Category: Cautionary Note
Subcategory: Corundum Irradiation Pre-results
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INDUCED AMORPHIZATION OF ZIRCON THROUGH IRRADIATION

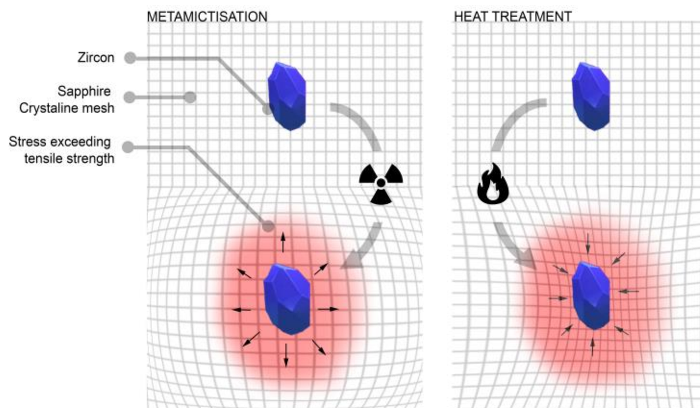
Abstract

182 Pink sapphire from Madagascar (Ilakaka) comprising of 74 heat-treated in our Bangkok facilities (from 500 to 1400 ^{o}C) and 108 not heat-treated as well as 258 Rubies from Mozambique both totalling 369 carats were irradiated using a ^{60}Co γ-ray source from 1 kGy up to 576 kGy for a maximum period of 37 days. Gemmological properties have been collected before and after using standard and advanced gemmological testing. The results show that the disorder degree of Zircon in Sapphire may increases without visible damage to the structure depending on the irradiation dose.

Introduction

Low heat treatment (<1000 ^{o}C) of pink sapphires especially from Madagascar (Ilakaka) present an important challenge for the gemmologist, due to the important overlapping consequence of Metamictisation and/or thermal expansion of radioactive protogenetic zircon present in abundance in Ilakaka sapphire (*see figure 1*).

Figure 1: Plastic deformation of Zircon in Corundum



Albeit not new, Raman spectroscopy on zircon inclusion specifically the quantification of the anti-symmetric stretching vibration through the full width at half maximum (FWHM) of ν_3 use to estimate the degree of structural damage, recently gain interest among some gemmological laboratories as an important indication of thermal treatment detection [1],[2],[3] (*see figure 2*).

Simultaneously the spotlight has been focused on the recent cautionary note of an irradiation treatment assumed to be gamma rays in Sri Lanka [4], followed by the implementation of mandatory or optional colour stability testing for rubies and sapphires by many laboratories [5].

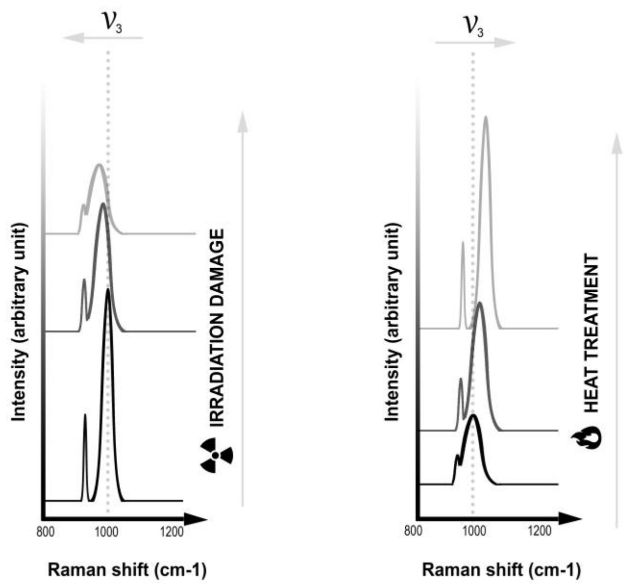


Figure 2: FWHM changes of ν_3 in Zircon after heat treatment and/or irradiation.

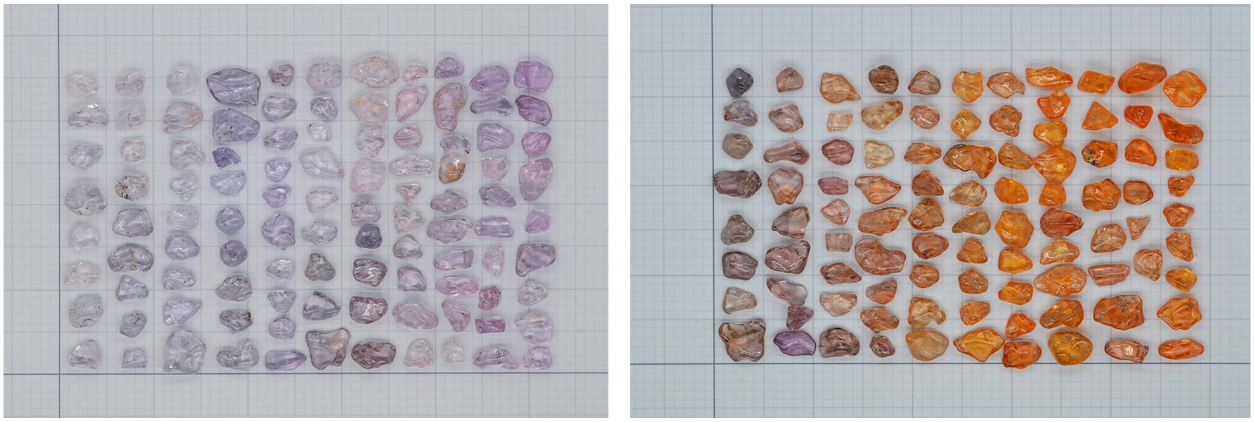
The metamictisation of Zircon is reversible up to the critical amorphization temperature [6]. Low heat treatment decreases the disorder degree of the zircon while irradiation (natural and/or induced) increase its disorder. We can see that irradiation shift the Raman band in lower frequency as well increasing its FWHM, while low heat treatment creates the opposite effect. Therefore, it must be interpreted with extreme caution as both may come from treatment.

Results and discussion

More than 80% of the pink sapphire change to an intense to vivid orange after irradiation, which completely disappear after been exposed to 15 minute of a strong halogen lamp (*see figure 3*). While rubies from Mafic-Ultramafic (Mozambique) origin have no noticeable changes in colour at any gamma irradiation level upon reception.

Figure 3: Gamma Irradiation of Pink sapphire before and after.

Before Irradiation *After Irradiation*



Some Zircon inclusion after a high irradiation present complete decomposition, the causes remain unclear, further research is ongoing focusing on the fraction of the gamma energy converted to heat in the corundum lattice, the homogeneity results of structural damage in zircon done by gamma irradiation, the roles of trace elements, as well as the possible interaction of gamma irradiation in OH related absorption bands.

Irradiation of sapphires is not new, but we may ask why the regain interest to treat a gem with a treatment that will stay for a very small amount of time, easily detectable and partly removable by gemmologist with standard equipment in this ever more integrated supply chain. The focus of the treatment may possibly not be its colour changing properties.

Conclusions

The present pre-assessment is a cautionary note on the interpretation of Raman spectroscopy in Zircon inclusion in Sapphire for the detection of low heat treatment. As the conclusion of thermal treatment based on zircon disorder degree alone may potentially open the possibility of a two-step treatment: heat followed by irradiation, therefore giving the erroneous interpretation of no indications of heating.

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