Fault zones in pumping tests – parameter studies for the Upper Jurassic aquifer of the North Alpine Foreland Basin by utilization of numerical simulations

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Abstract

After the drilling and completion operations of a new geothermal well are finished, up to three acidifications in conjunction with short airlift pumping tests (*a few hours*) are generally applied in the Upper Jurassic deep geother-mal reservoir of the North Alpine Foreland Basin (*Upper Jurassic aquifer*, also called *Malm aquifer*). At a later stage of the construction this is normally followed by a longer pumping test (*up to several days*) in which the pres-sure evolution in the geothermal well for stepwise increasing pumping rates is recorded. Those investigations are really important because they reveal if the geothermal exploration strategy was successful and if so how the reservoir is performing as well as what its hydraulic properties are. [Bourdet, 2002]

By applying pressure transient analysis and the *Bourdet Derivative* to the collected pressure data the identification and quantification of well, reservoir and boundary models becomes possible [Bourdet et al., 1983, Bourdet et al., 1989, Houze et al., 2011]. In this context the investigation of fault zones and their hydraulic characteristics in comparison to the aquifer's matrix is really important for the *Upper Jurassic aquifer*. Reason for this is that fault zones have been a key component of past exploration concepts and therefor many existing wells have been drilled through them [Savvatis, 2012]. Their effect on the pressure evolution can ideally be seen by observing the characteristic linear flow slope in the *Bourdet Derivative* in the early time region [Bourdet, 2002]. The *Upper Jurassic aquifer* shows in practice only rarely evidence for a flow regime dominated by faults like this [Steiner et al., 2012]. Which doesn't imply that the majority of all wells here isn't tapping into hydraulically active faults. On one hand technical effects (e.g. well bore storage, effects due to the used pumping technique, skin) can cloud the pressure signal in the early time region. But additionally a specific contrast between a fault and the aquifer matrix is needed for the system to actually show *linear flow* in a pumping test.

By performing parameter studies while observing the *Bourdet Derivative* the impact of possible fault zone and reservoir settings on pumping tests with respect to the *Upper Jurassic aquifer* was investigated. Therefor a representative but simplified, three-dimensional, numerical model was built using MeshIT [Blöcher and Cacace, 2013] and Paraview [Ahrens et al., 2005]. The simulation code MOOSE Framework [Gaston et al., 2009] was used together with the complementary reservoir simulation application GOLEM [Cacace and Jacquey, 2017]. To account for the variety of different parameter combinations automatic parameter sampling was realized by application of the RAVEN code [Alfonsi et al., 2017] on a HPC system (LRZ linux cluster and Supermuc).

Our investigations suggest that real linear flow is only visible for a very high hydraulic contrast between matrix and fault. Also the absolute matrix permeability determines how long this flow regime lasts. This means that for high values the linear flow behavior in the early time region is very fast and won't be visible in practice because well or technical effects will interfere. A contribution of a fault to the productivity of a well can therefore be present but not detectable in real world pumping tests.

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