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Passive Seismic Monitoring and Geomechanical Modelling of CO2 Injection at Weyburn

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SUMMARY

The IEA GHG Weyburn-Midale CO2 is currently the largest operational geologic carbon storage project, injecting 3 million tonnes of CO2 every year into a mature oilfield in central Canada since 2000. In 2003 a passive seismic monitoring component was added to the project with the installation of a downhole array near to a new injection well. In this paper we present the results from 5 years of passive seismic monitoring at Weyburn, focusing in particular on how microseismic observations can be linked with geomechanical models of the reservoir.

Few events have been recorded during injection - about 100 over 5 years. This suggests that the CO2 is moving through the reservoir aseismically, and geomechanical deformation is low. The few events recorded have been located using a 1-D model developed from well logs. We find that they are generally located near to the horizontal production wells that lie either side of the injector. Depths are poorly constrained, but many appear to be located in the overburden. Shear wave splitting measurements made on the event waveforms find a dominant fracture strike to the NW, matching one of the fractures identified in core samples.

Microseismic events are an observable manifestation of geomechanical deformation, so to interpret them create a simple geomechanical model to represent the model. When the reservoir is modelled as softer than the surrounding rocks, stress is transferred into the overburden and deviatoric stresses develop over the producing wells, placing these areas at greatest risk of shear-induced failure. Furthermore, the shear-wave splitting predicted by the model matches the measurements made on microseismic data. This demonstrates how passive seismic observations can be used to groundtruth geomechanical models, improving our understanding of deformation processes occurring during injection.