

Keynote Abstract

Character of Deposition from Shallow- and Deep-Marine Suspended-Sediment-Laden Gravity Flows

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Sediment-gravity flows are a special kind of density current in which the density contrast with the ambient fluid is maintained by suspended sediment. However, despite the first-order control of suspended sediment on the very existence of these flows little is known of the effect(s) of sediment concentration on the depositional record from these flows. For example, dating from the work of Bouma (1962), the idealized model of a turbidite lacks a stratal layer related to deposition from subaqueous unidirectional dunes (Fig. 1). Even more perplexing is the fact that in rare instances dune cross-stratification does occur where expected – sandwiched between upper-stage plane bed and ripple cross-stratified sandstone. Another common but puzzling observation is that in many turbidites the b-division is several times thicker than the c-division, which in many cases is a scant one to a few sets thick, or even more problematic absent.

Many of these puzzling issues may be explained by considering the deleterious effect of high suspended sediment concentration on the initiation and maintenance of dunes and ripples. In contrast, upper-stage plane bed appears to be unaffected by high sediment concentrations, at least up to 35 volume % sediment concentration, which are conditions bordering on hyperconcentrated flow (Leclair and Arnott, 2005). As a consequence, in many depositing sediment suspensions upper plane bed may remain stable bed even under flow conditions that in an otherwise clear-water flow would form dunes or ripples. This suggests that an important effect of high suspended sediment concentration is to depress the stability of upper plane bed to lower flow speeds compared to that in clear-water flows (Figs. 2A, B, C).

Although common in the deep-marine sedimentary record, turbidites, or at least turbidite-like beds are observed also in a number of other sedimentary environments, particularly the distal shallow marine (Hamblin and Walker, 1979). Here beds consist generally of fine and very fine sandstone interstratified with mudstone. In many examples sandstone beds are sharp-based and overlain by planar lamination capped by asymmetrical small-scale (ripple) cross-stratification with negligible angle of climb. Like in deep-marine turbidites, the lack of an intervening unit of medium-scale cross-stratification in strata coarser than very fine sandstone is problematical. Owing to the paucity of wave-formed sedimentary structures, including small-scale wave ripple cross-stratification, suggests that appealing to oscillatory or even combined-flow conditions as the formative mechanism is questionable. The most plausible explanation, like that in the deep

marine, is the negative effect of elevated sediment concentration on the inception of bed defects that later would evolve into angular bed forms like dunes, and to a lesser extent, current ripples.

References

Blatt, H. Middleton, G.V., and Murray, R., 1980. Origin of Sedimentary Rocks, Englewood Cliffs, New Jersey, Prentice-Hall Inc., 782 p.

Bouma, A.H. 1962, Sedimentology of some Flysch Deposits, Amsterdam, Elsevier, 168 p.

Hamblin, A.P. and Walker, R.G., 1979. Storm dominated shallow marine deposits in the Fernie-Kootenay (Jurassic) transition, southern Rocky Mountains. Canadian Journal of Earth Sciences, v. 16, p. 1673-1689.

Leclair, S.F. and Arnott, R.W.C. 2005. Parallel lamination formed by high-density turbidity currents. Journal of Sedimentary Research. v. 75, p. 1-5.

Southard, J.B., and Boguchwal, L.A., 1990. Bed configuration in steady unidirectional water flows: Part 2. Synthesis of flume data. Journal of Sedimentary Research, v. 60, p. 658-679.

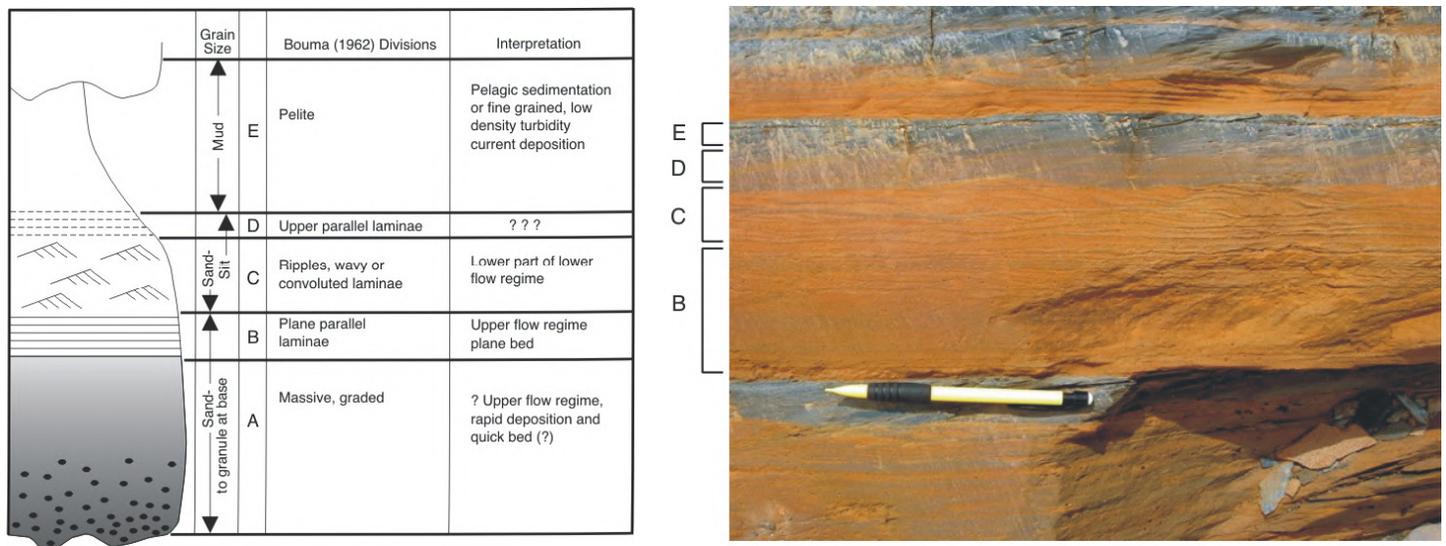


Figure 1. Idealized model of a (Bouma) turbidite (modified after Blatt et al., 1980) with an ancient example showing the position of the B through E turbidite divisions.

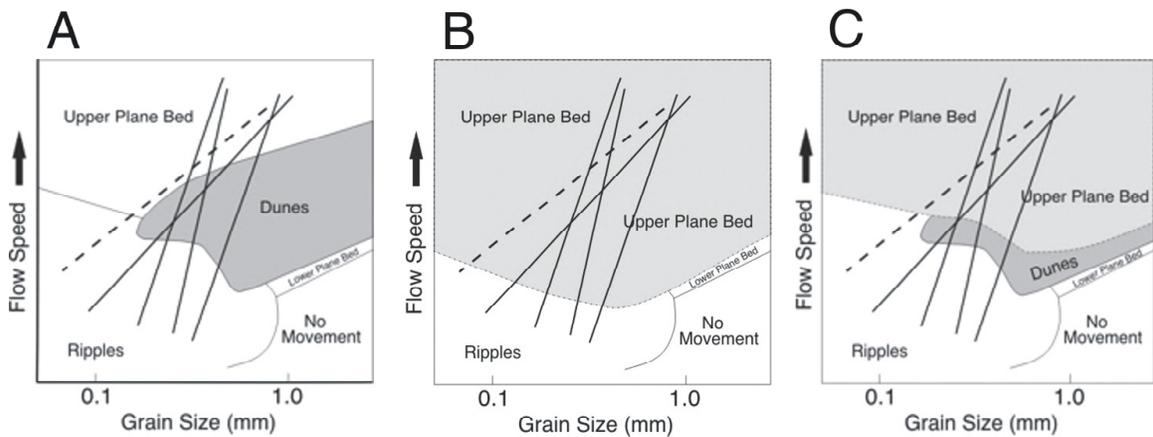


Figure 2. (A) Stability diagram for unidirectional bed forms in a clear-water flow (modified after Southard and Boguchwal, 1990). Lines sloping down to the left trace out bed form changes in a hypothetical-decelerating flow. Note that except for the dashed line, all decelerating flows pass through the dune stability field before encountering the ripple field. (B) Hypothetical stability diagram for a concentrated (i.e. non-clear-water) turbulent suspension. Throughout the deceleration history of the current, sediment concentration remains high and as a result the stability of upper plane bed is depressed downward into the dune and ripple stability fields. When sediment concentration becomes sufficiently reduced (due to flow waning) ripples most commonly develop because the flow is too slow or the sediment too fine to form dunes. (C) Hypothetical stability diagram for a turbulent suspension in which sediment concentration is reduced significantly during the event. Initially high-energy, high concentration conditions deposit upper plane bed. As flow speed and sediment concentration (and possibly also grain size) is reduced a point is eventually reached at which dunes become initiated and grow on the aggrading bed. As flow speed and/or grain size continue to decrease, dunes are replaced by ripples.