7707

Geological Factors Influencing Time-lapse Seismic Monitoring of Subsurface CO2 Storage

G. Cairns* (Imperial College London), H. Jakubowicz (Imperial College London), L. Lonergan (Imperial College London) & A. Muggeridge (Imperial College London)

SUMMARY

Carbon dioxide sequestration offers an immediate way to reduce CO2 emissions and mitigate global warming. Due to expense and potential danger, storage sites must be monitored to assess their long-term integrity and detect leakage. Ideally, monitoring must be able to locate the CO2, quantify its saturation distribution, and detect the CO2 trapping phase. Time-lapse seismic surveys are expected to form the foundation of this monitoring and their ability to fulfil these requirements must be established.
The seismic response of injected CO2 is dictated by the rock and fluid properties of the reservoir and overburden. In this work we study the combined effect of the fluid distribution and corresponding rock physics model on seismic data. Since seismic waves induce changes in pore pressure, the speed of propagation depends on whether the fluids equilibrate within the seismic period, and is in turn affected by the fluid distribution. If the fluids are well mixed and the distribution is homogeneous, the pressures equilibrate, and the rock properties can be described using a harmonic average. However, if the fluids are not mixed (i.e. are patchy), then the pressures may persist and stiffen the rock; the rock physics is then modelled using an arithmetic average. These two end-member models predict very different relationships between saturation and Vp.
In this study we simulate the seismic response from a generic sandstone, similar to that of the Sherwood formation, located beneath a uniform layer of shale. Our results show that, for homogeneous fluid distributions, injection of small quantities of CO2 (1-5%) significantly reduces the P-wave velocity, and can be detected at all the depths examined (1000 m to 2000 m). However, further CO2 injection has very little additional effect on the response, making any direct measurement of saturation difficult. On the other hand, for patchy saturations, the response is much more sensitive to changes in the amount of CO2, potentially allowing saturation to be measured directly. Indeed, the differences in the responses of homogeneous and patchy saturations are sufficiently large that it may be possible to quantify the amount of heterogeneity and mixing in the reservoir. It is therefore possible that seismic measurements could distinguish between different reservoir models of the CO2 distribution.