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Bedforms formed by experimental supercritical density flows

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This study reveals characteristics and formative conditions of bedforms produced by saline density flows in supercritical flow conditions, especially focusing on the mechanism of the formation of plane bed. The motion of sediment particles forming bedforms was resolved by high-speed cameras (1/1000 frame/seconds). Experimental density flows were produced by mixtures of salt water (1.01-1.04 in density) and plastic particles (1.5 in specific density, 140 or 240 mm in diameter). Salt water and plastic particles are analogue materials of muddy water and sand particles in turbidity currents respectively. Acrylic flume (4.0 m long, 2.0 cm wide and 0.5 m deep) was submerged in an experimental tank (6.0 m long, 1.8 m wide and 1.2 m deep) that was filled by clear water. Features of bedforms were observed when the bed state in the flume reached equilibrium condition. The experimental conditions range 1.5-4.2 in densimetric Froude number and 0.2-0.8 in Shields dimensionless stress. We report the two major discoveries as a result of the flume experiments: (1) Plane bed under Froude-supercritical flows and (2) Geometrical characteristics of cyclic steps formed by density flows. (1) Plane bed was formed under the condition of supercritical flow regime. In previous studies, plane bed has been known to be formed by subcritical unidirectional flows (ca. 0.8 in Froude number). However, this study implies that plane bed can also be formed by supercritical conditions with high Shields dimensionless stress (>0.4) and very high Froude number (> 4.0). This discovery may suggest that previous estimations of paleo-hydraulic conditions of parallel lamination in turbidites should be reconsidered. The previous experimental studies and data from high-speed camera suggest that the region of plane bed formation coincides with the region of the sheet flow developments. The particle transport in sheet flow (thick bedload layer) induces transform of profile of flow shear stress, which may be related with the formation of the plane bed. (2) This study also revealed geometrical characteristics of cyclic steps. Cyclic step is a type of bedform that is frequently observed in flanks of submarine levees. This study proved that cyclic steps of density flows show different geometry to those formed by open channel flows. Cyclic steps formed by open channel flows have generally asymmetrical geometry in which lee side is short, whereas cyclic steps formed by density flows are relatively symmetrical and varies their morphology remarkably depending on flow conditions.