IDDP-2 - DRILLING INTO THE SUPERCRITICAL AT REYKJANES

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ABSTRACT

The IDDP-2 well in Reykjanes, SW-Iceland, is the main topic of the presentation. The well was completed January 25th 2017 at 4659 m slant depth from rig floor. At Reykjanes, the landward extension of the Mid-Atlantic Ridge (Figure 1), it is possible to study an analog of the roots of a mid-ocean ridge black smoker geothermal system. Reykjanes is unique among Icelandic geothermal systems in being recharged by seawater, which has a critical point of 406°C at 298 bars. Drilling began 11th August, 2016 by deepening an existing 2.5 km deep production well (RN-15) to 3 km depth, and then angling it towards the main upflow zone of the system (Figure 2).

The Iceland Deep Drilling Project (IDDP) aims to improve geothermal economics by producing supercritical fluids (www.iddp.is). Wells producing from supercritical hydrous fluid could yield an order of magnitude more usable energy than that from conventional geothermal wells because of higher enthalpy and enhanced flow properties. In 2009, the IDDP-1 well in the Krafla caldera in NE-Iceland, was drilled into rhyolitic magma at only 2.1 km depth. The completed well became the world's hottest production well for a while and produced superheated steam with wellhead temperature of 452°C at 140 bar, and flow sufficient to generate ~35 MWe. Flow testing experiments until 2012 proved extremely valuable for future harvesting of a magma enhanced geothermal system, which will also be discussed during the presentation.

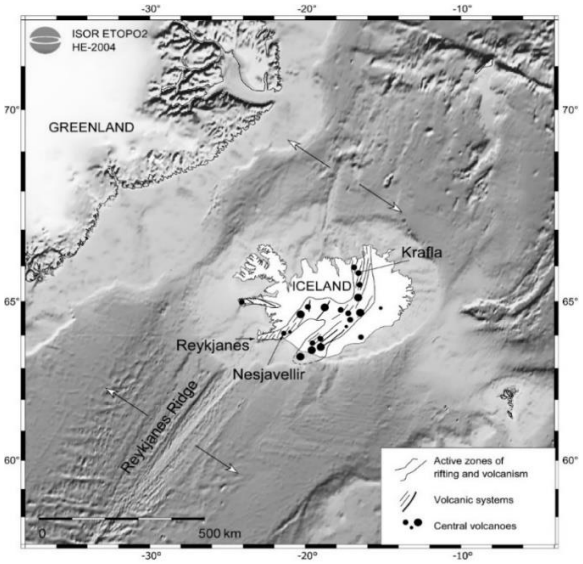

Figure 1 The location of Iceland on the Mid-Atlantic Ridge. The arrows show the spreading directions. Iceland's neo-volcanic zone with its active central volcanoes, is also shown and the location of the three high-temperature hydrothermal systems of Reykjanes, Nesjavellir, and Krafla, all targets for IDDP deep drilling.

In IDDP-2 at Reykjanes, total circulation losses were encountered so to speak from 2.5 km depth to the bottom of the well at 4650 m. After the 9 5/8" production casing had been cemented to 2,931 m depth, drill cuttings were intermittently returned to surface, but repeatedly interrupted by multiple loss of circulation, which could not be cured by lost circulation materials or by multiple cement jobs. Therefore, drilling had to be continued to total depth without any return of drill cuttings. We attempted 13 core runs below 3 km depth, only half of which recovered core. The cores are basalts and dolerites with

alteration ranging from lower greenschist facies to lower amphibolite facies, suggesting

formation temperatures >450°C. Close to the end of drilling, January 3d 2017, after inserting 7" casings (perforated liner to 4,570 m and a sacrificial casing to 1,300 m), and

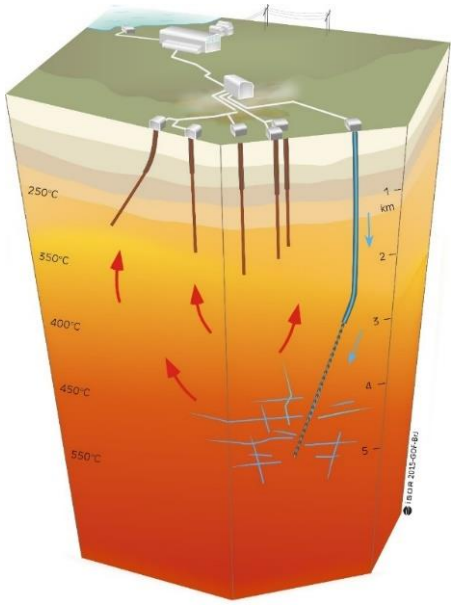

Figure 2. Conceptual model of the roots of the Reykjanes Geothermal field indicating existing wells and the track of the IDDP-2 to intersect the supercritical zone.

after only six days of heating, supercritical conditions (426°C at 340 bars) were measured in the well at a depth of 4.5 km (Figure 3). Drilling with 6" bits and coring tools continue through the perforated line to a depth of 4659 m, ending January 25th, 2017. Cold water stimulation is still ongoing, attempting to enhance the deep permeability. The well will not be allowed to equilibrate to full formation temperature until late 2017 and in 2018 it will be followed by a flow test and eventual production of the well.

ACKNOWLEDGEMENTS

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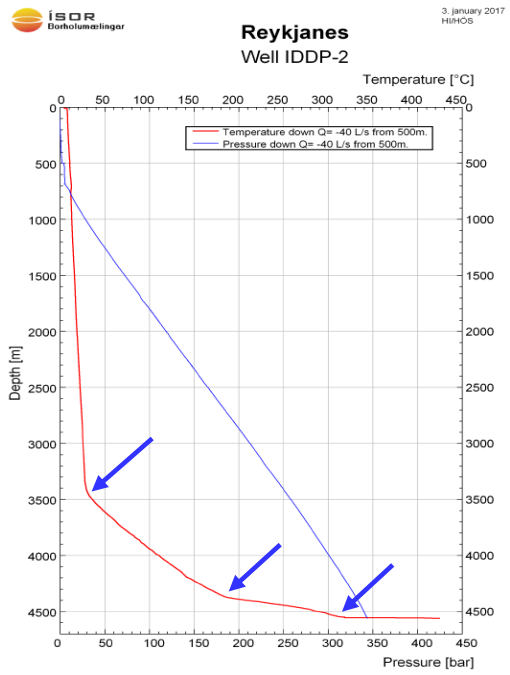

Figure 3. Temperature and pressure log to 4,550 m depth in IDDP-2 after only 6 days of heating. Blue arrows indicate feed points.

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