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Submarine venting of liquid carbon dioxide in the Horseshoe structure offshore Mayotte Island

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Although CO_2 is an abundant gas emitted during submarine volcanic eruptions or associated hydrothermal circulation, it has rarely been documented in the liquid form, which depends on pressure-temperature conditions of the site. Discharge of CO_2 in the ocean can lead to local perturbations in ocean acidity and alkalinity, with consequences on biogeochemical cycles, potential gas release at the ocean surface or sediment stability and geochemistry.

Here we document strong discharges of liquid CO_2 droplets recently discovered at about 1500 m below sea level, in the Horseshoe structure, on the eastern upper submarine slope of Mayotte Island (Comoros Archipelago, Indian Ocean). Since the eruption of Fani Maoré seamount (about 40 km to the east) in May 2018, the site has experienced an exceptionally deep seismic activity and a continuous increase of number of liquid CO_2 vent sites over time. This area is a natural laboratory to evaluate, through the study of dedicated geochemical processes, the impact of elevated level of CO_2 on the water column geochemistry at more global scales.

In April-May 2021, we investigated the water column geochemistry above the vents (primarily detected by ship-echo sounder) in terms of dissolved gases, total dissolvable metals and physicochemical parameters. Excess of tritiogenic helium, up to 19.4 fmol/kg, confirm the magmatic origin of the fluids. These excess in the water column are associated to strong pH anomalies (up to -0.5 pH unit) and elevated concentrations of dissolved gases with maximum measured of 26.7 µmol/kg for CO_2, 2956.3 nmol/kg for CH_4, and 175.2 nmol/kg for H_2.

Here we focus on the water column acidification and on the carbonate system perturbation that seems directly linked to the dissolved CO_2 input. Numerical modelling with PHREEQC software is used to evaluate and quantify these modifications of the water column geochemistry. Additionally, 2D-sections offer the opportunity to study spatial variability of the water column geochemistry at the Horseshoe structure, which is highly dependent on venting site activity, bathymetry and currents.