Electrical survey results in a sub-seabed CO2 release experiment (QICS)

Hideshi Kaieda 1 Koichi Suzuki 1 Akira Jomori 2

1 Central Research Institute of Electric Power Industry
2 NeoScience Ltd.

Abstract

It is important for operating CCS safely to evaluate environmental impacts and to establish methods for the early detection and monitoring, of carbon dioxide (CO2) leaks form a CCS system. A controlled sub-seabed CO2 release experiment named QICS (Quantifying and Monitoring Potential Ecosystem Impacts of Geological Carbons Storage) project was carried out during May–October 2012 in Ardmucknish Bay in Scotland, UK. A total of 4.2 tons of CO2 gas was released from May to June for 37 days at a maximum flow rate of 210 kg/d from 11 m below the seabed which is 12 m below mean sea level. During and after the CO2 release experiment, electrical survey was conducted to monitor CO2 migration under the seabed.

Three electrical survey lines with a length of 45 m were completed on the seabed. Line 1 was installed in the north and south direction. Line 2 and 3 were placed 60 and 120 degrees from the north to the east, respectively. These lines crossed at each center at the CO2 released point. Each line has ten electrodes made of carbon every 5 m. Signals of all electrodes were transmitted to a measurement system located onshore through three submarine cables.

The electrical resistivity surveys were conducted September 2012 and May 2016 with the almost same measurement system. Electrical direct current of from 1 to 2 amperre with alternate time interval of 16 second in 2012 and 20 second in 2016 was injected between each electrode and a reference electrode located about 700 m north-west from the survey area. Electrical potential deference was measured between each electrode and another reference electrode located about 500 m north-east from the survey area. The data were acquired with pole-pole electrode configuration. Two dimensional analysis was performed in the three lines. The determined resistivity structures showed that positive anomaly of the resistivity structure of 2012 compared with the structure of 2016 as a baseline structure distributed 10-20 m south-west of the CO2 released point. In this area CO2 bubbles was seen escaping the seabed by divers and video cameras, and CO2 migration under the seabed was estimated by the seismic survey. This anomaly was considered to be caused by CO2 migration because CO2 bubbles have higher electrical resistivity than formation water. The resistivity surveys were carried out about three months in 2012 and four year in 2016 passed after CO2 release ended, respectively. A leaked CO2 volume measured on the seabed by divers showed that a little CO2 leaked from the seabed during the CO2 release. Therefore most of CO2 was considered to be stored beneath the seabed and some of CO2 still remained beneath the seabed after three months passed. However most of the remained CO2 beneath the seabed might leak after four years passed.
The electrical self-potential (SP) survey was conducted during the CO₂ release in 2012. Electrical potential difference between each electrode and a reference electrode located southern edge of survey area was measured continuously every one minute during and after the CO₂ release. The SP survey results showed that positive SP anomaly with a maximum of 40 mV distributed south-west of CO₂ released point during the CO₂ release. This area is almost same as the positive electrical resistivity anomaly detected area in 2012. These results shows that the CO₂ migration sub-seabed caused positive electrical resistivity anomaly and also positive SP anomaly on the seabed. Therefore these electrical surveys are considered to be applicable as monitoring methods of CO₂ migration beneath the seabed.