Development and validation of a multi-size erosion and deposition model - GUSED

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Outline

- Multi-size class modelling of sediment deposition
- 3 case studies

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Why multi-size class and why modelling deposition?

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Case for multi-size class and deposition modelling

- Particle size varies enormously 10^4-10^9
- Particles behave differently - settling velocity
- Erosion may be not size-selective, but deposition is
- Sediment delivery ratio < 1 because of deposition
- Feedback on and interaction with micro-topography

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Intent of GUSED

- To simulate multi-size class soil erosion and deposition alone a complex hill slope profile
- To simulate changes to micro-topography as a result of erosion and deposition
- To describe a dynamic problem with piece-wise steady state equations

Deposition – the basics

Simple settling - governing equation for size class, *i*:

$$q\frac{dc_i}{dx} = -\omega_i c_i$$

Simple settling with re-entrainment - governing equation for size class, *i*:

$$q\frac{dc_i}{dx} = -\omega_i c_i + r_m f_i$$

Flow hydraulics/transport capacity

Partition coefficient for size class *i*

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3 Case Studies

Source	Location	Time	Main feature of the experiment	Flow rate ($10^{-3} m^2/s$)	Sediment size (d_{50}, mm)	Density (kg/m^3)	Intent
Davis et al	Purdue, the US	Late 1970s	Concave flume with decreasing slope steepness	0.2	0.1560-0.342	1600-1700 2640	To determine multi-size transport capacity
Beuselinck et al	Leuven, Belgium	Late 1990s	Abrupt change in slope steepness	0.3 – 1.7	0.041	2650	To determine transport capacity and deposition
Hussein et al	Griffith Uni, Australia	Mid 2000s	Backwater impoundment due to buffer strips	0.33-1.0	0.225	1600	To test multi-size deposition theory

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Case Study – I
Davis et al from Purdue, the US
Deposition on concave slopes

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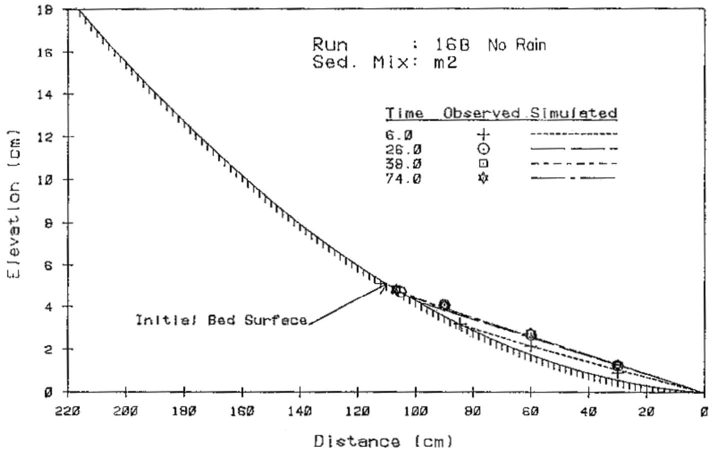
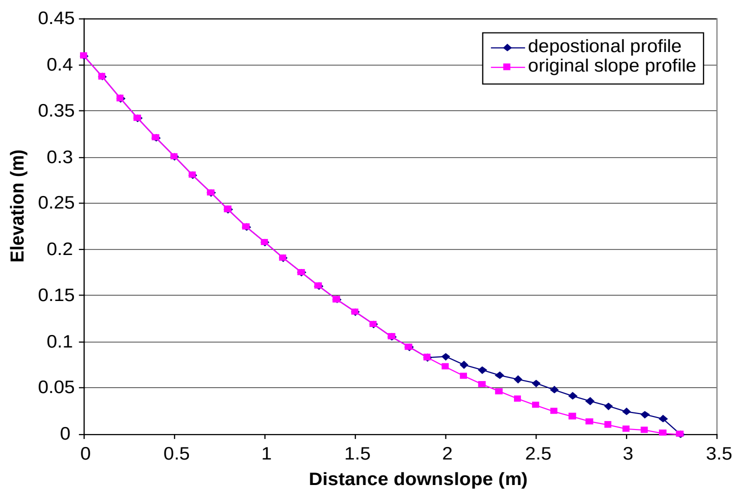
q= 0.122L/s; c_o=72.4kg/m^3



Simulated profile after 30-min



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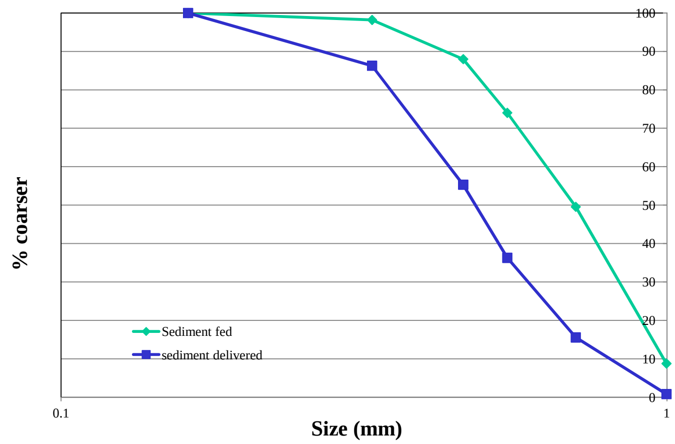
Size distribution



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Predicted sediment delivery ratio (SDR) with WinSEADS for concave slope profile and initial SDR observed by Davis (1978)

	Run No.	Inflow concentration (kg/m^3)	GUSED predicted steady-state SDR	Observed SDR at 2-min
Sand	7, no rain	106.6	0.0 %	0.0%
Large Coal	13, no rain	44.4	11%	31%
Large Coal	16B, no rain	72.4	8.3%	n/a
Small Coal	22, no rain	47.8	19.0%	23%
Small Coal	24A, no rain	73.1	10.6%	n/a

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Case Study – II

Beuselinck et al from K. U. Leuven, Belgium - deposition from sharp slope reduction

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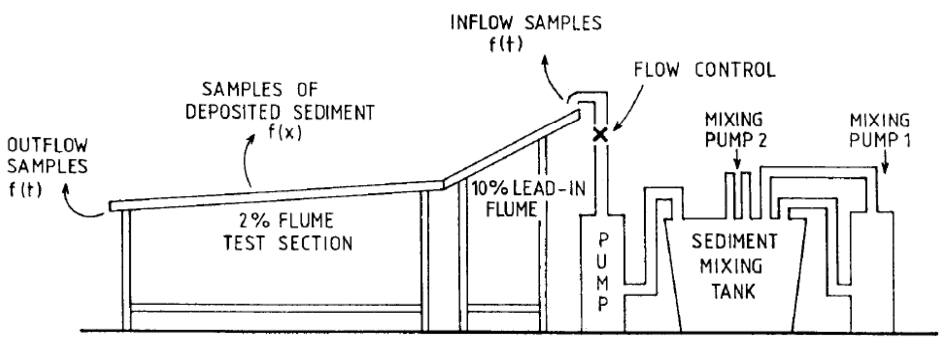

Figure 1. Schematic illustration of the experimental set-up

Deposition occurs on the lower slope (after Beuselinck et al. 1999)

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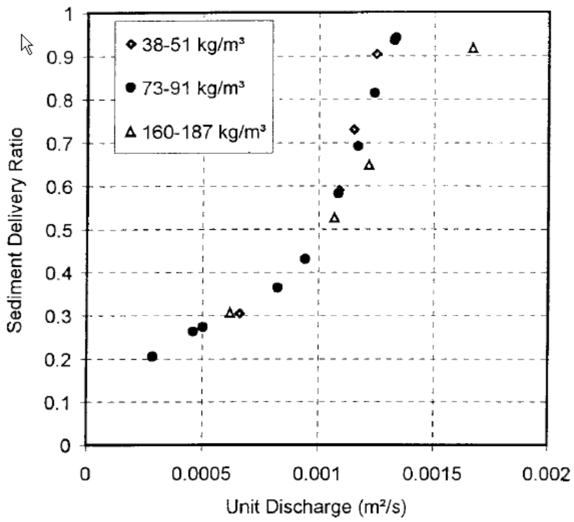
Some experimental observations



- **SDR increases with unit discharge**
- **SDR not very sensitive to sediment concentration**

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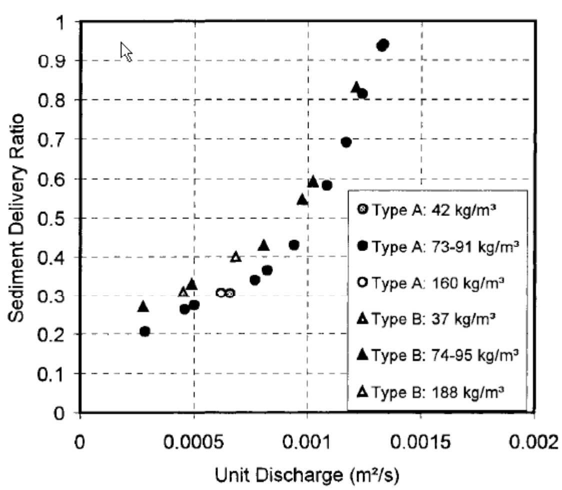
Some experimental observations



- **A threshold in unit discharge**
- **SDR not sensitive to soil type when $q > q_{cr}$**

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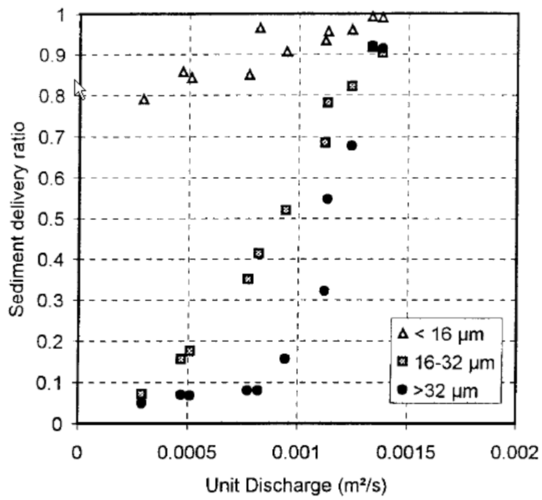
Some experimental observations



- **•Clearly the SDR is size selective**
- **•All things equal, SDR is higher for fine sediments**

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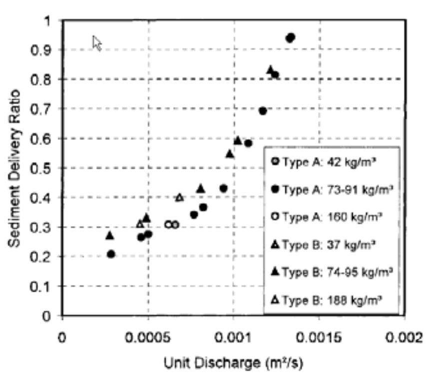
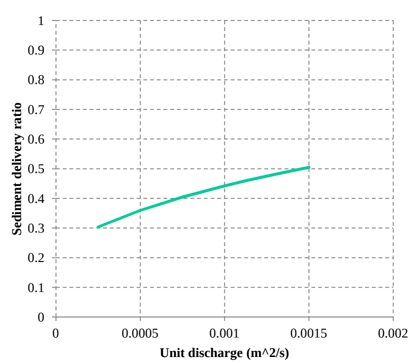
Simple settling – comparison with exp





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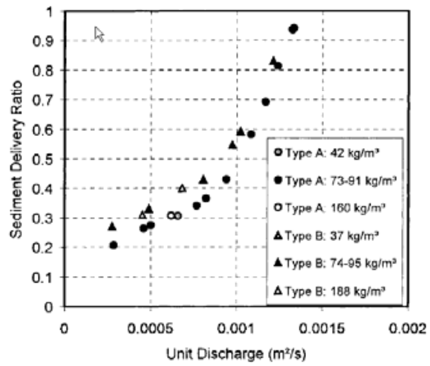
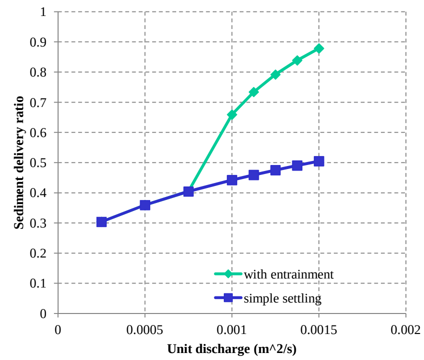
Simple settling – comparison with exp





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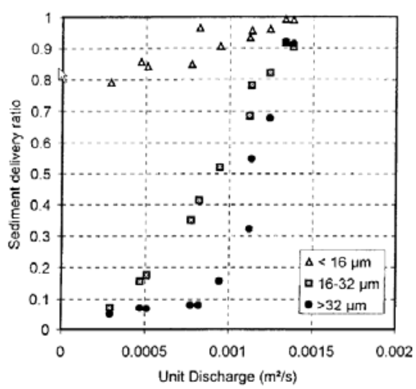
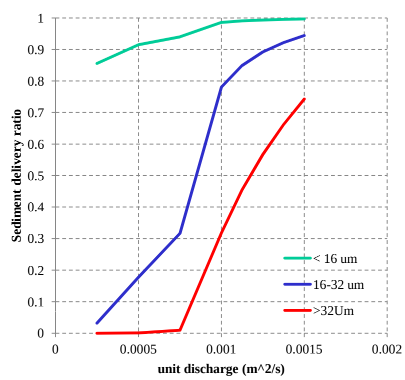
Size specific SDR





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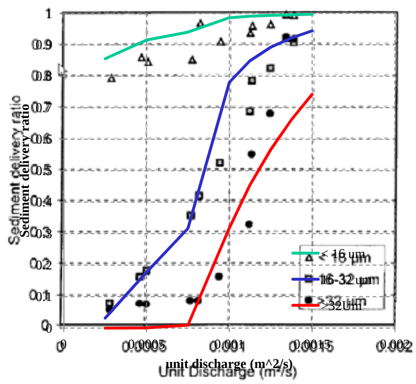
Some experimental observations



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Case Study – III
Hussein et al from Griffith
deposition u/s vegetation buffer strip

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Griffith Tilting-flume Simulated Rainfall facility (GUTSR)

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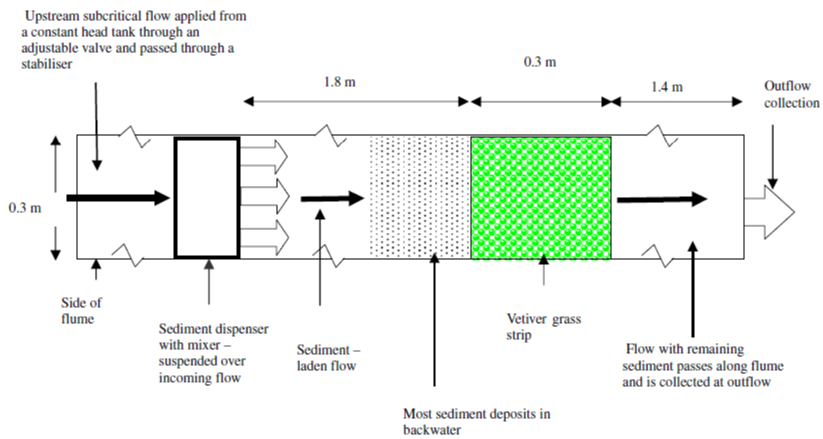

Deposition occurs u/s from the buffer

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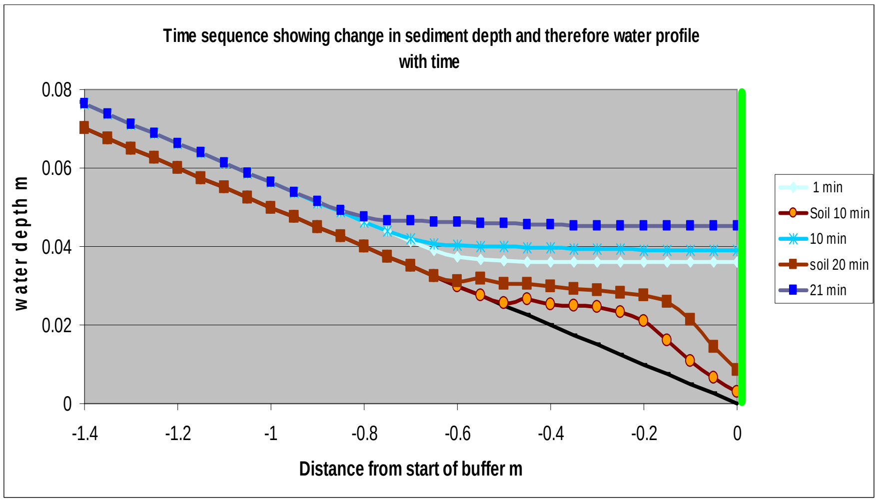
Time dependent changes showing sediment plus water profiles



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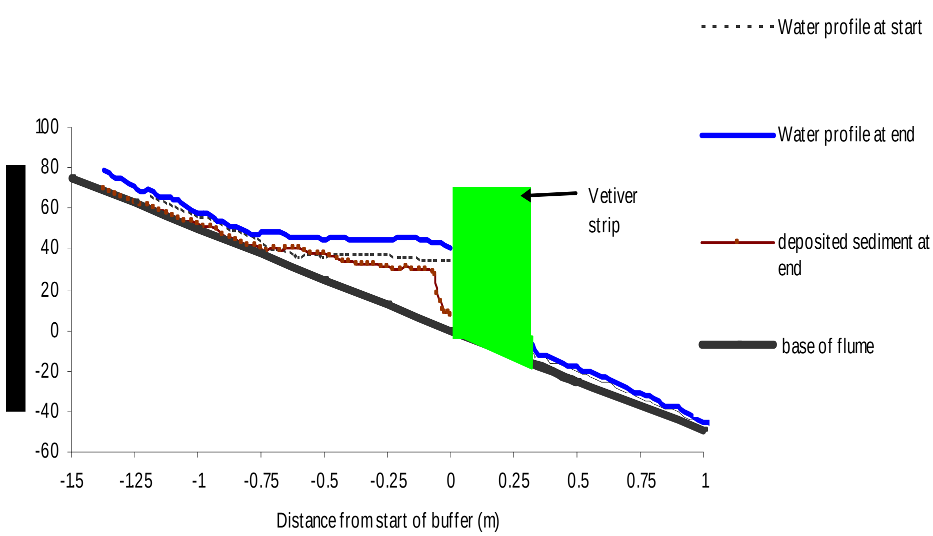

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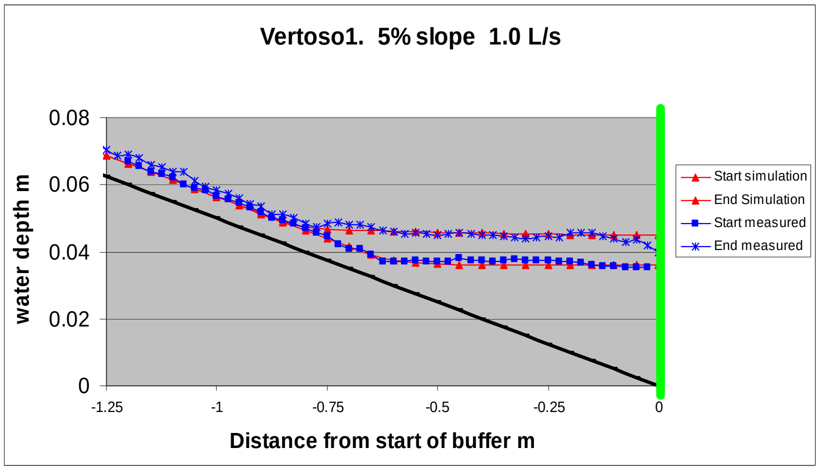
Validation of modeled flow profile



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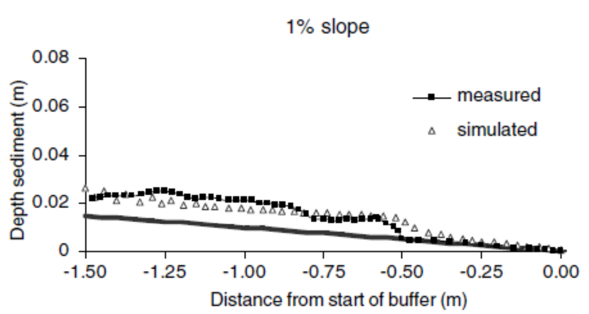
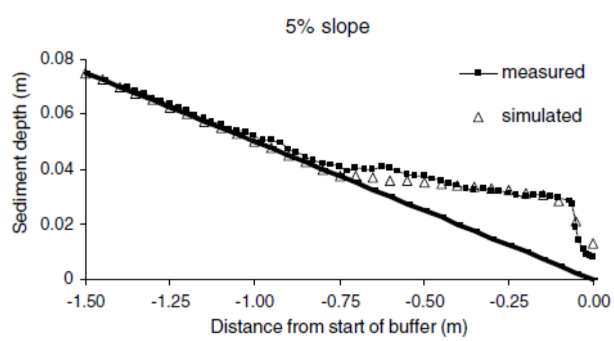
Validation of modelled deposition profile





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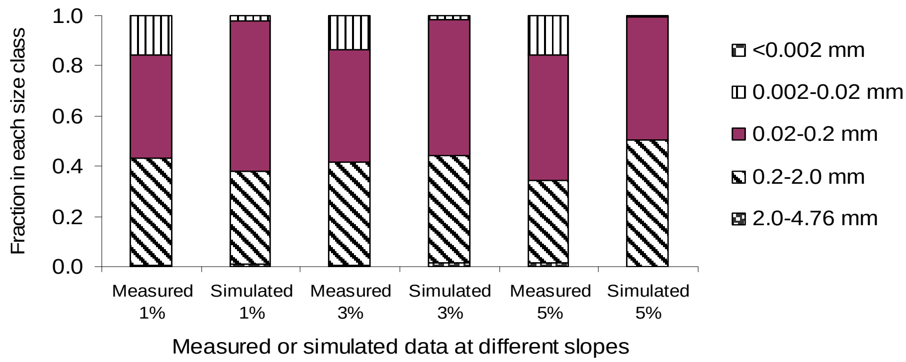
Size distribution of deposited sediments u/s buffer strip
Measured versus simulated



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Conclusions

- Multiple size classes are necessary for deposition modelling
- To get one size class right is easier; to get all classes right is a much harder.
- Feedback on micro-topography is important for depositional environments with low slopes

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Thank You!