Goldich's Weathering Series explained in terms of bond strength

In 1938, Samuel Goldich published a study of the weathering of various igneous rocks in which he concluded that igneous silicate minerals weather in an order much like that of Bowens Reactions Series, with mafic silicates the most susceptible to weathering and quartz the least susceptible[1]. The diagram below shows a modified form of Goldich's series, which has subsequently been confirmed experimentally[2]. Zircon and several non-silicates have been added below in the apparent order of their susceptibilty of weathering (the position of calcite relative to olivine and anorthite is debatable).

The diagram below shows that the order of this weathering series agrees well with the least bond strength in each of the minerals involved. That seems reasonable, because weathering, or the destruction of minerals, requires breaking of bonds in those minerals. The only special provision is to bear in mind that some minerals consist sufficiently of strongly bonded cations that a weakly bonded cation can be leached from the surface of a mineral grain without destruction of the entire mineral grain. That has been demonstrated experimentally to be the case with alkali feldspars, where weathering can preferentially remove the alkali cation (K^{1+} or Na^{1+}) but leave an Al-Si remnant structure on the surface of feldspar grains[3].

The diagram also has application for non-igneous materials. For example, aragonite and calcite are both present in marine sediments, but aragonite rarely survives in ancient limestones, where calcite is abundant. The weaker bond formed by Ca^{2+} in nine-fold coordination in aragonite, rather than the stronger bond of Ca^{2+} in six-fold coordination in calcite, explains aragonite's greater susceptibility to dissolution. Halite, an even more soluble sedimentary mineral, has even weaker bonds, and niter, a mineral that hardly survives in nature at all, has the weakest bonds.

1 Goldich, S.S., 1938, A study in rock-weathering: *Journal of Geology* 46: 17-58.
2 Table 7.1 of Langmuir, D., 1997, *Aqueous Environmental Geochemistry:* Prentice Hall.
3 Chou, L., & Wollast, R., 1984, *Geochimica et Cosmochimica Acta* 48: 2205-2217.