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The use of traditional and non-traditional stable isotopes to track methanogenesis intensification

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Over geological times, the evolution of carbon isotope composition of carbonates ($\delta^{13}C_{carb}$) in the sedimentary record is punctuated by numerous positive Carbon Isotopic Excursions (CIEs). Such significant perturbations of the carbon cycle are mainly interpreted as a consequence of an increase of organic carbon burial in sediments. However, the significant spatial and temporal variability observed in many Proterozoic sedimentary successions recording positive CIEs still challenge this postulate. Given its ability to generate similar isotopic signatures in modern analogues, methanogenesis has been sporadically suggested to explain some positive CIEs at a local scale. Its influence has been, however, considered only as limited to the sedimentary column through authigenic carbonate precipitation. But the main limitation to our understanding of the role that methanogenesis might have had lies in our ability to discriminate its influence, as its isotopic effect on the $\delta^{13}C_{carb}$ is similar to that of organic carbon burial increase. Here, we propose to investigate the potential of traditional (C, S) and non-traditional (Ni) stable isotopes to track methanogenesis intensification in a modern analogue of Proterozoic environments exhibiting positives $\delta^{13}C$ values. The Dziani Dzaha is a shallow volcanic crater lake located on Mayotte Islands (Comoros Archipelago, Indian Ocean). A previous study demonstrated the significant role of methanogenesis associated with methane degassing into the atmosphere on the carbon cycle in its water column, while a sediment core recording the first deposits shows normal marine isotopic signatures at the first stage of the lake history. Using isotopic tools to track methanogenesis activity (e.g. nickel is an essential enzymatic cofactor), and the required conditions for its intensification (e.g. sulfate depletion), the Dziani Dzaha sediment core is a perfect target to highlight the isotopic fingerprint associated with methanogenesis intensification, which will improve our ability to discriminate its influence on the CIEs observed in the sedimentary record.