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Rock particle fragmentation, as an alternative to fluvial transport, explains size sorting on arid hillslopes

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To date fluvial transport processes have been suggested as the underlying mechanisms explaining the sorting of rock particles on arid hillslopes, whereby mean particle sizes typically decrease in the downslope direction. Here we show that a dynamic fragmentation model of particles can also reproduce similar emergent patterns. We measured rock particle size distributions using photographic techniques on three mesa hillslopes slopes in the Great Sandy Desert, Australia. On each hill four transects were constructed in the direction of steepest descent and on each transect four photographs covering one square meter at a minimum resolution of 0.28 mm^2/pixel, were taken at each three meter interval to a maximum transect length of 60 meters. From the resulting photographs the projected Feret's diameter was determined following digitisation of individual rock particles. Rock particles were typically distributed lognormally at each location, with distributions narrowing and shifting to smaller sizes downslope. Both parameters of the lognormal distribution were found to decrease linearly with distance down the transects. As particle sizes were often much larger than those which could be expected to be transported downslope by fluvial processes on these short hills we assessed whether a dynamic fragmentation model could reproduce the observed patterns instead. The particle size distribution measured at the top of the slope was used as the initial condition. We further assumed that distance along a transect could be replaced by time in the fragmentation model. The model, with just two parameters, reproduced the observed trends in particle size distributions and did so better than the linear regressions. We found that in order for the fragmentation model to reproduce the observed behaviour a particular form of fragmentation was required where larger particles were less resistant to weathering fragmentation than smaller particles. Our results have implications for understanding the evolution of rock armoured slopes in natural and engineered contexts, sensitive to the dynamics of surface rocks affecting runoff, erosion and infiltration.