

The effect of deformation on permeability and porosity of the Neogene sedimentary rocks of Horonobe area, northern Hokkaido, Japan

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Permeability and porosity are essential physical properties for analyzing underground fluid flow. We have examined the effect of deformation on permeability and porosity of the Neogene drill core (Yuchi Formation, Koetoi Formation and Wakkanai Formation in the descending order), drilled in the Horonobe area, northern Hokkaido, by Japan Atomic Energy Agency (JAEA). Measurements were conducted in laboratory, either at confining pressures to 100 MPa or during triaxial deformation at pressures, using an intravessel machine at Hiroshima University. Permeability was measured mostly by N₂ gas-flow method, and porosity was measured using a picnometer with N₂, Ar or He comparing results from different gases. Major results are outlined below.

(1) Permeability decreases from Yuchi, though Koetoi, to Wakkanai Formations under the same conditions. Permeability decreases by one to two orders of magnitude as an effective pressure increases to 100 MPa, and it tends to recover as the pressure decreases with a characteristic hysteresis.

(2) Porosity is greatest in diatomaceous Koetoi Formation and is about the same for Yuchi and Wakkanai Formations. It also exhibits a similar hysteresis behavior upon effective-pressure cycling. Measurements with different gases yields porosity differences by as much as 2 to 6 %.

(3) Three formations exhibit contrasting behaviors with deformation. Yuchi and Koetoi Formations compact and their permeability decreases with deformation. In contrast, Permeability of Wakkanai Formation initially decreases with nearly elastic deformation, but it exhibits dilatancy and an increase in permeability with large inelastic deformation.

Results (1) and (2) are essential to estimate underground permeability and porosity structures. On the other hand, result (3) suggests that Wakkanai Formation can be fluid conduit when deformation, whereas Yuchi and Koetoi Formations do not necessarily become fluid-flow passes even with deformation. The deepest part of Koetoi Formation seems to have the highest seal capacity among the three formations.