The interplay of turbidity and contour currents: its representative products, flow dynamics, and significance

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A different type of deep-water channels characterized by unidirectional channel-growth trajectories, was recently recognized in northern South China Sea Slope (Gong et al., 2013), the Lowe Congo Basin (Gong et al., 2016), the offshore of Northern Mozambique (Fonnesu et al., 2020), and in many other deep-water basins. This type of submarine channels was termed unidirectionally migrating deep-water channels (UCs) by Gong et al. (2013) for the first time. Unidirectional channel migration is a depositional response to persistent actions of alongslope contour currents, while deep-water channels are conduits for downslope turbidity currents. UCs, thus, contain clear signals from both turbidity and contour currents.

Architecturally, UCs are characterized by unidirectional channel trajectories, and asymmetrical channel cross-sections with steep channel flanks developed towards channel migration, and short and relative straight channel courses. They are composed of different channel-complex sets, within each of which reworked turbidites in the lower part grade upward into muddy debris-flow deposits and, finally, into shale drapes. Hydraulically, we employed the concept of Wedderburn number (*W*) to quantify pycnocline response of turbidity flows to forcing events of contour currents in UCs recognized in the Lower Congo Basin. Bankfull turbidity flows in the Lower Congo UCs were computed to be supercritical [Froude number (*Fr*) of 1.11–1.38] and had velocities of 1.72–2.59 m/s. Contour currents with assumed constant velocities between 0.10 and 0.30 m/s flowing through their upper parts would result in pycnoclines between turbidity and contour currents, with amplitudes of up to 7.07 m. Such pycnoclines, in most cases, would produce Kelvin-Helmholtz (K-H) billows and bores that had velocities of 0.87–1.48 m/s and prograded toward the steep channel flanks by 4.0° to 19.2°. Their wavefronts with the strongest shocks and deepest oscillations would, therefore, occur preferentially along the steep channel flanks, thereby promoting erosion; on the other hand their wavetails with the weakest shocks and shallowest oscillations would occur preferentially along the gentle flanks, thereby promoting deposition. Such asymmetric intra-channel deposition, in turn, forced individual channels to consistently migrate toward the steep flanks, forming channels with unidirectional channel trajectories and asymmetrical channel cross-sections.

Our research on unidirectionally migrating deep-water channels provides two main contributions towards a better understanding of flow processes and sedimentation in submarine channels. First, our research success in documenting architecture and flow dynamics of a different type of deep-water channels, thereby contributing to a more compete picture of submarine channels. Second, our results suggest that pycnoclines between turbidity and contour currents could produce K-H billows and bores that impinged the steep channel flanks, therefore setting the tone in exploring further quantification of the interplay of oceanic contour currents and the sedimentology of turbidity currents.

Keywords: unidirectionally migrating deep-water channels, Wedderburn number, Kelvin-Helmholtz billows and bores, the interplay of turbidity and contour currents, contour current-controlled sedimentation