Reconstructing long term transition of denudation rates using a terrestrial cosmogenic nuclide in fluvial sediment in granite watersheds devastated by significant human impact

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This study conducted cosmogenic nuclide analysis for fluvial sediment to reconstruct long term shift of denudation rates in watersheds underlain by weathered granite bedrock at Tanakami Mountain, central Japan. Parts of the study area had been deforested and exposed bare hillslopes as a consequence of long term human impact on land use and consumption of forest resources. At present, the devastated watersheds in this area are difficult to be identified as they have been reforested since 1960s. We distinguished the anthropogenically-devastated and continuously-forested watersheds based on 1) historical documents, 2) aerial photos taken in 1947, and 3) field survey to verify soil coverage on hillslopes. Sediment samples for cosmogenic ^{10}Be analysis were collected from outlet of the selected devastated and forested watersheds.
The ^{10}Be concentrations in the current fluvial sediment show lower values in the devastated watersheds than the forested watersheds, providing several-times faster denudation rates based on a steady-state assumption for the devastated situation. The larger apparent denudation rates in the devastated watersheds should depend on the forest condition since there is no systematic difference in the watersheds topography. However, the difference in denudation rates seems smaller than expected from the situation that raised-bed rivers have been formed over the past 500 years in the lower reach by significant sediment discharge. Indeed, the direct observation for hillslope-plots in a decadal scale indicates that yield sediment in a rate of two order higher than the forested hillslopes.
The results obtained here indicate that ^{10}Be concentration at the surface of the devastated hillslopes has not yet reached to a steady-state. The soil layer on hillslopes should have been removed in a high rate in a short timescale, while cosmic-rays had penetrated through the thin soil and produced ^{10}Be in saprolite for a long term. The current fluvial sediment originates most probably from the uppermost part of the saprolite affected by the long-term cosmic ray irradiation.
We conclude that our approach provides a new way to estimate the thickness and timescale of the human-induced soil removal from the hillslopes. Understanding the mechanism of such drastic change in denudation rate requires quantification of the effect of tree root system for stability of the soil layer in steep hillslopes. The hypothetical reconstruction of a transition in denudation regimes would be verified by ^{14}C dating and ^{10}Be depth-profiling for lowland deposits forming raised-bed rivers.

Keywords: human impact, bald mountain, terrestrial cosmogenic nuclides, denudation rate, landscape evolution

