Geophysical Research Abstracts
Vol. 16, EGU2014-4514, 2014
EGU General Assembly 2014

Experiments on bedforms created by gravity flows

Juan Fedele (1), David Hoyal (1), Zachary Barnaal (2), and Shane Awalt (2)

(1) ExxonMobil Upstream Research Company, Houston, TX, United States (juan.j.fedele@exxonmobil.com), (2) St Cloud State University, St Cloud, MN, United States

We report experimental results that show a rich variety of equilibrium bedforms developed under dilute density and turbidity currents. More than 500 gravity flows were run aimed at testing the stability regions of bedforms using saline density currents or diluted sediment-laden currents running over low-density plastic sediment (SG∼1.5), confined in a 7-m long and 15-cm wide flume submerged in a large fresh-water tank. Experimental currents spanned a wide range of conditions with water discharges ranging 0.2-1.2 l/s (3-18 gpm) and initial slopes ranging 1o-10o, producing subcritical, critical, and supercritical flows (Fr=0.67-2.3). Results confirm some similarities between subaerial and gravity flow bedforms both in process and product, but also reveal some interesting differences. For example, ripples and dunes form under both sub and supercritical density currents while supercritical currents yield both small and long wavelength antidunes (when wavelength is scaled with current thickness), where the latter may transition to cyclic steps.

Ripples developed in flows with low bed shear stress, and therefore minimal bedload transport, and small sediment sizes. Like their subaerial counterparts, gravity flow ripples were insensitive to any length scale related to the flow, e.g., current thickness, and scale solely with sediment size. Supercritical, downstream-migrating dunes were observed to form in medium-to-coarse sediment sizes, for moderate to relatively large values of bed shear stress and bedload transport (relatively high Froude). A detailed description of the flow fields by PIV measurements indicated that supercritical dunes were not the result of instabilities of the flow interface, and did not interact with it in their final stages. Rather, these dunes scaled closely with the thickness of the inner region, i.e. the portion of the current between the bed and the velocity maximum, where vertical velocity gradients are positive, which is mechanistically analogous to the case of subaerial dune formation.

Two discrete categories of antidunes were recognized. Short-wavelength, downstream-migrating antidunes developed in the medium-to-coarse sediment sizes and are mechanistically related to supercritical dunes in the sense of their forming instability (i.e. independent of current interface); however their subsequent evolution and equilibrium state was governed by interfacial interaction. Outsized growth of these short antidunes induced interaction with the flow interface leading to interesting feedbacks between the bed and the interface, which set the final bedwave wavelength.

Stable, long-wavelength, upstream-migrating antidunes were observed to form for small sediment sizes with mixed bedload and suspended transport. The presence of suspension was crucial to maintain these long bedforms at equilibrium. For other cases with coarser sediment and predominately bedload transport, overgrowth of bedform crests choked the flow inducing an internal hydraulic jump upstream of the crest and therefore causing bed transition to cyclic steps.

These findings underscore the rich spectum of potential bed states produced by dense underflows and their deviation from bed behavior in open channel flows. As a result, inversion of gravity flow bed features based on known subaerial bedform regimes is potentially misleading.