PRF#: 57811-ND8
Project Title: Do Muds Sort? Experimental Test of a Hypothesis Key to Understanding Marine Bottom Currents
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Project Status at Submission of This Report (October 1, 2019):
The primary work of this project (ACS-PRF 'New Directions' grant #57811-ND8) has been completed. **We requested and received a no-cost extension to complete the remaining tasks** (complete data analysis and prepare manuscripts). The narrative below summarizes the second year (September 2018-August 2019).

Project Goals:
The goal of the project is to experimentally constrain the relationship between velocity of currents transporting mixtures of silt and clay with the measured grain-size distribution of deposits. The coarse silt fraction (i.e., 10-63 μm range) has been used by paleoceanographers to infer deep-sea bottom-current flow speed, but there is a surprising lack of laboratory validation. Our results aim to show to what degree size sorting occurs in relation to known parameters, which will allow us to refine the validity and interpretation of grain-size metrics from natural deposits. More broadly, we anticipate our work to improve the fundamental understanding of sediment transport processes of clay/silt mixtures relevant to numerous geoscience and engineering problems.

Work Done To Date (through Year 2):
Our objectives required the design and construction of a new sediment transport flume housed in the *Kelso Baker Environmental Hydraulics Laboratory* at Virginia Tech. A non-recirculating flume was designed to transport water and sediment at a variety of velocities (up to 28 cm/s, various concentrations and mixtures). The flume was used in August-October 2018 to conduct pre-experiment runs to calibrate flow rates, allow testing of observational procedures (e.g., photography), refine our sampling protocol, and run tests of grain-size measurement. In November-December 2018, a first set of experiments were run, which allowed for additional refinement of the experimental matrix, minor modifications to grain-size analysis routine, and provided content for our first presentation of preliminary results at the AGU Fall Meeting in Washington, D.C. in Dec 2018. (Abstract # EP31E-2408; Culp et al.).

The matrix of experiments (23 flume runs in total) was successfully completed in Jan-April 2019. An initial analysis of the results is summarized in M.S. student J. Culp's thesis, which was completed in May 2019. The experiments were conducted with 4 different sediment mixtures (pure clay, pure silt, 2:1 silt to clay, and 1:1 silt to clay) and current velocities ranging from 5 to 28 cm/s; above 28 cm/s, no deposits developed. Each experiment was run with a constant supply of sediment at the flume inlet for a set amount of time. Following the run, the bed was sampled at fixed locations from the flume entrance and processed with Micromeritics Sedigraph 5120 particle size analyzer. The bed morphology that developed in each experiment was dependent on the mixture used and the current velocity. The critical velocity for deposition, bedload, and bedform migration was identified. At a given location in the flume, the mean and median sortable silt was indeed linearly related to average flow velocity across all sediment mixtures. The relationship was strongest for the pure silt runs, but still present in the runs using silt and clay. The deposits fined in the downstream direction. This downstream fining changing the intercept and slope of the relationship between average flow velocity and mean or median sortable silt, but at any location within the deposit, the mean or median sortable silt was a positive linear function of velocity (Fig. 1).

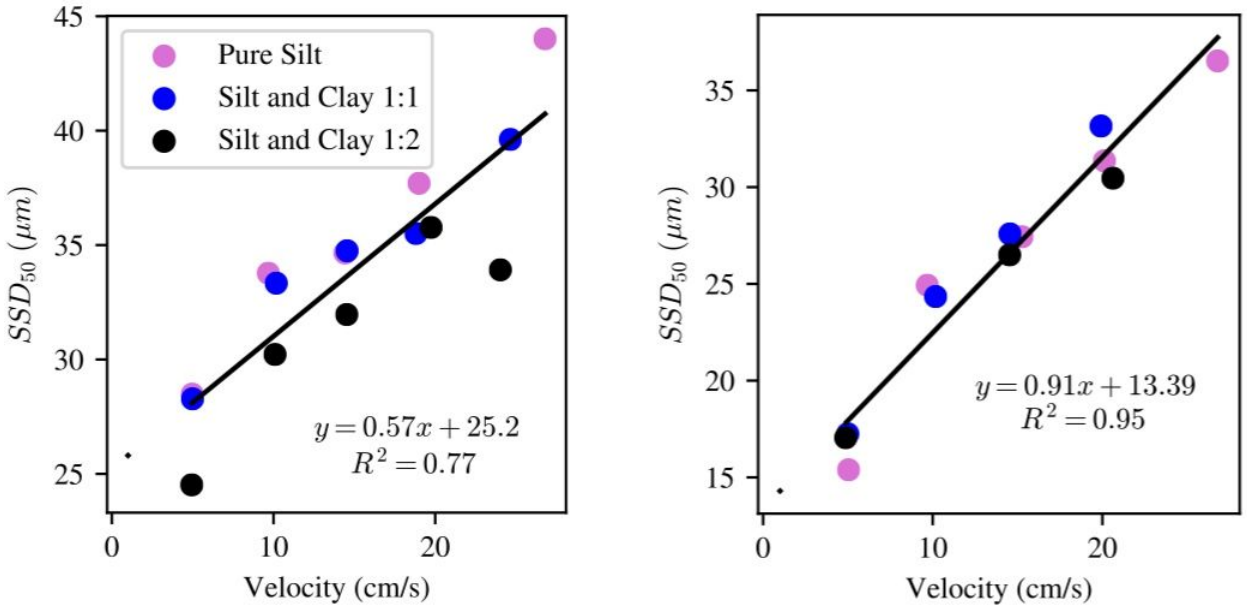

Fig. 1 Example regressions of the median sortable silt vs velocity at specific sampling location, 5 ft (left) and 20 ft (right).

Looking Forward (Close-out of Project):

As mentioned above, we are currently beyond the end of Year 2 and in a no-cost-extension phase of this project. Assuming abstract acceptance, we plan to share the results of this study at the AGU Fall Meeting in Dec 2019 via two abstracts (Part 1 on experiment design and general results and Part 2 on implications to paleoceanography). We then plan to finalize and submit manuscripts in the early part of 2020.

Impact on PIs and Student Participants:

This project was funded via a 'New Directions' grant and includes methods not previously employed by PI Romans. PI Romans' approach to sedimentological problems has already been influenced by this collaboration in the form of a more 'forward' and quantitative view of process-deposit relationships. Co-PI Strom is benefiting by enhancing his knowledge of oceanographic processes via discussions, recommended literature, and writing up results. A master's student in Civil and Environmental Engineering (J. Culp; advisee of co-PI Strom) co-designed and led the construction of the flume, ran the experiments, and completed his M.S. based on this work in May 2019. A Ph.D. student in Geosciences (A. Parent; advisee of PI Romans) participated in experimental design and led sampling and grain-size analysis of the experimental deposits. Both Parent and Culp have benefitted through the multi-disciplinary interaction and discussion inherent to this project and will make significant contributions to the synthesis and communication of the eventual results.