EPSC Abstracts
Vol. 8, EPSC2013-365, 2013
European Planetary Science Congress 2013

Fluvial deposition processes on Titan – origin and evolution of landforms

P. Witek and L. Czechowski
Institute of Geophysics, Warsaw University, Poland (ppwit@igf.fuw.edu.pl / Fax: +48-22-5546882)

Abstract

Observations of *Cassini* probe during flybys of Titan have revealed the existence of numerous hydrocarbon lakes and landforms of fluvial origin. We simulate processes of sediment transport and deposition under terrestrial and Titanian conditions, with several possible compositions of the liquid and the sediments. Comparison of our results for both objects reveal many similarities, but also some differences.

1. Introduction

River deltas are formed when the flow enters the standing body of liquid. On the southern hemisphere of Titan, a long, sinuous channel connects to the large lake, Ontario Lacus terminating at the feature interpreted as two-lobed river delta. Images acquired by *Huygens* probe show rounded icy 'pebbles' on the surface of Titan, indicating that icy sediments of various fractions may be transported by the flow. Determining whether fluvial landforms on Titan are created by the occasional flash floods or the persistent flow has implications for understanding the environment and modelling the climate of this unique moon.

2. Figures

Figures 1 and 2 show results of simulations with the same geometry, initial liquid level and discharge at the inflow, but with different liquids (water on Earth, methane-nitrogen mixture on Titan) and solids (quartz and water ice, respectively). Note that the sediments have been pushed deeper into the lake in Titanian conditions (Figure 2).

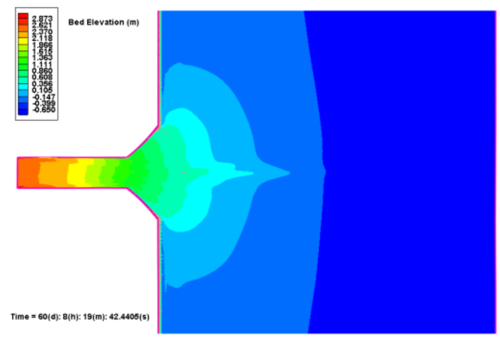

Figure 1: Bed elevation after 60 simulation days in terrestrial conditions.

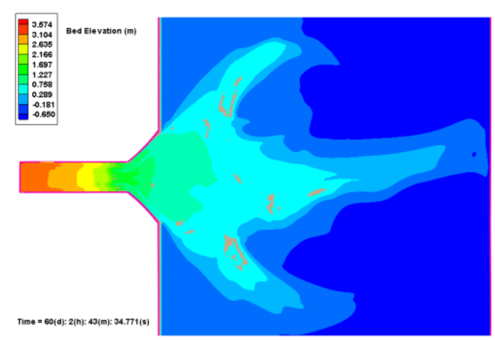

Figure 2: Bed elevation after 60 simulation days in Titanian conditions; branching of the stream results in faster development of the delta.

4. Tables

Table 1: Composition of two of the considered liquids that may be present on Titan's surface.

	"Rain"	Lake liquid
Methane	75%	10%
Ethane		74%
Propane		7%
Butane		8,5%
Nitrogen	25%	0,5%

5. Equations

We use two-dimensional depth-averaged hydrodynamic numerical model, based on the Reynolds approximation of momentum equations and the continuity equation.

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} = -g\frac{\partial Z}{\partial x} + \frac{1}{h}\left(\frac{\partial(h\tau_{xx})}{\partial x} + \frac{\partial(h\tau_{xy})}{\partial y}\right) - \frac{\tau_{bx}}{\rho h} \qquad (1)$$

$$\frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} = -g\frac{\partial Z}{\partial y} + \frac{1}{h}\left(\frac{\partial(h\tau_{yx})}{\partial x} + \frac{\partial(h\tau_{yy})}{\partial y}\right) - \frac{\tau_{by}}{\rho h} \qquad (2)$$

$$\frac{\partial Z}{\partial t} + \frac{\partial uh}{\partial x} + \frac{\partial vh}{\partial y} = 0 \qquad (3)$$

Where u and v are depth-averaged velocity components in the x and y directions, respectively; t is time; Z is the fluid surface elevation; h is the local fluid depth; g is the gravitational acceleration; τ_{ij} are the depth integrated Reynolds stresses; and τ_{bx} and τ_{by} are shear stresses at the bottom in the x and y directions, respectively.

Additional equations are used to describe bed-load transport, suspended sediment transport and deposition (see e.g. [2]).

6. Summary and Conclusions

Our results are in agreement with earlier analysis of Burr et al. (2006) in that the transport rate of icy sediments on Titan is higher than for quartz sediments on Earth. This conclusion has a profound impact on the development of river deltas. It indicates that on Titan the flow of the liquid is able to build these landforms faster than on Earth. The next step of our investigation will be to build model with more complex, realistic geometry, reproducing the shoreline of Ontario Lacus.

Acknowledgements

The Authors wish to thank Yaoxin Zhang and Yafei Jia from National Center for Computational Hydroscience and Engineering at the University of Mississippi for providing their programs, CCHE2D and Mesh Generator, used in this work.

References

[1] Czechowski, L., Kossacki, K.: Thermal convection in the porous methane-soaked regolith in Titan: Finite amplitude convection, Icarus, Vol. 217, pp.130 – 143, 2012.

[2] Duan, J., Julien, P.: Numerical simulation of meandering evolution, Journal of Hydrology, Vol. 391, pp. 34 – 46, 2010.

[3] Burr, D.M., Emery, J.P., Lorenz, R.D., Collins, G.C., and Carling, P.A.: Sediment transport by liquid surficial flow: Application to Titan, Icarus, Vol. 181, pp. 235-242, 2006.