Injecting carbon-dioxide into deep reservoirs

14.05.2021-Modelling Project Work 2
Said Ghemam Amara
Eötvös Loránd University (ELTE)
Faculty of Science -Applied mathematics(MSC)
Supervisor: Pr.**Izsák Ferenc**

Overview

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 720 years.

The simulation is done using the vertical average/equilibrium framework.

The injection of carbon-dioxide:

The injection of CO_2 is mainly driven by pressure differences as in oil recovery. However, as CO_2 moves into the aquifer and the effects of the injection pressure ceases, the fluid movement is gradually dominated by buoyant forces that cause the lighter CO_2 phase to migrate upward in the open aquifer system. This process can potentially continue over thousands of years. The basic flow physics and governing equations are the same in both cases, but the balances between physical forces are different, and this should be accounted for when formulating the overall mathematical models and appropriate numerical methods.

The important function:

1-Function explicitTransportVE:

solves the Buckley-Leverett transport equation:

h_t + f(h)_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,tf].

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

These are instructions:

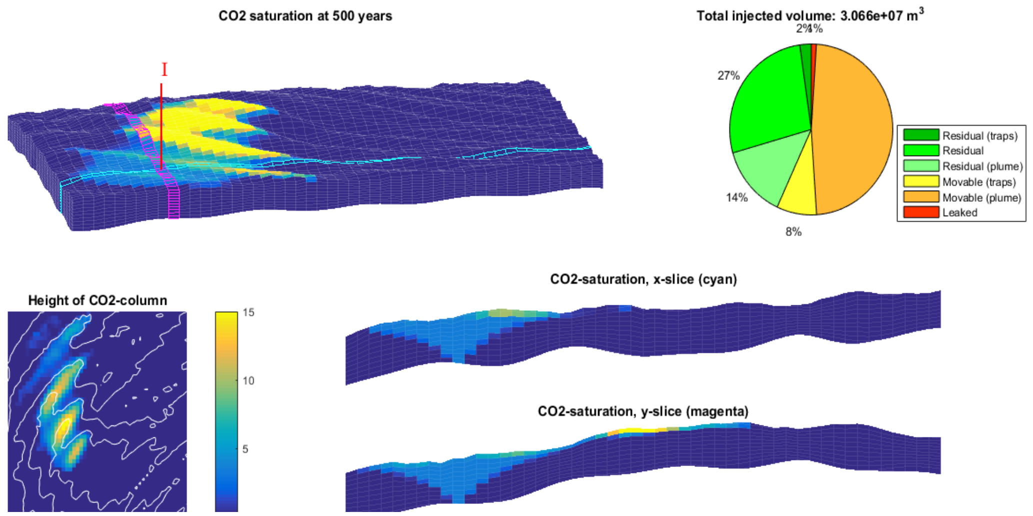
Water= a*ones(2500,1), a is a positive number between 0 and 1.

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.
the volume of CO_2 is not equal the volume H_2O.
when we change the values a and b we will have many changes in the results.
we can express it with these equations:
[CO_2] ' = - 0.01 * [CO_2] * [H_2O]
[H_2O] ' = - 0.01 * [CO_2] * [H_2O]
Here the symbol ' is for the differentiation with respect to time.

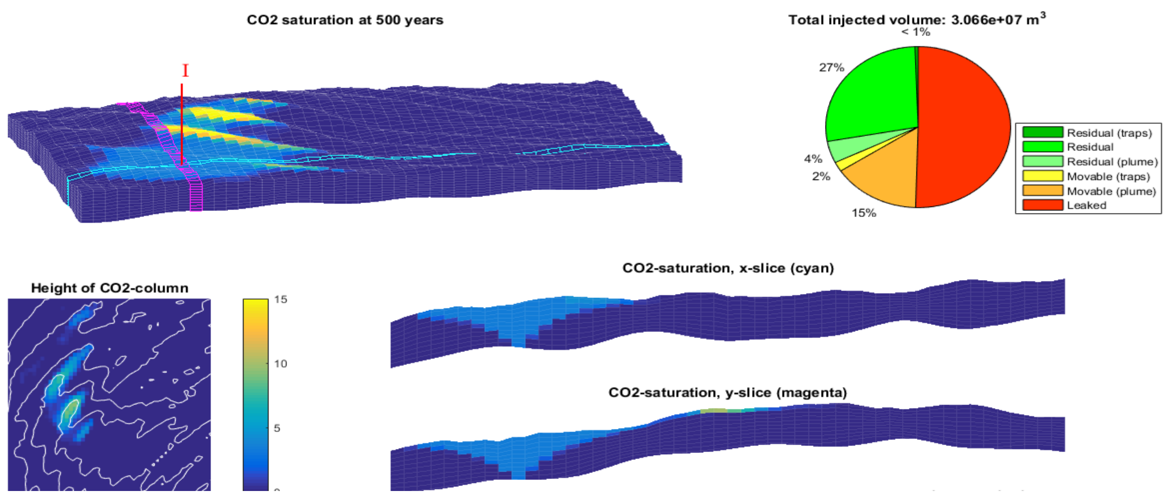
Final outcome and explanation:

Now, we would like to see the result and explain it.

This result for a=0.011 and b=0.001



This result for a=1 and b=0.001



Explain some result in the figure:

Residual trapping: 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.

Leaked: defined as the increase in CO_2 emissions outside.