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Wave ripple development in mixed clay-sand substrates: A self-limiting process of bed stabilization?

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This paper reports on a series of experiments that aim to provide a fuller understanding of ripple development within clay-sand mixture substrates under oscillatory flow conditions. The work was conducted in the Total Environment Simulator at the University of Hull and constituted 6 separate runs, in which 5 runs were conducted under identical sets of regular waves (an additional run was conducted under irregular waves, but is not discussed in present paper). The bed content was systematically varied in its composition ranging from a pure sand bed through to a bed comprising 7.4% clay. A series of state-of-the-art measurements were employed to quantify interactions of near-bed hydrodynamics, sediment transport, and turbulence over rippled beds formed by wave action, during and after, each run. The experimental results demonstrate the significant influence of the amount of cohesive clay materials in the substrate on ripple evolution under waves. Most importantly, addition of clay in the bed dramatically slowed down the rate of ripple development and evolution. The equilibrium time of each run increased exponentially from 30 minutes under the control conditions of a pure sand bed, rising to $\sim$350 minutes for the bed with the highest fraction of clay. The paper discusses the slower ripple growth rates with higher cohesive fractions, via an influence on critical shear, but highlights that the end equilibrium size of ripples is found to be independent of increasing substrate clay fraction. The suspended particles mass (SPM) concentration indicates that clay particles were suspended and winnowed by wave action. Additionally, laser granulometry of the final substrates verified that ripple crests were composed of pure sand layers that were absent at ripple troughs, reflecting a relatively higher winnowing efficiency at wave ripples crest and downward movement of clay particles ending in the deeper layer. The clay removal is inexorably linked to wave ripple development and evolution. The implications of the results for sediment dynamics in mixed-bed substrates are highlighted and discussed.