5.2 Transport Model of the EGL Oil Shale Process

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The EGL Oil Shale Process uses a combination of heated horizontal wells and vertical production wells to distribute the heat through the formation. The heat transfer from the source at the heater surface to the heat sink in the oil shale formation has been modeled both in 2D and 3D geometry. In addition to standard convective heat transfer, the process involves vaporization of oil components at the heater surface, vapor transport through permeable zones and condensation at cool surfaces. Liquid oil transport through these permeable zones back to the heater is important, but has not been included in the model to date. Water evaporation and kerogen pyrolysis kinetics are included in the model. The partial differential equations that describe these fundamental phenomena have been solved using the Comsol Multiphysics software package.

Simulated retort runs show the wave behavior of in-situ retorting: a thermal wave penetrates the shale formation with a leading edge producing permeability through fracturing at approximately 200°F, followed by a water evaporation wave at approximately 330°F (with retort pressure at 150 psig), and in turn followed by the kerogen pyrolysis-vaporization wave at 620°F. In addition to the waves in the solid material, the evaporation/condensation of oil produces a fluid mechanically driven heating wave emanating from the heater surface and expanding toward vapor-accessible cold surfaces. This phenomenon has been modeled in some detail because it is critical for setting an appropriate heat deposition rate for the heater, and consequently for setting the oil production rate. The vapor flow has been modeled using both a Darcy flow model with temperature-dependent permeability and a simpler approach involving modification of shale conductivity as a function of temperature. Model results quantify the relative rates of retorting in the horizontal and vertical wells as a function of heat deposition rate.