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The role of upper-regime flow bedforms in the morphodynamics of submarine channels

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Advances in acoustic imaging of submarine canyons and channels have provided accurate renderings of seafloor geomorphology. Still, a fundamental understanding of channel inception, evolution, sediment transport, and the nature of the currents traversing these channels remains elusive. Here, we review a mosaic of geomorphology, shallow stratigraphy, and morphodynamics of channelized deep-water depositional systems of tectonically active slopes offshore of California, USA. These systems are imaged in high-resolution multi-beam sonar bathymetry (dominant frequency ∼200 kHz) and seismic-reflection (2-16 kHz) data. From north to south, the Monterey East, Lucia Chica, and San Mateo channelized deep-water depositional systems show a breadth of geomorphology and stratigraphic architecture, including channel reaches of varying sinuosity, levees, terraces within channels, and crescent-shaped bedforms, especially in the thalwegs of incipient channel elements. Morphodynamic numerical modeling is combined with interpretations of seafloor and shallow subsurface stratigraphic imagery to demonstrate that the crescent-shaped bedforms common to channel thalwegs are likely to be cyclic steps. We propose that net-erosional and net-depositional cyclic steps play a fundamental role in the formation, filling, and maintenance phases of submarine channels in continental margins with high gradient, locally rugose bathymetry. These margins include passive-margin slopes subjected to gravity-driven tectonic deformation. In such settings, high gradients support the development of densimetric Froude-supercritical turbidity currents, and abrupt slope breaks can promote hydraulic jumps and the spontaneous evolution of an erodible seabed into cyclic steps. This morphodynamic investigation of turbidity currents and the seafloor has the potential to enhance prediction of the locations, stratigraphic evolution, and architecture of submarine canyon-channel systems.