Solubility Equilibria Workshop Bonus

Corals / Coral Reefs / Calcium Carbonate Solubility

Mushroom Coral

Corals were initially believed to be plants, until it was observed microscopically that corals actually have cell membranes resembling animals.

While a coral appears to be a single organism, it is a group of many individual, yet genetically identical, polyps. Formation of the polyps' calcareous exoskeletons involves deposition of aragonite, a calcium carbonate mineral, from calcium and carbonate ions, which polyps physiologically acquire from seawater.

Coral reefs are large calcium carbonate structures generally found in shallow tropical waters. Reefs are built up from coral skeletons, and are held together by layers of calcium carbonate produced by coralline algae. They are part of a highly diverse ecosystem hosting thousands of different fish, crustaceans, and mollusks.

Ocean acidification is of high concern, since it affects carbonate ion concentrations, calcium carbonate solubility, and the balance of coral reef formation and dissolution. Consider the calcium carbonate equilibrium reactions and the solubility product expression:

$$CaCO_3(s) \rightleftharpoons Ca^{+2}(aq) + CO_3^{-2}(aq)$$

$$K_{sp} = [Ca^{+2}]\,[CO_3^{-2}]$$

The equilibrium reaction going to right dissolves the calcium carbonate solid, and going to the left forms it from the respective ions. When at equilibrium, the rate of formation equals the rate of dissolution and the reactions balance their changes. The amounts of reactants and products are in stasis, much like homeostasis and blood pH. When the system is perturbed, it must make adjustments to re-establish equilibrium (Le Chatelier's Principle). In blood, buffering and the kidneys help to maintain the pH within a narrow range when there are changes. Unfortunately, the oceans have limited buffering capacity and lack anything that can act like our kidneys. They are becoming more acidic, and acidification will profoundly affect the calcium carbonate equilibrium and impact corals and coral reefs.

Consider what is known in relation to the solubility equilibrium and factors associated with it: 1) The published literature values of K_{sp} for calcium carbonate range from 3.7×10^{-9} to 8.7×10^{-9} 2) Calcium is relatively abundant in sea water with a reported average concentration of ~4mg/10.0mL in surface water. 2) The current carbonate ion concentration is reported as ~260µmol/L. Its concentration is believed to have been relatively stable over millions of years with several events perturbing it. Ocean acidification is one such event that is associated with atmospheric $CO_2(g)$ concentrations, which have increased dramatically since the start of the industrial revolution and the burning of fossil fuels. Refer to the graphs on the right.