Supplementary Material

Introduction

Text in the supplementary (**Text S1**) is a detailed description of Pecube.

Text S1

Pecube is a finite element code designed for solving the three-dimensional heat transport equation [1]. Its primary purpose is to assess and evaluate geomorphic and tectonic scenarios by comparing them to thermochronological data. Pecube allows users to utilize a variety of ages of thermochronological systems to predict the thermal structure, surface change, and exhumation history. In forward mode, a series of fixed thermal parameter values, such as thermal diffusivity and crustal heat production, are combined within a tectonic plot. This process exports the temperature–time path for a particle and the evolution of the 3D crustal temperature field over time, and then Pecube calculates ages for a variety of thermochronological systems using the temperature histories and compares them to observed ages. A yardstick parameter misfit is used to evaluate the mismatch degree between observed ages and predicted ages. The misfit is expressed as the function below:

$$misfit = \sqrt{\frac{1}{N}\sum_{i}^{N}\frac{(A_{Oi} - A_{Pi})^2}{eA_i^2}}$$

where N is the total number of age constraints, A_{Oi} and A_{Pi} are the observed and predicted ages of data point i, respectively, and eA_i^2 represents the error of the age constraint for point i.

Inversion is essentially a range of forward modeling, which employs the neighborhood algorithm (NA) developed by Malcolm Sambridge [2,3] to search the parameter space and extract the best-fit scenarios. The result of the NA calculation is represented by posterior probability density functions (PPDFs), either in 1D or 2D. The purpose of the inversion is to assist us in understanding the sensitivity of the provided parameters or to constrain some parameters in the model.

Table S1. Sheet 1 shows the summary of the age and rate of individual rift in NSTRs. Sheet 2 shows the summary of the end time of motion along the STDS.

Table S2. shows the input data in our Pecueb model, including the data in this study and previous studies.

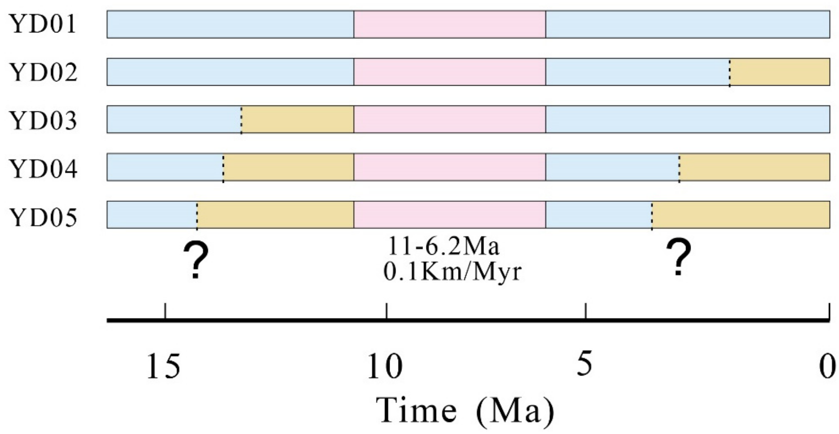

Figure S1. Exhumation periods and transition times of each model. Light blue and light yellow represent the exhumation periods with uncertain rates, and pale pink represents the exhumation period determined by the age–elevation relationship between 11 and 6.2 Ma. The black dotted line represents the uncertain transition time.

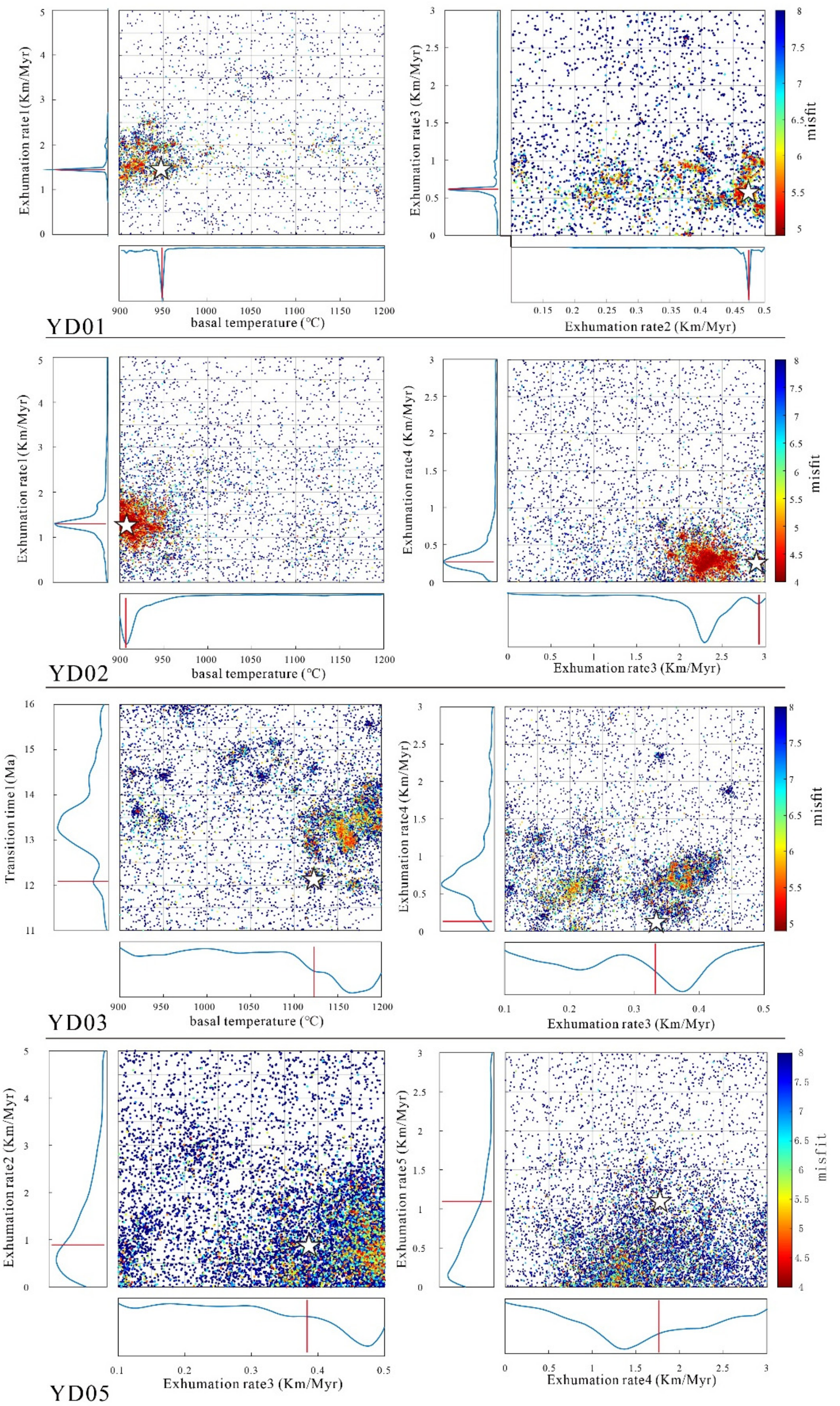

Figure S2. Scatterplots of the Pecube inversion results for models YD01, YD02, YD03, and YD05. Colored dots represent individual forward-model runs, with colors corresponding to misfit values between predicted and observed data (blue dots represent the highest misfit, and red dots represent the lowest misfit). Adjacent to the axes are the posterior probability density functions (PPDFs) for parameter values. The white star on the plot represents the best-fit solution. YD01: basal temperature versus exhumation rate of stage1, exhumation rate of stage2 versus exhumation rate of stage3;

YD02: basal temperature versus exhumation rate of stage1, exhumation rate of stage3 versus exhumation rate of stage4; YD03: basal temperature versus transition time between stage1 and stage2, exhumation rate of stage3 versus exhumation rate of stage4; YD05: exhumation rate of stage3 versus exhumation rate of stage2, exhumation rate of stage4 versus exhumation rate of stage5.

Reference

1. Braun, J. Pecube: a new finite-element code to solve the 3D heat transport equation including the effects of a time-varying, finite amplitude surface topography. *Computers & Geosciences* **2003**, *29*, 787-794, https://doi.org/10.1016/S0098-3004(03)00052-9.
2. Sambridge, M. Geophysical inversion with a neighbourhood algorithm—I. Searching a parameter space. *Geophysical Journal International* **1999**, *138*, 479-494, doi:10.1046/j.1365-246X.1999.00876.x.
3. Sambridge, M. Geophysical inversion with a neighbourhood algorithm—II. Appraising the ensemble. *Geophysical Journal International* **1999**, *138*, 727-746, doi:10.1046/j.1365-246x.1999.00900.x.