

Challenges in Understanding Channel Levee Development*

William D. McCaffrey¹, Gareth Keevil¹, Ian Kane¹, and Bret Dixon²

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¹School of Earth and Environment, University of Leeds, Leeds, United Kingdom (mcaffrey@earth.leeds.ac.uk)

²Anadarko Petroleum Corporation

Abstract

Submarine channel levee systems arise and develop due to complex feedbacks between turbidity currents and confining bathymetry. In particular, because the flow can be lost overbank, there must be a link between the flow transmitted downstream from any particular point and the evolution of the geometric form of the levee. Consideration of aspects of this complex system can potentially give insights into: auto vs. allo-cyclic controls on channel development and avulsion; monotonic evolution of flow properties within the channel; topological approaches to channel pattern development, such as avulsion node migration directions and inundation area analysis; bed thickness distribution patterns with the levee, and in channel-fed lobes. The implications for the interpretation of architecture development is explored, together with the implied limits on interpretation.

Challenges in understanding channel levee development

Bill McCaffrey¹

1. University of Leeds
School of Earth and Environment

with

Gareth Keevil¹

Ian Kane¹

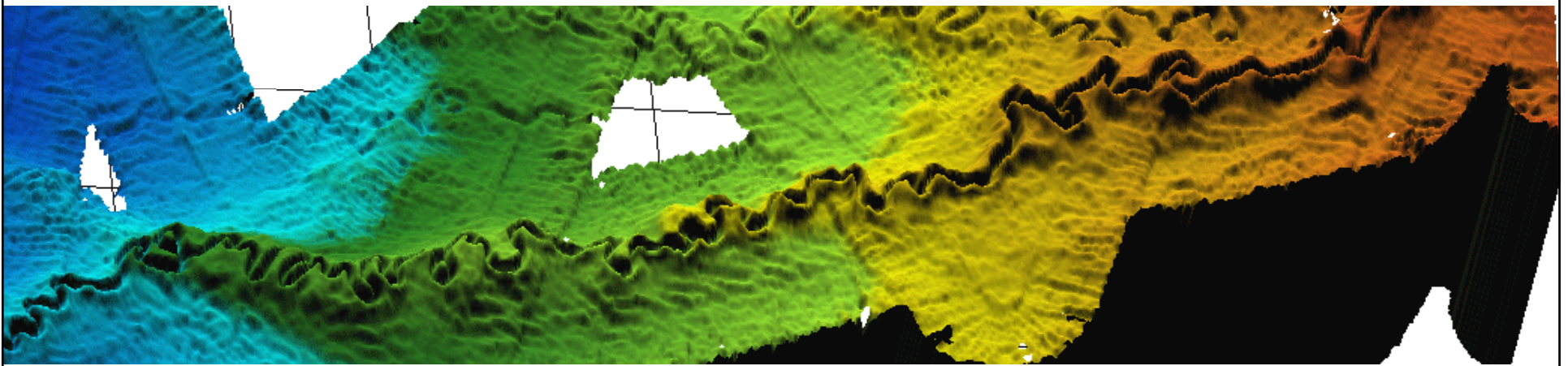
Bret Dixon (Anadarko)



TRG 

Or:

how James Clerk-Maxwell's problems with analysis of steam engine regulation can be applied to analysis of the channel-levee system ...



A 200 km long segment of the Amazon submarine channel (image courtesy Bruno Savoye, IFREMER)

Background

- Beacon channel (Pyles and co-workers)
- Leeds experimental work (Keevil, Peakall, McCaffrey)
- Leeds theoretical work (McCaffrey and others)

Beacon Channel: Permian of W. Texas

- intrachannel facies description
- facies interpretation indicates bypass-deposition transition
- key element - *monotonic* decrease in flow power

Suggests filtering mechanism on flow magnitude, with allocyclic overprint

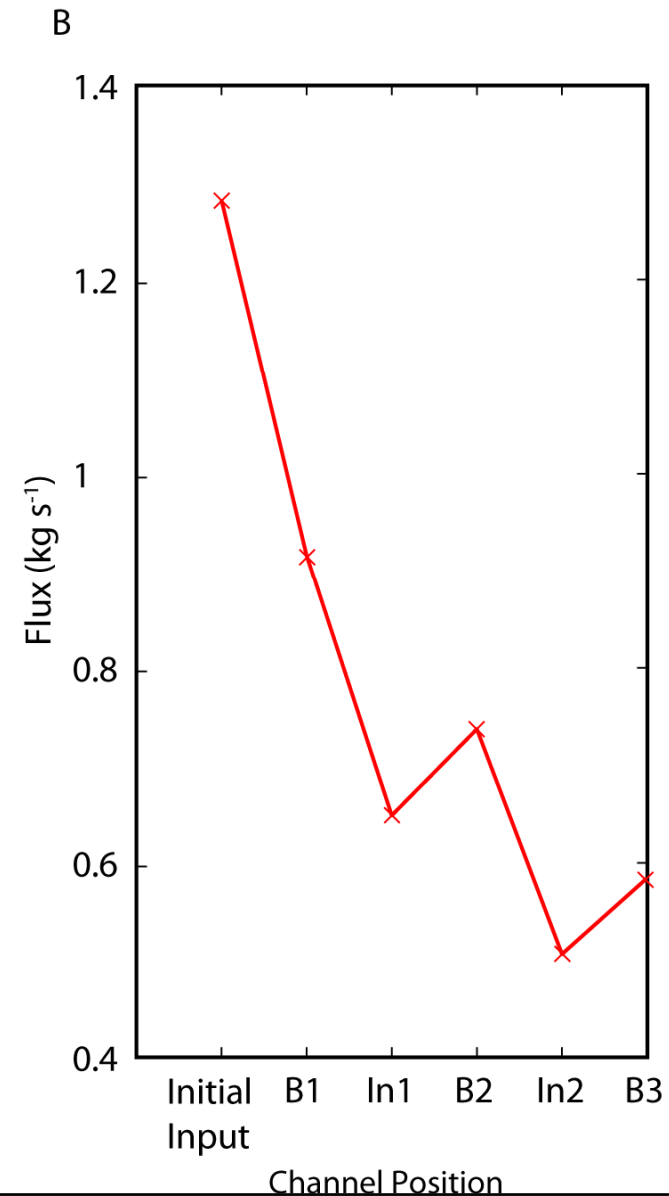
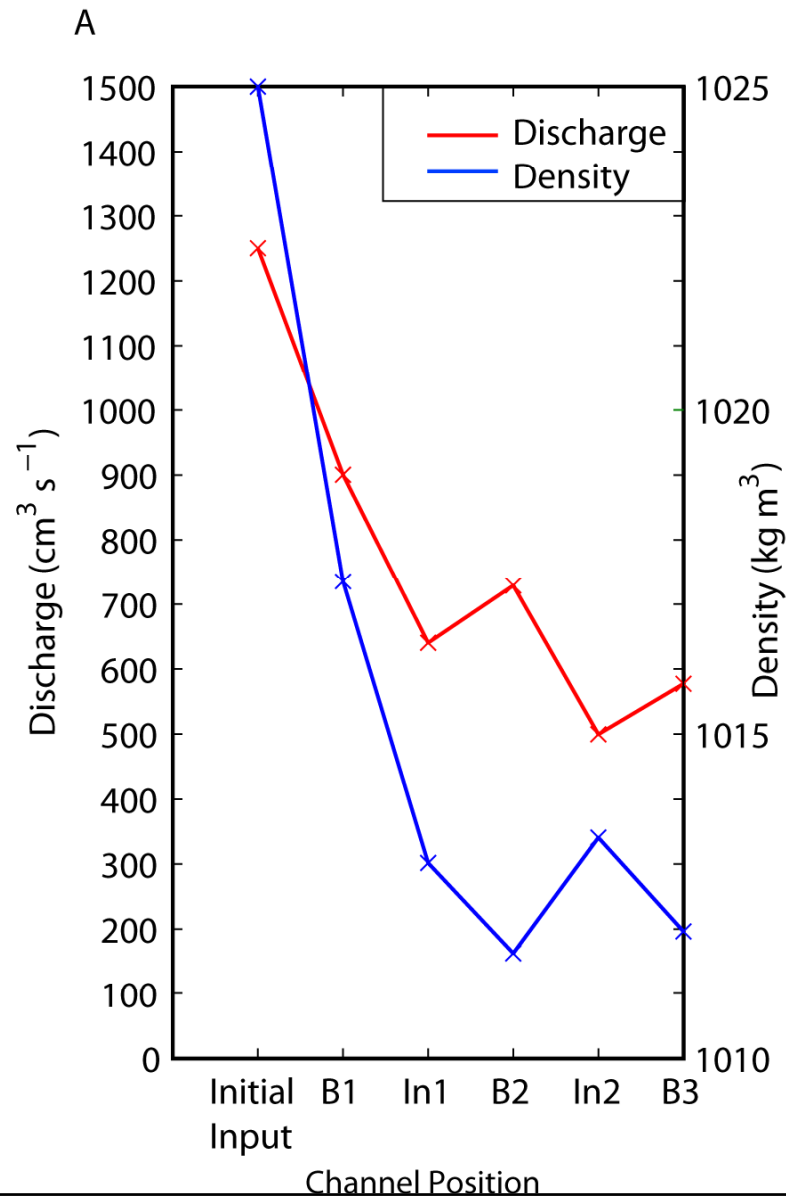
Flow tuning

Or "first bend as a filter": Straub et al. 2007

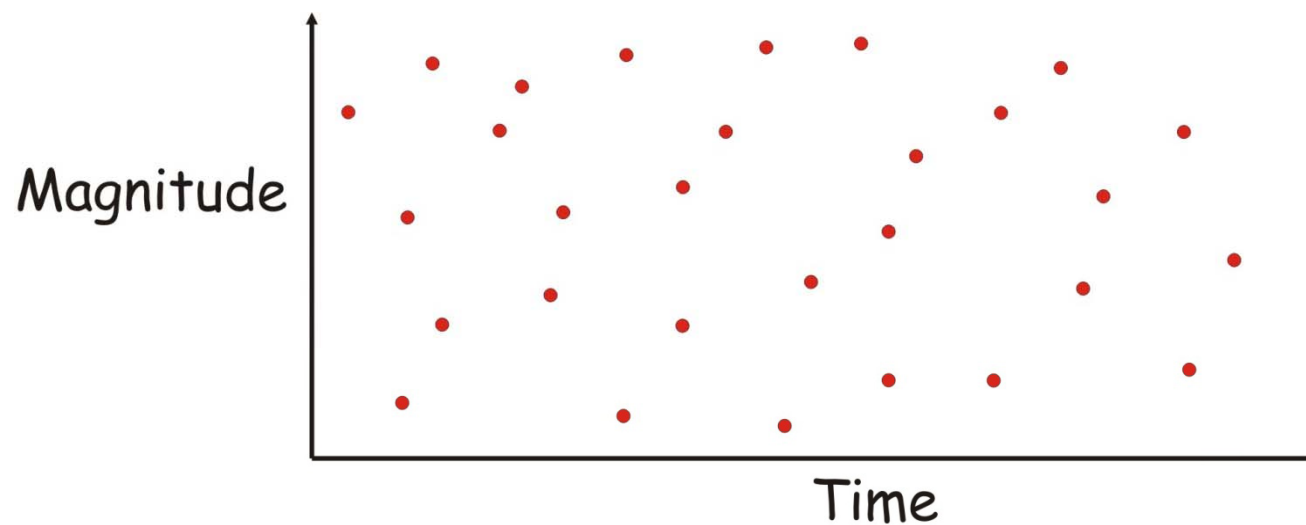
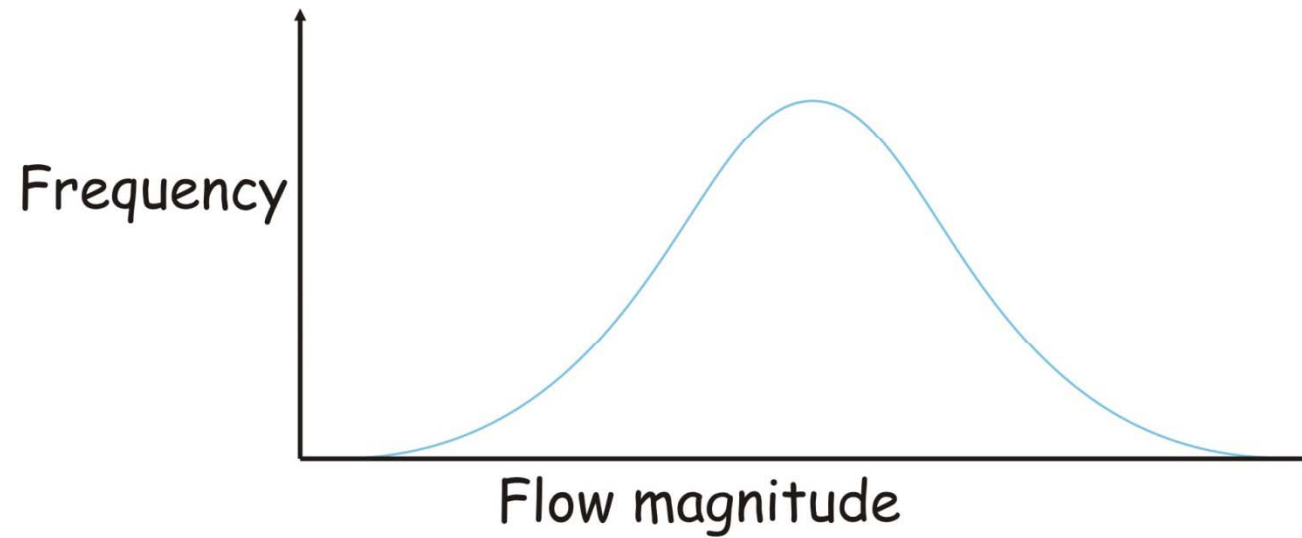
Leeds experimental work also suggests
channel levee form

- imposes a downstream reduction in flow magnitude
- flow evolution tends towards equilibrium condition

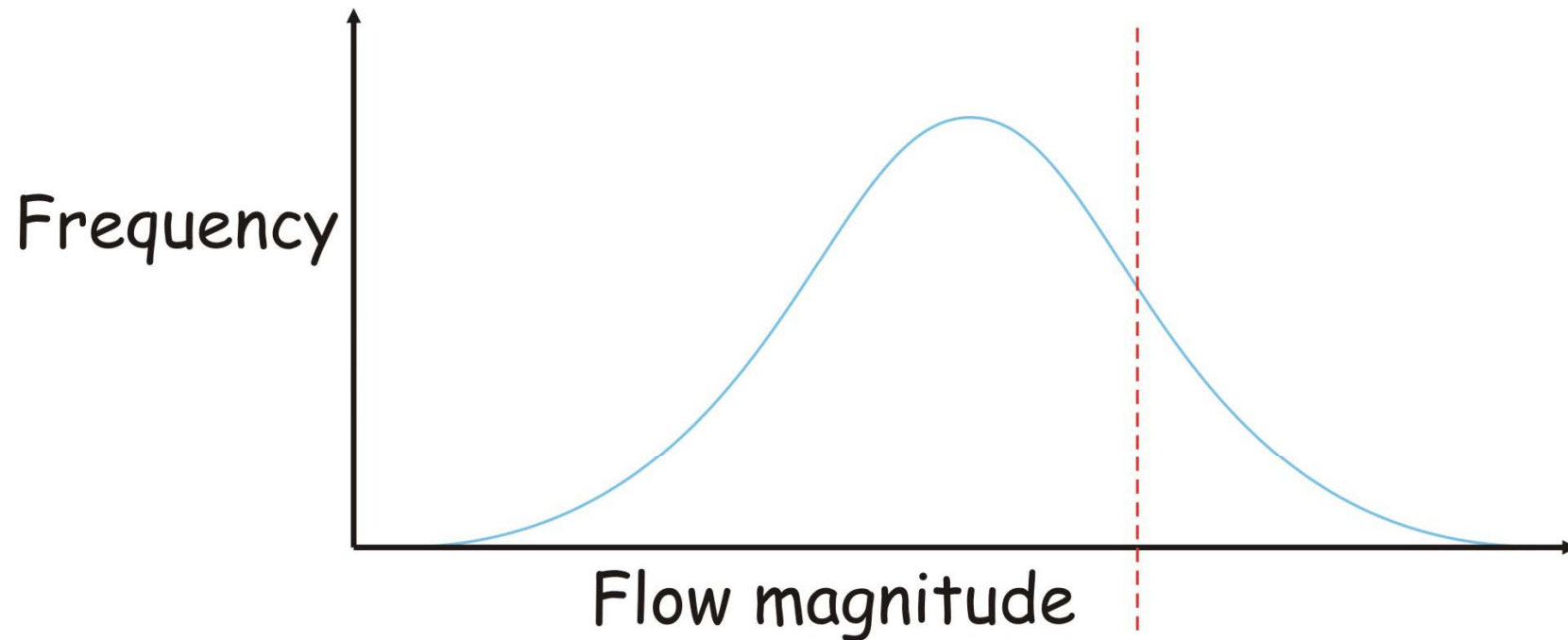
Laboratory data on discharge reduction



Inbound flow distribution



Tuned flow distribution:



- still a range of flow magnitudes
- does changed distribution affect channel evolution?

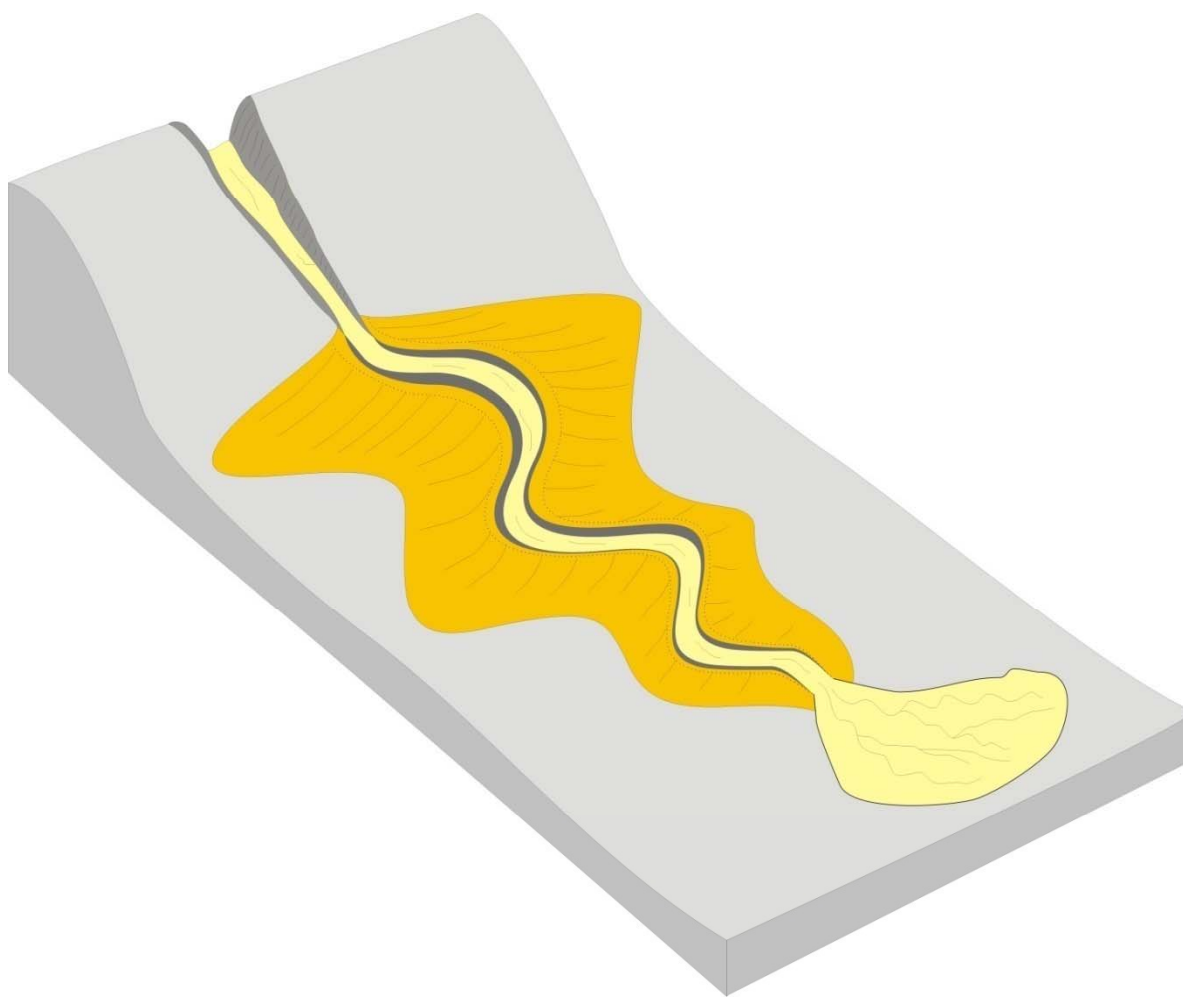
Application:

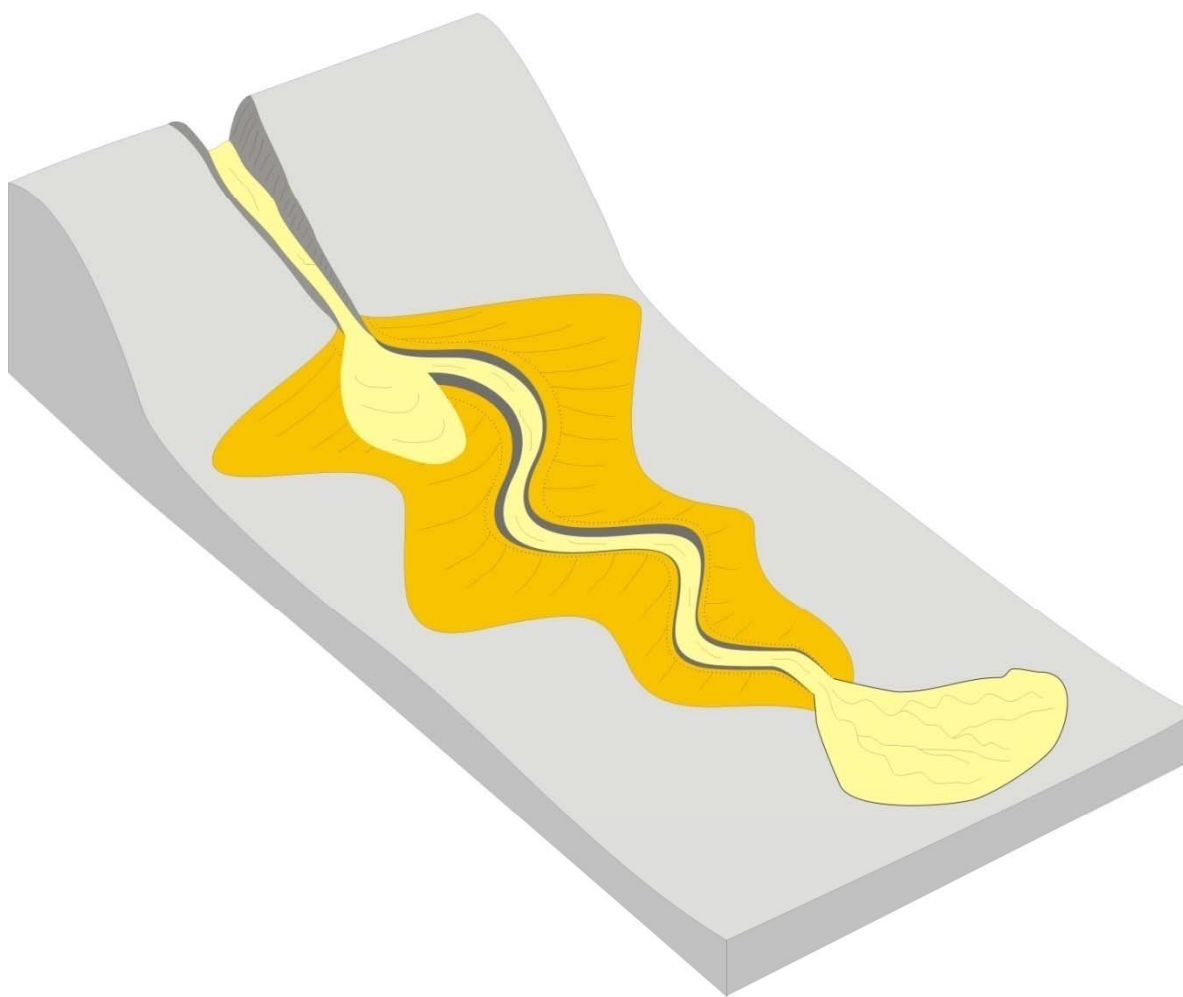
Interpretation of bed thickness distributions

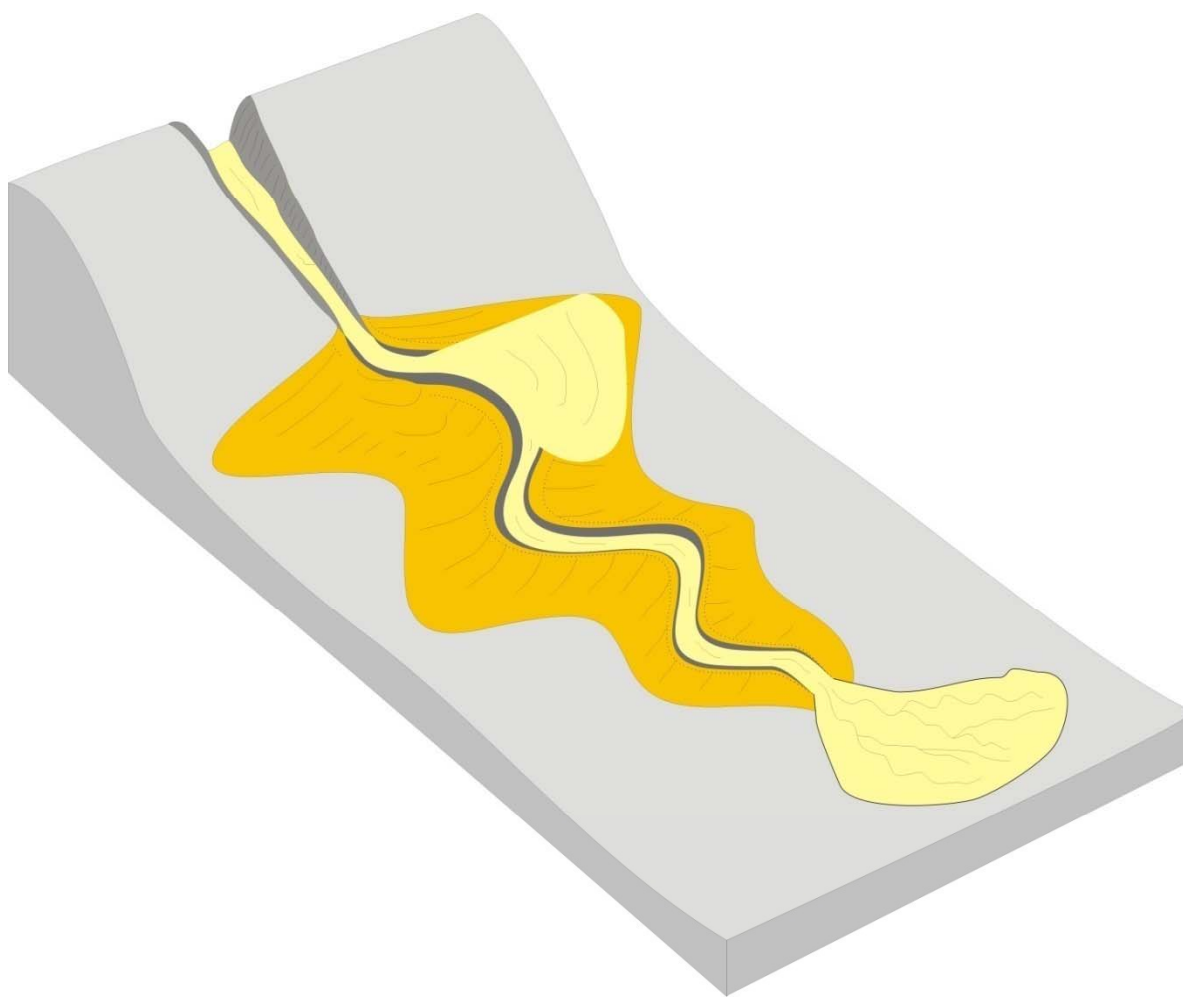
- levee (proximality)
- terminal lobes
- flow generation mechanism
- effect on sediment partitioning

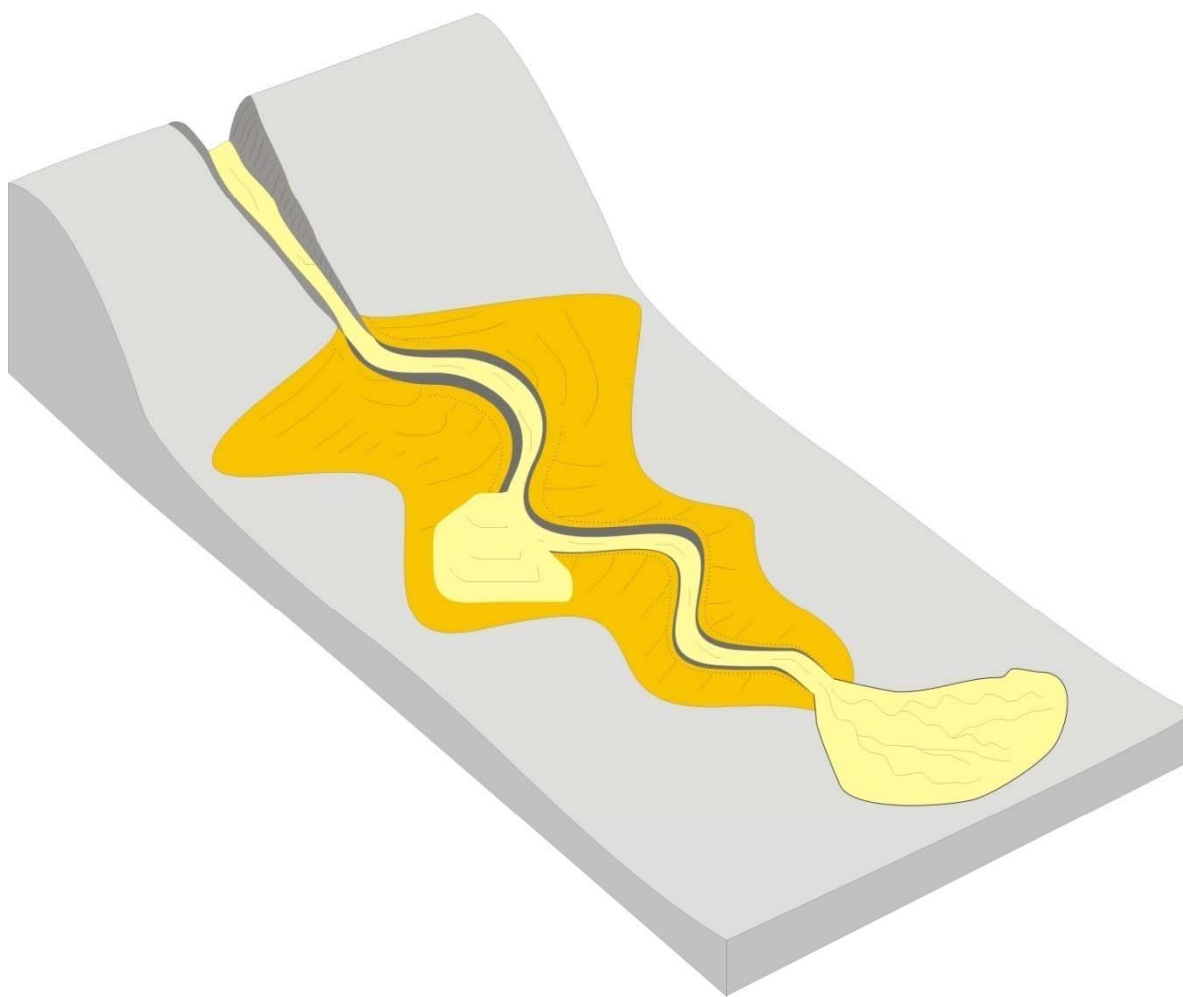
But....

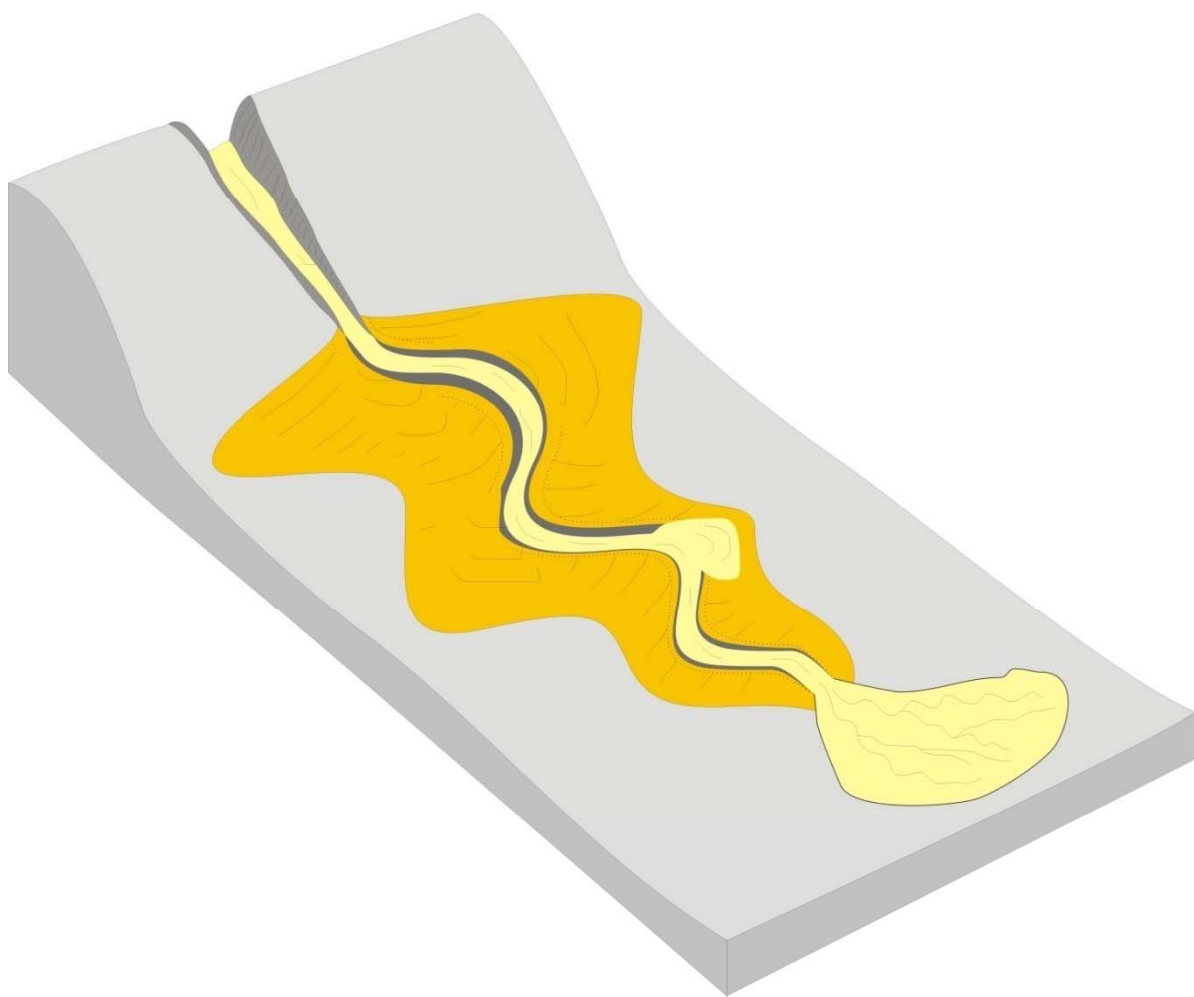
Feedback between the channel levee form and the tuning mechanism...

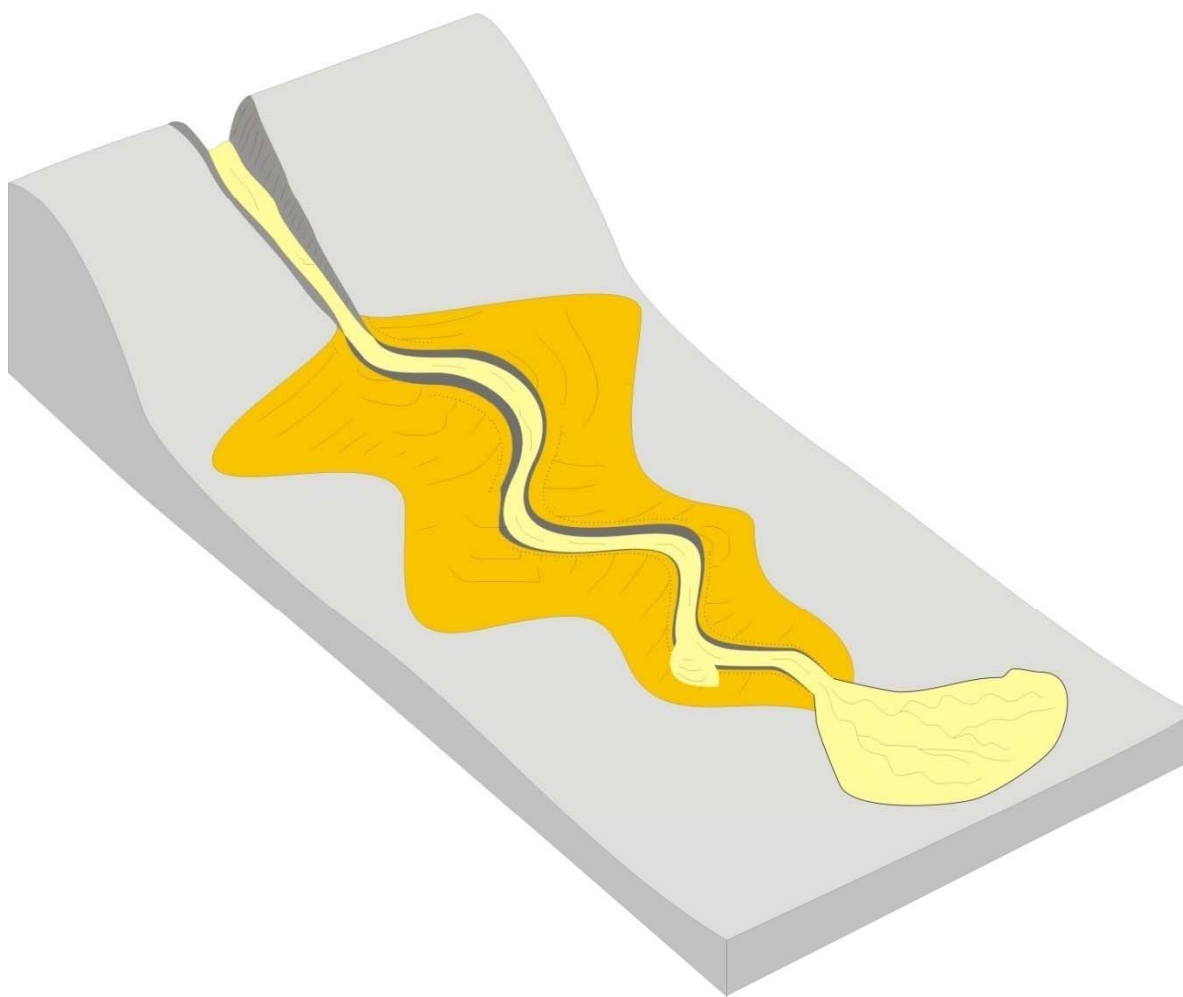












Infer:

- Gross pattern of levee growth should reflect the frequency magnitude distribution of turbidity current flows
- downstream inflexions in levee profile might correspond to inflexions in the distribution

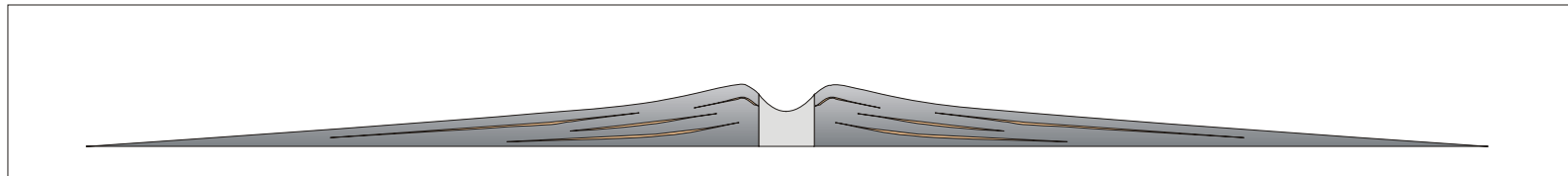
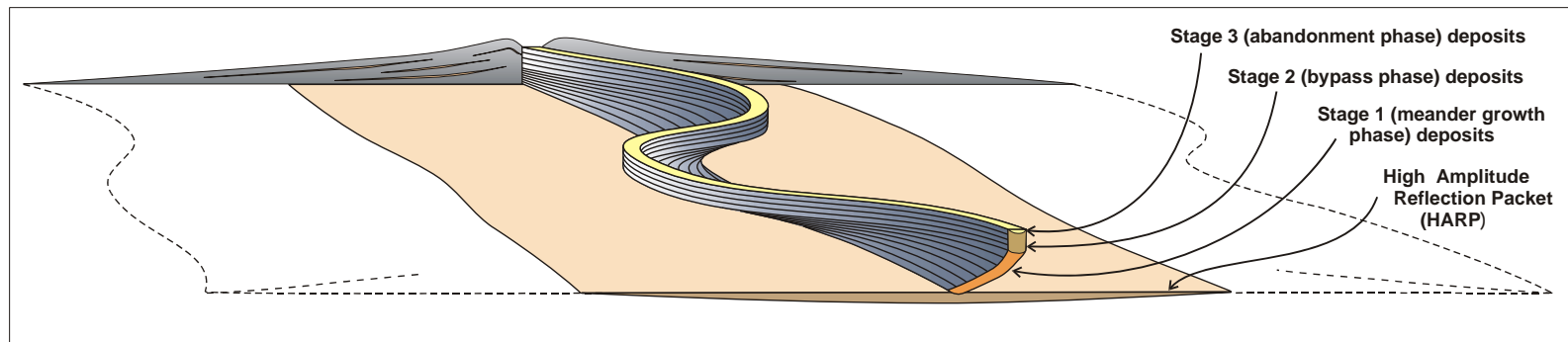
But....

Assumes no temporal change in flow magnitude distribution

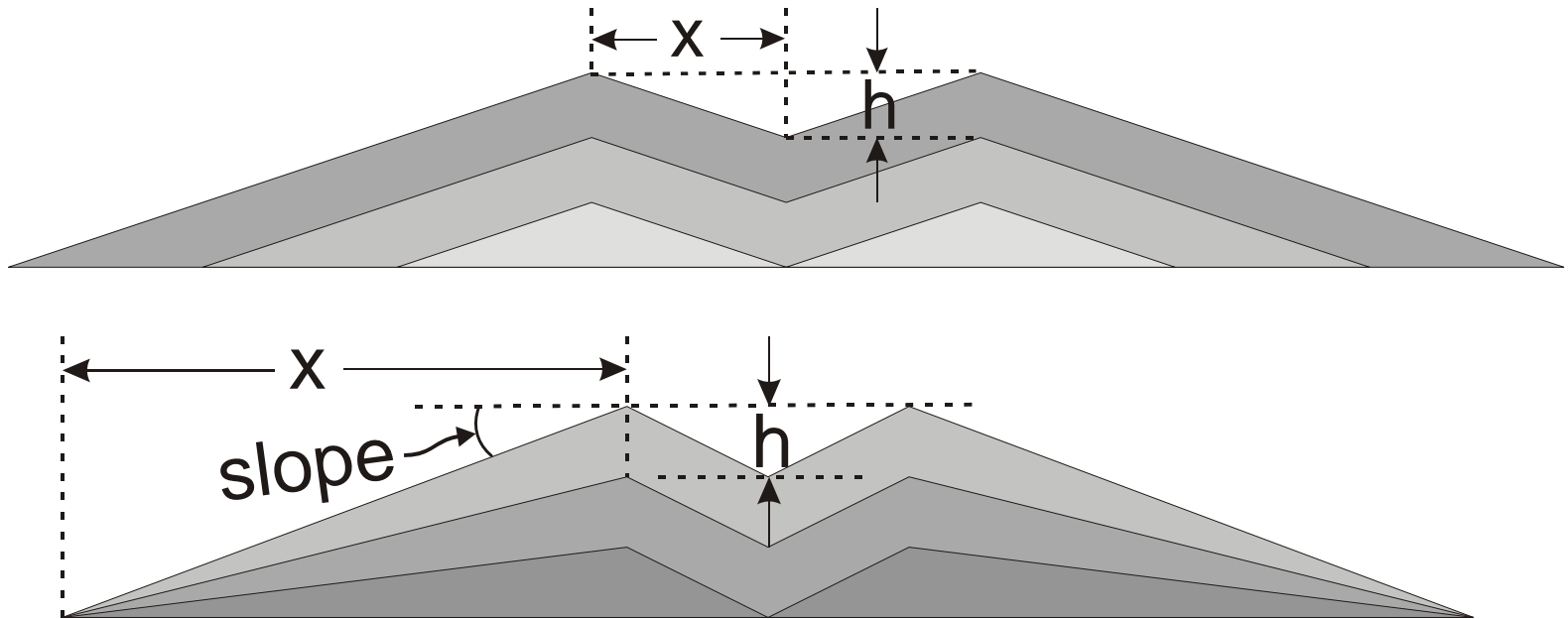
auto vs. allocyclic effects

Auto- vs. allocyclic

- what effect does the channel form have on system development?

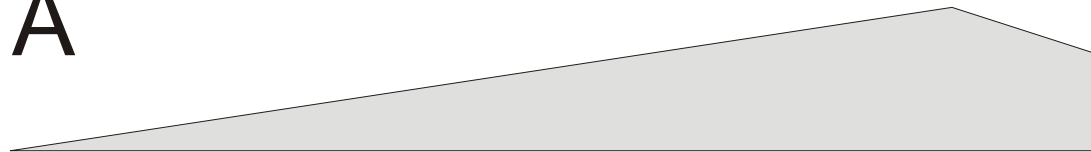


Internal forcing

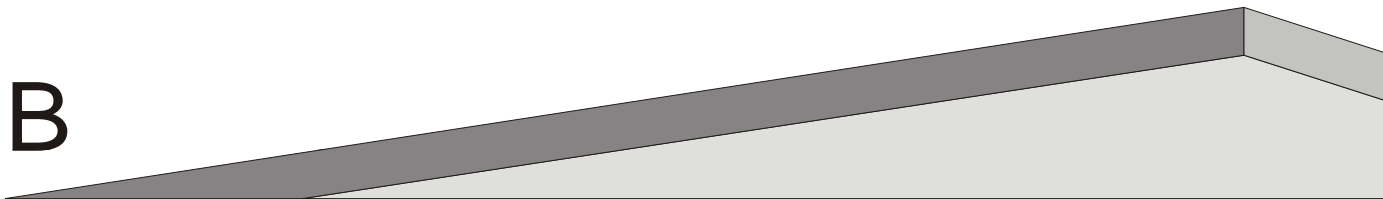


Internal forcing

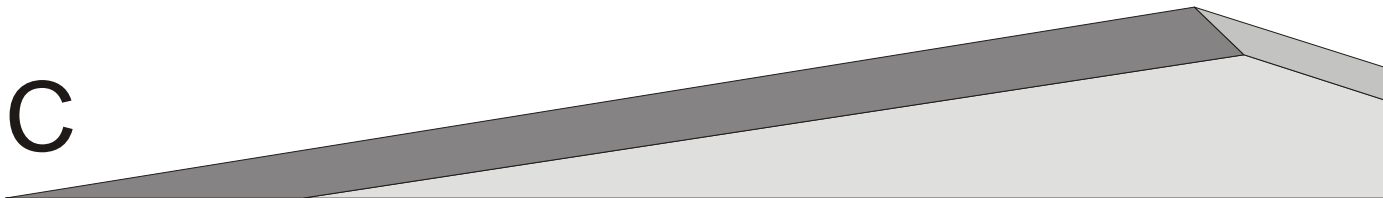
A



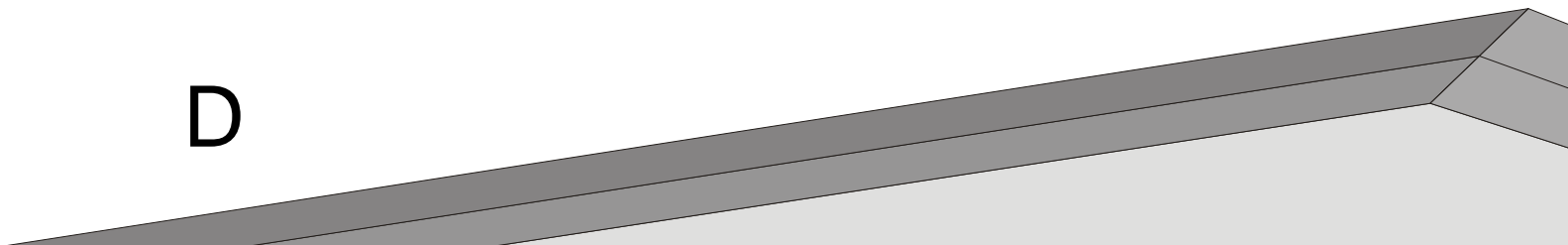
B



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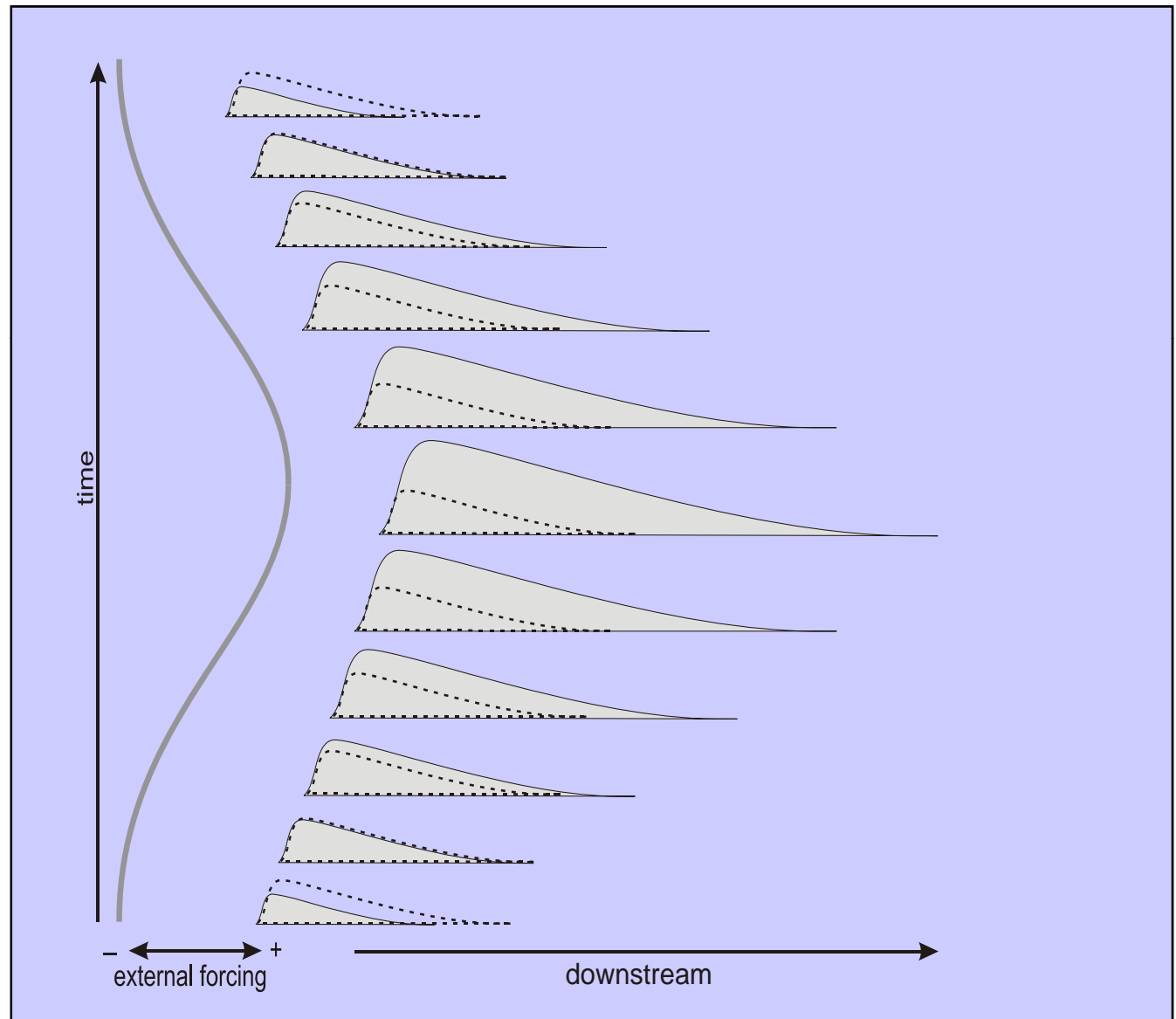


Autocyclic forcing

- The aggradational channel levee form is inherently unstable
- Without any external forcing channels will tend to avulsion state

But does external forcing also play a role?

External forcing



Application to gross fan evolution

We can identify different orders of avulsion in some systems

Can we differentiate internal and external forcings in these patterns of avulsion?

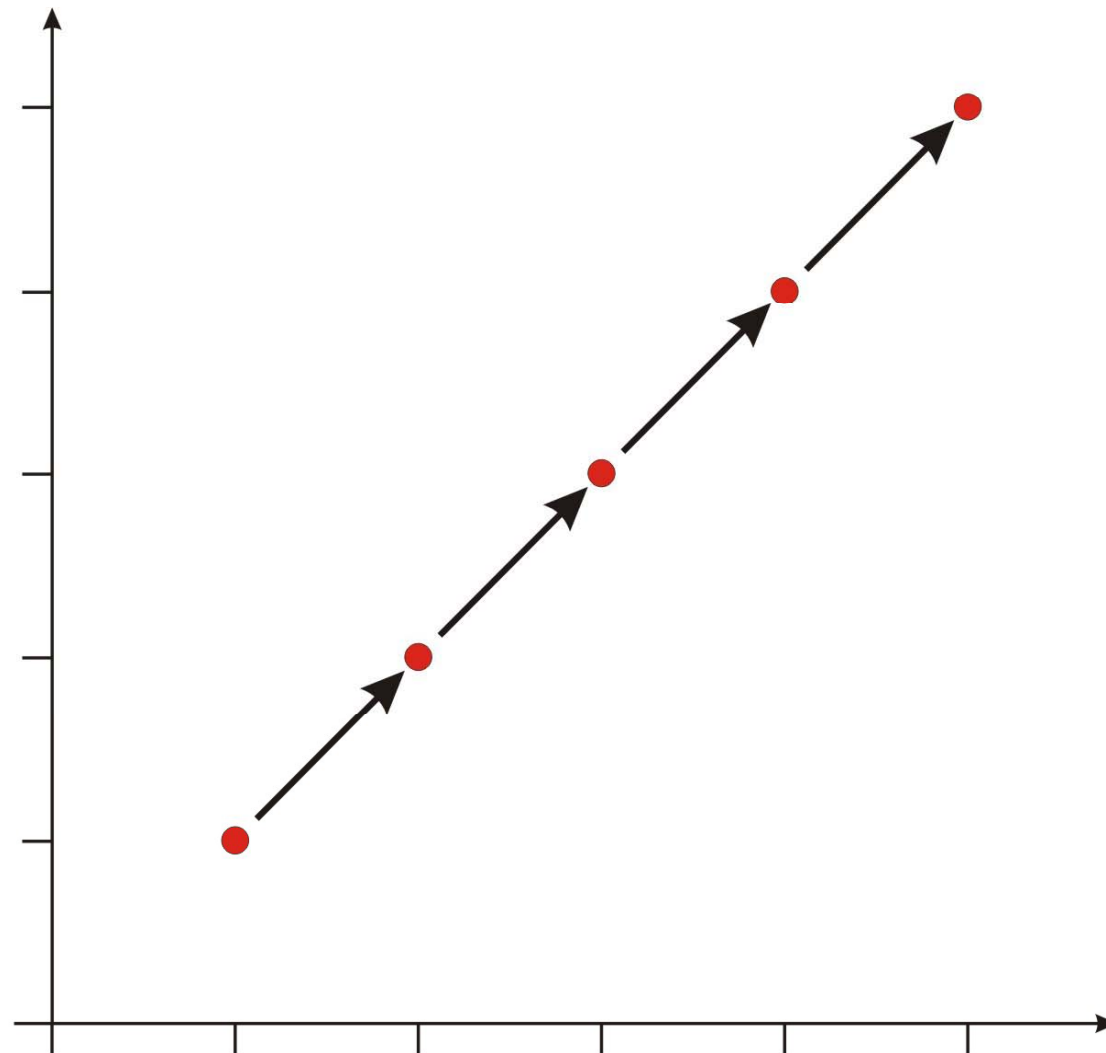
Suggests a topogological approach to fan development

Topological characteristics:

- avulsion direction sequence
- channel length change
- inundation area

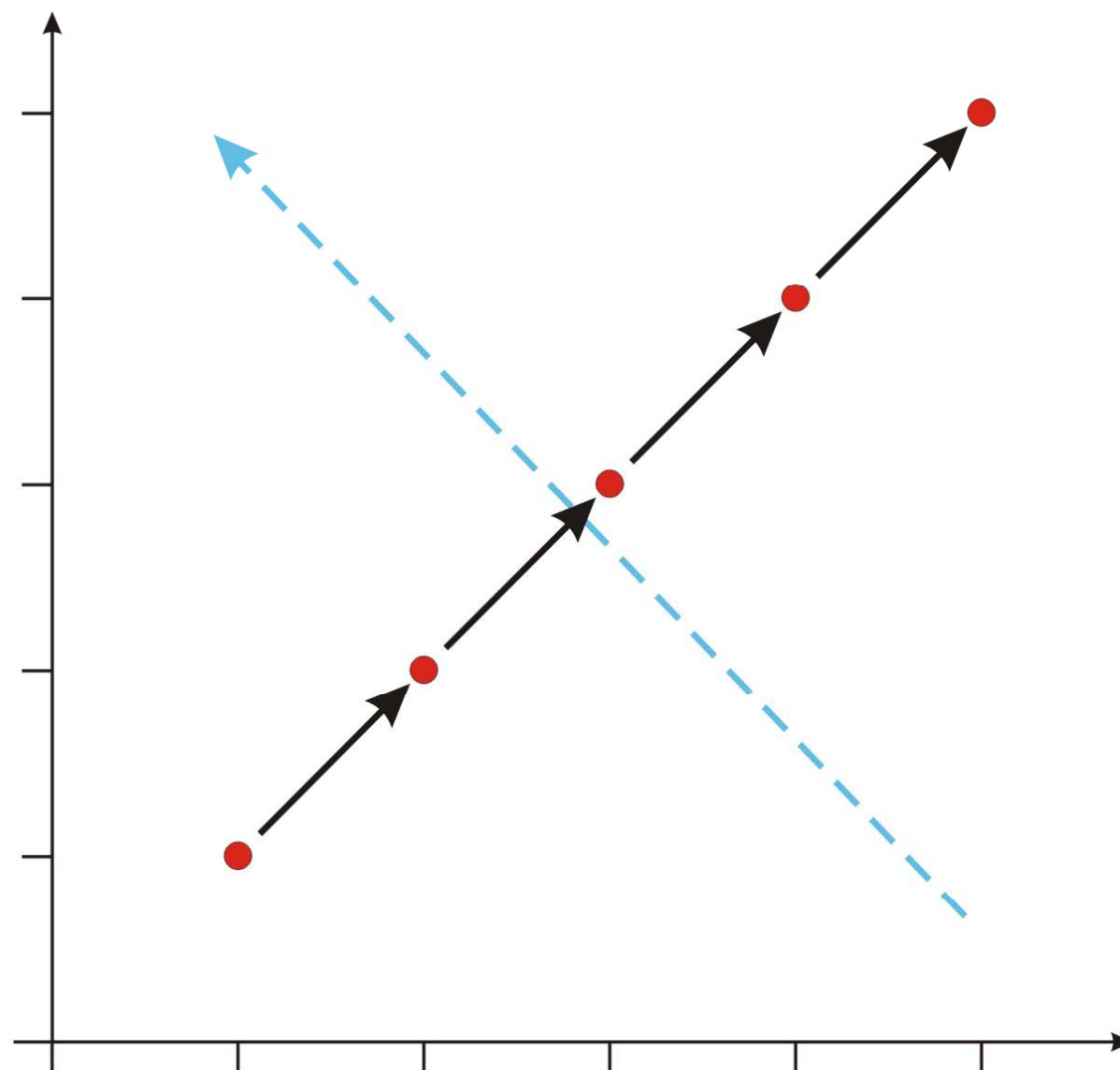
... others

Avulsion
number



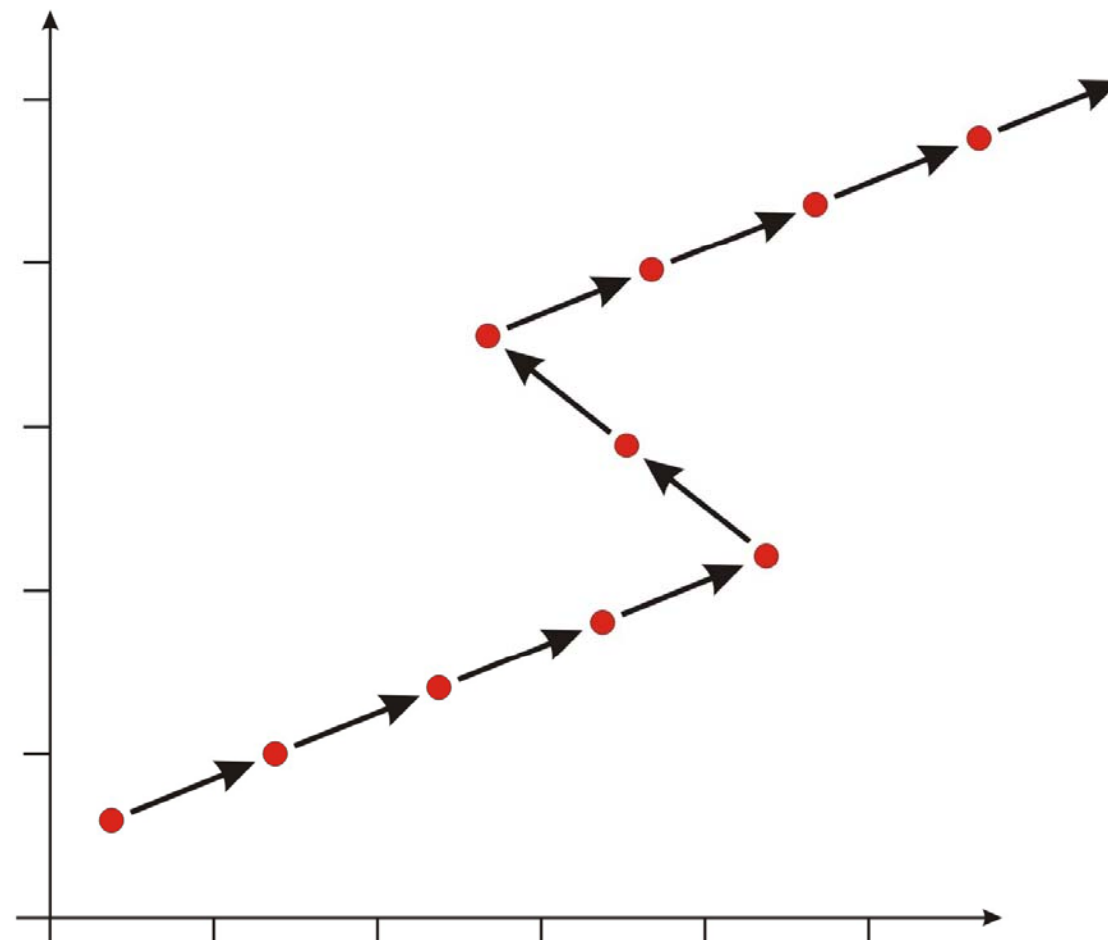
Avulsion location

Avulsion
number



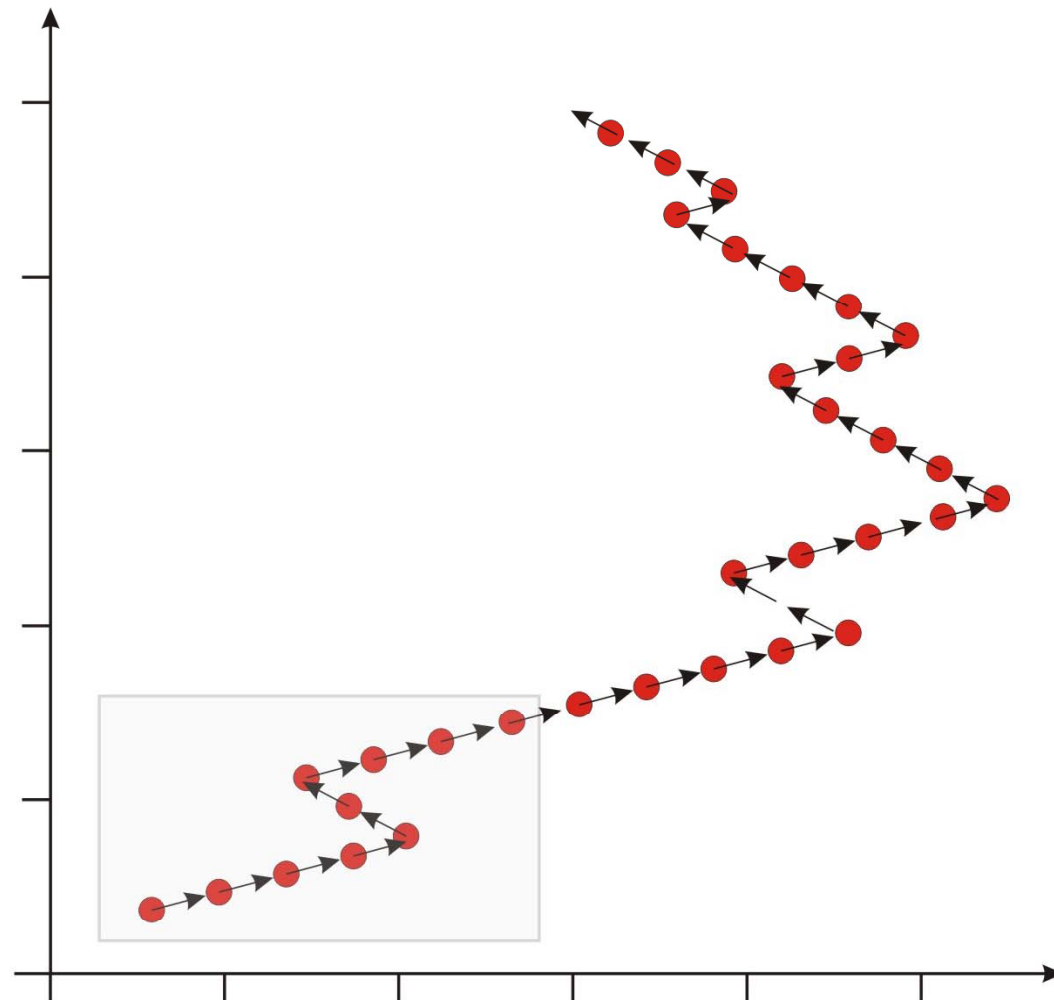
Avulsion location

Avulsion
number



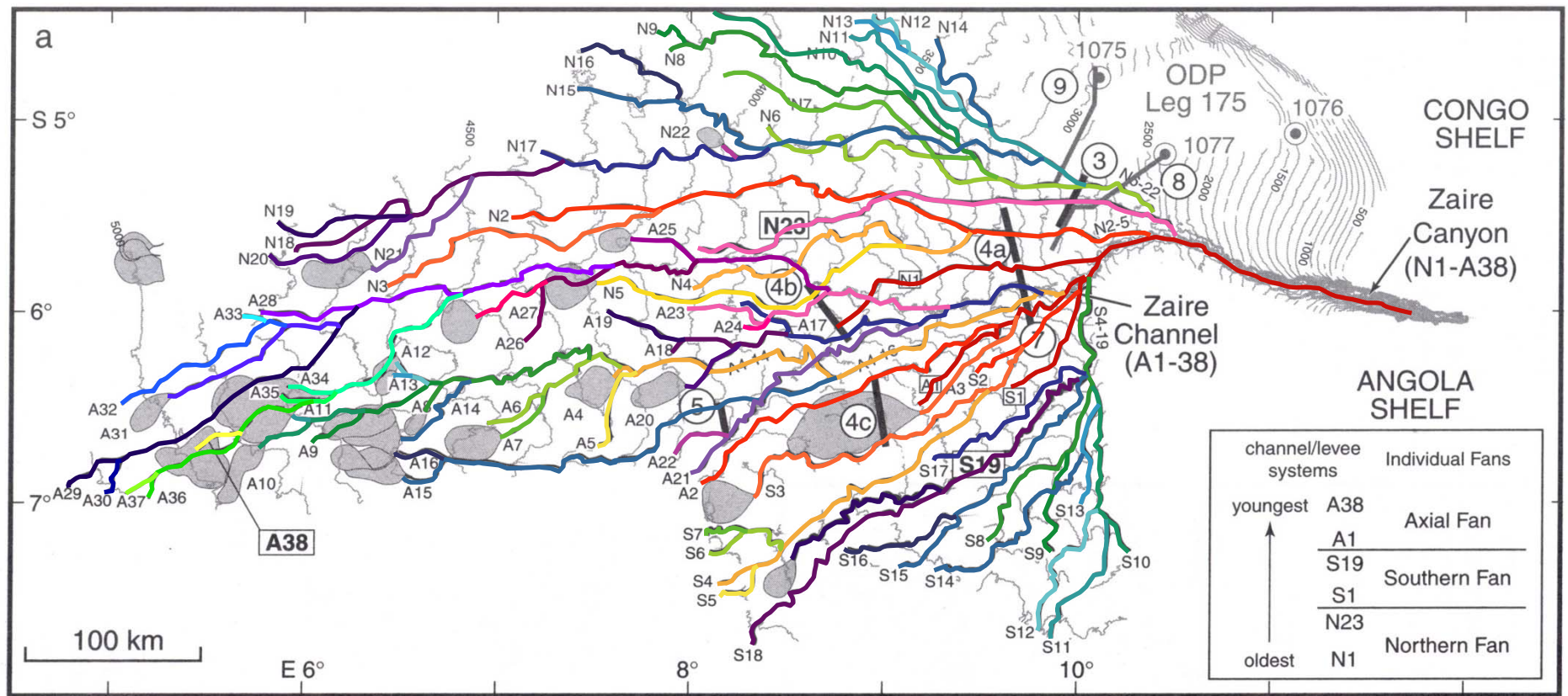
Avulsion location

Avulsion
number



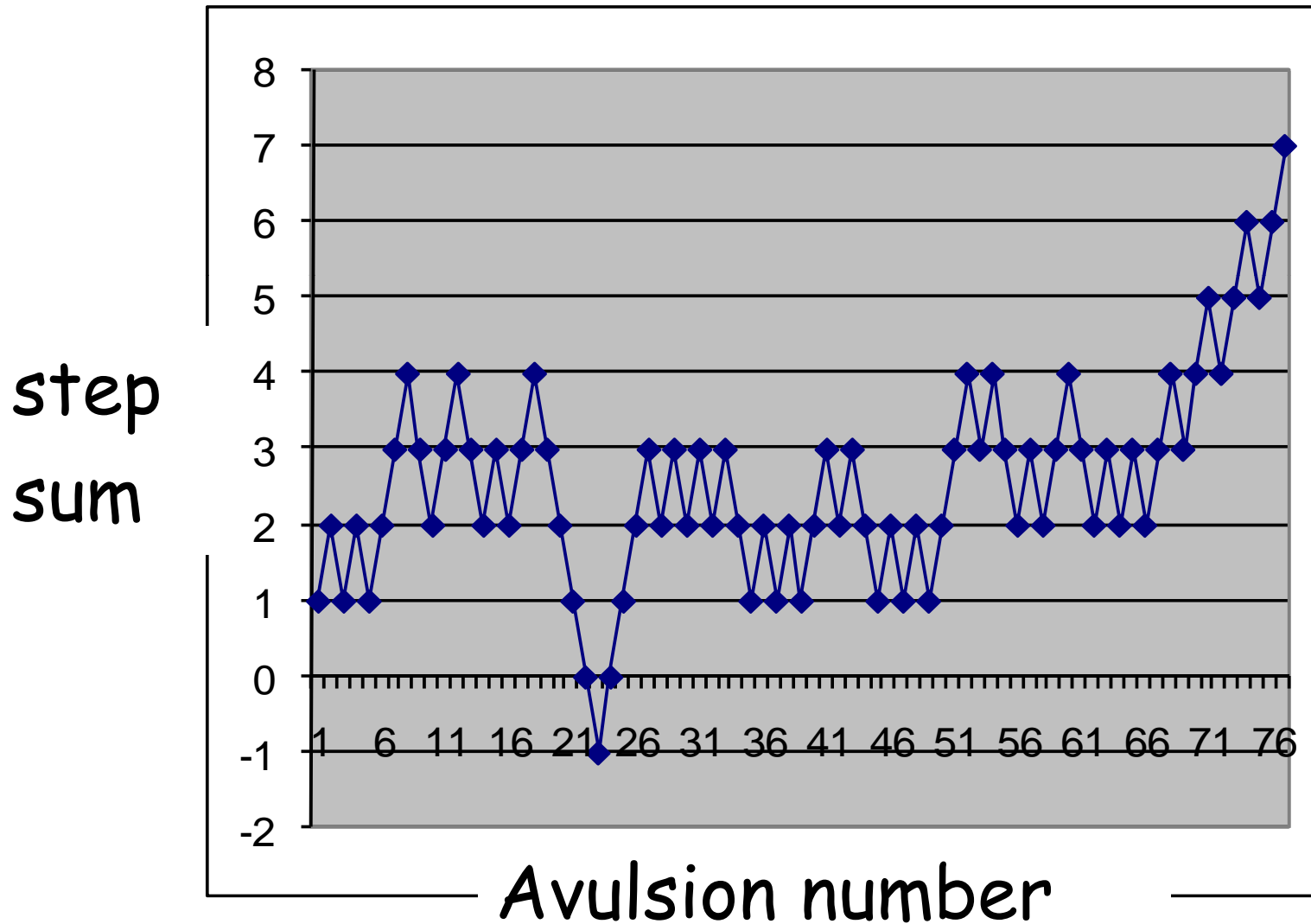
Avulsion location

Fan building as a dynamic process - an example from the Zaire Deep Sea Fan



Data from Babonneau et al 2002, and analysis Bret Dixon (pers comm)

Avulsion direction sequence



Conclude

- the channel levee system is complex!
- expect the channel height decay to reflect the frequency magnitude distribution of inbound flows in the allocyclic case
- potential overprint from
 - inherent autocyclically-driven avulsion
 - allocyclically-driven avulsion
- topological approach to fan evolution may enable recognition of auto vs. allo effects via their expression in different orders of system evolution

References

Babonneau, N. B. Savoye, M. Cremer and B. Klein, 2002, Morphology and architecture of the present canyon and channel system of the Zaire deep-sea fan: *Marine and Petroleum Geology*, v. 19/4, p. 445-467.

Straub, K.M. and D. Mohrig, 2007, Quantifying the morphology and growth of levees in a submarine tributary channel system offshore Brunei Darussalam: AAPG Annual Convention Long Beach, California, AAPG Search and Discovery. Web. 15 September, 2008 http://www.searchanddiscovery.net/documents/2007/07018annual_abs_lngbch/abstracts/lbStraub.htm