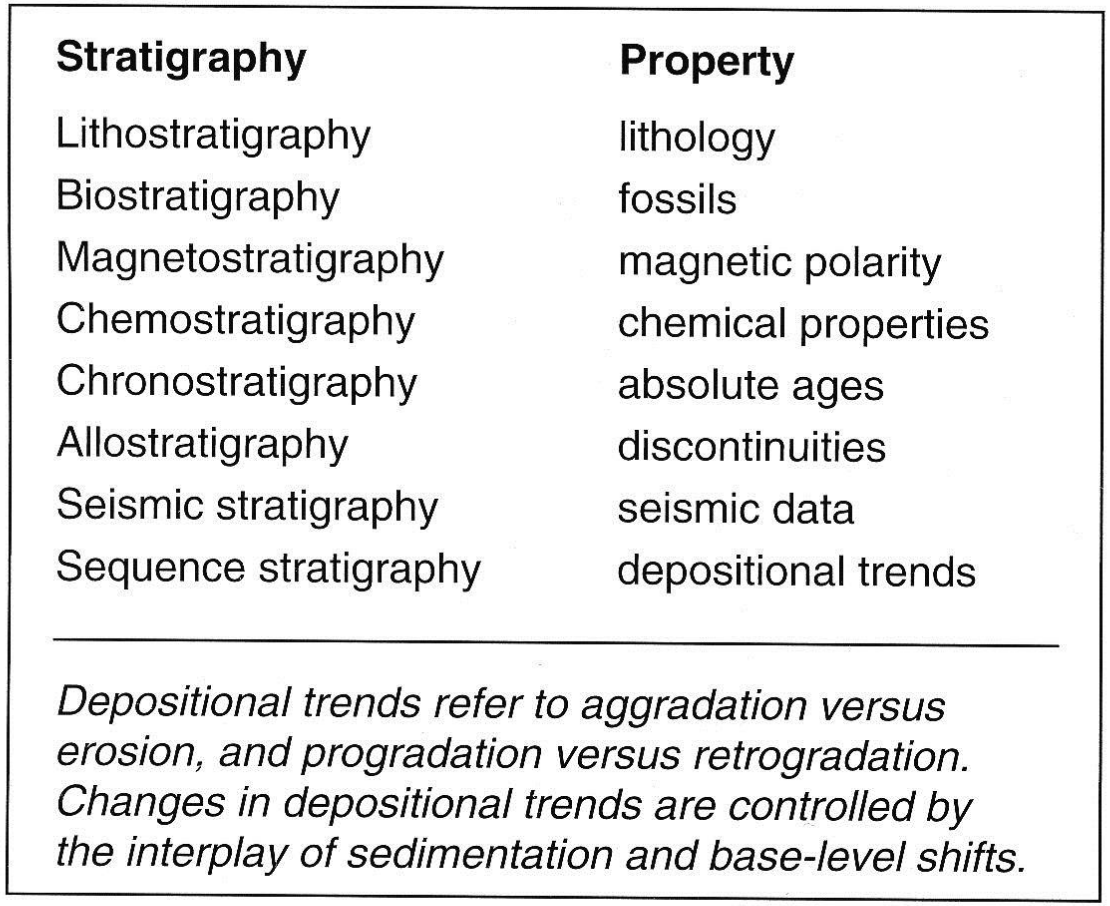
Stratigrafie

Geologie sedimentárních pánví

Stratigrafie

- biostratigrafie
- fyzická stratigrafie
  - litostratigrafie
  - genetická stratigrafie (alostratigrafie – uvažuje alogenní řídící mechanismy, extrapánevní, opak autogenních procesů, např. autocykličnost fluviálních nebo deltových sedimentů)
    - např. sekvenční stratigrafie



Stratigraphy	Property
Lithostratigraphy	lithology
Biostratigraphy	fossils
Magnetostratigraphy	magnetic polarity
Chemostratigraphy	chemical properties
Chronostratigraphy	absolute ages
Allostratigraphy	discontinuities
Seismic stratigraphy	seismic data
Sequence stratigraphy	depositional trends

Depositional trends refer to aggradation versus erosion, and progradation versus retrogradation. Changes in depositional trends are controlled by the interplay of sedimentation and base-level shifts.

FIGURE 1.3 Types of stratigraphy, defined on the basis of the property they analyze. The interplay of sedimentation and shifting base level at the shoreline generates changes in depositional trends in the rock record, and it is the analysis and/or correlation of these changes that defines the primary objectives of sequence stratigraphy.

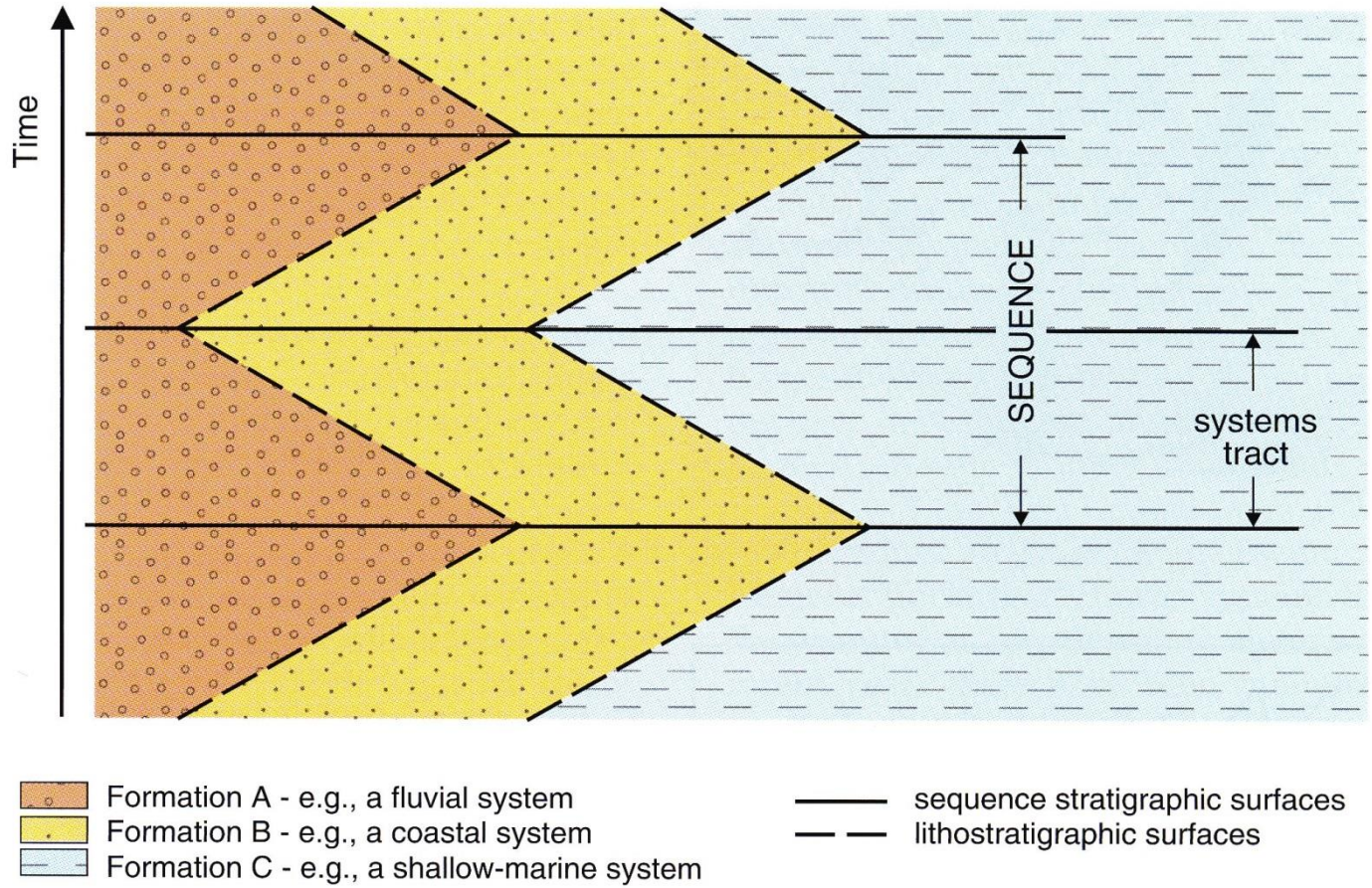
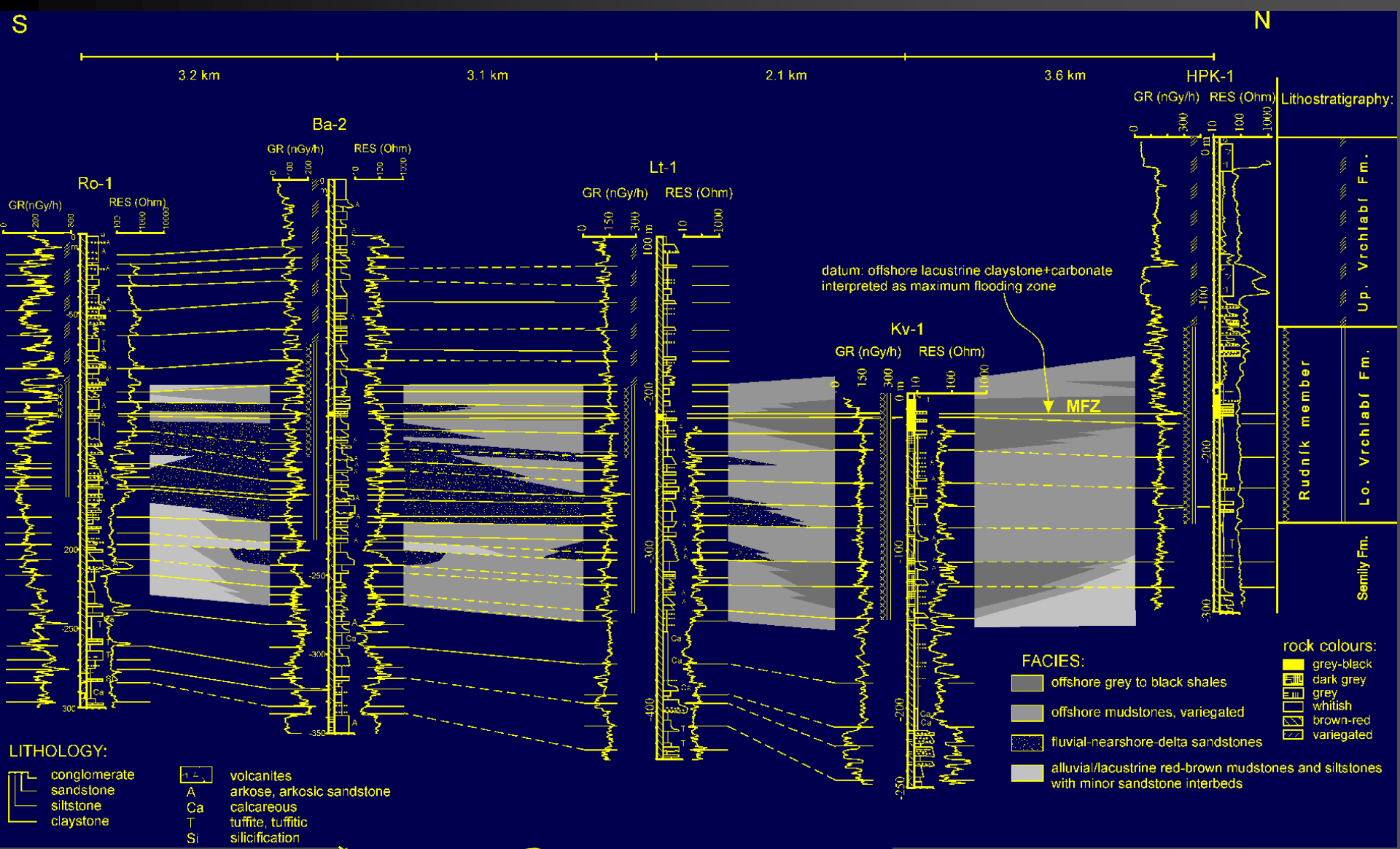


FIGURE 1.12 Conceptual contrast between lithostratigraphy and sequence stratigraphy. Sequence stratigraphic surfaces are event-significant, and mark changes in depositional trends. In this case, their timing is controlled by the turnaround points between transgressions and regressions. Lithostratigraphic surfaces are highly diachronous facies contacts. Note that the system tract and sequence boundaries cross the formation boundaries. Each systems tract is composed of three depositional systems in this example, and is defined by a particular depositional trend, i.e., progradational or retrogradational. A sequence corresponds to a full cycle of changes in depositional trends. This example implies continuous aggradation, hence no breaks in the rock record, with the cyclicity controlled by a shifting balance between the rates of base-level rise and the sedimentation rates.


S
N
3.2 km
3.1 km
2.1 km
3.6 km
Ro-1
Ba-2
Lt-1
Kv-1
HPK-1
GR (nGy/h)
RES (Ohm)
datum: offshore lacustrine claystone+carbonate
interpreted as maximum flooding zone
MFZ
Lithostratigraphy:
Up. Vrchlabí Fm.
Rudník member
Lo. Vrchlabí Fm.
Semily Fm.
LITHOLOGY:
conglomerate
sandstone
siltstone
claystone
volcanites
A arkose, arkosic sandstone
Ca calcareous
T tuffite, tuffitic
Si silicification
FACIES:
offshore grey to black shales
offshore mudstones, variegated
fluvial-nearshore-delta sandstones
alluvial/lacustrine red-brown mudstones and siltstones
with minor sandstone interbeds
rock colours:
grey-black
dark grey
grey
whitish
brown-red
variegated
Vrchlabí
Kundratice
Trutnov
Nová Paka

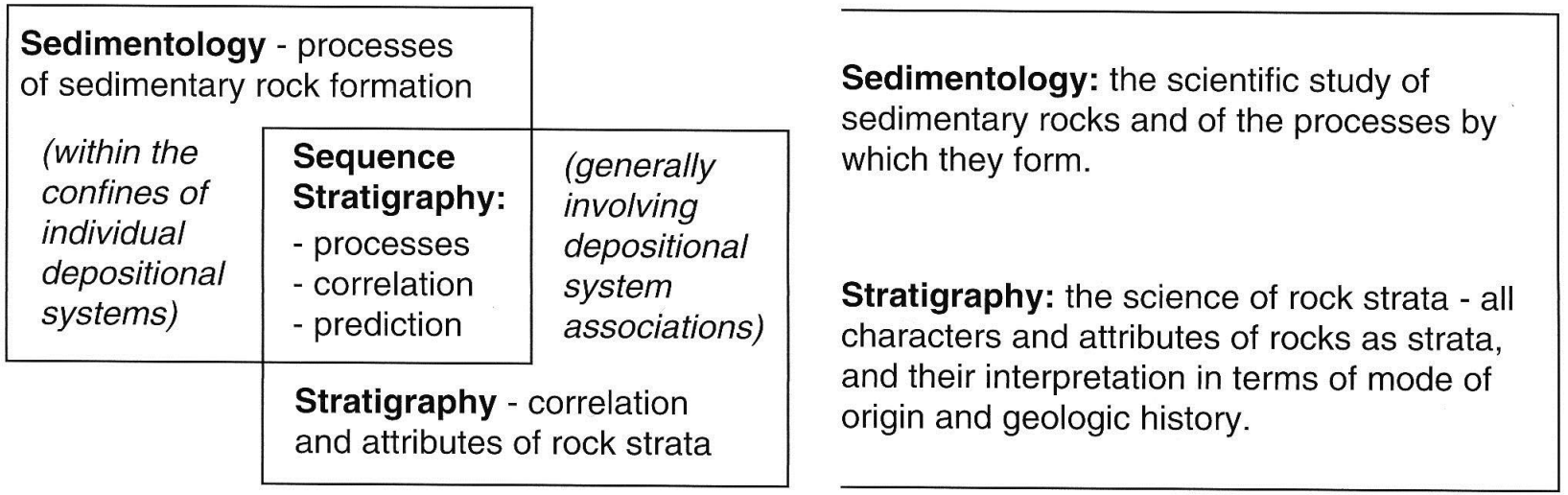


FIGURE 1.2 Sequence stratigraphy and its overlap with the conventional disciplines of sedimentology and stratigraphy (definitions modified from Bates and Jackson, 1987). When applied to a specific depositional system, sequence stratigraphy helps to understand processes of facies formation, facies relationships, and facies cyclicity in response to base-level changes. At larger scales, the lateral correlation of coeval depositional systems becomes a more significant issue, which also brings in a component of facies predictability based on the principle of common causality related to the basin-wide nature of the allogenic controls on sedimentation.

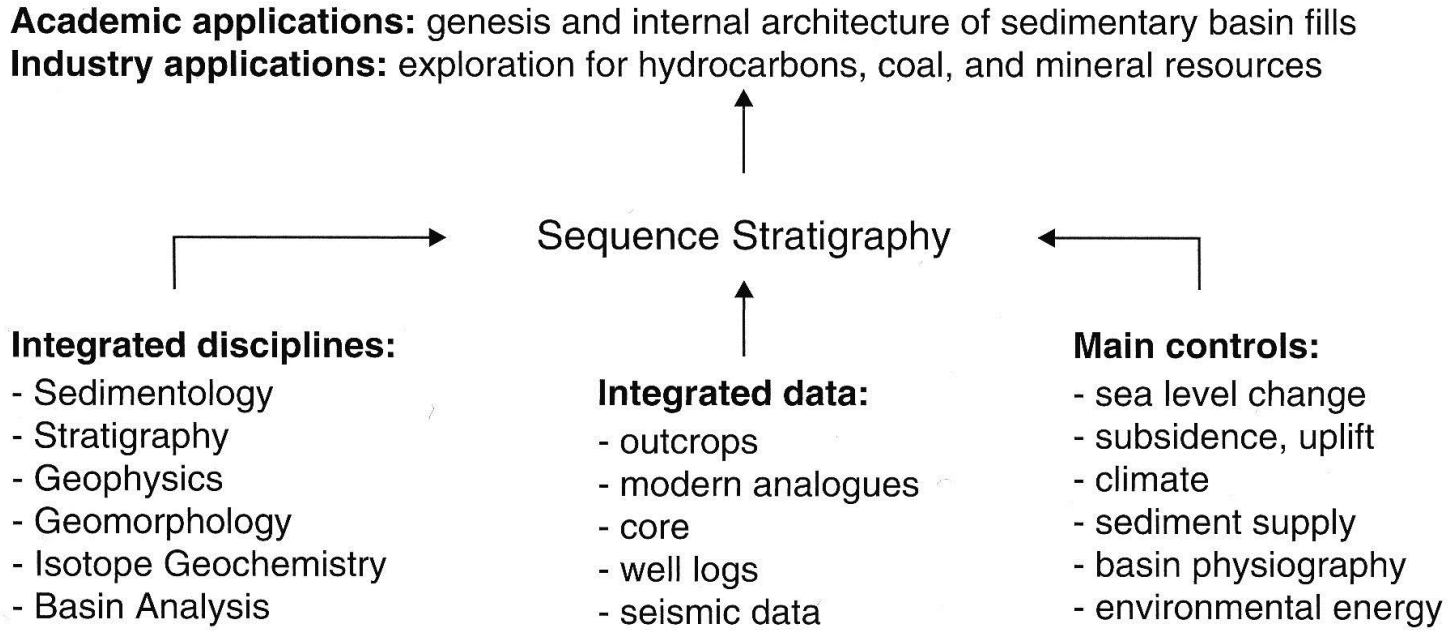


FIGURE 1.1 Sequence stratigraphy in the context of interdisciplinary research—main controls, integrated data sets and subject areas, and applications.

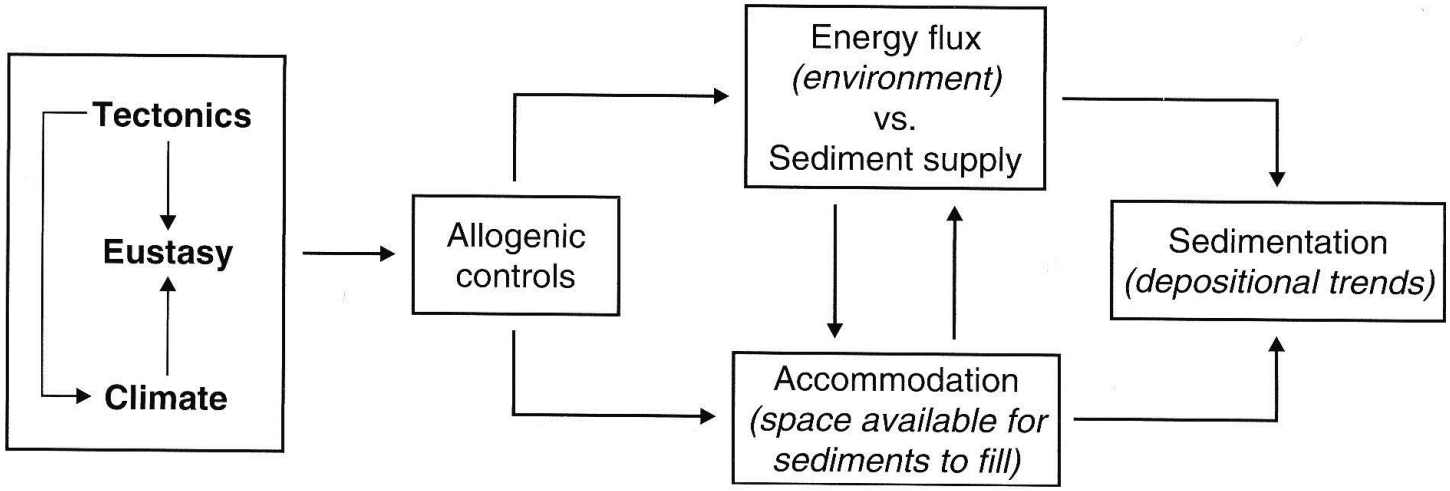


FIGURE 3.1 Allogenic controls on sedimentation, and their relationship to environmental energy flux, sediment supply, accommodation, and depositional trends (modified from Catuneanu, 2003). In any depositional environment, the balance between energy flux and sediment supply is key to the manifestation of processes of sediment accumulation or reworking. Besides tectonics, additional processes such as thermal subsidence (crustal cooling), sediment compaction, water-depth changes, isostatic, and flexural loading, also contribute to the total subsidence or uplift in the basin. Accommodation is affected by the balance between energy flux and sediment supply (i.e., increased energy 'erodes' accommodation; increased sediment supply adds to the amount of available accommodation), but it is also independently controlled by external factors such as eustasy and tectonism. At the same time, changes in accommodation controlled directly by external factors may alter the balance between energy flux and sediment supply at any location within the basin (e.g., deepening of the water as a result of sea-level rise lowers the energy flux at the seafloor). The interplay of all allogenic controls on sedimentation, as reflected by changes in accommodation and energy flux/sediment supply, ultimately determines the types of depositional trends established within the basin.

Hierarchical order	Duration (My)	Cause
First order	200-400	Formation and breakup of supercontinents
Second order	10-100	Volume changes in mid-oceanic spreading centers
Third order	1-10	Regional plate kinematics
Fourth and fifth order	0.01-1	Orbital forcing

FIGURE 3.2 Tectonic and orbital controls on eustatic fluctuations (modified from Vail *et al.*, 1977, and Miall, 2000). Local or basin-scale tectonism is superimposed and independent of these global sea-level cycles, often with higher rates and magnitudes, and with a wide range of time scales.

SEKVENČNÍ STRATIGRAFIE

Diagrams from
Coe, A. et al. 2003. The Sedimentary Record of Sea Level Change. Cambridge University Press
Nichols, G. 1999. Sedimentology and Stratigraphy. Blackwells
Plint, A.G. and Uličný, D. 1999. Notes for a short course in Sequence Stratigraphy

www.strata.geol.sc.edu/log-stacking.html

Stratigrafie – studuje stáří a chronologické vztahy horninových těles

SEKVENČNÍ STRATIGRAFIE

– studuje chronologické vztahy těles sedimentárních hornin, které vykazují určitou cyklicitu a jsou spojovány do geneticky provázaných celků - **sekvencí**

Sekvenčněstratigrafický vývoj je dán vztahem mezi

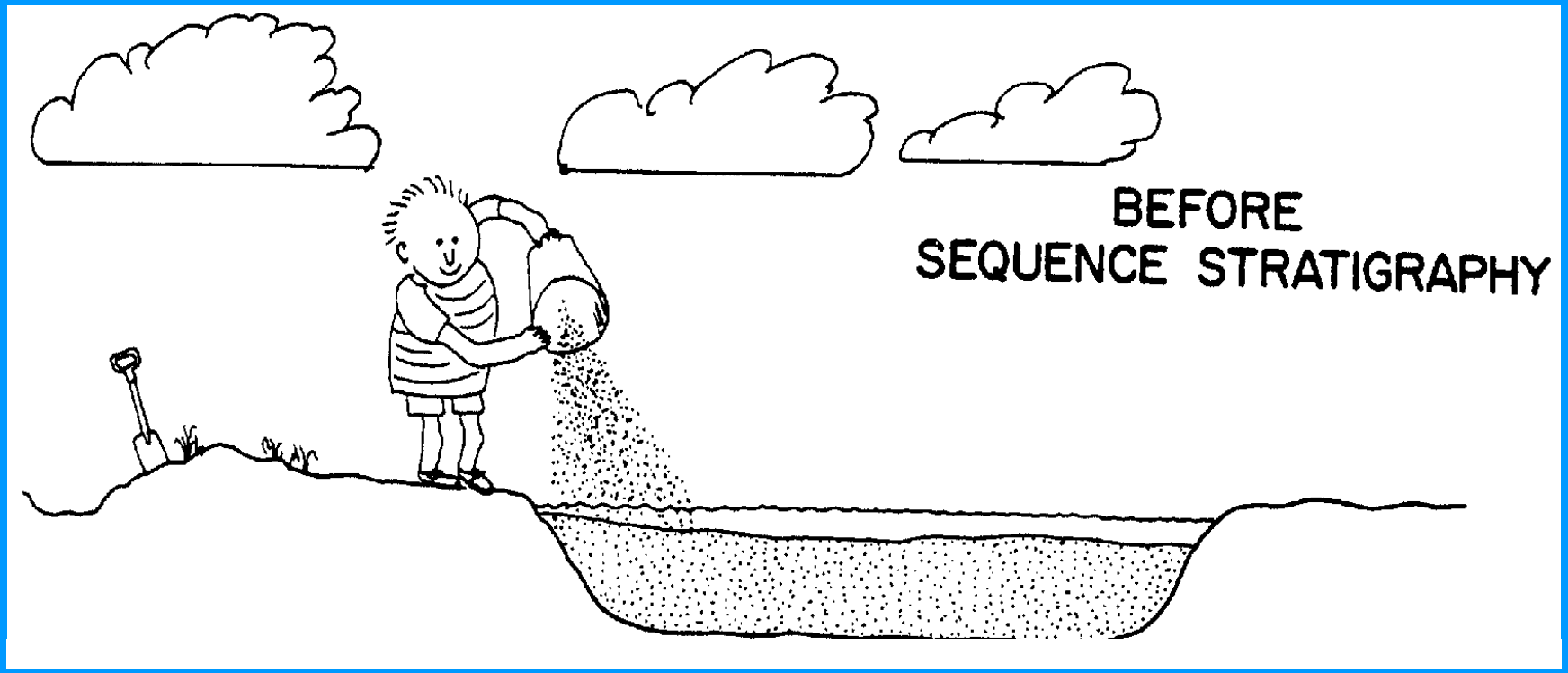
akomodací a přínosem sedimentu

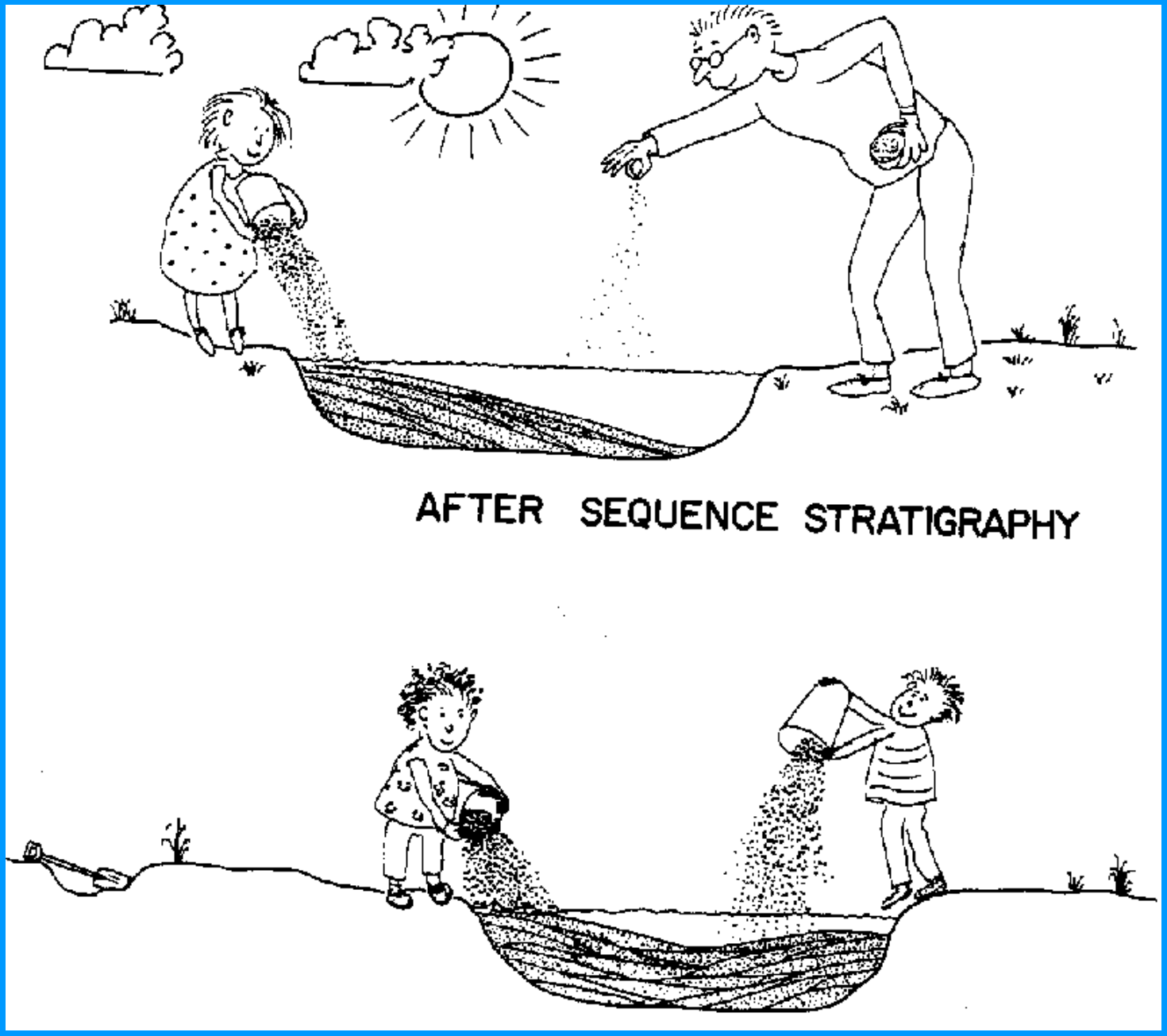
akomodační prostor – prostor pro potenciální akumulaci sedimentu

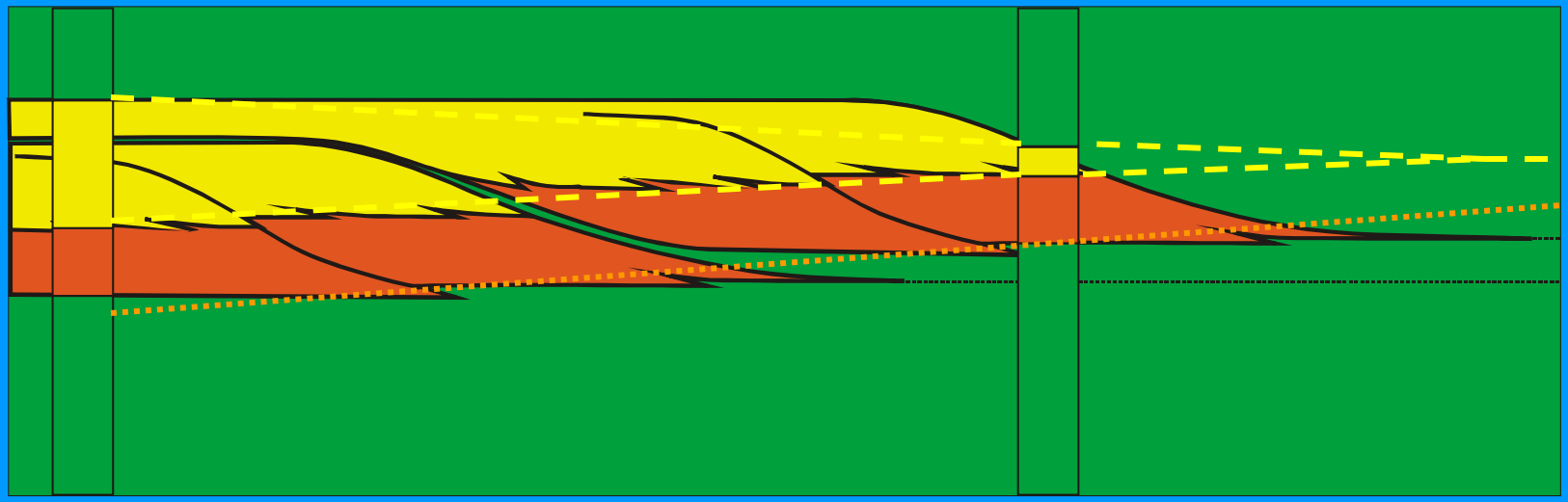
relativní změny hladiny – projev změn akomodačního prostoru; hrají významnou roli v prostředích citlivých na hloubku vody (šelfy, jezera,...)

fluviálních prostředích - akomodační prostor kontrolován **spádovou křivkou** řeky

eolická prostředí - akomodace ovlivňována geomorfologií, směrem větru, přínosem sedimentu a hladinou podzemní vody

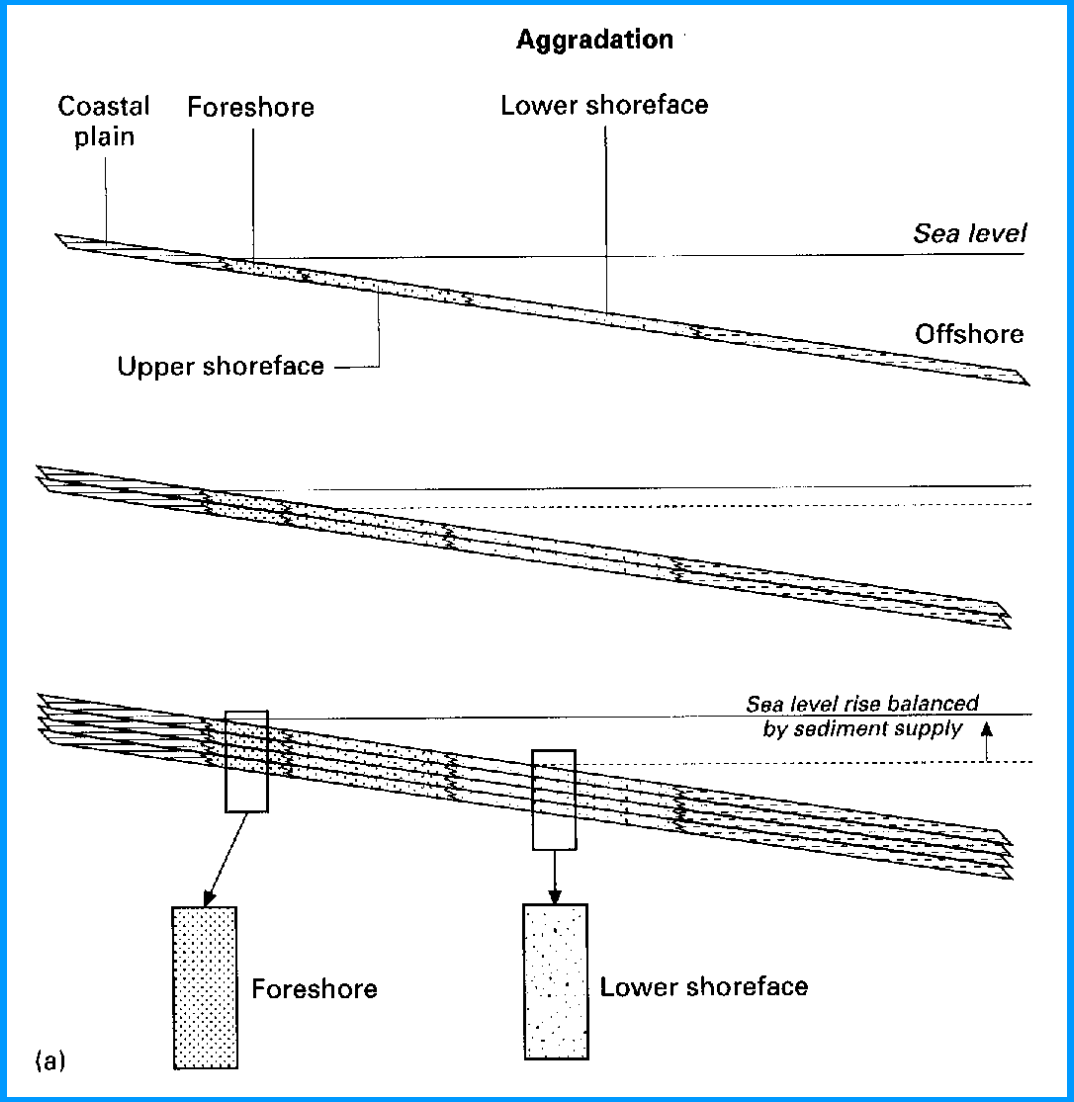

BEFORE
SEQUENCE STRATIGRAPHY


AFTER SEQUENCE STRATIGRAPHY

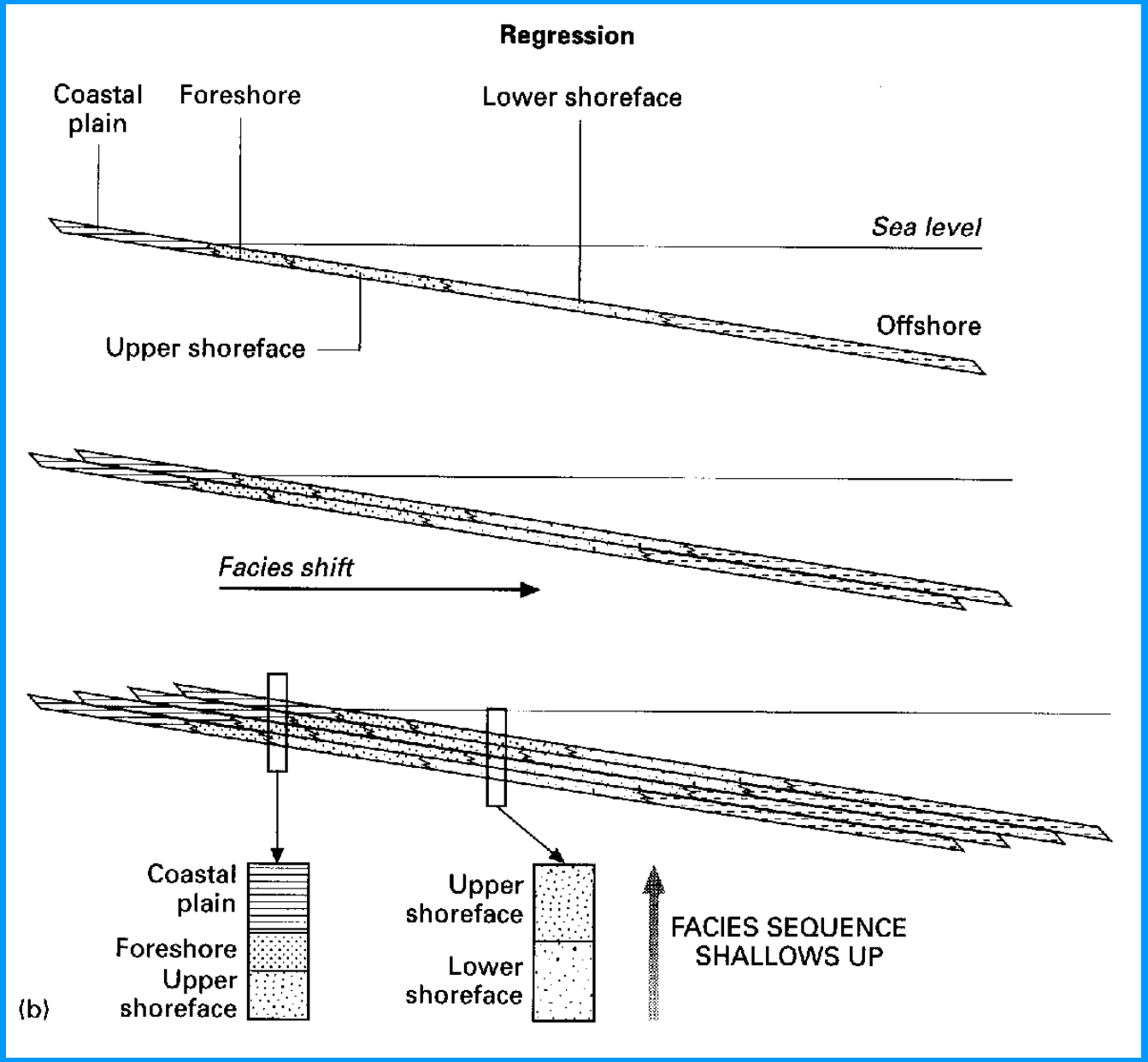


ZÁKLADNÍ REAKCE SEDIMENTÁRNÍCH SYSTÉMŮ NA RELATIVNÍ ZMĚNY HLADINY

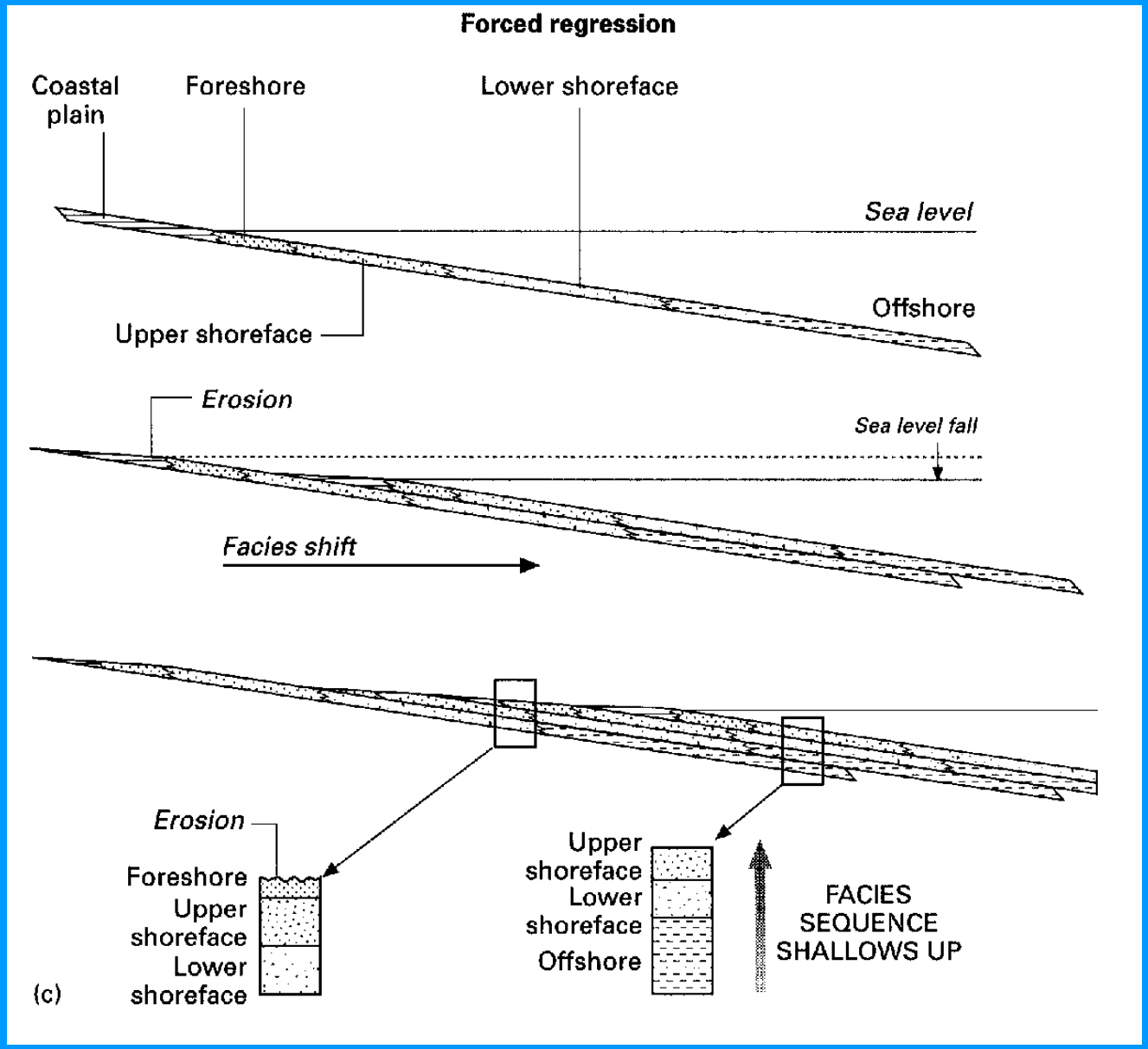
přínos sedimentu = akomodace ⇒ agradace



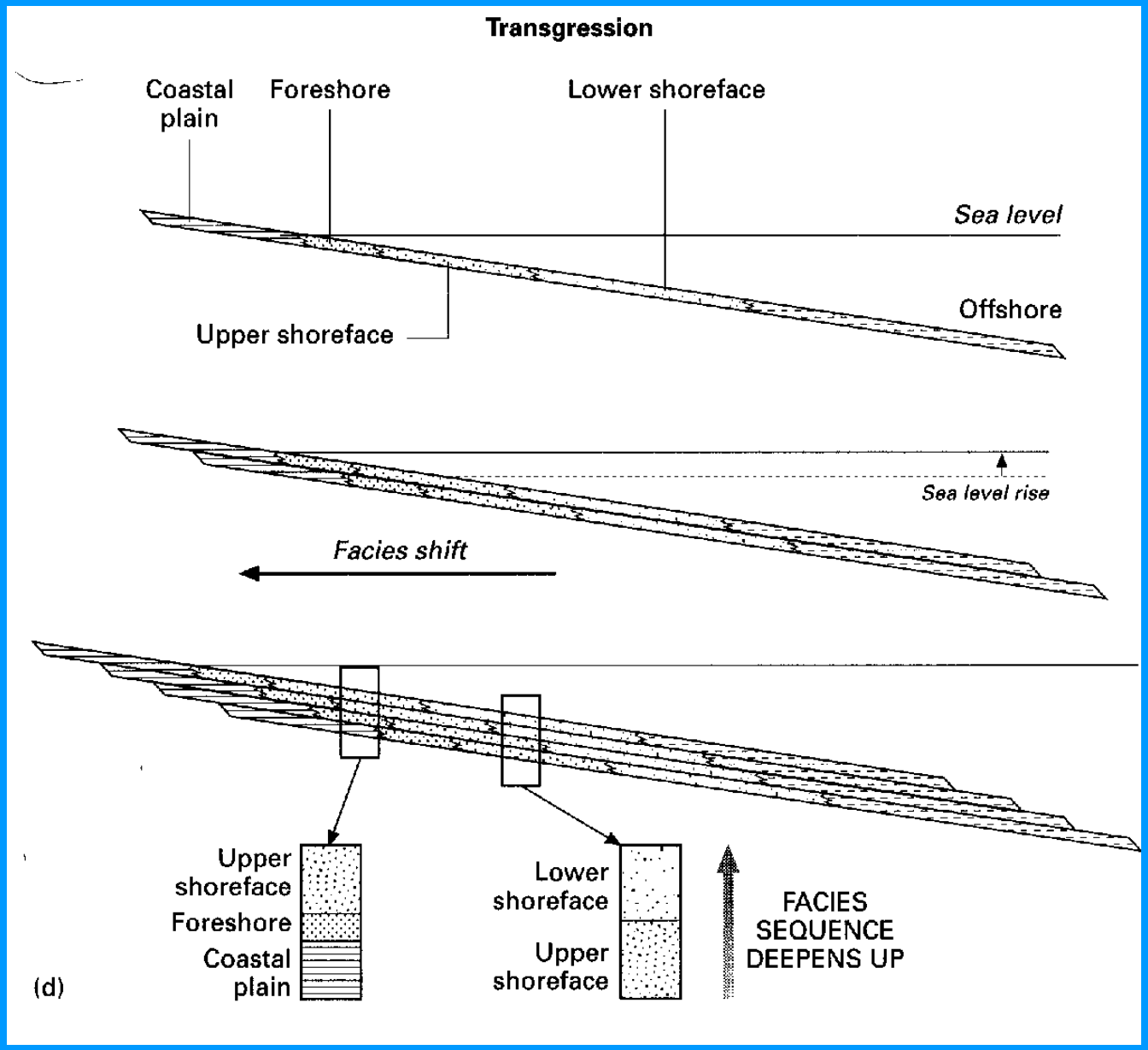
přínos > akomodace ⇒ progradace +/- agradace, regrese



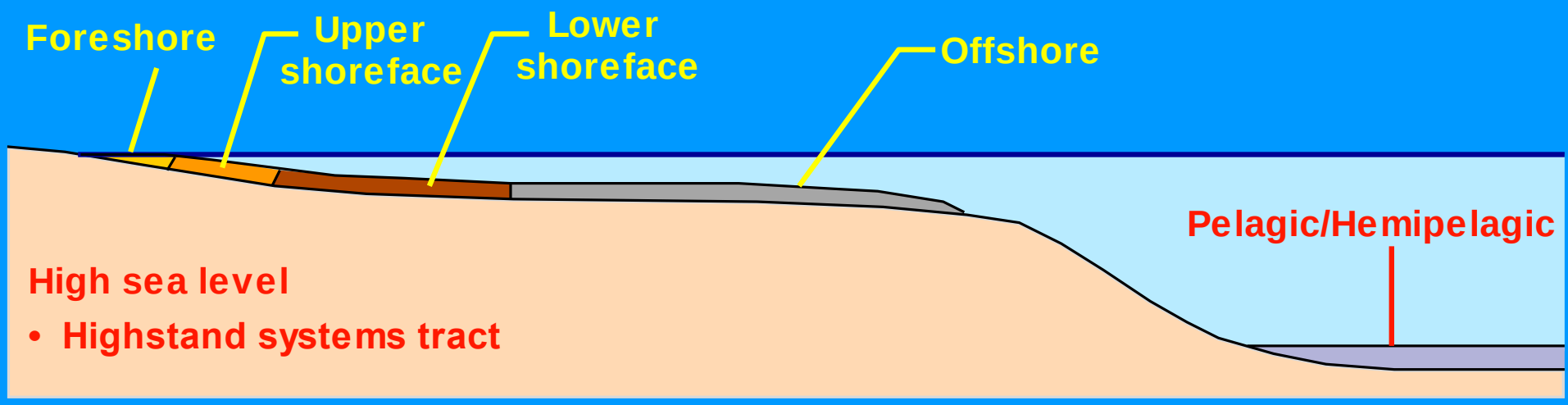
přínos >> akomodace ⇒ progradace , nucená regrese



přínos < akomodace ⇒ retrogradace, transgrese



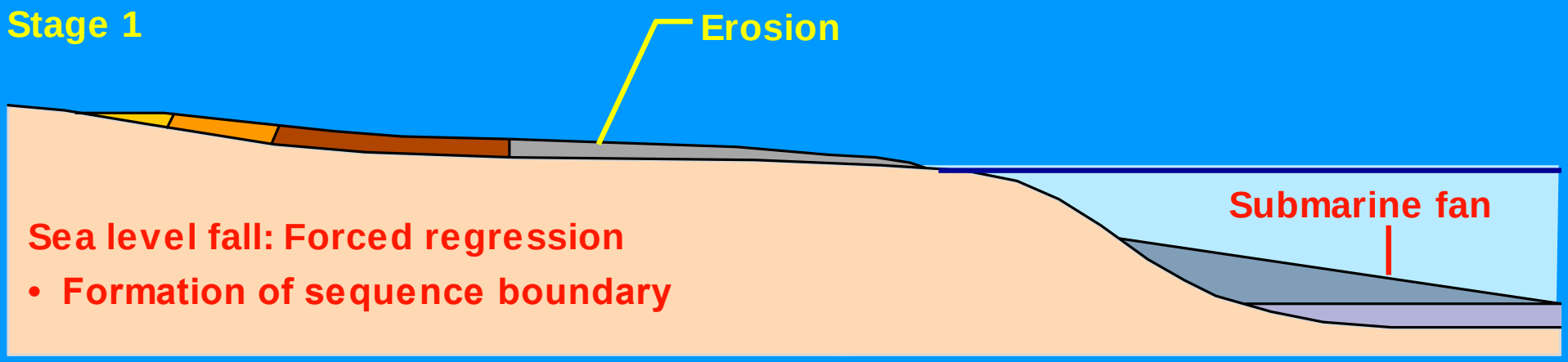
Depositional Sequences: clastic shelf



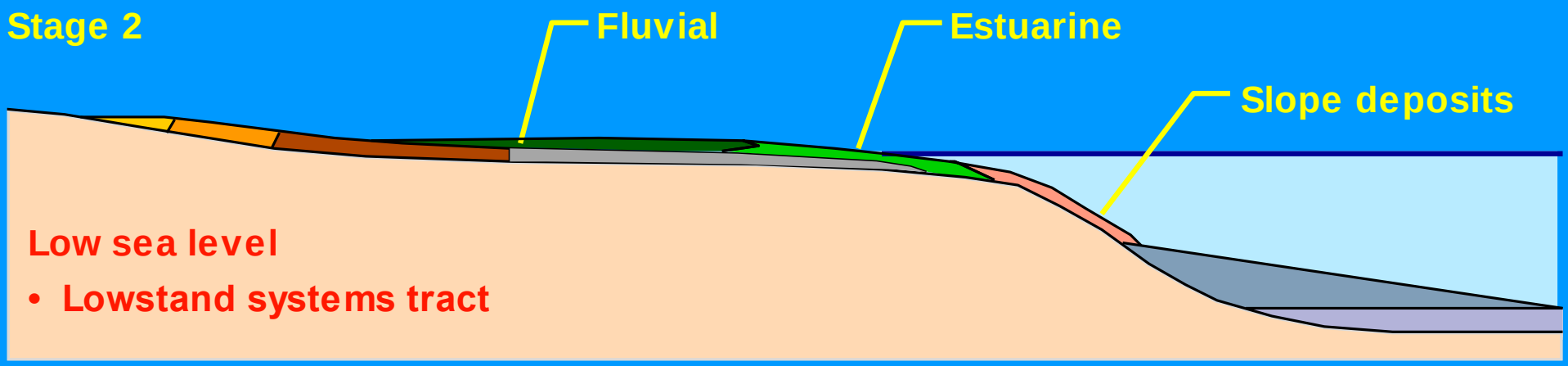
High sea level

- **Highstand systems tract**

VÝVOJ KLASTICKÉHO ŠELFU V ZÁVISLOSTI NA ZMĚNÁCH HLADINY



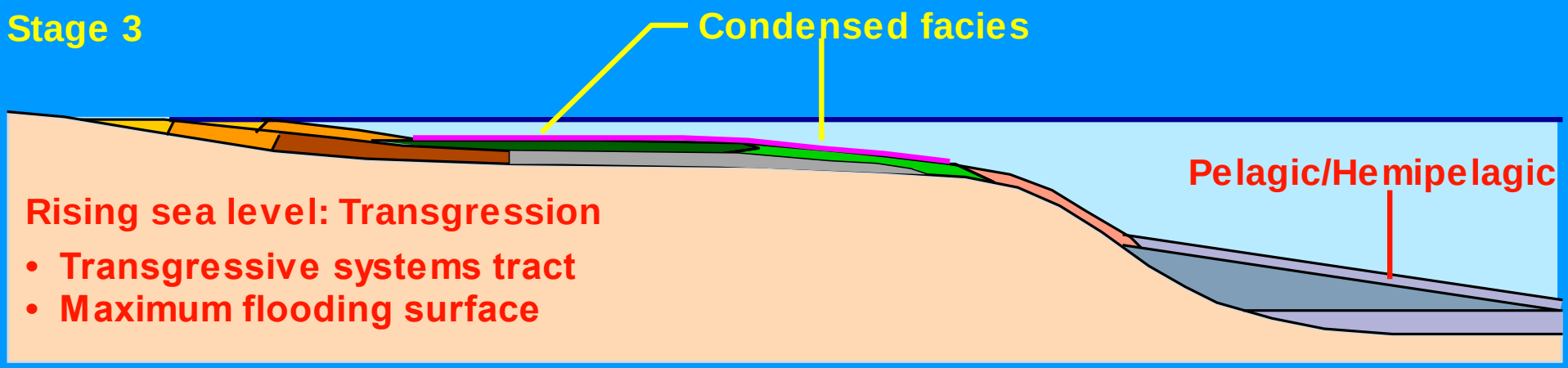
Stage 2



Low sea level

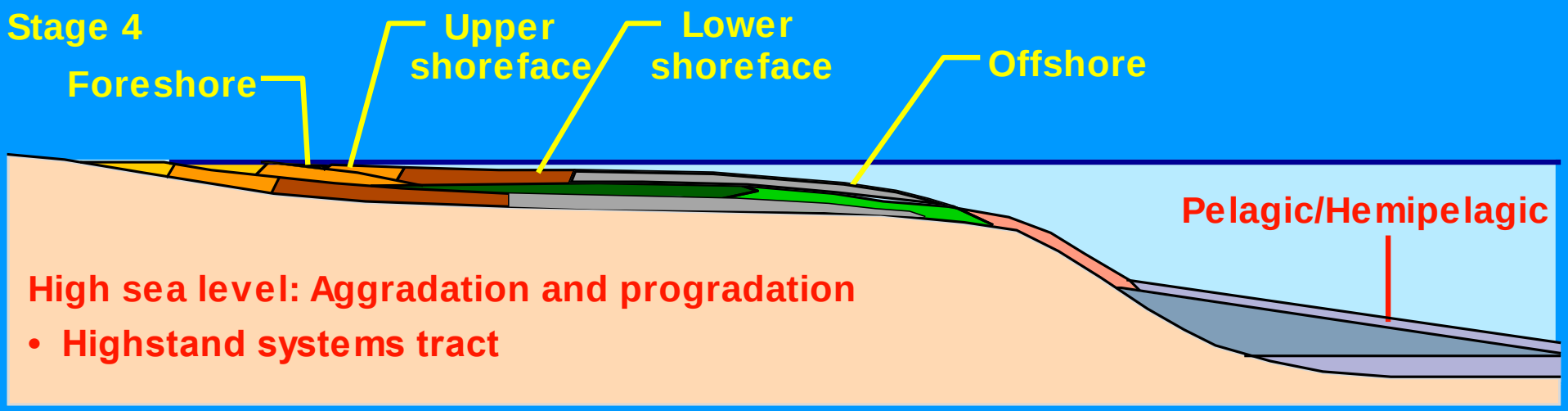
- Lowstand systems tract

Stage 3



Rising sea level: Transgression

- Transgressive systems tract
- Maximum flooding surface



High sea level: Aggradation and progradation

- **Highstand systems tract**

SEDIMENTÁRNÍ SEKVENCE

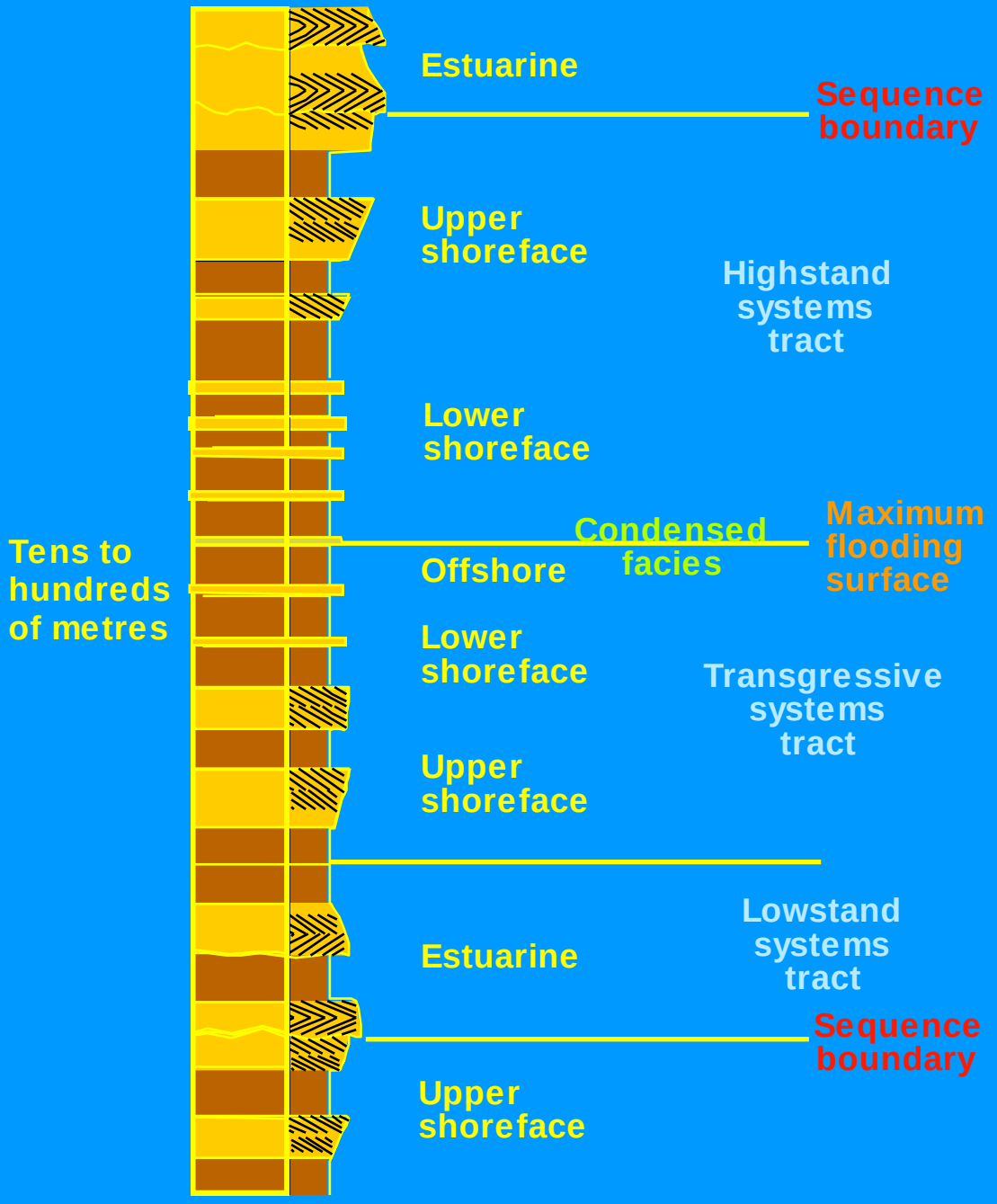
- stratigrafická jednotka, vymezena na bázi i na vrchu výraznými plochami diskordance nebo jejich korelačními ekvivalenty

- reprezentuje období sedimentace určitého sedimentárního systému mezi dvěma epizodami **výrazného poklesu hladiny**

⇒**sekvenční stratigrafie umožňuje rekonstruovat vývoj hladiny**

Sekvenční hranice – plocha představující povrch vzniklý během výrazného poklesu hladiny, často erozivní

SEDIMENTÁRNÍ SEKVENCE V KLASTICKÉM ŠELFU

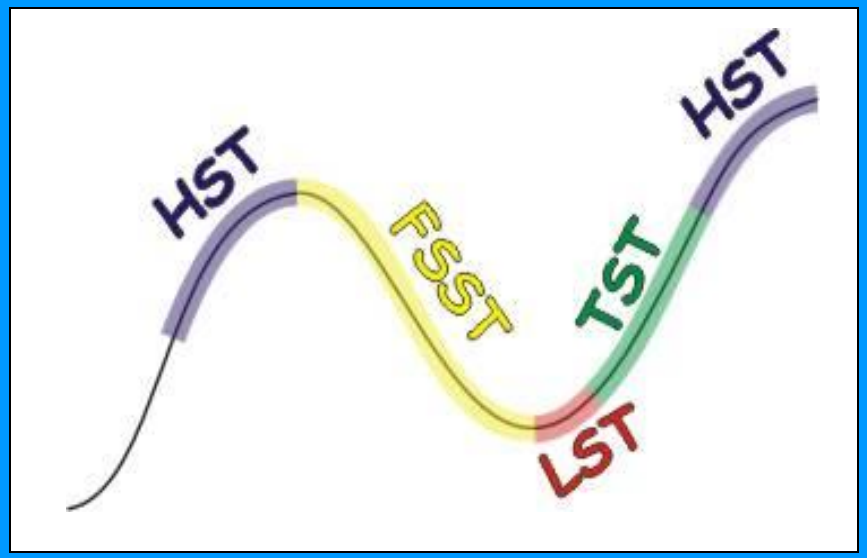


TRAKTY SEDIMENTÁRNÍCH SEKVENCÍ

trakty (*systems tracts*)

části sekvence odpvídající jednotlivým etapám vývoje hladiny

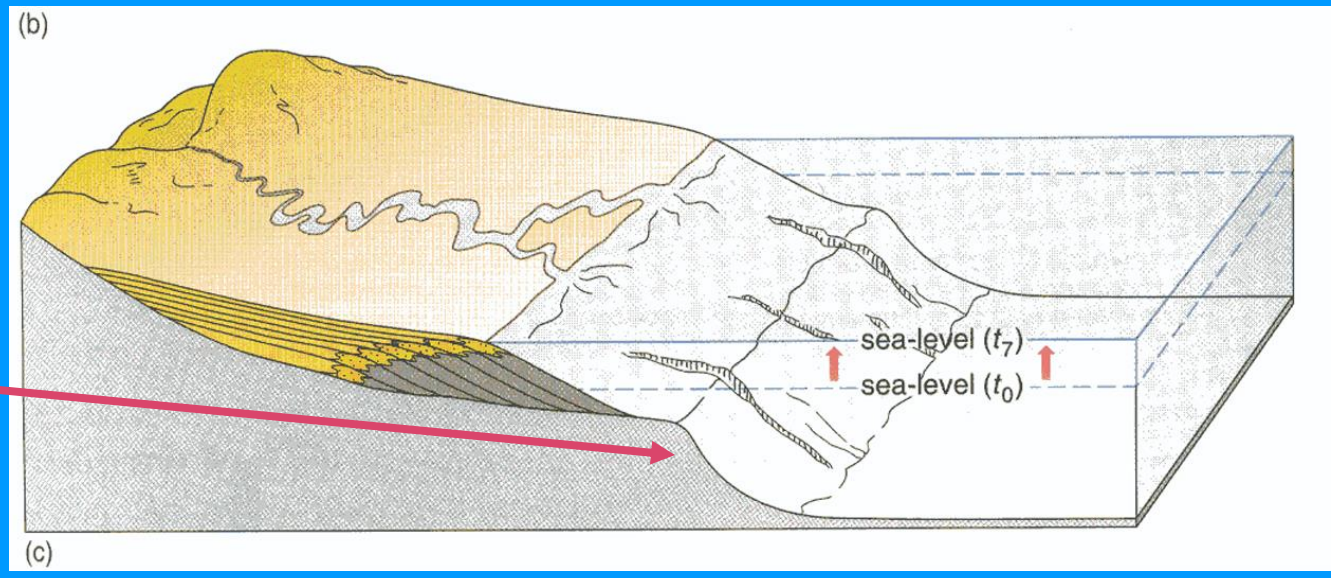
- **Trakt vysoké hladiny (HST)**
- **Trakt klesající hladiny (FSST)**
- **Trakt nízké hladiny (LST)**
- **Trakt rostoucí hladiny (TST)**



Types of shelf margin

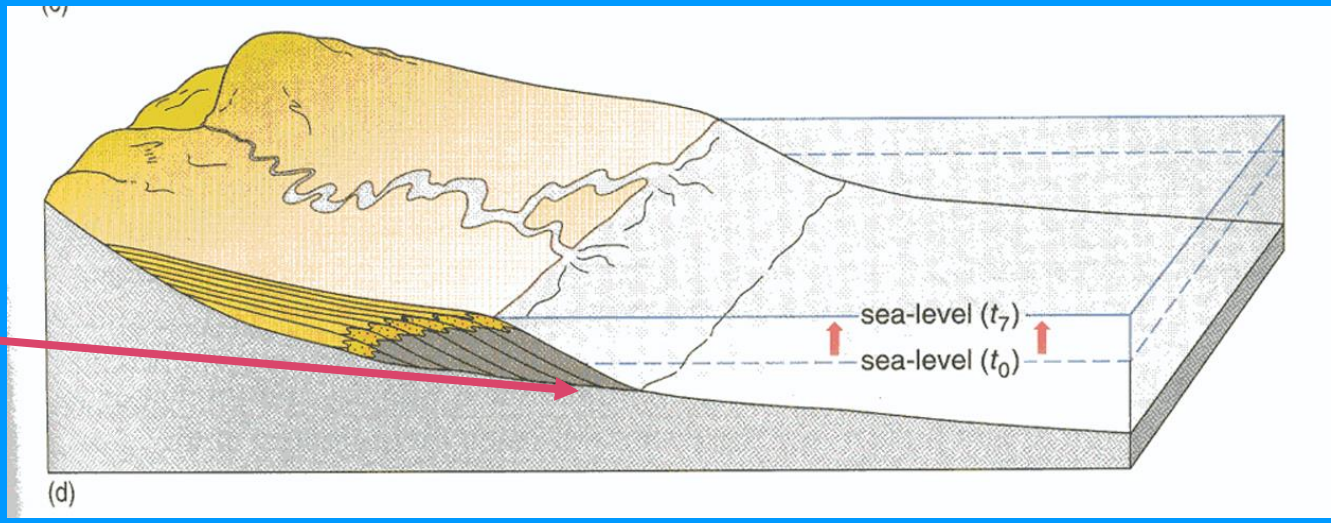
Shelf break margin

Steep slope at shelf edge



Ramp margin

No distinct shelf edge

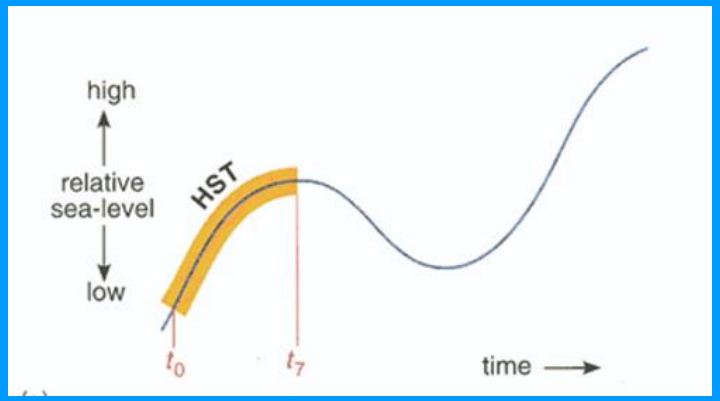


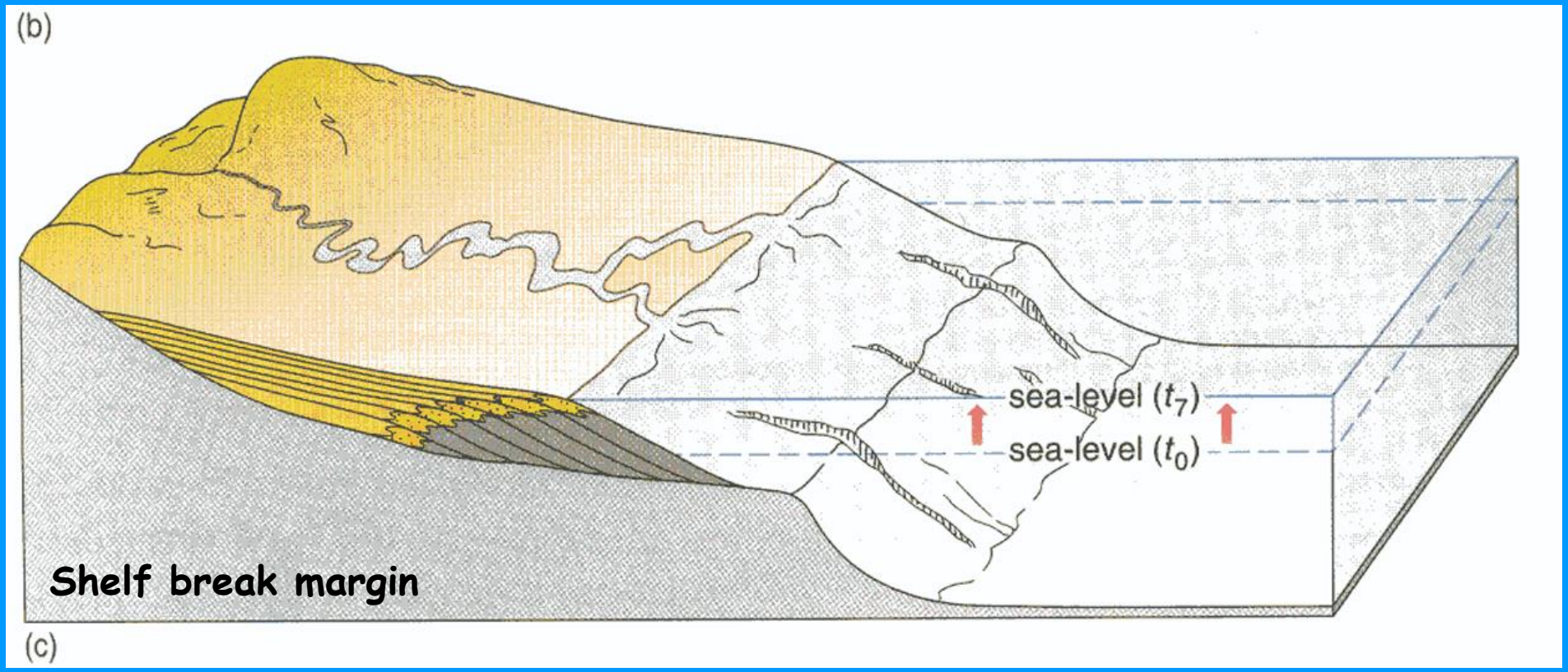
TRAKT VYSOKÉ HLADINY (HST)

- zpomalování transgrese

  ⇒ sedimentace vyrovnává nárůst akomodace

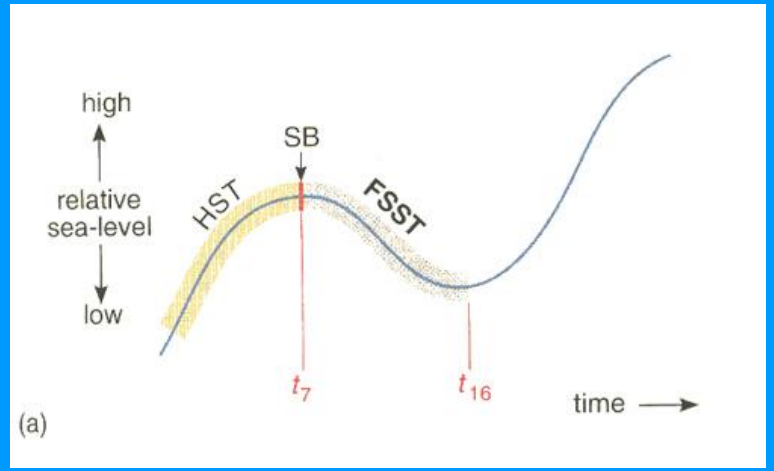
  ⇒ agradace, agradace+progradace
- oddělení HST od TST – **plocha maximální záplavy (MFS)**
- ve vertikálním profilu jako přechod mezi retrogradačním a agradačněprogradačním stylem

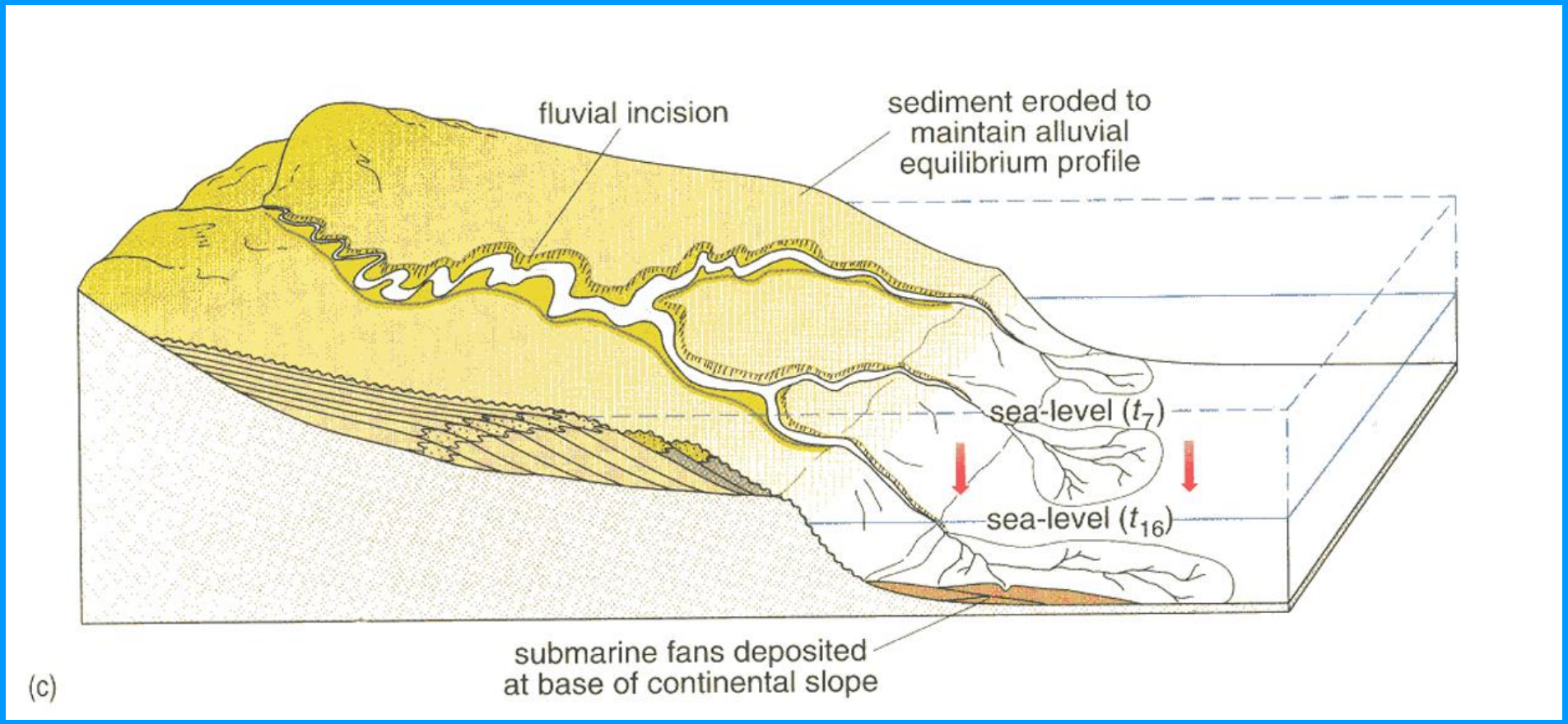


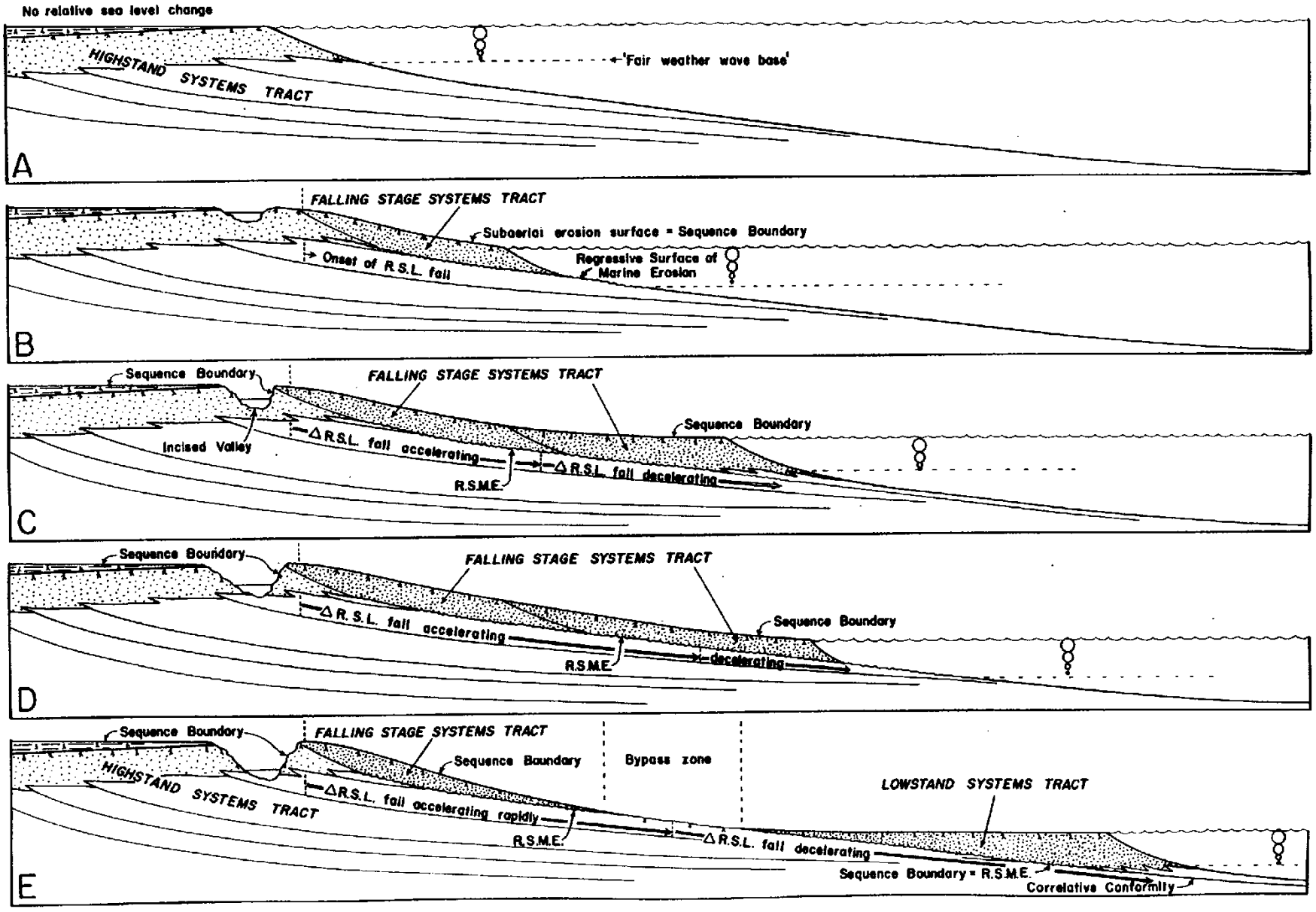


TRAKT KLESAJÍCÍ HLADINY (FSST)

- vzniká během poklesu hladiny (nucené regrese); není vždy vyvinut
- uspořádání parasekvencí – offlap
- FST je svchu vymezen sekvenční hranicí a na spodu **RSME** (regressive surface of marine erosion)



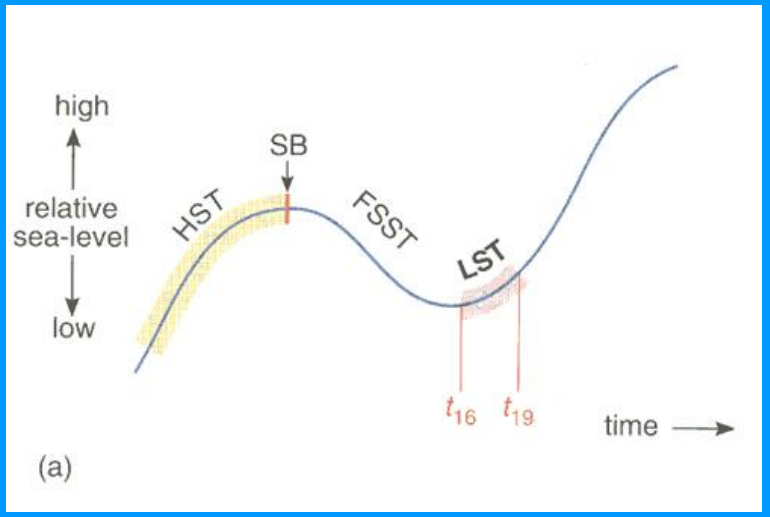


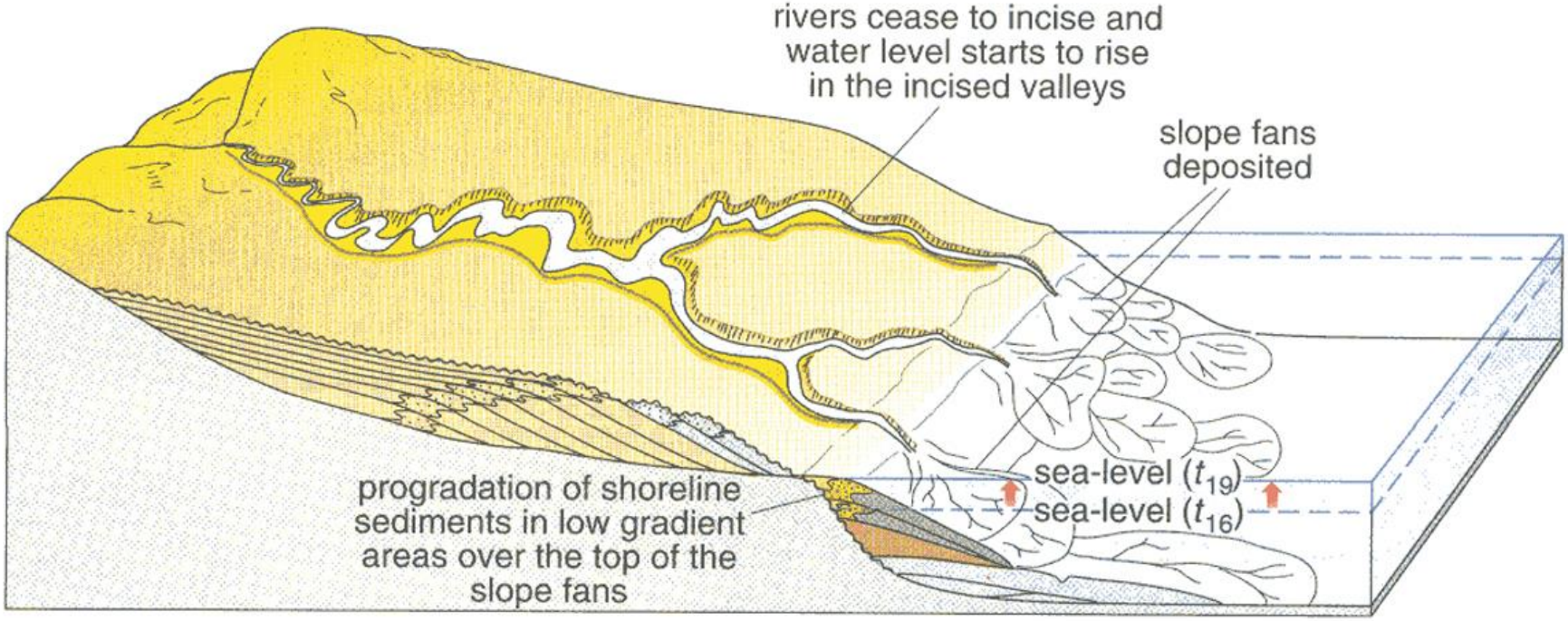

No relative sea level change
HIGHSTAND SYSTEMS TRACT
'Fair weather wave base'
A
FALLING STAGE SYSTEMS TRACT
Subaerial erosion surface = Sequence Boundary
Onset of R.S.L. fall
Regressive Surface of Marine Erosion
B
Sequence Boundary
FALLING STAGE SYSTEMS TRACT
Sequence Boundary
Incised Valley
ΔR.S.L. fall accelerating
ΔR.S.L. fall decelerating
R.S.M.E.
C
Sequence Boundary
FALLING STAGE SYSTEMS TRACT
Sequence Boundary
ΔR.S.L. fall accelerating
R.S.M.E.
decelerating
D
Sequence Boundary
FALLING STAGE SYSTEMS TRACT
Sequence Boundary
Bypass zone
HIGHSTAND SYSTEMS TRACT
ΔR.S.L. fall accelerating rapidly
R.S.M.E.
ΔR.S.L. fall decelerating
LOWSTAND SYSTEMS TRACT
Sequence Boundary = R.S.M.E.
Correlative Conformity
E

TRAKT NÍZKÉ HLADINY (LST)

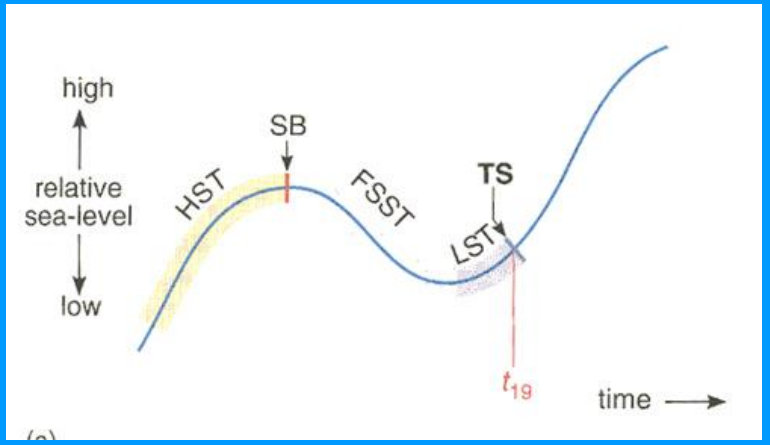
- sedimentace během nízkého stavu hladiny
  - – období zlomu mezi regresí a transgresí
  - ⇒ progradace, progradace +agradace

- sekvenční hranice je na bázi LST





TRANSGRESNÍ POVRCH (TS)



water table starts to rise rapidly and alluvial sediments are deposited, including infilling the incised river valleys

start of rapid relative sea-level rise (t_{19})

distal areas became starved of sediment as locus of sedimentation moves in a landward direction

first significant marine flooding surface. Where relative sea-level fell below the shelf break, the transgressive surface will mark the lowest flooding surface across the continental shelf

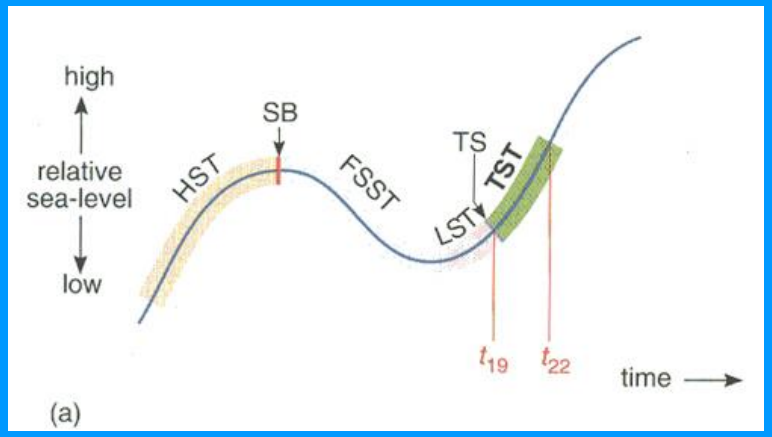
(b)

TRANSGRESNÍ TRAKT (TST)

• vzniká během period rychlého růstu hladiny ⇒ transgrese

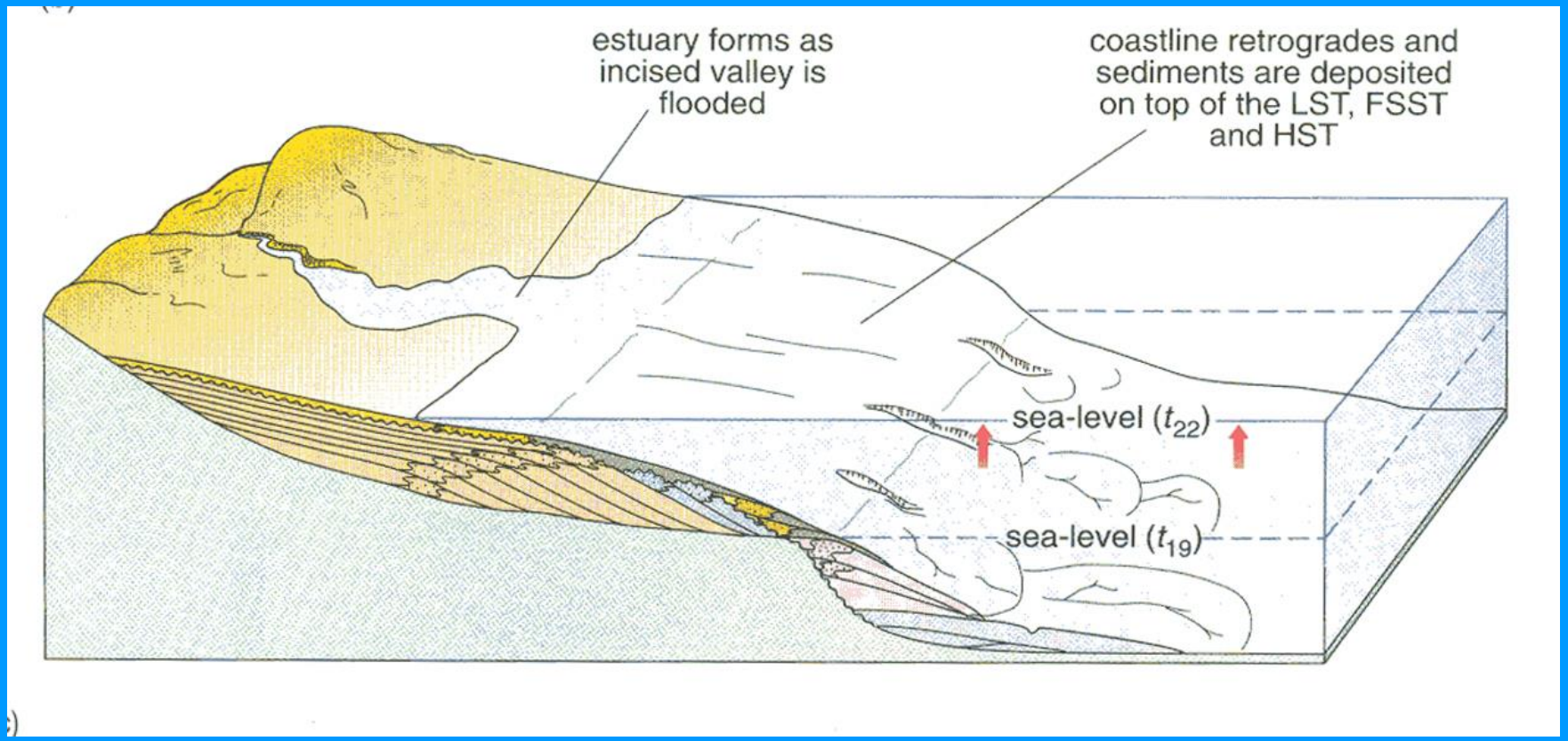
• retrogradace sedimentárního systému

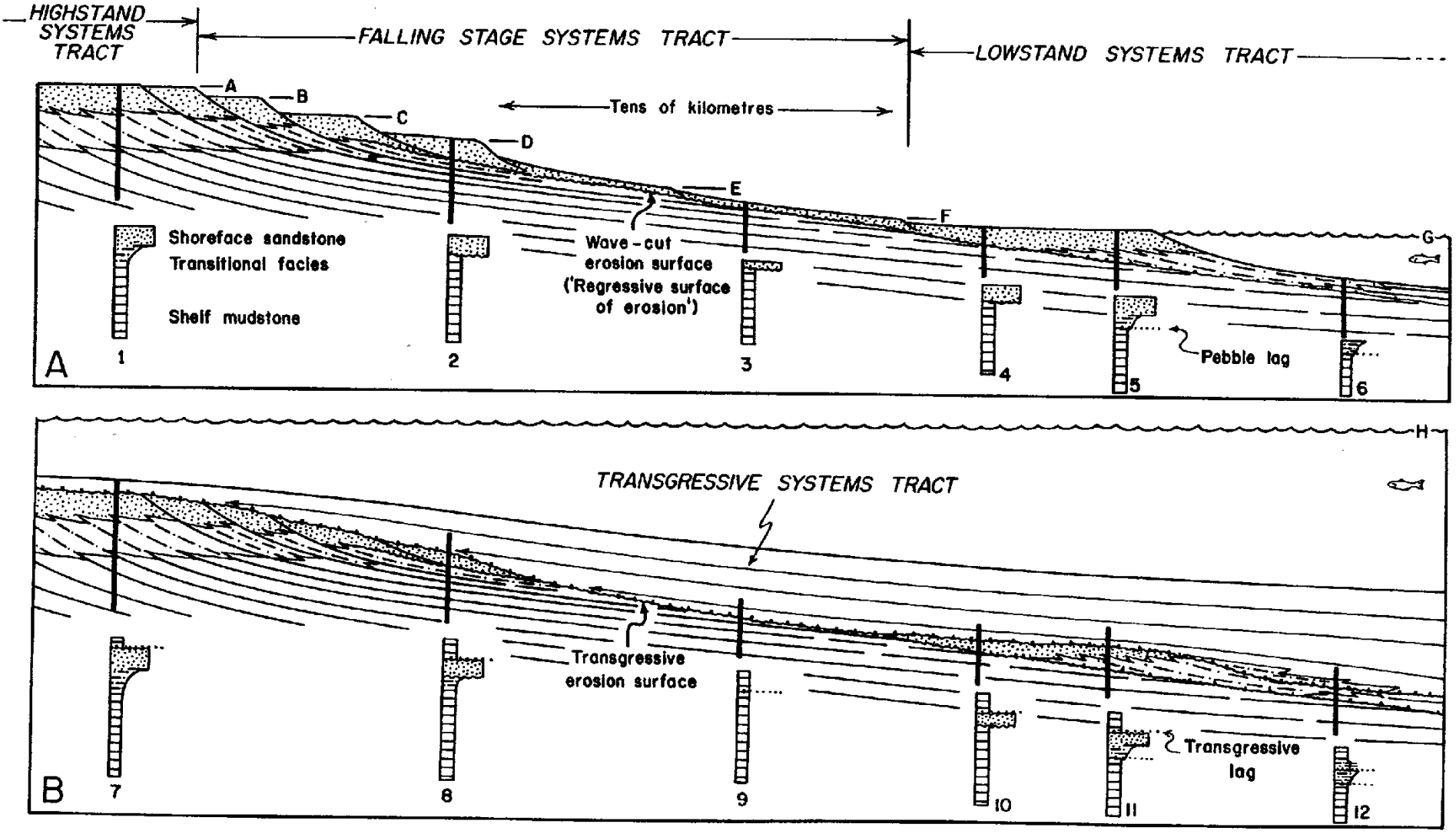
⇒ mělkovodní facie jsou překryty hlubokovodními



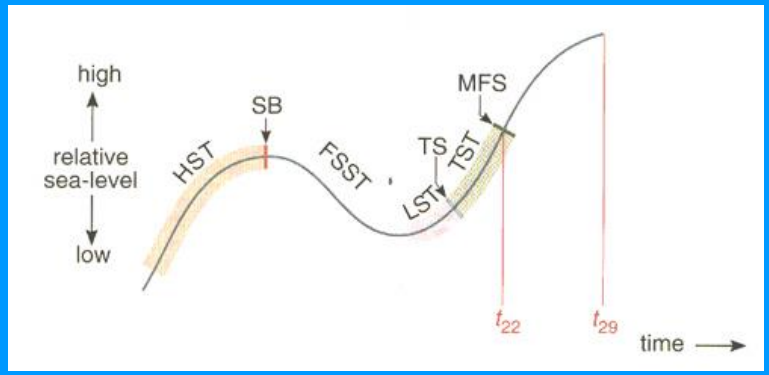
“ravinment surface“

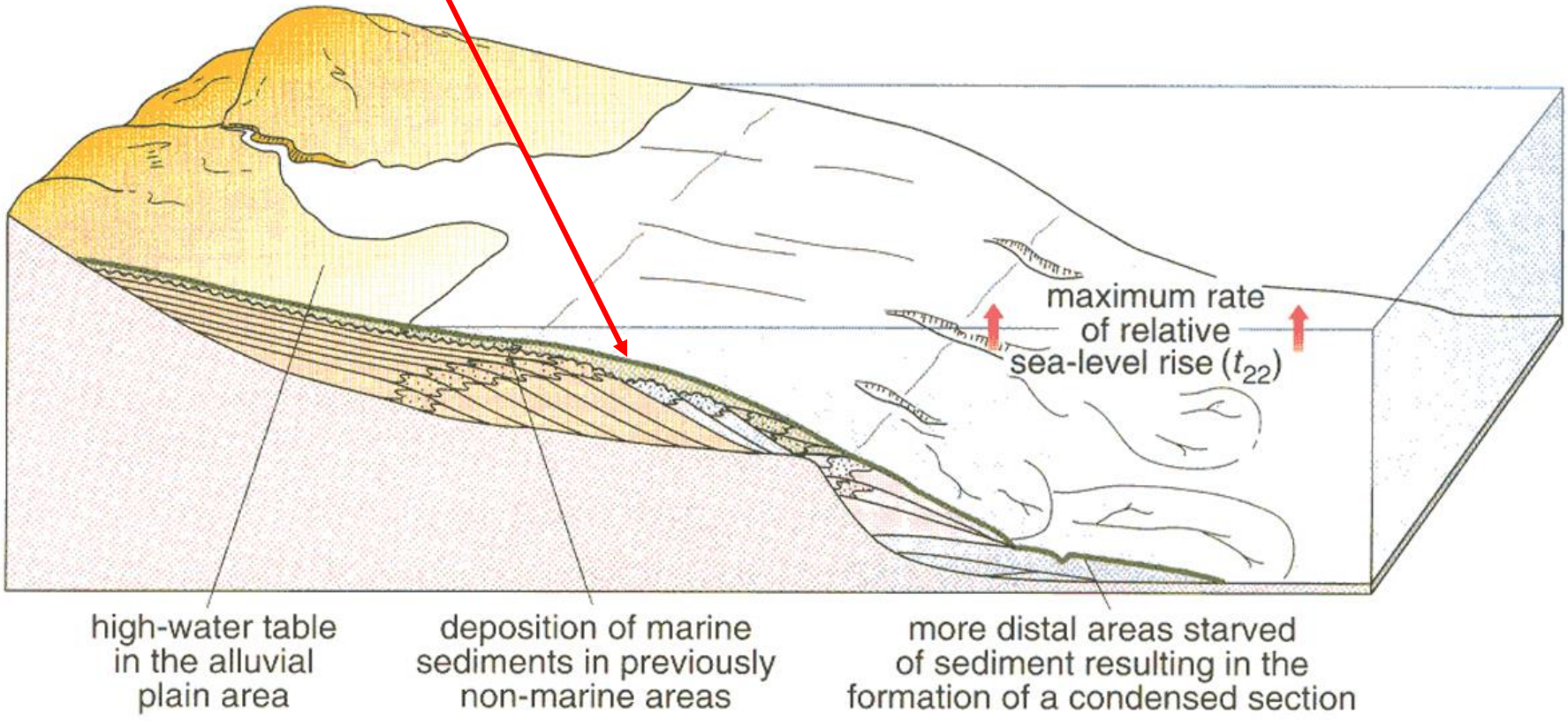
erozivní povrch vznikající účinkem postupující báze vlnění během transgrese ⇒ často přetiskuje účinek subaerické eroze za nízkého stavu hladiny



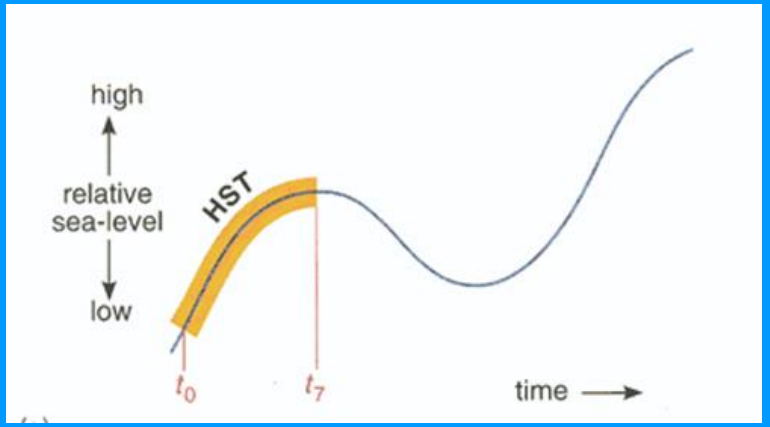

HIGHSTAND SYSTEMS TRACT
FALLING STAGE SYSTEMS TRACT
LOWSTAND SYSTEMS TRACT
A
B
C
D
E
F
G
H
Tens of kilometres
Shoreface sandstone
Transitional facies
Shelf mudstone
Wave-cut erosion surface ('Regressive surface of erosion')
Pebble lag
TRANSGRESSIVE SYSTEMS TRACT
Transgressive erosion surface
Transgressive lag
1
2
3
4
5
6
7
8
9
10
11
12

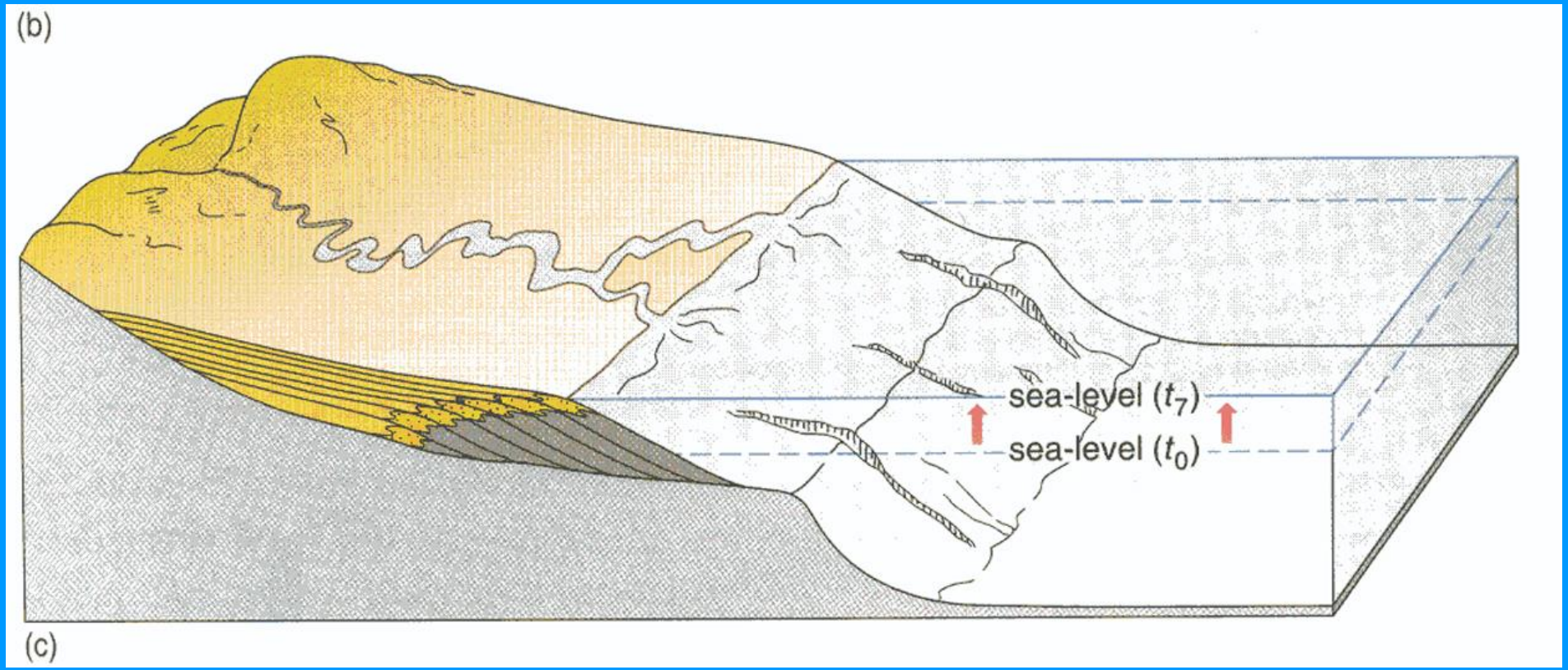
PLOCHA MAXIMÁLNÍ ZÁPLAVY (MFS)





TRAKT VYSOKÉ HLADINY (HST)

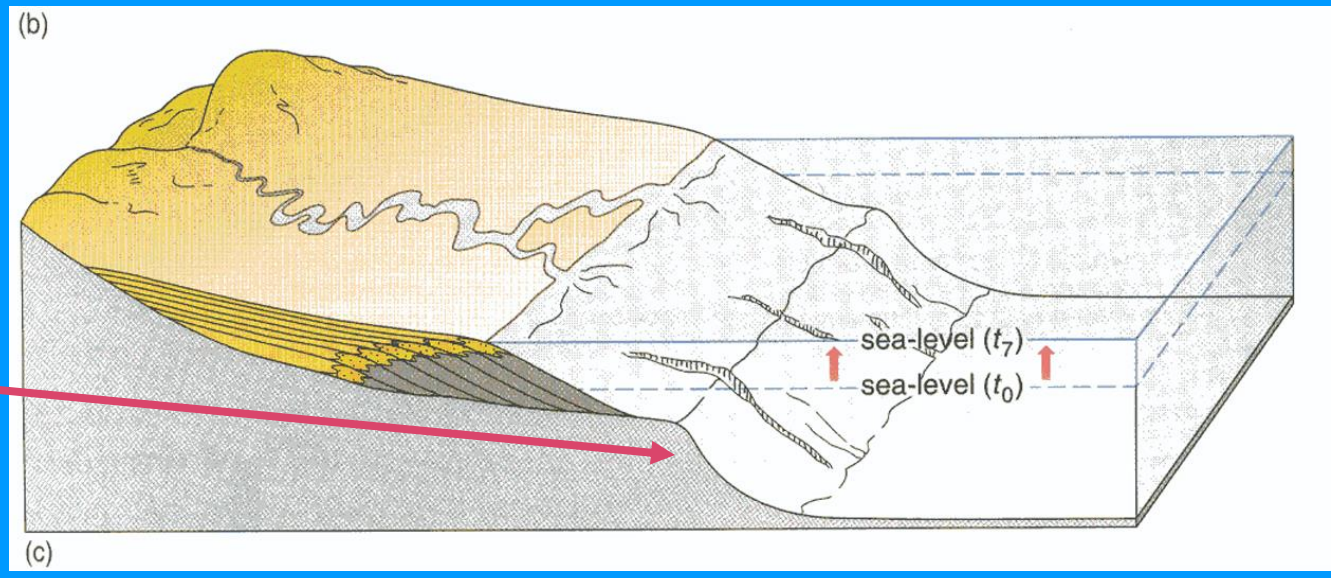




Types of shelf margin

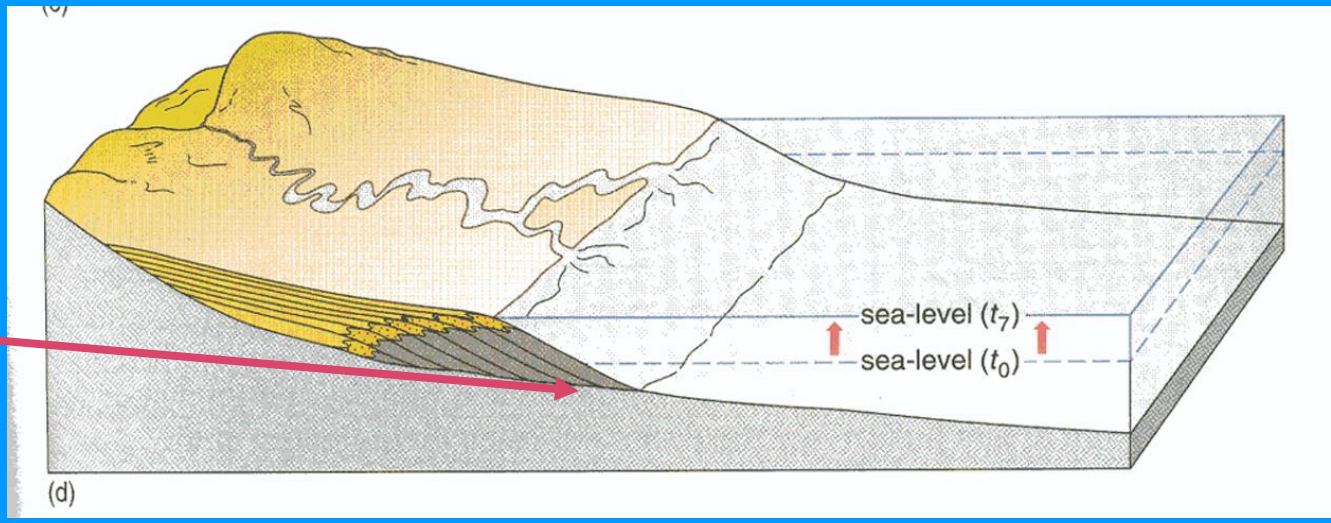
Shelf break margin

Steep slope at shelf edge

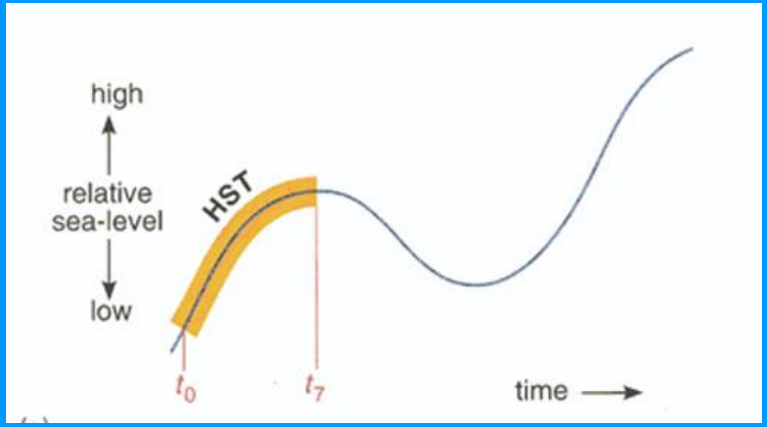


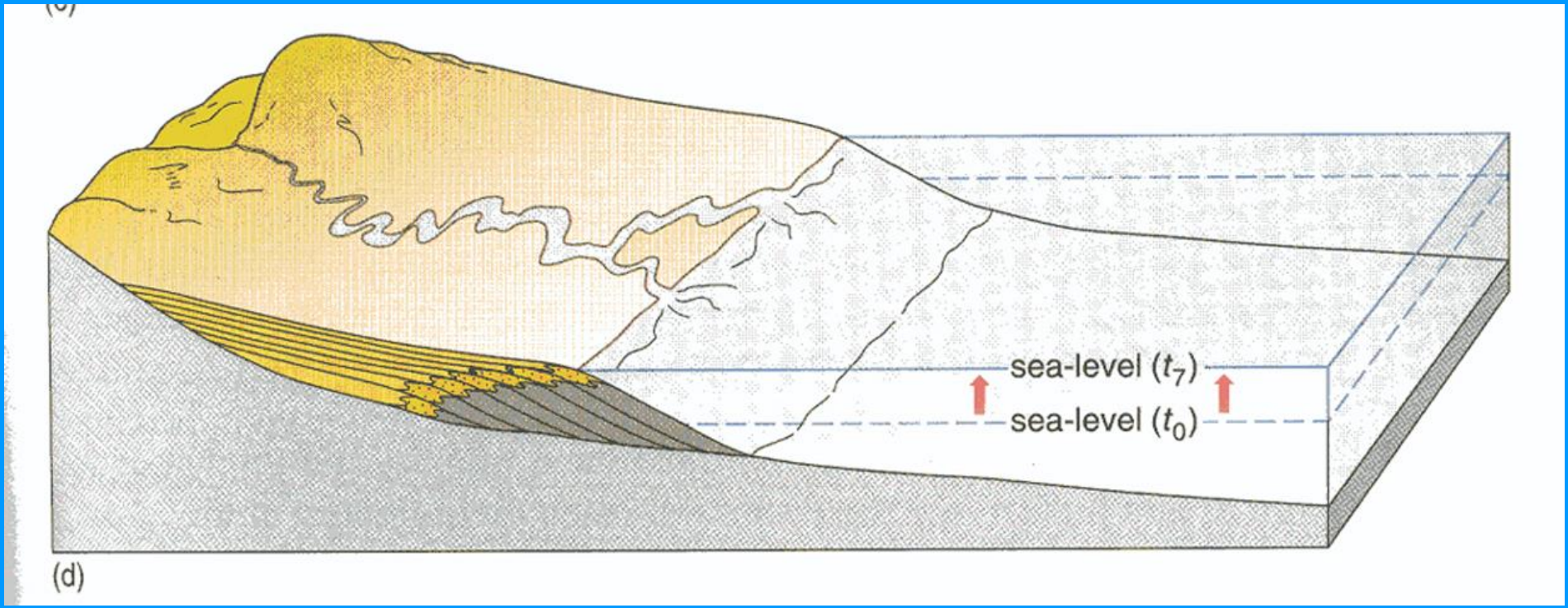
Ramp margin

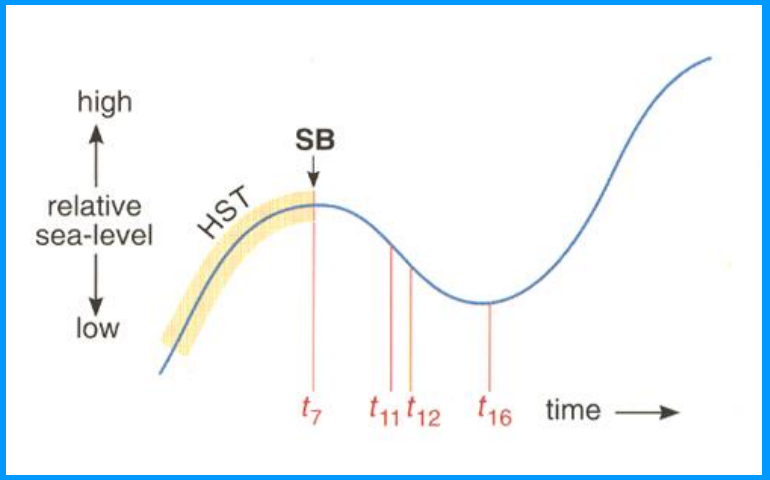
No distinct shelf edge

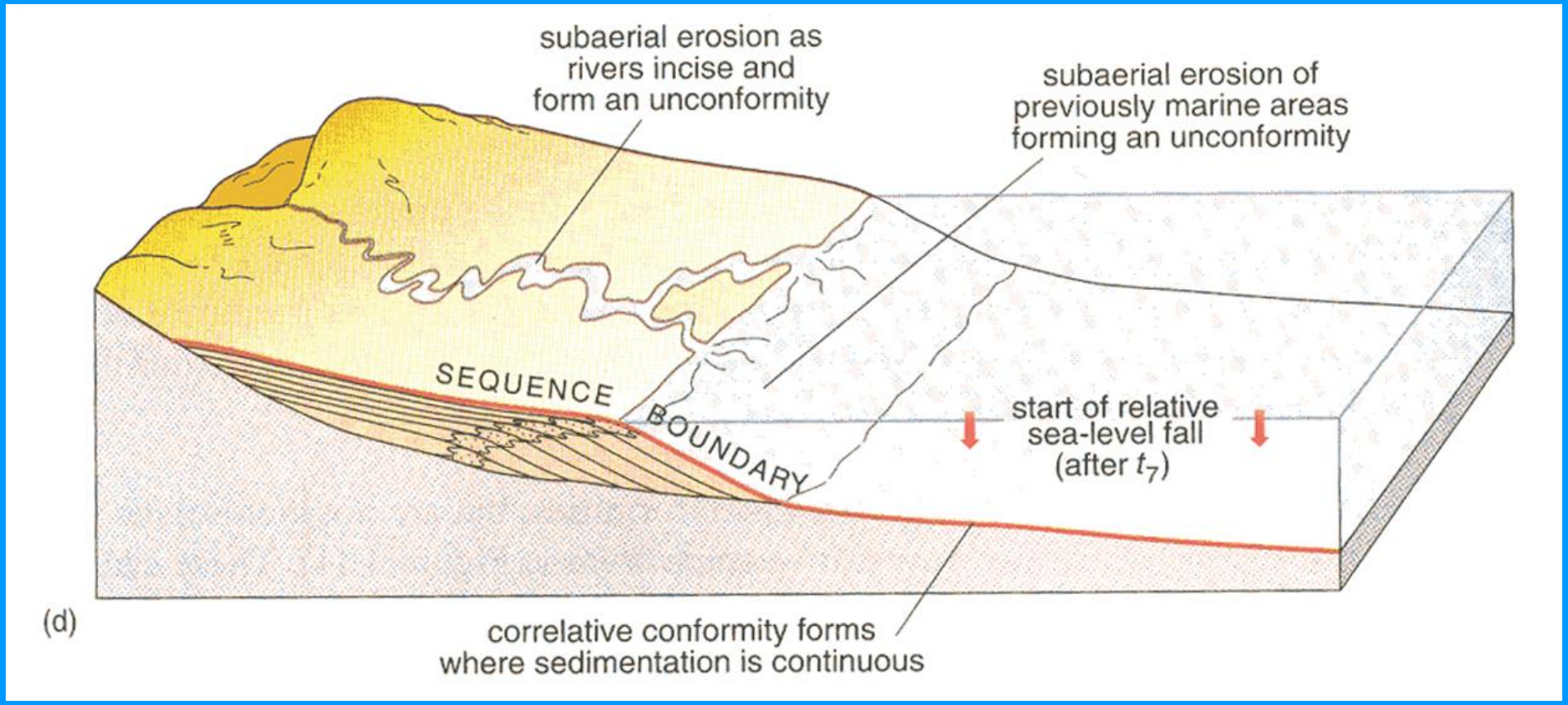


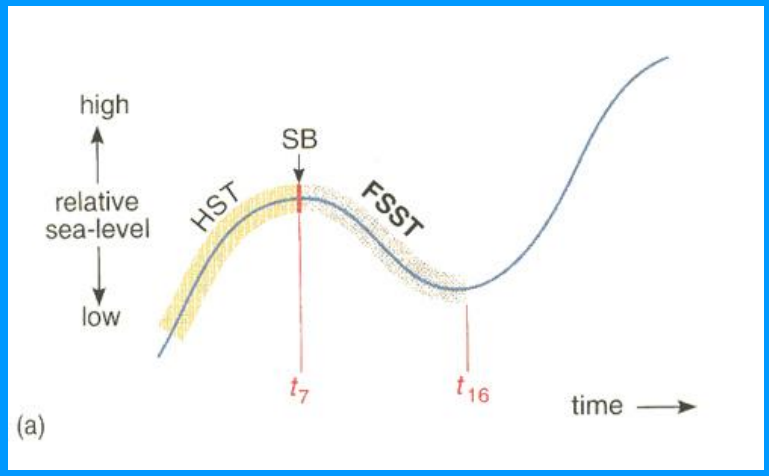
Ramp margin

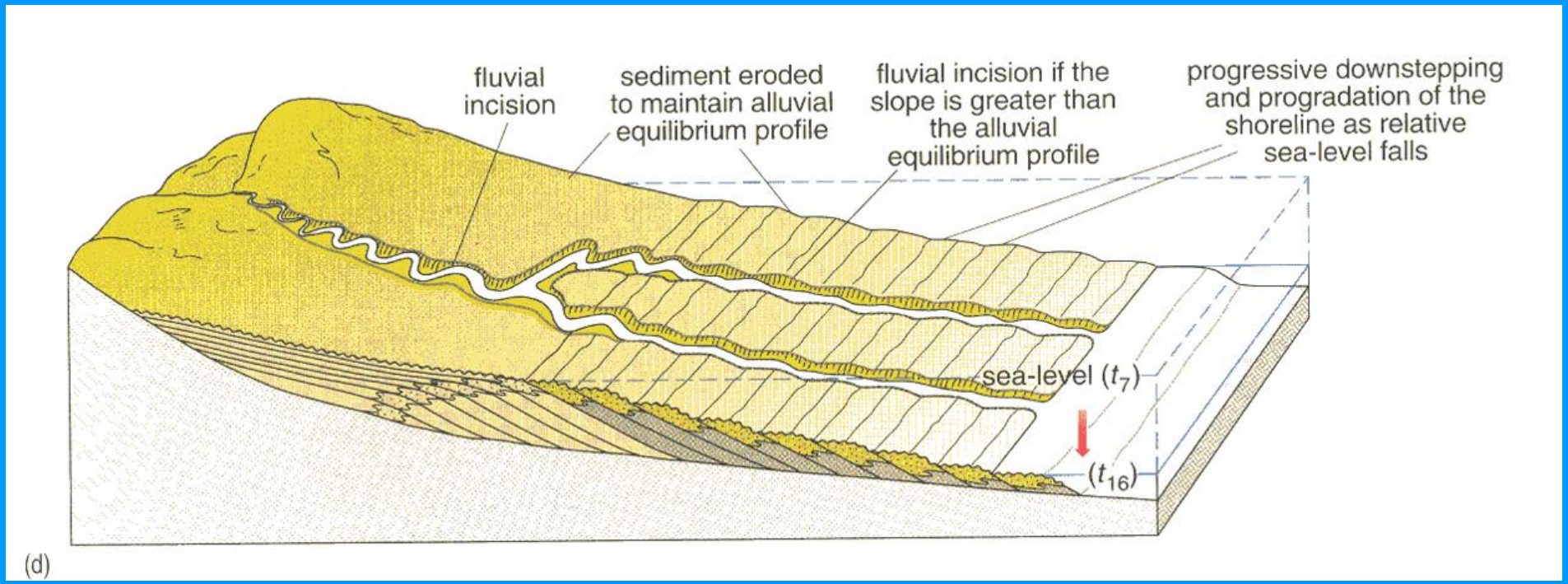

high
relative
sea-level
low
HST
t_0
t_7
time

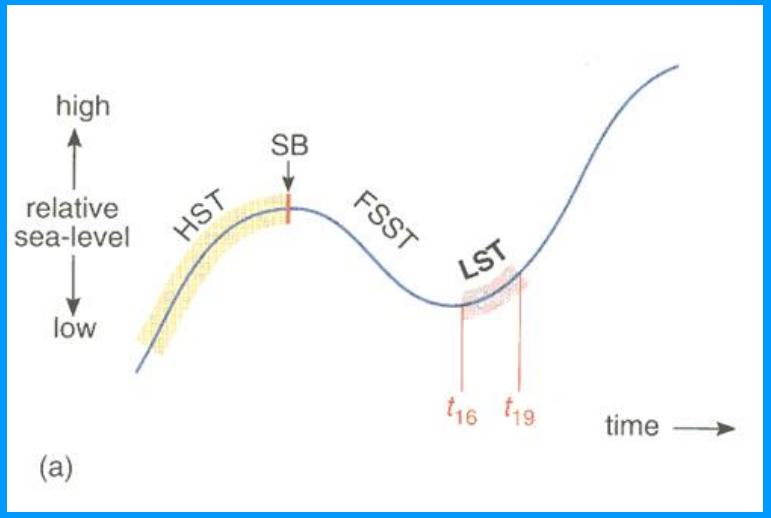

sea-level (t_7)
sea-level (t_0)
(d)

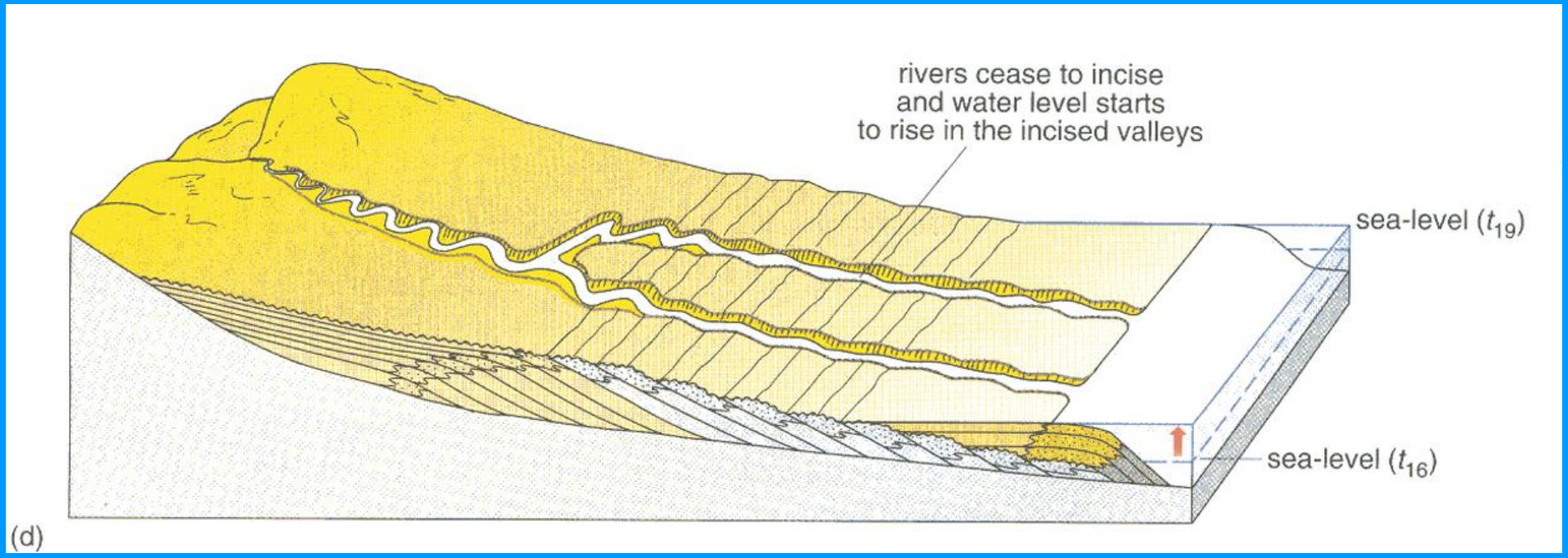

high
relative
sea-level
low
SB
HST
t_7
t_{11} t_{12}
t_{16}
time

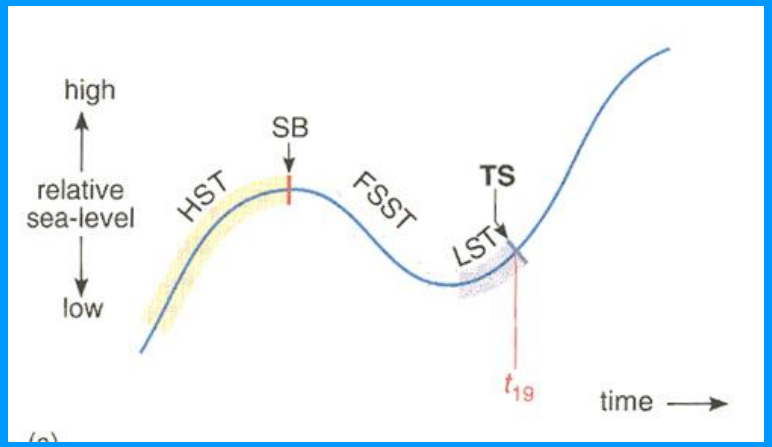

subaerial erosion as
rivers incise and
form an unconformity
subaerial erosion of
previously marine areas
forming an unconformity
SEQUENCE
BOUNDARY
start of relative
sea-level fall
(after t_7)
correlative conformity forms
where sedimentation is continuous
(d)

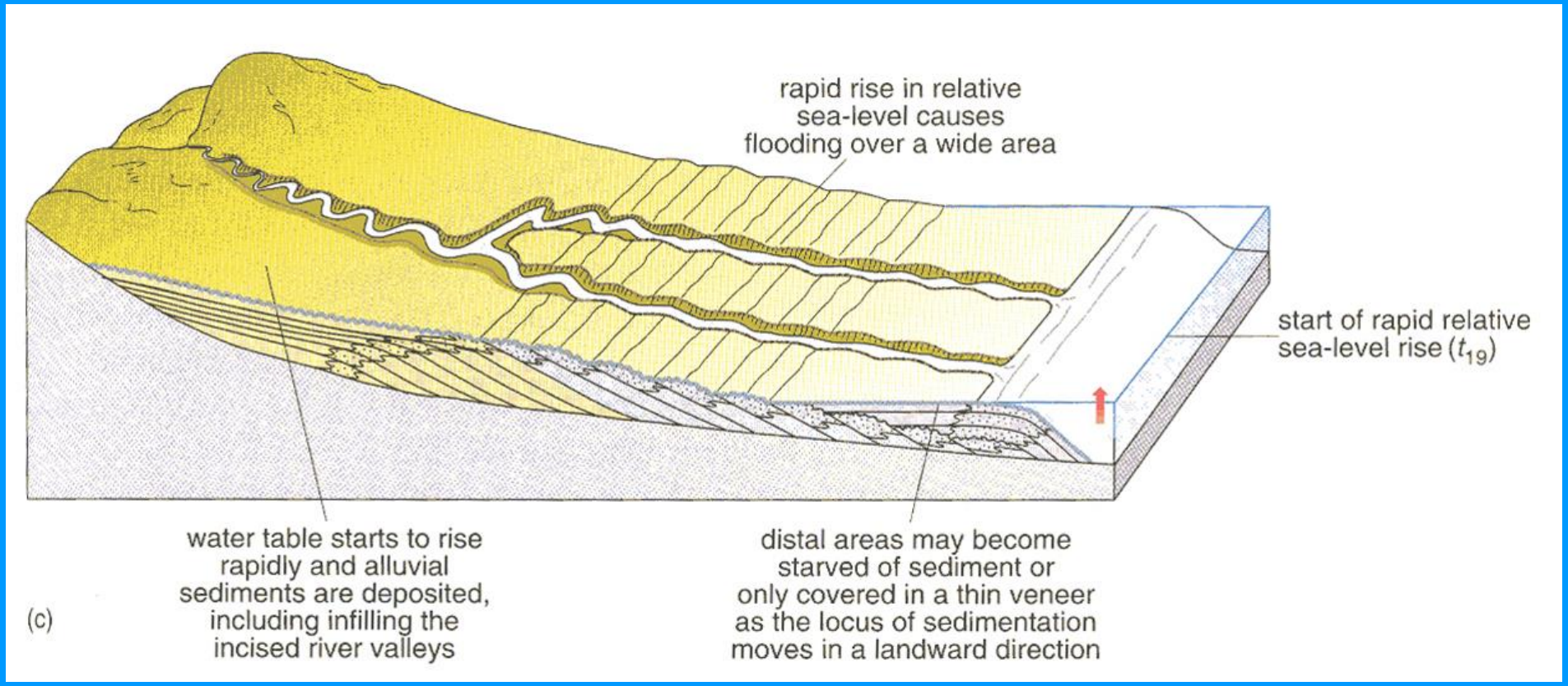

high
relative sea-level
low
SB
HST
FSST
t_7
t_{16}
time
(a)

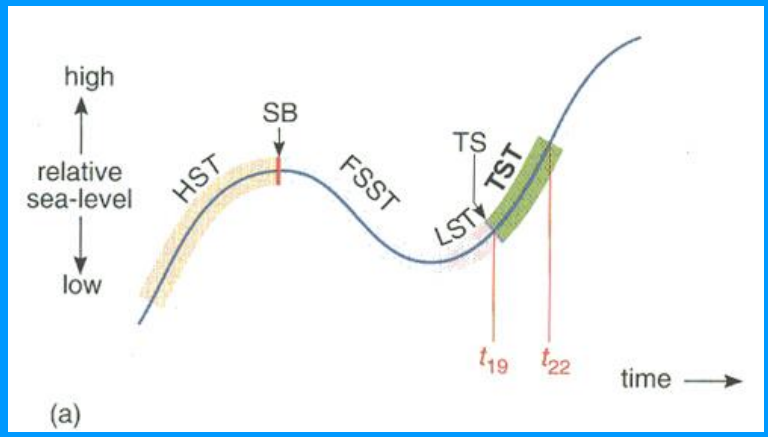

fluvial incision
sediment eroded to maintain alluvial equilibrium profile
fluvial incision if the slope is greater than the alluvial equilibrium profile
progressive downstepping and progradation of the shoreline as relative sea-level falls
sea-level (t_7)
(t_{16})
(d)

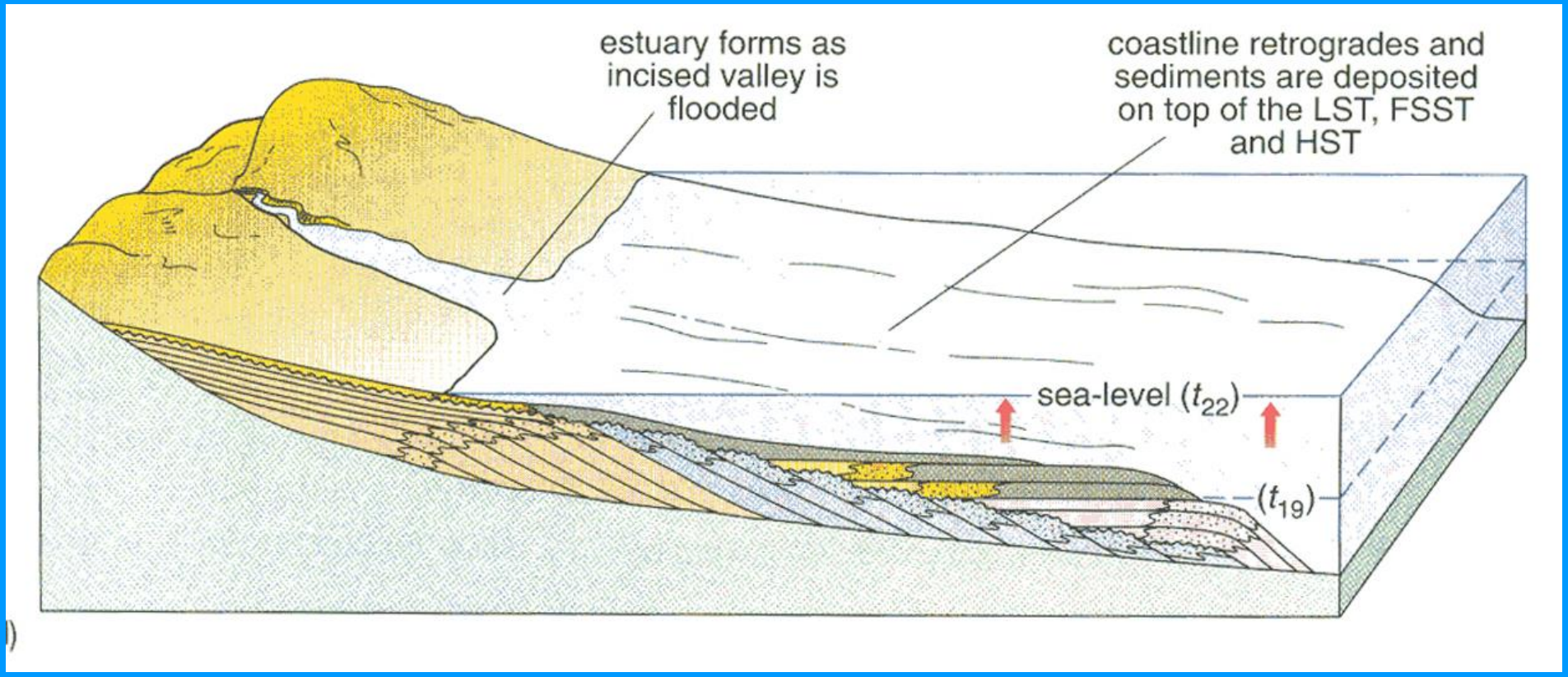

high
relative
sea-level
low
SB
HST
FSST
LST
t_{16}
t_{19}
time
(a)

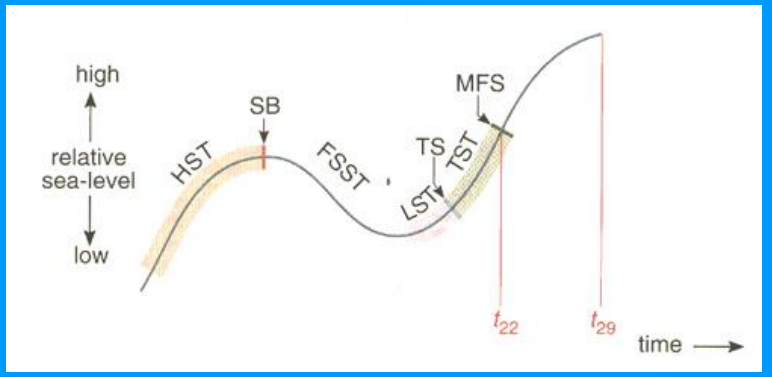

rivers cease to incise
and water level starts
to rise in the incised valleys
sea-level (t_{19})
sea-level (t_{16})
(d)

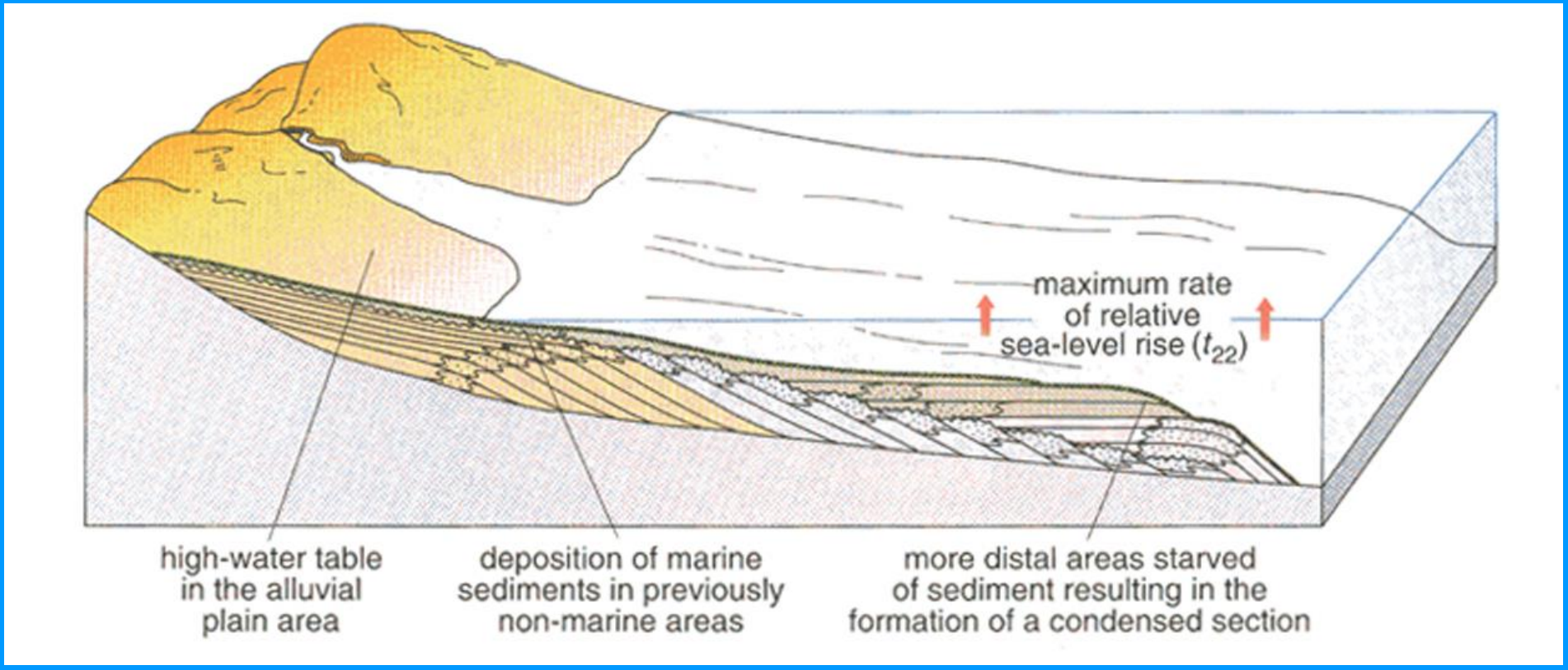

high
relative
sea-level
low
SB
HST
FSST
TS
LST
t_{19}
time

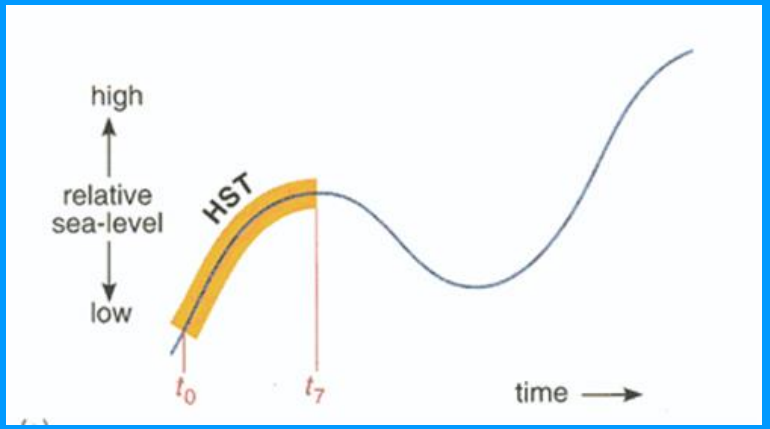

rapid rise in relative
sea-level causes
flooding over a wide area
start of rapid relative
sea-level rise (t_{19})
water table starts to rise
rapidly and alluvial
sediments are deposited,
including infilling the
incised river valleys
distal areas may become
starved of sediment or
only covered in a thin veneer
as the locus of sedimentation
moves in a landward direction
(c)

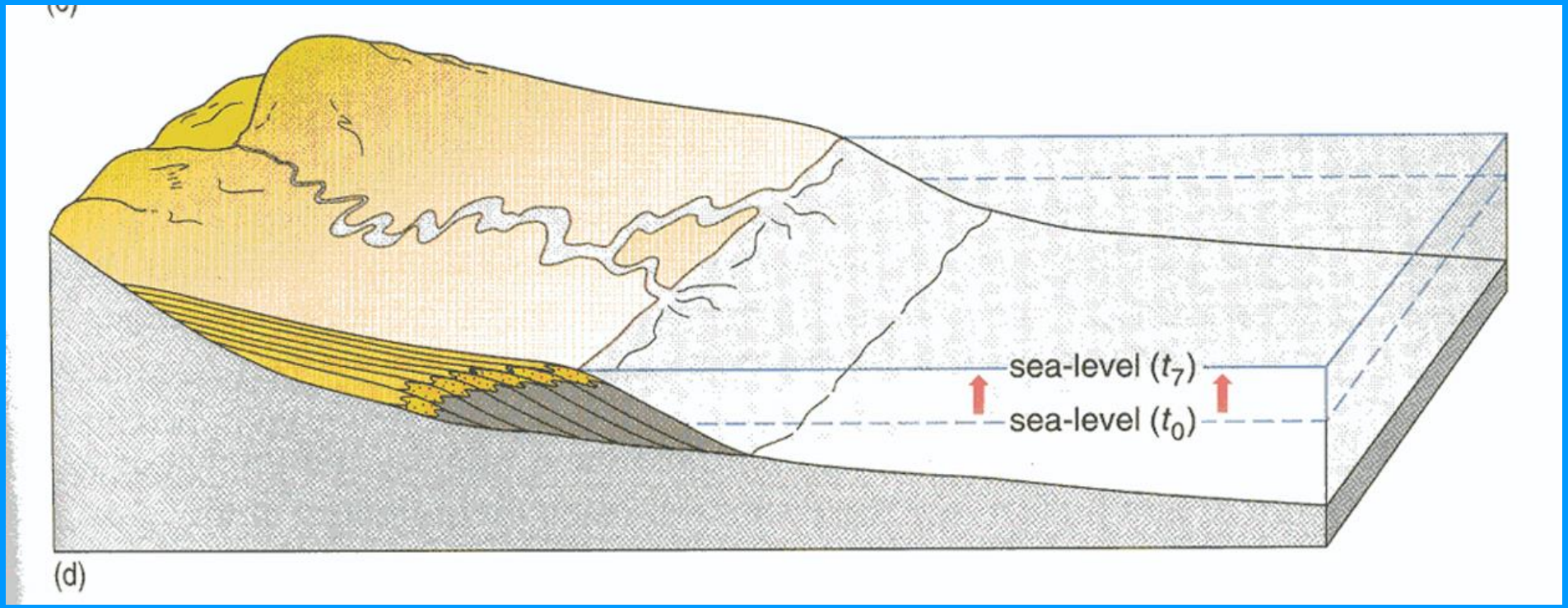

high
relative sea-level
low
SB
HST
FSST
TS
TST
LST
t_{19}
t_{22}
time
(a)


estuary forms as incised valley is flooded
coastline retrogrades and sediments are deposited on top of the LST, FSST and HST
sea-level (t_{22})
(t_{19})


high
relative
sea-level
low
HST
SB
FSST
LST
TS
TST
MFS
t_{22}
t_{29}
time

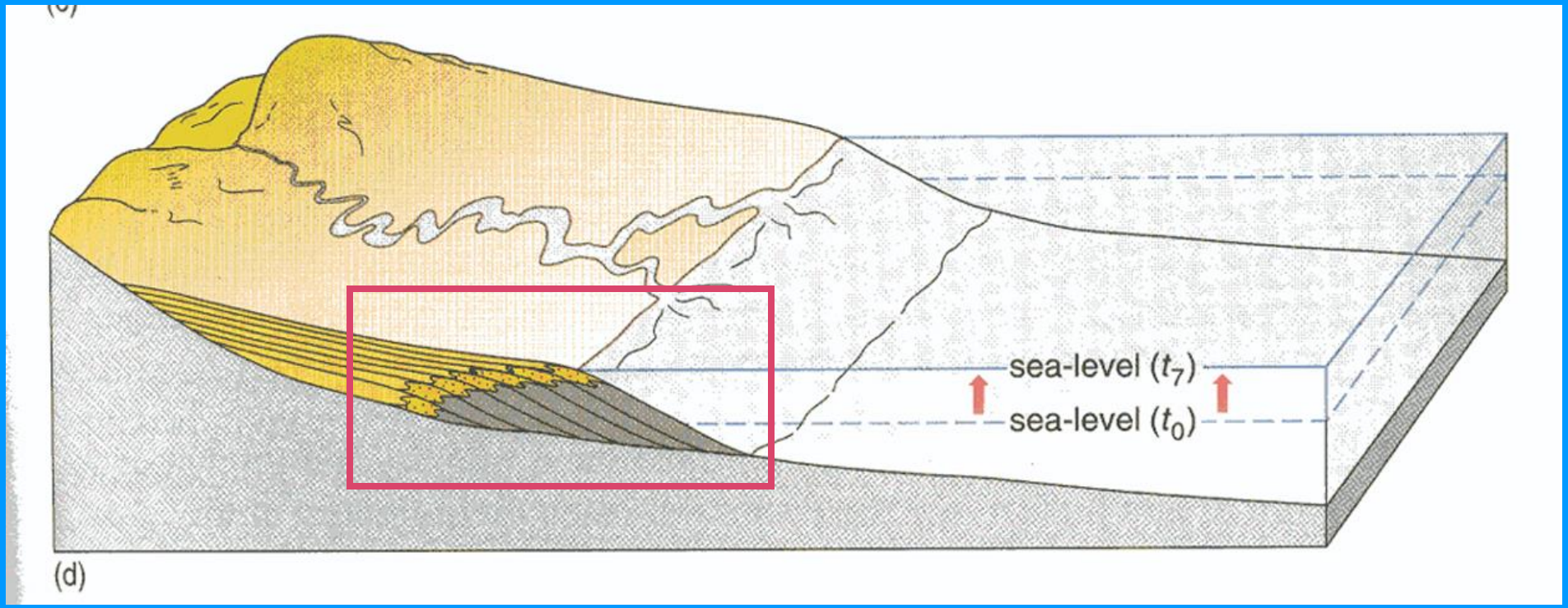

maximum rate
of relative
sea-level rise (t_{22})
high-water table
in the alluvial
plain area
deposition of marine
sediments in previously
non-marine areas
more distal areas starved
of sediment resulting in the
formation of a condensed section


high
relative
sea-level
low
HST
t_0
t_7
time

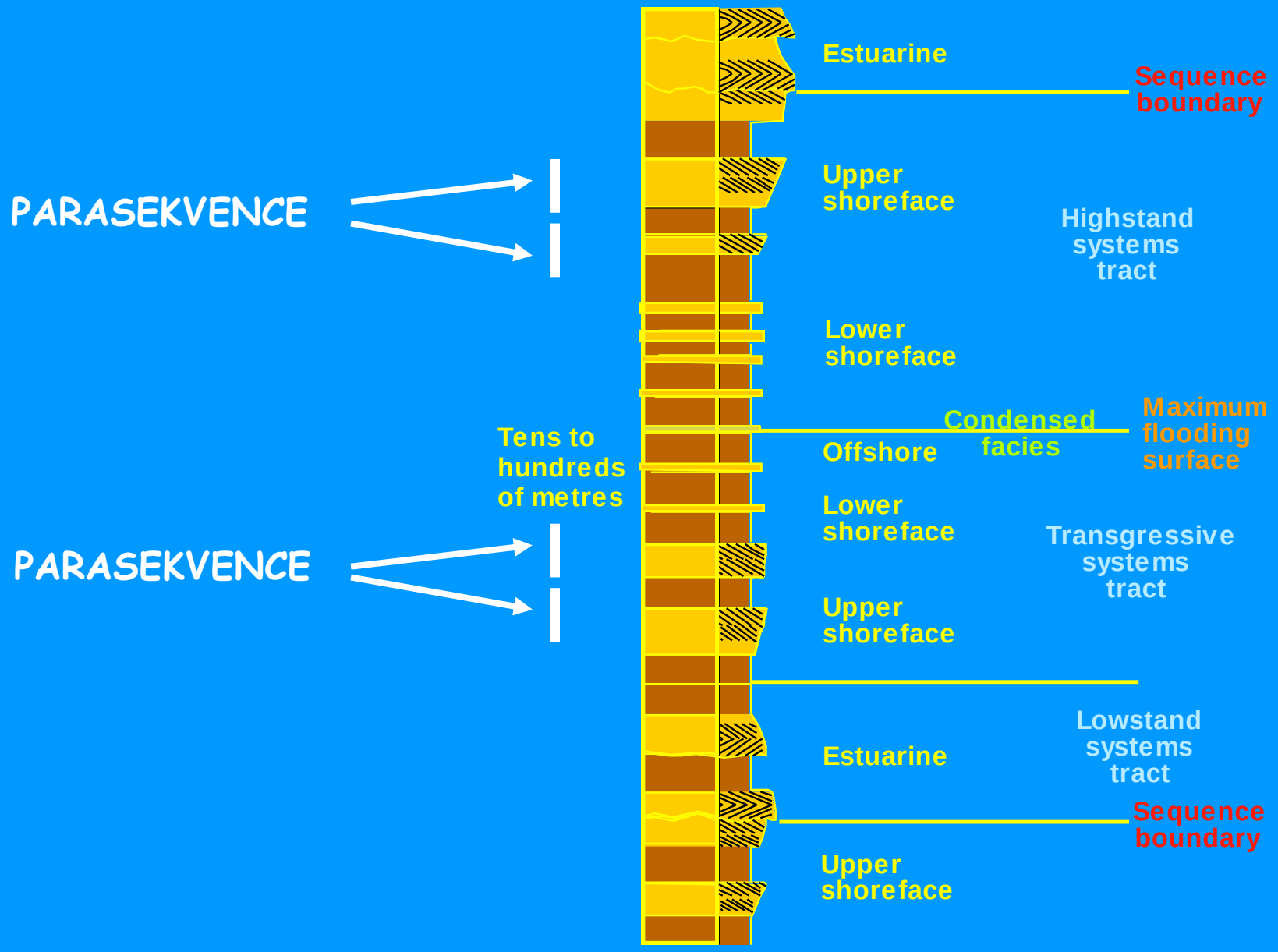

sea-level (t_7)
sea-level (t_0)
(d)

PARASEKVENCE

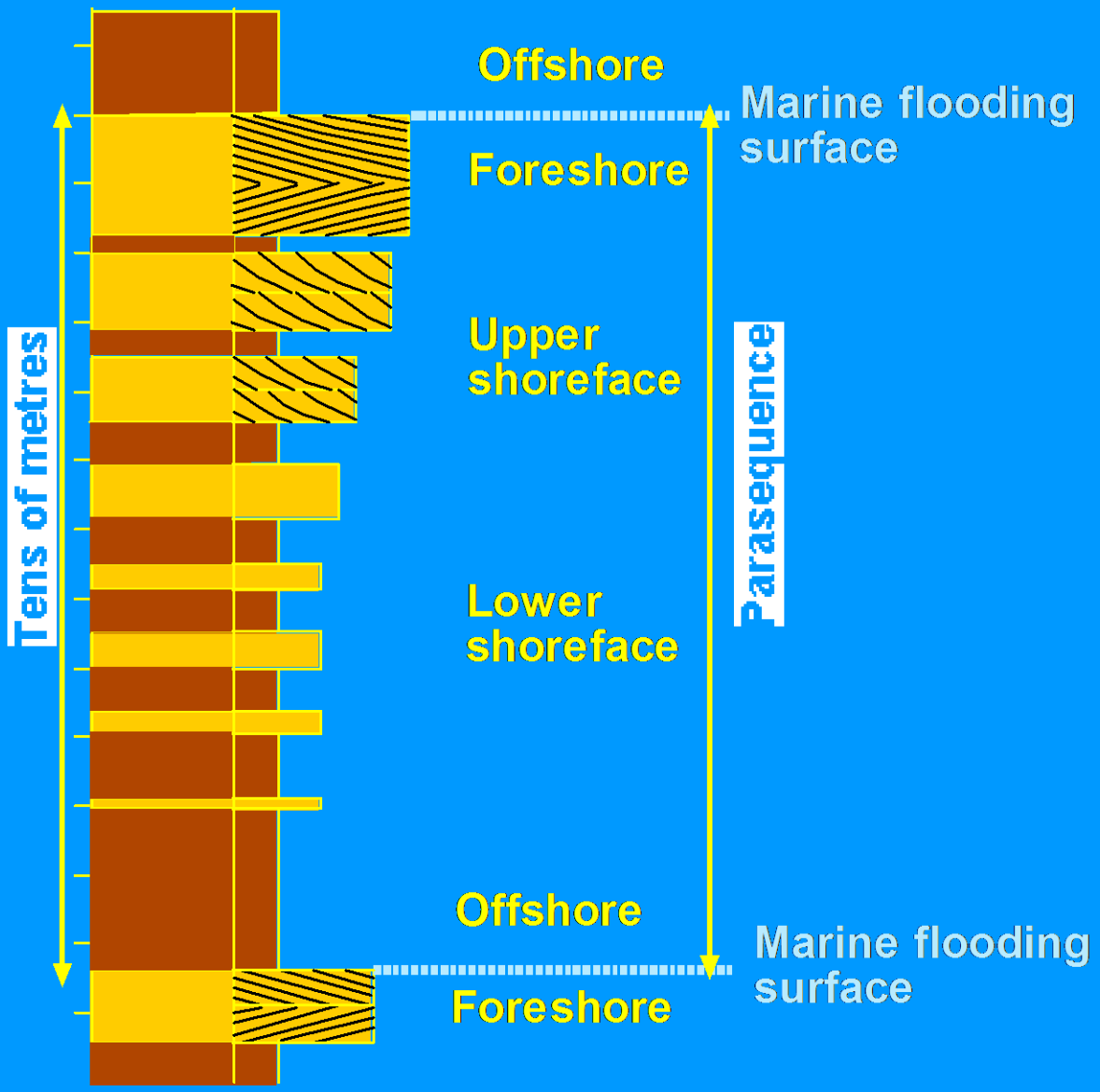
parasekvence – sukcese geneticky spjatých sedimentárních těles;
vymezena záplavovými plochami
- směrem do nadloží vykazuje změlčující trend
(v malém měřítku)



SEDIMENTÁRNÍ SEKVENCE



PARASEKVENCE – vnitřní stavba

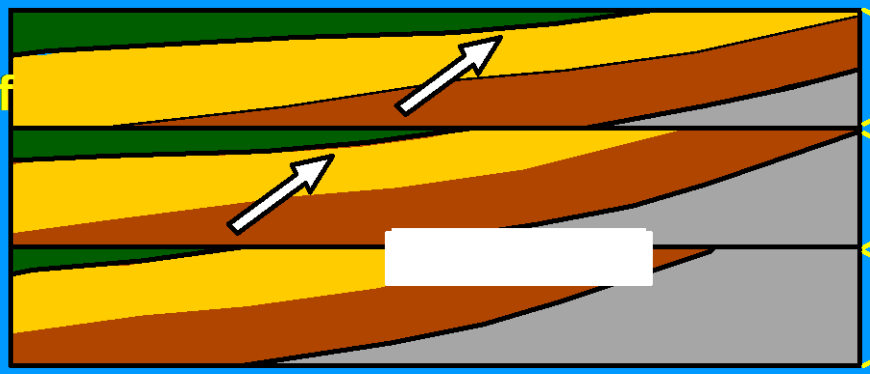


PARASEQUENCE SET (set parasekvencí)

- skupina parasekvencí, které vykazují určitý trend (uspořádání) daný dlouhodobými změnami hladiny

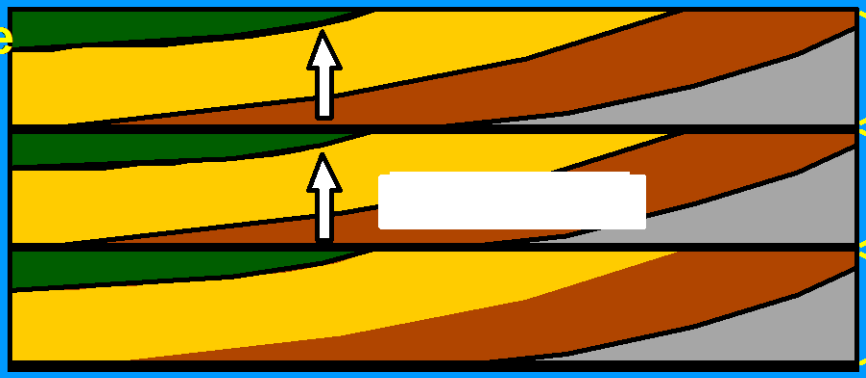
- každý sekvenční trakt (TST, HST,…) má svůj charakteristický parasekvenční set

Overall decrease in rate of creation of accommodation space (Highstand to falling stage)



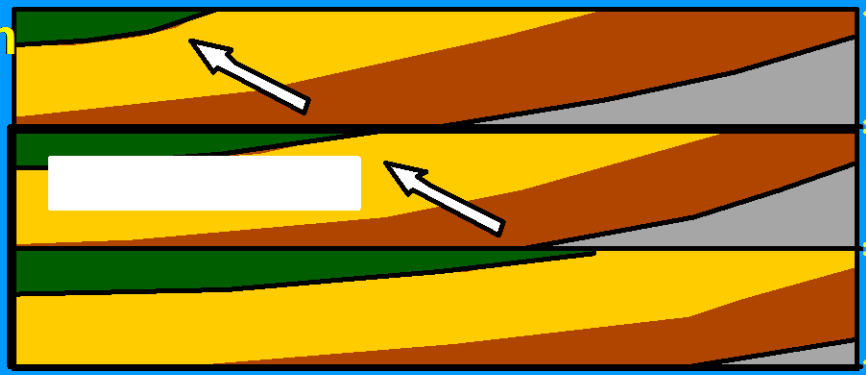
PARASEQUENCES

Overall steady rate of creation of accommodation space (Highstand)



PARASEQUENCES

Overall increase in rate of creation of accommodation space (Transgression)



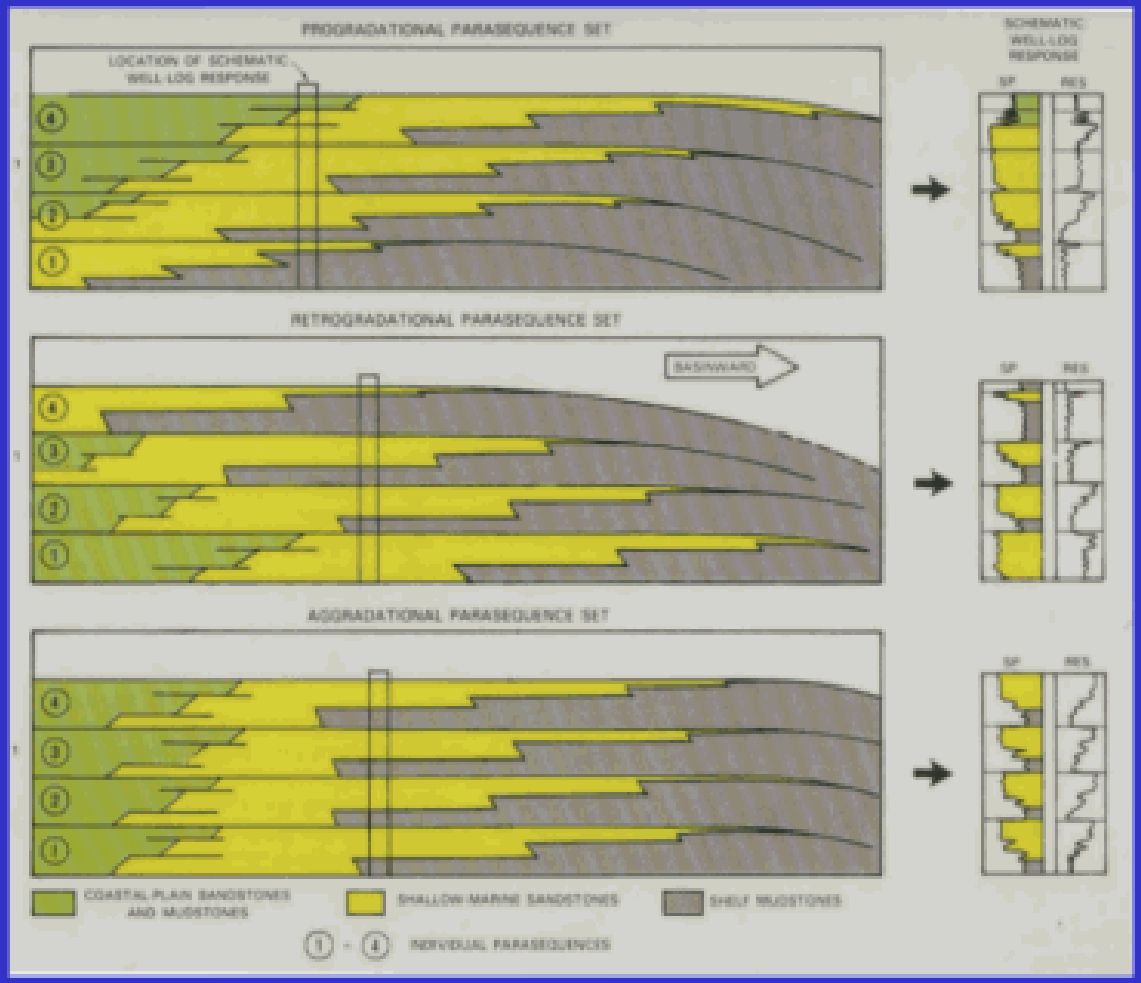
PARASEQUENCES

Parasequence stacking pattern

$\frac{\textit{Ratio}\ \text{rate of deposition}}{\text{Rate of accommodation}} > 1$

$\frac{\text{Ratio rate of deposition}}{\text{Rate of accommodation}} < 1$

$\frac{\textit{Ratio}\ \text{rate of deposition}}{\text{Rate of accommodation}} = 1$



Van Wagoner et al. (1987)

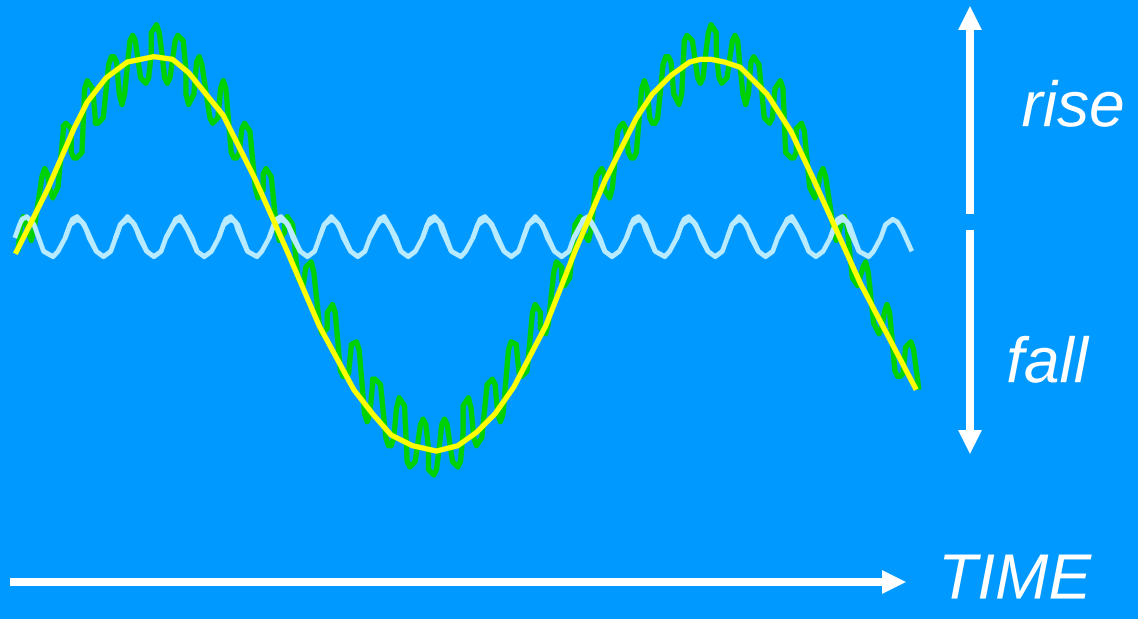
KŘIVKA RELATIVNÍCH ZMĚN HLADINY

PŘEDPOKLAD: křivka má tvar sinusoidy

Křivka krátkodobých změn

Křivka dlohodobých změn

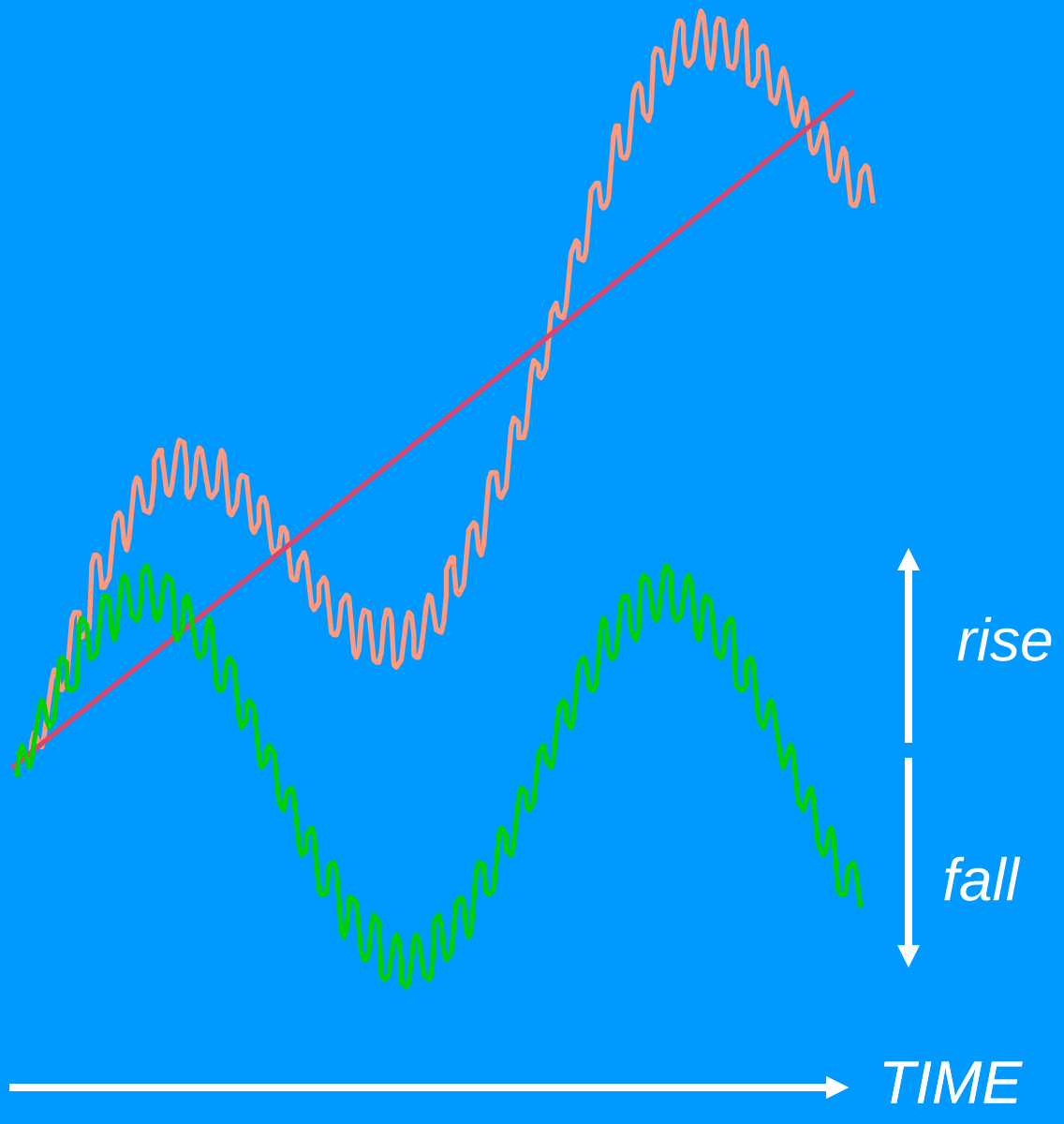
Kombinovaná křivka



Sea level curve

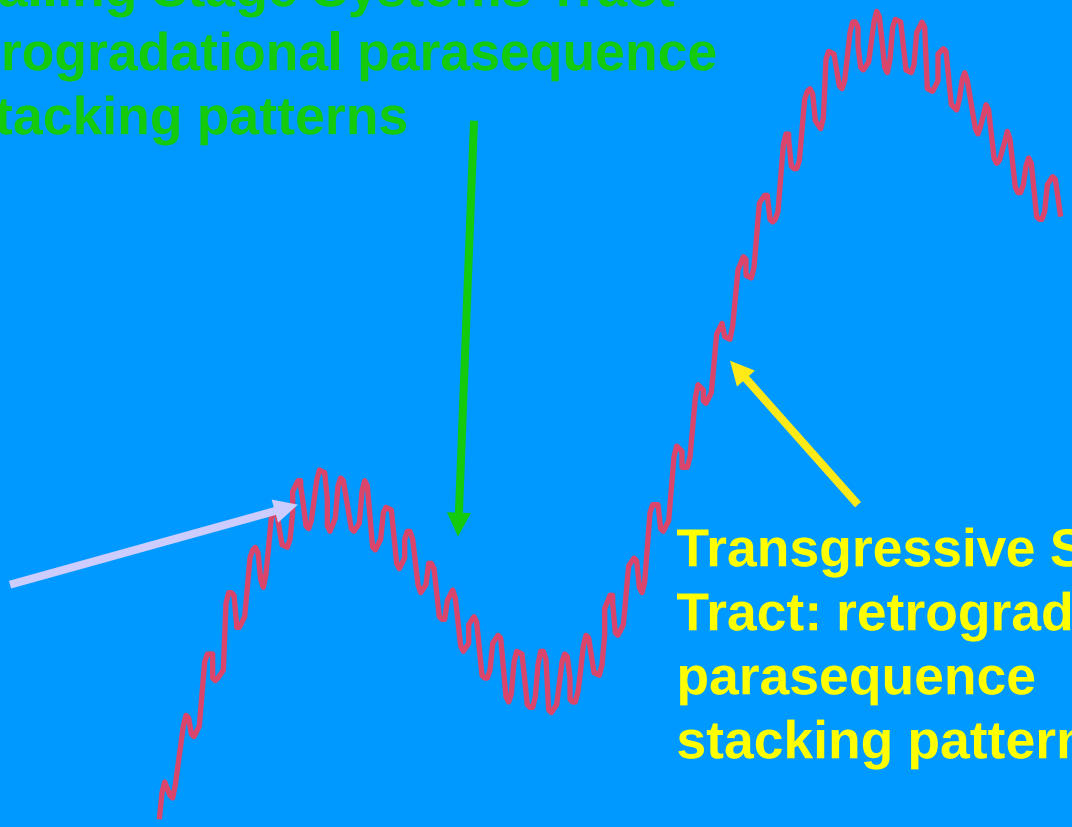
Subsidence

Combined sea level curve



Falling Stage Systems Tract
Progradational parasequence
stacking patterns

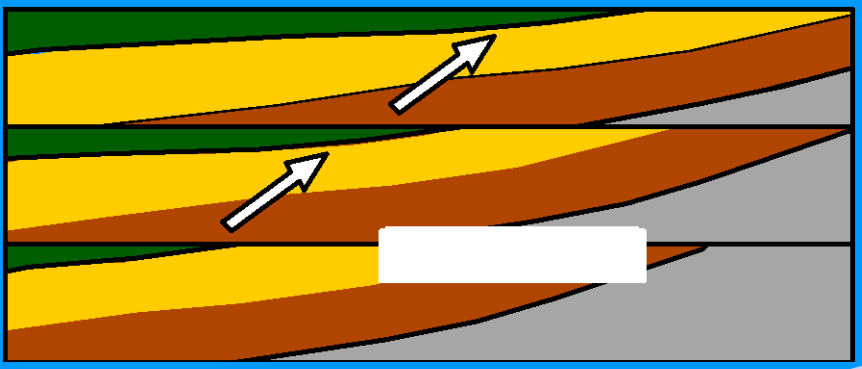
Sea level curve



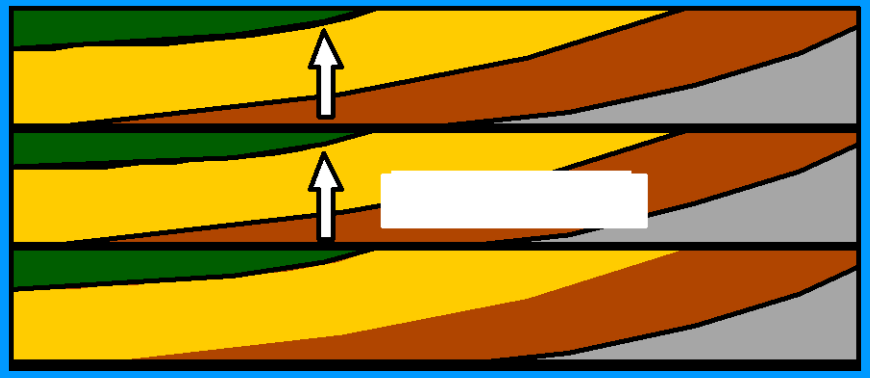
Highstand Systems
Tract: aggradational
parasequence
stacking patterns

Transgressive Systems
Tract: retrogradational
parasequence
stacking patterns

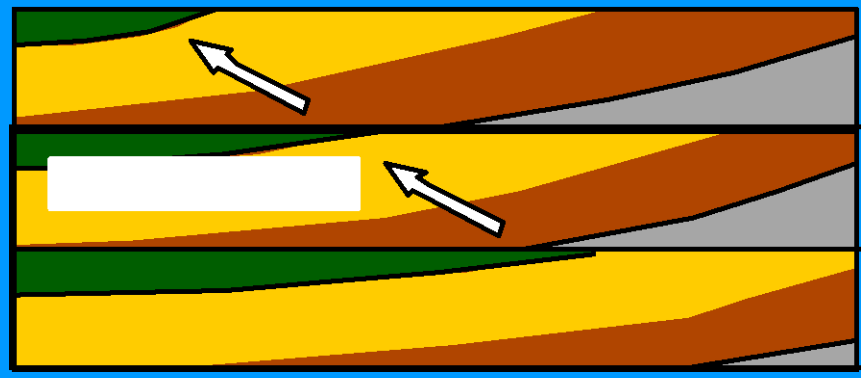
Falling Stage Systems Tract
Progradational parasequence
stacking patterns



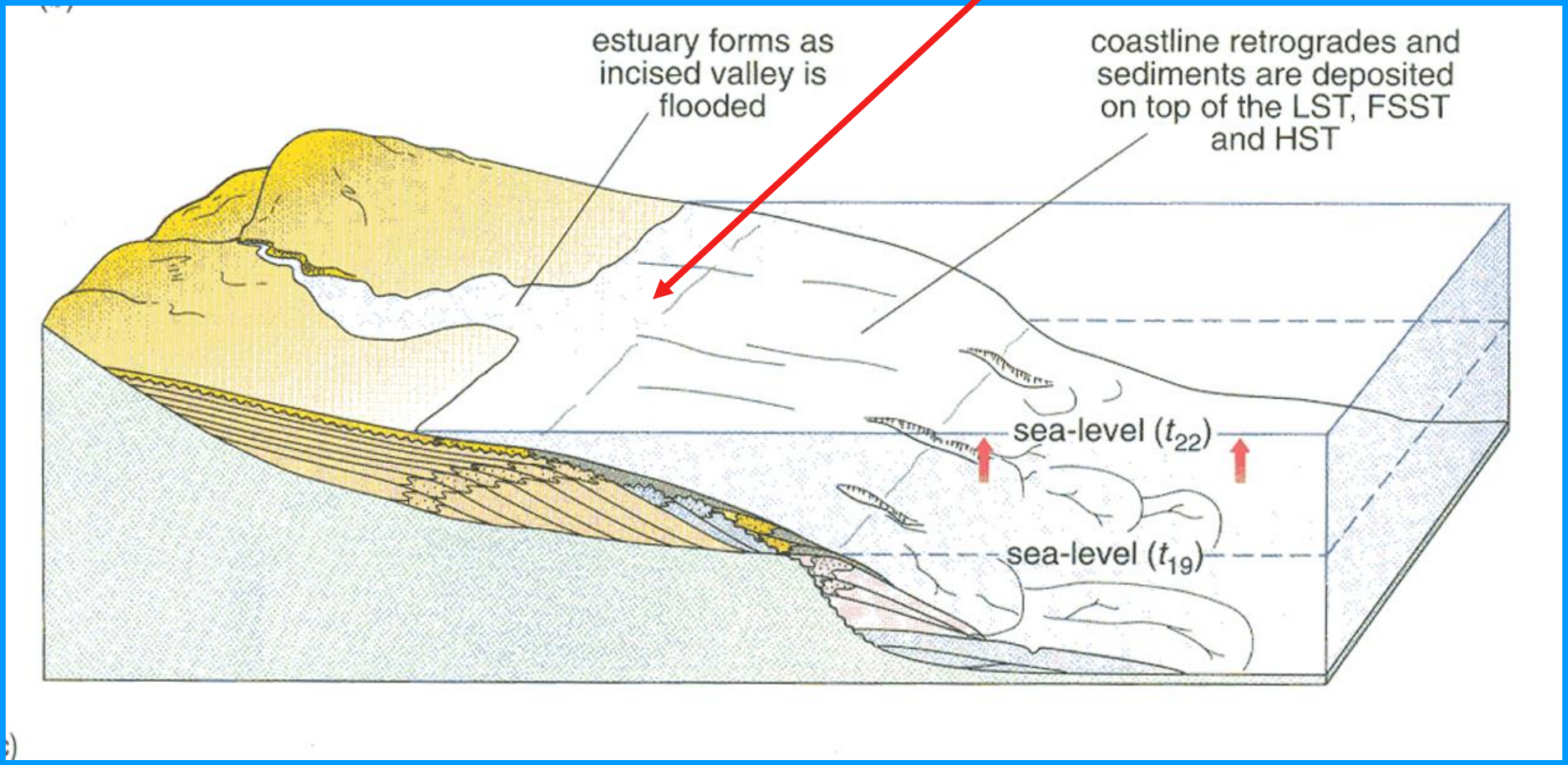
Highstand Systems
Tract: aggradational
parasequence
stacking patterns



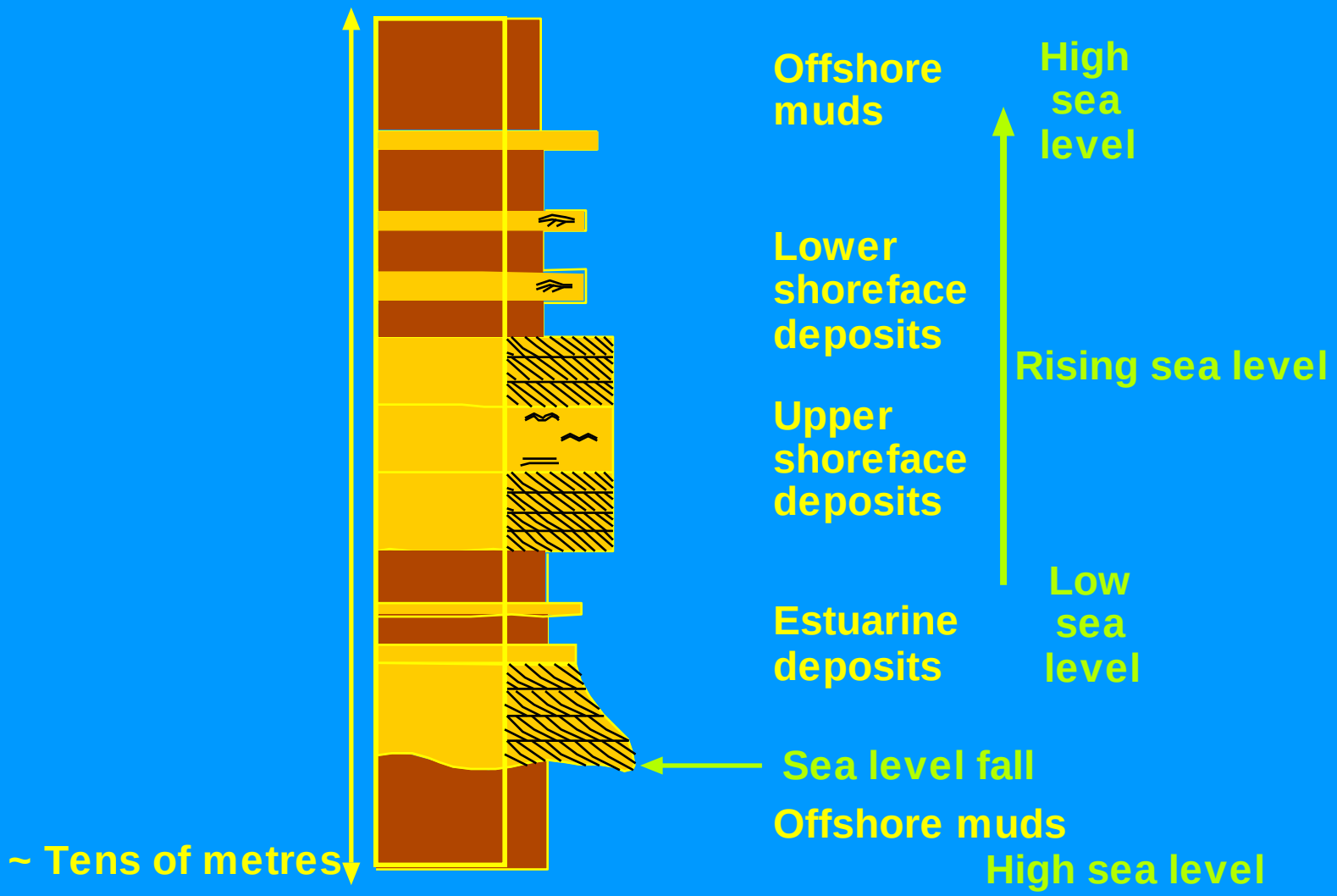
Transgressive Systems
Tract: retrogradational
parasequence
stacking patterns



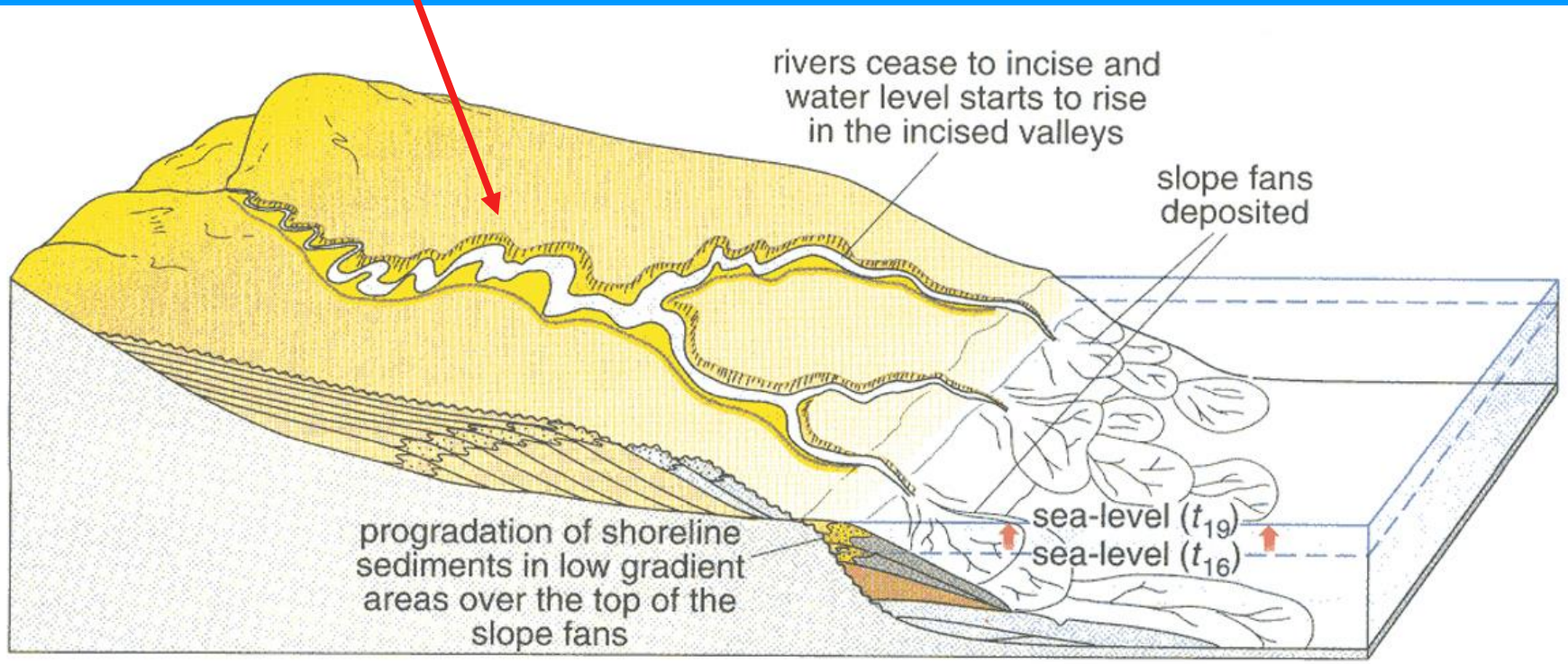
Shelf environments



Shelf environments



Fluvial environments



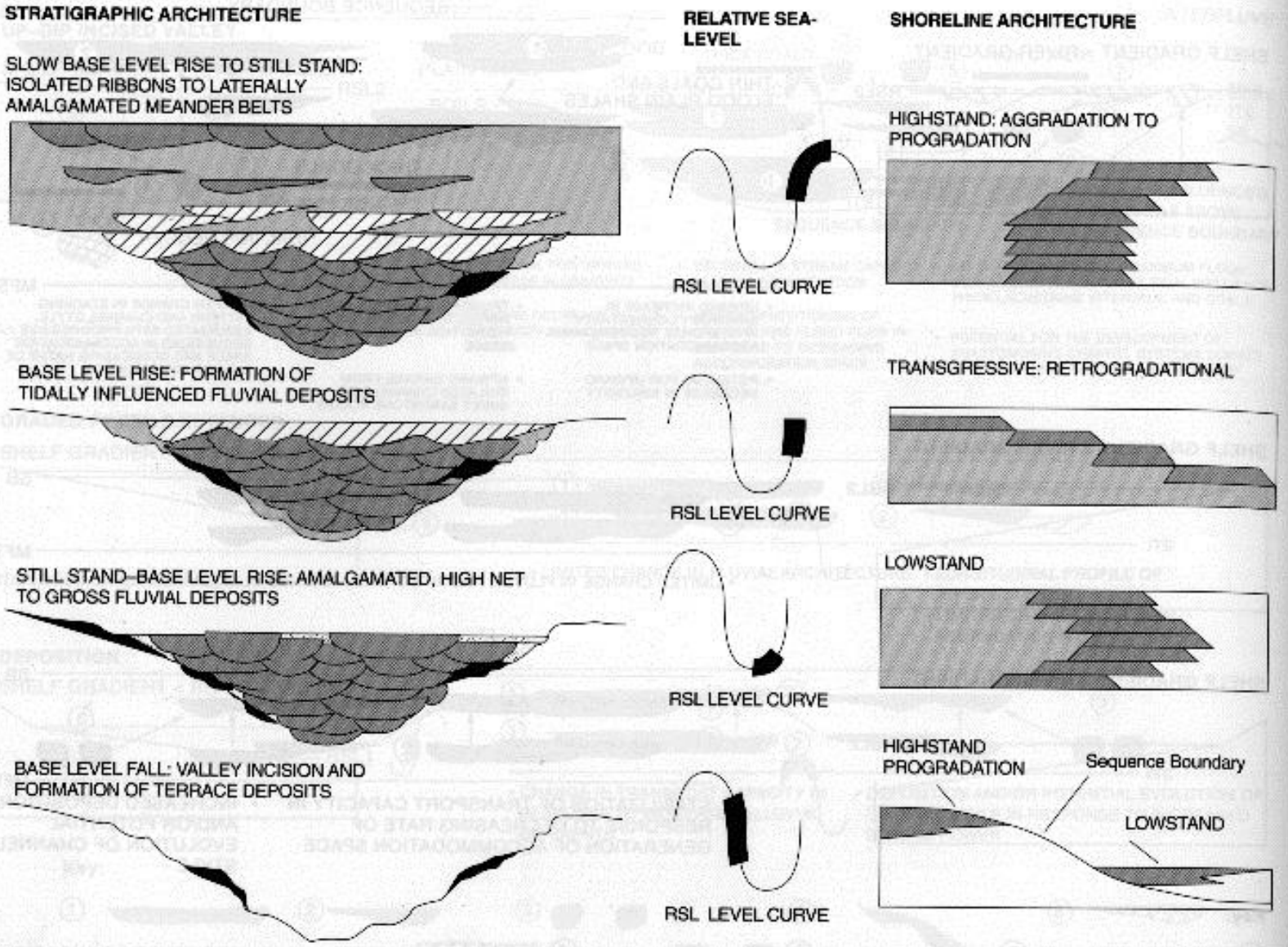
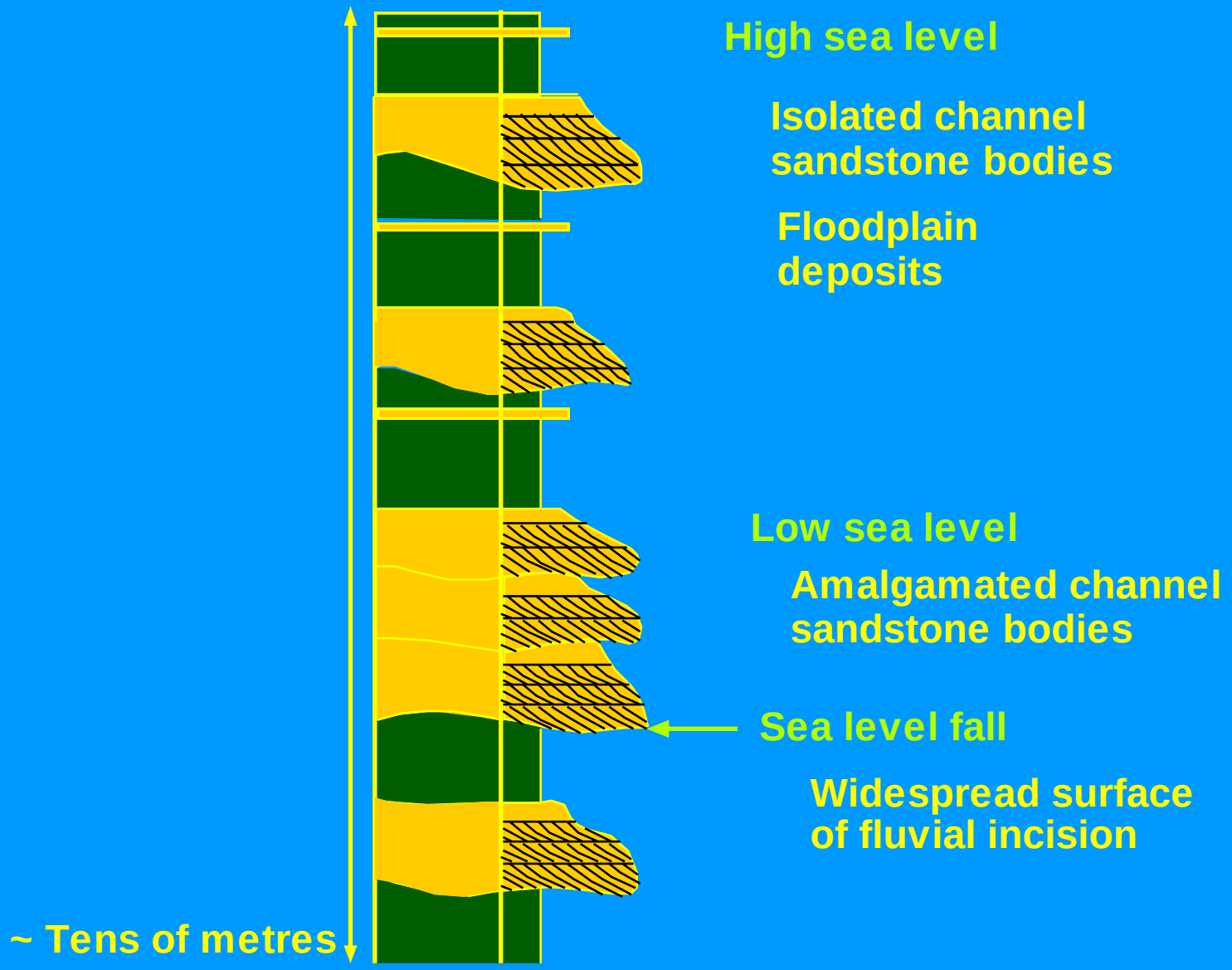
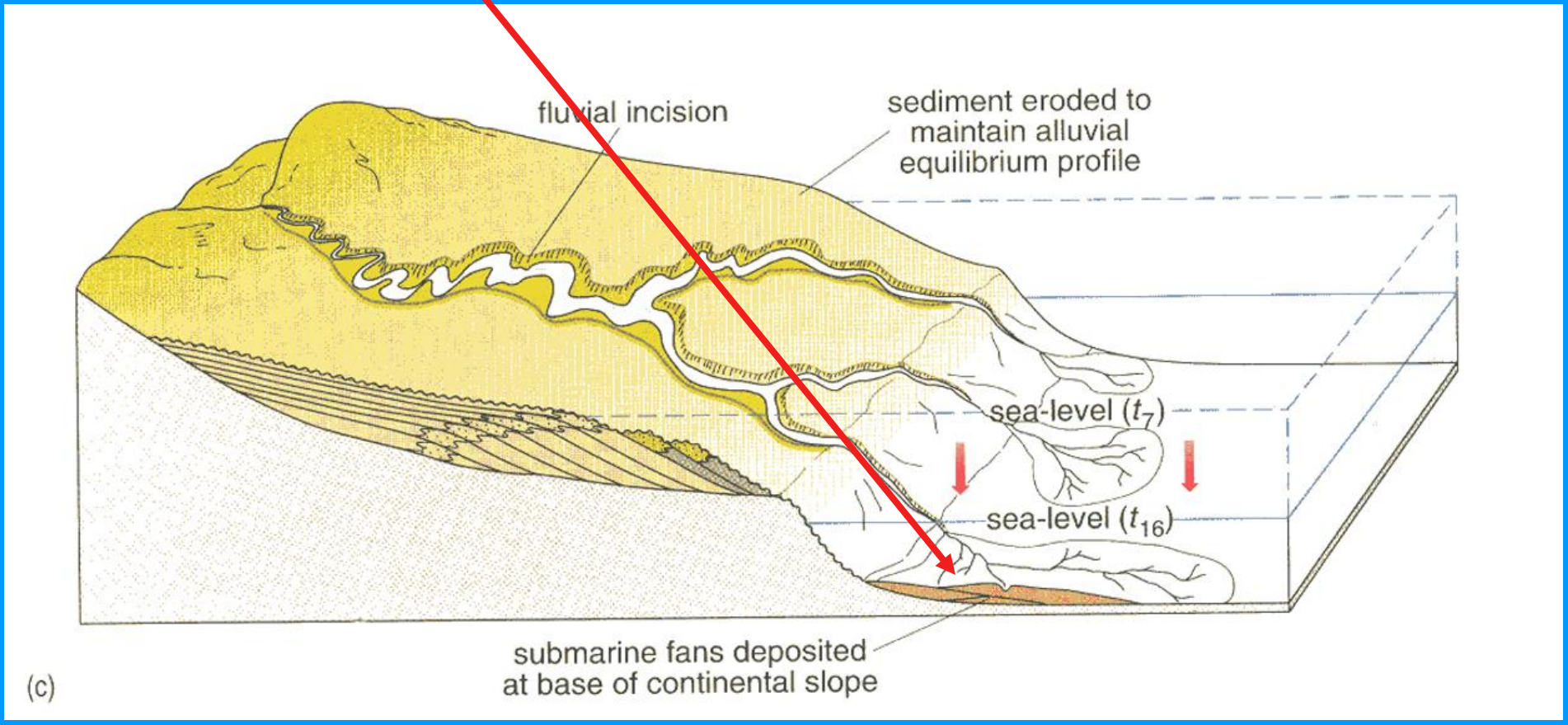


Fig. 7.11 Summary diagram illustrating the relationship between shoreface and fluvial architecture as a function of base level change (after Shanley and McCabe, 1993). Detailed correlations suggest the timing of the incised-valley fill occurred after the initial transgressive surface. For this reason Shanley and McCabe (1993) regard the valley-fill as 'alluvial-transgressive' deposits

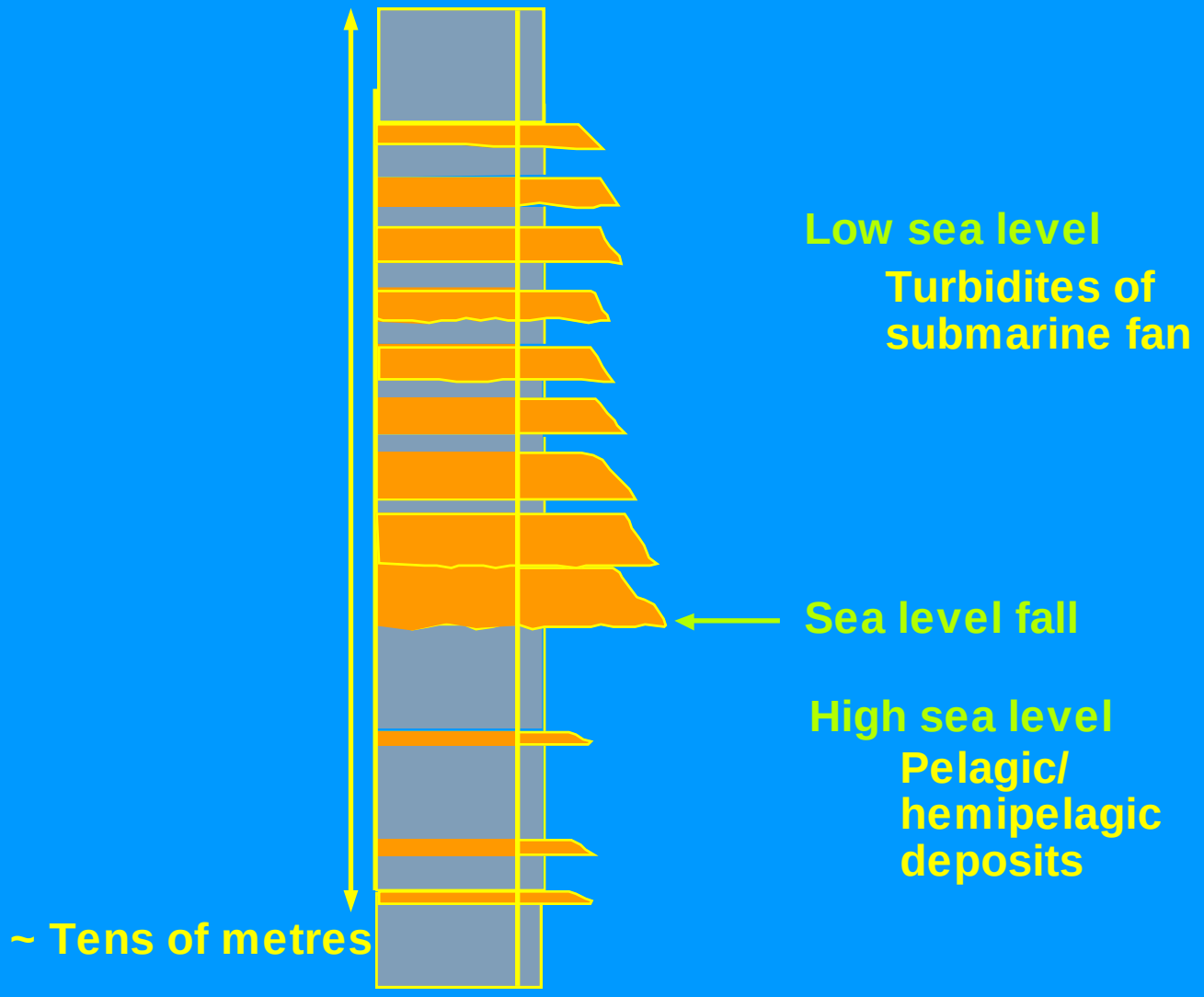
Fluvial environments

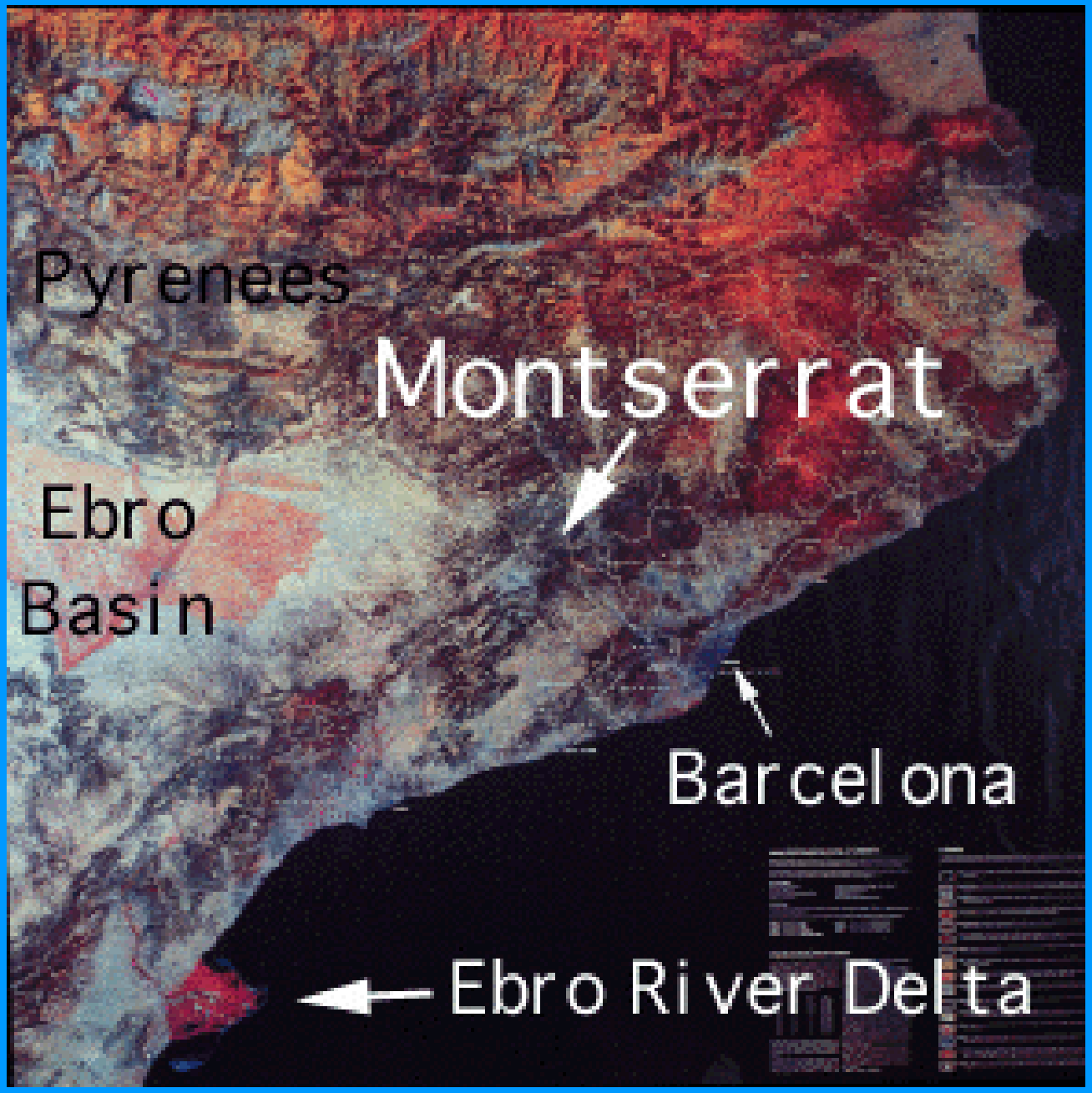


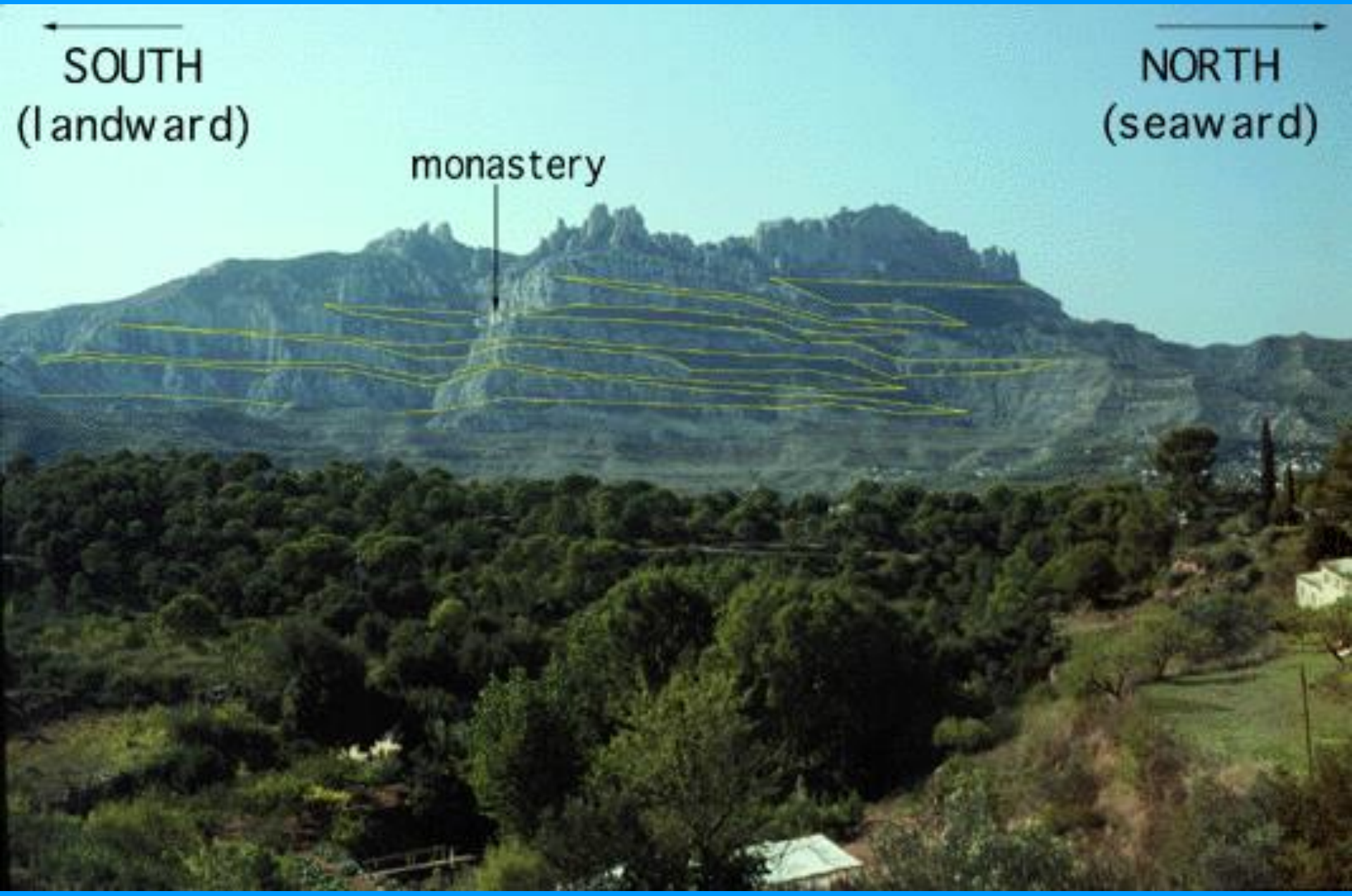
Deep marine environments

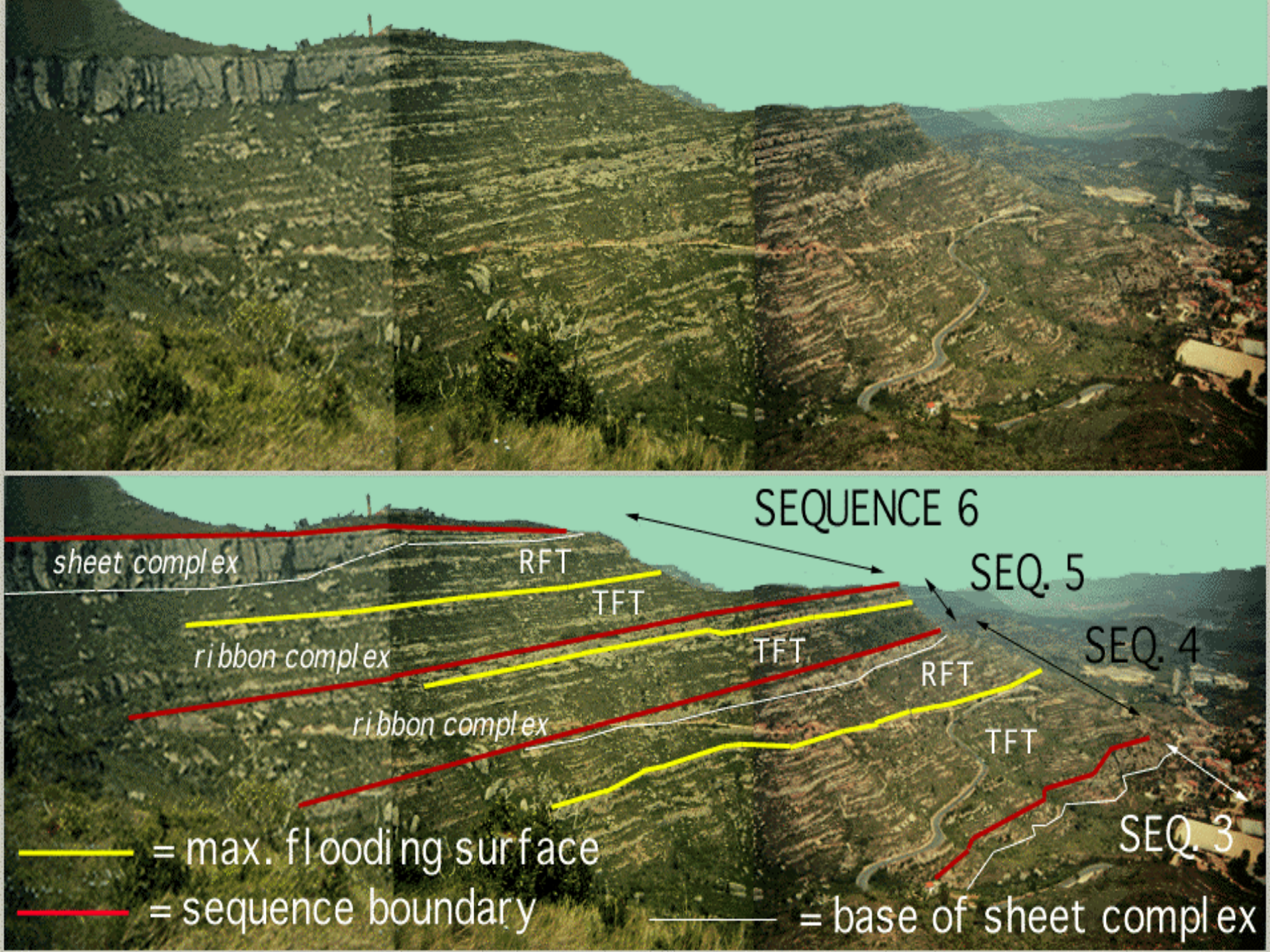


Deep marine environments



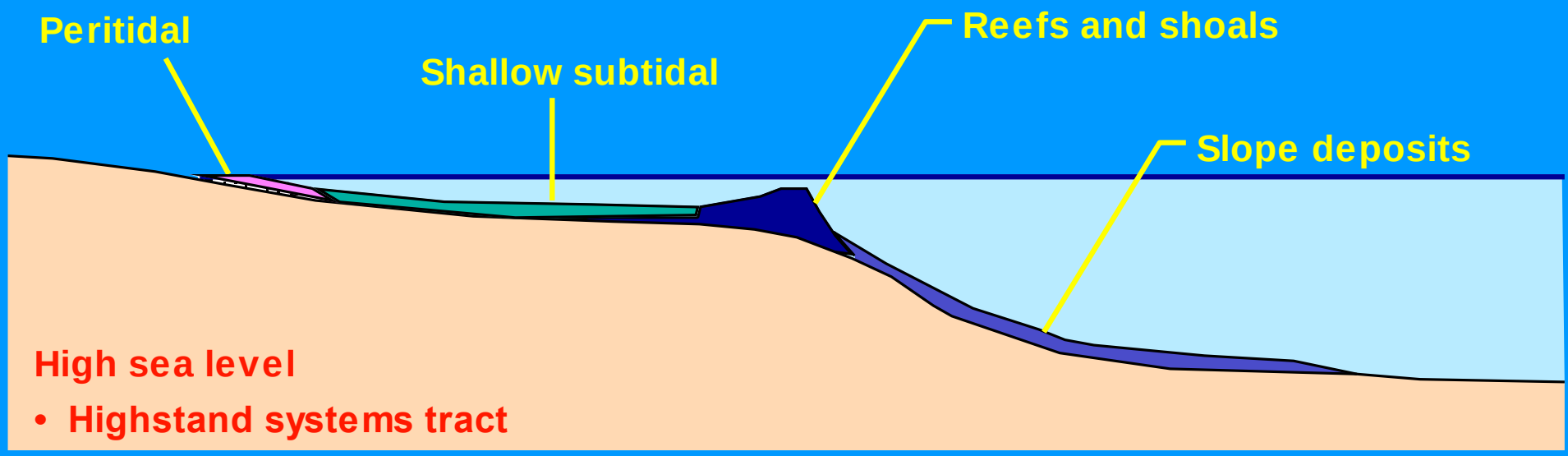

Pyrenees
Montserrat
Ebro
Basin
Barcelona
Ebro River Delta


SOUTH
(landward)
NORTH
(seaward)
monastery


SEQUENCE 6
SEQ. 5
SEQ. 4
SEQ. 3
sheet complex
ribbon complex
ribbon complex
RFT
TFT
TFT
RFT
TFT
= max. flooding surface
= sequence boundary
= base of sheet complex

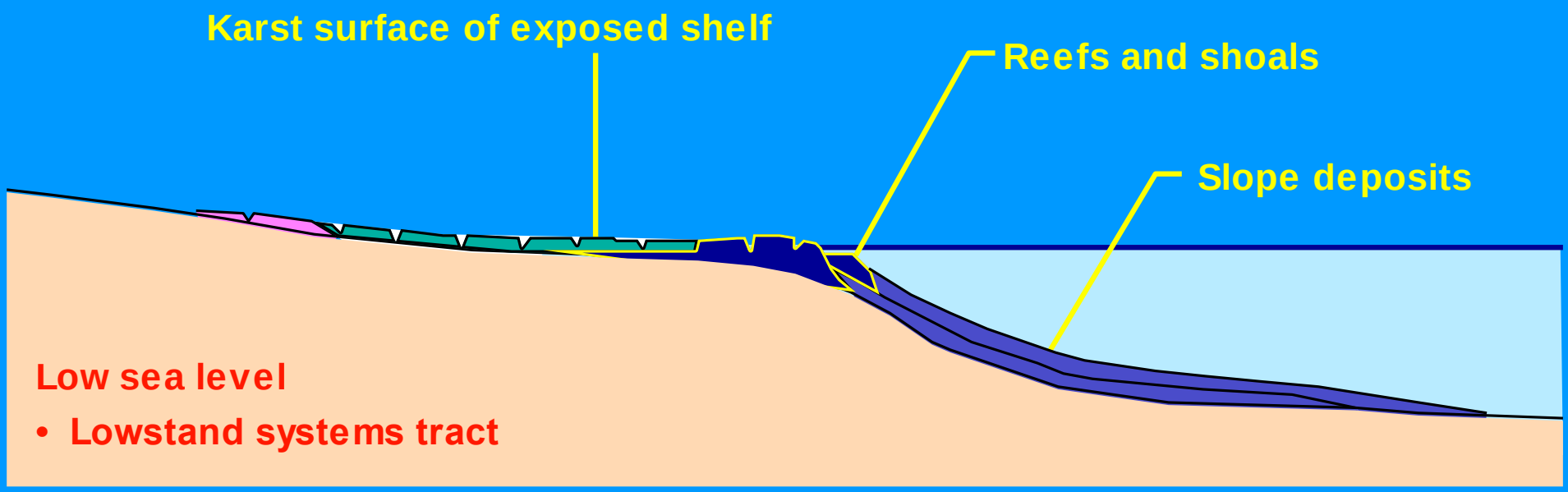

sequence
boundary

Depositional Sequences: carbonate shelf



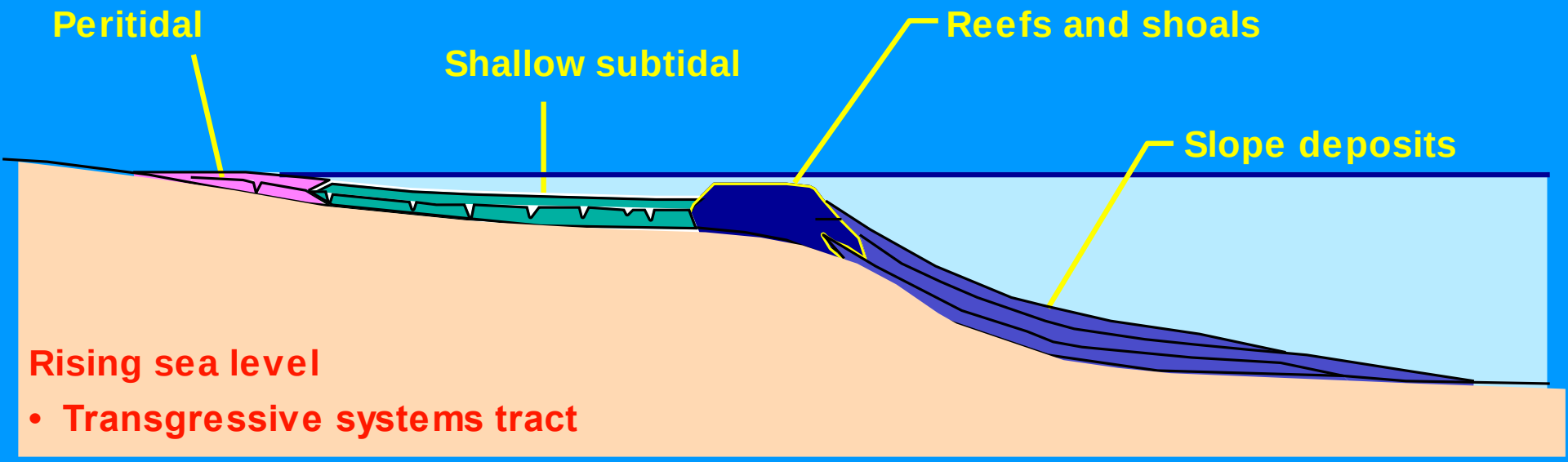
High sea level

- **Highstand systems tract**



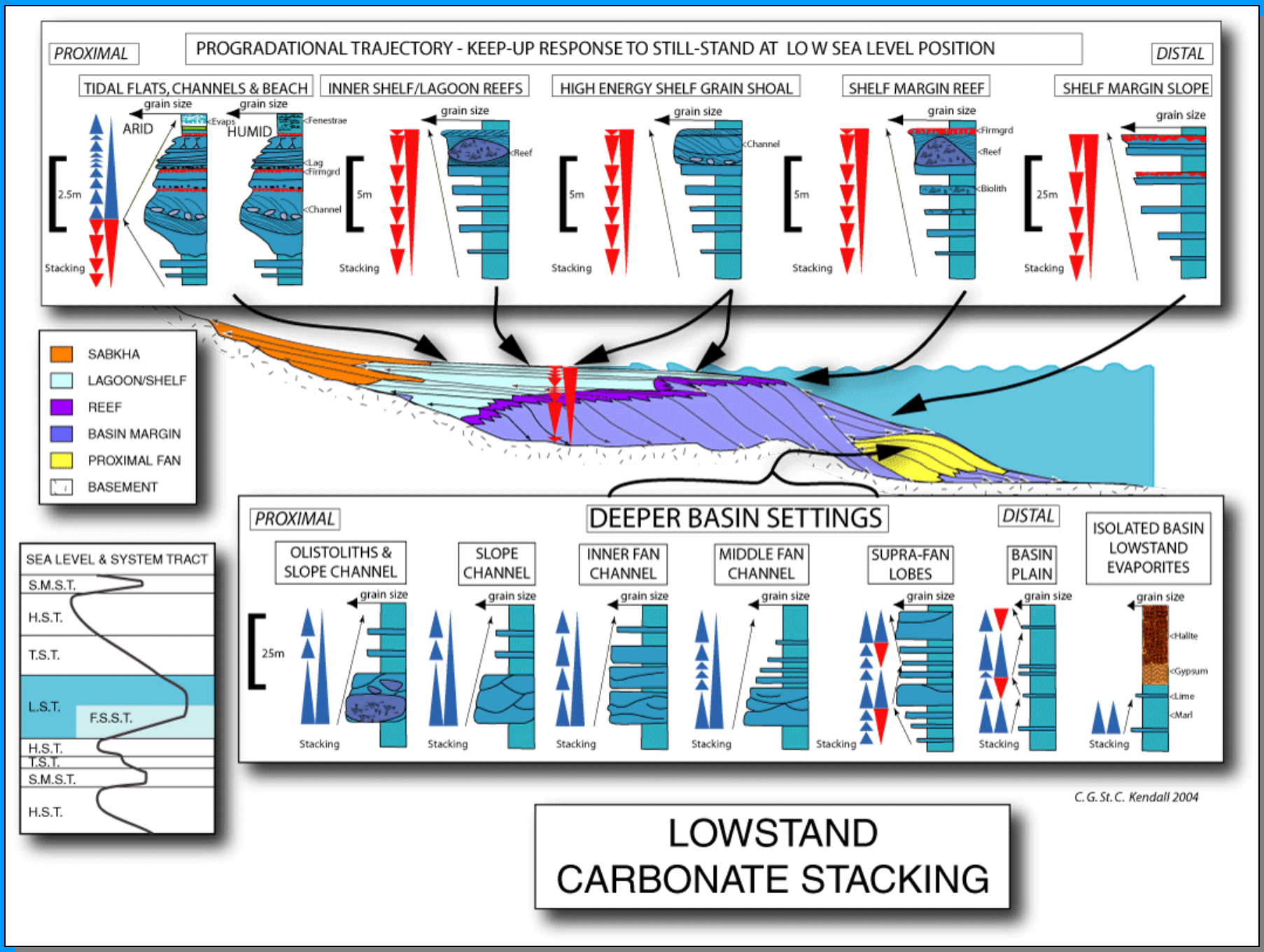
Low sea level

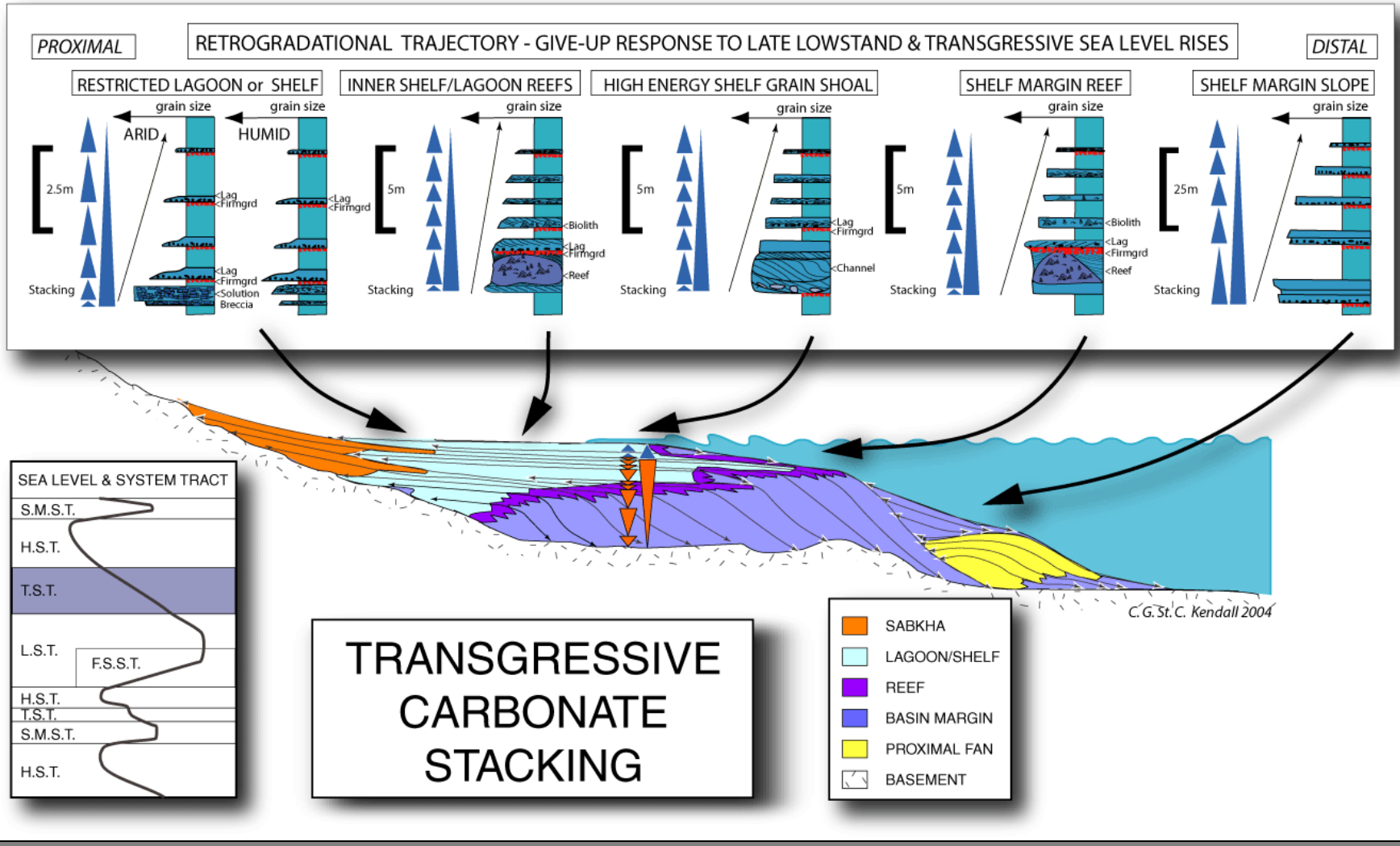
- **Lowstand systems tract**

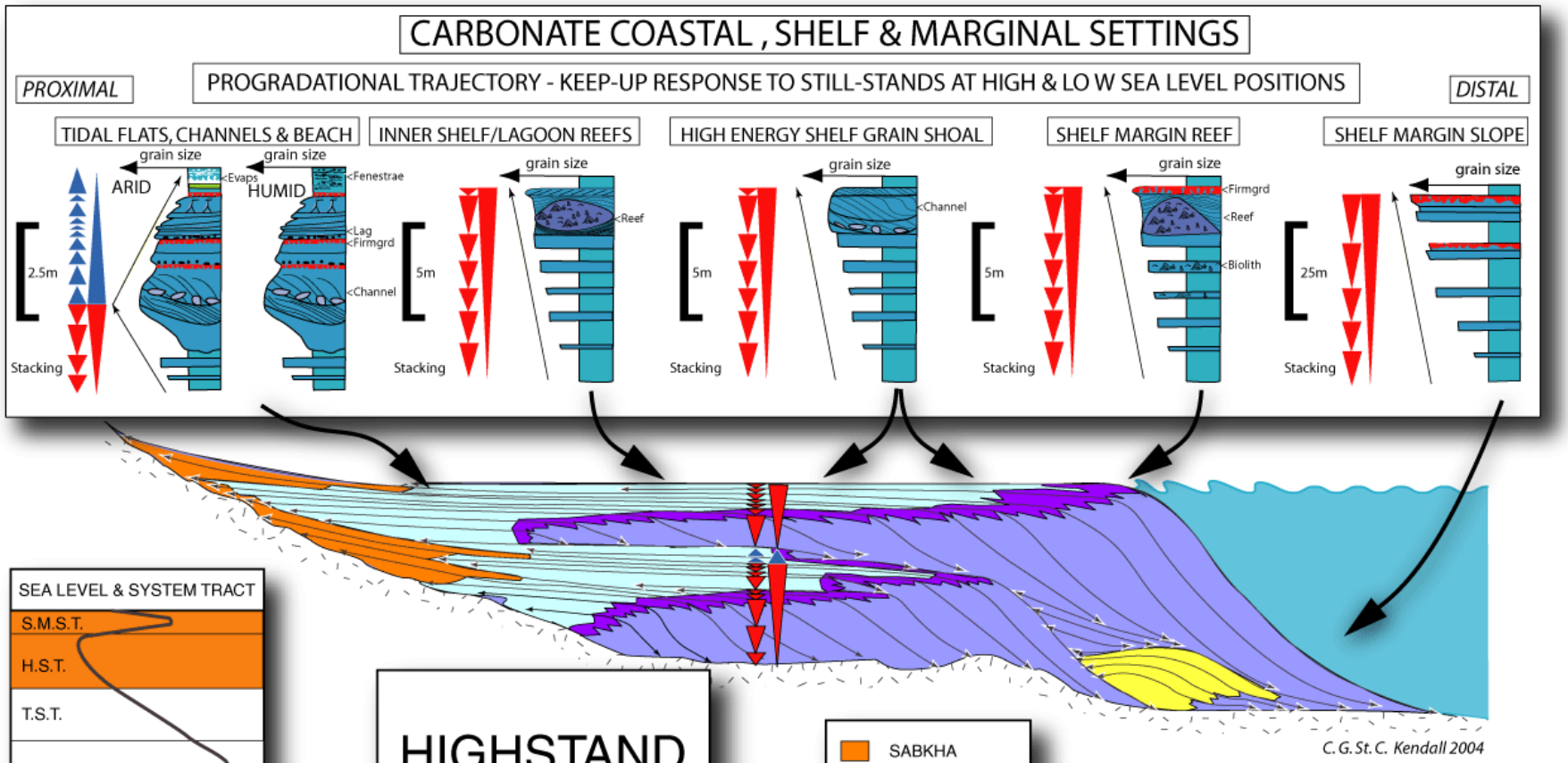


Rising sea level

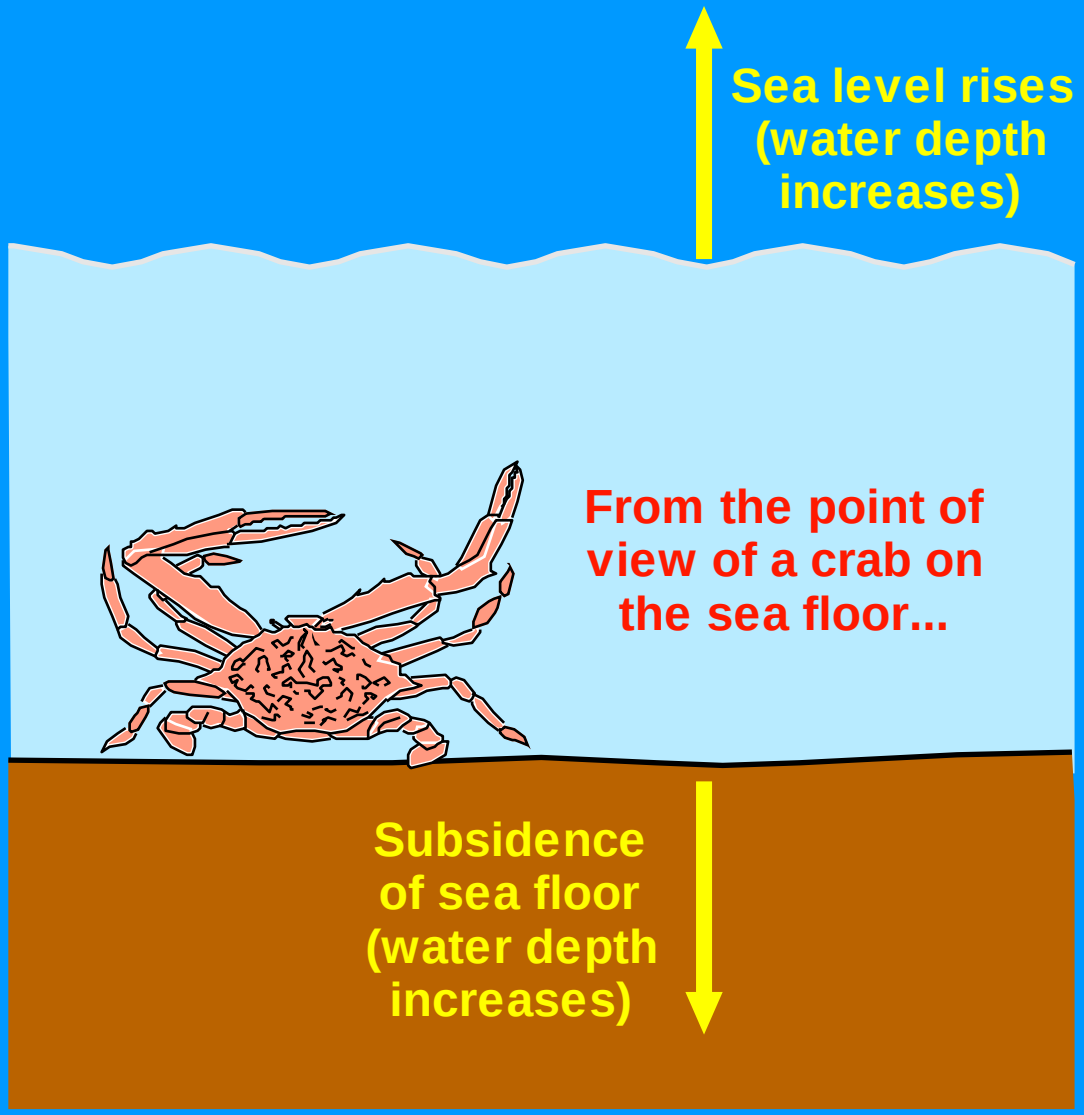
- Transgressive systems tract


PROXIMAL
PROGRADATIONAL TRAJECTORY - KEEP-UP RESPONSE TO STILL-STAND AT LO W SEA LEVEL POSITION
DISTAL
TIDAL FLATS, CHANNELS & BEACH
INNER SHELF/LAGOON REEFS
HIGH ENERGY SHELF GRAIN SHOAL
SHELF MARGIN REEF
SHELF MARGIN SLOPE
grain size
ARID
HUMID
Evaps
Fenestrae
Lag
Firmgrd
Channel
Reef
Biolith
2.5m
5m
25m
Stacking
SABKHA
LAGOON/SHELF
REEF
BASIN MARGIN
PROXIMAL FAN
BASEMENT
SEA LEVEL & SYSTEM TRACT
S.M.S.T.
H.S.T.
T.S.T.
L.S.T.
F.S.S.T.
H.S.T.
T.S.T.
S.M.S.T.
H.S.T.
PROXIMAL
DEEPER BASIN SETTINGS
DISTAL
OLISTOLITHS & SLOPE CHANNEL
SLOPE CHANNEL
INNER FAN CHANNEL
MIDDLE FAN CHANNEL
SUPRA-FAN LOBES
BASIN PLAIN
ISOLATED BASIN LOWSTAND EVAPORITES
Halite
Gypsum
Lime
Marl
C. G. St. C. Kendall 2004
LOWSTAND CARBONATE STACKING


PROXIMAL
RETROGRADATIONAL TRAJECTORY - GIVE-UP RESPONSE TO LATE LOWSTAND & TRANSGRESSIVE SEA LEVEL RISES
DISTAL
RESTRICTED LAGOON or SHELF
INNER SHELF/LAGOON REEFS
HIGH ENERGY SHELF GRAIN SHOAL
SHELF MARGIN REEF
SHELF MARGIN SLOPE
grain size
ARID
HUMID
2.5m
5m
5m
5m
25m
Stacking
Lag
Firmgrd
Solution Breccia
Biolith
Reef
Channel
SEA LEVEL & SYSTEM TRACT
S.M.S.T.
H.S.T.
T.S.T.
L.S.T.
F.S.S.T.
H.S.T.
T.S.T.
S.M.S.T.
H.S.T.
C.G.St.C. Kendall 2004
SABKHA
LAGOON/SHELF
REEF
BASIN MARGIN
PROXIMAL FAN
BASEMENT
TRANSGRESSIVE CARBONATE STACKING


CARBONATE COASTAL , SHELF & MARGINAL SETTINGS
PROXIMAL
PROGRADATIONAL TRAJECTORY - KEEP-UP RESPONSE TO STILL-STANDS AT HIGH & LO W SEA LEVEL POSITIONS
DISTAL
TIDAL FLATS, CHANNELS & BEACH
INNER SHELF/LAGOON REEFS
HIGH ENERGY SHELF GRAIN SHOAL
SHELF MARGIN REEF
SHELF MARGIN SLOPE
ARID
HUMID
grain size
Evaps
Fenestrae
Lag
Firmgrd
Channel
Reef
Biolith
2.5m
5m
25m
Stacking
SEA LEVEL & SYSTEM TRACT
S.M.S.T.
H.S.T.
T.S.T.
L.S.T.
H.S.T.
T.S.T.
S.M.S.T.
H.S.T.
HIGHSTAND CARBONATE STACKING
SABKHA
LAGOON/SHELF
REEF
BASIN MARGIN
PROXIMAL FAN
BASEMENT
C. G. St. C. Kendall 2004

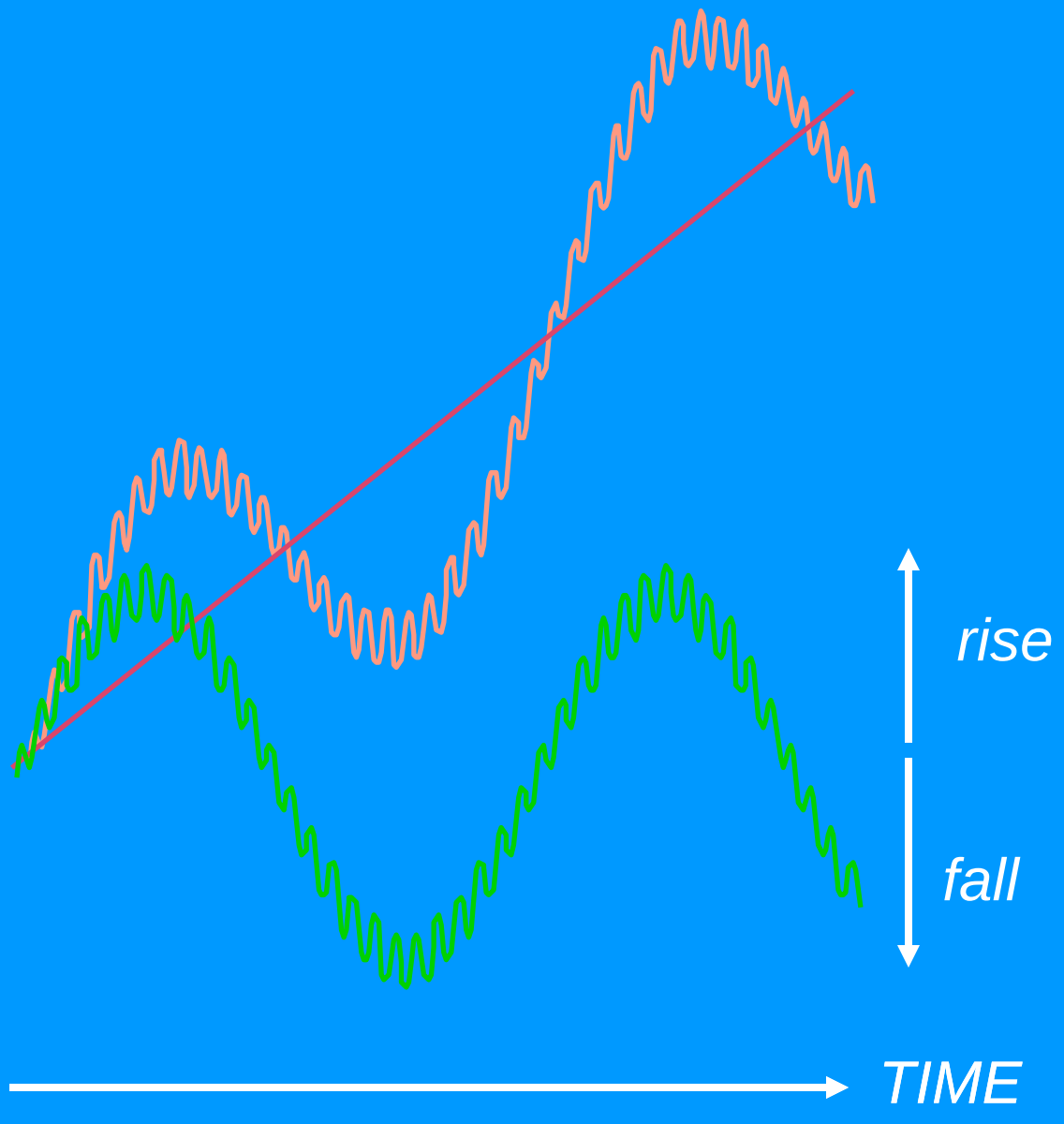
AKOMODAČNÍ PROSTOR A PŘÍČINY ZMĚN HLADINY



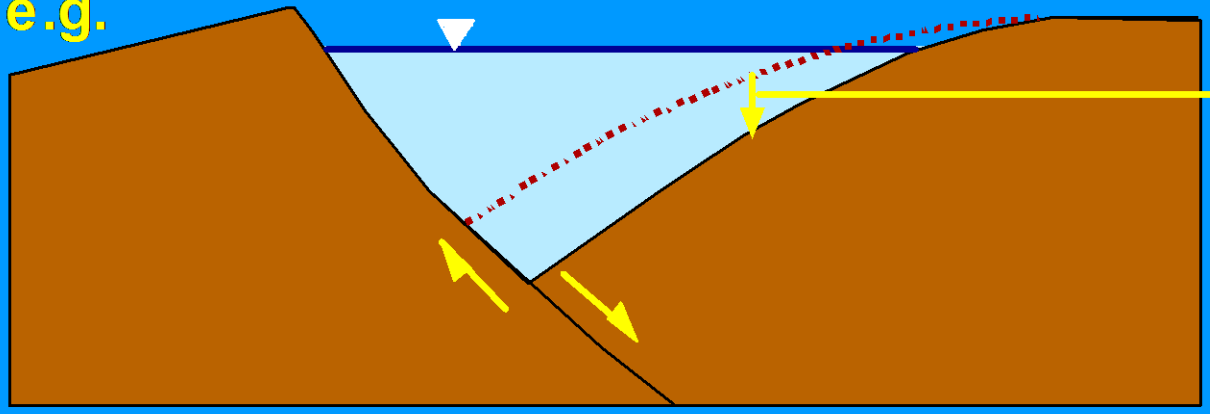
Sea level curve

Subsidence

Combined sea level curve



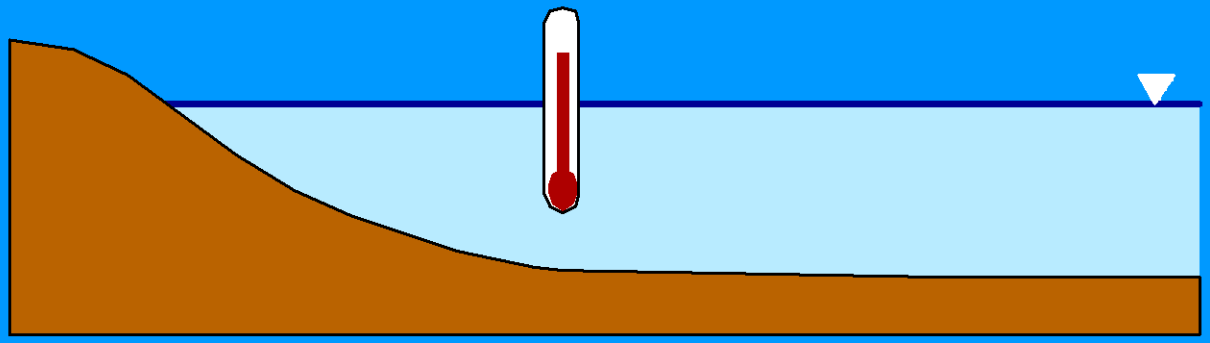
Local tectonics
e.g.



Relative sea level rise

Very variable rates and magnitudes of relative sea level changes

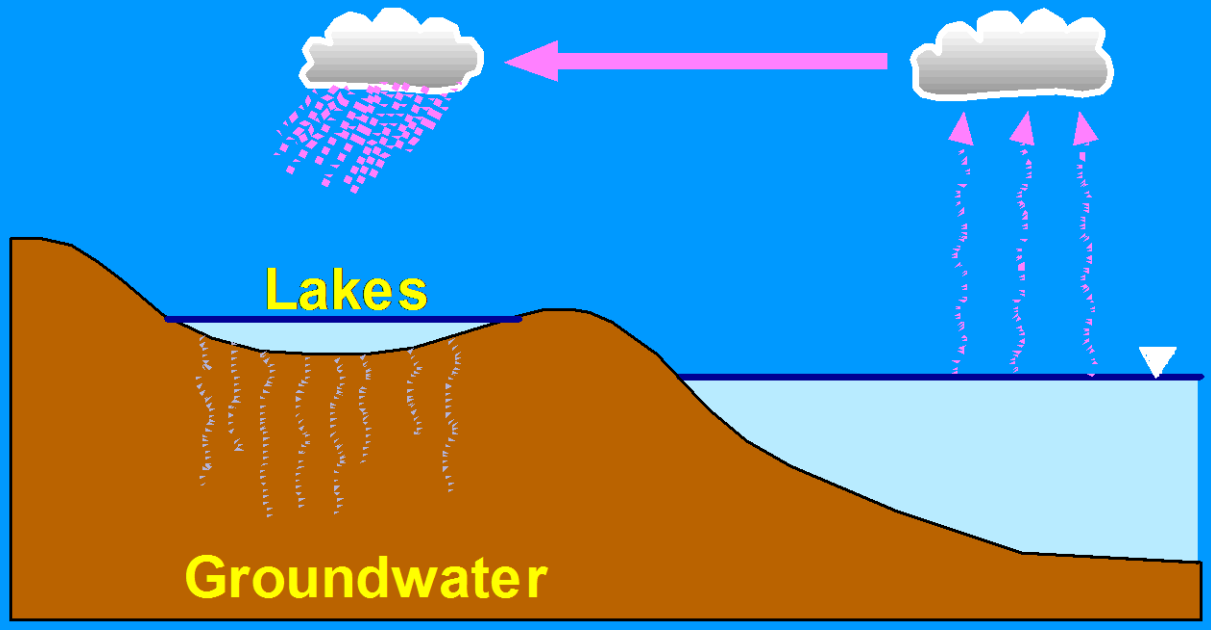
Sea water temperature



- Changes in sea water temperature cause thermal expansion/contraction

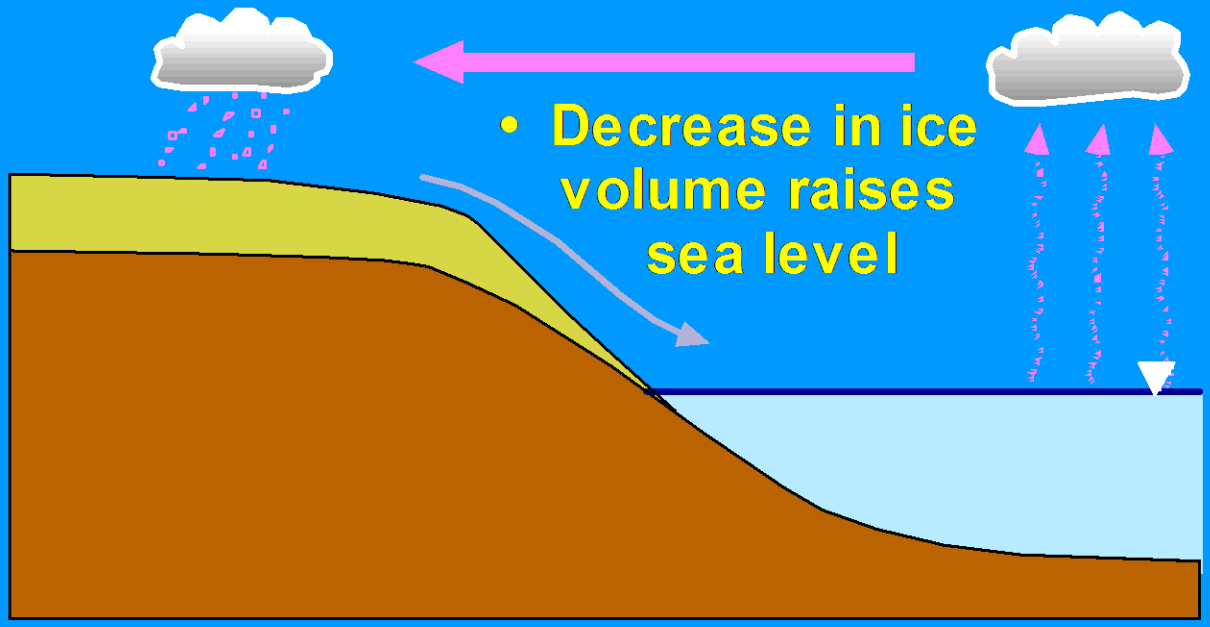
  Centimetres to a few metres change over hundreds to thousands of years

Exchange with water on continents



Centimetres to metres change over hundreds to thousands of years

Continental ice caps

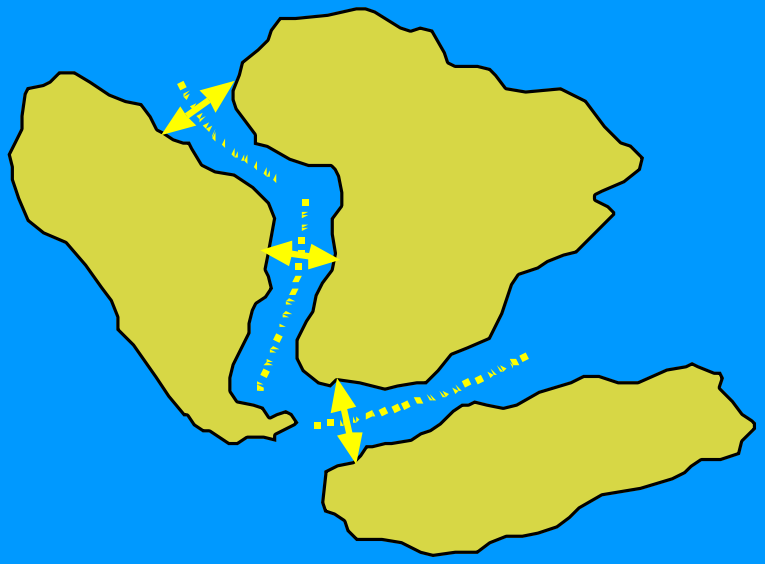


- Decrease in ice volume raises sea level

- Increase in ice volume lowers sea level

Around 100 m sea level change over 100 ka

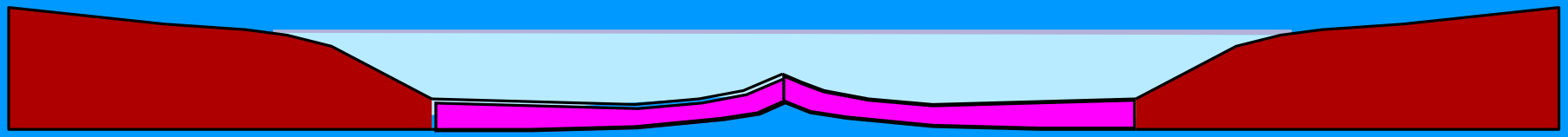
Global scale thermo-tectonic



- Formation and breakup of supercontinents
- Changes in rates of formation of ocean crust

10–100 m sea level change over 10–100 Ma

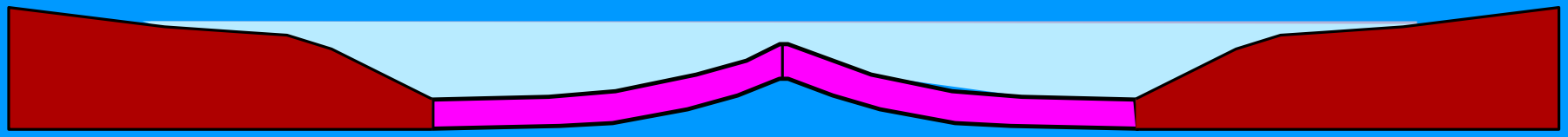
Slow mid-ocean ridge spreading



Oceanic crust cools and contracts

Fast mid-ocean ridge spreading

Sea water displaced onto continental shelves

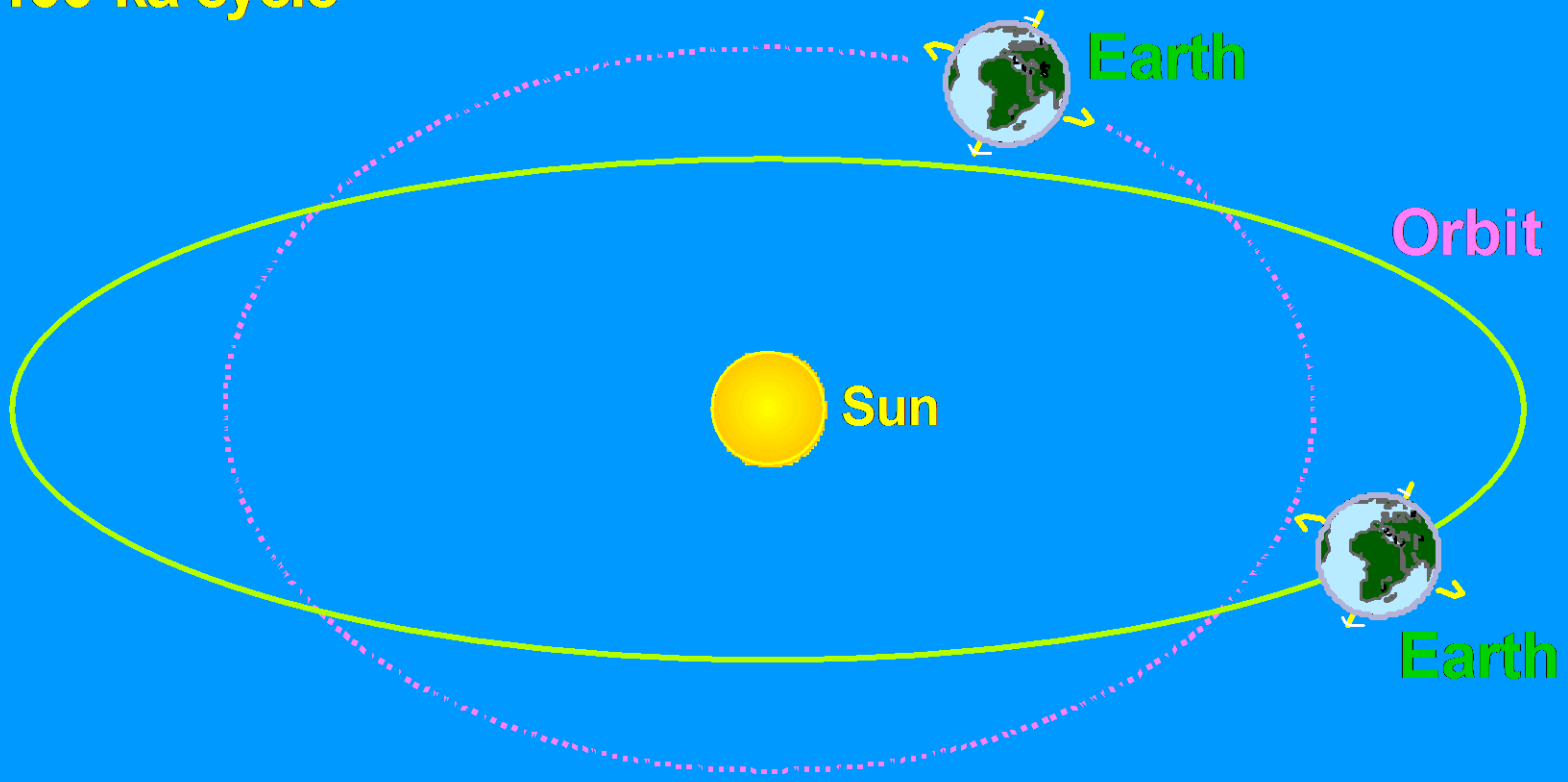


More hot, buoyant oceanic crust occupies more space in the ocean basin

Milankovitch Cycles

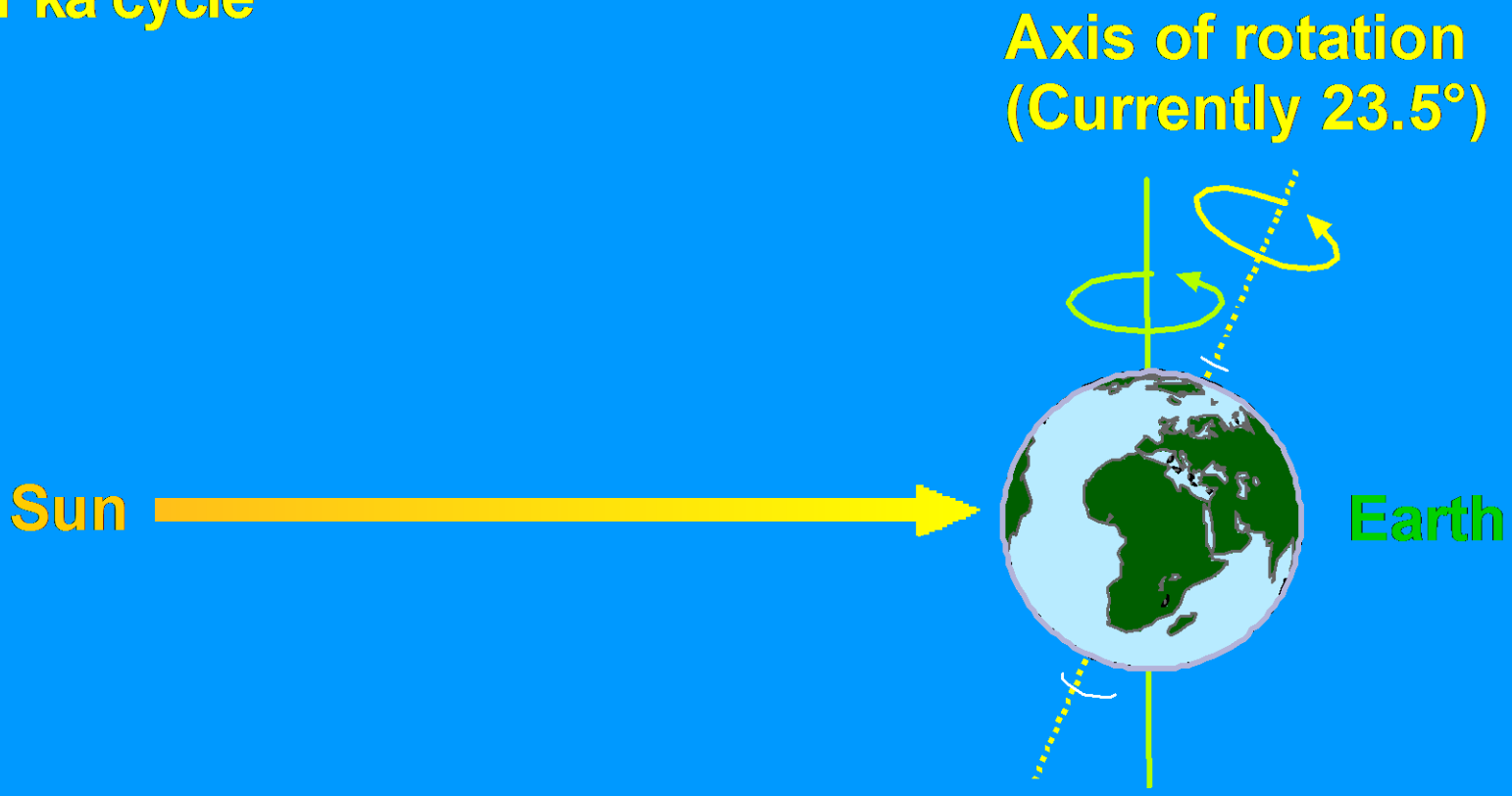
Changes in the eccentricity of the Earth's orbit around the Sun

100 ka cycle



Changes in the obliquity (tilt) of the Earth's axis of rotation

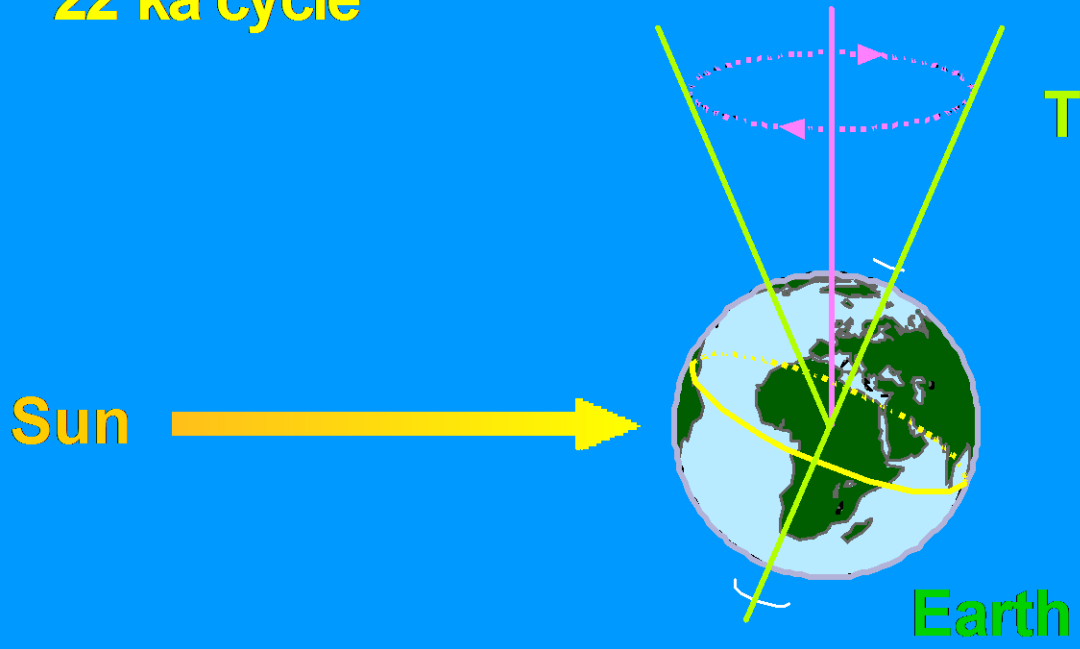
41 ka cycle



Milankovitch Cycles

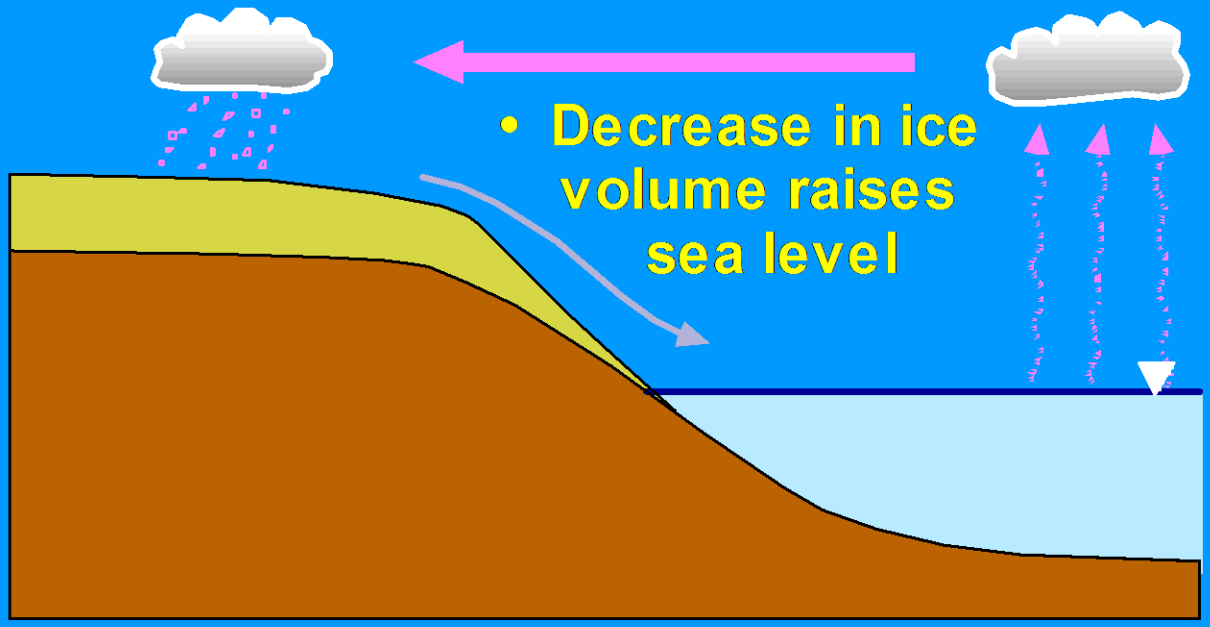
Precession of the axis of rotation

22 ka cycle



Tilt of the axis changes from being inclined towards the Sun to being inclined away from the Sun

Continental ice caps



- Decrease in ice volume raises sea level

- Increase in ice volume lowers sea level

Around 100 m sea level change over 100 ka

KŘIVKA RELATIVNÍCH ZMĚN HLADINY

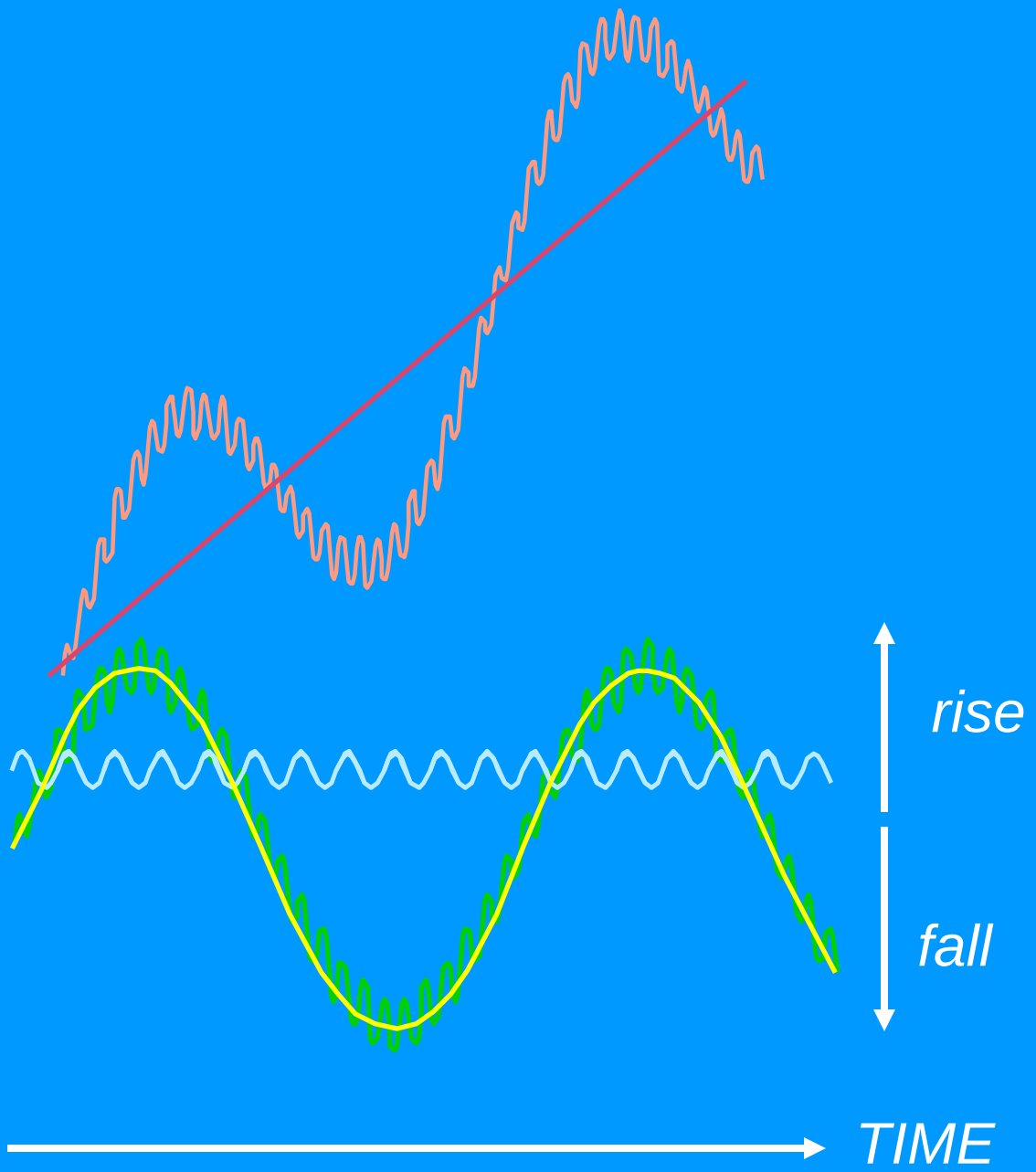
Křivka krátkodobých změn

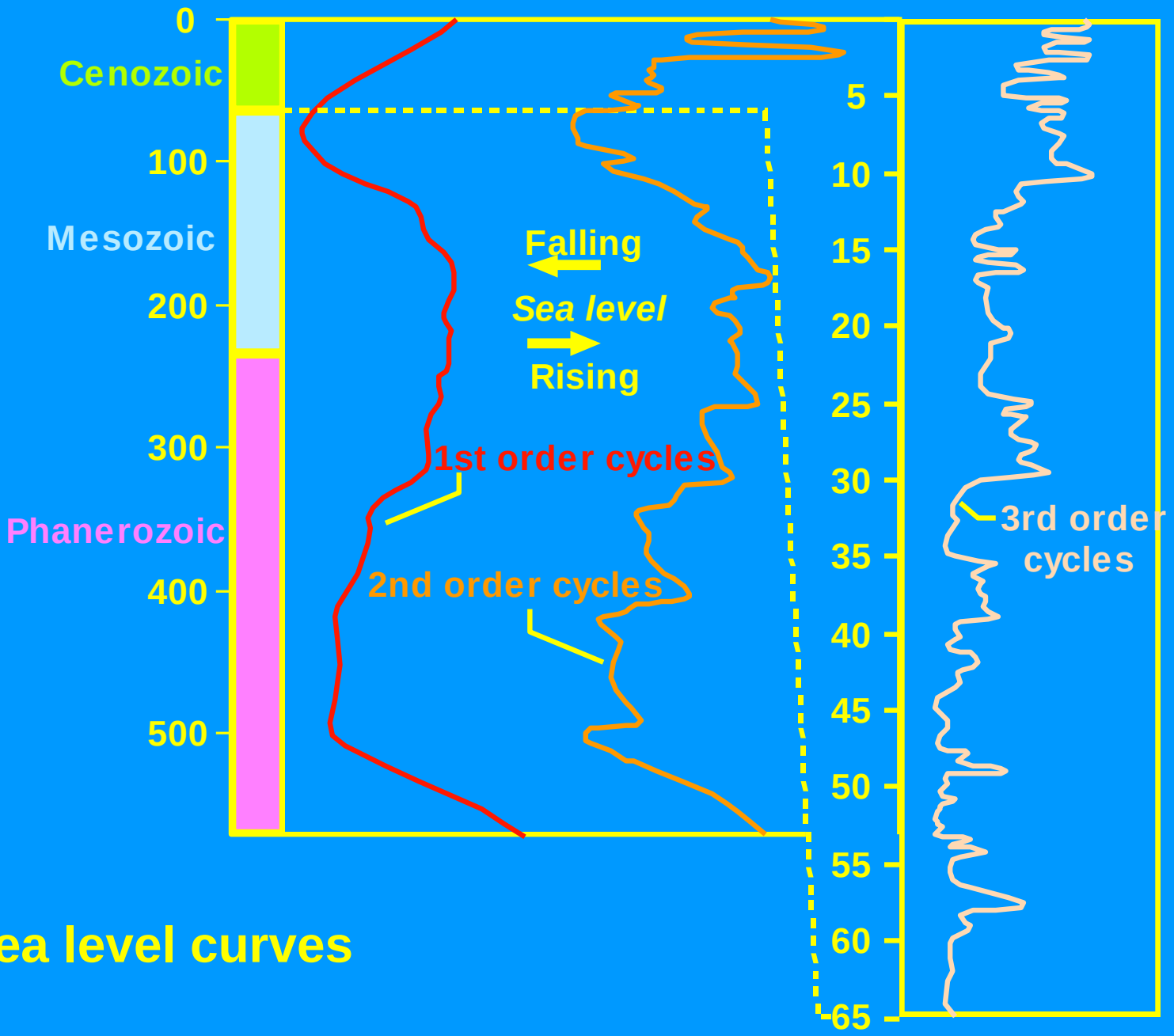
Křivka dlohodobých změn

Kombinovaná křivka

Subsidence

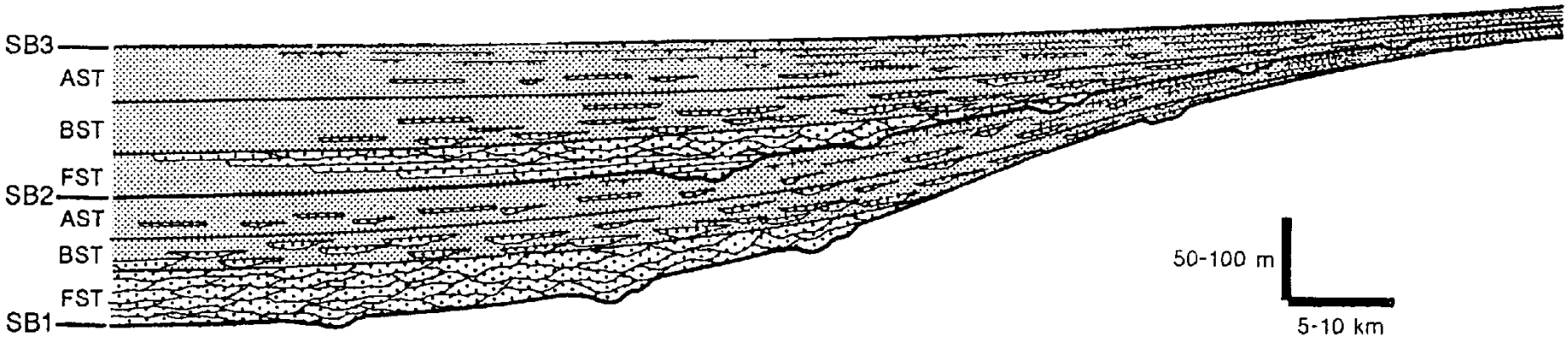
Křivka relativních změn hladiny

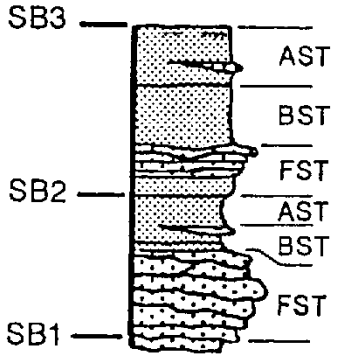


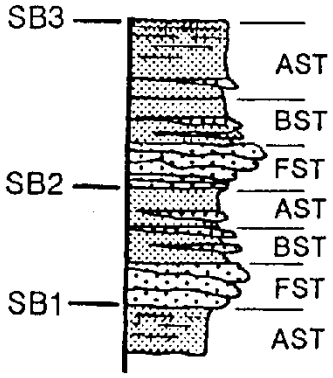


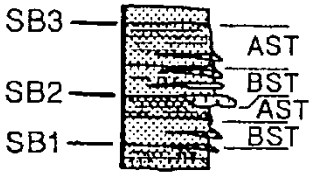
Global Sea level curves

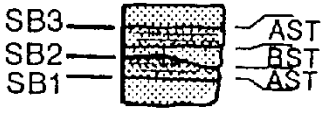
Legarreta & Uliana 1998

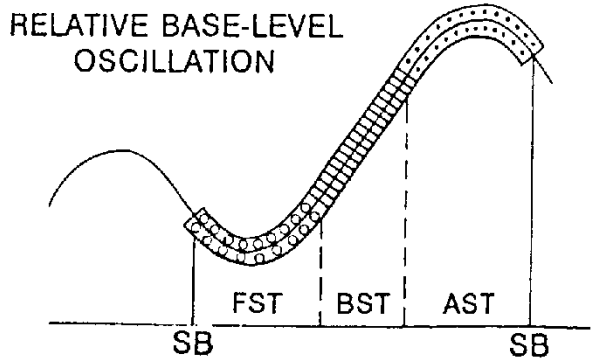




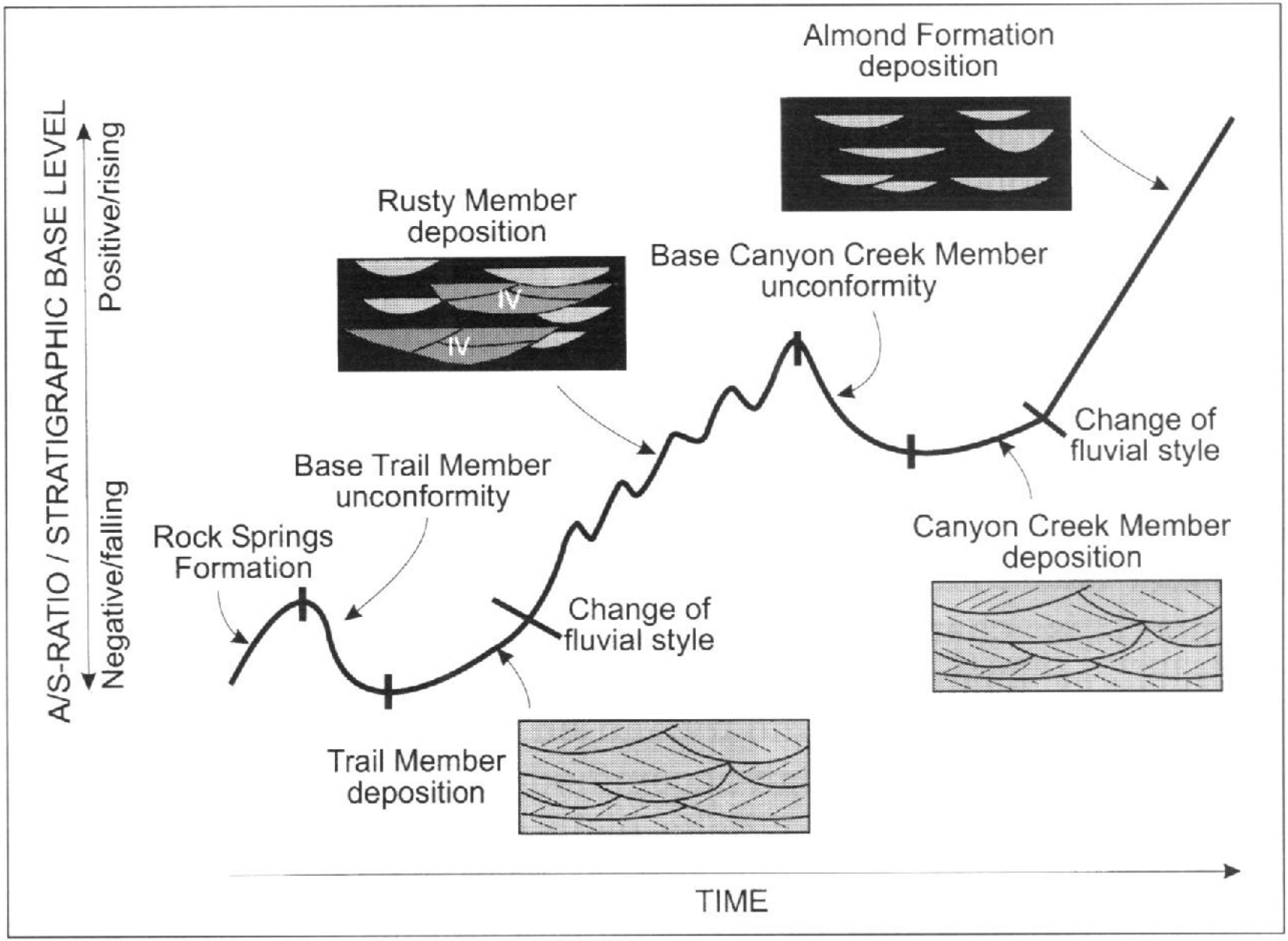






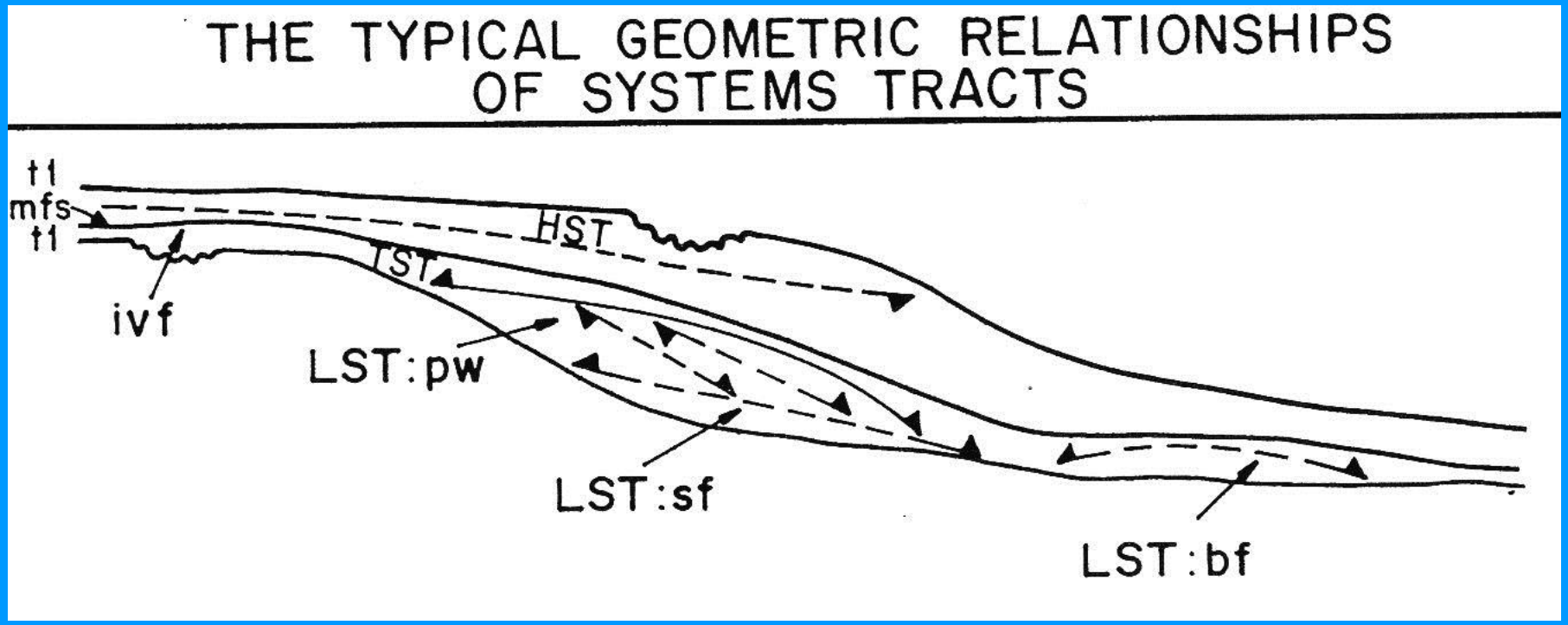


Martinsen et al. 1999



Praktika – interpretace seismického řezu

- interpretujte zlom(y), synriftové a postriftové sedimenty
- v postriftových sedimentech interpretujte sekvenční hranice a trakty



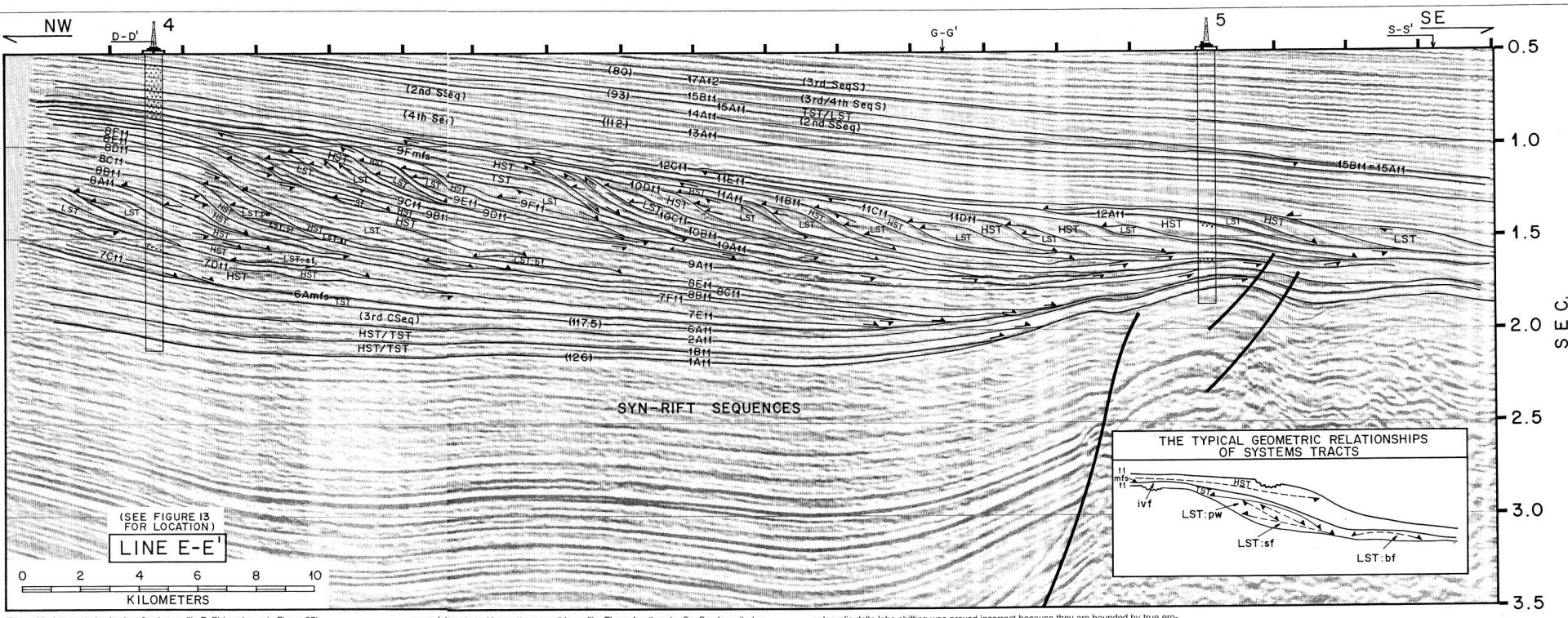


Figure 28. Interpreted seismic reflection profile E–E' (as shown in Figure 27). Aggradational fourth-order SeqSs 8 (115.5–115 Ma) and 12 (~112.75–112 Ma) and progradational fourth-order sets 9 (115-–114.3 Ma) and 11 (113.5-–112.75 Ma) are shown. Because of low subsidence rates, SeqS 10 (114.3–113.5 Ma) displays uncharacteristic progradational stacking patterns on this profile. These fourth-order SeqSs, deposited on rising and falling limbs of third-order eustatic cycles (see Figures 32, 33), are systems tracts within third-order CSeqs 7\8, 9\10, and 11\12. Fourth-order Seq boundaries are highly erosional and were correlated throughout the basin. Speculation that Seqs represent autocyclic delta lobe shifting was proved incorrect because they are bounded by true erosional unconformities (not flooding surfaces) and because each Seq is composed of well-defined systems tracts. See wireline logs of borehole 4 with Seq and depositional systems interpretations in Figure 30.

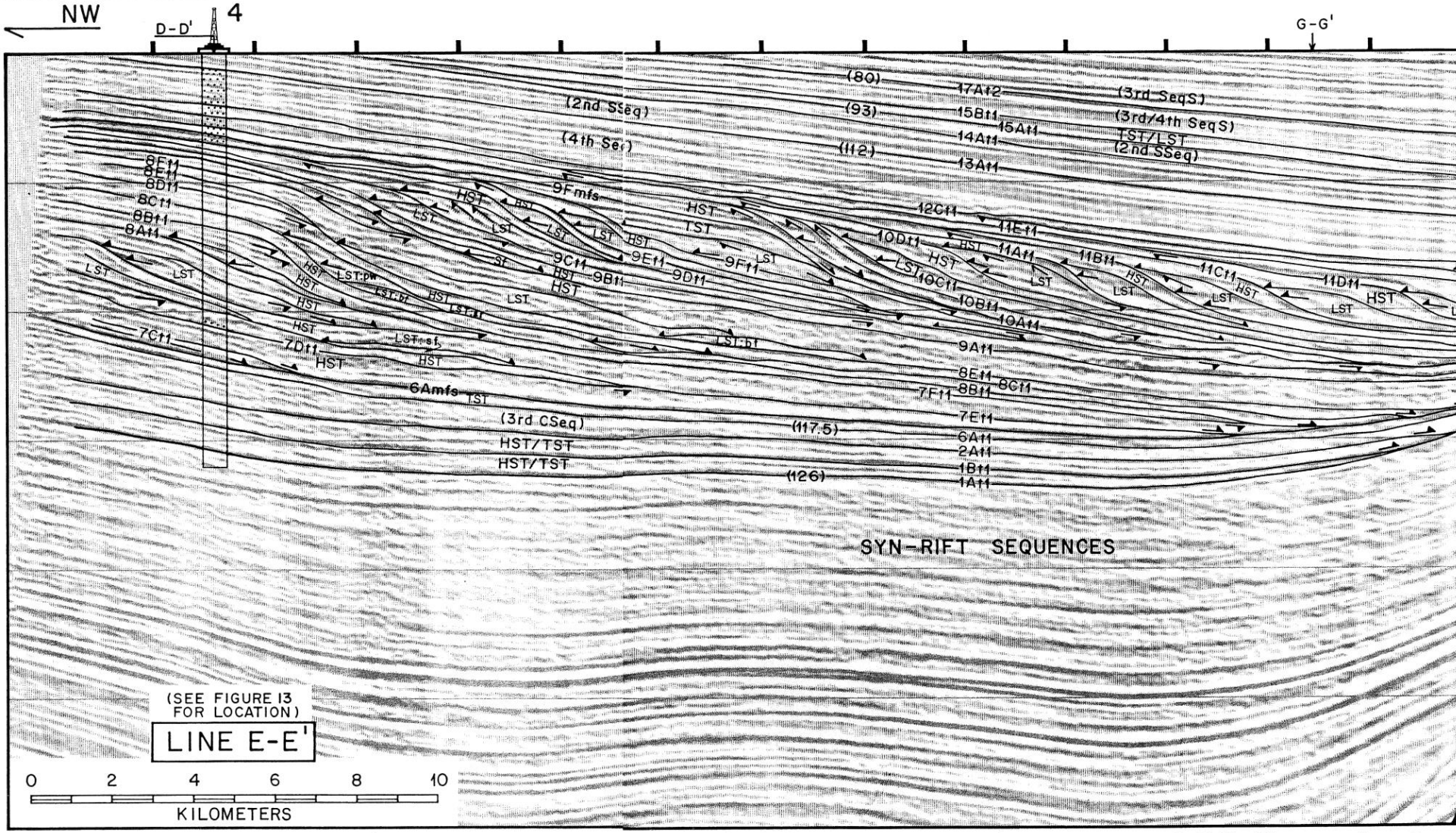
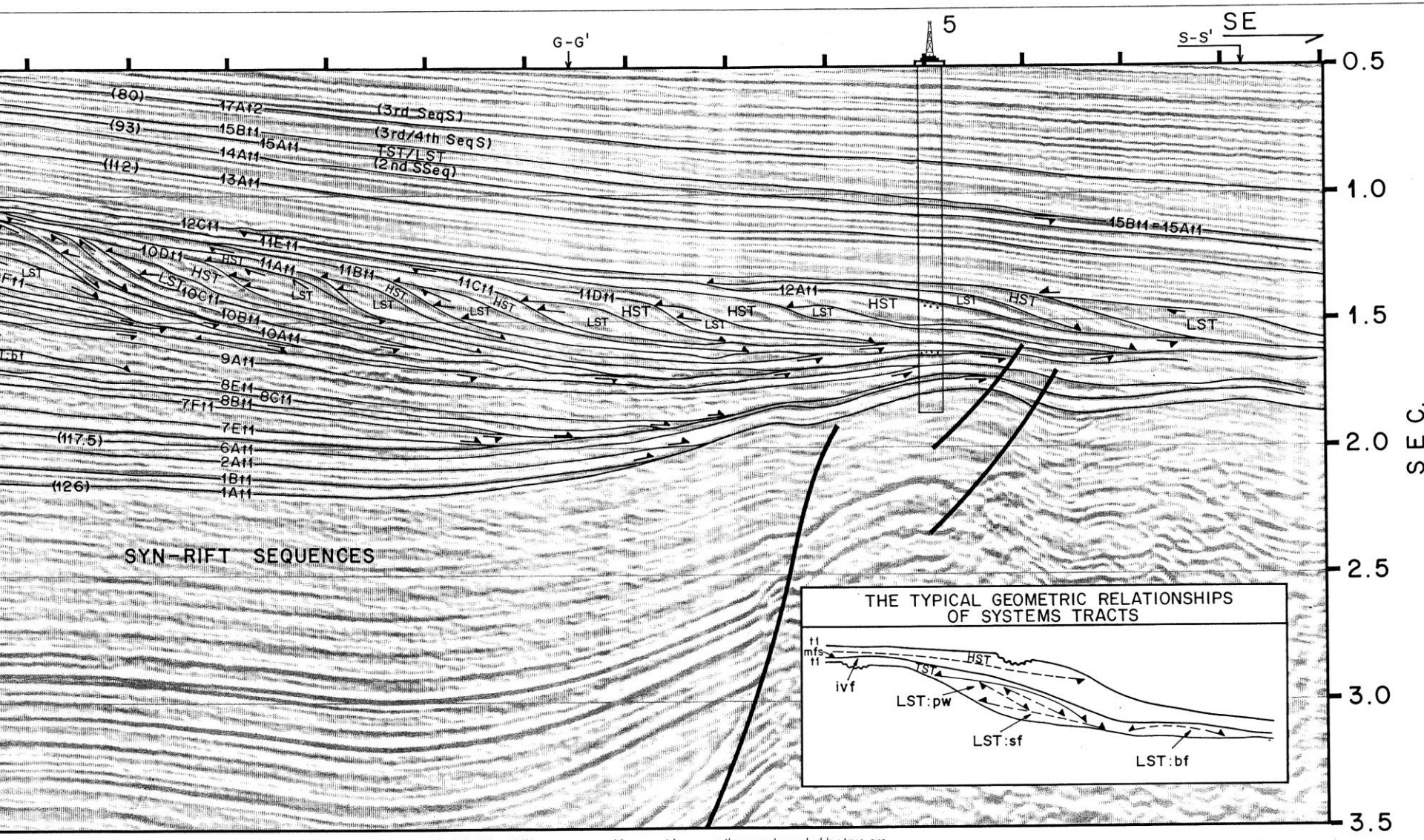


Figure 28. Interpreted seismic reflection profile E–E' (as shown in Figure 27). Aggradational fourth-order SeqSs 8 (115.5–115 Ma) and 12 (~112.75–112 Ma) and progradational fourth-order sets 9 (115–~114.3 Ma) and 11 (113.5–~112.75 Ma) are shown. Because of low subsidence rates, SeqS 10 (114.3–113.5 Ma) displays uncharacteristic progradational stacking patterns on this profile. These fourth-order SeqSs, deposited on rising and falling limbs of third-order eustatic cycles (see Figures 32, 33), are systems tracts within third-order CSeqs 7\8, 9\10, and 11\12. Fourth-order Seq boundaries are highly erosional and were correlated throughout the basin. Speculation that Seqs represent autocyclic delta lobe shifting was proved incorrect because sional unconformities (not flooding surfaces) and because defined systems tracts. See wireline logs of borehole 4 w interpretations in Figure 30.

L. F. Brown, Jr., J. M. Benson, G. J. Brink, S. Doherty, A. Jollands,
E. H. A. Jungslager, J. H. G. Keenan, A. Muntingh, and N. J. S. van Wyk

Soekor Ltd.



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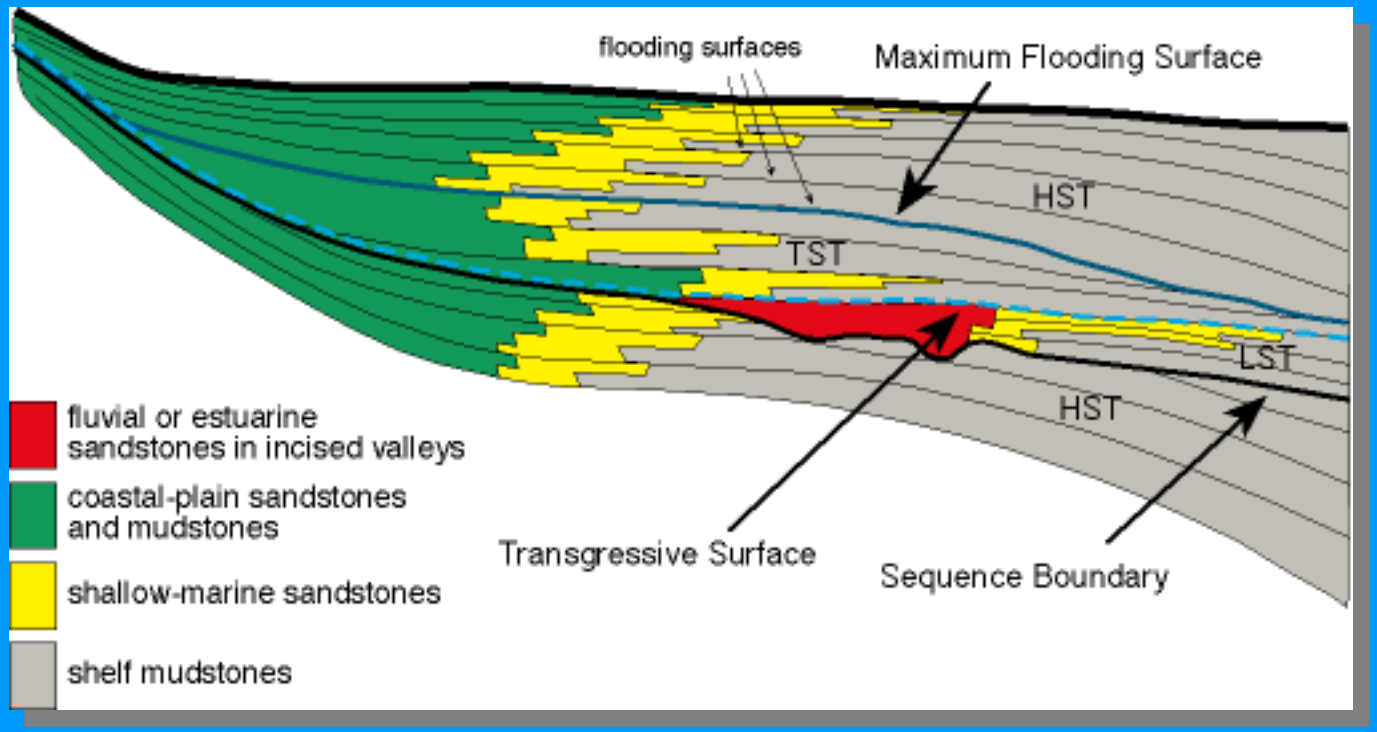
Shown below is an example of a prominent transgressive surface, combined with a sequence boundary. This surface separates underlying shallow subtidal carbonate from overlying deep subtidal carbonate and mudstone. Note the pyritization, visible as a rusty stain, at this surface. Photograph taken at the contact between the Upper Ordovician Carters Limestone (below) and Hermitage Formation at the Nashville International Airport. This outcrop has subsequently been removed and is no longer visible.

Dva způsoby vymezení sekvencí:

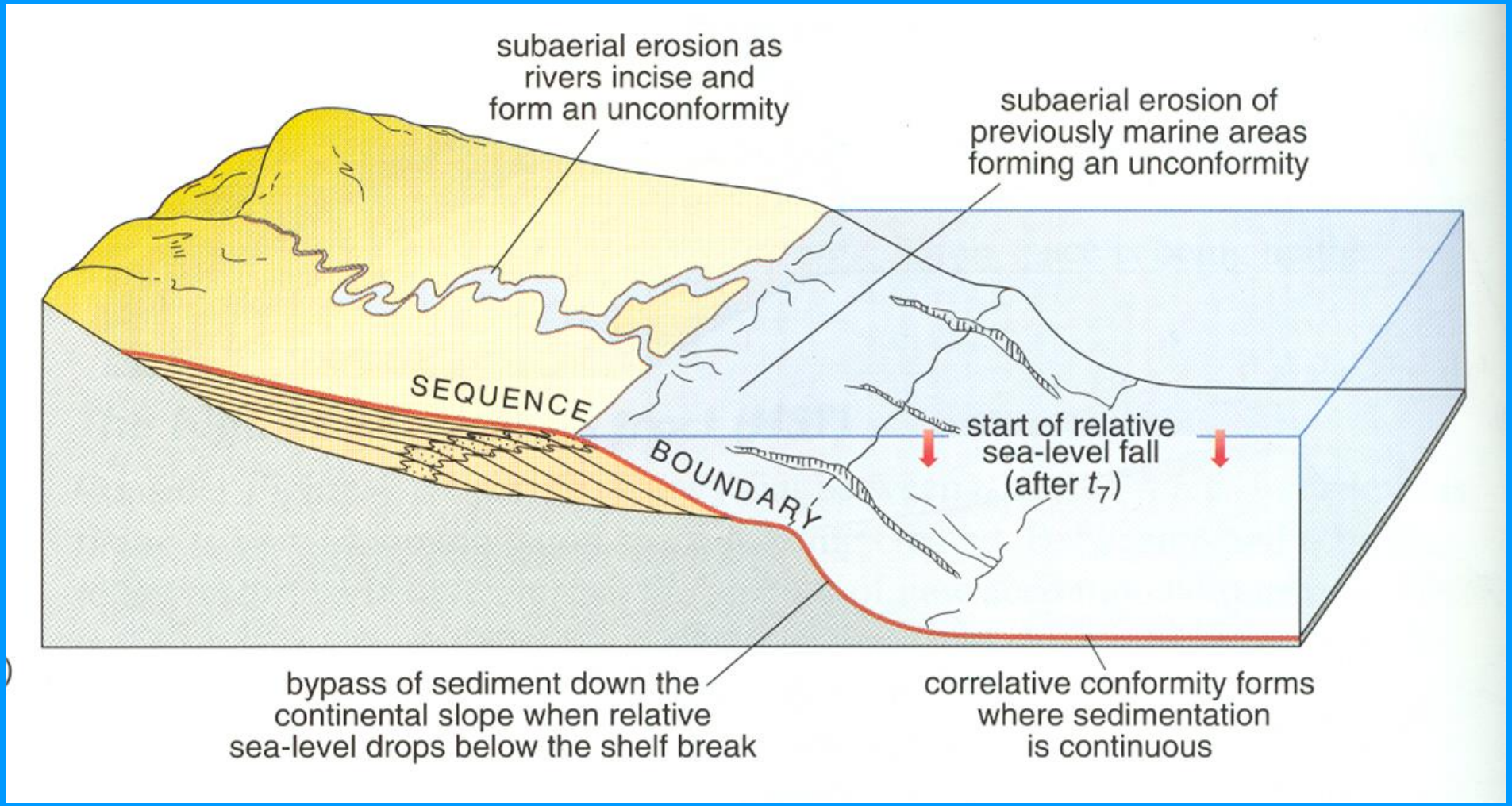
1) **Exonský (Van Wagoner et al., 1990)** – dělení podle SB
2) **Galloway (1989)** – podle ploch maximální záplavy (MFS)

Dva modely relativních změn hladiny během sedimentace :

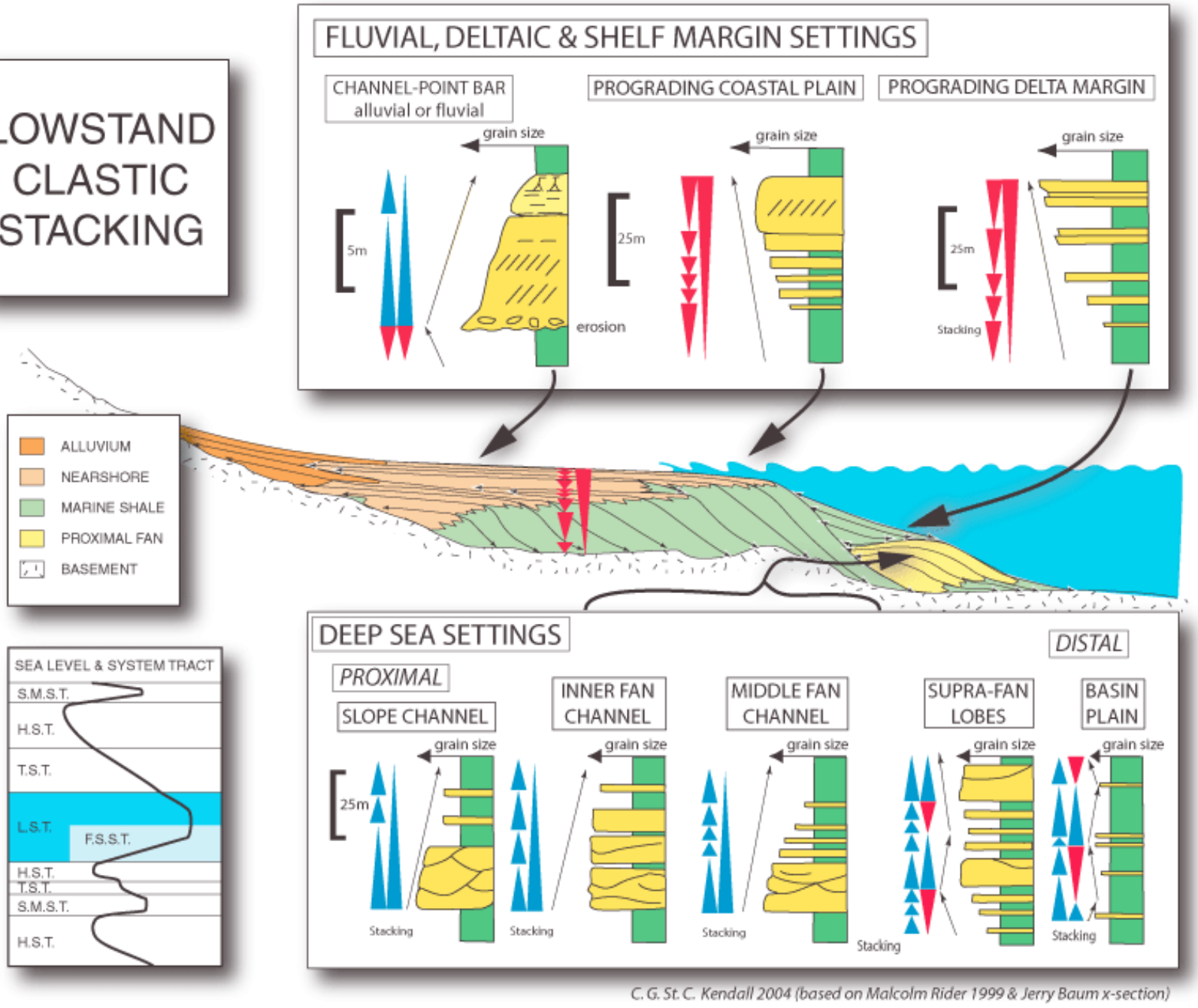
1) oscilace hladiny
2) hladina stále roste, ale kolísá rychlost růstu



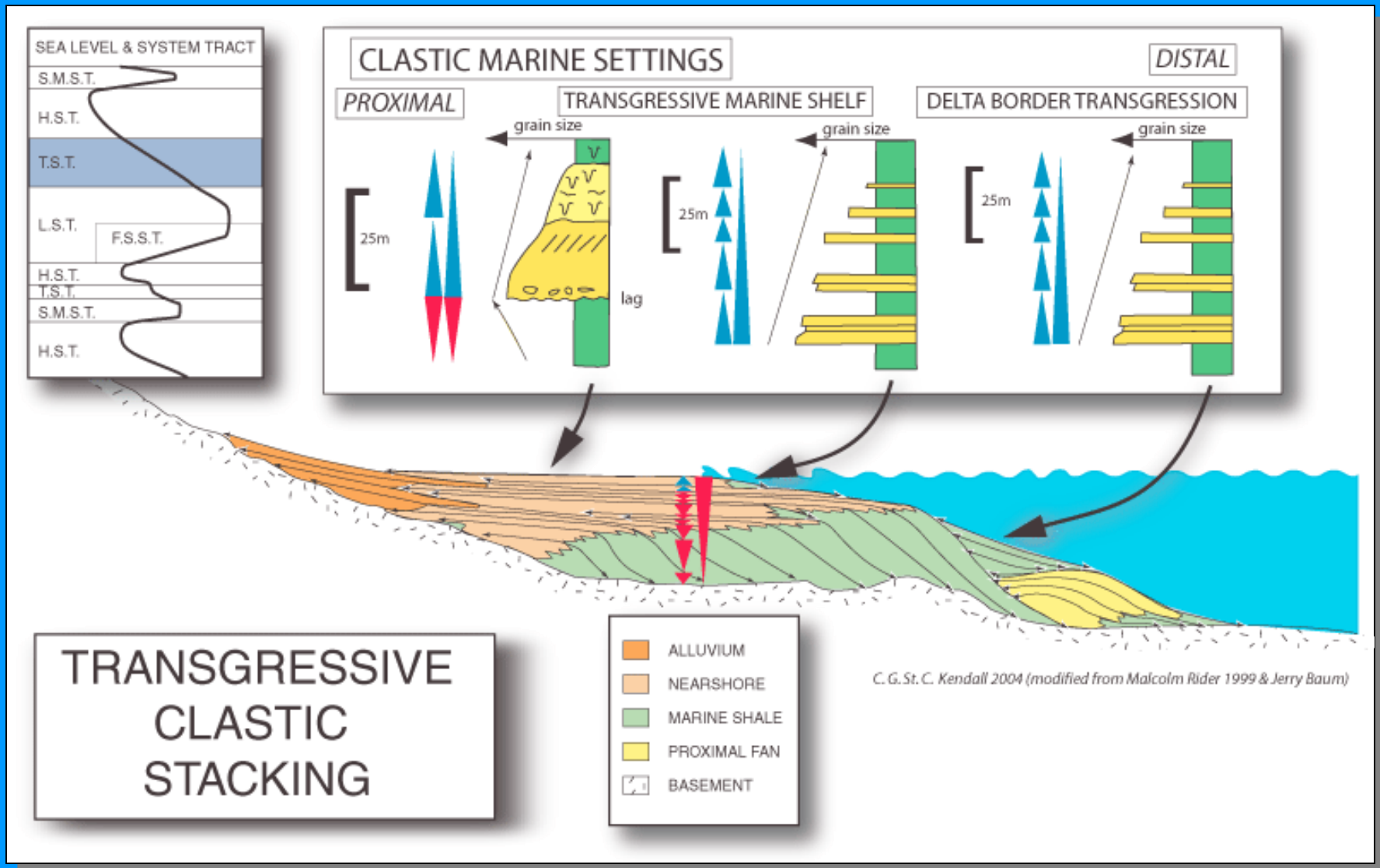
Depositional sequences



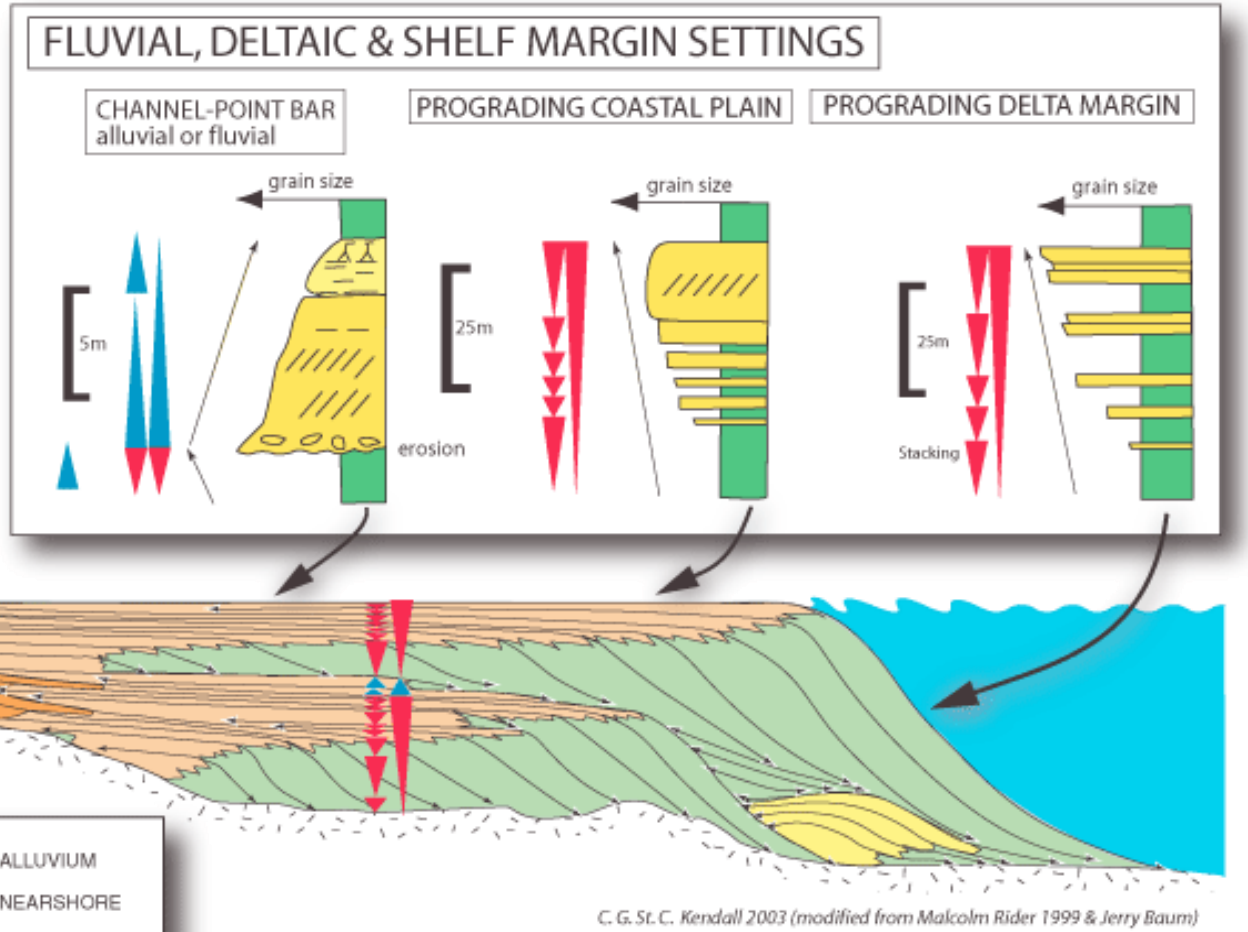
LOWSTAND CLASTIC STACKING



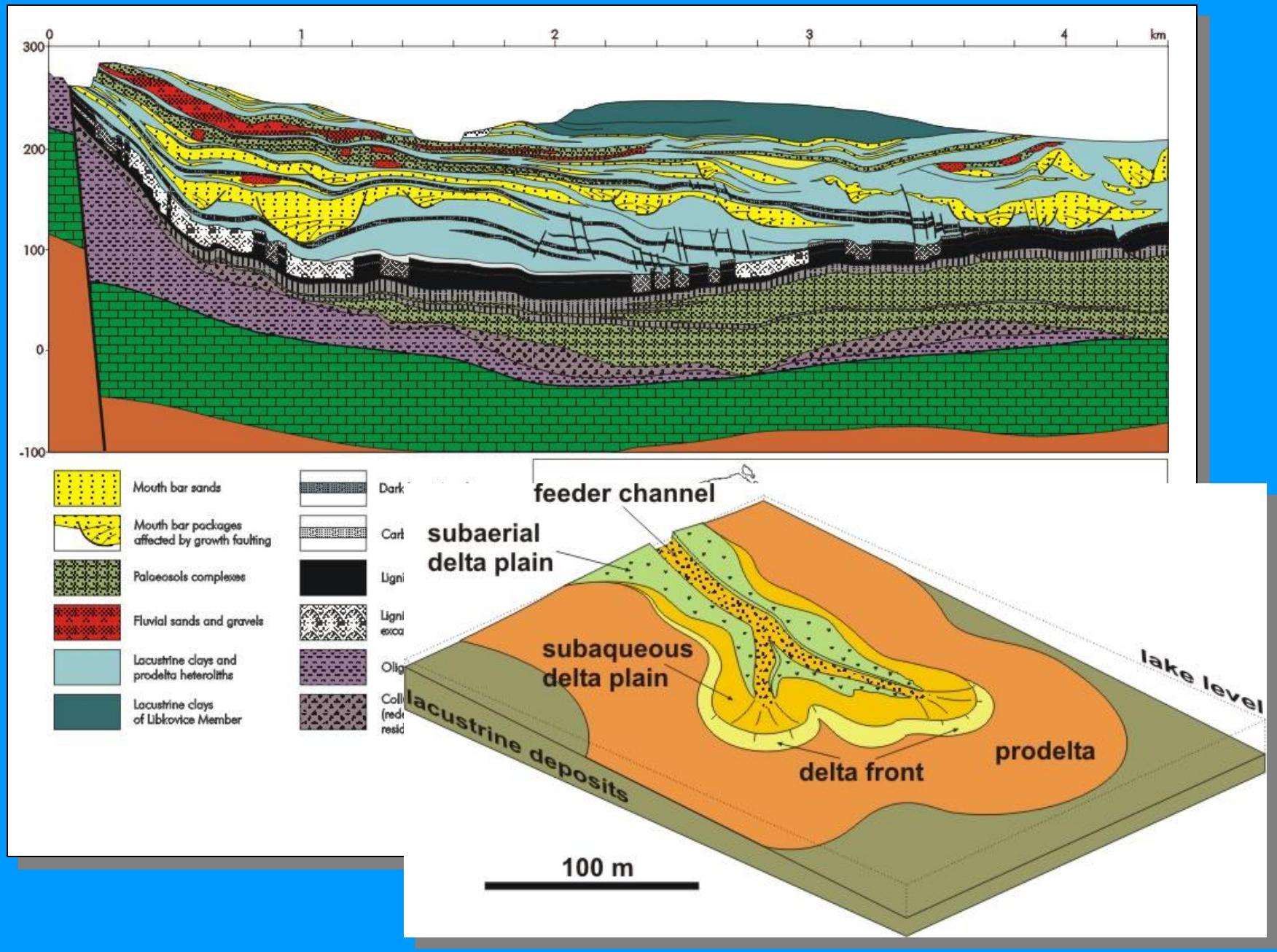
C. G. St. C. Kendall 2004 (based on Malcolm Rider 1999 & Jerry Baum x-section)

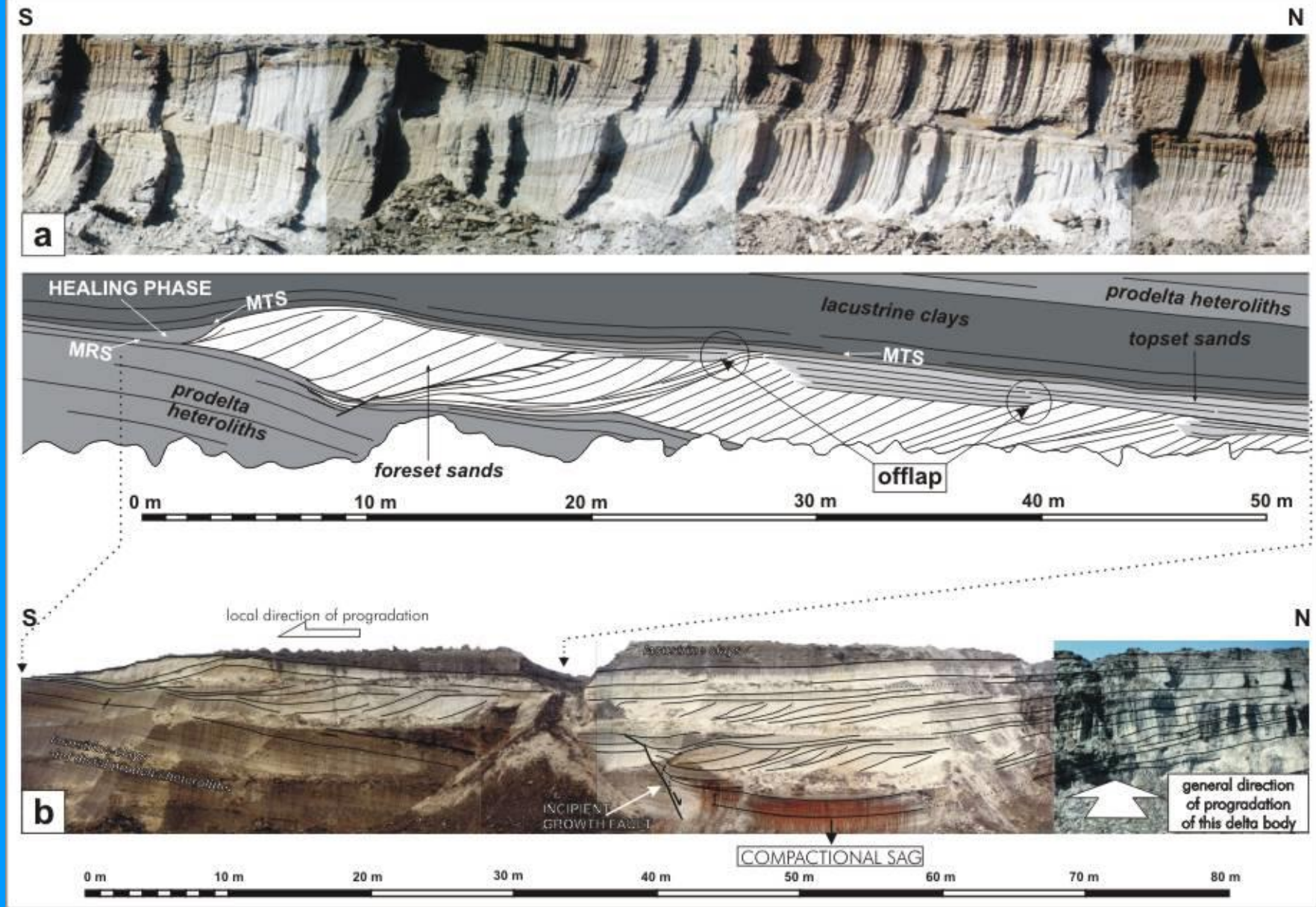

SEA LEVEL & SYSTEM TRACT
S.M.S.T.
H.S.T.
T.S.T.
L.S.T.
F.S.S.T.
H.S.T.
T.S.T.
S.M.S.T.
H.S.T.
CLASTIC MARINE SETTINGS
PROXIMAL
TRANSGRESSIVE MARINE SHELF
DELTA BORDER TRANSGRESSION
DISTAL
grain size
grain size
grain size
25m
25m
25m
lag
TRANSGRESSIVE CLASTIC STACKING
ALLUVIUM
NEARSHORE
MARINE SHALE
PROXIMAL FAN
BASEMENT
C. G. St. C. Kendall 2004 (modified from Malcolm Rider 1999 & Jerry Baum)

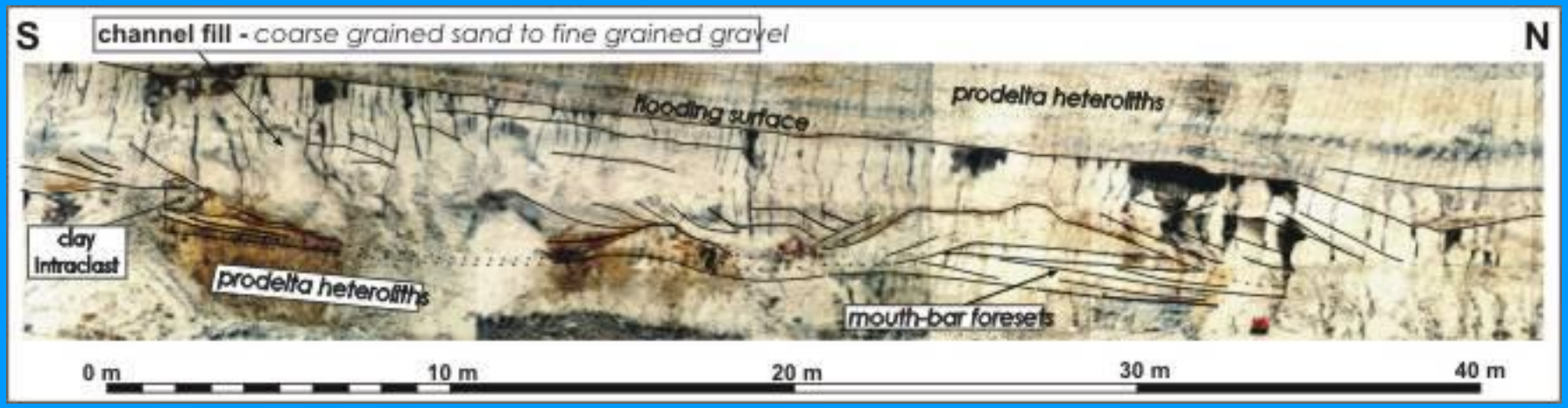
HIGHSTAND CLASTIC STACKING

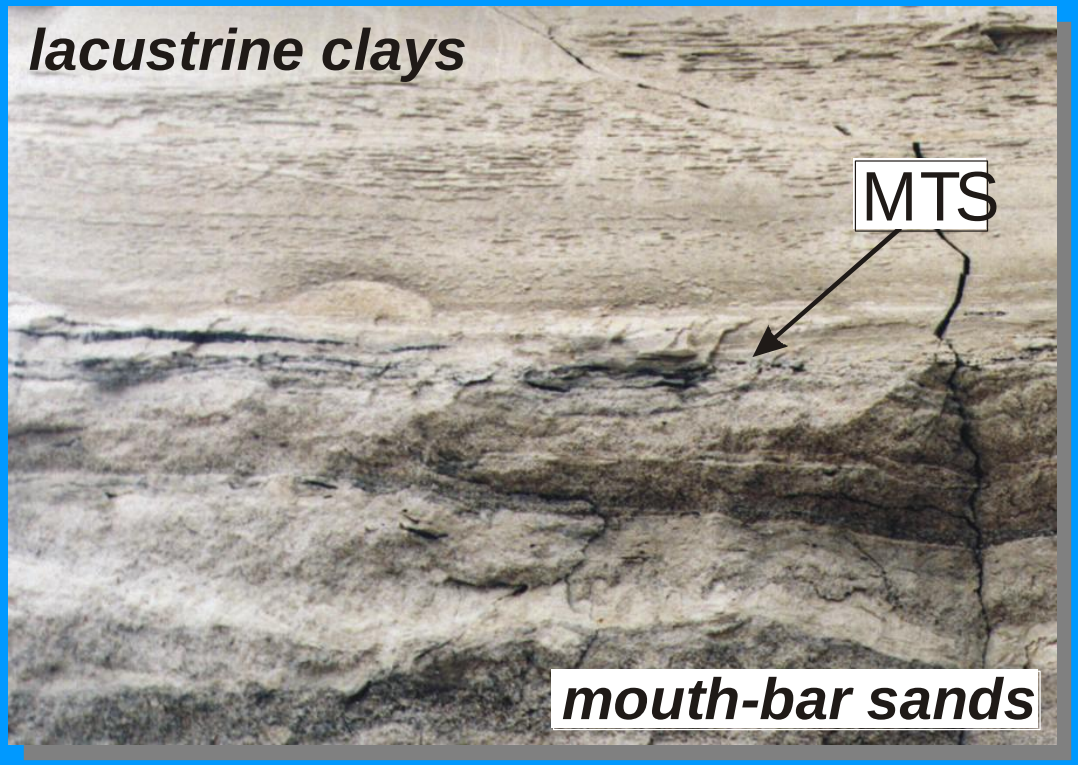


C. G. St. C. Kendall 2003 (modified from Malcolm Rider 1999 & Jerry Baum)

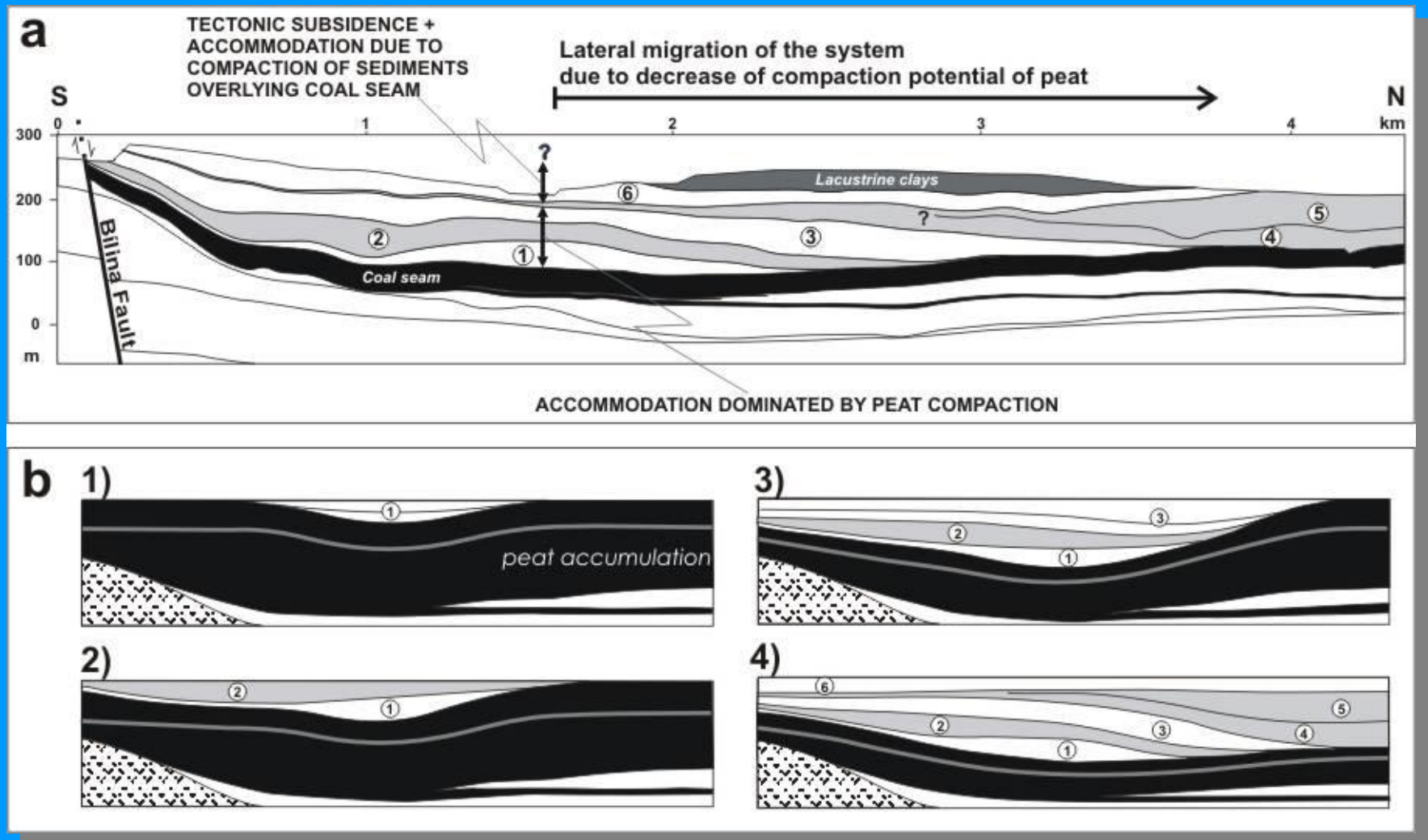

0
1
2
3
4
km
300
200
100
0
-100
Mouth bar sands
Mouth bar packages affected by growth faulting
Palaeosols complexes
Fluvial sands and gravels
Lacustrine clays and prodelta heteroliths
Lacustrine clays of Libkovice Member
feeder channel
subaerial delta plain
subaqueous delta plain
lake level
lacustrine deposits
delta front
prodelta
100 m

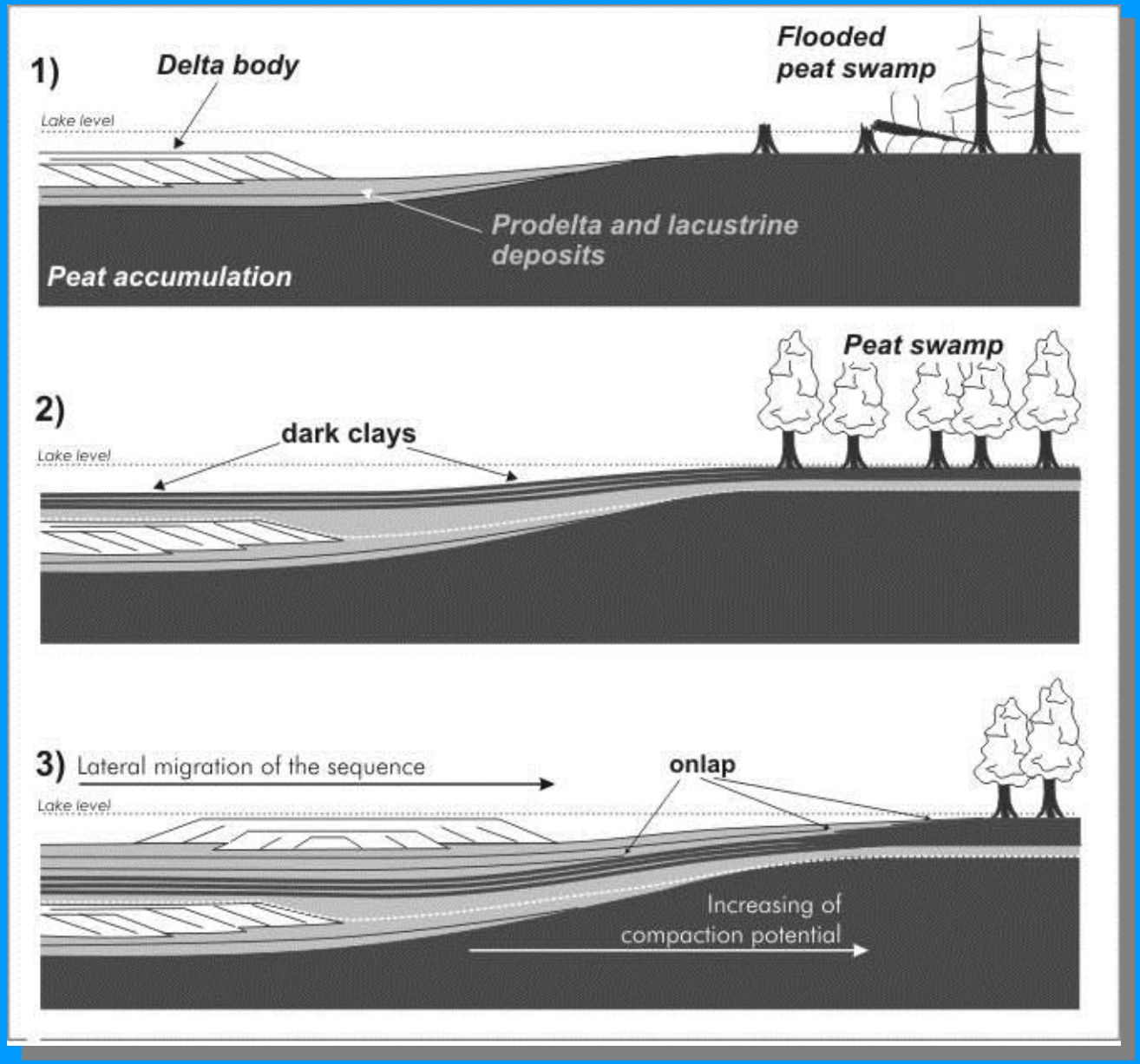

S
N
a
HEALING PHASE
MTS
MRS
prodelta heteroliths
foreset sands
lacustrine clays
MTS
prodelta heteroliths
topset sands
offlap
0 m
10 m
20 m
30 m
40 m
50 m
S
local direction of progradation
N
b
INCIPIENT GROWTH FAULT
COMPACTIONAL SAG
general direction of progradation of this delta body
0 m
10 m
20 m
30 m
40 m
50 m
60 m
70 m
80 m

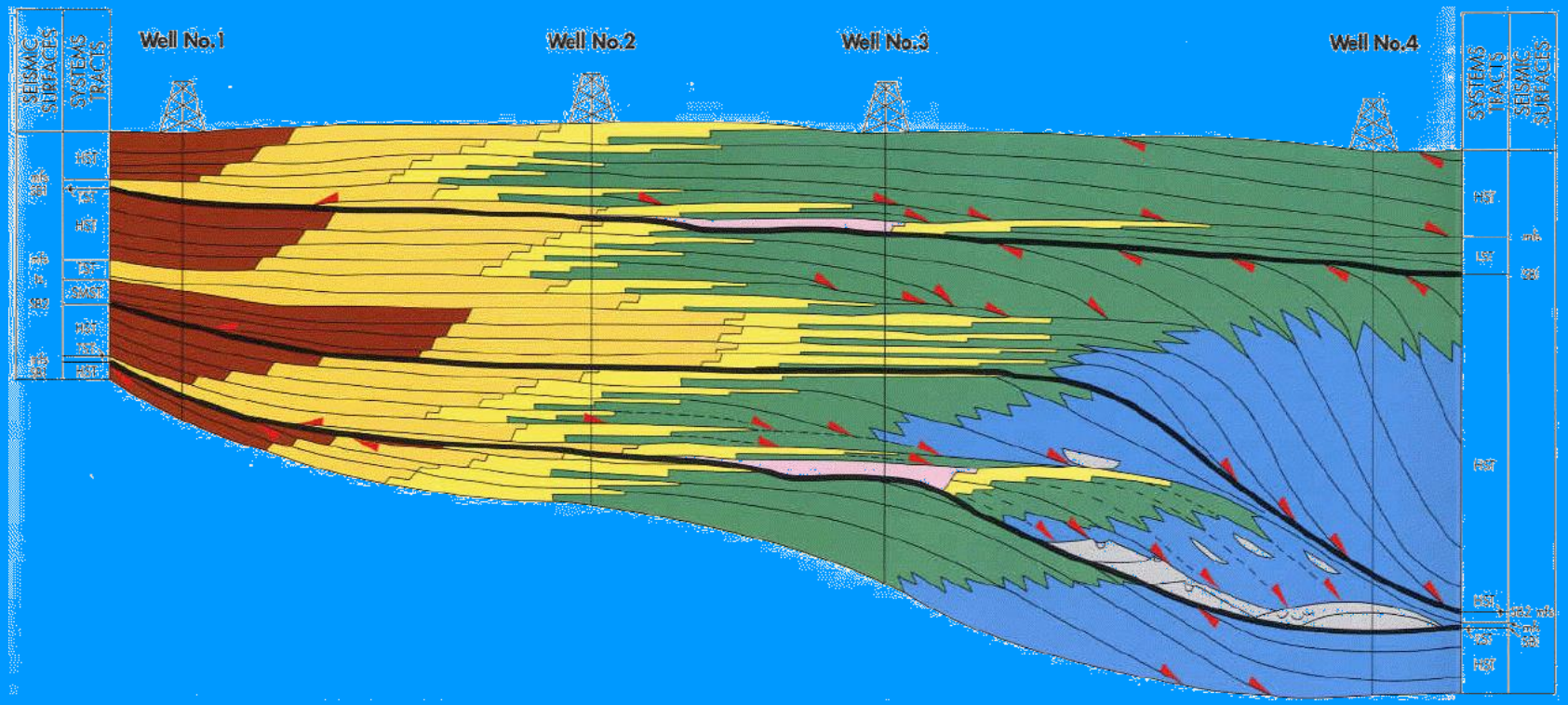

S
channel fill - coarse grained sand to fine grained gravel
N
flooding surface
prodelta heteroliths
clay intraclast
prodelta heteroliths
mouth-bar foresets
0 m
10 m
20 m
30 m
40 m

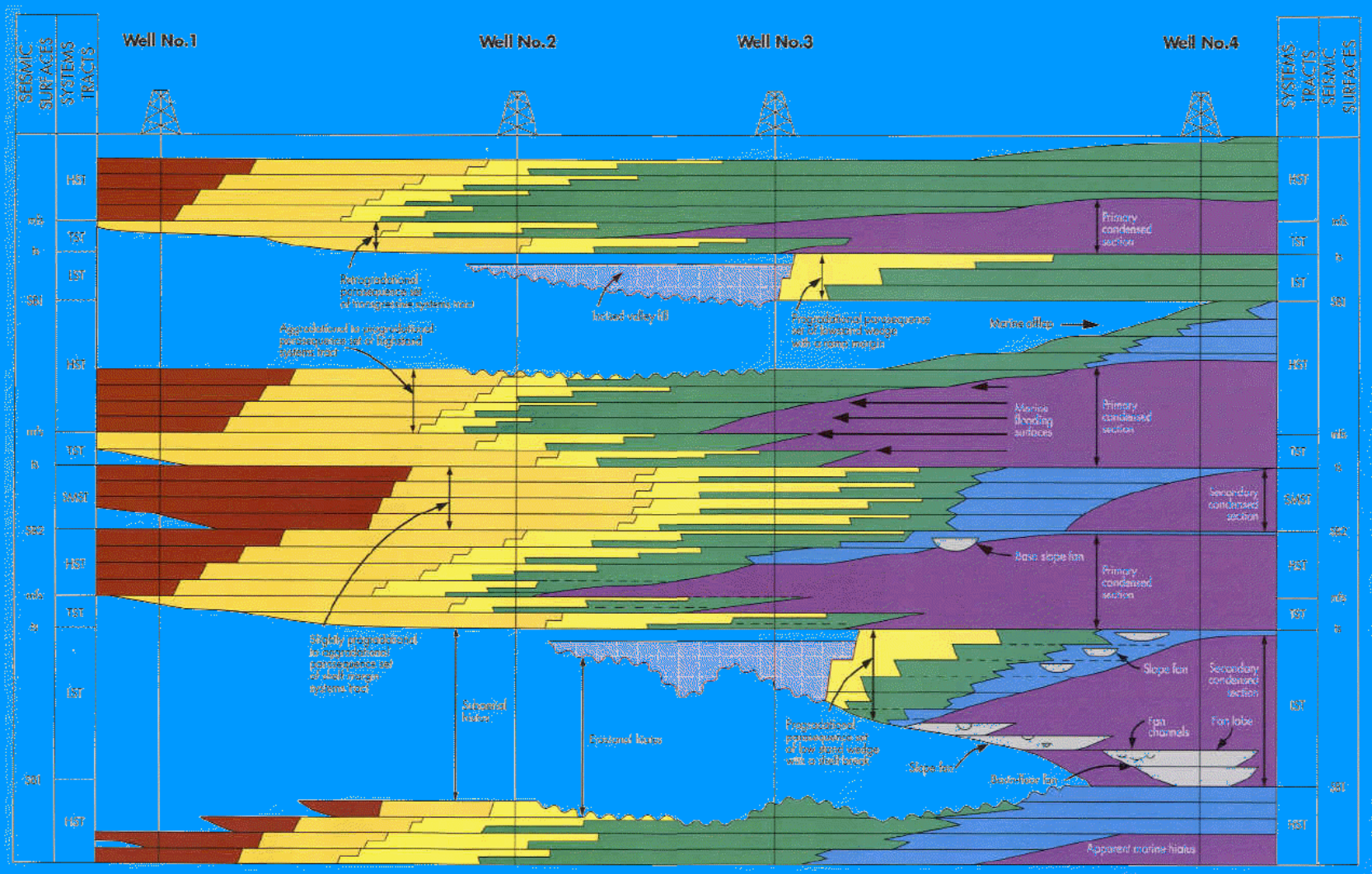

lacustrine clays
MTS
mouth-bar sands


S
N
a
lacustrine clays
Retrogradation of mouth bars
MTS
TST
MRS
SMR
RST
prodelta heteroliths
mouth-bar sands
Short-term sequence I
Short-term sequence II
0 m
5 m
10 m
15 m
20 m
25 m
vertically unexaggerated
b
MRS - originally horizontal surface
topsets
foresets
0 m
5 m


a
TECTONIC SUBSIDENCE + ACCOMMODATION DUE TO COMPACTION OF SEDIMENTS OVERLYING COAL SEAM
Lateral migration of the system due to decrease of compaction potential of peat
S
N
0
1
2
3
4
km
300
200
100
0
m
?
Lacustrine clays
Bilina Fault
Coal seam
ACCOMMODATION DOMINATED BY PEAT COMPACTION
b
1)
peat accumulation
2)
3)
4)


1)
Delta body
Flooded
peat swamp
Lake level
Prodelta and lacustrine
deposits
Peat accumulation
Peat swamp
2)
dark clays
Lake level
3) Lateral migration of the sequence
onlap
Lake level
Increasing of
compaction potential


Well No.1
Well No.2
Well No.3
Well No.4
SEISMIC SURFACES
SYSTEMS TRACTS
HST
TST
LST


Well No.1
Well No.2
Well No.3
Well No.4
SEISMIC SURFACES
SYSTEMS TRACTS
HST
TST
LST
Primary condensed section
Marine onlap
Marine flooding surfaces
Secondary condensed section
Basin slope fan
Slope fan
Fan channels
Fan lobe
Apparent marine hiatus