

Physical and Biological Cohesion Within Mixed Sand-Mud Beds: Implications for Erosion and Bedform Development

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ABSTRACT

Flow and sediment transport predictions from sedimentary structures found in modern environments and within the geological record are impeded by an almost complete lack of process-based knowledge of the behaviour of natural sediments that consist of mixtures of cohesionless sand and biologically-active cohesive mud. Indeed, existing predictive models are largely based on non-organic cohesionless sands, despite the fact that mud, in pure form or mixed with sand, is the most common sediment on Earth, and is also the most biologically active interface across a range of Earth-surface environments, including rivers and shallow seas.

The multidisciplinary COHBED project uses state-of-the-art laboratory and field technologies to measure the erosional properties of mixed cohesive sediment beds and the formation and stability of sedimentary bedforms on these beds, integrating the key physical and biological processes that govern bed evolution.

The erosive behaviour of cohesive mixed sand-mud beds and bedform development on these beds was quantified as a function of physical control on bed cohesion versus biological control on bed cohesion. The Shear Flume at Bangor University was used to measure the critical shear stress for bed erosion for different mixtures of fine sand, kaolin clay and xanthan gum. Kaolin clay is a proxy for physical cohesion within the mixed bed. Xanthan gum is a polysaccharide of bacterial origin used commonly in experimental biostabilisation research, and thus provided control over biologically-induced cohesion in the experiments. The experiments involved the

determination of suspended sediment concentration over a premixed and pre-consolidated sediment bed at progressively higher bed shear stress until an abrupt increase in concentration signified the critical shear stress for bed erosion.

Preliminary results show that the critical shear stress for bed erosion increases as the volume fraction of kaolin clay and xanthan gum in the sand bed is increased, but this effect is more pronounced for xanthan gum than for kaolin clay at similar volume fractions. This suggests that biological cohesion is more important than physical cohesion, and sedimentological process models should refocus on biostabilisation processes. However, this ignores any differences in the rate of production of biostabilisers versus the availability of cohesive clay in natural environments. Examples of sedimentary environments where biological cohesion might be more important than physical cohesion will be discussed and compared with environments where physical cohesion might outcompete biological cohesion.

The first results of experiments on bedform development in cohesive mixed sand will also be presented. These experiments show that winnowing of fine-grained cohesive sediment, including biological stabilisers, is an important process affecting the development rate, size and shape of the cohesive bedforms. Recommendations will be made if and how existing bedform predictors need to be modified to allow for cohesive bed behaviour by physical and biological processes.