Thermoelastic properties of radiation-damaged zircon

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Radioactive decay of unstable isotopes causes damage to zircon, which significantly reduces its elastic stiffnesses (e.g., Özkan, 1976). These damages can be partially healed by temperature treatment of the zircon crystal. In order to study in situ the recrystallization of radiation-damaged zircon, thermoelastic properties, and thermal expansion data were collected between 100 K and 1600 K utilizing resonant ultrasound spectroscopy, dilatometry, and high-temperature powder x-ray diffraction. The investigated samples of natural gem-quality zircon belong to the damage stage I introduced by Holland & Gottfried (1955), i.e., the damage in the crystal structure is mainly dominated by the accumulation of isolated point defects.

While non-metamict zircon samples display a linear decrease in elastic stiffnesses, the partial radiation-damaged zircon samples undergo strong irreversible effects detected in all utilized methods. The increase of elastic stiffnesses starts at about 700 K, while the thermal expansion decreases (Fig. 1). The severity of this effect becomes more pronounced with an increasing initial state of damage and thus can be related to the healing of defects induced by radioactive decay. A second effect sets in at about 1100 K, likely related to a transition from static to dynamic behavior. This supports the idea that reducing radiation damage is a multi-stage process, including point defect healing and recrystallization of an amorphous fraction.

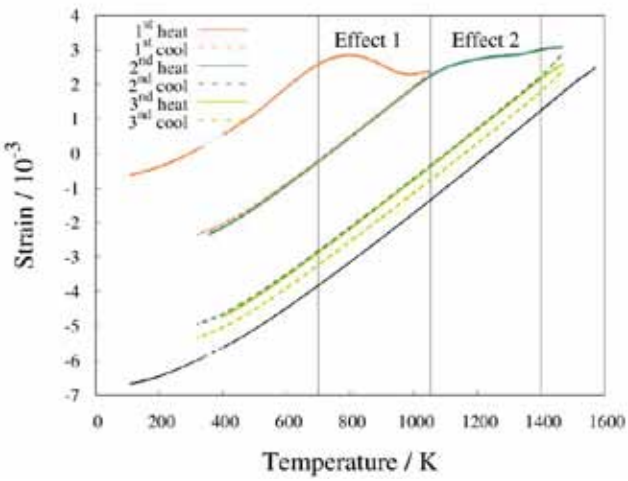

Figure 1. Different effects observed in thermal strain of radiation damaged zircon compared to non-metamict zircon (black line).

Özkan H (1976): Effect of nuclear radiation on the elastic moduli of zircon. - J Appl Phys 47, 4772-4779
Holland H, Gottfried D (1955): The effect of nuclear radiation on the structure of zircon. - Acta Cryst 8, 291-300