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Simulation of temperature logs in high-temperature well

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In the frame of the EU Horizon 2020 DEEPEGS project and the IDDP2 project, the well RN-15 located in the Reykjanes geothermal field (Iceland) was deepened. So far, this well, namely RN-15/IDDP2 is the deepest geothermal well drilled in Iceland with a final depth of 4659 m and a measured bottom-hole temperature of 427℃ and fluid pressure of 34 MPa. During drilling, several temperature logs were run whilst water was injected continuously to cool down the equipment in the borehole due to the high-temperature environment. The objective of our work, as part of the DEEPEGS project, is to apply numerical simulation methods to estimate the formation temperature and fluid loss along the well path, based on the recorded temperature logs acquired under dynamic conditions, during and after drilling. This is of particular interest for the development and understanding of the deep geothermal reservoir.

Our approach comprises the development of a transient thermal model in which the temperature evolution of the well and the surrounding formation is simulated. The numerical tool enables the use of the whole history fluid circulation data. In this work, we first evaluate synthetic data that reflect possible different technical logging conditions such as permanent cooling or fluid loss zones in the high-temperature environment. Concerns as to whether simple BHT type correction methods are still applicable to non-shut-in conditions of boreholes will be considered. Consequently, different application examples of temperature logs are presented. Firstly, we provide an example of estimating SFT in an extremely high-temperature well, which is continuously cooled down during logging, using the classic Horner-plot Method. The impact of using non-shut-in temperature logs for the SFT estimation is examined. Secondly, we demonstrate how temperature logs can be used for characterizing the fluid loss in the borehole. The results show that applying simple temperature correction methods on the non-shut-in temperature data could lead to large errors (24 ℃ to 74 ℃ at a flow rate of 0.7 L/s) for SFT estimation. Fluid loss leads to the local gradient increase in the vertical temperature profile. However, the amount of the temperature gradient increase and the percentage of fluid loss have a non-linear and non-monotonic relationship. This relationship depends on the flow rate and the lateral heat transfer between the fluid and the rock formation. As indicated by this study, under low fluid losses (< 30%) or relatively higher flow rates (> 20 L/s), the impact of flow rate on the temperature gradient increase can be ignored. The knowledge and experience gained from the synthetic models provide insights for the future work when the real temperature logging data are used to constrain the far-field formation temperature and to estimate the fluid loss. Herein, we also present some first results on the temperature analysis in the RN-15/IDDP2 well using real long-term drilling and logging data.

Keywords: RN-15/IDDP2, DEEPEGS, Numerical simulation, Formation temperature, Fluid loss

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