

Color of Minerals

The most common cause of color in minerals is interaction of light with outer-shell electrons. Thus minerals of hard cations (cations with no outer-shell electrons) typically have no color and so are white or clear. Quartz, calcite, and gypsum are good common examples. On the other hand, minerals containing intermediate to soft cations (cations with at least a

few outer-shell electrons) commonly have color. Those colors often are traceable to specific cations, so that we see the red of hematite with Fe³⁺ but the green of glauconite with Fe²⁺. The periodic table below is intended to show these patterns. For an example, see "Color in the olivine-group minerals", another page in this series.

Color of oxygen-bearing inorganic solids (e.g., minerals)



Typical colors of carbonates, nitrates, phosphates, silicates, arsenates, tungstates, oxides etc. of the cation indicated



Typical colors of sodium-, magnesium-, potassium, and calcium-bearing oxysalts of the cation indicated

Hard Cations (Cations with no outer-shell electrons)

H⁺ 1 Hydrogen ion ●						
Li 3 Lithium ion ●	Be²⁺ 4 Beryllium ion ●	B³⁺ 5 Boron as borate (B(OH) ₃) ●	C⁴⁺ 6 Carbon, as carbonate (CO ₃ ²⁻) ●	N⁵⁺ 7 Nitrogen as nitrate (NO ₃ ⁻) ●		
Na⁺ 11 Sodium ion ●	Mg²⁺ 12 Magnesium ion ●	Al³⁺ 13 Aluminum ion as Al ³⁺ or Al(OH) ₃ ●	Si⁴⁺ 14 as silicate (SiO ₄ ⁴⁻) ●	P⁵⁺ 15 Phosphorus as phosphate (PO ₄ ³⁻ and HPO ₄ ²⁻) ●	S⁶⁺ 16 Sulfur as sulfate (SO ₄ ²⁻) ●	
K⁺ 19 Potassium ion ●	Ca²⁺ 20 Calcium ion ●	Sc³⁺ 21 Scandium ion ●	Ti⁴⁺ 22 Titanic titanium ●	V⁵⁺ 23 Vanadium ion e.g., as vanadate ●	Cr⁶⁺ 24 Chromium, e.g. as chromate (CrO ₄ ²⁻) ●	
Rb⁺ 37 Rubidium ion ●	Sr²⁺ 38 Strontium ion ●	Y³⁺ 39 Yttrium ion ●	Zr⁴⁺ 40 Zirconium ion ●	Nb⁵⁺ 41 Niobium (or Columbian) ion ●	Mo⁶⁺ 42 Molybdenum e.g., as molybdate ●	
Cs⁺ 55 Cesium ion ●	Ba²⁺ 56 Barium ion ●	La³⁺& REEs 57-71 Lanthanum ion ●	Hf⁴⁺ 72 Hafnium ion ●	Ta⁵⁺ 73 Tantalum ion e.g., as tantalate ●	W⁶⁺ 74 Tungsten (Wolfram) ion e.g., as tungstate ●	Re⁷⁺ 75 Rhenium ion ●
Fr⁺ 87 Francium ion ●	Ra²⁺ 88 Radium ion ●	Ac³⁺ 89 Actinium ion ●	Th⁴⁺ 90 Thorium ion ●	Pa⁵⁺ 91 Protactinium ion ●	U⁶⁺ 92 Uranium, e.g. as uranyl (UO ₂ ²⁺) ●	

Caveats:

- 1) Colors of specific samples of minerals are commonly controlled by minor or trace elements, or are caused by vacancies of defects.
- 2) The colors shown here are generalizations among the mineral groups listed above (i.e., a generalization of the color of the carbonate, nitrate, phosphate, etc. of a cation)
3. "White" and "colorless" are both shown as white on this table.

Intermediate Cations (Cations with some remaining outer-shell electrons)

Ti³⁺ 22 Titanium ion ●	V⁴⁺ 23 Vanadium ion ●	Cr³⁺ 24 Chromic chromium ●	Mn³⁺ 25 Manganese ion ●	Fe³⁺ 26 Ferric iron ●	Co³⁺ 27 Cobaltic cobalt ●	Ni³⁺ 28 Nickel ion ●	Cu²⁺ 29 Cupric copper ●	S⁴⁺ 16 Sulfur as sulfate (SO ₃ ²⁻) ●	As⁵⁺ 33 arsenate (AsO ₄ ³⁻) ●	Se⁶⁺ 34 as selenate (SeO ₄ ²⁻) ●									
Ti²⁺ 22 Titanium ion ●	V³⁺ 23 Vanadous vanadium ●	Cr²⁺ 24 Chromous chromium ●	Mn²⁺ 25 Manganous Mn ●	Fe²⁺ 26 Ferrous iron ●	Co²⁺ 27 Cobaltous cobalt ●	Ni²⁺ 28 Nickel ion ●	Cu⁺ 29 Cuprous copper ●	Sn⁴⁺ 50 Stannic tin ●	Sb⁵⁺ 51 e.g., as antimonate ●	Te⁶⁺ 52 tellurate ●									
Zn²⁺ 30 Zinc ion ●	Ga³⁺ 31 Gallium ion ●	Ge⁴⁺ 32 Germanium ion ●	As³⁺ 33 Arsenic e.g., as arsenite ●	Se⁴⁺ 34 Selenium ion e.g., as selenite ●	Zn²⁺ 30 Zinc ion ●	Ga³⁺ 31 Gallium ion ●	Ge⁴⁺ 32 Germanium ion ●	In^{1,3+} 49 Indium ion ●	Sn²⁺ 50 Stannous tin ●	Sb³⁺ 51 Antimony ion, as in antimonites ●	Te⁴⁺ 52 Tellurium ion, as in tellurites ●	I⁵⁺ 53 Iodine, as iodate (IO ₃ ⁻) ●							
Mo⁴⁺ 42 Molybdenum ion ●	Ru^{3,4+} 44 Ruthenium ion ●	Rh²⁺ 45 Rhodium ion ●	Pd²⁺ 46 Palladium ion ●	Ag⁺ 47 Silver ion ●	Cd²⁺ 48 Cadmium ion ●	Pb²⁺ 82 Plumbous lead ●	Bi³⁺ 83 Bismuth ion ●	Po 84 Polonium ●	W⁴⁺ 74 Tungsten (Wolfram) ion ●	Re⁴⁺ 75 Rhenium ion ●	Os⁴⁺ 76 Osmium ion ●	Ir⁴⁺ 77 Iridium ion ●	Pt²⁺ 78 Platinum ion ●	Au⁺ 79 Gold ion ●	Hg⁺ 80 Mercurous ion ●	Tl⁺ 81 Thallic thallium ●	Pb²⁺ 82 Plumbous lead ●	Bi³⁺ 83 Bismuth ion ●	Po 84 Polonium ●
U⁴⁺ 92 Uranium ion ●	Hg²⁺ 80 Mercuric ion ●	Tl³⁺ 81 Thallic thallium ●	Pb⁴⁺ 82 Plumbic lead ●	Bi⁵⁺ 83 Bismuth ion ●															

Main observations:

1. Most minerals with color contain intermediate cations.
2. Minerals of hard cations typically have no color, unless impurities or defects give them color.
3. Exceptions to Observation 2 occur in hard cations of high (e.g. 6+) charge, probably because these cations have not truly lost all their outer shell electrons.

La³⁺ 57 Lanthanum ion ●	Ce⁴⁺ 58 Cerium ion ●	Pr³⁺ 59 Praseodymium ion ●	Nd³⁺ 60 Neodymium ion ●	Sm³⁺ 62 Samarium ion ●	Eu³⁺ 63 Europium ion ●	Gd³⁺ 64 Gadolinium ion ●	Tb³⁺ 65 Terbium ion ●	Dy³⁺ 66 Dysprosium ion ●	Ho³⁺ 67 Holmium ion ●	Er³⁺ 68 Erbium ion ●	Tm³⁺ 69 Thulium ion ●	Yb³⁺ 70 Ytterbium ion ●	Lu³⁺ 71 Lutetium ion ●
Rare earth elements (REEs)													
La³⁺ 57 Lanthanum ion ●	Ce³⁺ 58 Cerium ion ●	Pr³⁺ 59 Praseodymium ion ●	Nd³⁺ 60 Neodymium ion ●	Sm³⁺ 62 Samarium ion ●	Eu²⁺ 63 Europium ion ●	Gd³⁺ 64 Gadolinium ion ●	Tb³⁺ 65 Terbium ion ●	Dy³⁺ 66 Dysprosium ion ●	Ho³⁺ 67 Holmium ion ●	Er³⁺ 68 Erbium ion ●	Tm³⁺ 69 Thulium ion ●	Yb³⁺ 70 Ytterbium ion ●	Lu³⁺ 71 Lutetium ion ●

Source: all data about color of solids are from Weast, R.C., 1985, CRC Handbook of Chemistry and Physics (Boca raton, CRC Press) 2362 p.