What palaeo-environmental parameters do cross strata indicate?

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Although cross-strata formed by dunes are key evidence for the formative flows of fluvial, estuarine and shallow marine environments, the dynamics of dunes in spatially and temporally varying flows remain relatively poorly understood. Importantly, the bed shear stress that controls sediment transport, and hence dune adaptation, is largely controlled by both flow depth and watersurface slope, which can vary independently in time and space. For example, water-surface slope is out-of-phase with flow depth during short-lived flood waves (e.g. storm-related floods or tides), yet both vary in unison during longer-term changes in base flow (e.g. slow seasonal changes). Spatially, the magnitudes of depth and slope vary locally, for instance between the thalweg and bar tops, as well as downstream along a river between the tributaries and river mouth. Thus, there is clear need to understand the relative roles of depth and water surface slope in order to better understand and interpret the dune dynamics.

In order to investigate the relative importance of depth and water surface slope, uniform flow experiments were carried out in a 2 m wide and 11 m long flume, using sand with a D50 of 240 µm, and water depths of 0.175-0.225 m. The irregular geometry of the dunes that developed in the flume allowed antecedent morphology and bedform interactions to be identified as key controls on bedform merging, splitting and superimposition. The behaviour and influence of individual bed forms is unlikely to be identifiable when dunes have similar geometries because similar bed forms ought to respond identically. The adaptation of dune morphology was found to be more sensitive to stepwise changes in water depth and less sensitive to stepwise changes in discharge. These results confirm that spatial and temporal variations in the relative magnitudes of depth and water surface slope can indeed affect sediment transport, morphodynamics, and sedimentary preservation. The implication of such fundamental variability in the drivers of the hydraulic energy budget (depth, slope, velocity) is that the palaeo-hydraulic significance of cross-stratified sets from different environments may vary (estuaries & rivers; bar tops and thalwegs), even if the strata appear identical.

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