Development of geological model using core-well-seismic integration technique at the Nagaoka CO_2 storage site, Japan

*Takuma Ito[1], Takahiro Nakajima[1], Ziqiu Xue[1]

1.Research Institute of Innovative Technology for the Earth

When utilizing saline aquifers as a geological storage site, available dataset is limited due to their sparse geological information. Under such conditions, however, development of geological model is essential for site characterization. To overcome this condition, applying core-well-seismic integration technique appears to be one of the feasible solutions in addition to use of existing available dataset. Here we propose a geological modeling procedure using saline aquifer for geological storage of CO_2. The proposes are (1) to identify the depositional environments and the sequence boundaries used as a stratigraphic framework of a geological model, (2) to make the voxel model using the sequence boundaries, and (3) to show the spatial gamma-ray, porosity and permeability distributions using core-log-seismic integration technique as a case study of the Nagoaka site.
In the Nagaoka project, total of about 10,000 tons of CO_2 was injected into the saline aquifer, which situates about 1,000m depth below the Niigata Plain. The target saline aquifer is correlated to the early Pleistocene Haizume formation. During the project, one injection well (IW-1) and three observation wells (OB-2, -3 and -4) were drilled. Sediment core of the target reservoir rock was taken from the IW-1, and well log data was obtained from all of the wells. During CO_2 injection to date, detailed monitoring has been made by well logs to monitor CO_2 behavior in the underground.
Firstly, we carried out facies analysis and grain size measurements using the sediment core materials to identify depositional environment of the reservoir rock. Detailed sedimentological features indicate that the reservoir rock has fining-upward to coarsening-upward successions that developed on ravinement surface. The reservoir rock is attributed to a part of prodelta and deltafront deposits. Prodelta and deltafront deposits can be divided by mud content of about 40% as a threshold value at the Nagaoka site.
Secondly, we used geophysical logs at each well for stratigraphic correlation of the reservoir rock. Comparison between core and geophysical logs at the IW-1, profile of natural gamma-ray show similar pattern with that of mud content. Thus, prodelta and deltafront deposits can be divided by natural gamma-ray value of about 75 API. This fact indicates that natural gamma-ray value can be used as identification tool for depositional environments at the Nagaoka site. We defined the sequence boundary and correlated it at each wells. Moreover, we confirmed that positive correlation exists between natural gamma-ray intensity, porosity and permeability. The above information is used when constructing geological models.
Lastly, we used 3D seismic data for defining a stratigraphic framework. For making a stratigraphic framework, we defined the two sequence boundaries above and below the reservoir rock. The sequence boundaries were traced spatially by Petrel (Schlumberger software) using multiple 3D seismic slices, and then a grid model of the reservoir rock was developed. Spatial natural gamma-ray and permeability models were constructed using GDI (Geological Driven Integration)-based spatial porosity model as a guide by Sequential Gaussian simulation with collocated cokriging.
A given spatial distribution of natural gamma-ray and permeability shows the eastern part of the reservoir has fine-grained and low permeability. This trend is similar with the paleogeography that the sediments were supplied generally from west to east based on the previous geological survey around the Nagaoka site. Moreover, the result of CO_2 monitoring suggests that the CO_2 migration is not uniform that its breakthrough has not been observed at the OB-3, where is located at the most

east side. This fact is also supported that a given geological model is reasonable.

Keywords: Geological storage of CO_2, Nagaoka site, Sedimentology, Geological modeling, core-log-seismic integration

