Effective use of drill cuttings analysis for wellsite geological investigation in the CO_2 geological storage: a case study of the Nagaoka site, Japan

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Reservoir quality depends largely on geological heterogeneity recognized in the target reservoir. Geological heterogeneity is linked to changes of depositional environments as controlling factor of physical properties. For this reason, characterizing depositional environments and physical properties are essential for reservoir characterization. In geological storage, saline aquifer is selected as reservoir, which has limited data available. Such situation suggests that integration of available data is important for reducing uncertainty of reservoir characterization. In general, well logging, sediment core and drill cuttings analysis are widely used for characterizing wellsite geology. However, little is known about advantages of cuttings analysis for geological storage site. Herein we measured grain-size and pore-size distributions of drill cuttings, and propose advantages of drill cuttings analysis for CO_2 geological storage in addition to sediment core analysis as a case study of the Nagaoka site, Japan.

The Nagaoka Project was the first pilot injection test in Japan, and total of 10,400 tons of CO_2 was injected into the saline aquifer, which situates about 1,000 m depth under the ground. The target saline aquifer consists of shallow marine strata. One injection well (IW-1) and three observation wells (OB-2, -3 and -4) were drilled. Well logging data such as porosity and permeability were obtained from all wells, and these data were concordant with measured data using core materials. Sediment core were recovered from IW-1, and drill cuttings were sampled every 10 to 20 m in average at IW-1, OB-2, and OB-3. Well logging data such as gamma-ray, porosity and permeability were obtained from all wells. Drill cuttings are the broken bits of solid materials obtained during drilling of borehole, and have been widely utilized for identifying wellsite geology.

Natural gamma-ray logging shows the depositional cycles at each well, which enable us to correlate target reservoir among wells. The sediment core taken from IW-1 suggests that the target aquifer is composed of prodelta to delta front deposits, which can be related to the depositional cycle. Well logging and sediment core analysis suggested that delta front parts of the target reservoir are characterized by higher porosity and permeability than prodelta parts. This result indicates that delta front deposits can be regarded as a suitable reservoir rock. Delta front deposits show no significant difference among well.

Nishizawa et al. (2016) pointed out that the CO_2/brine flow behavior is mainly dominated by capillary fingering during the geological storage. Judging from capillary number (6.9×10^{-8}) during injection at the Nagaoka site, the CO_2/brine flow behavior can be regarded as dominating capillary fingering. This fact suggests that characterizing pore-size distribution, which is closely linked to capillary pressure, is important for better understanding flow behavior as well as porosity and permeability. In general, use of sediment core sample taken from the target reservoir is advisable for characterizing pore-size distribution. However, sediment core is available only at IW-1, and hence drill cuttings are used for measuring grain-size and pore-size distributions. Grain-size and pore-size distributions of the drill cuttings taken from OB-3 skewed toward fine-gained and dominated fine pores statistically than those taken from other wells. These results imply that target reservoir at OB-3 can be characterized by relatively fine-grained and higher

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capillary pressure. According to this, the monitoring results of the CO_2 breakthrough after injection can be interpret that CO_2 migrated by selecting the flow path with lower pressure in the reservoir rock. Furthermore, the result of drill cuttings analysis is consistent with geological settings that offshore environments distribute toward OB-3 in the target reservoir at the Nagaoka site. A great advantage of the drill cuttings analysis is possible for directly measuring physical properties such as grain-size and pore-size distributions. Use of drill cuttings combined with well logging and sediment core analysis appears to be effective for wellsite geological investigation for the geological storage.

Keywords: drill cuttings, well logging, sediment core, grain-size distribution, pore-size distribution, CO2 geological storage

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