Image well log data analysis to evaluate reservoir quality: Application to the Nagaoka storage site

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This paper discusses advanced well log data analyses to obtain better geological model for CO_2 storage. In order to evaluate the safety of stored CO_2 in the target reservoir, a reasonable geological model is required. Well log data is very helpful to evaluate geophysical parameters and to build detailed geological model. However the number of wells at the storage sites is smaller compare to oil/gas field in generally for economic reasons. Therefore, it is preferred that as much as information is extracted from well log data at the site. In this paper we introduced analyzing techniques for image data from Formation Micro-Imager (FMI) and Nuclear Magnetic Resonance (NMR) logging.
FMI is a tool to measures fine scale resistivity with 192 image button electrodes. The measured resistivity represents the rock types, but the high resolution resistivity image can be available for further advanced analysis. The shape of the histogram of resistivity data (Sandspect) has statistical information about the formation. Peak of the histogram reflects the largest rock element among the facies, and the unimodal and high histogram means that the sorting of the formation is good. The percentile resistivity is also interpreted as the part of mud or sand in a short interval. Therefore, Sandspect is used for sedimentological analysis.
NMR tool measures the decay of magnetization, and relaxation time (T2) of spin. In water-wet sandstone rock, T2 distribution reflects the pore size distribution, which provides information about porosity and permeability. The shape of the distribution has also information regarding reservoir quality. To extract the characteristics of T2 distribution, we introduce factor analysis, which is a statistical method to describe the observed data using lower number of underlying constituents (factors). These obtained factors would be called poro-facies.
We applied these two analyzing methods to the image data acquired at the Nagaoka CO_2 injection site in Japan. From the factor analysis, we concluded that it is the most reasonable to divide the all distribution data at the reservoir into eight factors. At the main target reservoir, good quality poro-facies was observed commonly over all four wells. Therefore the formation at this depth (4 m thickness) was considerable more homogeneous. Furthermore, we integrated Sandspect and factor analysis. Both results matched well with each other especially in the main target zone. We compared the result with Spinner test. The vertical heterogeneity along the injection well had high consistency. It should be noted that there is a limitation in these analyses, since both of Sandspect and poro-facies are based on relative relationship of log data. Even with these limitations, it is worth to apply the image data analyses to the reservoir characterization at geological CO_2 storage sites.
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Keywords: Geological CO2 storage, Image log data, Sandspect, Factor analysis, Nagaoka site

