Autogenic foreset-bottomset transition trajectory: Experiment and theory

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In a lake environment, a delta can develop with three distinct depositional surfaces: Topset, foreset, and bottomset –all of which are connected with moving boundaries. Topset and foreset surfaces are connected at the shoreline, where the fluvial topset meets sea level. The subaqueous delta front is subdivided into foreset and bottomset at a slope break (henceforth foreset-bottomset break). The foreset develops dominantly by grain avalanche processes, while the bottomset develops with gravity flow.

Shoreline response to base level change has been studied extensively, and it has been found that shoreline trajectory in sedimentary records is a good stratigraphic indicator of base level change. However, the foreset-bottomset break and its trajectory stored in the stratigraphic record have not been thoroughly investigated. We present physical experiments and modeling results of how the trajectory of this moving boundary responds to base level rise. Under a constant base level, the foreset-bottomset trajectory shows three stages of the moving boundary migration: 1) initial aggradation with minor progradation, 2) strong progradation with minor elevation change, and 3) stable (slightly decelerating) progradation with declining elevation. Under constant base level rise at different rates, the foreset-bottomset trajectory shows 1) more distinct initial aggradation with higher base level rise rates, 2) stronger and faster progradation with lower base level rise rates, and 3) decelerated progradation with minor elevation changes.

The results from theoretical work and experimental verification of the theoretical model provides a unifying theory for the autogenic foreset-bottomset break migration. Based on a comparison of foreset-bottomset trajectory in the sedimentary record with the norm for the foreset-bottomset break migration, we can interpret clinoform development in lake basins under changes in environmental forcing.

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