457.562 Special Issue on River Mechanics (Sediment Transport)

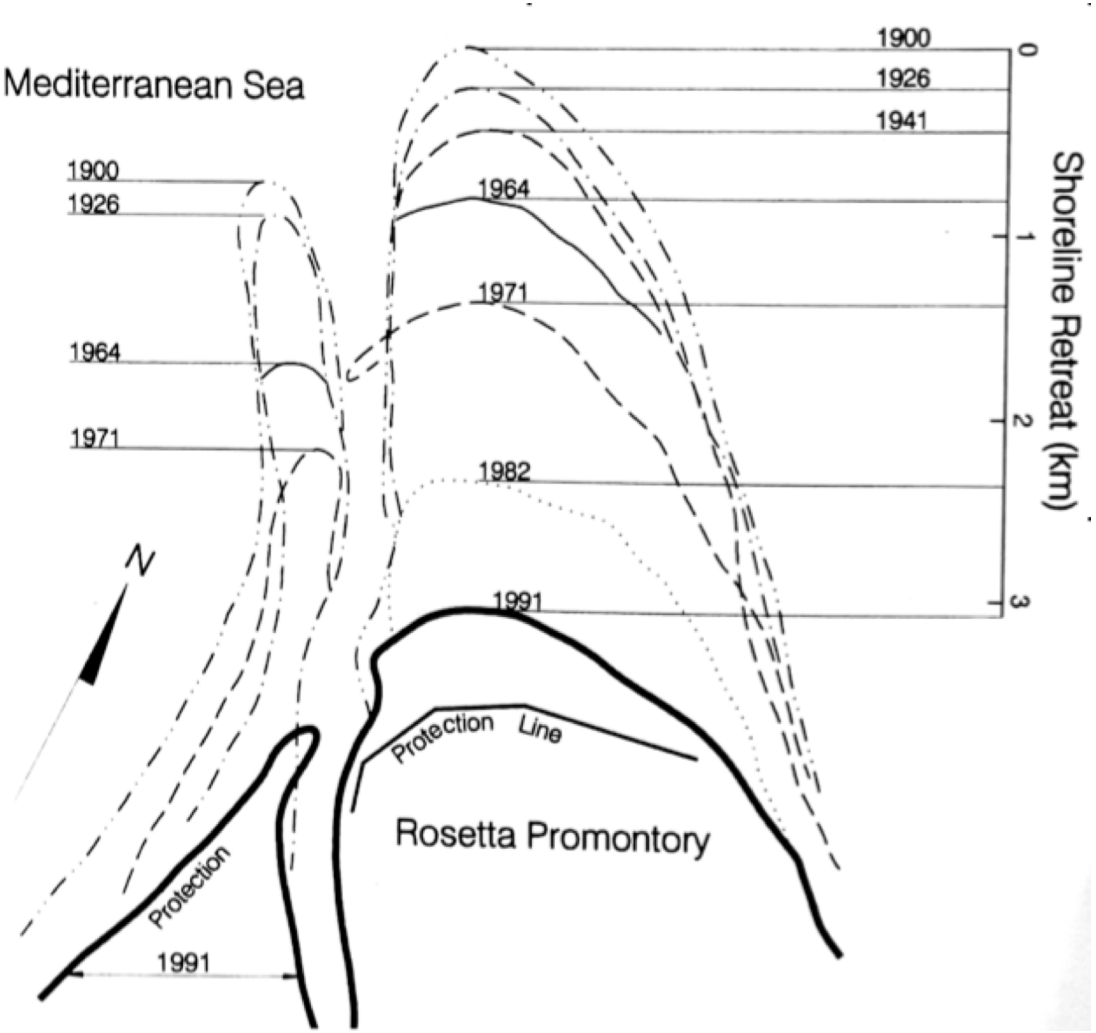
.01 Introduction



Sediment transport

- Nile river delta, historical chan ge of shore lin e
- Aswon high da m

(1967)

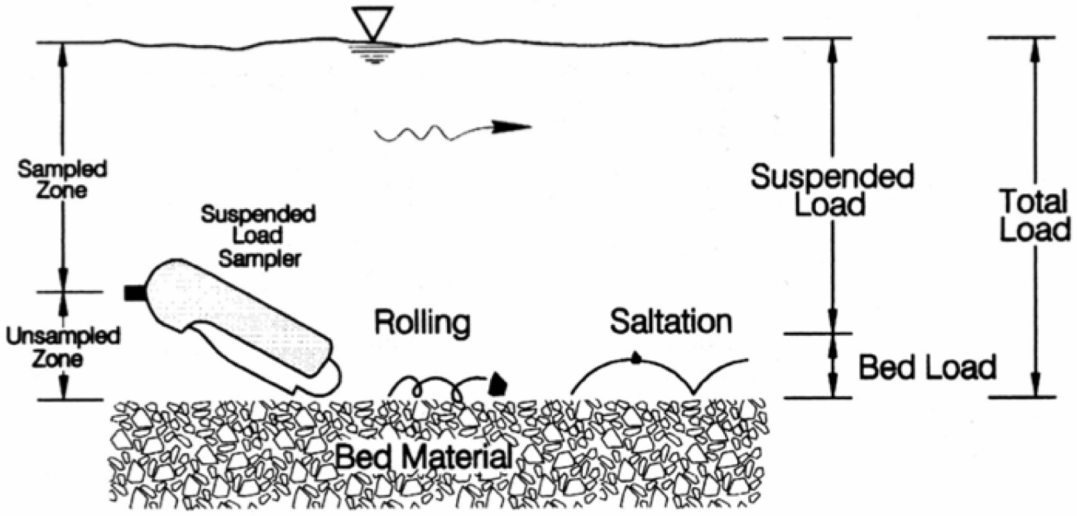


Lecture 1. Introduction

- Sediment Transport
  - Transport of granular particles by fluids
  - Two-phase flow; once phase is fluid and the other is solid
- River
  - Fluid phase is river water
  - Solid phase is sediment grains (e.g., quartz sand)
- The most common modes of sediment transport
  - Bedload and suspended load

Lecture 1. Introduction

- Bedload
  - Rolling
  - Sliding
  - Saltating
  - Never deviating too f ar above bed



- Suspended load
  - The fluid turbulence comes into play carrying the particles well u p into the water column.
- What is the main driving force for loading?
  - Gravity on the fluid phase and it is transmitted to the particles vi a drag.

Lecture 1. Introduction

- Phases
  - Solid Phase can vary greatly in size
    - Clay, silt, sand, gravel, cobbles, and boulders
    - Rock types can include quartz, feldspar, limestone, granite, b asalt, and other less common types such as magnitude
  - Fluid phase
    - Can be almost anything that constitutes a fluid.
    - In geophysical sense, the two fluids of major importance are water and air.

Other types of sediment transport

- Ice related transport
  - Water is supercooled, large quantities of particulate frazil ic e can form.
  - As this water moves under ice cover, one has the phenom enon of sediment transport in rivers stood on its head.
  - The frazil ice particles float rather than sink, and thus tend to accumulate on the bottom side of ice cover rather than ri ver bed.
  - Turbulence tends to suspend the particles downward rather than upward.

Other types of natural two phase flows

- Powder snow avalanche
  - The fluid phase is air
  - The solid phase consists of snow particles.
  - Dominant mode of transport is sus pension.
  - Close to turbidity current, due to th e driving force is gravity on the soli d phase.
  - In snow avalanche and turbidity cu rrents, the solid phase drags the fl uid phase along
    - In the case of sediment transport in rivers, it is accurate to say that the fluid phase drags the solid phase.

Other types of natural two phase flows

- Desert sand dunes
  - The fluid phase is air, but the domi nant mode of transport is saltation rather than suspension
  - Because air is so much lighter tha n water, quarz sand particles saltat e in long, high trajectories, relativel y unaffected by the direct action of turbulent fluctuations.
  - The dunes themselves are created by the effect of the fluid phase acti ng on the solid phase.
    - They, in turn, affect the fluid phase by changing the resistance.

Other types of natural two phase flows

- Single phase like
  - In the limiting cases of vanishing solids, the field reduces to pure fluid mechanics.
  - Grain flows:
    - Extreme case of avalanche (no air inside), that of the flow o f a granular substance in a vacuum.
    - Slab avalanche of snow

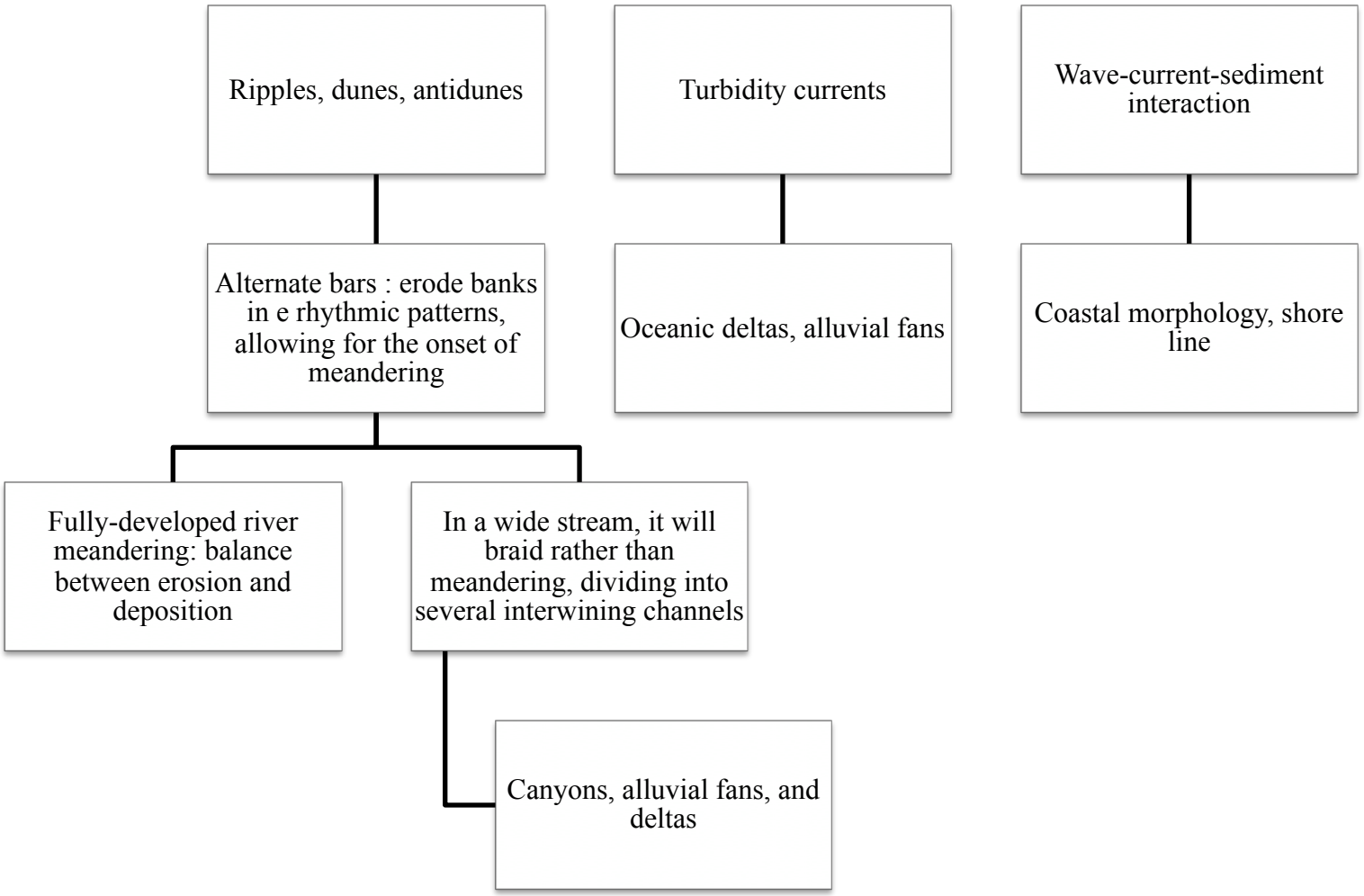
Other types of natural two phase flows

- Intermediate cases: the solid and fluid phases are pres ent in similar quantities.
  - Debris flows
    - Typically carry a heterogeneous mixture of grain sizes rangi ng from boulders to clay
  - Slurries
  - Hyperconcentrated flows
    - Slurries and hyperconcetrated flows are generally restricted to finer grain sizes.
- In most cases, it proves useful to think of such flows as consisting of a single phases, the mechanics of which a re highly non-Newtonian.

In the River

- The relative contribution of bedload vs. suspended load, a variety of rhythmic structures can form on the river bed .
  - Ripples, dunes, antidunes, and alternate bars
- The first three of these can have a profound effect on res istance to flow
  - Act to control river depth
- River banks themselves can also be considered to be a self-formed morphological feature.
  - Thus specifying the entire ***Container***

In the river


Ripples, dunes, antidunes
Turbidity currents
Wave-current-sediment interaction
Alternate bars : erode banks in e rhythmic patterns, allowing for the onset of meandering
Oceanic deltas, alluvial fans
Coastal morphology, shore line
Fully-developed river meandering: balance between erosion and deposition
In a wide stream, it will braid rather than meandering, dividing into several interwining channels
Canyons, alluvial fans, and deltas

Sediment transport

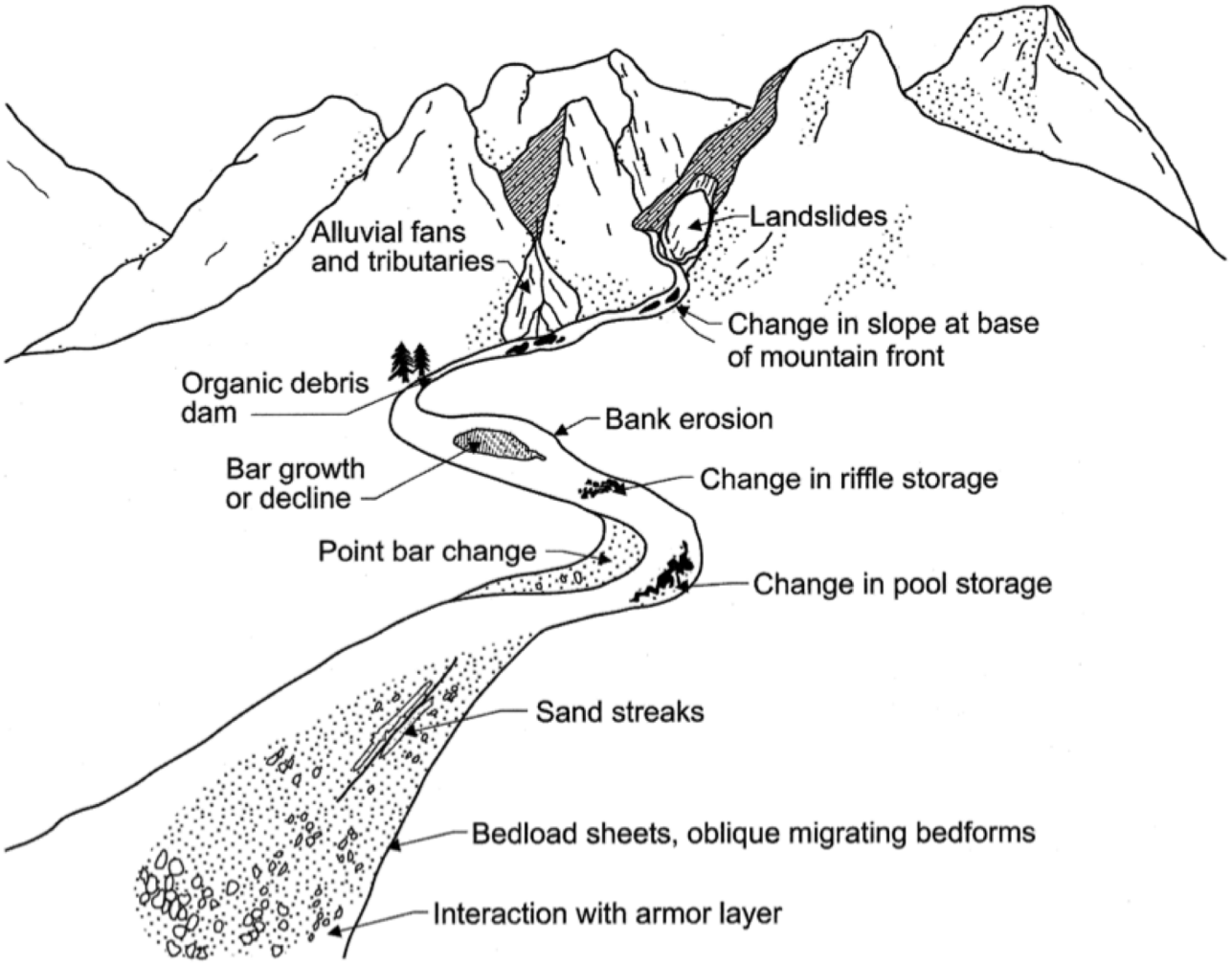


Fig. 2-1. Sedimentation processes and associated morphological changes in a Watershed (adapted from Dietrich and Gallinatti 1991).