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Analysis of Multilevel Pressure Transient Data at the Illinois Basin - Decatur Project

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Based on numerical studies in TOUH2/ECO$_2$N and analyses of multilevel (depth-discrete) pressure transient data at the Illinois Basin - Decatur Project (IBDP), this study demonstrates methods for using multilevel pressure transient data as a means to further characterize the storage formation and for monitoring carbon dioxide (CO_2) and displaced brine migration. By incorporating multilevel pressure monitoring into the monitoring program, additional information is available that can be used to minimize and manage potential risk associated with CO_2 and displaced brine migration to shallower depths.

Previously, we used simulated pressure data from numerical studies in TOUGH2/ECO$_2$N to identify diagnostics for reservoir structure (layering and anisotropy) and CO_2 plume migration. In particular, we found that important insights can be obtained by: 1) normalizing the pressure buildups to the pressure buildup at the depth of injection, and 2) calculating vertical pressure gradients normalized to the initial hydrostatic pressure gradient. Soon after the start of injection, pressure buildups normalized to the pressure buildup at the depth of injection and vertical pressure gradients normalized to the initial hydrostatic pressure gradient are diagnostic of reservoir structure, and over time provide information on the height of the CO_2 plume.

In this study, the identified diagnostics are applied to the pressure transient data at the IBDP, where the Westbay* multilevel groundwater characterization and monitoring system was installed in a deep in-zone verification well (2,000 m) to measure the pressure buildup at multiple depths within the Mt. Simon storage reservoir and above the Eau Claire Formation (primary seal) during CO_2 injection. Using the diagnostic tools, we are able to correctly identify the height of the CO_2 plume. Specifically, the multilevel pressure transient data alone indicate that the CO_2 plume remains largely confined to the 23-24 m interval into which it is being injected, and there is no indication of buoyancy driven flow towards the shallower portions of the Mt. Simon. This prediction is confirmed by RSTPro* reservoir saturation tool logs and sampling carried out by IBDP staff.

In addition, a multilayered, radially symmetric model with TOUGH2/ECO$_2$N is used to history match the pressure buildup at the injection well and the verification well. Our overall excellent match with the pressure transient data from the IBDP demonstrates that by history matching multilevel pressure transient data, a hydrogeological model can be developed that in turn can be used to predict future CO_2 migration. Uncertainty remains with regard to the lateral extent of low-permeability layers and their ability to provide capillary barriers to the upward migrating CO_2 across larger areas. Because pressure data are non-unique, rigorous sensitivity studies are conducted and other geologic model scenarios are also considered. Overall, the number and placement of monitoring zones will affect the vertical resolution of reservoir heterogeneity and the ability to constrain a hydrogeological model with pressure history matching.

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