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シール層中の亀裂透水性：深部条件下での新第三紀泥質岩中の亀裂透水性の推定

Fracture permeability in seal layers: evaluation of depth dependency of fracture permeability in Neogene mudstone

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It is important to establish a method to evaluate depth dependency of fracture permeability in Neogene mudstone due to evaluation of leakage or fluid flow thorough seal layers for carbon dioxide geological storage. To this goal, we have done laboratory permeability measurements under hydraulic stress of Neogene mudstone specimens with a single fracture. We have also been doing numerical simulations of a flow through a single fracture under normal stress, in order to understand mechanism deciding stress values over which a fracture closes, or fracture closing stress condition, and for upscaling in space and time of the results of laboratory tests in future.
Rock samples for measurements were collected from several Neogene mudstone formations of the Kazusa group, Boso, Japan. At first, we prepared cylindrical specimens with 50 mm of the diameter and 100mm of the length from the collected rock samples, and operated tri-axial deformational tests under various confining pressures up to 5 MPa. Then, we prepared cylindrical specimens containing a single fracture with 20 mm of the diameter from the specimens after the tri-axial deformational tests. We operated permeability tests with the specimens containing a fracture under hydraulic stress. We increased the confining pressure up to 40 MPa or more, and measured permeability values under several confining pressures. By comparing the measurement results with the results of specimens without a fracture, or intact specimens, we evaluated the confining pressure of a fracture closure. We measured permeability by using constant flow rate method for relatively high permeable cases, and pore pressure oscillation method for relatively low permeable cases. The confining pressures of a fracture closure range from 10 to 20 MPa, and pore pressure is around 1 MPa. The range of these effective pressure conditions is corresponding to depth of 1 to 2 km, on the assumption that the rock density is 2 g/cm^{3}and pore pressure of groundwater is hydrostatic.
The process of the numerical simulation of the laboratory permeability tests is as follows; (1) first, we create two rough surface topographies, considering fractal dimensions, correlation distance, and shear displacement. (2) Then we operated flow simulation and obtained permeability values for several distances between the surface topographies, and (3) for the same distances, calculated normal stress between the surfaces by considering deformations of the topographies. (4) Finally, we obtain the relationships between normal stress and permeability, which are comparable with the laboratory results. The results of the numerical simulations indicate that (1) fracture closing stress condition depends on fracture surface topography, mechanical properties of the rock, and permeability values of intact rock. (2) Varieties of fracture surface topography cause various stress dependency of the fracture permeability. This suggests the possibility of explaining the

variation on the stress dependencies of laboratory measured permeability. (3) There are gaps on the fracture closing stress between laboratory and simulation results.

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