**News from the Iceland Deep Drilling Project** (IDDP) 16. January 2014 – GÓF-WAE

## World's First Magma-EGS system created

The January issue of the international journal GEOTHERMICS is dedicated to Icelandic Deep Drilling Project (see also at www.iddp.is ). It contains 15 papers, most of which are written by Icelandic scientists and engineers, and mostly deals with the borehole IDDP-1, the first deep IDDP hole in Iceland. It was drilled at Krafla in 2008 and 2009, and as is well known, it ended in a molten magma at 2100 m depth, with a temperature of 900-1000 °C.

Drilling into magma is a very rare occurrence elsewhere in the world. Instead of inserting a concrete plug in the bottom of the hole, as was done in a similar situation in Hawaii, the IDDP, in cooperation with the National Power Company, the owner of the hole, decided to investigate the hole further and bear part of the substantial capital cost involved. For instance, the hole was lined with a steel casing (sacrificial casing), which was cemented most of the way down but kept open (perforated) in the bottom section closest to the magma. Then the hole was allowed to heat slowly and eventually allowed to flow superheated steam for the next two years until July 2012. Throughout that time various investigations at utilizing this resource were carried out that are described in the articles in Geothermics. The success of this drilling and research is amazing to say the least, and could in the near future lead to a revolution in energy efficiency in high-temperature geothermal areas of the world.

What was involved this good performance? Firstly, we were able to drill down into the molten magma and control it, despite some difficulties. Secondly, pumping cold water into the hole to break up the rock next to the magma created high permeability (hydrofracking) which reached connection to the colder geothermal environments above. Thirdly, we were able to set steel casing down to the bottom of the hole. Fourthly, allowing the hole to blow superheated , high-pressure steam for months at temperatures over 450 °C, beat the world record for geothermal heat as this well was the hottest in the world and one of the most powerful. According to the measured output the available power was sufficient to generate up to 36 megawatts electricity, compared to the installed electrical capacity of 60 megawatts in the Krafla power plant. Fifthly, we successfully demonstrated the capability of coping with the difficult chemical composition of steam from IDDP-1 by using simple counter measures. Sixthly, we demonstrated that the steam could be taken directly into the existing power plant at Krafla, and the National Power Company was preparing such an action just before the hole had to be closed due to a valve failure. The seventh and last place but not least, by successfully drilling the hole and carrying out experiments, the IDDP-1 demonstrated that a high-enthalpy geothermal system can be created in this way, meaning that a Magma-EGS system was created by IDDP-1.

In various parts of the world so-called EGS geothermal systems (Enhanced or Engineered Geothermal Systems) are being created by pumping cold water into hot dry rocks at 4-5 km depths. Then the heated water is taken up again as hot water or steam from nearby production wells. In recent decades, there has been considerable effort invested in Europe, Australia, USA,

and Japan, with uneven results and typically poor results. With IDDP project we can claim to have created such an EGS system, the first system in the world that supplies heat so to speak directly from a molten magma. This is remarkable globally. The hot and dry contact rocks were fractured by cooling during drilling and a connection established to the overlying conventional geothermal system. Then the process was reversed by flowing the IDDP-1 hole, emitting hot fluids up through the hole which created low pressure condition around the bottom of the hole, attracting colder fluids (~350°C) from above to descend downwards into the hole and be heated to temperatures ranging up to 452°C.

What is the future and do the results have a practical value? Sure - the future is bright and the answer is "yes". Although the IDDP - 1 hole is unusable at the moment, in future the aim is to drill a similar hole and/or to repair IDDP 1 hole. The experiment at Krafla suffered various setbacks and tried personnel and equipment throughout. However, the process itself was very instructive, and apart from scientific articles published in the journal Geothermics comprehensive reports on practical lessons learned are nearing completion. These lessons will be applied by the National Power Company in the future, and the Iceland Deep Drilling Project is benefitting from it by modifying the design of both the flow test equipment and in drilling the next borehole. The second borehole, IDDP -2, will be to be drilled at Reykjanes in the coming years.

Iceland Deep Drilling Project is a collaboration of three energy companies - HS Energy ltd, National Power Company and Reykjavik Energy, and the National Energy Authority of Iceland that was established in 2000 to investigate the feasibility of utilizing geothermal fluid at substantially higher temperatures and from deeper wells than currently used today. From the onset of the IDDP, international collaboration has been one of the trade mark of the project, and a group of USA scientist in particular has been very active, authoring several of the papers in the Special Issue of Geothermics on IDDP. Alcoa and Statoil also participated in the IDDP-1 project in Krafla. ICDP and NSF have also supported the IDDP since 2005.