# ICELAND DEEP DRILLING PROJECT – HOW TO HANDLE WORLDS HOTTEST GOETHERMAL WELL?

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## ABSTRACT

This year, The Iceland Deep Drilling Project (IDDP) celebrates its 10th anniversary. At the same time the first well of the project, well IDDP-1, is in its 3rd and final phase of the research project. The outcome, a 40 MW world's hottest geothermal well, is a significant achievement although several technical challenges are still to be met before commercial utilization. Well IDDP-2 is currently being planned in the Reykjanes Field in Iceland, expected to be drilled in 2013. New Zealand could be the next country to explore supercritical zones to expand the country's geothermal resources.

The concept of an international research project to explore for supercritical geothermal fluids was proposed at the WGC 2000 in Japan and the Iceland Deep Drilling Project, IDDP was officially founded the following year. Since 2008, the project is owned by the three leading power companies in Iceland; HS Orka Ltd, Landsvirkjun and Reykjavik Energy, the State of Iceland through the National Energy Authority, the American Alcoa Inc. and the Norwegian Statoil ASA. The project has furthermore received several research grants, most importantly from the National Science Foundation (NSF) and the International Continental Drilling Program (ICDP). The project budget to date is exceeding US$20 million.

## 1. INTRODUCTION

The IDDP project has been widely presented, including the NZGW[1,2]. The objective of the project is to drill three wells to 4.5-5 km depth to explore for geothermal fluid near the heat source, i.e. magma intrusions. At such depth, supercritical conditions are expected, that is temperature above 373°C and pressure above 220 bar (for non-saline environment). Such wells are expected to produce highly superheated fluid to surface that could produce up to 10 times the electrical power of a "normal" well, given the same volumetric flow rate.

## 2. DRILLING EXPERIENCES

Well IDDP-1 in the Krafla geothermal field, operated by Landsvirkjun, was the first and also the main science well of the project, drilled in 2008-2009. Drilling came to an unexpected halt at 2096 m depth when the drillstring became stuck for the third time at the same depth, in the second sidetrack. In all instances, the drillstring had been lifted at the same time by 20-25 m (ca 40 tones). This time, circulation could be maintained and volcanic glass was produced to surface, making it evident the bit had struck 950°C hot magma. Rather than putting a cement plug to the bottom of the well, as was done in the two other known cases of drilling into magma (Hawaii and Iceland), a decision was made to complete the well with both 13-3/8" anchor and 9-5/8" production casings to 1950 m and install the ANSI Class 2500 wellhead that had be produced for the well. Cold drilling water was injected for over a month before the well was shut in.

## 3. WELL TESTING AND OPERATION

After 8 months of slow heating up, following heavy injection, the well was initially flow tested through a 4" flowline in March 2010. The well appeared to be highly productive but enthalpy was not as high as expected. The well produced rather benign fluid with the exception of 30-50 ppm chloride gas, causing heavy corrosion. In an attempt to accelerate heating up of the well, the wellhead was redesigned to allow flow through a 10" flow line in May 2010. The well produced around 30 kg/sec at 20 bar wellhead pressure and heated up to 360-380°C, equivalent to superheating of 160°C and enthalpy of around 3100 kJ/kg. Initially, as the fluid was close to saturation curve, corrosion was evident. Later, when the superheating exceeded 100°C, particle erosion became evident causing bends and pipes where turbulence is expected to become thinner. The flow velocity of the flowline was up to 100 m/sec. Sampling proved difficult and the source of particles is still uncertain. In August 2010, the well was shut in and the wellhead re-designed with the aim of reducing flow rate in an attempt to minimize erosion. Three different experiments to test utilization of the fluid were designed, wet scrubbing, dry scrubbing and heat exchanger.

Well IDDP-1 was opened for the third time in May 2011 through a DN500 PD25 bar flowline with 70 bar wellhead pressure and 20 bar pressure on the flowline. The well had increased in productivity up to 50 kg/sec and produced powerful black plume for about 90 minutes before becoming superheated with up to 3 m of clear plume next to the rock muffler. The increase in capacity caused high vibration, leading to highly tight bolts to become loose, side valves to break off and finally spiral coil support to break the flow line. After another re-engineering aimed to minimize vibration, the well was opened for the fourth time in August 2011 through a double set of orifices, the first being a plate with several small holes and the latter being a conventional single opening orifice. This time, the vibration was no longer evident. However, the 12" Class 1500 operating valve was becoming hard to operate and eventually broke after becoming stuck in 40% open position. Pieces of casing up to 10 cm were discovered in the flowline, in front of the "strainer" orifice.

## 4. FUTURE WORK

When this paper is written, Landsvirkjun and the IDDP project has decided to re-engineer the wellhead for the fourth time to continue testing of the well. Although the operation is hard, the opportunity of producing 30-40 MW from a single well, 8-10 times the average of Krafla wells, is a challenge worth fighting, both for Landsvirkjun and for the future of geothermal utilization.

## 5. REFERENCES


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