Patterns in the compositions of minerals I: carbonates and sulfates

This is the first of a series of pages presenting the chemistry of minerals in the context of part of the Earth Scientist's Periodic Table of the Elements and Their Ions. The point of these pages will be that there are patterns and predictability in the compositions of minerals.

Minerals are defined as naturally occurring substances and thus must be sufficiently stable to survive and be recognized in nature. One way to explain the stability of some substances and instability of others is through the concept of ionic potential or charge density, which is quantified as ionic charge divided by ionic radius ($z/r$). The principal application of that concept here will be that cations have sufficient density of charge that repulsions between them can make substances unstable, and thus that minerals must be substances in which cations of great charge density must be shielded from each other.

We can begin with the panel for carbonate minerals. In the blue field, simple carbonates like CaCO$_3$ consist of cations whose positive ionic potential is sufficiently low that they are not repulsed by the high positive ionic potential of C$^{4+}$ in the carbonate group. Cations of higher ionic potential, such as Y$^{3+}$, Al$^{3+}$, and Ti$^{4+}$, must be shielded by H$_2$O (in the green field) or have their charge counterbalanced by OH$^-$ (the yellow field) or by O$_2^-$ (the red field) for a mineral to form.

The pattern just described in the upper panel showing carbonate minerals is replicated in the lower panel of sulfate minerals. We'll see more of this pattern, and a pattern of how it shifts, as we move to the other pages in this series.