Geophysical Research Abstracts
Vol. 16, EGU2014-1251, 2014
EGU General Assembly 2014

VALIDATING EXPERIMENTAL BEDFORM DYNAMICS ON COHESIVE SAND-MUD BEDS IN THE DEE ESTUARY

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SUMMARY

Recent laboratory experiments and field measurements have shown that small quantities of cohesive clay, and in particular 'sticky' biological polymers, within a sandy substrate dramatically reduce the development rate of sedimentary bedforms, with major implications for sediment transport rate calculations and process interpretations from the sedimentary record.

FURTHER INFORMATION

Flow and sediment transport predictions from sedimentary structures found in modern estuaries and within estuarine geological systems 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 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 development of current ripples on cohesive mixed sediment beds was investigated as a function of physical control on bed cohesion versus biological control on bed cohesion. These investigations included laboratory flume experiments in the Hydrodynamics Laboratory (Bangor University) and field experiments in the Dee estuary (at West Kirby near Liverpool). The flume experiments showed 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. The ripples developed progressively slower as the kaolin clay fraction in the sandy substrate bed was increased. The same result was obtained for xanthan gum, which is a proxy for biological polymers produced by microphytobenthos. Yet, the xanthan gum was several orders more effective in slowing down ripple development than kaolin clay, suggesting that the cohesive forces for biological polymers are much higher than for clay minerals, and that sedimentological process models should refocus on biostabilisation processes.

The first results of the field experiments show that the winnowing of fines from developing ripples and the slowing down of current ripple development in mixed cohesive sediment is mimicked on intertidal flats in the Dee estuary. In particular, these field data revealed that current ripples in cohesive sediment are smaller with more two-dimensional crestlines than in non-cohesive sand. The wider implications of these findings will be discussed.

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