Numerical study mitigation of pressure build-up mitigation by production of formation water during CO_2 injection

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Due to injection of supercritical CO_2 into the deep underground, the pressure in the geologic formation increases, first locally around the injection point, later spreads radially throughout the capture formation. The range of pressure increase depends on the injection rate, injectivity and reservoir volume. The increase of pressure in the reservoir may cause several problems, including fault reactivation.
In this study, numerical simulation was applied in order to investigate the effect of production of formation water to mitigate pressure build-up during CO_2 injection into the storage aquifer. The hypothesis, that it will be possible to reduce the pressure buildup in the reservoir during injection by applying pre-injection formation water (brine) production as proposed by Buscheck et al. in 2014 (dual-mode wells), or by production of brine at the same time during injection of CO_2 will be explored in this paper. Numerical simulations were conducted, using the TOUGH2/ECO2N code for non-isothermal, multi-dimensional coupled fluid and heat flow, developed at the Lawrence Berkeley National Laboratory (LBNL).
We employed a simple reservoir model based on available data of the large-scale CCS demonstration project at the Tomakomai area in Hokkaido, Japan. The efficiency and influence of different production/injection rates, reservoir volumes, and the appropriate arrangement of production / injection well on pressure build-up in the storage formation were tested. Three models (15 km x 8 km x 100 m, 24 km x 24 km x 100 m, and 5 km x 5 km x 100 m) with different volumes were employed, and two production / injection rates (200 kt/yr and 1 Mt/yr) were applied for generally three different cases. The first case was only injection of CO_2 for 100 years without previous production. The second case included previous production for 3 and 5 years with subsequent injection for 100 years. The last (third) case considered production of brine while injection of CO_2 by using a separate installed production well. Furthermore, for the third case, appropriate installation and management methods for the wells also were investigated.
In the case of pre-injection brine production, we found that due to production, pressure can be lowered in the storage formation effectively, but due to the recovery effect of pressure, after starting injection of CO_2, the pressure increases rapidly and reaches almost the same value after a view years comparing to the base case without initially production of brine, thus the pre-injection pressure lowering is only effectively for a short time. Regarding to the three different sizes, the results have shown that with smaller reservoir volume the pressure lowering effect increases in efficiency. The most promising result brought up the system of a separate production well and production of brine at the same time during injection. Here, the recovery effect is neglected during the injection, thus the pressure can be kept almost constant during injection.
Judging by the results, the conclusion that can be drawn is that pre-injection, or especially production and injection at the same time can be very effective in order to lower the reservoir pressure and avoid too much pressure build-up and harmful effects on the hydrogeological conditions due to high pressure rise in the storage formation. Even regarding the capacity of injectable CO_2, these methods can be applied to make CCS technology much more sufficient.
For these results, it has to be emphasized, that the effectiveness of the production strategies may highly depend on site conditions. Therefore, the results obtained in this study should be regarded as a preliminary evaluation for the Tomakomai site specifications. Further investigations would be

necessary, when more data becomes available through the site investigation and even operations.

Keywords: Carbon Capture and Storage, pressure build-up, production of formation water

