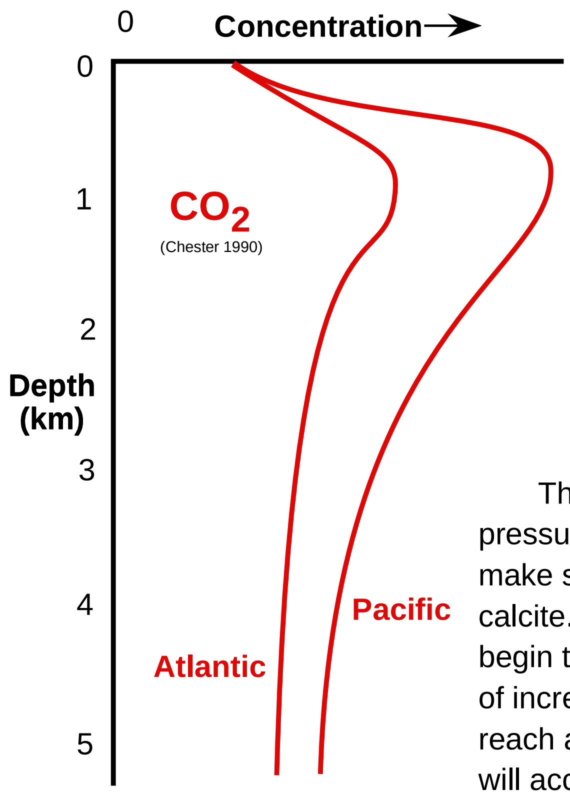
Variation in concentration of solutes in the oceans IIIa: carbon dioxide and the carbonate compensation depth (CCD)



In the deeper reaches of the ocean, $CaCO_3$ is more prone to dissolve for three reasons:

a) lower temperature (K_{sp} for both calcite and aragonite increases with decreasing T)[1]

b) greater pressure (K_{sp} for both calcite and aragonite increases with increasing P)[2]

c) acidity resulting from the presence of CO_2, as suggested by these reactions:

$$\underset{\text{Carbon dioxide}}{CO_2} + H_2O \dashrightarrow \underset{\text{Carbonic acid}}{H_2CO_3}$$

$$\underset{\text{Carbonic acid}}{H_2CO_3} + \underset{\text{Calcite}}{CaCO_3} \dashrightarrow Ca^{2+} + \underset{\text{Bicarbonate}}{2HCO_3^-}$$

As discussed in Part III of this series, concentrations of CO_2 in abyssal waters are greater than those in surface waters because oxidation of sinking organic particles produces CO_2.

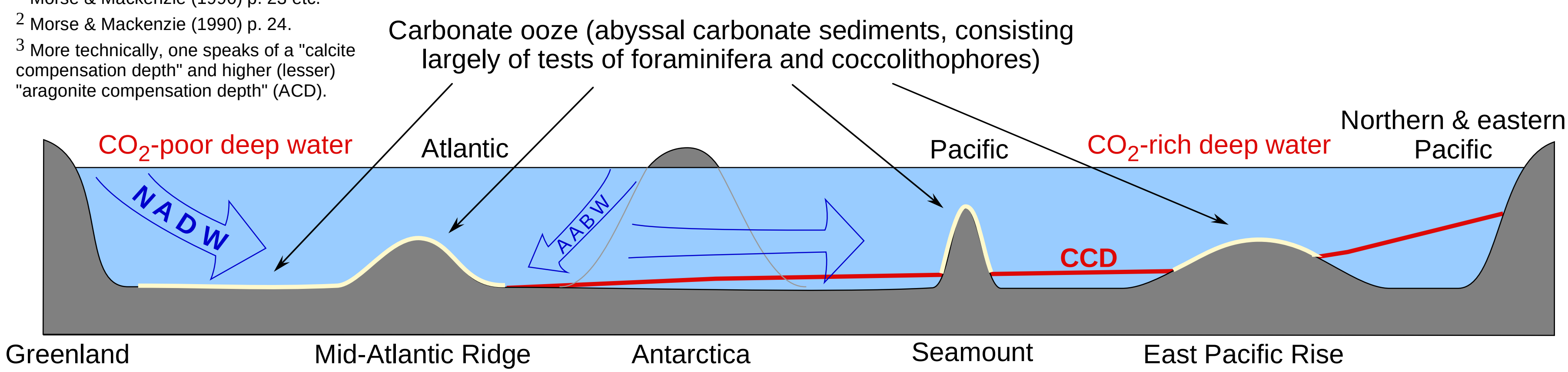
Thus at depth in the ocean, temperature, pressure and acidity commonly combine to make seawater undersaturated with respect to calcite. Calcite particles sinking past this depth begin to dissolve in a lysocline (the depth zone of increasing dissolution rate) and eventually reach a depth at which no carbonate sediment will accumulate on the seafloor. This depth is the carbonate compensation depth (CCD),[3] which is thus named because it is the depth at which the rate of dissolution of $CaCO_3$ equals ("compensates for") the rate of $CaCO_3$ sedimentation. Thus seafloor deeper than the CCD will be devoid of carbonate sediments. The CCD is higher (less deep) in the Pacific because deep water in the Pacific has more CO_2 and so is more acidic.

Notes:

[1] Morse & Mackenzie (1990) p. 23 etc.

[2] Morse & Mackenzie (1990) p. 24.

[3] More technically, one speaks of a "calcite compensation depth" and higher (lesser) "aragonite compensation depth" (ACD).



Seamounts: "the snow-capped peaks of the abyssal Pacific"