DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2016/19

Well Logging of 3 Geothermal Boreholes: B3, B4 & UB1 Kollafjørður, Faroe Islands

Per Rasmussen, Per Jensen & Klaus Hinsby

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
DANISH MINISTRY OF ENERGY, UTILITIES AND CLIMATE

GEUS

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Contents

1. Introduction

In the period 25 to 27 January 2016 GEUS carried out geophysical borehole logging in three geothermal boreholes in Kollafjørður, Faroe Islands (Figure 1-1). The investigations were carried out on behalf of Jarðfeingi (Faroese Earth and Energy Directorate), as part of groundwater investigations of the geothermal potential in the area.

Figure 1-1. *Location of the three geophysical logged boreholes (Google Earth and /1/[1])*

The borehole logging was carried out in cooperation with Geo. GEUS complemented Geo's logging program with a sonic-log of the formation velocity. This technical report follows the outline of the Geo report /1/[1].

The three boreholes are located about 25 km north of Tórshavn. Two of the boreholes are planned for extraction of geothermal energy for use in private houses (B3 and B4), and borehole UB1 is a research facility. The boreholes are around 200 m deep, where water temperatures of 25-27 degrees C have been measured, which is twice as high as the expected temperature at that depth /1/[1].

[1] /1/ Geo 2016. Geophysical Borehole logging. Jarðfeingi Groundwater Investigation, Kollafjørður, Faroe Islands. Geo project no 38648. Report 1, 2016-02-19.

2. Geophysical logging

2.1 Equipment

The logging equipment used for the present investigations consisted of a slim-line 45 mm Full-waveform Triple Sonic Probe (Appendix 4), a winch with cable and depth meter, and a data logger (Micrologger2). RG Winlogger is the operating software for the Micrologger2 surface system. All equipment is from Robertson Geologging Ltd. The logging procedures are controlled from a laptop computer.

Figure 2-1. *Photo showing winch, cable and shear legs from logging borehole UB1 (from "kvf.fo broadcast 25.01.2016 - 20:04")*

The Full-waveform Triple Sonic Probe consists of one transmitter and three receivers. The probe measures the time of the first compressional arrival (the P wave) at each receiver. The difference in arrival times between each pair of receivers allows determination of formation velocity independent of the borehole fluid path (Appendix 4).

Full-waveform Triple Sonic Probe also measures the natural gamma emission from the formation.

The direction of measurements is upward with a typical log speed of 0.8 m/min. Data are sampled and stored for each 1 cm during logging.

2.2 General procedure

During the logging operation a field journal are recorded including information on reference measurement point, run number, tool number, groundwater level, start and stop depth, log speed, and administrative informations on the borehole and the project.

The collected data have been processed and presented using the Viewlog software (EarthFX Inc.)

The advantage of having measurements of natural gamma emission from several probes (see Table 2.1 in /1/) is the possibility to control the depth measurements, and if necessary make depth corrections of the measurements. In Appendix 1, 2 and 3 natural gamma measurements from Geo's Fluid Temperature and Conductivity probe and GEUS's Sonic Probe are shown.

The data have been smoothed for reading purposes before presented in the composite plots. The sonic velocity data has been smoothed using a floating filter of 30 cm (B3 and B4) and 100 cm (UB1) (Boxcar smooth, 31 or 101 points), The natural gamma data has been smoothed using a floating filter of 50 cm (Boxcar smooth, 51 points), (Appendix 1, 2 and 3).

2.3 Comments on Geophysical Logging

The results of the sonic logging are shown in the composite plots Appendix 1 (B3), Appendix 2 (B4), and Appendix 3 (UB1). In the composite plots some results from the logging carried out by Geo /1/ are included for facilitating the interpretation of the measurements. Due to technical problems natural gamma data from the sonic probe are shown only from 90 to 200 meters depth for UB1.

The measurements in borehole B4 and UB1 were carried out with reference to the terrain. Whereas the reference point for B3 was top of concrete wall.

Informations on the geological formation from the drillers log are included in the composite plots as a distinction between red (rött) and black (svart) rocks.

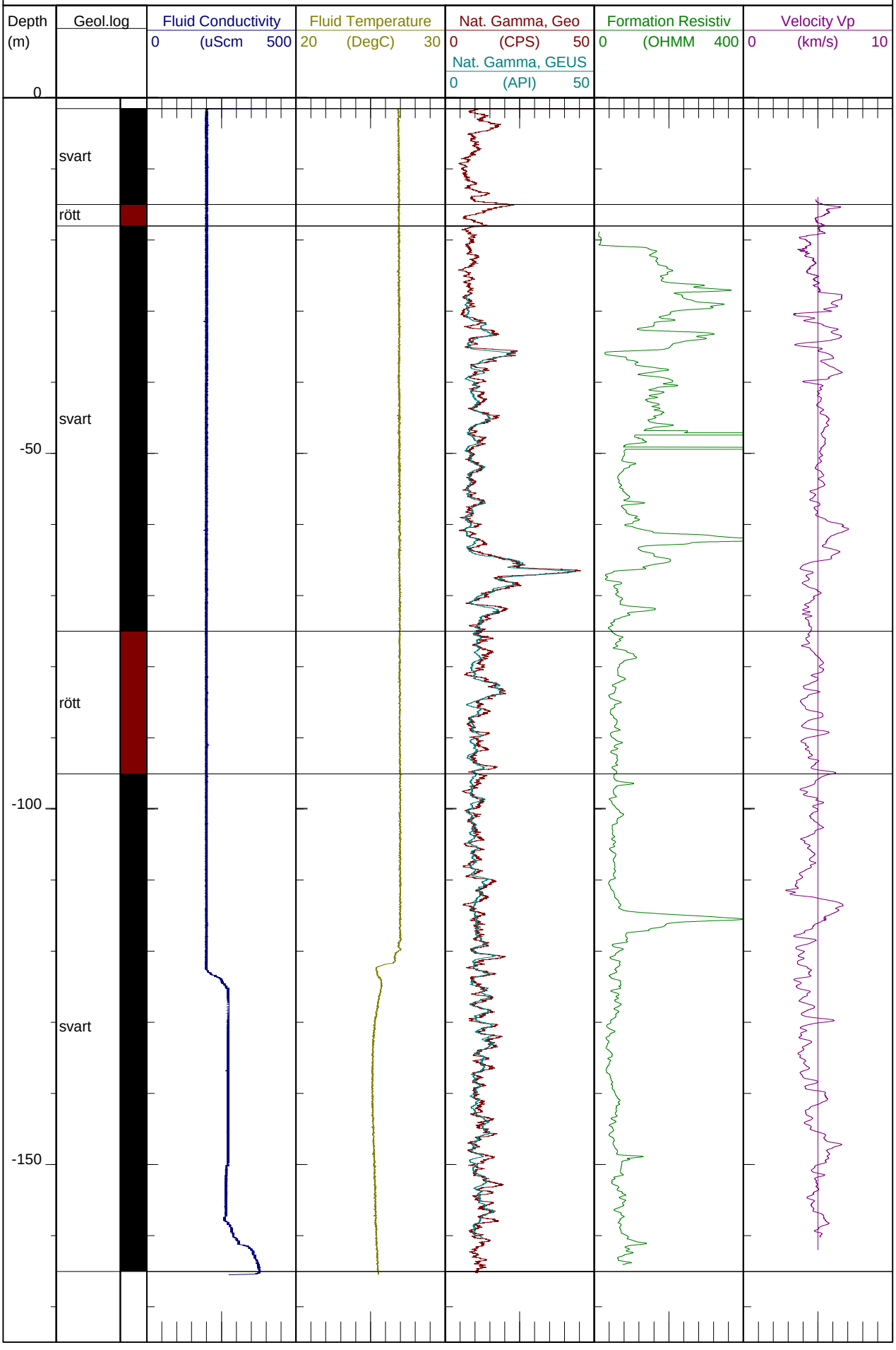
Appendices

1. Borehole Profiles B3
2. Borehole Profiles B4
3. Borehole Profiles UB1
4. Data sheet – Sonic TRGS 8068

Appendix 1: Borehole Profiles B3

Well Name: B3
Location: Kollafjørður, Faroe Islands
Reference: Top concrete wall (0,2 m below casing)

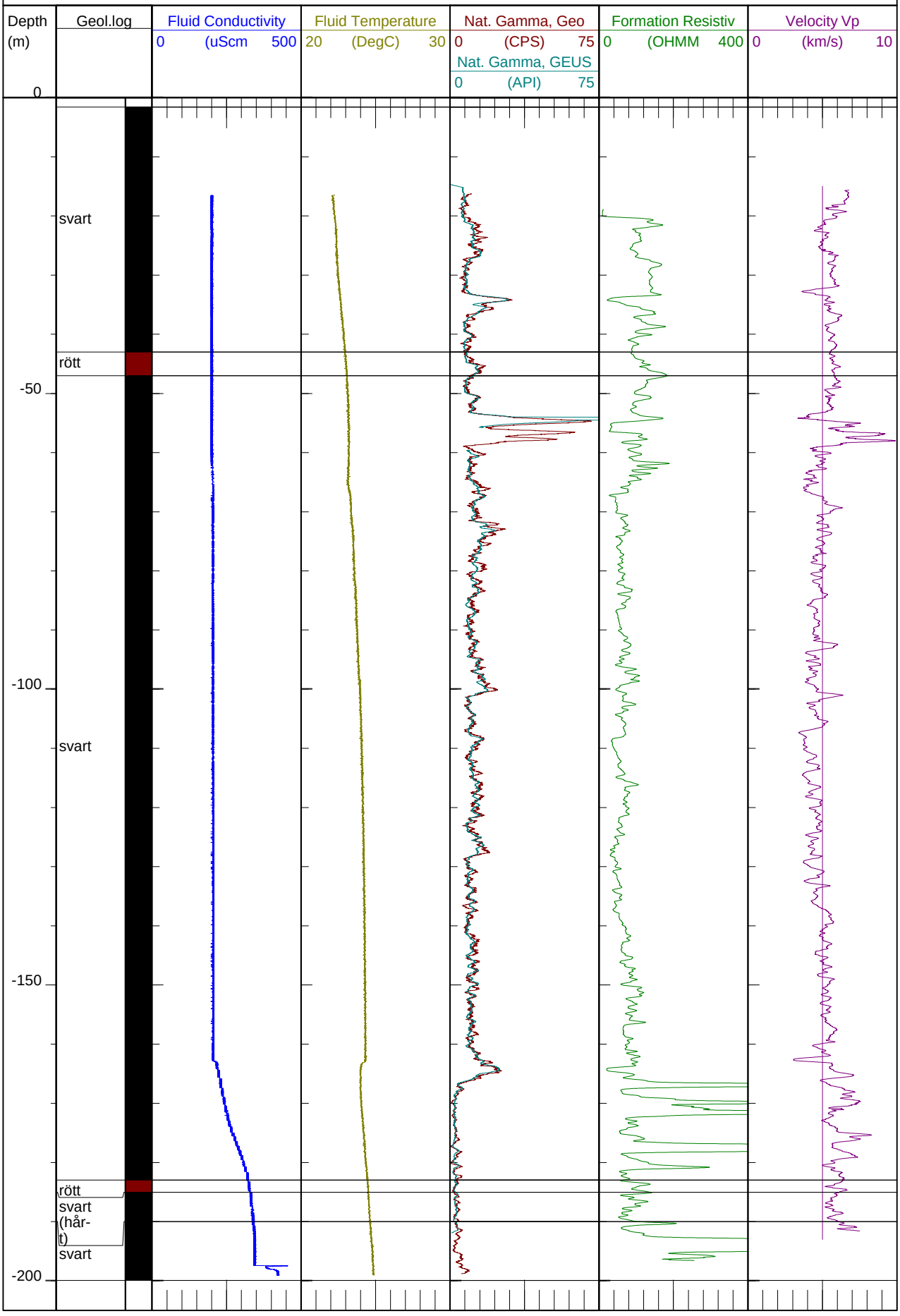
Logging date 26/1 2016, Sonic velocity-log by GEUS, other logs by Geo.



Appendix 2: Borehole Profiles B4

Well Name: B4
Location: Kollafjørður, Faroe Islands
Reference: Terrain (0.9 m below top casing)

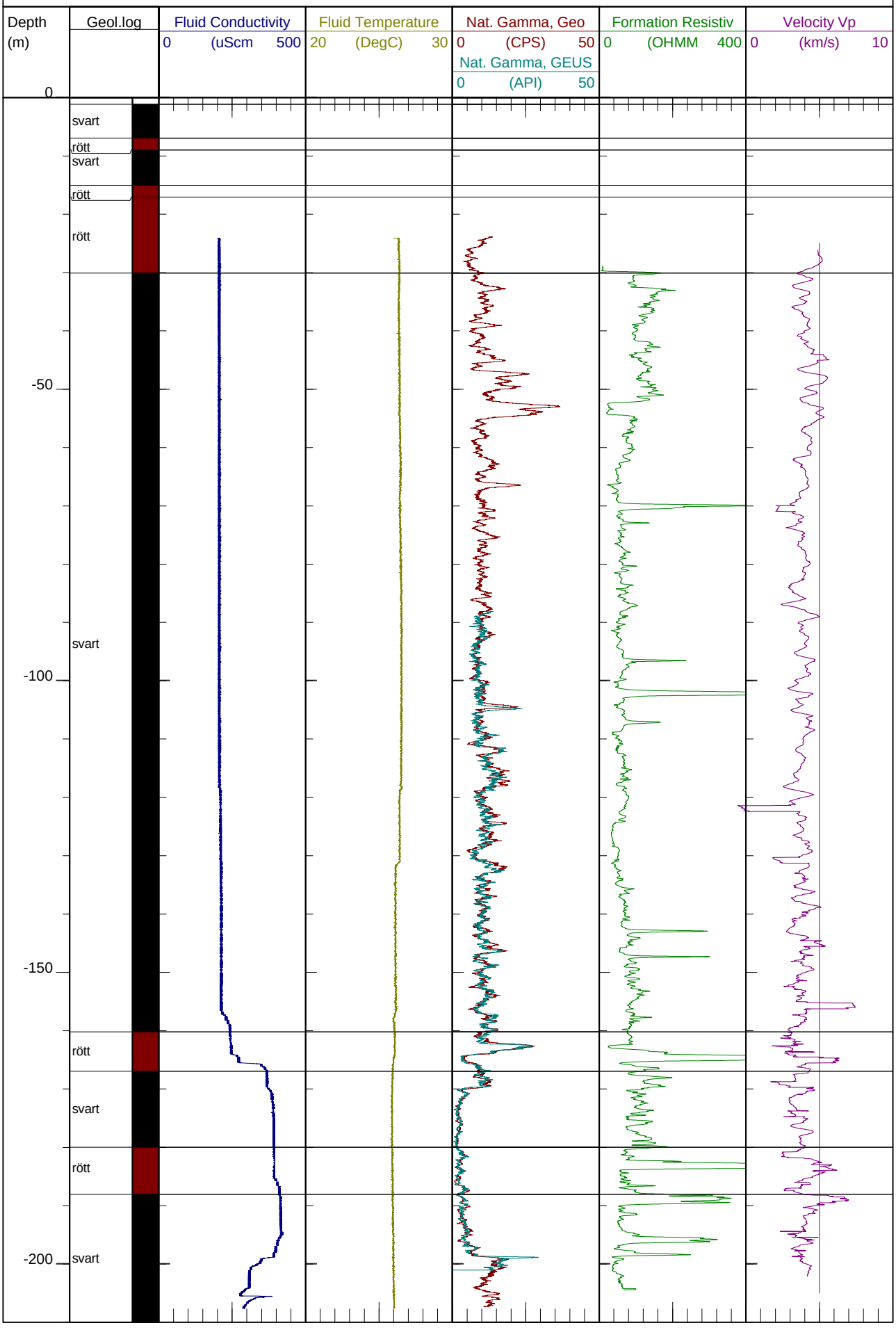
Logging date 27/1 2016, sonic velocity-log by GEUS, other logs by Geo.



Appendix 3: Borehole Profiles UB1

Well Name: UB1
Location: Kollafjørður, Faroe Islands
Reference: Terrain (0,2 m below top casing)

Logging date 25/1 2016, Sonic velocity-log by GEUS, other logs by Geo.



Appendix 4: Data sheet – Sonic TRGS 8068

45mm Full-waveform Triple Sonic Probe

This highly compact slimhole tool is designed specifically for geotechnical and mining applications. The probe acquires transit-time and full-waveform data simultaneously from a single transmitter and three receivers.

Principle of Measurement:

The piezoelectric transmitter is stimulated by a high-voltage pulse and radiates a high-frequency acoustic wave through the borehole fluid and formation to each receiver. An accurate quartz clock measures the first arrival transit time.

Compensated sonic mode: Three receivers are used. The probe measures the time of the first compressional arrival at each receiver. The difference in arrival times between each pair of receivers allows determination of formation velocity independent of the borehole fluid path.

Full-wave sonic mode: The probe records the full sonic wave-train at all receivers simultaneously. This can be displayed either as a variable-density log (VDL) or as a waveform (wiggle trace). The waveform data may be exported to packages such as WellCAD™ for calculation of compressional, shear and Stoneley velocities.

probe specification

> Features

Short probe can be handled by single operator and easily transported
Slim diameter for narrow boreholes
Rigid construction for effective centralisation
Down-hole digitisation of waveform data
Detection gain and threshold under operator control.
Detection point and wavelet display shown in realtime.

> Measurements

Formation velocity (slowness)
Time of first arrival (delta-t)
Integrated transit time
Full-waveform data from 3 receivers
Shear and Stoneley velocities (requires additional interpretation software)
Natural gamma

> Applications

Geotechnical/mining/water
Fracture and permeability indication in hard rock
Rock strength and elasticity
Lithology identification
Porosity
Correction of seismic velocity

> Operating Conditions

Borehole type:
Sonic: open-hole, water-filled
Centralisation: 2 essential

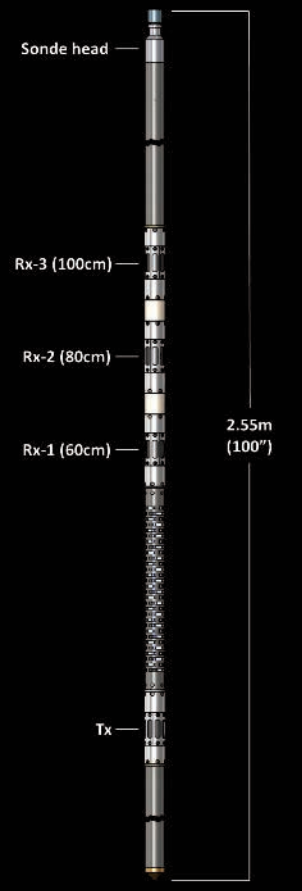
> Specifications

Diameter:	45mm
Weight:	8kg
Temperature:	0-70^{0}C (extended ranges available)
Max. pressure:	20MPa

> Sales Information

Probe:

I013861	Full-waveform triple sonic probe with natural gamma
I015464	Gamma test blanket
I001796	Centraliser 42mm Range 90-180mm (2 req)
I015096	Centraliser 42mm Range 70-110mm (2 req)
I001798	Centraliser 42mm Range 180-260mm (2 req)
I001800	Centraliser 42mm Range 260-342mm (2 req)



45mm full-wave triple sonic

sales@geologging.com www.geologging.com