

Reactive transport modeling in understanding carbonate diagenesis in deep sea sediment and associated pore fluid

SHUO ZHANG¹ AND DONALD DEPAOLO²

¹Tsinghua University

²University of California, Berkeley, Dept of Earth and Planetary Science

Presenting Author: zhangs2019@tsinghua.edu.cn

Deep sea carbonate sediment records important geochemical information on paleo climate and paleo seawater composition. Post depositional diagenesis of carbonate sediment alters the geochemical signal and therefore it is important to understand the rate of diagenesis. Reactive transport modeling is a powerful tool in extracting deep sea carbonate reaction rates from measured pore fluid trace element concentrations and isotope ratios. Pore fluid Sr and Ca concentrations, in particular, are widely available in the database of Deep Sea Drilling Project (DSDP) and Ocean Drilling Program (ODP). In order to extract dissolution and precipitation rates of calcite we first develop a kinetic model for Sr partitioning in calcite. The partition coefficient of Sr in calcite can be predicted with known pore fluid temperature, pressure, and composition. We extend the analysis of pore fluid Sr and Ca concentration data in the literature from ocean drilling archives to 21 drill sites in sediment sections where the fraction of carbonate is larger than 80% to systematically estimate the rates at which calcite dissolves and precipitates as a function of depth and sediment age. Using these data we evaluate simple models for calcite reaction kinetics and pore fluid sediment evolution and conclude that (1) reaction rates are extremely slow because the reactive site density of the bulk sediment decreases continuously and systematically approximately as age^{-1} , and (2) reaction persists to hundreds of meters burial depth and tens of millions of years because pore fluids never become closed due to diffusive communication with the oceans, and hence remain slightly undersaturated with respect to calcite. The systematic decrease in bulk reactive site density begins immediately upon deposition, greatly slowing the rate of dissolution and hence affecting models of calcite dissolution on the seafloor. The failure to reach equilibrium after millions of years and hundreds of meters of burial, is a consequence of extremely slow net reaction rates that cannot drive the pore fluids to equilibrium against the diffusive loss of Ca and DIC to the ocean.