

Heat treatment of zircon samples from Kanchanaburi, Thailand and Ratanakiri, Cambodia

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Introduction

Zircon is a valuable and beautiful gemstone. The favourite colour of zircon in the gem market is blue, which is commonly obtained by heating the reddish brown variety. Heat treatment of zircon is the most conventional method to improve their colour. The famous locality of heated blue zircon is Ratanakiri Province, North Eastern Cambodia. Nowadays, the amount of gem quality rough zircon is decreasing because mining areas are mainly replaced by rubber plantation. Then, zircon samples from another source have been investigated for heat treatment. Kanchanaburi Province, Thailand is an important source of blue sapphire; besides, zircon has also been found in sapphire mining areas. Zircon samples from Kanchanaburi are also reddish brown in colour similar to those of from Ratanakiri, but are smaller in size. The aim of this study is to examine and compare the heat treatment results of zircon samples from Ratanakiri and Kanchanaburi.

Materials and Methods

Some reddish brown zircon grains from Kanchanaburi, Thailand and Ratanakiri, Cambodia, were sampled for heat treatment experiments. They were polished as flat surfaces before further investigations. The physical properties and spectroscopic characteristics (UV-Vis-NIR and FTIR) of the samples were observed, measured and recorded before and after each step of heating experiment. Heating experiments were carried out in a reducing atmosphere. For each experiment, three maximum temperatures, 800 °C, 900 °C and 1000 °C, were set for one hour soaking time.

Results and Discussion

After heating at 800 °C, zircon samples from both localities lost their reddish brown colour. The samples from Kanchanaburi changed from reddish brown to light yellow and near colourless. The blue shade in the Cambodia samples was intensified after heating at 900 °C and 1000 °C, respectively (figure 1).

Most reddish brown zircon samples from Ratanakiri deposit have a potential to reach the best colour when thermal enhancement is applied under the proper conditions. Dark reddish brown samples appear to become dark blue after heat treatment at 1000°C.

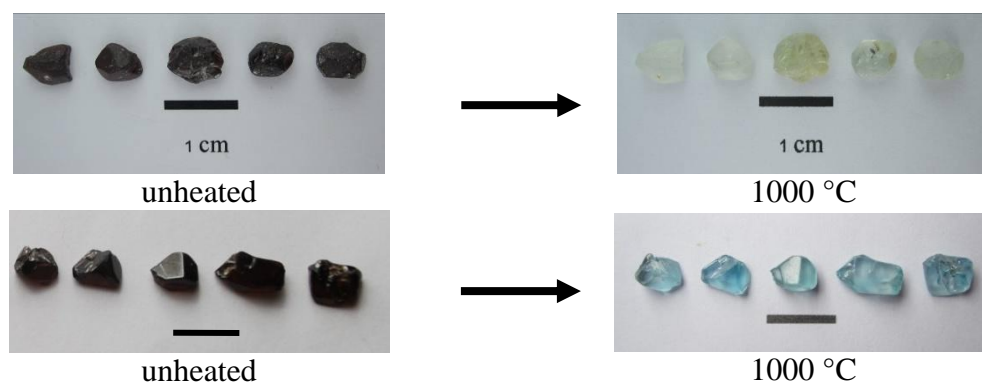


Figure 1. Zircon samples from Kanchanaburi, Thailand (top) before and after heat treatment in a reducing atmosphere at 1000 °C, compared to those of from Ratanakiri, Cambodia (bottom).

In this study, the FTIR spectra of zircon samples from Kanchanaburi and Ratanakiri are unique and clearly applied to separate unheated samples from the heated ones. The appearances of absorption peaks at 4072 and 4262 cm^{-1} are found only in unheated samples, which are due to OH-stretching; after heating these peak positions disappeared, while an absorption peak at 4833 cm^{-1} became visible (Zhang et al., 2003).

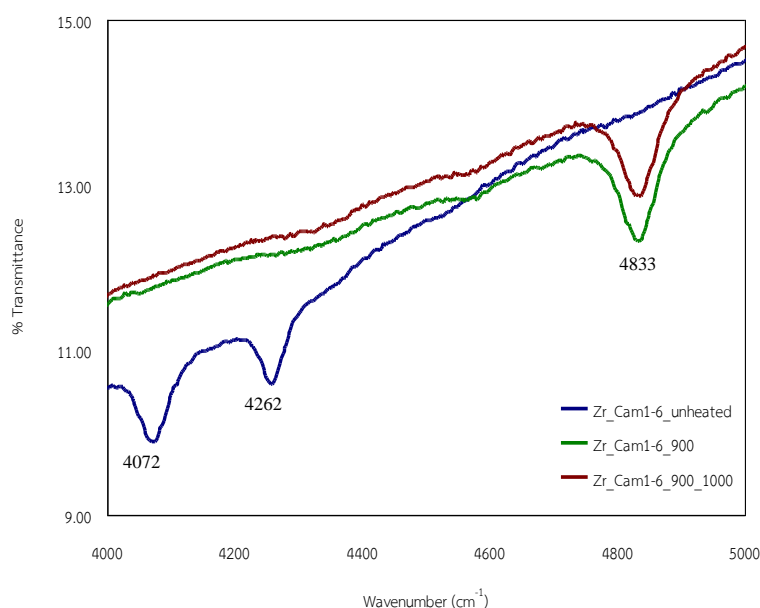


Figure 2. FTIR results of zircon samples before and after heat treatment.

The UV-Vis-NIR absorption spectra (figure 3) show that the change of colour after heat treatment is mainly caused by a change of valence state of uranium. The transition of U^{5+} to U^{4+} at 653 nm (Zhang et al., 2003) occurred during heating and this phenomenon produced the blue colour in the samples from Ratanakiri. In contrast, this absorption was not found in the heated samples from Kanchanaburi, which showed the near colourless and light yellow colour.

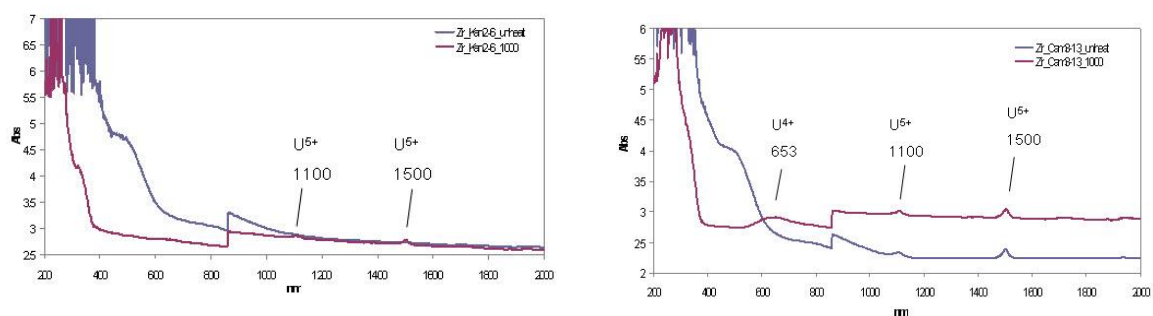


Figure 3. UV-Vis-NIR spectra of zircon samples from Kanchanaburi, Thailand (left) and Ratanakiri, Cambodia (right). Blue spectra: unheated samples; Purple spectra: heated samples.

Conclusion

Results of this study clearly indicate that the zircon samples from Ratanakiri, Cambodia have a potential for thermal enhancement. They can be changed from reddish brown to blue. The suitable condition for heat treatment is at 1000 °C for 1 hour soaking time, in a reducing atmosphere. However, the tested samples from Kanchanaburi deposit, Thailand, turned colourless after heating. Causes of blue colour can be obviously evidenced by the absorption of U^{4+} at 653 nm in UV-Vis-NIR spectra. FTIR spectra can be used to distinguish unheated from heated samples.

References

Zhang, M., Salje, E. K. H. and Ewing, R. C., 2003. Oxidation state of uranium in metamict and annealed zircon: near-infrared spectroscopic quantitative analysis. *Journal of Physics: Condensed Matter*, Vol. 15, p. 3445-3470.

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