Creating Distributary Fluvial Channel Networks with Floodplain Sedimentation in Flume Experiments

Renske C. Terwisscha van Scheltinga, J.T. Eggenhuisen, M.G. Kleinhans, D. Ventra
Faculty of Geosciences, Universiteit Utrecht, Utrecht, The Netherlands. R.C.terwisschavanscheltinga@uu.nl;

Objective

Our **objective** is to develop an **experimental methodology** that reproduces **distributive fluvial systems (DFS)** with a fan-like pattern of distinct channels and floodplains radiating away from an apex area. Experiments allow full control over conditions and process mapping. The key challenge is to obtain dynamic, laterally migrating channels in a cohesive floodplain in a system that builds up **stratigraphy** with a **large ratio of fines to channel sediment**.

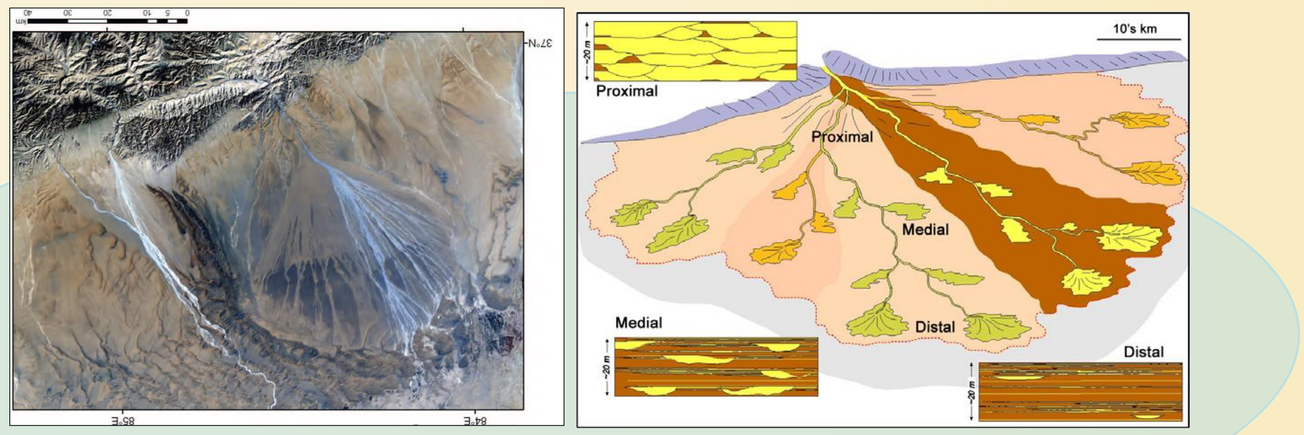


Illustration of principle of Distributive Fluvial Systems (DFS) with (1) channels radiating away from an apex, (2) the simultaneous occurence of active an inactive channels, and (3) proximal-distal variations in geometry and deposits. Satellite image from Hartley et al. 2010 and DFS characterisation from Nichols et al. 2012.

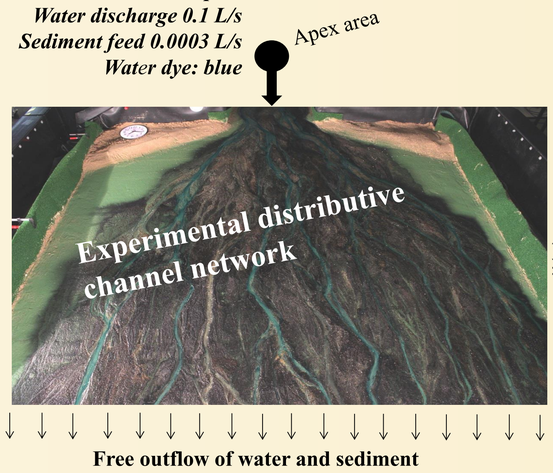
Experimental Setup

To mitigate the floodplain sediment mobility problem we investigate mixtures of sand with low-density materials (Table 1): crushed walnut shells with a density of 1200 kg/m^3 and crushed charcoal with a density of 1300 kg/m^3. The sand is poorly sorted with a density of 2650 kg/m^3 and a low average grain size to keep mobility high yet include larger particles to induce more near-bed turbulence. Pilot experiments were performed in a flume 1 m wide and 2 m long. Recent experiments are in a flume with dimensions 3.8 m wide and 4.3 m long.

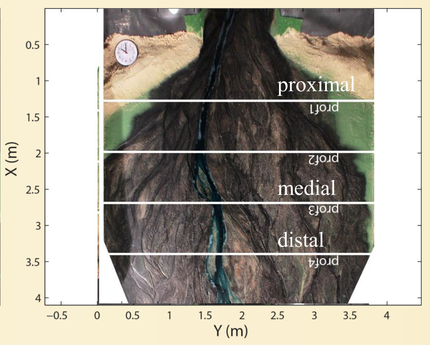
Table 1: Proportion of total feed for given sediment type

		sand	coarse walnut	walnut mix	fine coal	coal mix
Size range	mm	0.24-2.0	1.3–1.7	0.4–1.7	<0.01–0.15	<0.01–1.2
Exp5	feed	1/3	1/3		1/3	
Exp6	feed	1/3	2/3			
Exp7	feed	1/3			2/3	
Exp8	feed	1/3		1/3	1/3	
Exp10	feed	1/5		2/5		2/5
Exp11	feed	1				
ExpT1	feed	1/3		1/3		2/3

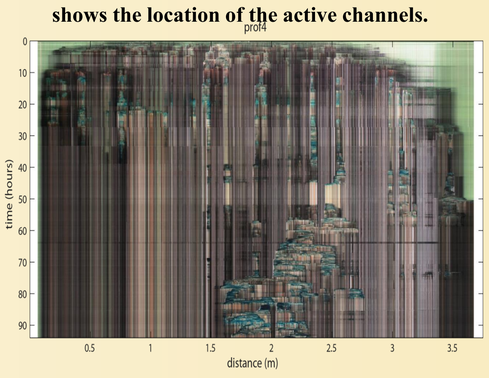
Input:
Water discharge 0.1 L/s
Sediment feed 0.0003 L/s
Water dye: blue



Profile locations.



RGB-colour timestack at cross-section → When converted to LAB-colour space the blue colour of the water is filtered out and shows the location of the active channels.

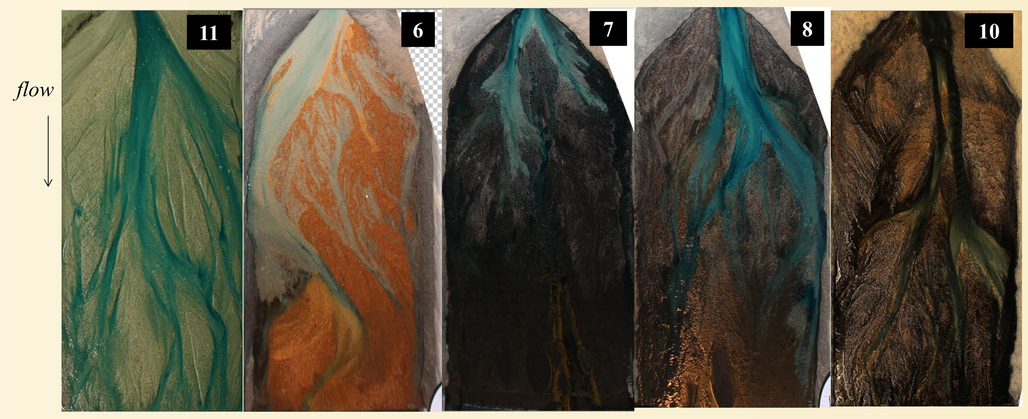


Results

Plan form patterns of mixtures (Table 1) are compared with a control experiment with only sand.
The effect of walnut shells added to sand (Exp. 6) :
- increased sinuosity of relatively wide channels
- more channelized flow
- less floodplain flow

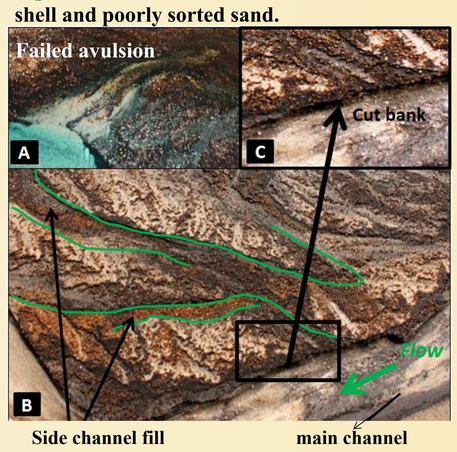
Coal (Exp. 7) added to sand:
- reduced channel width and length
- reduced lateral migration
- more avulsion processes including formation of splays

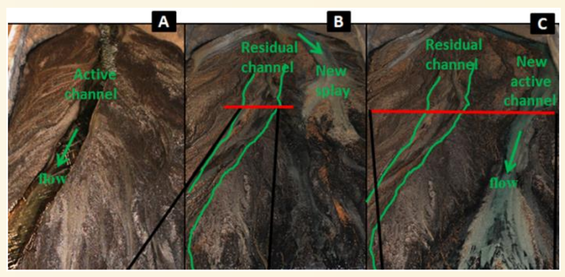
Coal and walnut added to sand (Exp. 8 and 10) :
- formed a channel system with a distributive character
- clear channelization and lateral migration of the channels
- distinct channel belt and floodplain deposits.



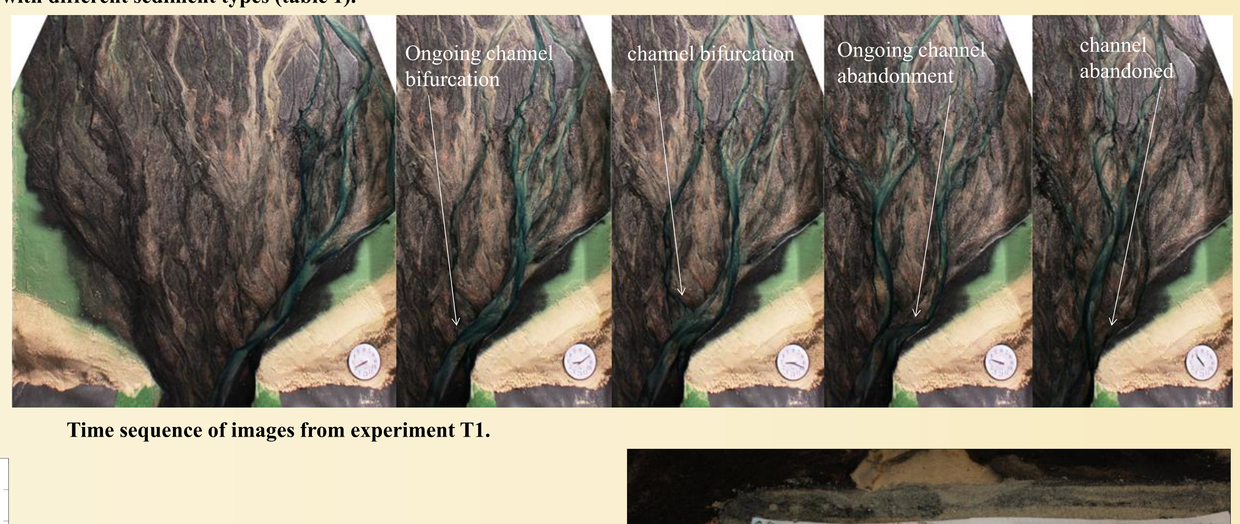
Planform of experiments with different sediment types (table 1).

Typical morphologyical elements of experiments with charcoal, crushed walnut shell and poorly sorted sand.



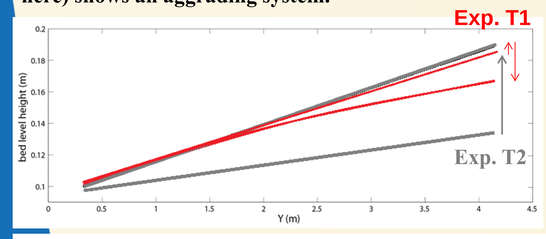


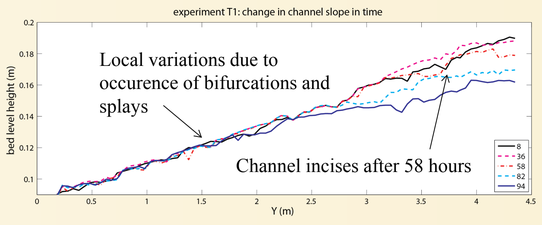
Avulsion process. A. Active channel. B. Residual channel with new splay in floodbasin. C. new active channel cuts into splay while frontal splay migrates into basin (experiment 9).



Time sequence of images from experiment T1.

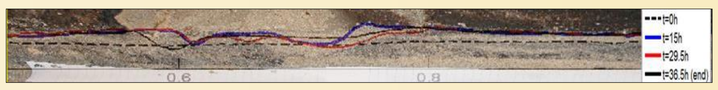
Schematisation of slope conditions in experiment T1 and T2. Exp. T1 started at an initially steep slope with subsequent incision while experiment T2 (not reported here) shows an aggrading system.





Time stacks that represent channel activity at three cross-sections in exp. T1.

Depositional style in down-dip direction with a channel fill body deposit, splay deposits and floodplain sheets of experiment with sand, crushed walnut shell and charcoal(exp. 10).



Linking morphodynamics to depositional elements: sediment surface height at different times shows migration of the channel before filling up.

Conclusions

- ✓ **Our sediment mixture forms channel-belts in floodplains with channels that migrate and avulse while the systems has a DFS plan form.**
- ✓ **Properties of crushed walnut shells, coal and poorly sorted sand are complementary and provide clear sorting patterns.**
- ✓ **The stratigraphic products show distinct channel and floodplain deposits.**
- ✓ **Our sediment mixture allows to study stratigraphic products of aggradation and erosion in relation to floodplain/channel belt ratios, sediment supply, discharge regimes and topographic controls.**

References:
- Hartley, A.J., Weissmann, G.S., Nichols, G.J., Warwick, G.L., 2010a. Large distributive fluvial systems: characteristics, distribution, and controls on development. Journal of Sedimentary Research 80, 167–183.
- Nichols , G.J., Hartley, A.J., Weissmann G.S., Scuderi, L.A. and Davidson, S.K., 2012. Fluvial Reservoirs: Using the Right Architectural Models. AAPG-ER Newsletter – September 2011.

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