# Spatialized optical thermometry to image the coupling between flow and heat transport processes in geological fractures

**Offer description**

We are pleased to announce a PhD position at University of Rennes, France on the modelling of heat transport processes in the subsurface. This position is offered in the frame of the recently funded ERC starting grant "CONCRETER" (Groundwater flow CONtrols on CRitical ZonE).

Understanding heat transport processes in the subsurface is central to many environmental, geological and industrial processes. This includes geothermal applications, near-field thermal effects in radioactive waste disposals, urban heat islands and quantification of surface water-groundwater interactions. Groundwater flow plays a key role in the distribution of heat at different scales. However, while this key role has been generally recognized, existing modeling frameworks have largely sidestepped the complexities associated with the heterogeneity in groundwater flow present at a wide range of spatial scales. The major scientific obstacle that prevents accurate understanding of the impact of subsurface heterogeneity in hydraulic and thermal properties on heat transport is related to our inability to image the hidden interaction between flow and heat transport processes at the pore/fracture scale [Heinze and Pastore, 2023, https://doi.org/10.1038/s41467-023-36034-w].

Recent studies raise questions regarding the relevance of classical models, i.e., models misrepresenting the structural heterogeneity, for modelling heat transport in the subsurface. Thus, in fractured media, our recent studies questioned the validity of the classical parallel plate fracture conceptualization [Klepikova et al., 2016, https://doi.org/10.1002/2016WR018789; Klepikova et al., 2021, https://doi.org/10.1016/j.advwatres.2021.104042]. This PhD project aims to examine the conditions in natural saturated fractured media under which classical formalisms, i.e., disregarding structural heterogeneity, apply and determine when they are expected to fail, and laboratory experiments are unique assets to tackle this issue. This raises technical challenges as current experimental techniques, based on point (sensor) temperature measurements, do not allow capturing the interplay between temperature gradients and 3D flow topologies. In this project, high resolution optical monitoring of the time-evolving temperature field will be achieved by a phosphor thermometry technique [Stelter et al., 2021, https://doi.org/10.18409/ispiv.v1i1.205]. The method will be applied to image the spatial distribution of temperature in rough geological fractures and to investigate the effects 3-D fracture geometry has on the scaling of heat recovery in both space and time.

**Requirements**

Research Field - Geosciences or Physics or Environmental science

Education Level - Master Degree or equivalent

**Skills/Qualifications**

- Sound and quantitative understanding of fluid mechanics

- Experience with computer programming /scripting (Matlab, Python, R) is an advantage

- Applicants must be proficient in both written and oral English

- Experience in fluid flow modelling in geological media is an advantage

- Applicants must be able to work independently and in interdisciplinary teams.

**Scientific environment**

Géosciences Rennes (GR) is a joint research unit (CNRS + UR1) with 60 permanent researchers. It hosts ~10 foreign researchers/year, and publishes ~ 100 papers/year. The Rennes hydrogeology group is composed of 15 permanent staff and is internationally recognized as one of the leading group in this field.

The PhD will be carried out in Geosciences Rennes and supervised by Maria Klepikova. The expertise on fluid experimentation in porous media systems will be provided by Y. Méheust, T. Le Borgne and J. Heyman, while the expertise in phosphor thermometry technique will be provided by B. Fond (ONERA - The French Aerospace Lab).

**Please include in your application:**

- a brief account of the applicant's research interests and motivation for applying for the position;
- the names and contact information for two referees (one of these should be the main advisor for the master's thesis or equivalent thesis);
- a CV;
- transcripts and diplomas showing completion of the bachelor's and master's degrees (if you have not yet completed your master's degree, please submit a statement from your institution confirming that the master's thesis has been submitted);
- relevant certificates/references;
- a list of any works of a scientific nature (publication list).

The application and appendices with translations into English or French must be sent to maria.klepikova@univ-rennes1.fr.