

Oxidizing Heat Treatment of Sapphires at 1850°C

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Heat treatment is one of the most common techniques to enhance the colour of rubies and sapphires. Several descriptions of the colour reactions upon treatment have been published. However, the only concept proposed so far violates several theoretical considerations and contradicts practical observations.

Based on new experiments, a graphical model of the interaction of trace elements with respect to causes of colour in corundum is presented for the system $\text{Al}^{3+}\text{-Fe}^{2+/3+}\text{-Ti}^{4+}\text{-Mg}^{2+}$ at 1850°C.

Blue and yellow sapphires from different localities were heat treated for 5 hours at 1850°C in a gas furnace with slightly oxidizing atmosphere, to destroy structurally bonded OH-groups and to develop the strongest possible colour. Afterwards the trace element contents (electron microprobe) as well as the absorption coefficients of the spin-forbidden Fe^{3+} transition bands and the $\text{Fe}^{2+}/\text{Ti}^{4+}$ - and $\text{Fe}^{2+}/\text{Fe}^{3+}$ -charge transfer bands (UV-VIS-NIR-microscope) were determined. The measurements of the spin-forbidden Fe^{3+} transition bands agree well with literature data.

When we calculate at first colourless MgTiO_3 clusters by stoichiometry and then with the remaining Ti and Fe content FeTiO_3 clusters (so-called colour-effective FeTiO_3 clusters), a linear correlation of this FeTiO_3 value with the absorption coefficient of the $\text{Fe}^{2+}/\text{Ti}^{4+}$ -charge transfer band is observed. Samples show precipitates after heat treatment the Ti content exceeds the Mg+Fe content. All yellow sapphires coloured by defect centres show an excess of Mg after calculating the colourless MgTiO_3 clusters. It was demonstrated with flame-fusion grown sapphires that, in addition to the excess of Mg, small amounts of Fe (about 50 atom mol ppm) are necessary to develop similar defect centres like the natural ones.