On deposition from lift-off turbidity currents

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INTRODUCTION

Many turbidity currents originate from continental shelf and slope settings where the background water is both warmer and fresher than the deep-water settings into which they travel, and therefore the fluid in which the grains are suspended (the interstitial fluid) is less dense than the fluid into which the current travels (the ambient fluid). Initially these turbidity currents travel along the ground, but gradual particle settling reduces the excess density sufficiently that they become lighter than the ambient and 'lift-off' the bed as a buoyant plume[1]. The remaining flow then continues as an intruding gravity current. The objective here is to assess the complex process of lift-off on deposition from turbidity currents.

METHODOLOGY

Lock-exchange experiments were conducted using mixtures of 36.5μm ['sand'] and 12.8μm ['mud'] silicon carbide grains (ρ_P=3127kg/m^3), suspended in a methanol / water interstitial fluid (ρ_I), which travels initially as a dense underflow into a 3m tank of water (ρ_A). While the total bulk density (ρ_C) remained constant, ρ_I, ϕ (solids mass fraction) and the sand:mud ratio, were varied. Laboratory data and complementary theoretical predictions for lift-off flows are compared with a series of bidisperse, ground-hugging experiments using the same sediment, techniques and tank geometry[2].

RESULTS

The key result is that the rapid drop-off in velocity to zero at the point of lift-off partitions the sand and mud fractions. This segregation has important consequences for the sedimentology and becomes more pronounced as γ increases, where $\gamma = (\rho_A\text{-}\rho_I)/\phi(\rho_P\text{-}\rho_I)$. Compared to experimental ground-hugging counterparts[2] sandy lift-off flows produce thick beds up to the point of lift-off (Fig. 1). In contrast, muddy lift-off flows produce beds of more uniform bed thickness from proximal to distal regions. The proportion of sand in the deposits of both lift-off and ground-hugging flows declines from source to sink. But its decline rate in coarser-grained flows with a high γ value and in natural lift-off flows where the fines may be carried away by ocean currents, is less (Fig. 2).

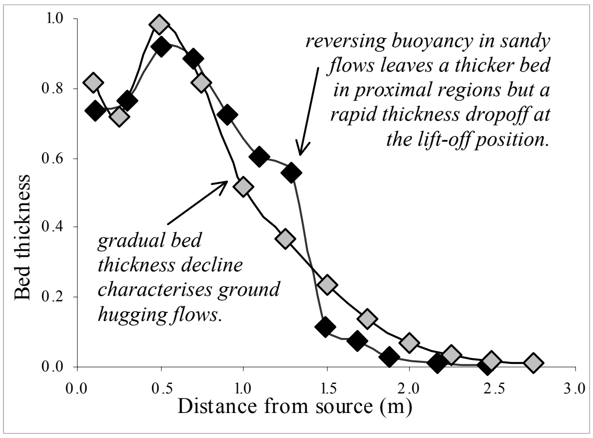

Fig. 1. Sand-dominated lift-off and ground-hugging flows show very different bed thickness patterns.

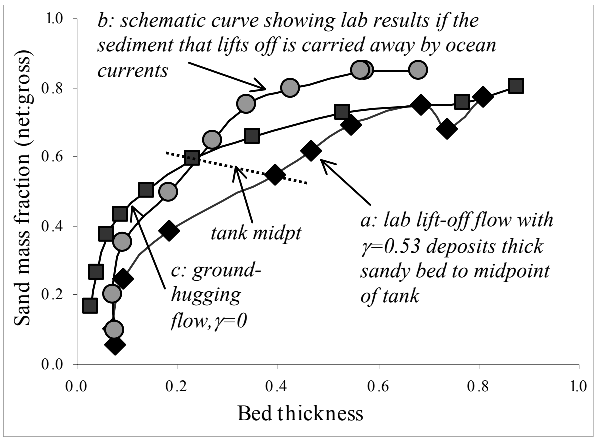

Fig. 2. Thick beds with good net:gross are a feature of bidisperse, sandy lift-off flows, up to the point of lift-off.

CONCLUSIONS

Lift-off flows produce beds with different characteristics from ground hugging flows and in general will lead to good quality reservoir rock near to source through grain size partitioning. Reversing buoyancy in turbidity currents may also explain how enigmatic features such as deep-water massive sands arise[3]. Here well-sorted sands are transported to distal settings, yet the mud which is required for the flow to reach these distances is somehow segregated and deposited elsewhere.

REFERENCES

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