

An Indian-Australian research partnership

## A numerical study of creation of optimal fracture networks for heat extraction from engineered geothermal reservoirs

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### The problem

Geothermal energy is a very attractive form of renewable energy. Globally, geothermal resources provide around 8900 MW of low emission, high availability, economically competitive base load electrical power. However, commercial exploitation of this renewable resource is currently limited to volcanically active parts of the Earth's crust, where hydrothermal processes bring superheated water and steam into naturally permeable rocks within a kilometre or two of the Earth's surface. Geothermal resources are theoretically available everywhere, however, as the temperature of the Earth's interior increases with depth at virtually every location. Factors limiting the widespread uptake of geothermal energy as a base load power source include the cost of drilling to appropriate depths, and the difficulty of extracting heat from rocks with low natural permeability. This project is designed to address the latter.

The permeability of mineral grains is usually very low. Fluid therefore circulates through rocks mainly through interconnected pores or fractures. Where hot rocks have high natural porosity or high density of interconnected fractures, the heat contained in the rock can be extracted at useful rates by circulating water through the rocks and to the surface via boreholes. However, in many locations around the world, hot rocks exist at drillable depth but with very little natural permeability. In a number of locations around the world substantial research efforts have been directed at artificially engineering geothermal systems by enhancing the permeability of hot rocks deep underground. In an engineered geothermal system, heat conducts from the rock mass into water which moves through an artificially generated fracture network from an injection well to a production well. The rate at which heat conducts from the rock to the fluid is a function of the total contact area and temperature difference between the rock and water. Fluid flow rates on the order of 100 litres per second per borehole are required to achieve commercial thermal extraction rates. The success of an engineered geothermal system depends on optimising the geometric arrangement and the fluid transport properties of the interconnected fracture network.

### Project aims

The main objective of this project is to improve our understanding of the mechanisms of crack initiation, propagation and interaction, and to use this improved understanding to optimise parameters for engineering horizontal geothermal reservoirs under a range of temperature, pressure and stress conditions. The project will develop theoretical model and numerical simulation to see the effects of range of techniques (hydraulic stimulation, dynamic loading, thermal loading, chemical processes) to 'stimulate' artificial geothermal reservoirs in a given rock mass. New fractures will be created, and existing and new fractures will open, extend, and interconnect. The aim is to find optimised parameters so that it can produce a connected network of fractures which minimises circulation losses and maximises the rate of heat extraction.

## **Expected outcomes**

1. Improved understanding of the mechanisms of crack initiation, propagation and interaction
2. Identify the effects of various parameters such as (insitu stress, temperature, degree of saturation) on the creation of network of fractures
3. Establish the applicability of a coupled thermo-geomechanical-reservoir simulator
4. Train high quality researchers in the area
5. Strength international corporation on research into characterization of particles in soil and rocks
6. Produce high quality joint research papers and other commercial outcomes
7. Establish India-Australia at the forefront in proposed research area