Precipitation of trace elements from an evolving fluid

The distribution coefficient for a given trace element substituting for a major element in a given solid

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

expresses the extent of preferential inclusion (D>1) or preferential exclusion (D<1) of that trace element in the solid relative to the solution. Through time, this preferential inclusion or exclusion into the solid decreases or increases the trace/major ratio in the solution, which changes the trace major ratio in the next solid precipitated from that parcel of solution. As a result, both the parcel of solution and the solids it precipitates change through time, as the examples below show.

This diagram arbitrarily assumes an initial trace/major ratio of 0.001 in the solution; any value is possible (even values greater than 1, as with the Mg/Ca ratio of seawater).

The trace/major ratios in the solid shown here are dictated by the solution ratio on the left plot. However, the preferential removal of trace element with D>1 then dictates a decreasing ratio in the solution – and preferential exclusion of the trace element from the solid with D<1 dictates an increasing ratio in the solution.

For examples, consider incorporation of Mg in calcite, where

$$D^{Calcite}_{Mg} = \frac{(Mg/Ca)_{Calcite}}{(Mg/Ca)_{soln}} = \sim 0.001,$$

or incorporation of Ba in aragonite, where

$$D^{Arag}_{Ba} = \frac{(Ba/Ca)_{Arag}}{(Ba/Ca)_{soln}} = \sim 3.$$

Mg concentration will *in*crease in the sequence of calcites precipitated from one parcel of water. Ba concentration will *de*crease in the sequence of aragonites precipitated from one parcel of water.

For an example of the progressive removal suggested by the horizontal axis, consider water in a cave seeping along a roof drapery, collecting at the tip of a stalactite, dripping onto a stalagmite, and flowing down the stalagmite and across the floor of the cave – all the while precipitating $CaCO_3$.

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