Subject offered for a contract starting October 2019

SUBJECT TITTLE:

Development of new methodology to estimate poro-elastic properties of rocks at regional and local scales

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Host lab/ Team: **ENS- Laboratoire de Géologie de l'ENS- UMR 8538**

Financing: Doctoral contract with or without teaching assignment

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Presentation of the subject: (1 or 2 pages)

The presence of fluids and their movements within the Earth's crust control many geological processes and sometimes trigger societal issues with significant environmental consequences. Fluids within the crust are directly related to: groundwater resources, energy, storage in deep geological formations, ore depositions and, biodiversity preservation (Alley et al., 2015). As a result, overexploitation of many aquifers around the world is of major concern, in particular considering current climate change (Taylor, 2014; Gorelick and Zheng, 2015). Yet, our capacity to understand the behaviour of fluid transfers decreases with the depth of physical processes at stake. Indeed, the main challenge in hydrogeology is to understand and quantify the physical processes responsible for fluid transfers even if the data available are insufficient to represent the complexity of the geologic system (Marsily et al., 2005).
More recently, the development of space-based techniques such as Interferometric Synthetic Aperture Radar (InSAR) or the Global Positioning System (GPS) has allowed to directly measuring ground motion related to hydrological processes. At the same time, space gravity measurements from the Gravity Recovery and Climate Experiment (GRACE) mission allows to quantify the equivalent load imposed by water height and its variations with time. Those new techniques were successfully applied to the well-documented example of Antelope Valley, revealing the potential of direct and indirect measurement methods such as: InSAR, GRACE, GPS, climatic and water level measurements, poroelastic rock properties, and groundwater numerical modelling, as well as the potential diversity of the issues addressed, either in relation to land subsidence or to groundwater resources depletion or seismic activity (Galloway et al., 1998; Hoffmann et al., 2003; Hoffmann and Zebker, 2003; Argus et al., 2014; Borsa et al., 2014). This highlights the added value of

these new geophysical techniques combined in order to decipher and quantify the relative roles of the different mechanisms in the resulting vertical displacements. With its dense temporal resolution and fine displacement accuracy, GPS measurements are well adapted to detect small local or regional deformations. Acquisition of long-term records would be fruitful, notably for the sustainable water management of un-documented areas. In complement, thanks to the recent launch of the Sentinel 1 constellation by ESA, the fine spatial resolution and regular temporal sampling of InSAR time series of ground deformation offers additional constraints on the physical mechanisms at stake.

We propose a comprehensive and integrated quantification study of aquifer resources through the implementation of an innovative method. The latter will combine observations acquired in situ and by satellite, with mechanical laboratory experiments and numerical modelling. The objective is to understand and quantify the poromechanical behaviour of multilayer systems such as aquifers (reservoirs) and aquitards (covers), and to identify the impact of fluid movements in the crust. We will develop a new approach to better assess the storage and transport properties of groundwater at the local and regional levels in order to better predict the future potential of aquifer resources in the context of climate change and increased human pressure. The methodology will be first validate on a well known sedimentary basin (i.e. Paris basin), then it will be test in other context such as systems with negligible climate forcing (ie, no refill at present time).

This PhD project offering innovative method to characterize at high space and time resolution the earth system, its poro-elastic properties and spatiotemporal evolution of its natural resources.

Student skills: Physician / rock mechanic with taste for hydrogeology or hydrogeologist / geophysicist with programming / physics skills

References

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