ABSTRACT

Gem stones are those stones which have beauty that can be based on its color, transparency, brilliance (degree to which light is scattered) and the crystalline perfection (no minerals or other inclusions).

Topaz $Al_2SiO_4(F,OH)_2$. Aluminum fluoro-hydroxyl-silicate, it belongs to class silicates and subclass cyclosilicates and it is used mainly as gemstones, It is the most common irradiated gem on the market.

High energy such as neutrons, have enough energy to produce color centers .Irradiation is most often carried out in nuclear reactors (high-energy neutrons). Irradiation of topaz in the Egyptian research reactor (ETRR-2) by neutrons changes its cloudy white color to a reddish pink which could be changed to blue by heating.

Nuclear reactions inside the irradiated stones produce radioisotopes, resulting to residual radioactivity. Residual radioactivity is potentially a problem; therefore stones have to be stored in storage for a period of time to reduce the residual radioactivity aiming to reach the safety level of transportation. The storage time of the stones is dependent on trace element concentrations connected with their life-times in topaz. Therefore, inspection of the trace elements in the stones and their half-life times are essential before irradiation.

Trace elements may cause residual radioactivity after neutron irradiation. This undesired residual radioactivity could be detected by trace element analytical techniques such as Laser Ablation Inductively Coupled Plasma Mass spectrometer (LA-ICPMS), Energy Dispersive X-rays (EDS), and Neutron Activation Analysis (NAA).

Topaz consists mainly of SiO_2, Al_2O_3 and variable amounts of F and OH group. Raman studies of irradiated and unirradiated stones at different temperatures and irradiation times showed a relation between the bands of scattered peaks corresponding to (OH) stretching modes of vibration with the color changes.

Samples were irradiated using transition pneumatic system (Rabbit system) for short time in the range (10-30) second and long irradiation in the hours range.

After irradiation of stones by neutrons, they have to be transefered into the auxiliary pool until their radioactivity reduces to permissible level, then transfered to hot cells for further treatment.

The Egyptian Second Research Reactor, (ETRR-2) is a Multipurpose Reactor, (MPR) at Inshas, Cairo Egypt. ETRR-2 is a 22 Mw, an open pool type and maximum thermal neutron flux of 2.7×10^{14} n cm^{-2} s^{-1} (neutron trap). The reactor is located at Inshas site of the Egyptian Atomic Energy Authority (EAEA) 60 km from Cairo-Egypt.

The apparatus used in the measurements consists of:

- ICP-MS based on double-focusing mass spectrometers (JMS-PLASMAX2) is applied for the analysis of topaz samples to investigate minor, trace and ultra trace element concenterations.

- Neutron activation analysis (NAA) is used to determine isotopes in the irradiated samples. NAA is an analytical technique based on the measurement of characteristic radiation from radio nuclides formed directly or indirectly by neutron irradiation of material of interest.

- NAA is used to study residual radioactivity in topaz after irradiation.

- NAA and radiation protection apparatuses are used to meet International Air Transport Association (IATA) regulations for radioactive materials transfer.

- Raman spectrometer is used to explain how coloration process is established in gemstones. Raman spectroscopy comprises the family of spectral measurements made on molecular media based on inelastic scattering of monochromatic radiation. During this process, energy is exchanged between the photon and the molecule such that the scattered photon is of higher or lower energy than the incident photon. The difference in energy is cause of by a change in the rotational and vibrational energy of the molecule and gives information on its energy levels.

- ICP-MS and NAA analyses are compared.

- Raman spectrometer is used to study variations in Raman spectra of different irradiated topaz samples at different times and at different temperatures.