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Timescales of Metamorphism, Deformation, and Migmatization in an Exhumed Continental Arc, North Cascades USA

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Methodology

Zircon and monazite were recovered from eleven leucosome samples, two biotite gneisses, and a metapelite through standard mineral separation techniques. Representative accessory minerals were selected based upon the color and morphology of the grains; in general, clear, euhedral grains were targeted. All grains were mounted in epoxy, polished and imaged using cathodoluminescence on a JEOL Superprobe 733 at the Massachusetts Institute of Technology (MIT) in order to evaluate the zoning/growth history of each crystal. Grains were selected based on zoning characteristics, plucked from the epoxy, and either analyzed as a whole grain or broken into smaller pieces to evaluate differences between the interior and rims. Prior to analysis, the grains underwent chemical abrasion following Mattinson (2005). The grains were annealed at 900 °C for 60 hours. Individual grains were then placed in 300 µl Teflon FEP capsules containing 75 µl HF at 180 °C for 12 hours to dissolve any inclusions and/or radiation-damaged portions of the grains. The leached grains were rinsed and sonicated in a series of steps involving H₂O, 6N HCl and 3N HNO₃. After rinsing, the grains were dissolved in 75 µl full strength HF with a mixed $^{205}$Pb-$^{233}$U-$^{235}$U tracer at 220 °C for 48 hours. The dissolved grains were dried to salts and then redissolved at 180 °C for 12 hours in 75 µl 6N HCl. Prior to adding the solutions to the columns, the 6N HCl solution was dried to salts and
then redissolved in 50 µl 3 N HCl. Pb and U were extracted from the dissolved grains by a HCl-based single-column anion exchange procedure modified after Krogh (1973). The dried Pb and U mixture was dissolved in silica gel (Gerstenberger and Haase, 1997) and loaded onto a previously degassed Re filament for analysis by thermal ionization mass spectrometry (TIMS) using the MIT VG Sector 54 multi-collector mass spectrometer. Pb isotopes were measured by peak-jumping on a Daly detector. U was measured as UO$_2^+$ with masses 270, 267, and 265 in the axial, H2, H1 faraday collectors, respectively. Pb isotope fractionation was corrected based on repeat analyses of NBS981 using a value of $0.25 \pm x$ %/amu. Use of the $^{233}$U-$^{235}$U double spike, allows real time correction for U fractionation.

For the monazite, similar procedures to the zircon method were followed; however, the grains were not annealed or chemically abraded. Monazites were dissolved in 75 µL 12N HCl with the same mixed $^{205}$Pb-$^{233}$U-$^{235}$U tracer at 220 ºC for 48 hours.

Following data acquisition, all data were evaluated statistically using Tripoli software (Bowring et al., 2008; McLean et al., 2008) and reduced using the algorithms of Schmitz and Schoene (2007). All dates were calculated using the decay constants of Jaffey et al. (1971). For both zircon and monazite, all $^{204}$Pb was assumed to be from lab blank and the data were corrected using measured lab blank isotopic compositions. The zircon analyses have been corrected for $^{230}$Th disequilibrium by assuming a magma Th/U ratio of 4. The zircon data is presented in standard concordia diagrams (Fig. 7, 12, 13) and Table 2 and the individual $^{207}$Pb/$^{235}$U dates are reported for monazite in Fig. 10 and Table 3.