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Does pebble abrasion influence detrital age population statistics? A numerical investigation of natural data sets

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Pebble abrasion is a key-factor controlling the release of minerals into sand, but few attempts have been made to model how abrasion could influence the liberation of minerals into the size fraction used in detrital geochronology. Studies show that knowing the U-Pb zircon age distribution both in upstream source units and in a downstream mixed river sample is sufficient to obtain the 'real' (best-fit) mixing of these source units. An artificial sediment mixture can also be created by accounting for empirical variables (e.g., source area, zircon fertility and gravel supply) and the mismatch between the best-fit and the artificial age distribution can be used to inversely estimate modern erosion rates in watersheds. We run numerical experiments with a model based on Sternberg's law to test the influence of abrasion by using natural data sets (Marsyandi watershed, Himalaya). Initially, we test if and in which conditions pebble abrasion is able to cause statistically significant distortion in the U-Pb age distribution of zircons in fluvial sands. We then test if the erosion rates inversely estimated from the U-Pb age distribution changes when pebble abrasion is accounted. The results suggest that pebble abrasion can generate different amount of sands and change the zircon proportions of upstream source units in downstream river sediments as well as the U-Pb age distribution of mixed fluvial sands. This change in the U-Pb age distribution is statistically significant ($p < 0.05$) when there is a large variation in the abrasion rates of the source rocks (e.g., Δ 20 % mass loss/km-1). Interestingly, statistically significant changes do not occur in simple settings of bedrocks with equal abrasion rates ($\Delta = 0$) as well in more complex scenarios of many abrasion rates occurring together (e.g., 4.3, 0.4, 1.2 and 9.4 % mass loss/km-1). In addition, pebble abrasion cannot accurately reproduce the distortions in U-Pb age distributions caused by other well-known factors that change the mixing proportion of sands such as hillslope gravel supply, erosion rates, and mineral fertility. In our study case (Marsyandi watershed, Himalaya), the abrasion model predicts age distributions that are statistically indistinguishable to those predicted by a no-abrasion model. However, the relative erosion rates estimated by our model largely differ from the results of a no-abrasion model, e.g., with a downstream increase of 29.3 (Tethyan series), 31.4 (Formation II-III) and 39.3% (Formation I) against a downstream decrease of 40.0, 34.4 and 25.6% predicted by the no-abrasion model. Yet, the erosion rates from the abrasion model are in agreement to the majority of independent research that suggests a correlation between modern erosion rates, tectonic activity and precipitation intensity in the central Himalaya. These findings highlight that, even in cases where there is no statistical evidence of change between the modelled U-Pb age distributions, small numerical differences can affect the erosion rates estimated from them. Therefore, quantifying the influence of abrasion in sand production is a relevant step not only to predict zircon mixing proportions but also to accurately assess erosion rates from their age distributions.