PRF#: 56832-ND8
Project Title: Linking River Channel Dynamics to the Dimensions of Channel Belts
P.I. Name, Affiliation: Chris Paola, Department of Earth Sciences and St. Anthony Falls Laboratory, University of Minnesota. Document prepared by Ajay Limaye, Department of Earth Sciences and St. Anthony Falls Laboratory, University of Minnesota.

Research summary

This project examined controls on the width of river channel belts. The channel belt is the area of the landscape adjacent to a river channel that bears markings of past river occupation—including abandoned channels, scroll bars, and eroded valley margins. Channel belts are common features of low-relief landscapes where rivers can shift laterally. In shifting, river channels deposit large volumes of sediment that are eventually preserved in sedimentary rock. These coarse-grained sedimentary deposits are key hydrocarbon reservoirs. Effective characterization of these reservoirs requires knowledge of their geometry in the subsurface, for example using empirical data sets. To improve stratigraphic prediction and the reconstruction of paleoenvironments from channel belt deposits, new models are needed to describe how channel belts develop, and how the width of the channel belt varies downstream. To address these knowledge gaps, we designed a set of physical experiments to evolve channel belts in a controlled laboratory setting (**Fig. 1**).

Figure 1. A downstream-looking view of a braided channel belt in the laboratory. Flow is dyed red and the flume width is 2.7 m.

In the second year of the project, we completed a set of four experimental runs to test how four key variables—water discharge, channel slope, downstream distance and time—affect the widening of channel belts (**Fig. 2**). A key challenge in designing the experiments was that the flume walls would typically constrain any channels early in their evolution. Therefore, we designed the experiments in a large flume, 2.7 m wide and 37 m long. Expressed in terms of the initial channel width, this area was equivalent to 9 channel widths in the cross-stream direction and 200 channel widths in the downstream direction, both of which enabled sustained and

Figure 2. Upstream-looking views of the channel belt during each run. Water discharge (Q) and channel slope (S) were varied independently to test their influence on channel belt development.

unconstrained channel motion. We gathered image and topography data with time resolution sufficient to capture the evolution from a straight channel to a fully developed channel belt.

We used the topography measurements to map the evolution of the channel belt for each run **(Fig. 3A)**. In all runs the channel belt widened rapidly at the start of the run, then evolved more slowly as the flow depth decreased within the channels. Importantly, time and downstream distance emerged as important variables for predicting the channel belt width. A quasi-equilibrium channel belt width developed in three of the four cases. With both variables expressed in dimensionless form, the final, average width of the channel belt scaled with stream power (**Fig. 3B**). We are currently preparing a manuscript for submission that investigates the causes of these channel belt dynamics and their implications for predicting channel belt dimensions in modern landscapes and the rock record. We anticipate that the time-resolved data sets from the experiments will be of continuing use for research in river morphodynamics.

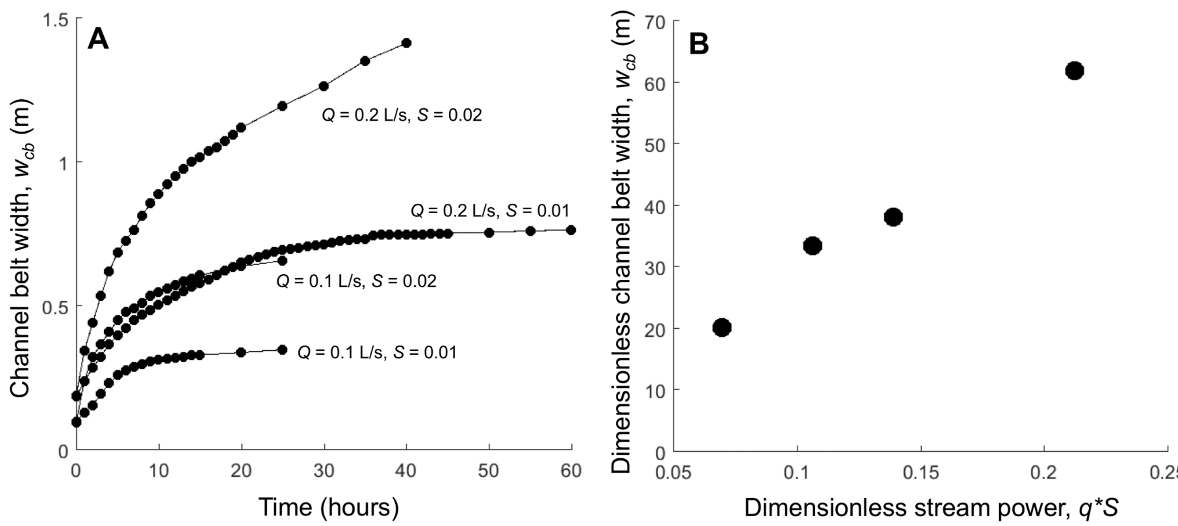

Figure 3. (A) Average channel belt width (w_{cb}) versus time for each run. (B) Dimensionless channel belt width (w_{cb}*) versus dimensionless stream power (q^*S), where $w_{cb}^* = w_{cb}/L$, $L = Q^{2/5}/g^{1/5}$ is a representative length scale for the channel, $q^* = Q/(L\sqrt{gRD^3})$, g is gravitational acceleration, R = 1.65 is the relative density of submerged sediment, and D = 0.42 mm is median sediment grain size.

Career impacts

The project impacted PI Paola's career by enabling new research in a facility at St. Anthony Falls Laboratory that is typically used for hydraulics experiments with deep flows (~ 1 m flow depth). The project enabled reconfiguration of this facility to house experiments with small-scale rivers (i.e., flow depth < 1 cm) in a large experimental space. These experiments further enabled a new direction in Paola's research, the dynamics of river channel belts in continental interiors.

The project had a profound impact on Research Associate Ajay Limaye's career. Limaye gained new experience in leading the design and execution of a large-scale morphodynamics experiment. As part of this work, Limaye developed management experience in tracking the project budget, coordinating undergraduate students, and working closely with engineering staff to address design challenges involved in preparing the experiments. While running the experiments, Limaye frequently interacted with visitors from the general public, high schools and universities, government laboratories, and civil engineering firms. Building on this experience, Limaye will begin a tenure-track faculty position in the Department of Environmental Sciences at the University of Virginia in August 2019. The research themes and skills developed during this project will seed future work in physical sedimentology.