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On the easiness of growth of the ordered anhydrous Mg-bearing double carbonate norsethite

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The easy precipitation of norsethite [$BaMg(CO_3)_2$] at ambient conditions is in vast contrast to the growth problems of anhydrous Mg-containing carbonate minerals in general and of the Ca-Mg double carbonate dolomite [$CaMg(CO_3)_2$] in particular. The striking structural similarity of dolomite and norsethite makes their different growth behavior even more noteworthy. In order to unravel the role of Ba in this remarkable discrepancy, we studied the fate and behavior of aqueous barium during growth of magnesite [$MgCO_3$] as magnesium endmember in the $BaCO_3$-$MgCO_3$ system.

Experiments were conducted with hydrothermal mixed-flow reactors and hydrothermal atomic force microscopy at 100 °C. The presence of barium left magnesite growth rates unaffected but led to norsethite precipitation. Norsethite growth rates were found to be controlled by the aqueous Ba concentration at the conditions of the experiments. The logarithm of the solubility product of norsethite was found to be lower than -18.2 at 100 °C. Microscopic investigations of the growth on the (104) surface of magnesite did not reveal any signs of Ba incorporation yielding a partitioning coefficient of barium between magnesite and solution in the range of 10^{-2} or smaller.

The preferential formation of the ordered double carbonate over a solid solution is presumably facilitated by the large difference between the ionic radii of Mg^{2+} and Ba^{2+}. Ordering into distinct Ba- and Mg-layers is the only way to combine both cations within one phase due to the likely very high free energy of formation of the solid solution. The lack of a solid solution, therefore, is one important prerequisite for the direct and unimpeded formation of an ordered double carbonate. This behavior is in great contrast to the $CaCO_3$-$MgCO_3$ system where solid solution occurrence is common and effectively inhibits dolomite formation over a wide range of conditions.