PhD Positions at the
University of Lorraine (FRANCE)

Context

The RING team is seeking two outstanding PhD candidates to address research questions in integrative numerical geology. These full-time positions are for a three-year term and shall start in early 2020. The PhD topics outlined below, can be tailored to the interests and experience of the successful candidates.

The PhD scholarships are sponsored by an international consortium of 14 companies and 141 research institutes. The successful candidates will work in the RING Team[1], a pluridisciplinary group of 12-15 researchers and graduate students working at the interface of geoscience, computer science and applied mathematics. The team is located at Ecole Nationale Supérieure de Géologie and is part of the GeoRessources[2] laboratory, a research lab of Université de Lorraine and CNRS. The research team is driven by passion for developing computer-based methods and theories for geological modeling, serving the geoscience community to address scientific and natural resource managements challenges. It has a strong industry partnership culture.

Location: Nancy, France. Nancy is a UNESCO World Heritage city with a vibrant student life and a rich cultural agenda, only 90 minutes away from Paris, Luxembourg and Strasbourg.

Candidate profile

The ideal candidate is passionate about science, has a solid background in applied mathematics, statistics and physics, and has good scientific writing skills. An experience in computer programming is required. A background or a proven interest in geoscience is appreciated.

Candidates should hold a MSc in (quantitative) Earth Sciences, Geophysics or Physics, Computer Science, Geostatistics, Porous Media, Applied Mathematics, or related fields.

A strong command of English language is required. French language is preferable, but not necessary.

How to apply:

Application files must be sent to jobs@ring-team.org before Nov 30th and must include:

- A cover letter,
- A CV, including contact information for two or more referees
- A research outcome (Master's thesis or paper) written by the candidate
- A transcript of grades

PhD topic 1: Flow-based behavior of channelized sedimentary deposits: analysis and reproduction

Keywords: Geostatistics, Flow simulation, Machine learning, Channels, Stochastic simulations

Advisors: Pauline Collon and Guillaume Caumon.

This PhD project aims at advancing the state of the art in porous medium modeling in channelized sedimentary deposits. Indeed, at geological time scales, rivers and submarine channels form heterogeneous reservoirs, which

[1] http://ring.georessources.univ-lorraine.fr
[2] http://georessources.univ-lorraine.fr/

host natural groundwater and hydrocarbon resources or may be used for subsurface energy storage and CO2 sequestration. Because of limited observations, models are essential for the sustainable estimation and exploitation of natural resources in these depositional environments. Models are also key to quantitatively understand the connections between sedimentary processes (erosion, deposition) and their controlling factors.

In terms of geomorphology, channels have a sinuous elongated shape which evolves through time by continuous lateral and vertical migrations, and abrupt events like avulsion or meander cut-offs. This results in complex 3D architectures (Figure 1) that directly impact underground flows.

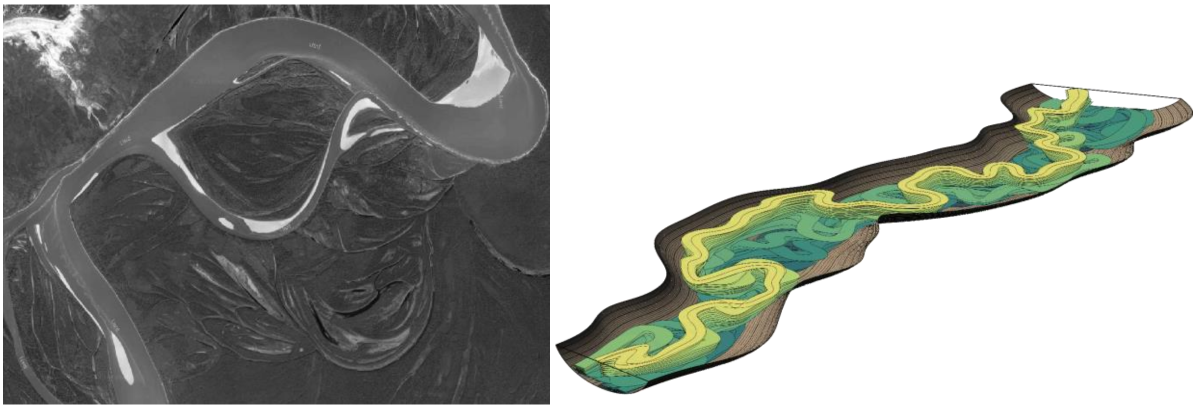

Figure 1. Left : Satellite image showing a channel and the associated deposits (Google Maps, 6103’59.9”N; 12313’56.9”W). Right : 3D channelized system architecture modeled with L-systems (from Rongier et al., 2017b)

Several modelling techniques have been recently developed to reconstitute those complex systems (e.g., Communian et al., 2012; Pyrcz et al. 2015, Rongier et al., 2017a and 2017b; Parquer et al., 2017; Yan et al., 2017; Wang et al., 2018), but challenges remain to both reproduce the complex geometries and connectivity patterns of sedimentary architectural elements while still honouring the available observations (boreholes, geophysical or satellite images, …). Moreover, persistent questions concern the relation between (1) the channel simulation method and the associated parameters, and (2) the subsurface reservoir response in terms of flow or transport processes. How could we objectively compare the benefit of using a particular model or another? Can we measure the flow impact of integrating a particular geological concept in the simulation method? How to efficiently update model parameters to honor historic flow data? The goal of this PhD is to develop new elements to address these important questions.

The first objective of the proposed PhD is to analyze the triangular relationship between spatial data, model and predictions, using the prediction focused approach (PFA) introduced by Scheidt et al. (2015) or other modern machine learning techniques. For this, a preliminary step is to accurately discretize the sedimentary objects in space in order to automatically perform flow simulations on the generated models. This implies to find ways to transfer geological main flow controlling features to an adapted simulation grid and simulation software.

The second objective of the PhD is to assess the effect of new channel simulation rules on the reservoir flow response. A possible aspect to be investigated concerns the statistical parameters controlling the 3D architecture of the system. The integration of accompanying geological features like levees or crevasse splays could constitute another aspect of this work.

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PhD topic 2: Local geomodel updating and trans-dimensional flow inverse problems

Keywords: Inverse problem, Upscaling, Machine learning, Geomodeling, Unstructured meshes.

Advisors: Guillaume Caumon and Mustapha Zakari

Collaboration: Thomas Bodin (ENS Lyon)

Inverse problem theory is a very powerful way to reduce subsurface uncertainty by updating earth model parameters to reflect some new indirect information (MacKay, 2005; Tarantola, 2005). Although the theory is very general, its application in geosciences is generally challenging because of: (1) the non-linearity between the model parameters and the data and, (2) the ill-posedness of the problem. A possible strategy to address these challenges is to use adjoint techniques efficiently identify where model changes have most impact on the simulated observations. These methods have gained significant popularity in subsurface flow problems (e.g., Ackerer et al., 2014) and in seismology (e.g., Fichtner et al., 2006). However, these approaches mainly consider continuous model parameters. In geology, however, some model components are discrete at the scale of concern (e.g., minerals, facies, fractures, layers), hence call for indicator (binary) variables or object-based parameterizations (Caumon, 2018). The number of parameters itself then becomes an unknown of the inverse problem. To address this issue, random vector parameterization in conjunction with point processes have been proposed (Cherpeau et al., 2012). Transdimensional inversion (Bodin et al., 2009) has also been considered to deal with a variable number of model parameters. However, transdimensional methods have mainly been applied to general model parameterizations such as Voronoi diagrams.

The first objective of this PhD is to **consider more suitable geological parameterizations in transdimensional inversion, such as layer boundaries defined by implicit functions, faults and fractures** (Wellmann & Caumon, 2018). This work will be applied to the physical problem of flow in layered fractured media. The second objective is to assess whether and how to best **exploit the *local* aspect of model updating in transdimensional methods** to reduce the computational burden. For this, a significant focus will be to consider the effect of topological changes in the geomodel by considering **flow-based upscaling methods**. In these approaches, machine learning may be considered to accelerate the exploration of the relationships between model space and data space.

The PhD candidate will be advised by Guillaume Caumon and Mustapha Zakari, in collaboration with Thomas Bodin (ENSG Lyon).

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