Fully-funded 3-year PhD opportunity

Modeling Fluid Migration and Rock Deformation in Subduction Zones

Keywords: Subduction, Two-phase flow, Numerical modeling, Reactive transport, Geodynamics

Join a cutting-edge research project exploring the role of slab-derived fluids in subduction zones and their impact on rock deformation and deep Earth dynamics. This PhD position focuses on developing petro-thermo-mechanical models to understand fluid migration and its feedbacks with deformation processes within the subducting plate. It is part of a joint program between the University of Montpellier and University of Minnesota, under the project UM2030-IDéES.

Background: Fluid release from subducting plates influences key geological processes such as chemical exchanges, earthquakes, and volcanism. While fluid production across various pressure-temperature conditions is well established, its migration pathways remain elusive. Recent numerical models suggest complex flow patterns in the slab [1], but overlook the interplay between reactions and deformation. Field studies of exhumed subduction plate relics highlight the importance of dehydration-rehydration reactions in strain localization. This project aims to bridge these gaps through advanced modeling techniques, including physics-based machine learning (ML) [2].

Research Objectives:

- Conduct a comprehensive literature review on feedbacks between mantle rock deformation and (de)hydration reactions at sub-solidus conditions.
- Build ML-surrogates of water transfers for subducting-slab mafic and ultramafic rocks.
- Extend existing models of two-phase flow models [1] to account for visco-plastic behavior of rocks, and incorporate water transfer during reactions through ML-based surrogates [2].
- Apply models to investigate fluid release and migration in subducting plates and forearc mantles, quantifying reaction-deformation feedbacks.
- Reassess fluid release depths in present-day subduction zones and their implications for global H2O exchange budgets.

Supervision and Collaboration: The PhD will be hosted at Geosciences Montpellier and co-supervised by N. Cerpa (CNRS, U. Montpellier) and Andrea Tommasi (CNRS, U. Montpellier), and remotely by I. Wada (University of Minnesota, US) under a joint program between UM and UoM. The program involves visits to University of Minnesota. The project complements a mirror PhD at U. Minnesota focusing on fluid viscosity effects in mantle wedge migration.

Other key Collaborators:

- José Alberto Padrón-Navarta (CSIC – IACT) – Expert in mantle petrology and thermodynamic modeling.
- Samuel Angiboust (ENS Lyon) – Specialist in metamorphic petrology and exhumed plate interfaces

Application Information: We are looking for motivated candidates with a solid training in (geo)physics and numerical modeling, excellent writing skills and good communication. Experience in geodynamics and petrology will be considered a plus. Proficiency in English is highly desirable.

To apply, please send your CV, cover letter, and references to nestor.cerpa@umontpellier.fr

Application Deadline: 15/05/2026

Location: Geosciences Montpellier, University of Montpellier, France

Expected start date: October 2026 as the latest

[1] Cerpa N. G. & Wada, I (2025) *JGR :SE*, https://doi.org/10.1029/2024JB030609
[2] Kerswell, B. et al., (2024), *JGR: MLC*, https://doi.org/10.1029/2024JH000264