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A review of global bedrock ($^{234}U/^{238}U$) disequilibrium and its impact on inferring sediment comminution age in Taiwan Island

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The ^{234}U-^{238}U disequilibrium system is widely used in Earth-surface process studies, but many applications require an assumption of initial bedrock ($^{234}U/^{238}U$) activity ratios (A_0) which is often assumed to be in secular equilibrium. However, recent studies have challenged this assumption, as A_0 can be modified by geologic factors such as tectonism, lithology, and climate, especially in the near-surface region. This study compiled published global A_0 values ranging from 0.700 to 1.280, with an average of 0.981 ± 0.070 (2σ; n = 160). The widely observed ^{234}U depletion among global bedrock is attributed to the preferential release of ^{234}U from microfissures created during rock diagenesis and hydrothermal alteration processes. The local lithology and precipitation amount also play an important role in bedrock A_0 disequilibrium. The study also highlights that bedrock samples can likewise be enriched with ^{234}U, as evidenced by the nine chemically treated bedrocks' A_0 compiled in this study, ranging from 1.002 to 1.020 (n = 9), attributed to alpha recoil gain from neighboring grains or surface deposits enriched with uranium. In addition, this study demonstrates the impact of A_0 on the "comminution age" approach, which enables quantitative constraints of sediment transport timescale since the genesis of detrital sediment. A case study of the Zhuoshui River (Taiwan Island) sediment comminution age is re-calculated using the newly measured A_0 from the Zhuoshui River basin, which is 0.978 on average. The newly derived comminution age is nearly three-fifths shorter than the values estimated using A_0 =1 in the previous study, demonstrating that assuming bedrock secular equilibrium could lead to overestimated comminution age. Therefore, A_0 should be carefully constrained with an optimal sampling strategy to provide a holistic perspective of catchment-scale earth-surface processes.