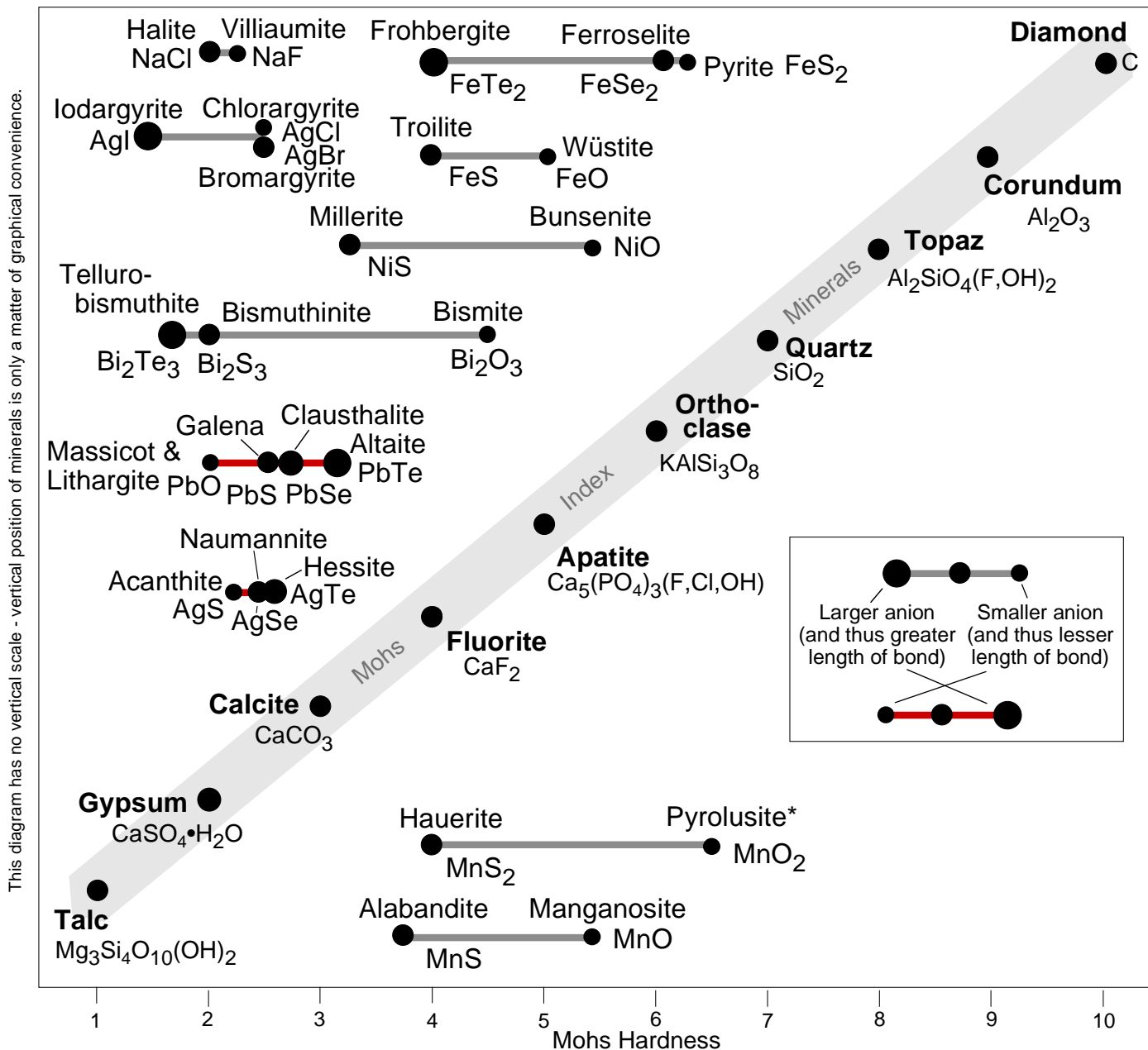


## Hardness of minerals IVb: variation with bond length and anion size



One control on the hardness of a mineral is the length of bonds within that mineral. To illustrate this point, this diagram shows pairs of chemically analogous minerals that differ only in their anions. In most of the examples shown on this diagram (the ones joined by light gray lines), minerals with larger anions, and thus greater bond lengths, are softer than their counterparts with smaller anions and thus shorter bonds.

However, in two cases shown here (the ones joined by red lines), larger anions lead to harder minerals. These are the examples where soft cations,  $Ag^+$  and  $Pb^{2+}$ , bond to 2- anions. In these cases, the bonds of soft cations to increasingly large and thus increasingly soft anions may lead to sufficiently covalent bonds to cause greater hardness of minerals.

Hardness data are from Nickel, E.H., and Nichols, M.C., 1991, *Mineral Reference Manual: New York*, Van Nostrand Reinhold, 250 p.

\* The hardness of pyrolusite is commonly listed as 2, but that is the value for earthy masses of minute crystals. The hardness of a single crystal of pyrolusite is 6.5 (Gaines et al., 1997, *Dana's New Mineralogy: New York*, John Wiley & Sons, 1819 p.).