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Pulsed-Neutron-Gamma (PNG) saturation monitoring at the Ketzin pilot site considering displacement and evaporation/precipitation processes

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The storage of carbon dioxide (CO_2) in saline aquifers is a promising option to reduce emissions of greenhouse gases to the atmosphere and to mitigate global climate change. During the proposed CO_2 injection process, application of suitable techniques for monitoring of the induced changes in the subsurface is required. Existing models for the spreading of the CO_2, as well as mixing of the different fluids associated with saturation changes or resulting issues from mutual solubility between brine and CO_2, need to be checked.
For well logging in cased boreholes, which would be the standard situation encountered under the given conditions, only a limited number of techniques like pulsed neutron-gamma (PNG) logging are applicable.
The PNG technique uses controlled neutron bursts, which interact with the nuclei of the surrounding borehole and formation. Due to the collision with these neutrons, atoms from the surrounding environment emit gamma rays. The main PNG derived parameter is the capture cross section (Σ) which is derived from the decline of gamma rays with time from neutron capture processes. The high Σ contrast between brine and CO_2 results in a high sensitivity to evaluate saturation changes. This makes PNG monitoring favourable for saturation profiling especially in time-lapse mode.
Previously, the conventional PNG saturation model based on a displacement process has been used for PNG interpretation in different CO_2 storage projects in saline aquifers. But in addition to the displacement process, the mutual solubility between brine and CO_2 adds further complex processes like evaporation and salt precipitation, which are not considered in PNG saturation models. These evaporation and precipitation processes are relevant in the vicinity of an injection well, where dry CO_2 enters the reservoir. The Σ brine value depends strongly on the brine salinity e.g. its chlorine content which makes PNG measurements suitable for evaporation and salt precipitation monitoring.
Within the framework of the EU project CO_2CARE, funded by the European Commission (FP7) and by industrial partners, an extended saturation model is developed. This extended saturation model, including both the displacement and evaporation/precipitation process, is applied to the PNG monitoring data of the injection well at the Ketzin pilot site. For the PNG monitoring data of the observation wells the conventional saturation model based on the displacement process is applied, because the arriving CO_2 is already water saturated and no water can be evaporated anymore. The methodological background of the extended saturation model and results of the PNG saturation monitoring program at the Ketzin pilot site are presented.