geoconvention
Virtual Event
September 21-23
2020
CSPG • CSEG • CWLS • GAC • MAC • IAH

Radionuclides in Zircon and Monazite: Implications to Age Dating and Mining

Mashrur Zaman
Geology Division, Agat Laboratories Ltd.

Summary

This study investigates the variations of crystal-chemical properties of zircon and monazite due to the presence of radionuclides and variable chemical composition in their crystal structures using single-crystal X-ray diffraction (SCXRD), conventional and synchrotron high-resolution powder X-ray diffraction (HRPXRD), X-ray fluorescence (XRF) and electron-probe micro-analysis (EPMA) techniques. Zircon crystal from the Canadian Arctic region has the smallest unit-cell parameters and bond distances, ideal stoichiometric composition, and has least amounts of uranium and thorium. On the other hand, another zircon crystal from Jemaa, Nigeria reveals the large structural parameters such as unit-cell parameters, average <Zr-O>, and Si-O distances and contains a significant amount of uranium and thorium. The SCXRD data for monazite showed that although the *a* and *b* unit-cell parameters vary systematically, the *c* unit-cell parameter does not vary with the unit-cell volume, *V*. The polyhedral arrangement along the [001] direction in the monazite structure is the O-O edge sharing between Ce polyhedra and P tetrahedra, and the P tetrahedra are stacked along this direction, resulting in limited variation of the *c* parameter. The increase or decrease of *a* unit-cell parameter is very pronounced and is related to the type of cations occupying the Ce site in monazite structure. The <Ce-O> distances for monazites obtained with SCXRD vary linearly with *V* but <P-O> distances do not show any correlation, which explains the rigid body behavior of PO_4 tetrahedron. Although the structure refinement of SCXRD data for the two granitic pegmatitic monazites resulted in single phase with the space group $P2_1/n$ and no violations of systematic absence in the reflections, the refinement of synchrotron HRPXRD data revealed more than one phase with distinct crystal structural parameters. One phase in each pegmatitic monazite showed large average <P-O> distances and may be related to radiation-induced changes. The monazite sample from Iveland, Norway contains an additional xenotime phase with the space group $I4_1/amd$ because of the redistribution of La, Ce, Pr, Nd, Sm, Gd, Dy, Si, and Y atoms. The main driving thermal energy for phase changes possibly comes from α-radiation events over a long geological time. Thus, the extent of internal radiations effect in the zircon and monazite structure is critical factor while both minerals are being used for geochronological study. Besides, the internal radiation doses for U and Th can damage the crystal structure and reduce the stability of mineral structure. Eventually, radionuclides can be exposed to the terrestrial environment during mining activity.