# Modelling of Geothermal Reservoirs - an Overview

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The review activity of modelling approaches is performed in the framework of ENGINE WP3. Combined imaging methods are essential for 3D modelling of permeable systems. The issues from WP3 will be integrated in the deliverables of WP6 for defining innovative concepts and proposing generic studies that will both be published in the Best Practice Handbook for Unconventional Geothermal Resources and Enhanced Geothermal Systems. The focus of this presentation is to introduce the state of art for individual approaches for the evaluation of various geothermal reservoirs.

Modelling of geothermal reservoirs is mostly focused on pure data interpretation of an experiment and more importantly on the understanding of dominant reservoir processes. The complexity of mass transport in a reservoir becomes more visible with larger number of geophysical and hydrogeological measurements conducted in a geothermal reservoir. Moreover, the non-linearity of hydraulic, thermal, mechanical or chemical processes is often only visible in especially designed experiments. From a theoretical point of view, geothermal modelling could offer the possibility of an overall system evaluation. In practice however, only conceptual models are derived and allow a quantitative description of individual aspects. Herein, the bandwidth from low-enthalpy, porous media simulators up to high enthalpy multi-phase flow models in fractured environment will be covered. Generally, the modelling of different physical behaviour is required for individual reservoir types.

High enthalpy systems or high temperature aquifers are often treated as porous and/or fractured medium. Darcy and non-Darcian hydraulic regimes are used to accommodate the high fluid velocities in the aquifer. Advection represents the major coupling from hydraulics to thermal calculation. Possible thermal effects influence density (buoyancy) and viscosity. Often two phase liquid and steam systems are treated.

EGS (Enhanced Geothermal Systems) have the most complex physical processes in an essentially fractured medium. Again, Darcy and non-Darcian flow at high fluid velocities in fractures are used. The same coupling mechanisms as in high enthalpy systems apply, but additionally, mechanical processes play an important role in the reservoir development and assessment. Therefore, fracture mechanics with shear / tensile fracturing processes need to be considered. Also the matrix elasticity can become important through poro- and thermoelastic effects due to high-pressure injections of cold fluids. There are also examples of biphasic flow or multicomponent transport. Recent advances on rock-water interaction set first steps towards a geochemical model that will be able to optimize the composition of the circulation fluid and to enhance chemical injection.

There are several reservoir simulators used. They can be globally characterized by continuum or discrete fracture network approaches. The classical "porous modelling" and "dual porosity models" (or MINC) represent rather continuum-type simulators, whereas "unique fracture model" (often used in geochemical approaches) or complete "stochastic discrete network approach" represent the discrete-type approaches.

New trends can also be identified mostly on inverse modelling approaches, automated calibration and on models enhancements that concentrate on the simplification of the physical processes by excluding second order features. In the past, the complex methodologies were often only for academic use to investigate principal mechanisms. In future, modelling may focus on more practical applications: the new developments will lead to the optimization of different injection strategies and to the design of utilization strategies.