Margin Morphodynamics: Debris Flows, Turbidity Currents and Experimental Margin Stratigraphy

Gary Parker
St. Anthony Falls Laboratory
University of Minnesota
Mississippi River at 3rd Ave. SE
Minneapolis, MN 55414
phone: (612) 627-4575 fax: (612) 627-4609 email: parke002@tc.umn.edu

Chris Paola
St. Anthony Falls Laboratory
University of Minnesota
Mississippi River at 3rd Ave. SE
Minneapolis, MN 55414
Phone: (612) 627-4010 fax (612) 627-4609 email: cpaola@tc.umn.edu

Grant Number: N00014-93-1-0300

LONG-TERM GOALS

The long-term goal of the project is to gain a deeper understanding of the role of turbidity currents and submarine debris flows as building blocks of continental margins.

OBJECTIVES

The objectives of the project are as follows. 1) Characterize the ability of eroding and depositing turbidity currents to shape the continental slope. 2) Describe the ability of submarine debris flows to interact with an antecedent bed. 3) Obtain an understanding of the interaction between tectonics and turbidity currents.

APPROACH

Three approaches have been taken to the study of submarine debris flows. 1) Measurements laterally constrained debris flow dynamics and pore pressure variation have been performed in the "Fish Tank" facility. 2) The dynamics of unconfined debris flows have been studied using the "Main Channel." 3) A numerical model of muddy debris flows is being extended to a) sandy debris flows and b) the reworking of antecedent deposits by overriding debris flows. Experiments on turbidity currents have been focused on deposition in diapiric intraslope minibasins and erosion of the ridges in between. An extensive program of experiments on both erosional and depositional turbidity currents in the 1-D "Garcia Tank" has been conducted. In addition, a single long experiment has been performed in the "Jurassic Tank" facility to understand the interaction of tectonic subsidence and depositional turbidity currents. The stratigraphy created in the experiments was constructed from numerous pulse-like and continuous turbidity currents. A numerical model is being developed based on the experimental results. Finally, experiments have been performed on prograding deltas, the bottomsets of which were

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE
30 SEP 2001

2. REPORT TYPE

3. DATES COVERED
00-00-2001 to 00-00-2001

4. TITLE AND SUBTITLE
Margin Morphodynamics: Debris Flows, Turbidity Currents and Experimental Margin Stratigraphy

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
University of Minnesota,,Mississippi River at 3rd Ave. SE,,Minneapolis,,MN, 55414

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT
The long-term goal of the project is to gain a deeper understanding of the role of turbidity currents and submarine debris flows as building blocks of continental margins.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**6**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

deposited from turbidity currents. The results of these experiments have been incorporated into a moving-boundary model of delta progradation.

WORK COMPLETED

The following work was performed in Fiscal Year 2001 (October 1, 2000 to September 30, 2001).

- Experiments were performed to study the ability of turbidity currents to erode a weakly consolidated bed.

- Experiments were performed to study the process of deposition from a turbidity current in a laterally constrained intraslope minibasin.

- The results of the above two experiments have been incorporated into a numerical model which is able to capture a) the internal hydraulic jump formed as the turbidity current flows into the minibasin and b) detrainment of water from the turbidity current in the minibasin.

- The existing experimental base on the formation of prograding deltas has been extended by the performance of a run which verifies the tendency of an overriding turbidity current to lower the slope of the foreset deposit. In addition, the run helped characterize the nature of bedforms associated with the bottomset turbidites. The results have been used to further develop a moving-boundary model of deltas.

- An extended experiment on the interaction of deposition from turbidity currents in intraslope minibasins and tectonics was performed in the "Jurassic Tank" facility. The experiment, which included numerous continuous and pulse-like turbidity currents, was performed over a period of 150 hours. The turbidity currents carried a poorly sorted mix of silt and sand. The deposit, which is presently being sliced, shows a rich pattern of deposition, as well as local erosion and channelization.

- Experiments on laterally confined debris flows containing a slurry of sand and clay have been used to characterize the dissipation of pore pressure during flow events. To date no evidence of pore pressure dissipation has been found from the time of release to the time of deposition.

- The largest experiments performed to date on laterally unconfined debris flows further demonstrate the tendency of such flows to hydroplane and undergo auto-acephalation. The experiments were performed on a submerged ramp with a width of 2.7 m and a length of 10 m, beyond which the flows can continue for over 50 m on a horizontal bed.

- A theory for the hydroplaning of auto-acephalated debris flow heads has been developed and submitted for publication.

- The elements necessary to extend the numerical program BING to the reworking of submarine debris flow deposits by successive flows have been developed.

Figure 1. Turbidity current entering the "Jurassic Tank" subsiding basin.

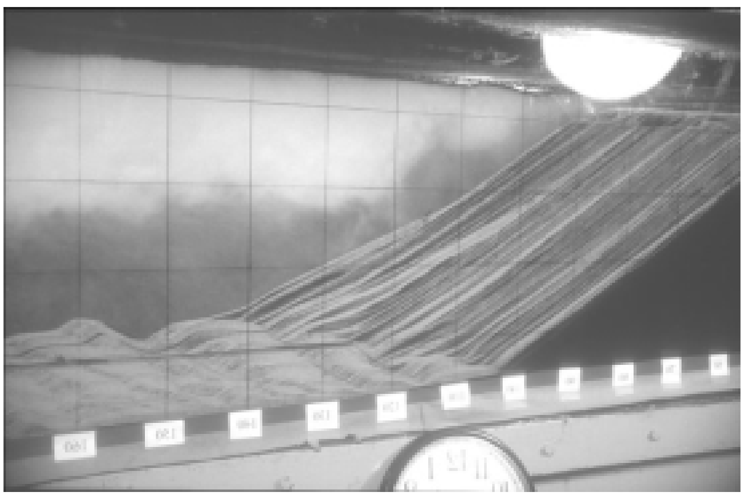

Figure 2. Topset, foreset and bottomset of delta with a plunging turbidity current, which has been made visible by the addition of crushed coal.

Figure 3. Subaqueous debris flow deposit with auto-acephalated glide block at distal end.

RESULTS

Major results of the research performed in the aforementioned fiscal year can be summarized as follows.

- The roles of internal hydraulic jumps and water detrainment in the process of deposition from 1-D turbidity currents have been identified for the first time. The first theory and numerical model describing these processes has been developed for uniform sediment. Major progress has been made toward an extension to sediment mixtures.
- The experiment in "Jurassic Tank" provides for the first time an experimental view of the interaction between subsidence and 2-D depositional turbidity currents under controlled conditions.
- The first measurements of pore pressure variation of subaqueous debris flows have been performed.
- Hydroplaning of subaqueous debris flows has been verified as the largest scale to date, and a predictive model of auto-acephalated hydroplaning glide blocks has been completed.

IMPACT/APPLICATIONS

Several impacts and applications of the work can be described as follows.

- Hydroplaning debris flows can pose a serious risk to undersea cables and pipelines. With sufficient mud content, pore pressure is not dissipated over the time of a flow event.
- The patterns and stratigraphy of turbidity current deposition in experimental intraslope minibasins have helped reveal the focus of deposition of sand in them. This can help in the exploration for deep-water hydrocarbon reserves.
- The identification of the roles of internal hydraulic jumps and water detrainment serve to elucidate the characteristics of deposition by turbidity currents in confined basins.

TRANSITIONS

Some of the work described above will be making a transition to cold storage due to the fact that the first PI of the project faces considerably reduced funding from ONR in the near future. This notwithstanding, the results from depositional turbidity currents will be made available to other members of the ONR Strataform team for incorporation into numerical models.

RELATED PROJECTS

The research on submarine debris flows and minibasin filling is also being supported by the St. Anthony Falls Oil Consortium. The research on prograding deltas is also being supported by the Minnesota Sea Grant program.

REFERENCES

No references are quoted above.

PUBLICATIONS

Swenson, J. B., Voller, V. R., Paola, C., Parker, G. and Marr, J. 2000 Fluvio-deltaic sedimentation: a generalized Stefan problem. *European Journal of Applied Math.*, 11, 433-452

Paola, C., Mullin, J., Ellis, C., Mohrig, D., Swenson, J., Parker, G. and Hickson, T. Experimental stratigraphy. *GSA Today*, July, 2001.

Marr, J. D., Harff, P., Shanmugam, G. and Parker, G. 2001 Experiments on subaqueous sandy debris flows: the role of clay and water content in flow dynamics and depositional structures. *Geological Society of America Bulletin*, 113(10).

Parker, G. and Kostic, S. 2002 Role of turbidity currents in setting the foreset slope of clinoforms prograding into fresh water. To appear in the May edition of *Journal of Sedimentary Research*.

Harbitz, C., Parker, G., Elverhoi, A., Mohrig, D.,. and Harff, P. Submitted Hydroplaning of debris glide blocks: analytical solutions and discussion. *Journal of Geophysical Research.*

PATENTS

No patents have been obtained or applied for.