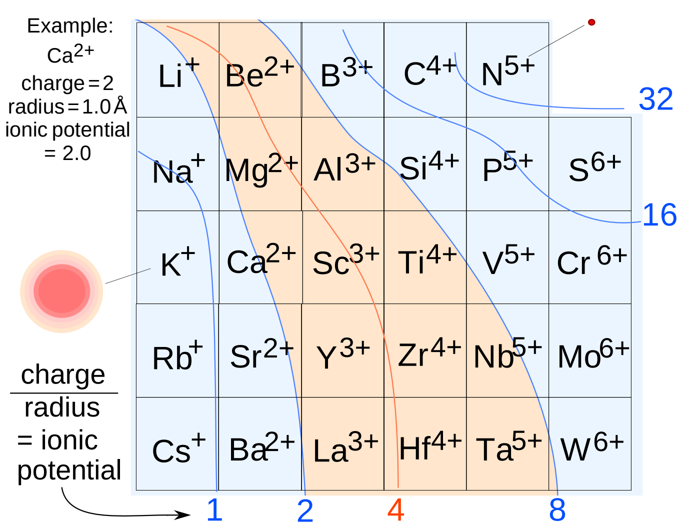
Ionic potential

One important way to characterize ions is by their ionic potential. Ionic potential is an ion's charge divided by its radius, and it is thus a measure of density of charge. Ionic potential gives a sense of how strongly or weakly the ion will be electrostatically attracted to ions of opposite charge, and to what extent the ion will repel other ions of like charge. Ionic potential varies greatly for cations, from 0.75 for K^{+} to 45 for N^{5+}.

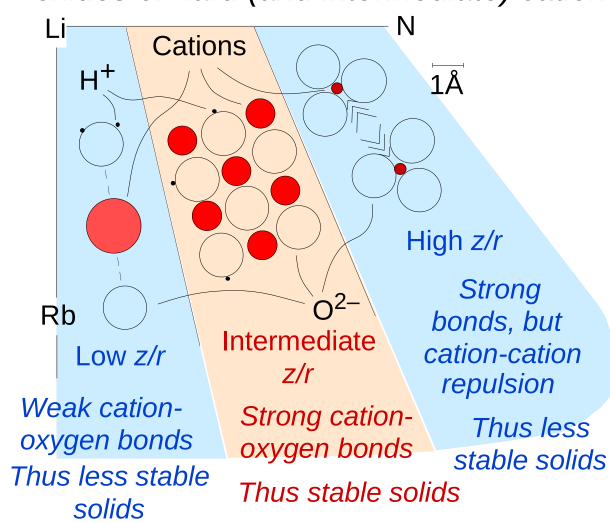
Ionic potential is very useful in understanding the behavior of relatively hard cations (see below). Cations of low ionic potential like Na^{+} are typically soluble and enter into solids only at relatively low temperatures, because they make weak bonds to O^{2-}. On the other hand, cations of high ionic potential, like S^{6+}, bond so well to O^{2-} that they make oxocomplexes like SO_4^{2-} (sulfate) that are soluble. Repulsions between S^{6+} ions, and between the $S6^{6+}$ ion and other highly charged cations, make most sulfate minerals relatively soluble, and S^{6+} thus is an incompatible or volatile ion in high-temperature systems. In between, cations of intermediate ionic potential like Al^{3+} have sufficient density of charge to bond strongly to O^{2-} but not such dense charge as to repel each other, and so they make stable oxides and/or hydroxides and thus are insoluble. The cations of intermediate ionic potential also enter into solids at high temperatures.

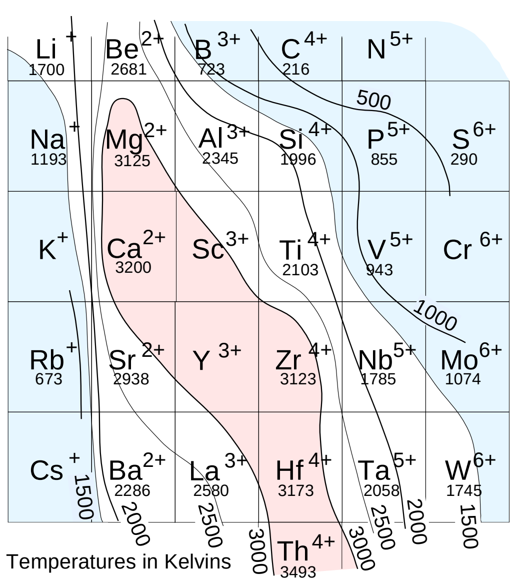
The diagrams here show the effect of these trends in the melting temperatures and solubilites of oxides. The Earth Scientist's Periodic Table of the Elements and Their Ions shows many more geoscience trends that result from variation in ionic potential. In addition, this book's page on "A bit of the Earth Scientist's Periodic Table of the Elements and Their Ions as a cross-section of the Earth" shows the implications of these trends at even larger scale, the pages on Bowen's Reaction Series shows how ionic potential affects igneous crystallization, the pages on solutions and aqueous speciation show how ionic potential controls the behavior of catons in solution, and the page on "The Special Siituation of Silicon" shows the implications of ionic potential for one important element.

Contours of ionic potential:



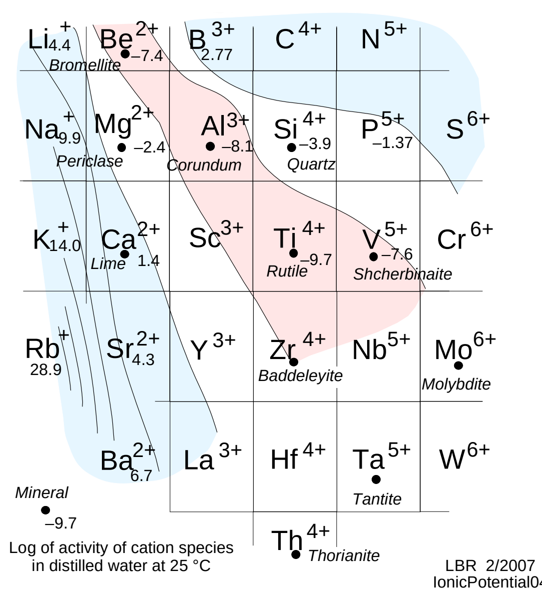
Conceptual model of the behavior of oxides of hard (and intermediate) cations





Melting temperature of oxides of hard cations

Solubility of oxide minerals of hard cations



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