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Quantifying differential erosion across ancient structures using 3D Bayesian Partition Modelling

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In assessing the contribution of inherited structures and their reactivation to long term landscape evolution, we need to quantify the response of the landscape, such as the timing and amount of erosion across recognised structures. To this end, thermochronology is often used, exploiting the low temperature sensitivity of systems such as apatite fission track and (U-Th)/He analysis to infer cooling (as a proxy for erosion) over timescales of millions of years. One issue is how best to assess spatial variability in the signal, and in particular, whether we can resolve differential cooling across ancient structures, indicative of more recent reactivation.

Some of our recent work has led to new methods for simultaneous modelling thermal histories of multiple samples from different locations and elevations. One advantage of this approach is that we minimise problems in overinterpreting the data. In the simplest case, we group multiple samples into one large sample and look for a common thermal history. However, this generally doesn't provide a good fit to the observed data. In the more general case, we allow the samples themselves to determine how they should best be grouped together. This is achieved with Bayesian Partition Modelling in which we need to infer both the number and geometry of partitions (spatial groups), as well as the thermal history in each partition. Futhermore, our approach allows us to exploit the thermal information contained in vertical profiles to infer the palaeotemperature gradient at the same time. A natural consequence of this modelling strategy is that we can identify boundaries or discontinuities between regions requiring different thermal histories, and by association different erosion histories. These boundaries may then be interpreted to reflect major structural discontinuities which have been reactivated. We will present the basic methodology with examples from case studies.