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New Multisensor Core Logger (MSCL) on Core from Supercritical Conditions

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ABSTRACT

Drilling of RN-15/IDDP-2 in the Reykjanes geothermal field in southwest Iceland, was carried out in 2016 and 2017. With a total measured depth of 4650 m the well RN-15/IDDP-2 marks the deepest well drilled in Iceland to date. In total, 13 core runs were conducted during drilling of phase 4 and 5, whereas during phase 5 3 core runs retrieved about 22 m of continuous core.

The core has been scanned using the multisensor core logger (MSCL) provided from the International Continental Scientific Drilling program and reveal new insights into the sheeted dike complex that occur within supercritical conditions at a depth of about 4400 m within the Reykjanes geothermal field

The Horizon 2020 project Deployment of deep enhanced geothermal systems for sustainable energy business (DEEPEGS) aims at demonstrating the feasibility of deep enhanced geothermal systems (EGS) as a competitive energy alternative for commercial use.

1. INTRODUCTION

The Iceland deep drilling project (IDDP) was formed in the year 2000 with the aim of increasing the potential usable geothermal energy by producing supercritical fluids which are believed to exist deep beneath the high temperature geothermal fields. With this aim drilling of well IDDP-2 conducted by deepening an already existing well RN-15 at Reykjanes. This well was drilled vertically to a depth of 2500 m with a production casing down to 792 m and without a liner. The well is now identified as RN-15/IDDP-2. It was cooled down slowly, deepened with a bit to 3000 m, and a new production casing was cemented in place (Friðleifsson et al.2017). It is the deepest drill hole so far drilled in Iceland and has reached a depth of 4650 m. During the course of the drilling 13 core runs have been conducted and a total of 27.31m of core have been recovered with 22m of continuous core and a recovery of 63%. The cores have been scanned using a multisensor Core logger (MSCL) provided from the International Continental Scientific Drilling program (ICDP) and revealed new insights into the sheeted dike complex that occur within supercritical conditions at a depth of about 4400 m within the Reykjanes geothermal field.

2. DRILLING

The RN-15/IDDP-2 was drilled vertically from 2500m down to 2750 m, and below that drilled directionally to the southwest to intersect the main up flow zone of the Reykjanes system. The bottom of the well is at a vertical depth of about 4500 m and is situated 738m southwest of the wellhead (Figure 1) (Friðleifsson et al. 2017). The deepening of well RN-15 was initiated in the Reykjanes geothermal field on August 11th, 2016. Drilling phase 3 started at 2500 m depth was completed at a depth of 3000 m on September 8th, 2016. No cutting samples were retrieved during this phase of drilling hence, no direct information is available about the lithology and the mineralogy for this section. Drilling phase 4 continued and reached its total depth at 4626 m on December 17th, 2016. Cuttings were retrieved from this phase between 3000 and 3200 m which is the only direct information available on the nature of the drilled formation. Drilling phase 5 was completed on January 19th, 2017 at a measured depth of 4659 m (referenced to the rig floor) and marked the total depth of RN-15/IDDP-2 (Weisenberger et al. 2019). Temperature log conducted after five days of heating up has shown a maximum temperature of 426°C and a pressure of 340 bar (Figure 2).

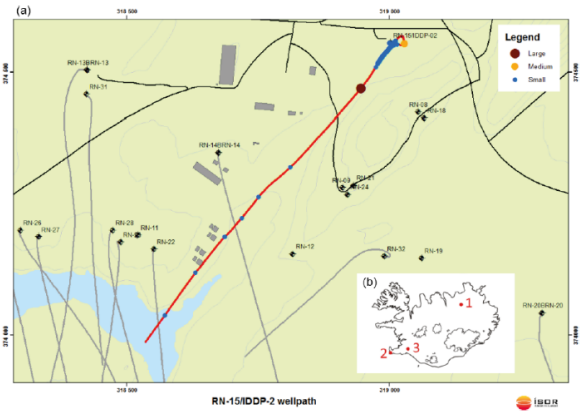

Figure 1: The track of well RN-15/IDDP-2 with feed points (Friðleifsson et al. 2017)

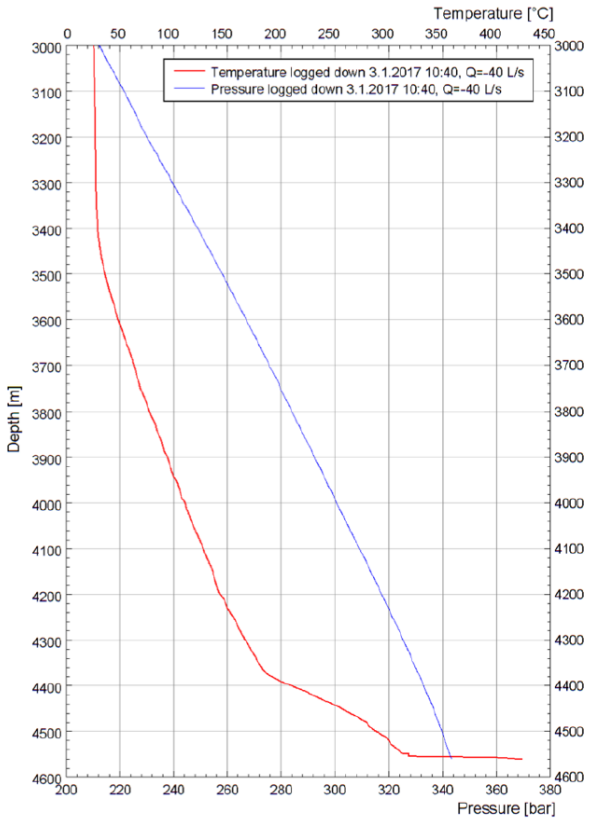

Figure 2: Temperature log in RN-15/IDDP-2 showing a maximum temperature of 426°C and a pressure of 340 bar

3. CORING

A total of 13 core runs have been conducted and spot drill cores recovered between drilling depths of 3,648.00 m and 4,657.58 m. These cores are the first samples ever recovered from the supercritical roots of an active basalt-hosted hydrothermal system (Zierenberg et.al. 2017). The different core runs, core interval, core length and their recovery percentages are tabulated below (Table 1). Core runs 1, 2, 4 and 9 did not recover any intact core samples.

IDDP-2 Core Run	Cored Interval (m)	Core Length (m)	Recovery (%)
3	3,648.0 – 3,648.9	0.52	58
5	3,865.5 - 3,869.8	3.85	90
6	3,869.8 – 3,870.2	0.15	38
7	4,089.5 – 4,090.6	0.13	11
8	4,254.6 – 4,255.3	0.28	40
10	4,309.9 – 4,311.2	0.22	17
11	4,634.2 – 4,642.8	7.58	88
12	4,642.8 – 4,652.0	9.0	98
13	4,652.0 – 4,659.0	7.0	80

Table 1: Core runs in RN-15/IDDP-2 showing core interval, core length and recovery percentage

4. MSCL INSTRUMENT

The core samples have been scanned with a multisensor core logger. It accomodates a maximum core diameter of 10 cm and a maximum length of core section of 1.5 m. The MSCL is equipped with sensors for p-wave verlocity, magnetic susceptibility, and spectrum gamma (U, Th, K). The strength of this instrument lies in its ability to save time by simultaneously measuring multiple parameters in an automated fashion. Core is moved past the array of stationary sensors, and data is collected from all sensors at once when the core pauses at a measurement point (see schematic diagram Figure 3). The MSCL can be operated with as many or as few sensors as desired, and new sensors can be added to an existing system (GEOTEK MSCL Manual) .

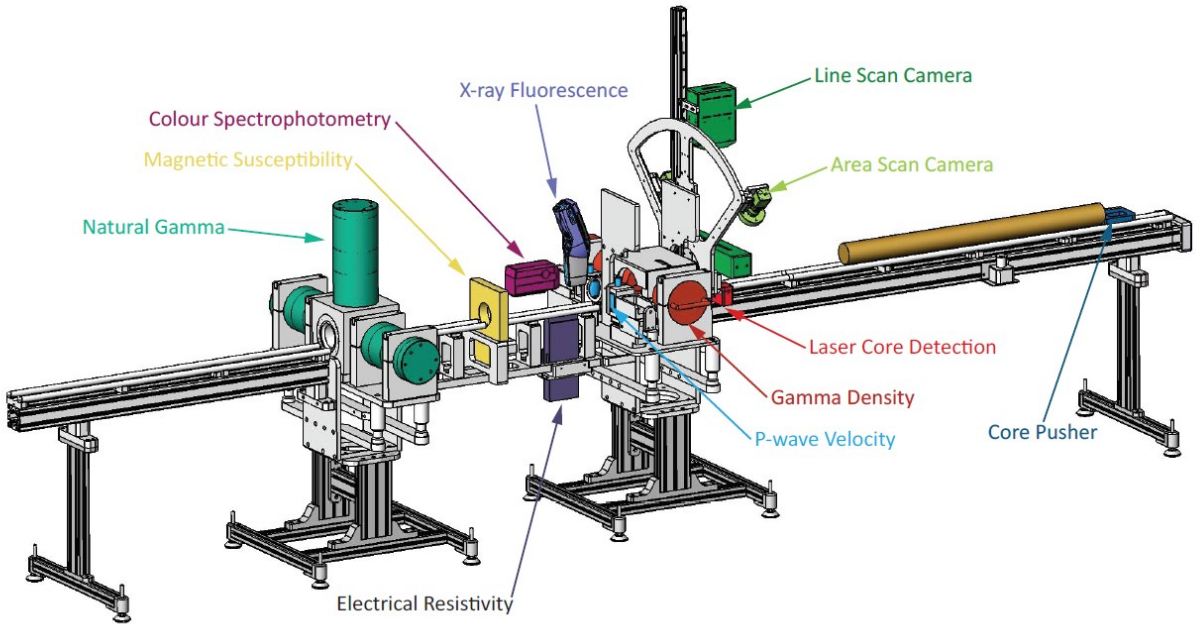

Figure 3: General schematic diagram of the Multisensor Core Logger (GEOTEK MSCL Manual)

5. GEOLOGY

The upper part of the core is comprised of medium grained doleritic basalt, glomeroporphritic basalt, diabase and mafic intrusives at the bottom of the cored interval with 3 chilled margins separating the units. The groundmass in the medium grained basalt consists of 1 mm euhedral to subhedral glassy unaltered green-brown Cpx (65-70%) separated by 1 mm long euhedral Pl laths (20-25%). Elongate Pl phenocrysts (5%) up to 5 mm, and occasional 3 mm euhedral greenish crystals that appear to be Ol. Less than 5% 1 mm euhedral TiMt (titanomagnetite). Unit appears to coarsen down core. This dike is chilled against an underlying dike. Felsite segregation veins are more prominent in the top part of the scanned core and are well identified by the natural gamma giving a high peak on the larger vein at 4638 m. The chilled margins and the felsite veins are shown in Figure 4. The lower intrusion in Core 11 is glomeroporphyritic with both plagioclase and clinopyroxene glomercrysts. Clinopyroxene is more abundant than plagioclase. Some plagioclase occurs as 1-2 mm elongated crystals, but generally the plagioclase is somewhat irregular shaped and forms a weakly felted matrix that is interstitial to clinopyroxene. The lower intrusion has ~5-8% equant titanomagnetite crystals, which appears to be more abundant than in the upper dike. (Zierenberg et al. 2017). This is well depicted in the magnetic succeptibility which shows higher values below the contact with the doleritic basalt (Figure 4). The change in base line for the natural gamma at ~4651 m coincides with a change from biotite alteration above to no biotite alteration below observed from thinsection analysis prepared at different depths. The locations of thinsections with (filled circles) and without biotite alteration (open circles) are shown in Figure 4.

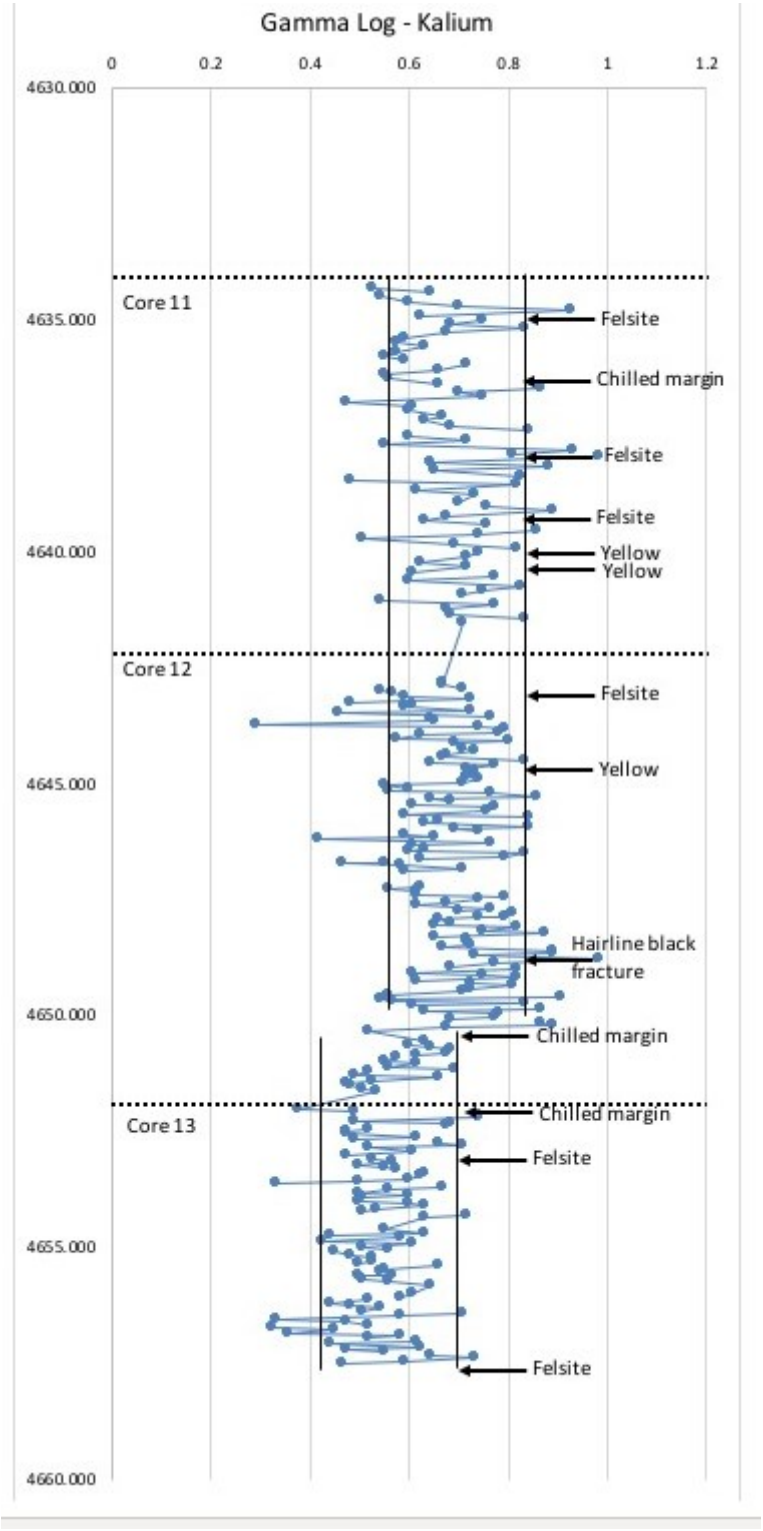

Figure 4: Locations of the chilled margins and the felsite veins in the natural gamma plot.

6. CONCLUSION

The cores has been scanned using the multisensor core logger (MSCL) provided from the International Continental Scientific Drilling program and reveal new insights into the sheeted dike complex that occur within supercritical conditions at a depth of about 4400 m within the Reykjanes geothermal field. It has clearly identified the different dikes with different alteration and mineralogy within the scanned section.

6. ACKNOWLEDGEMENTS

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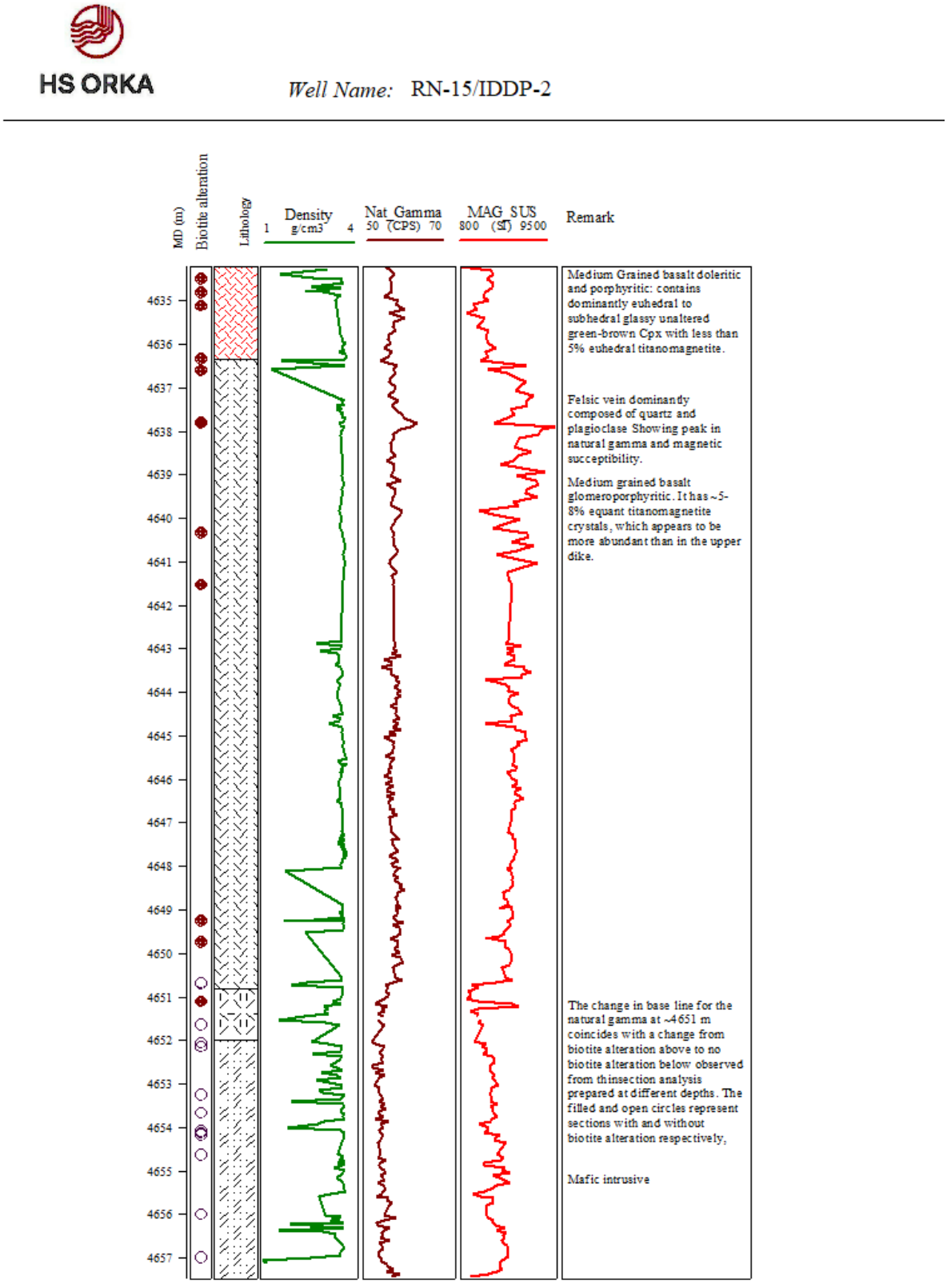

Figure 4: Logplot of the physical properties and alteration of the scanned cores.

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