The Role of Fluid:Solid Ratio in Explaining the Inhibition of Calcite Growth by Magnesium

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Magnesium (Mg^{2+}) in seawater plays a substantial role in governing carbonate minerals formation and diagenesis. For example, Mg^{2+} favors the precipitation of aragonite over calcite despite aragonite being less stable than calcite at Earth surface conditions. It has also been shown experimentally that Mg^{2+} inhibits the transformation from aragonite to calcite. Despite the inhibitory effect of Mg^{2+}, carbon and oxygen isotopes, as well as trace element data indicate that the majority of diagenetic calcite in the rock record have formed in the shallow burial realm, likely in the presence of abundant Mg^{2+}.

Here, a series of aragonite to calcite stabilization experiments were conducted at 70 ℃ to evaluate the role of fluid to sediment ratio (FSR) on the inhibitory effect of Mg^{2+}. Consistent with previous findings, our results show that stabilization in high FSR (150 ml to 1 g) occurs in deionized (DI) water but not in Mg-bearing solution. In contrast, stabilization in low FSR (<1:1), which corresponds to sediments with ~70% porosity, occurs both in DI water and in the Mg solution. Our results further show that the amount of Mg^{2+} incorporated in the diagenetic calcite increases with FSR.

Our findings provide significant insights into stabilization of aragonite sediments in nature. The experiments show that at geologically reasonable FSRs, stabilization to calcite proceeds relatively rapidly in seawater-like fluids. This suggests that previous experimental studies that attempted to stabilize aragonite in Mg^{2+} containing solution have used abnormally high fluid to sediment ratios. Such high ratios are unnatural and do not reflect the diagenetic conditions where stabilization takes place. Furthermore, our findings may explain aragonite sediments stabilization to calcite in natural settings, which is observed to take place in the marine shallow burial realm. In such settings, fluid to sediment ratio is generally low and fluid circulation is limited.