geoconvention
Calgary • Canada • May 12-14 2025

# Influence of Depositional Slope and Sediment Concentration on the Morphology of Deepwater Turbidite Lobe Systems: An Experimental Approach

*Arijit Chattopadhyay, Elisabeth Steel, Junho Choi, Ruby Saban*
*Department of Geological Sciences and Geological Engineering, Queen's University*

## Introduction

Confinement, seafloor gradient, local topography, and sediment supply are major factors controlling the dimensions of turbidites and submarine lobes [1]. The same factors that control individual lobe morphology are also likely to influence the larger-scale submarine fan morphology, however, lobe dimensions can vary even within a single submarine fan [2]. This study focuses on how sediment concentration and basin gradient affect the morphology of turbidite lobe elements [3,4], and whether lobe element morphology scales with the morphology of the larger lobe complex over time.

## Experimental Methodology

A series of physical laboratory experiments were conducted in a 4 m x 4 m x 1 m basin. Experiments were imaged with overhead time-lapse photos and videography and a submersible topographic scanner (ULS-100, 2G Robotics) (Fig.1). The slope gradients were explored: 3°, 5° and 7°. At each slope gradient, 3 sets of experiments were conducted with 5%, 7.5%, and 10% (weight %) sediment concentration. Sediment type (crushed glass), grain size (ranging from 20-700µm, with an average $D_{50}$ 105µm), discharge, and fluid density were held constant. Each set of experiments comprised five successive turbidity currents with the same parameters to build a composite lobe. As such a total number of 45 turbidity current experiments were conducted.

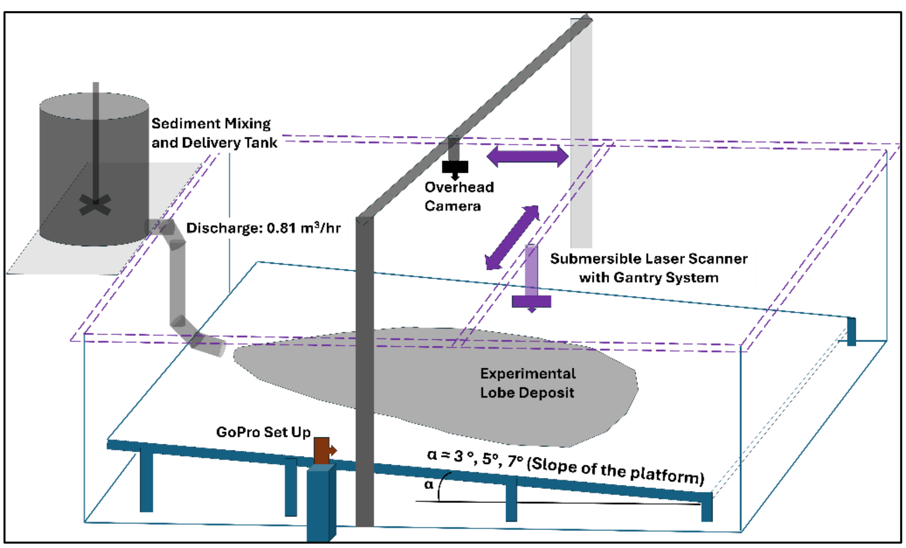


Fig. 1 Schematic Design of Experimental Set-Up

## Results

From the topographic scans, individual and cumulative lobe thickness maps (Fig. 2) were prepared to study the effect of basin gradient and sediment concentration on deposit morphology.

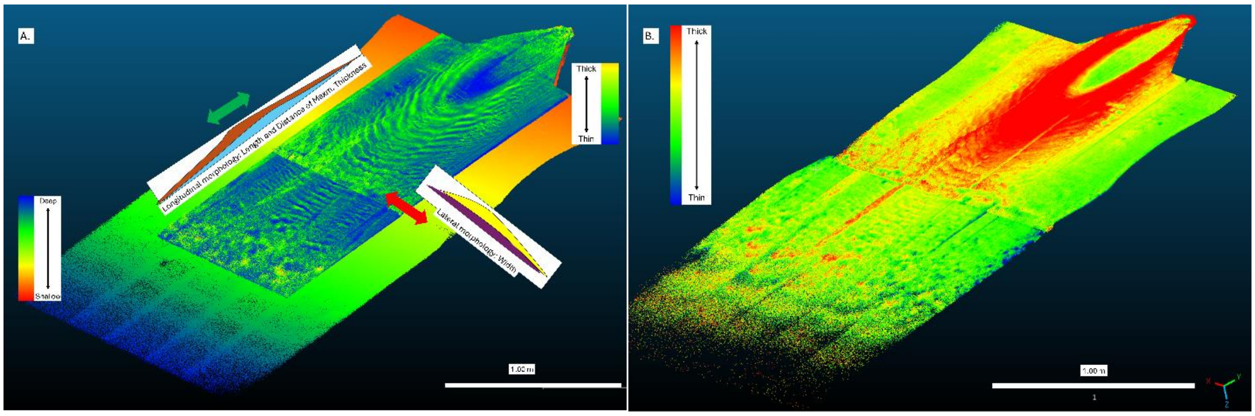


Fig. 2 A. 3D Perspective of Experimental Data: Morphology (Thickness Map) of individual turbidite lobe (5th run, 7° slope, 10% conc.) overlain on a topographic scan of a lobe from the previous run (1st run, 7° slope, 10% conc). B. 3D Perspective of Experimental Data: Morphology (Thickness Map) of composite turbidite lobe (after 5th run, 7° slope, 10% conc.).

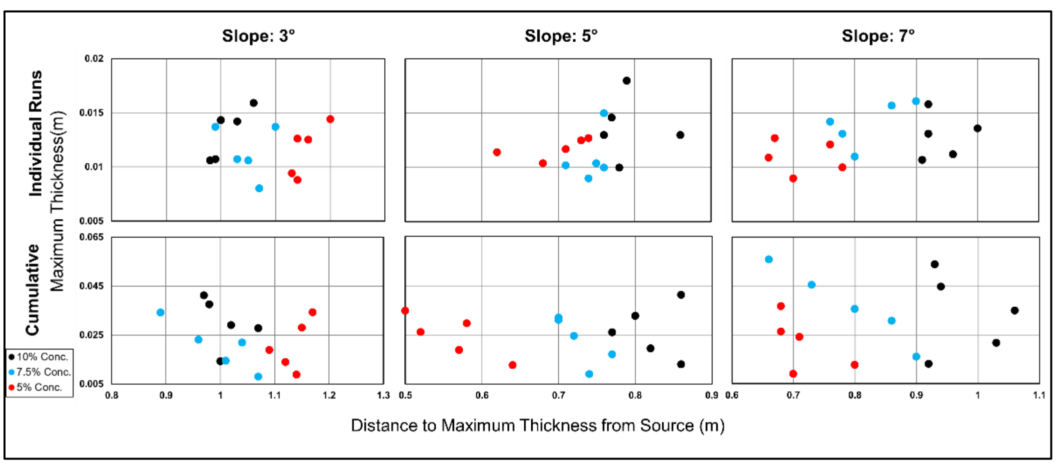


Fig. 3 Maximum thickness of individual and cumulative lobes vs. distance from the source, generated by five successive turbidity currents with different sediment concentrations (5%, 7.5%, and 10%) while keeping the basin gradient constant (3°, 5°, and 7°).

Over the 3° slope, individual and composite stacked turbidite lobes with 5% sediment concentration travel further from the source than the turbidite lobes with higher sediment concentrations (10% and 7.5%) (Fig. 3, 4). As the gradient was increased from 3° to 5° and finally to 7° a reversal of pattern was observed (Fig. 3, 4). Turbidite lobes generated by currents with 5% sediment concentration were deposited proximally, while the lobes generated by currents with higher sediment concentrations were deposited farther basin-ward (Fig. 3). The data shows the turbidite lobes with 10% sediment concentration have overlapped depositional loci with 3° and 7° gradients, in contrast with the 5° slope setup (Fig. 4). Change in sediment concentration from 5%

to 7.5% shows that the compensational composite lobe stacking pattern changes from vertical aggradation to back-stepping irrespective of slope setup (Fig. 4).

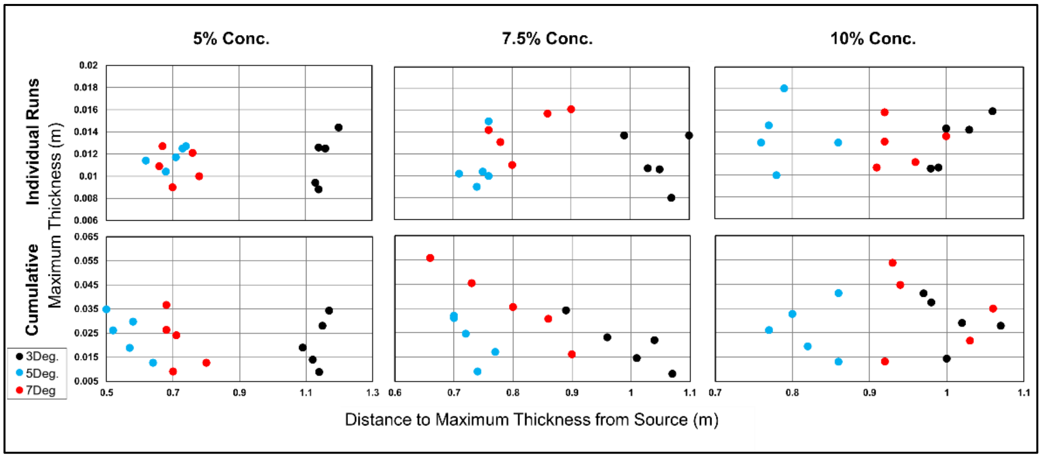


Fig. 4 Maximum thickness of individual and cumulative lobes vs. distance from the source, generated by five successive turbidity currents over different basin gradients (3°, 5°, and 7°) while keeping sediment concentrations (5%, 7.5%, and 10%) constant.

## Discussion: Deepwater Lobes

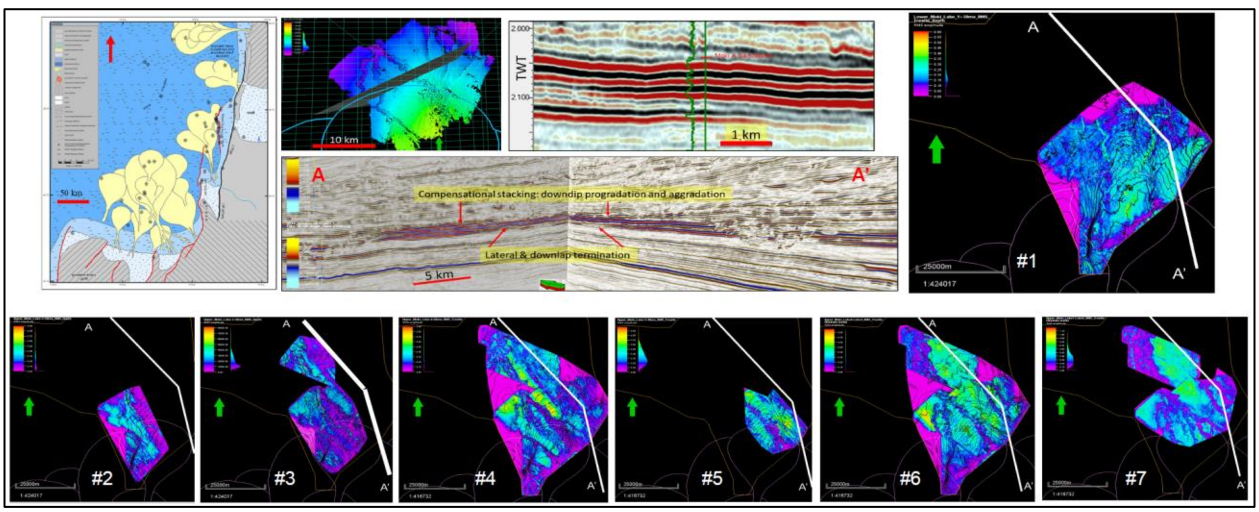


Fig. 5 Spatial distribution and vertical stacking of Upper Moki deepwater lobe complex from 3D seismic.

Seismic geomorphology of deepwater lobes of the Mid-Miocene Moki Formation, Taranaki Basin, Offshore New Zealand [5], demonstrates that the compensational stacking of composite lobe systems complements the scaled experimental results in terms of morphology. An attempt was made to map finer details of seven stacked deepwater channelized lobe systems from the Upper Moki Formation using 3D seismic supported by well-log information [6]. The seven RMS amplitude maps extracted on the mapped horizons exhibit the spatial distribution of the lobe units within the resolution limits of 3D seismic data. The successive lobes #1 to #7 in Fig. 5, exhibit compensational stacking through downdip progradation, aggradation, and retrogradation/back-stepping. Morphology of the lobe underneath has guided the depositional trend of the next lobe, thus controlling the overall lobe-shaped morphology of the Moki fan complex. The experimental results also exhibit progradation, vertical aggradation, and retrogradation/backstepping of the turbidite lobes like the real-world subsurface examples.

## Conclusions

At higher slope gradients turbidite lobes formed by flows with higher sediment concentration exhibit initial progradation and vertical aggradation before back stepping/retrogradation. At lower slope setting turbidite lobes formed by flow with higher sediment concentration exhibit aggradation rather than progradation.

## Acknowledgements

We thank the Ontario Graduate Scholarship (OGS) program and the AAPG Foundation Grants in Aid for financial support for this research. We acknowledge the support of the Natural Sciences and Engineering Research Council of Canada (NSERC), RGPIN-2019-04760. We also thank Mr. Taewoo Chun for his valuable help in building the experimental setup.

### References

[1] Prélat, A., Covault, J. A., Hodgson, D. M., Fildani, A. and Flint, S. S. (2010) Intrinsic controls on the range of volumes, morphologies, and dimensions of submarine lobes. Sedimentary Geology, 232, 66–76.
[2] Deptuck, M. E., Piper, D. J. W., Savoye, B. and Gervais, A. (2008) Dimensions and architecture of late Pleistocene submarine lobes off the northern margin of East Corsica. Sedimentology, 55, 869–898.
[3] Baas, J. H., Van Kesteren, W., and Postma, G. (2004) Deposits of depletive high-density turbidity currents: a flume analogue of bed geometry. Sedimentology, 51, 1053 – 1088.
[4] Spychala, Y. T., Eggenhuisen, J. T., Tilson, M. and Pohl, F. (2020) The influence of basin setting and turbidity current properties on the dimensions of submarine lobe elements. Sedimentology, 67, 3471–3491.
[5] King P, Thrasher GP. (1996) Cretaceous-Cenozoic geology and petroleum systems of Taranaki Basin, New Zealand. Institute of Geological and Nuclear Sciences Monograph 13.
[6] NZPM 2018 Petroleum Data Pack from Resource Markets branch of the Ministry of Business, Innovation and Employment (MBIE) by Government of New Zealand.