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Experimental study of cemented interfaces for applications in CO₂ storage re-using depleted oil and gas reservoirs

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The European ERA-ACT REX-CO₂ project aims to develop a tool to assess the compatibility of existing wells for CO₂ sequestration. Indeed, the reuse of existing wells for storage in depleted reservoirs is an attractive medium-term solution for geological sequestration of CO₂.

The mechanical integrity of the wells is a critical point in term of storage durability. A variety of flow paths that could lead to a migration of the stored CO₂ to surrounding geological layers or the surface have been identified. Among those, operational feedback shows that a likely leakage route are along the interfaces of the well structure. These potential flow path can be generated by the debonding of the cement sheath from the steel casing or surrounding rocks. One ambition of REX-CO₂ project is to ultimately predict the wells integrity as a function of the variations in undergone mechanical loadings. In order to reach this objective, it appears relevant to characterize the mechanical strength of these interfaces.

IFPEN work consists in carrying out mechanical tests on bimaterial specimens to study cement/steel or cement/rock interfaces in different configurations representative of downhole conditions. Two types of tests are performed allowing the characterization of the bonding in two different stress states: the pull-out test and the push-out test. Combined with simulations, these results can either be used directly or feed a damage interface models. The authors are currently running an extensive parametric study, to explore the impact of various downhole conditions, such as pressure or environment, and to CO₂ exposure.

The presentation focuses on the mechanical testing methodology. The pull-out test is a tension test performed on a cylinder made of two materials. In this case, the stress pattern is obvious, the interface is loaded in tension. This test is difficult to carry out perfectly due to the weak and scattered behaviour in tension, and finding proper gluing solutions. The push-out test, commonly used in the literature, consists in pushing a plug (steel or rock) into a cement ring to measure the bonding resistance. Despite other push-out tests, a surrounding steel ring ensures the cement confinement and avoid radial cracks. FEM analysis shows stress pattern is more complex than a pure shear at the interface, as often assumed in the literature. An analysis of loading curves enables to understand the different damage stages of the interfaces.