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CHENILLE : Coupled beHaviour undErstaNdIng of fauLts : from the Laboratory to the fiEld

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The understanding of the coupled thermo-hydro-mechanical behaviour of fault zones is of fundamental importance for a variety of societal and economic reasons, such as the sustainable energy transition for the safe use of natural resources (energy storage, nuclear waste disposal or geothermal energy). The overall objective of this inter-disciplinary project is to create a dataset that will allow to highlight the physical processes resulting from a thermal and hydric load on an existing, identified and characterized fault zone.

An in situ experiment will be performed at IRSN's Tournemire Underground Research Laboratory to evaluate the hydraulic properties and mechanical behaviour of a fault zone in a shale formation due to an increase of gas or water pressure under incremental thermal loading. This fracturing field tests will be conducted using four types of boreholes drilled from the URL : (i) one injection borehole (INJ) with one chamber measuring 10 m in length; (ii) four boreholes (H1 to H4) dedicated to host steel canister electrical heaters, (iii) 5 boreholes (S1 to S5) dedicated to the geophysical monitoring of seismic and aseismic fracturing processes, (iv) two to four boreholes (M1 to M4) to record deformation and estimate fracture location, which will help assess the seismic survey. After an initial saturation phase of the chamber, successive sequences of fluid injection tests are planned. The preliminary injection tests will be done stepwise either at constant flow or at constant pressure rate in order to obtain a steady-state flow regime at normal in situ temperatures. The hydraulic conductivity and permeability of the fault zone will be then inferred. A second stage of hydraulic testing will involve the determination of the main hydraulic parameters during a stepwise increase of temperature within the volume (maximum temperature 150°C). In the meantime, the seismological responses of the injected structures, from the static deformation to the high-frequency (100-kHz) acoustic emissions will be surveyed. The evolution of temperature and deformation will be monitored thanks to fibre optic array. In addition, a controlled seismic experiment is proposed, using coupled magnetostrictive vibrators to investigate the structural environment before and after experiment.

Moreover, to accompany the field study, a series of laboratory experiments will be conducted to understand the chemical and structural evolution occurring within fault zones during the thermal and hydraulic loading. Experiments in climatic chambers exposing the samples to the same heat treatment as that of the in situ experiment will be carried out in order to compare the mineralogical composition evolution of the samples with those taken from the field investigated zone. Finally, a rock mechanical study, from the microscopic to the centimeter scale with monitoring of the acoustic properties will be carried out. This study will include experiments from Scanning Electron Microscope with Energy Dispersive Spectroscopy (SEM-EDS) allowing the identification of the micro-scale mechanisms of deformation localization to which it is planned to add an acoustic measurement system. In order to study the evolution of mechanical behaviour as a function of scale, experiments in triaxial press, again with acoustic monitoring, are planned.