Categorizing cations

The Earth Scientist's Periodic Table of the Elements and Their Ions presents a graphical approach to understanding and predicting the behavior of naturally-occurring ions. This page attempts to do the same with a two-step tabular approach. The first step is to categorize each ion in terms of the configuration of its outermost shell of electrons (see Table 1). Because electrons are the atomic component involved in bonding, this first step establishes the nature of the bonds, and thus the bonding partners, typical of the cation.

Table 1: General catagories of cations

	Hard (Type A)	*Intermediate*	*Soft (Type B)*
Defining characteristics	No outer shell electrons (inert-gas-like outer shell)	At least some outer-shell electrons	Many outer-shell electrons
Examples	Na^{+}, Mg^{2+}, Al^{3+}, Si^{4+}	Fe^{2+}, Fe^{3+}	Ag^{+}, Au^{+}
Bonding character	Ionic	Intermediate	Covalent
Typical coordinating ions	F^{-} and O^{2-}	O^{2-} and S^{2-}	S^{2-}, Cl^{-}, Br^{-}, I^{-}

Table 2: Hard and intermediate cations categorized by ionic potential

Value of ionic potential (charge ÷ radius)	≤ 3	3 to 9	≥ 9
Examples among hard cations	Na^{+}, K^{+}, Ca^{2+}	Be^{2+}, Al^{3+}, Ti^{4+}	C^{4+}, P^{5+}, S^{6+}
Examples among intermediate cations	Mn^{2+}, Fe^{2+}	Mn^{4+}, Fe^{3+}	As^{5+}, Se^{6+}
Behavior in nature	Prone to stay in or go into liquid phases (solutions or magmas)	Prone to enter or stay in solids in which O^{2-} is dominant source of negative charge	Prone to stay in or go into liquid phases (solutions or magmas)
Speciation in solution	Hydrated (aquo ions)	Hydroxo-complexes	Oxocomplexes

Step 2 involves categorizing hard to intermediate cations by the ionic potential (charge ÷ radius), which is an expression of density of charge. Cations of low ionic potential form weak bonds with O^{2-} and thus are late to enter solids and are easily removed to solution. Cations of great ionic potential make strong bonds to O^{2-}, but their density of positive charge causes cation-cation repulsions that make them likewise late to enter solids and readily dissolved. The cations in between, with moderate ionic potential, make strong bonds to O^{2-} but do not have sufficient density of charge to set up cation-cation repulsions, so they enter solids early and are less likely to go into solution.

Step 2 has little significance to soft cations because they are mostly cations of low ionic potential and because Table 2 implicitly assumes coordination with O^{2-}, an unlikely situation for soft cations.