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Letter

Sodium nanoparticles in alkali halide minerals: Why is villiaumite red and halite blue?

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Abstract

The presence of metal Na nanoparticles causes the bright, thermally unstable colors of villiaumite (NaF) and halite (NaCl). These nanoparticles have been suspected for a long time to be caused by external irradiation. Metal nanoparticles, often referred to as metal colloids, cause surface plasmon resonance effects, characterized by a single Lorentzian-shaped absorption band. The color of these minerals is due to metal Na nanoparticles of 2.5–3 nm. A key point is that the resonance wavelength, which corresponds to the maximum of the absorption band, is inversely related to the value of the refractive index of the embedding mineral. This causes the position of the main absorption band to be offset downward by 140 nm in halite relative to villiaumite. As a consequence, the optical transmission window is shifted from the long to the short wavelength domain, explaining the color of blue halite and red villiaumite, respectively. Similar refractive index dependence may explain the purple color of fluorite caused by metallic Ca nanoparticles. Finally, the origin of the villiaumite irradiation may be the presence of Th-rich (about 8.8 wt% ThO_2) nano-inclusions, about 500 nm large, illustrating the specific geochemistry of peralkaline rocks where villiaumite is found.

Keywords: Villiaumite, halite, fluorite, peralkaline rocks, color, radiation damage, UV-visible spectroscopy, nanoparticles; Nanominerals and Mineral Nanoparticles