Construction of an integrated geological model characterized by a seismic survey data and calibrated by log-based monitoring data: A case study at Nagaoka CO_2 injection site

*Takahiro Nakajima[1], Takuma Ito[1], Ziqiu Xue[1], Shun Chiyonobu[2]

1.Research Institute of Innovative Technology for the Earth, 2.Faculty of International Resource Sciences, Akita University

This paper discusses a methodology for the site characterization of deep saline reservoirs evaluated through dynamic flow simulations. Not only the traditional site characterization techniques, but also the injection and monitoring data can be used for the geological modeling. In this study we carried out flow simulations using a geological model based on a seismic survey data and monitoring data after the CO_2 injection at Nagaoka site.

Nagaoka project was undertaken in order to verify an ability of CO_2 injection into Japanese formation. The target reservoir consists of marine strata at a depth of 1100m. Between 20 and 40 tons of CO_2 were injected and a total of 10.4 k-tones of CO_2 was injected into a thin permeable zone. Bottom-hole pressure measurement, time-lapse well loggings and cross-well seismic tomography were conducted using three observation wells drilled between 40m and 120m from the injection point.

For the modeling of the reservoir with heterogeneity, the method presented by Ito et al. (2016) was used; determined the sequence boundaries of the formation from the analysis of depositional environments, constructed a 3D reservoir framework by horizon picking of seismic trace, and developed a 3D distribution of reservoir parameter after the integration of lithologic records, well logging data, and 3D seismic attributes. It is worth to note that the heterogeneous feature from NNE to SSW direction can be seen in the revised interpretation model. For the hydrological properties we referred measured results as reported in Nakajima et al. (2015).

For the simulation of multiphase flow, we used TOUGH2/ECON2 simulator. The model was calibrated through the process of history matching to the bottom-hole pressure and CO_2 saturation. Several absolute permeability models were tested manually and good matches were achieved between monitoring data and simulated CO_2 behaviour. The results of CO_2 distribution were also consistent with the observed velocity anomalies from the cross-well tomography. The numerical results revealed the migration of CO_2 plume to up-dip direction along the most permeable zone during the post-injection period.

Sensitivity studies were conducted to investigate the effect of poorly constrained model parameters. We tested alternative parameters on absolute permeability, ratio of horizontal to vertical permeabilities, and pore compressibilities. We found that the effect of the ratio between horizontal and vertical permeabilities was relatively large, and pore compressibility had effects on pressure response. A small anisotropy in horizontal direction could also explain a better matching. These anisotropies could be created during the depositional process of the reservoir.

We will report the long-term fate of CO_2 in the reservoir to evaluate the contribution of the trapping mechanisms.

Keywords: CO2 geological storage, Nagaoka site, multiphase flow, trapping mechanism

