AAPG/SEG/SPE HEDBERG CONFERENCE
"GEOLOGICAL CARBON SEQUESTRATION: PREDICTION AND VERIFICATION"
AUGUST 16-19, 2009 – VANCOUVER, BC, CANADA

Simulation of CO_2 Distribution at the In Salah Storage Site Using High-Resolution Field Scale Models

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The In Salah CO_2 storage site, Algeria, is part of an industrial-scale capture and storage project within the In Salah Gas Joint Venture. CO_2 from several fields within the development is removed from the production stream and injected into a saline aquifer 1900 m below the surface and several kilometers away from one of the gas reservoirs - the Carboniferous sandstone at Krechba.

CO_2, injected into three horizontal wells down-dip from the natural gas field at Krechba, has been actively monitored since the injection start-up in 2004. Satellite surveys (InSAR) showing subtle surface deformation and analysis of well data (gas geochemistry and tracer analysis) give indications of the spatial distribution of the injected CO_2. The 20 meter thick reservoir/aquifer unit is pervasively fractured with the predominant joint set (NW-SE) in close alignment with the present-day stress field. The reservoir/aquifer is also segmented by a number of strike-slip faults (E-W) related to a regional mid-to-late Carboniferous basin inversion. The heterogeneous nature of the storage formation is a key influence on the distribution of stored CO_2 in the subsurface.

We use a non-deterministic stochastic modeling approach assuming capillary limit conditions to simulate the CO_2 migration process. The field-scale model involves 410 million cells with dimensions of 10x10x2 meters. The high-resolution model captures the reservoir heterogeneity with respect to both fault and fracture distributions and uses invasion percolation algorithms to assess the distribution of CO_2 within the storage unit. The simulation results are consistent with the observed CO_2 distribution after 5 years of injection and indicate that the current distribution of CO_2 is principally related to the fracture network. Initial results for predictive simulations of the post-injection period (decadal distributions) are sensitive to, and principally constrained by, the fault distribution and the multi-phase flow behavior. The simulations results highlight the key role that high-resolution heterogeneous field-scale models can play in developing a comprehensive, cost-effective and fit-for-purpose storage monitoring program. We now aim to model the pressurization of the reservoir near the injection wells to further understand the initial CO_2 distribution and investigate the capillary limit conditions of the invasion percolation model.