The QICS project. Outcomes and implications for the development of CCS

Jerry Blackford

Abstract

Quantifying and monitoring potential ecosystem impacts of geological carbon storage (QICS) is a UK funded project that aims to quantify both the impacts and detectability of leakage from carbon dioxide geological storage. The project developed a coupled experimental and modelling approach based around a unique real world release of CO_2 beneath the sea-floor, mimicking a small scale leak event. The project involves a consortium of UK institutions working in partnership with a consortium from Japan.

The experimental plan involved drilling a narrow borehole from land to 350m offshore, terminating in unconsolidated sediments 10m below the sea floor. Just over four tonnes of CO_2 were injected into the sediments over a period of 37 days, during May-June 2012. Physical flow mechanisms, chemical transformations and ecosystem impact were monitored throughout and various detection methods tested. Monitoring continued for several months after the gas release to assess the rate of biological and chemical recovery. In addition to the experimental deployment we developed several modelling approaches ranging from fine scale modelling of CO_2 flow through sediments, via hydrodynamic models of the release site to large scale models of NW European shelf seas which contain many candidate sites for storage.

The outcomes of the QICS experiment have in several ways challenged pre-conceptions and revealed a wealth of complex interactions that modify both impacts and monitoring strategies:

- Within a 12 metre vertical migration through the sediments, considerable lateral spread is observed, and that flow mechanisms are specific to individual layers within the sediments. Above a certain threshold gas flow within sediments may be acoustically detected.
- Buffering by sediment carbonates considerably modifies the chemical transformations within the sediments, at least in the short term.
- Even with a highly focussed source, gas flow at the sediment – water interface only accounts for a small fraction of the injection and occurs via numerous, sometimes transient small pockmarks. Potentially significant dissolved phase flow may be associated with the bubble streams.
- Acoustic techniques showed promise for both detection and quantification of bubble flow in the water column.
- The chemical signal in the water column is readily apparent close to the bubble streams, but undetectable at distances approximating to 20m from the release point, for a leak of this size. However there is a very large heterogeneity in chemical signals, with implications for monitoring and quantification.
- Biological impacts were only significant within a small radius of the leak and biological recovery was rapid, within a few weeks.

From an operational point of view we would suggest that small leaks of the order of 1T/d will not cause significant ecosystem damage in a regional context, however there is a potential threshold as exhaustion of finite carbonate dissolution would cause an order of magnitude increase in local acidity. We demonstrate that monitoring may be effectively achieved by both acoustic and chemical methods but spatial resolution of surveys will be critical. Given natural heterogeneity, accuracy and precision of chemical sensors along with a good understanding of natural variability will be far more important than instrument sensitivity or resolution. The results from QICS are informing monitoring and assessment strategies for the industrial consortia developing full scale CCS in the UK.