Effects of river bifurcations on downstream fining

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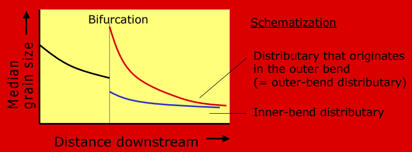
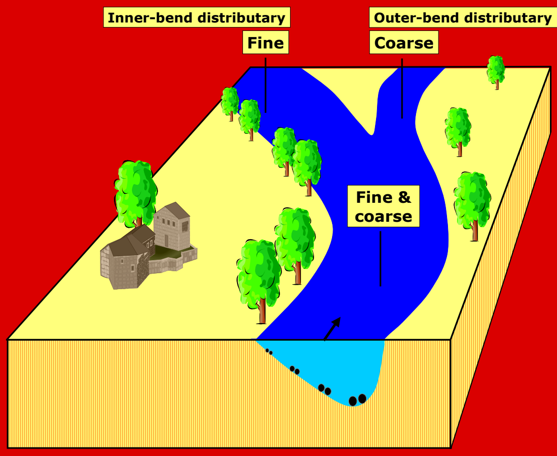
Background

Many rivers show a gradual decrease in bed grain size in downstream direction, caused by abrasion and selective transport. Discontinuities in downstream fining trends occur at the so-called gravel-sand transitions (*e.g.* Sambrook Smith & Ferguson, 1995), at tributary confluences (*e.g.* Knighton 1980), but also at river bifurcations.

Distributaries which bifurcate from an outer bend are much coarser than the main channel, while distributaries bifurcating from an inner bend are much finer. Bend sorting in the river bend upstream of the bifurcation thus seems to be the governing process.





Possible mechanisms

Bend sorting can cause dowstream fining discontinuities in two ways, depending on the sediment mobility:

1. Mobile sediment:
   Fine grains in the inner bend of the main channel move into the inner-bend distributary (i.e. the distributary that originates in the inner bend). Coarse grains from the outer bend enter the outer-bend distributary.
2. Partly mobile sediment:
   Fine grains from the inner bend move into the inner-bend distributary, but coarse grains in the outer bend are immobile. The outer-bend distributary therefore hardly receives any sediment, transport is supply-limited and fine grains are winnowed away from the bed.

Case study: Rhine bifurcations

Purpose: Distinguishing between winnowing and coarse-sediment-supply as cause for the coarseness of the outer-bend distributary at Rhine bifurcations.

Research Area

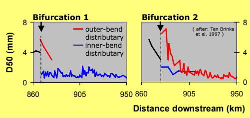
Two large bifurcations in the Dutch Rhine Delta

- Heavily engineered
- No lateral migration
- Discharge 1000-12000 m^3/s
- Channel width: 80-360 m
- Bimodal bed sediments (modes at 1 and 8 mm)

Bifurcation 1 "Pannerdensche Kop"

Bifurcation 2 "IJsselkop"

Downstream fining

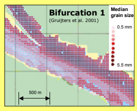


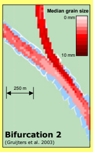
Field measurements

- Bed grain size (± 200 vibracores)
- Bed load transport (echosoundings/dunetracking)
- Bed load grain size (bed load samplers)
- Suspended load transport (ASTMs)
- Flow velocity, water discharge and water level

→ *measured during several high and low flow periods (1997-2004), always over the entire river width, at different discharge conditions.*

Results



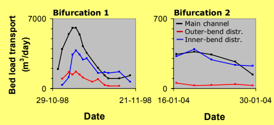


A) The grain size maps confirm a strong bend sorting upstream of the bifurcations

B) Bed load measurements show that the coarse grains in the outer bend of the main channel are immobile (Shields value = 0.03)

→ *Discontinuities in downstream fining cannot be explained by a supply of coarse sediment towards the outer-bend distributary*

Results continued



C) Most of the bed load transport in the main channel is directed towards the inner-bend distributary

→ *The bed load transport in the outer-bend distributary is likely to be supply-limited*

→ *Winnowing of fines in the outer-bend distributary must be the main cause of the discontinuity in downstream fining*

Conclusions: Upstream of the Rhine bifurcations a strong bend sorting pattern is present. The coarse sediment in the outer bend is immobile, causing supply-limited transport conditions in the outer-bend distributary. The coarseness of this distributary is mainly caused by winnowing of fines. At extremely high discharges, however, all grain sizes may be mobile, leading to a supply of coarse sediment to the outer-bend distributary.

Towards more natural rivers...

In natural rivers, regularly new bifurcations develop and meanders continuously migrate downstream. Discontinuities in downstream fining then can only develop if the timescale of bed grain size adaptation is smaller than the meander migration rate and much smaller than the avulsion frequency. In most rivers this probably is the case. Discontinuities in downstream fining trend thus can occur both in natural rivers and in engineered rivers.

I would like to compare the grain size discontinuities at the Rhine bifurcations with those at other river bifurcations. Any help would be very welcome!

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