Sediment Concentration vs. Grain Size -- Does it Matter?

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Abstract

Turbidites are deposited by dense sediment suspensions called turbidity currents. First described by Bouma (1962) sharp-based turbidites show a characteristic upward-fining grain size profile and succession of variously formed sedimentary structures. Collectively these attributes suggest a linear, or more likely convolute net decelerating flow history. Conspicuously absent in this succession, and rare in the deep-marine sedimentary record as a whole, is dune cross-stratification, which for sediments coarser than middle fine sand in a decelerating unidirectional flow should occur between the planar- (b-division) and ripple cross-stratified (c-division) units. Recently it has been argued that the lack of dunes, and in some cases ripples too, is the result of the general inability of turbidity currents to become sufficiently density stratified in the near bed region that (bed) defects develop on the bed, and subsequently angular bed forms grow. However, this idea lacked experimental verification.

Experimental turbidity currents consisting of one of four grain sizes (0.07, 0.15, 0.23, 0.33 mm) and varying sediment concentration, ranging from 1 to 12% by volume, were run through a 7 m-long enclosed water channel. Flow velocity and sediment concentration and distribution were simultaneously monitored by an acoustic velocity profiler and medical-quality CT scanner, respectively. Results show that at sediment concentrations more than 4% by vol, all flows, regardless of grain size, formed a plane bed during the entire run. At 4% by vol, however, current ripples formed in the runs with 0.23 and 0.33 mm sand, but not in the 0.15 and 0.07 mm flows where the bed surface remained planar. Note that flow speed was the same in all the flows, and that all flows were supercritical. This, therefore, begs the question as to what was different. Data from the CT scanner, an instrument designed to measure density, which in our experiments equates to sediment concentration, show significant differences for flows of equal sediment concentration (and speed) but different grain size. Specifically, currents composed of 0.33 and 0.23 mm sand are highly sediment stratified, forming a thin, high concentration near-bed layer. Under similar flow conditions, the 0.15 and 0.07 flows formed a thick, ~uniformly high-density layer that hugged the bottom. The lack of ripple development in these latter flows is thought be a consequence of this dense bottom layer and the inability to initiate and amplify bed defects.

Reference Cited

Bouma, A.H., 1962, Sedimentology of some Flysch deposits: A graphic approach to facies interpretation. Elsevier. 168 p.