

Development Of Gullies And Bedforms In Continental Slopes By Turbidity Currents

Marcelo H. Garcia
Department of Civil and Environmental Engineering
University of Illinois at Urbana-Champaign
205 North Mathews Avenue
Urbana, Illinois 61801
phone: (217) 244-4484, fax: (217) 333-0687, email: mhgarcia@uiuc.edu
Award Number: N00014-93-1-0044
<http://cee.ce.uiuc.edu/contact/faculty/garcia1.htm>

LONG-TERM GOAL

Our long-term scientific goal is to develop sound theoretical models for submarine sediment movement that can be used to predict the initiation, spatial development, and time duration of mud flows and turbidity currents. Of great interest are the characteristics of the sedimentary deposits that these flows generate, in particular their capability to develop bed forms and gullies by means of sediment erosion and deposition in continental margins.

OBJECTIVES

Our main objective this past year has been to test the hypothesis that turbidity currents could be responsible for the development of gullies and submarine channels in continental slopes. A second objective has been to explore the ability of turbidity currents to generate bedforms, such as antidunes, along their path.

APPROACH

Our approach has consisted of theoretical work, laboratory experiments, and numerical modeling. The theoretical work has concentrated in a perturbation analysis of the equations of motion for turbidity currents, with the goal of assessing the conditions for which bedforms will develop. Laboratory experiments have been directed to the formation of bedforms by channelized turbidity currents, as well as the formation of submarine gullies by three-dimensional turbidity currents emanating from a line source at the head of a model slope. Numerical modeling, with the help of layer-averaged equations of motion together with a cellular model, has been used to explore the formation of submarine gullies through sediment erosion and deposition.

WORK COMPLETED

A linear stability analysis of the equations of motion for turbidity currents (Parker et al., 1986) flowing over a movable sediment bed, was completed. A conservative component (i.e. clay) was added to a sand-laden turbidity current. The main goal was to study the growth or decay of small bed-level perturbations in the flow direction. The conditions prescribed by the theoretical analysis were then used to design and conduct a set of laboratory experiments with channelized turbidity currents, with the goal of observing the development or lack of bedforms. Preliminary experiments were also completed in the MARGINS tank, to explore the generation of submarine gullies by 3-D turbidity currents. To

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complement and guide the laboratory work with turbidity flows from a line source, a numerical model was set up. The model combines the set of equations for turbidity currents proposed by Parker et al. (1986), with a simple, rule-based cellular model proposed by Murray and Paola (1994) for the modeling of braided streams.

RESULTS

Both the theoretical perturbation analysis and the laboratory experiments have shown that clay content in turbidity currents plays an important role in the formation of submarine bedforms. Figure 1 shows a picture of antidunes generated by a turbidity flow that was sustained for more than 20 minutes. The amplitude of the antidunes is about 2 cm. and the wavelength is approximately 15 cm.

Morphological features generated by the passage of turbidity currents on a continental slope are shown in Figure 2. The erosional and depositional patterns rendered by our numerical model are qualitatively similar to those observed on the northern California slope (Field et al., 1999).

IMPACT AND APPLICATION

Our results have important implications for the recognition of morphological features in the field. Turbidity currents are considered to be the architects of many, but not all, submarine canyons. Our findings show that they are also capable of causing longitudinal instabilities, such as antidunes, as well as spanwise instabilities such as gullies. Our understanding of the mechanics of bedforms in continental margins until now was very limited and we hope that our findings will facilitate both the interpretation of the geologic record and the design and placement of submarine structures on stable sediment deposits.

TRANSITIONS AND RELATED PROJECTS

Our knowledge about kinematics of bedforms is being used to assess sediment loads reaching the delta of the San Joaquin river, California, as part of a CALFED project to find a solution to the land subsidence problem, with potential saline intrusions, experienced by several agricultural areas within the delta.

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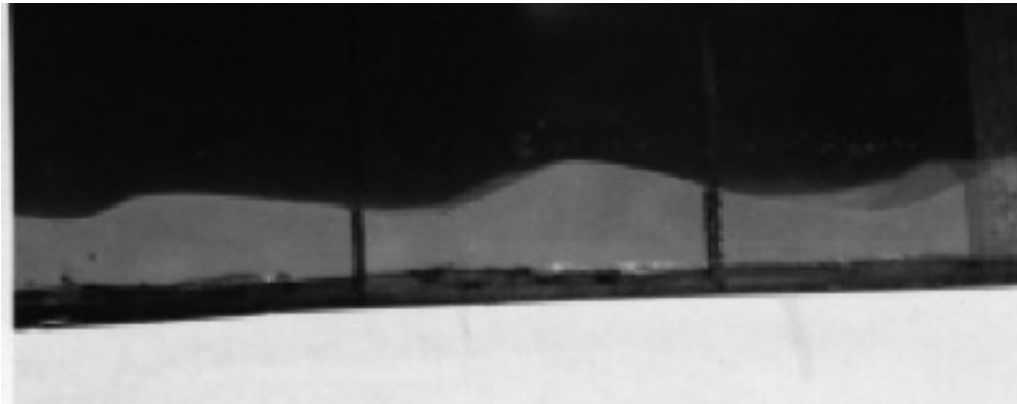


Figure 1. *Antidunes generated by turbidity currents*

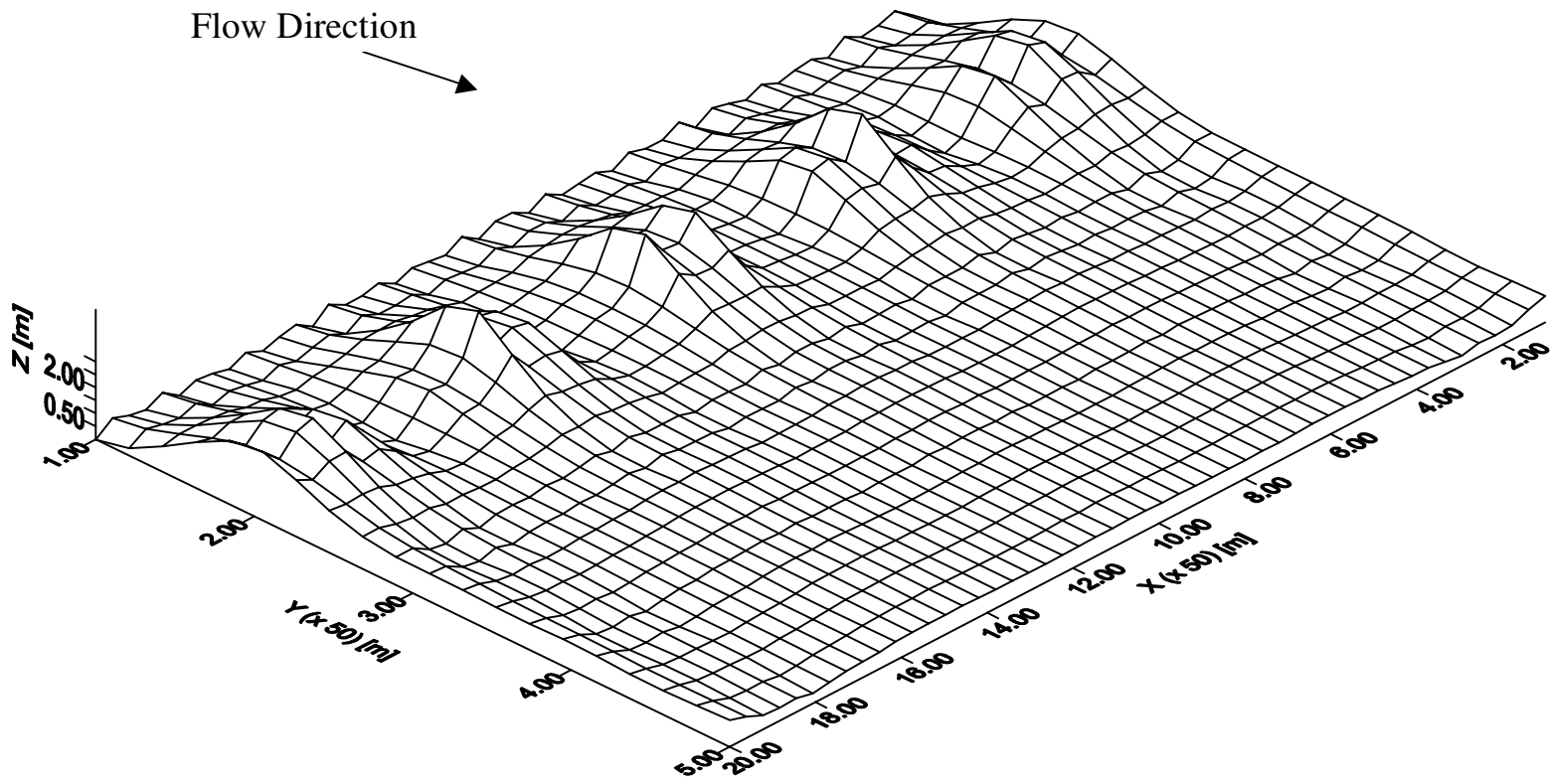


Figure 2. *Morphological features generated by turbidity currents on continental slopes.*