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Effects of uplift rate on the development of experimental erosion landforms

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Development of experimental landforms is expected to provide some ideas for better understanding of the landform evolution. Experiments with rainfall-erosion and uplift of various rates, in which miniature erosion landforms develop on a square mound of a mixture of fine sand and kaolinite, revealed that the rate of uplift has critical importance on the development of experimental landforms. The results of experiments suggest the existence of two threshold uplift rates, across which experimental landforms show different aspects of development. When the uplift rate is below the lower threshold, a certain characteristic relief determined by mound erodibility and rainfall intensity dominates (characteristic relief phase). Erosion is exclusively fluvial under the detachment-limited condition in this phase. The uplift gradually increases relief through the promotion of "erosion with knickpoints," which is generated by the creation of elevation differences across faults regardless of the surface relief. When relief reaches the characteristic height, "erosion of declining slopes" becomes effective and fluvial erosion starts to increase with slope. Relief tends to stay at this height with the slow uplift, but this does not mean the dynamic equilibrium between rates of uplift and erosion. The stable relief in this phase reflects the characteristic relief determined by the mound material and rainfall intensity independently of uplift rates. The erosion rate with this characteristic relief can be higher or lower than the uplift rate, and the average height may decrease or increase with uplift while keeping relief constant. Although the duration of this change in average height is ultimately controlled by the condition of deposition around the mound, it can be long enough to follow the duration of constant uplift. When the uplift rate exceeds the lower threshold, the uplift starts to exceed the erosion from the upstream most area where fluvial erosion works less. Hills grow until slope failures occur and reduce their height. Sediment supply increases, and the condition of fluvial erosion becomes transport-limited. Slope failures and creep on the slopes inside the uplifted area, which reduce the height of hills, do not change average height unless sediments supplied from slopes are carried away from the uplifted area by fluvial processes. When the uplift rate becomes higher, hills grow more and sediment supply from slopes increases, but the resultant increase in gradients helps fluvial processes carry more sediments. Uplift and erosion become balanced to keep average height constant, and similar landscapes exist for a long time while the configuration of landform changes with slope failures occurring in different places. This state probably is the "flux steady-state," but the continuous changes in landform configuration and gradual thinning of the hills through the process of repeated slope failures give the impression very different from the "topographic steady state." "Quasi-steady state phase" seems to be the appropriate name. When the uplift rate becomes even higher and crosses the upper threshold, the uplift overwhelms the erosion. Hills will grow into high mountains regardless of the condition of erosion or deposition. This phase can be called "mountain building phase." This high rate of uplift could be generated for only short time, because the uplift generating device hit the limit easily, but even in the case of real mountains the uplift of this kind of high rate probably does not last for long time. Although it is still too early to compare the results of experiments with the real landform development, the results of experiments suggest that the ultimate form, toward which landforms develop, changes in relation to the threshold values of uplift rate. During a round of orogeny, the rate of uplift is supposed to change. Assuming the establishment of a steady state on real landforms seems to be very difficult.

Keywords: rainfall-erosion experiment, uplift, landform development, dynamic equilibrium, fluvial erosion, slope processes