Grain size segregation on cyclic steps formed by turbidity currents

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Cyclic steps are long-wavelength bedform formed by Fr-supercritical flows and are characterized by the sustained occurrence of hydraulic jumps at the boundary between the downstream (lee side) and upstream (stoss side) slopes. Cyclic steps are frequently observed in deep-sea submarine fans and have recently been regarded as typical bedform formed by turbidity currents. Since submarine fan deposits often comprise large-scale hydrocarbon reservoir rocks, it is expected that the properties of reservoir rocks formed by cyclic steps will be understood in detail.

However, the cyclic step is a recently discovered bedform, and its properties especially on grain-size segregation process is still poorly understood. In this study, we developed a two-dimensional shallow-water equation model of turbidity currents that takes into account the mixed grain size, and conducted numerical experiments to clarify the grain-size segregation behavior of sediment composed of cyclic steps formed by turbidity currents. In the numerical model, the conservation law of kinetic energy is considered in addition to the conservation law of momentum and mass, and the active layer (sediment exchange layer) is set at the bottom to calculate the transport of sediment of mixed grain size.

Numerical experiments exhibited that coarse-grained sediment selectively accumulate on the upstream slope in cyclic steps caused by turbidity currents. In particular, the rapid accumulation of coarse-grained particles occurs at the points of hydraulic jumps, which correspond to the troughs of the bedform, and poorly sorted sediment is accumulated there as a result. This is consistent with the results of flume experiments in previous studies. In addition, the wavelength of the bedform changed with the grain size distribution of the turbidity currents. The flows transporting finer sediment tended to form steps of longer wavelength, and the shape of steps was also affected by the grain-size distribution of the suspended sediment. In the future, these characteristics will be compared with those of deposits of modern cyclic steps to validate the numerical model. We also aim to predict the characteristics of cyclic step deposits in the strata by numerical calculation.

Keywords: sediment gravity flow, bedform, grain size segregation, turbidity current, submarine fan

