Incipient meandering and self-formed floodplains in experiments

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Research group
River and delta morphodynamics

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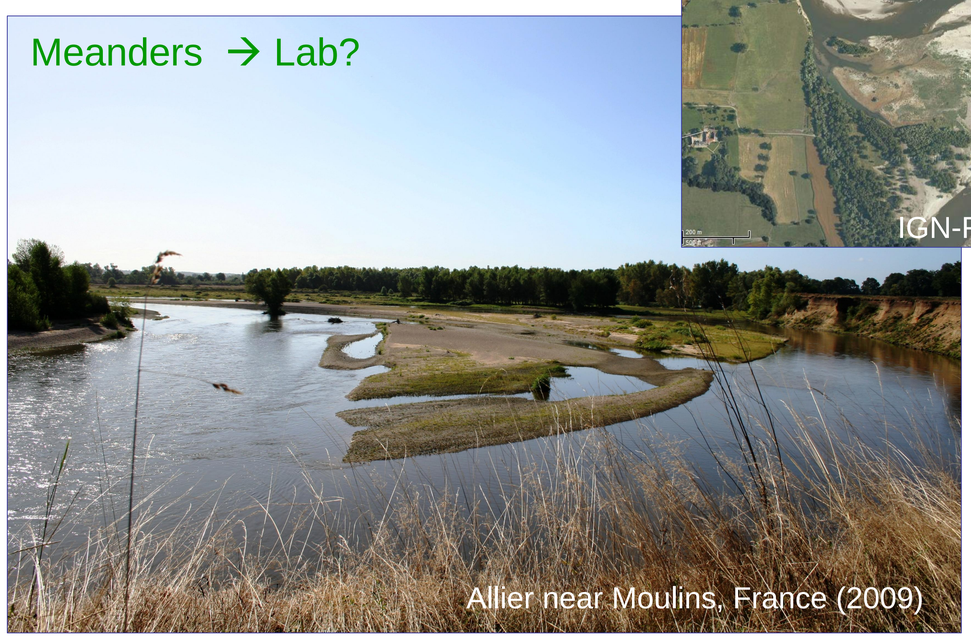
See also Proc. p. 1001

Real World

Meanders → Lab?

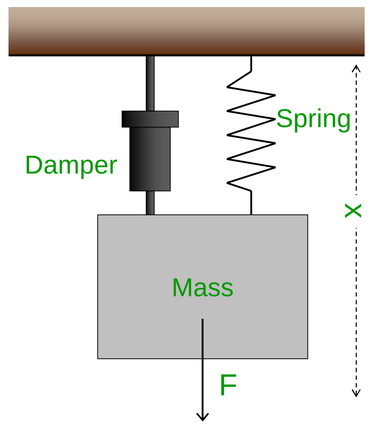


Objective: to understand the formation and heterogeneity of an experimental self-formed floodplain and the effect on incipient meandering

Background

Experiments from literature:

- Vegetation → bank strength + hydraulic resistance
  (Gran and Paola, 2001; Tal et al., 2004; Van de Lageweg et al. 2010, Proc. p. 1331)
- Cohesive sediment → bank strength
  (Friedkin, 1945; Schumm and Khan, 1972; Smith, 1998)
- Fine sediment → filling up chutes
  (Braudrick et al., 2009)



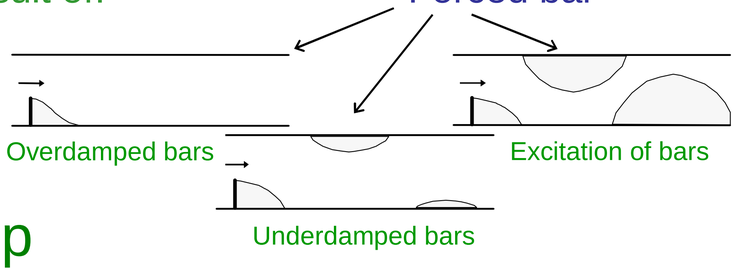
Spring-mass damper ≈ Forced bar

Linear bar theory (Struiksma et al.1985):

- Perturbation (ex. curvature)
  → Forced bars (static position)
- Spontaneously develop and migrate
  → Free bars

Forced 'alternate' bar result of:

- Width-depth ratio
- Hydraulic resistance
- Sediment mobility



Experiment Setup

Scaling:

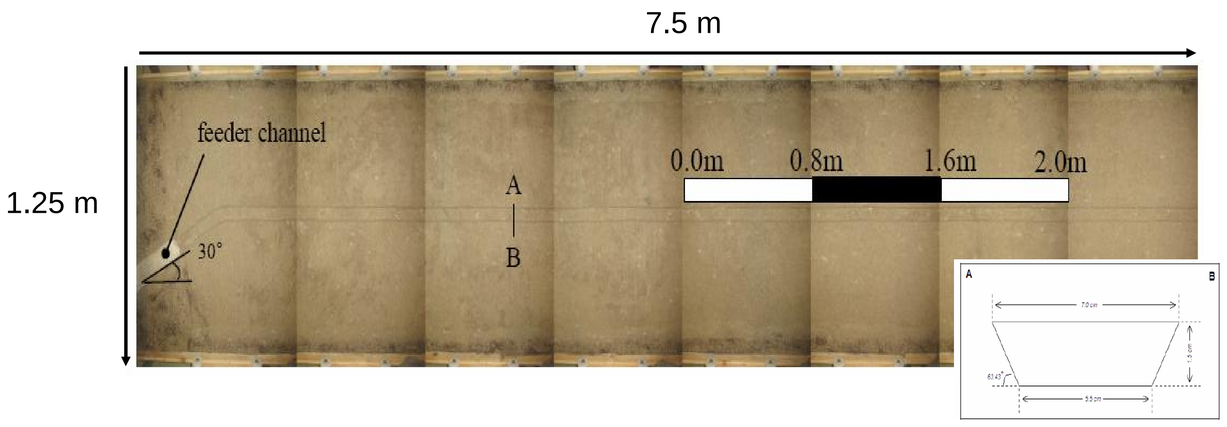
- Froude < 1; Sediment mobility > critical; Re^* = Hydraulic rough
  (see also Oral Session 5, Thursday, September 9, 15:50-17:30 (room Weser) by M.G. Kleinhans (Proc. p. 1001))

Flume:

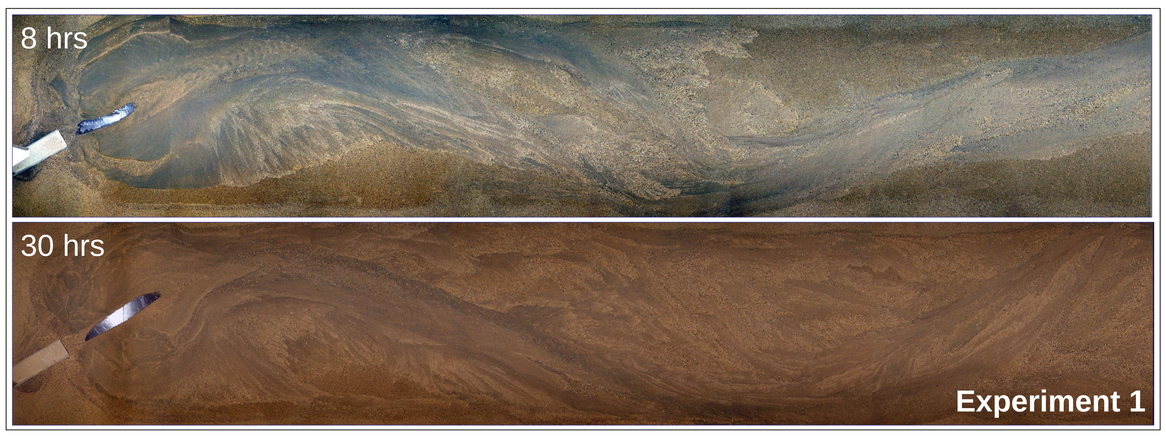
- 7.5 m long and 1.25 m wide,
- Slope of 0.005 m/m
- Constant discharge 0.9 L/s
- Feed rate 1.65 kg/hr.

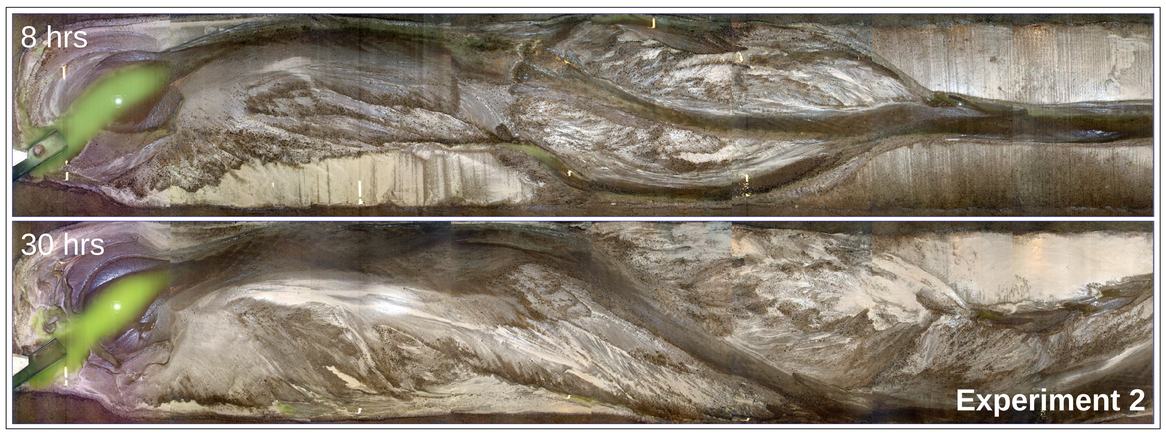
Two Experiments:

- Poorly sorted sand (D_{50}=418 µm);
- 'Cohesive' sediment mixture (D_{50}=353 µm):
  poorly sorted sand (80%) + silica flour (20%)



Lab World

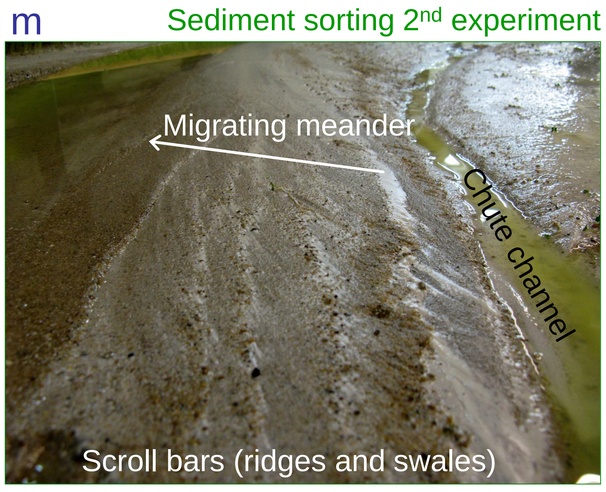




A cohesive heterogeneous bed causes:

- Decrease erosion rate
- Upstream migrating backward steps
- Forced bars: excited → underdamped
- Bar wave length: 4.0 m → 3.5 m
- Width–depth ratio: 26 → 22
- Sediment sorting in bends
- Silica filling in chute channels
- Decreased # of cut-offs
- And floodplains to form!

Sediment sorting 2nd experiment

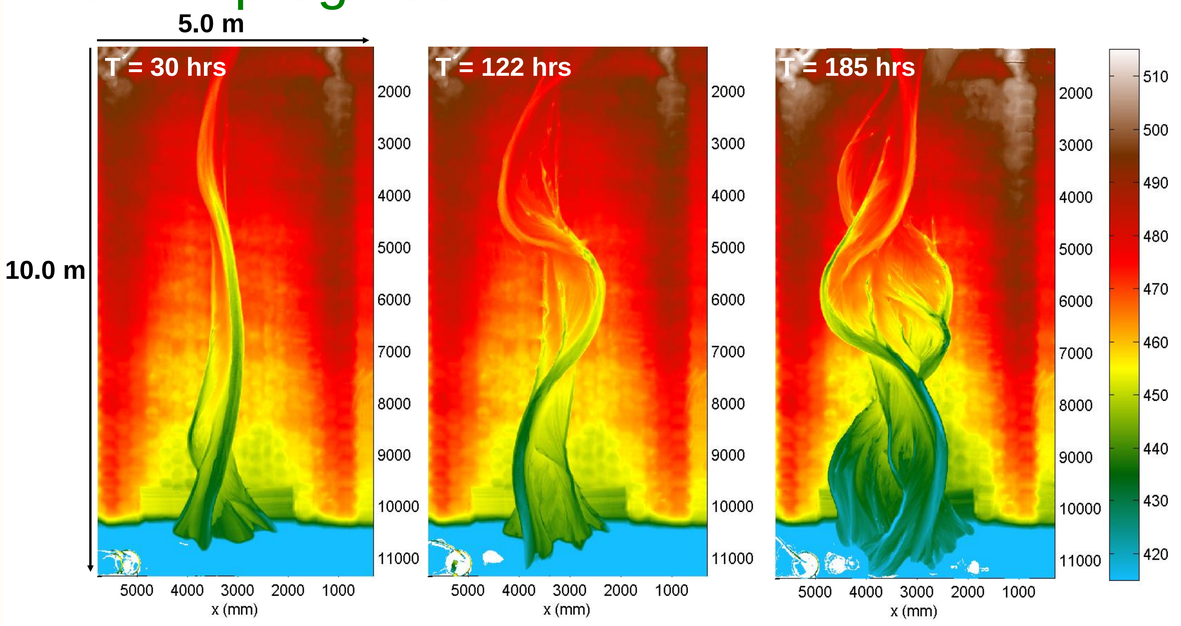


Conclusion

- Bar theory predicts bar wave length of a heterogeneous bed well
- The addition of silica results in:
  Increase bank strength
  Decrease width-depth ratio

→Important step in sustaining single-thread channel in flumes.

Work in progress



- Flume (Eurotank): 11m x 6m
- Line-laser scanner → digital elevation model.
- X-Y positioning table
- Bed material = poorly sorted sand
- Sediment feed = 'cohesive' sediment mixture.

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