Sediment Transport through Transfer Zones in Rift and Passive Margin Settings: Fundamental Differences between Subaerial and Subaqueous Environments*

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Search and Discovery Article #40532 (2010)
Posted May 14, 2009

*Adapted from initial oral presentation at session, "Basin Genetics – How Things Work," at AAPG International Conference and Exhibition, Rio de Janeiro, Brazil, November 15-18, 2009

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Conclusions

Sedimentary pathways observed in subaerial transfer zones of rift margins cannot be readily applied to subaqueous situations.

Inertia, density stratification and the slow response to topography causes much sediment to be shed directly across the bounding faults, unless strong flow confinement is present (channels, ramp tilts, salt cores…).

Flow splitting may play a major role in controlling sediment distribution

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AAPG International 2009 Rio de Janeiro

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Contents

- "Transfer Zones" in Rift Settings
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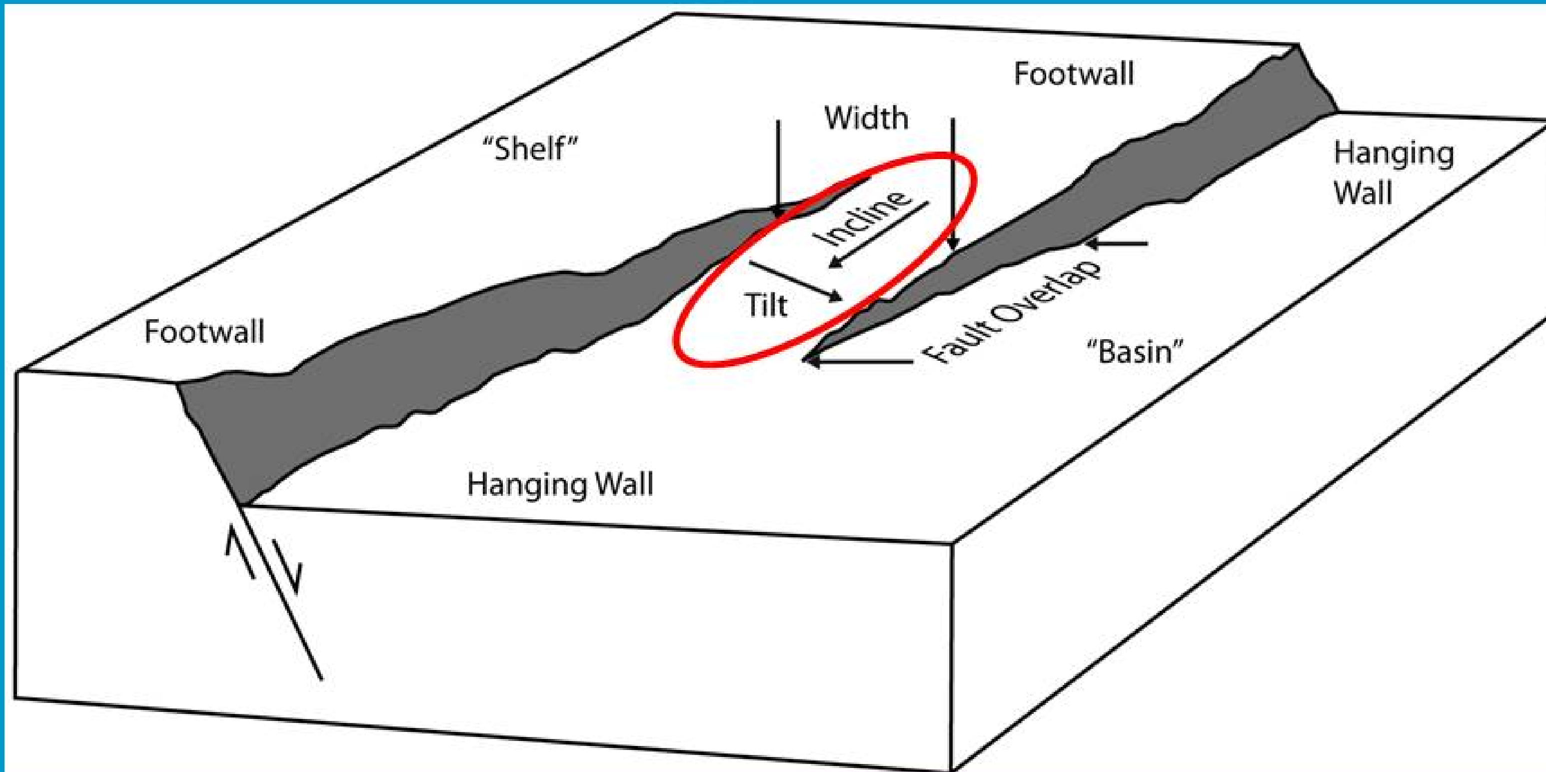
"Transfer Zones" in Rift and Early Drift Settings

- Incompletely linked border faults form relay ramps
- These are considered major pathways for sediment transfer from the shelf into the basin
- Most evidence comes from terrestrial and deltaic settings

Note by Presenter:
Relay ramps are really only one type of transfer zone. SEPM Special Publication no. 73 (Renaut, R.W., and G.M. Ashley, 2002) contains quite a few papers on the topic.

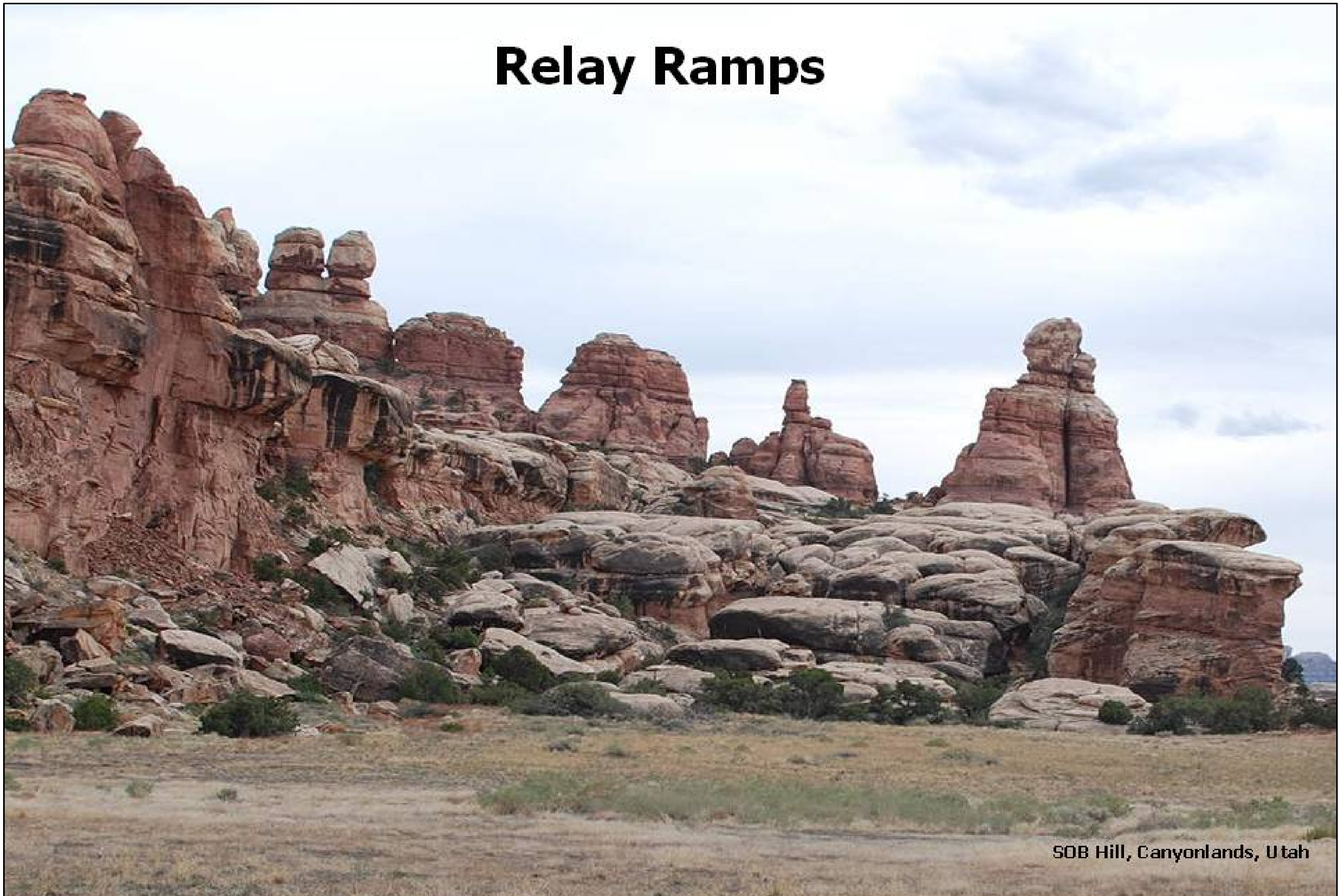
Relay Ramps



Athmer et al., in press

Note by Presenter:
The circled parameters, together with width and length, are the most important ones.

Relay Ramps



Note by Presenter:
Tilt is low, incline of a few degrees.

Relay Ramps

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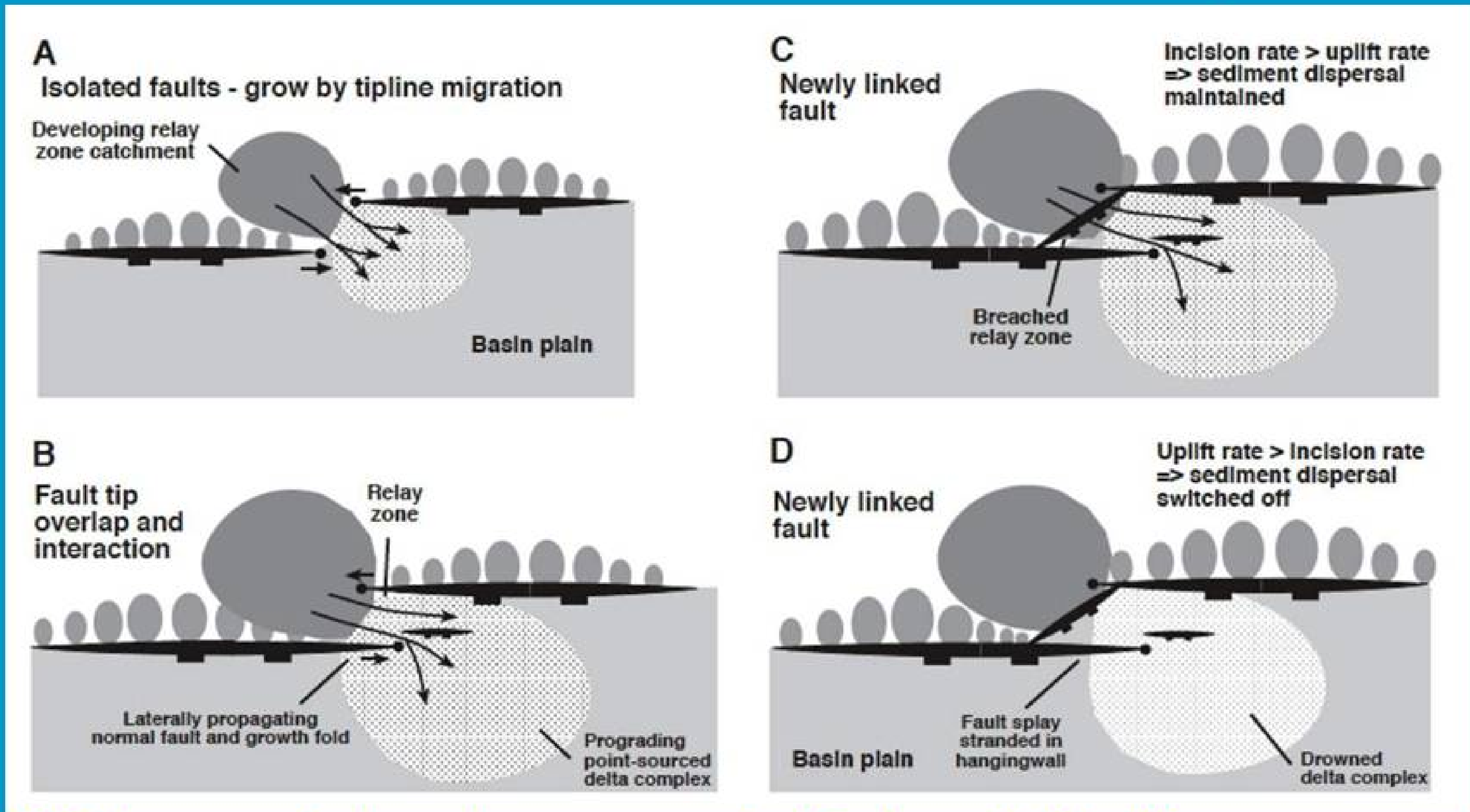
Note by Presenter:
Also here: Low tilt, slightly higher incline.

Transfer Zones in Deltaic Settings

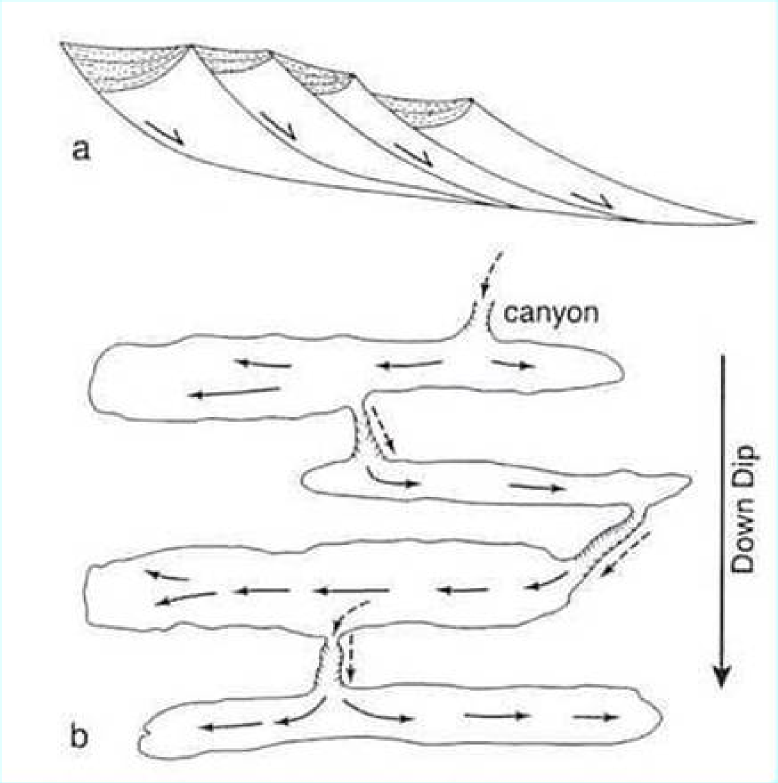


Similar scenarios have been suggested for terrestrial settings

Gupta et al., 1999

Note by Presenter:
This is from the work of Gupta et al (1999) in Egypt. The incision/uplift rate ratio is indeed a controlling factor.

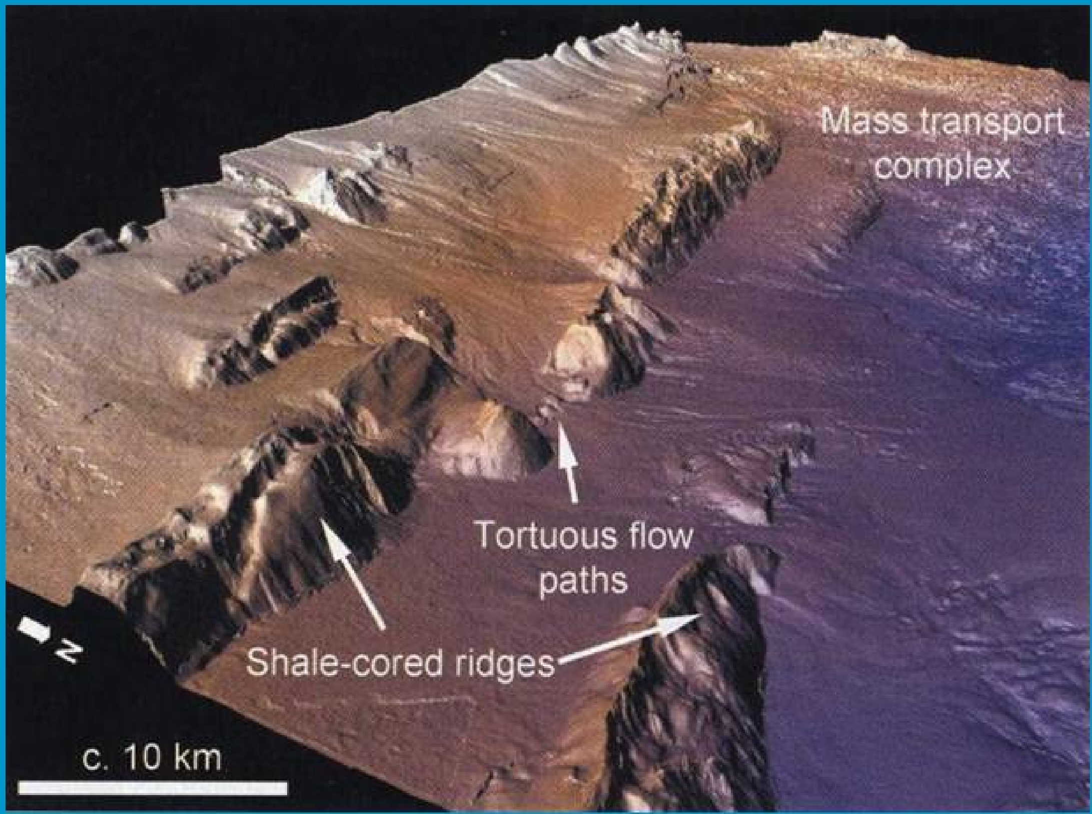
Suggested Flow Paths in Submarine Fault-Controlled Margins



Bouma, 2005

Note by Presenter:
This is Bouma's very simplified idea of "how things work." It turns out that submarine gravity flows are probably not very good slalom skiers.

Suggested Flow Paths in Complex Slope Topographies



Smith, 2005

Note by Presenter:
Ru Smith's idea (2005) is that the flows carefully avoid these salt-cored ridges. But do they really?

What Really Happens in Subaqueous Transfer Zones?

- To get some ideas we have to look at the principal physical properties of subaqueous gravity flows
- We will focus on turbidity currents (TCs) as most subaqueous gravity flows develop them least partially.
- TCs have the longest run-out distance of all subaqueous gravity flows and are thus most relevant for coarser-grained deepwater sedimentation.
- We will only consider "sufficiently high slopes" where by-pass or sediment transfer dominates.

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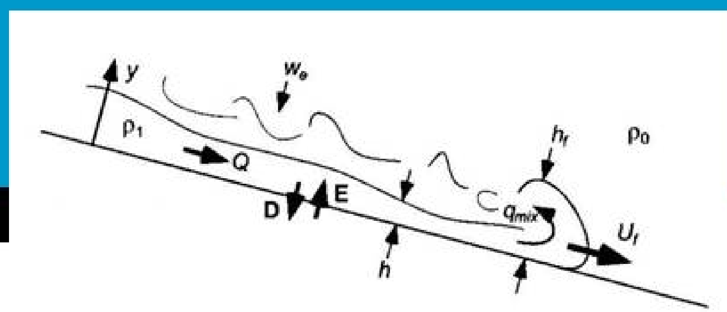
Relevant Physical Considerations …

- TC in these settings dilute vertically due to entrainment of ambient fluid. The degree of entrainment is directly related 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

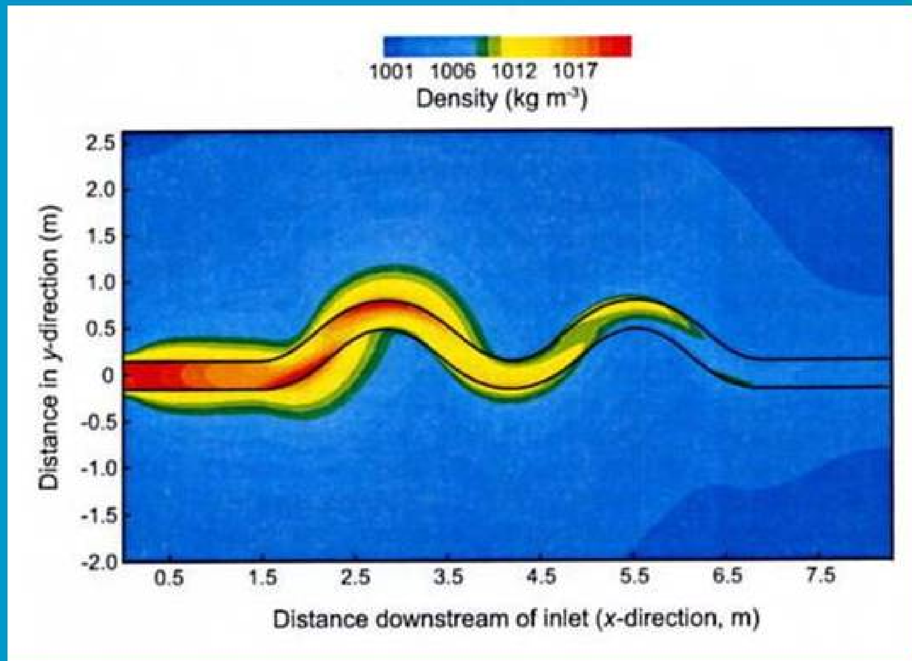
Note by Presenter:
The difference between confined and unconfined flow is really quite important as far as the flow dilution is concerned.

… and What They Really Mean

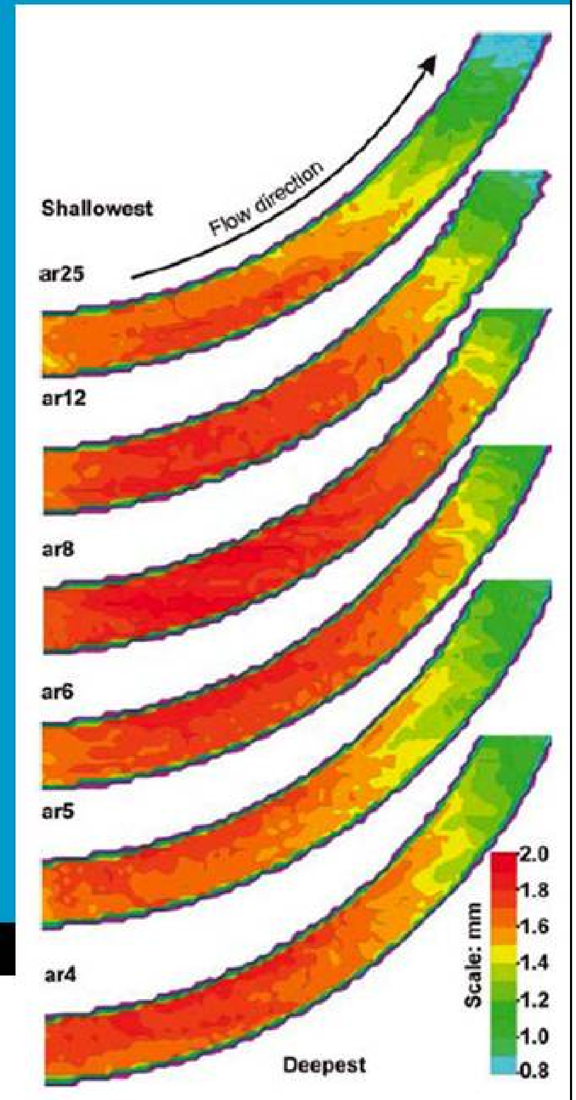
- TCs are "lighter" than in the subaerial environment and especially so in their upper part (and their margins, in unconfined settings)
- Yet they have a significant momentum due to the amount a water involved
- Therefore, TCs have a considerable inertia, and because of this and their "light" weight they are slow in responding to changes in topography
- Because of the density and velocity gradients the lower part of TCs may behave differently from the upper part
- In channelized settings the effects of these properties have been studied quite extensively

Note by Presenter:
TC's typically are 10-50 times "lighter" than rivers, but they move a large mass (of mostly water).
Therefore, their inertia is large and their reaction to gravity slow.

Experiments with Channels



Parsons et al., 2007



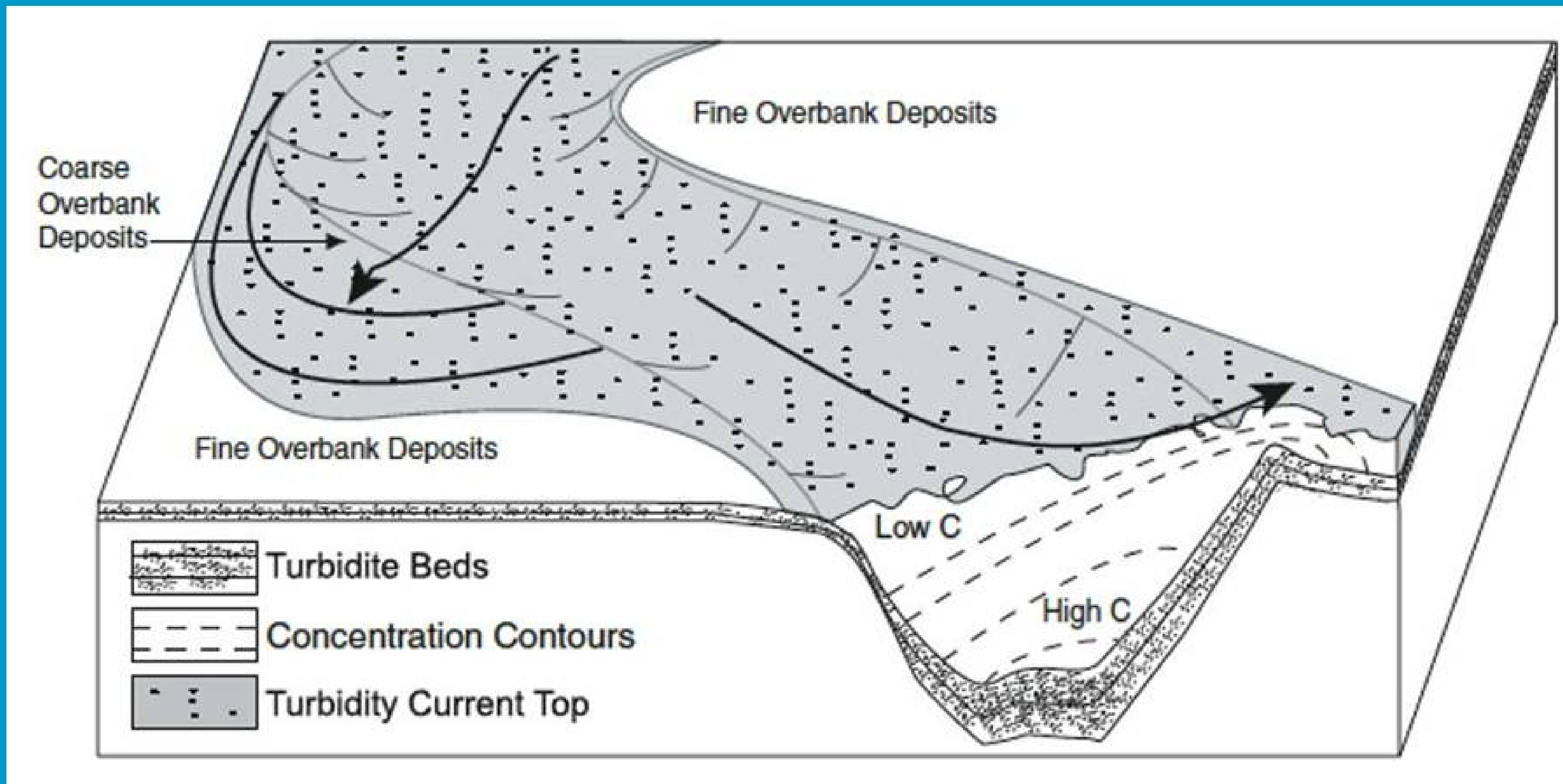
Kane et al., 2008

Note by Presenter:

The left image shows early spreading and overbank flow (the densities are shown in a slice just above the channel banks).

The right image shows how deeper channelization preserves the higher densities. This then leads to a different depositional pattern (inner vs outer banks) (cf. the LAPs by Abreu et al., 2003).

Run-up and Spillover in Submarine Channels



Straub et al., 2009

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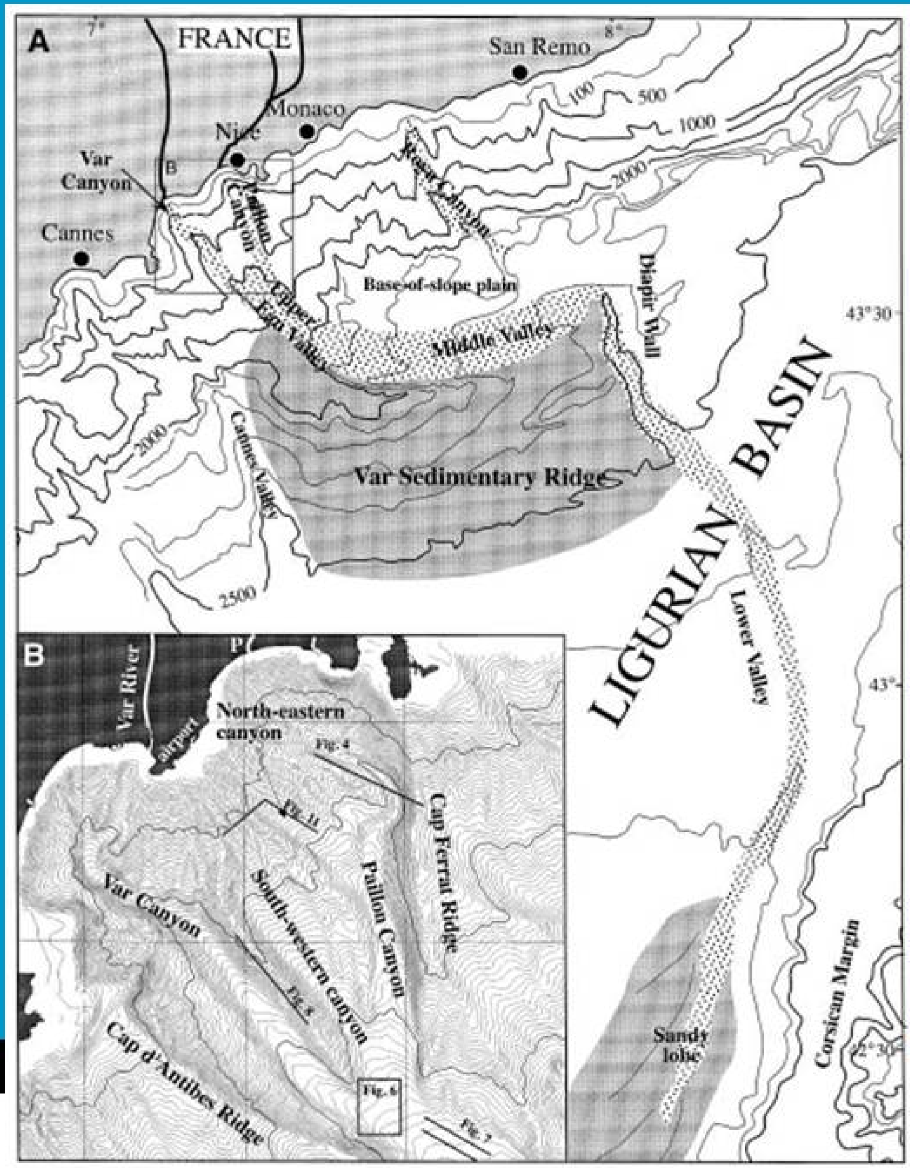
Note by Presenter:
This is an experimental result, although I don't know how widely applicable their coarse-grained deposits on the outer bank are.

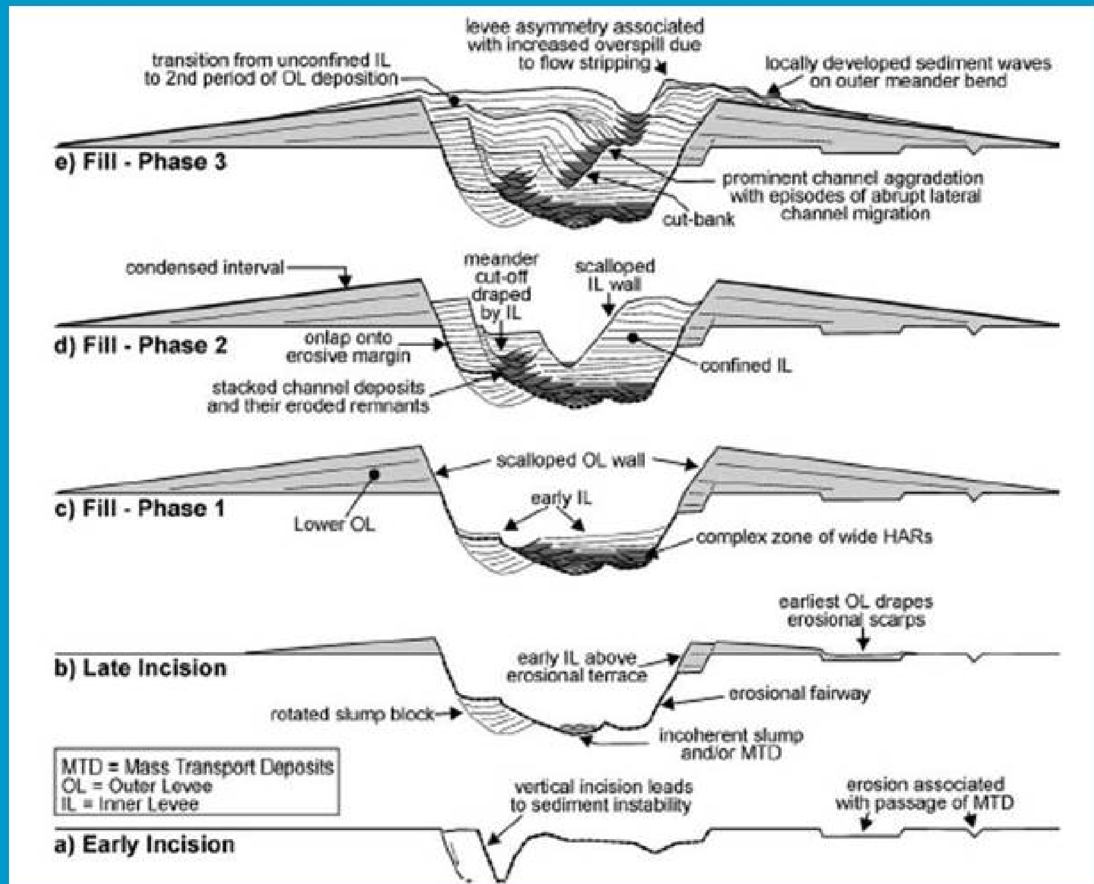


Formation of Extensive Asymmetric Levees in Channel Bends

Klaucke et al., 2000

Note by Presenter:
One of the most impressive run-up and spillover levees! Clearly, the flows don't "like" to take the turn.
The steep slopes involved make for a strong vertical flow dilution.

Formation of Inner and Outer Levees



Deptuck et al., 2003

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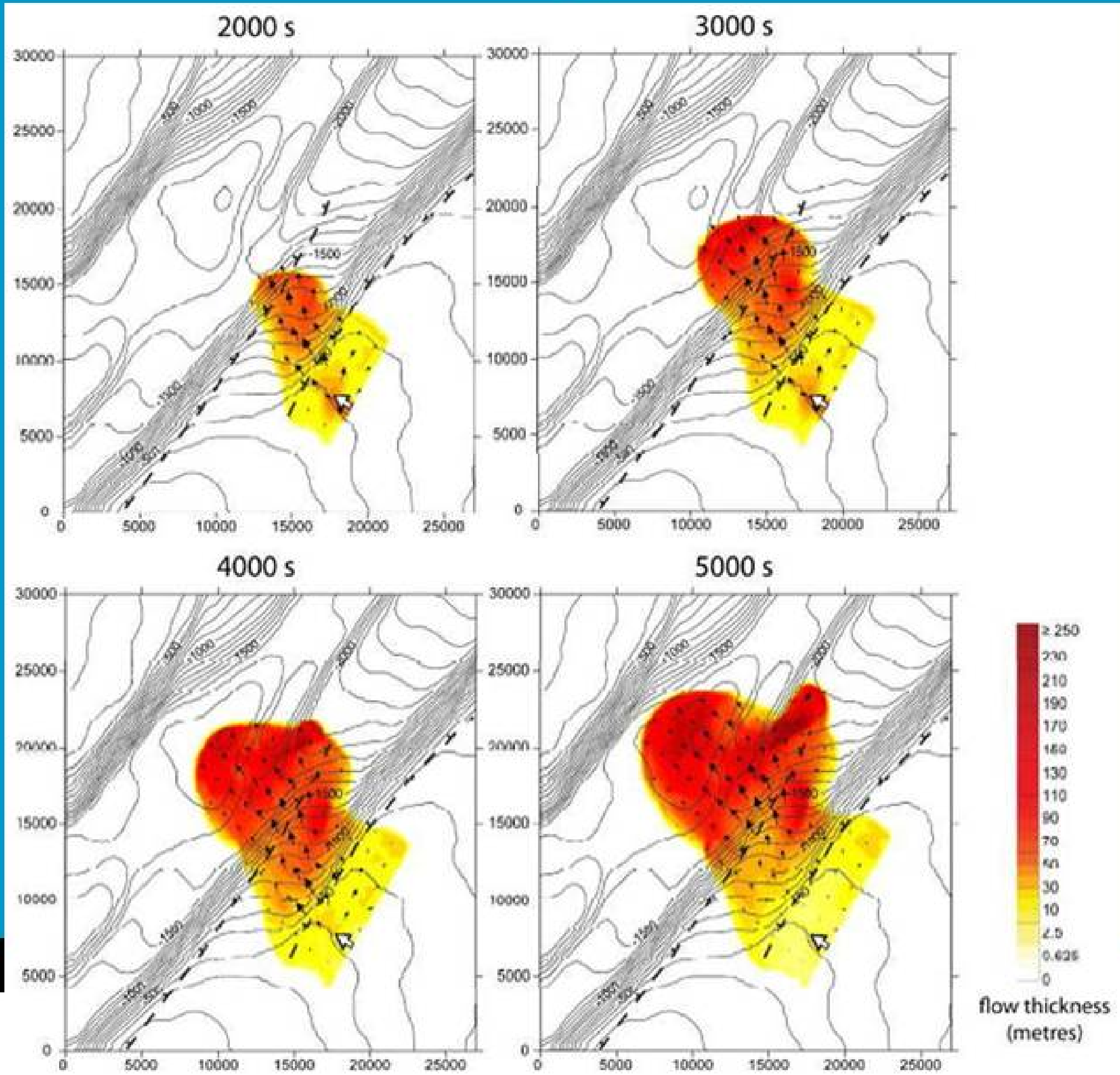
Note by Presenter:
A flow can split and spill even WITHIN channels!

But What Happens in Transfer Zones ?



"Unconfined":

- **No channel**
- **Basinward tilt**
- **Inflow perpendicular to ramp axis**

Athmer et al., in press

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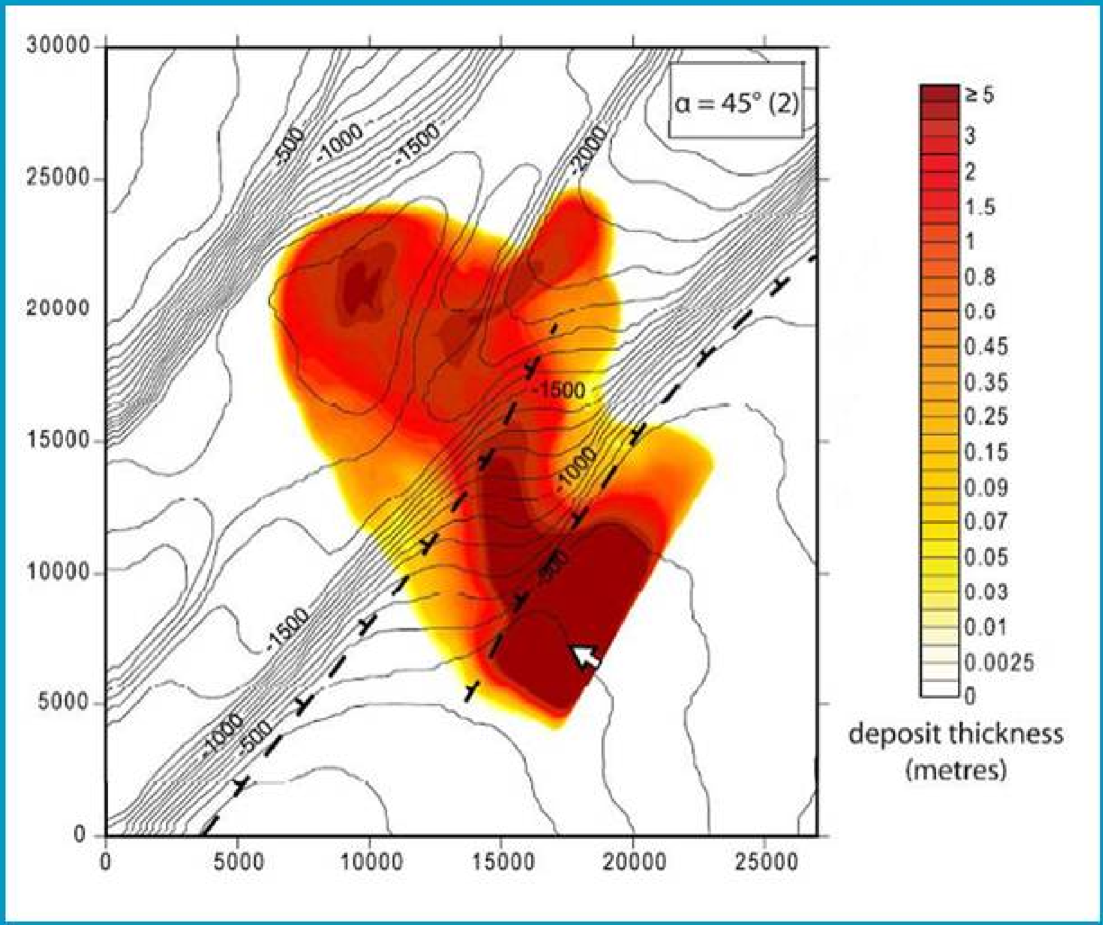
Note by Presenter:
These and the following are well known

Deposit Thickness



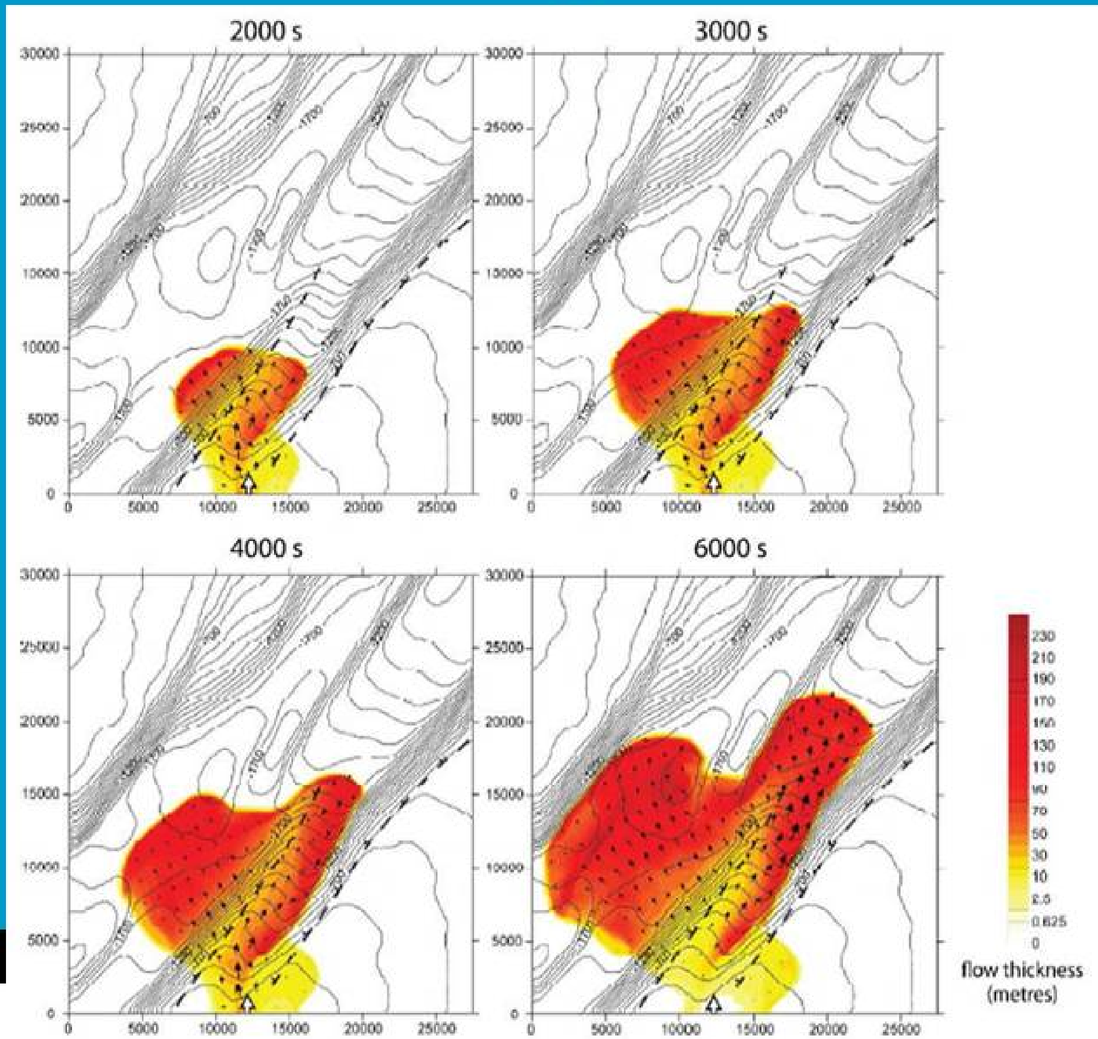
"Unconfined":

- **No channel**
- **Basinward tilt**
- **Inflow perpendicular to ramp axis**

Athmer et al., in press

Note by Presenter:
Mulder in Bordeaux has recently used CATS and obtained similar results.

But What Happens in Transfer Zones ?



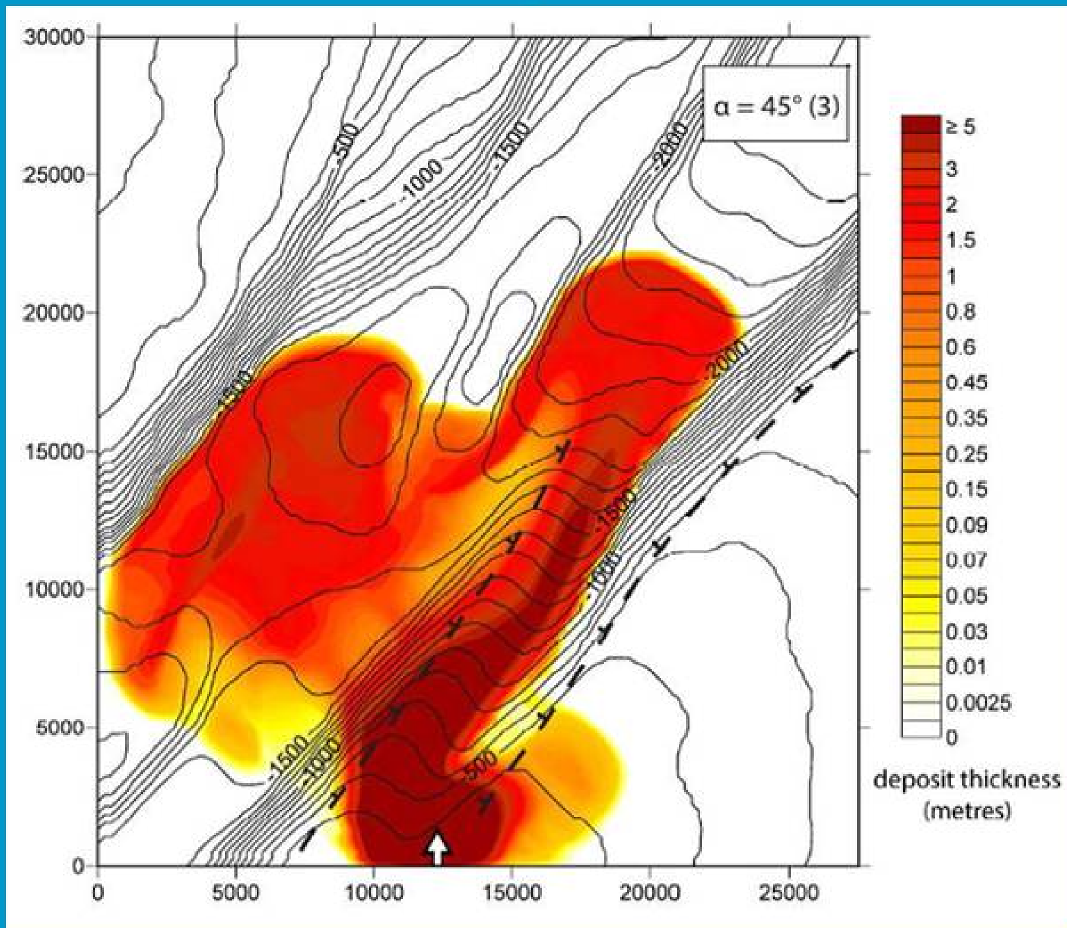
"Confined":

- Channel
- Landward tilt
- Inflow parallel to ramp axis

Athmer et al., in press

Note by Presenter:
Wiebke corrected me: There is no channel involved here. This does not alter the conclusions.

Deposit Thickness



"Confined":

- **Channel**
- **Landward tilt**
- **Inflow parallel to ramp axis**

Athmer et al., in press

Note by Presenter:
The impression could be that the flow made a U-turn at the base of the ramp. But the flow vectors show otherwise.

Conclusions

- Sedimentary pathways observed in subaerial transfer zones of rift margins cannot be readily applied to subaqueous situations.
- Inertia, density stratification and the slow response to topography causes much sediment to be shed directly across the bounding faults, unless strong flow confinement is present (channels, ramp tilts, salt cores…).
- Flow splitting may play a major role in controlling sediment distribution