Application of Stable Isotope Techniques to Monitor CO_2 Storage at the Pembina Cardium CO_2 Monitoring Pilot, Alberta, Canada

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Monitoring of geological CO_2 storage is necessary to prove both the safety and validation of geologic storage (e.g. Raistrick et al., 2006). Monitoring is also required under the emerging regulatory regimes being developed for Carbon Capture and Storage (CCS) in the USA (EPA Draft Rule), EU (EU CCS Directive, London Convention) and Australia (Offshore Petroleum and GHG Storage Act 2008) amongst others. Geochemical and isotopic monitoring allows both qualitative and quantitative determination of CO_2 presence in the subsurface through the sampling of produced fluids and gases at production and/or monitoring wells. This is demonstrated by data from 3 years of monitoring at the Pembina Cardium CO_2 Monitoring Pilot in central Alberta, Canada. Eight wells centered around two CO_2 injectors were sampled monthly between February 2005 and March 2008. Stable isotopic analysis of the samples revealed that changes in the $\delta^{13}C_{CO2}$ values in produced gas as well as changes in the $\delta^{18}O$ value in the produced fluids indicate CO_2 presence and identify trapping mechanisms at select production wells. The eight wells are divided into three groups identifying different responses. Group I wells show marked increase in both the CO_2 content of the gas and the $\delta^{13}C$ value of CO_2 with a concurrent increase in the $\delta^{18}O$ of the produced fluids. Group II wells show very little increase in CO_2 content and $\delta^{13}C$ value of CO_2 and showed no increase in the $\delta^{18}O$ values of the fluids. Group III wells show intermediate behavior between group I and II wells. Using equilibrium isotope exchange relationships and CO_2 solubility calculations, fluid and gas saturations in the pore space in excess of that occupied by oil were calculated. Group I wells show that the fluids are saturated with CO_2 (solubility trapping) and have free-phase CO_2 saturations in the range 0.1-0.6 whilst Group II wells show no free phase CO_2. Group III wells show CO_2 saturation values of <0.1. These values correlate with the changes in both CO_2 content and $\delta^{13}C$ value observed in the gas phase at the wells as well as other geochemical proxies (Shevalier et al., 2009). It is thus shown that stable isotopic measurements of produced fluids and gases at CO_2 storage sites can be used to determine both qualitatively and quantitatively the presence of CO_2 around the observation well, given that the injected CO_2 is isotopically distinct.