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Estimating CO_2 storage capacity in saline aquifers: Revisited concept and application to the Bécancour area (Québec, Canada)

Tien Dung (T. D.) Tran Ngoc (1), René Lefebvre (1), Michel Malo (1), and Christine Doughty (2)

(1) Institut national de la recherche scientifique, Centre Eau Terre Environnement, 490 rue de la Couronne, Québec, QC G1K9A9, Canada (tien_dung.tran_ngoc@ete.inrs.ca, +1 418 654 3726), (2) Earth Sciences Division, E.O. Lawrence Berkeley National Laboratory, Berkeley, CA 94720, U.S.A.

Knowledge of effective storage capacity is needed to assess CO_2 geological storage projects. Although many efforts have been made to define and estimate storage capacity in deep saline aquifers, it is a complex issue due to the multiphase-multicomponent displacement processes involved. There are difficulties and differing views about the use of existing dynamic/static capacity estimation approaches, especially regarding the application of these approaches to various types of reservoirs. In this research, a revised methodology to assess the amount of CO_2 that can be injected into a saline aquifer is presented in terms of reservoir boundaries, capacity definitions and efficiency storage factors. For the dynamic approach, the TOUGH2 numerical simulator was used to calculate the CO_2 storage capacity for a bounded reservoir volume, using a definition of "capacity" based on the mass of all forms of CO_2 present in the reservoir after injection (mobile, immobile and dissolved). It is necessary to distinguish the efficiency storage factors, and thus the storage capacity, that are estimated on mass or volume basis because the factors based on mass are greater than the ones based on volume. Local and global efficiency storage factors are respectively averaged over domains containing CO_2 and the whole reservoir and they change with space and time. For the static approach (i.e. USDOE volumetric and compressibility methods), in order to compute the storage capacity the only difficulty resides in the estimation of the efficiency storage factors, which are related to the areal, vertical, gravity and microscopic displacements in the volumetric static method. These factors were quantitatively estimated from correlations used in petroleum engineering to relate multiphase displacement processes with dimensionless numbers.

The methodology proposed herein was applied to the estimation of the CO_2 effective storage capacity of the deep saline aquifers of the Potsdam sandstones in the Bécancour area (Québec, Canada). This reservoir can be divided into three sub-reservoirs having different conditions: initial pore pressure gradients (12 to 16 MPa/km), unit thickness (120 to 420 m with 3.5-6% of porosity and 0.1-10 mD matrix permeability), depths (1.1 to 2.7 km) and areas (33 to 75 km2). The estimated effective storage capacity of the North-East, North-West and South-East equivalent cylindrical sub-reservoirs are 10-21, 7-20 and 68-110 Mt of CO_2, respectively. These estimates were obtained from various approaches (TOUGH2 dynamic method, static volumetric and compressibility methods) and considering the maximum pressure threshold for fracturing and the CO_2 injection in a single well. None of the methods consistently provides the lowest or highest storage capacity for all three sub-reservoirs. Nevertheless, for the whole reservoir the storage capacity estimated by the dynamic method is about 0.6 times smaller than what was obtained by the static methods, and the global efficiency storage factors based on the mass range from 1.2% to 4.2%. This research highlights the importance of assessing storage capacity based on representative reservoir characteristics. Results also show that the available estimation methods can provide significantly different results. Therefore, no generalization can be made about which method generally provides low or high estimates.