Cyclic steps inside submarine canyon and in canyon-fan transition zone: Numerical experiments by 2D shallow-water model of turbidity currents

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Cyclic steps are upstream-migrating bedforms accompanied with hydraulic jumps. Recent high-resolution geophysical surveys indicated that they are common topographic features especially in submarine canyons and fans where turbidity currents are dominant process of landform developments. Cyclic steps are common in submarine canyons or upstream regions of submarine fans (canyon-fan transition zone), but their morphological features are significantly different. Upstream bedforms inside submarine canyons are relatively small in wavelength and height, and generally show the crescent shaped or mound-like morphology. On the other hand, cyclic steps in less confined canyon-fan transition zone tend to be large in wavelength and height. The origin of these morphological features has not been clarified yet. Thus, we conducted numerical experiments to investigate the conditions for producing cyclic steps at the canyon-fan transition zone. The model is based on two dimensional shallow water equation of turbidity currents, and it was solved by CIP-CUP method that is the the third-order-accurate scheme. We set a submarine canyon and a flat basin plain in calculation domain, and the experimental turbidity currents is injected from the upstream end of the canyon. The canyon was 5% in slope, 2 m long and was 20 cm wide at the transition to the basin. The basin was 3 m in length and 2 m in width. The turbidity currents were 10 cm thick in maximum, 1vol.% in concentration. Grain size was set to be 30 micron meters. As a result of numerical experiments, upstream-migrating bedforms were formed both inside submarine canyon and on the canyon-fan transition zone. All bedforms are associate with hydraulic jumps, so that it can be classified to cyclic steps. However, bedforms inside the canyon show mound-like shape and have relatively short wavelength, whereas those developed on the canyon-fan transition zone were longer in wavelength and their crests were more continuous. The mound-like bedforms in canyons produced in this study resemble crescent bedforms observed in modern submarine canyons, and the laterally continuous cyclic steps are common features of lobate submarine fans at the upstream end. Judging from the observation of the velocity fields, it is inferred that difference of two bedforms was caused by diagonal cross waves that are steady three-dimensional surface waves of supercritical flows. It has been known that the steady surface waves interact with step and pool structures in mountain rivers. This study implies that the same mechanism may govern the supercritical bedforms in the natural submarine canyons systems.

Keywords: turbidity current, numerical model, bedform

