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Can vertical Stacking of low-angle Bedforms produce rhythmic Bedding in Slurry Flow Deposits?

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A new bedform type forming below a laboratory flow carrying large volumes of non-cohesive sand/silt and cohesive clay was discovered. The stratification formed by vertical stacking of these bedforms during prolonged suspension settling bears similarities to rhythmic bedding ("banding") in slurry flow deposits (Lowe & Guy 2000).

The bedforms have a flat, elongate shape with metre-scale lengths, cm-scale heights, and low-angle lee slope angles. Their internal organisation consists of a cohesive fine-grained core topped with a thin layer of sand-sized sediment. The formation and stability of the bedforms is closely related to changing flow dynamics as suspended sediment concentration decreases due to progressive settling of non-cohesive and cohesive particles.

The experiment that produced the bedforms started with a well-mixed suspension laden with $\sim$16 vol.% of sand/silt and clay (ratio: $1 \div 4.3$). The initial mean velocity and depth of the flow were 1 ms^{-1} and 0.15 m, respectively. At these conditions, the flow was oversaturated with sediment, and sand particles (and some silt and clay) were deposited within several minutes. The resulting sand bed was loosely packed, as shown by interfacial bursts and waves, and the formation of fluid escape structures attributed to elutriation of fines. Velocity time-series suggest that the bursting was caused by near-bed, asymmetric velocity fluctuations, typical of transient turbulent behaviour (transitional plug flow sensu Baas & Best 2002).

In the next phase, fines were deposited and formed a slow-moving fluid mud layer on

top of the sand bed, while transitional flow persisted. After about one hour, the mobile fluid mud halted, compacted and formed a deposit, but at the same time a change from transitional plug flow to turbulence-enhanced flow (i.e. intermediate between classical turbulent and turbulence-suppressed) was recorded. This change accompanied a gradual decrease of flow density. The increased turbulence caused a return to fluid mud conditions, and also promoted local erosional scouring. Subsequently, these scours evolved into the troughs of the low-angle bedforms described above.

After two hours, the bedforms attained their characteristic shape and internal organisation. The bedforms migrated slowly in a downstream direction, but in a manner notably different from sandy dunes and ripples in clear water. Recirculation behind the bedforms was rare, thus making the bedform trough a zone of relative quiescence protected form the free flow above. Moreover, grain flow down the bedform lee was absent. Instead, particles within the thin sandy top of the bedforms crept slowly along the stoss side and a short distance down the lee side before being buried by mud settling from suspension into the bedform trough. Due to the lack of avalanching and recirculation, cross-stratification was virtually absent. Hence, the internal structure of each bedform consisted of a mud-sand couplet. The bedforms climbed as a result of continuing settling from suspension and migration.

The final bed configuration after 10 hours into the experiment consisted of a stack of two bedforms had formed on top of the early sand bed under turbulent flow conditions similar to those in clear water. Away from the bedform crests, the sedimentary succession resembles rhythmic bedding of mud and sand layers. This type of rhythmic bedding is formed in steady, uniform flow, which implies that it is not always necessary to invoke periodic changes in flow strength (such as in tidal rhythmites) to explain the genesis of alternating sand and mud laminae.The sedimentological properties of the beds formed in the laboratory are compared with grain-size controlled banding in slurry flow deposits.

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