Laboratory-Scale Channel Formation by Sheet-Like Density Underflows

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The processes by which turbidity currents channelize the continental slope are incompletely understood. We present the results of a successful attempt to induce channelization on an erodible surface, composed of a mixture of low-specific gravity plastic sediment and kaolinite, by unconfined turbulent density currents. The original surface possessed irregular, undulating topography in the down- and cross-slope directions. Local surface relief was comparable to density current thickness; at high discharge the currents were 1-10 times thicker, and at low discharges the currents were much thinner than local topographic relief. The experiment consisted of 6 successive salt currents. Each experimental run was 30 minutes long, consisting of a 20-minute high discharge flow followed by a 10-minute low discharge waning flow. Photographs and topographic maps collected after each flow show the most change in the bed surface occuring during the first flow with considerably less change during later flows.

The most rapid, focused bed incision was observed during the lowest current discharges. During the high discharge flow, the density currents were thick, covering the entire experimental surface, and generally producing linear scours. Their upper surface slopes mimicked the system-averaged bed slope. However, during the low discharge period, the density currents were thin relative to the local topographic relief and became restricted within the pre-existing linear scours. We hypothesize that the surface slopes of the low-discharge thin flows conformed to the local bed slope, raising the bed shear stresses at locations of high bed slope and generating local bed erosion exceeding that during the high-discharge, thick flow period.

Two types of cross-sectional channel morphology were observed, V-shaped and trapezoidal. The V-shaped channels quickly incised into the substrate while trapezoidal channels incrementally evolved. V-shaped forms were cut during a single flow, with very little or no modification by subsequent flows. Trapezoidal channels show a slow deepening and widening with successive flows. The observations indicate that V-shaped channel incision is self-limiting. We suggest that for V-shaped forms the drag against the side-wall reduces the flow momentum to a point where channel-bottom incision is suppressed. Conversely, the steady deepening and widening observed in trapezoidal forms indicates that bed stresses are sufficient for continued incision.