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Dimensional Analysis on CO_2 Injection Processes in Saline Geologic Formations

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To answer questions related to CO_2 storage capacity and storage security it is of importance to identify and asses dominating processes occurring in the reservoir during and after CO_2 injection. These processes are highly complex and change with time. On the short time scale, structural and stratigraphic trapping together with a minor contribution of solubility trapping are most important. Over time, the contribution of residual, solubility and mineral trapping mechanisms increases, as does the storage security, since these mechanisms represent a long-term storage of CO_2. The varying importance of the different trapping mechanisms over time is due to varying dominating processes. These processes also occur on different time scales. The advection-dominated multiphase flow regime occurs on the short to medium time scale. With declining pressure gradients and density differences, these processes lose their driving forces. Phase-transfer processes, like the dissolution of CO_2 in brine, become more and more important on the medium to large time scale. Geochemical reactions eventually lead to a very secure trapping of CO_2 on the large time scale. For investigations on storage capacity and storage security issues, the processes on the earlier time scales are of high relevance, since all later processes depend on those early happenings (e.g. chemical reactions and dissolution can only occur where CO_2 is found). Therefore, the focus of this research is on the injection process, relevant primarily on the short to medium time scale.

To identify and assess dominating forces and processes during CO_2 injection in

saline geologic formations a dimensional analysis is performed. First of all, characteristic values like characteristic time, length and flow velocity are defined, being representative for the plume evolution. These characteristic values are used to non-dimensionalise the well known equations describing two-phase flow (CO_2 and brine) in fractional flow formulation. The resulting set of equations consists only of dimensionless pressure gradients, dimensionless numbers (relating acting forces on the system) and dimensionless functions depending both on phase saturations and relations of viscosity and density of the fluids. The physically sound, dimensionless numbers can now be used to estimate and compare dominating forces over time for reservoirs with different properties. This allows to quickly screen reservoirs with respect to storage capacity and security. Typical reservoirs are defined by analysis of a comprehensive reservoir parameter database. Furthermore, measured relative permeability relations are considered.