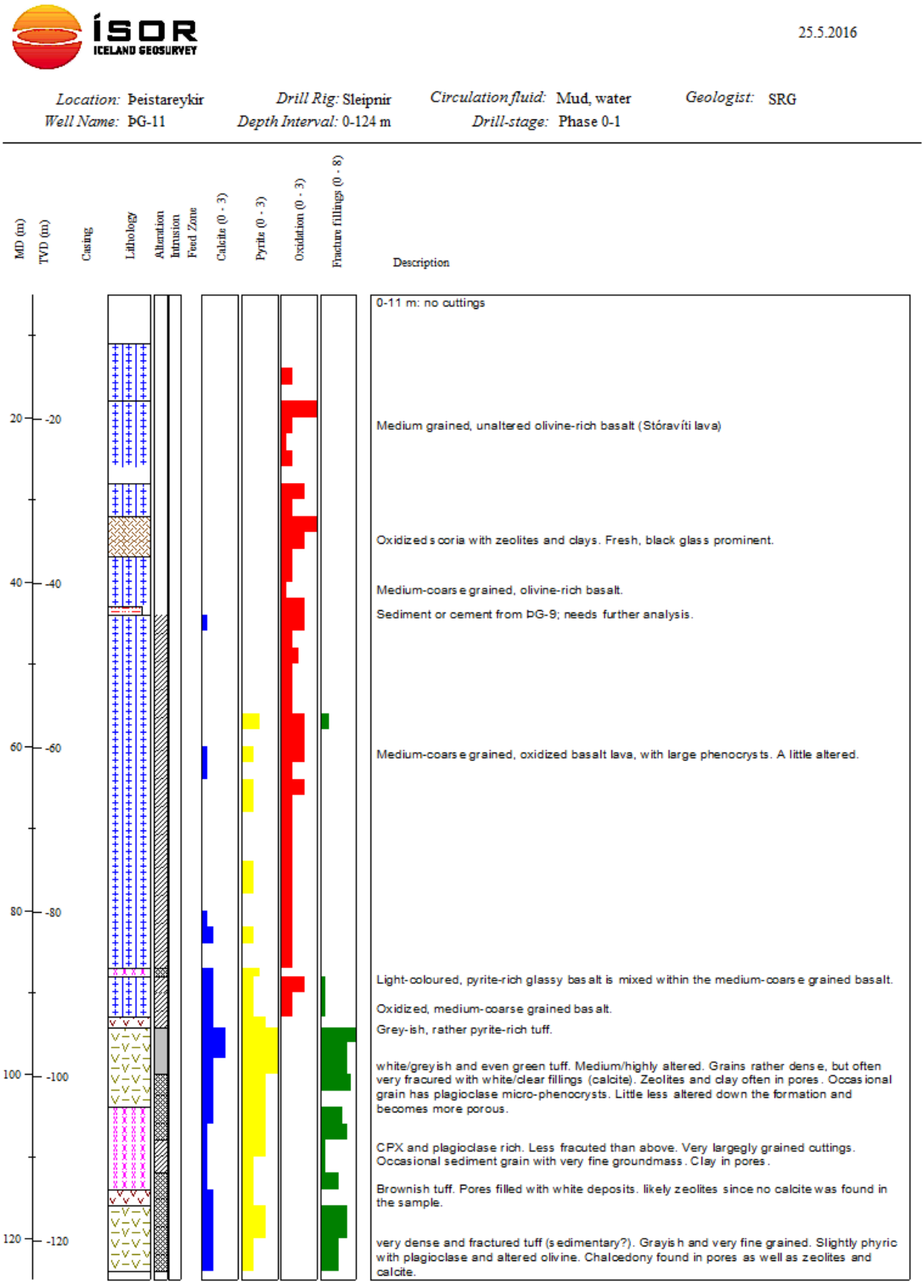


Figure 3. Lithology and descriptions from ÞG-09.

ÍSOR ICELAND GEOSURVEY	**ÞG-11**	**Thursday** **26th of May 2016** Workday #17

Þeistareykir	**Report #15** **Preliminary results**	**Phase 1** **(13 ⅝" anchor casing)**

Operator:	**Landsvirkjun**	*Drilling Company:*	**Iceland Drilling Company**
Well Name:	**ÞG-11**	*Drill-Rig:*	**Sleipnir**
Well-Id:	**60411**	*Geologist/Geophysicist:*	**SRG** **(E-mail: srg@isor.is)**

Last casing size:	**18 ⅝"** **(surface casing)**	**Depth at 24 hrs.**	**242 m**	**Hole made last 24 hrs. :**	**97 m**
Last casing depth:	**91.5 m**	**Depth at 8 hrs.**	**267m**	**Drilling time:**	**20.5 hrs.**
Drilling fluid:	**Mud**	**Circulation losses at 8 hrs.**	**0 l/s**	**Average ROP:**	**4.7 m/hr**

Drilling operations

Drilling started again at 09:30 yesterday, after the 2.5 hour maintance break. Drilling was continuous the rest of the day and the depth of the well was 242 m at midnight. No circulation losses were observed. The ROP was generally low, ranging from 3-7 m/h. Currently at 08:00 the well is 267 m deep. According to the night shift toolpusher the formations last night became very hard with very low ROP at around 235 m, the same depth basaltic lava formations replaced the hyaloclastite in well ÞG-09. Drilling is expected to be stopped around 300 m.

Geology

According to the drill crew, the drill bit penetrated through a fault at 178 m, similar depth that an overpressurized feed zone was detected in well ÞG-09. No signs were however of that here.

The lithology from 124-224 m in well ÞG-11 is as follows:

124-126 m: BASALTIC TUFF
Mostly green and quite altered basaltic tuff grains. Calcite and zeolites in pores.

126-128 m: BASALTIC BRECCIA
Some plagioclase and olivine (altered) rich grains, but mostly tuff grains.

128-142 m: BASALTIC TUFF
Highly altered, coarse grained and very green tuff. Pores up to 50% filled with chalcedony, pyrites, zeolites. Partly xx grains with plagioclase needles. Alteration increases downward.

142-150 m: REWORKED TUFF
Dense and tuff-rich sediment. Highly fractured with white/clear fillings. Mixed in are basaltic tuff grains. Cuttings gets more mixed downward where xx basaltic grains are mixed in with clay in pores.

150-166 m: BASALTIC BRECCIA
Quite mixed with tuff and partly xx grains. Calcite and zeolites in pores. Generally very tuff-rich. Quartz found at 166 m.

166-186 m: GLASSY BASALT
Less tuff grains. Porous with zeolites, clay and calcite in pores. Pyrite lumps in the middle of the formation. lower in the formation more xx basaltic grains are mixed in.

186-194 m: FINE-MEDIUM GRAINED BASALT
Mixed with tuff and glassy grains, but still mostly fine grained basalt grains with little alteration. Clay in pores, but still rather dense formation.

194-204 m: BASALTIC BRECCIA
More tuff appears in the cuttings. Abundant of pyrite associated with the tuff grains. Crystalline and more dense and less altered grains mixed in with the porous and filled hyaloclastite grains.

204-224 m: BASALTIC TUFF
Completely pyrite covered and white tuff grains. Grains fractured with pyrite as filling. White pore fillings as well. Still some xx basaltic grains mixed in and noticed calcite fracture. Occasional partly xx basaltic grains with plagioclase needles.

Figure 1 shows the lithology and alteration minerals from 90-224 m. From the figure it is clear that the alteration is increasing down the well. Quartz and waikarite appear semi-continuously around 200 m, and the low temperature zeolites disappear, indicating rock temperature over 180°C. Quartz was first noticed at 166 m as a very euhedral cluster. Since then the evidence of quartz has been more unclear with more anhedral and broken fragments, still indicating the existence of quartz.

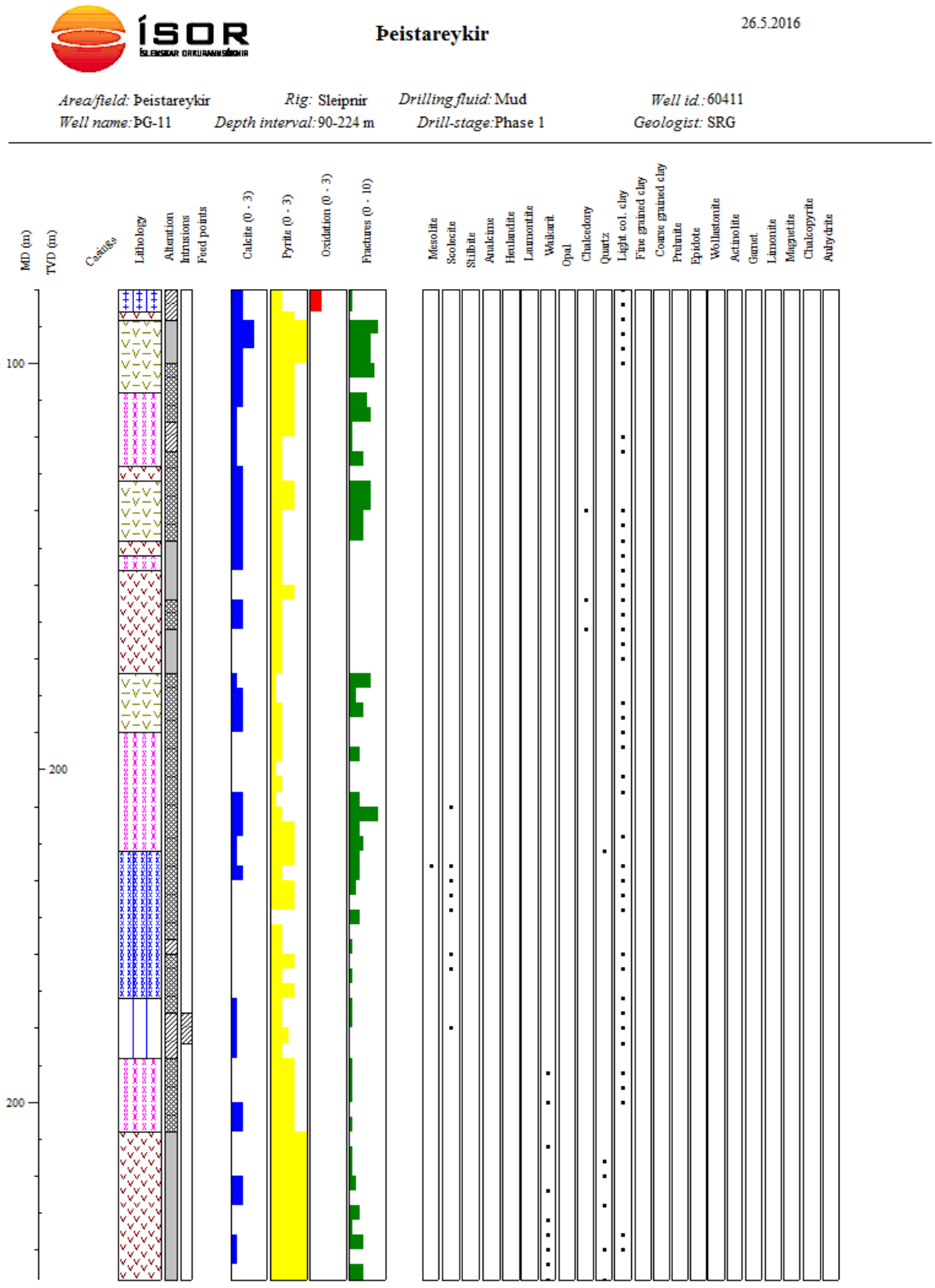


Figure 1. Lithology and alteration minerals from 90-224 m in well ÞG-11.

Figure 2 shows parts of the drilling data (ROP, WOB, MD, DeltaT) from the 24th of May, the beginning of phase 1.

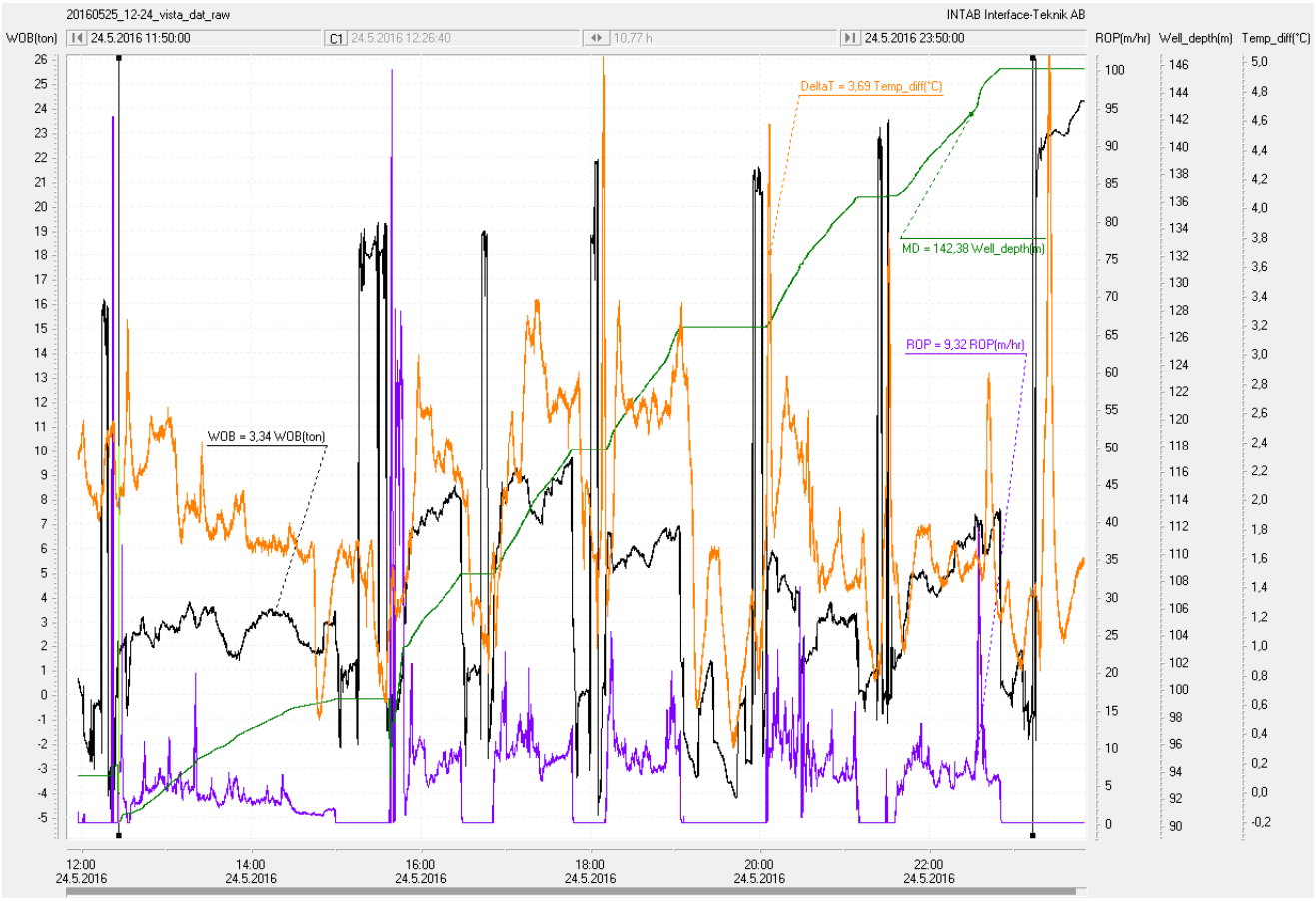


Figure 2. Drilling data from drill rig Sleipnir the 24th of May.

ÍSOR ICELAND GEOSURVEY	**ÞG-11**	**Friday** **27th of May 2016** Workday #18

Þeistareykir	**Report #16** **Preliminary results**	**Phase 1** **(13 ⅝" anchor casing)**

Operator:	**Landsvirkjun**	*Drilling Company:*	**Iceland Drilling Company**
Well Name:	**ÞG-11**	*Drill-Rig:*	**Sleipnir**
Well-Id:	**60411**	*Geologist/Geophysicist:*	**SRG** **(E-mail: srg@isor.is)**

Last casing size:	**18 ⅝"** **(surface casing)**	**Depth at 24 hrs.**	**304 m**	**Hole made last 24 hrs. :**	**62 m**
Last casing depth:	**91.5 m**	**Depth at 8 hrs.**	**304 m**	**Drilling time:**	**17 hrs.**
Drilling fluid:	**Mud**	**Circulation losses at 8 hrs.**	**0 l/s**	**Average ROP:**	**3.6 m/hr**

Drilling operations

Drilling was ongoing yesterday from 242 m-304 m when drilling was stopped and the anchor casing depth was reached. No circulation losses were observed. After drilling was stopped at around 17:00, the well was circulated clean for few hours. Bottom hole deposits was 1.5 m so the well was circulated further. At 22:30 Ísor´s logging engineers prepared for a temperature and warm up log, and started logging in the string with no pumping at 23:00. The warm up at 155 m and the temperature log are shown in figures 1-2. According to the temperature log the well has high temperature and there is an inflow at around 180 m where temperature rises rapidly. According to Figure 3 (from well ÞG-09) the formation temperature at that depth could easily be around 207°C. Figure 4 (from ÞG-09) shows that the system´s pressure at that depth is around 18 bar.

Further logging in the well has yet to be decided. Currently at 09:00 the 27th of May, POOH is in operation. Drilling progress of well ÞG-11 is shown on Figure 5.

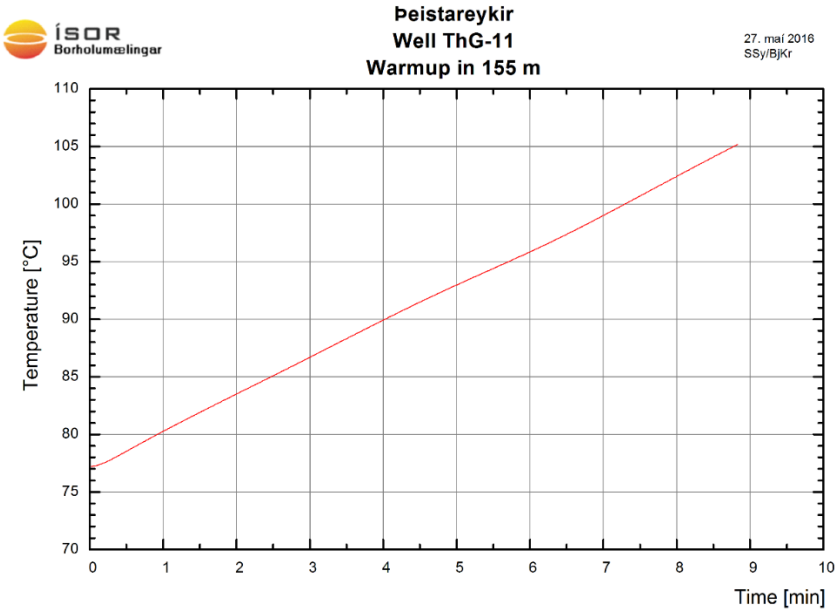


Figure 1. Warmup log at 155 m in well ÞG-11.

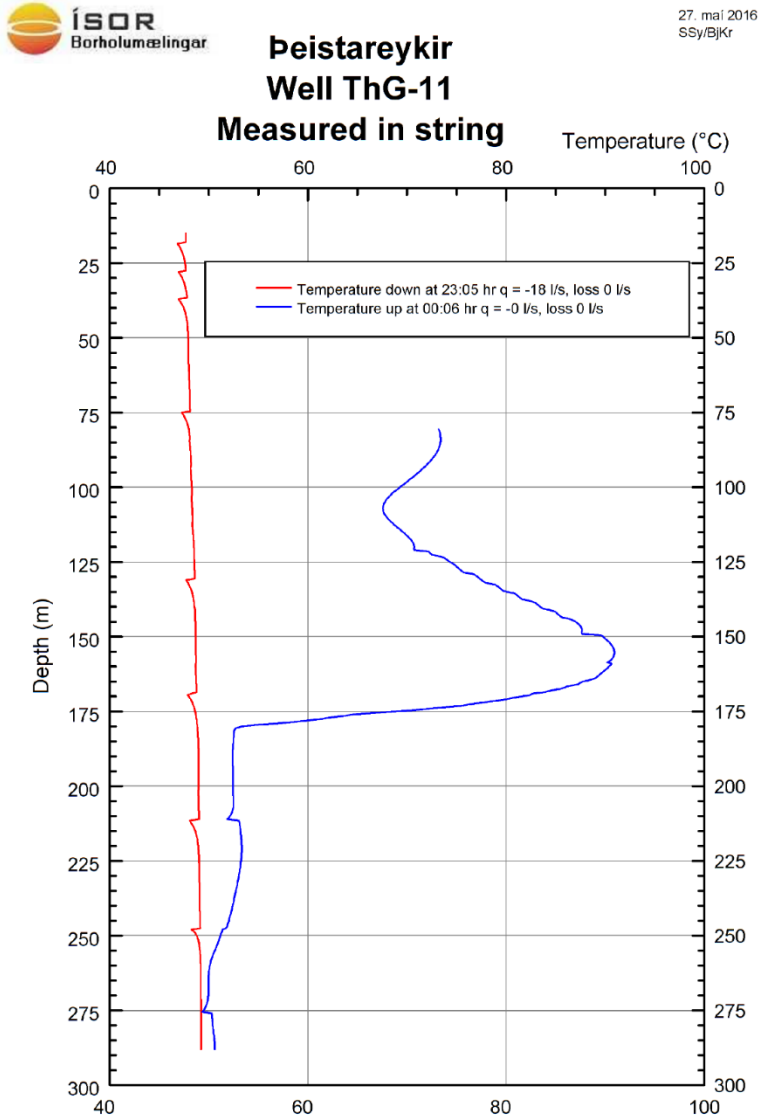


Figure 2. Temperature log from the 27th of May in well ÞG-11.

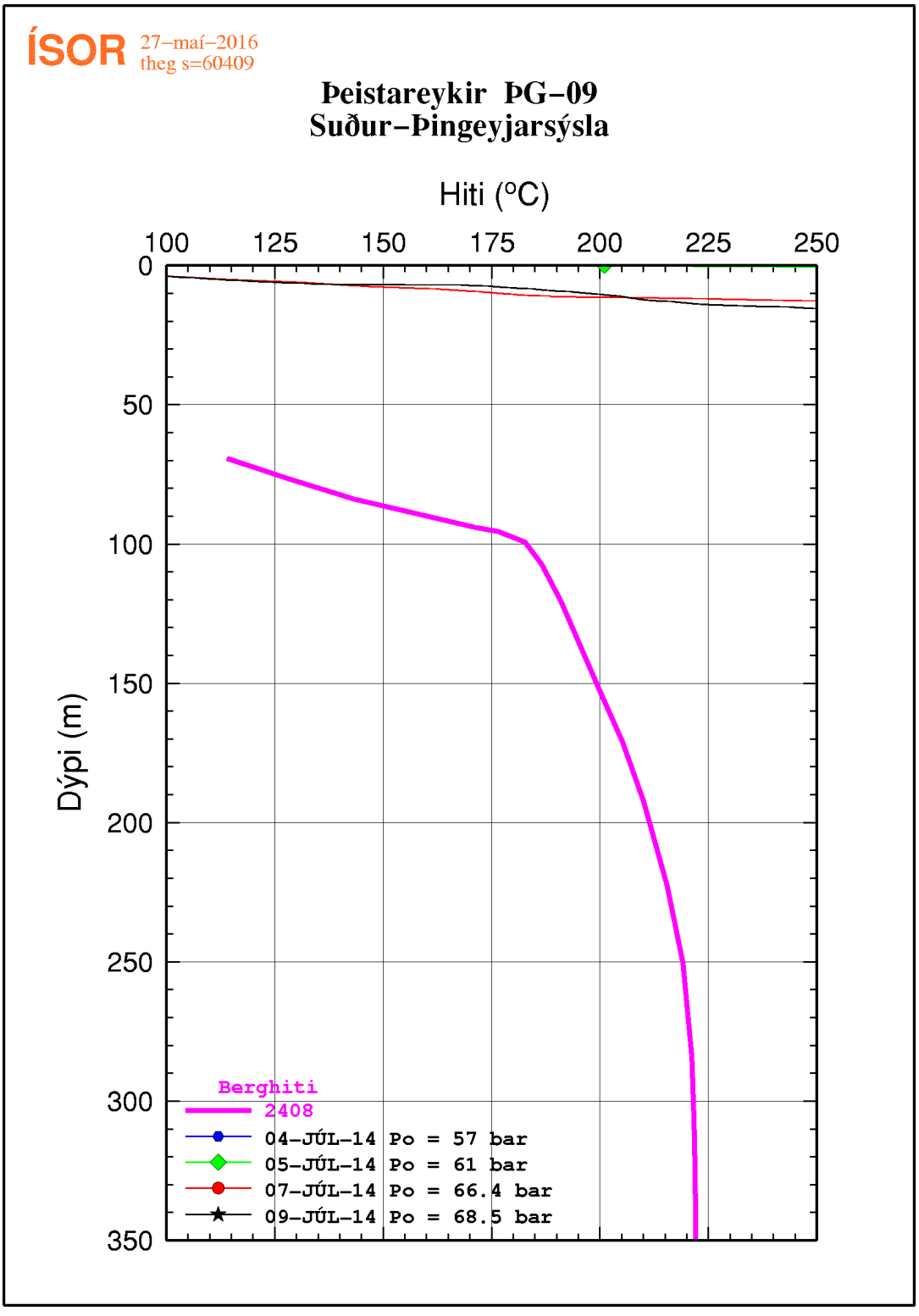


Figure 3. The formation temperature in ÞG-09.

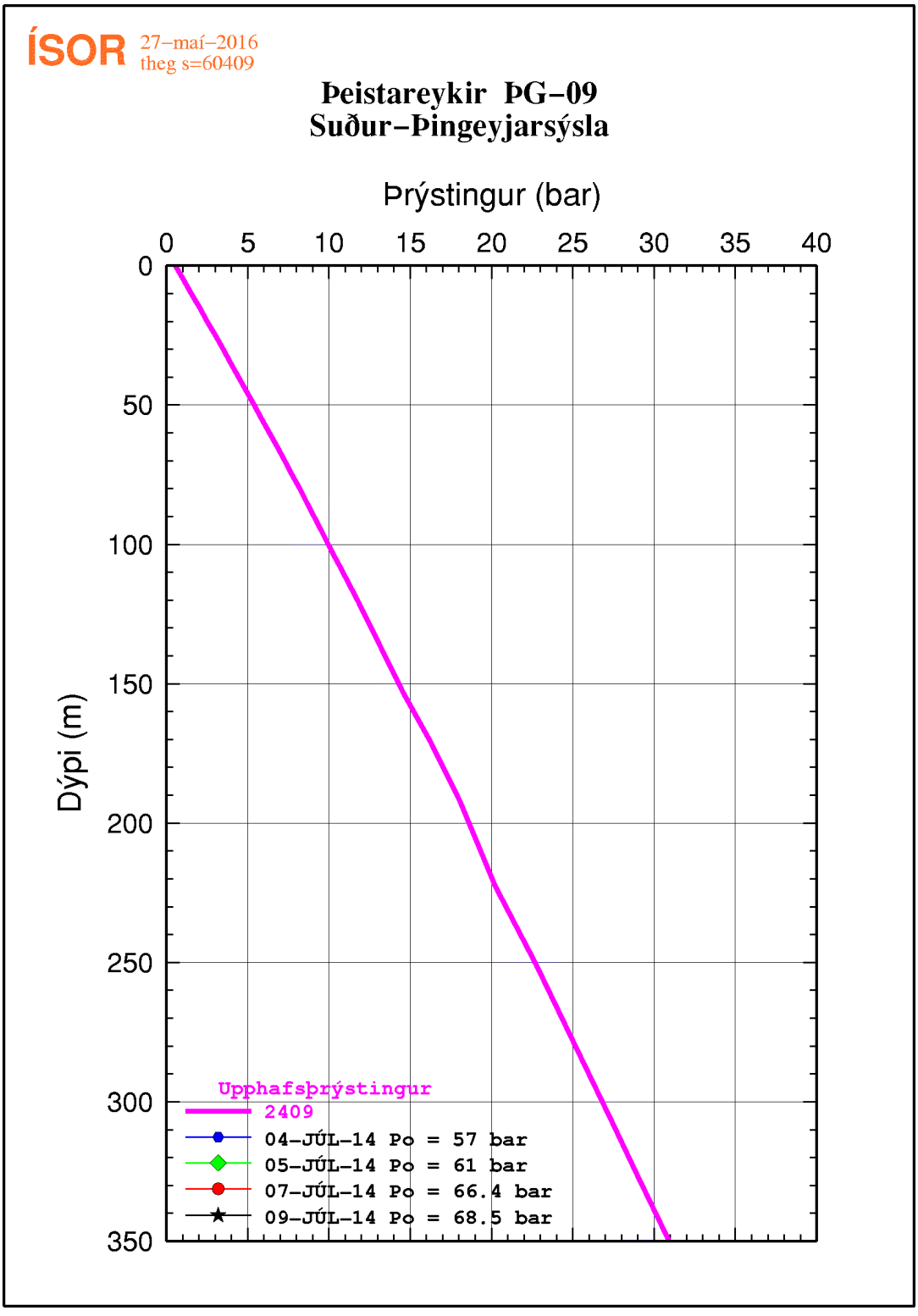


Figure 4. Pressure measurements from ÞG-09.

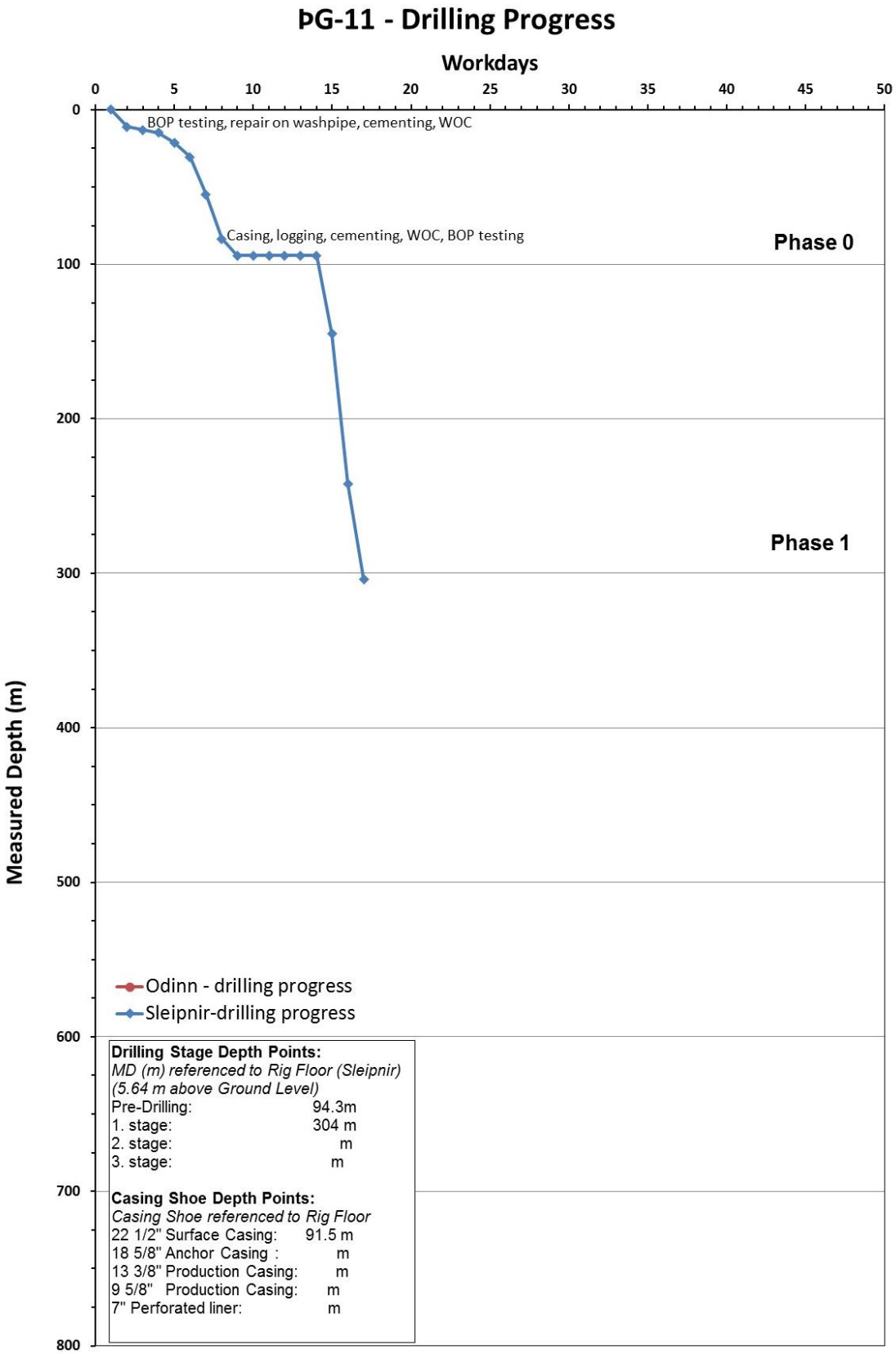


Figure 5. Drilling progress of ÞG-11.

Geology

The lithology from 204- 304 in well ÞG-11 is as follows:

204-236 m: BASALTIC TUFF

Almost completely pyrite covered and white tuff grains. Grains fractured with pyrite as filling. White pore fillings as well. Still some xx basaltic grains mixed in and noticed calcite fracture. Occasional partly xx basaltic grains with plagioclase needles.

236-246: FINE-MEDIUM GRAINED BASALT

Tuff mixed but mostly little/medium altered basalt. Dark grains and few a little greenish.

246-258 m: BASALTIC BRECCIA

White and fractured tuff grains with high amount of pyrite mixed with basalt grains. Various alteration. Down the formation tuff increases and coarse grained clay and quartz in pores. Small amount of calcite in pores as well.

258-262: BASALTIC TUFF

Totally altered white tuff grains with abundance of pyrite.

262-266 m: BASALTIC BRECCIA

Increase in dark crystallized basaltic grains, less altered with plagioclase needles.

266-290 m: FINE-MEDIUM GRAINED BASALT

Very altered greenish basalt with plagioclase needles. Mixed with white pyrite rich tuff. Quite hard to distinguish the lithology, could as well be a hyaloclastite formation, at least the upper parts. Pores filled with clay and pyrite in fissures. Slight increase in calcite downward. Alteration decreases around 282 m where grains become darker (partly xx) with plagioclase needles. Becomes more homogenous, well crystallized and partly altered at 290 m.

Figure 6 shows chosen drilling parameter from the drill rig Sleipnir during drilling the 25th of May. From the figure it can be seen how the differential temperature (DeltaT) rises from approximately 5.5°C-8.5°C at around 16:00, which is at similar depths (around 190 m) where the influx is seen on the temperature log (Figure 2). Figure 6 also shows fluctuations in the ROP from approximately 194-236 MD, where the drill was penetrating through hyaloclastite formations. The ROP than suddenly decreased and stabilized when fine grained basalt basalt formation replaced the hyaloclastite at 236 MD.

Figure 7 shows the strings for the anchor casing being transported to the drill site.

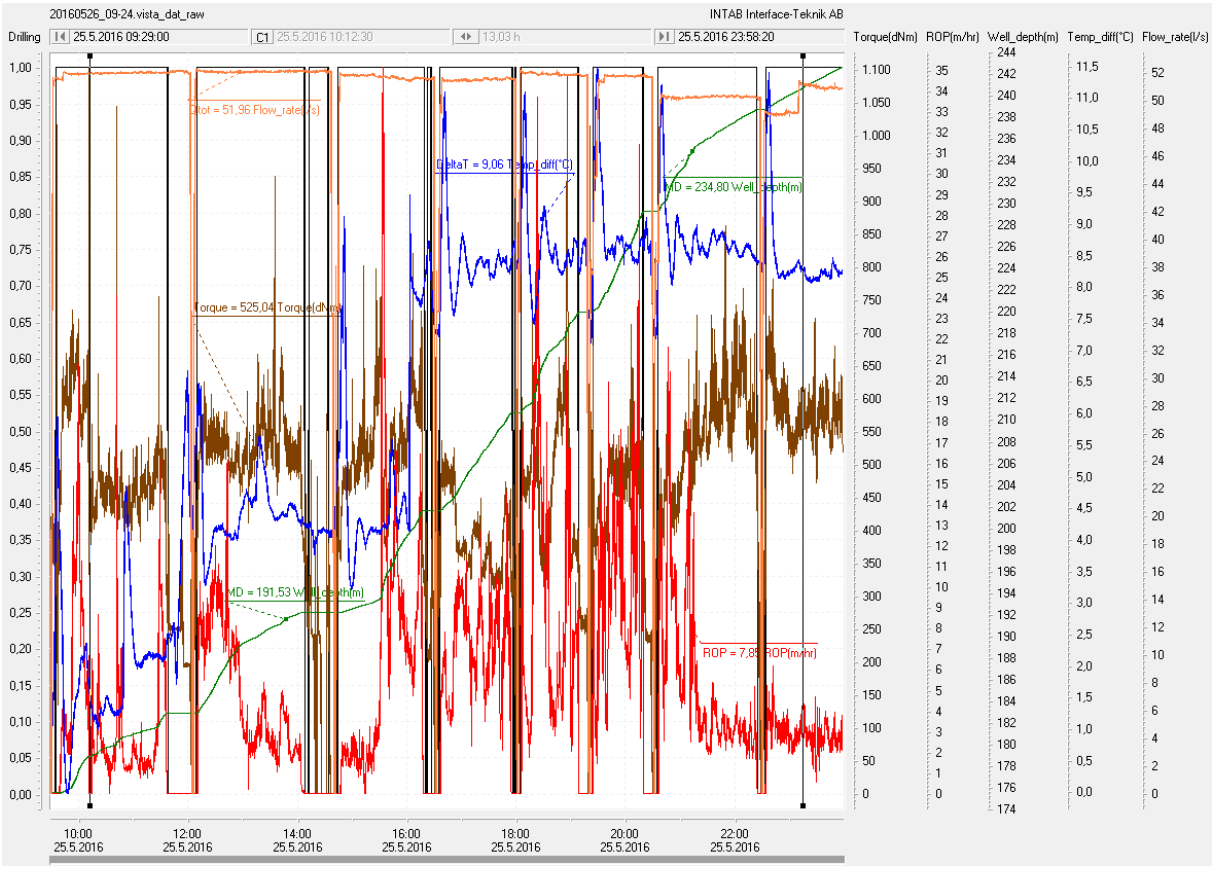


Figure 6. Drilling data (Qtot, Torque, ROP, DeltaT, Well depth) the 25th of May

Figure 7. The 13⅝" anchor casing being transported to the drill site.

ÍSOR ICELAND GEOSURVEY	**ÞG-11**	**Saturday** **28th of May 2016** Workday #19

Þeistareykir	**Report #17** **Preliminary results**	**Phase 1** **(13 ⅝" anchor casing)**

Operator:	**Landsvirkjun**	*Drilling Company:*	**Iceland Drilling Company**
Well Name:	**ÞG-11**	*Drill-Rig:*	**Sleipnir**
Well-Id:	**60411**	*Geologist/Geophysicist:*	**BG/ÞEg BK** **(E-mail: bg@isor.is)**

Last casing size:	**18 ⅝"** **(surface casing)**	**Depth at 24 hrs.**	**304 m**	**Hole made last 24 hrs. :**	**0 m**
Last casing depth:	**91.5 m**	**Depth at 8 hrs.**	**304 m**	**Drilling time:**	**0 hrs.**
Drilling fluid:	**Mud/Water**	**Circulation losses at 8 hrs.**	**0 l/s**	**Average ROP:**	**m/hr**

Drilling operations

After the temperature log was completed early Friday morning it was clear that some gas was seeping into the well at ~180 m depth. POOH started around 05:30 yesterday morning. Shortly after 9:00 AM yesterday morning, when pulling out the first collar, the well erupted a considerable amount of mud (Fig. 1). The annular BOP was closed immediately. At this time the bit was at approximately 90 m depth. The top part of the well was then cooled down by circulating mud. The mud was gradually diluted with water. According to the well-site engineer the amount of fluid needed to fill the well was approximately equal to the well volume above the aquifer at 180 m. Shortly after lunch POOH continued with stripping the BHA through the annular BOP's. The bit was on the surface shortly after 19:00.

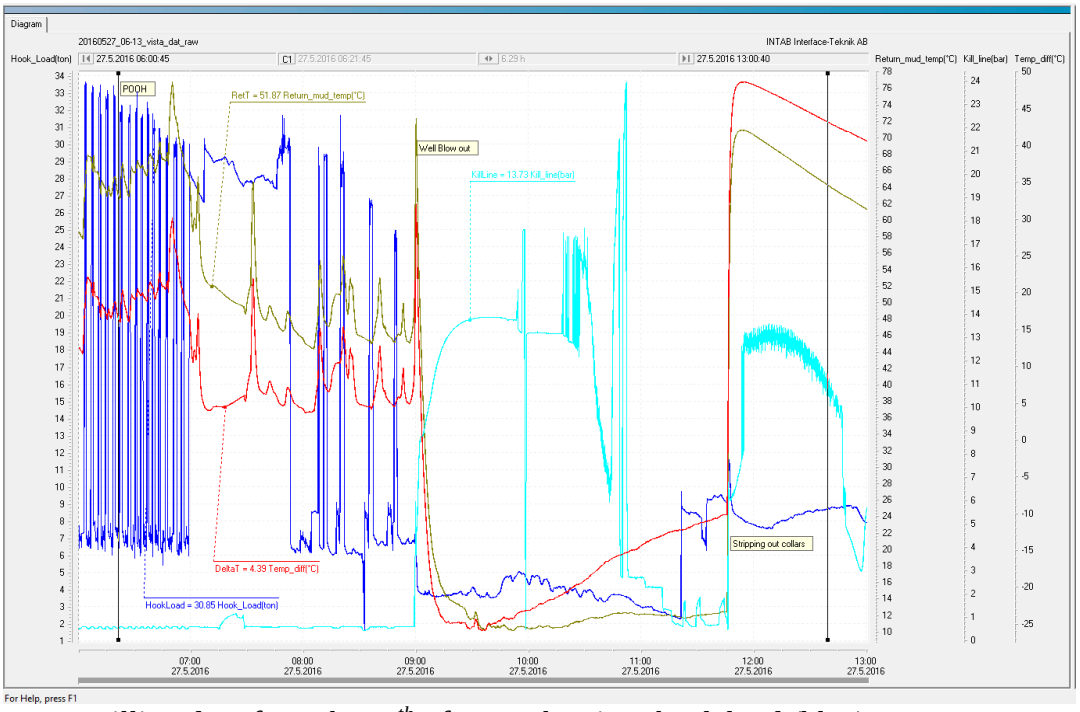


Figure 1. *Drilling data from the 27th of May, showing: hook load (blue); temperature difference (red); return temperature (green); kill-line P (light blue).*

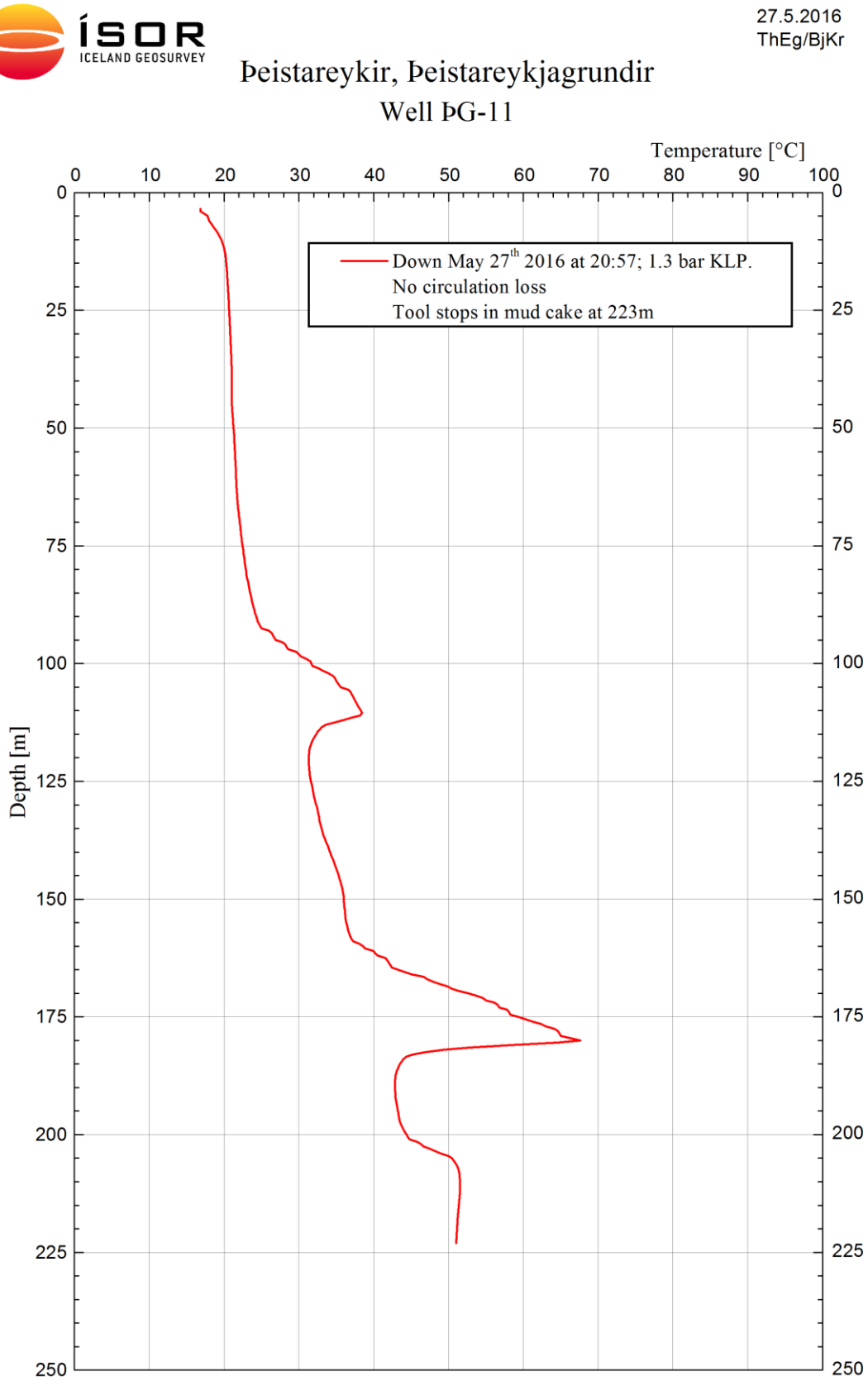


Figure 2. *Temperature log from ÞG-11 (27.05.2016). The gas-seep or aquifer at 180 m is clearly visible and in addition some gas is probably seeping into the well at 110 m, just below the casing.*

A temperature log was run in the well starting around 21:00 last night. A pup-joint with poor-boy was put in the well and the pipe-ram and annular BOP were closed. The temperature tool was mounted with the blind ram closed and the well was kept full and well head assembly cooled by circulating water through the pup-joint and out on the kill line. Pressure on the kill-line was 1.3 bar and no circulation loss was detected.
Results of the temperature-log are shown in Fig. 2. The gas-seep (or aquifer) at 180 m is clearly visible and in addition some gas is probably seeping into the well at ~110 m depth. This gas seep was not visible in the earlier run.
After the temperature log was run a decision was made to abandon further logging in this section and to prepare for casing the well. The crew started to prepare for casing the well. Various extra measures are introduced because the casing will be stripped through the annular BOP's. Shortly after midnight it was discovered that the 13 ⅝" single valve float collar delivered to the drill-site does not meet all the required specifications. The issue is being dealt with but it will cause delays.

Figure 3. *ÍSOR's vehicle was exposed to a spray of mud early Friday morning.*

ÍSOR ICELAND GEOSURVEY	**ÞG-11**	**Sunday** **29th of May 2016** Workday #20

Þeistareykir	**Report #18** **Preliminary results**	**Phase 1** **(13 ⅝" anchor casing)**

Operator:	**Landsvirkjun**	*Drilling Company:*	**Iceland Drilling Company**
Well Name:	**ÞG-11**	*Drill-Rig:*	**Sleipnir**
Well-Id:	**60411**	*Geologist/Geophysicist:*	**BG/ÞEg BK** **(E-mail: bg@isor.is)**

Last casing size:	**18 ⅝"** **(surface casing)**	**Depth at 24 hrs.**	**304 m**	**Hole made last 24 hrs. :**	**0 m**
Last casing depth:	**91.5 m**	**Depth at 8 hrs.**	**304 m**	**Drilling time:**	**0 hrs.**
Drilling fluid:	**Mud/Water**	**Circulation losses at 8 hrs.**	**0 l/s**	**Average ROP:**	**m/hr**

Drilling operation

A modified float collar arrived at the drill site around lunch-time yesterday. The casings had been laid out, numbered and measured, and the float shoe and float collar attached to what will become the bottom two casings. However, running in with the casing has been delayed since then due to the fact that the elevator that was delivered to site cannot be used on this rig. A suitable elevator is expected to arrive around mid-day today, and hopefully casing of the well will start in the afternoon.

Figure 9. *The 17½" bit that was used for drilling for the 13⅝" anchor casing, Mt. Bæjarfjall in the background.*

Geology

The lithology and alteration in the top 300 m of well ÞG-11 is similar to what was observed in well ÞG-09. Both wells are drilled from platform B, so strong similarities to be were expected.

The lithological log for well ÞG-11 from surface to 304 m depth is compiled in Figures 2, 3 and 4. For comparison the lithology of well ÞG-09 is shown as well.

The uppermost 90 to 100 m in these wells are characterized by medium grained basalts, overlying a thick succession of tuffs (including reworked tuffs), and glassy basalts. This formation is cut by a fine grained basalt at 190 m depth. Below 240 m the succession is characterized by fine grained basalts.

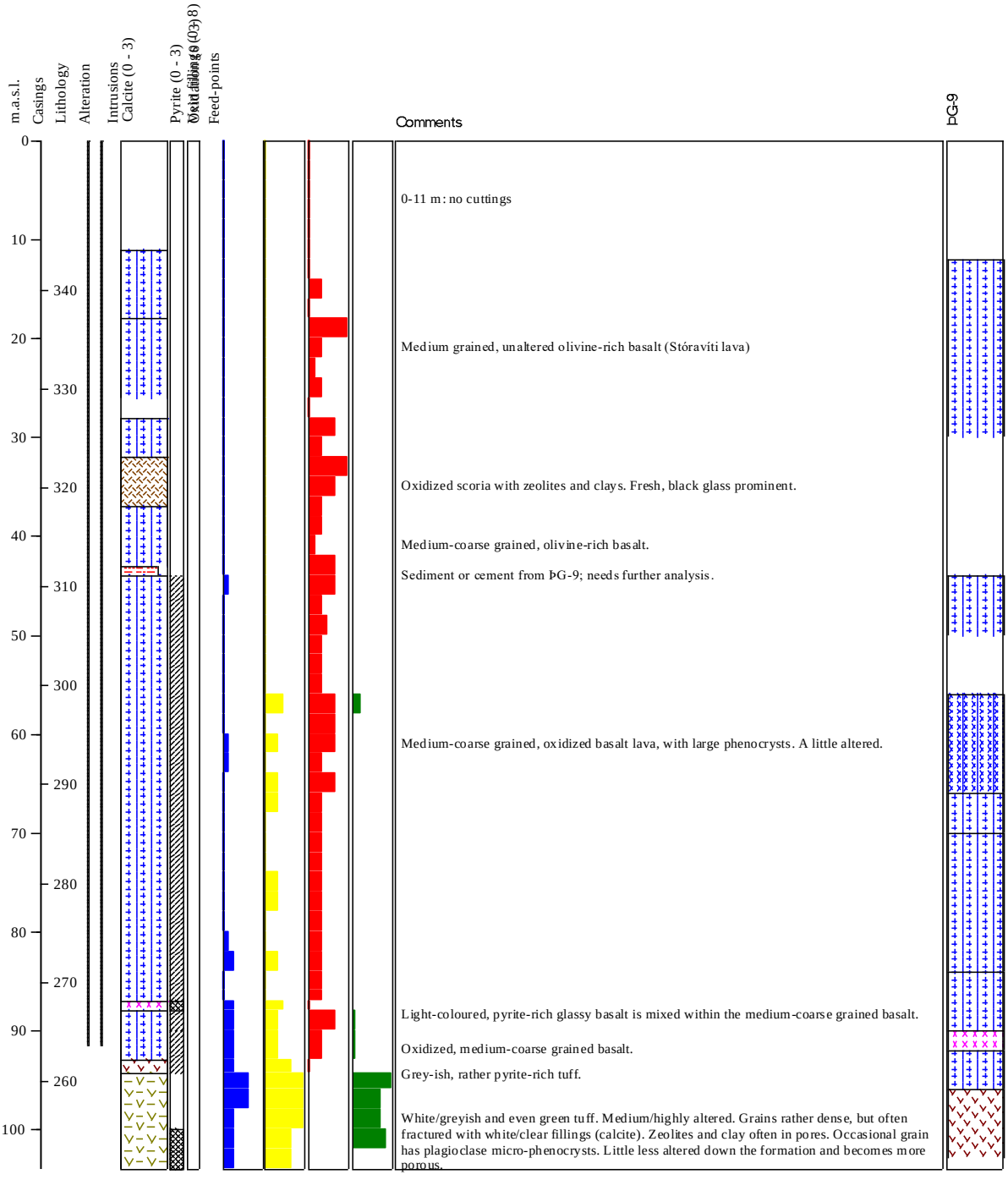


Figure 2. *Stratigraphy (0-100 m) and key alteration parameters, from the 0th and 1st section of well ÞG-11, with comparison to well ÞG-9.*

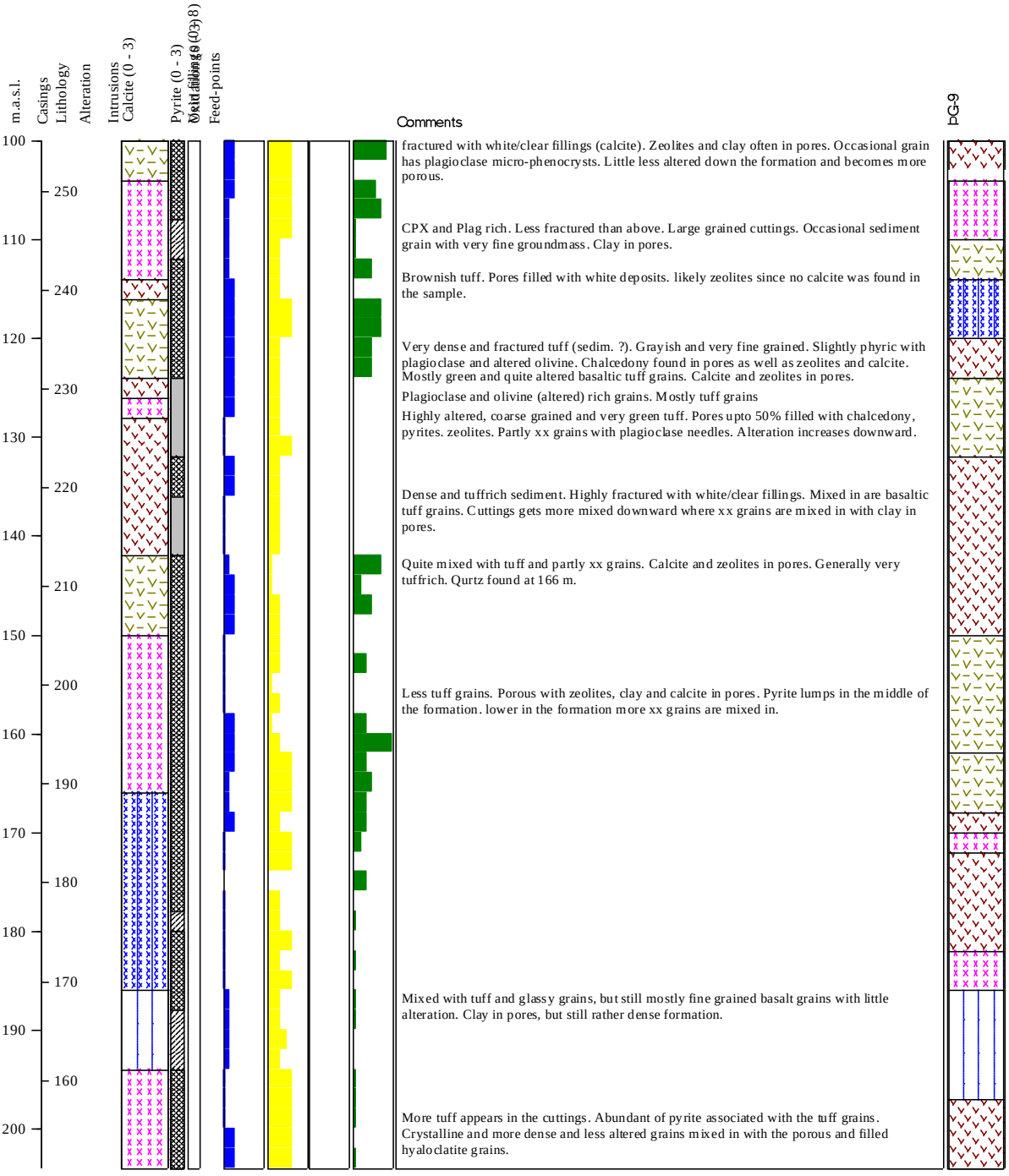


Figure 3. *Stratigraphy (100-200 m) and key alteration parameters, from the 0th and 1st section of well ÞG-11, with comparison to well ÞG-9.*

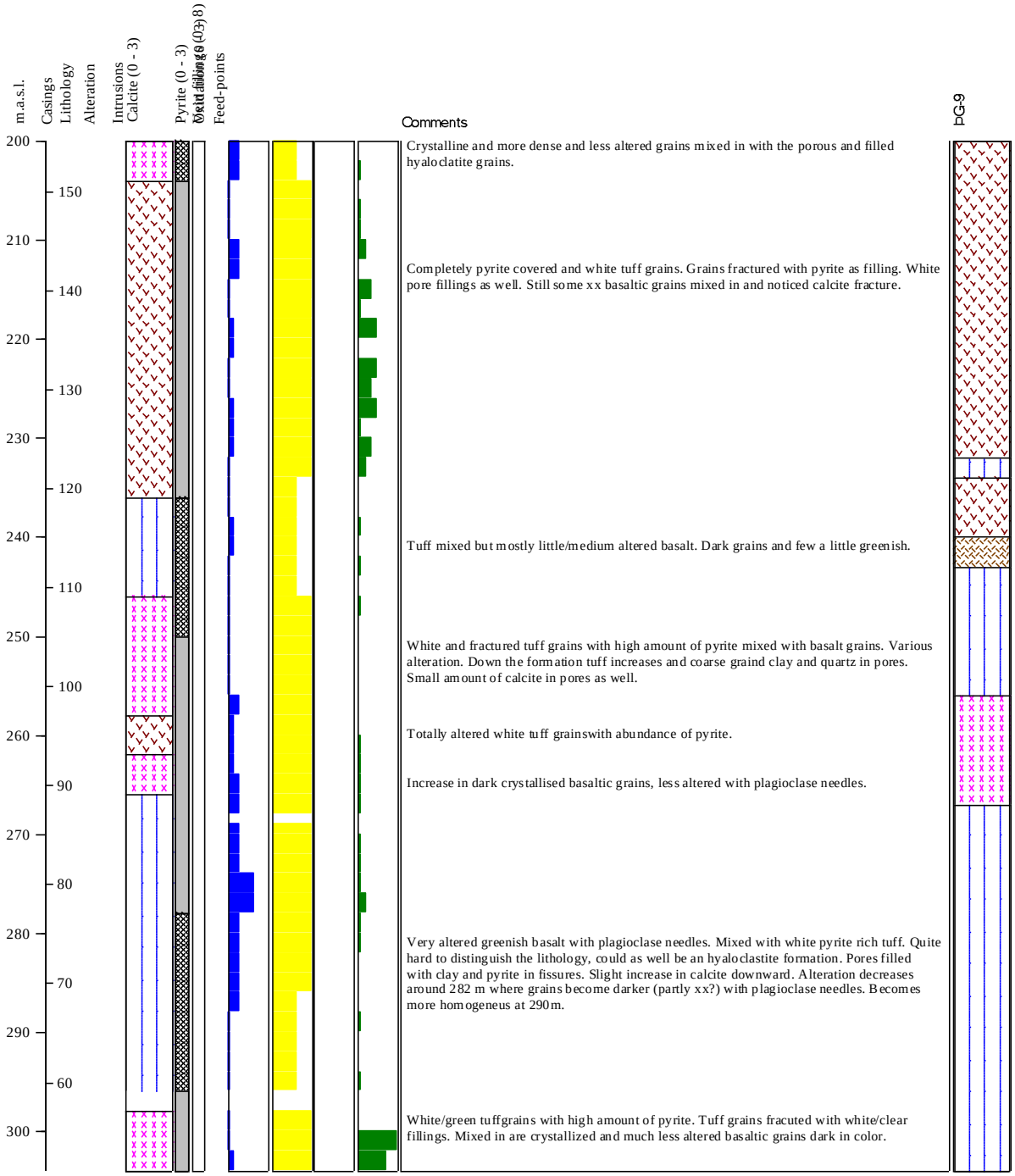


Figure 4. *Stratigraphy (200-304 m) and key alteration parameters, from the 0th and 1st section of well ÞG-11, with comparison to well ÞG-9.*

ÍSOR ICELAND GEOSURVEY

ÞG-11

Monday
30th of May 2016
Workday #21

Þeistareykir

Report #19
Preliminary results

Phase 1
(13 ⅝" anchor casing)

Operator:	**Landsvirkjun**	*Drilling Company:*	**Iceland Drilling Company**
Well Name:	**ÞG-11**	*Drill-Rig:*	**Sleipnir**
Well-Id:	**60411**	*Geologist/Geophysicist:*	**BG/ÞEg BK** (E-mail: bg@isor.is)

Last casing size:	**18 ⅝"** (surface casing)	**Depth at 24 hrs.**	**304 m**	**Hole made last 24 hrs. :**	**0 m**
Last casing depth:	**91.5 m**	**Depth at 8 hrs.**	**304 m**	**Drilling time:**	**0 hrs.**
Drilling fluid:	**Mud/Water**	**Circulation losses at 8 hrs.**	**0 l/s**	**Average ROP:**	**m/hr**

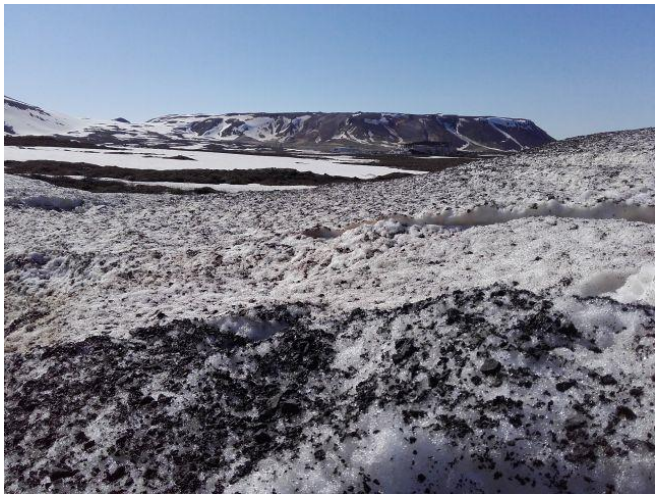


Figure 10. *Snow is rapidly melting away in the Þeistareykir area*

Drilling operation

The modified elevator arrived at the drill site around 18:00 yesterday. When the crew attempted to start running in with the casing it became clear that the upper annular BOP was not functioning properly. The rubber "donut" in the annular BOP had to be replaced. Early this morning running in with the 13 ⅜" casing commenced. Since the casing is being stripped in the procedure is expected to take up to 24 hrs.

Geology

A recap of the drilling history during the drilling for the preliminary casing, surface casing and anchor casing is shown in Figs 1. and 2. A cursory inspection of the figures reveals that the tuffs and glassy basalts are in general easier to drill through (higher ROP's for a given WOB) than the crystallized basalts, either fine- or medium grained. No major losses of circulation have occurred but gas rich aquifers were revealed in temperature logs last Friday as has been discussed in previous reports.

Location: Þeistareykir *Drill rig:* Sleipnir *Drilling fluid:* Mud, water *UWI:* 60411
Well: ÞG-11 *Depth interval:* 0-304 m *Work phase:* Anchor Casing *Geologists:* MÁS/SÁ/SRG

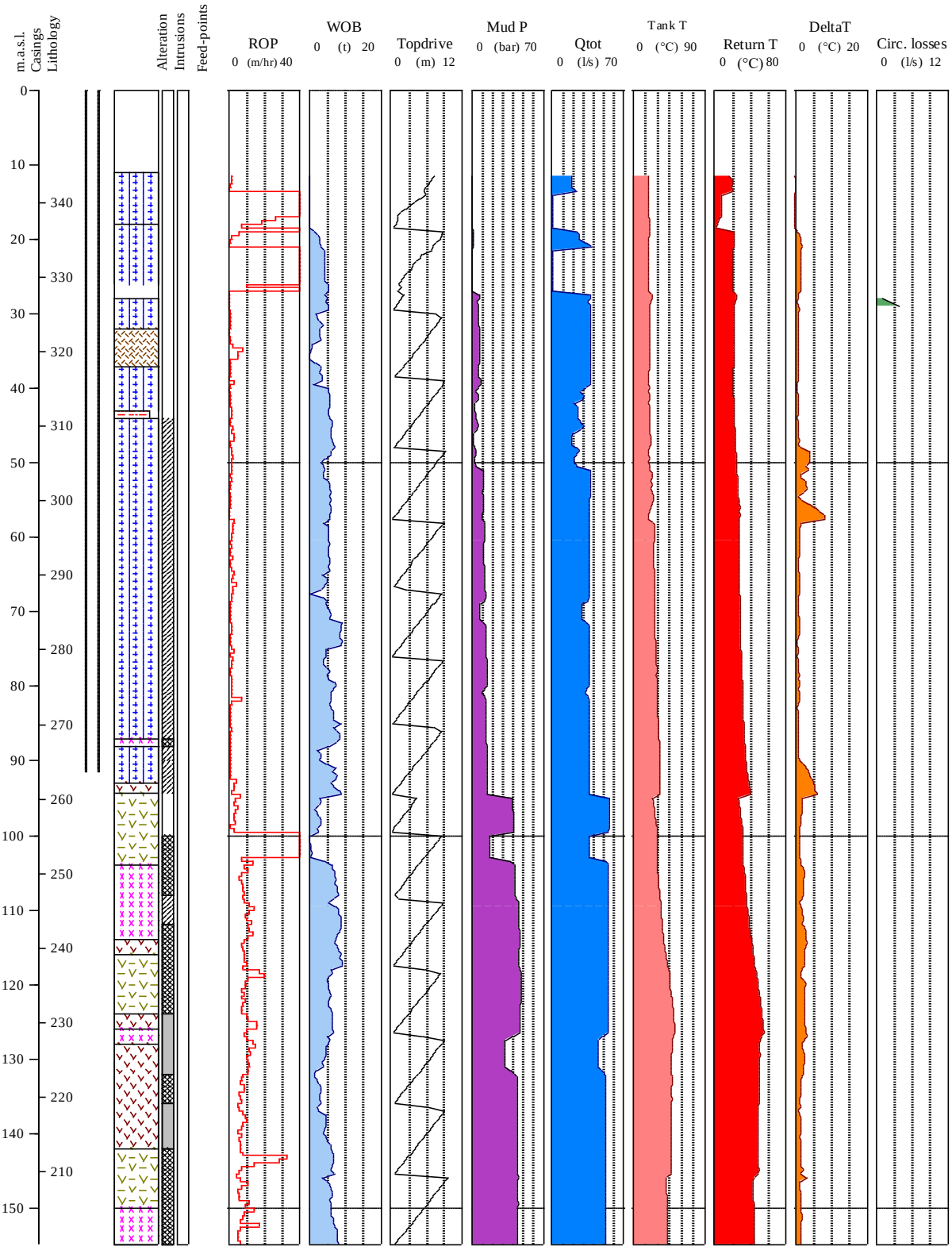


Figure 11. *Lithology and alteration in ÞG-11 plotted with key drilling parameters (0-155 m)*

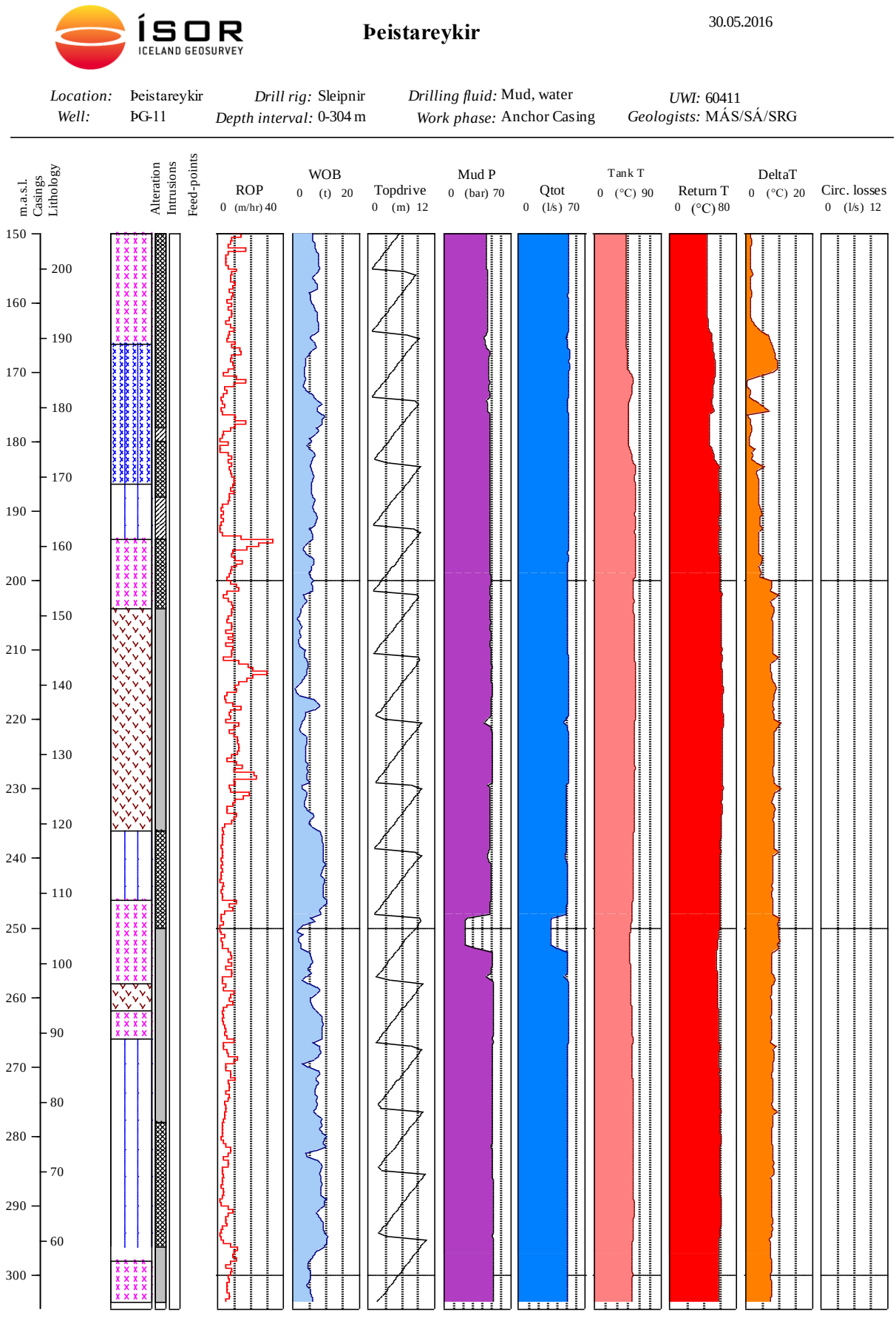


Figure 12. *Lithology and alteration in ÞG-11 plotted with key drilling parameters (150-305 m)*

ÍSOR ICELAND GEOSURVEY	**ÞG-11**	**Tuesday** **31th of May 2016** Workday #22

Þeistareykir	**Report #20** **Preliminary results**	**Phase 1** **(13 ⅝" anchor casing)**

Operator:	**Landsvirkjun**	*Drilling Company:*	**Iceland Drilling Company**
Well Name:	**ÞG-11**	*Drill-Rig:*	**Sleipnir**
Well-Id:	**60411**	*Geologist/Geophysicist:*	**BG/ÞEg BK** **(E-mail: bg@isor.is)**

Last casing size:	**18 5/8"** **(surface casing)**	**Depth at 24 hrs.**	**304 m**	**Hole made last 24 hrs. :**	**0 m**
Last casing depth:	**91.5 m**	**Depth at 8 hrs.**	**304 m**	**Drilling time:**	**0 hrs.**
Drilling fluid:	**Mud/Water**	**Circulation losses at 8 hrs.**	**0 l/s**	**Average ROP:**	**m/hr**

Drilling operation

When the crew started running in with the casing yesterday morning a problem with threading on the second casing tube caused delays. Several attempts were made to rectify the problem to no avail. The casing tube in question was subsequently replaced.

Running in with the casing finally started shortly after lunch. It turned out, that it was possible to run the casing in with both annular BOP´s open. While each of the casing tubes was added to the casing column in the well the upper annular BOP was closed. The casing column was then rapidly pushed in to the well with both annular BOP's open. Water was circulated through the casing and out to the flow line.

Running in with the casing was completed early this morning. In the lower most part of the well a mud cake had developed which to some time to flush out and in the bottom most 15 m sediment (cuttings) had accumulated that also had to be flushed up to the surface.

Preparations for cementing the casing are underway.

ÍSOR ICELAND GEOSURVEY	**ÞG-11**	**Wednesday** **1st of June 2016** Workday #23

Þeistareykir	**Report #21** **Preliminary results**	**Phase 1** **(13 ⅝" anchor casing)**

Operator:	**Landsvirkjun**	*Drilling Company:*	**Iceland Drilling Company**
Well Name:	**ÞG-11**	*Drill-Rig:*	**Sleipnir**
Well-Id:	**60411**	*Geologist/Geophysicist:*	**BG/ÞEg BK** **(E-mail: bg@isor.is)**

Last casing size:	**13 ⅝"** **(surface casing)**	**Depth at 24 hrs.**	**304 m**	**Hole made last 24 hrs. :**	**0 m**
Last casing depth:	**302.5 m**	**Depth at 8 hrs.**	**304 m**	**Drilling time:**	**0 hrs.**
Drilling fluid:	**Water**	**Circulation losses at 8 hrs.**	**0 l/s**	**Average ROP:**	**m/hr**

Drilling operation

Cementing of the casing got underway last night. The work was delayed because a makeshift centralizer had to be made to make sure the cement string would connect properly to the float collar.

After the cement string had connected to the float collar water was circulated through the well and the well cooled. The well site engineer notes that when the water which had been stagnant outside the casing during the preparations for cementing returned to the surface it was very dark due to the influx of gas. Later testing of the well behavior however confirmed that the "aquifer" that delivers gas to the well is not permeable to water at modest well head pressures.

Cementing of the casing started shortly after dinner. The cement job took approximately 90 minutes. A total of 30 m^3 of cement slurry with 1.7 g/cm^3 density was used for the job. Cement-slurry was returned to the surface after 30 minutes. Approximately 1,5 m^3 was added on top between the casings after the top slurry-level subsided slightly between the casings.

Early this morning temperature and CBL logs were run in the well. The temperature logs are shown in Figure 1 together with the open-hole temperature log from May 27th.

Figure 2 shows the CBL-log measured inside the casing six hours after the cement job finished. The cement between the surface casing and the anchor casing showed no sign of hardening but below 90 m the cement already shows clear sign of bonding. Another CBL-log will be measured today.

In order to estimate the heat-up rate inside the casing a roughly one hour heat-up log was measured, see Figure 3. Plotted on logarithmic scale it can be seen that the temperature at 180 m will not exceed 82°C in up to 18 hours after the cement job finished. Further information on the heat-up rate will be obtained in the todays temperature log measured in combination with the final CBL-log.

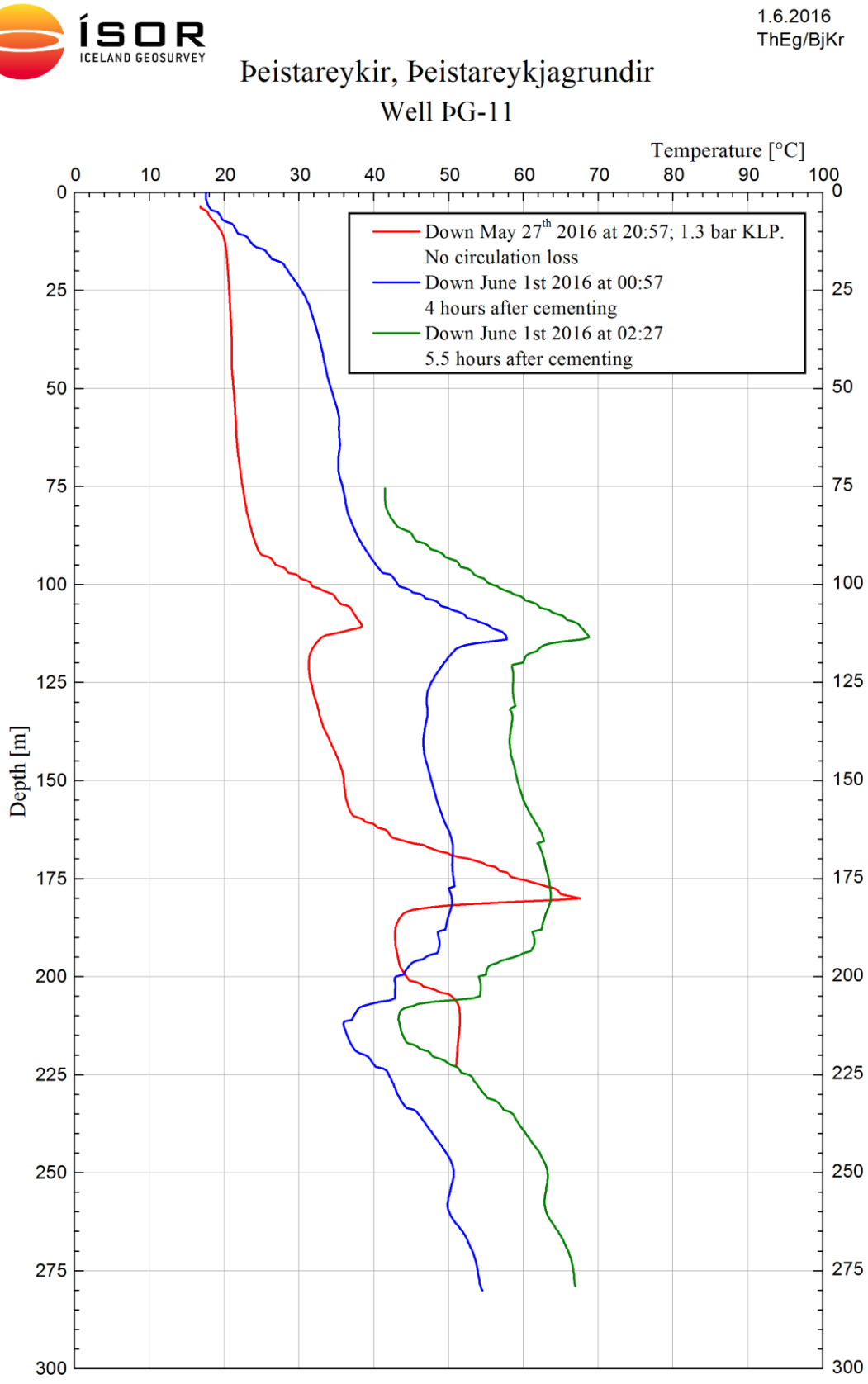
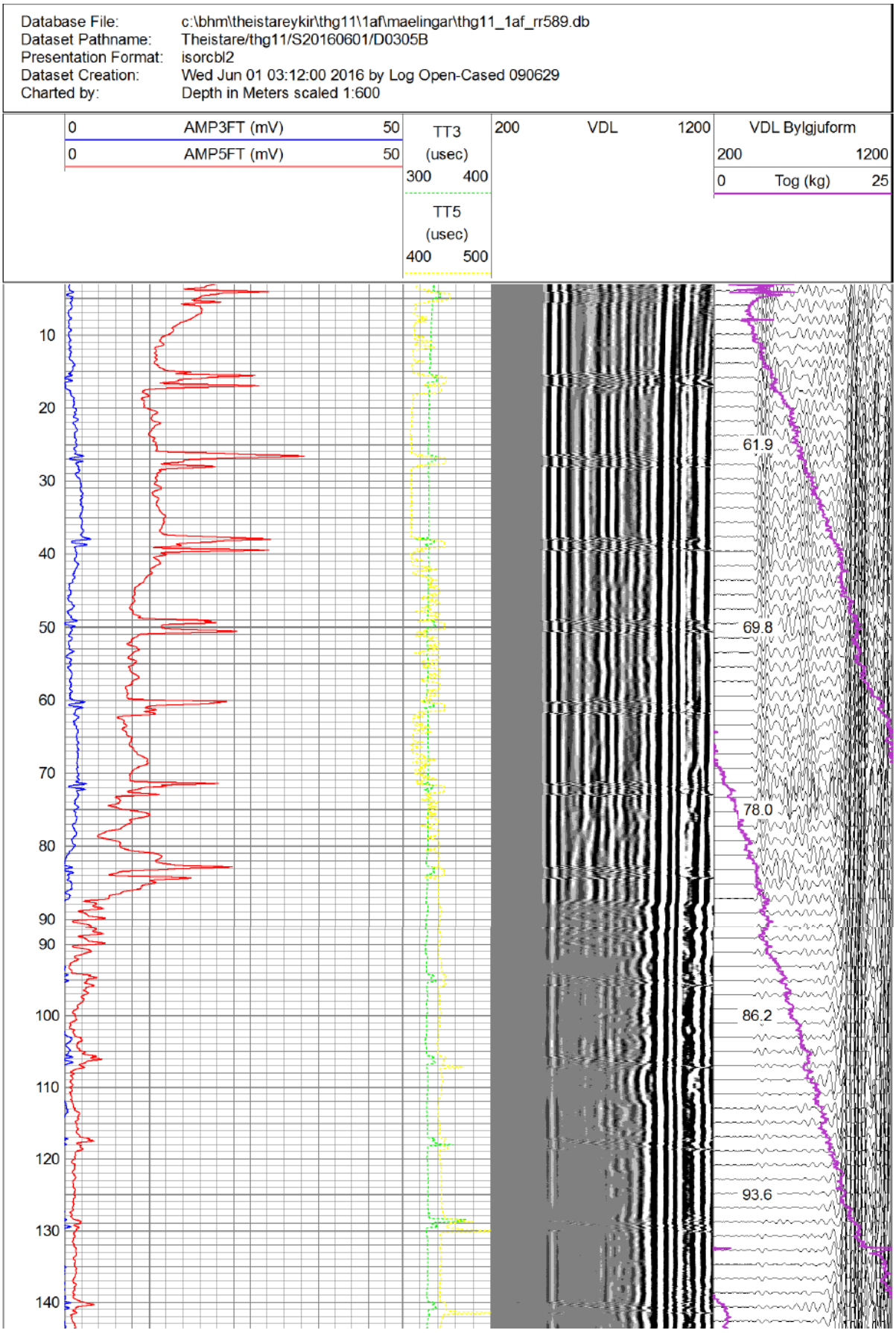


Figure 1. *Temperature logs four hours (down-log) and five and a half hours (up-log) after the cementing job finished. An approximate one hour heat-up is about 10°C.*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Dataset Pathname: Theistare/thg11/S20160601/D0305B
Presentation Format: isorcbl2
Dataset Creation: Wed Jun 01 03:12:00 2016 by Log Open-Cased 090629
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0 AMP5FT (mV) 50
TT3 (usec) 300 400
TT5 (usec) 400 500
200 VDL 1200
VDL Bylgjuform 200 1200
0 Tog (kg) 25
10
20
30
40
50
60
70
80
90
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100
110
120
130
140
61.9
69.8
78.0
86.2
93.6

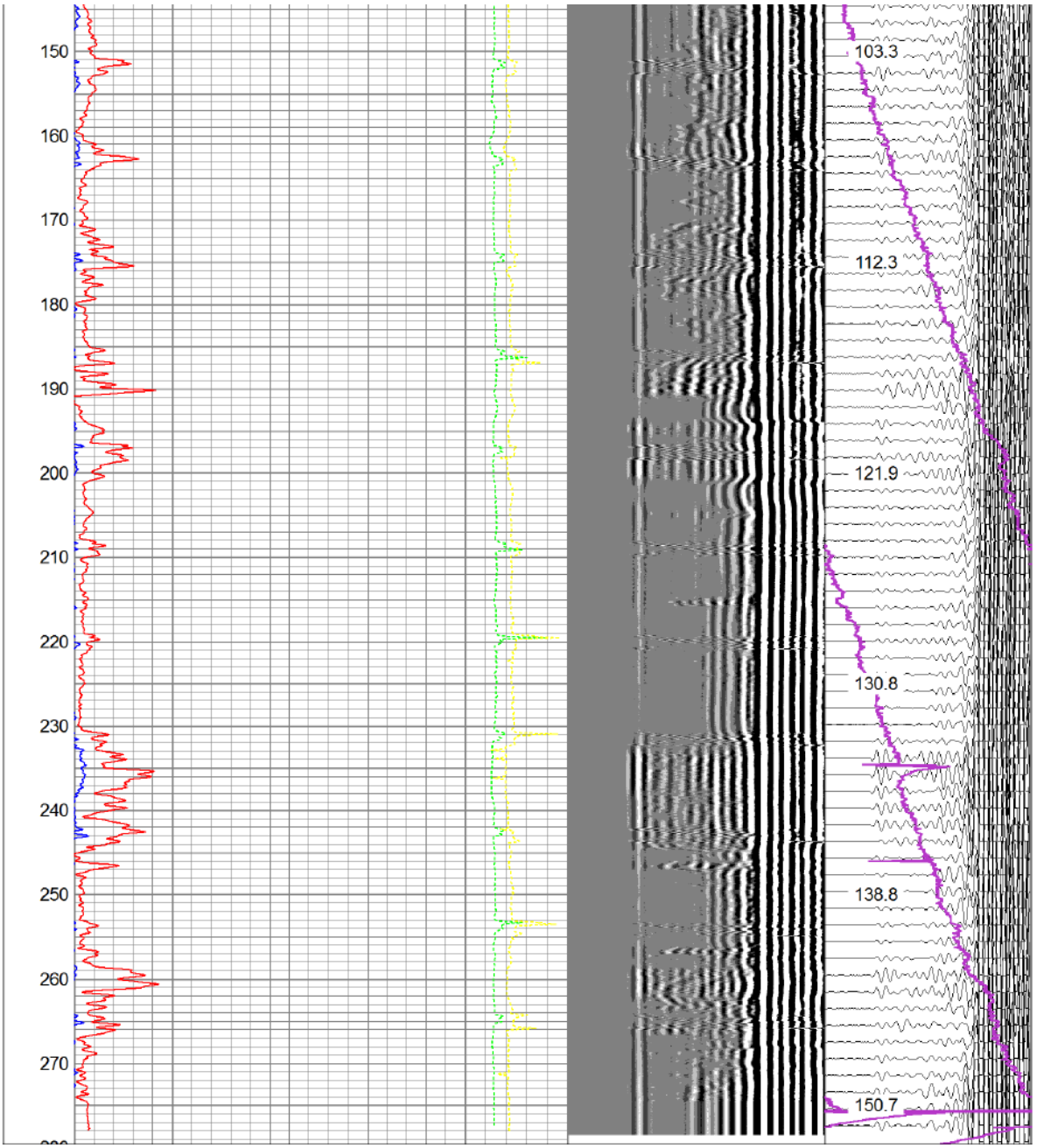


Figure 2. *The CBL-log six hours after cementing finished. Between the surface casing and the anchor casing almost no hardening of the cement is seen. Below the surface casing cement bonding is already active.*

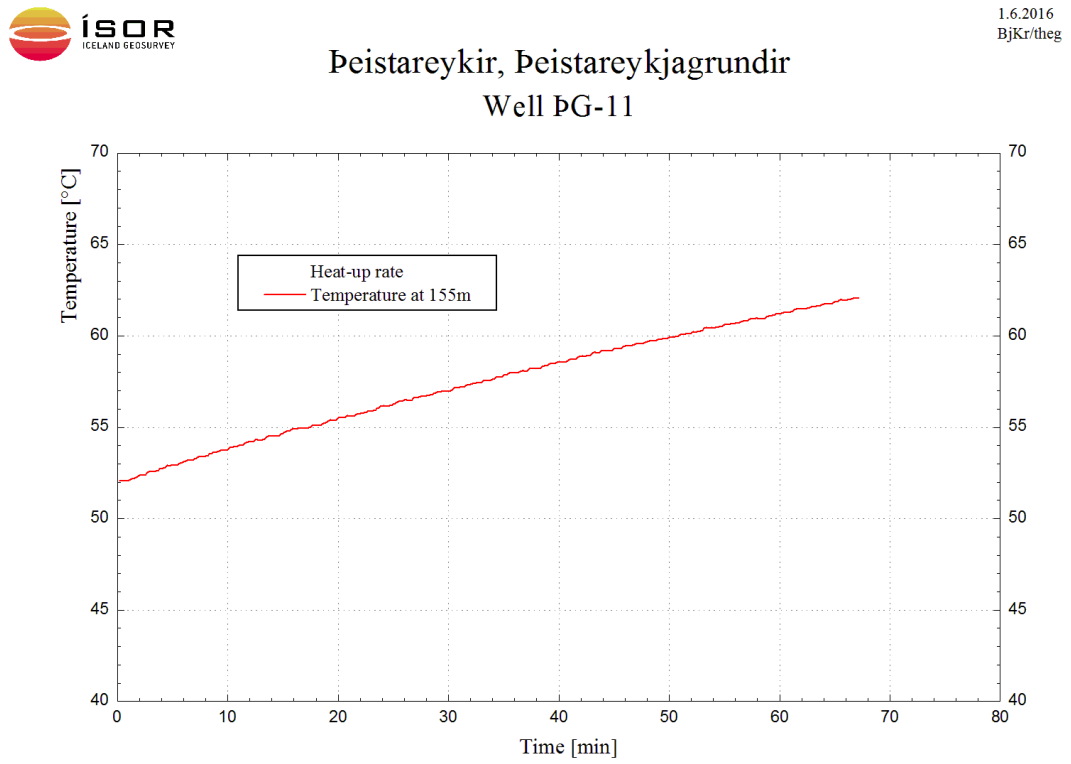


Figure 3. *About one hour heat-up log at 180 m on a linear scale.*

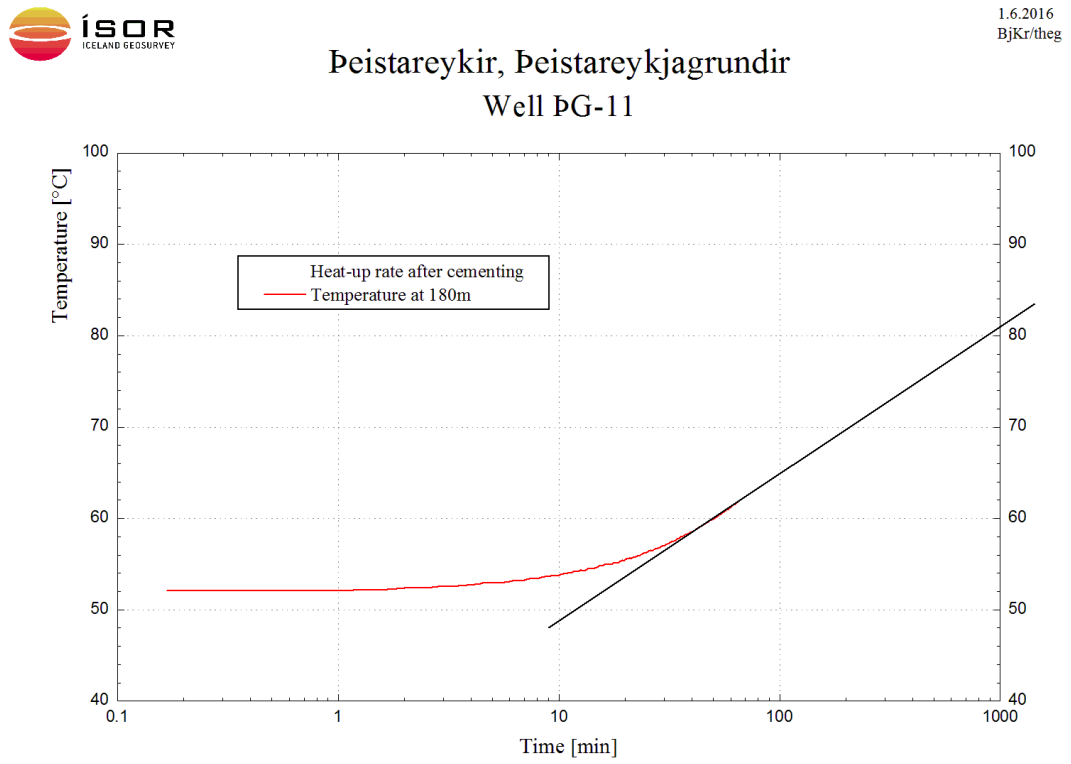


Figure 4. *On a logarithmic scale the heat-up rate indicates that the temperature at 180 m inside the casing will not exceed ~80°C in sixteen hours from when the heat-up log started, i.e. eighteen hours after the cement job finished.*

ÍSOR ICELAND GEOSURVEY	**ÞG-11**	**Wednesday** **2nd of June 2016** Workday #24

Þeistareykir	**Report #22** **Preliminary results**	**Phase 1** **(13 ⅝" anchor casing)**

Operator:	**Landsvirkjun**	*Drilling Company:*	**Iceland Drilling Company**
Well Name:	**ÞG-11**	*Drill-Rig:*	**Sleipnir**
Well-Id:	**60411**	*Geologist/Geophysicist:*	**BG/ÞEg BK** **(E-mail: bg@isor.is)**

Last casing size:	**13 ⅝"** **(surface casing)**	**Depth at 24 hrs.**	**304 m**	**Hole made last 24 hrs. :**	**0 m**
Last casing depth:	**302.5 m**	**Depth at 8 hrs.**	**304 m**	**Drilling time:**	**0 hrs.**
Drilling fluid:	**Water**	**Circulation losses at 8 hrs.**	**0 l/s**	**Average ROP:**	**m/hr**

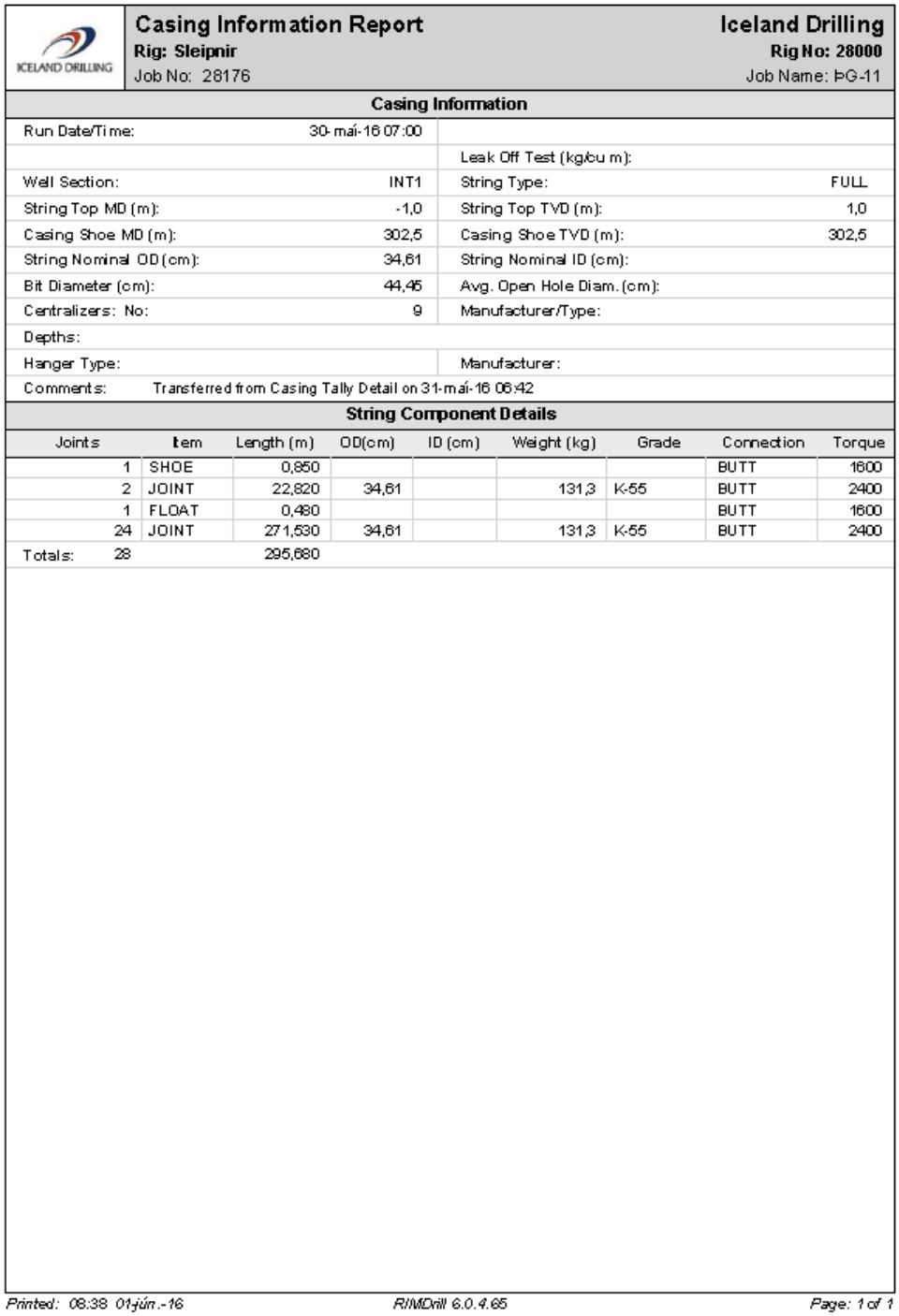
Drilling operation

Yesterday the crew was preparing for the rig to move to another platform while the cement was hardening in the well. The contractors casing- and cement-report are included in this daily report as Figs. 1 and 2 respectively.

Shortly after lunch yesterday, temperature and CBL-logs were run for the second time in this section. The temperature log (17 hours after cementing) is shown in Figure 15 together with former logs and the open hole temperature log from May 27th for comparison. During the 12.5 hours between the first and the last temperature logs after the cementing the well heated up approximately 45°C

A CBL was measured 17.5 hours after the cement job and the result is shown on Figure 16, which shows a good overall bonding between the casing and the formation. Also, the cement between the surface casing and the anchor casing is forming a good bond.

When these results were available the crew replaced and cooled the water in the casing to have ample time to work with the BOP stack and putting a flange on the 13⅝" casing.



Casing Information Report
Rig: Sleipnir
Job No: 28176

Iceland Drilling
Rig No: 28000
Job Name: ÞG-11

Casing Information

Run Date/Time:	30-maí-16 07:00		
		Leak Off Test (kg/cu m):	
Well Section:	INT1	String Type:	FULL
String Top MD (m):	-1,0	String Top TVD (m):	1,0
Casing Shoe MD (m):	302,5	Casing Shoe TVD (m):	302,5
String Nominal OD (cm):	34,61	String Nominal ID (cm):	
Bit Diameter (cm):	44,45	Avg. Open Hole Diam. (cm):	
Centralizers: No:	9	Manufacturer/Type:	
Depths:			
Hanger Type:		Manufacturer:	
Comments:	Transferred from Casing Tally Detail on 31-maí-16 06:42		

String Component Details

Joints	Item	Length (m)	OD(cm)	ID (cm)	Weight (kg)	Grade	Connection	Torque
1	SHOE	0,850					BUTT	1600
2	JOINT	22,820	34,61		131,3	K-55	BUTT	2400
1	FLOAT	0,480					BUTT	1600
24	JOINT	271,530	34,61		131,3	K-55	BUTT	2400
Totals: 28		295,680						

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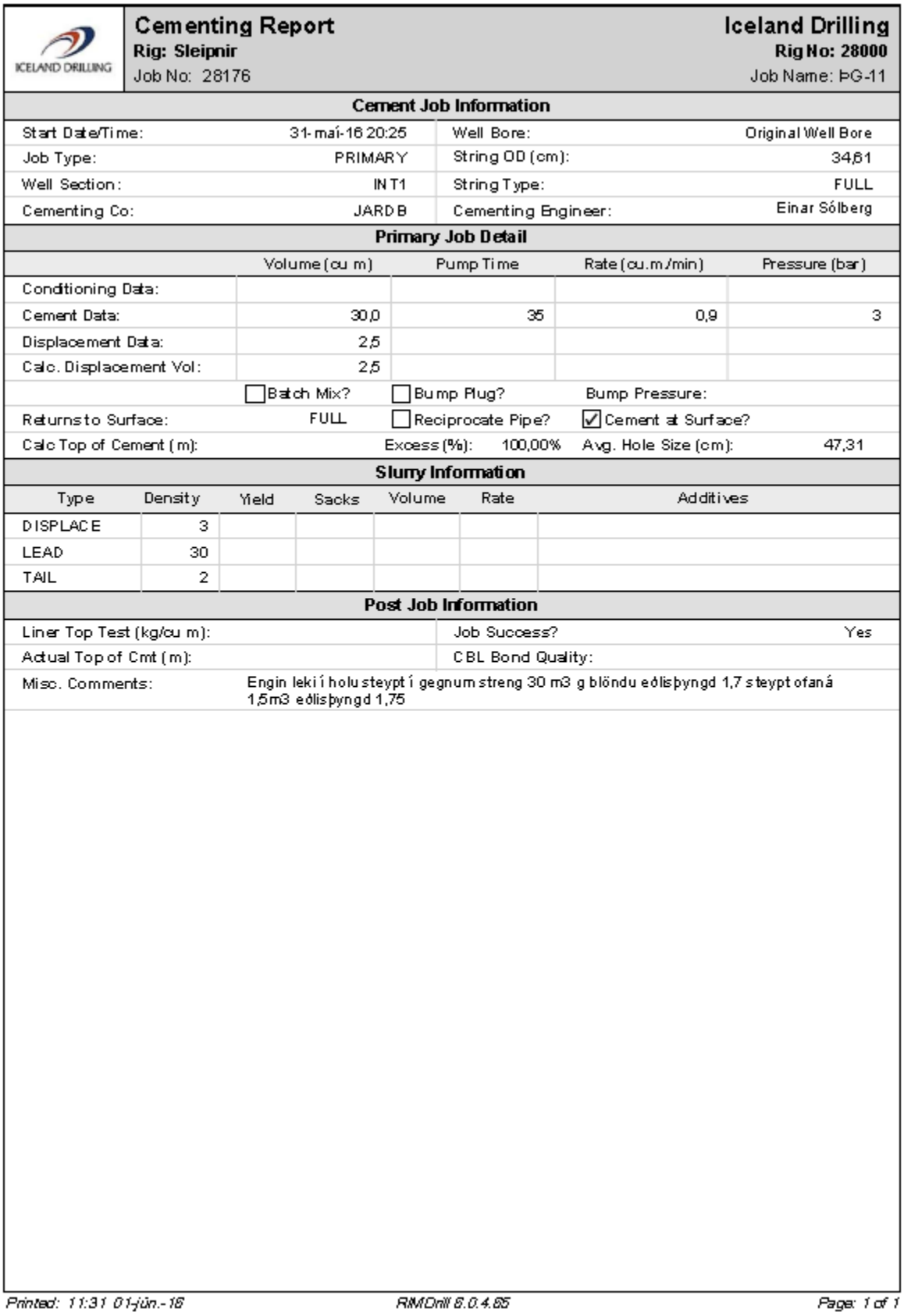
Figure 13. *Contractors Casing Report for the anchor casing in ÞG-11.*



Cementing Report
Rig: Sleipnir
Job No: 28176

Iceland Drilling
Rig No: 28000
Job Name: ÞG-11

Cement Job Information

Start Date/Time:	31-maí-16 20:25	Well Bore:	Original Well Bore
Job Type:	PRIMARY	String OD (cm):	34,61
Well Section:	INT1	String Type:	FULL
Cementing Co:	JARDB	Cementing Engineer:	Einar Sólberg

Primary Job Detail

	Volume (cu m)	Pump Time	Rate (cu.m./min)	Pressure (bar)
Conditioning Data:				
Cement Data:	30,0	35	0,9	3
Displacement Data:	2,5			
Calc. Displacement Vol:	2,5			

	☐ Batch Mix?	☐ Bump Plug?	Bump Pressure:		
Returns to Surface:	FULL	☐ Reciprocate Pipe?	☑ Cement at Surface?		
Calc Top of Cement (m):		Excess (%):	100,00%	Avg. Hole Size (cm):	47,31

Slurry Information

Type	Density	Yield	Sacks	Volume	Rate	Additives
DISPLACE	3					
LEAD	30					
TAIL	2					

Post Job Information

Liner Top Test (kg/cu m):		Job Success?	Yes
Actual Top of Cmt (m):		CBL Bond Quality:	
Misc. Comments:	Engin leki í holu steypt í gegnum streng 30 m3 g blöndu eðlisþyngd 1,7 steypt ofaná 1,5m3 eðlisþyngd 1,75		

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Figure 14. *Contractors cement report for cementing the anchor casing in ÞG-11.*

Þeistareykir, Þeistareykjagrundir
Well ÞG-11

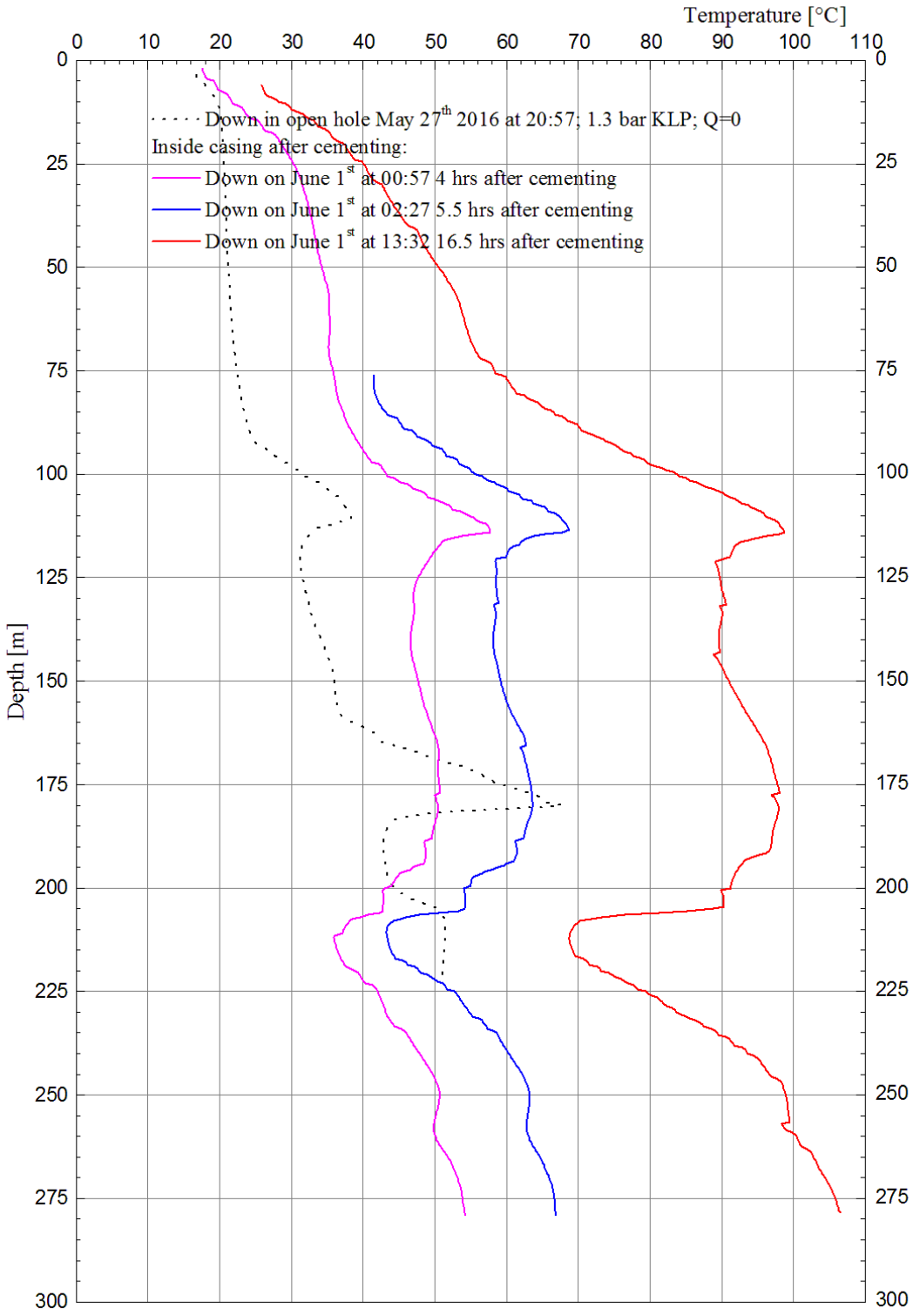
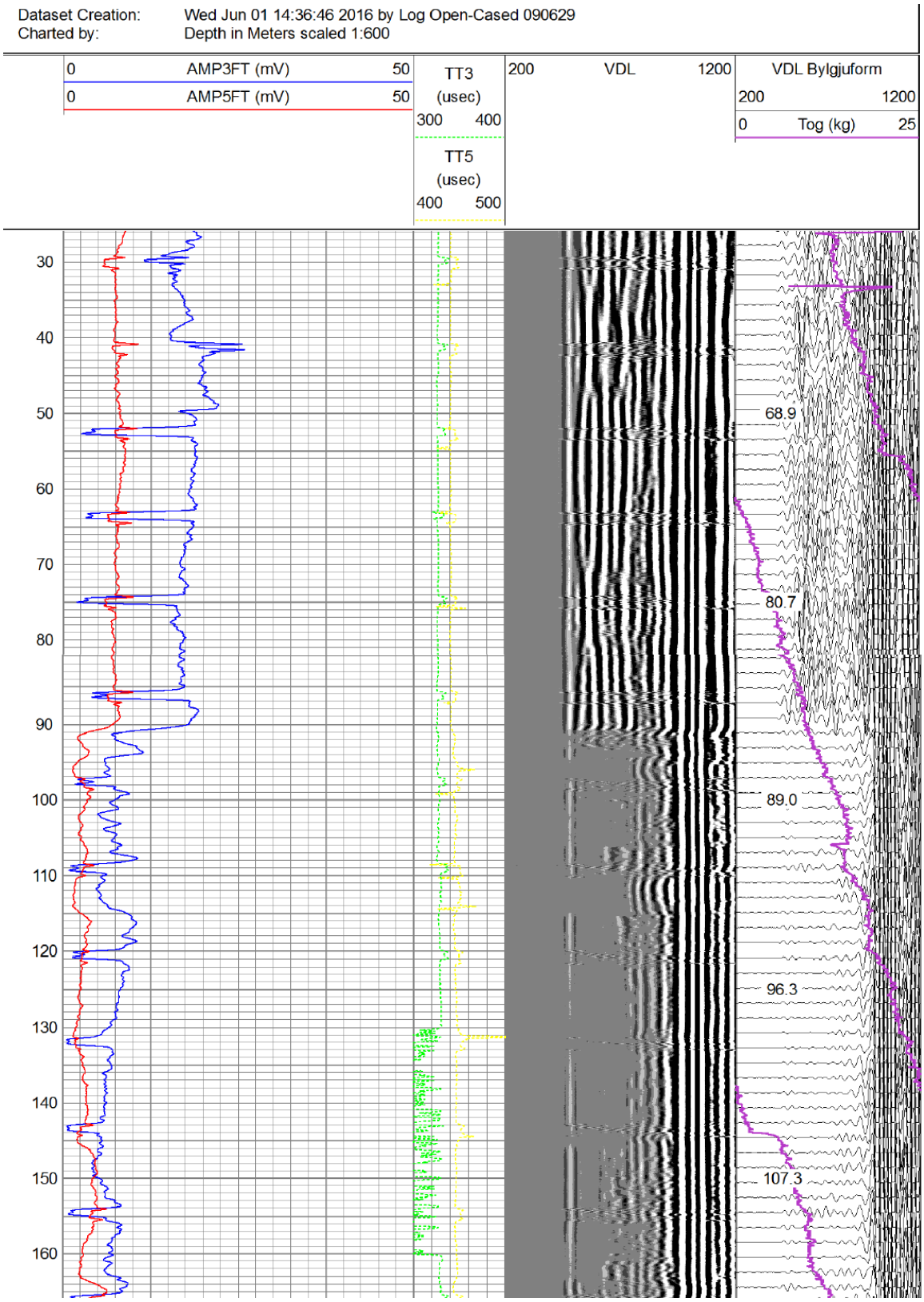


Figure 15. *Temperature profiles inside the anchor casing after it had been cemented together with the temperature profile run in open hole before the cement job.*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0 AMP5FT (mV) 50
TT3 (usec) 300 400
TT5 (usec) 400 500
200 VDL 1200
VDL Bylgjuform 200 1200
0 Tog (kg) 25
30
40
50
60
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120
130
140
150
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68.9
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96.3
107.3

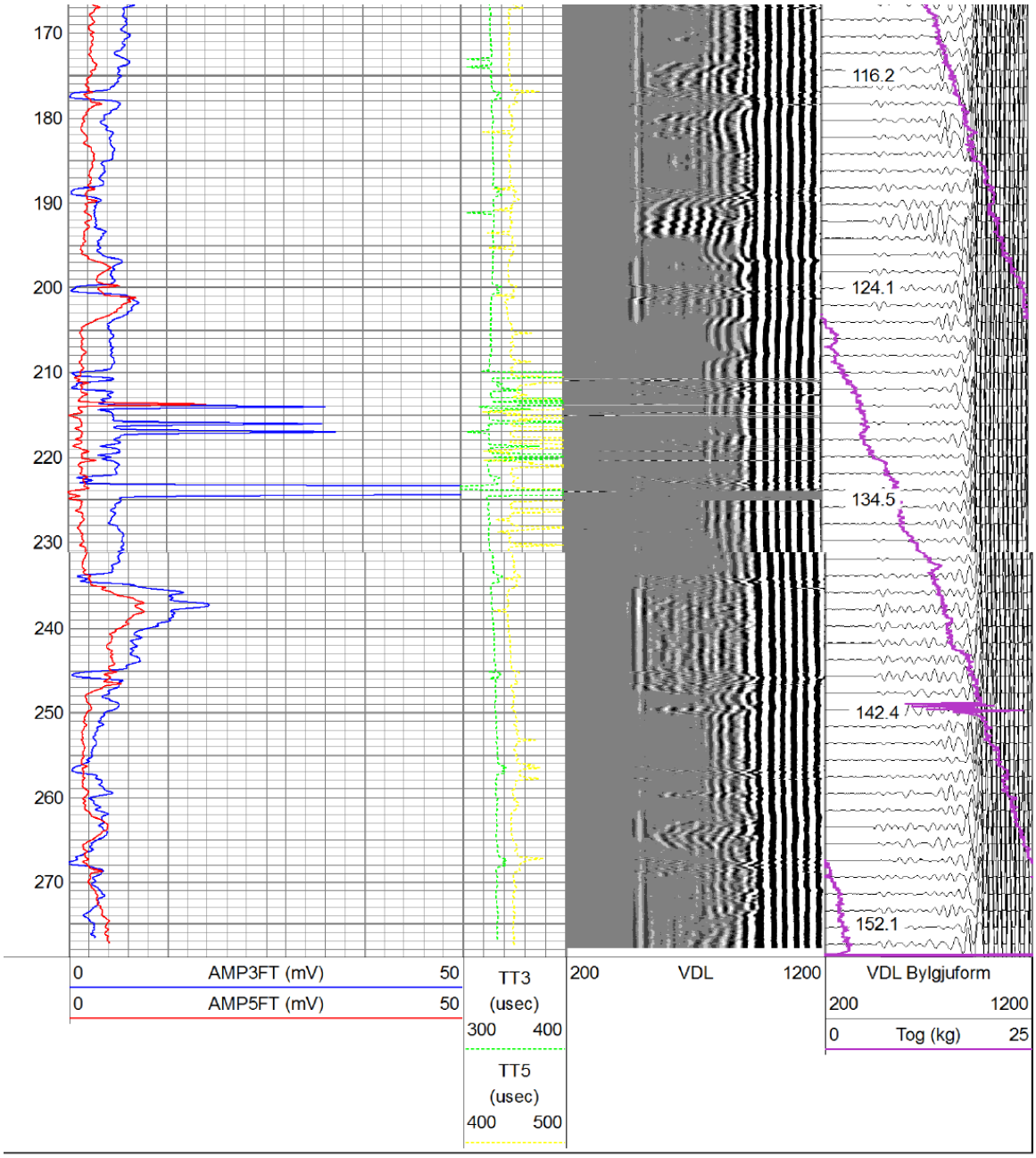

Figure 16. *The CBL-log 17.5 hours after the cement job finished confirms an overall good bonding of the anchor casing.*