# Radiation Induced Colour and Crystal Defects in Topaz

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Changes of the colour of Topaz on $\gamma$-irradiation and corresponding crystal defect induced changes of X-ray transparency and IR spectra are observed and discussed.

Topaz, an aluminium flourosilicate, has the formula $Al_2[F_2|SiO_4]$, where F is generally replaced in varying amounts by OH. Some colourless topaz, when treated with $\gamma$-rays, high energy electrons or neutrons, develop brown and/or blue colour [1]. The present note deals with the distribution of the brown colour caused by $\gamma$-irradiation and the corresponding crystal defects, as revealed by the infrared spectra. Several crystals of colourless Brazilian topaz were treated by $\gamma$-rays, upon which certain parts of the crystals turned brown.

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The crystals could be devided into two types, according to the distribution of colour. In the first type of crystals the colour was confined in certain mantle zones, running parallel to the prism faces, leaving the central part of the crystal colourless (Figure 1). The colouration in the second type of crystals, on the other hand, was not zonal but quite uniform in one part, while the other part remained colourless; the boundary between the coloured and the colourless region was sharply marked (Figure 2).

X-ray radiograms of 2 mm thick plates cut perpendicular to the *c*-axis of the crystals showed that the brown coloured areas of the treated crystals had become more transparent to X-ray, due to the radiation induced crystal defects, than the colourless areas, which remained unaffected by irradiation.

In addition to that, the infrared spectra (Fig. 3) of the samples taken from the brown coloured regions differ from those taken from the colourless regions of the crystals, particularly between 3650 $cm^{-1}$ and 3400 $cm^{-1}$.

This phenomenon is correlated with the crystal defects produced by irradiation. According to [2] the $Fe^{2+}$ impurity atoms in topaz are ionized to $Fe^{3+}$ by the irradiation and the free electrons are localized on

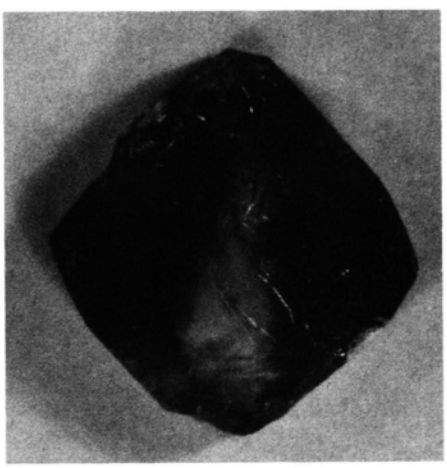

Fig. 1. Effect of $\gamma$-irradiation in a topaz crystal (first type): Crystal plate (001) cut perpendicular to the *c*-axis; mantle zone turned brown, middle part remained colourless.

Fig. 2. Effect of $\gamma$-irradiation in topaz (second type): Crystal plate (001) cut perpendicular to the *c*-axis; sharp boundary between the brown and colourless part of the crystal.

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the $(OH)^-$ vacancies, forming defect centers. It was proposed, that special hydroxide sites, rather than the crystallographically identified ones, correlate with the formation of brown colour centers [3].

X-ray topographic investigation of the treated topaz (in progress) may be helpful in localizing the crystal defects more exactly.

[1] K. Nassau, Gems of Gemology, Spring (1985).
[2] A. N. Platonov and P. Belichenko, Morfol., Svoistav, Genesis Mineralov AN Ukr. SSSR 69 (1965).
[3] R. D. Aines and G. R. Rossmann, Amer. Miner. 71 (1986).

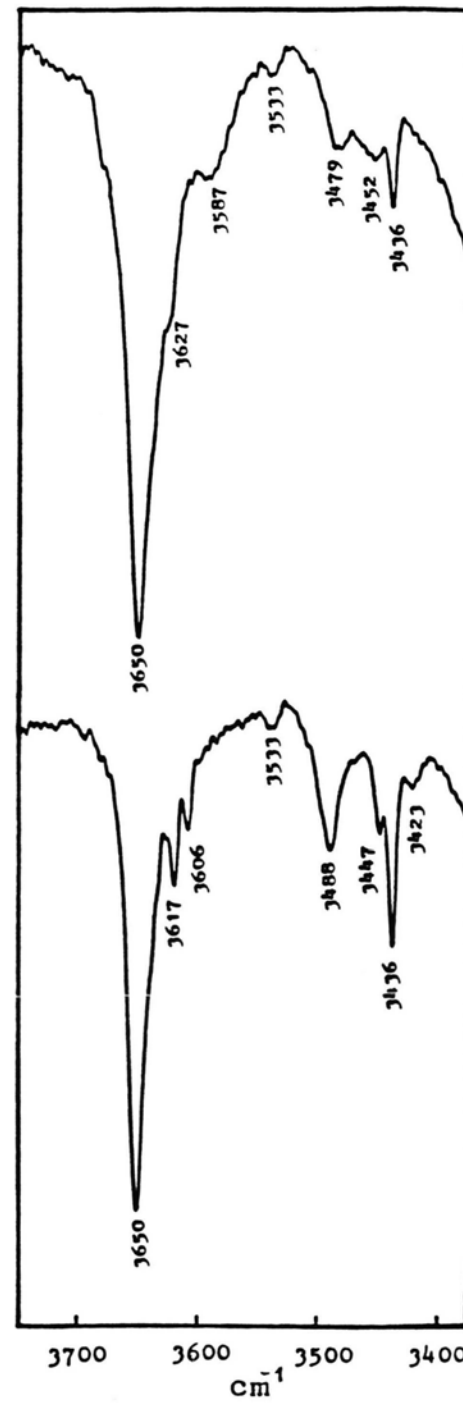


Fig. 3. IR spectra of a topaz after $\gamma$-irradiation. *Top:* colourless region; *below:* brown coloured region.


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