American Mineralogist, Volume 85, pages 633–648, 2000

Th-Pb ion-microprobe dating of allanite

E.J. CATLOS,[1,*] SORENA S. SORENSEN,[2] AND T. MARK HARRISON[1]

[1]Department of Earth and Space Sciences and Institute of Geophysics and Planetary Physics, University of California, Los Angeles, California 90095-1567, U.S.A.
[2]Department of Mineral Sciences, NHB-119, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560, U.S.A.

ABSTRACT

Allanite, which is a common accessory mineral in a wide variety of rock types, typically contains high concentrations of Th and U; thus, an in-situ method of U-Th-Pb dating of this phase would have broad application. We describe a method to permit Th-Pb ages of allanite to be determined with approximately ±10% accuracy using a high-resolution ion microprobe. Knowledge of the composition and substitution mechanisms of this complex mineral is key to understanding the relative ionization efficiencies of Th^+ and Pb^+. The chemical compositions of three allanite samples used as age standards (Cima d'Asta Pluton, 275.5 ± 1.5 Ma; Atesina Volcanic Complex, 276.3 ± 2.2 Ma; La Posta Pluton, 94 ± 2 Ma) were determined using an electron microprobe, permitting an assessment of matrix effects on ionization. An ion-microprobe calibration curve involving elemental and oxide species of Th and Pb (i.e., $^{208}Pb^*/Th^+$ vs. ThO_2^+/Th^+) yields highly scattered apparent ages when allanite age standards with different Fe contents are used. However, a three-dimensional plot of $^{208}Pb^*/Th^+$ vs. ThO_2^+/Th^+ vs. FeO^+/SiO^+ improves the accuracy of the calibration to about ±10%. Even though this level of uncertainty is substantially greater than that expected for U-Th-Pb ion-microprobe analyses of zircon or monazite, Th-Pb ages of allanite can still be used to address important geologic questions.

We used this method to date two metamorphic allanite grains from the footwall of the Main Central Thrust, Nepal Himalaya, and an allanite grain from the Pacoima Canyon pegmatite, California. Allanite inclusions in garnet from Nepal yield significantly older ages than the coexisting monazite, indicating that allanite formation in these rocks records a previous metamorphic cycle that predates slip along the fault. The Pacoima Canyon allanite grain yields a younger age than that reported for zircon, implying Pb loss during cooling of the pegmatite.