Bottom-water acidification and $CaCO_3$ dissolution at the seafloor caused by anthropogenic CO_2

OLIVIER SULPIS[1*], BERNARD P. BOUDREAU[2], ALFONSO MUCCI[1], CAROLINA DUFOUR[3], CHRIS JENKINS[4], DAVID S. TROSSMAN[5], BRIAN K. ARBIC[6], ROBERT M. KEY[7]

[1]GEOTOP and Earth and Planetary Sciences Department, McGill University, Montreal, QC, Canada (olivier.sulpis@mcgill.ca)
[2]Department of Oceanography, Dalhousie University, Halifax, NS, Canada
[3]Atmospheric and Oceanic Sciences Department, McGill University, Montreal, QC, Canada
[4]INSTAAR, University of Colorado Boulder, Boulder, CO, USA
[5]Institute of Computational Engineering and Sciences, University of Texas-Austin, Austin, TX, USA
[6]Department of Earth and Environmental Sciences, University of Michigan, Ann Arbor, MI, USA
[7]Atmospheric and Oceanic Sciences, Princeton University, Princeton, NJ, USA

Anthropogenic CO_2 has been accumulating in the atmosphere and the ocean since the beginning of the industrial era and, according to projections of future emissions, will continue to do so well beyond the end of this century. The consequent ocean acidification reduces the seawater CO_3^{2-} concentration and leads to a shoaling of the saturation depth with respect to calcite, causing increased calcite dissolution at the seafloor. The rate of this reaction has been shown to be a linear function of the saturation state of the overlying waters and controlled by the presence of a diffusive boundary layer above the sediment bed, whose thickness is inversely correlated with the speed of bottom currents.

We combine recent databases of bottom-water chemistry, corresponding sediment calcite content and rain rates, and modelled future bottom-current velocities and seawater chemistry under the RCP8.5 scenario to derive the first global distribution of benthic calcite dissolution rates from 1765 to 2100, and obtain primary confirmation of an anthropogenic component.

We find that significant anthropogenic dissolution of calcite at the seafloor currently occurs in the western North Atlantic, where the bottom waters are youngest, and at various hot spots in the southern Atlantic, Indian and Pacific Oceans. According to results of the GFDL ESM2M model, over the next century, global bottom-water current velocities will decrease. Accordingly, the thickness of the diffusive boundary layer at the sediment-water interface could increase and counteract the effect of increasing bottom-water acidification on calcite dissolution rates.

Our findings constrain future predictions of ocean acidification and indicate that a by-product of human activities is currently altering the geological record of the deep sea.