Low-Temerature Thermochronology Course – Fission Track Dating

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Forward & Inverse Modeling of Apatite Fission Track Data

OBJECTIVE: Gain an intuition for how to quantify permissible thermal histories from measured apatite fission track (AFT) data (ages and track lengths). Learn a common software tool (HeFTy) for forward & inverse modeling of AFT data and develop some of your own results and interpretations on two real sample data sets.

INSTRUCTIONS:

- You will use the program HeFTy developed by Richard Ketcham. For additional information see Chapters 11 & 22 of the MSA vol. 58 on low-temperature thermochronology.
- I recommend to create a folder 'FTexercise' to store your data/results.
- HeFTy is already installed on ….
- Download this document, HeFTy manual (if needed) and the sample data from ...

IMPORTANT NOTES:

HeFTy: Windows platform only. When you save your work on HeFTy it creates an .hft file.

HINTS: Click directly on t or T axis to change the maximum value. Right click on an imposed t-T constraint to delete it or all of them. Right click on the segment parameter abbreviation (e.g. 2E) to change its behavior. Right click on a plot to save as an image file to the clipboard and then past it into your write up. The HeFTy manual in .pdf is included so that you can figure out anything else on your own.

EXERCISES: There are two different samples you will work with for this lab. Each sample will have two files (grain ages & track lengths) with "BC" (Coast Mountains, B.C.) in the file name, the other "Sevier". **Perform the following steps 1-3 for EACH sample and START with the BC one first, then write up your results.**

Background on the samples you are working with:

1. The BC sample is from the Coast Mountains Batholith. The rock was a coarse to medium grained granodiorite. This batholith is thought to have cooled at mid crustal depths between ~160-80 Ma. More recent exhumation has brought it to the surface. The sample came from the bottom of an age-elevation profile (i.e. low elevation from valley bottom) collected in a previously heavily glaciated valley.
2. The Sevier sample was collected from exhumed foreland basin sediments in Utah. The basin deposits were originally sourced from exhumed Paleo- and Mesozoic sedimentary rocks in the hanging wall of a Sevier age (~120-50 Ma) mountain range. Consequently, the thermal history must at least involve a) initial cooling (~120-50 Ma) during Sevier deformation then b) transported as sediments at surface temperatures (~30-0°C shortly thereafter) then c) buried as sediment in a basin (i.e. reheated) and finally d) cooled again as it was exhumed to the surface.

1. *Loading the data*. Start HeFTy. Go to the "File" menu and select "New." Now go to the "Models" menu and click "Add AFT model." In the window that pops up click on the "Import" buttons for the Length and Age data to load the appropriate data files.

1. Take a minute to scan menus and input boxes in the 'AFT' tab/window. Make sure you know what the model inputs are and get a sense for what it is calculating.

2. Scan through the spreadsheet values for the length and age data windows to make sure these values make intuitive sense to you (e.g. are the track lengths reasonable?) and so you can get a sense for what the raw data looks like.
3. Now click on the "Kinetic Populations" button to view a plot of length and age data. Although we won't get into it in detail in this exercise, note that you can define different kinetic populations here that might effect track annealing. This can be VERY important for some samples – so make a mental note that this option exists.

2. *From time-temperature history to track lengths*. At first, you should get an understanding of how different time-temperature histories produce different track length distributions. This is also a good way to test whether your idea of an exhumation history holds up to the measured data. Click on the "Time-Temperature History" tab and play around a bit. Take a while to define different temperature histories and see how well you fit the measured track length distribution. While you are doing this, pay particular attention to how sensitive the track lengths are to when you have the sample go through the temperature range AFT data are most sensitive to (~150-60°C).

Fit the track length distribution and age as best you can. When you are happy with the result save the plots (right click on each graph and copy as a bitmap image and paste into MS Word for your write up). Also pay attention to how well you are modeling the age (bottom right of track length plot: Model v. Measured and GOF (= goodness of fit, where 1.00 is perfect match, 0 is no fit). Record the age and track length predictions and GOFs to the sample data from your best-fit model to include in your write up.

3. *Inverse models: Extracting time-temperature history from track length*. Go to the "Models" menu and click on the "Inverse Modeling" option. Set the number of simulations (Ending Condition) to ~500 in the beginning. You need to give the t-T history simulation some boundaries for its search, so click on some high temperature (>AFT-sensitive temperatures, i.e. 200-250°C) in the t-T history graph at some significant age (about 150 Ma since either sample was probably pretty hot and deep back then) and it will automatically pin the other end to surface temp (20°C) at today (0 Ma). Adjust some of the different pull down box options and "Start" the simulation to get a feel for what these boxes do. Now, uncheck the "watch it go" box (this increases computation speed a lot), set the ending condition back to 10,000 and run a final set of simulations. Export final plots you are happy with to your word document to include in your write up.

4. *Repeat, repeat, repeat*. Repeat the previous 3 steps for the Sevier sample files provided. Warning: this sample is a little trickier!

5. *Write up your results*. Collect your plots **in one document** and write answers to the following questions. For the plots generated for each sample do the following:
1. For the plots generated in part 2*:* write a short description explaining the source of any discrepancies (i.e. variations in the thermal history needed to fit the lengths better) between your best-guess thermal history and those generated by the inverse model. Was your thermal history part of a good or acceptable fit? Is your thermal history a unique solution to the data?
2. For the plots generated in part 3: write one short paragraph description of how you interpret the cooling history based on the a) brief geologic context of the sample provided above and b) inverse model results. Write this paragraph as if you were describing the sample in a scientific paper.