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Evaluation for the sealing capacity of the fine-grained sediments in Japan

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Japan is located in tectonically active area around the Pacific Ocean and the older geological formations which suffered many faults activities are not suitable for the geological storage. On the other hand, large-scale CO2-emission sources are concentrated on the big city areas and the geological formations from Pleistocene to Miocene are widely distributed near these areas. Considering the suitability for the geological storage and the reduction for the cost of CO2 transportation, it is very important to achieve the CO2 geological storage in such relatively younger formations. These younger formations consist of multiple layers of low-permeable fine-grained sediments (mudstone or clay) and high-permeable coarse-grained sediments (sandstone or sand), and it is not difficult to find the required sets of reservoirs and sealing layers for the geological storage. The large porosities of these younger sediments may be efficient for the storage volume, while there is a fear that the CO2 would leak by penetrating through the fine-grained sediments which would be thought as the sealing layers. The capillary-sealing efficiency must be strictly assessed especially in case of the storage near the urban area where the leakage risk directly affects the public acceptability.
In this study, a general evaluation for the capillary-sealing efficiency of the fine-grained younger sediments in Japan was done by laboratory breakthrough experiment and data collection from the referential papers.
The laboratory testing results and the existing data revealed the following facts;
(a)The entry pressures by injecting nitrogen or air into water-saturated samples of the fine-grained younger sediments are in the range from 0.5 to 5MPa, while the permeability coefficients range from 10^-4 to 10^-1 md.
(b)For the wide-ranging materials from hard-rocks to soils, the entry pressures are in the range from 0.001 to 30MPa, while the permeability coefficients range from 10^-6 to 10^5 md. There is the inversely proportional relation between the entry pressures and the permeability coefficients in logarithmic scales. For the samples in older ages, the entry pressures become larger and also the permeability coefficients become smaller. This relation is harmonized with those of fine-grained sediments in Japan.
(c)The porosities of the rocks before Tertiary are in the range from 0.1 to 30%, while the porosities of fine-grained younger sediments range from 20 to 60%. Besides of such larger porosities, the entry pressures of the fine-grained sediments are almost equal (or slightly lower) to those of the older rocks.
To ensure the capillary-sealing efficiency of fine-grained sediments as described in (c), we examine the change of the pore-size distribution during the consolidation tests which were intended for the samples in the upper layers of these sediments. While the overburden pressure increase, the porosities decrease in the manner as the larger-size pores collapse sequentially. As the inter-connected pores of larger size which determine the entry pressure would diminish selectively, younger sediments under low overburden pressures could have relatively large entry pressures.
An estimation of CO2 storage height in the Osaka bay basin which consists of the formations of Pleistocene was attempted. Using the relation between the porosities and the permeability

coefficients from the consolidation test of fine-grained sediment that composed the basin, the permeability change with depth was estimated from the distribution of the porosities. The permeability distribution was converted into the entry pressure using the relation as described in (b). Then the CO_2 storage potential was calculated from the entry pressure, density of CO_2 and interfacial tension in the examined depth. The calculated height was about 50m in the depth of 100 0m. This result is thought to be one of the criteria to avoid the leakage risk of CO_2.

Keywords: CO_2 geological storage, cap rock, entry pressure