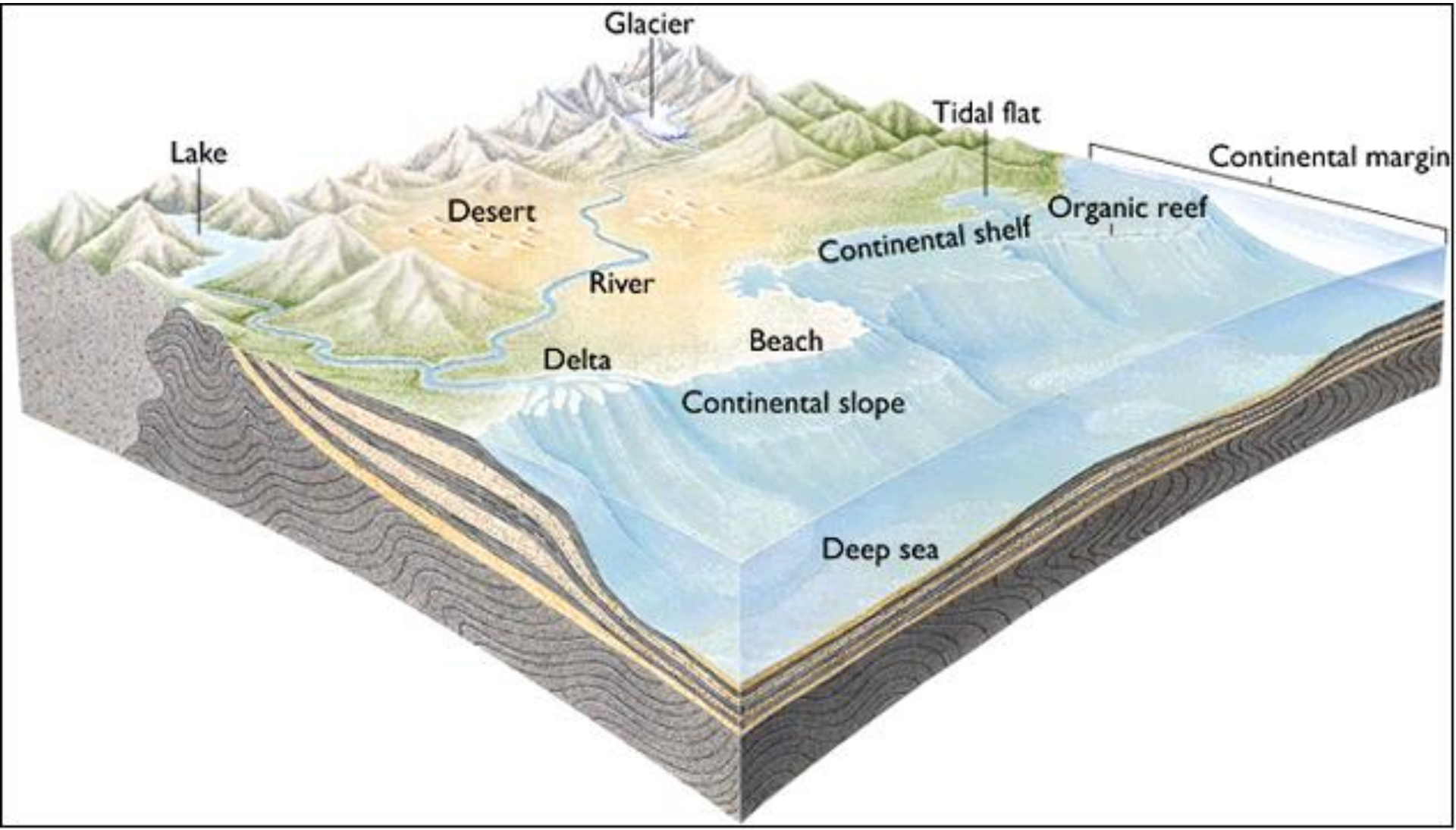
Sedimenti

Stefano Lugli



Proprietà base

- Composizione: mineralogica, chimica
- Tessitura: caratteristiche dei componenti (granuli)
- Struttura: stratificazione

- Sabbia:
- quarzosa, carbonatica
- granuli di varie dimensioni a spigoli vivi o arrotondati
- stratificazione prodotta da onde nella spiaggia o da vento nel deserto

Classificazione dei sedimenti

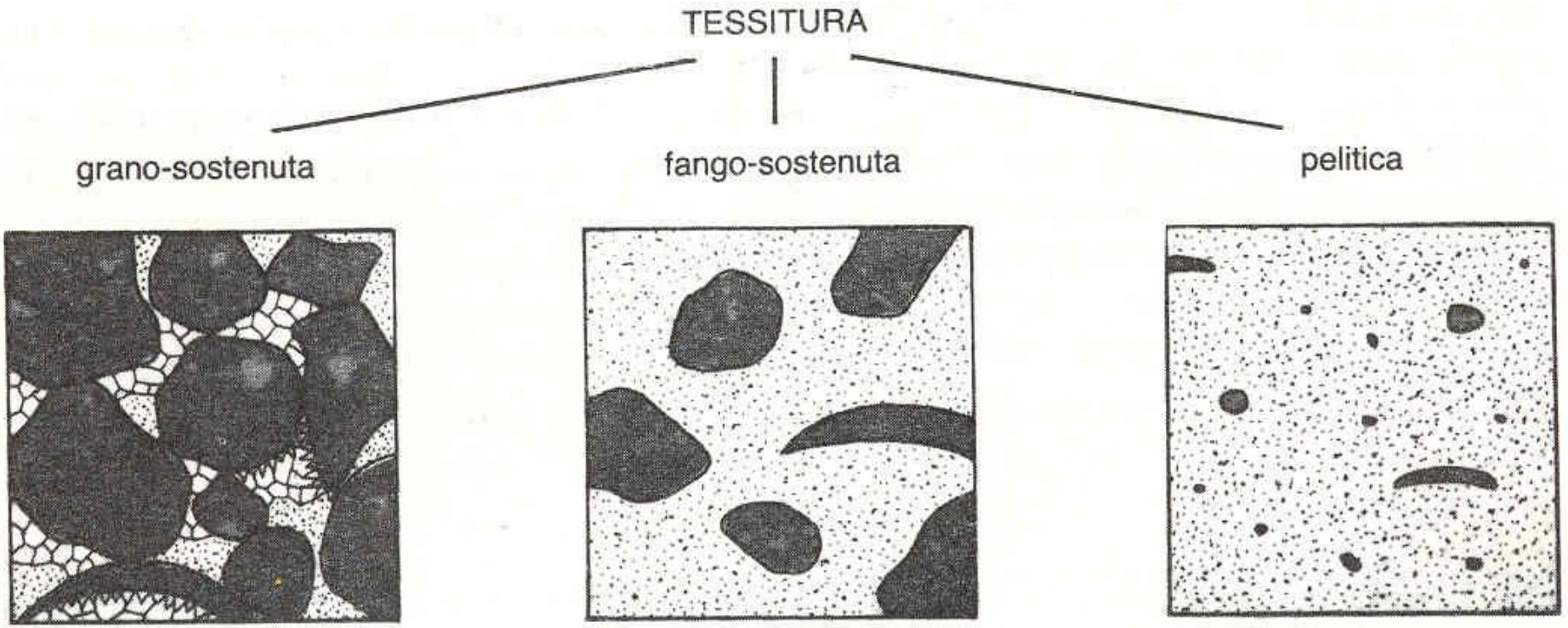
- **Componenti terrigeni**: derivano dalla disgregazione e frammentazione di rocce preesistenti e vengono trasportate nel bacino di sedimentazione come particelle singole (granuli di quarzo, feldspato, frammenti di calcare, ecc.)
- **Componenti allochimici**: particelle originate per precipitazione chimica o secrezione organica direttamente nel bacino di sedimentazione dove possono essere poi spostate e accumulate (gusci interi)
- **Componenti ortochimici** precipitati chimici prodotti all'interno del bacino o nel sedimento stesso e non hanno subito trasporto (concrezioni)

Componenti tessiturali dei sedimenti

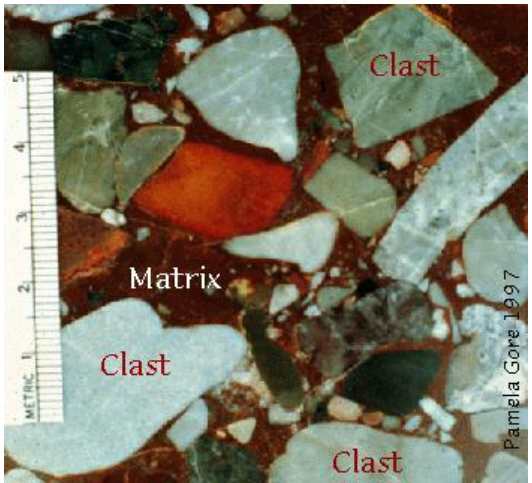
- Granuli: ossatura che sostiene il peso del sedimento
- Vuoti: occupati da fluidi o fango che fa da matrice dell'impalcatura granulare (successivamente possono essere eliminati dal costipamento o riempiti da precipitati chimici)

- Impalcatura granulare (granuli), fango detritico (matrice) e precipitati chimici (cemento)

Tessitura e matrice: significato idrodinamico



Alta energia



Bassa energia

Composizione

Granuli terrigeni

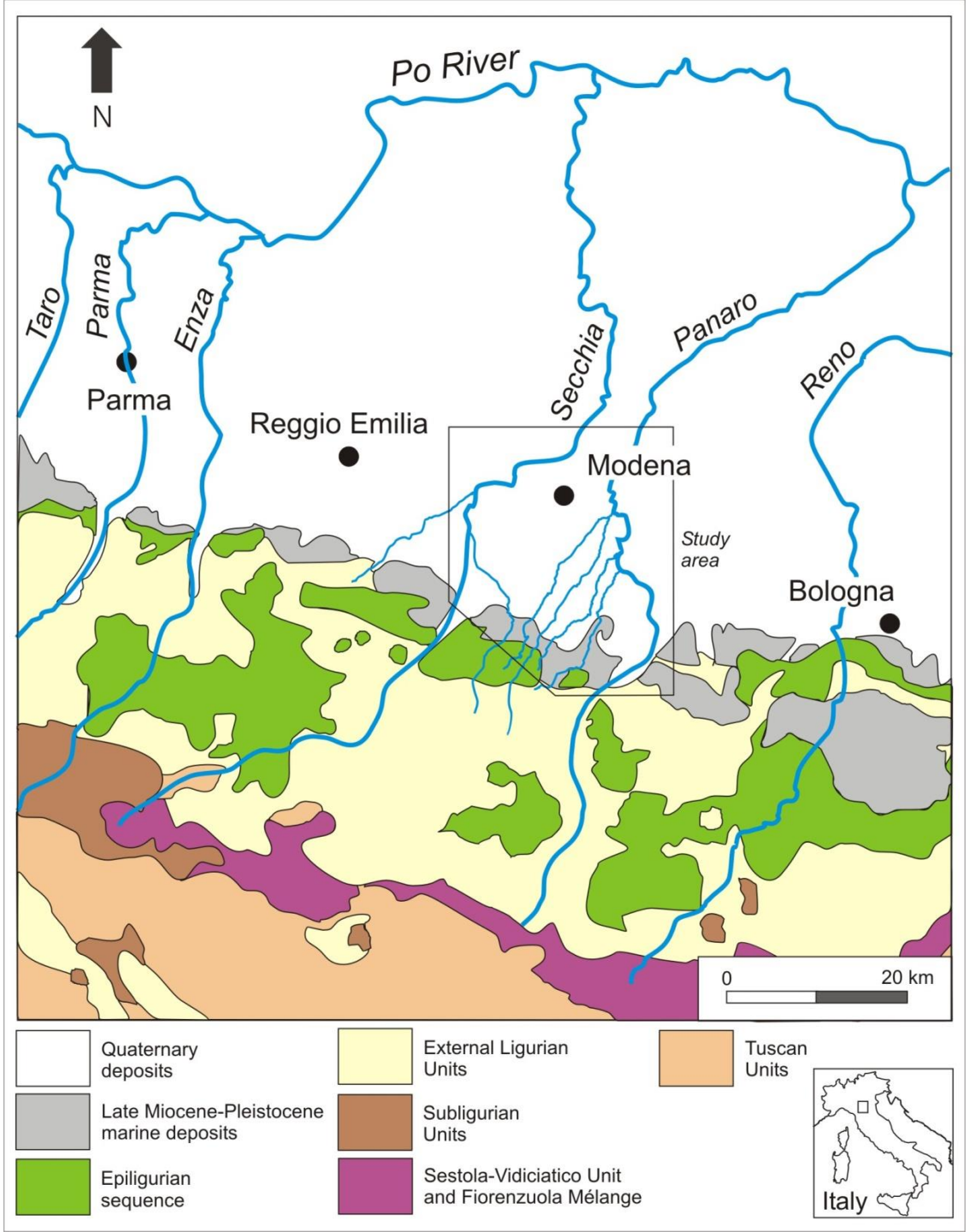
Area provenienza

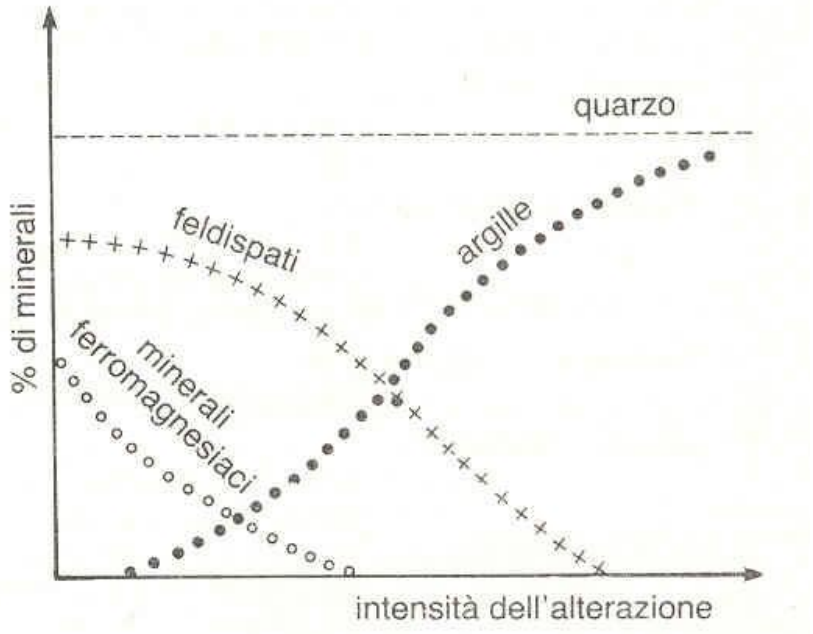
Clima e rilievo (stabilità chimica)

Durata e intensità del trasporto (resistenza meccanica)

Minerali ortochimici

Condizioni chimiche ambiente di deposizione (pH, Eh, temperatura, età)





Proximal
to weathered rocks

Distal

Intensity of Weathering

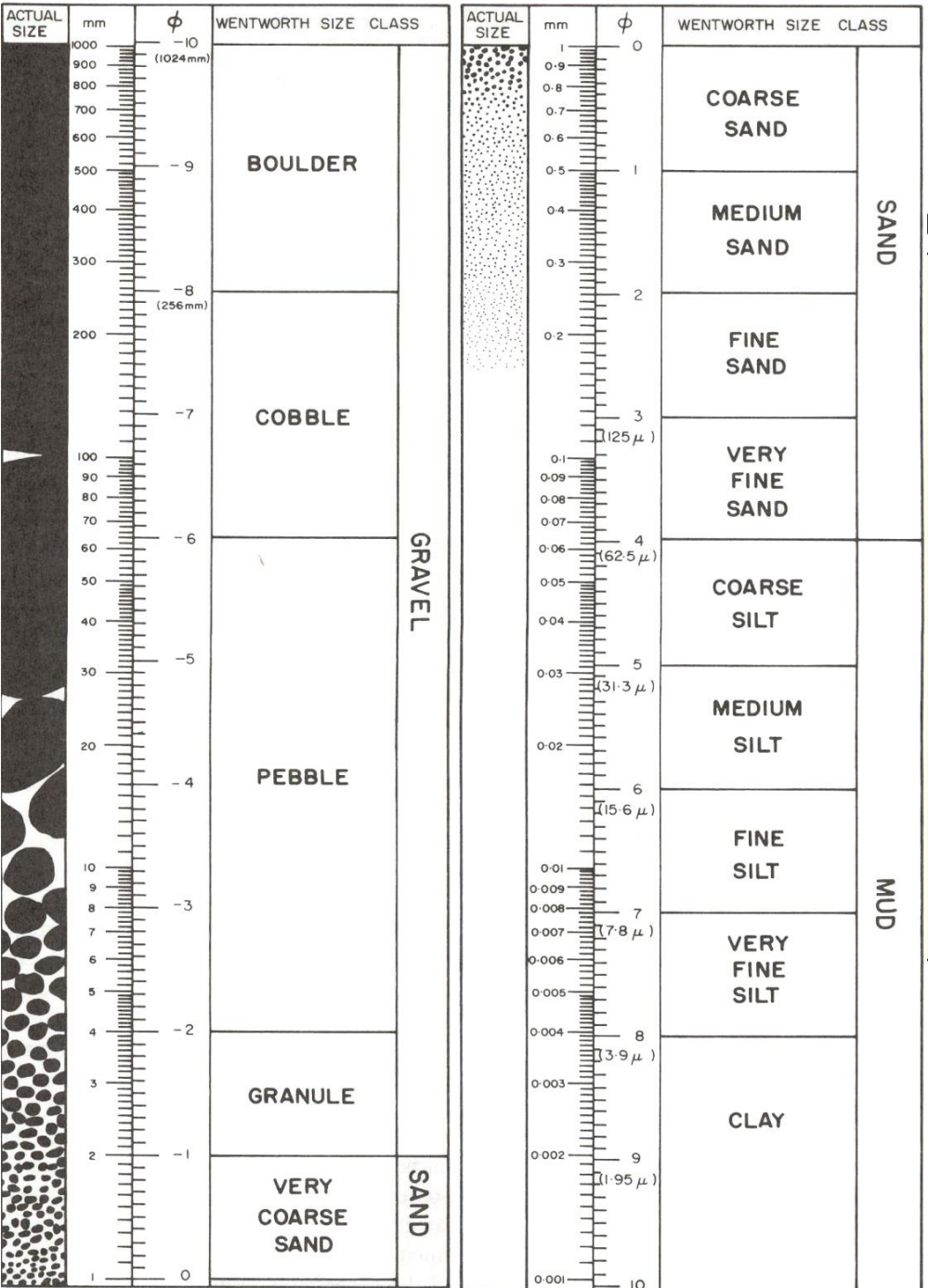
Low	Medium	High
Quartz	Quartz	Quartz
Feldspar	Feldspar	Clay minerals
Mica	Mica	
Pyroxene	Clay minerals	
Amphibole		

SCALA GRANULOMETRICA

MILLIMETRI	MICRON	SCALA Ø	CLASSI GRANULOMETRICHE (Wentworth)	
4096		−12	Blocchi	
256		−8	Ciottoli	GHIAIA
64		−6	Ciottoletti	GHIAIA
4.00		−2	Granuli	GHIAIA
3.36		−1.75	Granuli	GHIAIA
2.83		−1.50	Granuli	GHIAIA
2.38		−1.25	Granuli	GHIAIA
2.00	2000	−1	Granuli	GHIAIA
1.68		−0.75	Sabbia molto grossa	SABBIA
1.41		−0.50	Sabbia molto grossa	SABBIA
2.19		−0.25	Sabbia molto grossa	SABBIA
1.00	1000	0	Sabbia molto grossa	SABBIA
0.84		0.25	Sabbia grossa	SABBIA
0.71		0.50	Sabbia grossa	SABBIA
0.59		0.75	Sabbia grossa	SABBIA
0.50	500	1	Sabbia grossa	SABBIA
0.42	420	1.25	Sabbia media	SABBIA
0.35	350	1.50	Sabbia media	SABBIA
0.30	300	1.75	Sabbia media	SABBIA
0.25	250	2	Sabbia media	SABBIA
0.210	210	2.25	Sabbia fine	SABBIA
0.177	177	2.50	Sabbia fine	SABBIA
0.149	149	2.75	Sabbia fine	SABBIA
0.125	125	3	Sabbia fine	SABBIA
0.105	105	3.25	Sabbia molto fine	SABBIA
0.088	88	3.50	Sabbia molto fine	SABBIA
0.074	74	3.75	Sabbia molto fine	SABBIA
0.0625	62.5	4	Sabbia molto fine	SABBIA
0.053	53	4.25	Silt grosso	SILT (limo) / FANGO
0.044	44	4.50	Silt grosso	SILT (limo) / FANGO
0.037	37	4.75	Silt grosso	SILT (limo) / FANGO
0.031	31	5	Silt grosso	SILT (limo) / FANGO
0.0156	15.6	6	Silt medio	SILT (limo) / FANGO
0.0078	7.8	7	Silt fine	SILT (limo) / FANGO
0.0039	3.9	8	Silt molto fine	SILT (limo) / FANGO
0.0020	2	9	ARGILLA ↓	FANGO
0.00098	0.98	10	ARGILLA ↓	FANGO
0.00049	0.49	11	ARGILLA ↓	FANGO
0.00024	0.24	12	ARGILLA ↓	FANGO

$\Phi = -\log_2 \text{diam}$

The Udden-Wentworth grade scale for grain sizes, with σ/mm conversion chart



Phi Units*	Size	Wentworth Size Class	Sediment/Rock Name
-8	256 mm	Boulders	Sediment: GRAVEL Rock RUDITES: (conglomerates, breccias)
-6	64 mm	Cobbles	
-2	4 mm	Pebbles	
-1	2 mm	Granules	
0	1 mm	Very Coarse Sand	Sediment: SAND Rocks: SANDSTONES (arenites, wackes)
1	1/2 mm	Coarse Sand	
2	1/4 mm	Medium Sand	
3	1/8 mm	Fine Sand	
4	1/16 mm	Very Fine Sand	
8	1/256 mm	Silt	Sediment: MUD Rocks: LUTITES (mudrocks)
		Clay	

Udden-Wentworth Scale

Grains visible with naked eye

Grains visible with naked eye (course), with aid of x10 hand lens (fine)

Grains not visible with aid of x10 hand lens

Mudrocks

Breccia
(angular fragments)
Conglomerate
(rounded fragments)

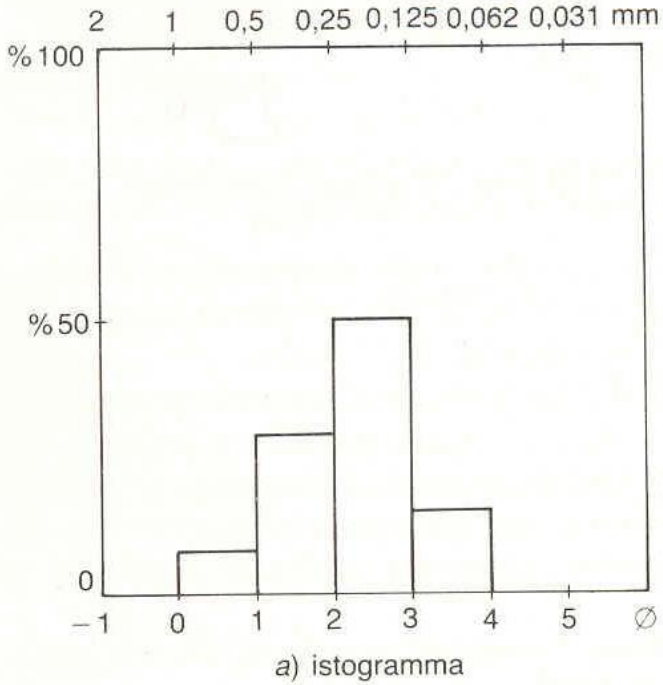
Sandstone

Siltstone

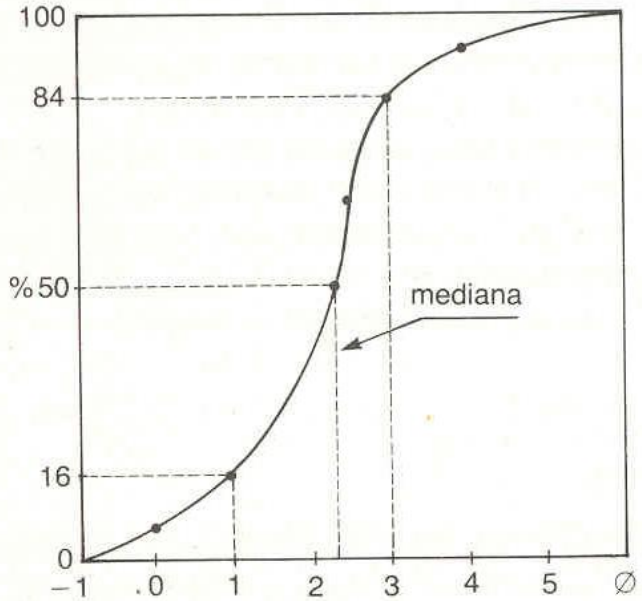
Claystone
Shale

Gravel			Sand			Silt	Clay
Course	Medium	Fine	Course	Medium	Fine		

60mm 20 6 2mm 0.6 0.2 0.06mm 0.002mm



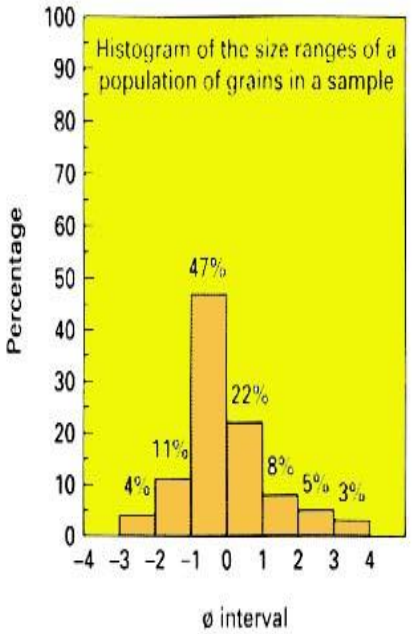
a) istogramma

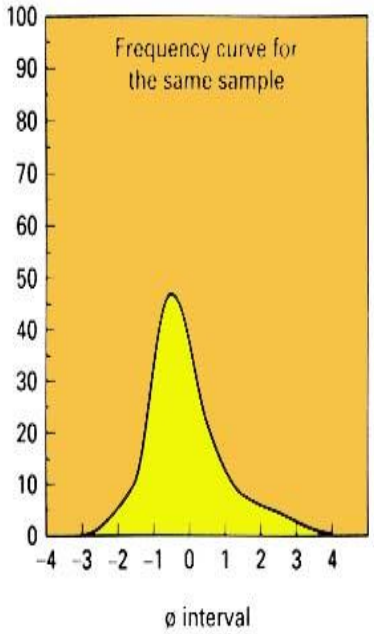


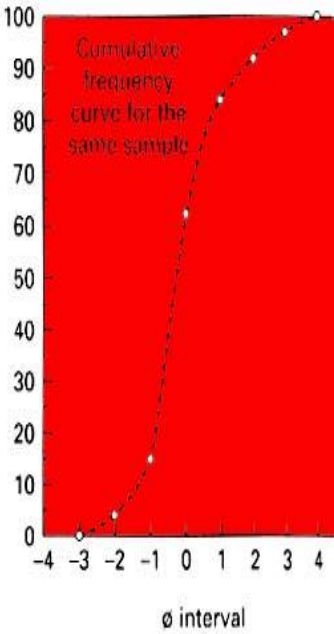
c) curva cumulativa
(ordinata in scala aritmetica)

Granulometrie

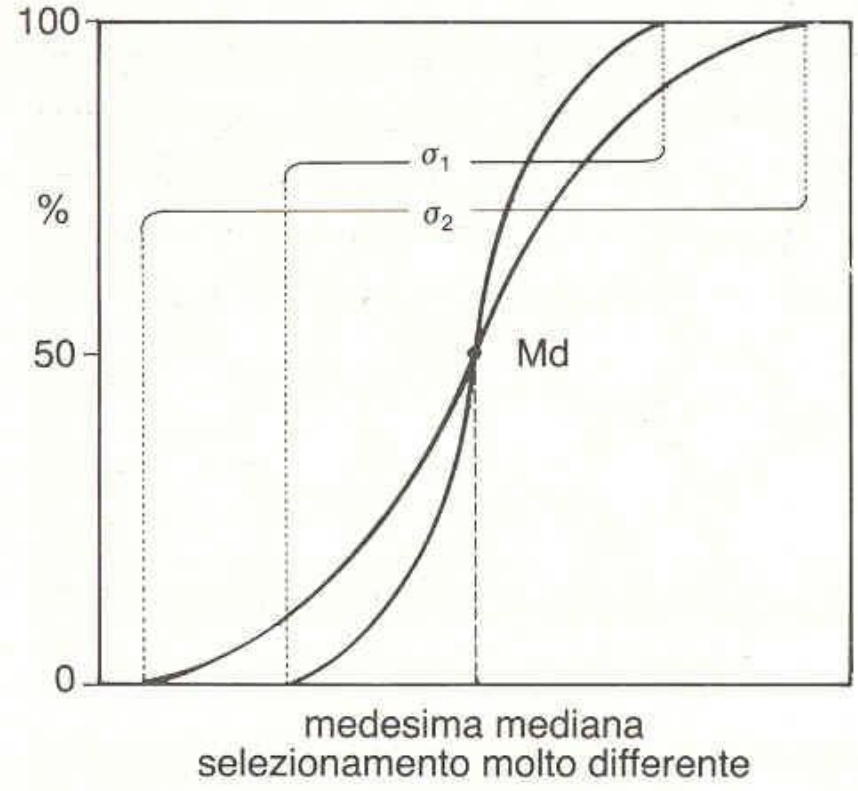
Curve Granulometriche



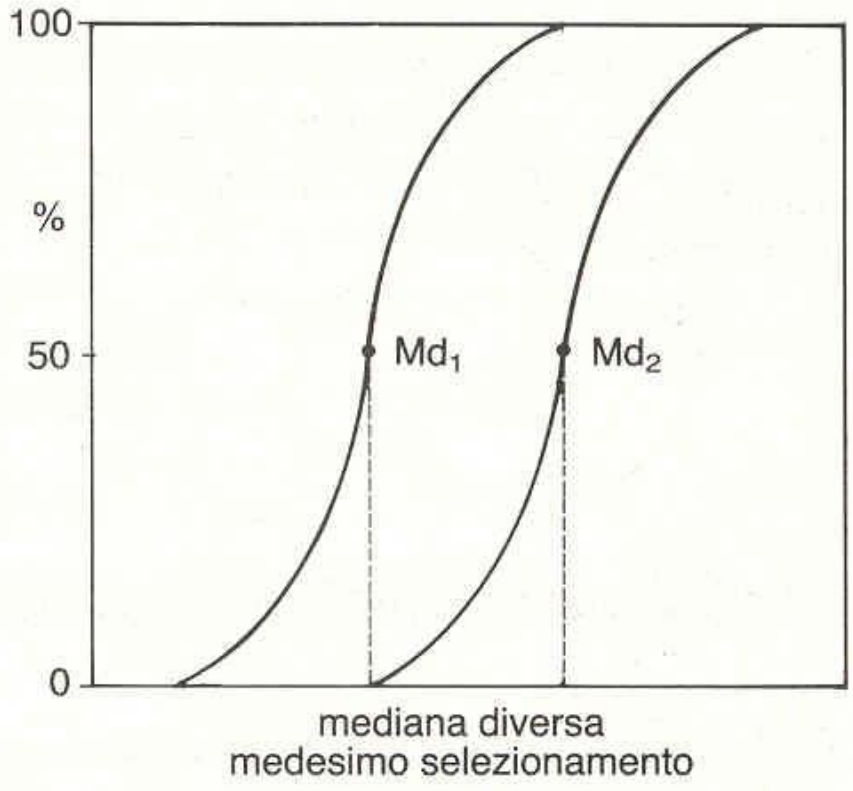




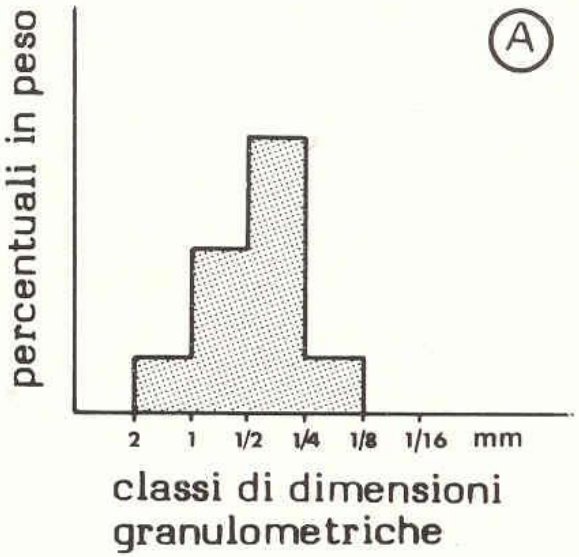
Grado di selezionamento (*sorting*)

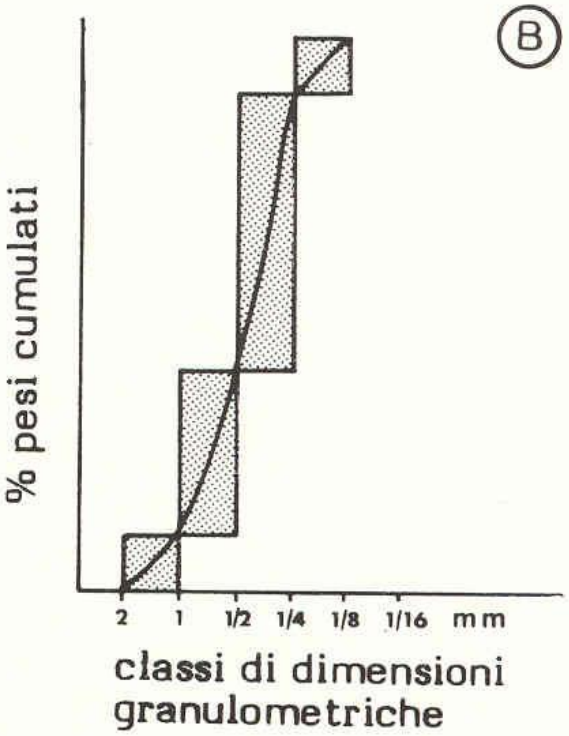


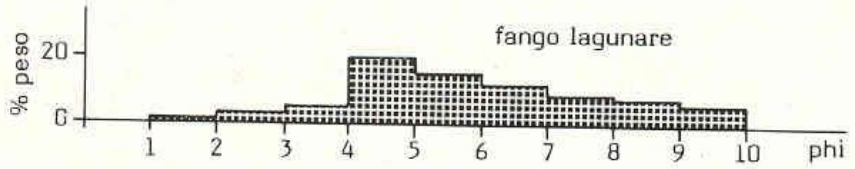
medesima mediana
selezionamento molto differente

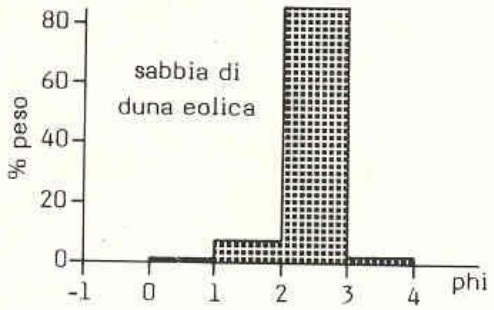


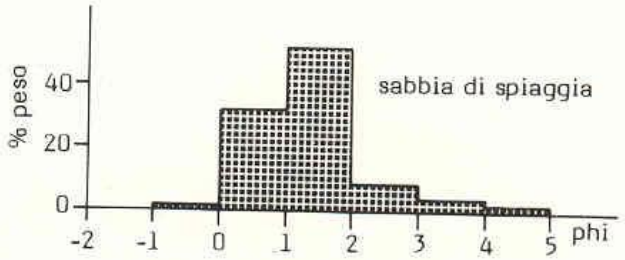
mediana diversa
medesimo selezionamento

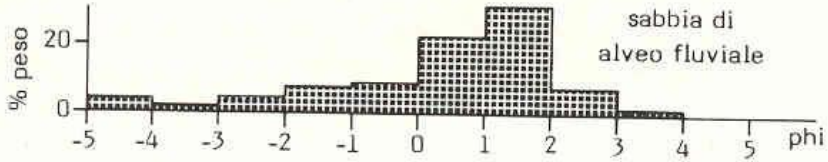




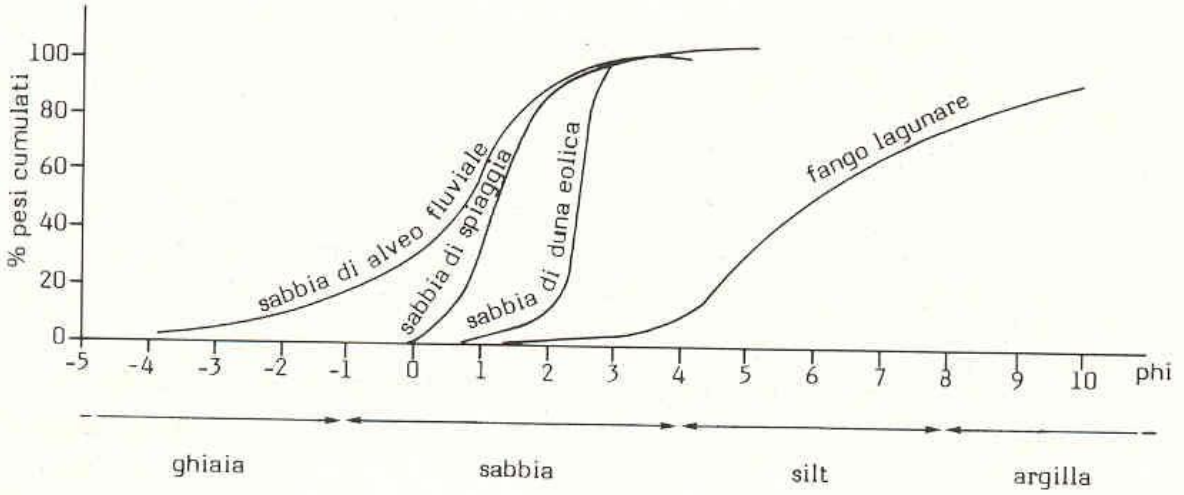


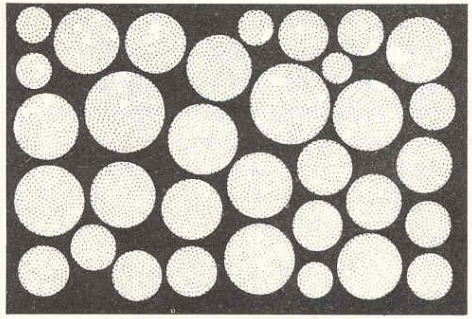




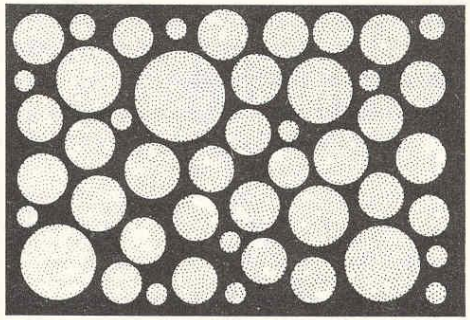


Modalità trasporto e Energia dinamica del mezzo

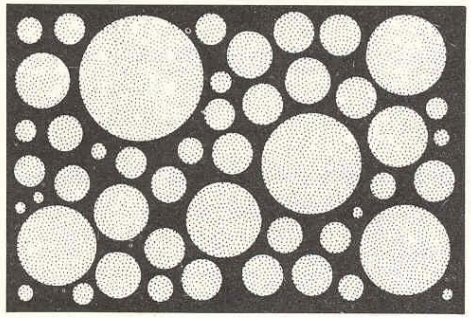




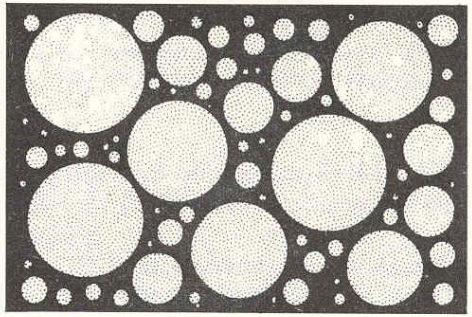
molto ben selezionato $\sigma = 0{,}35\ \varnothing$



ben selezionato $\sigma = 0{,}50\ \varnothing$

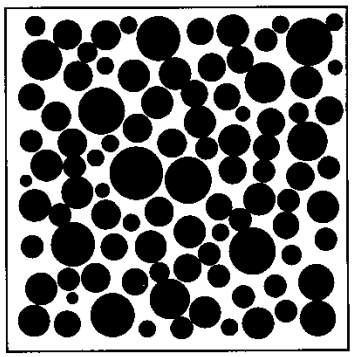


moderatamente selezionato $\sigma = 1{,}00\ \varnothing$

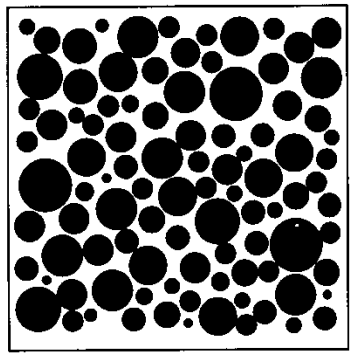


poco selezionato $\sigma = 2{,}00\ \varnothing$

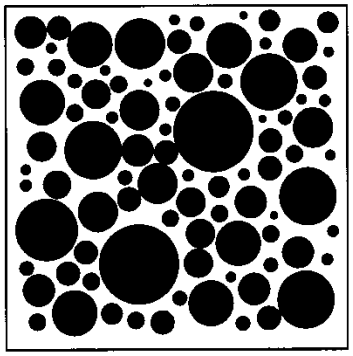
Very well sorted	'Standard deviation' < 0.35
Well sorted	= 0.35–0.5
Moderately well sorted	= 0.5–0.71
Moderately sorted	= 0.71–1.0
Poorly sorted	= 1.0–2.0
Very poorly sorted	> 2.0



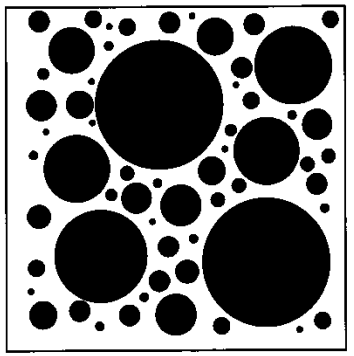
'Standard deviation' = 0.35



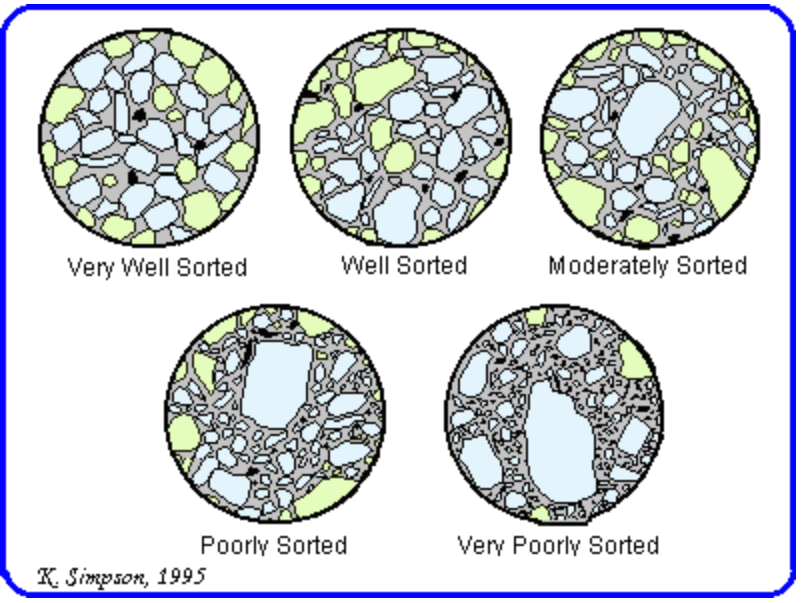
'Standard deviation' = 0.5



'Standard deviation' = 1.0



'Standard deviation' = 2.0



Miglior selezionamento in natura =
Sabbie dune eoliche e spiagge
Selezionamento molto scarso = Morene

Well-sorted sand

Poorly sorted sand

Significato geologico dei parametri granulometrici

Processi deposizionali responsabili del deposito

$$\frac{\text{Quantità di materiale fornito all'ambiente}}{\text{Efficienza selezionatrice del mezzo}}$$

Scorrimento superficiale (rotolamento) **Saltazione** **Sospensione**

Sedimenti grossolani **sedimenti fini**

Selezionamento

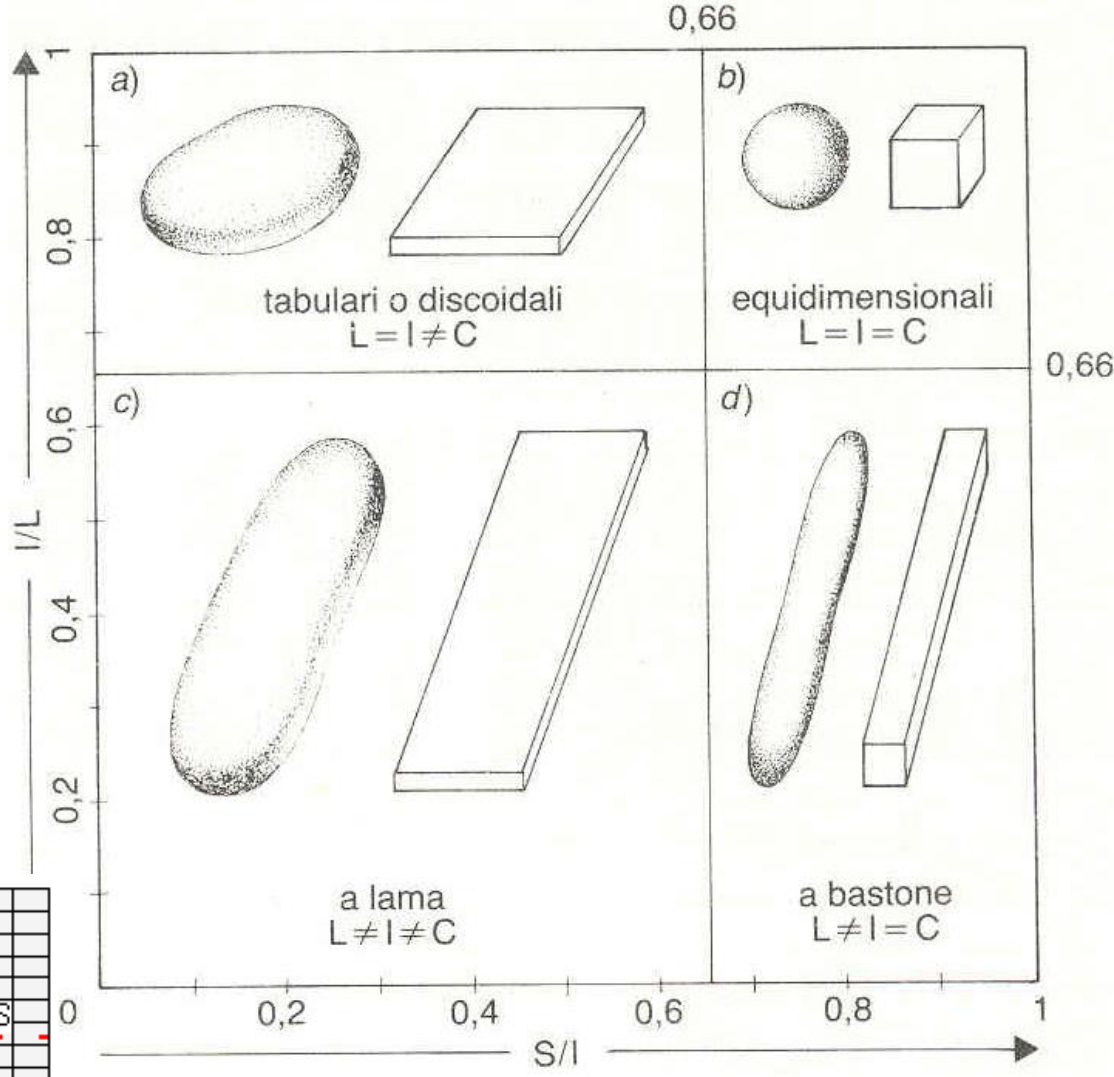
- Selezionamento ottimale: corrente opera continuamente su strato sottile di granelli (spiaggia)
- Selezionamento pessimo: deposizione forzata da impilamento quasi istantaneo (piene fluviali)

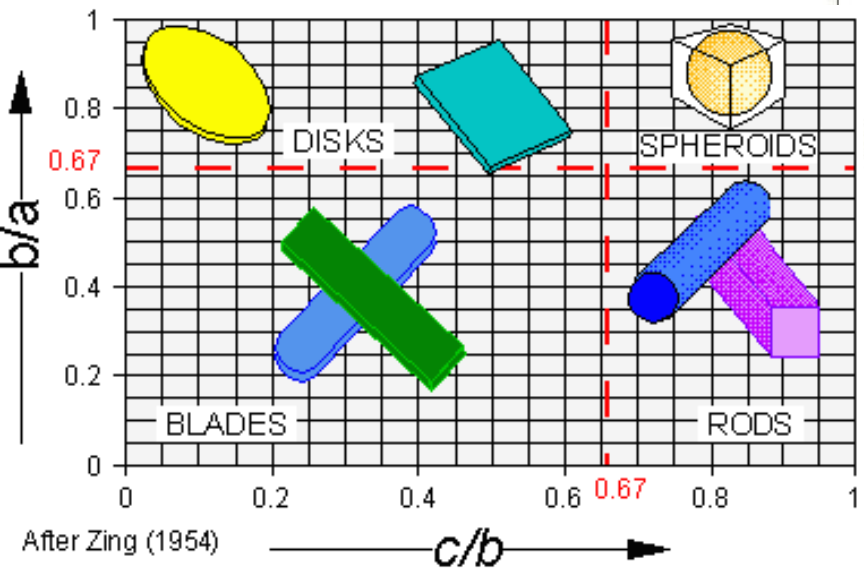
- Correnti costanti selezionano meglio di quelle che variano rapidamente di intensità

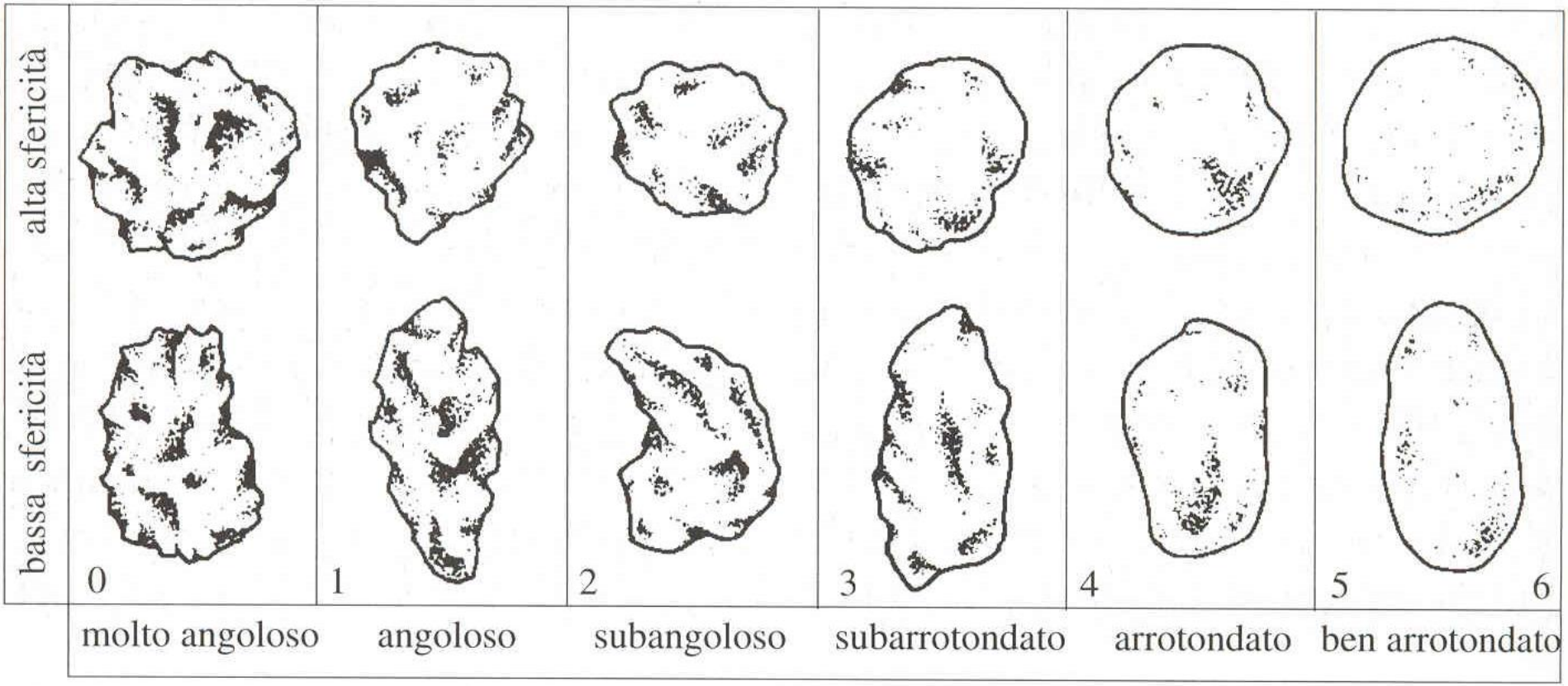
Morfometria

- Assi

- L = lungo
- I = intermedio
- S = corto







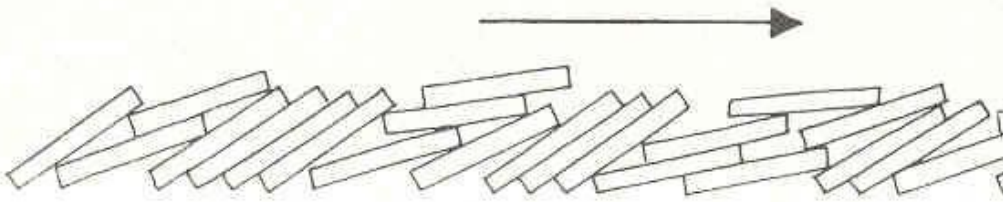
Arrotondamento

Sabbia media con grani quarzo angolosi
Perde 1% in peso dopo trasporto di 20.000 km!

Fabric (tessuto – struttura)

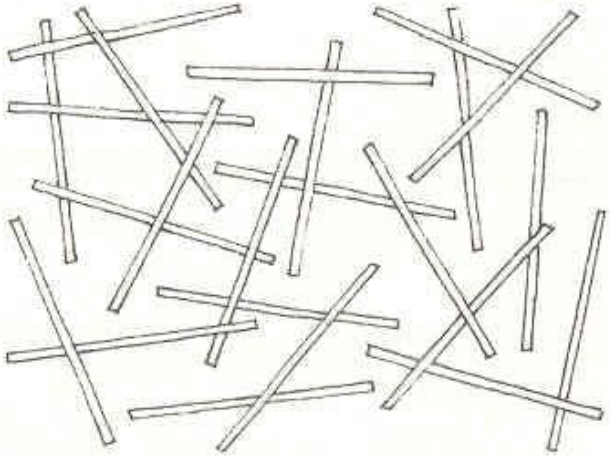
- Orientazione e disposizione spaziale degli elementi che compongono un sedimento

a) gravità

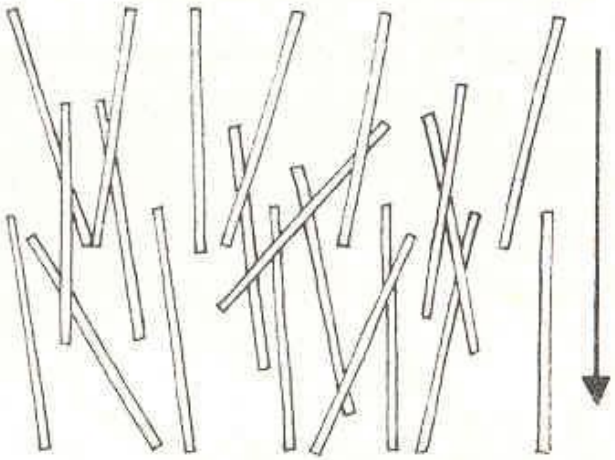


b) gravità + corrente

embriciatura



a) gravità

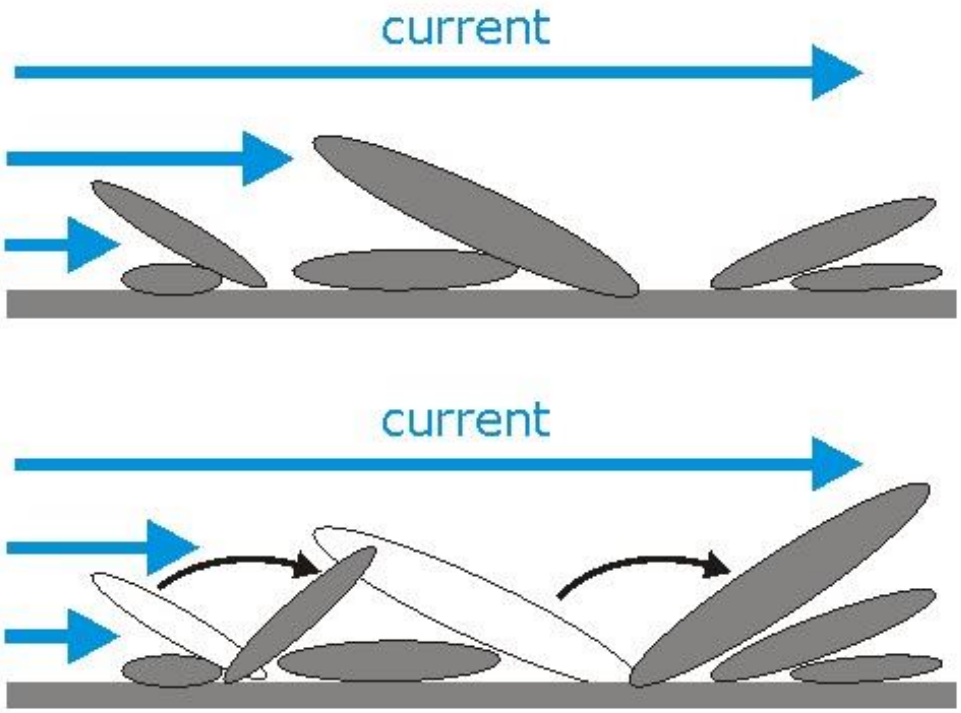


b) gravità + corrente

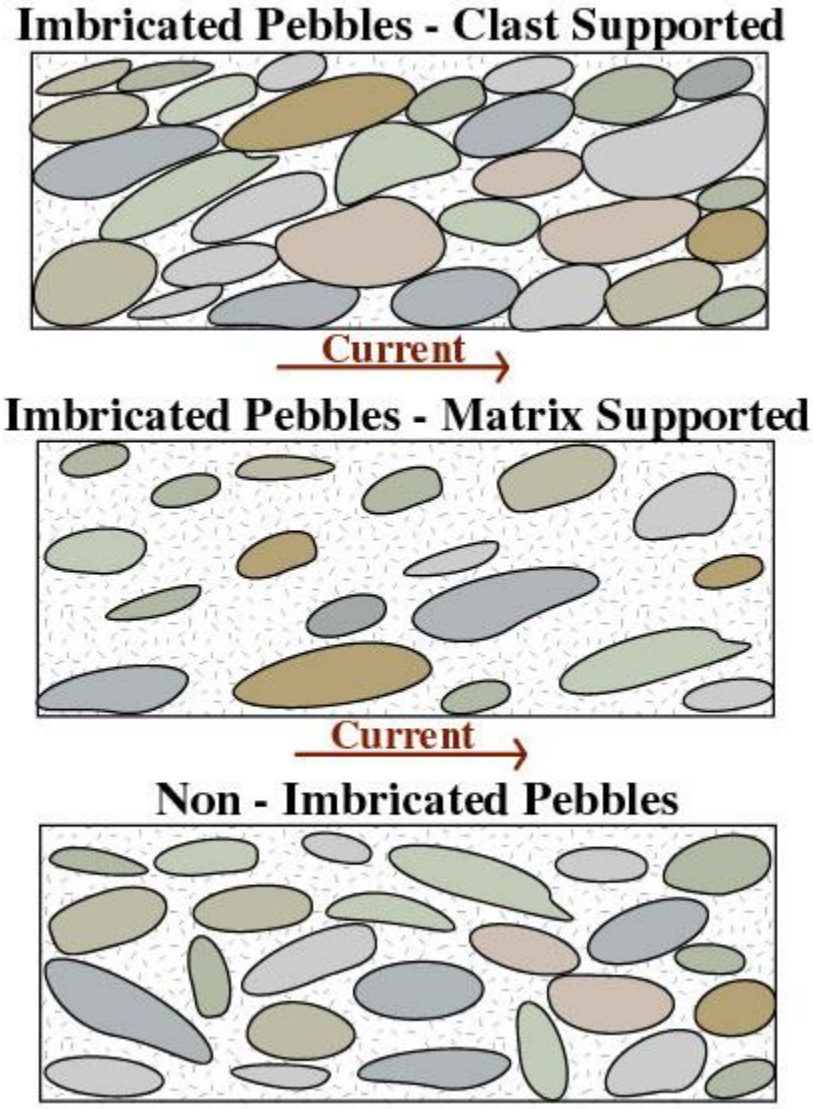
Fiume Tànaro, Alba


Minjiang river

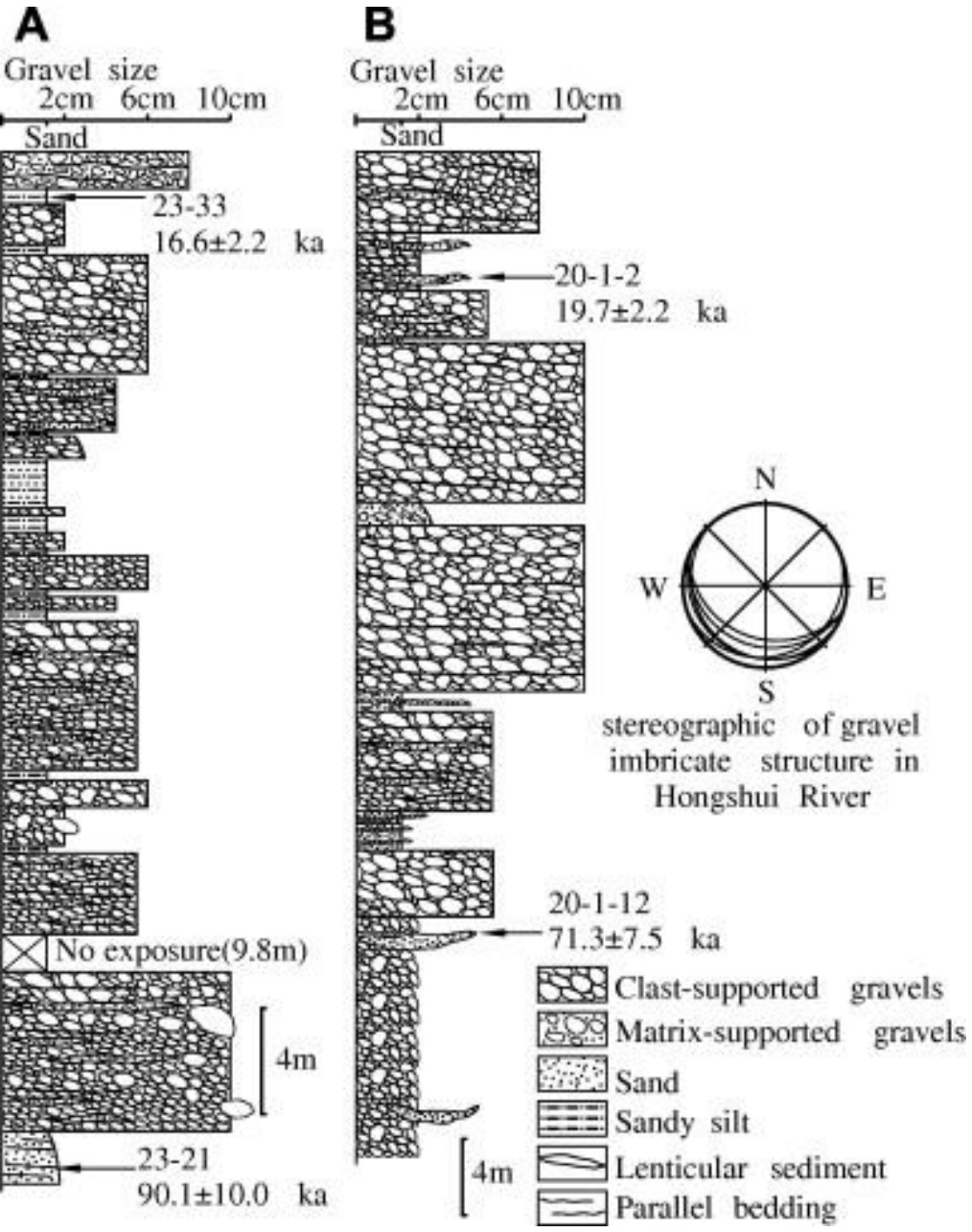
Embriciatura
Imbrication
edge-wise conglomerate



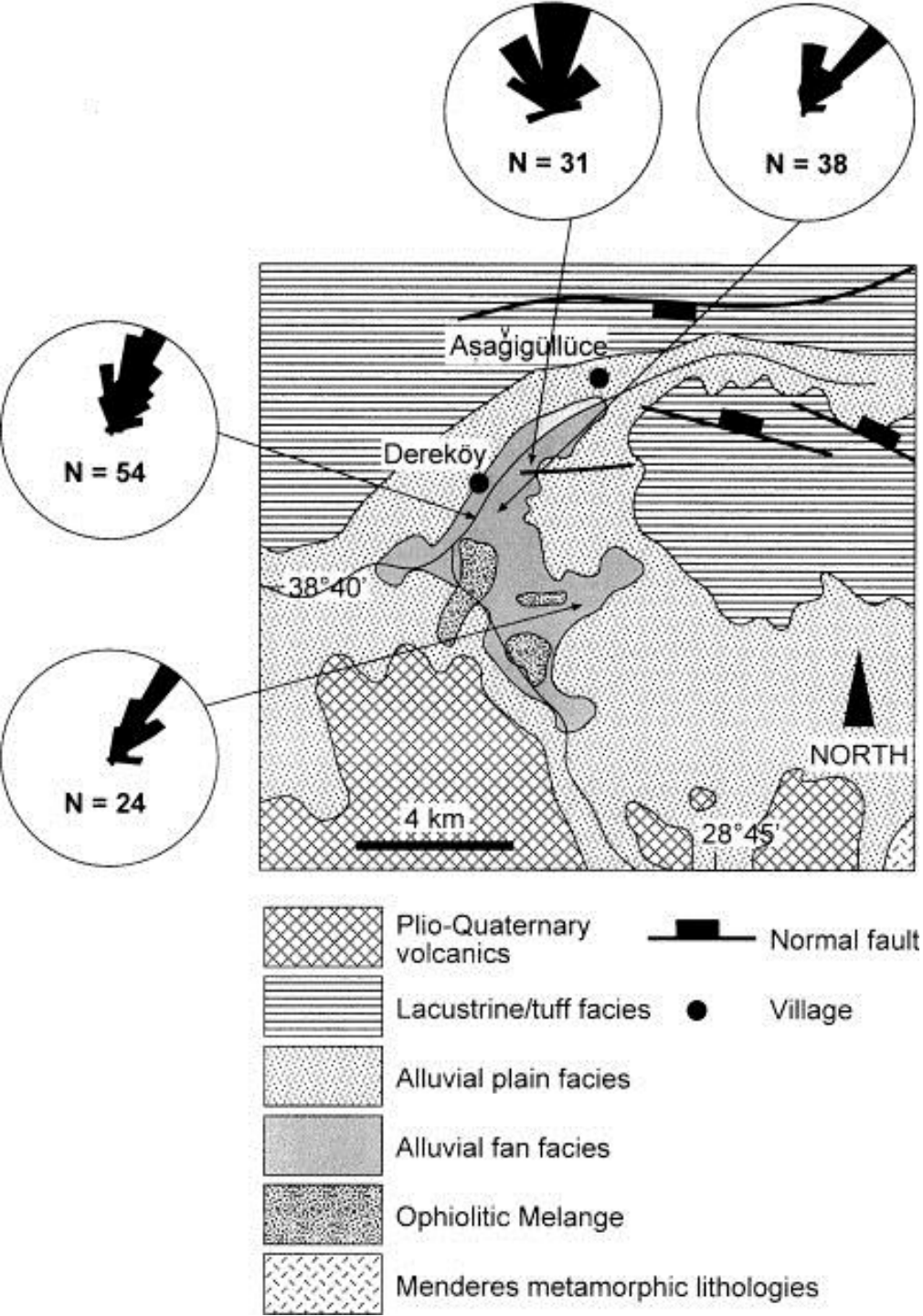
http://all-geo.org/highlyallochthonous/2008/02/imbrication-and-potholes-in-the-zebra-river/



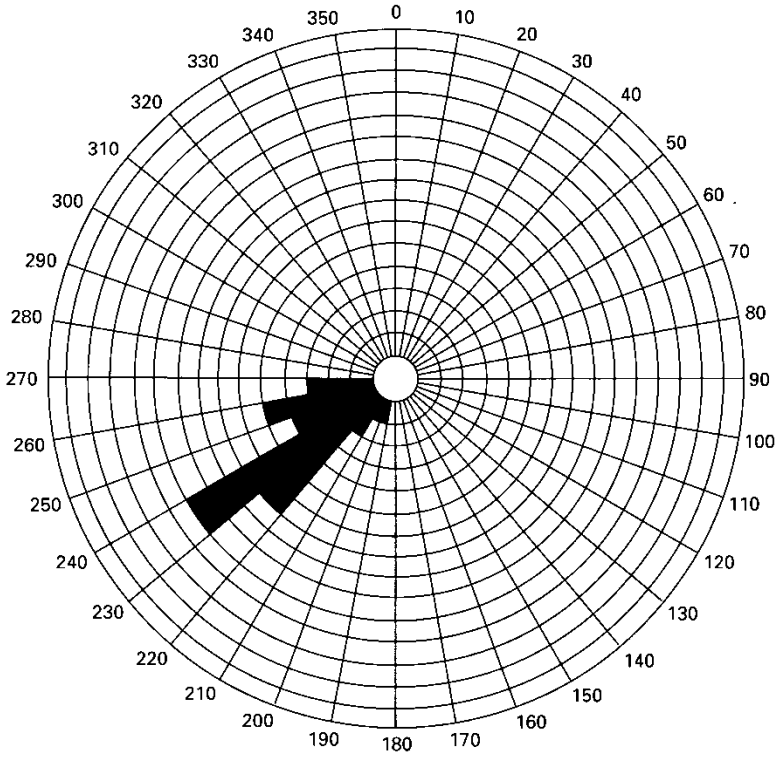
University of Montana Geology Department [2011]



Stratigraphic columns of valley fill sequences. (A) Kunlun River valley at Sanchakou (35°53.42′N, 94°23.52′E, 3690 m asl). (B) Hongshui River valley (35°52.58′N, 92°12.43′E, 4204 m asl); gravel imbricate structure in this sequence is plotted in stereographic projection.
Wang et al., 2009

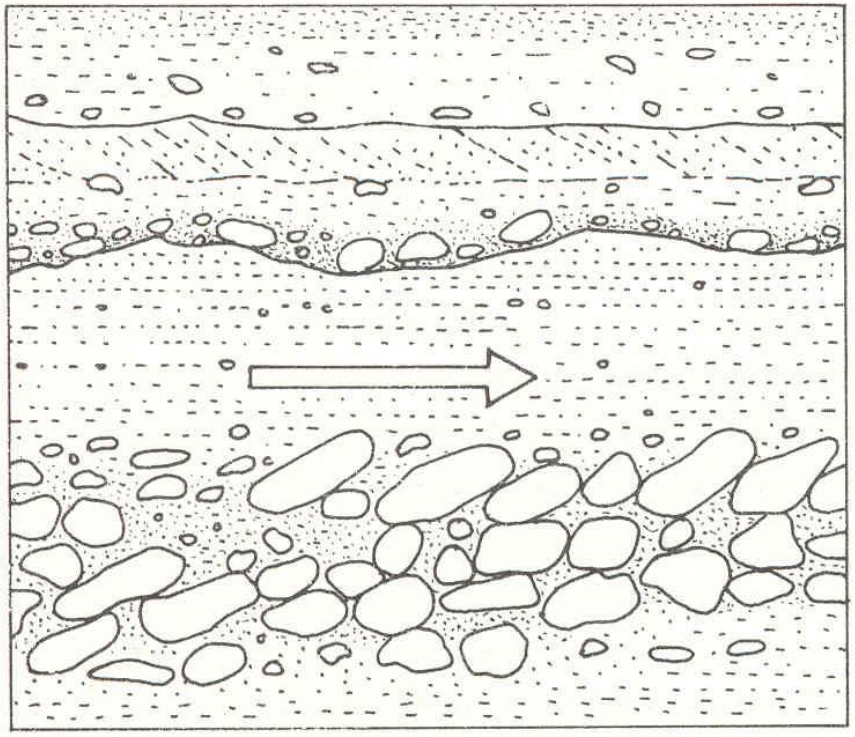


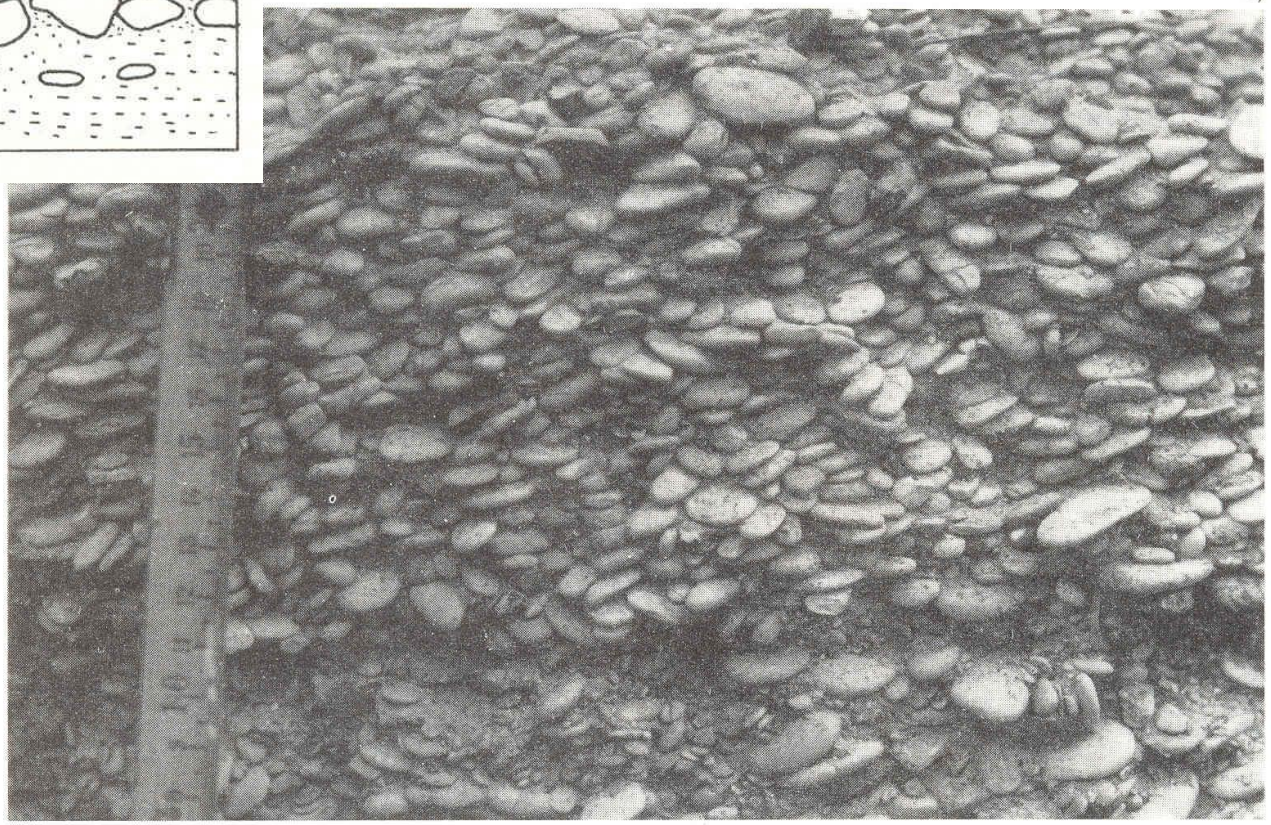
- Geological map of the Selendi Basin (Turkey) showing palaeocurrent trends determined from clast imbrication (100 measurements per location)



Purvis & Robertson, 2005

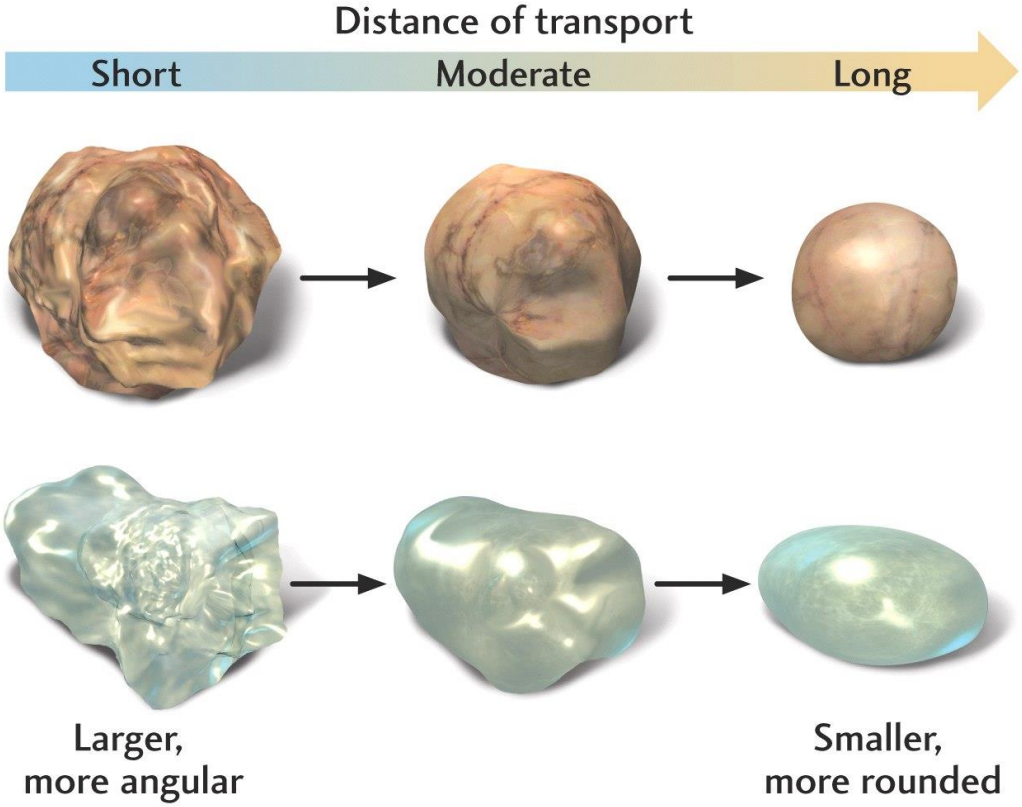
Embriciatura

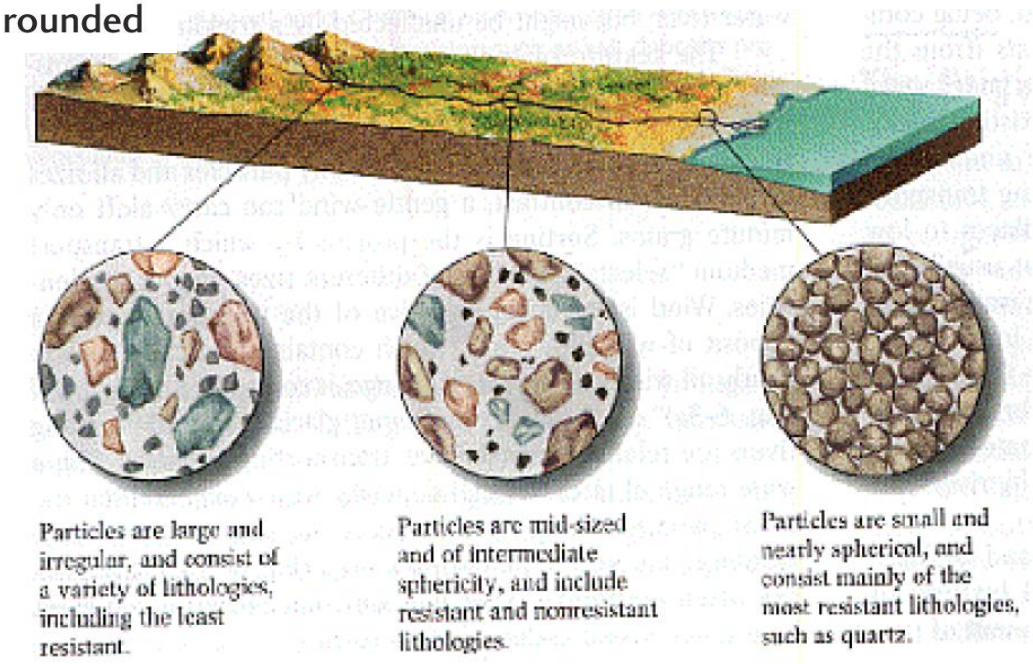




Ciottoli discoidali: piano di massima proiezione inclinato contro corrente (verso monte)

- Fiumi: 10-30°
- Spiagge: 15° verso mare
- Morene 20-25°


Distance of transport
Short
Moderate
Long
Larger,
more angular
Smaller,
more rounded


Particles are large and irregular, and consist of a variety of lithologies, including the least resistant.
Particles are mid-sized and of intermediate sphericity, and include resistant and nonresistant lithologies.
Particles are small and nearly spherical, and consist mainly of the most resistant lithologies, such as quartz.

Trasporto selettivo e trasporto in massa

- Comportamento idraulico: è funzione di dimensioni, forma e peso specifico, ma soprattutto della **granulometria**

- Processo di smistamento (selezione idraulica) per forma (frustoli vegetali, lamelle di mica) e peso specifico (minerali pesanti)

Trasporto selettivo e trasporto in massa

- L’azione selettiva si riflette nella tessitura e nell’organizzazione geometrica resa visibile dalle strutture sedimentarie

- Trasporto **selettivo**: deposito strutturato e organizzato (strati suddivisi in lamine, clasti orientati)

- Trasporto in **massa**: depositi disorganizzati (omogenei, massivi caotici, privi di strutture)

Selezione idraulica

- Separazione tra carico di fondo (ghiaia, sabbia) e carico sospeso (silt, argilla)

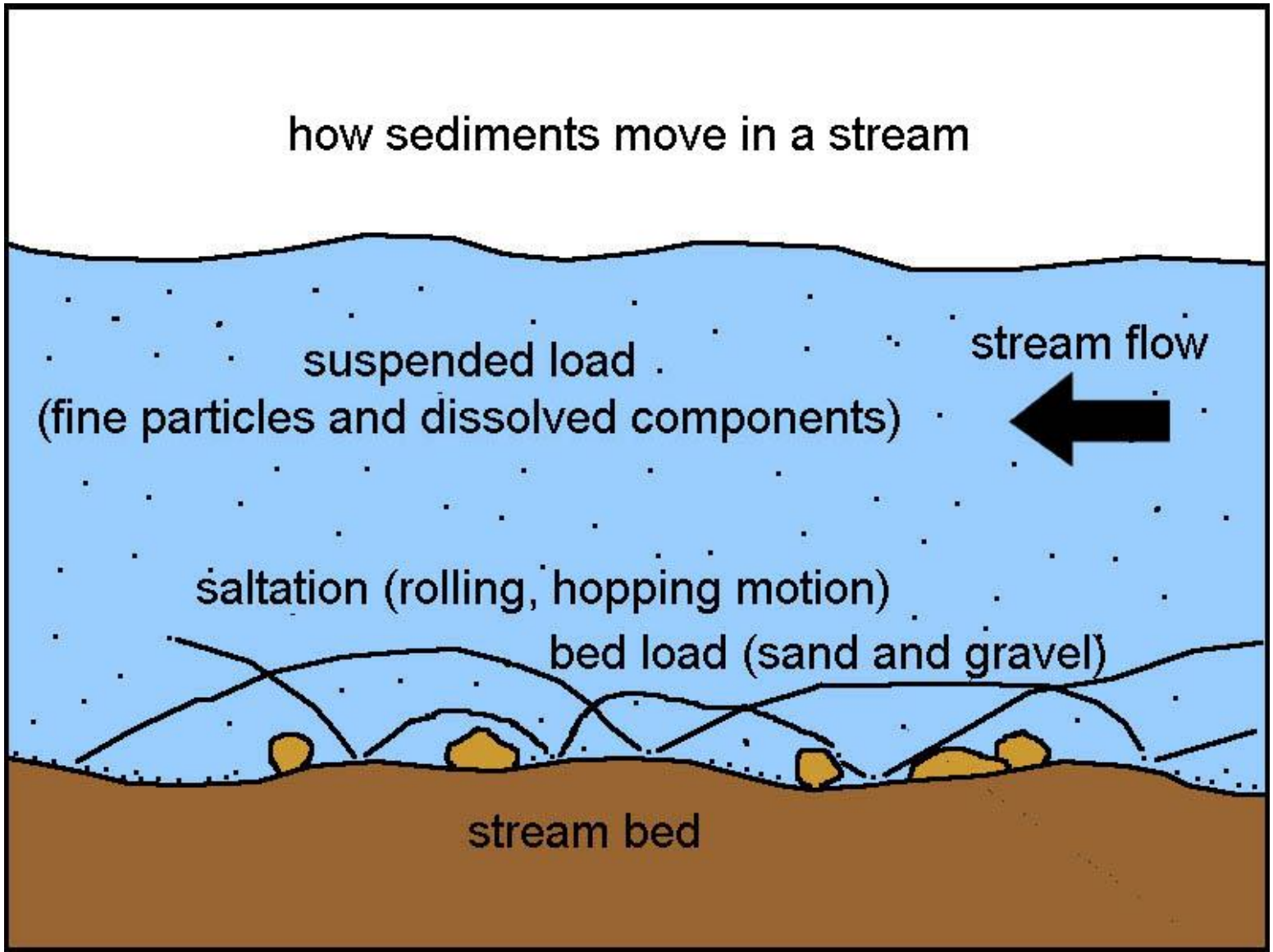
- **TRAZIONE**: trascinamento delle particelle sul fondo (rotolamento, scorrimento, saltellamento)

- **DECANTAZIONE**: deposizione di materiale in sospensione

- Processi selettivi: trattivi e decantativi

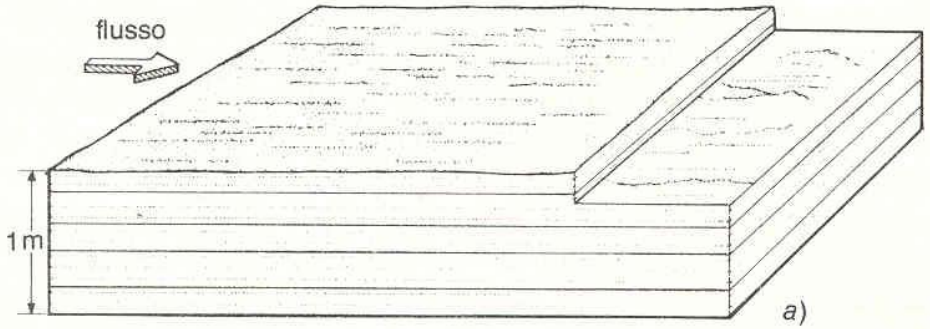
Suspended load: Mud (silt+clay)

Bed load: Boulder gravel sand

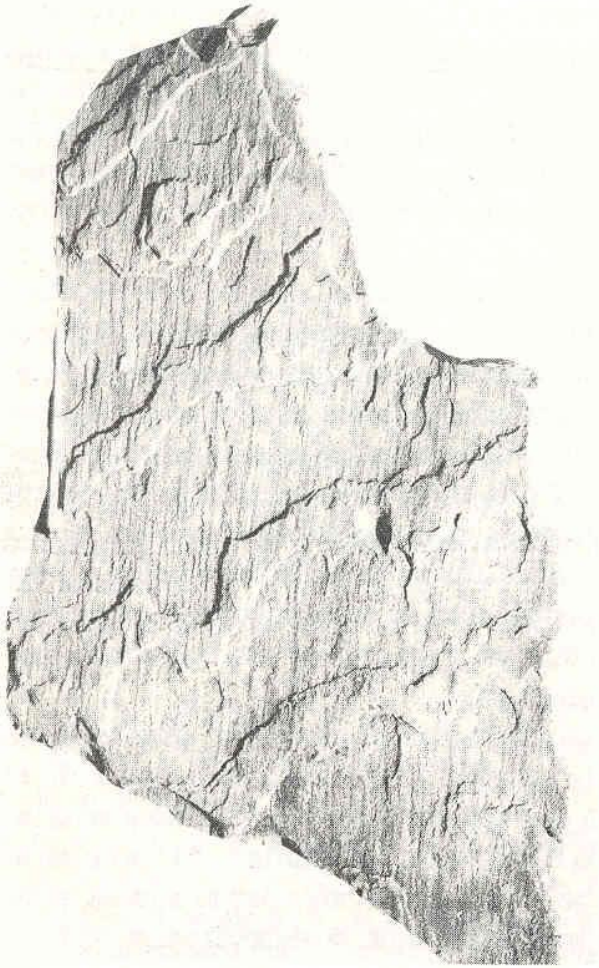


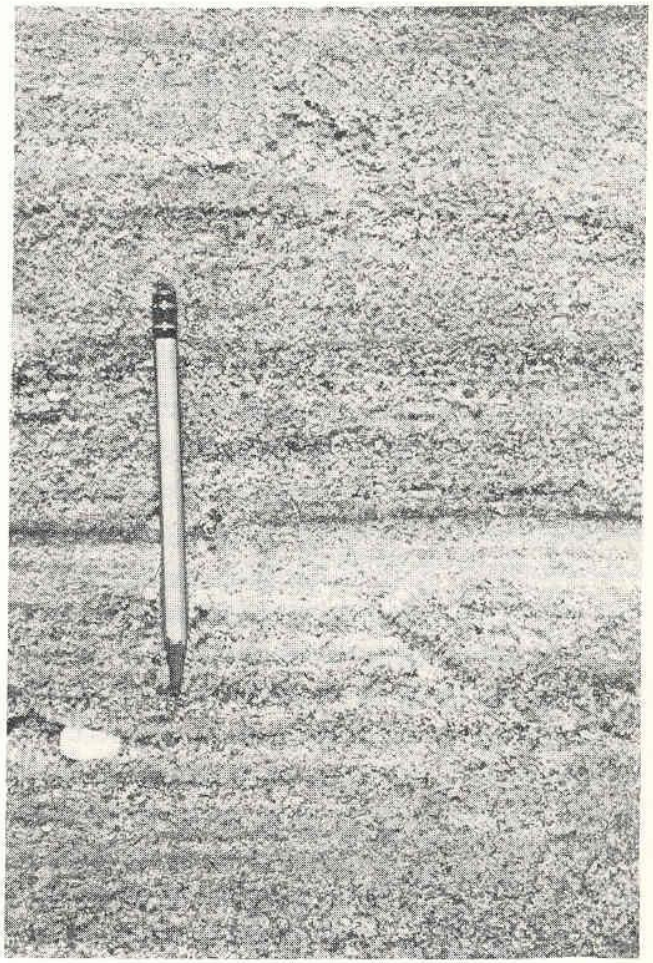
Processi trattivi

- Velocità carico di fondo << velocità corrente
- Azione trattiva può essere associata a decantazione: sabbie sporche (matrice) e forme di fondo particolari
- Azione trattiva può alternarsi a decantazione. Particolare tipo di stratificazione (alternanze sabbia e fango)



b) c)

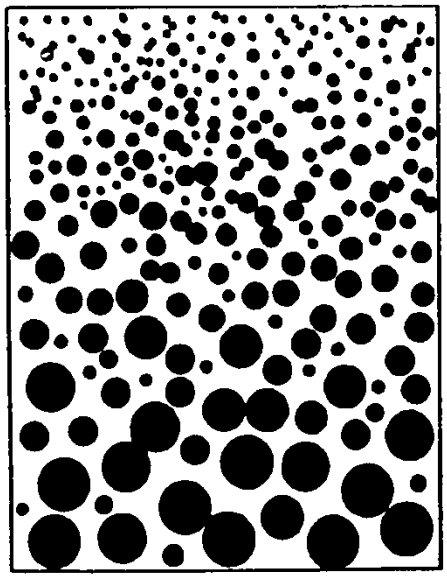




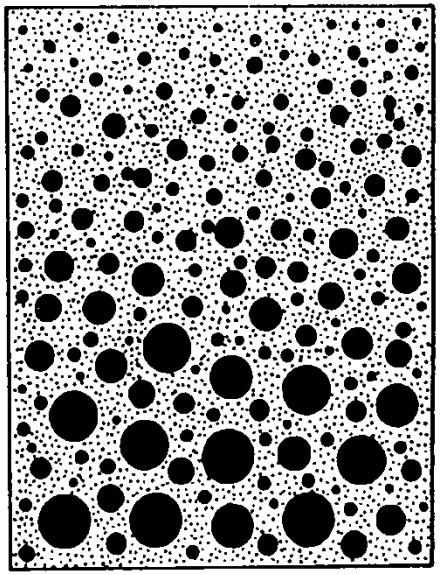
Lineazioni e lamine da corrente trattiva

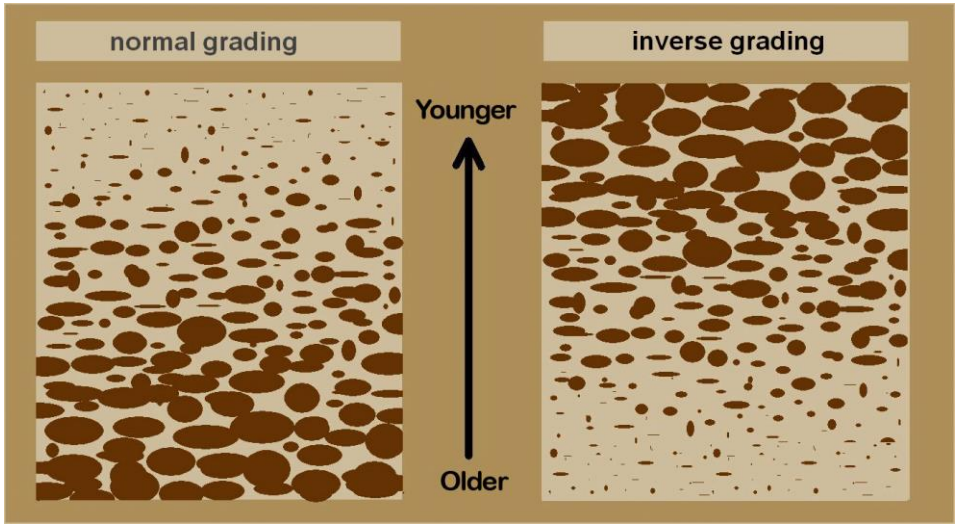
Lamine gradate Inversamente (pressione collisionale e effetto “setaccio”)

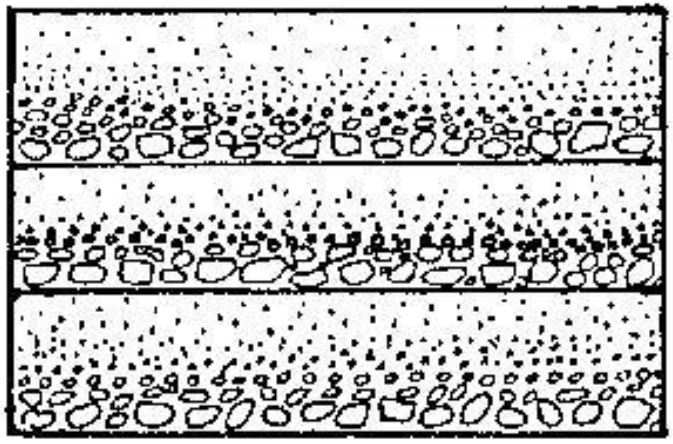
Gradazione
Graded bedding



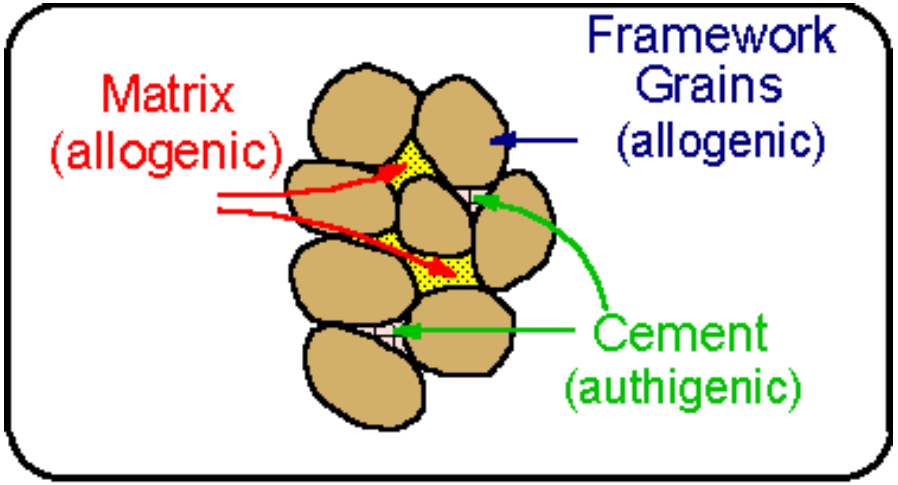
(a)







Normal Grading

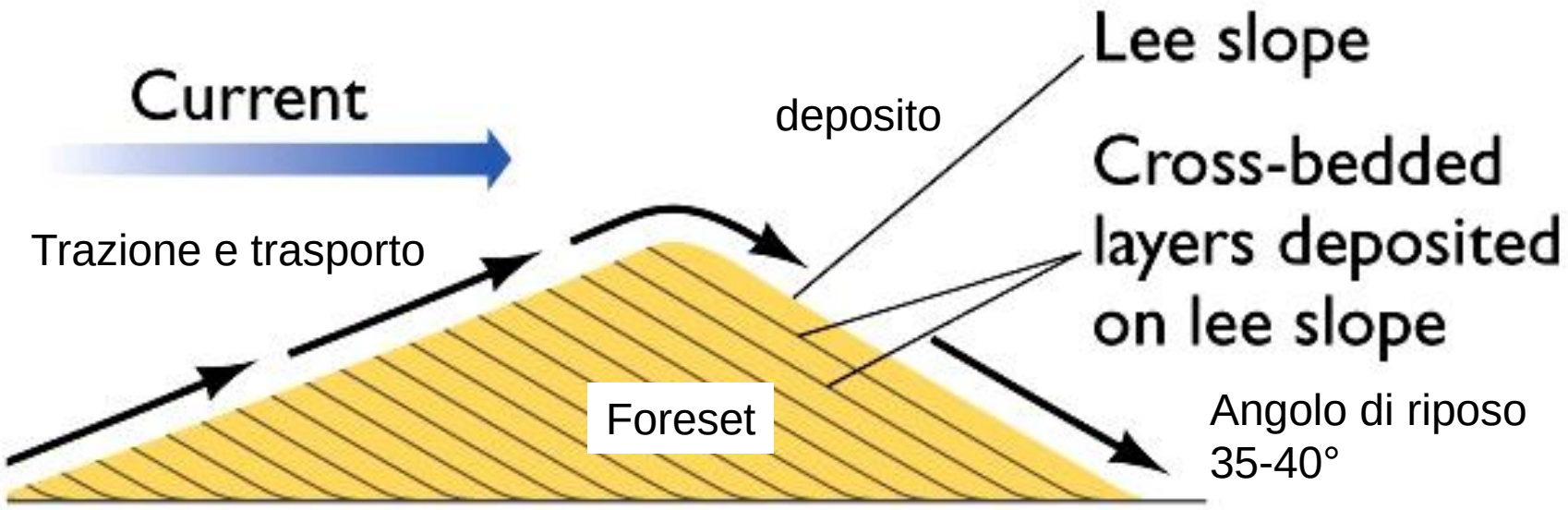


Ripples (increspature)

Correnti deboli:
10-30 cm/s

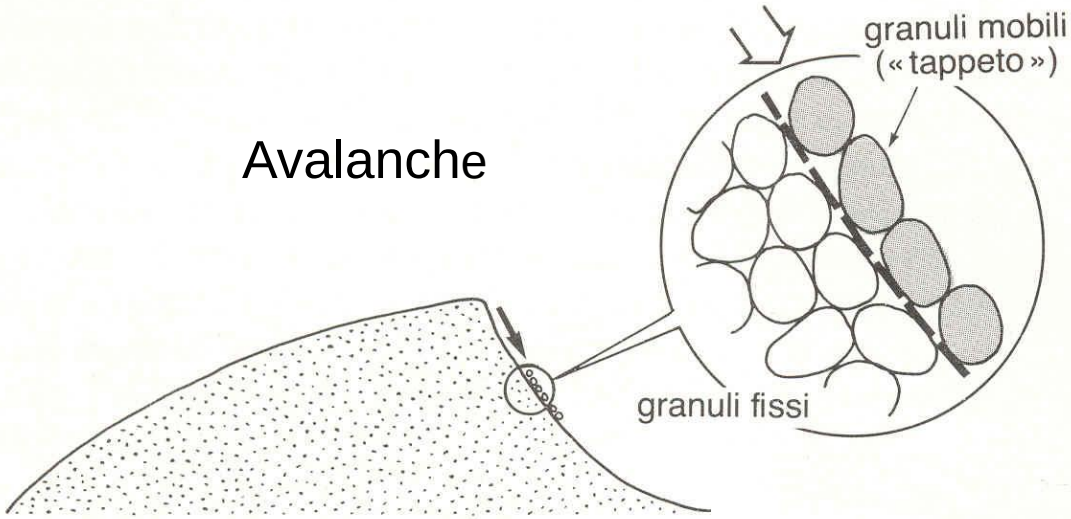
Formazione in
pochi minuti

Ripples (increspature)

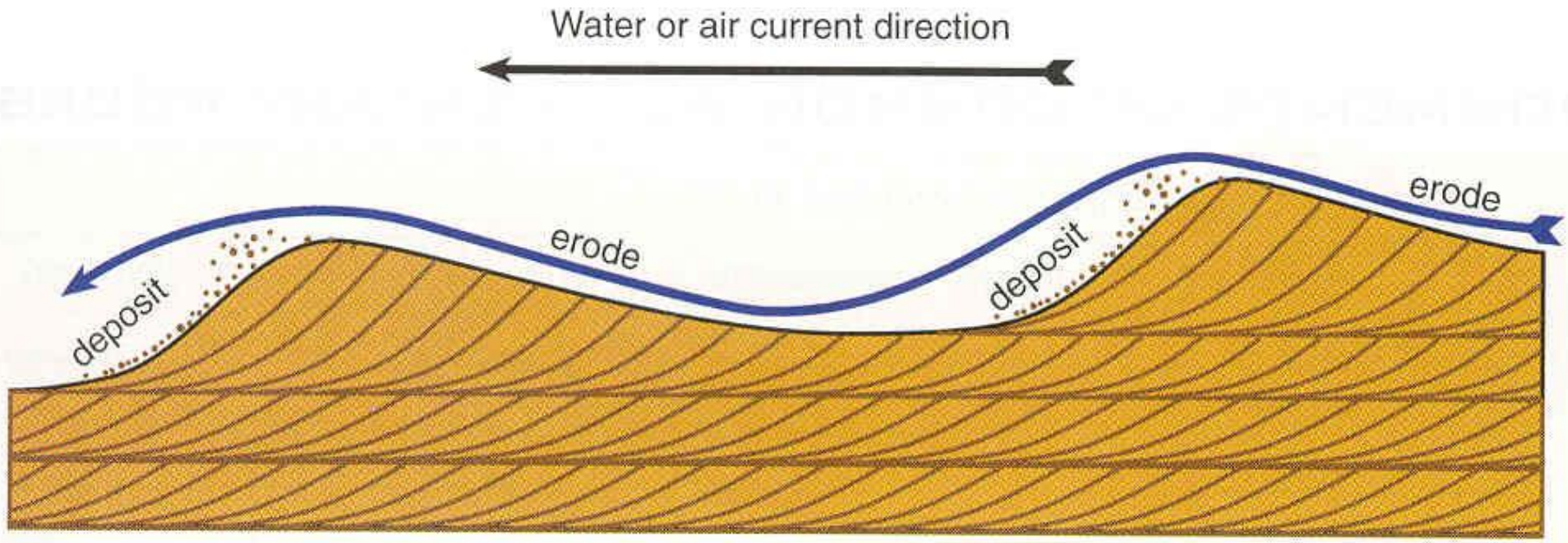


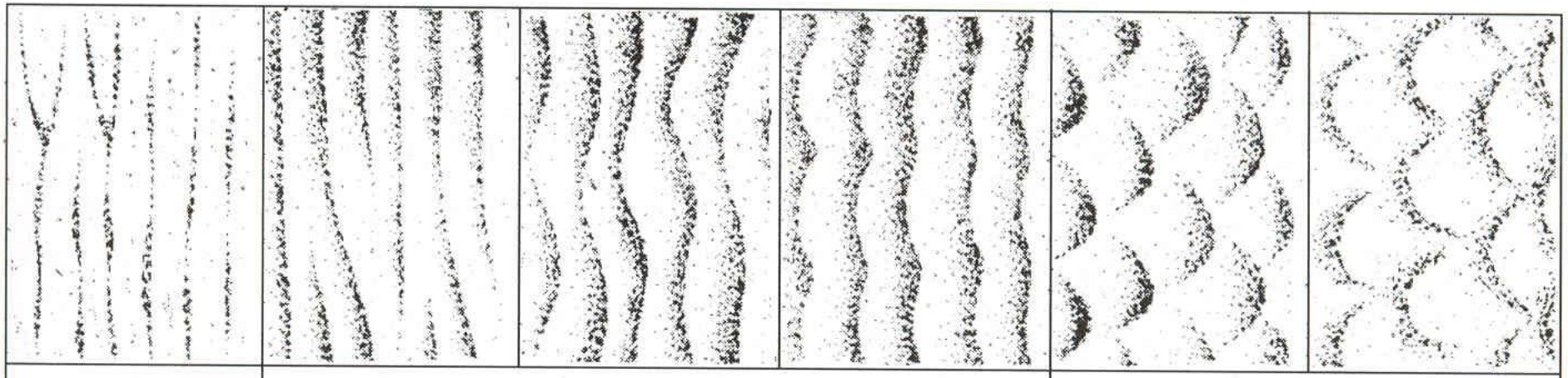
Stratificazione incrociata
o
Laminazione obliqua

Avalanche

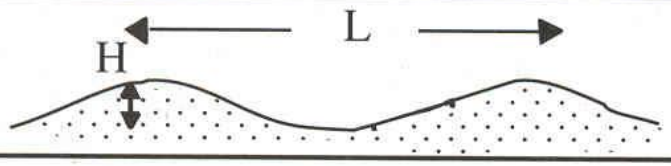


sand


Water or air current direction
deposit
erode
deposit
erode
A.



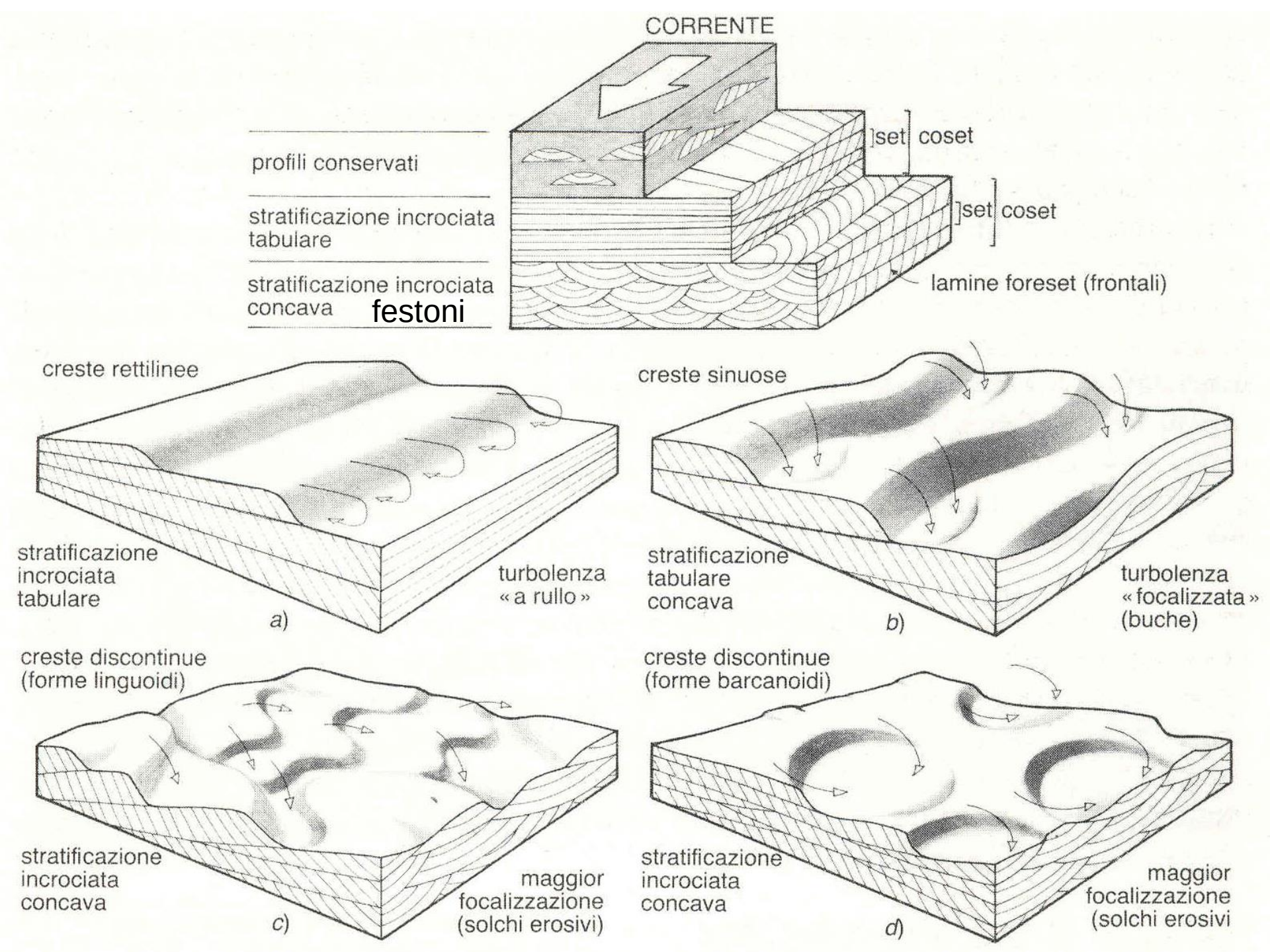
ripple da onda + (biforcazioni)	rettilinei	sinuosi	catenari	*ripple* linguoidi	dune barcanoidi
	ripple e dune da corrente				

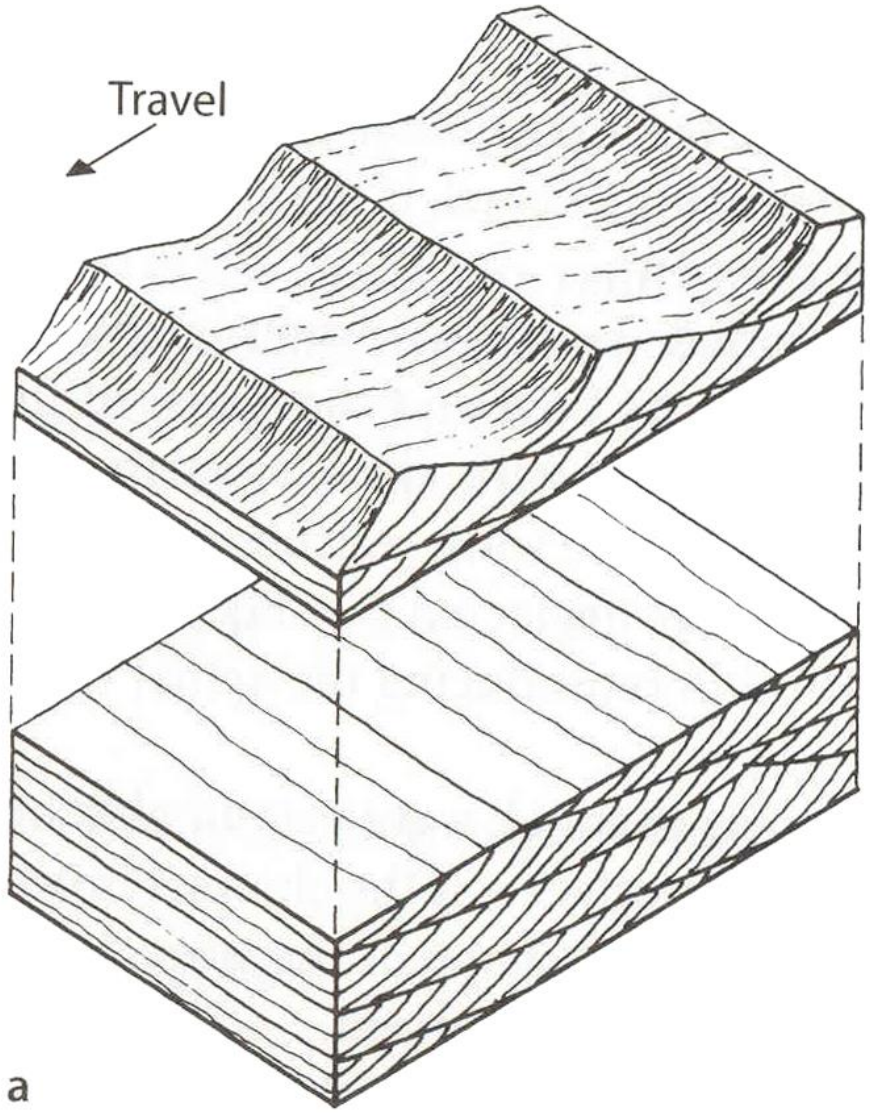


indice di *ripple* = L/H

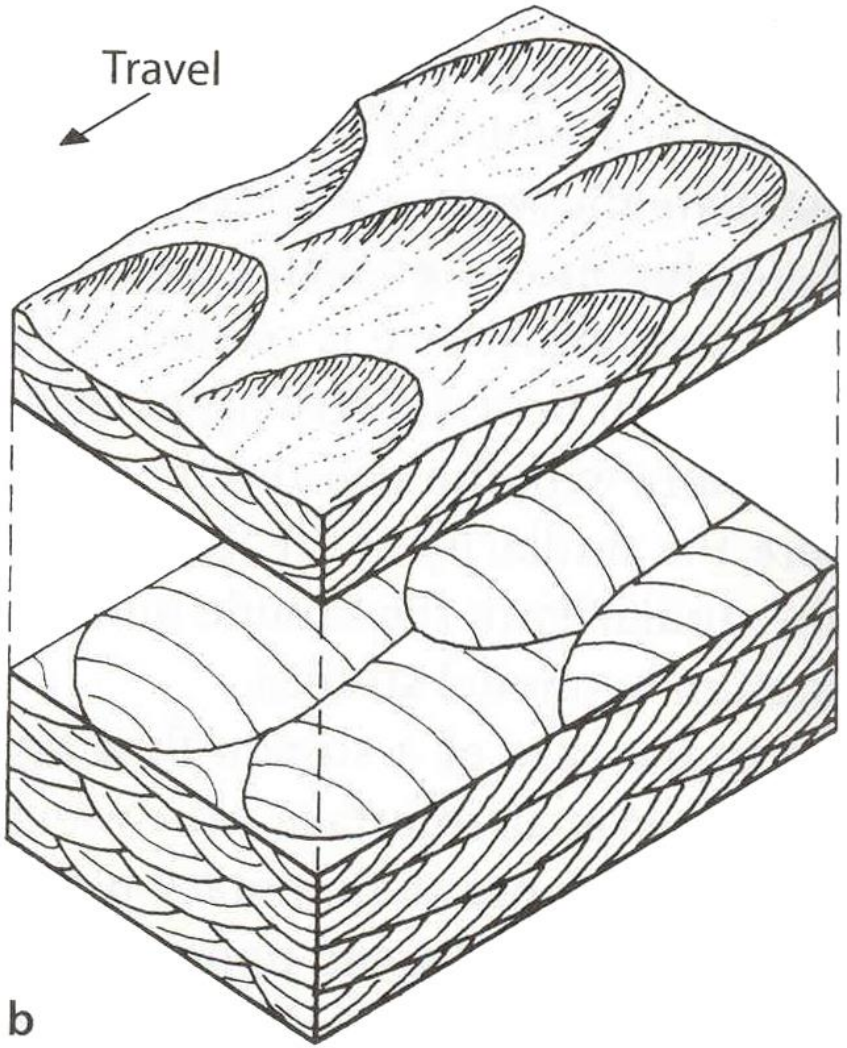
ripple eolici	L 2,5 - 25 cm H 0,5 - 1,0 cm	in genere 10 - 70
ripple da onda	L 0,9 - 200 cm H 0,3 - 25 cm	4 - 13 in genere 6 - 7
ripple da corrente	L< 60 cm H < 6 cm	> 5 in genere 8 - 15

Più piatti


CORRENTE
profili conservati
stratificazione incrociata tabulare
stratificazione incrociata concava
festoni
set
coset
set
coset
lamine foreset (frontali)
creste rettilinee
stratificazione incrociata tabulare
turbolenza « a rullo »
a)
creste sinuose
stratificazione tabulare concava
turbolenza « focalizzata » (buche)
b)
creste discontinue (forme linguoidi)
stratificazione incrociata concava
maggior focalizzazione (solchi erosivi)
c)
creste discontinue (forme barcanoidi)
stratificazione incrociata concava
maggior focalizzazione (solchi erosivi)
d)

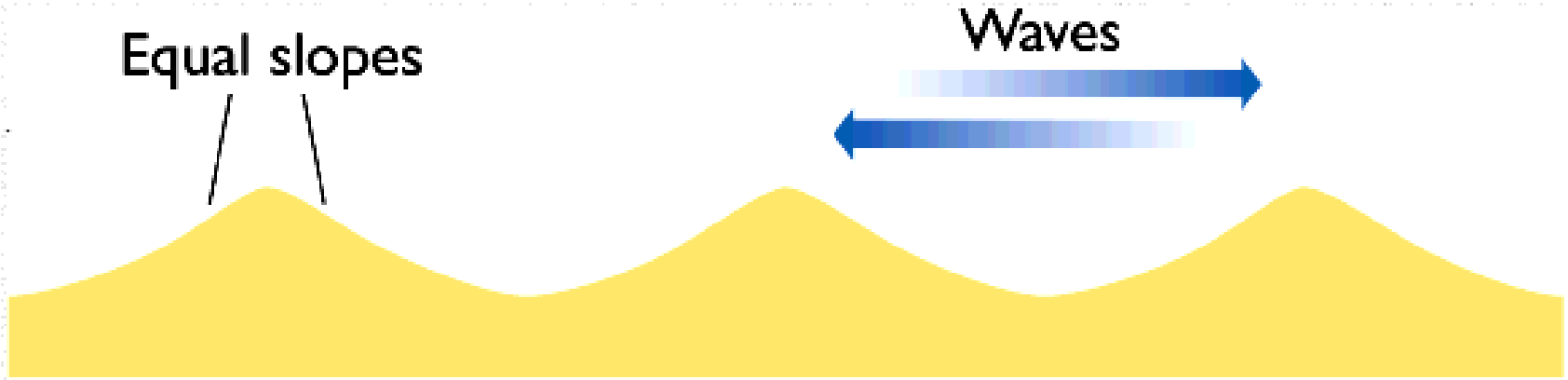


a

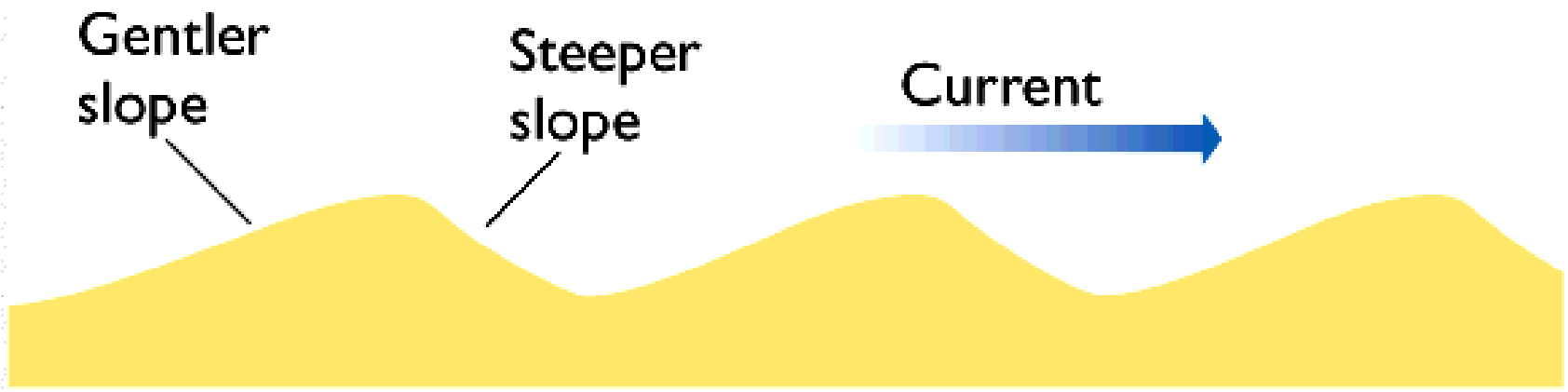


b

Strutture trattive da correnti oscillatorie



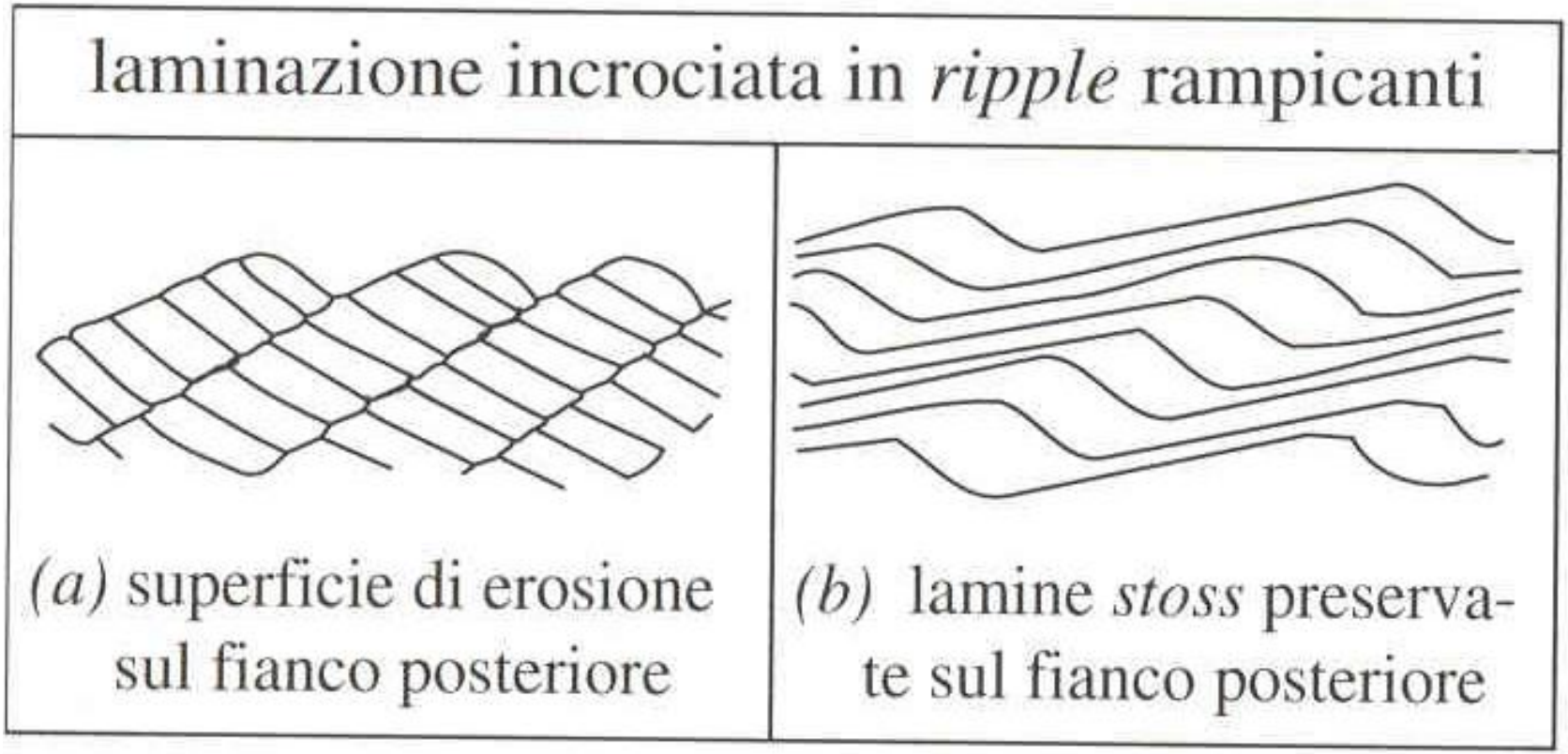
Symmetrical ripples (beach)

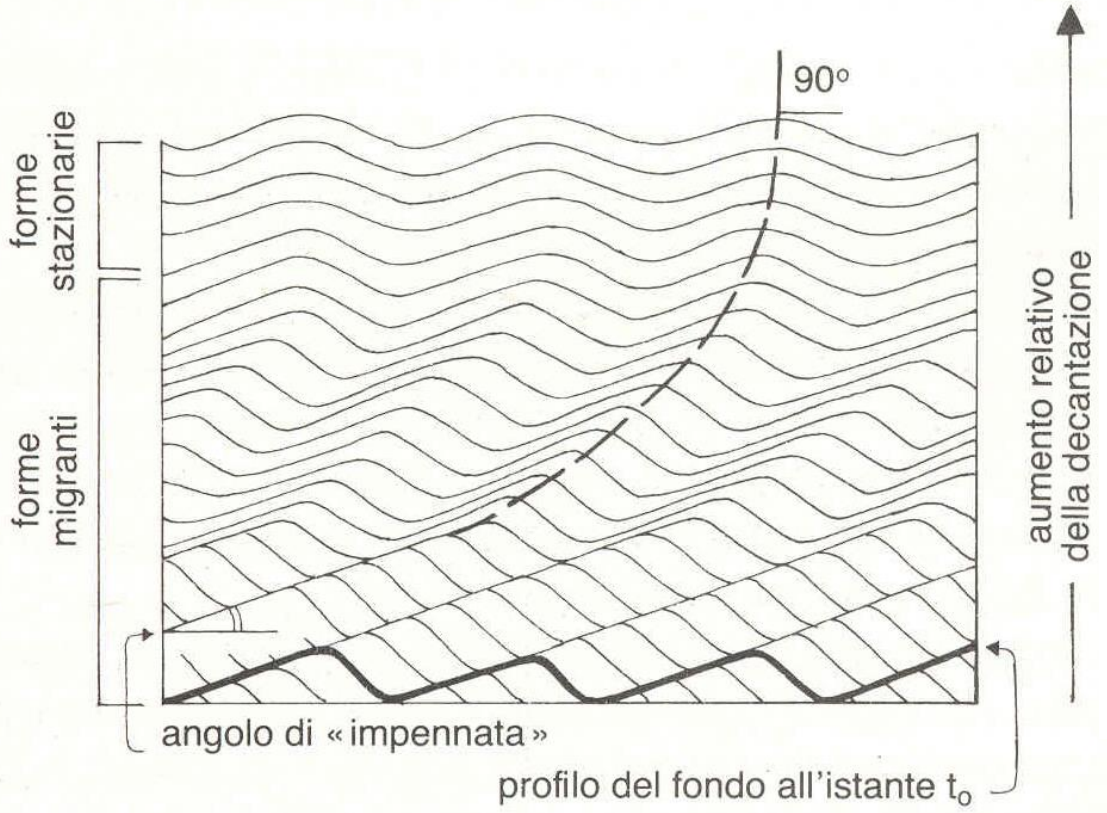


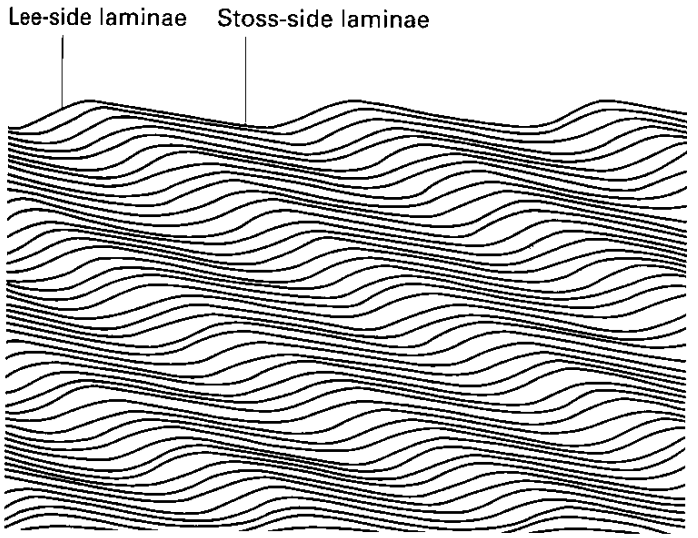
Asymmetrical ripples (dune)

Trazione e decantazione

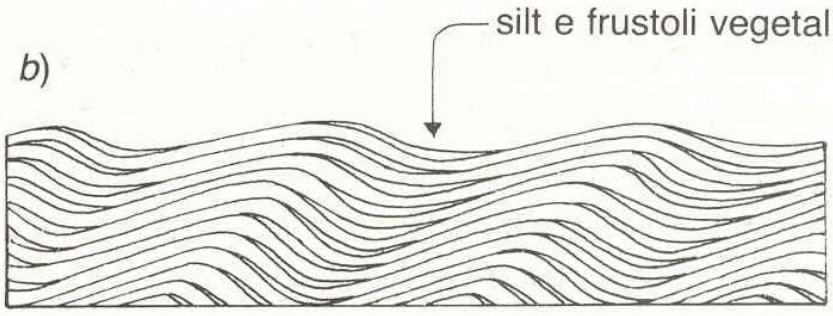
- Corrente in fase calante (decelerazione, diminuzione di profondità): deposizione
- Se ci sono particelle in sospensione la trazione è accompagnata dalla decantazione (matrice o lamine scure), trazione è ostacolata, migrazione rallenta: deposizione anche sul lato posteriore: *climbing ripples*

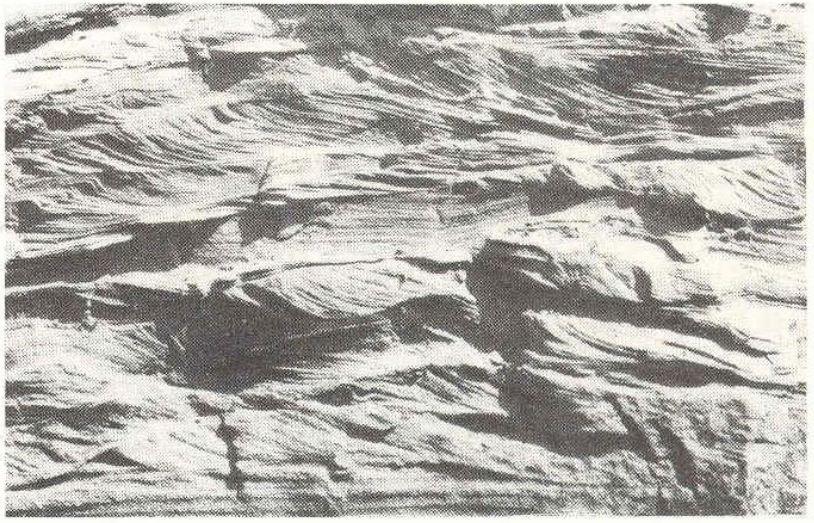






Decantazione e trazione

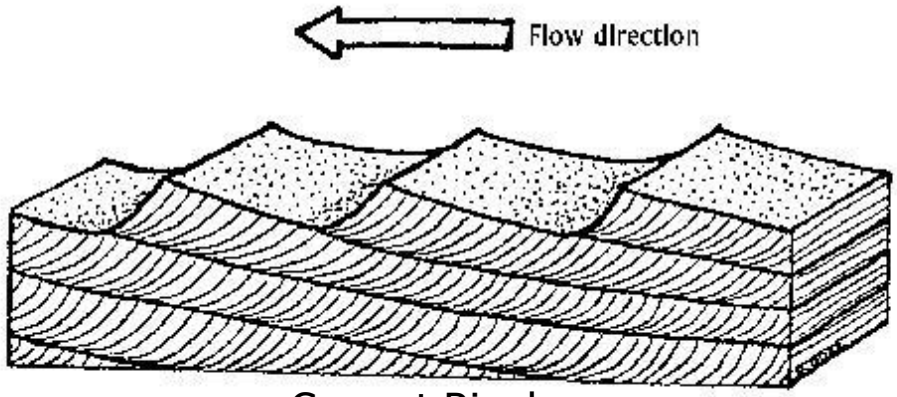




Palazzo Ferrari, Modena

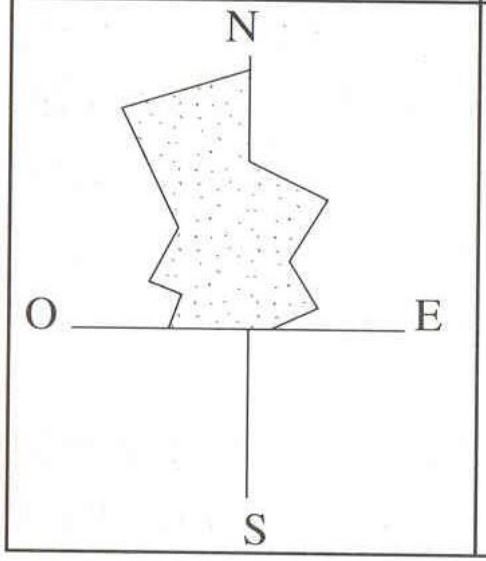
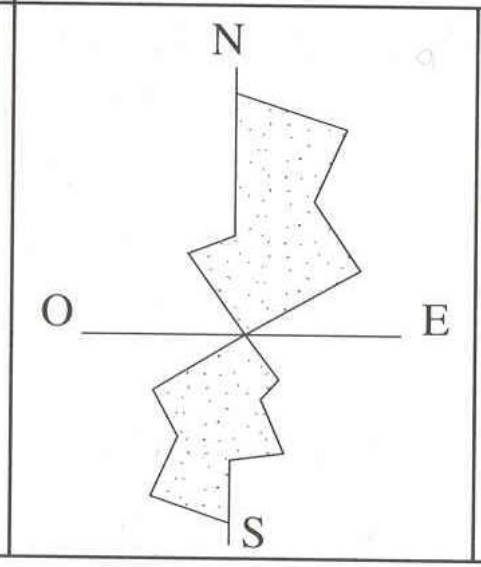
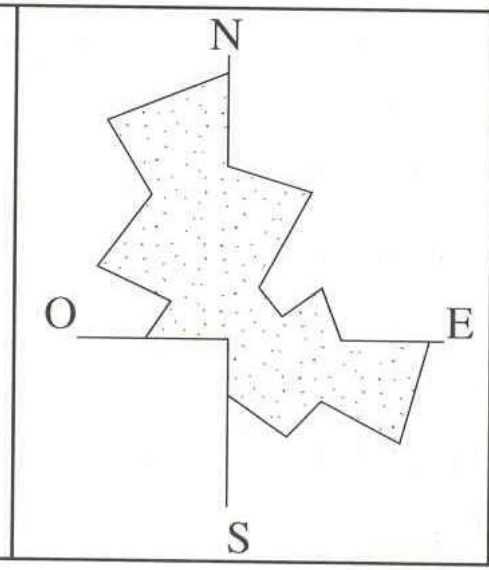
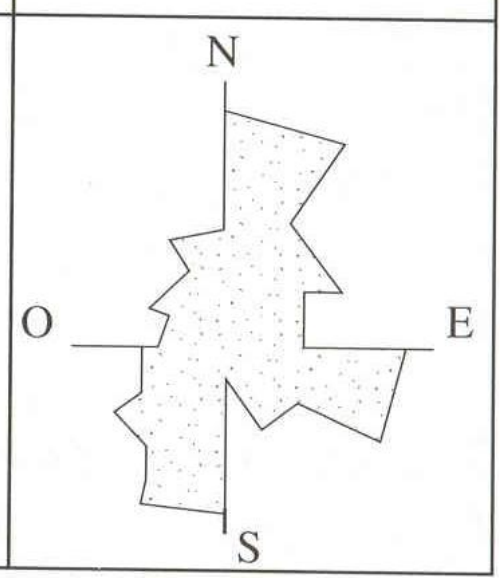

Palazzo Ferrari, Modena

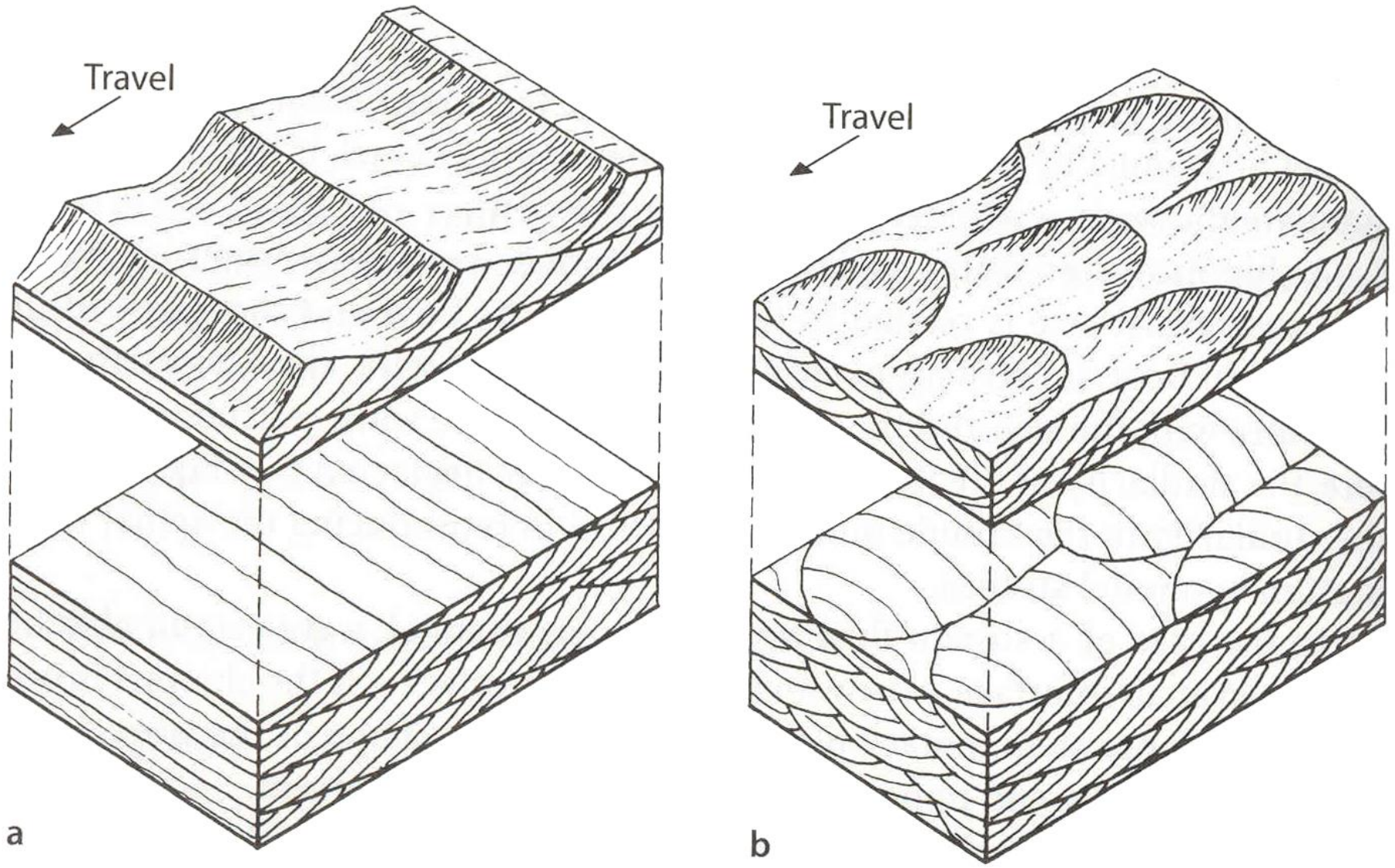

Palazzo Ferrari, Modena



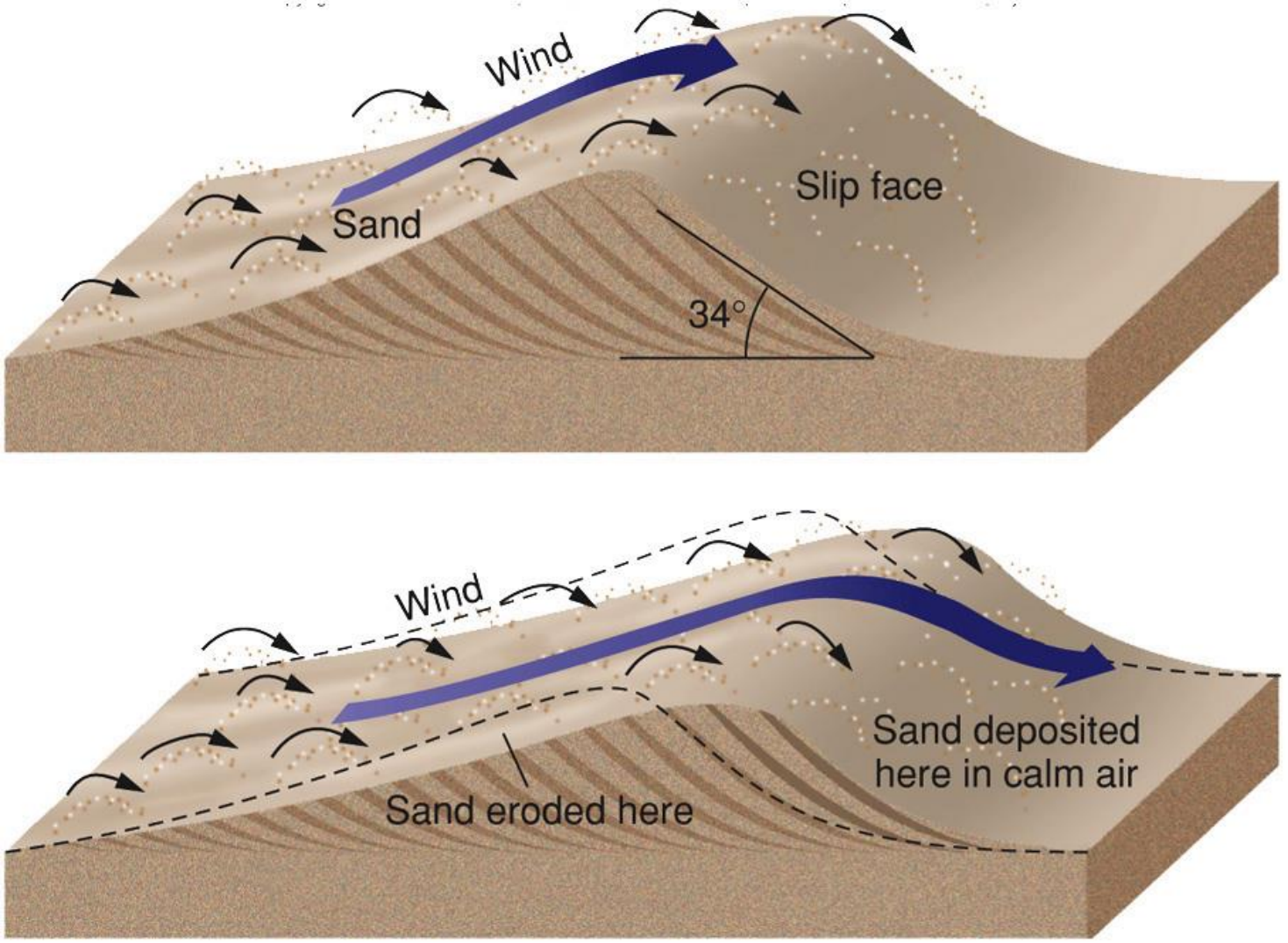
Current Ripple

Direzione corrente

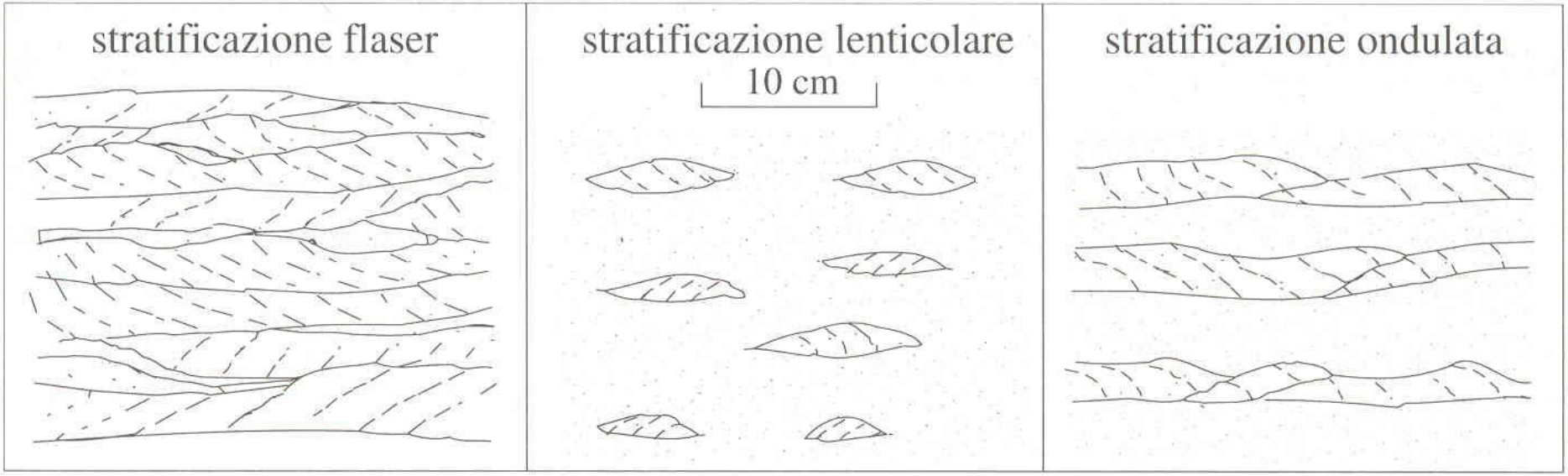
unimodale	bimodale		polimodale
	bipolare	obliqua	
			


Travel
a
Travel
b

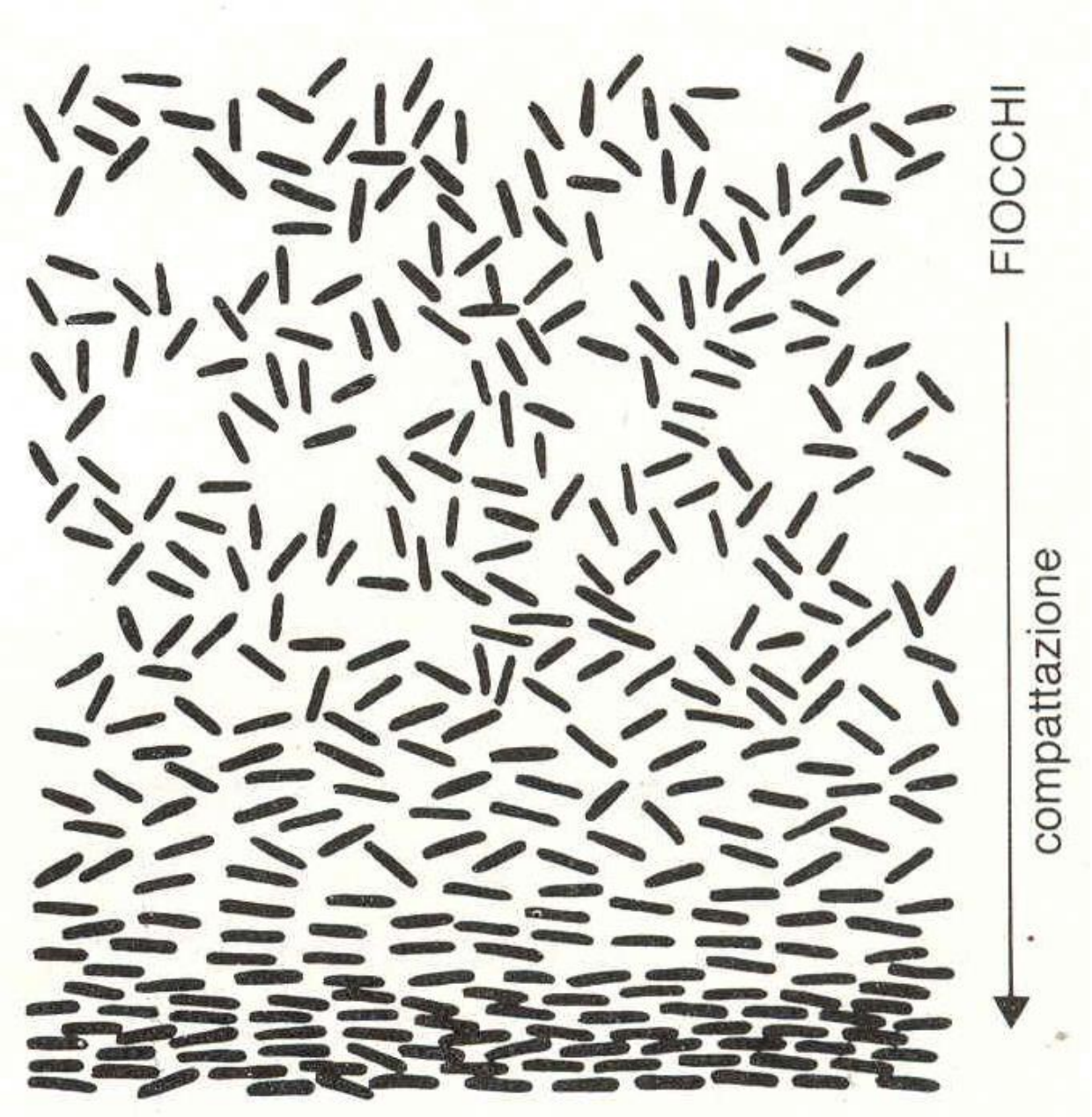
Dune eoliche



Alternanza trazione-decantazione: stratificazione ritmica

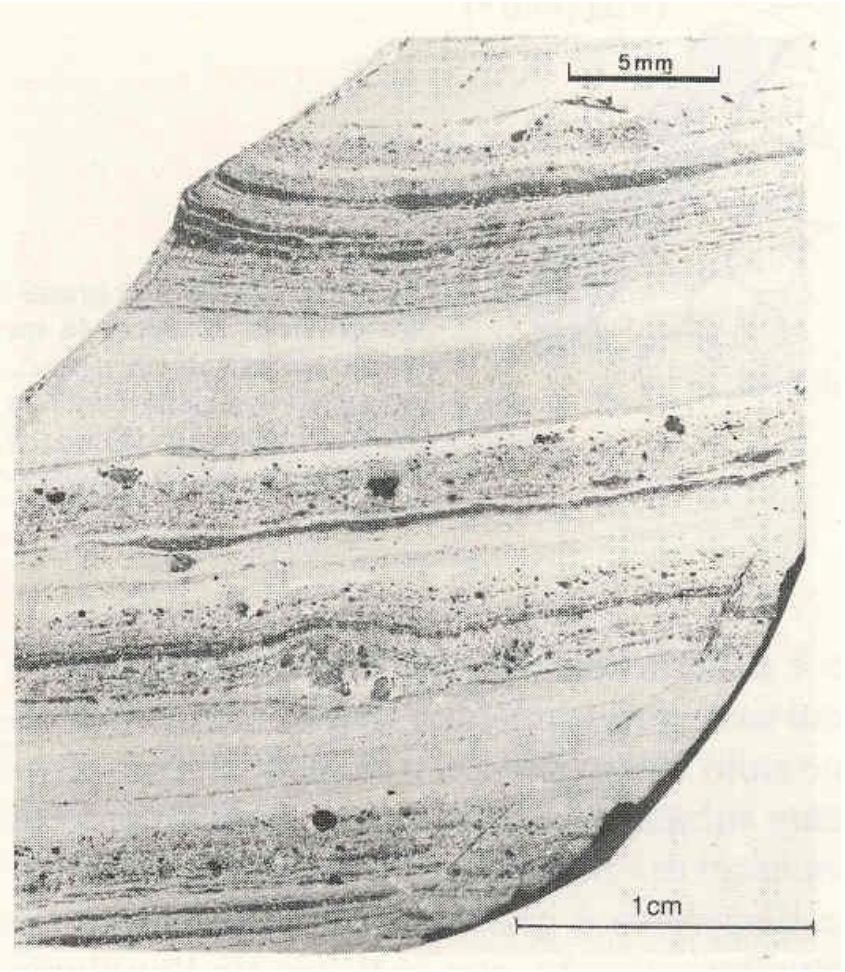


Decantazione



- Da sospensioni diluite (concentrazione <0.1%) quando V della corrente scende e turbolenza non sostiene particelle
- Fango (silt+argilla+grani “leggeri”) gradato
- Sottili lamine piano parallele

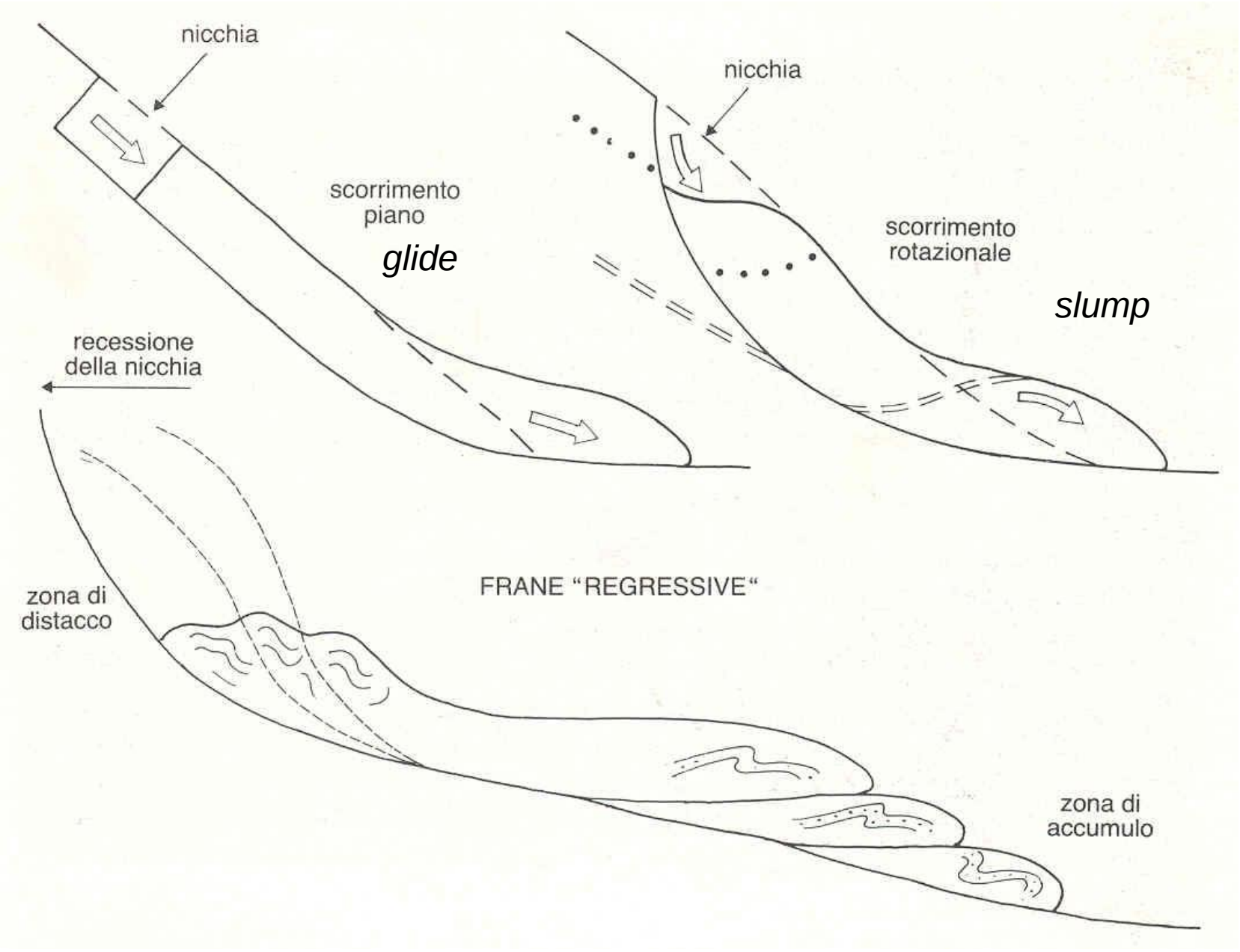
Varve



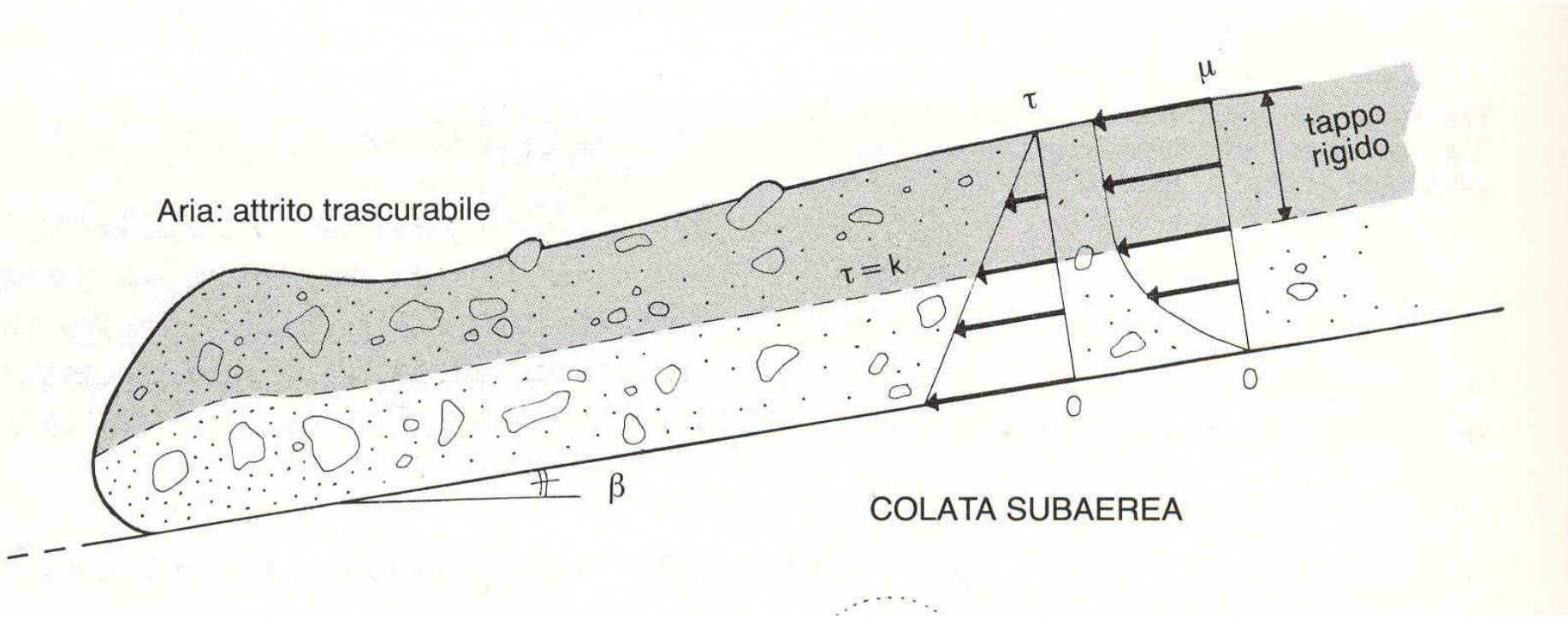
Sottili strati di decantazione organizzati in coppie annuai che hanno colmato i laghi periglaciali quaternari

Estate: grossolano
Inverno: fine e sottile

Processi gravitativi: frane



Processi gravitativi: colate fangose



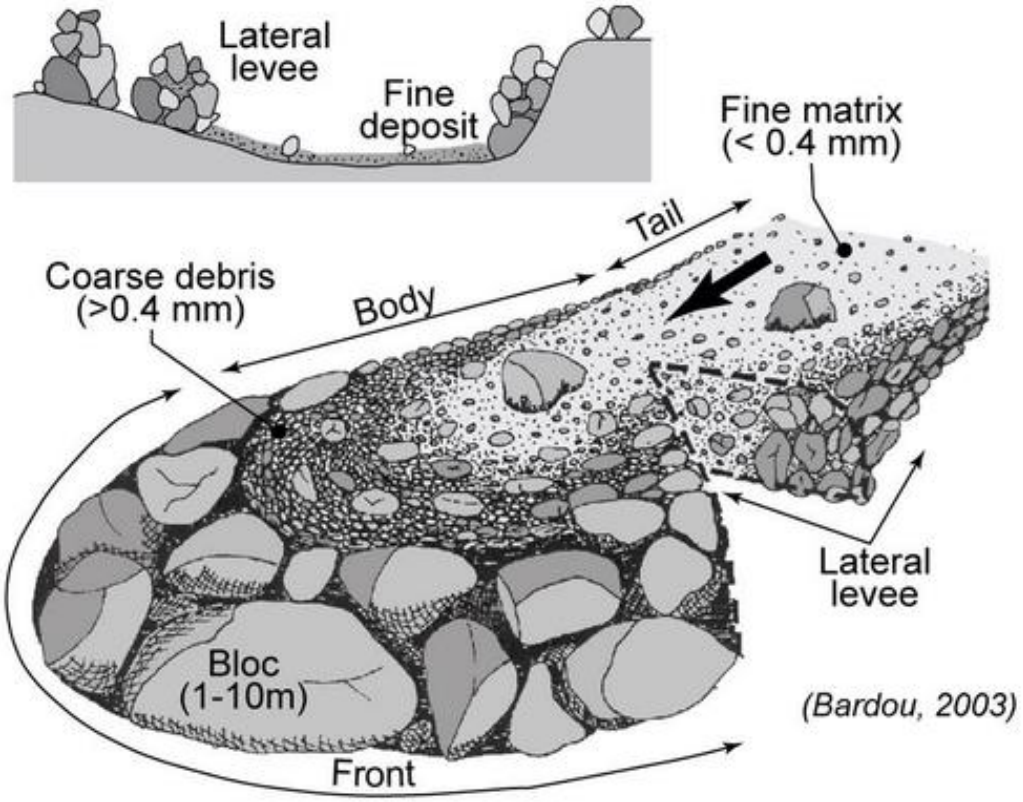
- Mud flow
- Sand flow
- Debris flow

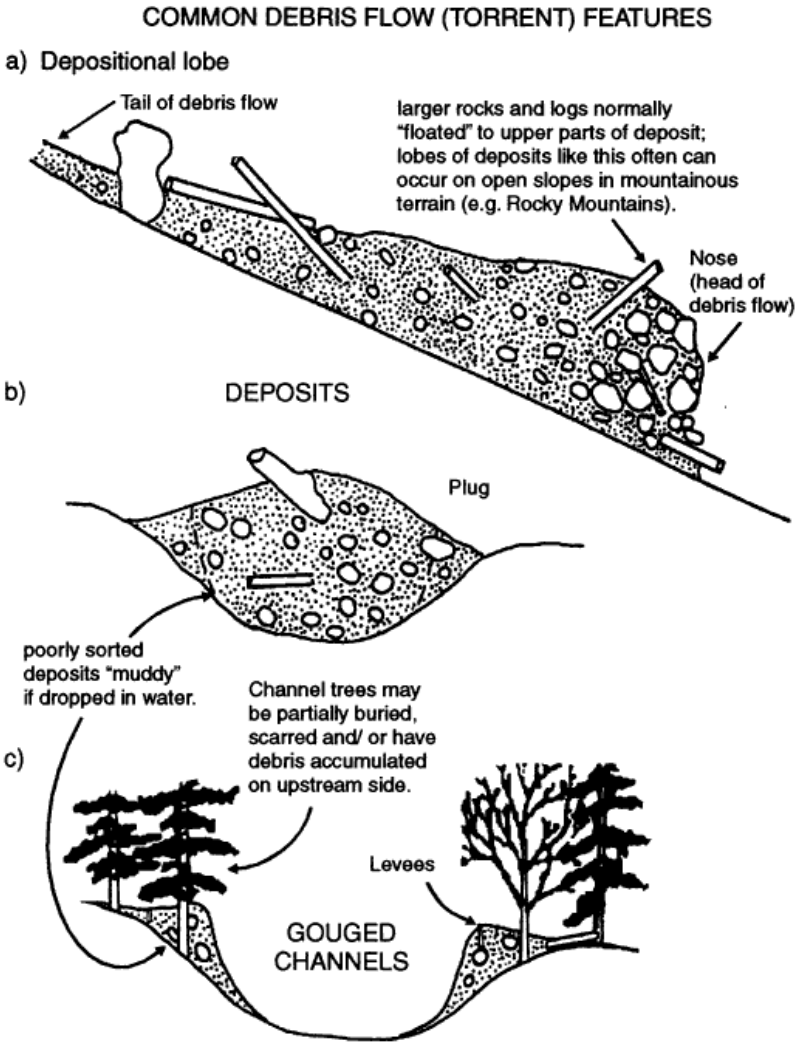
Fango supporta le particelle grossolane e smorza gli attriti: competenza
Colata con v = 50 cm/s può trasportare blocchi di 1m

Postseismic debris flows fan driven by heavy rainfall in Hongchun Gully on August 13, 2010 (taken 14 August, 2010)

Li et al., 2014

Debris flow



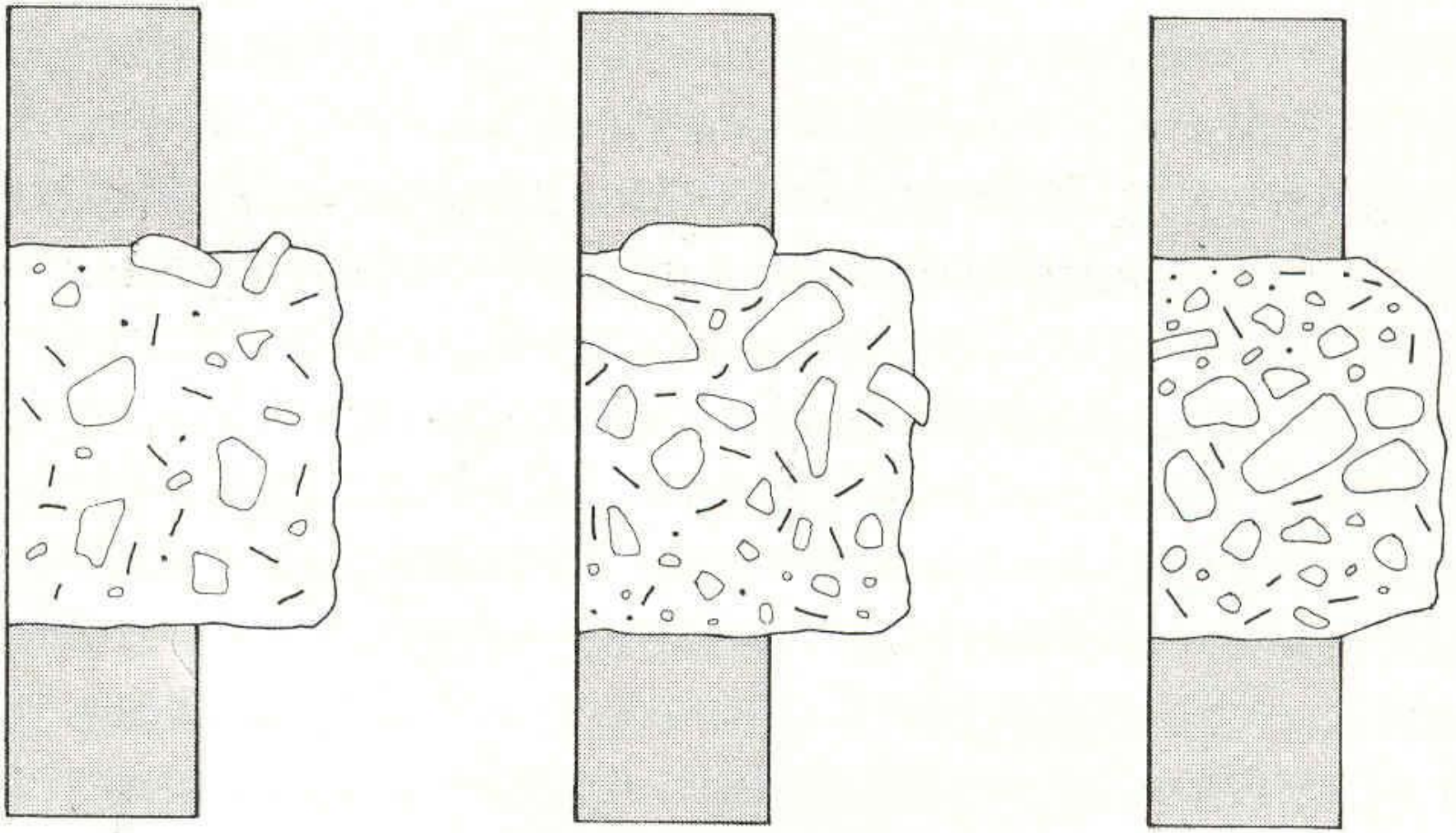


- Debris flows are made up of "loose" particles that move independently within the flow, at least 50% of particles are sand-size or larger particles
- A slide is a coherent block of material that "slides" over a failure surface.
- A mud flow is composed of mud and water.

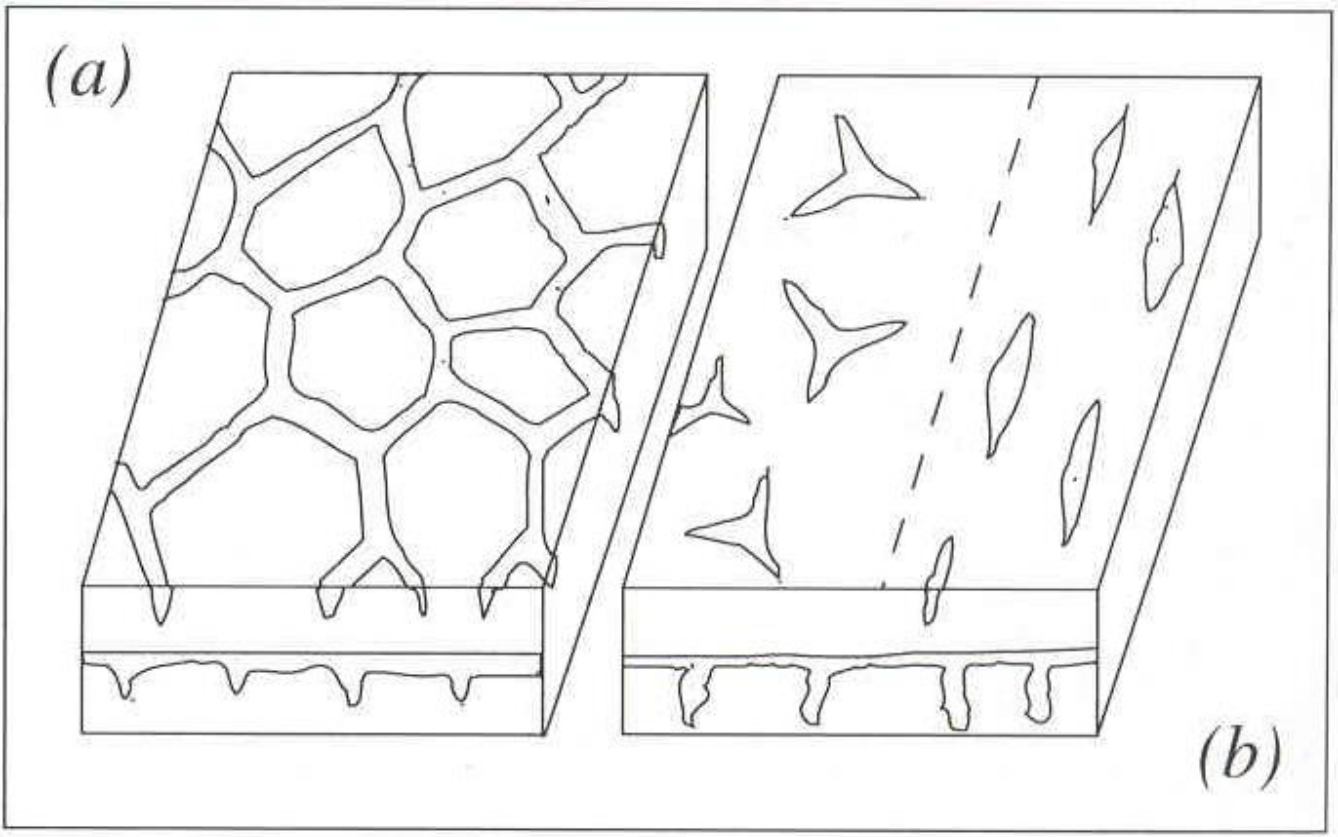
In areas of very steep slopes they can reach speeds of over 160 km/hour. However, many debris flows are very slow, 30 to 60 cm/year)

Colate di detrito (*debris flow*)

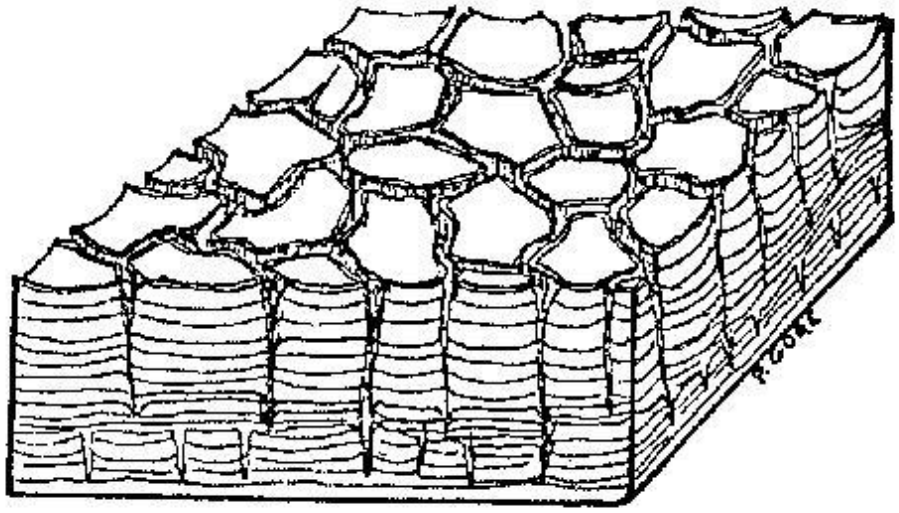
Arresto: “congelamento” - giacitura tipicamente caotica e disorganizzata



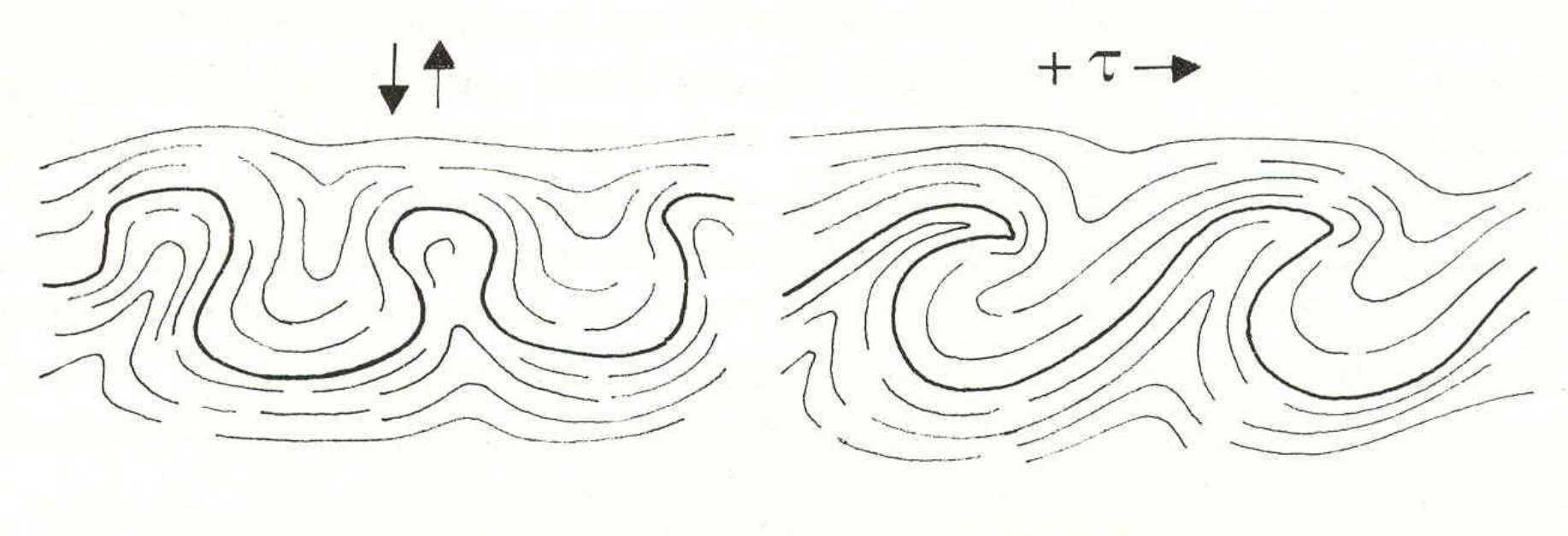
Mud Cracks
poligoni da disseccamento



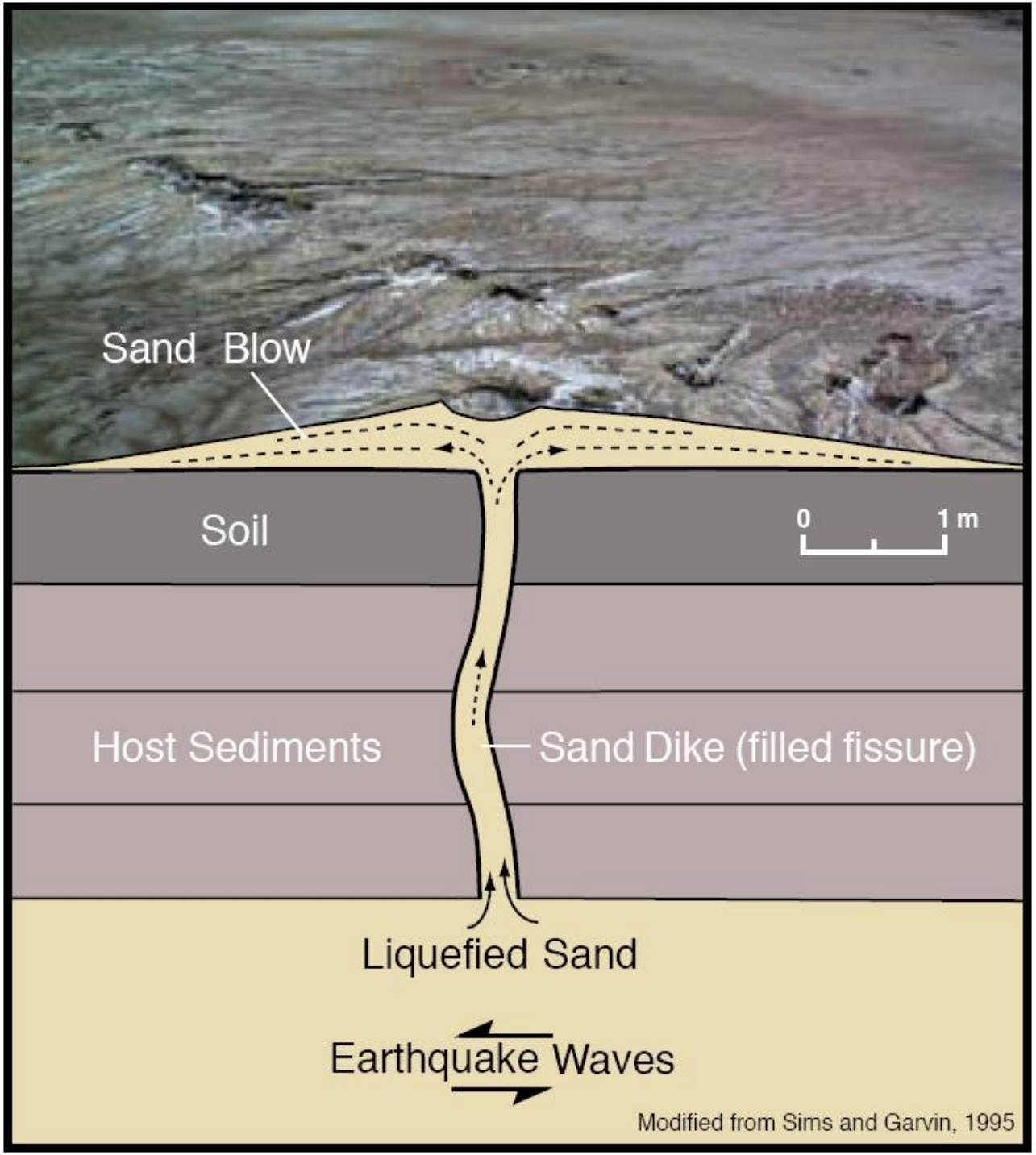
Mud Cracks
poligoni da disseccamento



Strutture deformative



- convoluzioni



Liquefaction

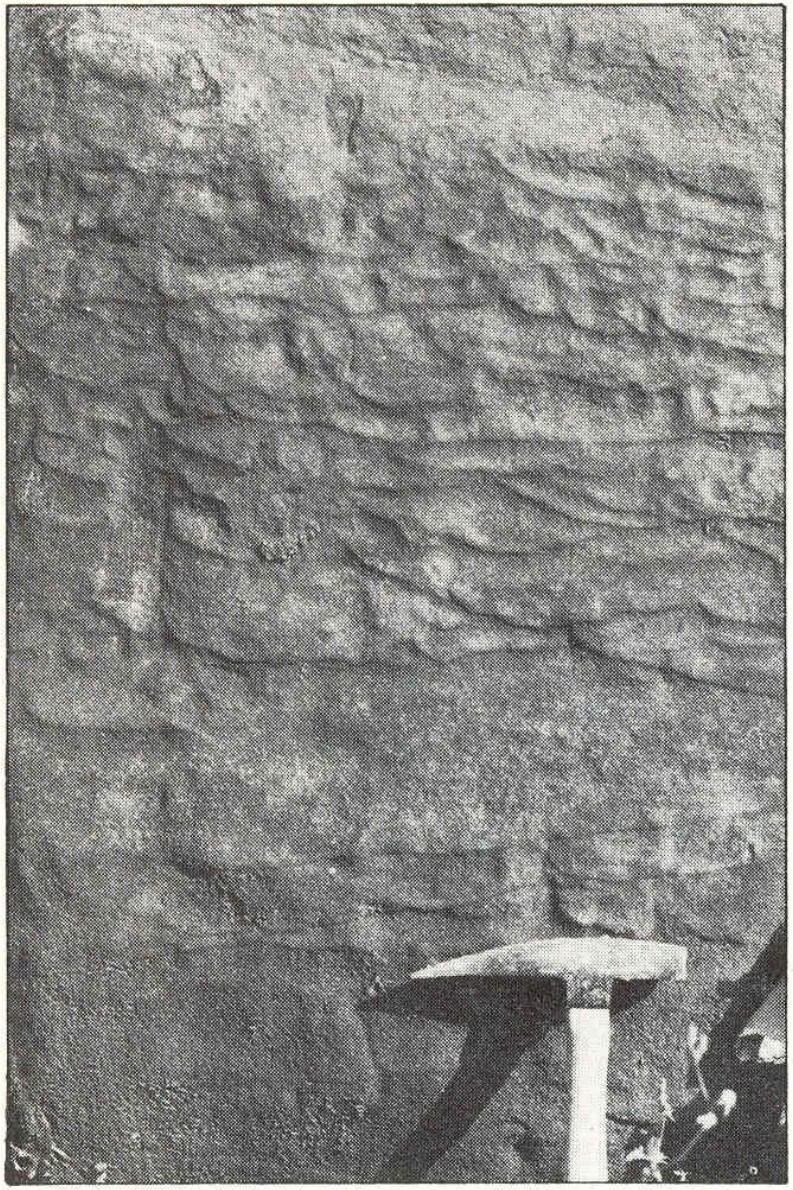
Tuttle, 2011

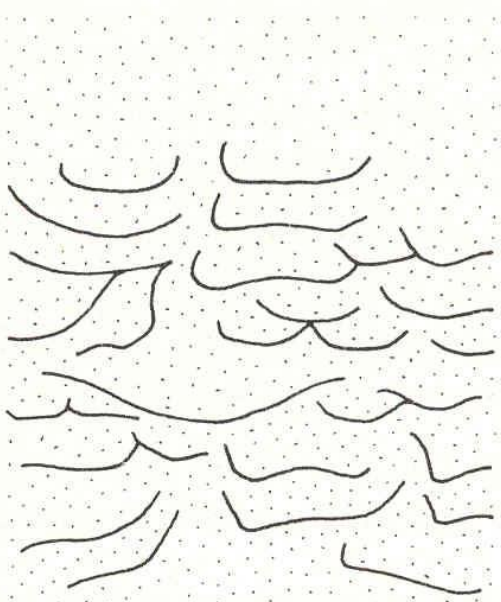
80 % of the effects **induced on May 20**,
20% on May 29.
Many **liquefaction phenomena** have been **reactivated by the second quake**.

Castaldini and Tosatti, 2013

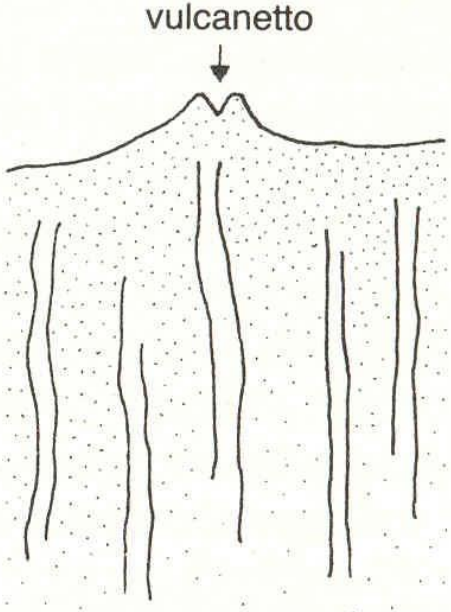
Castaldini and Tosatti, 2013

Iniezione e fluidificazione

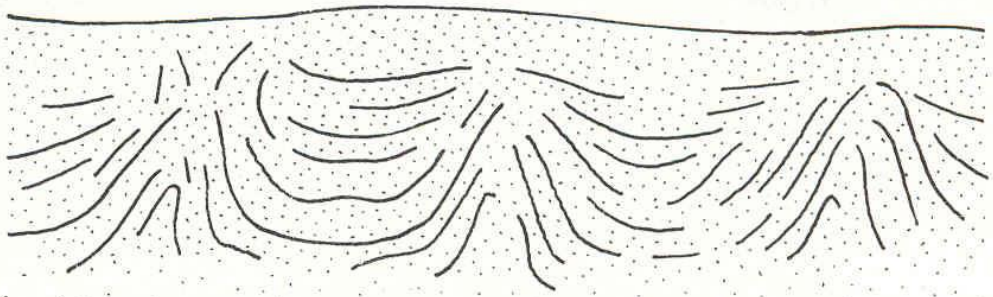




DISH



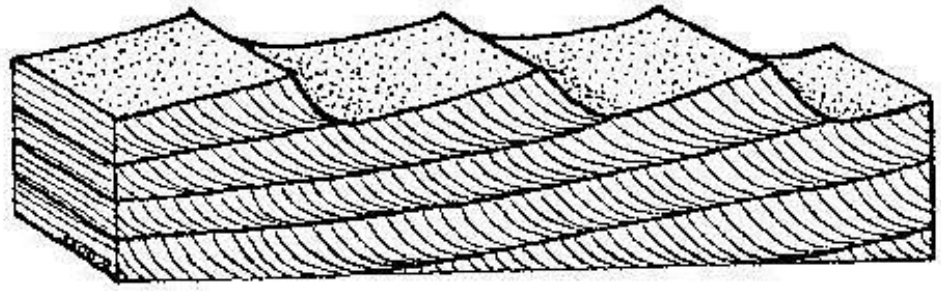
PILASTRI

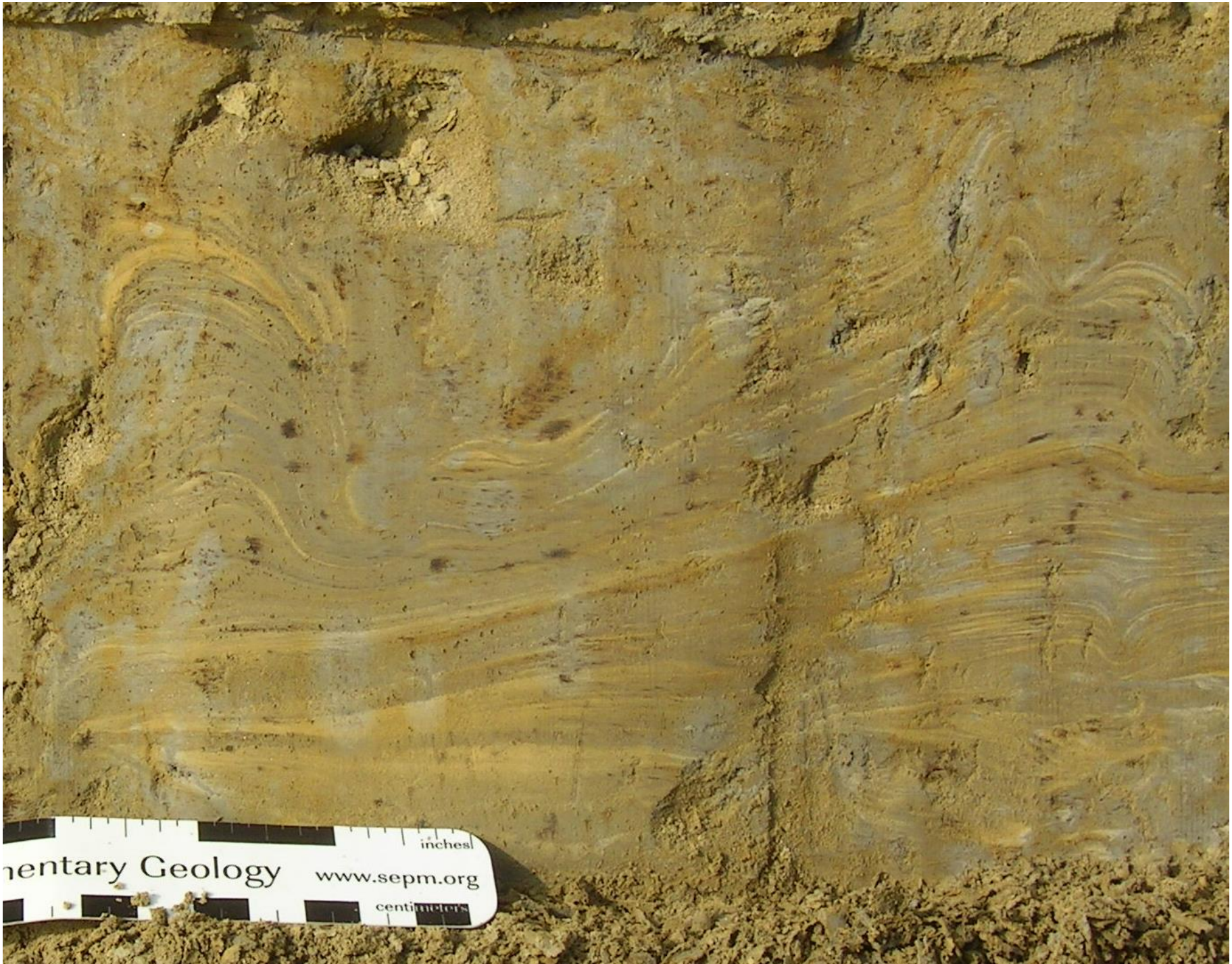


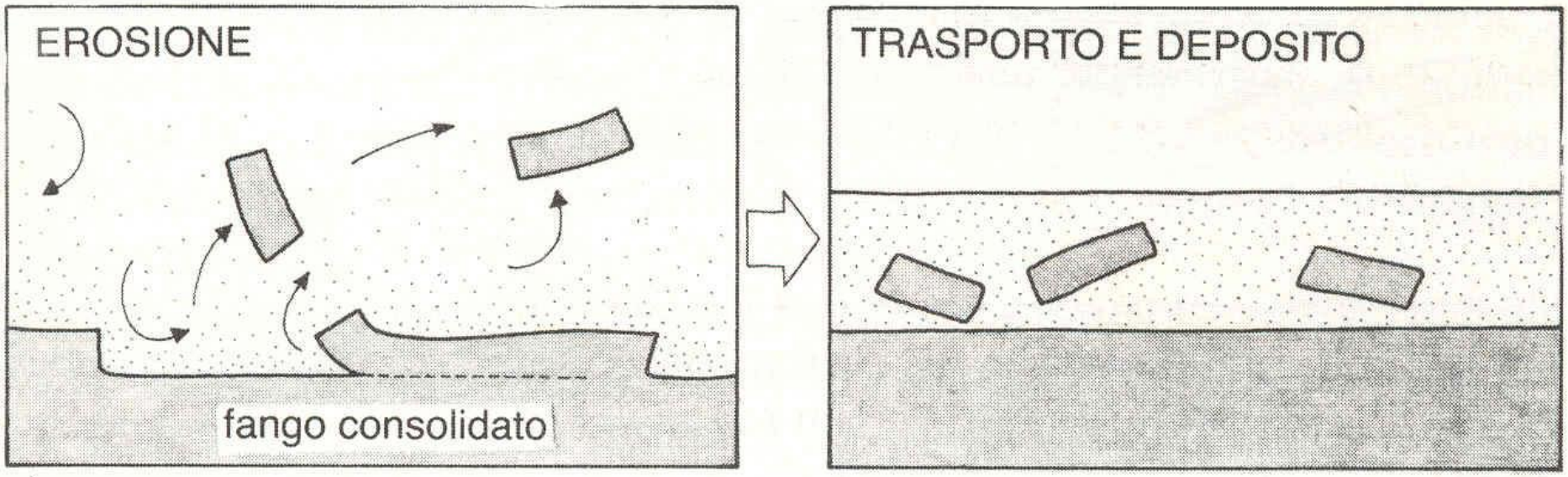
"CONVOLUZIONI A CUSPIDE"

Lo scavo di Via Emilia Est

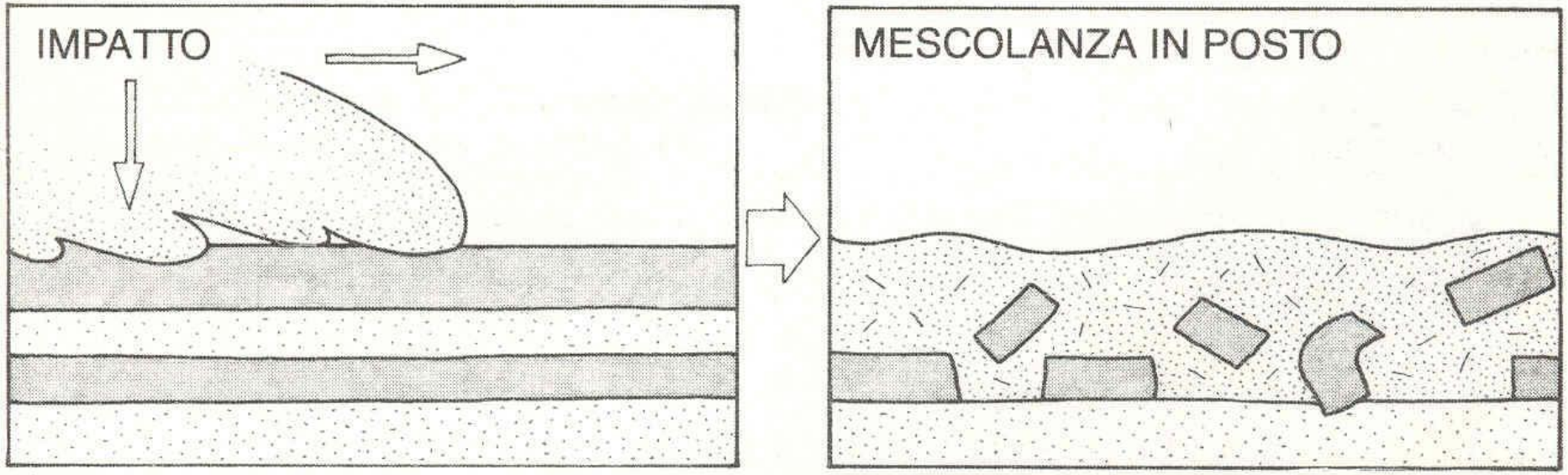
corrente




nentary Geology
www.sepm.org
inches
centimeters


EROSIONE
fango consolidato
TRASPORTO E DEPOSITO

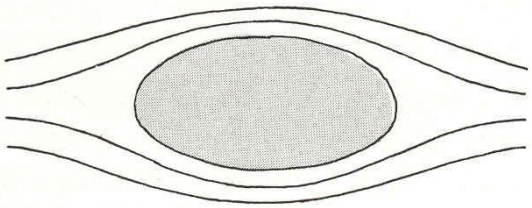
a)


IMPATTO
MESCOLANZA IN POSTO

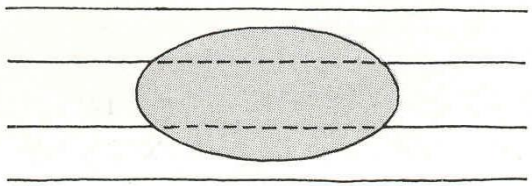
b)

Strutture chimiche

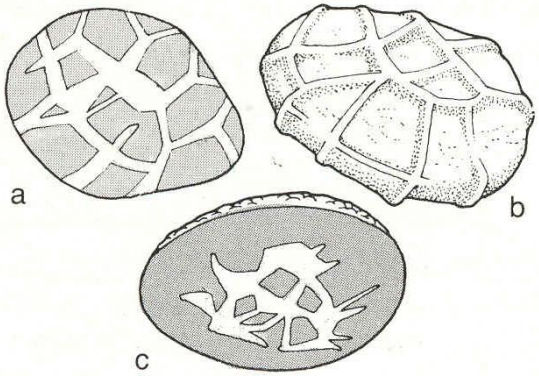
CONCREZIONE



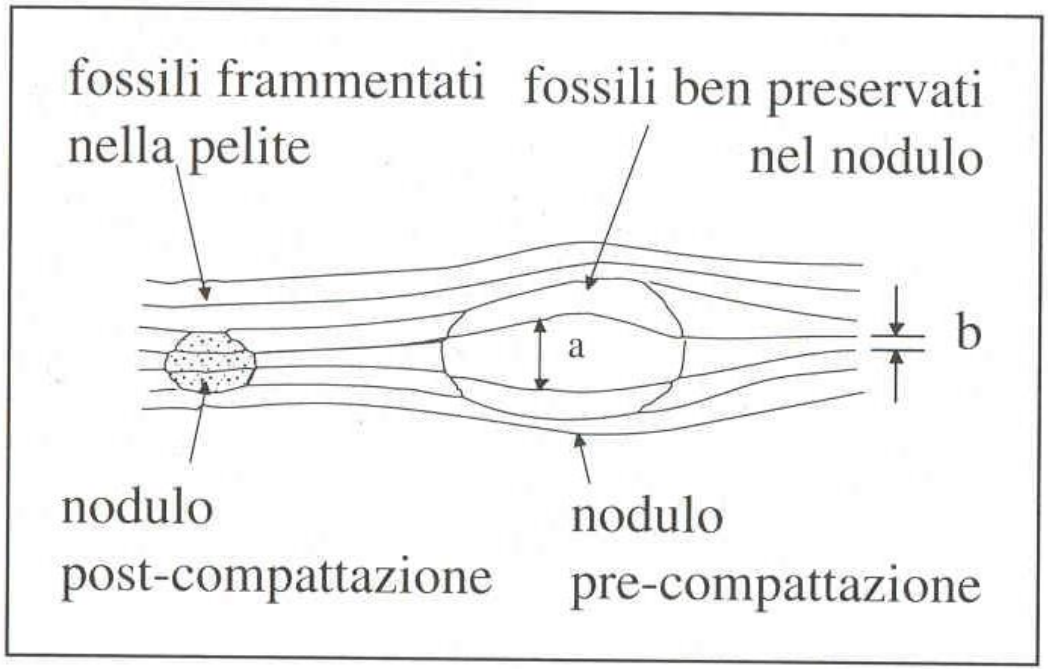
a) Diagenesi precoce (pre-consolidamento): deformazione passiva



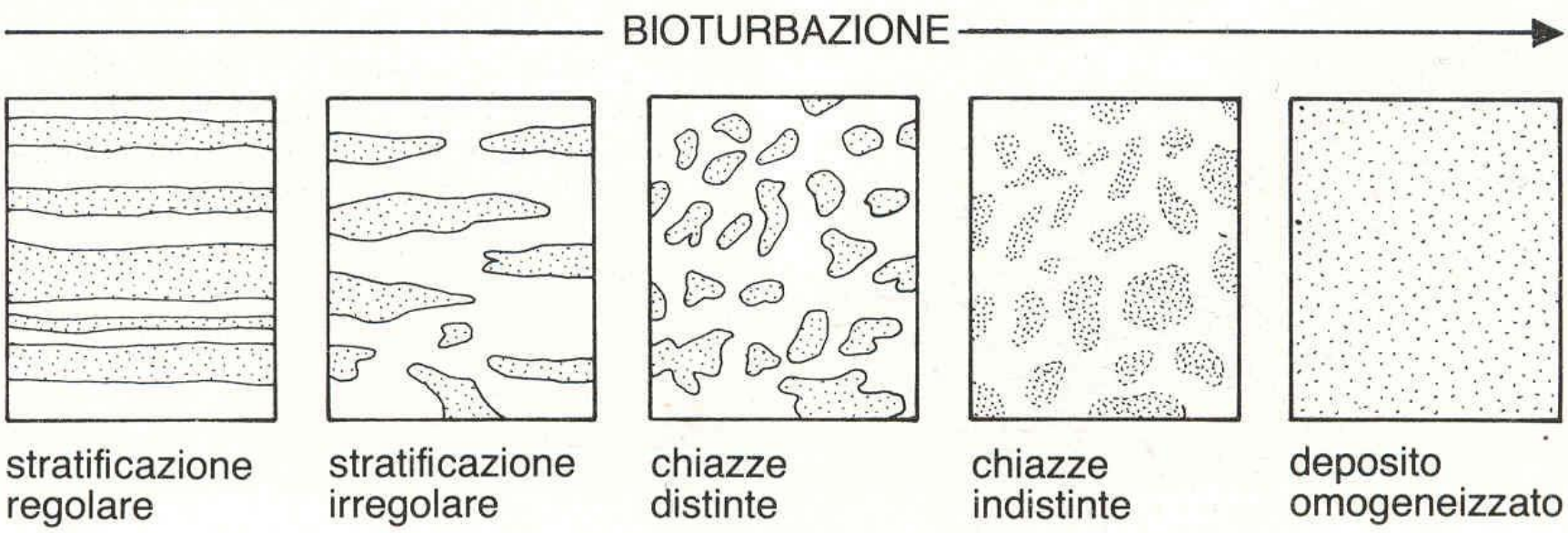
b) Diagenesi tardiva (post-litificazione): assenza di deformazione

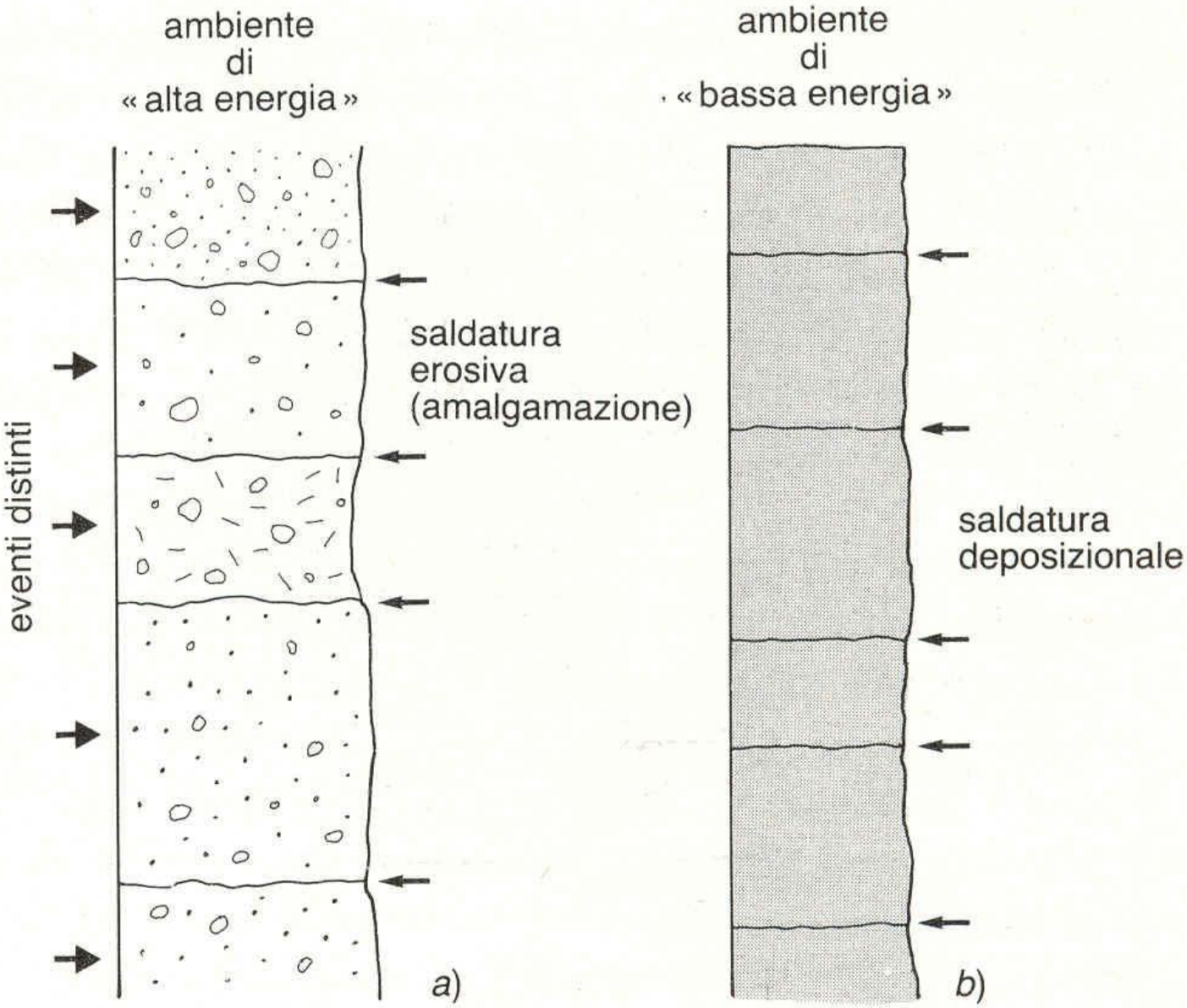


c) septarie: a) levigata da trasporto fluviale, b) con creste sporgenti per erosione della marna, c) in sezione (cavità riempita da sali)



Strutture biogene




ambiente
di
« alta energia »
ambiente
di
« bassa energia »
saldatura
erosiva
(amalgamazione)
saldatura
deposizionale
eventi distinti
a)
b)

	strati molto spessi
1 metro	
	strati spessi
0,3 m	
	strati medi
0,1 m	
	strati sottili
0,03 m	
	strati molto sottili
10 mm	
	lamine spesse
3 mm	
	lamine sottili

- Strato: singolo evento deposizionale “finito” (sedimentazione come fenomeno discontinuo)
- Lamina: evento minore “infinitesimo” (pulsazione o fluttuazione delle condizioni entro un processo contino)