Geophysical Research Abstracts
Vol. 13, EGU2011-776-4, 2011
EGU General Assembly 2011

Distributed temperature sensing behind casing within a hot geothermal well - Results from a flow test in well HE-53, SW Iceland

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Wellbore integrity is an important issue for a sustainable provision of geothermal energy. Monitoring the status of a well can therefore help to optimize expensive work-over activities, but can also prevent a severe hazard for human lives and neighboring wells. This study reports on logging data that has been acquired prior to a casing failure in the hot geothermal well HE-53 within the Hengill area, SW Iceland. Fiber optic distributed temperature sensing (DTS) data, measured in the annulus behind the anchor casing, are used in combination with conventional logging data in order to study thermal processes during a flow test in summer 2009.

In spring 2009, a fiber optic cable has been installed behind the anchor casing of a conventional geothermal well HE-53 down to a depth of 270 m. The well was finished by the end of June 2009 with a depth of 2400m. During the onset of a flow test in August 2010, distributed temperature measurements were performed for a period of two weeks. Within this period, the wellhead temperature increased up to 240°C and maximum temperatures within the annulus behind the anchor casing rose up to 230°C. Although a steady increase in wellhead temperatures was observed, a short term temperature decrease was measured within the annulus, locally. Successively, decreasing temperatures were detected in adjacent depth intervals. The effect migrated along the wellbore axis with a velocity of 5-10 m/100 h and lasted for a few hours in each depth interval.

In this work, conventional casing bond logs are used to evaluate the cementation prior to the flow test. With the knowledge about the cement quality, DTS measurements are then used to examine the process of decreasing temperatures during the flow test. One hypothesis to explain the temperature depression might be the evolution of latent heat of vaporization. The large temperature increase (>200°C) led to a rising vapor pressure of the pore fluid in the cement sheath of the casing. Eventually, the vapor pressure was released and the fluid vaporized, consuming thermal energy.

Within this study it was examined if the evolution of latent heat might be caused by the formation of small fractures within the cement. Due to the thermal expansion of the casing, mechanical stress is applied to the cement. If the stress exceeded the strength of the cement, small fractures could evolve. These fractures might have caused an increase in available volume for the pore fluid, leading to the vaporization and thus to a reduction of the temperature.