Comparing (semi-) analytic solutions used to model the impact of deep carbon injection on the displacement and pressurization of the resident brine

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Injection of carbon dioxide into deep saline formations is seen as one possible technology for mitigating carbon emissions from utilities. The safety of the sequestered carbon dioxide is the focus of many studies with leakage through faults or abandoned wells as some of the main failure mechanisms. The focus of this study is on the displacement of resident brine and the resulting changes in pressure due to the injection of large volumes of super-critical phase carbon dioxide into the subsurface. The movement of brine becomes important if it travels vertically and reaches an existing or potential underground source of drinking water where an increase in salt content may threaten the viability of the drinking water source. Vertical displacement of brine may occur slowly through confining layers, or more rapidly through faults and abandoned wells.

This presentation compares several (semi-) analytic solutions to determine their applicability to the problem of brine pressurization and displacement. The goal is to find ranges of formation parameters (e.g., formation seal conductivity, distance to lateral boundary, …) for which simplifying assumption are justifiable Each simplification in the conceptual model (e.g., neglecting the lateral boundary turns a bounded domain into an infinite one) leads to a simpler (semi-) analytic solution. The process involves a solution hierarchy from the most complex solution down to the basic Theis solution. A software tool-kit implementing several (semi-) analytic solutions was developed for this study to facilitate the comparison of the solutions.