

# Offer for a Thesis Allowance

## *Subject: Characterization of natural tracers for the identification of gaseous effluents in gas storage areas*

From July 22, 2020 to September 30, 2020

The research topic proposed in this PhD thesis falls within the context of energy conversion and the reduction of the environmental impact of industrial activities. It will contribute to one of the major issues that gas industries are facing: the detection, the identification and the mitigation of uncontrolled leaks when underground storage activities are implemented.

The work to be carried out will closely associate:

- 1 . measures to detect, identify and characterize natural tracers (traceelements, isotopic tracers) and
- 2 . modeling of water/gas/rock/bacteria interactions to understand biological and physico-chemical mechanisms involved in gas migration and thus discriminate the origin of an effluent present in natural gas storage areas.

The PhD will take place in the brand-newSENGA Joint Laboratory (TEREGA-UPPA).

**Keywords: tracers, natural gas, biogenics, measurements, isotopes, modeling**

## Mission and principal activities

### Scientific context

Detecting and reducing gas effluent leaks is one of the major challenges that gas companies are facing, particularly when underground storage activities are implemented. The aim is to meet not only immediate safety requirements to protect personnel and facilities, but also, given the volumes involved, economic and environmental issues.

Indeed, a medium-sized natural gas storage site may have several dozen injector, producer and monitoring wells. On a global scale, this means several tens of thousands of units. These wells necessarily involve contact between the storage and the atmosphere. The perfect integrity of the storage is guaranteed by a total tightness obtained through adequate engineering and the use of appropriate materials. However, various physico-chemical phenomena can alter well completions and cementing and lead to leaks (1,2). These are very often progressive and present very low flow rates. They are not only particularly difficult to detect, but can also be confused with natural emanations of biogenic methane produced by the degradation of organic

matter in the soil. Identification of the biogenic or thermogenic nature of the percolating gas is therefore essential.

The work to be carried out as part of this PhD is therefore fully in line with the energy transition and the reduction of the environmental impact of industrial activities. Thus, the production of reliable data and their interpretation taking into account the physicochemical phenomena governing gas/rock/cement interactions and those prevailing in biodegradation phenomena are of major importance.

The IPREM and FLCR laboratories have been carrying out joint actions with TERECA for several years on related topics (3,4). The PhD will therefore be carried out in a high level and stimulating scientific environment.

## Objectives

The work that will be carried out in the framework of this thesis should lead to the development of a methodology combining measurements and modelling for the characterization of the nature and origin of gaseous effluents present in underground natural gas storage areas. This project concerns on the one hand the quantification and determination of the isotopic fractionation of carbon from BTEX, CO<sub>2</sub> and CH<sub>4</sub> and possibly deuterium from CH<sub>4</sub> in gas samples.

It will involve optimizing the development of a preconcentrator for the determination of isotope ratios <sup>13</sup>C of BTEX or other trace compounds of interest in gas samples under storage conditions. The above list of elements is not exhaustive, as if necessary, other elements and compounds deemed to be of interest may be included. The characterization of the major gas compounds (excluding CO<sub>2</sub>) by gas chromatography (C<sub>1</sub> to C<sub>3</sub>, H<sub>2</sub>, H<sub>2</sub>S) will complete the study.

The PhD work will not deal exclusively with analytical aspects: it will integrate an essential dimension of modelling with the in-depth interpretation of the mechanisms of gas/rock/cement interactions as well as those of biological degradation in the geological context of industrial infrastructures.

## Work plan

Setting up of an experimental unit for sampling and preconcentration of gaseous effluents, under various operating conditions ranging from very low flow rates (a few milliliters per hour) to ambient conditions at high flow rates (which can correspond to several hundred liters per hour) at high pressure (10 MPa).

Development of analytical methodologies including a specific preconcentration/sampling system for the target gaseous effluents and markers using analytical separation techniques (GC) and analytical couplings such as GC-ICPMS and GC-IRMS.

Sampling and/or measurements at industrial sites. Methodological and analytical developments will make it possible to characterize the different origins of the sampled gases.

Modelling. Using the analytical results obtained, an equilibrium model will be proposed to estimate the effects on isotopic tracers of the biophysical-chemical mechanisms of action.

### **Literature references:**

- 1 . California Council on Science and Technology (2018). <https://ccst.us/publications/2018/2018NGS.php>.
- 2 . Bérest P, Réveillère A., Evans D., Stöwer M., Oil Gas Sci. Technol. (74), 2019, 27.
- 3 . Cachia M., Bouyssièrè B., Carrier H., Garraud H., Caumette G., Le Hécho I., Energy and Fuels, 2017, 31 (4), 4294-4300
- 4 . Cachia M., Bouyssièrè B., Carrier H., Garraud H., Caumette G., Le Hécho I., Energy Fuels, 2018, 32(5), 6397–6400

### **Hosting laboratories:**

The Institute of Analytical Sciences and Physico-Chemistry for Environment and Materials (IPREM) is a Joint Research Unit CNRS / UPPA (UMR 5254).

The IPRA research federation and, more precisely, the Laboratory of Complex Fluids and their Reservoirs (LFCR).

### **Laboratory expertise:**

IPREM's research work focuses on the development of instrumentation and analytical methods for trace analysis, speciation (detection, identification and quantification of chemical forms of metals and metalloids) and isotopic analysis in environmental and biological media

Part of the LFCR's research activities focus on experimental developments necessary to characterize physico-chemical properties of petroleum fluids (oils, gases)

**Localisation:** Université de Pau et des Pays de l'Adour ; Technopole Hélioparc, 2 av. Président P. Angot, 64000, Pau, France

**PhD Director:** Isabelle Le Hécho

**PhD co-Director:** Hervé Carrier

**Starting date:** October 2020

**Length:** 3 years

**Employer:** Université de Pau et des Pays de l'Adour (UPPA), doctoral school ED 211 Doctoral School of Exact Sciences and their Applications

**Gross monthly salary:** 1878 €, including 32h of teaching activities, each year (UPPA doctoral contract, according to E2S UPPA project)

## Required skills and competences - Who can apply ?

- \* The candidate must hold a master or equivalent degree with majors in analytical chemistry, solution chemistry, environmental chemistry, chemical engineering, hydrogeology, geochemistry
- \* He/she is passionate for identifying solutions to environment related concerns and for multidisciplinary research.
- \* Experimental skills / hands on activities
- \* Modeling skills
- \* Sense of initiative, autonomy, organization and thoroughness, good relational qualities.
- \* The candidate is rigorous and highly motivated
- \* Good knowledge in English and good writing skills are a plus.

## Application - Evaluation criteria

### Selection process step:

- \* Establishment of the selection committee
- \* Evaluation of the applicants files
- \* 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 basic knowledge in organic and physical chemistry, geochemistry and modelling, plus his/her experimental skills
- \* Academic results : grades and ranking in M1 and M2 (or engineering school) ; steadiness in the academic background
- \* English language proficiency
- \* Oral and written communication skills
- \* Candidate's ability to present her/his work and results
- \* Professional experience (e.g. Work experience similar to an internship in a laboratory – or likewise, any previously achieved research work, reports, publications ...)

# Application file composition

Application must be written **in English** and sent to both of the following email addresses:

[isabelle.lehecho@univ-pau.fr](mailto:isabelle.lehecho@univ-pau.fr) and [herve.carrier@univ-pau.fr](mailto:herve.carrier@univ-pau.fr)

with the title “Doctoral application”, and the following documents attached (altogether, **in a single pdf file**):

- \* CV (max 2 pages) including the publication list when applicable
- \* Cover letter detailing the candidate's motivations (max 2 pages)
- \* Copy of your Master diploma (or equivalent)
- \* Copy of your Master transcripts (marks and ranking)
- \* Any letter of recommendation
- \* Contact details ( Name and e-mail addresses) of 2 referees (including the Master thesis supervisor)



***Submission deadline : September 30<sup>th</sup>, 2020***