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Age calibration of weathering fractures in desert clasts: A new approach to dating geomorphic surfaces in arid landscapes

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Advances in geomorphological and sedimentological research depend on the availability of reliable exposure age constraints. Establishing robust age models at a high spatial and temporal resolution is crucial for measuring rates of geomorphological change and decoding complex landscapes shaped by time-dependent forces, e.g. climate fluctuations. A number of isotopic and luminescence techniques are now available for dating geomorphic surfaces, however they remain expensive and time-consuming to deploy with detailed coverage over space and time in many study areas. For this reason, quick and accessible methods for correlating and extrapolating these chronologies are needed. In arid landscapes, among others, a variety of weathering-induced changes occur to geomorphic and sedimentary surfaces, and many of these processes occur at predictable rates and can be quantified using objective, field based measurements. One example is the gradual widening of fractures that exist within boulders on desert surfaces, by a combination of processes including salt weathering and freeze-thaw cycles. The recent emergence of very detailed exposure age models in a number of locations means it is now possible to measure the rates of desert weathering processes, and use them as fully calibrated age indicators themselves. With the potential to significantly extend the coverage of existing age constraints, this kind of quantitative age correlation would enable a broad range of geomorphological and sedimentological research that depends on detailed absolute age models. We have measured the mean widths of hundreds of vertical fractures that dissect granitic boulders, on a variety of alluvial surfaces in Owens Valley, California, which have themselves been independently dated in detail using cosmogenic nuclides. Our data demonstrates for the first time that these fractures widen at a predictable, steady rate of approximately 1 mm ka^{-1} for at least the last 150 ka, in this arid study area in the south-western United States. This finding, which is repeatable at a number of test sites, allows clast fracture widths to be exploited as a simple and powerful technique for the inexpensive dating of geomorphic surfaces in the field. We introduce a robust statistical method for this new approach to exposure dating, perform a full uncertainty analysis on its results, and discuss the potential usefulness of this technique in other arid landscapes.