Tracing the movement and fate of injected CO_2 in a mature oil field using geochemical, isotopic and modeling approaches

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Carbon capture and geological storage is a potential technology to reduce CO_2 emissions into the atmosphere. Monitoring of CO_2 storage sites is required by many of the emerging regulations with specific interest in accounting of injected CO_2 in various target reservoirs. At the Pembina Cardium CO_2 Monitoring Project in central Alberta (Canada), we have used chemical data and carbon and oxygen isotope ratios of produced water and gases sampled repeatedly from various observation wells to trace the movement of injected CO_2 and assess pore space saturation with CO_2. The distinct carbon isotope ratios of injected CO_2 in association with gas compositional and flux data were used to determine the percentage of injected CO_2 produced at several observation wells using two end-member mixing calculations [1]. Changes of $\delta^{18}O$ values of produced water of up to 4 ‰ were caused by oxygen isotope exchange between CO_2 and H_2O following CO_2 injection [2]. The changes in the $\delta^{18}O$ values of water were used for a quantitative assessment of CO_2 dissolved in the fluids and of free phase CO_2 in the pore space of the reservoir. Subsequently, we combined seismic and geochemical information with reservoir modeling approaches in an attempt to determine a carbon budget for injected CO_2 in the mature oil field. Results of partitioning calculations indicate that two years after commencement of CO_2 injection the majority of the CO_2 remained in a free phase within the reservoir, while smaller amounts of injected CO_2 were dissolved in water and oil. In April 2010, CO_2 injcetion at this pilot site was stopped but geochemical monitoring commenced for an additional 2 years until June 2012. We observed continued increases of $\delta^{18}O$ values of formation water suggesting increases in CO_2 pore space saturation in the vicinity of two observation wells. The obtained results indicate that chemical and isotopic techniques can play a crucial role in monitoring the movement and the fate of CO_2 in geological reservoirs during and after CO_2 injection.

[1] Johnson *et al*. (2011), IJGGC 5, 933-941;
[2] Johnson *et al*. (2011), Chem Geol 283, 185-193.

Adsorption of ^{109}Cd onto metaloxide nanoparticles

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To reduce the environmental impact of hazardous pollutants, as the highly toxic metal Cd, geochemical barriers providing confinement are required. To enhance contaminant retention in geochemical barriers, different nanoparticles (NPs) are being analysed, taking into account their inherent retention properties, either single or combined with other materials.

To assess which NPs better prevent the risk of contaminant leakage, detailed experimental and theoretical sorption studies in a wide range of geochemical conditions, are demanded. The stability of the NPs, upon contaminant adsorption in different environments, is an aspect that must be also evaluated.

In this study, the retention capability of two metaloxide NPs (Al_2O_3 and CuO) as candidate sorbents for Cd immobilisation in geochemical barriers was analysed.

Sorption experiments have been carried out in different electrolytes ($NaNO_3$, $NaHCO_3$, Na_2SO_4 and $NaClO_4$) and in a wide range of pH and ionic strengths, to simulate different environmental and salinity conditions. Sorption isotherms at different Cd concentration were also performed.

In addition, particles size and surface charge were systematically measured in all experiments to assess NPs stability, essential to predict their performance.

Geochemical modelling of a wide set of experimental sorption data contributes to probe the capability of selected NPs as ^{109}Cd adsorbents in geochemical barriers and contamination risk assessment.

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