**PhD Position in Geophysics**

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<th>PhD thesis subject</th>
<th>Groundwater monitoring by seismic noise correlations</th>
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<td>Supervisor</td>
<td>Clarisse BORDES</td>
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**Social and economic issues**

The characterization of geological reservoirs has been a major economic and social issue for many decades. It implies a very large set of applications for deep or shallow georesources (groundwater, geothermal applications, gas storage, oil and gas resources). For this purposes, geophysical surveys are generally based on active methods, especially on seismic imaging when dealing with deep targets.

However, it has been shown in 2000s that passive surveys might be more efficient with less implementation costs. These methods, based on the seismic crosscorrelation of ambient noise (SCAN), have the surprising ability to detect very weak changes in seismic velocities (less than 0.1%) that are not picked by classical active methods. They are still poorly used in companies, but they might be a “game changer” for many applications within the next decades. In this project, we aim at exploring the ability of passive seismic surveys for monitoring the fluid saturation of a porous medium.

**Scientific issues and context**

The SCAN has been largely used for imaging geological structures at different scales: at Earth’s scale Nishida et al. (2009) provided an original map of S wave velocity using very low frequency noise; at regional scale, spectacular maps of California were proposed by Shapiro et al (2005) and Lin et al (2009); at kilometric scale, interesting results were obtained for volcanoes imaging (Brequier et al, 2007, De Siena et al 2018, Huang et al, 2018), landslide characterization (Voisin et al, 2016, Bièvre et al, 2018) or for smaller geotechnical applications (Salvermoser et Hadziioannou, 2015). Actually, many recent studies showed the great potential of SCAN as a novel tomography tool for imaging 3D structures.

Some authors used the SCAN in the context of geological reservoirs. Gassenmeier et al. (2015) monitored the Rayleigh waves velocities during CO2 injections in Ketzin (Germany), and observed clear seasonal velocity changes. With similar approaches, Fehr et al (2018) and Zhou and Paulssen (2017) obtained the dispersion curve of Rayleigh waves that can be inverted to provide shear waves velocity profiles. In the geothermal context of Salton Sea, Matzel et al (2018) computed a map of fluid circulation along faults, and Taira et al (2018) observed sudden velocity reductions due to opening of fractures and weak velocity increase due to poroelastic contraction after geothermal production.
Nevertheless, very few studies focused on the quantitative monitoring of changes in fluid content. Actually, Voisin et al (2016) first used the ambient noise crosscorrelation as a tool for estimating small velocity variations due to water content changes. Their results showed a very good correlation between water level and seismic velocity changes. By using pore pressures and piezometric levels, they proposed a convincing interpretation based on a simple fluid substitution approach. Fores et al (2018) obtained similar results in a karst environment and confirmed the great potential of ambient noise crosscorrelation for hydrological monitoring.

The Experimental Geophysics group within the CRG team of LFCR has been developing different laboratory experiments for exploring geophysical observations in light of petrophysical models. Preliminary studies performed on a sand sample under variable water saturation confirmed some theoretical expectations and showed promising results concerning the link between crosscorrelations and water content.

The objective of the PhD project will be exploring the ability of SCAN methods as a tool for estimating the global saturation of a geological reservoir. These objectives will be reached and strengthened by combining 3 complementary approaches: laboratory experiments, field data processing and numerical studies.

**PhD program**

The PhD programme will be led with three ambitious approaches:

- **Laboratory experiments (LAB):** a metric scale experiment will be customized for SCAN methods, composed of loudspeakers for generating controlled noise and of 3D accelerometers for measuring seismic waves/noise within the sand. The water saturation will be controlled by an imbibition/drainage system, in a very homogeneous and well-controlled porous medium.

- **Field data processing (FIELD):** this part of the project will be implemented in collaboration with ISTERRE (Grenoble), based on the original dataset of Voisin et al (2017) from the Crépieux-Charmy (Lyon, France) groundwater exploitation field. These data are already available.

- **Numerical experiments (NUM):** this part of the project will be implemented in collaboration with other PhD students and the ISTERRE team. By using a numerical approach, the reconstruction of seismic propagation by the SCAN method (effective Green’s functions) will be discussed for both laboratory and field scales.
Host laboratory and collaborations

Laboratory of Complex Fluids and their Reservoirs – E2S UPPA

From the nanometer to hundreds of kilometers, from the nanosecond to a million years, from the physics and chemistry of interfaces, through the thermodynamics of fluids under flow, to reservoir geology, geomechanics and geophysics, status as an “industrial” UMR (Joint Research Unit), supervised by TOTAL, the CNRS and the UPPA, the LFCR is an innovative and remarkable research unit in more ways than one. Its specific focus, essentially based on the study of fossil georesources, and totally in phase with the local socio-economic context, sets it apart regarding applications and enables it to host internationally-recognized teams.

The LFCR is a joint research unit attached to the UPPA, the CNRS and TOTAL. It is organized into four research teams:

- “Interfaces and dispersed systems” led by Daniel Broseta
- “Thermophysical properties” led by Hervé Carrier
- “Geomechanics and Porous media” led by David Grégoire
- “Characterization of geological reservoirs” led by Daniel Brito (CRG)

The PhD student will join the CRG team (35 people, 12 PhD students), which aim is to analyze properties and characteristics of geological reservoir systems. Reservoir systems can be considered on a scale ranging from a meter to several kilometers and are the geological interface that enables the integrated analysis of all the processes at play in the construction of a sedimentary basin. The processes involved are played out at basin scale and right down to that of the pore network, linking solid rock and fluid layers. The team’s activities combine geological approaches (structural geology, sedimentology, geochemistry, geomorphology and neo-tectonics) with geophysics, rock physics and mineralogy.

The PhD student will benefit from the supervision/support of the experimental Geophysics group: Clarisse Bordes (Associate Professor), Daniel Brito (Professor), Federico Sanjuan (Research Engineer for any technical support).

Collaborations with ISTERRE – Université Grenoble Alpes

The project will be led in collaboration with ISTERRE, that have been one of the world’s most active laboratories on waves and structures for 30 years. In particular, they have prompted the SCAN method for imaging structures at many different scales.

The PhD student will benefit from the collaboration with Christophe Voisin (CNRS Researcher) and Stéphane Garambois (Professor). He/she may have to spend time in Grenoble for short stays (few days to few weeks).
## The E2S consortium

The consortium at the heart of the Energy Environment Solutions (E2S) project is composed of the University of Pau and the Pays de l’Adour (UPPA) and two national research organisations, National Institute for Agronomy (INRA) and Institute for Research in Computer Science and Automation (Inria). The core scientific domain of the project focuses on Environment and Energy and relies on strongly recognised laboratories supported by state-of-the-art equipment. The assessment and acceptance of new solutions and the public regulations will supply the area with interdisciplinary reflection.

One of E2S UPPA principal assets is its strong relationships with major international companies that can find in this partnership the scientific excellence they expect. Their industrial R&D centres on the site are already a key factor in consortium policy and will play a growing part for the next ten years.

These companies have created CEPyA (Cluster Enterprises Pyrénées Adour) which will support E2S UPPA in its trajectory towards a model for scientific excellence and international visibility.

Another primary goal is to increase international attractiveness in both education and research: to attract the world's best students, the university will achieve higher and higher level of quality. An aggressive recruiting policy will generate an increase in academic researchers and PhD students. The industrial partnership will provide new forces, which, associated with the consortium's potential, will have a leverage effect on research and innovation.

## Who can apply?

Graduated students in Geophysics, Earth Sciences, Acoustics or Physics.

Skills in signal processing and seismic/acoustic propagation are necessary.
Hands-on experience in Matlab, Scilab or Python is essential.

Fluency in English is mandatory. Basic French is necessary (free French courses are available).

Interest in teaching: the PhD student will be involved as teaching assistant in our bachelor and master programs (32h/year). Bachelor of Earth Sciences is taught in French. Part of master of Petroleum engineering is taught in English. The teaching assistant will have to manage exercises and practical sessions in general geophysics, basic computing, petrophysics.
PhD Position in Geophysics

Application

Application files:

- CV
- Cover letter presenting the motivation of the applicant
- Master degree grade transcripts and ranking
- Reference letter
- Contact details of at least two people, from your work environment, who can be contacted for further reference

Selection process:

- Establishment of the selection committee
- Evaluation of the applicants' file
- Interview with the selected candidates and ranking

Application files will be evaluated based on the following criteria:

- Candidate's motivation, scientific maturity and curiosity
- Candidate's knowledge in geophysics and computing
- Grades and ranking during your Master degree, steadiness in your academic background
- English language proficiency
- Oral and written communication skills
- Candidate’s ability to present her/his work and results

Salary

Starting Date: September 1st 2019
Duration: 3 years

Gross salary: 1 870 € / month (which includes extra gratification for teaching duties – 32h per year)

Contacts

Clarisse Bordes

All application files must be sent to
Clarisse.bordes@univ-pau.fr

Application deadline: 3 July 2019