Forum Comment

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Release of uranium from highly radiogenic zircon through metamictization: The source of orogenic uranium ores

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INTRODUCTION

McGloin et al. (2016) propose that metamict zircon from U-Th-K-rich A-type granites, like the Kitty Plain Microgranite (KPM) in the Mt Isa Inlier, Australia, would be a major source of U for what they termed "orogenic uranium deposits." This interpretation is supported mainly by synchrotron X-ray fluorescence spectroscopy and electron microprobe mineral mapping of zircon crystals and associated alteration minerals. In this Comment, I demonstrate that metamict zircon from such A-type granites can provide only minor amounts of U. However, importantly, these granites contain other types of accessory minerals, much richer in U than zircon, such as uranothorite and allanite, which are known to be U sources for many types of U deposits (e.g., Bonnetti et al., 2016, and references therein).

ZIRCON AS A URANIUM SOURCE

In the KPM, Zr contents vary from 164 to 282 ppm (McGloin et al., 2016, GSA Data Repository 2016004) but the U content of zircon is not provided. According to Belousova et al. (2003), average U content of zircon from granites is 764 ppm. In A-type granites, average U content of zircon may reach several thousand parts per million (e.g., Appleby, 2007). An average content of 250 ppm Zr in the KPM corresponds to 500 ppm $ZrSiO_4$; Zr comprising ~50% of the zircon mass. Taking an average content of 2000 ppm U in the zircon, the contribution of zircon to the whole rock U content is 1 ppm U only (i.e., $500 \times 10^{-6} \times 2000 \times 10^{-6}$). This simple calculation demonstrates that the quantity of U hosted within zircon represents <10% of the average U content (11.3 ppm) of the KPM. Consequently, if metamict zircon is considered to be a U source, it cannot be a major contributor.

IMPORTANCE OF OTHER ACCESSORY MINERALS AS A U SOURCE

The KLM A-type granite corresponds to a high-K calc-alkaline granite according to Cuney (2014), or the A2-type granites of Eby (1992). Such granites are typically metaluminous ($0.86 < (Al/2Ca+Na+K)_{KLM} < 0.88$ in cationic proportions), rich in K, U, and Th. The common U-Th-bearing accessories in this type of granite are uranothorite or allanite (Cuney and Friedrich, 1987; Cuney, 2014). Uranothorite may host up to 30 wt% UO_2, and allanite several wt% (Cuney and Friedrich, 1987). These two minerals are silicates with much higher U-Th contents, and become more rapidly metamict than zircon. The presence of metamict thorite crystals can be seen in McGloin et al. (2016, their figures 4A and 4B) as orange-colored areas attributed to a Th-Zr silicate. Like zircon, thorite is tetragonal and partial solid solutions exist between these two minerals (Förster, 2006), explaining the occurrence of Zr together with Th and Si in the orange areas of the EMP images. In McGloin et al.'s figure 4A, Zr-rich thorite crystal (orange-colored) exhibits epitaxial growth around an earlier zircon crystal (in yellow). The zircon crystal is highly fragmented because it has suffered intense alpha irradiation from the enclosing thorite crystal. Around this composite crystal, radial microfissures, enriched in U, have developed in the enclosing minerals. In figure 4B, the Zr-rich thorite is located above the zircon crystal which is here much less damaged. To the left of the thorite crystal, a 30-µm-wide red rim, attributed to a U-Th-Zr silicate, developed along the contact with plagioclase. This red zone should correspond to an irradiation rim caused by alpha particles in which U liberated from the former Zr-rich uranothorite has migrated together with some Th and Zr.

ORIGIN OF THE Zr-ENRICHMENT

McGloin et al. relate Zr-enrichment in the U deposits of the Mount Isa area to highly saline fluids which would have dissolved fluorite and rare earth element (REE) fluocarbonates in the KPM, "allowing concurrent CO_2 and F complexation with U, Zr, and REEs." The mechanism proposed in the last part of the sentence is difficult to understand. Even, if carbonates are dissolved by the saline fluids, CO_2 has a very limited solubility in such fluids (Carvalho et al., 2015). Furthermore, no saline fluid has been described in the Na-metasomatic U deposits of Vallalah (Polito et al., 2012), or in the largest deposits of this type in Ukraine (Cuney et al., 2013). In Na-metasomatic deposits, the commonly observed Zr-enrichment is attributed to enhanced Zr solubility in the highly alkaline hydrothermal fluids associated with Na-metasomatism (e.g., Aja et al., 1995; Cuney et al., 2014).

CONCLUSIONS

Metamict zircon cannot be considered as a major U source in the KPM, because the amount of U in the structure of zircon represents less than 10% of the whole rock U content. Another major uranium-bearing accessory mineral, such as Zr-rich uranothorite, can account for the major part of the U content within the KPM, and may have represented a U source for the U deposits and showings from the Mount Isa Inlier.

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