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Parameterisation of numerical Models for CO_2 Storage with Regard to Storage Security during Longwall Mining Operations

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CO_2 storage in operating and abandoned coal mines appears to be a reasonable option for greenhouse gas control considering the technically mature injection and storage techniques as well as the attainable storage potentials. When considering CO_2 storage in operating coal mines, the aspect of storage security becomes essential in terms of safety regulations for longwall workings in world-wide coal mines.

The present study deals with the development and evaluation of techniques for sorptive CO_2 storage on mining wastes from coal processing. Various underground storage techniques are developed within this research to provide concepts for efficient CO_2 storage accompanied by subsidence mitigation and underground mining waste disposal. Therefore, proven stowage techniques for mining wastes and residues from industrial combustion processes have been enhanced and adapted for CO_2 storage. Their implementation is based on the utilisation of a sorption reactor at the surface to establish a CO_2 mining waste suspension that is subsequently injected into the goaf areas of the mine. The main element of uncertainty with regard to storage security is the possible CO_2 outgassing from the stowed areas.

Numerical simulations will be applied focussing on the potential CO_2 outgassing in terms of quantity, time and space. The MUFTE_UG software package for simulation of multi-component flow and transport in porous and highly fractured media will be used to simulate the complex interaction of gas flow parameters. Different CO_2 storage scenarios will be taken into account by the application of parameterisation based on results of experiments in a laboratory scale. The corresponding experimental studies comprise CO_2 single-gas sorption experiments on mining wastes and investigations of their gas permeability under high pressures. Additionally, a triaxial cell setup modified for simultaneous recording of gas and water permeability at low pressures will be used to determine the interaction of gas and water phases in the CO_2 mining waste suspension with respect to diffusion and outgassing processes. The results of consolidation tests on the mining waste suspension will be used to relate its compressibility with the time-dependent development of the permeability in the stowage areas involving the load of the collapsing bedrock.

The stowed area in the goaf consists of the injected CO_2 mining waste suspension and a skeleton of non-permeable collapsed bedrock. The CO_2 desorbs from the mining waste and diffuses into the direction of lower pressure based on the pressure gradient resulting from an injection pressure above the ambient pressure. This shifts the CO_2 concentration and may be described by the laws of Fick. Nonetheless, the system is more complex, and the interaction of further effects relevant for the CO_2 flow needs to be integrated into the models forming the main challenge of this study. Specifically, CO_2 phase transitions within the framework of sorption processes on mining wastes and bedrocks, as well as solution and dissolution in the pore water influence the time-dependent development of the CO_2 flow process.

The low permeability of the mining wastes is the main sealing factor to prevent CO_2 flow. This parameter varies due to time-dependent changes of capillary effects resulting from the water discharge of the suspension during its hardening. Furthermore, the load of the roof compresses the suspension and parameters like density, porosity, permeability and viscosity are consequently changing. Overall, the models component dynamics complicate its character. Therefore, a basic model setup for an evaluation of the interacting model parameters with regard to their relevance is necessary for an implementation of continuative complex flow models.