Sedimentary structures

Stratification and bedforms – Part I

Introduction

- Goals for this lecture:
  - Identify common sedimentary structures.
  - The effect grain size has on creating sedimentary structures.
  - Connect sedimentary structures to depositional environment.

Primary Bedforms

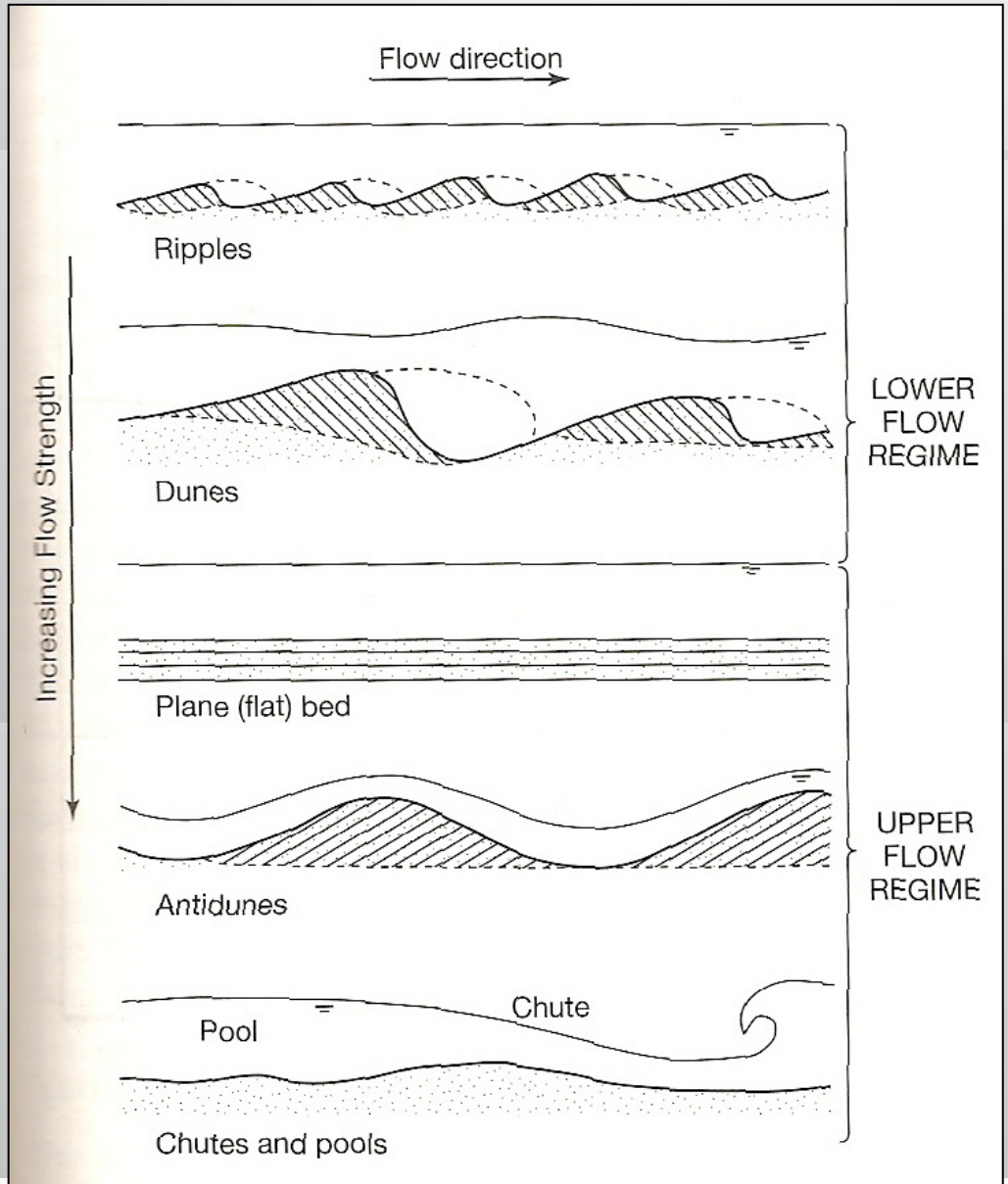
- Patterns formed by the deposition of sediments produced mechanically following transport by a fluid.

(Doesn't include changes from secondary processes such as post-depositional modification and biologic processes)

Bedforms and flow regime

Froude numbers < 1

Froude numbers > 1

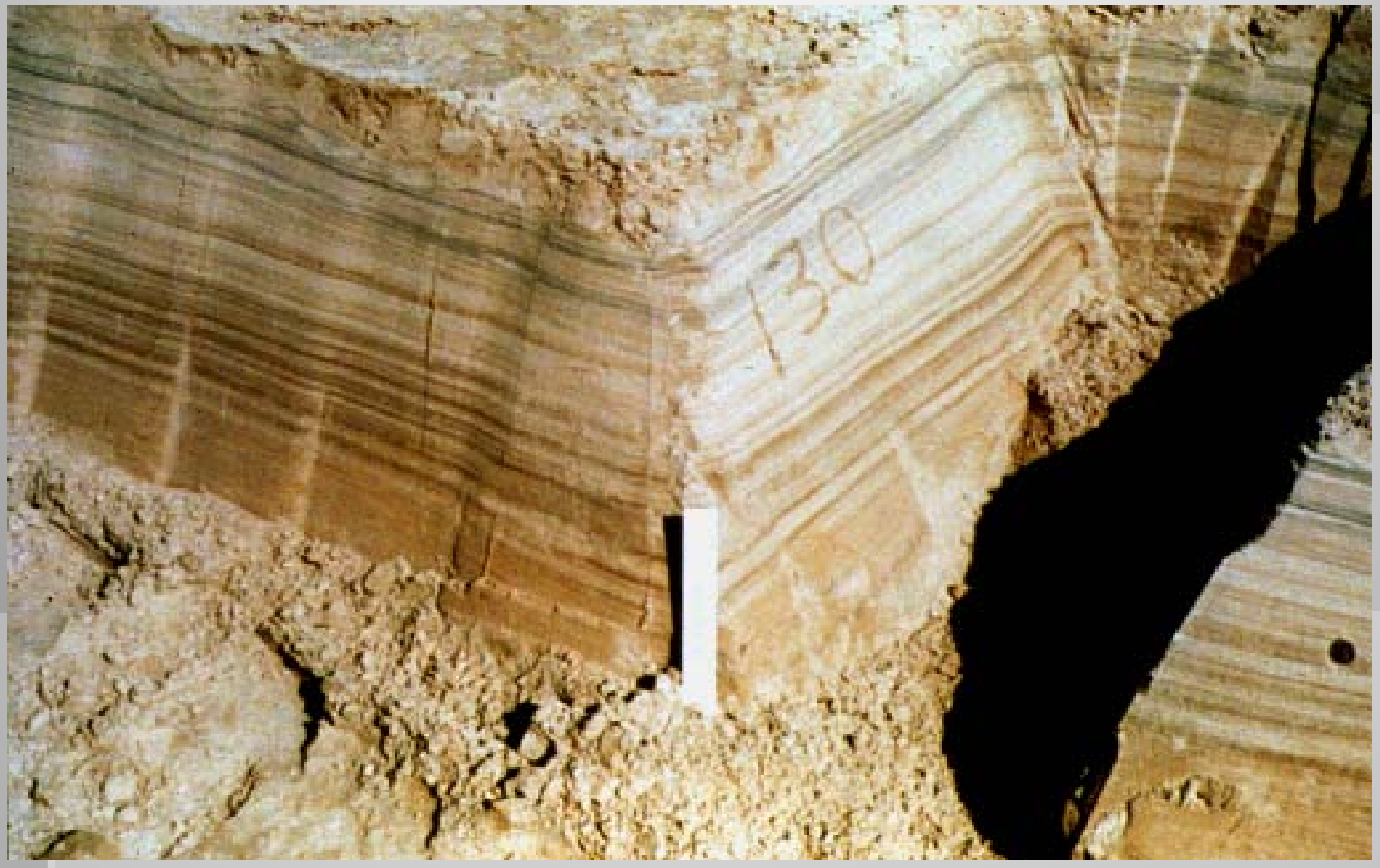


Under unidirectional flow conditions with sandy sediments (0.25 – 0.7 mm) along the streambed.

Upper plane bed

- Upper plane bed flow occurs in fine and very fine sand when the flow velocity is increased above that needed for ripple formation (very fine sand) or dune formation (fine sand). Upper plane bed flow occurs in the upper flow regime (Fd>1). Basically, upper plane bed flow is intense sediment transport over a flat bed.

Upper plane bed stratification



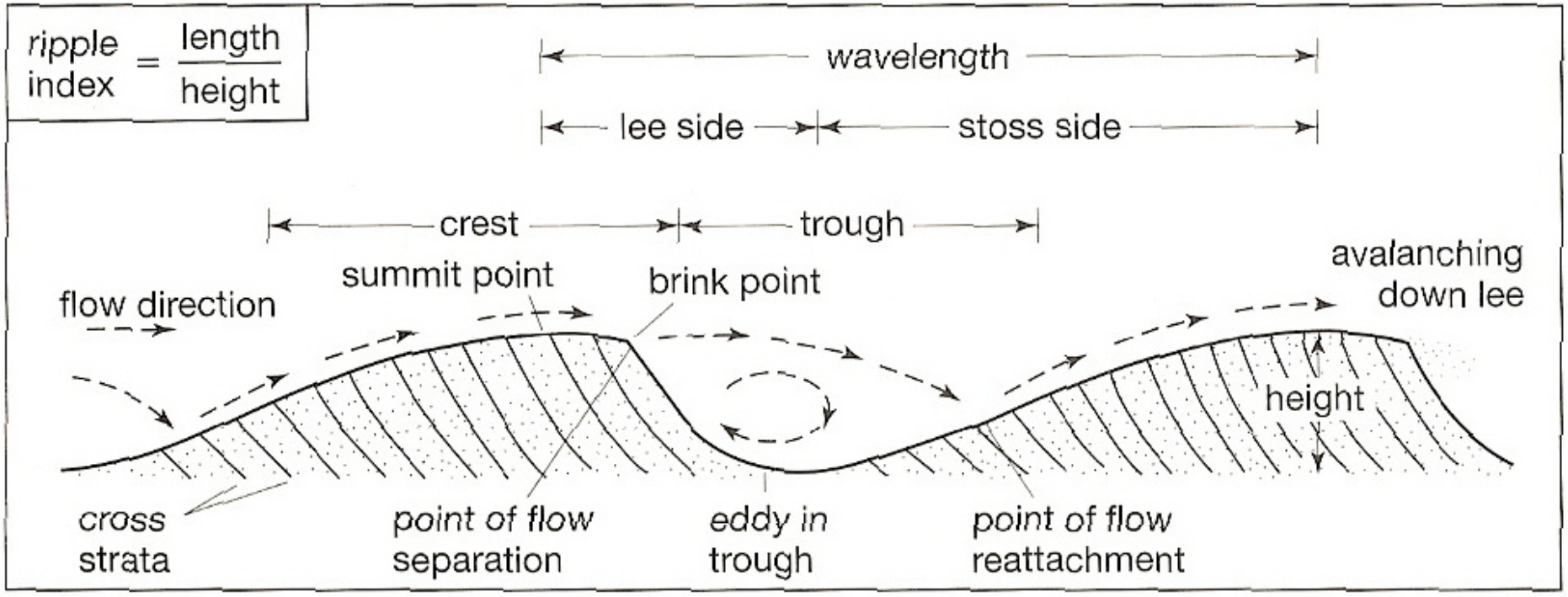
Modern beach deposit. Note that the 3D nature of the cut demonstrates the horizontal and planar aspect of this structure

Parting lineation

Bedforms - Ripples

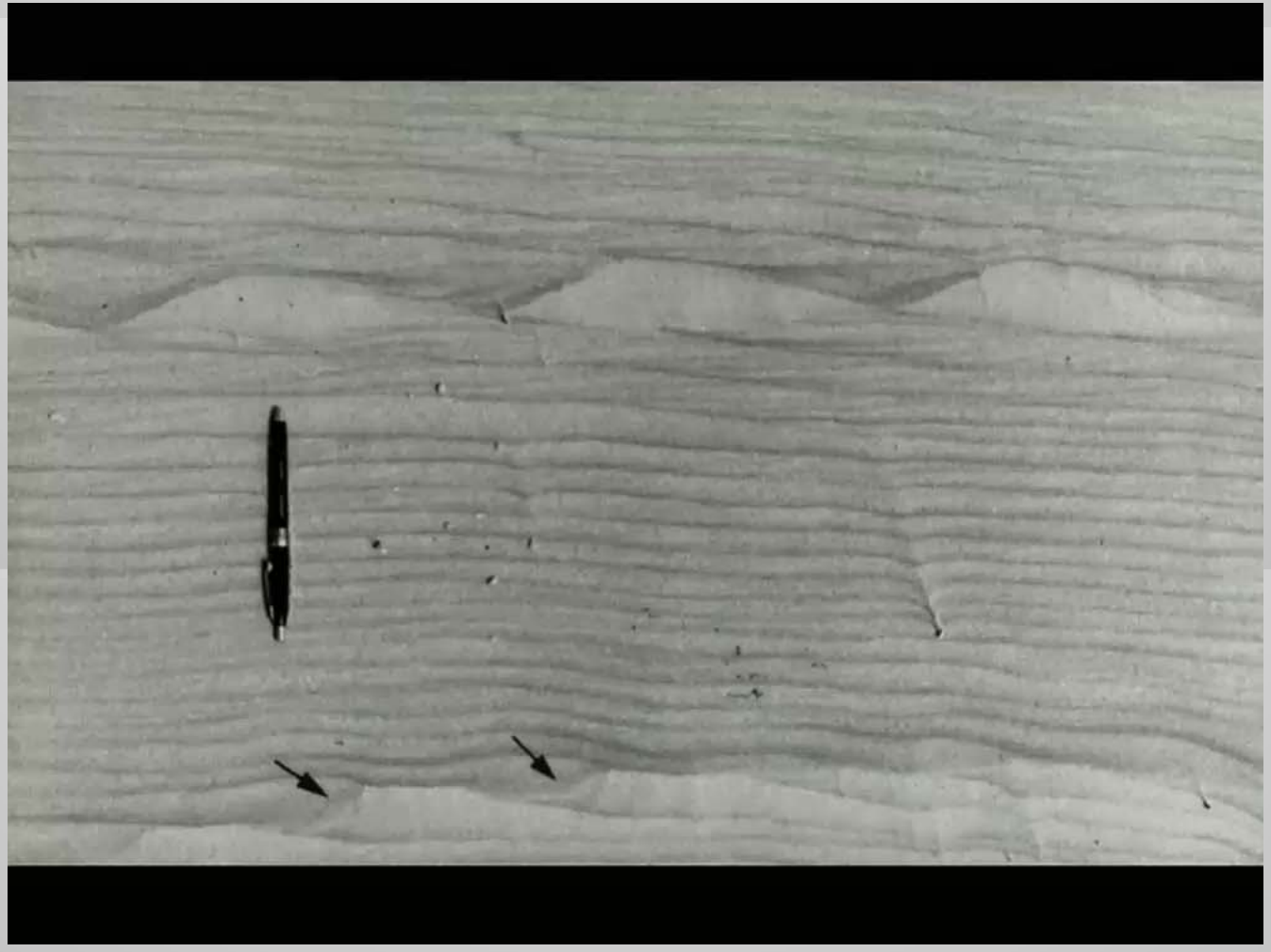
C.E. Jones, UPitt

Asymmetric ripples



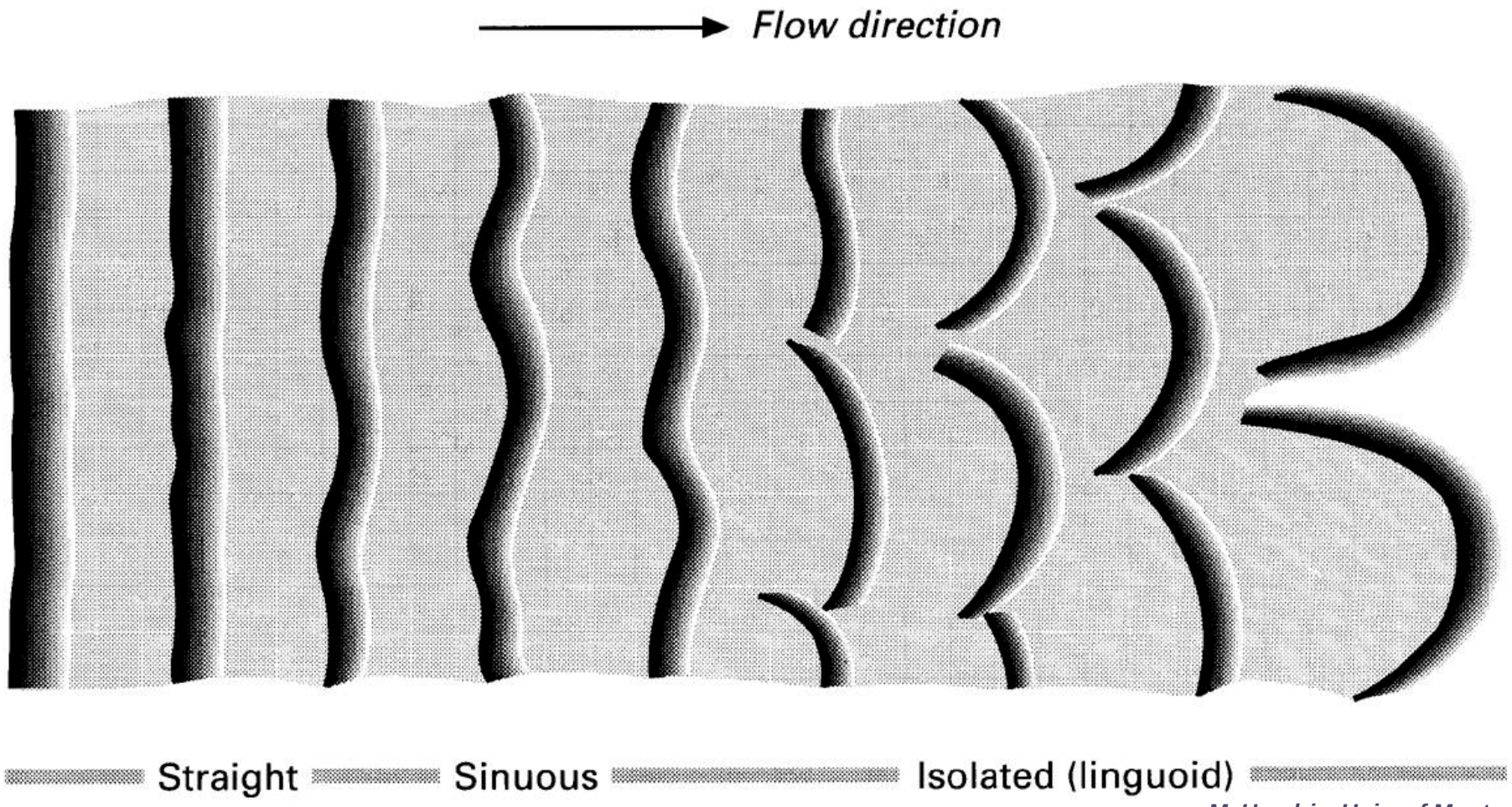
Ripple formation

(Unidirectional Flow)



https://walrus.wr.usgs.gov/seds/bedforms

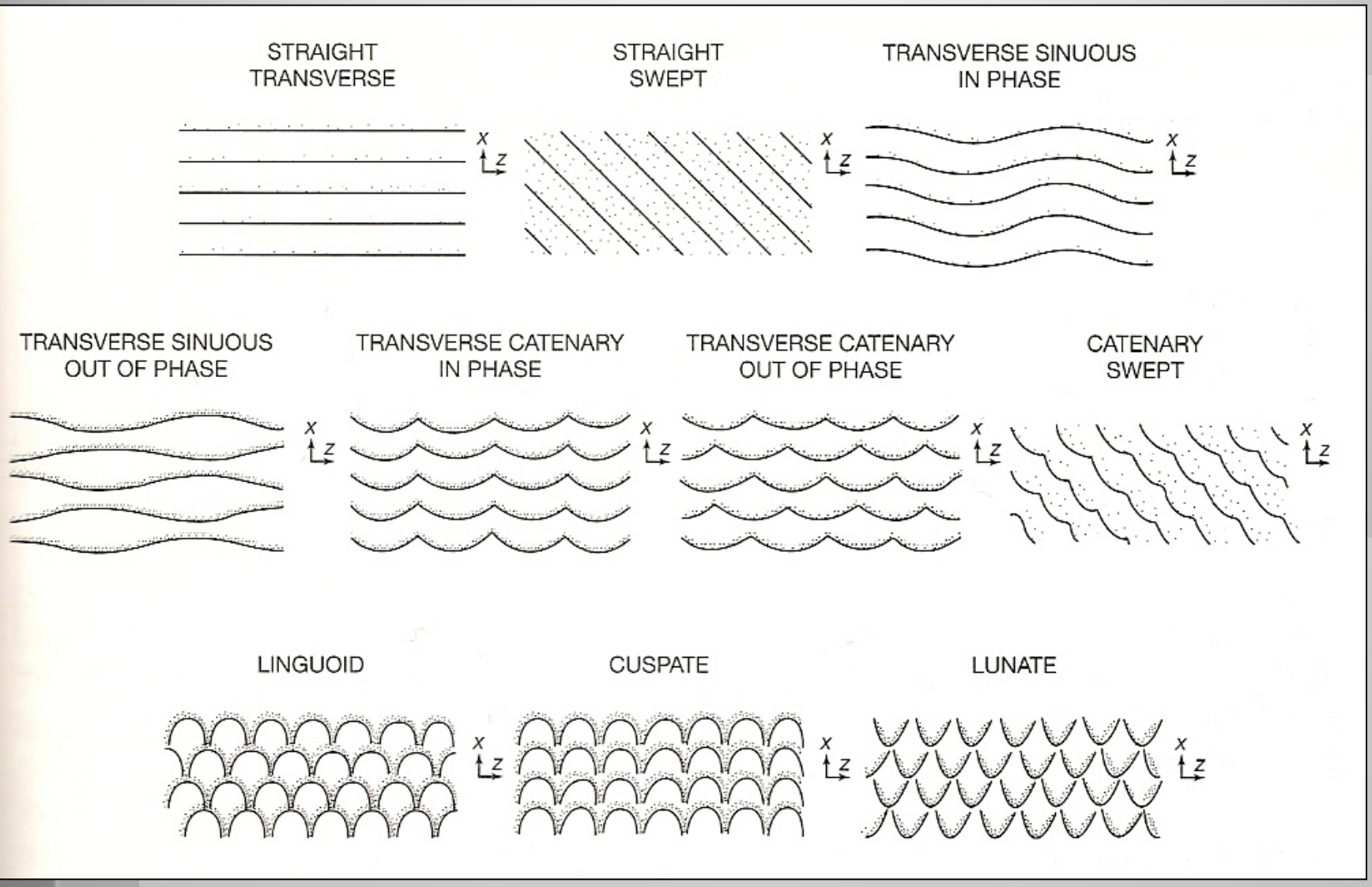
Ripple morphology



M. Hendrix, Univ. of Montana

Symmetric ripples

Types of ripple crests



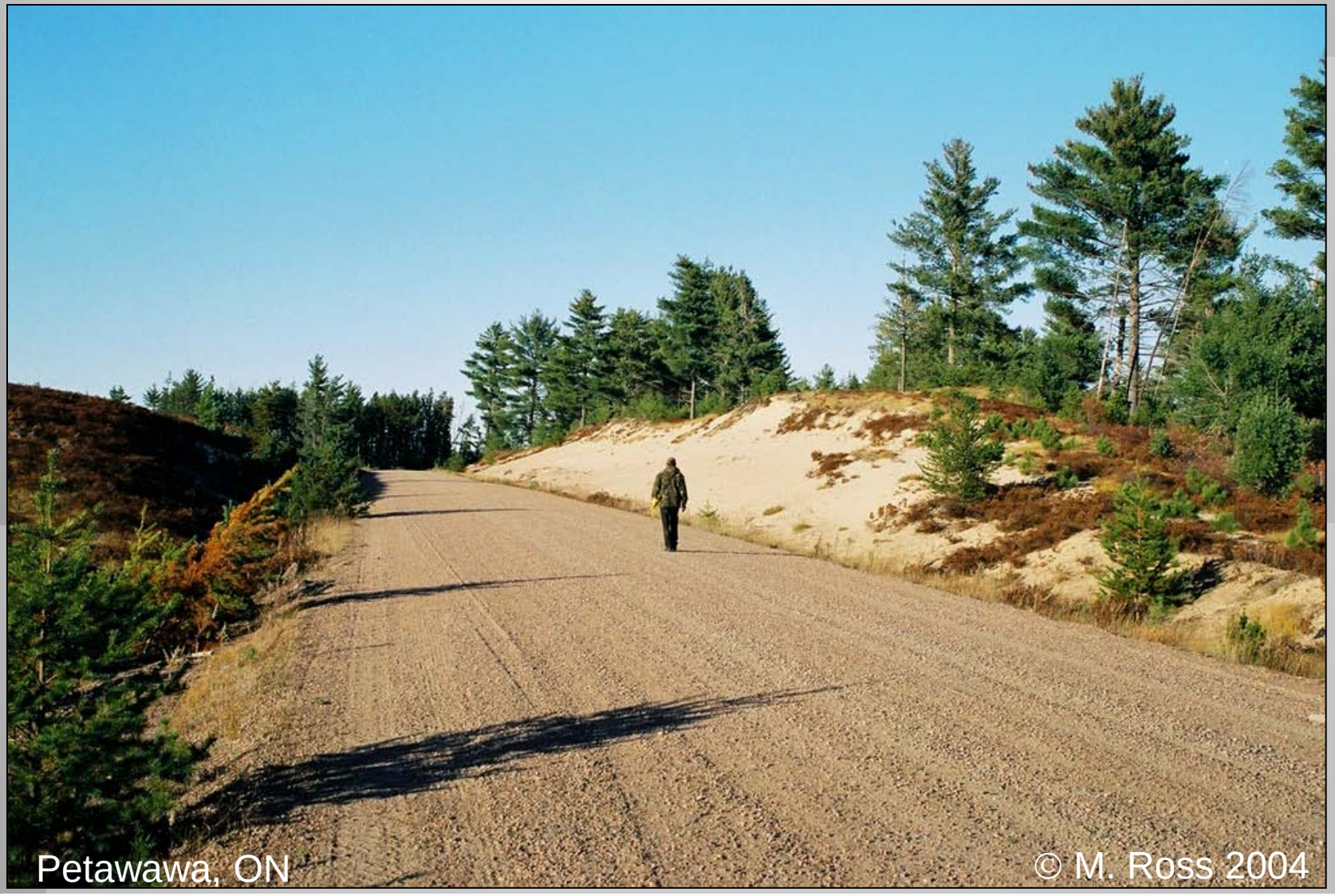
Flow

Bedforms - Small-scale dunes

From fine sand to gravel

Porcupine River, Yukon

Large bedforms (landforms) - Eolian dunes



Antidunes

- Antidunes are produced by in-phase, shallow flow at ca. Fr > 0.8
- Antidunes migrate upstream, giving rise to low angle cross laminations that are dipping upstream
  - Faint (no grain sorting by avalanching)
  - Migration is due to grain accretion

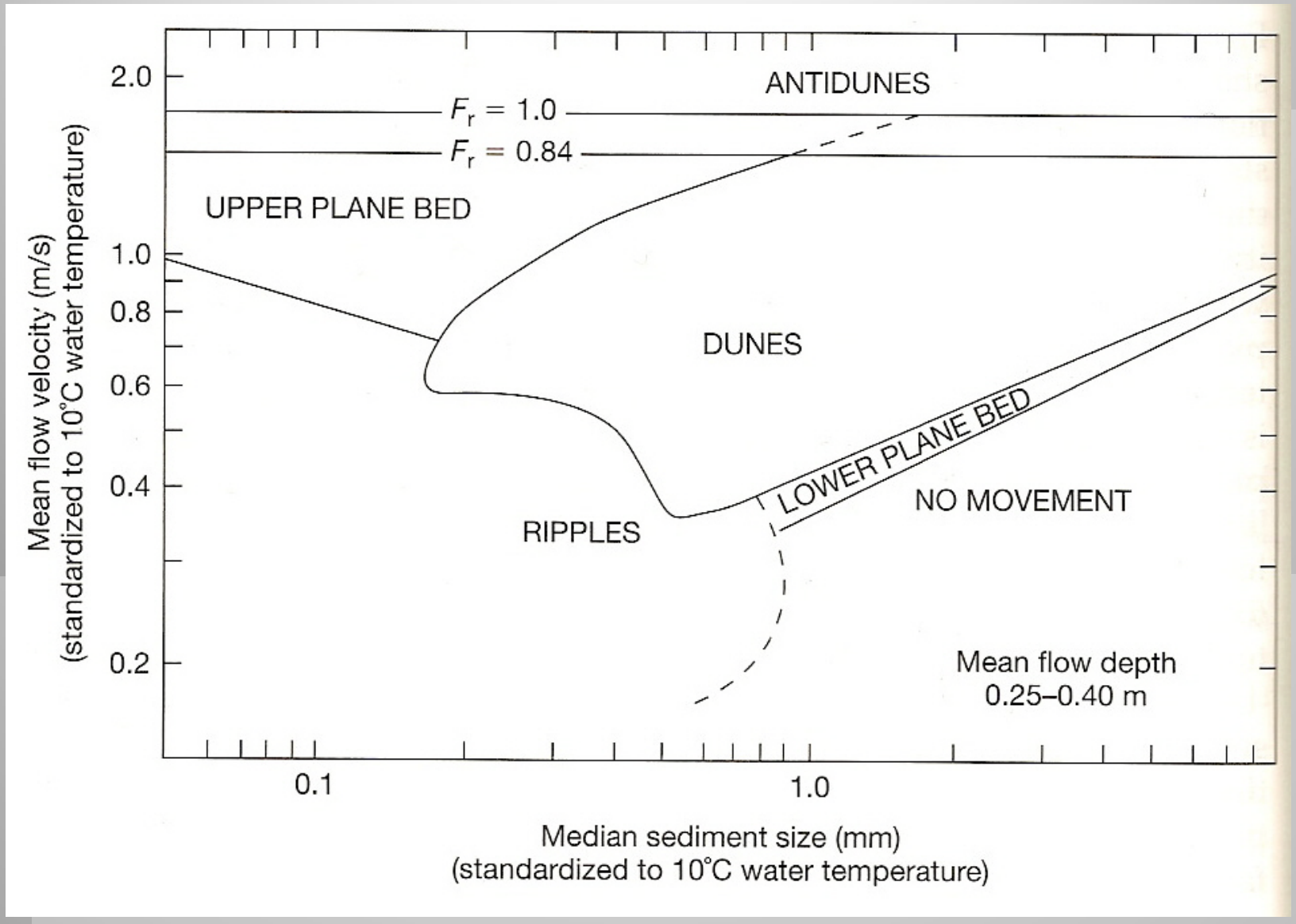
Antidunes

Antidunes forming in a small tidal channel on the California coast

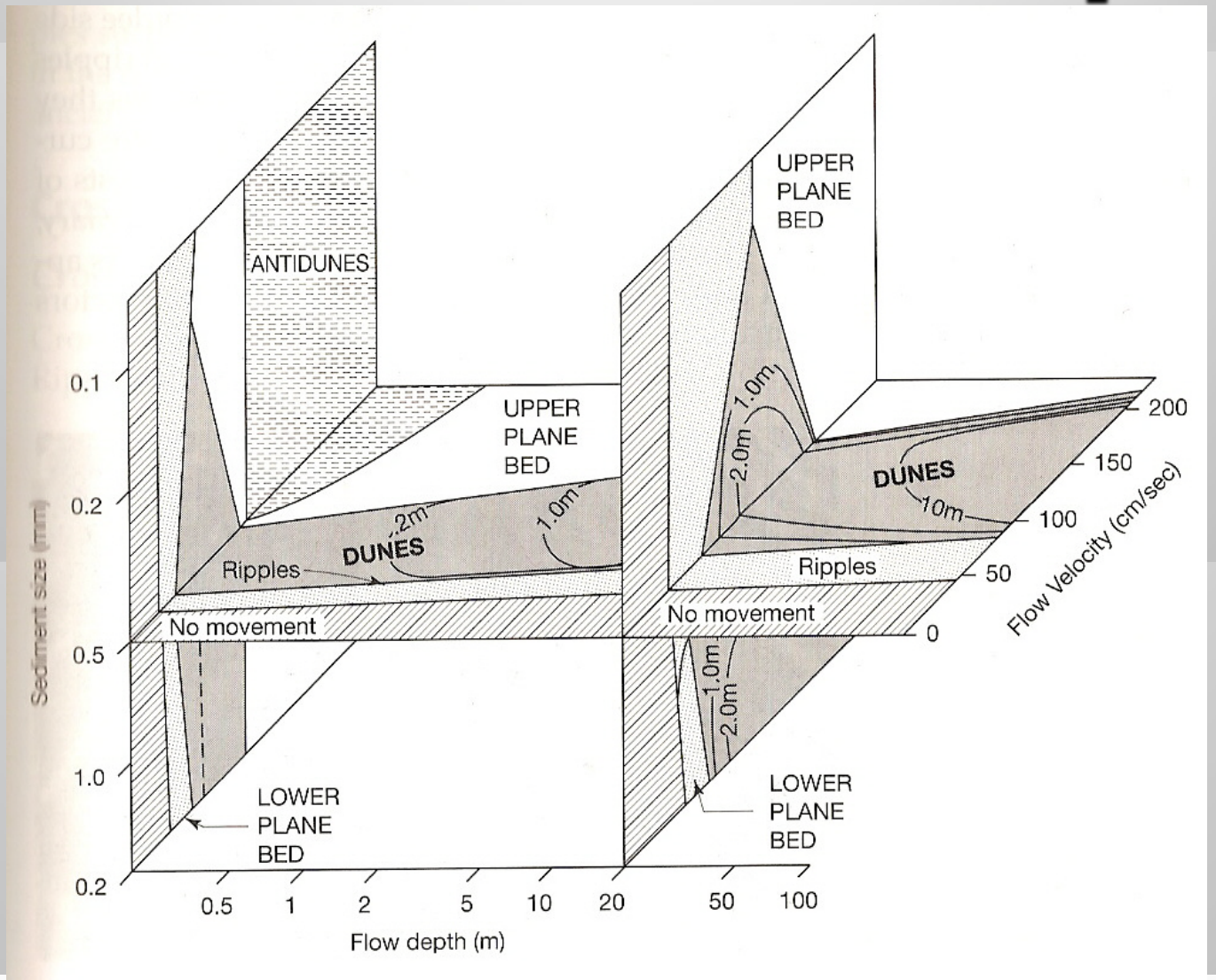
ca. 4 m

A standing wave train with associated antidunes

Effect of grain size



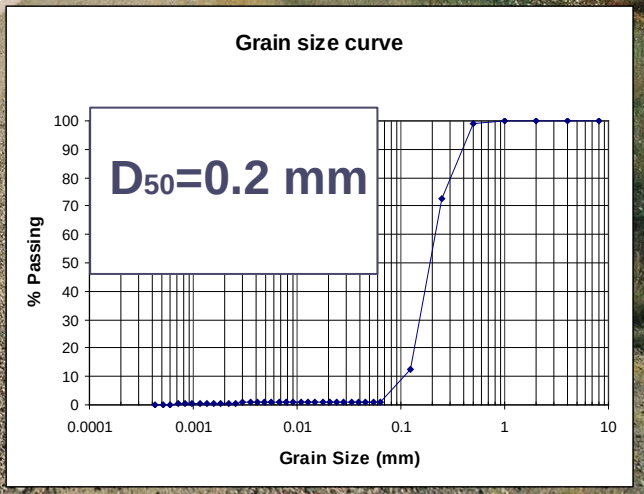
Depth-velocity-grain-size-bedform... relationships!



Are they aeolian dunes or 'giant' subaqueous dunes?

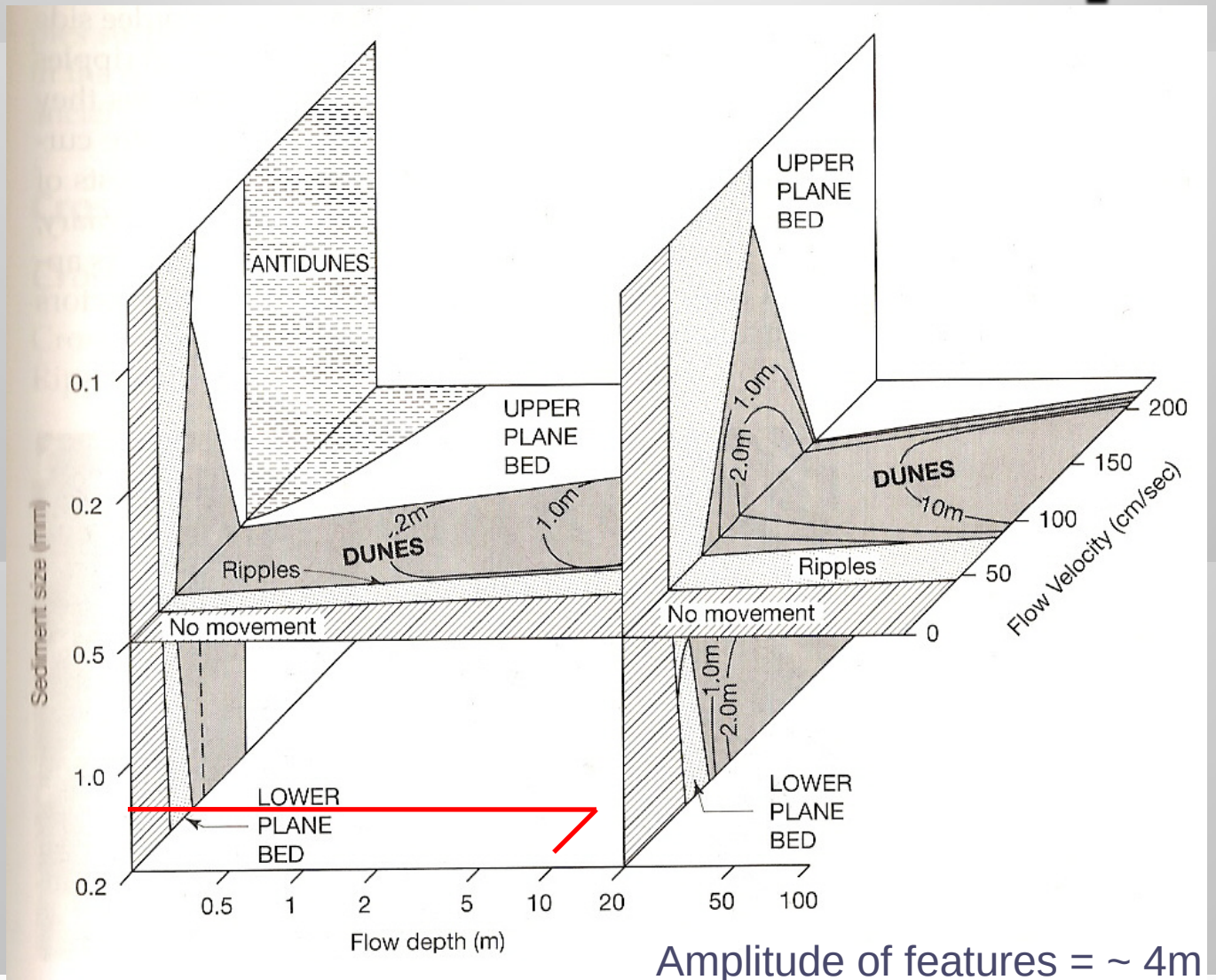
Marine Limit = 10 m higher than landforms

4 m



Chalk River, ON

Depth-velocity-grain-size-bedform... relationships!

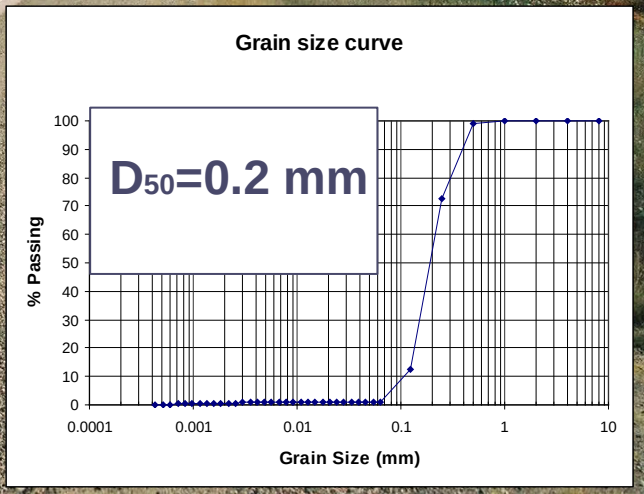


Amplitude of features = ~ 4m

Are they aeolian dunes or 'giant' subaqueous dunes?

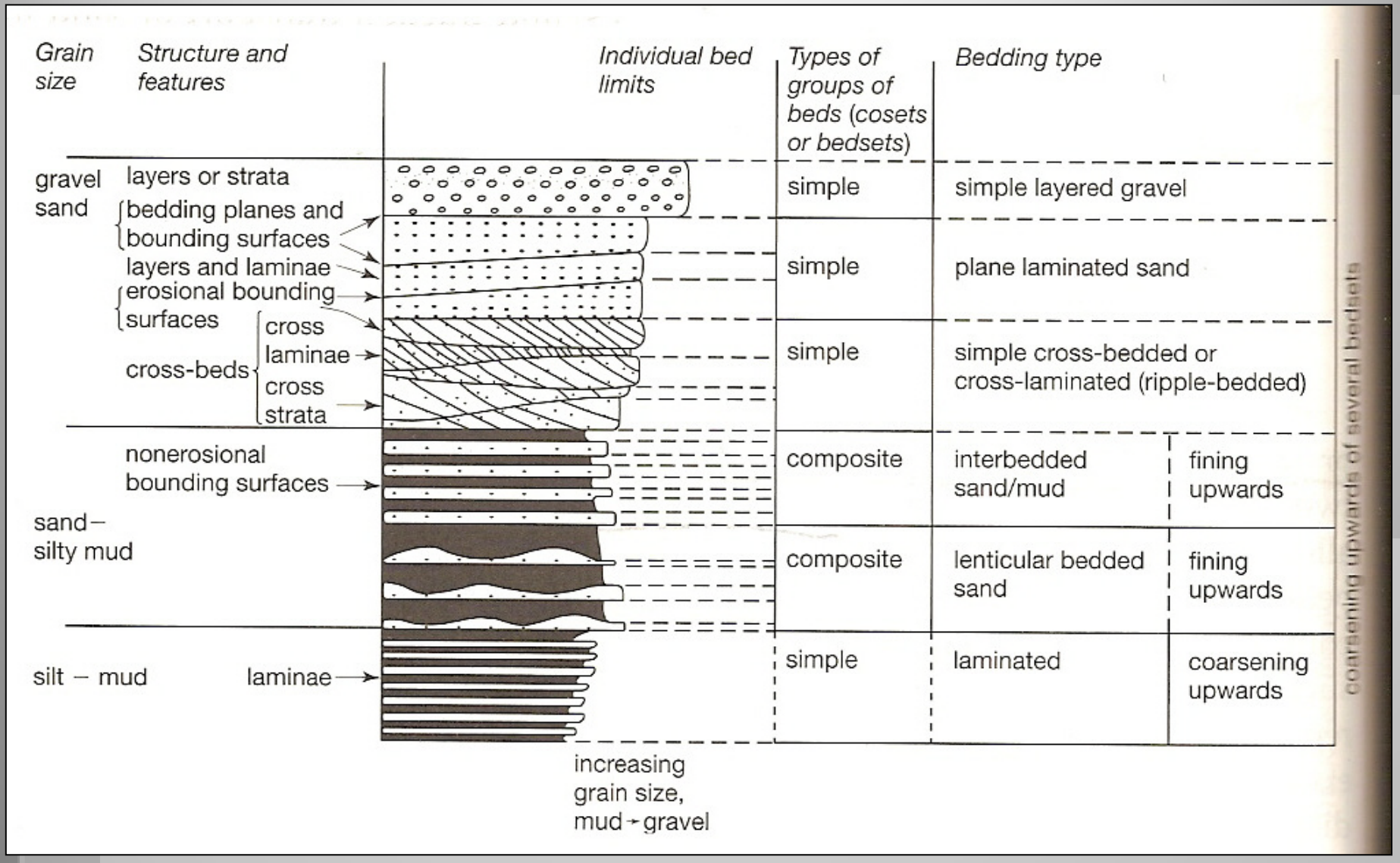
Marine Limit = 10 m higher than landforms

4 m



Chalk River, ON

Bedding and lamination



Coarse-grained strata

Basic types of cross lamination

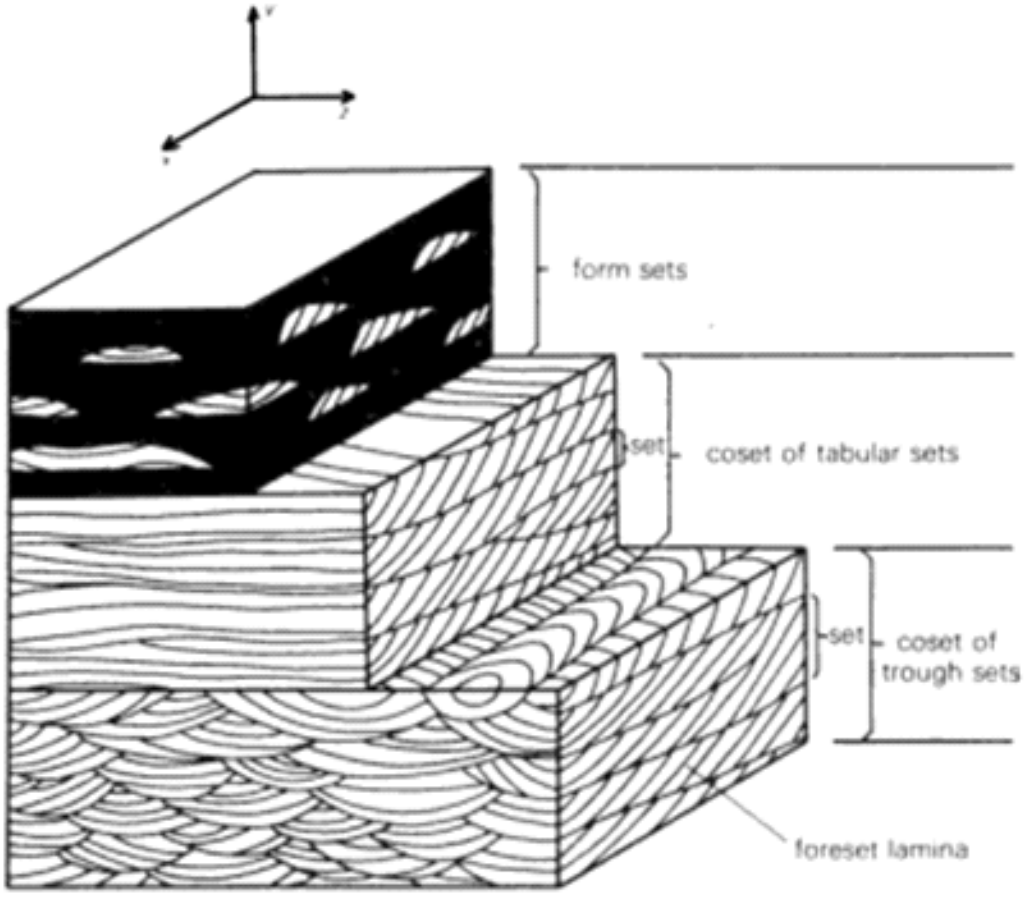
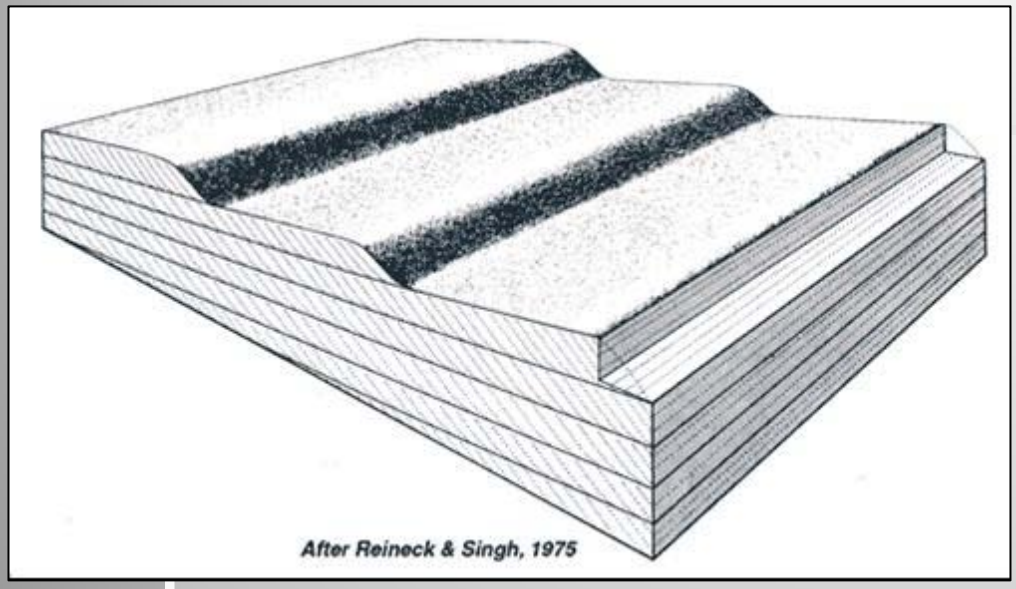
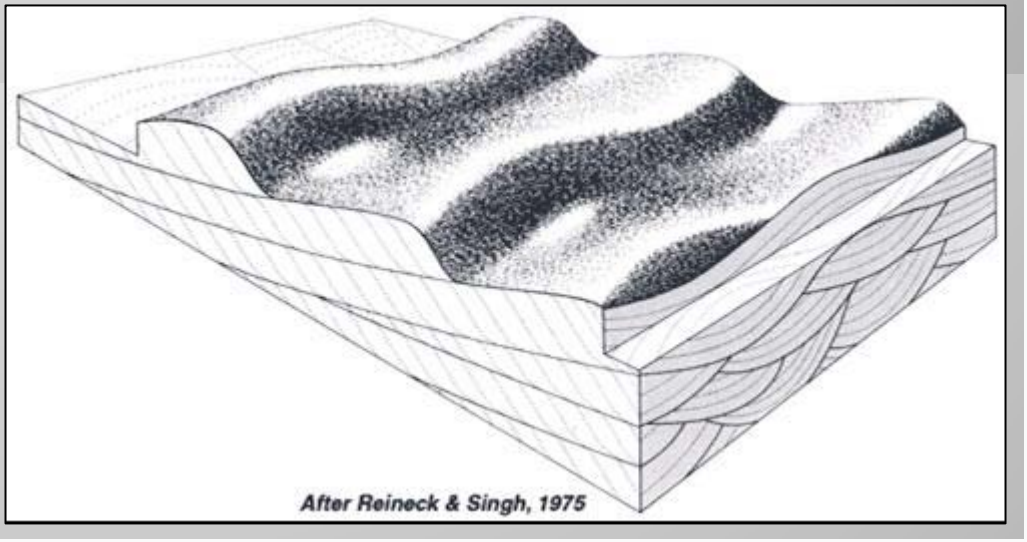


Figure 6.9 Definition diagram for the basic types of cross lamination. The same terms apply at a larger scale to cross bedding (based on Allen 1968).

3D block model...



Planar cross beds created by straight crested ripples

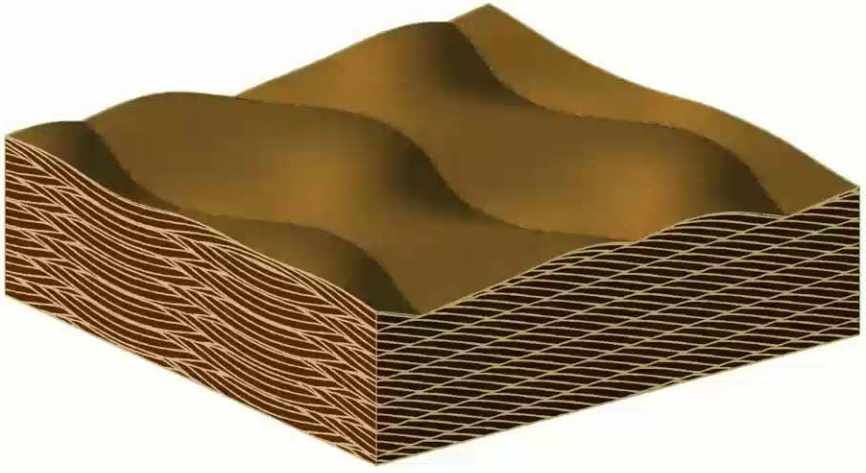


Trough cross beds created by sinuous crested ripples

Basic types of cross lamination

Planar cross beds created by straight crested ripples

Trough cross beds created by sinuous crested ripples

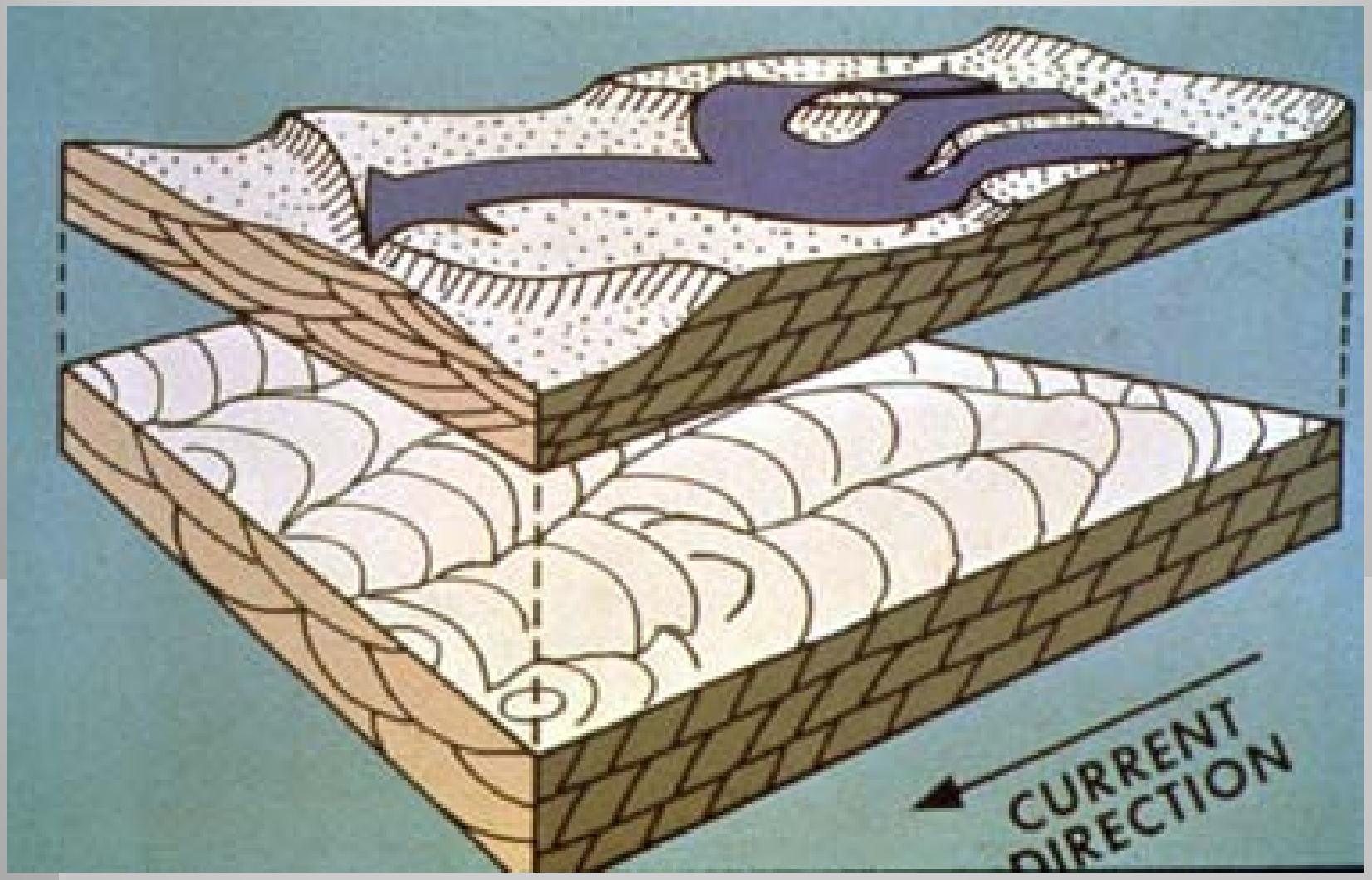


Cross-beds – Cross-strata

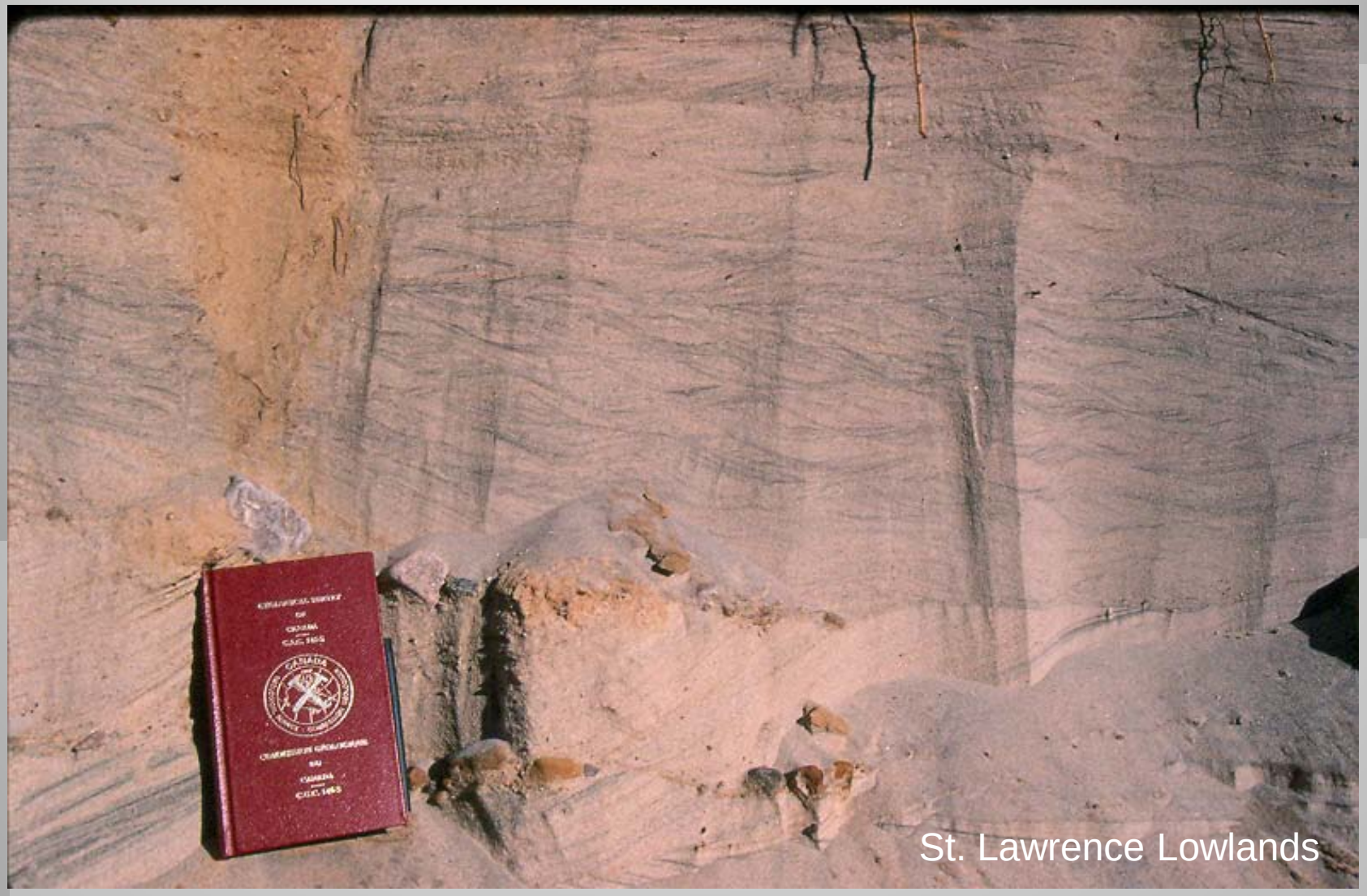
Zion National Park, Utah

Cross-beds – cross-laminations

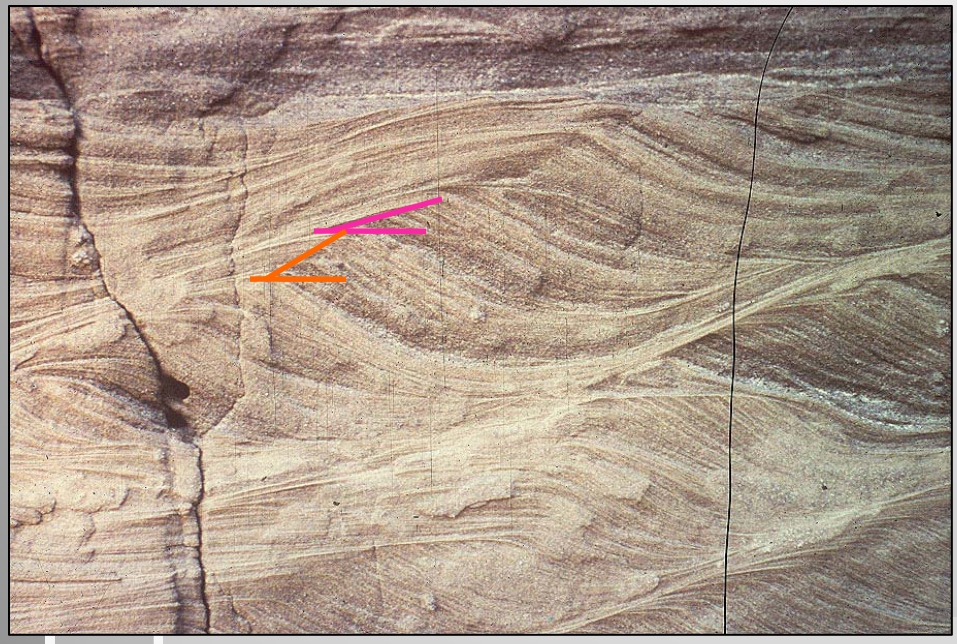
Trough cross bedding

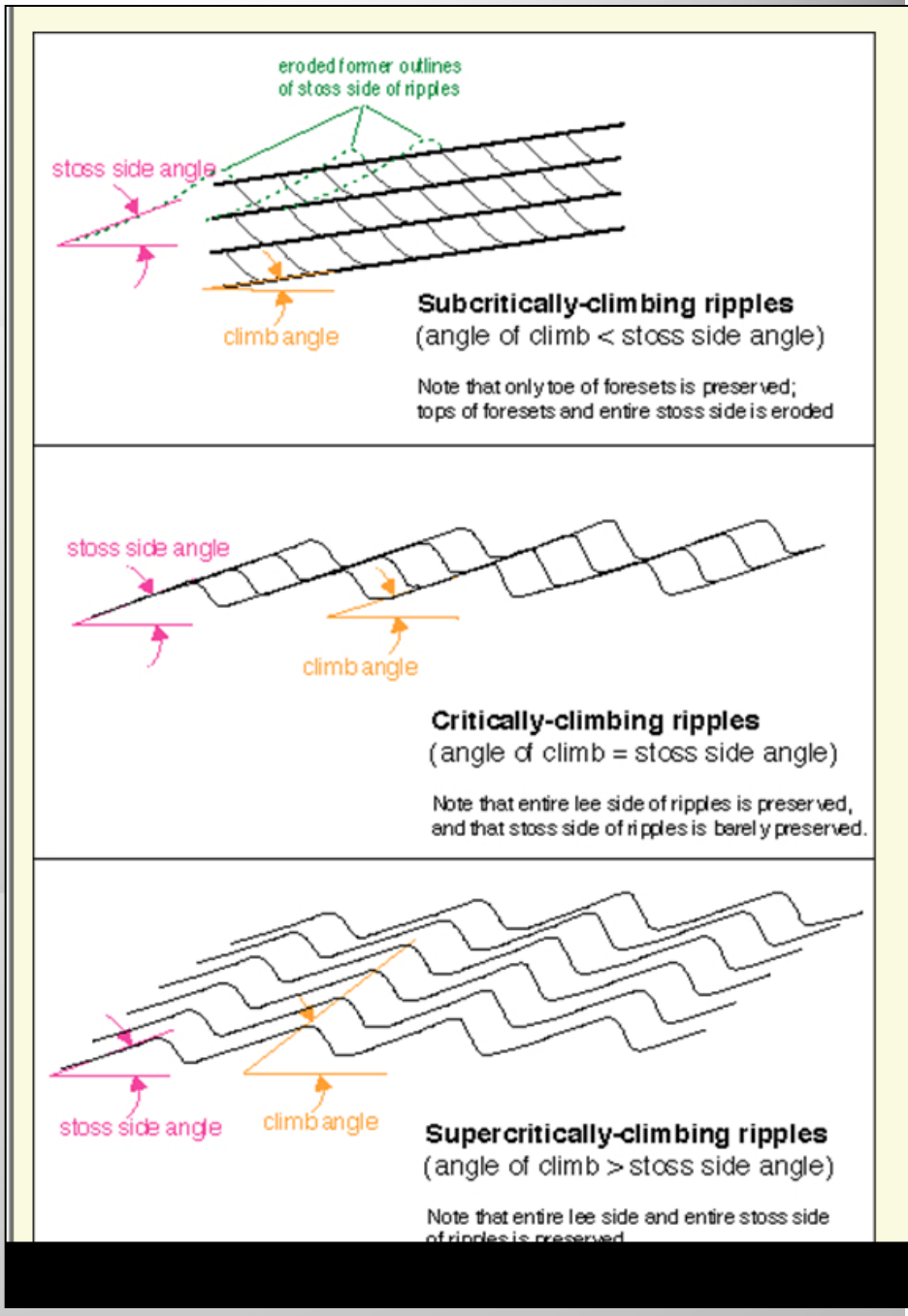


Small-scale trough cross lamination

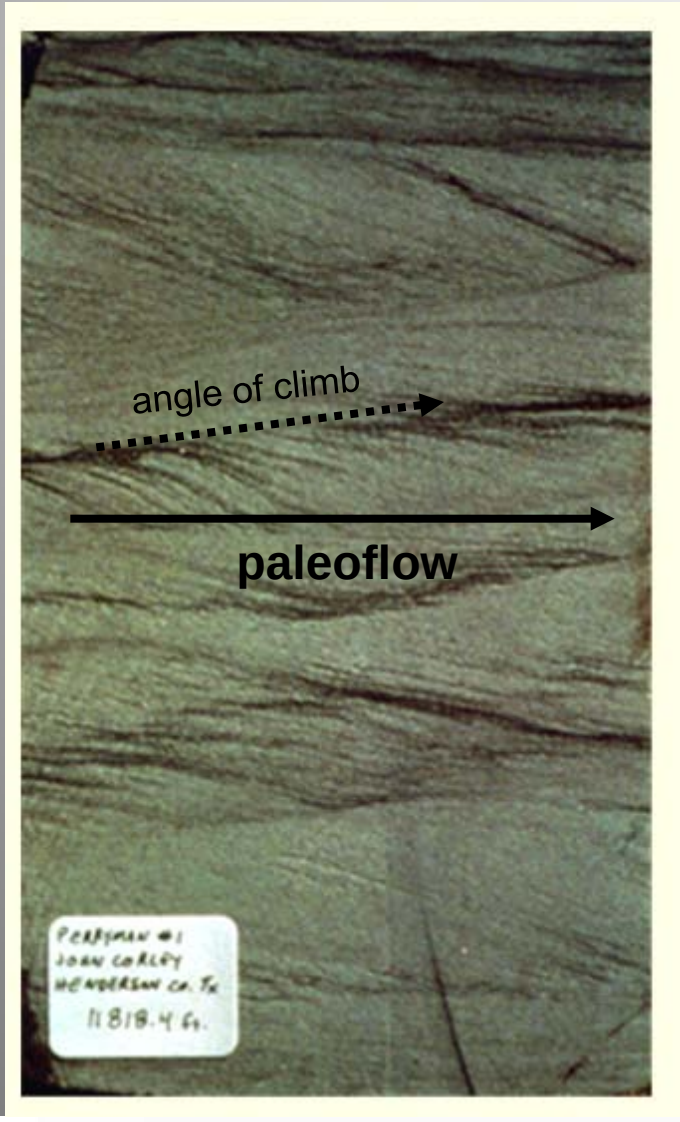


Climbing Ripples





What is the paleoflow direction?



http://www.umt.edu/geosciences/faculty/hendrix/g432/g432_L7.htm

What is the paleoflow direction?

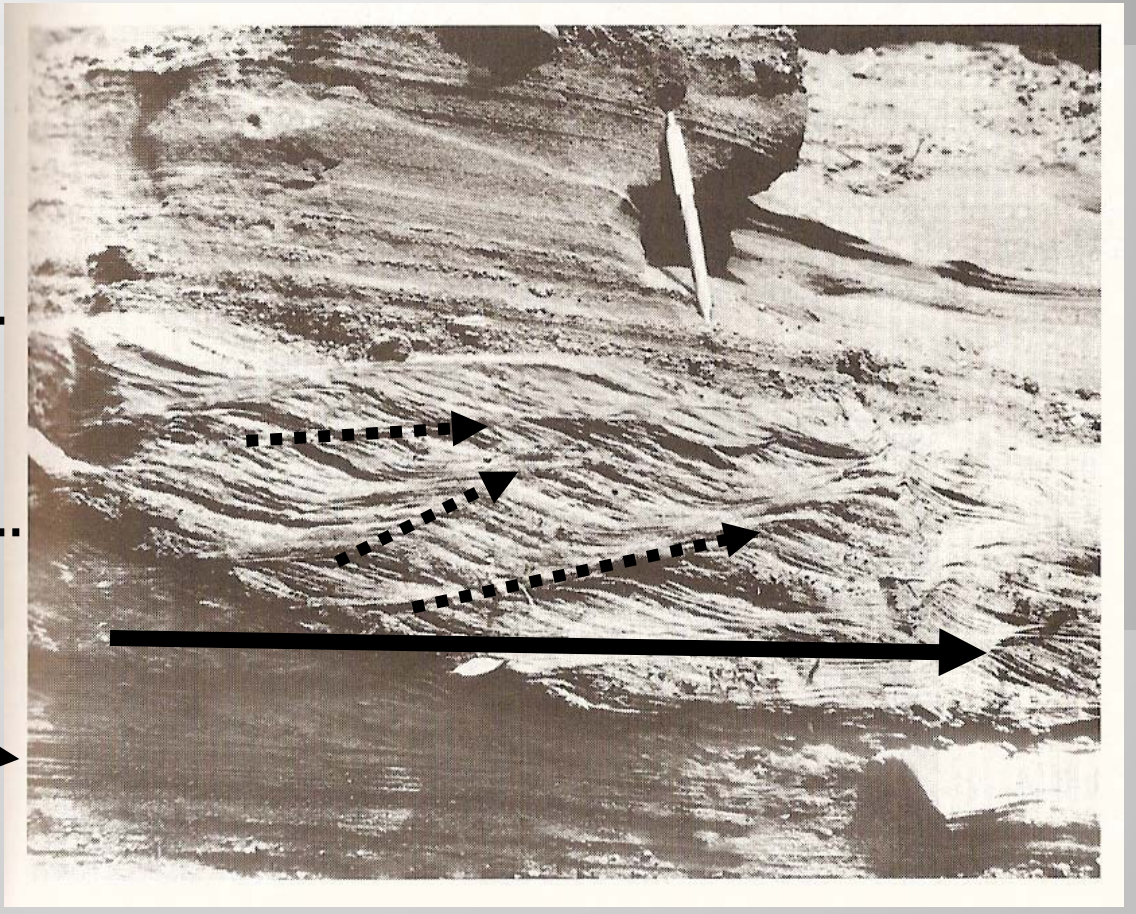
http://www.umt.edu/geosciences/faculty/hendrix/g432/g432_L7.htm

Typical sequence…

Ripple-cross lamination
Low-flow regime

Waning
Flood stage

Plane-bed
Upper-flow regime



Environments characterized by rapid sedimentation from suspension
-Fluvial flood plains, point bars, turbidite sedimentation

Type of bed and bedform? Paleoflow direction?

ca. 4 m

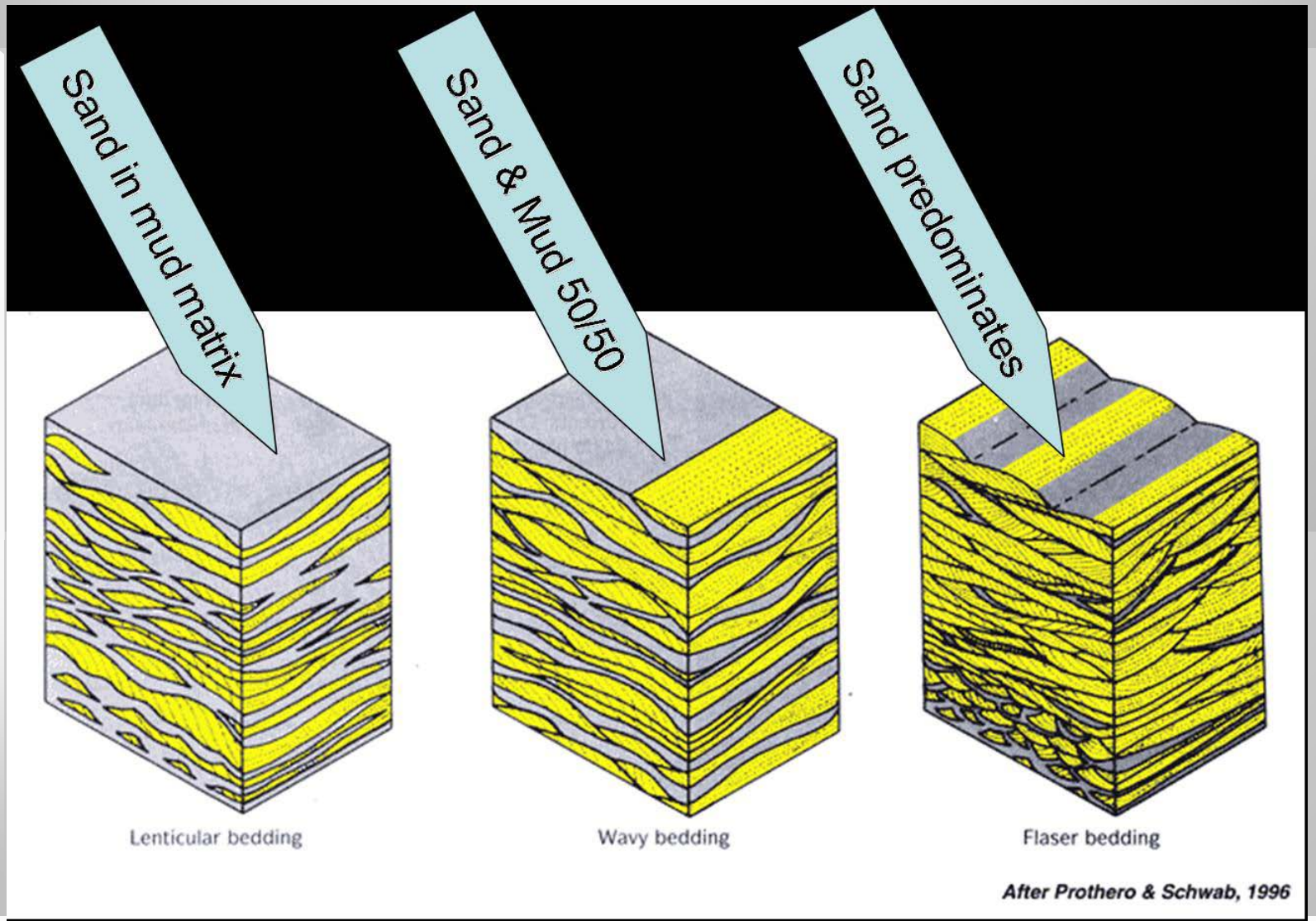
Subcritical climb

Overturned foresets

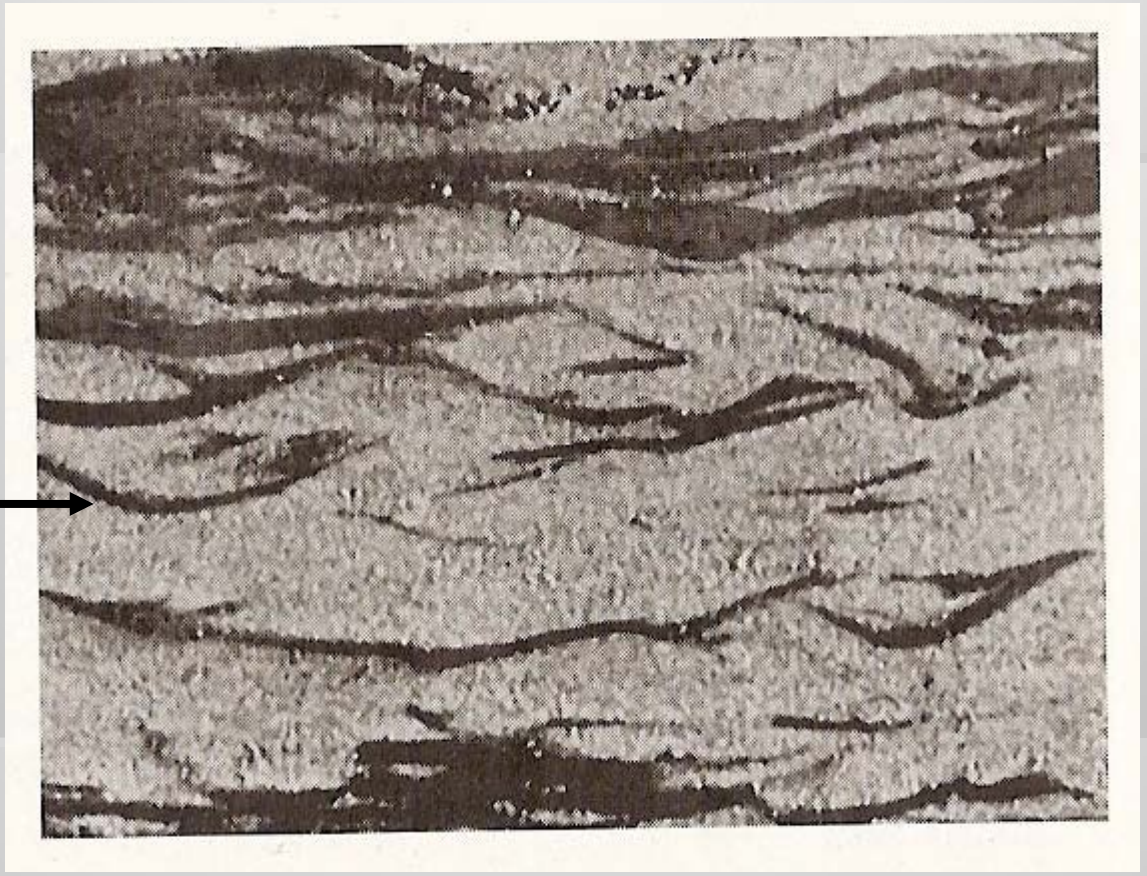
http://www.umt.edu/geosciences/faculty/hendrix/g432/g432_L7.htm

Cross beds and “herringbone” structures

Variations in Grain Size



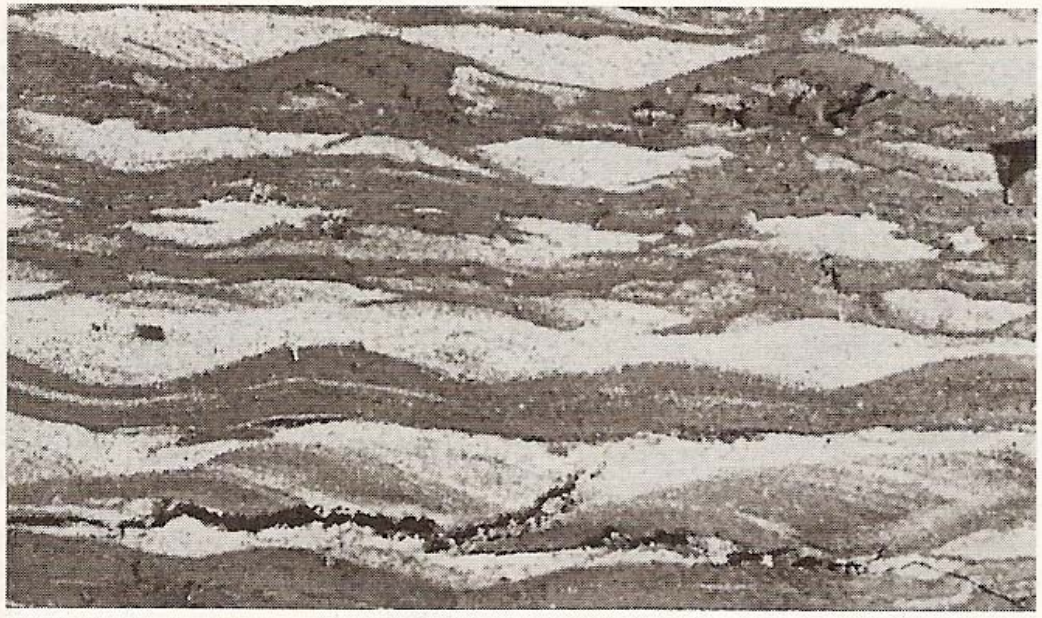
Flaser bedding



Fluctuating hydraulic conditions (current activity and periods of settling)
Deposition and preservation of sand over mud is more favorable

Tidal flats

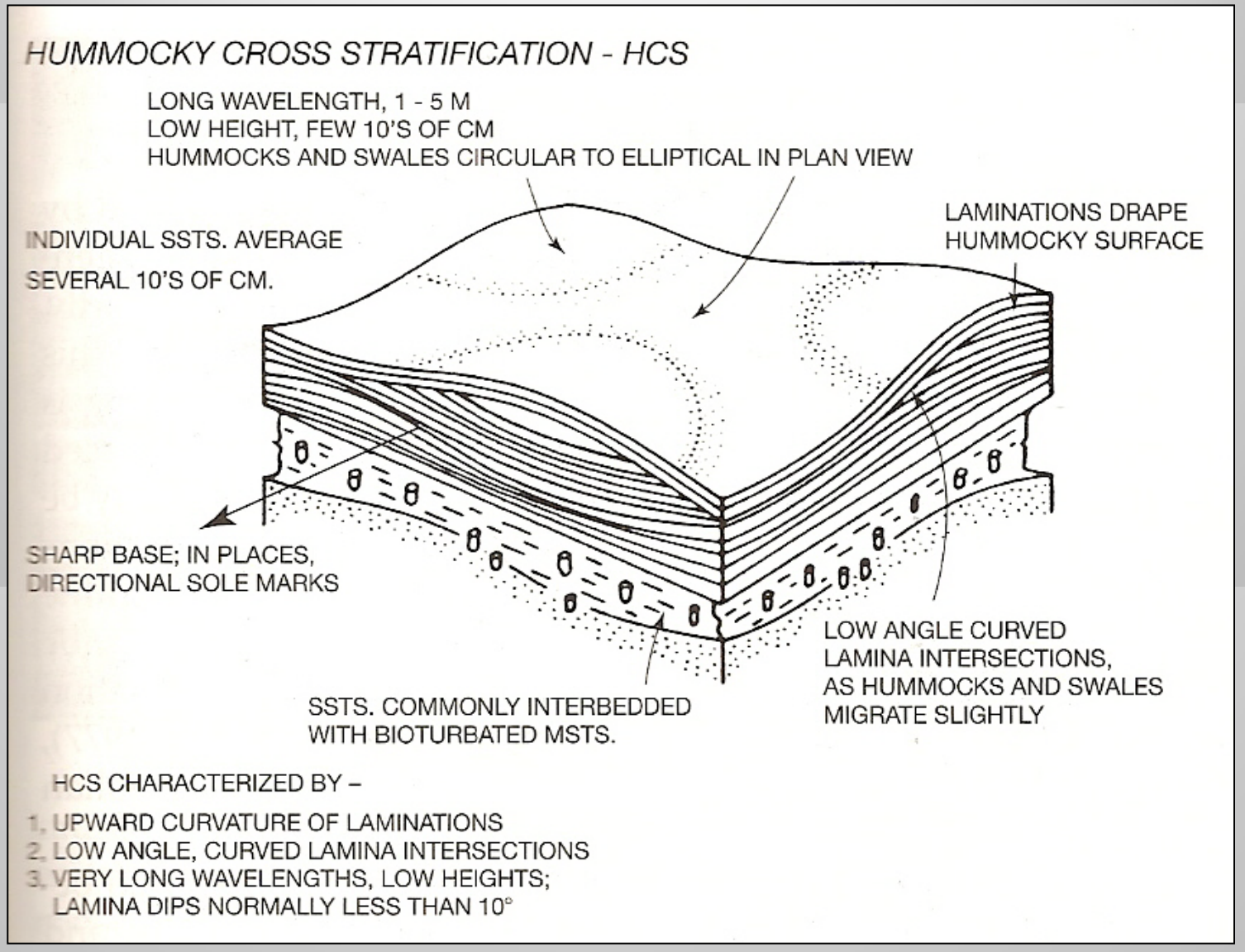
Lenticular bedding



Interbedded mud and discontinuous ripple cross-laminated sand
Deposition and preservation of mud over sand is more favorable

Tidal flats

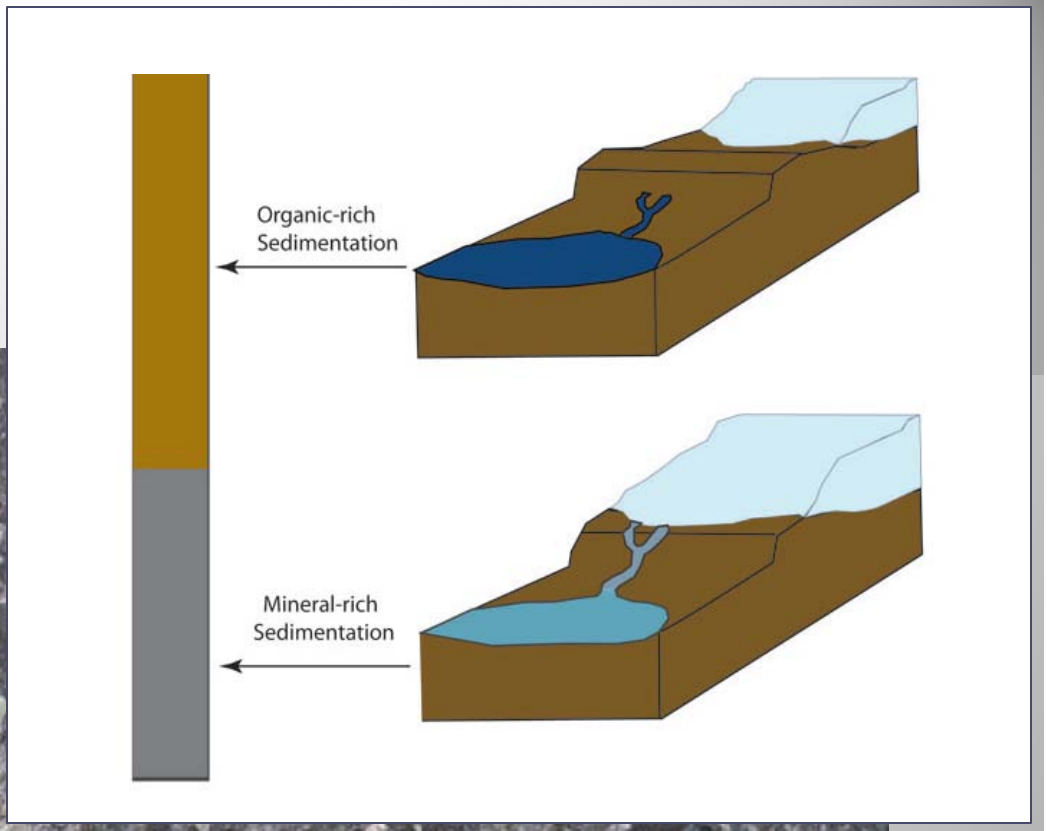
Hummocky cross-beds



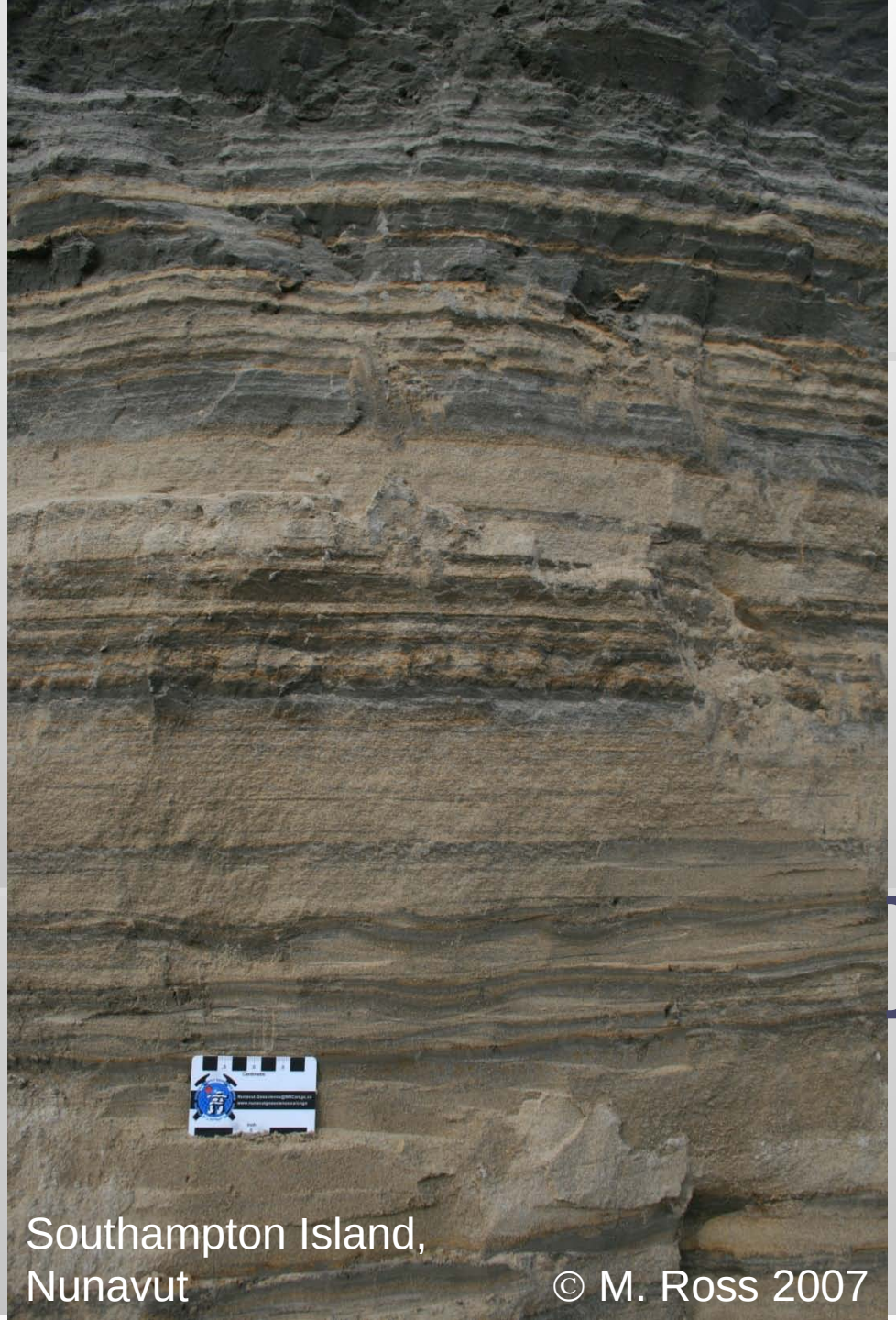
Tempestite beds with hummocky cross stratification, Comstock East outcrop. Note pen for scale. Many of the tempestite beds have concentrations of reworked oysters in the basal part.

Interbedded sand/silt or (mud) beds

Laminae



Southwest Greenland

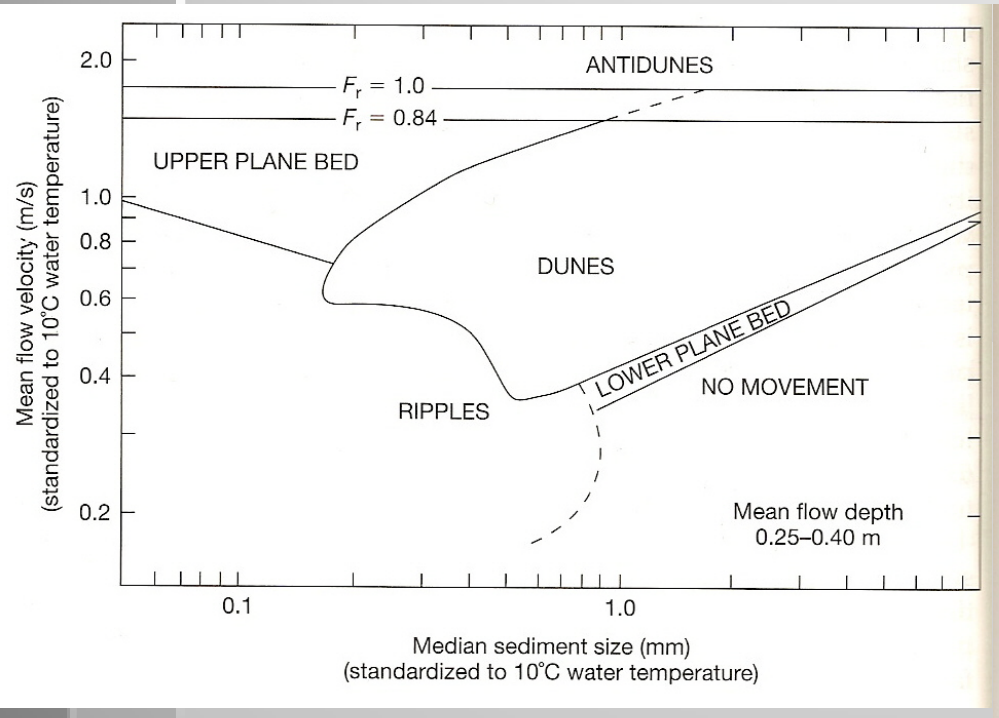

Deeper water
Pro-fan/delta
Marine deposition
Subaqueous fan
deposition
Fining-upward
Ripples
(traction transport; bedload)
and draping laminations
(wavy grey laminae;
particle settling)
Southampton Island,
Nunavut
© M. Ross 2007

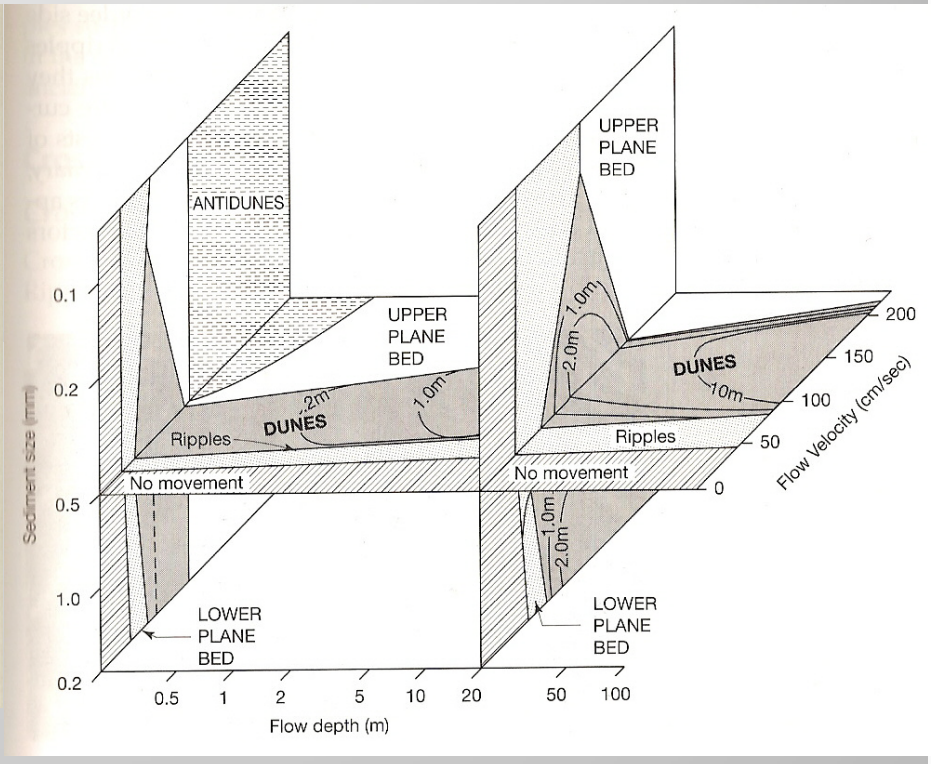
Summary:

- Common Bedforms:
  - Planar Beds
  - Ripples
    - Characteristics (scale, symmetry, orientation.
  - Dunes
  - Anti-Dunes

Summary

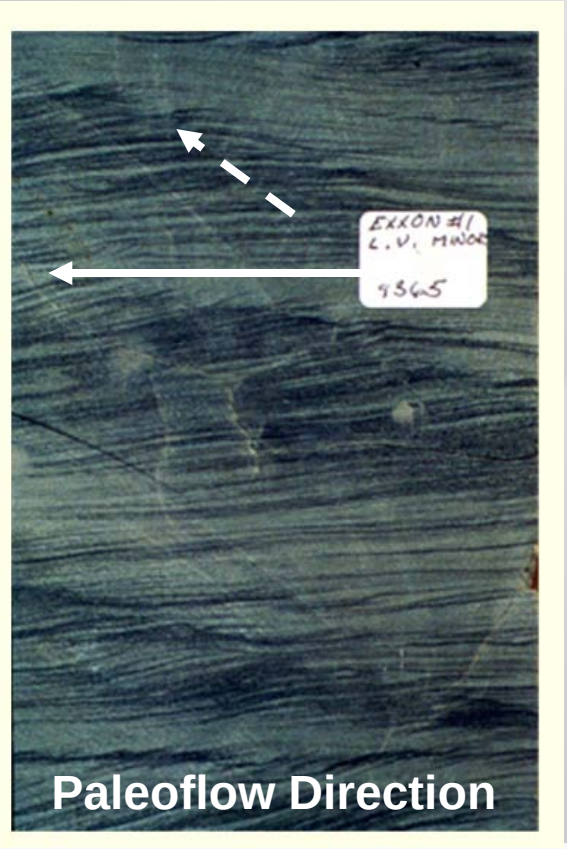
- The effect of grain size and velocity on creating sedimentary structures.





Summary

- Connect sedimentary structures to depositional environment.



Symmetric vs Asymmetric ripples