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Turbiditic minibasin infill patterns: Insights from a novel integrated modeling approach

Stefan Luthi (1), David Hodgson (2), Xiaoxi Wang (1,4), and Remco Groenenberg (3)

(1) Delft University of Technology, Geoscience and Engineering, Delft, The Netherlands, (2) School of Earth and Environment, University of Leeds, Leeds, LS2 9JT, The United Kingdom, (3) Petrotechnical Data Systems, Lange Kleiweg 10, 2288 GK Rijswijk, The Netherlands, (4) Beijing Research Center, Aramco Asia, Wangjing East Road 4, 100102 Beijing, PR China

The seafloor bathymetry of intraslope minibasins on continental margins is known to play a significant role in controlling turbidity current pathways and the resulting sediment distribution. To investigate the governing processes, we combine laboratory analogue modelling of intraslope minibasin formation with numerical flow simulations of multi-event turbidity currents, an approach that allows an improved understanding of evolving flow-bathymetry-deposit interactions and the resulting internal stacking patterns of the minibasin infills. The bathymetry includes a shelf-to-slope channel followed by an upper minibasin, which are separated by a confining ridge from two lower minibasins that compares well with analogous bathymetries reported from various natural settings. A series of 100 consecutive flows is here reported in detail. They are released into the top of the channel and upon reaching the upper minibasin they follow a series of stages from short initial ponding, filling-and-spilling and an extended transition to long retrogradational ponding. Upon reaching the upper minibasin floor the currents undergo a hydraulic jump, causing much sediment to be deposited in the central part of the minibasin and on the counterslope. This modifies the bathymetry such that during the fill-and-spill stage, flow stripping and grain size partitioning cause some finer sediment to be transported across the confining ridge into the lower minibasins. Throughout the basin infill process the deposits retrograde upstream accompanied by lateral switching into locally formed depressions in the upper minibasin. After the fill-and-spill stage, significant deposition occurs in the channel where cyclic steps with wavelengths of 1-2 km develop as a function of pulsating flow behaviour that switches repeatedly between sub- to supercritical flow conditions. These results are at variance with conventional schemes that emphasise sequential downstream minibasin filling through ponding dominated by vertical aggradation. Comparison of these results with published field and experimental examples are provided and support the main conclusions.