

Origin and architecture of channels versus gullies in an ancient mixed siliciclastic-carbonate slope system, Neoproterozoic Isaac Formation, Cariboo Mountains, BC

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Abstract

Deep-water slope channels represent important hydrocarbon reservoirs, and over the past decades have been exhaustively studied in both modern and ancient siliciclastic-dominated systems. Significantly less is known, however, are slope processes and deposits in mixed siliciclastic-carbonate and carbonate systems. An up to 175 m thick slope succession consisting of mixed siliciclastic-carbonates and carbonates is superbly exposed at the Castle Creek study area in the southern Canadian Cordillera. This lithologically distinctive succession, sandwiched within the siliciclastic-dominated Windermere turbidite system in the Cariboo Mountains of east central B.C., is an important stratigraphic marker for examining changes in facies, composition and stratal architecture styles during the long-term evolution of this continental-scale turbidite system.

Based on detailed field-based observations in the study area two end-member kinds of submarine channels have been identified: leveed channels and gullies. Leveed channels are composite features, up to 20 m thick, >1.2 km wide and filled with smaller, amalgamated channel fills with high net-to-gross. Smaller channels are up to 10 m thick, at least 400 m wide and filled predominantly with thick-bedded, quartz-dominated sandstone and conglomerate, as well as mixed carbonate-siliciclastic sandstone and conglomerate with common shallow-water carbonate clasts and variable carbonate cementation. Adjacent levee deposits consist of thin- to thick-bedded, calcareous sandstone interbedded with mudstone. In contrast, gullies are isolated, narrow (100-300 m wide), shallow (up to 2 m deep) features with low net-to-gross ratios. They are filled consistently with a tripartite stratal succession, which stratigraphically upward consists of medium-bedded, planar or (single set) dune cross-stratified coarse-grained

sandstone, overlain by up to 0.8 m thick fine-grained siliciclastic turbidites, and then capped by up to 1 m thick succession of calciturbidites. Gullies then stack (at least 6-7) to form up to Dm-thick units.

The formation of leveed channels versus gullies is interpreted to be controlled by differences in input variables including sediment flux, size and mineralogical composition, which in turn are thought to be linked to differences in relative sea level. Leveed channels probably formed during episodes of lowered relative sea level when a voluminous supply of coarse siliciclastic sediment that previously had bypassed the shelf was added to sediment eroded from the carbonate platform and together were fed directly to the slope. Gullies, on the other hand, are interpreted to have formed during or after rises of relative sea level when carbonate production on the shelf overwhelmed the siliciclastic supply and sediment delivery to the slope became dominated by a mix of carbonate and siliciclastic mud. Locally, fine-grained sediment deposition was interrupted by the influx of coarse siliciclastic sand, which was confined to shallow, narrow, erosionally-based gullies. This sediment most probably represents coarse palimpsest sediment that became stranded on the shelf during the rise of relative sea level.

The upward change from leveed channels to gullies might also reflect changes in sediment supply to the slope, specifically from siliciclastic- to carbonate-dominated sedimentation. As noted by earlier authors (e.g. Ross et al., 1994), the change to a more carbonate-dominated slope is marked by an increase in the inclination of the slope. Moreover, such changes have been shown, based on observations from modern continental slopes, to be manifest in the preferential development of slope gullies instead of slope channels (e.g. Mulder et al., 2012).

References

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