ÉCOLE DOCTORALE
SCIENCES DE LA TERRE ET DE L'ENVIRONNEMENT
ET PHYSIQUE DE L'UNIVERS, PARIS

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Titre du sujet :

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Volcanic Gas Emissions in Petite Terre (Mayotte)

Volcanoes release gases in the form of plumes at the vent during eruptions, but also during quiescent phases, when they can escape diffusely from magmatic reservoirs or hydrothermal systems. These gases migrate through the lithosphere before reaching the hydrosphere, soils, biosphere and atmosphere. At the surface, their manifestations vary in space and time depending on the architecture of volcanic systems, the dynamics of magmatic reservoirs, and interactions with the surrounding environment. The study of these signals presents both an opportunity and a challenge for the volcanological community. On one hand, they provide valuable information on volcanic system dynamics and have significant potential for monitoring and forecasting. On the other hand, isolating the volcanic signal from environmental noise is often difficult. This complexity is particularly evident on the volcanic island of Mayotte, where REVOSIMA (Réseau de Surveillance de l'Activité Volcanologique et Sismologique de Mayotte) monitors magmatic gas emissions on Petite Terre.

From a geological point of view, Mayotte is part of the Comoros archipelago in the Indian Ocean. After a quiescent period of nearly 6,000 years, a new volcanic edifice, Fani Maoré, formed between 2018 and 2020 on the ocean floor, 50 km off the coast. Its formation triggered intense seismic activity, with earthquakes reaching magnitudes of up to 5.9, as well as significant land displacement and subsidence of the island, with vertical movements reaching 20 cm at the east of the island. Among the manifestations associated with this activity, gas emissions, primarily composed of CO_2, have been observed offshore in the form of plumes. On Petite Terre, a populated island located in the extension of the seismically active zone, gas emissions occur as bubbling on Petit Moya beach, within Lake Dziani, and as diffuse soil emissions.

Since the cessation of lava emissions in December 2020, the island's subsidence and displacement have stopped, and seismic activity continues but has stabilized. However, CO_2 degassing has intensified significantly, both offshore and in Lake Dziani (REVOSIMA Bulletin, August 2023). These gas emissions are currently monitored using several approaches, including regular chemical and isotopic analyses of gases from bubbling areas and soils, continuous monitoring of CO_2 concentrations in the soil, and drone imaging campaigns to map bubbling zones. However, these various observations reveal amplitude variations that are not systematically correlated, as they are controlled by both volcanic and environmental processes (Bénard et al., 2023; Liuzzo et al., 2022).

The objective of this thesis is to identify and quantify the processes governing these gas emissions in order to better constrain their origin and evolution over time. A key challenge will be to develop an integrated approach combining geochemistry and imaging to distinguish the magmatic signal from environmental noise. To achieve this, the student will analyze multi-source data, including high-resolution geochemical measurements (chemical and isotopic composition of gases from bubbling areas and soils), time-series data on CO_2 concentrations, and drone imagery for detailed mapping of gas emissions.

In a second phase, these data will be correlated with other monitoring parameters to gain a better understanding of the interactions between magmatic reservoir dynamics and the variability of surface gas emissions. The results will be integrated into a conceptual model describing the transfer processes of volcanic gases from deep reservoirs to emission zones. This model will provide a global view of the current functioning of Mayotte's volcanic system in its post-eruptive phase and help explore the factors influencing the distribution and intensity of gas emissions.
The chosen approach relies on a combination of innovative analytical methods, particularly:

- The integration of geochemical data and multi-scale imaging to identify spatial and temporal trends,
- The application of advanced statistical techniques to distinguish volcanic and environmental influences,
- Gas flux modeling based on geophysical and geochemical parameters.

The student will work with these datasets, combining field data acquisition and numerical analysis, thereby contributing to the improvement of volcanic gas monitoring methods within the REVOSIMA framework. Proficiency in Python programming for data analysis is desired.