Linkages between tectonics, denudation, and landscape evolution in humid active orogens, revealed by terrestrial cosmogenic nuclides

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This lecture overviews methodology and applications of terrestrial cosmogenic nuclides for quantifying denudation of diverse mountainous landscapes in humid active orogen. We measured cosmogenic ^{10}Be by accelerator mass spectrometry in quartz grains in bedrock and/or fluvial sediment sampled from outlet of watersheds underlain by granite or granodiorite in Japan, to determine the millennial-scale average rate of denudation over the catchment areas. Topography of the study sites spans from low-relief gentle hills to high-relief steep mountainous terrains under diverse tectonic settings. The ^{10}Be-based catchment-averaged denudation rates increase nonlinearly with increasing mean gradient of the watersheds. The watershed denudation rates are comparable to soil production rates in gentle landscapes but exceed it beyond orders in steep areas. This seems concordant with a model simulating process transition from soil creep with shallow landslides to direct bedrock landsliding, thereby forming threshold hillslopes controlled by rock mass strength. Our data also reveal the existence of steep but slowly eroding watersheds over the threshold slope condition, implying the significant role of large-scale deep-seated bedrock landslides in evolution of a high-relief mountainous landscape. The approach using terrestrial cosmogenic nuclides combined with topographic analysis on geographic information systems and long-term tectonics obtained by low-temperature thermochronology reveals relationships between tectonic uplift (base-level lowering), rates and processes of hillslope denudation, and development of mountainous topography in a tectonically active margin under humid temperate climates.

Keywords: terrestrial cosmogenic nuclides, denudation rate, low-temperature thermochronology, geographic information systems, landscape evolution modeling

