

Evaluation of underground porosity-permeability structures of Niigata Basin and Katakai fault zone

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One of the ways of reducing carbon dioxide in the atmosphere is considered to inject carbon dioxide into underground aquifer. This method is expected to utilize for decreasing greenhouse gas and relieving greenhouse effect. However there is little agreement on fluid flow in underground. The question of how fluid flow would behave in fault zone and fracture remains unsettled. What is very important in fluid flow in sedimentary rocks and fault zone is to measure hydraulic parameters of porosity and permeability. In this study, I have investigated the Niigata basin (the west part of Chuetsu area, Niigata Prefecture) and estimated underground porosity and permeability structure by using hand samples.

Because the Niigata basin has many oil and natural gas fields in Japan, many geological surveys and geophysical loggings were conducted to mine for them. Therefore there are a lot of geological data on underground. The folding activity occurred in the upper Pleistocene. Consequently the group of anticlines with the folding axis which had trend of NNE-SSW widely developed, from the lower to upper layers of the Niigata basin continually crop out. I collected several lithofacies samples of the Niigata standard type section (Tsugawa, Nanatani, Teradomari, Shiya, Nishiyama, Haizume and Uonuma Formations) and of the Katakai fault zone exposed in the Pleistocene sandstone.

I measured porosity and permeability by using the Intra Vessel Deformation and Fluid-flow Apparatus, while confining and pore pressure were varied. Confining pressure was increased stepwise up to 130 MPa with porosity and permeability measurements. 130 MPa confining pressure corresponds to the pressure of about 8 km in depth. I used nitrogen instrument method to examine porosity value. For permeability measurement, constant flow method was applied using nitrogen gas as the pore pressure medium.

As a result, the porosity of each horizon remarkably decreased with increasing confining pressure. Concerning porosity of the Uonuma Formation at the same pressure, siltstone indicated the highest porosity and fault gouge displayed the lowest value. Also the igneous rock showed low porosity. Compared with the geological time, the sample is older, the porosity change tend to be smaller. In the case of lower samples, increasing paths in confining pressure coincide with decreasing path.

The permeability about sedimentary rock also decreased as confining pressure increased. At the same pressure in the Uonuma Formation, sandstone has a tendency to indicate higher permeability than others, and fault gouge showed the lowest value of permeability. Generally, the lower horizon displays lower permeability.

In Katakai fault zone, both porosity and permeability in fault zone indicated lower than those of host rock for the same pressure condition. The result clearly shows that fault gouge plays role in a seal layer.

I estimated the underground porosity and permeability structures by data obtained from experiments. The result indicated that porosity in the Hizume Formation which carbon dioxide was injected showed higher than the upper formation. From the result of permeability structure, cap rock also seems to exist on the Haizume Formation. Accordingly the Haizume Formation is considered to be suitable for a reservoir formation.