CO_2 migration characteristics of microbubble and conventional sequestration in Berea sandstone revealed by X-ray CT imaging

*Hongyu Zhai[1,2], Yi Zhang[1,2], Hyuck Park[1,2], Ziqiu Xue[1,2]

1. Geological Carbon dioxide Storage Technology Research Association,9-2, Kizugawadai, Kizugawa Shi, Kyoto, 6190292 Japan, 2. Research Institute of Innovative Technology for the Earth (RITE),9-2, Kizugawadai, Kizugawa Shi, Kyoto, 6190292 Japan

CO_2 geological sequestration is an effective technique to mitigate the increase of global CO_2 emission and warming effect. To improve CO_2 storage capacity in porous sediments, we applied a new technology, of which a particular filter is utilized to generate supercritical CO_2 (SC) microbubble, for the SC injection. A Berea sandstone sample was used for the tests: the microbubble injection (MBI) and conventional injection (CI). By X-ray CT imaging, we find that the MBI can enhance the SC migration and sweep efficiency, and finally result in a higher SC saturation. To quantify the difference in SC saturation variation for MBI and CI, we classify the porous space (as imaged volume) into three subsets (low-porosity: $\Phi_L \leqq$ 19%; medium-porosity: 19%$<\Phi_M\leqq$22%; and high-porosity: 22%$<\Phi_H$). We identify that there are different SC migration patterns (P1: rapid and high-massed SC flow occupied large-sized porosity sites with an apparent migration trace; P2: slow and low-massed SC flow diffused into small-sized porosity sites; and P3: a mixed migration pattern of P1 and P2) dominated by the porosity distribution and sediment layers. The main differences in the flow characteristics of MBI and CI for the three groups of porosity sites are outlined as follows.

(1)-Φ_H: At the beginning, the MBI formed a step-increased SC saturation gradient in the Φ_H sites along the axial direction. Subsequently, several times of SC saturation accumulation occurred before the injected SC reached 0.15 PV. In contrast, in the CI, there was a continuous SC flow migrated in the high-porosity sites from the inlet side to the outlet side before the injected SC reached 0.1 PV. After the SC flow transported to the left part (with a distance >150 mm from inlet side), the SC sweep efficiency became weakened. When the injected SC was greater than 0.08 PV, the increase of SC saturation propagated simultaneously from the central position towards inlet and outlet sides.

(2)-Φ_M: In the Φ_M sites, before the injected SC smaller than 0.9 PV, the P1 model controlled the flow migration for MBI. Then the P3 model dominated the SC flow migration. In the CI, similar SC flow transport features also occurred, however, with a lower SC sweep efficiency, and the P3 model commenced until the injected SC approximated 0.15 PV.

(3)-Φ_L: In the Φ_L sites, both the MBI and CI produced only the P1-type SC transport pattern. But the MBI had an earlier trigger time and higher SC saturation than CI.

These analyses demonstrate that the SC flow in the MBI can permeate into more porous space and build a higher CO_2 saturation than CI. The MBI has the potential to provide a more efficient and lower cost choice for the CO_2 geological storage.

Keywords: CO2 migration, Microbubble sequestration, Conventional sequestration, X-ray CT imaging

©2019. Japan Geoscience Union. All Right Reserved.