N_2-CO_2 co-injection field test at Ketzin pilot CO_2 storage site

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Abstract

Between June 2008 and August 2013 67,271 t of high-purity CO_2 were injected into a saline aquifer of the Stuttgart Formation at Ketzin, Germany. Both R&D programs as well as the applied monitoring methods at the Ketzin site are amongst the most comprehensive worldwide. Hence, scientific investigations at Ketzin provide fundamental knowledge for geological CO_2 storage in saline aquifers and the site is recognized as a reference project for the investigation and realization of geological CO_2 storage in general.

In summer 2013, a four week N_2-CO_2 co-injection field test was conducted at the Ketzin site within the scope of the IMPACTS project. The IMPACTS project is granted under the Seventh Framework Program by the European Commission and intends to evaluate the chemical and physical effects of impurities within the CO_2 stream during capture, transport and storage of (impure) CO_2. Major objectives of the N_2-CO_2 co-injection field test were i) demonstrating the technical feasibility of a continuous CO_2-N_2 co-injection scenario, ii) monitoring pressure evolution at the wellhead and of the reservoir, iii) monitoring spreading and behavior of the CO_2-N_2 gas mixture in the reservoir, and iv) analyzing potential chromatographic effects within the reservoir. In order to extend the monitoring strategy, 10,000 L (10 Nm^3) of krypton (Kr) were injected as an additional conservative chemical tracer. Moreover, CO_2 from a natural CO_2 source was injected instead of the previously used industrial CO_2 from a refinery process. The natural CO_2 has a much heavier carbon isotope composition ($\delta^{13}C$ = -3.4±0.2‰) compared to the industrial CO_2 ($\delta^{13}C$ = -30.6±0.4‰) and additionally allows for examination of isotopic effects due to mixing between the injected natural CO_2 and formation brine, and previously injected industrial CO_2. Vital parameters during monitoring include injection rates of N_2 and CO_2, pressure and temperature at the injection and observation wells, and reservoir pressure, respectively. A permanently installed capillary riser tube was used for collecting reservoir fluid and gas samples. These were analyzed for gas and carbon isotope compositions.

Preliminary results show the successful realization of the N_2-CO_2 co-injection field test next to effective and permanent monitoring of the injected gases (N_2, CO_2 and Kr). During the field test, 32 t of N_2 and 613 t of CO_2 were co-injected in total to ensure a CO_2:N_2 volume ratio of approximately 95:5. Despite some variation of both N_2 and CO_2 injection rates, wellhead pressure and reservoir pressure were well controlled during the entire field test, and thereafter. Based on Kr data determined by mass spectrometry measurements, the gas mixture arrived after about 4 days at the first observation well (Ktzi 203) located about 20 m away from the injection well (Ktzi 201).

Increasing Kr concentrations at the Ktzi 203 observation well positively correlate with both increasing N_2 concentrations as well as $\delta^{13}C$ values. Additionally, the $\delta^{13}C$ data also indicate mixing between natural and industrial CO_2 within the reservoir.