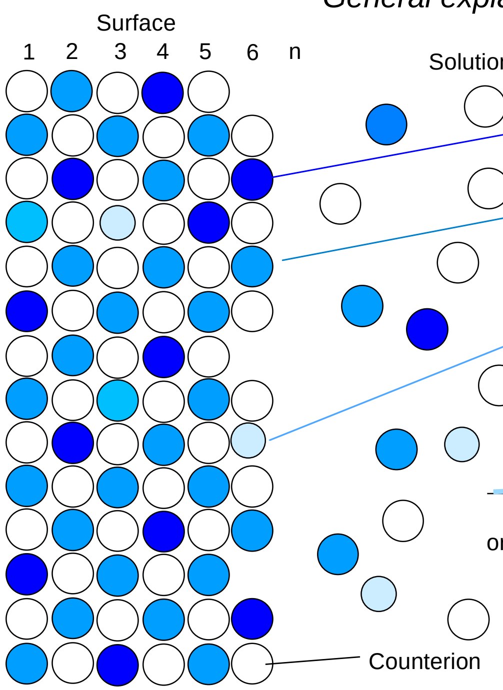
An explanation of why distribution coefficients vary with precipitation rate and temperature

A distribution coefficient

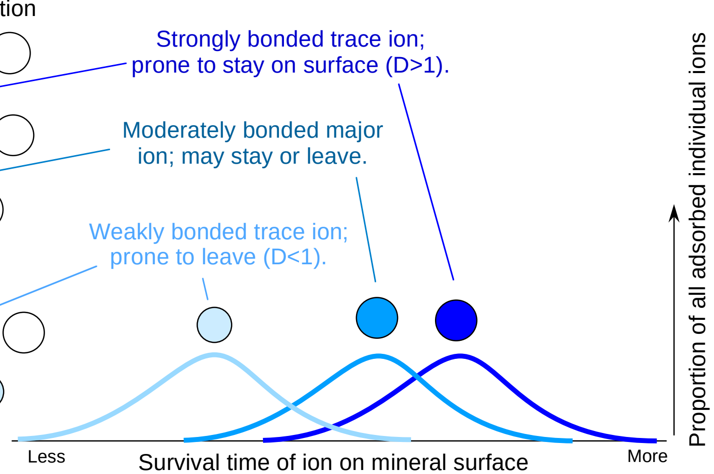
$$D_i^x = \frac{[i]/[j] \text{ in solid } x}{[i]/[j] \text{ in precipitating solution}}$$

expresses the extent to which a trace ion "i" is preferentially included (D>1) or preferentially excluded (D<1) from growing crystals of a particular solid ("x") containing major ion "j". Distribution coefficients are observed to approach unity with increasing precipitation rate and with increasing temperature. This document tries to explain that pattern.

General explanation:



Surface 6 will after some lifetime bury Surface 5, which buried Surface 4, etc.



Survival time of ion on mineral surface or ***amount* of time** spent by individual ions on the mineral surface. Along this line, *amount* of time increases from left to right; it is *not* a timeline along which time passes from earlier to later.

For each of the three ions, the curve above is the distribution of the probability (vertical axis) of survival for different lengths of time (horizontal axis).

The distributions are *assumed* here to be normal (i.e., symmetrical around coincident mean, median, and mode).

This linkage of the distribution coefficient to the probability of survival times on the mineral surface lets us then consider the different diagrams at right as explanations of why distribution coefficients vary with precipitation rate and temperature.

In the example on this page, the ion with D<1 ( ) is portrayed as a smaller ion. It might instead be a larger ion or an ion of different charge.

Specific cases:

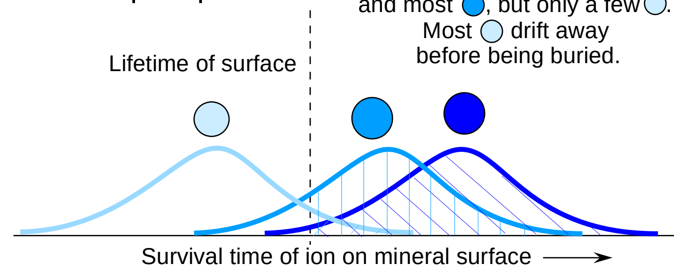
Ions that are not buried and leave the mineral surface

Ions that are buried and thus incorporated in mineral

Lower temperature; slower precipitation

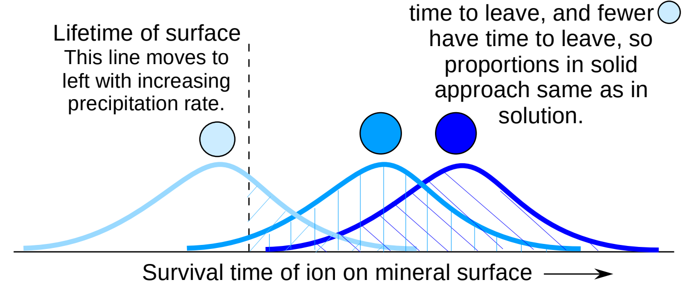
(default or "normal" case)

Growth buries almost all and most , but only a few . Most drift away before being buried.



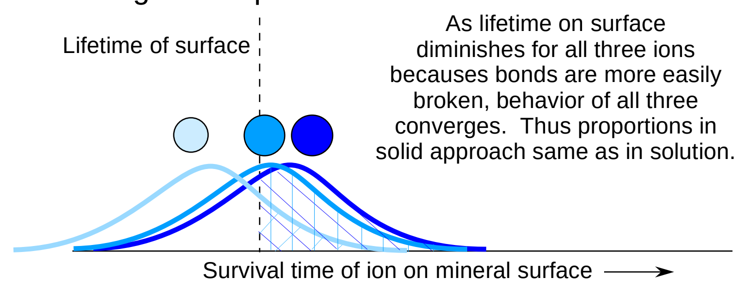
Faster precipitation

With faster precipitation, most and haven't time to leave, and fewer have time to leave, so proportions in solid approach same as in solution.



Higher temperature

As lifetime on surface diminishes for all three ions becauses bonds are more easily broken, behavior of all three converges. Thus proportions in solid approach same as in solution.



The logic used here to explain variation in distribution coefficients of trace elements can also be applied to two (or more) isotopes of one element, where is the heavier isotope.