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Numerical simulation of pore size dependent anhydrite precipitation in geothermal reservoirs

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Porosity and permeability of reservoirs are key parameters for an economical use of hot water from geothermal installations and can be significantly reduced by precipitation of minerals, such as anhydrite. The borehole Allermöhe 1 near Hamburg (Germany) represents a failed attempt of geothermal heat mining due to anhydrite precipitation (Baermann et al. 2000). For a risk assessment of future boreholes it is essential to understand how and when anhydrite cementation occurred under reservoir conditions.

From core samples of the Allermöhe borehole it was determined that anhydrite precipitation took place in regions of relatively high porosity while regions of low porosity remained uncemented (Wagner et al. 2005). These findings correspond to the fact that e.g. halite precipitation in porous media is found only in relatively large pores (Putnis and Mauthe 2001). This study and others underline that pore size controls crystallization and that it is therefore necessary to establish a relation between pore size and nucleation. The work presented here is based on investigations of Emmanuel and Berkowitz (2007) who present such a relation by applying a thermodynamic approach. However this approach cannot explain the heterogeneous precipitation observed in the Allermöhe core samples. We chose an advanced approach by considering electric system properties resulting in another relation between pore size and crystallization.

It is well known that a high fluid supersaturation can be maintained in porous rocks (Putnis and Mauthe 2001). This clearly indicates that a supersaturation threshold exists exceeding thermodynamic equilibrium considerably. In order to quantify spatially heterogeneous anhydrite cementation a theoretical approach was chosen which considered the electric interaction between surface charges of the matrix and calcium and sulphate ions in the fluid. This approach was implemented into the numerical code SHEMAT (Clauser 2003) and used to simulate anhydrite cementation in a 2D hypothetical core flooding experiment.

With this new approach cementation patterns observed in the Allermöhe core samples can be explained now. The obtained results show that the variation of fluid supersaturation within a pore governs spatially heterogeneous anhydrite cementation. This variation and the fluid velocity determine the precipitation. Our numerical simulation results clearly emphasize the necessity to consider the spatial variation of supersaturation on the pore scale.

References

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