

Carbonate compensation in the Anthropocene

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Since the end of the preindustrial era, the invasion of anthropogenic CO₂ in the ocean has lowered seawater pH and [CO₃²⁻], decreasing the saturation state of seawater with respect to CaCO₃ minerals, impeding their precipitation and favouring their dissolution. The latter reaction neutralizes CO₂ and is considered to be the ultimate short-term (10²-10⁴ years) sink for anthropogenic CO₂, acting as a negative feedback mechanism referred to as carbonate compensation.

We will review the various estimates of CaCO₃ export from the surface and, using a range of Earth System and climate models run under high-CO₂ emission scenarios, discuss the possible evolutions of CaCO₃ export in the 21st century. Using recent databases of seawater chemistry and bottom-current velocities, we use state-of-the-art empirical descriptions of calcite dissolution kinetics in seawater to compute calcite dissolution in the water column and at the seafloor. Currently (in year 2002), most of the dissolution occurs at the seafloor, rather than in the water column, and the anthropogenic fraction of the total dissolution is ~10%. Nevertheless, we estimate that anthropogenic water-column CaCO₃ dissolution, coupled with the abated surface export and bottom-current velocities predicted by models, will reduce the CaCO₃ flux reaching the seafloor and decrease CaCO₃ dissolution at the seafloor throughout the 21st century. The amount of anthropogenic CO₂ currently neutralized each year by seafloor or water-column calcite dissolution is negligible, less than 1% of the current CO₂ emission rate, and will remain so throughout the 21st century.

Based on a comparison of our observation-based best estimates of CaCO₃ surface export, abiotic dissolution and accumulation in marine sediments, we isolate the CaCO₃ “missing sink”, primarily found in coastal areas. This neritic missing sink could correspond to respiration-driven dissolution in sediments, water-column biotic dissolution, or dissolution of more soluble CaCO₃ phases shallower in the water column.