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DI PADOVA

# Significance of the sediment properties and aquatic environmental conditions on the erodibility of deposited beds

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# the sediment transport problem

previous studies highlighted the strong influence of fractions of **organic** and **cohesive** sediments on the resistance to erosion of deposits in aquatic environments

ecological impacts  
enhance on prediction performance



more sustainable management of the  
pollution and anthropogenic impacts  
on natural environments



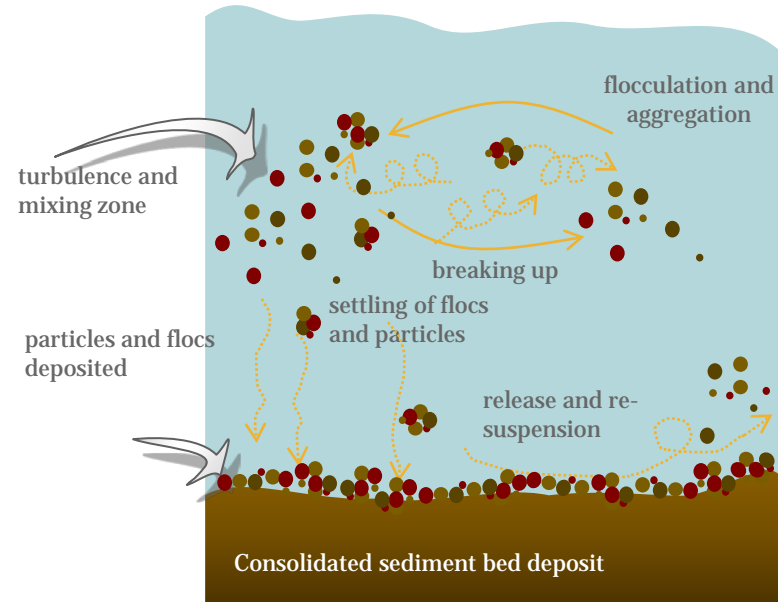
# sediment transport load prediction

deposition , release, re-suspension and transport

hydraulic, dynamics  
of water flows

cohesive sediments and sediment  
mixtures

mechanical and biochemical  
interaction between particles

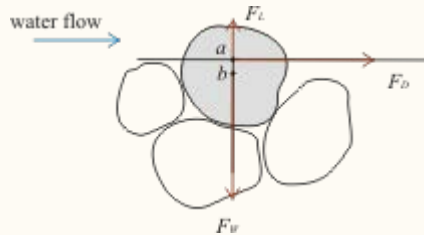


# entrainment and transport

## non-cohesive sediment deposits

eroded, transported or deposited  
depended on physical factors

- particle size and shape
- sediment density
- flow rate of the water



## cohesive and sand-mud mixtures deposits

relevant influence of interaction between  
particles

- **binding forces** (cohesion and adhesion)
- **flocculation** and particles **break down** (dependent on suspended sediment concentration)

## initiation of motion

difficulties in predicting entrainment leads to  
high **uncertainty** in predicting transport loads



# objective

sediment properties significance on transport mechanisms



highlight significance on  
assessment of re-suspension and  
mobilization mechanisms in  
aquatic environments

reliable predictions on cohesive  
sediment transport loads

# sediment properties

## sediment beds in aquatic environments

- complex mixtures of inorganic and organic material
- non-homogeneous particle size distribution
- non-homogeneous chemical and biological composition
- can vary widely in composition depending on time dependent sources (punctual anthropogenic sources)

pollutants (heavy metals, hydrocarbons, organic matter, nutrients) attached to finest sediment fraction

environmental conditions leads to physical, chemical and biological transformation processes within deposits

# attributes affecting erodibility

Physical  
characteristics

Biochemical and  
biological factors

# attributes affecting erodibility

## Physical characteristics

### Particle size

- mean particle size
- distribution of particle size by ranges
  - Inter-particle forces enhanced in fine sediments
- “effective particle size” (apparent sediment floc diameter)

### Porosity and water content

Combined volume occupied by particles and inter-particle voids

$$p = \frac{V_v}{V_T} \quad \uparrow p \quad \uparrow \text{erodibility}$$

### Bulk density ( $\rho_b$ )

$$\rho_b = \frac{m_{dry}}{V_T}$$

Proportion between solid and water in bed

Level of consolidation



# attributes affecting erodibility

## Biochemical and biological factors

### composition

- organic matter, clay type, salinity
- microorganism presence

### environmental conditions

- temperature, oxygen availability

residence time in the deposit



role in  
inter-particles  
bonding

deposit structure might  
be strengthened or  
weakened under  
environment influence

# consolidation in cohesive sediments

## Physical consolidation

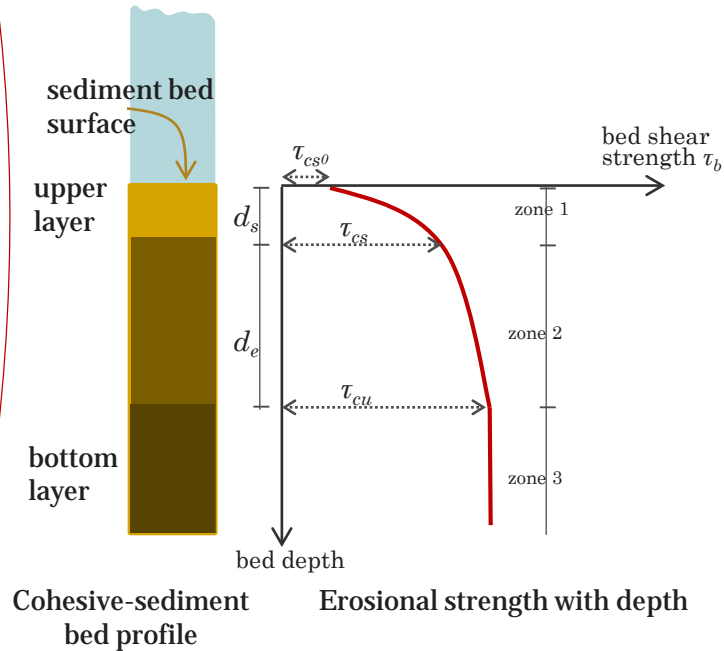
- self-weight consolidation
- time dependent physical mechanisms on intra-grain pore water

## Biological consolidation

- complex time-dependent transformation processes (maturation, dehydration, biological and chemical degradation, organic matter decomposition)
- biological transformations and microorganisms growth strong influenced by environmental conditions (temperature, oxygen availability, residence time)

Both process might act simultaneously or at different times

# consolidation in cohesive sediments

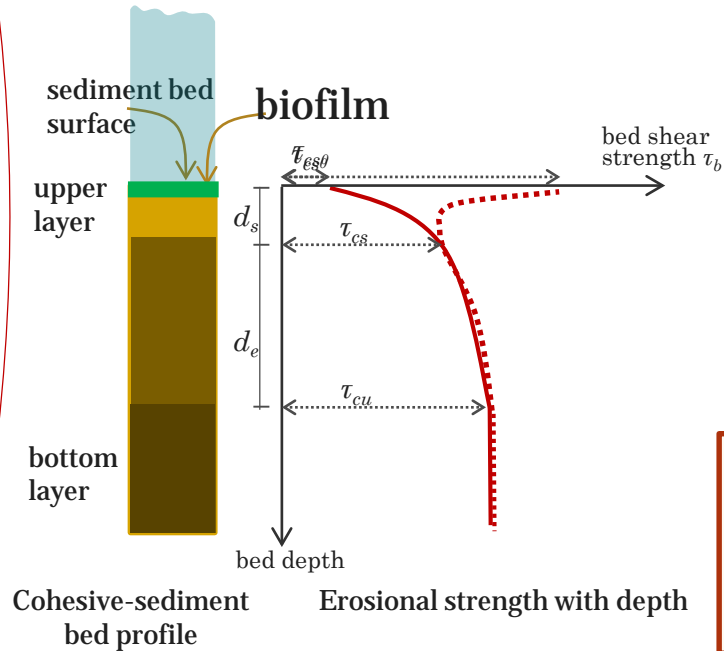


## vertically stratified sediment beds (erosion strength)

- specific thickness
- specific critical shear stress
  - linked to the layer bulk density and consolidation time

**Sediment bed strengthens  
with depth**

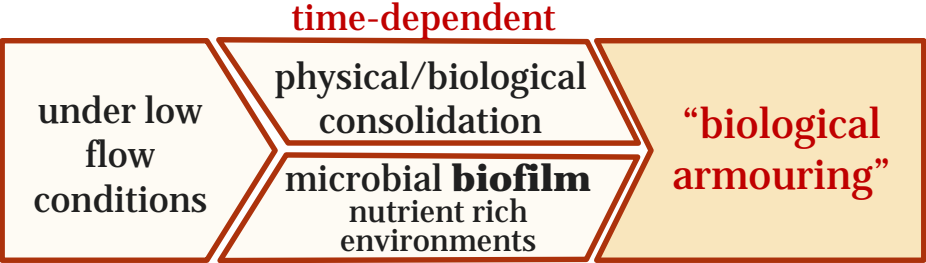
# consolidation in cohesive sediments



**SFGL**  
(superficial fine-grained lamina)

low density and high porosity layer (initial low resistance)

- sediments that are continuously flocculating and re-suspending



↑ consolidation time

↑ probability of formation of stronger consolidated biological layer at the top



# summary of the review

## sediment characteristics

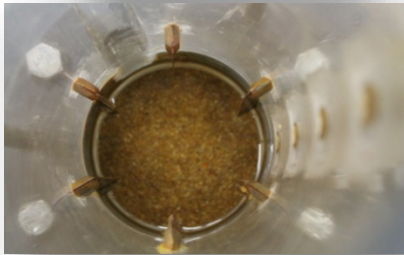
- influencing on deposition and consolidation of deposits
- assessing re-suspension and mobilization mechanisms
- enhancing transport prediction performance

## quantitative evaluation of critical shear stress cohesive deposits

- complex assessment  
interaction of transformation processes  
(physical, chemical and biological)
- strongly time and environmental dependent  
residence time in the deposit, consolidated bed structure
- site specific  
variability in sediment nature and behaviour



# ongoing work



- analysis previous results from **erosion** tests with **cohesive** sediment mixtures at controlled conditions
  - analysis of **turbulence** and **organic** composition influence on **flocculation**, and thus on erodability
- broaden the knowledge to understand and quantify **interaction** between biological processes in cohesive sediments and particles collision

# acknowledgements



The research leading to these results has received funding from the European Community's Seventh Framework Programme FP7-PEOPLE-2012-ITN under grant agreement n° 316546.



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# Thanks for your attention

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