PhD position at Cergy-Pontoise University, France

Fluid substitution in reservoir rocks: impact of water-weakening and seismic monitoring

Context: In Earth sciences, fluid substitution processes in porous media impact several areas like hydrocarbon reservoir production, groundwater management, carbon dioxide sequestration, geothermal energy production or building stones durability. For example, production of hydrocarbon reservoirs leads to a decrease of pore pressure which induces compaction and loss in production rate. Among the different techniques for enhanced oil recovery, massive fluid injection in situ to raise pore pressure and drive the oil towards production wells has been used for years. However, this technique lead to an acceleration of the subsidence rate in the Ekofisk oil field in the eighties which cost millions of dollars to the oil companies to lift up their production platforms due to the sea floor sinking. The physical mechanism responsible for the accelerated subsidence at Ekofisk is water weakening which occurs when water is injected in the reservoir. When water replaces oil in a reservoir at depth, physico-chemical effects take place like stress corrosion at crack tips, which can lead to the mechanical failure of the reservoir.

Previous studies: The GEC (Geosciences & Environment Cergy) laboratory at Cergy-Pontoise University in collaboration with CSIRO Energy, Perth (Australia) are studying for several years fluid substitution processes and their impact on mechanical stability of reservoirs, and are also developing methods for monitoring fluid substitution using ultrasonic techniques at the lab scale. Recent experiments on the Sherwood sandstone have shown that mechanical instabilities leading to failure can be triggered, with no significant change in stress state, only by fluid substitution involving water weakening effects (David et al., 2015a; Dautriat et al., 2016, David et al., 2016). Furthermore advanced signal processing methods adapted from large scale seismic techniques were developed for monitoring fluid substitution processes and their impact on rock properties (David et al., 2015b, 2017a, 2017b).

Objectives: The objective of the proposed work is to better understand these phenomena, focusing on carbonate rocks. Several points will be addressed:

- Laboratory studies to determine the conditions under which water weakening becomes important, and what the impact would be on the stability of geological reservoirs; parameters to be taken into account are the rock composition (mineralogy), the fluid composition (salinity), the rock microstructure and the experimental conditions (stress, fluid pressure, temperature).
• Improvement of the monitoring techniques for fluid substitution processes aiming at the prediction of their impact on reservoir properties; for example the current techniques can be extended to incorporate monitoring based on S waves and electrical methods.
• Microstructural characterization of the damage induced by water-weakening using microscopy techniques.
• Development of a micro-mechanical model to predict the impact of water-weakening on the mechanical behavior of reservoir rocks.

**Job details:** The PhD will be hosted by GEC laboratory at the University of Cergy-Pontoise, France, with short stays in the Australian partner’s lab at CSIRO Energy, Perth. The PhD advisors will be Prof. Christian David and Dr. Beatriz Menéndez (GEC) with collaboration with Dr. Christophe Barnes (GEC). The main collaborator in Australia is Dr. Joël Sarout (CSIRO Energy, Perth) with collaboration with Drs. Jérémie Dautriat, Lionel Esteban and Claudio Delle Piane. Both laboratories have leading edge facilities for rock physics and rock mechanics studies (triaxial press), passive ultrasonic monitoring (acoustic emissions recording), active ultrasonic monitoring (recording of elastic waves velocity) and microstructures analyses (optical and confocal microscopy, SEM coupled with RAMAN, CT-scan and RX micro-tomography, NMR and MICP). The appointment is for a maximum duration of 3 years, starting October 1st, 2018. **Funding of PhD salary has been granted by the University of Cergy-Pontoise.**

**Candidate’s profile:** The candidate should have (or finalizing) a Master degree in rock physics, geomechanics, geophysics, material sciences or mechanical engineering. Background in rock mechanics, rock physics, geophysics, scilab/matlab coding is an asset. The candidate should have a strong interest for laboratory experiments.

**Lab web site:** [https://www.u-cergy.fr/fr/laboratoires/laboratoire-gec.html](https://www.u-cergy.fr/fr/laboratoires/laboratoire-gec.html)

**Recent works on « water weakening »**


**Recent works on fluid substitution monitoring**


To apply, each candidate should send a cover letter, CV, transcripts of diploma, list of courses attended with grades, and if possible letters of support from references and/or from the Director of the current Master degree, at the following e-mail address: christian.david@u-cergy.fr

**Deadline for sending applications:** May 31st, 2018