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PhD Project Description

Project Title Unlocking Carbon Storage Potential: Evaluating Offshore Basalts of the Southwest Atlantic Margin

Supervisors

Lead Supervisor: Jenny Collier

Co-supervisor(s): John Armitage (Université Paris Cité, France)

Research Group

Plates and Mantle

Project Summary

Global CO_2 storage potential via mineralization in mafic and ultramafic rocks is estimated to be vast, with most sites located offshore. This PhD project will quantify storage capacity in Seaward Dipping Reflectors, which are promising reservoirs found along passive continental margins. Focusing on the SW Atlantic margin, we will assess the volume of basalt available for storage and map its distribution to evaluate associated limitations and costs. Such an appraisal of CCS mineralization has never been done before and is a critical step in assessing the feasibility of this breakthrough technology.

Research Context and Objectives

Achieving global climate goals increasingly depends on the effective deployment of carbon capture and storage (CCS) technologies. These methods, particularly in sedimentary basins and mafic or ultramafic rocks, offer promising solutions for reducing emissions in hard-to-decarbonize industries like fertilizer and cement production. While CO_2 mineralization mechanisms at the pore-scale are advancing, broad-scale estimates of accessible mafic reservoirs, particularly basalt, remain underexplored. This project focuses on this gap by focusing on offshore basaltic reservoirs as a viable CCS site.

Notable pilot projects have demonstrated the efficacy of CCS in basalt flows in Iceland and the US. However, these onshore sequences are spatially limited and often distant from major CO_2 sources. Offshore basaltic flows along continental margins present an alternative, offering proximity to industrial zones, shallow water depths, and existing infrastructure from hydrocarbon extraction that can be repurposed for CCS. These flows, forming Seaward Dipping Reflector (SDR) series mapped along 60% of passive continental margins, are potentially an ideal site for stable carbonate formation. Their CCS potential is influenced by factors such as flow thickness, porosity, eruption conditions, and lava chemistry.

This project is structured around three primary objectives: (1) estimating the global volume of continental margin basalt suitable for CCS, (2) modelling the CO_2 storage capacity of submarine basalt geometries, and (3) mapping and quantifying the storage potential of these reservoirs. To achieve these goals, seismic imaging will be utilized to analyse stacking patterns and correlate SDR types with basalt flow thickness. Fluid flow and reactive transport models will provide estimates of CO_2 capacity, while GIS databases will map basalt reservoirs in the

Southwest Atlantic, creating a scalable workflow for other regions. This approach aims to provide actionable insights into the role of basaltic reservoirs in global CCS strategies and climate mitigation efforts.

Collaborators and partners on the project:

Matthew Gidden (Center for Global Sustainability, University of Maryland, USA)

Nathalie Collard (IFPEN, France)

Alina-Berenice Christ (IFPEN, France)

Further reading:

Christ, A. B., Cacas-Stentz, M. C., Collard, N., Nader, F. H., Bemer, E., Bunevich, R. B., ... & de Souza Jr, O. G. (2025). Integrated 3D forward stratigraphic and basin modeling of the Santos Basin, offshore Brazil: Implications of sedimentary depositional facies and CO2 migration for silicification of continental carbonate reservoirs. Marine and Petroleum Geology, 180, 107455.

Collard, N., Faney, T., Teboul, P. A., Bachaud, P., Cacas-Stentz, M. C., & Gout, C. (2023). Machine learning model predicting hydrothermal dolomitisation for future coupling of basin modelling and geochemical simulations. *Chemical Geology*, *637*, 121676.

Collier, J.S., C. McDermott, G. Warner, N. Gyori, M. Schnabel, K. McDermott & B.W. Horn, 2017. New constraints on the age and style of continental breakup in the South Atlantic from magnetic anomaly data, Earth and Planetary Science Letters, 477, 27-40.

Gidden, M. J., Gasser, T., Grassi, G., Forsell, N., Janssens, I., Lamb, W. F., ... & Riahi, K. (2023). Aligning climate scenarios to emissions inventories shifts global benchmarks. Nature, 624(7990), 102-108.

Mattioni, L., **Armitage, J.**, **Christ, A.**, Frey, J., Granjeon, D., Lemgruber-Traby, A., ... & Bourgeois, F. (2023, August). Why It is Important to Perform a Fully Integrated Basin-Scale Modeling of CO2 Storage in Saline Aquifers? Insights from the Paris Basin (France). In *EAGE Workshop on Unlocking Carbon Capture and Storage Potential* (Vol. 2023, No. 1, pp. 1-3). European Association of Geoscientists & Engineers.

Who are we looking for?

We are looking for motivated, hard hard-working students with an excellent background in geophysics or closely related subject, e.g. environmental science, physics, mathematics, or engineering, and with the willingness to learn computational methods as needed. Skills developed will include advanced data analysis methods, with extensive training provided.

Successful applicants have a proven aptitude for analytical work and working in multi-disciplinary teams as well as having a genuine passion for research.

The candidate will have the opportunity to develop their career and profile by presenting at international conferences and publishing in high-impact journals. The projects involve interaction and research visits with other project members.