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Constraining the effects of the mantle plumes in driving denudation by using a combination of low temperature thermochronometers

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Mantle plumes cause transient and permanent uplift on the crust underneath which they impinge, creating a new relief. The effect that this uplift has on denudation and on the landscape in general is, however, very poorly constrained In Scotland the offshore record indicates that sedimentation was enhanced in several pulses at around 60 Ma. The broad correspondence of these pulses with the volcanic activity related to the ancenstral Icelandic plume has been taken to indicate that sedimentation and hence denudation in the Palaeogene was driven by the mantle plume activity.

Here we present new apatite fission track (AFT) and (U-Th)/He (AHe) data from two sub-vertical profiles from the Scottish Highlands and the outer Hebrides. The AHe and AFT are older than the Tertiary magmatic activity. The AFT ages are Triassic and Permian , whereas the He ages are Jurassic to Cretaceous. The largest difference between the two chronometers (Δt) is shown by the samples at lowest elevation. The track length distributions indicate that the samples at the highest elevation have resided below 60˚C (the temperature below which the AFT thermochronometer is least sensitive to) for at least 100 Myr. The samples now at sea-level, however, show a bimodal track length distributions and short mean track lengths, which suggest they experienced two

periods of enhanced cooling, the second one occurring in the last 100 Myr. We use the variation in Δt and track length distributions along the vertical profiles to constrain the erosional response of the landscape. Exploiting the fact that the samples lie on sub-vertical profiles we are able to constrain the palaeogeothermal gradient and, thus, to calculate the total amount of denudation since the Tertiary. Also by modelling apatite fission track and (U-Th)/He together we constrain timing, amount and rates of denudation at the sample locations through time. We conclude that the western Scottish Highlands experienced a period of rapid denudation between 80 and 40 Ma during which 1.5 ± 0.3 km of crust was removed at the sample locations.

The low temperature thermochronological data do not resolve a rapid Neogene denudational event as inferred by geomorphologic and sedimentologic records in other areas of the North Atlantic. We conclude that either northern Britain was not affected by this event, or its magnitude was not sufficient (less than 1 km of erosion) to affect the fission track and/or the (U-Th)/He thermchronometers of rocks exposed at the surface.