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The importance of material characterization in (U-Th)/He thermochronometry: Diffusivity of He and heterogeneous distribution of U and Th in monazite

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(U-Th)/He thermochronometry of accessory minerals such as apatite, zircon, titanite and monazite have begun to provide excellent constraint on the low temperature thermal histories of orogenic systems. However, as the technique matures, complications such as composition-dependent and or thermal history-dependent closure temperatures, and increasingly complex recoil corrections have limited the precision and accuracy of the technique. In order to evaluate these complexities, microanalytical techniques are required. We describe here an alternative to conventional laser-heating (U-Th)/He: Excimer laser-ablation (U-Th)/He chronometry (ExLA-He). This technique provides μm-scale spatial resolution, rapid sample throughput, and the ability to evaluate chemical variations which can affect both the precision and accuracy of (U-Th)/He chronometry.

As an example, we present the first ExLA-He of monazite from the Nanga Parbat massif, Pakistan. These monazites contain weight percent U+Th, are variably zoned, and would have complicated ejection corrections, in addition to large ^{230}Th-induced ^{4}He excesses. Despite these complications, our preliminary data demonstrate the excellent reproducibility of ExLA-He, with 5 individual laser dates from one monazite crystal yielding a mean closure age of 1.020 Ma $\pm$ 0.044, ($<$5% at 2σ, while another yields an apparent age of 0.413 Ma $\pm$ 0.011 ($<$3% at 2σ, N =2. As would be expected, these ages are younger than 0.6-1.5 Ma U-Pb ID-TIMS ages for the same samples (Crowley et al., in prep).

Interpreting these (U-Th)/He ages in terms of exhumation rates requires assuming a closure temperature (T_c), which may be a function of monazite composition (Stockli

and Farley, unpublished). Until a quantitative composition-diffusivity relationship is determined, the best manner of constraining the T_c for a specific monazite is to perform step-heating experiments on the same sample. Because only small volumes of monazite are needed for ExLA-He geochronology, we can perform both T_c and multiple age determinations on the same crystal. Step-heating experiments in progress will further constrain the closure temperature for these specific monazites.