New approaches for tracing potential leakage of CO_2 from geological storage reservoirs using stable isotope tracer techniques

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Geological storage of CO_2 is a promising technology to reduce CO_2 emissions into the atmosphere. Tracer methods are an essential tool for monitoring CO_2 plume distribution in the target formation and for tracking of potential leakage of CO_2 outside of the storage reservoir. The stable isotope composition of injected CO_2 constitutes a cost-effective inherent tracer for the movement and the fate of injected CO_2 provided that it is isotopically distinct. To refine the stable isotope tracer approach for assessing potential leakage of CO_2 from storage reservoirs we conducted numerous laboratory experiments to determine carbon and oxygen isotope fraction effects between CO_2, dissolved inorganic carbon (DIC) and saline reservoir waters at pressure and temperature conditions that cover the transition from supercritical to subcritical CO_2. We found that this transition encountered during potential CO_2 leakage towards near-surface environments does not cause additional isotope effects and hence does not compromise the use of stable isotopes as a tracer in CO_2 storage projects. To further demonstrate the utility of the stable isotope tracer approach for tracing injected CO_2 we have commenced a field demonstration at the newly established field research station (FRS) of CMC Research Institutes and the University of Calgary near Brooks in south-eastern Alberta, Canada. During drilling of a potential CO_2 injection well we obtained a continuous record of mud gas samples as well as drill cuttings and core that were placed in sealed containers in water and outgassed for several weeks. Concentration and isotope ratio measurements on these samples yielded a detailed profile of CO_2 and CH_4 distribution and isotopic fingerprints throughout the intermediate zone below shallow groundwater and above the storage reservoir. This detailed record of gas occurrences above the storage reservoir will be a major asset for future tracking of potential leakage of isotopically distinct injected CO_2 and for potential stray gas leakage from oil and gas development.