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Preliminary results of MT monitoring during reservoir engineering in IDDP2 (Iceland)

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ABSTRACT

The European DEEPEGS (DEPLOYMENT OF DEEP ENHANCED GEOTHERMAL SYSTEMS FOR SUSTAINABLE ENERGY BUSINESS) is a Horizon2020 project of the European Union. The project aims at demonstrating advanced engineering technologies in geothermal reservoirs under different geological conditions in Iceland and France. The focus of the here presented work is magnetotelluric (MT) monitoring of massive and soft hydraulic stimulation in the high enthalpy geothermal reservoir at Reykjanes in Iceland. The IDDP2 borehole is the deepest borehole (4.6 km depth 01/17) in Iceland. MT monitoring during massive hydraulic stimulation is useful to obtain information on the directional development of the reservoir and the evolution of preferential hydraulic connectivity. In September 2016, the first MT monitoring campaign took place at the Reykjanes. The goal was to accomplish the time-lapse MT campaign at different locations in a radius of about 2-5 km from the borehole before hydraulic stimulation to obtain the initial condition. In a second steps selected stations were planned to be monitored continuously. The first MT time-lapse measurements included eight sites around IDDP2. Continuous MT monitoring was running at two sites between December 2016 and July 2017 with a sampling frequency of 512 Hz. Due to bad data quality, one station was stopped and time-lapse measurements were not repeated. First results from the continuous monitoring reveal changes in the resistivity distribution over time. The interpretation in terms of hydraulic changes is ongoing.

1. INTRODUCTION

The concept of developing a deep EGS well at Reykjanes comprises injection of fluid underneath the conventional geothermal field to support production. Therefore, the 2,500 m deep RN-15 production well was deepened to 4,659 m depth in the framework of the Icelandic Deep Drilling Program IDDP-2. The drilling operation IDDP-2 was completed after 168 days on January 25th, 2017. Complete loss of circulation fluid occurred below 3,200 m. Temperature and pressure measurements at the well bottom suggest P/T condition of 340 bars and 427°C and thus, supercritical condition of the fluid. Well logging highlights a large permeable zone above 3,400 m and smaller feed zones at 4,450 m and 4,500 m. Continuous fluid loss at high flow rates impedes the acquisition of the initial resistivity condition in the reservoir after drilling by time-lapse measurements. Therefore, the focus of the current work is on the continuous monitoring.

2. MT MONITORING

Magnetotelluric monitoring was carried out at the MT stations RAH (6km away from RN-15) and GUN (1km away from RN-15), since December 2017 until July 2017, each equipped with two electric dipoles in N-S and E-W direction, as well as three magnetic sensors oriented in N, E and vertical direction. Magnetotelluric monitoring during massive hydraulic stimulation may reveal information on the directional development of the reservoir and the evolution of preferential hydraulic connectivity. First results from the late drilling phase were processed. Due to bad data quality of the MT station RAH (stopped in May 2017) , MT data are processed using single site method.

2.1 First MT results from GUN

Figure 1 shows a representative example of electric resistivity and of phase as a function of the period , which were acquired between January 13th and 14th, 2017 at the GUN station. A core section was drilled at 4,634 m to 4,642.8 m depth during this period. Note that the period can be related to depth following the concept of skin depth of the electromagnetic signal, therefore, the resistivity-period distribution is a function of the resistivity distribution with depth. The results are decomposed into to XY and YX components that represent different directional components of the electric and magnetic fields. They reveal rather homogenous resistivity of about 10 Ωm down to periods of about $2 \cdot 10^{-1}$ s. Below resistivity drops by up to 1 order of magnitude with preference in the YX component. Two minima at $5 \cdot 10^{-1}$ s and 5 s are observed. Low resistivity in conventional geothermal reservoirs indicates either a clay cap layer that seals the reservoir at its top or the reservoir itself (e.g. Uchida, 2005). From 10 seconds on, resistivity increases with depth. The periods between 10^{-1} and 10 s corresponds to the reservoir depth.

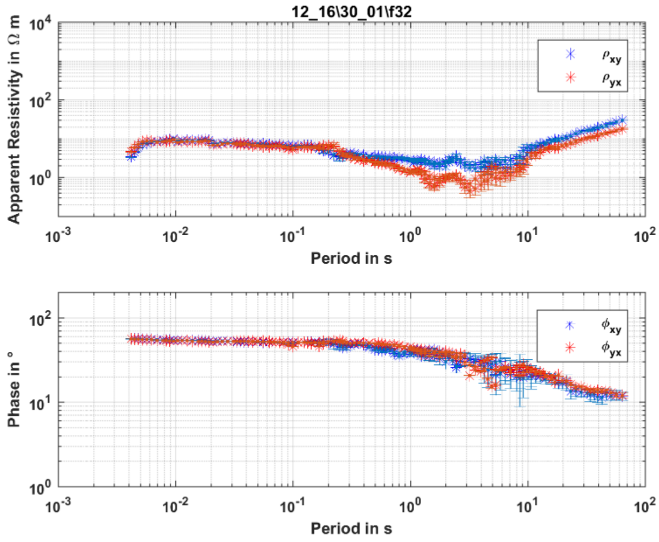

Figure 1: Electric resistivity and phase versus period from the magnetotelluric monitoring from two monitoring days in December 2017 at station GUN. Blue curves show the XY-component, the red curves the YX-component.

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