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Daniel F. Stockli[1], Kenneth A. Farley[2] (1) University of Kansas, Lawrence, KS (2) California Institute of Technology, Pasadena, CA

Deciphering Thermal Histories Through Apatite (U-Th)/He Multi-Grain-Size Analysis

Apatite (U-Th)/He dating has been shown to be a powerful tool to elucidate low-temperature thermal histories and quantify upper-crustal processes such as basin burial and inversion histories. However, individual (U-Th)/He age determinations, much like K/Ar analyses, are total gas ages and in contrast to fission track length measurements and $^{40}Ar/^{39}Ar$ step-heating experiments do not reveal any thermal history information. The Apatite (U-Th)/He system is characterized by a closure temperature of ~70ºC (10ºC/Myr cooling rate) and a partial retention zone (HePRZ) between ~80 and ~40ºC. Studies have shown that He diffusivity correlates with the physical dimensions of the apatite crystal, indicating that smaller grains are less retentive of He than larger grains (Reiners and Farley, 2001). Therefore the analysis of multiple grain size fractions can be used as a tool to constrain the cooling history of individual samples and to more fully reconstruct thermal histories. To demonstrate the feasibility of (U-Th)/He multi-grain-size analysis as a thermal history tool, we systematically analyzed multiple grain size fractions from the Cajon Pass drill hole, California. We performed laser single-grain analyses of different grain size fractions from different samples with down-hole temperatures ranging from 28 - 84ºC. Our results show the predicted systematic correlation between age and grain size. In particular, samples within the HePRZ display a large dependence of apatite (U-Th)/He ages on grain size, indicative of very slowly cooling. These data illustrate that grain size sensitivity of apatite (U-Th)/He ages can be used to deduce thermal history information by analyzing multiple grain sizes from a single sample.