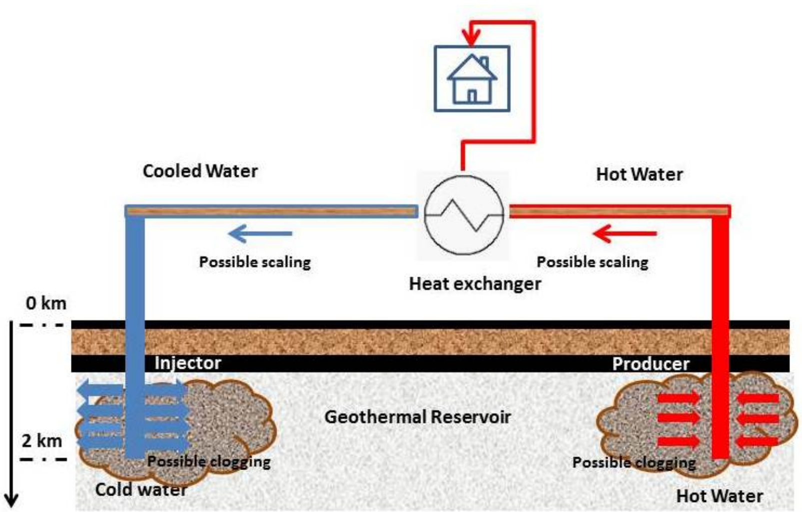

A PDE model for geothermal energy (MEP)

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General introduction

In a fossil fuel free future many renewable energy sources are required to provide sufficient energy to the society; one of these sources is geothermal energy. The idea of geothermal energy is illustrated in the figure. Cold water is injected via an injection well in the subsurface[1], pumped through the subsurface and heated by the exchange of energy with the hot environment. The warm water (of about 80°C) is recovered by the production well and used to generate power.

The subsurface can be viewed as a sponge: it consists of solid material (the rock grains) and void space (the pores). The typical dimensions of a single pore are of the order $10^{-6} - 10^{-3}$m. These pores form a pore network; significant fluid flow through this network is possible, provided enough pressure is applied. This means that circulating the water through the subsurface from injection to production well requires pumping energy.

Project description

Due to the injection of cold water in the subsurface, the chemical composition of the water may change. As a result, minerals dissolved in the water can precipitate on the rock grains. Consequently the pore network gets clogged and higher pumping power is required to keep the fluid circulation going. At a certain point the pumping energy exceeds the heat extracted; further operation of the geothermal doublet is not economically viable anymore and the operation has to be terminated. The aim of this project is to model this clogging process and to investigate how it can be influenced.

We will model the fluid flow through the subsurface as a (set of) reaction-convection diffusion equation(s) and an energy balance equation to include temperature effects. We will investigate a simplified (1D, single reaction) version of the model analytically and a more complicated version (2D, multiple reactions) analytically. Our final goal is to determine which minerals/reactions cause clogging and whether we are able to influence this, e.g., by changing pH or salinity.

Literature

1) Geochemistry, groundwater and pollution, C.A.J. Apello and D. Postma, CRC Press (2005)
2) Transport phenomena, R.B. Bird, W.E. Stewart and E.N. Lightfoot, Wiley (2006)

[1] Outside volcanic areas the temperature of the earth increases with increasing depth at a rate of about 30°C per kilometer, leading to a temperature of about 80°C at a depth of 2300 m. In volcanic areas this increase can be much larger.