COLOUR ENHANCEMENT OF SRI LANKAN GEM-QUALITY QUARTZ BY GAMMA-RAY & NEUTRON-BEAM IRRADIATION

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P.R.K.FERNANDO

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Abstract

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P.R.K.Fernando
Postgraduate Institute of Science
University of Peradeniya

The colour of gemstones originates due to three basic factors, namely, crystal field splitting, charge transfer transitions and colour centres. Various techniques like heat treatment, diffusion, impregnation and laser treatment are used to enhance colour of gemstones. High-energy radiation (e.g. γ-rays, X-rays) and high-energy particles (e.g. α-rays, β-rays, neutron-beams) also can be employed for this purpose. It is believed that irradiation induces colour by generating colour centres. This research was carried-out to understand the colour enhancement of Sri Lankan gem-quality quartz by γ-rays and neutron-beams. According to the literature search, it was understood that this would be the first ever publishing research report on irradiation of any gem-species in Sri Lanka.

Although many varieties of quartz are available in Sri Lanka, citrines (yellow), amethysts (violet), water-clear quartz (colourless) and green quartz were selected for this study, considering their distinct colour differences. Faceted (cut and polished) stones and thin-sections prepared from above varieties were used for experiments. Gamma irradiation was carried-out at the Atomic Energy Authority (AEA) of Sri Lanka. The irradiation source was a Co-60 gamma irradiator capable of providing a dosage of irradiation of 7.5 kGy/hr (kiloGray per hour). Whenever the colour changes of gemstones are found to be very sensitive to irradiation, the dosage of irradiation was increased in steps of 5 kGy to reach a maximum of 50 kGy, whereas significant colour changes were not observed, irradiation dosage was increased in steps at 25 kGy, 50 kGy or 100 kGy to reach a maximum of 500 kGy. Fifteen to twenty samples from each variety of quartz including both faceted stones and thin-sections were gamma irradiated. Neutron irradiation using Am/Be (Americium and Beryllium) source was carried-out at the Department of Physics, University of Peradeniya. Five to ten samples

from each variety were neutron irradiated. Colour enhancements of quartz by irradiation were studied under the UV-Visible spectrophotometer at the Department of Chemistry, University of Peradeniya.

Water-clear quartz turned into smoky quartz and citrines turned into smoky yellow colour under low dosages of γ-rays (5 kGy to 25 kGy) whereas amethysts and green quartz did not show any visible colour change even by subjecting them to high (50 kGy to 500 kGy) dosages of γ-rays. During neutron irradiation citrines turned into deep yellow colour, whereas water-clear quartz, amethysts and green quartz did not show any visible colour change. The reason for the colour enhancement of both water-clear and citrines is the formation of $(AlO_4)^{4-}$ hole colour centres.

No radioactivity was found in these irradiated quartz samples. Therefore, these colour-enhanced quartz samples are safe to wear. Also it was noticed that the enhanced colours are stable enough under mild sunlight.

In the gem-market, smoky quartz is more valuable than water-clear quartz, thus gamma irradiation is a useful technique to add value to water-clear quartz. The deep yellow coloured citrines are more valuable than its light colours and thus neutron irradiation can be used for value addition of citrines.