

Large heterogeneity in a small rock body—U-Pb dating and trace element imaging of Zr and Th minerals in a serpentinite body of the Sanbagawa metamorphic belt

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The analysis of various accessory minerals, especially zircon, using laser ablation inductively coupled plasma mass spectrometry (LA-ICPMS) has significantly contributed to the progress of Earth sciences in recent decades. To advance geological research utilizing rapidly evolving analytical techniques, there is a need for exploration of new available accessory minerals, isotopes, and geochemical indicators. In this context, we discovered an aggregate of fibrous crystals of baddeleyite, with a length of up to 2 mm, in the Higuchi Serpentinite body (HSB) exposed in Kanto mountains. The HSB is a 15 m × 8 m serpentinite body characterized by a block-in-matrix structure due to deformation, surrounded by pelitic schist and featuring a layer of chlorite rock with a thickness of several tens of centimeters at its boundary. The baddeleyite aggregate was found only in one block of approximately 50 cm within the HSB, despite observing about 50 kg of serpentinite samples without finding additional occurrences. Porous zircons with a width of less than 20 μm were observed at the edges of the baddeleyite aggregate. Results of U-Pb dating by LA-ICPMS indicated an age of ca. 95 Ma for both baddeleyite and zircon. Furthermore, analysis of U-Pb dating spots and trace element imaging revealed localized areas within baddeleyite and zircon with high Th/U ratios of >10 at sub- μm scales. No correlation was observed between Th/U ratios and U-Pb ages. On the other hand, the chlorite rock at the edge of the HSB exhibited Th-enriched minerals such as monazite and thorite, present only in a few specific areas. Monazite occurred both as individual crystals and surrounding the edges of apatite crystals. In general, Zr and Th are classified as high field strength elements and are considered immobile during low-temperature hydrothermal alteration. Conversely, the present study, specifically the mm-scale Zr enrichment and μm -scale Th enrichment, indicate extremely localized mobilization and precipitation during alkaline hydrothermal activities associated with serpentinitization. LA-ICPMS analysis proves to be a crucial tool for understanding the age constraints and chemical characteristics of such hydrothermal events. To effectively utilize this, techniques are needed to efficiently discover milli- to sub-millimeter-scale accessory minerals in areas ranging from a few meters to tens of meters, such as reaction zones at boundaries of geological bodies. Fast elemental imaging by micro-XRF for large rock sections holds the potential to fulfill this role.

Keywords: inductively coupled plasma mass spectrometry , laser ablation , zircon, baddeleyite, phosphate mineral