PhD Proposal: Downscaling FWI models for fault system characterization

Mapping faults in the subsurface and understanding fault properties (i.e., geometry, dimensions, seal behaviour, fault growth) is fundamental to drive decision-making in subsurface earth resources applications. Nowadays, fault interpretations at depth are mainly derived from high-resolution models obtained by full waveform inversion (FWI), in addition to migrated images. Although the ease and accuracy of seismic imaging and interpretation are continually increasing, issues such as limited data bandwidth, noise, approximation of the physical model, and incomplete data coverage, are still sources of challenges in the detailed imaging of faults (e.g. faults with throws that fall below vertical seismic resolution) (DIMMEN, ROTEVATN & LECOMTE, 2023). Under-estimating the associated uncertainties can lead to overly optimistic model-based forecasts and increase the financial risk associated with subsurface projects.

In a recent work, (RUGGIERO, CUPILLARD & CAUMON, 2024) propose a two-scale approach which combines FWI with a downscaling inversion to estimate fault parameters (e.g., length, dip, throw) in a probabilistic way. The approach builds on previous studies (HEDJAZIAN, CAPDEVILLE & BODIN, 2021; SANTOS ET AL., 2024), and is called inverse homogenization. Assuming that FWI provides a smooth representation of the real structures, it aims at recovering all the finer scale fault models compatible with the FWI solution. In the present project, we propose to apply this approach to a fault system, i.e., to not only one but multiple, possibly connected faults. After testing the method in a 2D synthetic case, a real data case and/or an extension to 3D will be considered.

Advisors: Paul Cupillard and Guillaume Caumon (Université de Lorraine)

Starting date: From September 2025

Requirements

The candidate should hold a MSc in quantitative Earth Sciences, Geophysics, Physics, Geomechanics, Applied Mathematics or Computer Science. He/she is passionate about science and has solid scientific writing skills. An experience in computer programming and a strong command of English language are required. French language is preferable, but not necessary.

How to apply

Application files must be sent to jobs@ring-team.org before **Mai 31, 2025**, and must include:

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

Location

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

Working environment

The successful candidate will work in the RING Team, a pluridisciplinary and diverse group of 12-15 researchers and graduate students working at the interface of geoscience, computer science and applied mathematics. The team is part of École Nationale Supérieure de Géologie in the GeoRessources 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 and geophysical modeling, serving the geoscience community to address scientific and natural resource management challenges.

References

DIMMEN V, ROTEVATN A & LECOMTE I. (2023). Imaging of small-scale faults in seismic reflection data: Insights from seismic modelling of faults in outcrop. Marine and Petroleum Geology 147:105980. https://doi.org/10.1016/j.marpetgeo.2022.105980

HEDJAZIAN N, CAPDEVILLE Y & BODIN T. (2021). Multiscale seismic imaging with inverse homogenization. Geophysical Journal International 226(1):676-691. https://doi.org/10.1093/gji/ggab121

RUGGIERO G, CUPILLARD P & CAUMON G. (2024). Quantifying fault-related uncertainty with inverse homogenization. Proc. 2024 RING Meeting.

SANTOS T, BODIN T, SOULEZ F, RICARD Y & CAPDEVILLE Y. (2024). Refining tomography with generative neural networks trained from geodynamics. Geophysical Journal International 238(3):1676-1695. https://doi.org/10.1093/gji/ggae240