

Density of minerals VII:

The effect of OH⁻ in oxysalts

Previous pages of this series have considered controls on the density of oxysalt minerals (e.g., carbonates, sulfates, chromates, etc.). Those controls have included mass of the inter-radical cation (e.g., Ca²⁺ in CaSO₄), mass of the intra-radical cation (e.g., S⁶⁺ in CaSO₄), and inclusion of structural water (e.g., the H₂O in CaSO₄·H₂O). This page looks at the role of OH⁻, as found for example in malachite (Cu₂CO₃(OH)₂).

The plot at right shows density of oxysalts of particular cations, with density plotted against the ratio of OH⁻ groups to anion groups (for example, that ratio is 2.0 for malachite). A generalizable pattern emerges: density increases with OH⁻:anion ratio to a maximum at a value of that ratio of 1 to 2 and then decreases, with the ultimate limit of that decrease defined by the density of hydroxide minerals, where the OH⁻:anion ratio goes to infinity. One apparent exception to this generalization is the Zn carbonates, but one might instead use this plot to hypothesize that Zn₃(CO₃)₂(OH)₂, with a OH⁻:anion ratio of 1.0, would have a density of about 4.4 gm/cm³.

The increase in density from OH⁻-less minerals to minerals with OH⁻:anion ratios of 1 to 3 can be rationalized in terms of the charge contribution made by OH⁻ groups. Two OH⁻s contribute the same charge as a CO₃²⁻ group, but in about two-thirds the volume, so incorporation of OH⁻s rather than anionic radical groups would allow an increase in density. That remains valid so long as the positive loci of charge on the OH⁻s are located away from cations. With increasing OH⁻:anion ratio, the latter issue inevitably arises, leading the observed decrease in density at large values of the OH⁻:anion ratio and ultimately exemplified by the hydroxide minerals at the right side of the diagram.

