Project Number	7
Name/title of the PhD course	Doctoral Thesis in Earth and Environmental Sciences
Name/Title of the PhD project	*Permeability and migration paths up to the surface at the scale of the rock mass*
Recruiting organisation and Department/Faculty of reference	ISTerre laboratory is part of the Université Grenoble Alpes, and it is a world leading research institution in geoscience (ranked 24th by the Shanghai QS ranking; Earth Science field 2022), with 110 permanents scientists and 41 engineers. ISTerre has a strong expertise in the field of H_2 generation, migration and reactivity in geological environments with five permanents scientists and three engineers working in this field for more than one decade. The PhD student will work in the Natural Hydrogen Observatory Group Grenoble (https://nativeh2project.osug.fr/) led by Laurent Truche & Frederic Victor Donzé. Equipment and infrastructures available to the recruited DC is presented in the Web site of the H_2 group.
Scientific context and Objetives	Fault zones crossing caprocks are critical objects for massive storage of H_2 in porous reservoirs. We have shown recently that subcritical mechanical response of a fault may be enough to explain why the permeability of a fault zone can increase by several orders of magnitude when slightly increasing the fluid pressure, while strain records do exhibit generally very low plastic deformation (Donzé et al. 2020). This has been observed during fluid injection tests performed inside a clay-rich fault zone at the Tournemire IRSN underground laboratory.. Now, due to the high diffusivity, low viscosity, and low density of hydrogen leads to a high mobility and therefore the potential loss due to leakage along fault zones and permeability law needs to be revisited. The main objective of the project is to formulate this permeability evolution within a fault zone for H_2 flow to be used in numerical model to study the integrity of massive H_2 geologic reservoir.
Expected Results	The expected result is the formulation of the permeability in terms of THMX environment inside the fault zone to describe a H_2 flow at the reservoir scale. From laboratory experiments carried out at the TUDelft and field monitoring, formulations of permeability will proposed and plugged in numerical models of H_2 reservoirs, taking into account scaling effects, i.e. possible homogenization of the problem and in situ effective stress conditions. The numerical investigations will require high coding skill levels. Testing permeability laws imply a full control of the software environment, which can be written in matlab or C++. Understanding the meaning of state equations for multiple components in different phases is mandatory to develop reliable and clear codes. Development frameworks could be MRST toolbox (Finite volume method) or YADE-DEM (Discrete element method). Validation of the model will done by comparing the results with known and well-constrained experimental tests and/or other numerical simulations. Parametric studies will be carried to rank the contributions of the parameters used in the model. Then, predictive analyses will be conducted at the scale of a reservoir to better understand the geomechanical issues during cyclic loading in presence of fault zones crossing the caprock.
Secondment opportunities	TUDelph, Hadi Hajibeygi, Experimental tests.
Brief CV of main Supervisor	Frederic Victor Donzé is professor of Geomechanics & Geophysics and co-leading the Natural Hydrogen Observatory Group Grenoble, responsible for assessing the potential of native hydrogen (https://nativeh2project.osug.fr/). He is specialized in the development of numerical modelling applied to geosciences (tectonics, fault systems, fracturation, HM coupling) and civil engineering (dynamic loading, slope stability, soil mechanics). He is also involved in Geophysical prospection, ElectroMagnetic & MagnetoTelluric methods to identify the presence of faults and ground water) (https://www.researchgate.net/profile/Frederic-Donze/research). He (co-)supervised 21 PhD theses, 14 post-docs and 12 master students in geophysics geomechanics and civil engineering. Publication list: https://scholar.google.fr/citations?hl=fr&user=66zPxNUAAAAJ
Publications	1- Lefeuvre, N., Truche, L., Donzé, F. V., Gal, F., Tremosa, J., Fakoury, R. A., ... & Gaucher, E. C. (2022). Natural hydrogen migration along thrust faults in foothill basins: The North Pyrenean Frontal Thrust case study. Applied Geochemistry, 145, 105396. 2- Lefeuvre, N., Truche, L., Donzé, F. V., Ducoux, M., Barré, G., Fakoury, R. A., ... & Gaucher, E. C. (2021). Native H2 exploration in the western Pyrenean foothills. Geochemistry, Geophysics, Geosystems, 22(8), e2021GC009917. 3- Donzé, F. V., Truche, L., Shekari Namin, P., Lefeuvre, N., & Bazarkina, E. F. (2020). Migration of natural hydrogen from deep-seated sources in the São Francisco Basin, Brazil. Geosciences, 10(9), 346.
Projects	1- Natural H_2 exploration (French National Research Agency)