Laboratory experiment of a mixed-sediment Gilbert delta under varying base level

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1. Introduction

When a river ends in a basin or sea characterized by a flow depth that is much larger than the one of the fluvial reach and homopycnal flow dominates (i.e., the water bodies have equal density which leads to intense mixing and sedimentation), a foreset-dominated delta (i.e., a Gilbert delta) is formed. If such a Gilbert delta progrades in a basin confined by a narrow canyon, it has a typical one-dimensional longprofile. It consists of (a) a topset, which is formed through deposition of sediment over the fluvial reach, (b) a foreset, which is formed through sediment avalanches over the front of the delta deposit, and (c) a fine bottomset, which is formed through deposition of fine sediment that passes the delta front as suspended load. The deposition of particles over the foreset is governed by the formation of a wedge at the topmost part of the foreset through grain fall. The wedge fails when its angle of repose is exceeded, which initiates a grain flow. In such a grain flow coarse particles preferentially deposit at lower elevations of the foreset, while finer ones show a preference for the upper ones. As such, these discontinuous grain flows typically result in a fining upward pattern (Figure 1).

Figure 1. Flume experiment of a Gilbert delta using three well-sorted size fractions (fine blue, medium red, coarse yellow).

Viparelli et al. (2012) have developed a numerical model describing the progradation of such a mixed-sediment Gilbert delta. The purpose of the numerical model is to enable the interpretation of past sea level changes from stratigraphy formed by delta progradation. The model is validated using laboratory data from mixed-sediment Gilbert deltas (Viparelli et al., 2013). The objective of the present study is to provide detailed data from a laboratory experiment on how the stratigraphy of a Gilbert delta deposit is affected by a temporal variation in sea level.

2. Methodology

The experiment was conducted in the Water Lab of the Department of Hydraulic Engineering of Delft University of Technology. The flume has an effective length of 14.2 m and a width of 40 cm. Three well-sorted grain size fractions were used: 0.8-1.2 mm, 1.7-2.5 mm, and 3-5 mm. The volume fractions of the three grain sizes in the mixture fed to the flume were 0.50, 0.35, and 0.15, respectively. The grains were painted blue, red, and yellow, respectively, using a concrete mixer. The discharge was set at 9.8 l/s. The Froude number at the brinkpoint was equal to 0.42.

A new image analysis technique (Orrú et al., 2013) was used to measure the streamwise sorting over the fluvial reach. The stratigraphy within the delta deposit was measured using the same image analysis technique combined with a vacuum pump for removing thin layers of sediment. Orrú et al. (2013) show how the resulting data for the stratigraphy agree well with the ones based on sieving of the samples.

2. Results and conclusions

The mixed-sediment Gilbert delta deposit is characterized by:

a. the formation of a topset resulting from aggradation over the fluvial reach, which is due to the lengthening of the delta deposit in combination with the slope required to transport the sediment fed to the flume downstream;
b. an armour layer forming the upper layer of the topset, which is due to the fact that the fluvial reach needs to coarsen its bed surface to be able to transport the mixture fed to the flume downstream;
c. a slight downstream fining of the bed surface material over the fluvial reach, which is due to the fact that the bed profile of the fluvial reach is slightly upward concave as a result of the progradation of the delta;
d. an upward fining of sediment within the foreset, which is due to sorting mechanisms in the grain flows down the lee face of the delta deposit.

References

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