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Portfolio Paper

Three-Dimensional Flow Structure at the Frontal Zone of a Gravity-Driven Fluid Mud Flow

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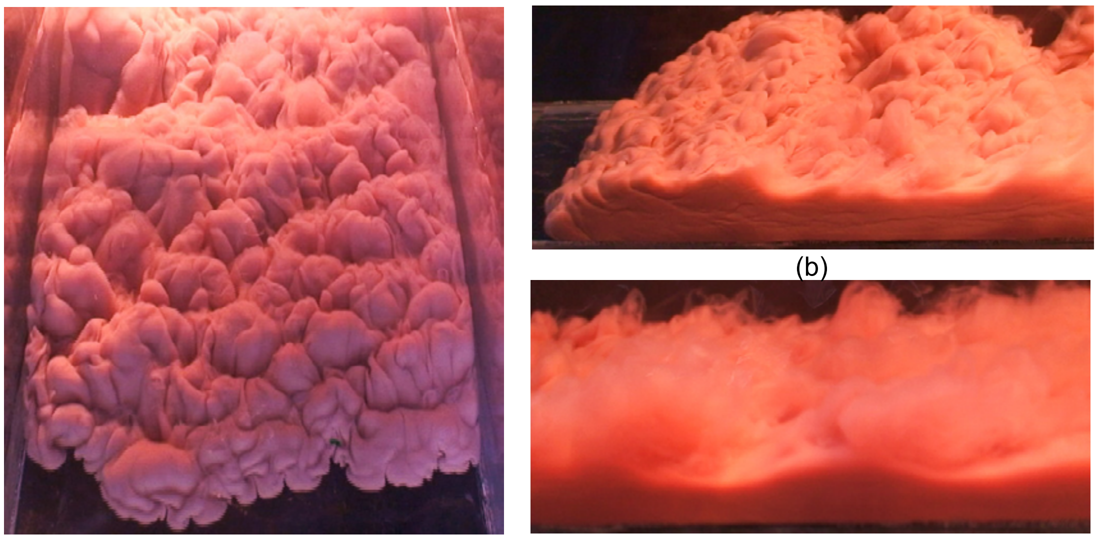

(a) (b) (c)

Fig. 1. Gravity-driven fluid mud flow. Top- (a) and side-view (b, c) photographs of the fluid mud gravity current are presented. In these photographs, lobe-cleft patterns at the leading edge of the current (a), nose and billows above and behind the head of the current (b), and decay/breakdown of billows (c) behind the nose can be seen.

This portfolio paper demonstrates three-dimensional flow structure at the frontal zone of a gravity-driven fluid mud flow. Experiments were conducted in a rectangular lock-exchange tank (4m - length, 0.25m – width, 0.3m - height) made of Plexiglas for visualization purposes. Fluid mud was prepared by homogeneously mixing fine-grained clay particles with fresh water, and the resulting suspended solution was colored with red food coloring for better visualization. The lock section of the tank was filled with the prepared high-concentration (= 70 g/l) mud suspension and separated by a sealed vertical gate from the rest of the tank that is filled with fresh water. The mud suspension was released by rapidly lifting the gate which then generated fluid mud gravity current, caused by the density difference of the fluid mud and the ambient fresh water. The leading edge of the gravity current was recorded using a high-definition video camera from the top and side of the tank with different oblique angles.

The fluid mud gravity current forms a frontal zone with a distinct dividing line between the intruding current and ambient fresh water. The leading edge of the frontal zone has a foremost point, or nose, that is slightly raised above the bed. The fluid mud gravity currents exhibit three-dimensional flow patterns that consist of protruding regions (lobes) that are separated by sharp cusps (cleft) at the leading edge of the current and billows that form above and behind the head of the current, as can be clearly seen in Fig. 1a and b. Billows grow in size with distance from the nose. After attaining a maximum size, the billows gradually breakdown as can be seen in Fig. 1c. In their investigations of the dynamics of the head of a salt-water gravity current, Simpson and Britter[1] suggest that the formation of lobe-cleft patterns are driven by a gravitational instability of the less dense ambient fluid overrun by the dense gravity current. As the lighter fluid is displaced by the current, a portion of the dense fluid is swept up behind the head of the current by the lighter fluid, causing the formation of billows at and behind the head of the current.

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References: (1) Simpson, J.E. and Britter, R.E., J. of Fluid Mechanics, 94 (1979), 477-495.