Advective Sediment Transport on Mud-Dominated Continental Shelves: Processes and Products

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Mud is the dominant sediment present on both recent and ancient continental shelves. Muddy shelves are also commonly sites of significant natural carbon burial. Organic carbon-rich mudstones act as source rocks and shale-gas reservoirs. Unfortunately, dark-colored, fine-grained rocks such as these, are commonly fissile, and reveal few obvious sedimentary structures under casual examination. These attributes cause most geologists to assume that these materials were deposited in low-energy settings, by continuous settling out of suspension from dilute buoyant plumes.

Recently, this paradigm has been challenged by data from three lines of investigation: (a) detailed in-situ observations of fine-grained sedimentary rocks using petrographic techniques, (b) flume experiments of mud transport and (c) studies on modern shelves. These data demonstrate that these natural, fine-grained materials contain a great deal of small-scale evidence of erosion and advective sediment transport, where they have not been homogenized by biological activity. Moreover, physical modeling demonstrates that unconsolidated mud commonly forms ripples in conditions previously thought to allow only sand deposition.

Detailed examination of shelfal mud and mudstone from Proterozoic to Recent revealed several recurring bed types, each with distinctive lithofacies associations and successions of lamina geometries. Although they share broad aspects of deposition from waning episodic flow, these bed types record different flow-evolution pathways among sediment-gravity, traction, and suspension transport. Until now it has not been possible to investigate the relative importance of wave-, tide-, or storm-induced mud-dispersal processes in any particular succession because the characteristic microfabrics produced by the different mechanisms had not been fully documented. As a first step to resolving this problem, we here illustrate and compare microfabrics present in mudstones from the ancient record that likely accumulated by storm set-up and geostrophic flows, waves, and wave-enhanced sediment-gravity flows of fluid. Products of wave-enhanced sediment-gravity flows, a newly recognized class of combined-flow, appear effective in transporting sediment downslope in muddy shelfal environments, are relatively common in the ancient record. Key recognition criteria enable their recognition and differentiation from other types of fluid-mud deposits, turbidites, and classical tempestites.