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Variations in physiography, tidal forcing, and bottom shear stress in palaeo-seas: lessons learned from numerical modelling.

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The physiography (geometry and bathymetry) of a basin and its latitude are the primary parameters that dictate the tidal dynamics in shoreline–shelf systems. Understanding the impact that changes in physiography have on tides allows researchers to 1) improve interpretations of historical sedimentary processes in shallow-marine basins, and 2) better predict potential variations in tidal dynamics in response to an anthropogenic-driven relative sea level change.

Here, we present an analysis of numerical modelling of tidal propagation in the Upper Jurassic Sundance and Curtis Seas demontrating that basin-scale amplification and dampening of tides occurred in different palaeophysiographic configurations, and more localised amplification relating to tidal harmonics occurred in certain physiographic scenarios. Consequently, palaeophysiography was the primary control on both the magnitude and location of tidal amplification, flow speed, and bed shear stress, whereas secondary controls were initial tidal forcing and bottom drag coefficient.

Simulation results for the palaeophysiography with a 600 m depth at the mouth of the system suggest a distribution of sedimentary facies comparable to those documented in the Upper Jurassic lower Curtis Formation, apart from the innermost Curtis Sea, near to the palaeoshoreline. Sediments potentially supplied by aeolian processes during regression and increased aridity were likely reworked by tides during a subsequent a transgression as the climate became more humid. The palaeophysiography with a 600 m depth at the mouth of the system can therefore be considered a realistic palaeophysiographic configuration for the Sundance and Curtis Seas given the similarities that exist between the predicted distribution of sedimentary facies and their actual distribution in the lower Curtis Formation. In this palaeophysiography, the Sundance Sea and the Curtis Sea would have thus attained a maximum depth of ~240 m and 40-45 m, respectively. In this context, the simulated tidal range in the Curtis Sea would have reached 2.60 m, which would classify the Curtis Sea as a meso-tidal system (2x 1.30 m tidal amplitude).

Finally, using change in palaeophysiographic configuration as a proxy for relative sea-level variations revealed the non-uniqueness (sensu Burgess & Prince, 2015) of sedimentary successions deposited in tide-dominated basin, given that tidal amplification in the system was controlled by palaeophysiographic configuration: one specific succession could be the product of several, equally-valid relative sea-level histories. Reciprocally, the impact of relative sea-level change on different successions is non-unique, since local tidal harmonics and the characteristics of coeval deposition may vary significantly during relative sea level changes.