Geophysical Research Abstracts
Vol. 20, EGU2018-17674, 2018
EGU General Assembly 2018

From spinning grains to dune trains: processes in sedimentology

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The understanding of modern environments, deciphering the ancient sedimentary record, and reconstructing depositional processes and palaeoenvironments, must be founded on interpretations that are based on robust fluid dynamic principles and explanations of sediment erosion, transport and deposition. The development of 'process sedimentology', as pioneered by sedimentologists in the 1960's and 1970's, but recognised for over 150 years, has witnessed great strides in the last few decades and is providing new insights into the sedimentology of many environments, from aeolian dunes to deep-sea density underflows.

Progress in our understanding of turbulent, transitional and laminar boundary layers, their interactions with many scales of topography, and the resultant deposits, has progressed hugely in the past twenty years due to a mixture of laboratory, numerical and field studies, as well as a greatly improved ability to document the products of these depositional processes in modern and ancient sedimentary sequences. This talk will review a number of topics concerning the physical processes of sedimentation that span scales from individual grains to the world's largest river channels, in order to demonstrate the central role of process sedimentology.

It has become evident that sediment-laden flows may possess a very different fluid dynamics to their clear-water counterparts, and that the modulation of turbulence may be the norm rather than the exception in many aqueous flows. Such turbulence modulation ranges from the influence of grain rotation upon turbulence enhancement, to turbulence dampening caused by cohesive networks of clays. Such modulation thus enables modification of sediment transport, bedform morphology and sedimentary structures when compared to those present in clearwater flows, and suggests a more complex phase space for bedform stability. Such flows also interact with, and are modified by, topography, that then becomes a source for fluid turbulence and modified patterns of flow and sediment transport. For example, laboratory modelling reveals the fluid dynamics of the interactions between bedforms and how these can explain processes of dune amalgamation and their internal re-activation/erosion surfaces. Study of contemporary large rivers is also uncovering a different morphology of dunes to that commonly assumed, with the corollary that low-angle foreset surfaces, and dunes that do not well-scale with flow depth, may be more common than previously thought. These studies have many implications for how we reconstruct past sedimentary environments, and estimate the scale and magnitude of ancient flows and their depositional systems.

These studies highlight that, in the age of Google-Earth geology, it is still paramount not to lose sight of the need for understanding the fluid and sediment dynamics of depositional processes that can help us better interpret modern and ancient environments from alluvial fans to the deep seas.