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Thermal stress effect on fracture integrity in enhanced geothermal systems

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In an enhanced geothermal system (EGS), fluid is injected into pre-existing fractures to be heated up and then pumped out for the electricity generation; injected fluid is cold as compared to surrounding bedrock. The rock-fluid temperature difference induces thermal stress along the fracture wall, and the large thermal stress could damage some of the self-propping asperities and result in a change of the topography and lifespan of the fractures. Although fracture sustainability has been extensively studied, the mechanism of asperity damage due to rock-fluid temperature difference remains unknown. We have constructed a finite-element based three-dimensional model, which uses a hemisphere contact pair to resemble a single self-propping asperity, to investigate the effect of temperature difference on the asperity damage. In the model, the rock mechanical properties are coupled with temperature and stress state of the bedrock. Two trends of asperity deformation with temperature effect are identified: opening zone and closure zone. Closure squeezes asperity further and induces more element damage at bottom. Higher temperature difference damages elements on asperity top whereas has negligible impact on elements at asperity bottom. In other aspect, a higher temperature expand closure zone and degrades elements at the asperity bottom. Accordingly, two potential mechanisms of asperity damage are qualitatively characterized.

References

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