Distribution coefficients and the co-precipitation of trace and minor elements

For any mineral with the general formula AX, other cations B, C, D, etc. may substitute for A to a small extent, or other anions Y or Z or so on may substitute for X to a small extent. We refer to B, C, and D and Y or Z as trace constituents or more commonly as "trace elements" (even though X, Y, and Z might be CO_3^{2-}, SO_4^{2-}, or even PO_4^{3-}). They substitute for the "major" elements or constituents A and B.

When a mineral precipitates from solution, we can predict the concentration of a trace element in that mineral if we know the distribution coefficient *D* for that element in that mineral. *D* relates the ratio of the concentrations (*C*) of trace and major elements in the precipitated mineral solid to that ratio in the precipitating solution as follows:

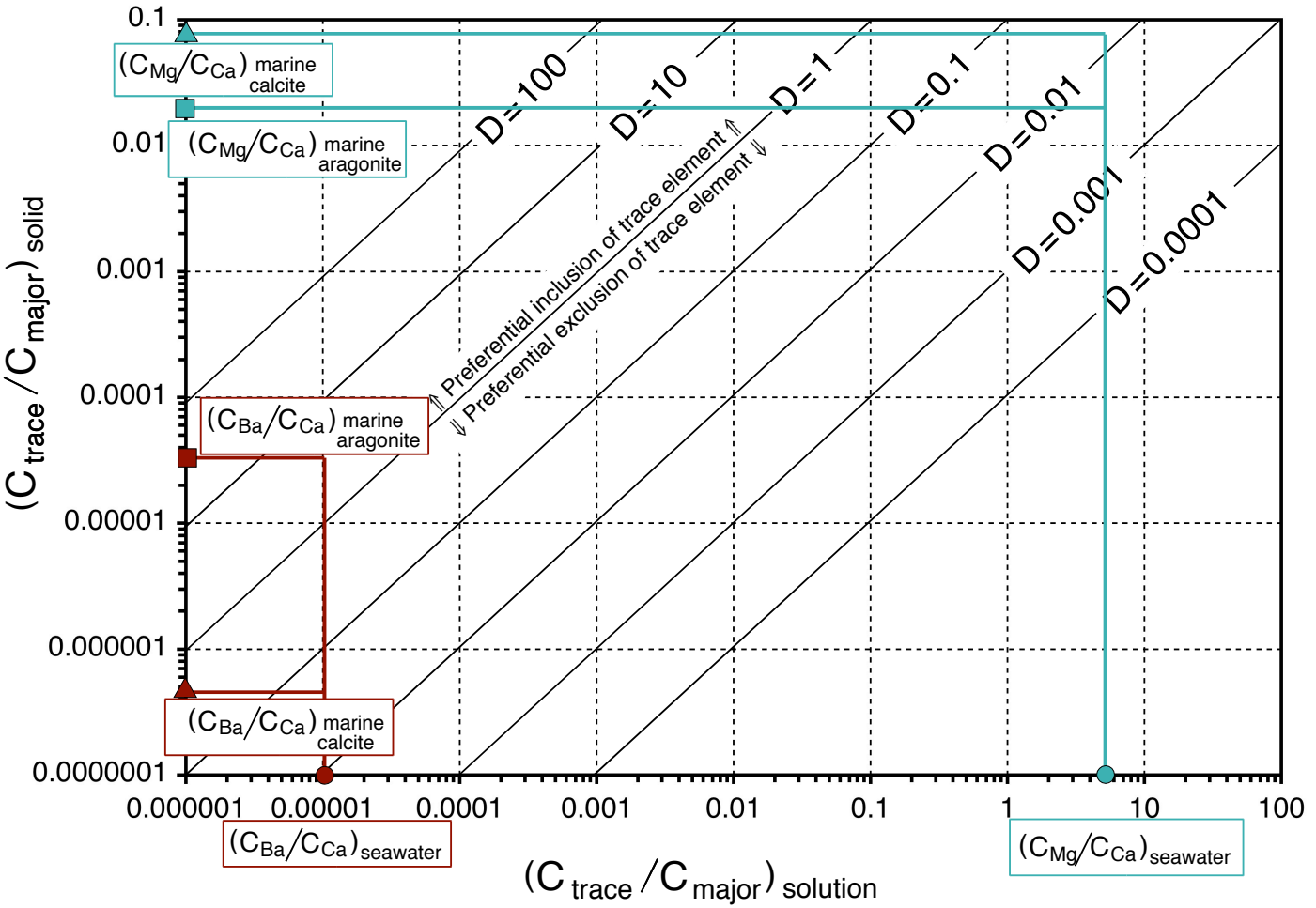
$$D^{solid}_{trace} = \frac{(C_{trace}/C_{major})_{solid}}{(C_{trace}/C_{major})_{solution}}$$

Two examples involving carbonate minerals are

$$D^{Calcite}_{Mg} = \frac{(C_{Mg}/C_{Ca})_{solid}}{(C_{Mg}/C_{Ca})_{solution}}$$

$$D^{Aragonite}_{Ba} = \frac{(C_{Ba}/C_{Ca})_{solid}}{(C_{Ba}/C_{Ca})_{solution}}$$

The distribution coefficient thus expresses the extent of the preferential inclusion (D > 1) or preferential exclusion (D < 1) of the trace element in the solid relative to the solution.



The diagram above illustrates the relationship between elemental ratios in solution, elemental ratios in precipitated mineral solids, and possible values of D. Precipitation of Mg and Ba as minor to trace elements in calcite and aragonite are shown as examples. Note that D depends *both* on the trace element *and* on the mineral.

Distribution coefficients can be used in both predictive and interpretive senses. In the former, they allow prediction of the composition of a mineral from a present solution of known composition. In the latter, they allow estimation of the composition of a now-long-lost solution from the composition of a presently surviving ancient mineral.

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