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Effective confining stress-dependence of hydraulic properties of mudstones under conditions of geological storage of CO2

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For implementation of the carbon dioxide (CO_2) capture and storage, during CO_2 injection process, overpressure within targeted reservoirs might occur because of changes in stress related to the CO_2 pressure, which could lead to deformation of the surrounding rocks, including caprocks which are geological formations with low permeability overlying a CO_2 storage reservoir. The understanding for impact of effective pressure (i.e., the difference between confining pressure and pore pressure) on hydraulic parameters (i.e., threshold pressure and permeability) of such caprocks has a critical role in the safe implementation of CO_2 geological sequestration. The purpose of this study was to examine the hydraulic properties of mudstones, which were taken from Otadai (OTD), Ohara (OHR), and Namihana (NMH) formations of Kazusa group, depending on effective pressure at 40 ^{0} C and effective pressures of the range from 1-20 MPa. Change in porosity as a function of effective pressure was also investigated in order to infer the critical pressure, which provided an insight into the relationship between threshold pressure and permeability. Our results demonstrated that with increasing effective pressure, OHR mudstone exhibited a steeply decreasing trend in permeability at around 5 MPa, whereas OTD and NMH mudstones exhibited a monotonous decrease. All data of threshold pressure as a function of effective pressure exhibited linear correlation with permeability data on a log-log scale, except for the OTD and OHR mudstones at below the inferred critical pressure. It was suggested that the relationship between threshold pressure and permeability depends strongly on changes in pore structures as a function of effective pressure for each mudstone tested.

The present results pointed out that the presence of microfractures could be critical in characterizing the hydraulic parameters of mudstones, and mudstones with crack-like pores and/or microfractures such as the OTD and OHR mudstones might be significantly more susceptible to decreasing threshold pressure compared with fracture-less structures under below the critical pressure condition. However, considering CO_2 injection process which means that CO_2 is injected into the targeted reservoirs within normal stress states, all the obtained data above the critical pressure could be explained fully by the linear correlation between threshold pressure and permeability, even if the mudstones incorporated micofractures.

Keywords: threshold pressure, permeability, mudstone, effective pressure, CO2 geological storage