Combining $^{4}He/^{3}He$ thermochronometry with LA-ICPMS maps of U and Th to extract low temperature cooling paths

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The U-Th/He system is sensitive to low temperatures (<100ºC), and thus constrains the timing of thermal conditions of crustal rocks in eroding landscapes. However, overdispersion of (U-Th)/He ages can represent an obstacle to extracting accurate and precise thermal paths. An alternative to analysis of (U-Th)/He ages of multiple crystals from the same rock sample is to collect a large amount of information from one or two crystals using $^{4}He/^{3}He$ thermochronometry, which measures the spatial distribution of ^{4}He within an individual crystal [*1*]. The observables are a function of both the contunuous thermal path of the sample and the spatial distribution of the parent nuclides. In regions of low erosion rates and thus slow cooling rates, the $^{4}He/^{3}He$ spectrum commonly deviates from canonical trends. This is likely due to different parts of the crystal effectively evolving separately due to radiation damage and annealing. If such complexity within an individual crystal is adequately understood, each crystal has potential to tightly constrain its continuous thermal path. Here, we present an example from Yosemite Valley in which the $^{4}He/^{3}He$ spectra for three different crystals from the same sample are internally inconsistent under the assumeion of spatital uniform parent nulides. As revealed by laser ablation ICP-MS data from polished sections through the same crystals, U and Th zonation is the cause of the differences between samples. However, the smearing of zonation boundaries due to large ablation spot sizes impedes accurate recovery of thermal paths. This can be accounted for by using linear inverse methods with spatial smoothness constraints designed to deconvolve overlapping spots. We will show how the resulting high-resolution map can then be used to infer the spatial distribution of U and Th, and, when combined with $^{4}He/^{3}He$ data, accurately constrain the crystal's contunuous thermal path.

References: (*1*) Shuster and Farley, 2004, *Earth and Planet. Sci. Lett.* 217, 1–17.