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## How many grains do we need for tracer thermochronology?

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Detrital tracer thermochronology exploits the relationship between bedrock cooling age and elevation, whereby detrital cooling age distributions can inform the pattern of erosion in the upstream area. Typically bedrock ages exhibit a positive relation with elevation, since the exhumation path from the closure isotherm to the surface is longer. Therefore, spatially uniform erosion should yield a detrital cooling age distribution that mirrors the catchment's hypsometric curve, corrected for mineral fertility. Applying thermochronometers is time consuming and expensive, hence measured detrital age populations have a limited sample size (rarely exceeding 100 grains) and only provide an approximation of the natural continuous detrital age distribution. With such limited sample sizes, discerning between two detrital age distributions resulting from different erosional patterns may be statistically impossible at a high confidence level.

Here, we investigate the impact of sample size on the detrital cooling age distributions and the resulting uncertainty in addressing the erosional pattern of the upstream area. To do so, we forward model a continuous detrital age distribution as a function given parameters, such as catchment hypsometry, mineral fertility, exhumation rate, analytical uncertainty and erosion scenario. A random subsample of the entire detrital population is drawn for each possible sample size, from which an approximate cumulative distribution function (CDF) is calculated. Then we compute the divergence of the approximate CDF from the reference continuous CDF as well as from the continuous CDF obtained for a different erosion scenario. The confidence level at which an approximate CDF can be tied to a specific erosion scenario is iteratively estimated for each sample size. We carry out the outlined approach for a synthetic catchment with elevations ranging between 0.5-2.2 km, where bedrock cooling ages increase by 30 My/km and prescribing a 10% standard deviation for single grain ages.

We find that, if the location of the erosion maximum coincides with the peak of the hypsometric curve, 100 grains do not suffice to resolve a local tenfold increase in erosion at the 95% confidence level. In this worst case scenario 240 grains would be required. However, for the same case, 70 grains are enough at the 68% confidence level. This study provides a method to consistently quantify the uncertainty of detrital tracer thermochronology as a function of sample size, case-specific variables and the initial scientific question.