Laser microprobe (U-Th)/He thermochronometry of monazite

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Monazite, with it's high U and Th contents (up to a few wt.%), is an excellent candidate for high-precision low-temperature thermochronometry on the young rocks found in orogenic systems such as the Himalayas. However, strong parent-element zonation common in natural monazites, in combination with their typically small size (<100µm) would likely result in large, poorly constrained recoil corrections. In addition, preliminary diffusion data suggests closure temperature (T_c) variations in excess of 50C°, possibly due to variations in composition (Farley and Stockli, unpublished, and our data, to be presented here). These issues combine to make conventional furnace or laser-heating ages difficult to interpret. An alternative is excimer laser-ablation (U-Th)/He chronometry (ExLA-He), which enables all of the above problems to be minimized or avoided completely.

We present the first ExLA-He of monazite from the Nanga Parbat massif, Pakistan. 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 ± 0.044, (<5% at 2σ), while another yields an apparent age of 0.413 Ma ± 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., this volume), and are also consistent with existing apatite fission track data (e.g. Zeitler et. al, 1985, summary in Treloar et al., 2000).

Using existing diffusion data for He in monazite, the spatially variable T_c corresponding to the individual ExLA-He dates range from ~100 C° to ~250 C°. The wide range in modeled exhumation rates that would be derived from this data is in large part due to the uncertainty in T_c for these specific samples, emphasizing the need for more detailed diffusion studies, as well as chemical characterization of individual grains used for (U-Th)/He chronometry. Step-heating experiments in progress will further constrain the closure temperature for these specific monazite crystals, thereby providing more precise exhumation rate constraints.

As methodological refinement continues, ExLA-He of monazite should prove to be a useful chronometric tool for leucogranites and other appropriate lithologies.

Evidence for underestimation of long-term FT annealing in apatite from natural FT and (U-Th)/He data

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Apatite Fission Track (AFT) data from cratons have commonly been interpreted in terms of major episodes of sedimentary burial and subsequent denudation, often in the absence of any remaining sedimentary sequences or other supporting geological evidence. Reconciling these interpretations with geologically documented episodes of denudation or outcropping regional stratigraphy can be problematic. Also, repeatable apatite (U-Th)/He ages from cratonic igneous rocks that are older than paired AFT ages are commonly discarded as 'too old.' For example, AFT data from Finland and central Sweden have been interpreted to reflect, first, burial by a Caledonian foreland basin several kilometres in thickness and, subsequently, its denudation. However, there is no supporting geological evidence that such a deep, extensive foreland basin ever existed in this area and indeed some geological evidence points to the contrary. Repeatable apatite (U-Th)/He ages from this area are in many cases older than their AFT pairs but have been interpreted by their authors as 'too old' relative to the AFT ages and not geologically meaningful. Additionally, extreme local variation between AFT ages exists, which cannot be attributed to variations in apatite chemistry or structural offset.

We demonstrate that AFT data from Finland and central Sweden are largely a function of the apatite uranium content. Studies related to nuclear waste disposal have shown radiation-enhanced lattice repair (α-annealing) is dominant over thermal annealing at sub-APAZ temperatures. Increased uranium content enhances lattice repair, and thus may be expected to reduce AFT ages and MTLs. Existing annealing models would compensate by predicting excess *thermal* annealing, which would be conventionally interpreted as a heating-cooling cycle. Thus we suggest that 1) AFT ages in cratons are 'too young' rather than that the (U-Th)/He ages are 'too old'; 2) repeatable sequences of (U-Th)/He ages are more likely to record the true denudation history of cratons, and 3) interpretations of cratonic AFT data based on conventional FT annealing models significantly overestimate sedimentary burial and subsequent denudation. Where apatite uranium concentrations are sufficiently high, young AFT data are potentially also compromised.