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Diagenetic biogeochemical processes in sediments of the volcanic high-CO_2 Lake Laach (Germany)

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The Laacher See (Lake Laach) is the largest volcanic lake in Germany, formed by a major phreatomagmatic eruption around 13,000 years ago. The lake basin remains affected by volcanic activity, offering a rare natural setting to explore the dynamics of dissolved carbon and the cycling of elements in steep chemical gradients. The lake and its surroundings experience degassing of magmatic CO_2 with numerous moffettes distributed in the catchment, along the shoreline, and at various depths in the lake. Here, we report on the benthic diagenesis and the dominating biogeochemical processes occurring in the lake's sediments in areas affected by different intensities of CO_2 degassing.

We investigate the porewater gradients of major and trace elements and dissolved inorganic carbon (DIC) cycling from several short gravity cores (up to ~ 1m depth) taken in different seasons, and from a 6 m long piston core at a reference site in the central basin. The water column and surrounding groundwaters were sampled to constrain boundary conditions and their potential elemental source function. An underwater drone equipped with a temperature & depth sensor sampled the water column accurately at regular depth intervals. Groundwater springs were sampled from the catchment. The stable H and O isotope signatures provide insight into the water sources and the seasonal water balance of Lake Laach. The stable C isotopic composition indicates the sources (e.g., organic matter degradation vs. volcanic exhalations) and fate of DIC, and allows to explain isotope signatures previously reported for authigenic sedimentary carbonates, such as siderite. Porewater gradients from cores of a moffette field display heterogeneity with respect to concentrations and isotopic signatures of DIC, some of which are similar to results encountered in more localised degassing sites, such as a ~7-meter-wide pockmark. We further explore how the elevated high DIC fluxes potentially affect metal accumulation in, and liberation from, the sediments of Lake