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Hydro-geochemical processes in the emplacement cavern of a low and intermediate-level waste repository in an indurated clay-rock

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By 2080, Germany will have to store around 600 000 m^3 of low and intermediate-level nuclear waste (L-ILW) with negligible heat generation. This kind of waste is largely made up of used parts of nuclear power stations such as pumps, pipelines, filters, etc. placed in various types of waste containers made from either steel, cast iron, or reinforced concrete in different designs and sizes (i.e. cylindrical or box shaped). It is already decided that a total of 303 000 of the 600 000 m^3 L-ILW will be disposed in a final storage facility in the former iron ore mine Schacht Konrad which is under construction. However, it is still not clear where the L-ILW emplaced in in the old salt mine Asse (200 000 m^3) will be stored in the future. The situation is particularly critical, as the waste have to be retrieved from the instable mine shafts partially flooded with groundwater, causing strong socio-political concerns as radioactive waste could contaminate the water nearby. For this reason, the new search for a nuclear waste repository for high-level waste (HLW), started in 2017, should also consider the possibility to accommodate the waste from Asse. Obviously, this is still subject to critics as this will make finding a final repository more difficult as storing HLW and L-ILW together requires different concepts and designs for each other and, above all, much more space.

In this context, in this contribution we have defined conceptual and numerical models to assess the hydro-chemical evolution of a L-ILW disposal cell in indurated clay rocks, involving the interaction of different components/materials and the expected hydraulic and/or chemical gradients over 100 000 years. The L-ILW disposal cell leverages a multi-barrier concept buried 400 m below the surface. The multi-barrier system is comprised of the waste matrix (i.e. backfilling the waste drums), the disposal container, the mortar backfill in the emplacement tunnel (where the disposal containers are located) and the clay host rock. The dimensions and design of the emplacement tunnel (e.g. 11 × 13 m) and disposal cells represent and consider some aspects taken into account in the designs of some European countries. In addition, tunnel walls reinforced with a shotcrete liner and the Excavation Damaged Zone is considered in the concept. The model is implemented in OpenGeoSys-6, an open-source version-controlled scientific software based on Finite Element Method which is capable of handling fully coupled hydro-chemical models by coupling OpenGeoSys to iPHREEQC. First calculation results, demonstrate that the most important processes affecting the near-field chemical evolution are i) the degradation of the concrete and cementitious grouts with porewater migrating inwards from the host rock and ii) the significant

quantities of reactive and non-reactive gases (i.e. hydrogen, carbon dioxide and methane) that are generated as a result of: i) the anaerobic corrosion of metals present in the waste and containers and ii) the degradation of organic compounds by microbial and chemical processes. As a first approximation, some assumptions and simplifications have been considered, probably resulting in a wort case scenario.