Model for predicting sulphide fluxes in a spent nuclear fuel repository at Olkiluoto, Finland: Implications for the corrosion of copper canisters

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We use reactive-transport models patterned after the multibarrier KBS-3 spent fuel repository design developed by Posiva, Finland and SKB, Sweden to determine critical parameters affecting sulphide fluxes and thus the corrosion of the copper canisters encapsulating spent nuclear fuel. The swelling clay materials used as tunnel backfill and as buffer surrounding the copper canisters contains accessory gypsum and organic carbon. Gypsum dissolves over time owing to concentration gradients between the porewater in the bentonite and the natural groundwater thereby releasing sulphate. Sulphate reducing bacteria may utilize sulphate and organic carbon for energy production and growth thereby releasing sulphide. Bacterial activity is expected to occur primarily in the less compacted backfill and in the excavation damaged rock along the contact between the backfill and the rock. Thus predicting transport rates of sulphate and organic carbon towards the contact zone is essential for reliable estimates of sulphide fluxes towards the canister. Reactive transport simulations suggest that 1) the transport properties of the rock (i.e. the diffusivity of the rock matrix, the size and distribution of fracture zones), 2) the concentration of Fe in the porewater that, if sufficiently high, may lead to the precipitation of Fe-sulphide minerals and 3) the distribution and size of bacterial communities and their rate of metabolism are all important factors affecting the magnitude of sulphide fluxes.