Geophysical Research Abstracts
Vol. 20, EGU2018-8807, 2018
EGU General Assembly 2018

Unique, reverse dichromatism in andalusite related to total pleochroism of the Fe2+-Ti4+ IVCT

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We document a dichromatism effect in gem andalusite that turns from light brownish pink at low thickness to medium green at high thickness. This color shift is roughly reverse to that usually observed in all other dichromatic materials such as chlorophyll, pumpkin oil, Usambara tourmalines… where color shifts from roughly green at low thickness to roughly red at higher thickness. This is due to the presence of two transmission windows in the visible absorption spectrum, and the competition between them at various thicknesses. Hence, dichromatism in these cases is intrinsically related to an alexandrite effect.

In andalusite, colors are strongly pleochroic: they vary from a strongly absorbing orangey-brown in the c direction to much less absorbing medium green in a and b directions. The brown absorption is so strong that it becomes opaque (black) for thickness above about 1.5 mm (this value may vary according to concentration of the chromophore and intensity of the light source), and hence does not contribute to coloration anymore. For such high thicknesses, only a and b directions remain transparent, and hence only the green component contributes to the color and the sample appears green. For lower thicknesses, the green color combines with the orangey-brown color that becomes transparent, resulting in a light brownish pink. Hence, we show that reverse dichromatism in andalusite is due to a very strong pleochroism, and not to an alexandrite effect. To our knowledge, this is unique to andalusite.

From trace elements analysis in zoned samples, we also confirm that the dark orangey-brown color is due to Fe2+-Ti4+ inter-valence charge transfer, and bring evidences that the light green color is due to the combination of isolated Fe3+ and Mn3+.