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Field-observed Thermal Fractures during Reinjection and Its Numerical Simulation

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Abstract : One key process that partly controls the success of geothermal projects is fluid reinjection, which benefits in dealing with waste water, maintaining reservoir pressure, and supplying heat-exchange media, etc. Thus, sustaining the injectivity is of great importance for the efficiency and sustainability of geothermal production. However, the injectivity is sensitive to the reinjection process. Field experiences have illustrated that the injectivity can be damaged or improved. In this paper, the focus is on how the injectivity is improved. Since the injection pressure is far below the formation fracture pressure, hydraulic fracturing cannot be the mechanism contributing to the increase in injectivity. Instead, thermal stimulation has been identified as the main contributor to improving the injectivity. For low-enthalpy geothermal reservoirs, which are not fracture-controlled, thermal fracturing, instead of thermal shearing, is expected to be the mechanism for increasing injectivity. In this paper, field data from the sedimentary low-enthalpy geothermal reservoirs in the Netherlands were analysed to show the occurrence of thermal fracturing due to the cooling shock during reinjection. Injection data were collected and compared to show the effects of the thermal fractures on injectivity. Then, a thermo-hydro-mechanical (THM) model for the near field formation was developed and solved by finite element method to simulate the observed thermal fractures. It was then compared with the HM model, decomposed from the THM model, to illustrate the thermal effects on thermal fracturing. Finally, the effects of operational parameters, i.e. injection temperature and pressure, on the changes in injectivity were studied on the basis of the THM model. The field data analysis and simulation results illustrate that the thermal fracturing occurred during reinjection and contributed to the increase in injectivity. The injection temperature was identified as a key parameter that contributes to thermal fracturing.

Keywords : injectivity, reinjection, thermal fracturing, thermo-hydro-mechanical model
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