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Unidirectional – oscillatory flow
For measuring vertical – longitudinal distances
For measuring wave length - time

Bedform Morphology under Combined Flows*

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Abstract

Combined flow, which commonly refers to a combination of unidirectional and wave-induced oscillatory flow, is omnipresent in natural environments and generates a range of bedforms on sandy bottoms. However, few experimental studies have focused on the relationship between the morphology and flow conditions of combined-flows. Arnott and Southard (1990), Dumas et al. (2005), and Takagawa (2009) examined, relatively long (> 8sec) oscillatory periods, while Yokokawa (1995) and Sekiguchi and Yokokawa (2008) examined shorter period (<2 sec) waves. There is thus a wide range of unexplored conditions for such bedforms, especially with intermediate oscillatory periods. Recently, Perillo et al. (2009) reported examples with 5 sec period and in the present paper we describe one set of conditions for a 4 and 6 sec period. Experiments were conducted using the Large Oscillatory Water-Sediment Tunnel (LOWST) in the University of Illinois, which has a test section 12.5 m long, 0.8 m wide, and 1.2 m high. Half of the tunnel height was filled with uniform 250 μm diameter sand. The oscillatory velocity was fixed at 25 cm/sec, whilst the superimposed unidirectional velocities, Uu, were varied between 0 and 40 cm/sec. Longitudinal one-beam sonar data was obtained every 30 sec to measure the bed morphology and its spatio-temporal development. In these conditions, distinctive bedform types were observed:

2D Ripples, 3D Symmetric Small Ripples (SSR), Asymmetric Small Ripples (ASR), Asymmetric Large Ripples (ALR) with rounded crests, and dune-like ALR.

Short descriptions of each bedform are:

- 2D Ripples: Symmetrical, straight-crested ripples with sharp crests, with wavelength (λ) of about 20-30 cm.
- 3D-SSR: Nearly symmetric ripples with sharp crests but whose crestlines were discontinuous.
- ASR: Asymmetric ripples with λ of about 15cm, discontinuous crestlines.
- ALR with rounded crests: Asymmetric current-affected ripples with rounded crests, λ of about 20-30 cm.
- Dune-like ALR: Asymmetric bedforms with a λ of about 60 cm.

From these results, we recognize three boundaries in the combined flow "phase diagram":

a) 2D to 3D between Uu = 5 and 10 cm/s for 6sec and Uu = 10 and 20 cm/s for 4sec,

b) symmetrical to asymmetrical ripples at Uu = 10 and 20 cm/ s for both 6 sec and 4sec, and

c) a bedform size boundary, between small and large ripples, at Uu = 20 and 30 cm/s for both 6 and 4 sec.

We show how, compared with the previous studies, the present experiments appear to show an effect of oscillation period on the boundaries of the bedform phase-diagram.

Selected References

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Bedform morphology under combined flows

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Introduction

UNIDIRECTIONAL FLOW

OSCILLATORY FLOW

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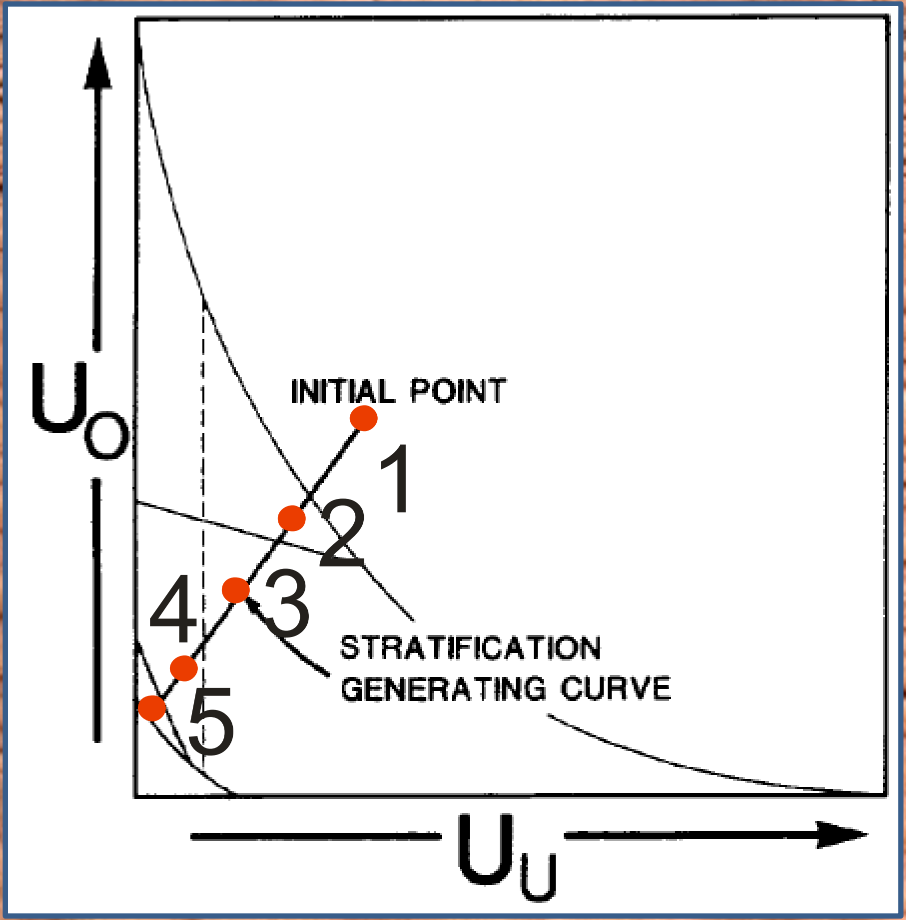
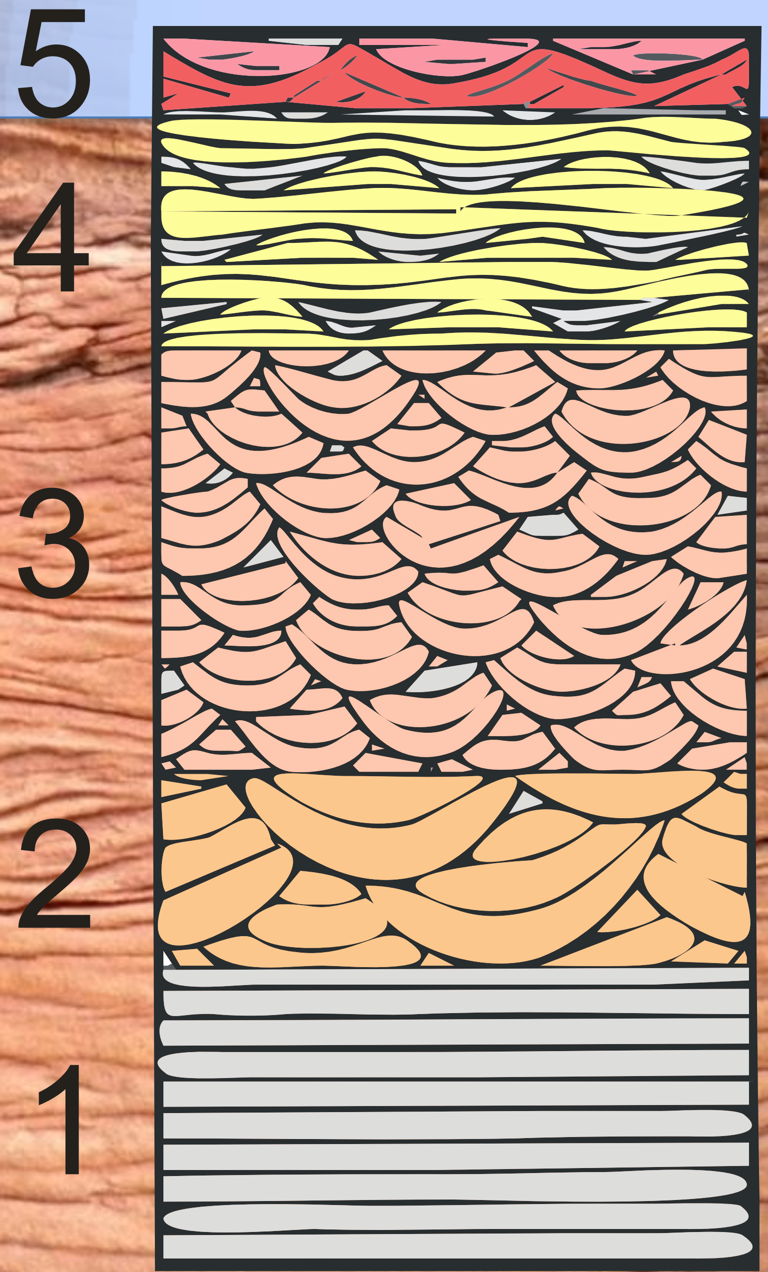
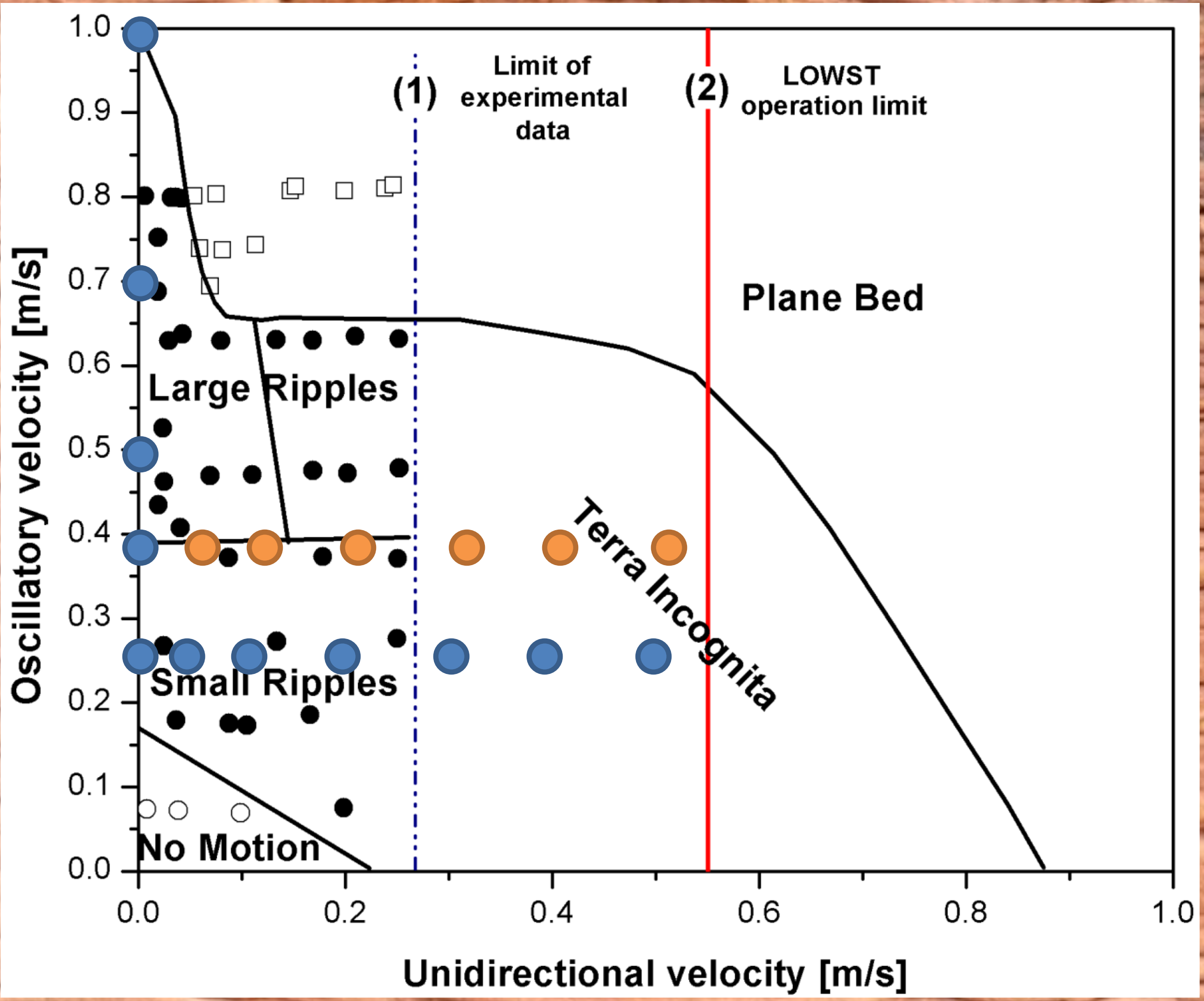
Previous Work



Modified from Myrow & Southard, (1991). *JSR*



Previous Work



Southard (1991). *Annual Review of Earth and Planetary Sciences*

Facility

Large oscillating water-sediment tunnel

Ven Te Chow Hydrosystems Lab., University of Illinois

Experiments and Data Acquisition

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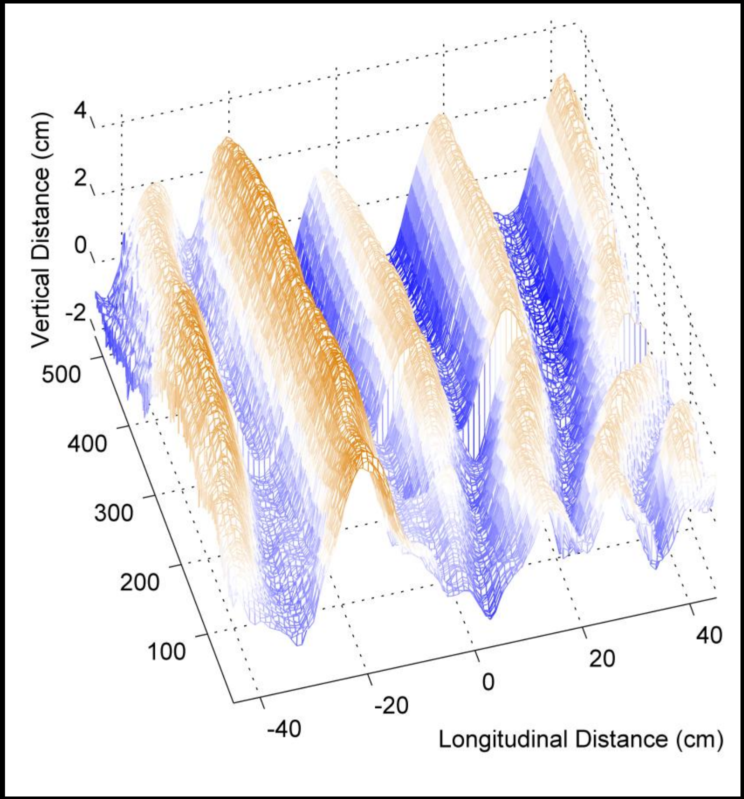

Experiments and Data Acquisition

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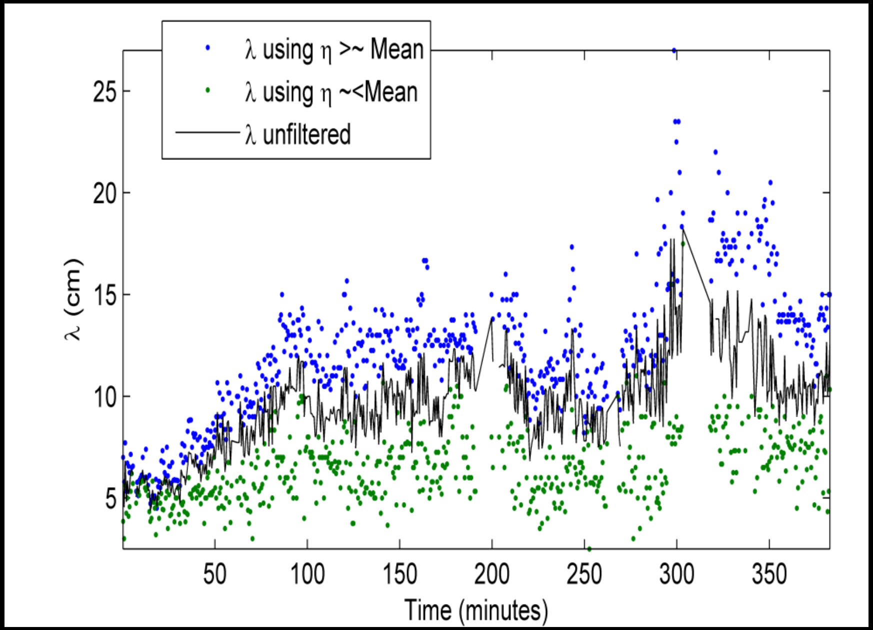
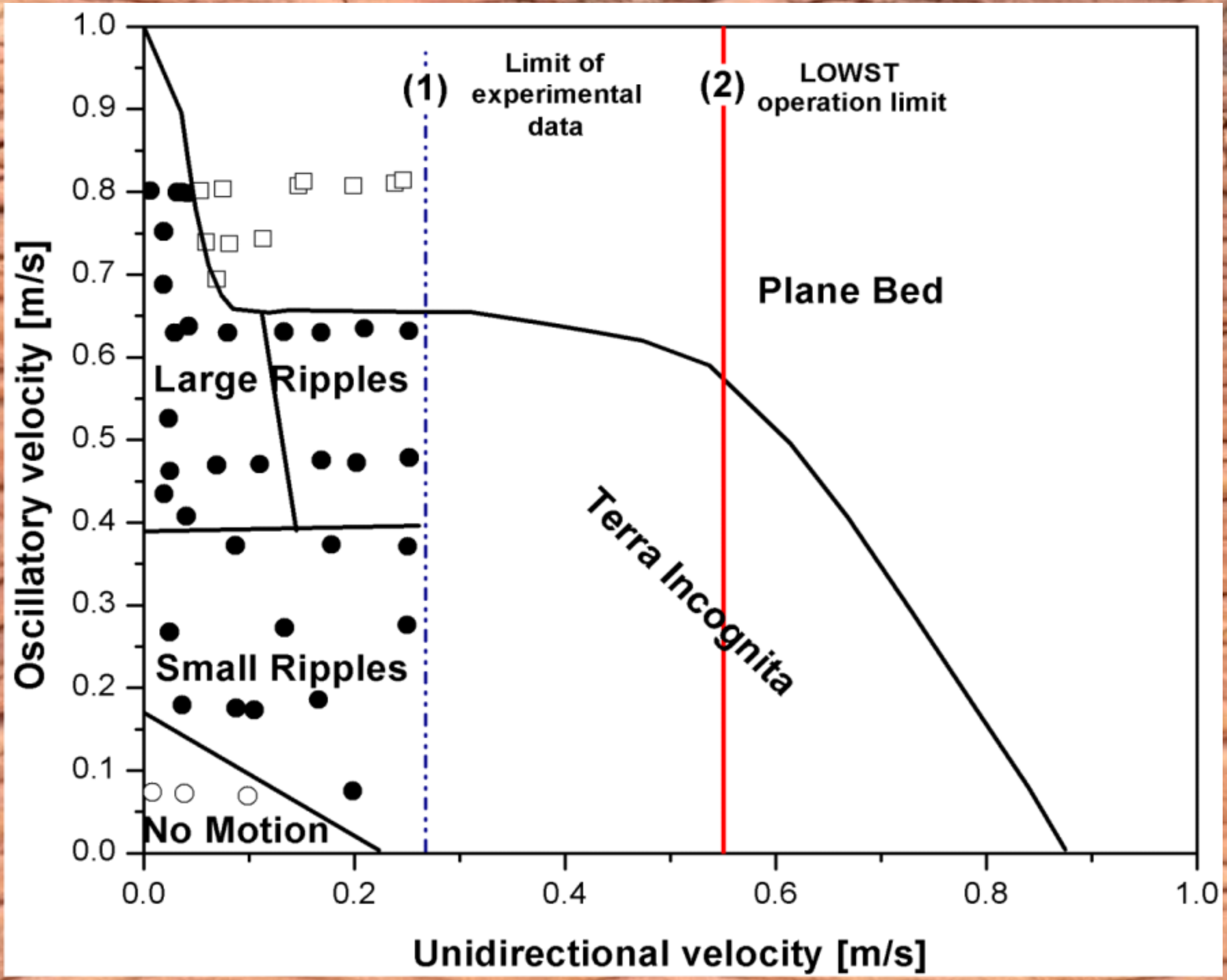
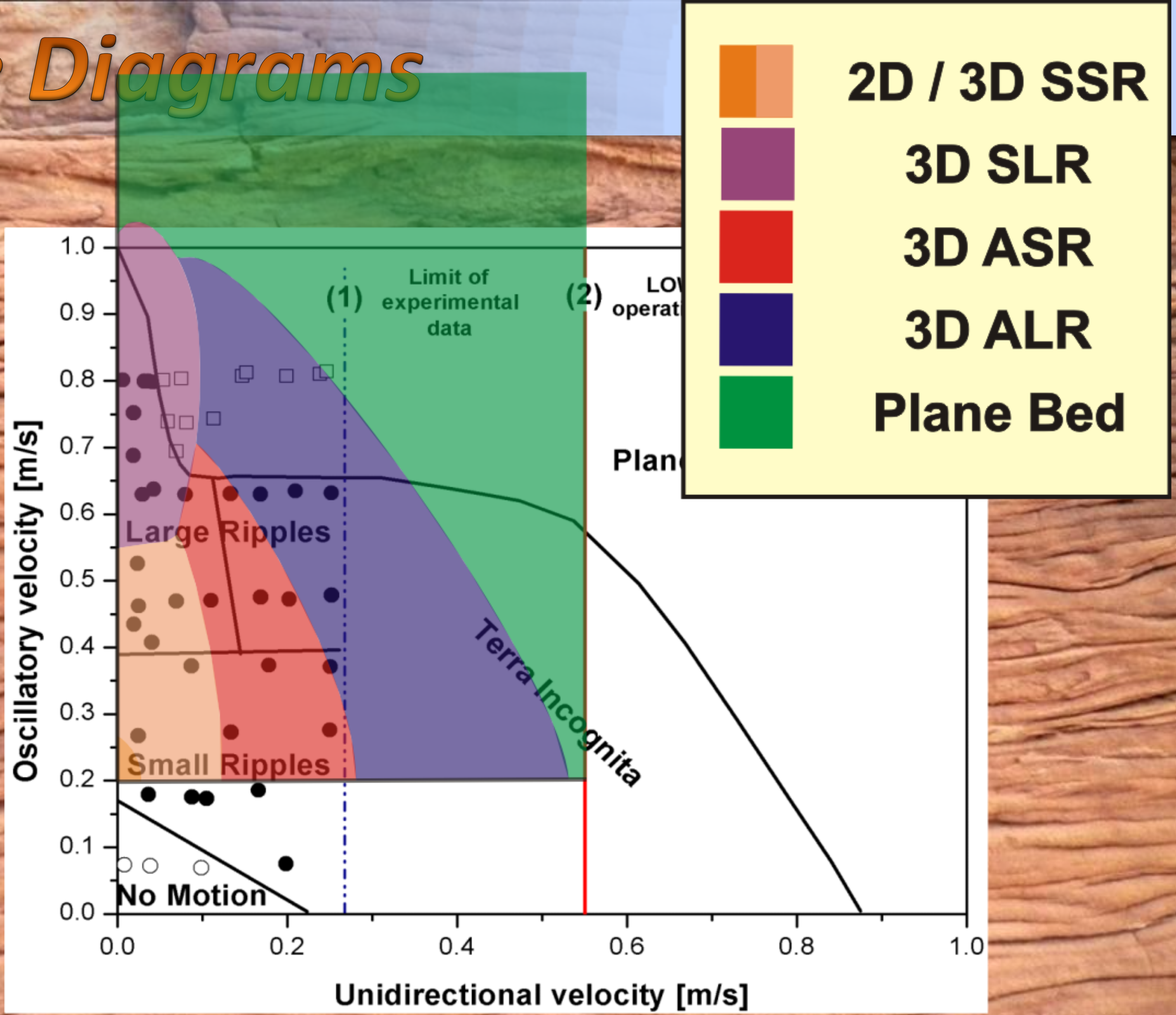


Phase Diagrams

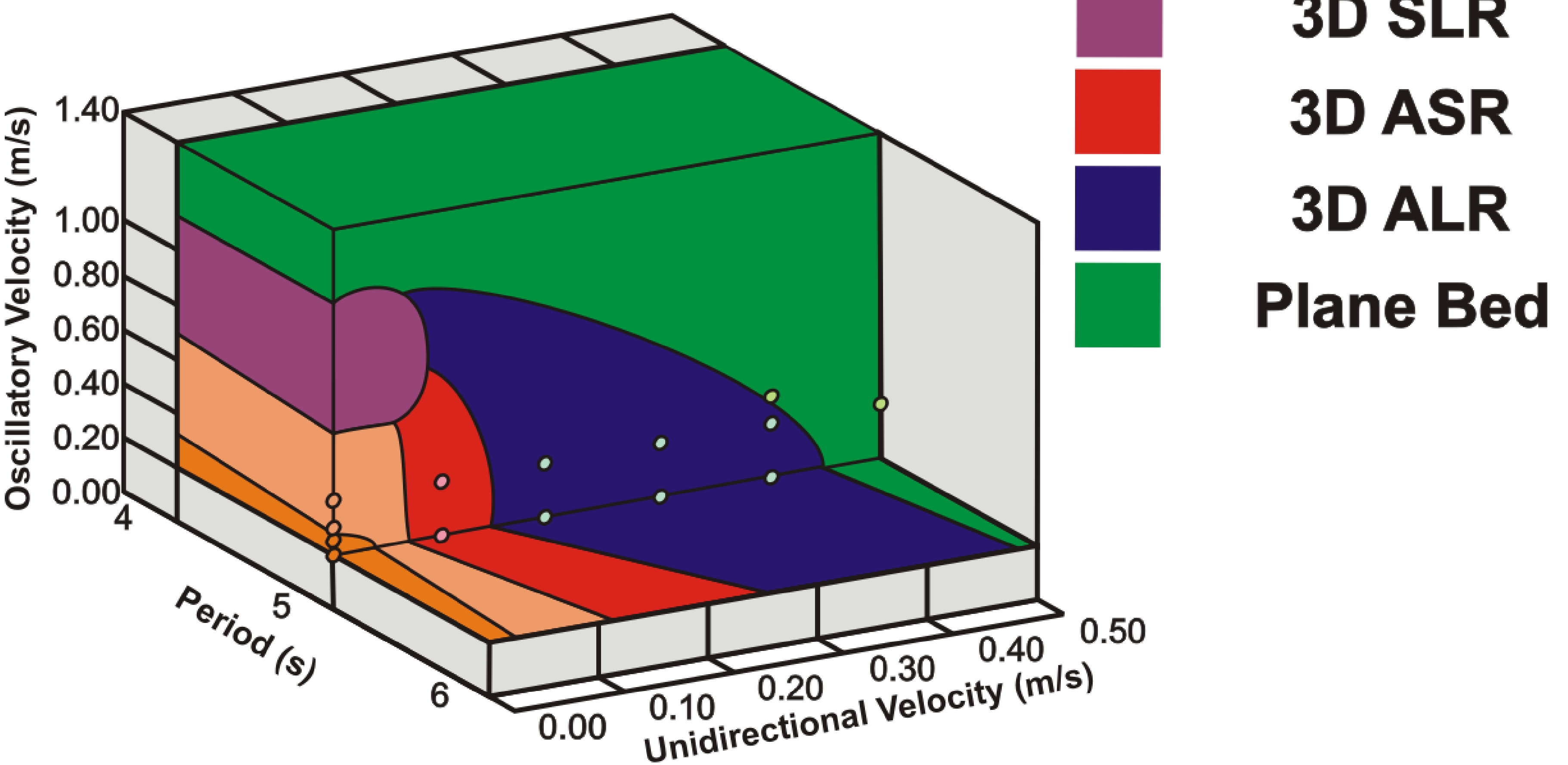


Phase Diagrams

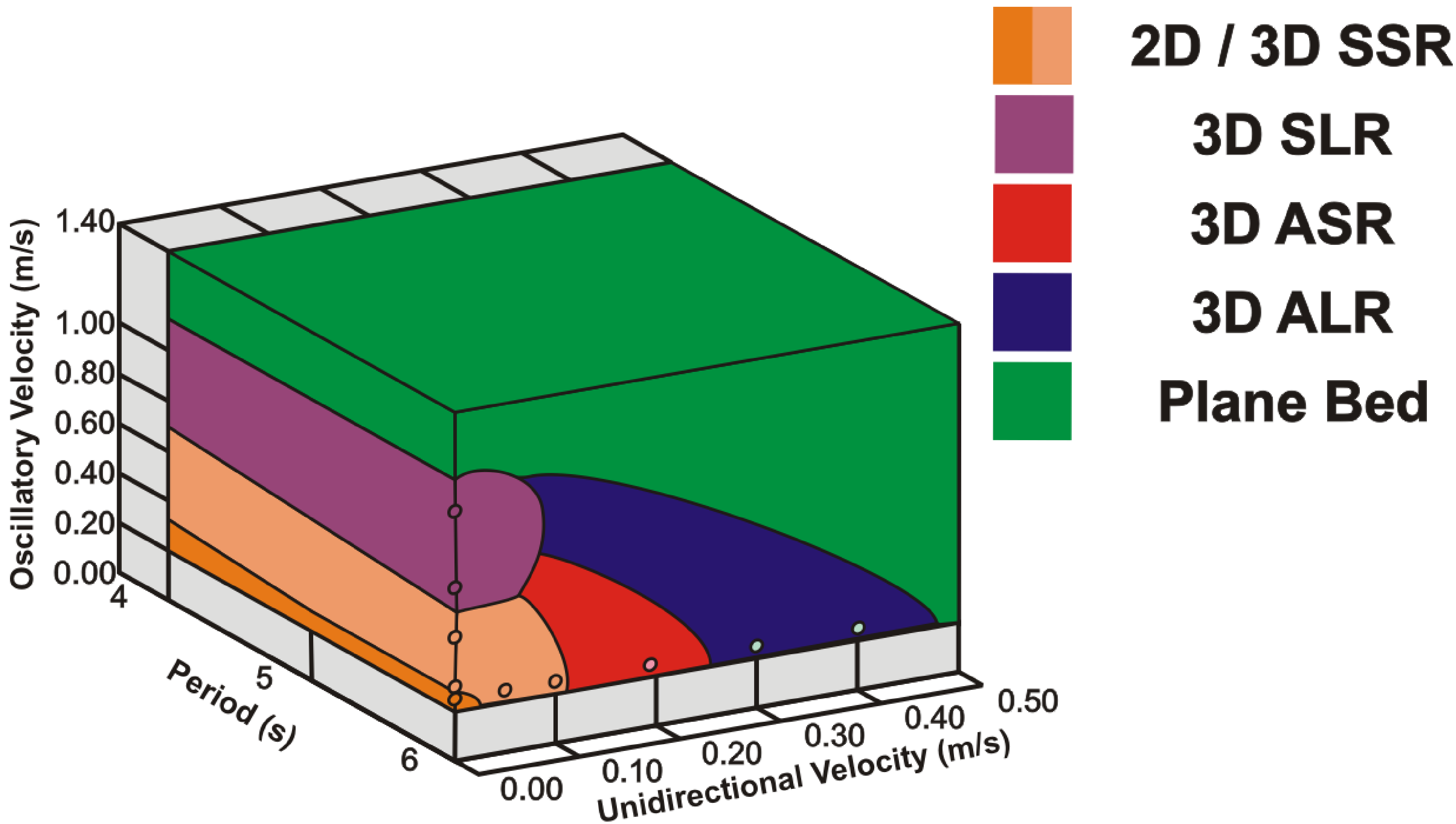


Phase Diagrams

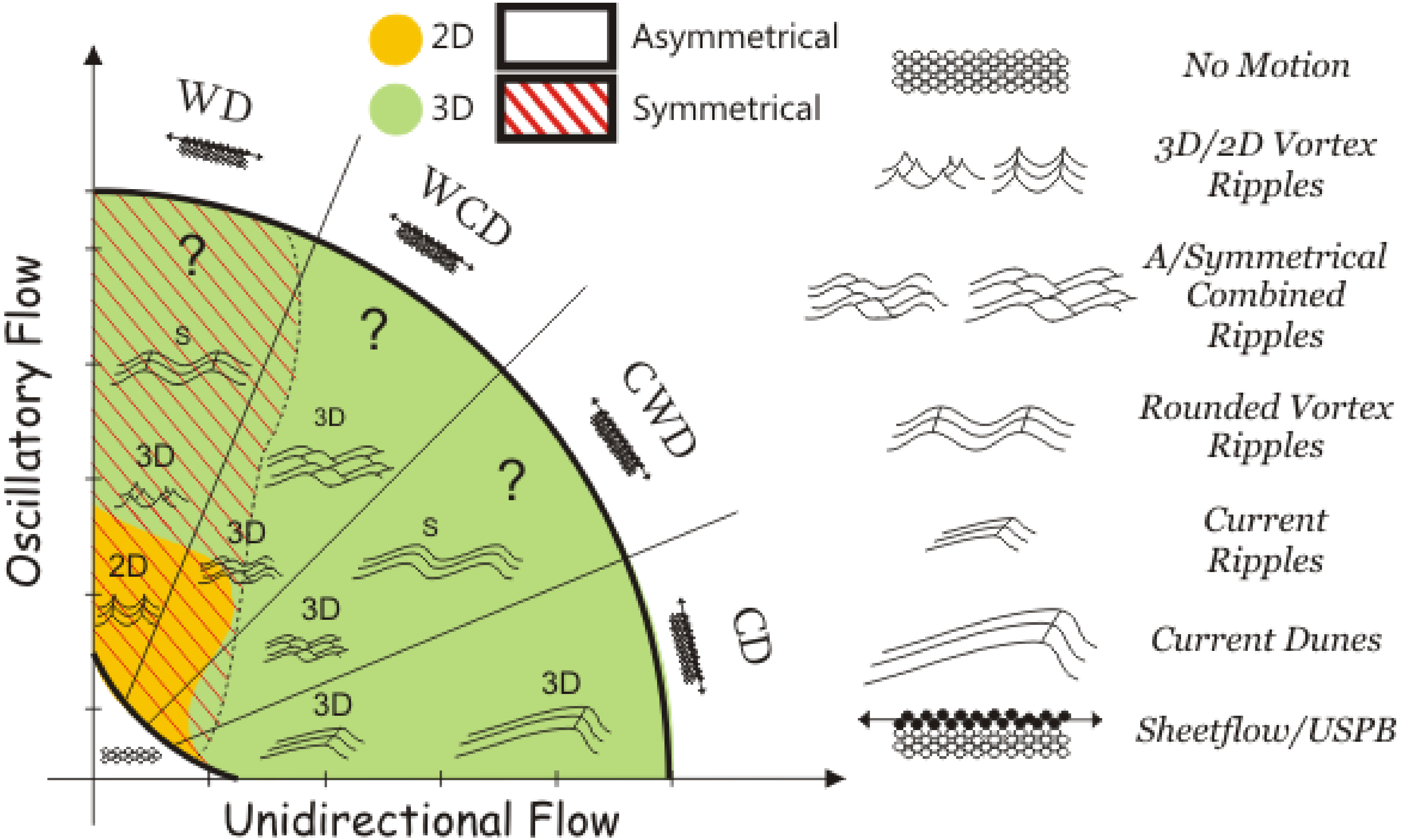
Names following Dumas, Arnott & Southard (2005). *JSR*



Phase Diagrams



Phase Diagrams



Conclusions

- Bed configurations under combined flows
  - Symmetrical Small Ripples (SSR)
  - Asymmetrical Small Ripples (ASR)
  - Symmetrical Large Ripples (SLR)
  - Asymmetrical Large Ripples (ALR)
  - Plane Bed (PB)

- First measurements in “Terra Incognita”
  - Previous researchers measure up to 0.30 m/s. Present work up to 0.5 m/s.

- 2D-3D and Small-Large ripples transitions

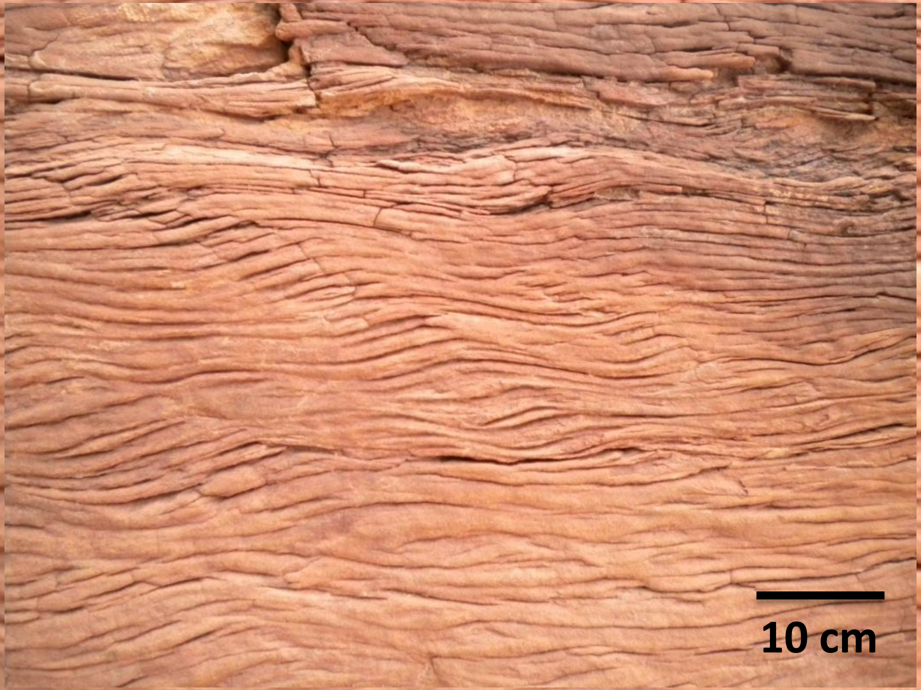
Future Work

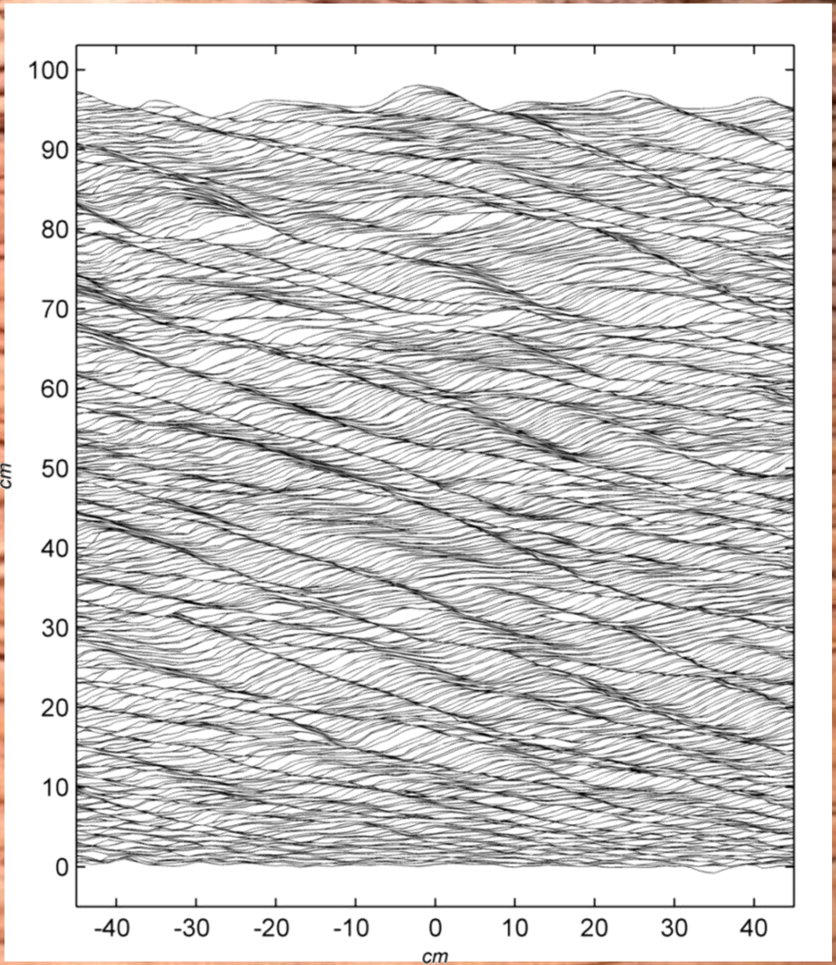
1 –Effect of wave period in the bed morphology of combined flows. Shorter/Longer periods?

2 – Storm Deposits

3 – Effects on cross-stratification as you increase the unidirectional flow. Differences between Pure unidirectional flows vs. Combined flows.

Pure unidirectional vs Combined





Thank you...