Patterns in the compositions of minerals V: the "ide" 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.

Any one panel on this diagram shows the same progression of blue to green to yellow fields. For example, among the chlorides, cations of low ionic potential like K^+ and Na^+ form simple minerals, but the low anionic potential of Cl^- fails to shield cations of higher ionic potential from each other, so that there are no simple chlorides of Mg^{2+} and Al^{3+}. Instead, chlorides of Mg^{2+} and Ca^{2+} must also have H_2O to shield positive charges from each other, and minerals of Al^{3+} must have the counterbalancing negative charge of OH^-.

From the bottom to top of the panels on the right, increasing anionic potential of the anion allows greater cationic potential in the simple minerals and H_2O-bearing minerals, so that the colored fields shift to the right. Thus, among the simple chloride, fluoride, oxide, and carbide minerals of hard cations, ionic potential of cations is proportional to that of anions (e.g., from KCl to SiC).

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, TiF_4 is shown to be an unlikely titanium fluoride mineral, whereas $TiF_2(OH)_2.nH_2O$ is shown to be plausible candidate for such a mineral. That can be a meaningful thought when one encounters a new phase and begins to deduce its chemistry, and perhaps to discover a new mineral.

One obvious peculiarity of the panels at right is that there are no iodide and bromide minerals of hard cations. That's because iodide and bromide are sufficiently soft cations that they don't bond well to hard cations (a thought covered in other *SFMG* pages).