

Patterns in the compositions of minerals III: the oxysalt or "ate" 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). Each of the panels at right shows part of the periodic table, and dashed contours show variation in ionic potential across that part of the table. Pages I and II of this series showed the upper four panels in a more easy-to-see format.

The panel for carbonate minerals provides a good place to start seeing patterns in mineralogy. 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_2O (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. To the left of the blue field, positive charge in the form of H^+ , rather than negative charge, must be added to maintain a balance of ionic potential.

Any one panel on the diagram thus has a general array of purple to blue to green to yellow to red fields. From bottom to top across the five panels, those fields shift from left to right as one progresses from nitrate minerals, in which the N^{5+} of NO_3^- repels all but the weakest positive charges, to silicates, in which the lower ionic potential of Si^{4+} in SiO_4^{4-} tolerates cations of higher ionic potential. Thus as we go from bottom to top through the oxysalt minerals, ionic potential of inter-radical cations is inversely proportional to the ionic potential of the cations in the oxysalt radical (e.g., from KNO_3 to ZrSiO_4).

The ultimate point of this diagram is that chemical formulae of minerals are not random assemblages constrained only by balance of charge. Instead, consideration of ionic potential provides a means to understand mineralogy and to predict which substances may form minerals and which will not. For example, $\text{Ti}(\text{SO}_4)_2$ is shown to be an unlikely titanium sulfate mineral, whereas $\text{TiSO}_4(\text{OH})_2 \cdot \text{nH}_2\text{O}$ or $\text{Na}_2\text{TiO}(\text{SO}_4)_2$ are shown to be plausible candidates for such a mineral. Likewise, although quartz and calcite are common minerals that often form together, these principles illustrate why an $\text{Si}(\text{CO}_3)_2$ mineral combining the constituents of those two minerals is not among the roughly 5000 minerals that have thus far been recognized.

