

Application of Reactive Transport Modelling to the Interpretation of pH Changes in Sediments

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A complex set of transport and reaction processes control geochemical conditions in sediments. Reactive transport models can account for the coupling of these processes. So far, however, existing models have not been able to reproduce satisfactorily observed pore water pH profiles. In order to understand the factors affecting pH changes in sediments, we adopt a systematic approach to modelling the relevant processes.

Process formulations, their corresponding parameters, as well as the fluxes of organic and inorganic carbon at the sediment-water interface are factors that influence the predicted pH profiles to varying extents. We evaluate the role of these factors through a Biogeochemical Reaction Network Simulator. This modeling framework provides an efficient and flexible modeling environment in which modifications of model formulations are easily implemented and tested.

Our current research focuses on the effects of solid deposition fluxes on the resulting pH profiles. Sediments from the deep sea and the continental shelf dominated by different organic carbon degradation pathways (oxic respiration/denitrification; iron reduction; sulfate reduction) are considered. For each of these redox systems, the buffering effect of calcite dissolution/precipitation on the pH profiles is evaluated quantitatively under contrasting conditions of inorganic carbon fluxes reaching the sediment-water interface.

Deuterium in the terrestrial water cycle: Present-day distribution and paleoclimatic applications

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Whereas the deuterium/hydrogen ratio is practically constant in the world ocean, the main water reservoir on Earth the situation differs for the atmosphere, the hydrosphere and the cryosphere. This is due to fractionation processes that occur at each phase change of the water (except sublimation and melting of compact ice) owing to slight differences in physical properties of HDO and H₂¹⁶O molecules, mainly their saturation vapor pressure and their molecular diffusivity in air. As a result, the deuterium distribution vary both spatially and temporally in the atmosphere, in the precipitation and, in turn, in the hydrosphere and of the cryosphere. Those isotopic variations have applications in such fields as climatology and cloud physics. More importantly, they are at the origin of two now well-established disciplines isotope hydrology and isotope paleoclimatology.

We will focus our presentation on the use of deuterium in paleoclimatology which is based on the observed relationship between δD and climatological parameters. Of primary interest is the linear correlation between annual values of δD and mean annual temperature at the precipitation site that is observed at middle and high latitudes and has given rise to the notion of "isotopic paleothermometer". We will first review the various models that allow to describe isotopic distributions in water vapor and precipitation, and their ability to account for present-day observations. We will then focus on paleodata and more specifically on Greenland and Antarctic deep ice cores with the longest record covering the last 420 000 years at the Vostok site in Antarctica, and discuss the calibration of the "isotopic paleothermometer" through the comparison with other methods allowing to estimate temperature changes in polar regions.