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Shaft sealing issue in CO_2 storage sites

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Carbon capture and storage is an innovating approach to tackle climate changes through the reduction of greenhouse gas emissions. Deep saline aquifers, depleted oil and gas reservoirs and unmineable coal seams are among the most studied reservoirs. However other types of reservoir, such as abandonned coal mines, could also be used for the storage of carbon dioxide. In this case, the problem of shaft sealing appears to be particularly critical regarding to the economic, ecologic and health aspects of geological storage. The purpose of the work is to study shaft sealing in the framework of CO_2 storage projects in abandoned coal mines. The problem of gas transfers around a sealing system is studied numerically using the finite elements code LAGAMINE, which has been developped for 30 years at the University of Liege. A coupled hydro-mechanical model of unsaturated geomaterials is used for the analyses.

The response of the two-phase flow model is first studied through a simple synthetic problem consisting in the injection of gas in a concrete-made column. It stands out of this first modeling that the advection of the gas phase represents the main transfer mechanism of CO_2 in highly unsaturated materials. Furthermore the setting of a bentonite barrier seal limits considerably the gas influx into the biosphere.

A 2D axisymetric hydromechanical modeling of the Anderlues natural gas storage site is then performed. The geological and hydrogeological contexts of the site are used to define the problem, for the initial and boundary conditions, as well as the material properties. In order to reproduce stress and water saturation states in the shale before CO_2 injection in the mine, different phases corresponding to the shaft sinking, the mining and the set up of the sealing system are simulated. The system efficiency is then evaluated by simulating the CO_2 injection with the imposed pressure at the shaft wall. According to the modeling, the low water saturation of concrete and its higher intrinsic permeability give the concrete a higher gas permeability than the one of the rock. Thus, the major part of CO_2 fluxes flows through concrete elements. Moreover, the hydraulic seal of bentonite doesn't contribute to the reduction of CO_2 fluxes to the atmosphere since it is in contact with the concrete shaft support. Indeed, in the present case, CO_2 fluxes bypass the seal, going through the more permeable concrete. Consequently, the design of the shaft sealing system contributes significantly to a loss in performance and appears to be a significant parameter to evaluate the risks of CO_2 leakage.