Putting the data to work - strategies for modelling multiple samples in multiple dimensions

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Modelling strategies for thermochronological data require a reliable model for annealing or diffusion. Given such a model, most approaches deal with the inference of a thermal history for a given sample. Various issues arise at this stage concerning the complexity of a thermal history and impact of laboratory uncertainty on the inferred geological timescale thermal history. In principle, it is straightforward to use multiple systems for a single sample (e.g. AFT, AHe, ZHe, ZFT). This requires some thought about the best measure of the fit to the combined data, and the recognition that there will be variable amounts of common information in the data as, in some cases, the thermal history information will be independent for each system.

We suggest it is preferable to combine data from multiple samples which have common thermal history information. This approach tends to reduce the uncertainty associated with the inferred thermal history, and also will typically lead to relatively simple solutions (i.e. reduces the potential for overinterpreting the data). It is straightforward to combine samples from different elevations from nearby locations – the vertical profile or 1D approach – assuming there are no structural disruptions between the samples. In this case we assume that the form of the thermal history is the same for all samples, but the lowest elevation (or deepest) sample is required to always be hotter than the highest elevation (or shallowest) sample, by an amount to be estimated as part of the modeling process. This allows us to estimate the palaeotemperature gradient directly and the approach can be used to assess whether this has changed over time.

To extend this concept to 2D and 3D, we need to group, or cluster, spatially separated samples with common thermal history. However, the problem is that we do not know in advance which samples we should group together, nor how many groups there should be. Within each cluster, we also need to estimate the thermal history and its uncertainty. While samples may be spatially close, their thermal histories may be very different due to faulting, for example, and so we need an approach that allows for this too. We solve this by using a method known as partition modelling, which allows us to sample many different clusters or partitions and make probabilistic inference of the most likely and range of possible partitions. We will present the general approach from 1D to 3D and discuss the application to both synthetic and real data examples.