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

S.M. Luthi¹, R.M. Groenenberg¹, W. Athmer¹, and M.E. Donselaar¹

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¹Delft University of Technology, The Netherlands (s.m.luthi@tudelft.nl)

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

References


Klaucke, I., B. Savoye, and P. Cochonat, 2000, Patterns and processes of sediment dispersal on the continental slope off Nice, SE France: Marine Geology, v. 162, p. 405-422.


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Fundamental Differences between Subaerial and Subaqueous Environments

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_Delft University of Technology, The Netherlands_
Contents

- “Transfer Zones” in Rift Settings
- Physical Considerations
- Experiments and Field Evidence in Channels
- What Happens in Subaqueous Transfer Zones?
"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.
Note by Presenter:
The circled parameters, together with width and length, are the most important ones.
Note by Presenter:
Tilt is low, incline of a few degrees.
Note by Presenter:
Also here: Low tilt, slightly higher incline.
Transfer Zones in Deltaic Settings

A. Isolated faults - grow by tipline migration
   Developing relay zone catchment

B. Fault tip overlap and interaction
   Laterally propagating normal fault and growth fold
   Prograding point-sourced delta complex

C. Newly linked fault
   Incision rate > uplift rate
   Breached relay zone
   Sediment dispersal maintained

D. Newly linked fault
   Uplift rate > incision rate
   Sediment dispersal switched off
   Fault splay stranded in hangingwall
   Drowned delta complex

Similar scenarios have been suggested for terrestrial settings

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

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.
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.
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.

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 of 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.
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

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

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

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

Note by Presenter:
These and the following are well known
Note by Presenter:
Mulder in Bordeaux has recently used CATS and obtained similar results.
Note by Presenter:
Wiebke corrected me: There is no channel involved here. This does not alter the conclusions.
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.

“Confined”:
- Channel
- Landward tilt
- Inflow parallel to ramp axis
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