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A coupled wellbore-reservoir model of self-producing fluids during a push-pull experiment at Heletz (Israel) pilot CO_2 injection site

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To evaluate in-situ CO_2 residual trapping for CO_2 geological storage, two dedicated single-well push-pull experiments have been done at the Heletz, Israel pilot CO_2 injection site. The site is well characterized and instrumented for CO_2 injection including sophisticated sampling and monitoring (Niemi et al., 2016). The first residual trapping experiment (RTE I) was carried out in autumn 2016. In this experiment the residually trapped zone of CO_2 was created by first injecting 100 tons of CO_2 into the target reservoir, followed by fluid withdrawal - first by self-production, then by active pumping - until CO_2 was deemed to be at residual saturation. In this work, the aim is to develop a simulation model that reproduces the measured pressure and temperature data at the injection well. Because of the overlap in wellbore and reservoir response time scales during the fluid withdrawal, the numerical simulator T2Well/ECO$_2$N (Pan et al., 2011) is used to account for the wellbore-reservoir coupling. Of particular interest in this work is to accurately model the period after well opening when the well is self-producing fluids and to analyze what conditions are causing the observed oscillating pressure and periodic gas-liquid release. Comparison of numerical simulations and the measured data suggests that the CO_2 phase is trapped in the target reservoir and only carbonated brine moves upward during the self-producing period. By performing numerical simulations with new sets of relative permeability curves against the measured data, we show that the observed behavior during the self-production could be explained by a zone of dispersed CO_2 bubbles near the wellbore. Here, the new sets of relative permeability curves reflected the reduction in relative permeability in both the CO_2 and the brine phase caused by a zone of dispersed gas phase (Zou et al. 2013), which could be formed due to snap-off and exsolution near the wellbore.

Keywords: CO_2 geological storage, residual trapping, push-pull test, wellbore-reservoir coupling, dispersed CO_2 bubbles

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