# High Resolution Prediction of Gas Injection Process Performance for Heterogeneous Reservoirs

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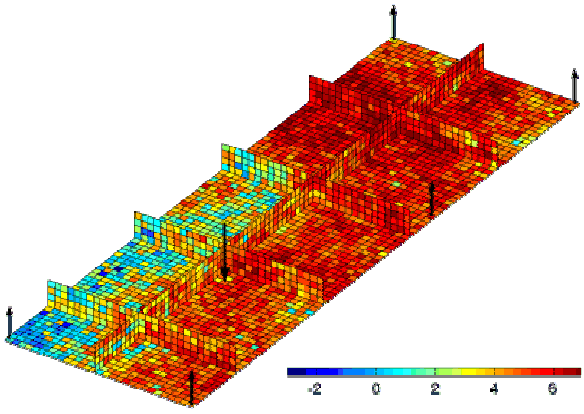
**Description:** High pressure gas can displace oil and gas relatively efficiently in subsurface geologic formations if displacement conditions are selected appropriately. Our fundamental objective is to understand the physical mechanisms that control displacement performance in gas injection processes and use that understanding to develop efficient and accurate computational tools for prediction of project performance at field scale.

Previous research on the interplay of viscous fingering, gravity segregation and permeability heterogeneity indicates that in many reservoir settings, the flow is dominated by the heterogeneity of the reservoir rocks. Thus any simulation tool that we use for field-scale predictions must be able to handle high resolution representations of the heterogeneous permeability field if it is to represent the flow realistically.

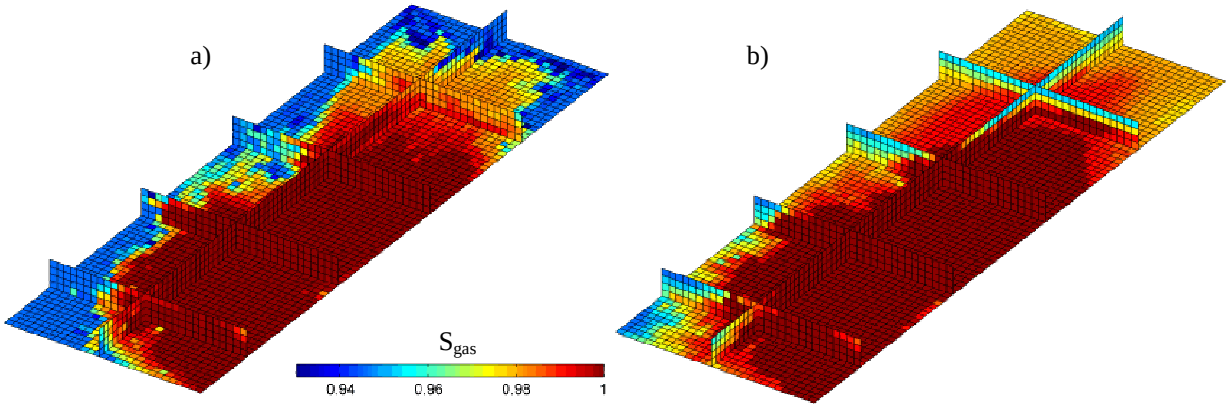
In addition, gas injection processes are fundamentally compositional. It is the interaction of phase behavior and flow that controls local displacement efficiency in high pressure gas drives. Compositional simulation is appropriate for such flow systems. Unfortunately, conventional compositional finite difference simulators are too computationally intense for high resolution 3D computations to be practical, and computations with coarser grids are generally badly affected by numerical dispersion.

We are developing the streamline compositional simulation approach for gas injection processes. Streamline methods decompose the problem into a 3D pressure solve used to determine the streamlines and a set of 1D computations along those streamlines that represent the physics and chemistry of the displacement. The streamline methods are fast if the flow is dominated by heterogeneity as the positions of the streamlines change slowly in time allowing for larger timesteps relative to the FD approach. In addition, streamline methods are natural candidates for parallel computations and adaptive mesh refinement on the pressure grid as well as the streamline grid.




Permeability field and well locations in 3D example calculation.

We are investigating ways to assess the limitations of streamline methods (they do not represent flow across streamlines, for example). Finally, we are investigating experimentally how low interfacial tensions that arise in some high pressure gas drives influence flow behavior.




Saturation distribution after 2500 days of injection by: a) SL simulation and b) FD simulation. Speedup ~ 1600 times.

**Status:** A three-dimensional streamline compositional simulator has been developed. It allows assessment of the performance of gas displacement processes using an analytical solution for multicomponent displacement along a streamline in combination with high resolution representation of heterogeneities in the calculation of streamline locations. The resulting predictions of process performance are more accurate than conventional finite difference compositional simulations and can be obtained with orders of magnitude less computation time. Investigation of efficient methods for inclusion of gravity, capillary phenomena, streamline updating, and numerical solution for the 1D flow problem are underway.

**Publications:**

Mallison, B., Gerritsen, M., Jessen, K. and Orr, F.M. Jr.: “High Order Upwind Schemes for Two-Phase, Multicomponent Flow”, SPE 79691, SPE Reservoir Simulation Symposium, Houston, TX, February 3-5, 2003.

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Zhu, J., Jessen, K., Kovscek, A.R and Franklin M. Orr, Jr., “Recovery of Coalbed Methane by Gas Injection,” SPE 75255, 2002 SPE/DOE Improved Oil Recovery Conference, Tulsa, OK, April 13-17, 2002.

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Jessen, K., Sam-Olibale, L., Kovscek, A, Orr, F.M. Jr.: "Increasing CO2 storage in Oil Recovery", First National Conference on Carbon Sequestration, sponsored by the National Energy Technology Laboratory, Washington, DC, May 14-17, 2001.

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