

A Tool to Interpret High-Density Turbidity Current Processes from High-Density Turbidite Lithofacies*

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Abstract

Many deposits in deepwater depositional systems are described as "High-Density Turbidites", without proper reference to the variability in lithofacies, grain fabrics, and therefore reservoir quality that may be included in deposits from high-concentration suspensions. In this contribution, we use observations and quantifications of experimental high-density turbidity currents to construct an interpretative tool that can be used for inversion of HDTC flow processes from HDT lithofacies.

High-density turbidity currents exhibit internal density stratifications. In the basal part of these stratified flows, high sediment concentrations cause rheological deviations from the Newtonian turbulent flow that dominates clear water and low density conditions. Previous field studies have classically linked crude stratification bands, spaced laminations, and internal erosion surfaces to high-density turbidity currents. Various mechanisms have been proposed for these variable depositional characteristics; however, none of these propositions has been thoroughly tested by experiments or theory.

We present experiments of quasi steady high-density turbidity currents varying in initial sediment concentration between 9-26 v% by volume.

Three distinct internal flow layers were distinguished. Type I layers have lower sediment concentrations and show strong turbulent behaviour in both observations and velocity measurements. At higher sediment concentrations an additional type II layer forms below the type I layer. This layer has a higher concentration, while turbulence levels are low compared to those of type I layers. At even higher sediment concentrations turbulence levels are dampened further, and a type III stratification develops.

Small-scale fluctuations (0.2-2 seconds) in the otherwise steady flows were observed to control depositional behaviour. However, the influence of these fluctuations gradually decreases with increasing sediment concentrations as function of the different types of basal flow layers.

By combining these observations with theoretical grain size sorting mechanism and previous experimental results that link depositional expressions to flows of different sediment concentrations, the different layer types observed here are linked to distinct depositional expressions within the family of high-density turbidity current deposits known from the rock record.

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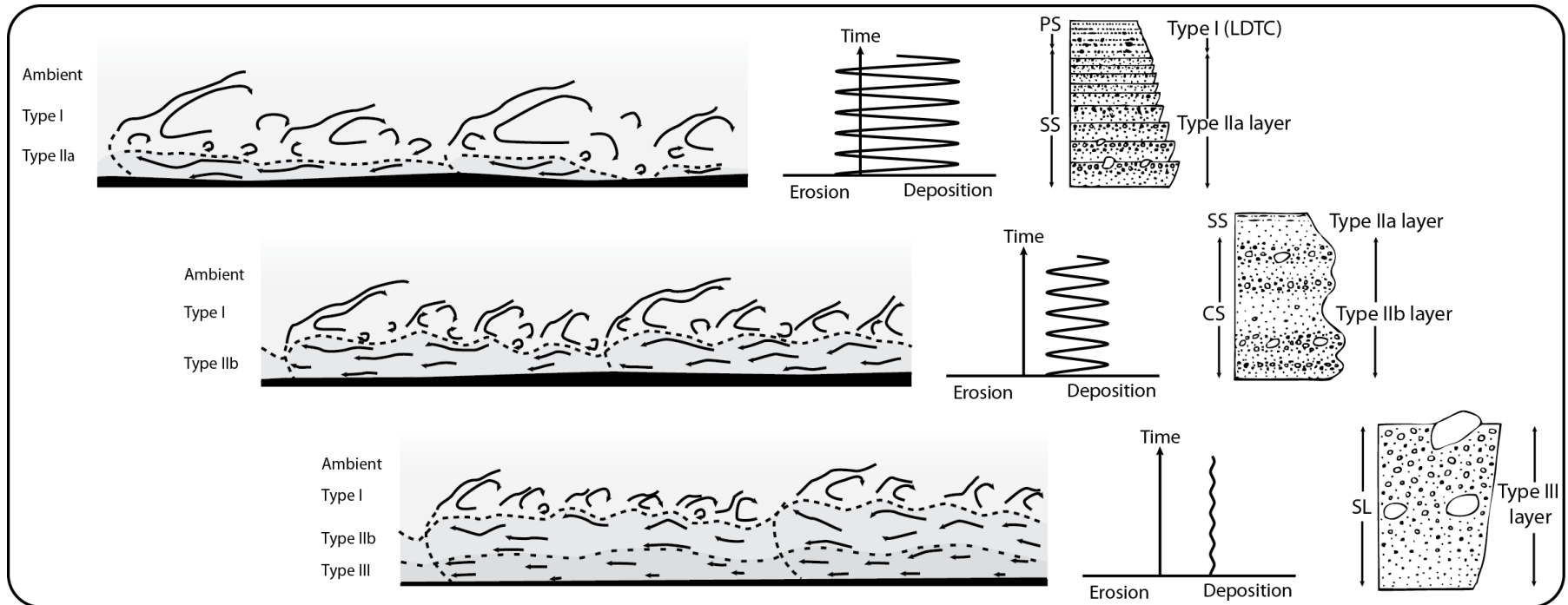
Massari, F., 1984, Resedimented conglomerates of a Miocene fan-delta complex, Southern Alps, Italy, *in* E.H. Koster and R.J. Steel, eds., Sedimentology of gravels and conglomerates: Canadian Society of Petroleum Geologists, Memoir 10, p. 259-278.

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Universiteit Utrecht

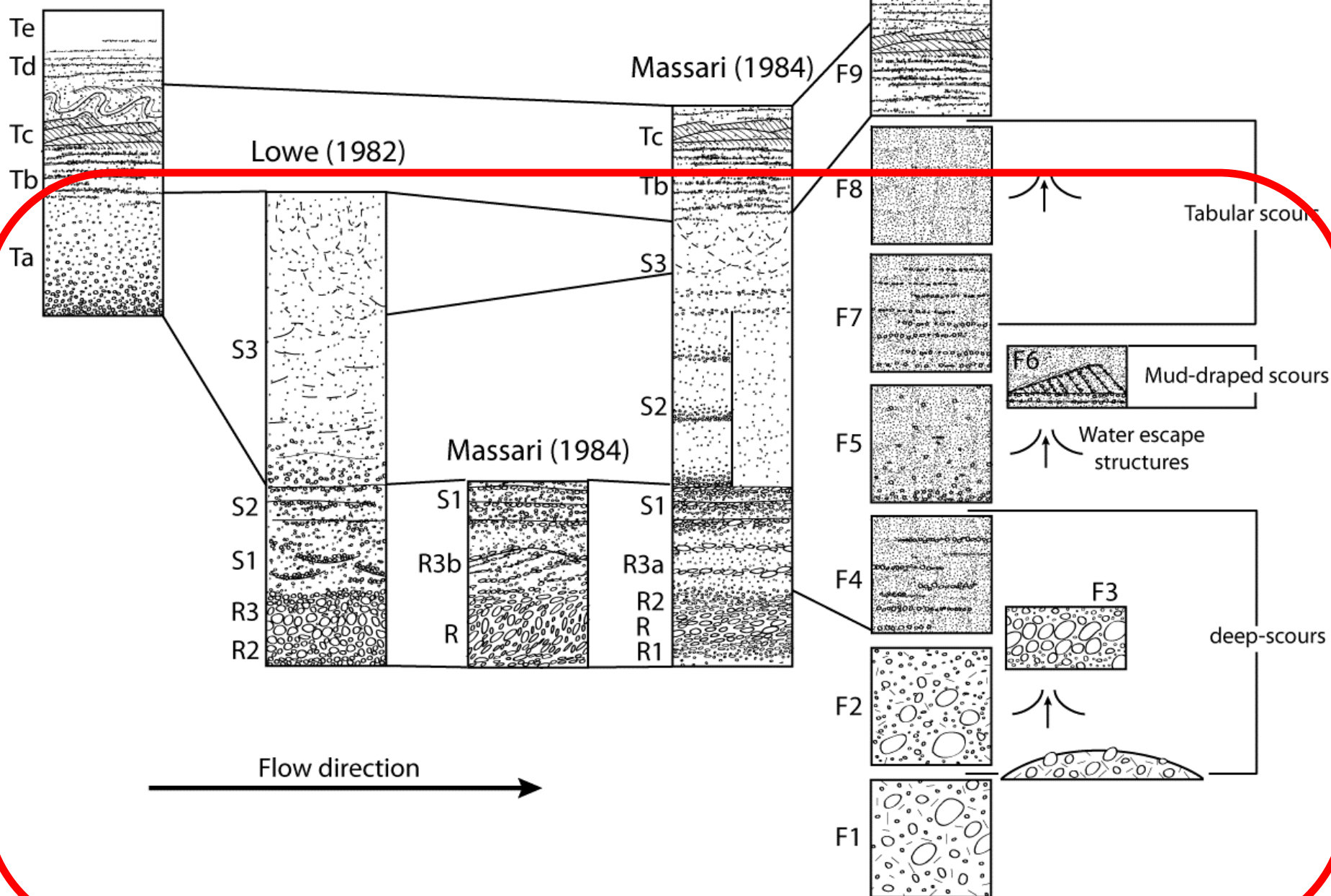


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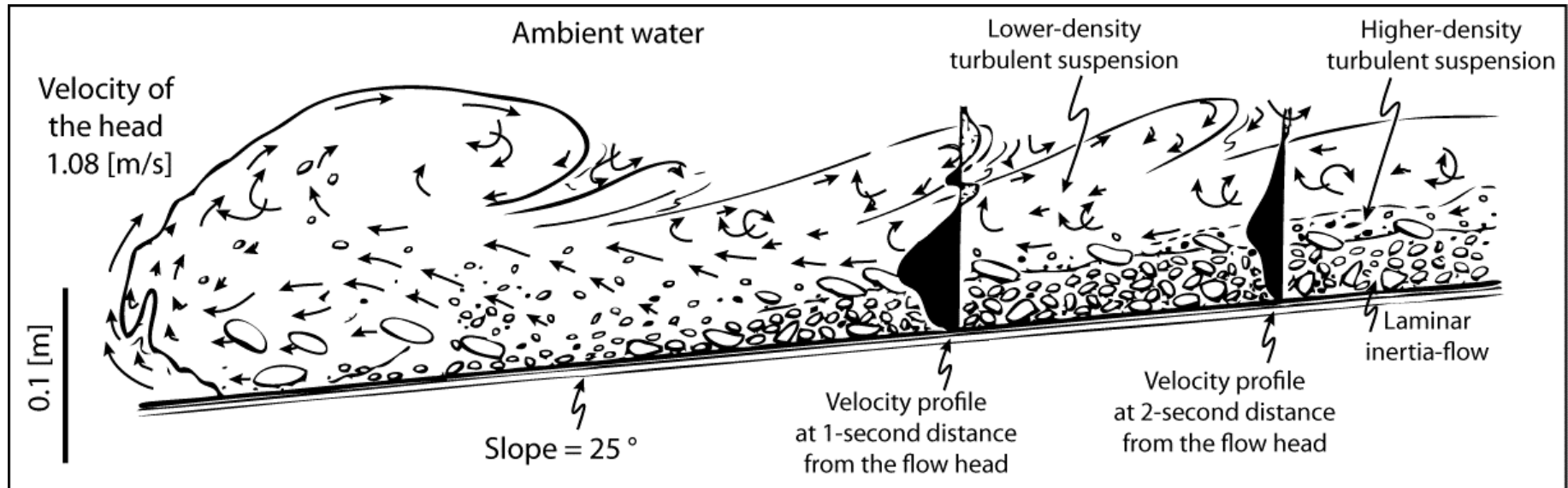
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Bouma (1962)

Mutti (1992)



High-density turbidity current



Postma, 1988

Different grain-support mechanisms are active for different sediment concentrations:

Laminar inertia-flow

Higher density turbulent suspension

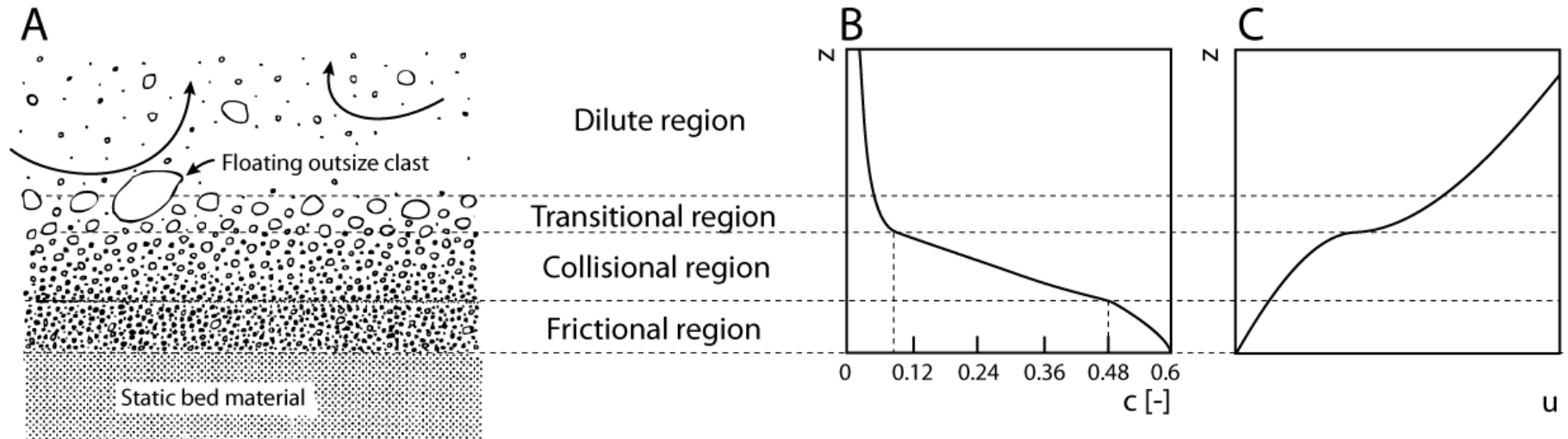
Lower density turbulent suspension

Frictional grain contacts, Upward flux of pore fluid

Collisional contacts, Upward flux of pore fluid

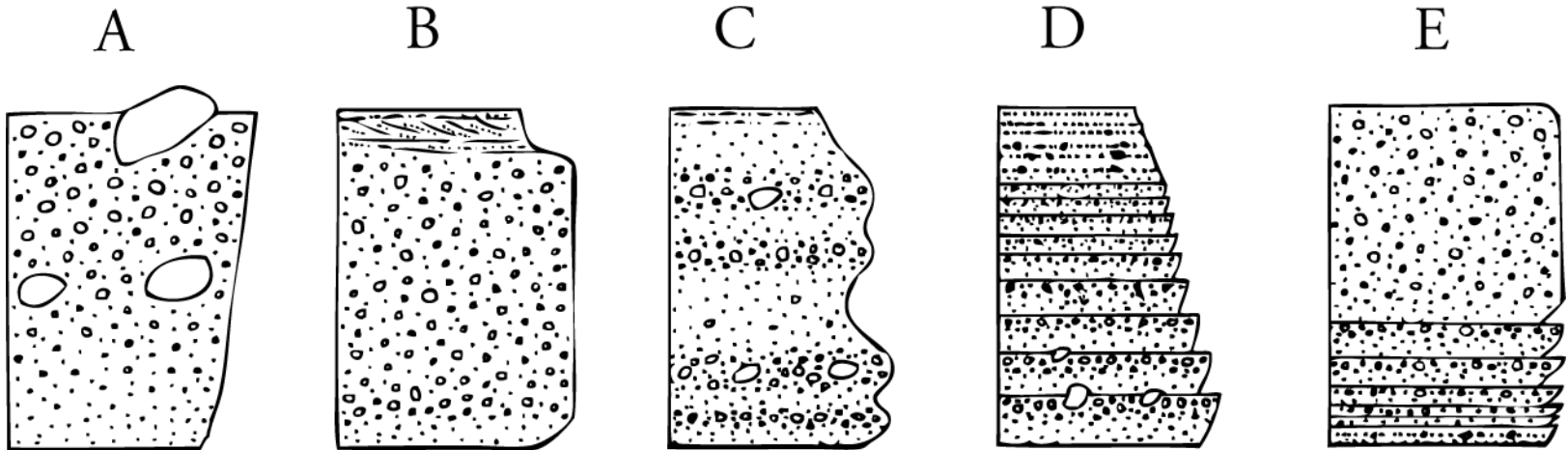
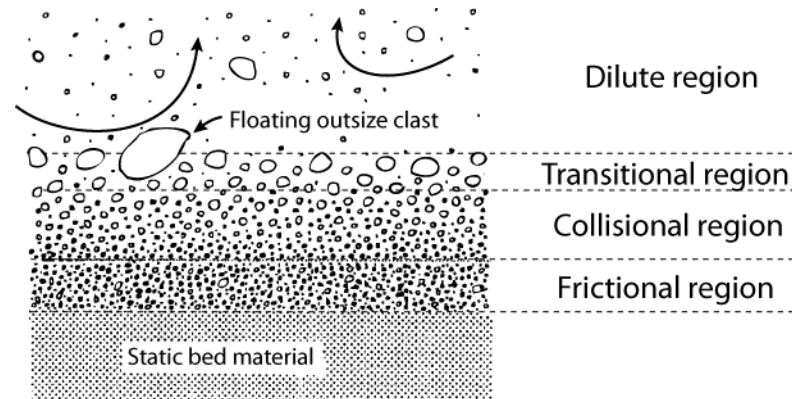
Turbulence

Flow stratification high-density turbidity current



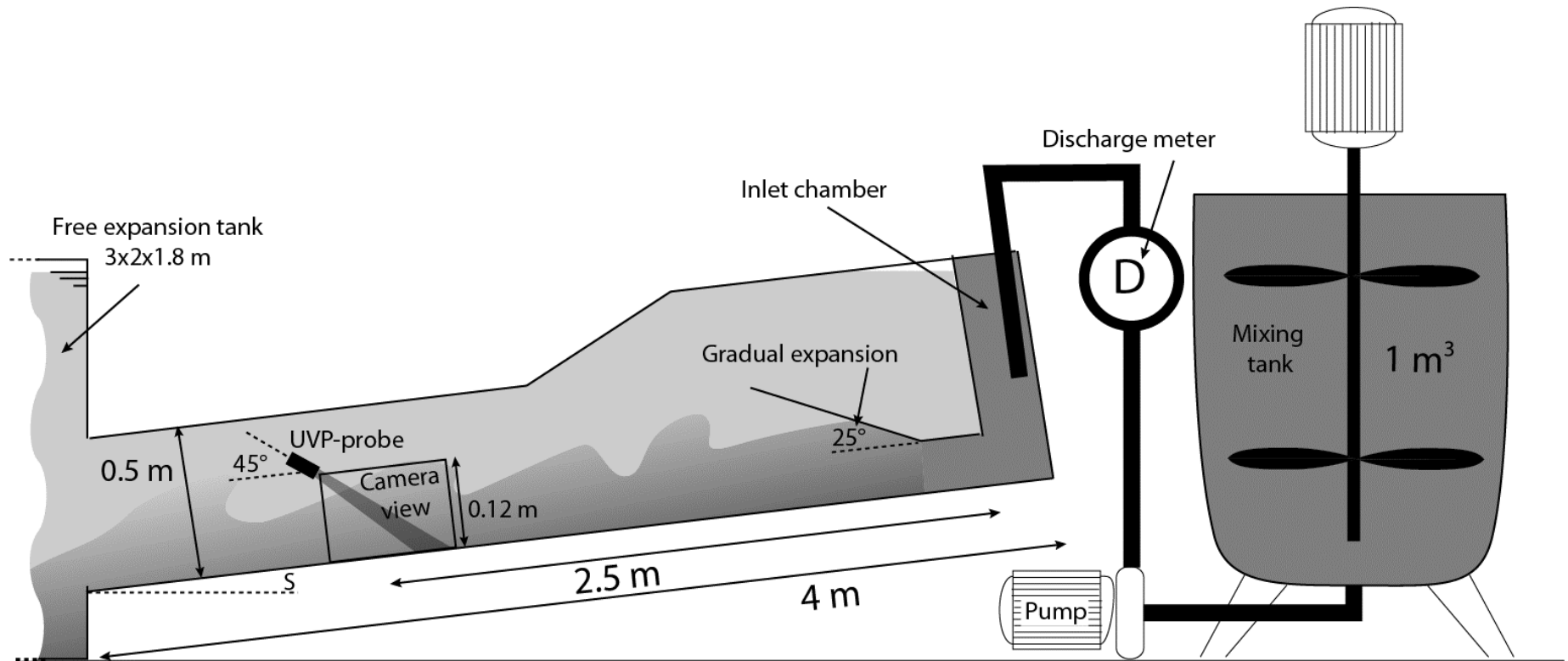
Sohn, 1997

Flow stratification to stratified deposits

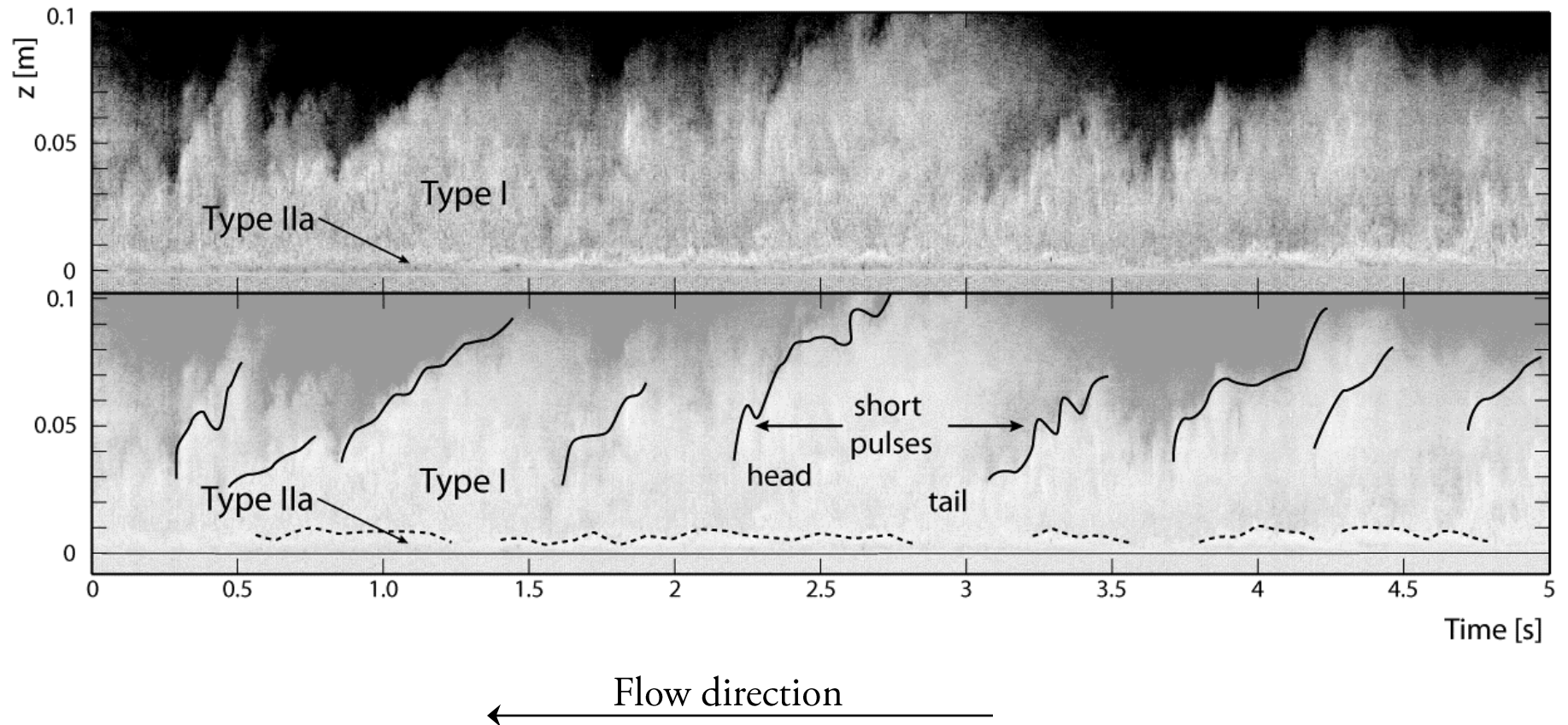


Small-scale variations in sorting and abundant erosional surfaces
point to
Small-scale non-steady behaviour of the flow

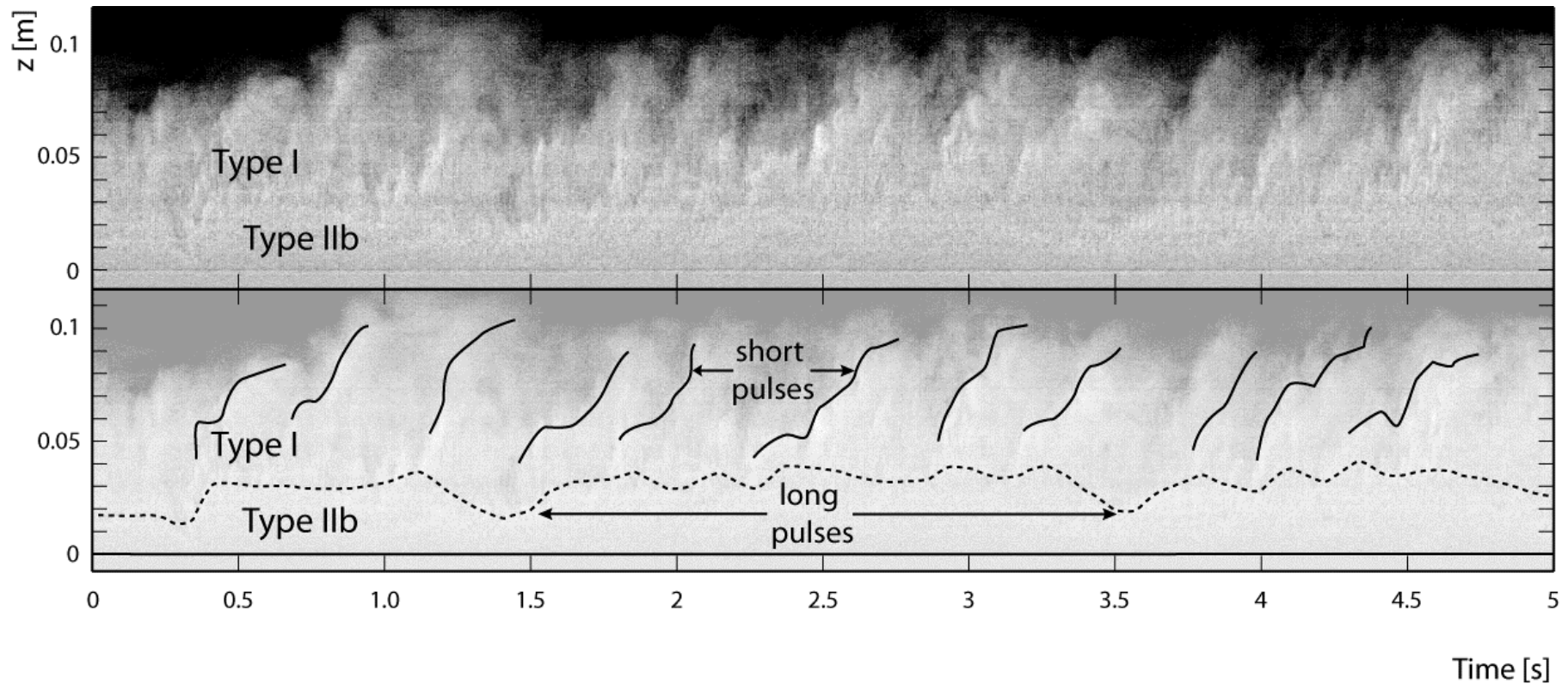
Experiments



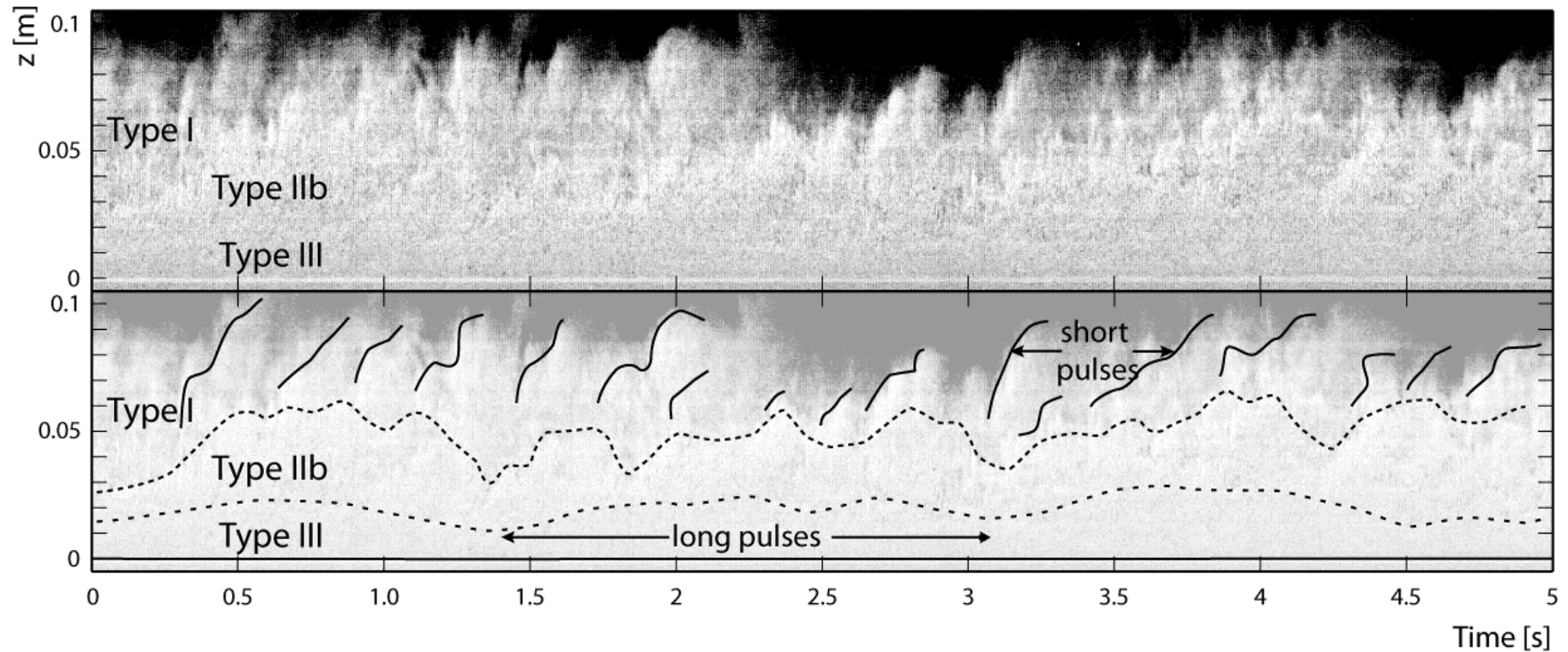
Initial sediment concentration of 9%



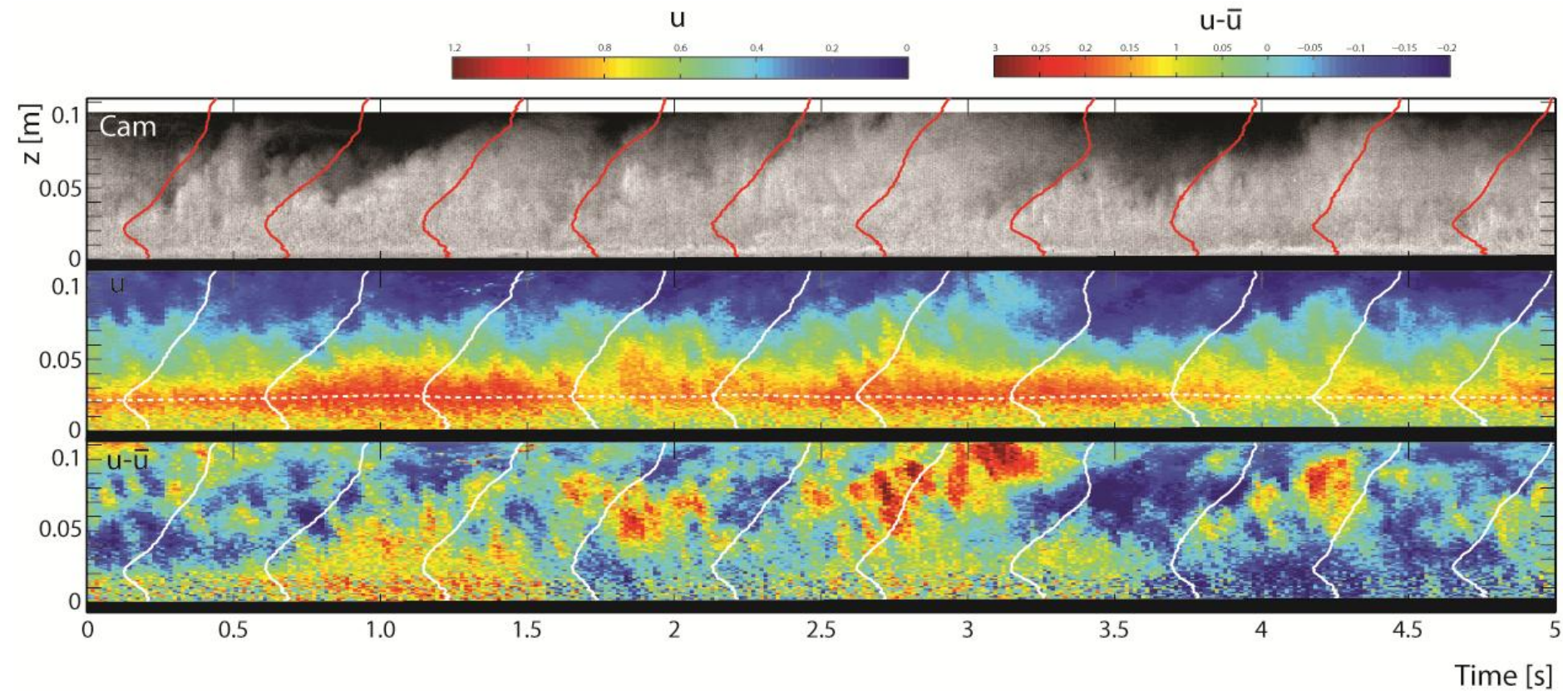
Initial sediment concentration of 17%



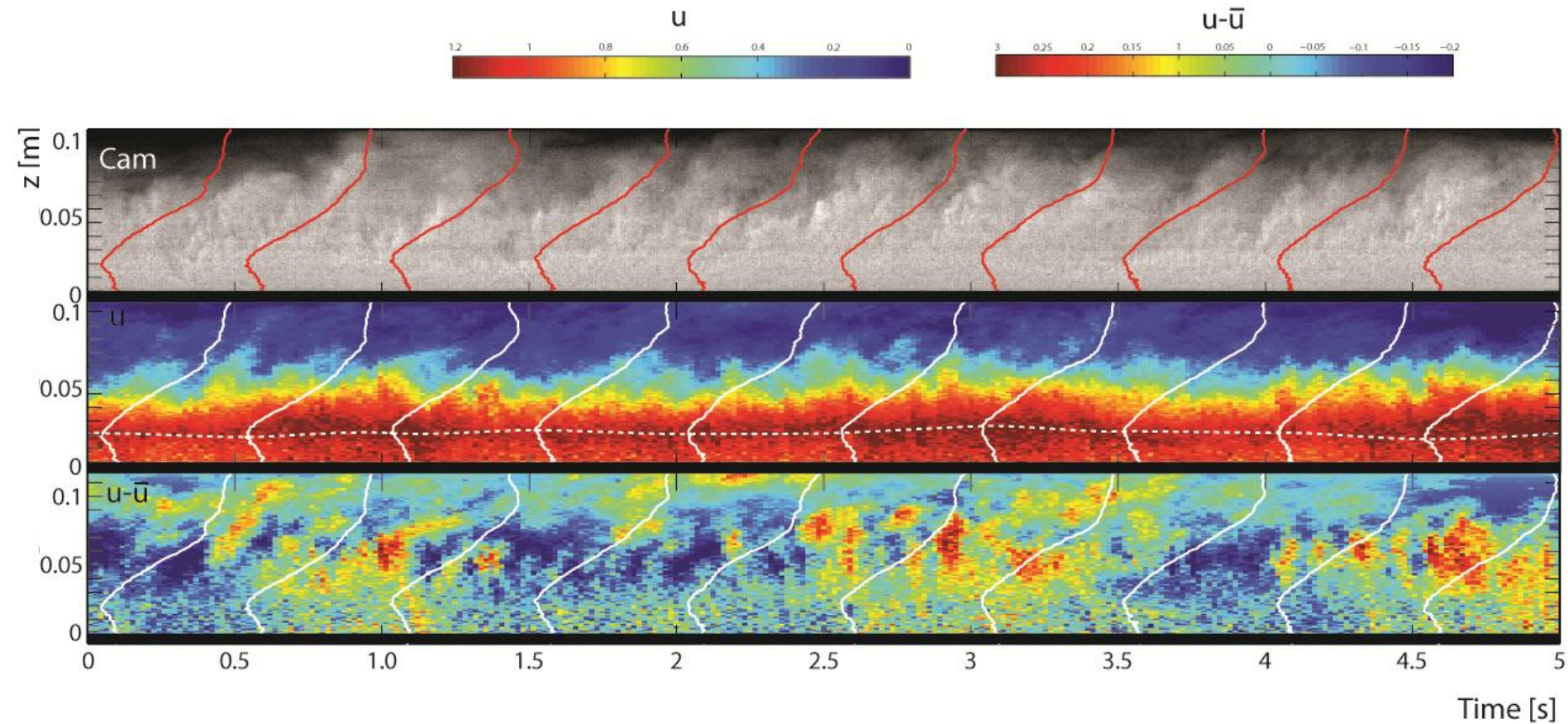
Initial sediment concentration of 26%



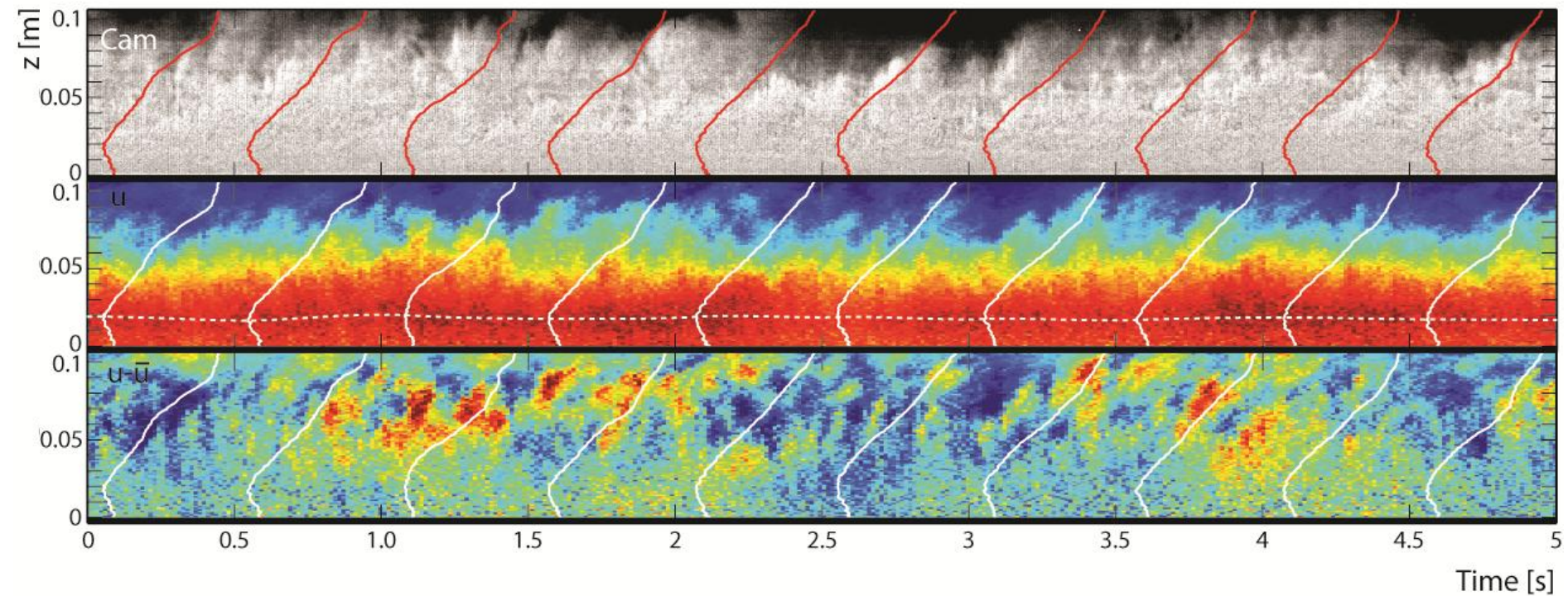
Initial sediment concentration of 9%



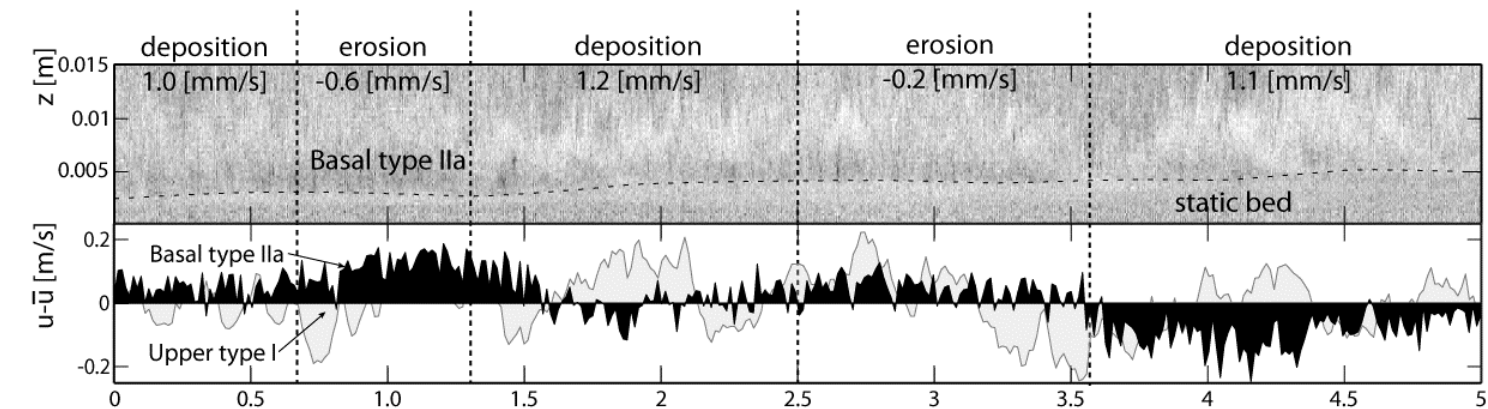
Initial sediment concentration of 17%



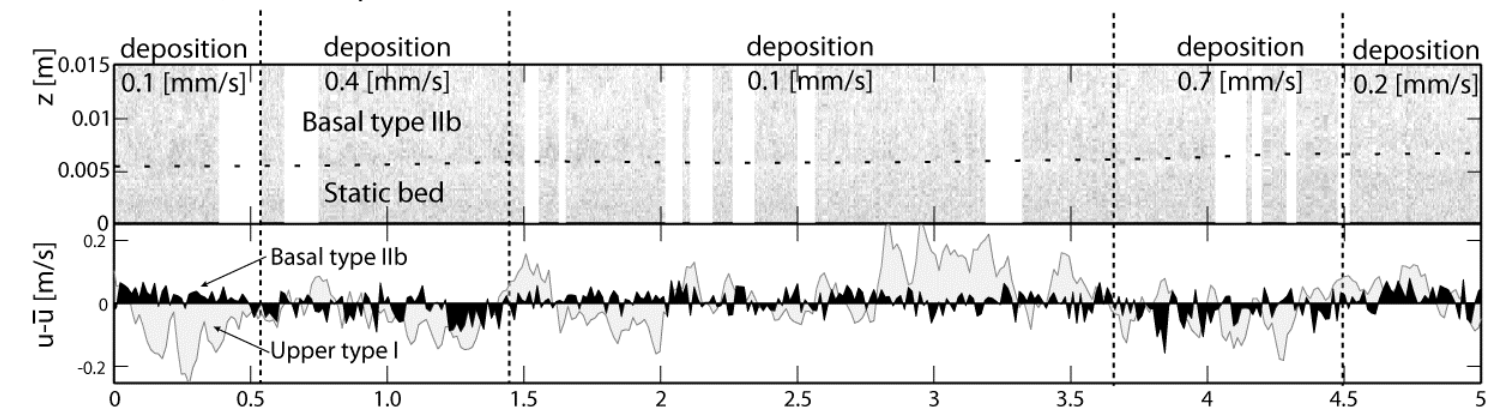
Initial sediment concentration of 26%



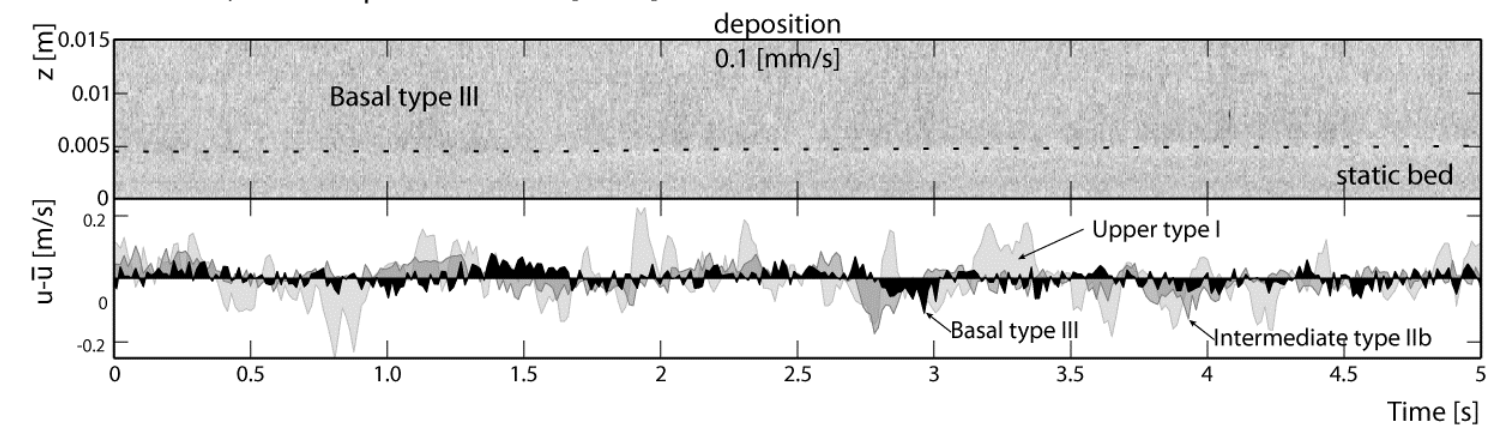
A. Run C09S11A; overall deposition rate 0.6 [mm/s]



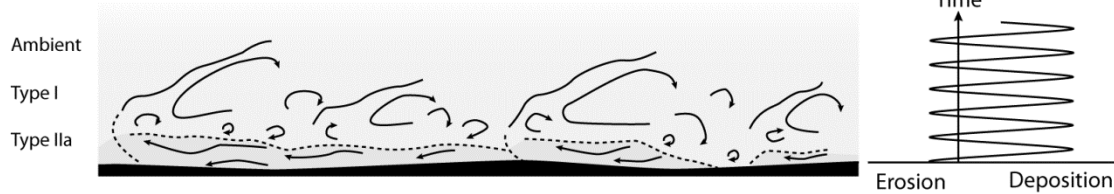
B. Run C17S07A; overall deposition rate 0.3 [mm/s]



C. Run C26S07A; overall deposition rate 0.1 [mm/s]

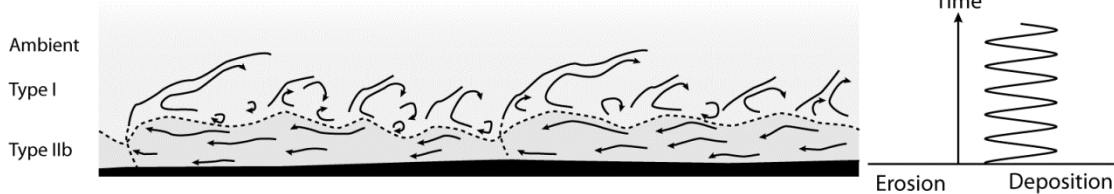


A. Spaced stratification (SS) resulting from a basal type IIa layer.



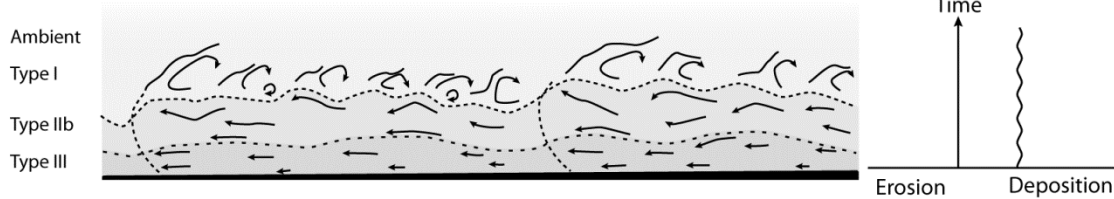
Alternating periods of erosion & deposition associated to long pulses are linked to abundant erosion surfaces, basal inverse grading overlain by ungraded intervals (Spaced Stratifications, SS).

B. Crude stratification (CS) resulting from a basal type IIb layer.



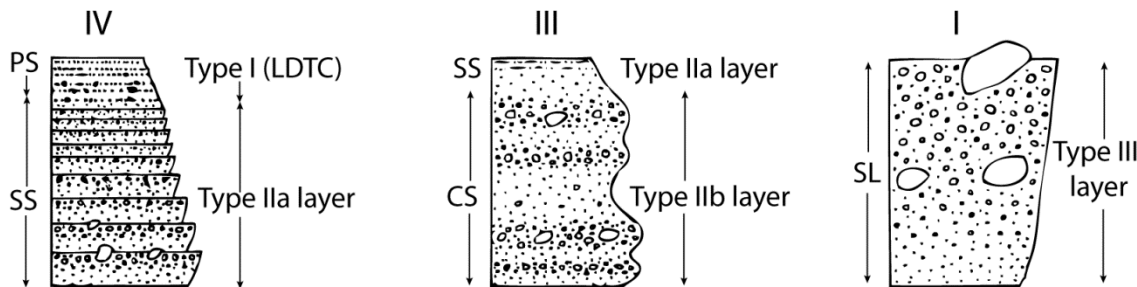
Periodical variations in aggradation rate associated to long pulses are linked to alternating patterns of coarsening and fining upwards (Crude Stratifications, CS).

C. Crude stratified (CS) to structureless (SL) deposits resulting from a basal type III layer.



Steadily aggrading bed with nearly full turbulence damping are linked to minor alternating patterns of coarsening and fining upwards (Crude Stratifications, CS) or structureless deposits (SL).

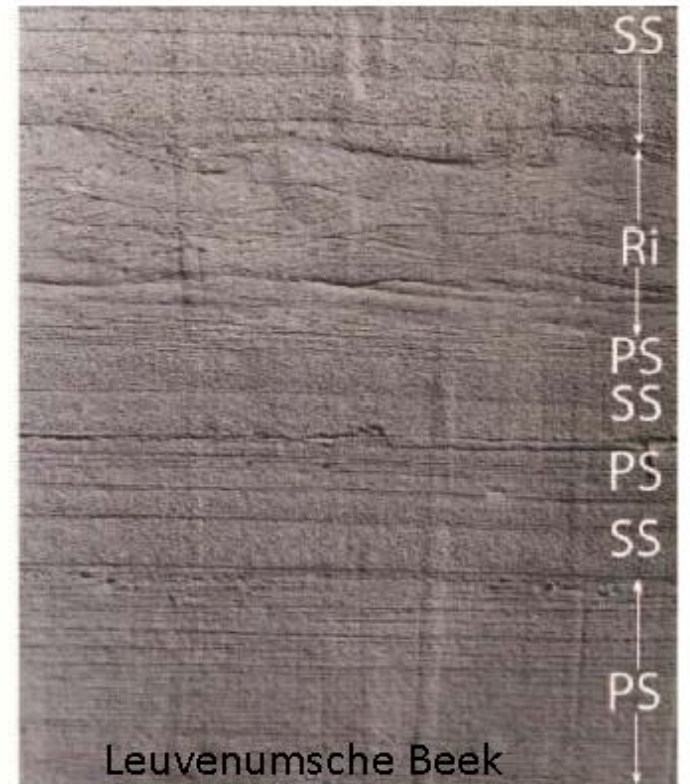
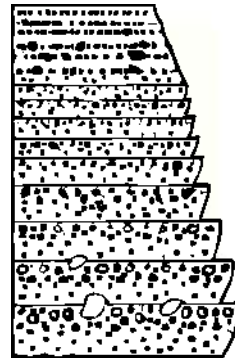
D. Application to some of the traction carpet successions of Sohn (1997)



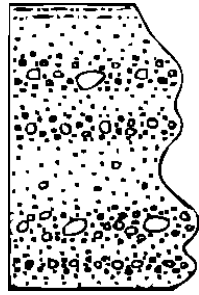
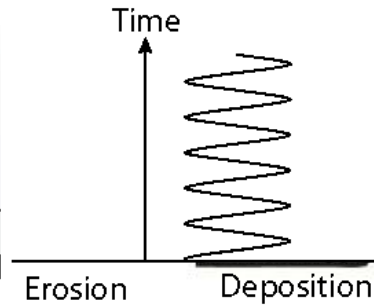
Parallel stratifications (PS) are here linked to low-density turbidity currents due to their dependence on turbulent structures. Type III layers are most likely to collect floating oversized clasts due their high density.

Basal concentration up to 10%

Ambient
Type I
Type IIa



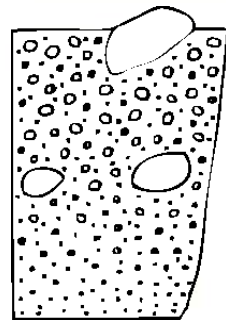
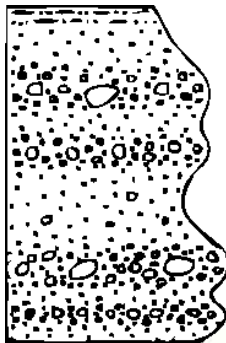
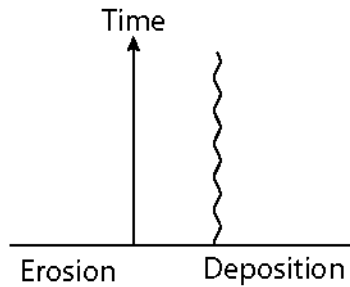
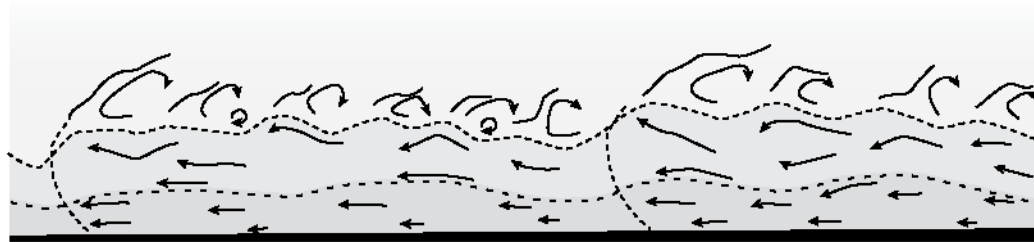
Basal concentration between 10% and 20%



Basal concentration over 20%

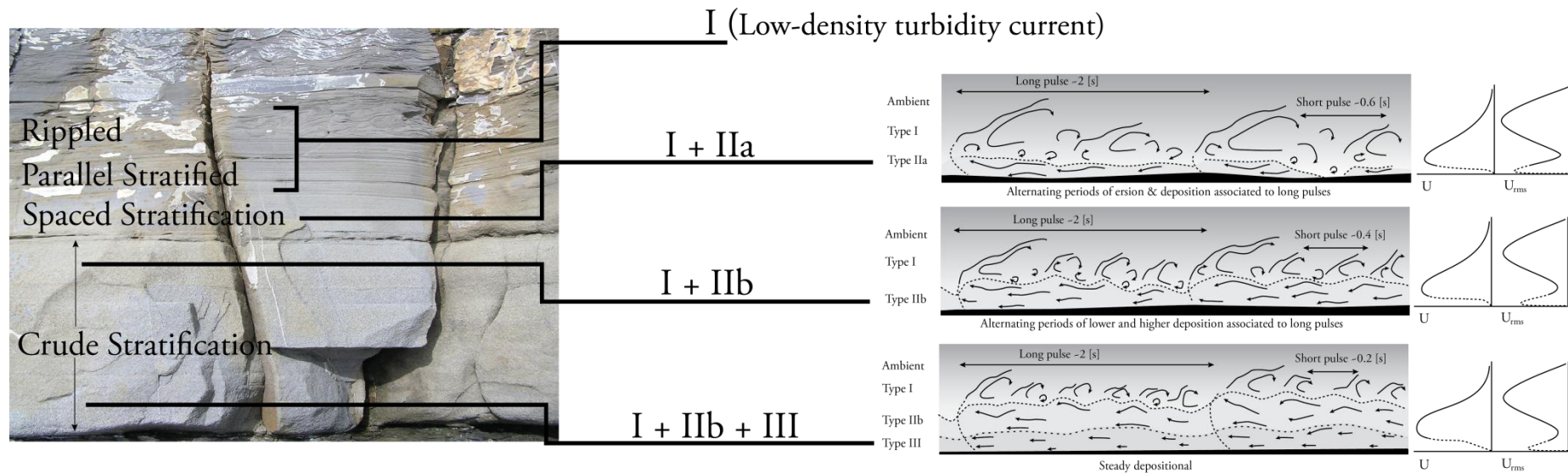


Ambient
Type I
Type IIb
Type III

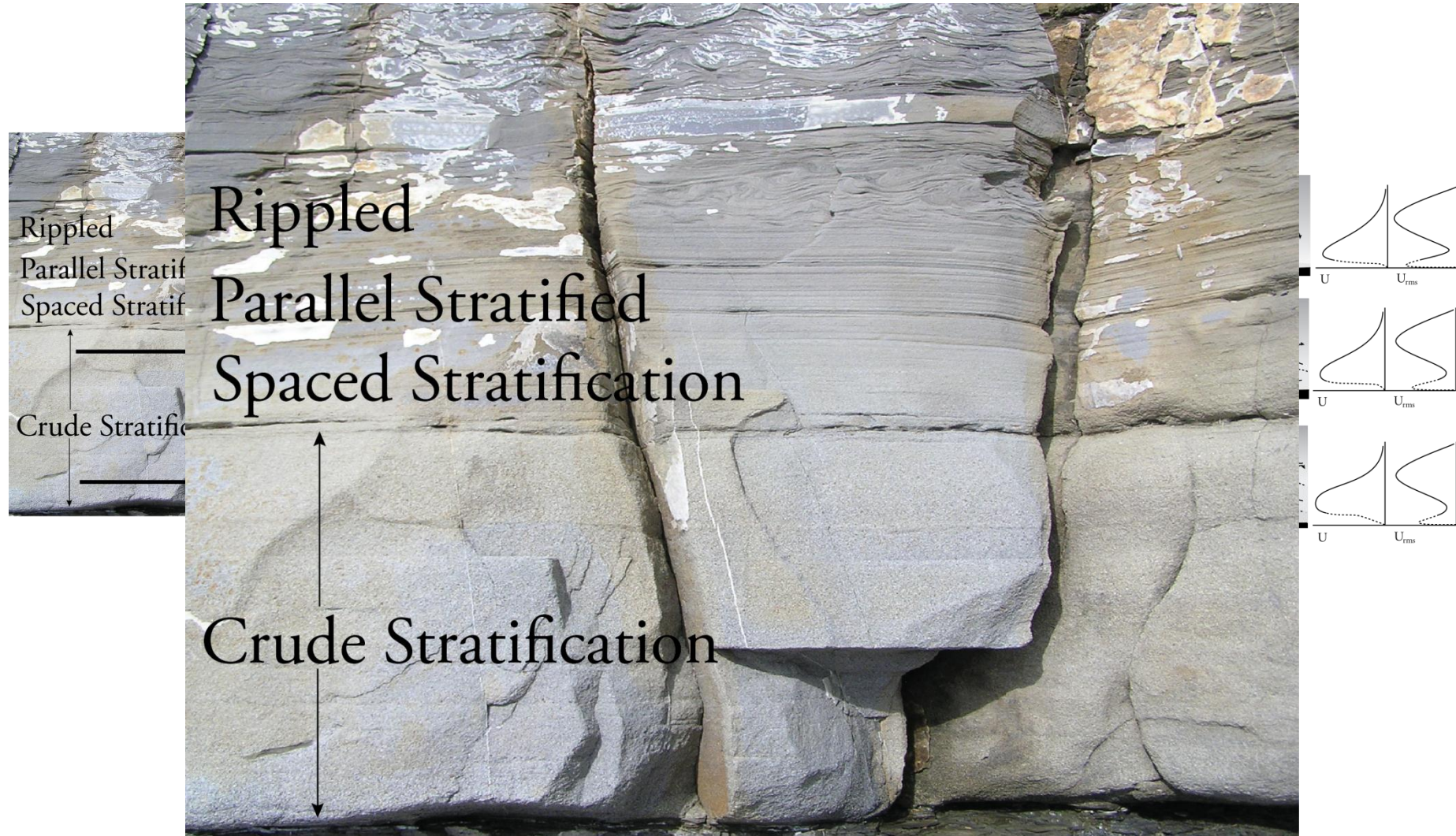


Tabernas Basin, Spain

A tool to interpret high-density turbidity current processes from high-density turbidite lithofacies



A tool to interpret high-density turbidity current processes from high-density turbidite lithofacies



Conclusions

- High-density turbidity currents show three different types of density stratified layers
- Each with a characteristic dynamic flow-bed interaction
- And therefore also their own sedimentary signature