Evaluation of seismic event location accuracy of Tomakomai CO2 injection site: a numerical simulation case study

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For CO2 injection monitoring in many CCS project, the most basic monitoring information is the seismic events. The seismic event location is the first step to understanding the causal process of a natural or induced fracture. In the case of CO2 geological storage, the location of an event is of special importance. The events in the reservoir may affect the storage capability. The events in the cap-rock may indicate the CO2 leakage. However, the location of the seismic event is probably to contain bias, especially for the limited seismic observation system. Therefore, the operator should understand that there is uncertainty in the location estimation of a detected event. In this study, we use the Tomakomai (Ocean Bottom Cable) OBC and borehole system (OB1 well) to study the seismic location accuracy in Tomakomai site. We believe that it can help to evaluate the event location effect with different azimuths and different depths. Moreover, this study may also be applied to the optimization of the seismic observation system.

At Tomakomai site, the permanent OBC is arranged as a line (length 3.6 km, containing 55 available sensors), deployed 2 m under the seabed. It is located above the CO2 reservoir and the center point is 3 km from the coast. The OB1 contains 4 sensors in the well with depths ranging from 2 km to 2.2 km. All sensors of OBC and OB1 contain a three-component geophone. Therefore, we can use only detected P phase signal for seismic location. We assume that the velocity model is layered and homogeneous, so that a simple model can be built based on the logging result. The ray-tracing method is employed in the seismic simulation and location process.

We compared the modelling event location accuracy for different azimuths and different depths. All events were distributed around Tomakomai site. The results showed that as the epicenter distance increases, the location errors increases. For the events which the epicenter is far away from the area enclosed by OBC and OB1, the locating effect is significantly worse. In addition, as the event depth increases, the location error also increases. The location error of shallow (0-1 km) events can be maintained within 1 m, while the location error of deep (8 km) events can reach the scale of several hundred meters. Ignoring the effects of the simulation method, it is obviously affected by the geometric distribution of the observation system.

Secondly, we also compared different observation system optimization strategies. The result indicated that, based on the Tomakomai seismic monitoring system, if the number of sensor is fixed, the longer OBC line can provide a better location result. Based on these analyses, future seismic monitoring system designs can be optimized for specific purposes (number of sensors, expected depth of monitoring, etc.).

Keywords: event location, Seismic monitoring, 3D ray tracing, Tomakomai site

