Incorporating $^{4}He/^{3}He$ thermochronometry datasets into exhumation rate inversions

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$^{4}He/^{3}He$ thermochronometry measures both the (U-Th)/He age and the spatial distribution of radiogenic ^{4}He within individual apatite crystals. Together, these two observations constrain the temperature histories of rocks from depth to near Earth's surface (*1*). Because the $^{4}He/^{3}He$ method is sensitive to temperatures characterizing the uppermost crust, $^{4}He/^{3}He$ datasets are particularly useful for quantifying and understanding spatiotemporal trends in exhumation and topographic relief change. Formal inverse methods used to model exhumation rates through space and time (e.g., *2*) often define the inverse problem in terms of closure temperatures (T_c) of different thermochronometric systems. $^{4}He/^{3}He$ datasets are not readily incorporated into such inversions because the $^{4}He/^{3}He$ release spectra constrain details of a sample's continuous time-temperature (*t-T*) path, as opposed to one modeled age.

Here, we describe an approach to include $^{4}He/^{3}He$ data and other thermochronometric datasets with release spectra (e.g., K-feldspar $^{40}Ar/^{39}Ar$) into existing inverse methods. First, we identify *t-T* paths that predict both the observed (U-Th)/He age and $^{4}He/^{3}He$ release spectrum of a given sample. From this family of *t-T* paths, we extract the distribution of times corresponding to 80, 55, and 30 ºC. We then define the age and uncertainty of three artificial thermochronometers to be the mean and standard deviation of each time distribution, with T_c equal to the extracted temperatures. These artificial ages and their uncertainties can then be incorporated as additional thermochronometric systems into existing inverse methods. We illustrate the influence of incorporating $^{4}He/^{3}He$ data using this approach with a large compilation of thermochronometric data (n ~300) from southern Tibet.

References: (*1*) Shuster and Farley, 2004, *Earth and Planet. Sci. Lett.* 217, 1–17. (*2*) Fox *et al.*, 2014, *Earth Surf. Dyn.* 2, 47–65.