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The U-series comminution approach: where to from here

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Quantifying the rates of landscape evolution in response to climate change is inhibited by the difficulty of dating the formation of continental detrital sediments. The 'comminution age' dating model of DePaolo et al. (2006) hypothesises that the measured disequilibria between U-series nuclides (^{234}U and ^{238}U) in fine-grained continental (detrital) sediments can be used to calculate the time elapsed since mechanical weathering of a grain to the threshold size ($\sim$50 μm). The comminution age includes the time that a particle has been mobilised in transport, held in temporary storage (e.g., soils and floodplains) and the time elapsed since final deposition to present day. Therefore, if the deposition age of sediment can be constrained independently, for example via optically stimulated luminescence (OSL) dating, the residence time of sediment (e.g., a palaeochannel deposit) can be determined.

Despite the significant potential of this approach, there is still much work to be done before meaningful absolute comminution ages can be obtained. The calculated recoil loss factor and comminution age are highly dependent on the method of recoil loss factor determination used and the inherent assumptions. We present new and recently published uranium isotope data for aeolian sediment deposits, leached and unleached palaeochannel sediments and bedrock samples from Australia to exemplify areas of current uncertainty in the comminution age approach.

In addition to the information gained from natural samples, Monte Carlo simulations have been conducted for a synthetic sediment sample to determine the individual and combined comminution age uncertainties associated to each input variable. Using a reasonable associated uncertainty for each input factor and including variations in the source rock and measured (^{234}U/^{238}U) ratios, the total combined uncertainty on comminution age in our simulation (for two methods of recoil loss factor estimation: weighted geometric and surface area measurement with an incorporated fractal correction) can amount to $\pm$ 220-280 ka. The modelling shows that small changes in assumed input values translate into large effects on absolute comminution age.

To improve the accuracy of the technique and provide meaningful absolute comminution ages, much tighter constraints are required on the assumptions for input factors such as the fraction of alpha-recoil lost ^{234}Th and the initial (^{234}U/^{238}U) ratio of the source material. In order to be able to directly compare calculated comminution ages produced by different research groups, the standardisation of pre-treatment procedures, recoil loss factor estimation and assumed input parameter values are required. We suggest a set of input parameter values for such a purpose.