

Estimation of the recurrence interval of shallow landslides by coupling of a soil production–transport model and a slope stability analysis: a case from hillslopes underlain by granite and hornfels

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This study reveals soil production and transport rates using cosmogenic ¹⁰Be and high-resolution digital terrain models, and characteristics of pore-water pressure fluctuation along granite and hornfels hillslopes in Kyoto City, Western Japan. We simulated the spatiotemporal development of the soil layer using a cell-based model of soil production and transport with hydro-slope stability analysis, and then estimated recurrence interval of shallow landslides. Higher soil production rates are generally observed along the granite hillslope, and decrease with increasing the soil thickness. While both hillslopes show an inverse relationship between the topographic curvature and soil thickness, the granite hillslope indicates smaller soil thickness than the hornfels hillslope. The soil transport coefficient along the granite hillslope is four times larger than that along the hornfels hillslope, which is estimated from the soil production function and spatial distribution of soil thickness along the hillslopes. Shear strength of soil around the sliding surface was measured by direct shear testing using undisturbed specimens. The granite-derived sandy soils possess a smaller cohesive strength and larger shearing resistance angle than the fine-grained hornfels-derived soils. Pore water pressure in granite and hornfels hillslopes increased rapidly in cases of a wet condition by preceding precipitation. The soil and saprolite layers along both hillslopes remained in an unsaturated state, even during an extreme rainfall event. Based on the results of hydrological monitoring and probable rainfall data, we identify the hydrological condition for triggering shallow landslides. Finally, we simulate the spatiotemporal development and destabilization of the soil layer to estimate the recurrence interval of shallow landslides in the granite and hornfels hillslopes.

Keywords: shallow landslide, recurrence interval, simulation