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Relationships among permeability, porosity and specific surface area of sedimentary rocks in Horonobe area, Japan

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Determination of underground hydraulic properties is important in modeling underground fluid flow problems such as fluid circulation in the Earth, waste isolation, and CCS (carbon dioxide capture and sequestration). Uehara et al. (2009, JPGU meeting) and Okazaki et al. (2009, JPGU meeting) reported detailed measurements of permeability, k, and porosity, n, of Neogene sedimentary rocks in Horonobe area, northern Hokkaido, Japan, using an intravessel deformation and fluid-flow apparatus at room temperature and at effective pressures to about 100 MPa. Laboratory tests were done on fresh surface samples or drill core of JAEA from Yuchi Formation (sandstone), Koetoi Formation (diatomaceous mudstone) and Wakkanai Formation (siliceous mudstone) in the descending stratigraphic order.
In this study, we have measured specific surface area per unit pore volume, S [1/length], of the those samples and discuss the relations among k, n, and S. In Kozeny-Carman equation, k is described as a function of n, S, and a nondimensional geometrical factor, $G = kS^2/n^3$. Carman (1937) reported G of unconsolidated porous media is almost constant (=5) on an experimental basis. However, G of a consolidated medium such as a sedimentary rock is probably different because of changes in the pore structure associated with burial diagenesis (e.g. pressure solution and cementation). We have estimated G of Neogene sedimentary rocks in Horonobe area from measurements of k, n, and S, and compared it at different confining pressures and between samples from different formations. k, n, and S were measured with a gas flow method, a picnometer, and with Brunauer, Emmet and Teller's (BET) absorption method, respectively. When the confining pressure, P, is increased/decreased, all samples show a decrease/increase in both k and n. Values of geometrical factors of samples from Yuchi and Koetoi Formations defined by $G = d(k/n) / d(n/S)^2$ is constant 1.6-4.5 each specimens during confining pressure cycling tests. In construct, for Wakkanai Formation, the result does not agree with Kozeny-Carman equation with a constant G with its value changing from 7.6-115 ($P < 20$ MPa) to 0.5-2.9 ($P > 20$ MPa). This implies that the pore structure of Wakkanai Formation changes in a hydraulic sense with increasing P.
The average grain diameters, $D = Sn / (1-n)$, obtained from measured n and S have similar values to D from mercury-injection tests for samples from the same formations, conducted by Hara et al. (2004).

References

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