

Transport-controlled, linear calcite dissolution kinetics at the sediment-seawater interface

OLIVIER SULPIS¹, ALFONSO MUCCI², BERNARD BOUDREAU³

¹GEOTOP and Department of Earth and Planetary Sciences, McGill University, 3450 University Street, Montreal, QC H3A 0E8, Canada, olivier.sulpis@mcgill.ca

²GEOTOP and Department of Earth and Planetary Sciences, McGill University, 3450 University Street, Montreal, QC H3A 0E8, Canada, alfonso.mucci@mcgill.ca

³Department of Oceanography, Dalhousie University, 1355 Oxford Street, Halifax, NS B3H 4J1, Canada, bernie.boudreau@dal.ca

The dissolution of anthropogenic CO₂ in seawater results in a decrease in the pH, the CO₃²⁻ concentration, and saturation state of seawater with respect to CaCO₃ minerals (calcite and aragonite). Transfer of this CO₂ to the deep sea leads to a shallowing of their saturation depths, triggering an increase in their dissolution at the seafloor. Although CaCO₃ dissolution kinetics in seawater have been extensively investigated in past decades, previous studies focused on the dissolution kinetics of material kept in suspension in seawater, an inadequate representation of conditions encountered at the sediment-water interface of the seafloor.

Results of our experimental dissolution kinetics study of synthetic, calcite-rich sediments in a thermostated, stirred flow-through reactor reveal: (1) that the dissolution rates are linearly dependent on the saturation state of the overlying seawater; (2) a square-root dependence of the dissolution rate on the calcite content of the sediment, regardless of the control regime; and (3) that calcite dissolution kinetics at the seafloor are largely controlled by the diffusion of reactants and reaction products through the diffusive boundary layer (DBL) at the sediment-water interface rather than processes occurring at the surface of the minerals. These results contrast with the current paradigm that calcium carbonate mineral dissolution kinetics are reaction-controlled and with the highly non-linear dissolution kinetics laws published to date.

Given our preliminary results, we have designed a new rotating-disk reactor that is specifically constructed to precisely reproduce the shear velocities and diffusion conditions encountered in the deep sea, and can be used to study chemical exchange at the sediment-seawater interface.