Lateral and Longitudinal Compensational Stacking in Sub-Basins Based on Numerical Models of Turbidity Currents on Complex Margin Topographies*

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Abstract

Complex seafloor topography, such as sub-basins formed on converging margins plays a significant role in controlling turbidity current behavior and sediment dispersal pattern. One method to investigate the interaction of sediment gravity currents and topography is process-based numerical simulation. Potential topographical templates can be generated from laboratory analogue experiments or directly obtained from 3D bathymetric data.

In this study we adopt the above two sets of topographical seafloor data, experimental topographies, and high-resolution surfaces from areas of the present-day seabed, where there is evidence of sub-basin formation. These inputs not only provide both experimental and 'real-world' templates to investigate the extent these topographies affect flow character, routing, and the resulting deposit geometry, but also offer a perspective on the validation of the experimental method by comparison among a variety of results.

To simulate natural subaqueous density flows, a range of parameter combinations (flow volume, height, input velocity, frequency) has been chosen within the appropriate ranges expected to occur in nature. The flows show complex behavior that includes extensive entrainment of ambient fluid, flow splitting, and run-up on topographic bends. A significant result we found is that the resulting deposits in sub-basins not only show lateral compensational stacking, but also in the direction of the flow. This longitudinal compensational stacking occurs as deposition on the counterslopes shifts the topographic lows upstream, which in turn moves the depocenters upstream. Continued infill there moves subsequently the depocenters again downstream. These cycles are repeated until the topographic depression is no longer an active sediment trap and bypass occurs. The implications on reservoir architecture and development are discussed.

Selected References

Bouma, A., 2005, Shale, siltstone and mudstone in our future: AAPG Annual Meeting Abstracts, v. 14, p. A17.

Prather, B.E., 2003, Controls on reservoir distribution, architecture and stratigraphic trapping in slope settings, *in* E. Mutti, G.S. Steffens, C. Pirmez, M. Orlando, and D. Roberts, (eds.), Turbidites; models and problems: Marine and Petroleum Geology, v. 20/6-8, p. 529-545.

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With contributions by

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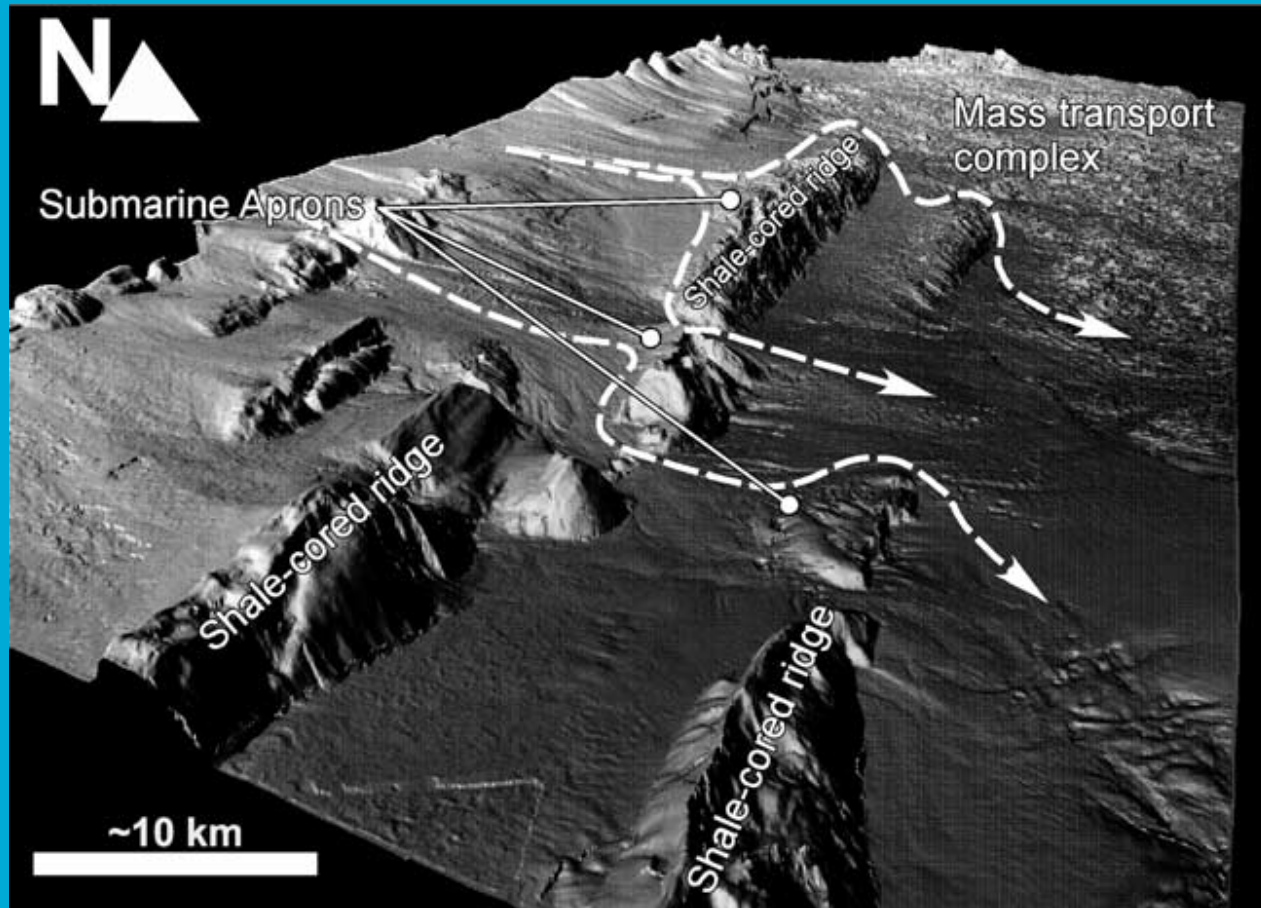
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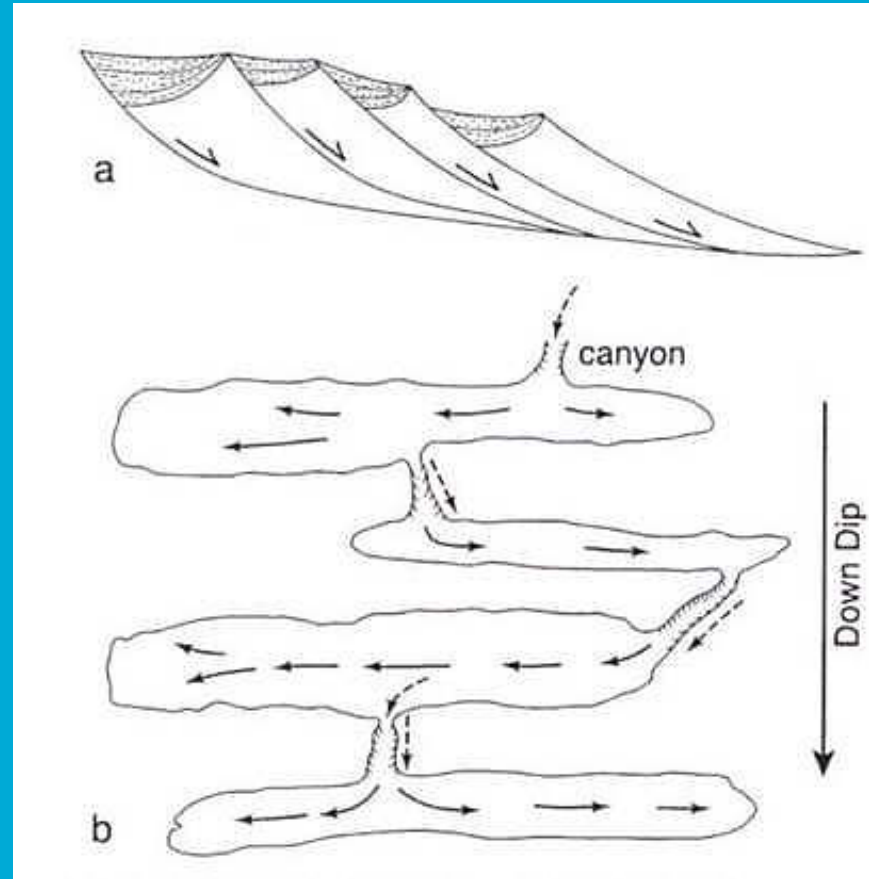
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Complex Margin Topographies and Suggested Flow Paths


Prather, 2003

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Sub-Basins (Minibasins) on Submarine Fault-Controlled Margins and Suggested Flow Paths

Bouma, 2005

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Relevant Physical Considerations

- TCs on sufficiently high slopes (>1°) dilute vertically due to entrainment of ambient fluid. The degree of entrainment is proportional to the slope.

- In both confined and unconfined settings the turbidity currents develop strong vertical gradients of density and velocity.

- In unconfined settings additionally strong lateral density and velocity gradients develop due to pressure gradients and lateral entrainment.

- The degree of these gradients is a function of the initial density.

Parsons et al., 2007

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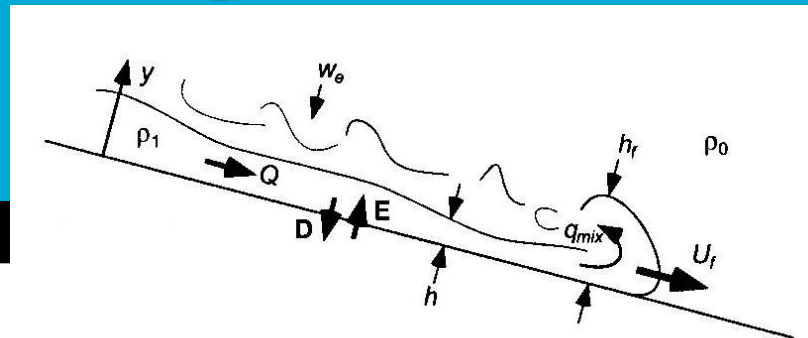
... and What They Really Mean

- TCs are "lighter" than in the subaerial environment and especially so in their upper part (and their margins, in unconfined settings)

- Yet they have a significant momentum due to the amount a water involved

- Therefore, TCs have a considerable inertia, and because of this and their "light" weight they are sluggish in their response to changes in topography

- Because of the density and velocity gradients the lower part of TCs may behave differently from the upper part

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Inertia Due to Momentum

John Truden,
Heavyweight Skiing Champion 1970

Modeling Minibasins
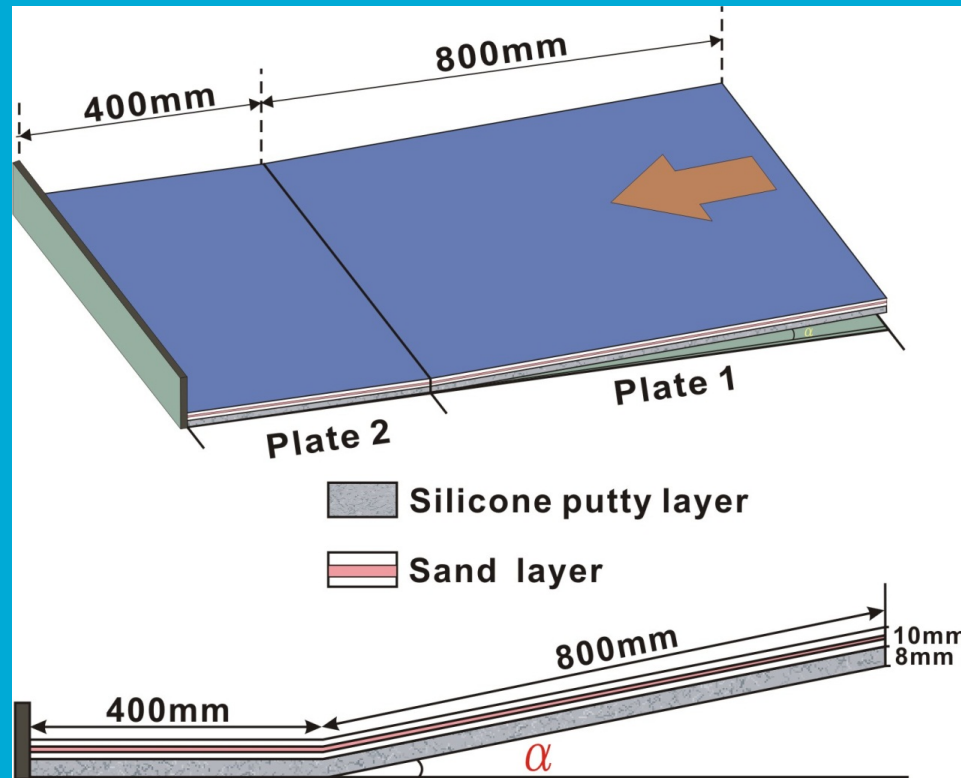
Laboratory experimental set-up: A layered model with a confined downslope boundary is built up on a rigid two-plate base. Plate 1 is inclined at angle of α = 5°; Plate 2 is horizontal.

Modeling Minibasins

Cross section of the model after experiment for 48 hours, with three tectonic subdomains: (a) extensional diapirs between rafts, (b) translation and (c) folds, thrusts and compressional diapirs.

Tectonic deformation progrades downslope during the experiment.

Domain a) is scanned, digitized and upscaled to obtain a Digital Elevation Model (DEM) of minibasin topographies

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**Wiebke, Wieske and Remco in the TecLab, VU Amsterdam**

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Numerical Simulation of TC with FanBuilder

Flow heights of one event in meters 4000 (A) and 6000 (B) seconds after release of the flow at the channel entrance in lower left. Maximum flow heights in the first minibasin are 93 and 60 meters for the two cases. The modelled area is 15 by 30 km.
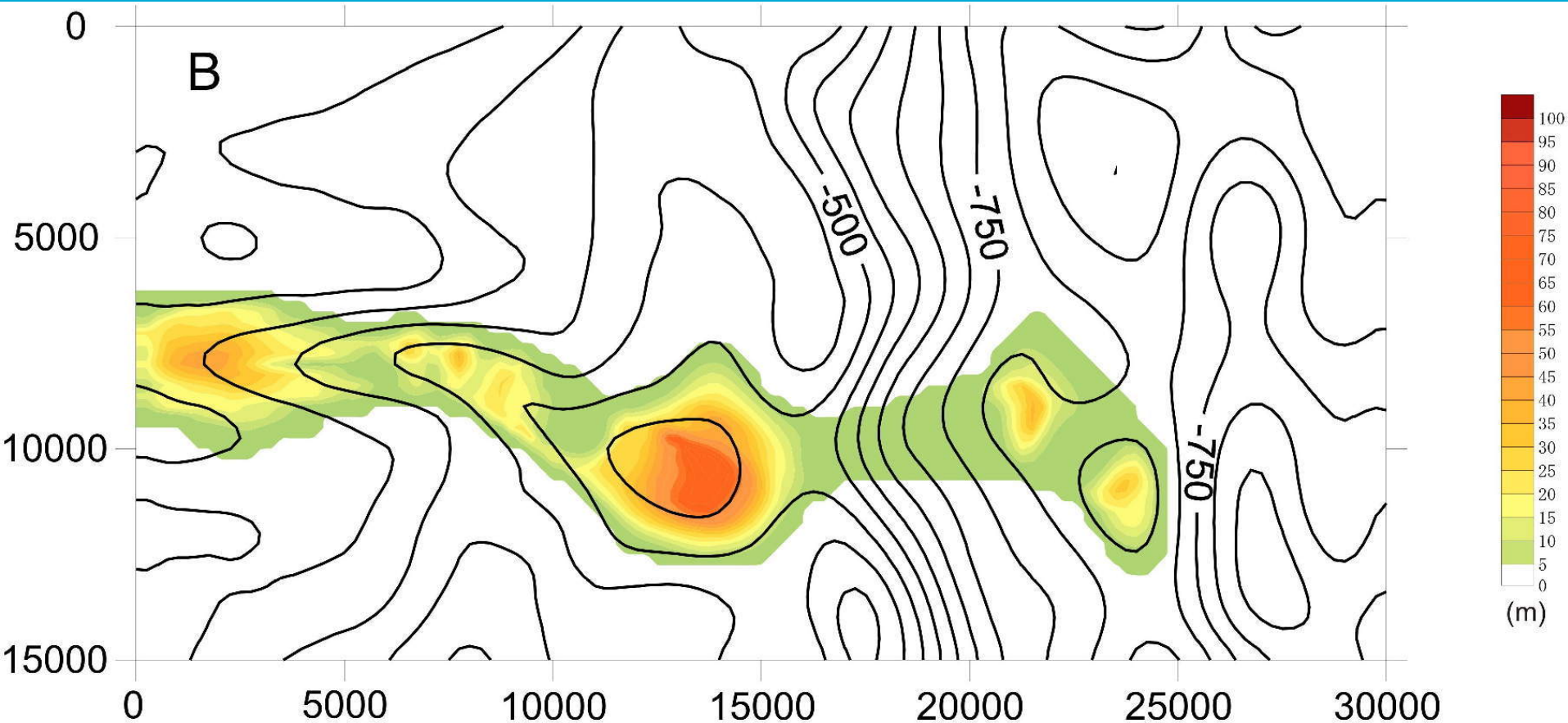
Main initial input parameters: Flow depth 300m; velocity 15m/s, density 1092kg/m^3; volume released per event 10^{7}m^3; grain size 60% 250μm and 40% 100μm; sediment concentration 4%.
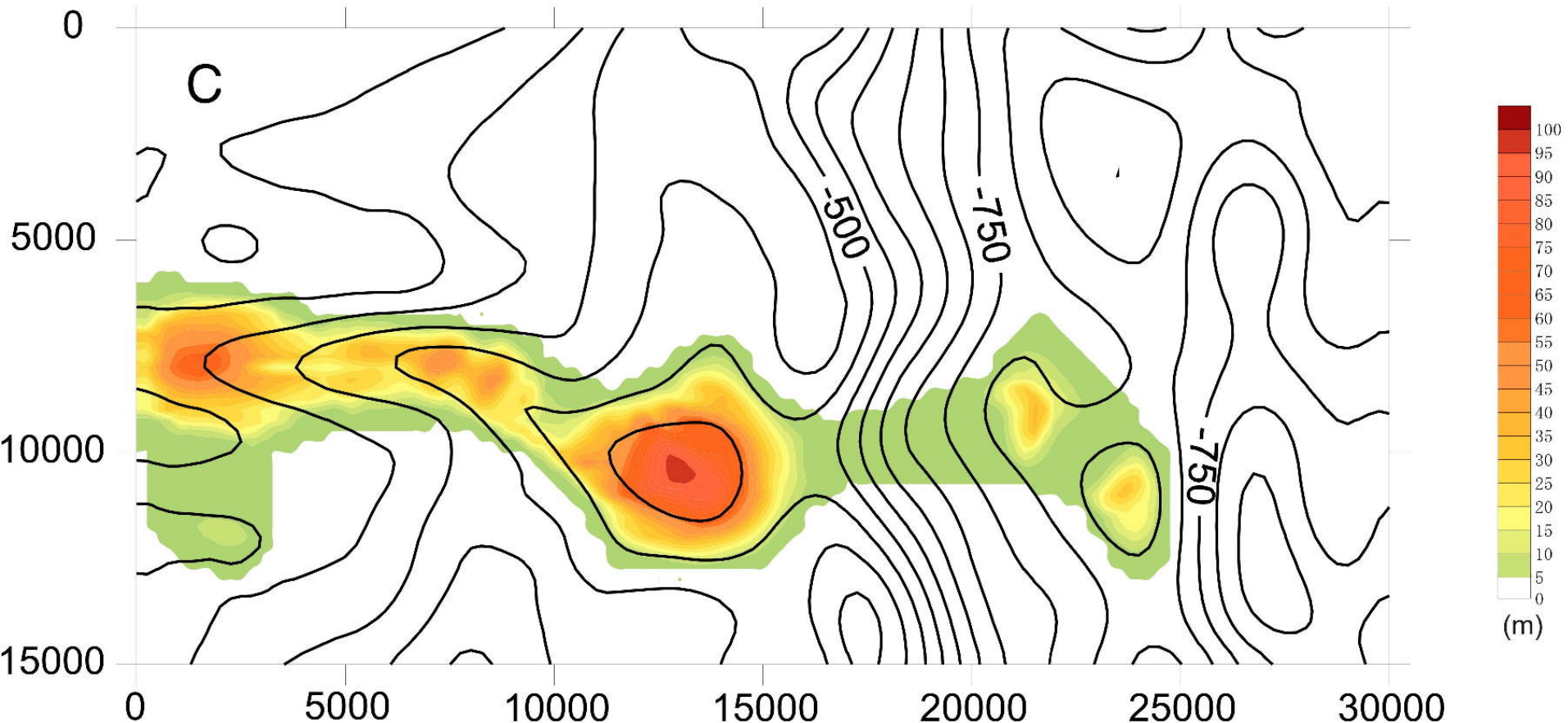
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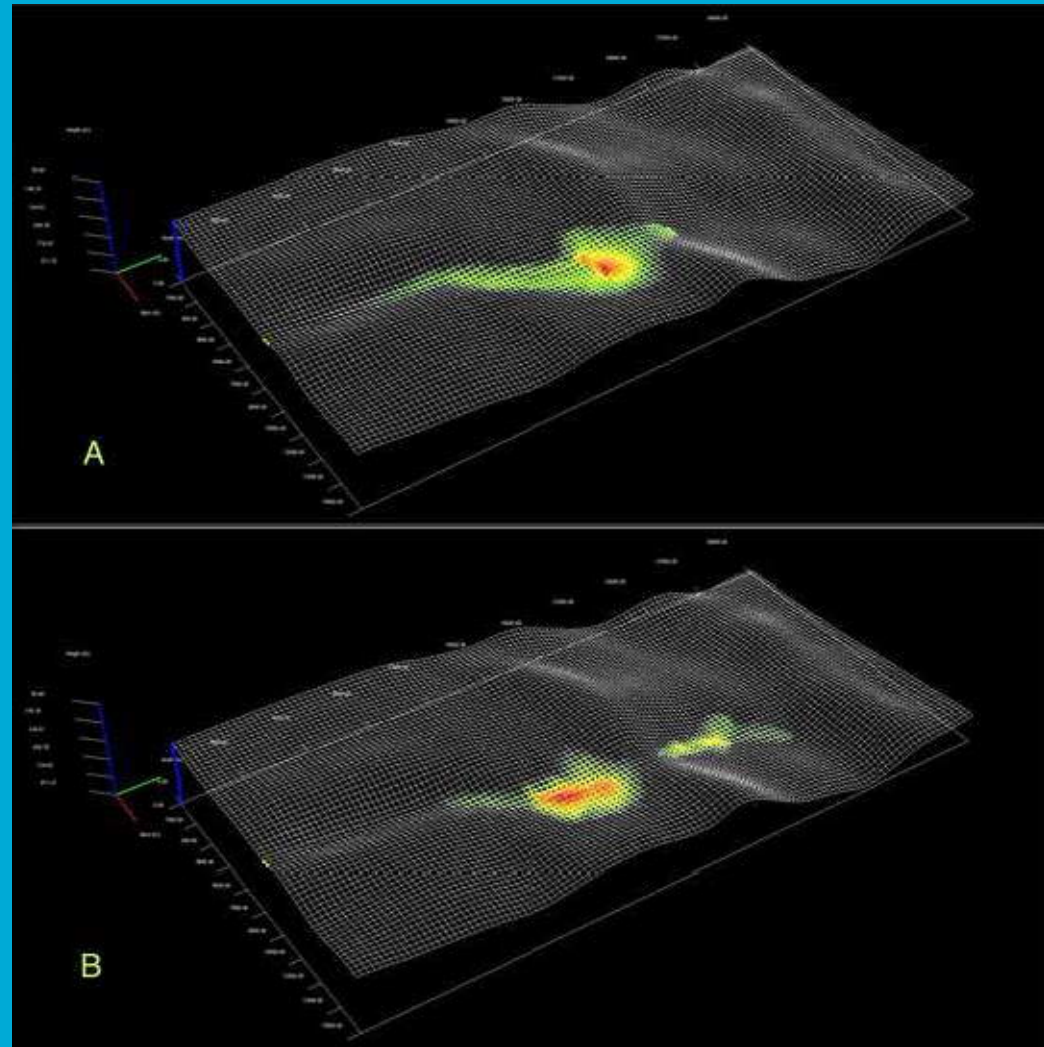
Depositional Thickness after 5 Events
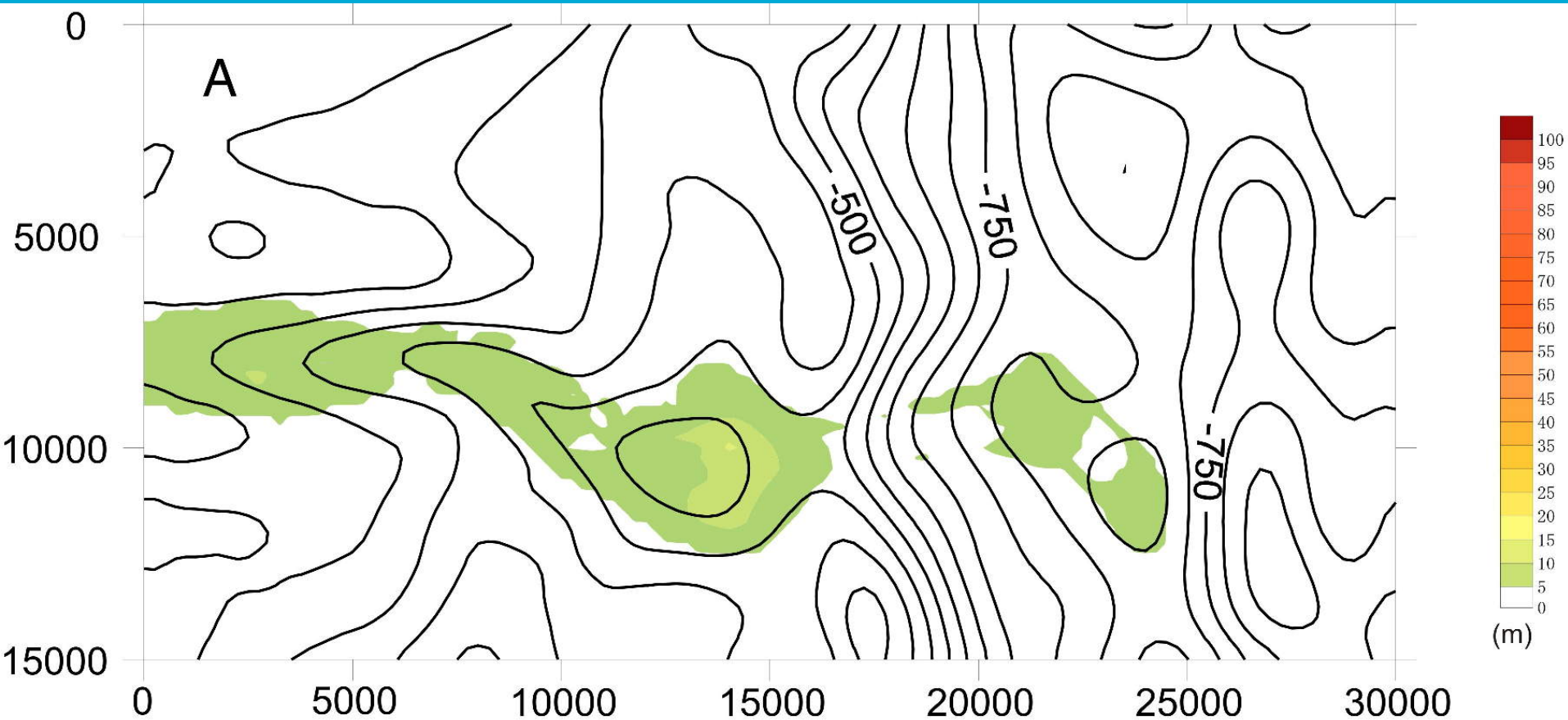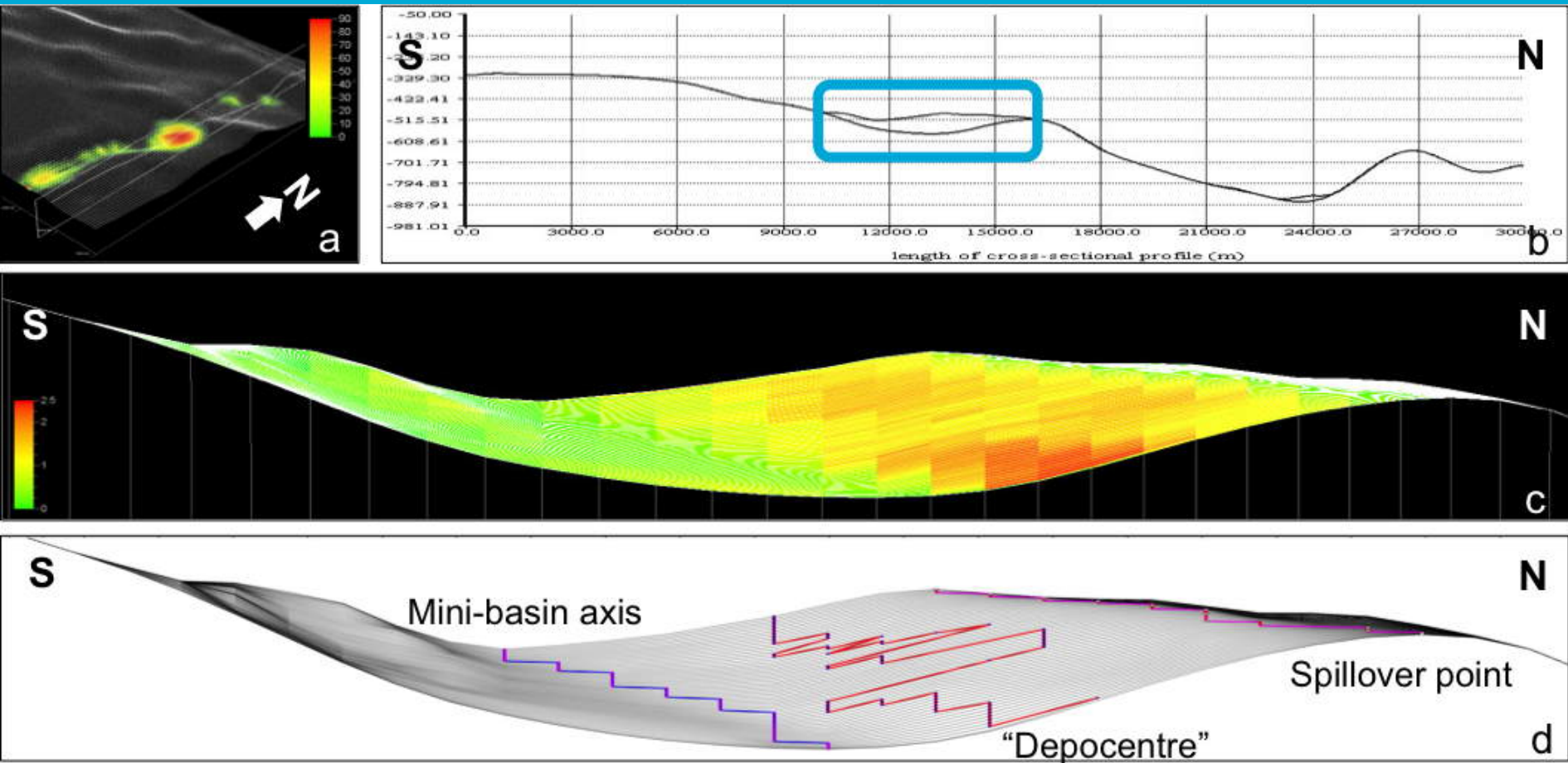
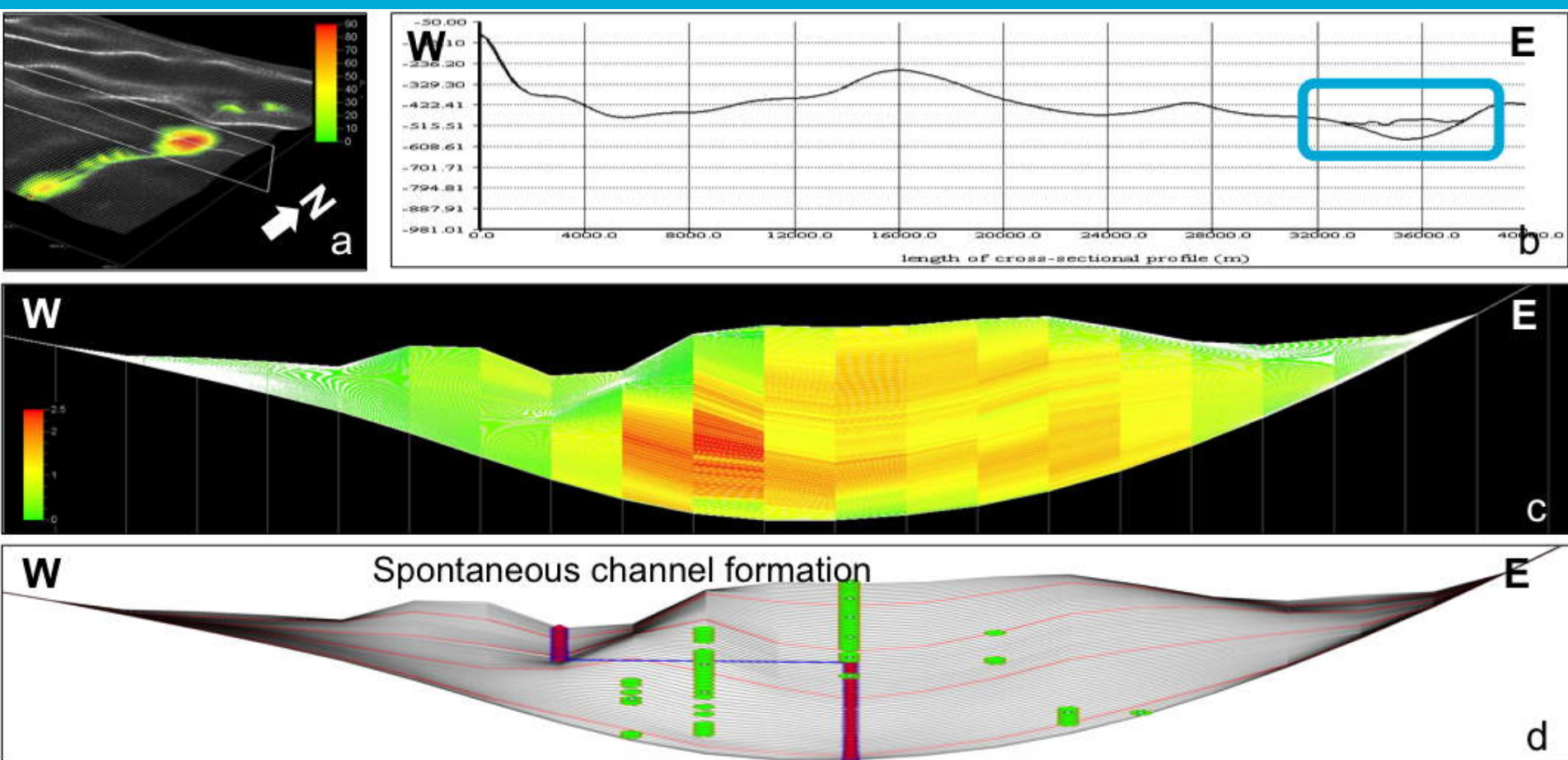# Depositional Thickness after 50 Events

Depositional Thickness after 90 Events

Axial Cross-Section: Development of Axis, Maximum Thickness and Spill Point

After 70 Events

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Strike Cross-Section: Development of **Axis** and **Maximum Thickness**

November 2, 2012

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After 70 Events

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Conclusions

- The flows show entrainment of ambient fluid, flow splitting and run-up on topographic bends and counterslopes.

- The resulting minibasin deposits show lateral compensational stacking, but also in the flow direction

- This longitudinal compensational stacking occurs as deposition on the counterslopes shifts the topographic lows upstream, which in turn moves the depocenters upstream.

- Continued infill there moves subsequently the depocenters again downstream.

- These cycles are repeated until the topographic depression is no longer an active sediment trap and bypass occurs.

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