Two-year postdoc position (full time) at University of Lorraine (France)

Innovative AI methodologies for interpreting geophysical data for subsurface characterization and modelling.

Applicative context

Groundwater is increasingly being used for the supply of drinking water, as well as for agriculture, industry and recreation, leaving several areas in a critical situation in the summer. Integrated water resource management is vital for long-term social, economic and environmental well-being of the population. Aquifers are bodies of rock and/or sediment that hold groundwater which have considerable storage capacity. Aquifers may be used as recharges to store temporary storage of excess water from various sources for later use.

Managed aquifer recharge is thus an innovative and valuable tool for improving the resilience to climate change in French regions and elsewhere. Characterizing the first tens of meters below the surface has a tremendous has a tremendous importance for understanding aquifer recharge, mapping and mitigating the impact of natural and anthropogenic hazards, and optimizing land use.

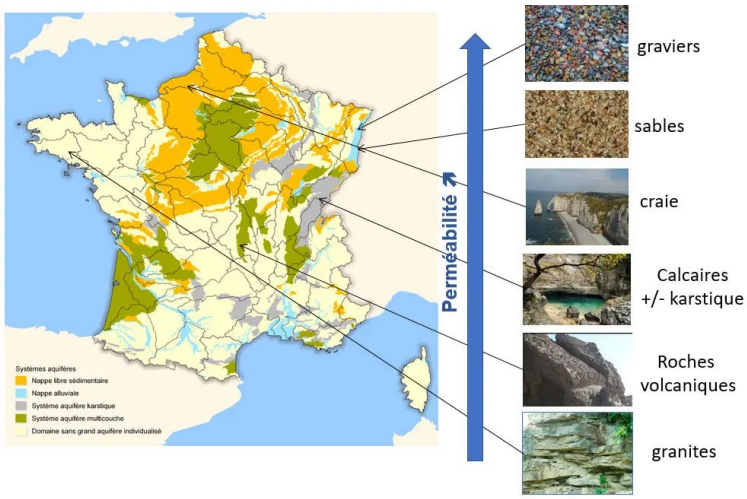

Figure 1: Map of aquifer types in France

France has 6,500 aquifers, including 200 aquifers of regional importance (with surface areas ranging from 1,000 to 100,000 km2), hosted by various rock formations (Fig. 1). To discover and characterize aquifers, a preliminary step is to integrate various types of data and geological knowledge.

Scientific objectives of the project

This project positions itself at the intersection of data science, geology and geophysics. Its goal is to define a new methodology to characterize the subsurface over large geographic areas using advanced multi-modal algorithms. This type of multi-modal spatial data represents a unique opportunity to develop new spatially and geologically aware methods for the interpretation of the features of the critical zone.

The main task is to develop cutting-edge machine learning models to characterize and spatially map the subsurface down to a few tens of meters deep, and to describe its geological nature. The data at hand for realizing this task,

provided by the French Geological Survey (BRGM), consist of a large diversity of geophysical measurements and images (Fig. 2): airborne gamma spectrometry, airborne electromagnetism; topography, geological descriptions and maps; seismic data; boreholes data including logs and core descriptions and magnetic resonance sounding. Several works have considered the use of machine learning for individual processing or interpretation of these data types (e.g., Asif et al, 2022; Colombo et al, 2023; Kawo et al, 2024) and for integrating diverse sources of data to characterize the shallow subsurface from multiple data (e.g., Uhlemann et al, 2022; Neven & Renard, 2024). In this project, a key aspect will be to define innovative ways to infuse geological and geophysical knowledge and data into the process to guarantee the interpretability of the forecasts. The multidisciplinary nature of this project offers opportunities to learn new interpretable and causal AI concepts in a high-impact field with significant publication potential.

From a machine learning point of view the main challenges are to:

- **Deal with heterogeneous/multimodal spatial data** of various types (points, lines, 2D maps, 3D geophysical images) geometry and resolutions
- **Handle uncertainty** (Gruber et al, 2023): for geological outputs to provide meaningful insights, the uncertainties, errors and assumptions made throughout the data acquisition, processing, modeling and interpretation procedures need to be carefully considered.
- **Ensure the model's interpretability** (Il Idrissi, 2024). As geoscience AI models are progressively utilized for significant predictions in crucial situations, interpretability is essential to build quantitative geological understanding and ensure the quality of forecasts.

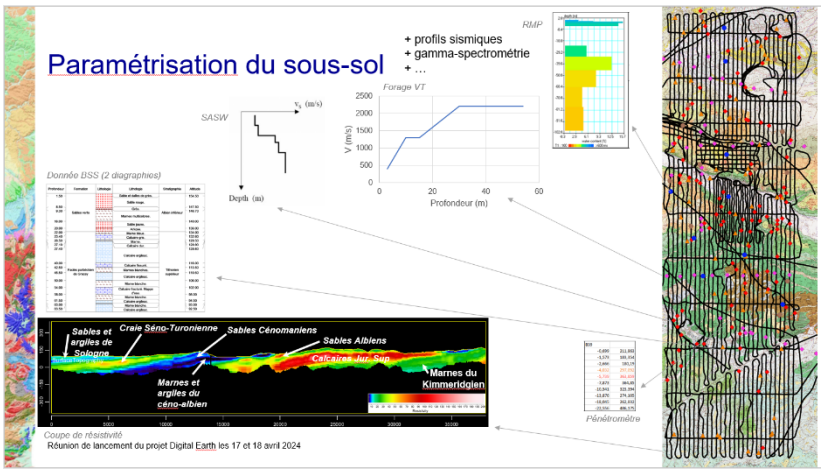

Figure 2: Typical data available for the project

Context

The postdoctoral researcher will be located at Université de Lorraine, and will work in a multidisciplinary environment with mathematicians, geologists and geophysicists. The scientist will have a dual appointment at GeoRessources Laboratory in the RING team[1], a pluridisciplinary group of 12-15 researchers and graduate students, and the IECL Mathematics Laboratory. Missions to the BRGM scientific center in Orléans and to the study area will also be planned. She/he will collaborate closely with Prof. Marianne Clausel (UL / IECL), Prof. Guillaume Caumon (UL / Georessources), Dr. Behshad Koohbor (UL / GeoRessources) Dr. Pierre-Alexandre Reninger (BRGM), Dr. Aurélie Peyrefitte (BRGM), Jihad Bourassi (BRGM) and Dr. Nicolas Giraldi (BRGM). The successful candidate will join the network of researchers involved in the Digital Earth project[2] of the PEPR *Sous-sol, Bien Commun*.

The postdoctoral scholarship (2600 to 3500 EUR monthly depending on experience) includes full salary and social benefits (incl. 44 days of paid leave annually), and budget to attend national and international conferences. The goal of the postdoc is to produce and publish innovative methodologies and the associated software. A particular

[1] http://ring.georessources.univ-lorraine.fr
[2] https://www.soussol-bien-commun.fr/fr/terre-numerique-une-plateforme-unique-pour-connaissance-du-sous-sol

attention will be put on the professional development of the successful candidate and on establishing connections both with industrial and academic partners.

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 has a PhD in data science, spatial statistics, or geosciences. An experience in **computer programming and familiarity with machine learning is required**. A background or a proven interest in geoscience is appreciated but not mandatory. She/he has strong scientific writing and communication skills. Proficiency in English is required; knowledge of French is desirable, but not necessary.

The contract is expected to start during Q1 of 2025, but may be shifted to Q2 or Q3 depending on the successful candidate's availability.

How to apply

Application files must be sent to jobs@ring-team.org before Jan 5, 2025 and must include:

- A cover letter
- A CV, including list of publications and contact information for two or more referees
- The PhD thesis
- If available, the PhD review and defense reports.

References

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Gruber C., Schenk P.O., Schierholz M., Kreuter F., Kauermann G.. Sources of Uncertainty in Machine Learning--A Statisticians' View. arXiv preprint arXiv:2305.16703. 2023 May 26.

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Uhlemann, S., Dafflon, B., Wainwright, H. M., Williams, K. H., Minsley, B., Zamudio, K., Carr, B., Falco, N., Ulrich, C., and Hubbard, S.: Surface parameters and bedrock properties covary across a mountainous watershed: Insights from machine learning and geophysics, Sci. Adv., 8, eabj2479, https://doi.org/10.1126/sciadv.abj2479, 2022.