Goldschmidt 2022 Abstract
https://doi.org/10.46427/gold2022.9422

Controls of temperature and mineral growth rate on Mg incorporation in aragonite

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In this study we have examined how growth rate and temperature affect the incorporation of Mg in aragonite. The examined growth rates were in the range of $10^{-8.6} \leq r_p \leq 10^{-7.1}$ (mol/m^2/s), whereas the temperatures examined were 5, 15 and 25 ^{o}C. Between these two parameters, aragonite growth rate was found to be the major parameter affecting the Mg partitioning coefficient between aragonite and fluid, whereas the effect of temperature is smaller but measurable. For experiments performed under similar surface-normalized growth rates, the Mg partitioning coefficient decreased as temperature increased from 5 to 25 ^{o}C. Interestingly, the magnitude of decrease as a function of temperature is similar for all the experiments of this study. Overall the combined effect of aragonite growth rate and temperature on D_{Mg} can be described by the linear equation:

Log D_{Mg} = 0.583(±0.020) Log r_p – 0.026(±0.001) T + 0.863(±0.153); R^2 = 0.97

where T is the temperature in degrees Celsius.

The observed increase of Mg distribution coefficients at decreasing temperatures in experiments conducted at similar growth rates is consistent with the increase of fluid supersaturation with respect to the precipitating mineral phase. This observation suggests that the elevated Mg incorporation at higher degrees of fluid supersaturation with respect to aragonite is likely associated with the greater presence of defect sites on the growing mineral surface. Overall, the relationship between Mg content of aragonite with the degree of saturation of the fluid with respect to this mineral phase suggests that Mg distribution coefficients and/or Mg/Ca ratio in natural aragonites can be used as a proxy for saturation degree of the formation fluid with respect to $CaCO_3$ minerals (see Mavromatis et al., 2022).

References:

Mavromatis, V., Brazier, J.M. and Goetschl, K.E. (2022) Geochim. Cosmochim. Acta 317, 53-64.