Infrequent large events versus frequent small events: importance for submarine channel evolution

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Turbidity currents carve spectacular canyons and channels in the seafloor, which can extend for thousands of kilometres, rivalling the length of rivers on land. However, turbidity current systems differ from rivers in their large variability in discharge. Subaqueous channels host many small events and more infrequently, large events. How these large and small events contribute to the evolution of submarine channels is currently poorly understood.

These canyons and channels are important conduits for sediment, nutrients, pollutants, and organic carbon to the deep-sea. Understanding these systems is important because they can influence marine ecosystems and geochemical cycles. The deposits they create can form valuable hydrocarbon reservoirs, while the flows themselves pose a hazard to seafloor infrastructure including cables that facilitate >95% of global data transfer. The often remote nature of submarine channels, and the powerful episodic flows that occur within them, pose challenges to direct monitoring of active systems; hence, much of our existing understanding is based on ancient systems or scaled-down experiments.

Recent developments in technology have enabled direct measurements to be made of turbidity currents in the field. However, the flows that have been measured to date are presumably on the smaller end of a spectrum, and may not be those that fundamentally sculpt seascapes or build seismically-resolvable depositional sequences. Sequences of frequent small ‘canyon filling’ events followed by an occasional bigger ‘canyon flushing’ event have been proposed to control sediment transport in these systems. However, smaller flows have been demonstrated to be able to create and cause migration of bedforms, that are hypothesised to be the ‘building blocks’ of submarine channels. The role of small frequent flows compared to infrequent larger events in channel evolution remains unclear, and competing ideas exist.

Here we present time-lapse bathymetry mapping of an extremely active submarine channel in Toba Inlet, British Columbia. Here we can compare the erosional and depositional patterns related to different scales of events. The surveys record the influence of frequent sub-annual turbidity currents, which dominantly promote deposition in the proximal reaches of the channel. Between two of the surveys, a 1,000,000 m^3 submarine slope failure occurred on the prodelta slope. This is the first site ever where we can directly compare the resulting erosion and deposition of these different scale events in a single system. The collapse triggered up to 15 metres of erosion and eroded metres deep into the prodelta, before reaching the main channel. This event affected the channel along its full length, including up to 8 metres of erosion in the most distal part of the channel. This distal part of the system remains inactive between surveys that do not cover this submarine slope failure. Here, our results show that frequent flows create sediment accumulation on the prodelta and promote channel fill in the proximal part of the system; this occurs over short timescales. Instead, infrequent large events control the submarine channel evolution and the ultimate preservation potential of channel fill deposits along the full-length of the channel.