Geophysical Research Abstracts
Vol. 17, EGU2015-6919, 2015
EGU General Assembly 2015

Numerical Modeling of Fluid Migration and Propagation of Multiple Hydraulic Fractures in Crystalline Geothermal Reservoir

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This paper presents discrete element based numerical model which is applied to simulation of multiple stage hydraulic fracturing in crystalline granitic geothermal reservoir. Target site modeled locates in south of state of Saxony Germany. Particle Flow Code 2D (Itasca) is used in which fluid flow algorithm and moment tensor based seismicity computation algorithm are implemented. Crystalline rock layer to be stimulated locates at 4-6 km depth with relative low density of pre-existing joints and faults. Hydraulic stimulation is modeled with five stages of fluid injection with distance of several hundreds of meters. Hydraulic fracturing is done on the stages from toe to heel direction along a series of sub-horizontally drilled wellbore with constant rate of fluid injection. Fracture propagation paths and induced seismic events are documented based on their time of occurrence and their magnitude. In addition to the evolution of the fracture propagation path and distribution of the induced events, migration of the injected fluid is investigated in space and time. This is to see how the results relate to the fluid migration front in low permeability crystalline reservoir subjected to multiple stage hydraulic fracturing. Moreover, this paper addresses advantages and disadvantages of the inclined drilling of the wellbore in low permeability reservoir and multi-stage fracturing setting. We try to seek an optimum inclination of the drilling in relation to the gradients and magnitudes of the in situ stresses, which are horizontal minimum and vertical stresses. Preliminary modeling results show that inclination angle of the drilling has a significant effect on lowering of the stress shadow effect and level of induced seismicity in terms of total number, magnitudes and the Gutenberg-Richter relation.