Geophysical Research Abstracts
Vol. 19, EGU2017-19069, 2017
EGU General Assembly 2017

A Classification of Subaqueous Density Flows Based on Transformations From Proximal to Distal Regions

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Transformations of a subaqueous density flow from proximal to distal regions are investigated. A classification of these transformations based on the state of the free shear and boundary layers and existence of a plug layer during transition from a debris flow to a turbidity current is presented. A connection between the emplaced deposit by the flow and the relevant flow type is drawn through the results obtained from a series of laboratory flume experiments. These were performed using 9%, 15%, and 21% sediment mixture concentrations composed of sand, silt, clay, and tap water, on varying bed slopes of $6°$, $8°$, and $9.5°$, and with discharge rates of $10[m^3/h]$ and $15[m^3/h]$. Stress-controlled rheometry experiments were performed on the mixtures to obtain apparent viscosity data. A classification was developed based on the imposed flow conditions, where a cohesive flow may fall within one of five distinct flow types: 1) a cohesive plug flow (PF) with a laminar free shear and boundary layers, 2) a top transitional plug flow (TTPF) containing a turbulent free shear layer, a plug layer, and a laminar boundary layer, 3) a complete transitional plug flow (CTPF) consisting of a turbulent free shear and boundary layers and a plug, 4) a transitional turbidity current (TTC) with a turbulent free shear layer and a laminar boundary layer, and, 5) a completely turbulent turbidity current (TC).

During the experiments, flow type PF resulted in en masse deposition of a thick uniform ungraded muddy sand mixture, which was emplaced once the yield stress overcame the gravitational forces within the tail region of the flow. Flow type TTPF resulted in deposition of a thin ungraded basal clean sand layer during the run. This layer was covered by a muddy sand deposit from the tail. Flow type TTC did not deposit any sediment during the run. A uniform muddy sand mixture was emplaced by the tail of the flow. Flow type TC resulted in deposition of poorly sorted massive bottom sand layer. This layer was overlain by either a muddy sand mixture or a sand and silt planar lamination. Flow type CTPF was not observed during the experiments. Furthermore, it was observed that flows which are in transition from a TTC to a TTPF result in a thin bottom clean sand layer covered by a banded transitional interval. This was overlain by a muddy sand layer and a very thin clean sand layer, resulting from traction by dilute turbulent wake. In all cases a mud cap was emplaced on top of the deposit after the runs were terminated.