EGU General Assembly 2024

EGU24-4735, updated on 15 Aug 2024
https://doi.org/10.5194/egusphere-egu24-4735
EGU General Assembly 2024

Spreading and mixing of hydrogen in heterogeneous porous media

Alejandro Fernandez Visentini[1], Luis Cueto-Felgueroso[2], Juan Jose Hidalgo[1], and Marco Dentz[1]
[1]CSIC, IDAEA, Spain (afvash@cid.csic.es)
[2]Universidad Politécnica de Madrid

The efficiency of hydrogen storage and recovery cycles largely depends on how the fluid spreads as it is injected in the reservoir, and how well it mixes with the in-situ fluids. Spreading leads to the stretching of the fluid front and to the creation of chemical concentration gradients, whereas mixing is driven by the existence of such gradients and it tends to erase them by molecular diffusion. Spreading is caused by spatial heterogeneity in the gas flow velocity, which in turn depends on the spatial distribution of the host rock permeability, the latter exhibiting orders of magnitude variation over a wide range of spatial scales. Quantification of the impact of permeability heterogeneity on the spreading and mixing behaviour of gases can help to better predict the outcome of hydrogen production cycles, but it has not been systematically studied to date in the context of underground hydrogen storage. Further, the dependence on pressure and chemical composition of the hydrodynamic properties of gases, namely, viscosity, density and compressibility, leads to a non-linear relationship between spreading and mixing of hydrogen and permeability that requires detailed numerical modelling. Here, we investigate the dependence of standard spreading and mixing measures on the hydrodynamic parameters of evolving mixtures of hydrogen and other fluids (e.g., cushion gases, water) for different permeability models. We simulate isothermal hydrogen injection and extraction for different permeability models, imposed pressure gradients and regimes of flow stability (e.g., viscous and gravitational). We consider different test cases where invading and residing fluids go from mildly- to highly-contrasting hydrodynamic properties. The considered spectrum of spreading and mixing behaviours for given permeability models helps to develop uncertainty measures and analytical models. We perform the modelling using open-source Matlab Reservoir Simulation Toolbox (MRST).