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Use of Anticlines for Geologic Sequestration of Carbon Dioxide in a Saline Aquifer in Northwestern Taiwan

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In this study, migration of CO_2 in a deep saline aquifer with anticlines under various injection schemes was numerically simulated using the ECO_2N simulator. The hypothetical study site was selected at the Taoyuan Plateau near the second largest coal-fired power plant, Datan power plant (annual CO_2 emission of 1.5 Mt/yr), in Northwestern Taiwan. A 15x15 km2 simulation domain, containing two sub-parallel east-northeast Hukou and Pingzhen anticlines, was discretized into unstructured grid with spatial refinement at the injection borehole. Kueichulin sandstone and Chinshui shale in the simulation domain were considered as the storage formation and the cap rock, respectively. It was assumed that no CO_2 exists in the aquifer prior to injection, and that the aquifer has a hydrostatic pressure distribution and a constant salinity of 3%. All boundaries were assumed to be "open". Isothermal simulations with 1 Mt/yr injection rate and 20 years of injection period were considered. van Genuchten capillary pressure and Corey relative permeability were assumed for all rock formations. Simulation results indicated that pressure buildup characterized the CO_2 migration into three different phases: drainage of brine, formation dry-out, and dissolution and gravity take-over . It was found that the worst leakage scenario occurs if a single injection borehole is placed along the anticline axis. In this case, rock formations near the anticline axis provide a leakage path such that CO_2 ultimately leaks out of the upper boundary. On the other hand, CO_2 can be safely sequestrated in the storage formation if the injection borehole was placed away from the anticline axis. This is because gas phase CO_2 migrates along the counter dipping direction of the anticline as a result of buoyancy. More favorable scenarios were found if a multiple-borehole injection scheme was used. In such cases, not only pressure buildup was significantly mitigated but the amount of precipitated salt was reduced. If a five-borehole scheme was used, for example, pressure buildup and the amount of precipitated salt can be reduced by 20% and 90%, respectively. More interestingly, if injection borehole was placed midway between the two anticlines, buoyancy dominates the migration of CO_2 such that most CO_2 is accumulated under the apex of anticline. Therefore, it is suggested that a multiple-borehole injection scheme would be a preferable scenario because of the reduced risks of pressure buildup and salt precipitation. Moreover, it would be better to place the injection boreholes away from the anticline axis in order to make good use of all possible trapping mechanisms to permanently sequestrate CO_2 in deep rock formations.