Effects of uplift rate on the development of experimental erosion landforms rising from a flat surface

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The development of experimental landform, which can show the time sequence of landform development in a scale of experiment, may provide some ideas for better understanding of the long-term landform development. Here, four runs of experiments, in which miniature erosion landforms were developed with rainfall-erosion and constant uplift of different rates, are reported.

A mixture of fine sand and kaolinite compacted in a square-prism-shaped stainless container (c.a., 60x60x30 cm) was pushed out above the ground level by a stepping motor and worm gears set beneath the bottom plate. Artificial rainfall of about 40mm/hour was applied on this square sand mound rising from a flat surface. The surface topography in the area of 110x110cm, including surrounding areas, was periodically measured by a laser point gage. Four runs (Runs 18-21), each of which lasted 582 hours, with the uplift rate and duration; 1.2mm/hour and 270 hours (Run 18), 0.5 and 582 (Run 19), 5.0 and 62 (Run 20), and 0.2 and 582 (Run 21), were performed.

The erosion started with fine shallow grooves on mound edges, and wide flat-bottomed valleys and a hill-like topography with steep side slopes developed, without deep valley incision and large slope failures, except for Run 20 in which the uplift rate was the highest. In Runs 18 and 19, the initial flat surface rising with uplift reduced its area by erosion and disappeared with slope failures while the uplift continued. The development of flat and low erosional surface with a gentle hill-like topography was prominent in these runs. After the uplift ended in Run 18, the surface was eroded to a mostly flat surface with some small residual hills. In Run 21 with the lowest uplift rate, rising of the initial flat surface and slope failures were not clearly observed, but round-topped gentle hills developed with uplift. In Run 20 with the highest uplift rate, cliffs appeared at mound edges, and valley incision and slope failures occurred frequently. High mountain-like topography appeared around the end of uplift. After the uplift ended, the mountain was eroded to a rather flat surface surrounded by some small residual hills of dissected alluvial fans.

Average height of the uplifted area increased at a rate lower than uplift, but the rate of increase declined with time reflecting the increase in the erosion rate with relief. It would possibly have reached a relatively stable height corresponding to the uplift rate, if the experiments and uplift had continued longer. After the uplift ended in Runs 18 and 20, average height decreased exponentially. Minimum height slowly increased with the uplift reflecting the development of alluvial fans around the mound, but became relatively stable after these alluvial fans reached to the edge of experimental platform. Maximum height first increased as much as the uplift and then stayed around a certain height before lowered rapidly by slope failures while the uplift continued in Runs 18 and 19. In Runs 20 and 21 the same change would have occurred if the uplift had continued longer.

The mountainous topography appeared only with the highest rate of uplift in Run 20, in which valley incision and frequent slope failures were prominent. The extremely high uplift rate indicates that rapid uplift is the requirement for mountain formation. In other runs with slower rates of uplift, in which hill-like topography with low and flat surface developed, the higher uplift rate seemed to promote the development of more rugged topography. The decrease in the rising rate of average height indicates the possible attainment of the stable average height corresponding to the uplift rate in a long-term, in other word, the steady state between uplift and erosion. However, it requires a very long period of constant uplift and erosion to reach this state even in the experiment. The establishment of equilibrium between uplift and erosion in real landforms is still difficult to imagine.