Click to view carbonate sedimentation movie (22.0 MB)

Decoupling Allogenic Forcing from Autogenic Processes: Clastic and Carbonate Experimental Stratigraphy*

Wonsuck Kim[1], Andrew Petter[2], Bruce W. Fouke[3], Terrence M. Quinn[4], Charles Kerans[2], Fred Taylor[4], David Mohrig[2] and Chris Paola[5]

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Abstract

Decoupling external (allogenic) forcing from internally generated (autogenic) "noise" written in the sedimentary and stratigraphic records remains a fundamental goal in the sedimentary geosciences. One of the major stumbling blocks for distinguishing allogenic and autogenic origins in the stratigraphic record lies in the lack of quantitative understanding of autogenic processes. So far no existing computational models can explicitly model geomorphic self-organization. However, flume studies with sediment and water, which clearly show self-organized, internally driven sediment transport processes, do give the opportunity to model and investigate autogenic processes under controlled boundary conditions. Autogenic processes occur at frequencies less than those of the basin-scale response. Yet the time scale over which internal processes operate are also modified when coupled with external forcing and can be significantly extended.

We present two flume experiments with clastic sediments conducted under both static relative sea level and active relative sea-level rise to explore the effects of coupling autogenic processes with environmental forcing on the time scale of autogenic processes. In contrast to ongoing theoretical and experimental studies of autogenic processes in clastic sedimentary systems, there are still fundamental tools missing that are needed to understand autogenic processes in carbonate system. These include 1) response time scale

for carbonate basin, and 2) laboratory experiments for carbonate sedimentation. Here we revise the carbonate basin time scale, and also present an initial result from a flume experiment for carbonate precipitation using artificial spring water.

Selected References

Castelltort, S. and J. van den Driessche, 2003, How plausible are high-frequency sediment supply-driven cycles in the stratigraphic record?: Sedimentary Geology, v. 157/1-2, p. 3-13.

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Warrlich, G.M.D., D.A. Waltham, and D.W.J. Bosence, 2002, Quantifying the sequence stratigraphy and drowning mechanisms of atolls using a new 3-D forward stratigraphic modelling program: Basin Research, v.14/3, p. 379-400.

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DGS
Department of Geological Sciences
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UTIG
Institute for Geophysics
University of Texas, Austin

Notes by Presenter: Autogenic processes observed in physical experiments

Play Dough?

http://ptinterns.files.wordpress.com/2009/02/playdough5.jpg

Play Dough? – ***Midas Touch***

http://www.elmsmontessori.ie/play_dough_square.jpg

Play Dough? – ***Midas Touch***

http://pittsburghmom.com/blogs/pittsburghmom/archive/2009/01/05/is-barbie-driving-the-fire-truck-the-joys-of-toy-organization.aspx

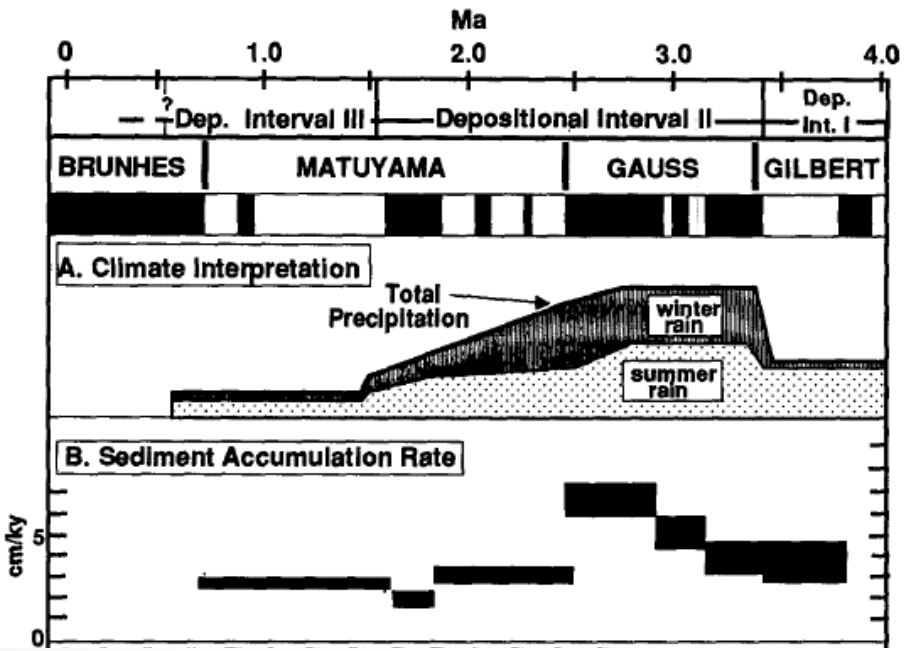
Complex Stratal Responses – ***How to decouple?***

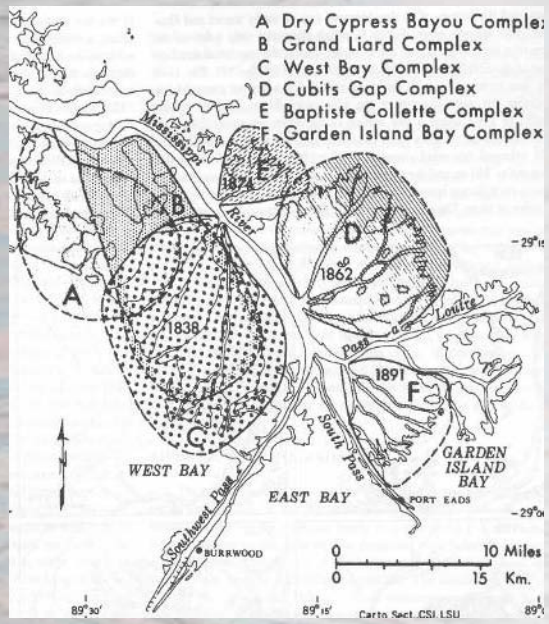
http://pittsburghmom.com/blogs/pittsburghmom/archive/2009/01/05/is-barbie-driving-the-fire-truck-the-joys-of-toy-organization.aspx

Cyclic and Acyclic Nature of the Processes

External forcing:
Climate, Tectonic, Sea-level variation…

Climatic influences on continental deposition during late-stage filling of an extensional basin, southeastern Arizona (Smith, 1994)





Autogenic processes:
Delta-lobe switching, Channel avulsion…
Internal, local “noise”

Subdeltas of the modern Mississippi River Delta. Dates indicates years of the crevasse openings (Wells, 1996)

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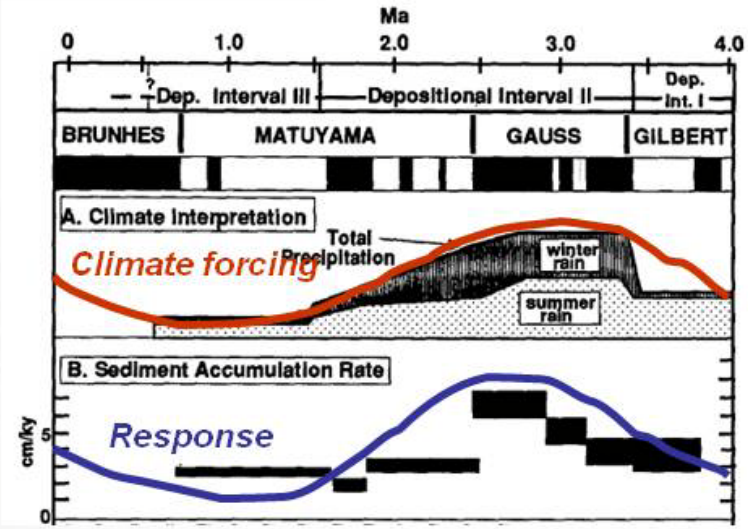

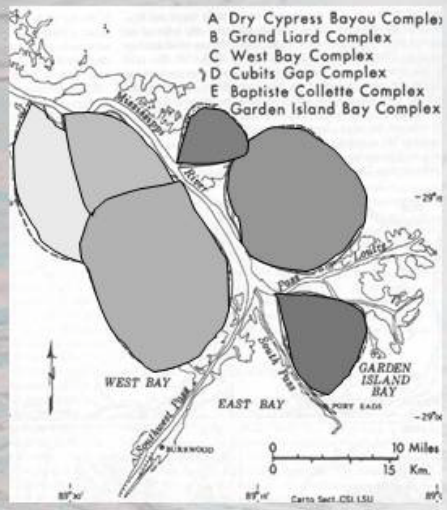

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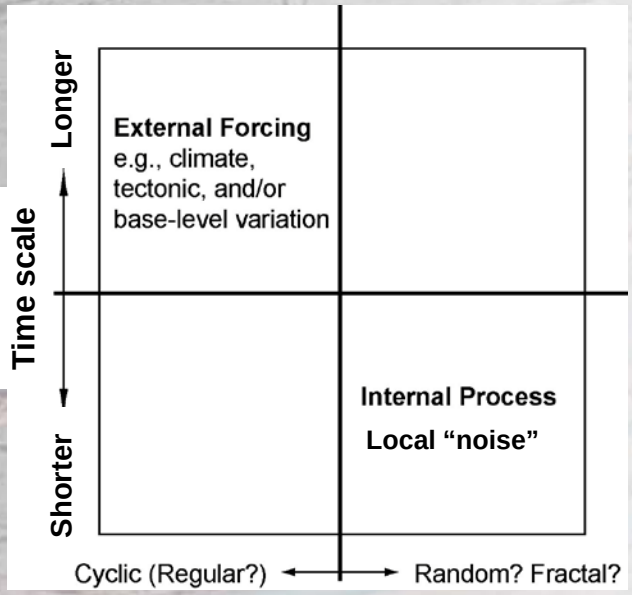
Notes by Presenter: Cyclic nature in sedimentary records is common. Climate forcing. Dry and wet period controls sediment yield.

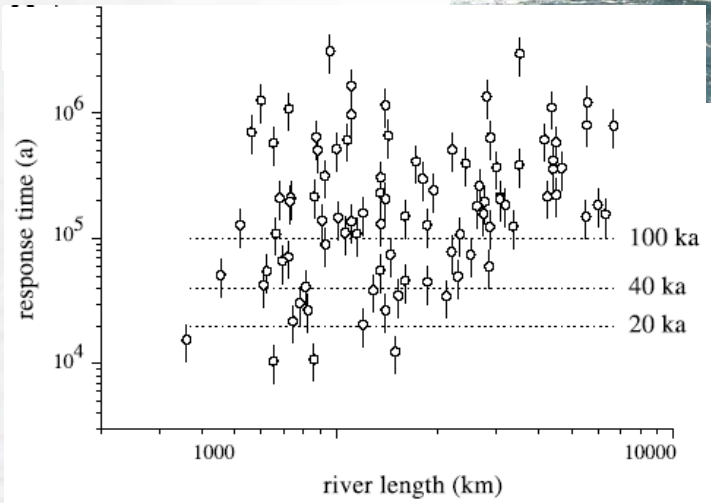
Allogenic forcing: **Cyclic** depositional sequences at **Longer Times,**
Autogenic fluctuations: Acyclic deposits at **less than the Response Time** of the system.



Time scale for sedimentary systems to response to environmental changes

$$T_{eq} = \frac{L^2}{\nu}$$

L: Basin length scale
ν: Diffusivity governing sediment transport



(Castelltort and van den Driessche,

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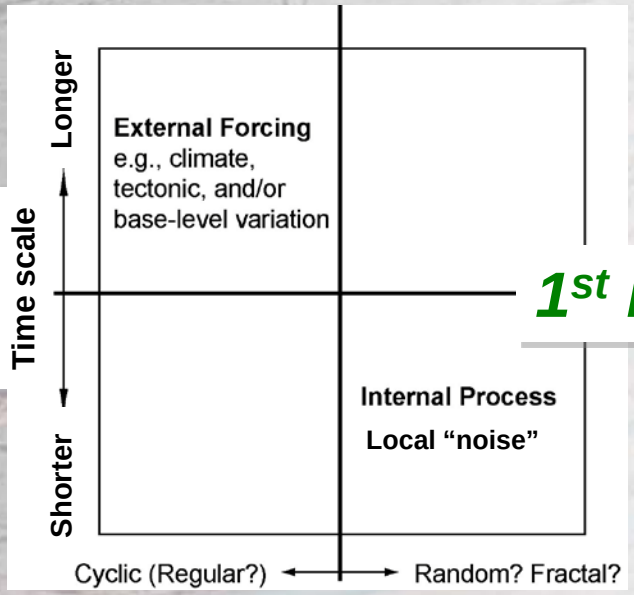

1st Key to decouple: Basin Response Time

Time scale for sedimentary systems to response to environmental changes

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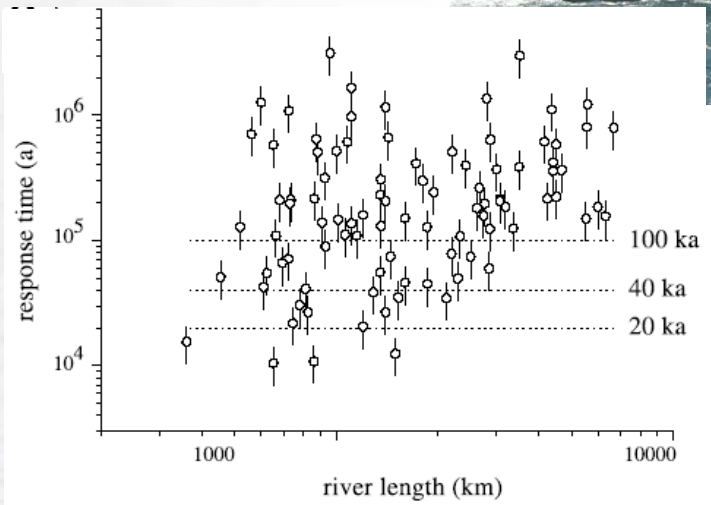

(Castelltort and van den Driessche,

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Experimental EarthScape (XES) 02 and 05 Runs

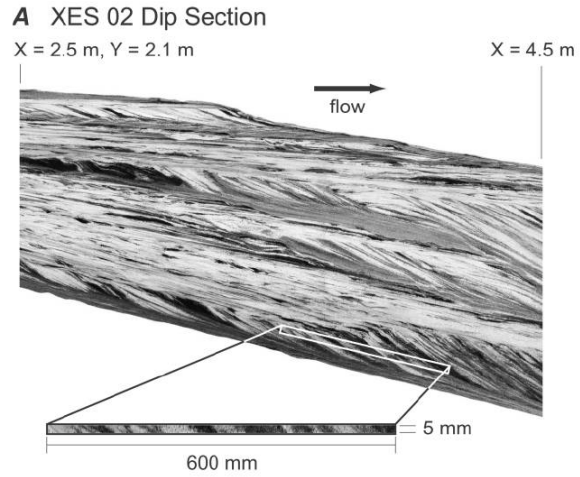
Shoreline Fluctuation at time scale less than T_{eq}

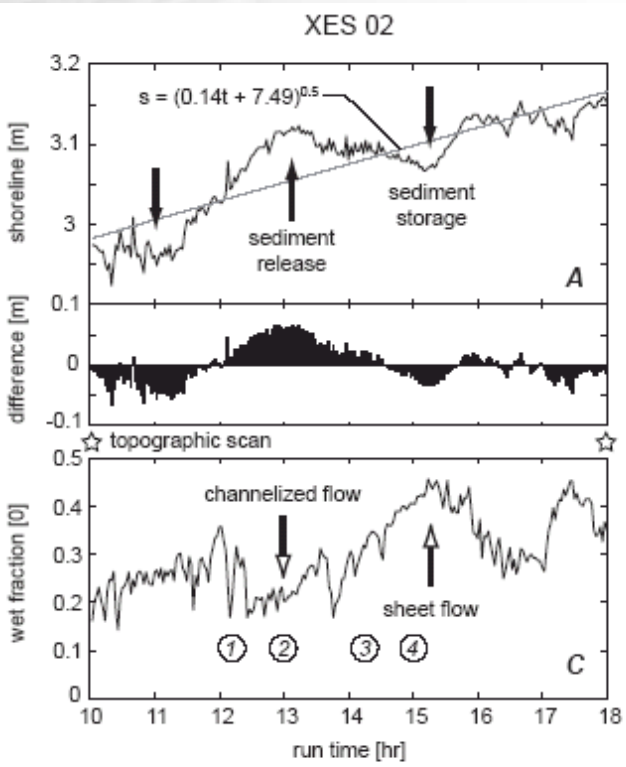
Period between sheet- and channelized flow, T_{ap}:

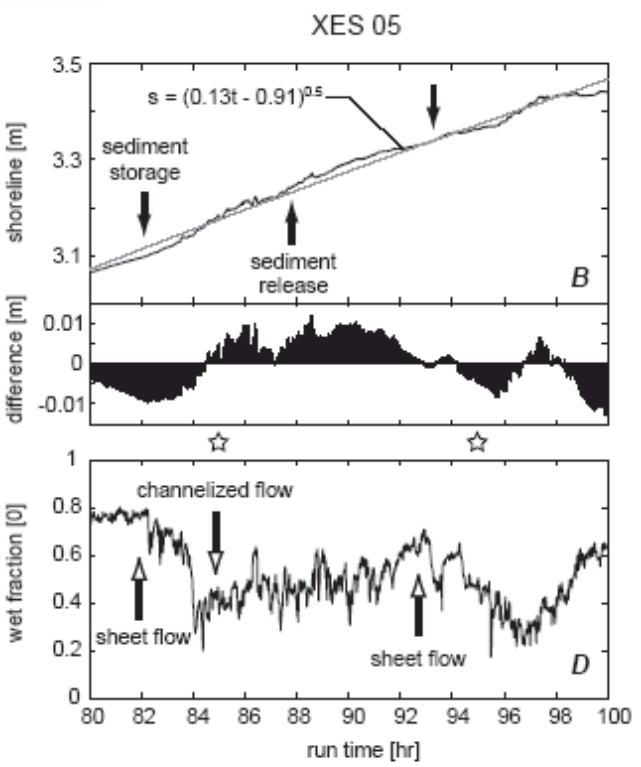
- ~ 5 hrs in XES 02

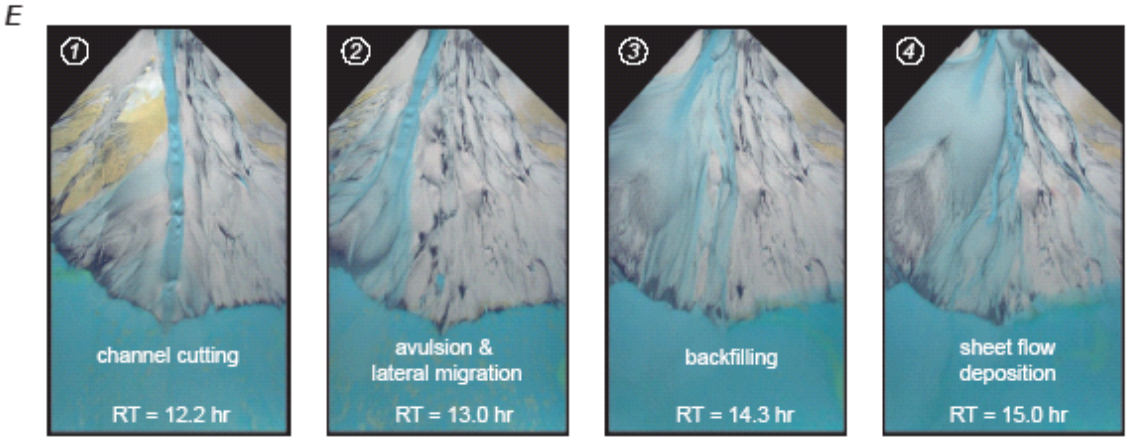
  $< T_{eq}$ = 60 hrs
- ~ 13 hrs in XES 05

  $< T_{eq}$ = 390 hrs









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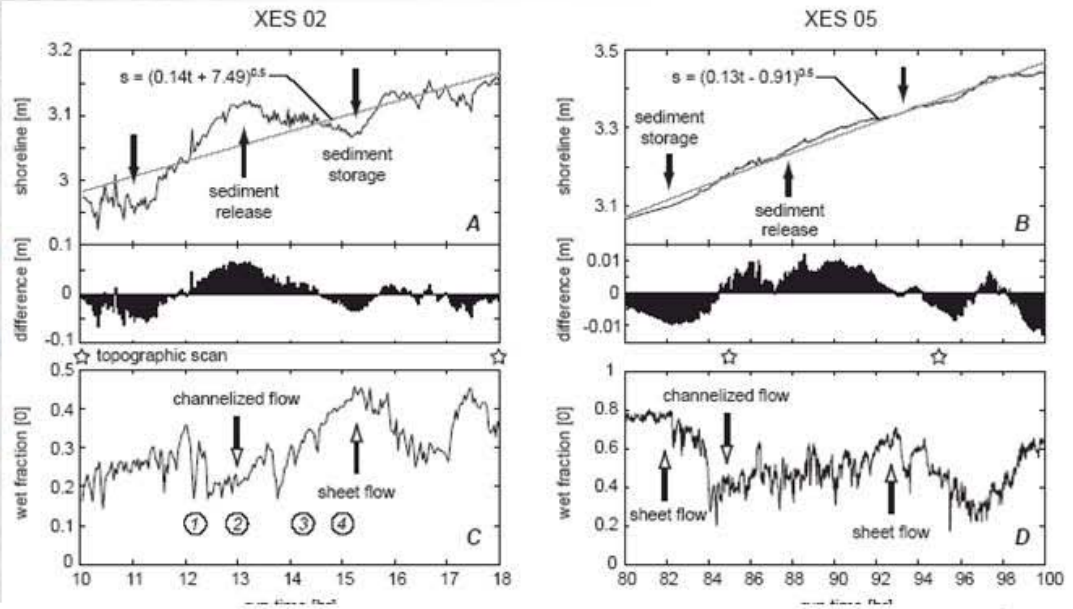

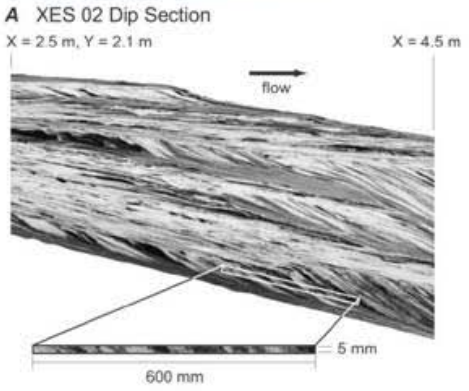

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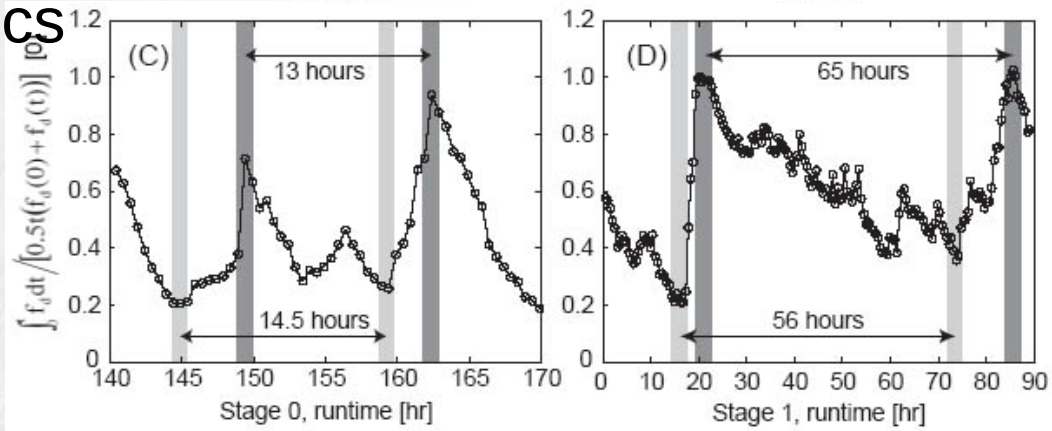
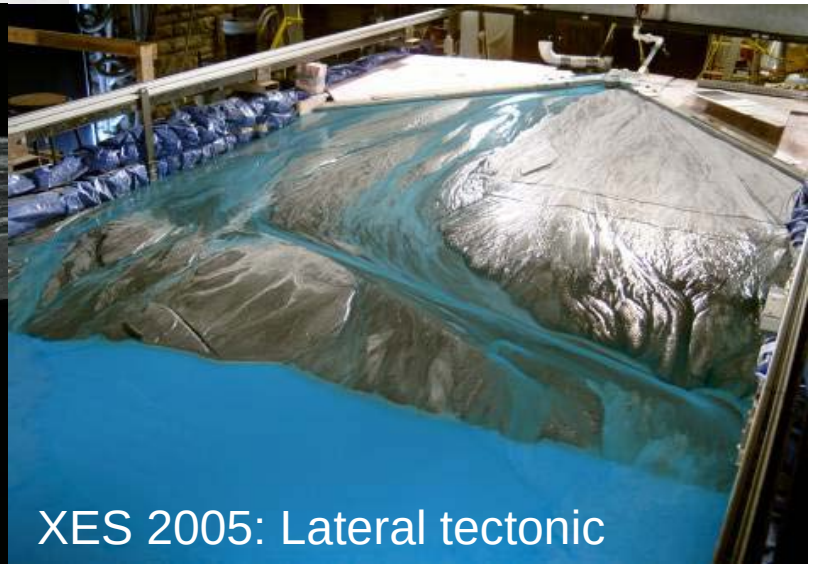
2nd Key to decouple: Autogenic Time & Event scales

Notes by Presenter: Stars representing a time that topo scans took.

Complex Responses: ***Long-term autogenic processes***

- Increase in the time period of the fluvial autogenic variation by active tectonics
  - Stage 0: No tectonics
    - 13~15 hours
  - **Stage 1: Lateral Tilting**
    - ***56~65 hours***





XES 2005: Lateral tectonic

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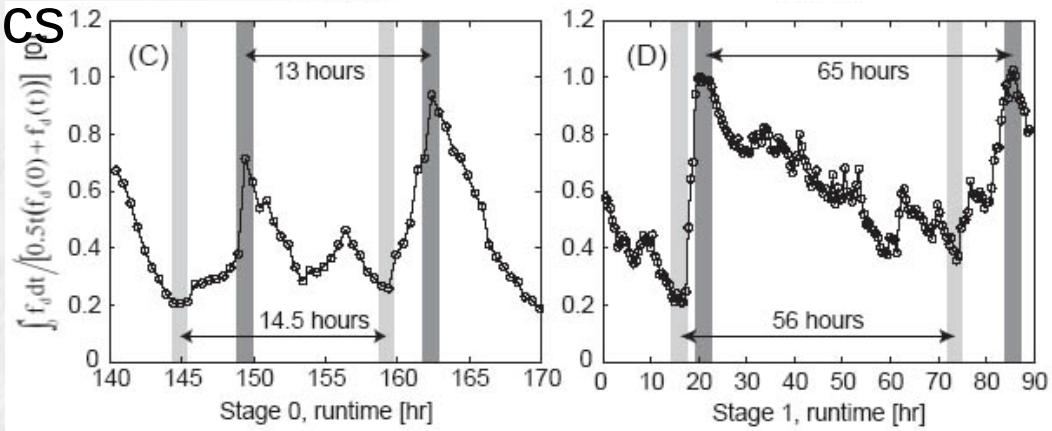


3rd Key to decouple: Understand Complex Allogenic-Autogenic Coupling

XES 2005: Lateral tectonic

Complex Stratal Responses – ***Where to start?***

http://pittsburghmom.com/blogs/pittsburghmom/archive/2009/01/05/is-barbie-driving-the-fire-truck-the-joys-of-toy-organization.aspx

http://ptinterns.files.wordpress.com/2009/02/playdough5.jpg

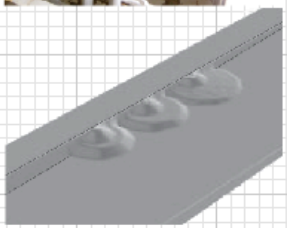
Understand Individuals, Then Mix One by One!

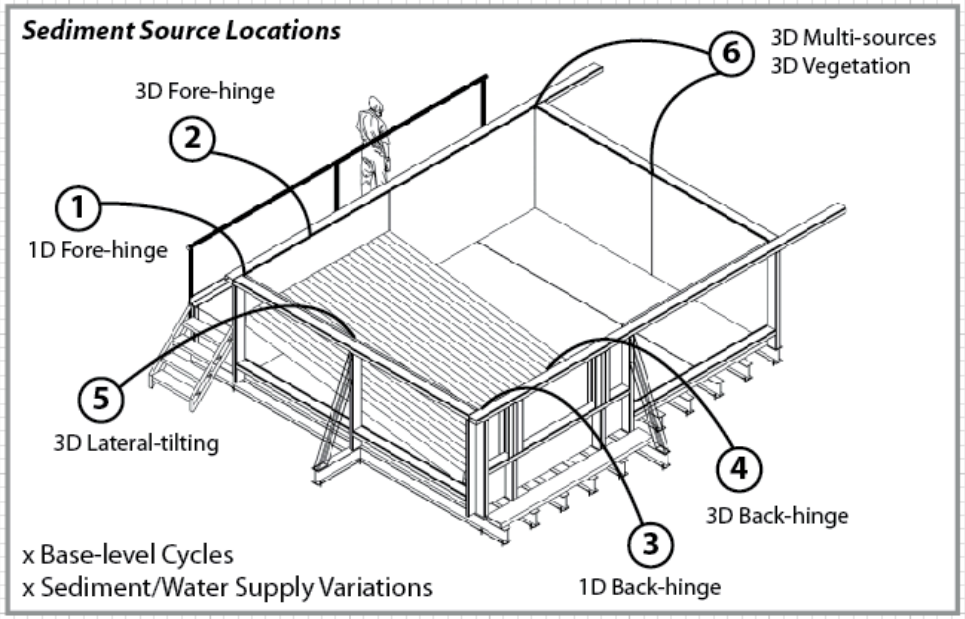
Complex Stratal Responses – ***Where to start?***

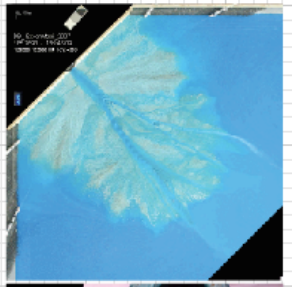
Understand Individuals, Then Mix One by One!

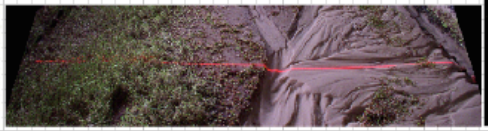
University of Texas Experimental Delta (UTED) Basin

- Morphodynamics Laboratory, J.J. Pickle Research Campus, UT at Austin









http://www.ig.utexas.edu/people/staff/delta/experiments.html

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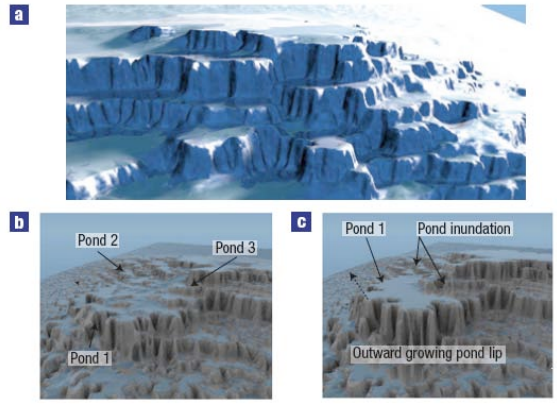
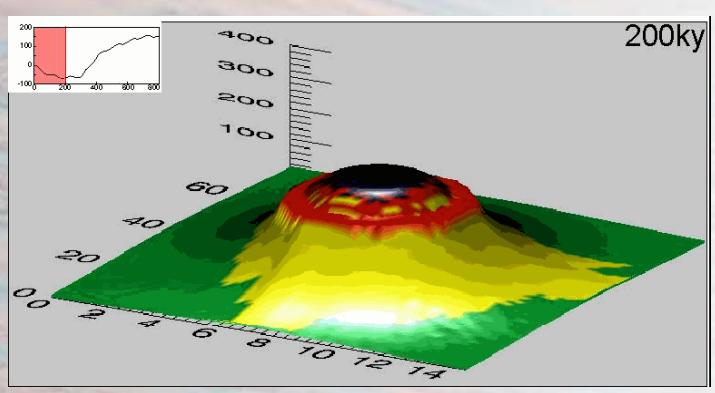
Further Outlook: Carbonate?

(Bahama Bank, NASA Earth Observatory)

(Yellowstone, Travertine dams)



(Veysey and Goldenfeld, 2008)



(CARBONTE3D, Warrlich et al. 2002)

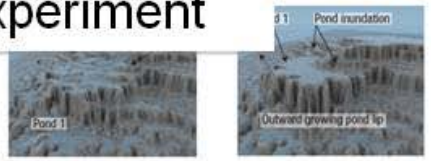
Further Outlook: Carbonate?

(Bahama Bank, N

(Yellowstone, Travertine dams)

MISSING!

- Carbonate Basin Response Time Scale
- Bio-Chemo-Geo-Flume Experiment



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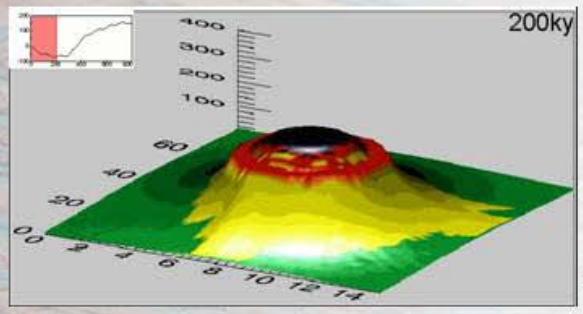

(CARBONTE3D, Warrlich et al. 2002)

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Notes by Presenter: Outlook for the future of experimentation in surface process sciences.

Carbonate Experiment