Systematically changes in MT signal during deep drilling operations

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ABSTRACT

The Horizon 2020 project "Deployment of deep enhanced geothermal systems for sustainable energy business (DEEPEGS)" aims at demonstrating advanced engineering technologies in geothermal reservoirs under different geological conditions in Iceland and France. 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) from August 2016 until January 2017. The drilling progress was accompanied by partial and up to total circulation loss. Below 3,200 m total circulation loss indicates a highly permeable zone and led to total lack of cuttings. The Iceland Deep Drilling Project 4.5 km deep well, IDDP-2, in the seawater-recharged Reykjanes geothermal field in SW Iceland has successfully reached its supercritical target (Friðleifsson et al, 2017).

Contemporaneously to the drilling, continuous magnetotelluric (MT) monitoring was carried out in order to reveal information on the directional development of the reservoir and the evolution of preferential hydraulic connectivity at comparably high flow rates.

Two continuous running MT stations, GUN and RAH, were installed on the Reykjanes peninsula. RAH and GUN are located about 6 and 1 km away from IDDP-2. Both MT stations are 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 was carried out between December 2016 and July 2017 with a sampling frequency of 512 Hz. The processing of the first data from the late drilling phase revealed the bad data quality of RAH hence it was stopped in May 2017. Consequently, MT data were processed using single site method with the code Bounded Influence Remote Reference Processing (Chave and Thomson, 2003). Due to a temporally noise signal in the time series they were down filtered to get the lower bands and hence to clean the time series.

First results from the late drilling period reveal changes in the resistivity distribution over time. Prominent drops in electric resistivity are observed in a time period of about 24-48 hours before "major" seismic events (M_L>1.0 or frequency >10/d) occurred. They occur at frequencies of 0.25-5 Hz. A second frequency range (0.2-0.125 Hz) of transient decrease in electric resistivity correlates with time periods of large losses of circulation fluids. In general, most of the changes are observable in the YX-component of the transfer functions suggesting a directional development.

However, for final interpretation, different possible sources of the signal changes will be investigated such as comparison with the variation of the Earth's magnetic field and ongoing operations at the drilling site.

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