HRE28-08　　会場:105　　時間:5 月 25 日 11:15-11:30

CO2分布に対する地層不均質性の効果：長岡サイトCO2貯留層中の数値シミュレーション
Effects of heterogeneity on the distribution of CO_2: Numerical simulation in a CO_2 storage reservoir at Nagaoka

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This paper discusses heterogeneity of petrophysical properties in the reservoir for geological carbon dioxide (CO_2) storage at Nagaoka pilot site in Japan. Detailed site characterization is critical for successful geological storage of CO_2. Not only the traditional site characterization techniques, but also the injection and monitoring data can be used for the geological modeling with heterogeneity. In this study, we carried out numerical simulations using reservoir models with heterogeneity, and compared the results to investigate effects of heterogeneity in the reservoir.

Nagaoka pilot-scale CO_2 injection site was used in this study. Nagaoka project was undertaken in order to verify an ability of CO_2 injection into Japanese formation. CO_2 was injected into a thin permeable zone at a depth of 1100m, and the total amount of injected CO_2 was 10.4 k-tons. Bottom-hole pressure, time-lapse well loggings and cross-well seismic tomography were conducted as the monitoring of injected CO_2.

For the modeling of the reservoir at this site, the method presented by Ito et al. (2015) was used; constructed a profile of the reservoir using seismic results, and generated horizontal distribution of petropysical properties by applying Random function Gaussian Simulation. It is worth to note that the feature along N-S direction had reported at this site (Chiyonobu et al., 2013). The derived models showed that the high porosity and permeability area located in the eastern part of the reservoir.

For the reservoir simulation, hydrological properties for the multiphase flow are also important. We measured capillary pressure function using mercury injection tests. The measurements indicated that the functions in sandy and shaly rocks were different. For the relative permeability function, we referred the results reported by Ohtake (2013), and approximated to van Genchten function. We did not assume hysteretic functions in this study.

We made simulation using the reconstructed models and TOUGH2 simulator. For the history matching, bottom-hole pressure and CO_2 saturation data were used. Several absolute permeability models were tested manually in order to find the best match between the monitoring data and the reservoir simulation. We could find a geological model reasonably matched to the monitoring data. The result of CO_2 distribution was also consistent with the observed velocity anomalies by the cross-well tomography. The numerical results revealed the migration of CO_2 plume to up-dip direction. This explained the behavior of CO_2 distribution observed by the wire-line logging very well.

During the history matching, sensitivity analysis of the model was conducted. The results suggested that anisotropy of the permeability was essential to explain the monitored CO_2 behaviors. This anisotropy could be created during the depositional process of the reservoir. It should be noted that not only the permeability distribution, but the properties depending on facies were also important to the matching.

This work was supported by Ministry of Economy, Trade and Industry of Japan under the research contract ”Development of Safety Assessment Technology for Carbon Dioxide Capture and Storage”.

キーワード: CO2 地中貯留, 長岡サイト, 多相流, 不均質
Keywords: CO2 geological storage, Nagaoka site, multiphase flow, heterogeneity