# Preparation for Radial Jet Drilling Stimulation in a Geothermal Well in Iceland

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## ABSTRACT

Radial water Jet Drilling (RJD) is widely discussed in the geothermal community as a potential technology to stimulate low performing geothermal wells. For RJD, a focused water jet is being used to jet slim hole laterals out of an existing well in order to access (higher) permeable structures in the vicinity that were initially not well connected to the well or increase the contact area of the well with the formation. Based on the knowledge gained from laboratory experiments and numerical investigations, a workflow to select and stimulate a geothermal well and evaluate the radial water jet drilling technology is presented. The paper provides a discussion on preparations for a field test in Iceland in which a thorough monitoring approach is taken to gain a deeper understanding of the technology in the geothermal realm.

## 1. INTRODUCTION

In the SURE project (EU Horizon 2020 grant agreement No 654662) the main objective is to test feasibility and sustainability of utilizing Radial Jet Drilling (RJD) technology to stimulate poorly producing wells in sedimentary and magmatic geothermal environments. Compared to hydraulic stimulation treatments where large volumes of water is needed, a fraction is needed for RJD, thereby reducing environmental footprint and risk of induced seismicity. The feasibility study involves analysing if relevant rock types are jettable at conditions found in various downhole situations.

Well candidates in Iceland were searched for and evaluated. A candidate, well HN-13, located in Botn N-Iceland (Figure 1), stood out because of its particularly low output despite being drilled in between two producers. To evaluate target depths for the RJD operation, a downhole logging campaign was conducted. From drilling data and various downhole logging data, a promising target of a sedimentary intermediate layer was located at a depth of 956-963.5 m from surface. Additionally, to determine the initial condition of the well, a production test was conducted, confirming prior production tests.


**Figure 1.** *Well HN-13 a non-producer sits between two producing wells used was intended for direct use district heating in Akureyri and nearby communities in North-Iceland.*

## 2. RADIAL JET DRILLING TECHNOLOGY

Radial Jet Drilling (RJD) is a technology used to stimulate oil and gas wells in sedimentary formations. In the SURE project, one of the main objectives is to extend this technology to stimulation to geothermal wells in sedimentary and magmatic environments.

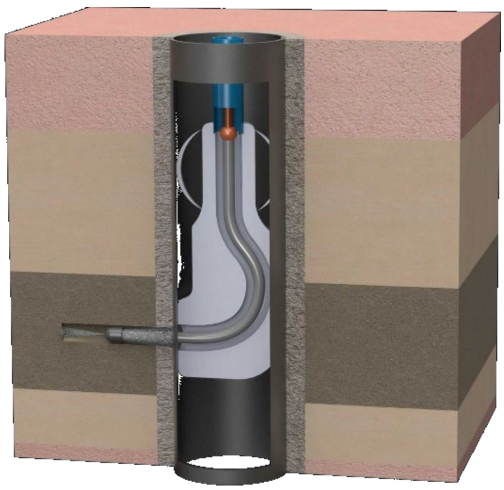

**Figure 2.** *A deflector shoe is placed in the wellbore and coil tubing with attached nozzle feed through it and directed towards the wall of the borehole (Reinsch & Blöcher, 2017).*

A deflector shoe is placed in the wellbore, normally within the casing that is initially milled out before jetting into the formation can be performed (Figure 2). For the field test in Iceland there is no need to mill out a casing beforehand since the target depth is below the casing shoe. Once the deflector shoe has been placed with drill pipes, coil tubing with a nozzle is run in hole. High-pressure water jet is then initiated and the jetting process begins. Once a lateral has been jetted, the coil is run out of the hole and the drill string moved to start jetting in a new direction/depth.

## 3. PREPARATIONS FOR A FIELD TEST IN LOW TEMPERATURE GOETHERMAL WELL HN-13 IN ICELAND

Well HN-13, a candidate for radial jet drilling (RJD) experiment and owned by power company Norðurorka, is a low temperature well drilled in Botn, North-Iceland. It was intended for hot-water production for the district heating in Akureyri and nearby communities. The well was completed in September 2016 to 1905 m depth. However, contrary to all expectations, it was a non-producer. Obviously the well is poorly connected to feed zones that feed the other two producing (deep) wells, BN-1 and HN-10, of which it sits in between.

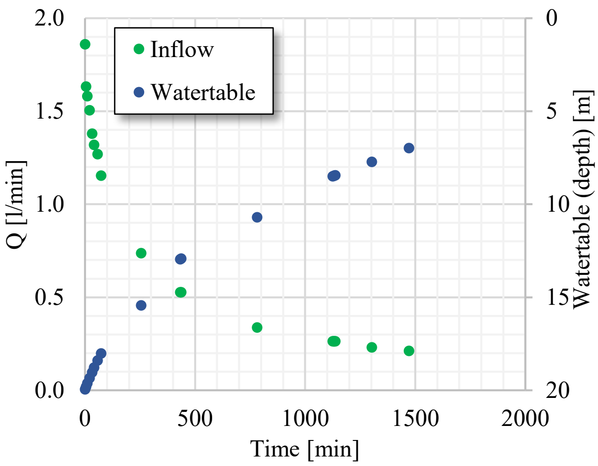


**Figure 3.** *Production test (September 2018) by free recharge after pumping out water until the water level was at 20 m depth after 2.5 hours of pumping. Well far from being productive with inflow less than 0.2 l/m (Vilhjálmsson & Tryggvason, 2018).*

A flow test carried out on September 2018. The inflow into the well was estimated to be less than 2 dl/min after 24 hours (Figure 3). This gives a clear baseline for improvements by stimulation.

Open hole wireline logging campaign was conducted that included gamma, NN, resistivity, SP and caliper (shown in Figure 5) down to 1840 m. Additionally, sonic and Televiewer logging was conducted in January 2017, but was only be logged down to ~1400 m due to blockage in the well. As jetting through hard basaltic rocks (with low matrix permeability) is challenging with current field equipment, a target zone for RJD is in an interbasaltic sedimentary layer, seeking connection to the fracture dominated reservoir. The layer is located at a depth where the wellbore diameter is 8½″.

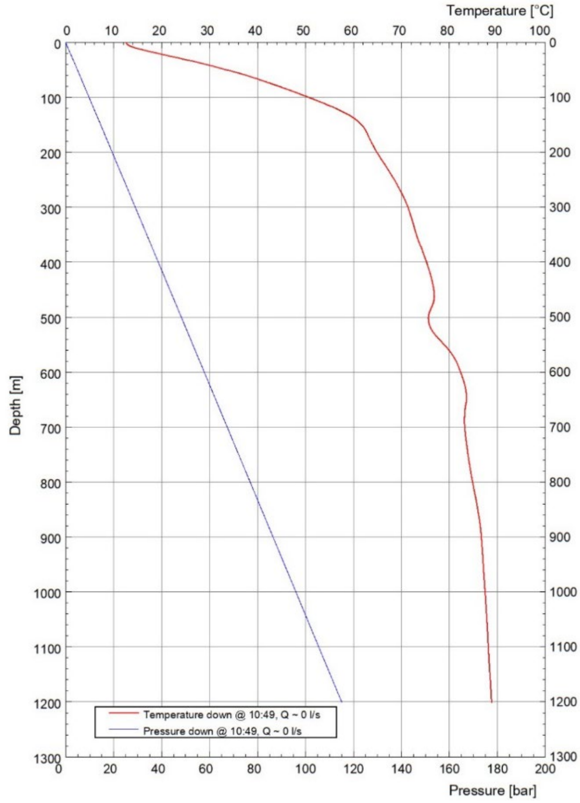


**Figure 4.** *Temperature (red) and pressure (blue) log of the well in September 2018 (Vilhjálmsson & Tryggvason, 2018).*

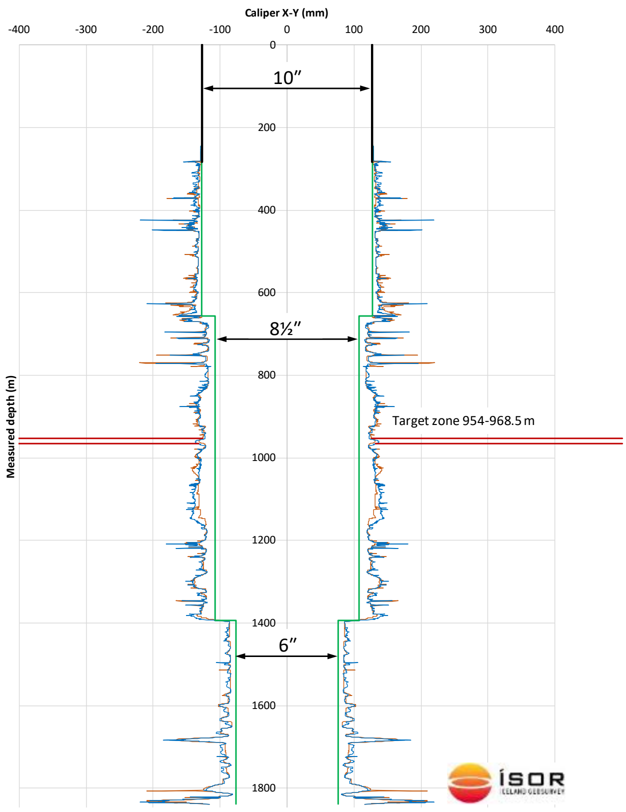


**Figure 5.** *Caliper log of well HN-13. Target zone for RJD is shown in red.*

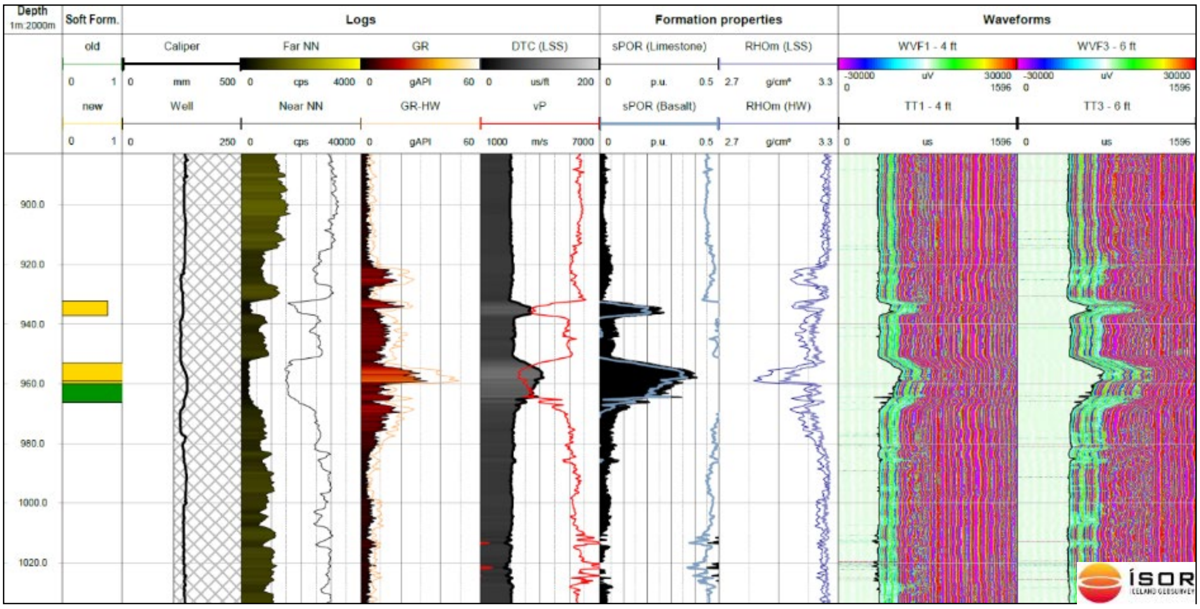


**Figure 6.** *Sonic log integration showing potential target zone of interbasaltic sedimentary layer at 952-960 m (from rig floor) shown in yellow (Kästner, 2017).*

The target layer is rather thick, approximately 12 m. From analysing drilling cuttings from the well it is located at approximately 956-968.5 m depth (from surface). Downhole wireline logging data, i.e. NN, gamma, sonic (Figure 6), caliper and televiewer (Figure 7), confirms this indicating that the softest part of the layer is at 956-963.5 m depth from surface. A geological conceptual model has been compiled based on surface exploration, drilling and wireline data (Figure 8).

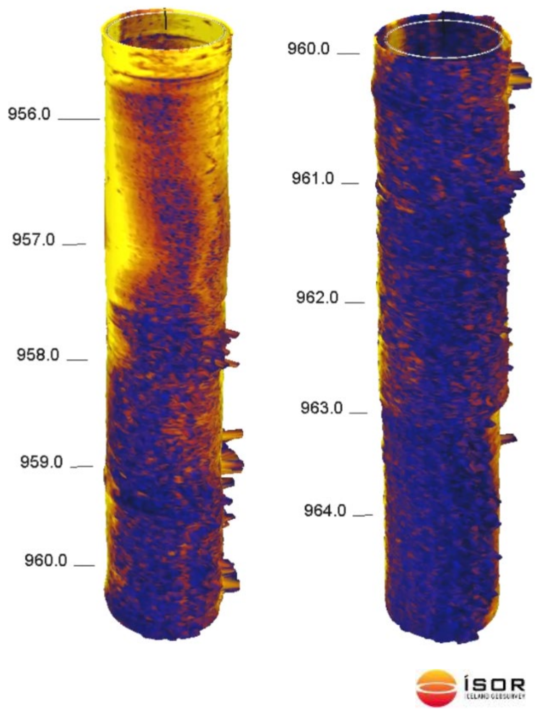


**Figure 7.** *Televiewer data indicates softest formations at 956-963.5 m depth from surface (Erlendsson, 2018).*

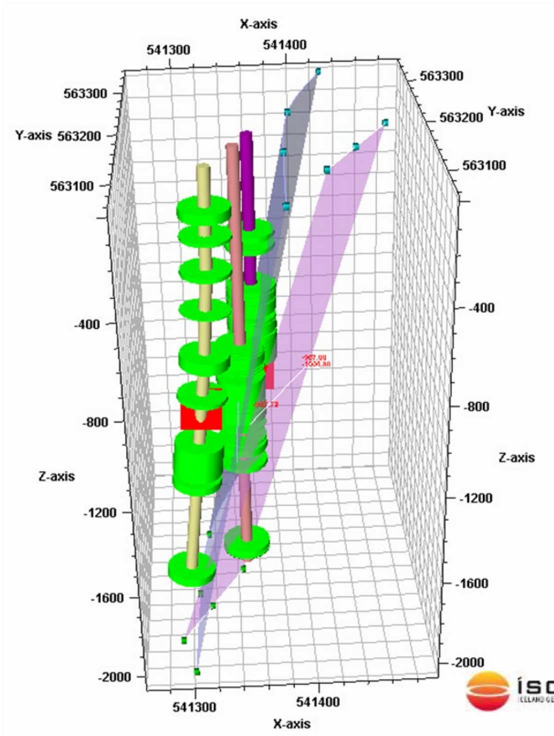


**Figure 8.** *A conceptual geological model (preliminary) based from surface exploration, drilling and wireline data (Einarsson, 2017).*

## 4. CONCLUSION

Preparations for a RJD field test in a low-temperature geothermal well (~90°C) in Iceland were described. Well HN-13 in N-Iceland was selected as it was a non-producer sitting in between two productive wells that are used for district heating in the neighbouring communities. Due to the known baseline, the well is an excellent candidate to test the stimulation technique. The RJD field test is planned for mid-June 2019.

## 4. ACKNOWLEDGEMENT

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