Geometry and dynamics of braided channels and bars under experimental density currents

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Submarine channels convey turbidity currents, whose deposits are key hydrocarbon reservoirs and indirect records of continental denudation. Submarine channel patterns resemble those of their subaerial counterparts, but controls on the form and dynamics of submarine channels and associated deposits remain comparatively uncertain. Existing laboratory experiments show that braided channels can develop under similarly high flow width-to-depth ratios for both subaerial and submarine conditions. We conducted a new set of experiments with net-depositional density currents to (1) further test the conditions for channel formation; (2) test the response of channel and bar geometry to changes in the ratio of water-to-sediment flux, inlet conditions, and submarine versus subaerial conditions; and (3) quantify the relative timescales of channel lateral migration, abandonment, and aggradation. We generated density currents within a freshwater basin using saline inflows that transported plastic sediment as bedload across a platform 2 m long and 1 m wide. We find that across a 2.7-fold range in the ratio of water-to-sediment flux, submarine braided channels consistently develop, are more pronounced upstream, and can transition to zones of sheet flow downstream. We measured topographic statistics directly, and using a reduced-complexity flow model. The topographic analysis showed that braiding index is higher for subaerial than for submarine conditions with other variables fixed. For a representative submarine experiment, channel lateral motion decorrelated in double the time to move laterally one channel width, and one-third the time to aggrade one channel depth. We propose a new stratigraphic model for submarine braided channels, wherein sand bodies are more laterally connected and less vertically persistent compared to those formed by submarine meandering channels. These results suggest that channel pattern is a key variable for predicting stratigraphic architecture in submarine environments.

Keywords: Geomorphology, Sedimentology, Submarine channels, Braided rivers, Turbidity currents

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