

# Simulating Fracture Networks for Engineering Geothermal Production

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## Abstract

**Objectives:** Optimized engineering of energy production from a geothermal system requires comprehensive geological evaluation of the potential reservoir followed by an effective design study that simulates the reservoir development. Simulations have used three-dimensional numerical methods to accurately consider the physical processes in the reservoir combined with field monitoring for validation and feedback. In this paper, we review the methods and technologies used in simulations during resource assessments and illustrate the dependence of reservoir production on the three-dimensional fracture network using case studies from Enhanced Geothermal Systems (EGS).

**Procedures:** This study provides a review of numerical modeling technologies for simulating fracture network behavior in a geothermal reservoir undergoing production or injection. Examples of case studies from the FORGE program funded by the US Department of Energy, and elsewhere, are used to show the requirements for three-dimensional Dynamic Fracture Modeling with Thermo-Hydraulic-Mechanical (THM) coupling to simulate the behavior of a Discrete Fracture Network during hydraulic stimulation and production of a reservoir.

**Results:** The effectiveness of geothermal energy production from both a hydrothermal system and an EGS rely on fluid flow through fractured reservoirs undergoing changes in coupled characteristics. Hydraulic pressure and temperature changes, disturbing or extending fractures during injection and extraction, cause induced seismicity in some subsurface environments, requiring engineered design to reduce microseismic magnitudes to acceptable limits. Advanced Geothermal Systems (AGS) that use closed-loop heat exchange isolated within the borehole is potentially enhanced by fluid flow through fracture networks in the reservoir volume near the well as temperatures are drawn down.

**Conclusions:** Fracture network behavior within a given geothermal reservoir, whether natural or induced, determines productivity during heat harvesting and power generation, including using conventional hydrothermal systems, unconventional EGS, and closed loop AGS. Resource assessment with conceptual engineered reservoir design determines the economics, bankability, and viability of many geothermal projects during planning phases. Comprehensive simulation of coupled reservoir behavior is therefore essential in assessment workflows to facilitate successful project execution.