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Concentration-dependent flow stratification in experimental high-density turbidity currents and their relevance to turbidite facies models

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High-density turbidity currents exhibit internal density stratifications. In the basal part of these stratified flows, high-sediment concentrations cause rheological deviations from the Newtonian turbulent flow that dominates clear water and low density conditions. Previous studies have distinguished different types of basal layers on the basis of concentration-dependent differences in grain interactions. Field studies have classically linked crude stratification bands, spaced laminations, and/or abundant internal erosion surfaces to high-density turbidity currents. Studies of high-density turbidity current deposits have proposed various mechanisms for this variation in depositional characteristics; however, none of these propositions has been thoroughly tested by experiments or theory. This study presents experiments of high-density turbidity currents (varying in initial sediment concentration between 9-26 vol%) moving quasi steady on an inclined bed surface, being close to their equilibrium slope in a 4 m x 0.5 x 0.07 tank. Three distinct internal flow layers were distinguished on the basis of their observed behavior as captured by a high-speed camera. Ultrasonic velocity profiler (UVP) probes were used to measure the overall velocity and turbulent intensity profiles of the flows, and the change therein as a result of different stacking patterns of internal flow layers. The relation between maximum velocity, shear stress and equilibrium slope for different types of high-density turbidity current was investigated in the experiments. Velocity and camera data were combined to study the interactions between the different flow layers over time. Small-scale fluctuations (0.2-2 seconds) were observed to have a clear control on the depositional behavior of the flow. However, the influence of these fluctuations gradually decreased with increasing sediment concentrations as function of the different types of basal flow layers. By combining these observations with theoretical grain size sorting mechanism previous experimental results, the different flow layers were linked to distinct depositional expressions known from the rock record.