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Application of stable isotope techniques to characterize CO_2 storage sites

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Injection of CO_2 into the subsurface causes geochemical changes of the water and its dissolved load. It also causes stable isotope alterations of dissolved inorganic carbon (DIC). If CO_2 is present in large enough amounts, changes of the water isotope composition can also be expected. Therefore, stable isotope alterations provide additional tools to quantify turnover and interaction of the injected CO_2. In a first step, the geochemistry and isotope composition of the undisturbed storage site fluids have to be characterized before injection. This implies careful retrieval of samples from depth in order to avoid pressure changes that might alter the isotope ratios of water or DIC. Reservoir fluids were sampled using an open flow-through sampler ('Doppelkugelbüchse', DKB), or a pressure-sealed Positive Displacement Sampler (PDS) and showed that pressure conservation becomes particularly important after injection of CO_2 when pressure gradients between atmosphere and formation become more pronounced. Stable carbon isotope differences between the injected CO_2 and the already present DIC helped to establish mass balances. These showed that up to 70 % of DIC after injection may consist of added CO_2. Stable isotopes also established its own tracer when batches of injected CO_2 had different isotope compositions. For instance, at the Ketzin site, a carbon isotope shift of the DIC of about 2 permille was found a few days after changeover of a gas from a different source with a distinct isotope ratio. This breakthrough coincided well with the ones of other implemented tracers (krypton and sulfurhexafluorid). The combination of stable isotopes and conservative tracers have therefore proven to be suitable tools for identifying different sources of CO_2. They also help to trace migration behaviour and spreading of injected CO_2 in a storage reservoir.