Injecting carbon-dioxide into deep reservoirs

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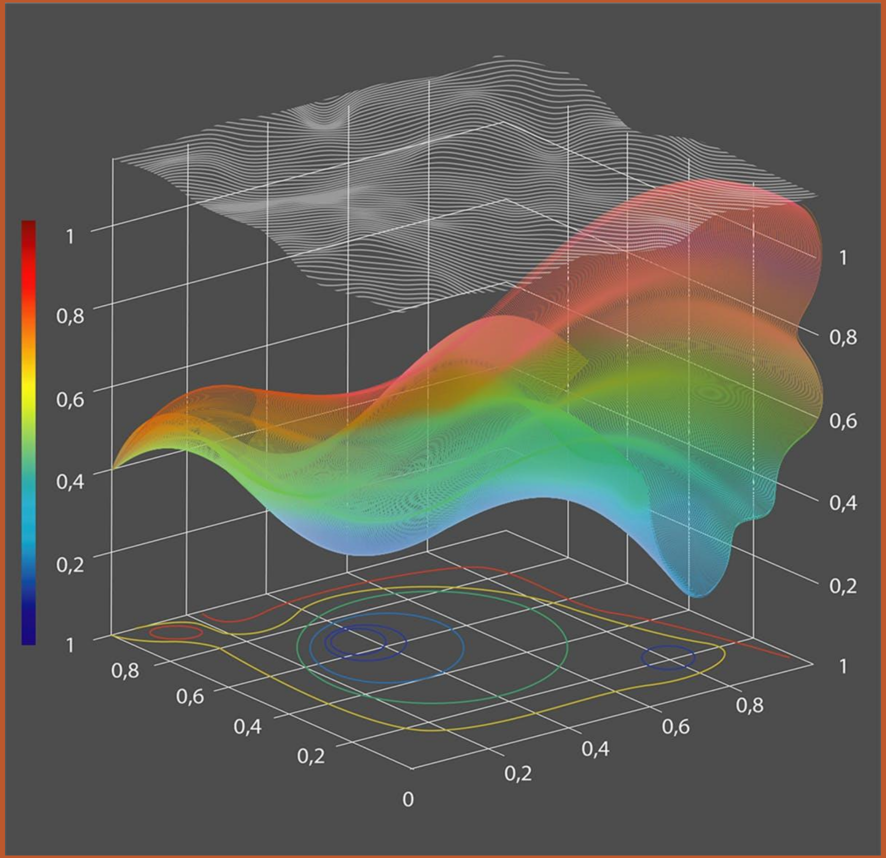


Contents

Introduction

The problem of injecting carbon-dioxide into deep reservoirs is important from the practical point of view and its modeling is mathematically challenging. In the framework of the planned project, first, the corresponding one-phase flow. Another important task is the computer simulation of the corresponding process using the Matlab toolbox MRST. In this study, CO_2 is injected in the aquifer for a period of 30 years. Thereafter we simulate the migration of the CO_2 in a post-injection period of 500 years The simulation is done using the vertical average/equilibrium framework.

The previous result

Construct stratigraphic and petrophysical model
- Top and bottom surfaces
- 3D grid
- Top-surface grid
- Petrophysical parameters
- Find pressure boundary
-Set time and fluid parameters
-Set well and boundary conditions

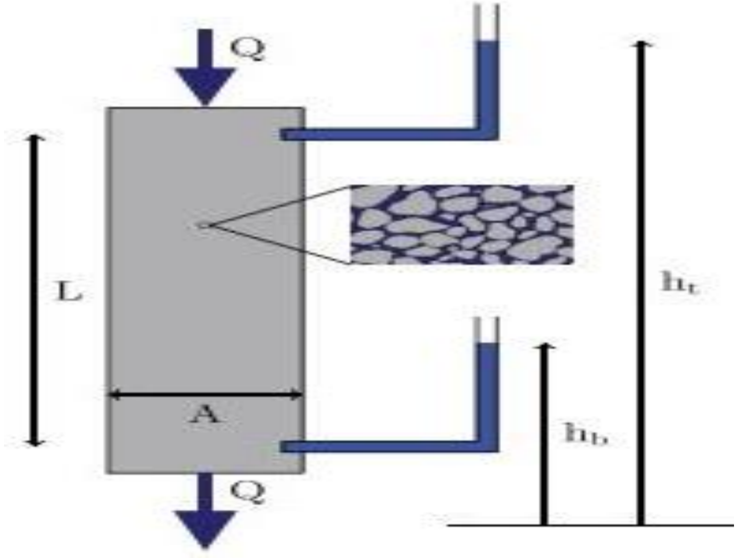
The new features in the code

Solve incompressible flow problem (fluxes/pressures) for VE equation

This function assembles and solves a (block) system of linear equations defining interface fluxes and cell and interface pressures at the next time step in a sequential splitting scheme for the reservoir simulation problem defined by Darcy's law $q = \frac{Q}{A} = k\left(\frac{\ln - h_2}{L}\right)$ and the Vertical Equilibrium assumption and a given set of external influences (wells, sources, and boundary conditions).

Some important function

Darcy's law: $q = \frac{Q}{A} = k\left(\frac{h_a - h_b}{L}\right)$



Darcy's law for a single-phase fluid: $\vec{v} = k\mu(\nabla p - g\rho\nabla z)$

The new features in the code

Explicit single point upwind solver for two-phase flow using VE equations

Function explicitTransportVE solves the Buckley-Leverett transport equation $u_t + f(u)_x = q$ using a first-order upwind discretisation in space and a forward Euler discretisation in time. The transport equation is solved on the time interval [0,T].

We add a new instruction on this function for changing some volume and chemical reaction between H_2O and CO_2.. These are instructions:

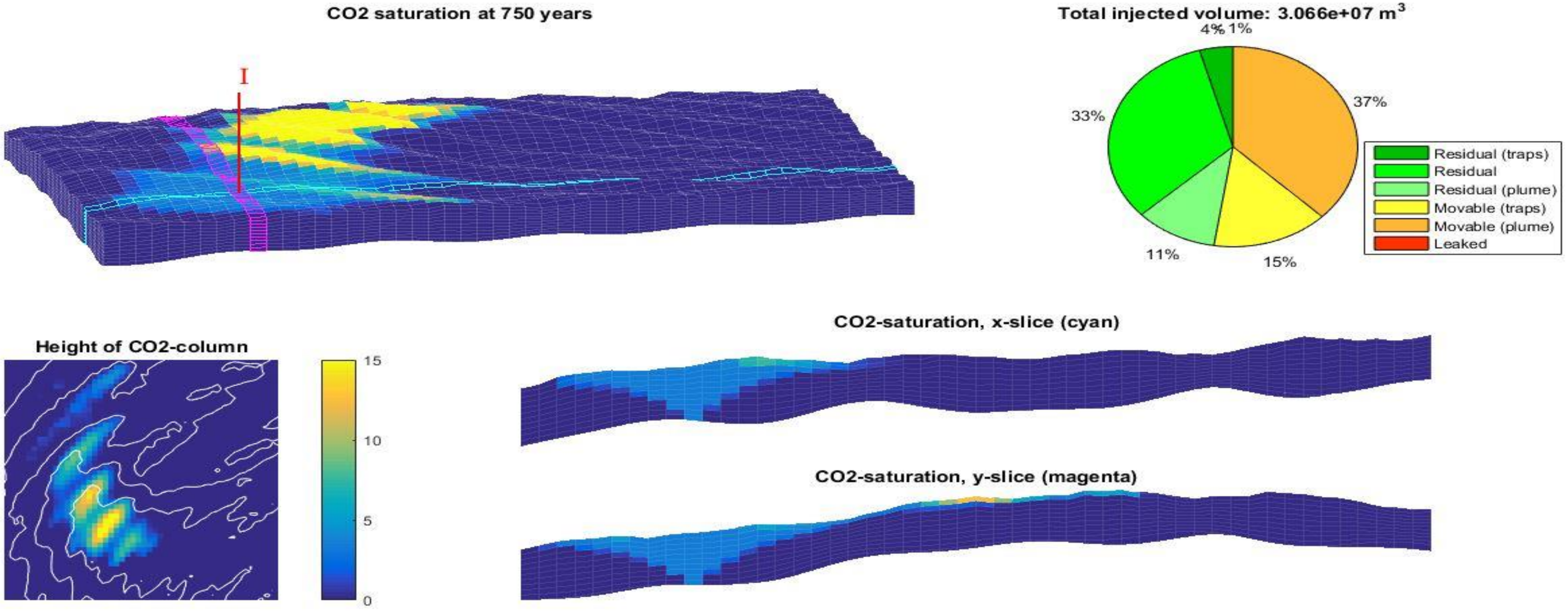
Water= a*ones(2500,1), a is a positive number between 0 and 1.

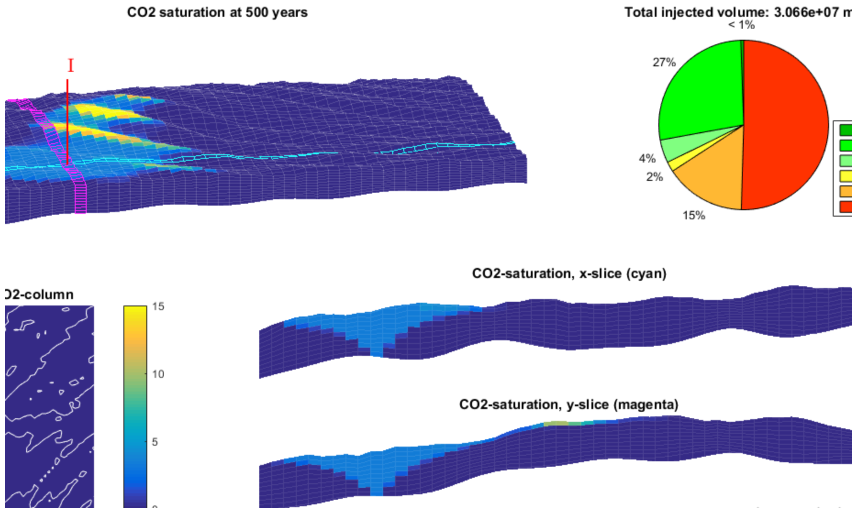
vol_new=vol_new-b*vol_new.*water, b is a small number.

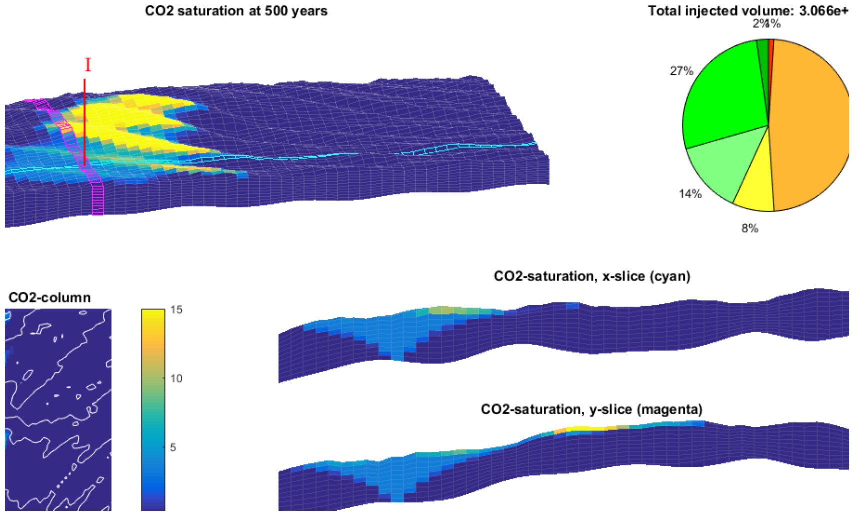
vol_new is an instruction for the new CO_2 volume after reaction with H_2O.

Final outcome and explanition

We can see here the result without the new features :







final outcome and explanition

These results for different input value and after reaction between water and carbon-dioxide.

The first picture there is more carbon-dioxide leaked, because does not have much water, that is mean the volume of carbon-dioxide does not change effectively (little change). But in the second picture does not have much carbon-dioxide leaked, because new volume of the carbon-dioxide is changed.

Final outcome and explanition

The figure meaning:

Residual (traps): this phase of trapping happens very quickly as the porous rock acts like a tight, rigid sponge. As the supercritical CO_2 is injected into the formation it displaces fluid as it moves through the porous rock. As the CO_2 continues to move, fluid again replaces it, but

some of the CO_2 will be left behind as disconnected – or residual – droplets in the pore spaces which are immobile, just like water in a sponge. This is often how the oil was held for millions of years.

Residual: Residually trapped CO_2 outside free plume and residual traps.

Residual (plume): CO_2 still in the free-flowing plume, but destined to be left behind after imbibition.

Movable: the movable CO_2 plume never grows large, and as it moves it is quickly dissolved and does not migrate far. On the other hand, since the brine below the plume is saturated with CO_2 at all times, no additional dissolution occurs in areas where the plume remains present.

Leaked: CO_2 that has left the simulated domain.

Thank you for your attention