OGS Istituto Nazionale di Oceanografia e di Geofisica Sperimentale

Università degli studi di Trieste

LAUREA MAGISTRALE IN GEOSCIENZE

Classe Scienze e Tecnologie Geologiche

Curriculum: Esplorazione Geologica

Anno accademico 2025 - 2026

Analisi di Bacino e Stratigrafia Sequenziale (426SM)

Docente: **Michele Rebesco**

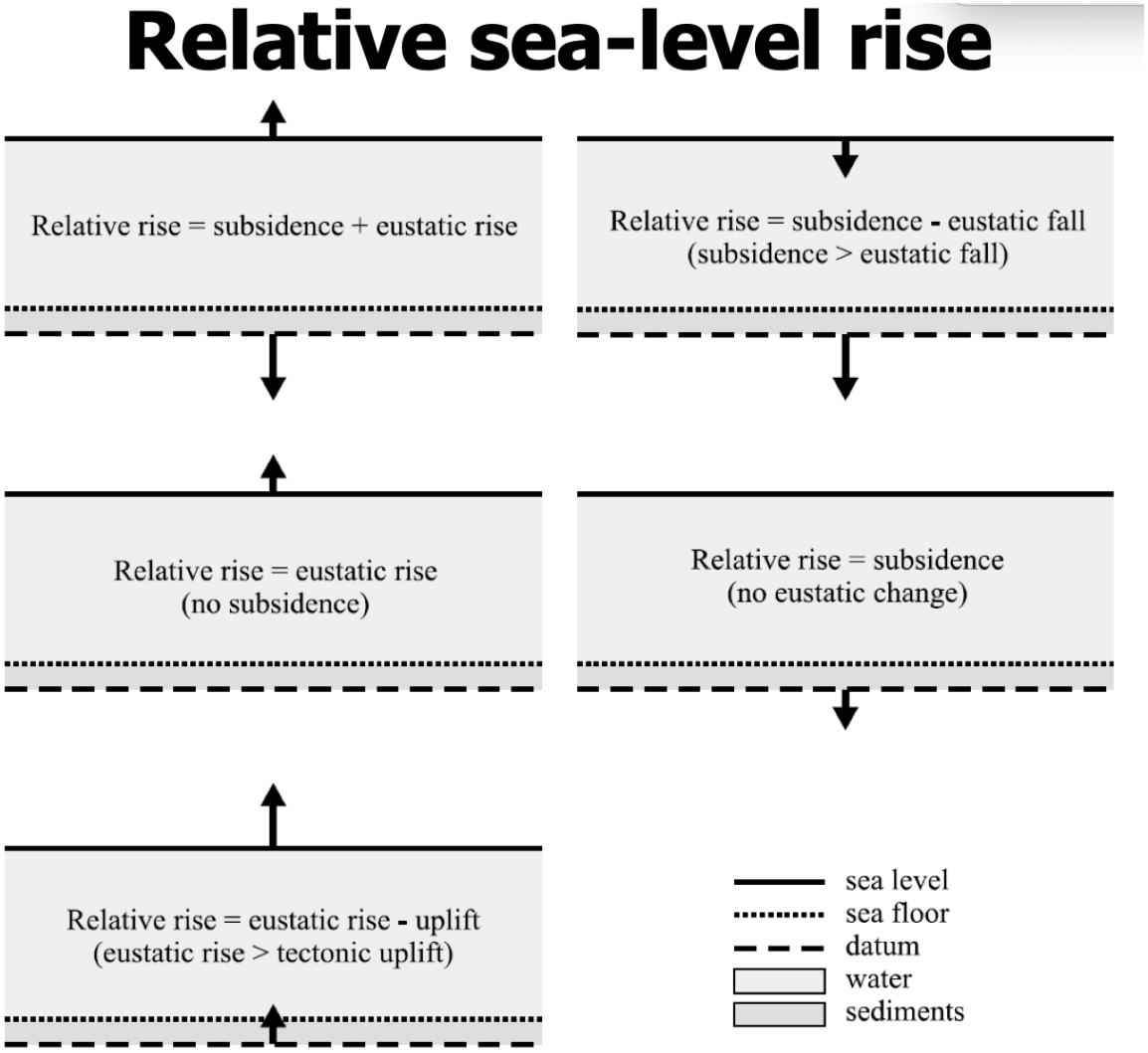
Modulo 4.2
Sequence stratigraphy – closer view

Outline:

- Your questions?
- Additional question and **First exercise**
- Stratigraphic surfaces within System Tracts (*threefold*):
  - Stratigraphic surfaces subdivided by System Tract;
  - Continuous succession of surfaces/system tracts;
  - All-in-one Stratigraphic surfaces & System Tracts
- Hiatus and Wheeler diagram
- Wheeler diagram of stratigraphic sequences
- **Second and third exercise**

-Gabiele Della Longa:

1) La trasgressione/regressione sono solamente legate a variazioni eustatiche o possiamo anche attribuirle a tettonica?



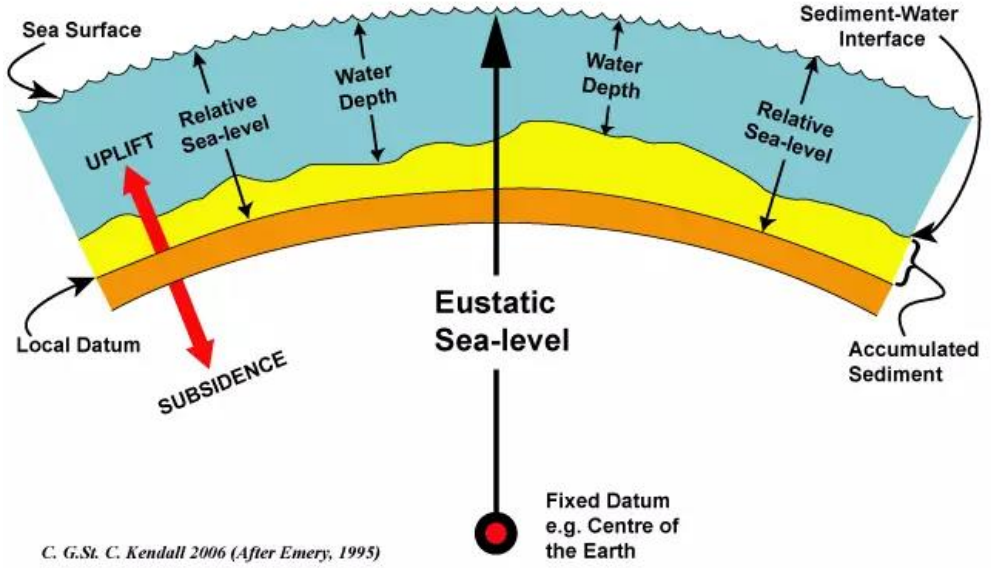
-Gabiele Della Longa:
2) Approfondimento sulla formazione di Hiatus, dove si trovano, motivi per i quali avvengono.

Depositional hiatuses are widespread across diverse geological environments and result from a combination of physical, chemical, climatic, and biological processes, with their identification and classification relying on stratigraphic, sedimentological, and geophysical evidence. They can be subdivided in various categories, including:
Omission surfaces (sediment starvation near maximum flooding surfaces)
Erosional surfaces (current/density flow scouring)
Seafloor exposure surfaces (sea-level fall/tectonic uplift)
Dissolution surfaces (chemical corrosion)
Ravinement surfaces (wave/tidal erosion during transgression)
Hardground surfaces (seafloor carbonate cementation)

-Lorenzo Galliussi:
1) Il DATUM di riferimento è sempre minore o uguale al fondo mare?
2) Ripetere la nomenclatura fondamentale da ricordare in vista dell'esame.

Relative sea level is defined as the distance or depth between the sea surface and a local datum, which can be a basement or a surface within a submarine sediment accumulation. The datum serves as a subsurface reference horizon, and can be any mappable horizon in the subsurface, such as the basement top or a stratigraphic marker within the basin fill.

The datum is essential for defining both accommodation (changes in the elevation of the sea level relative to the datum) and sedimentation (changes in the elevation of the seafloor relative to the datum)



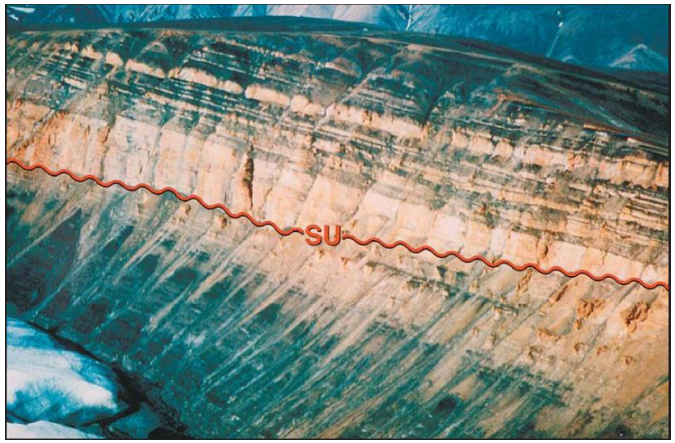
- Federico Pessina:

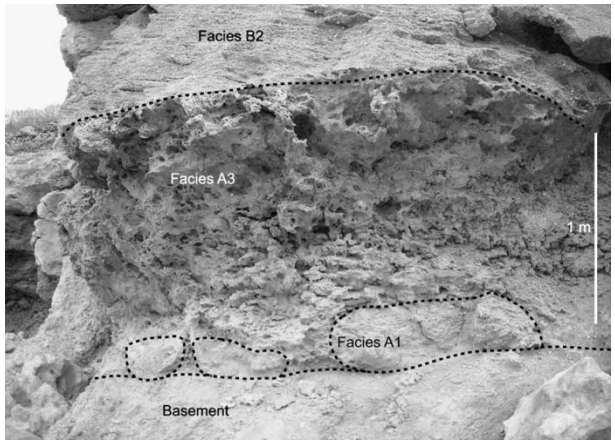
1) Ci si puo' basare solo ed esclusivamente sulla su dati sismici per ricostruire l'evoluzione di un system track?

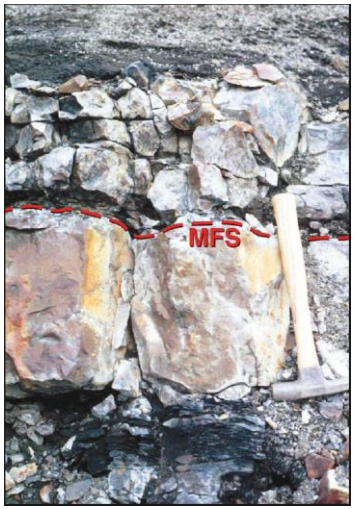
System tracts reconstructions ideally requires the integration of geophysical, sedimentologic, petrographic, biostratigraphic, and geochemical data from multiple datasets:

- Seismic Data to identify sequence boundaries and reflection geometrie.
- Well Data: Core and logs to delineate lithofacies, successions, surface.
- Outcrops: bed-by-bed logging of thickness and lithology.

Sequences and their system tracts are expressed in the field by the recurrence of sequence stratigraphic surfaces, which can be correlated along with associated facies across outcrops and boreholes over large distance.

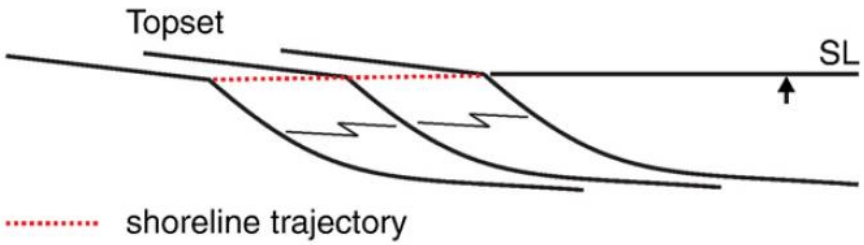






- Federico Pessina:
2) Come si distingue una normal da una forced regression?

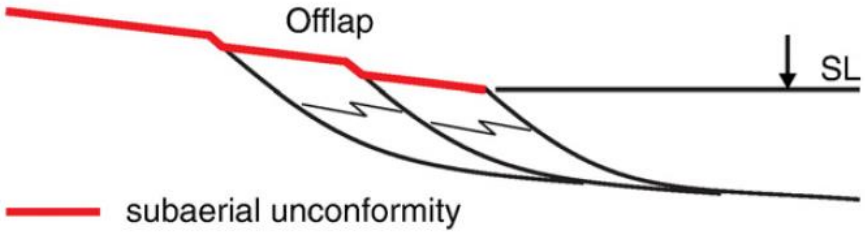
Normal regression



Definition: progradation driven by sediment supply. Sedimentation rates outpace the rates of base-level rise at the coastline.

Depositional trend: progradation with aggradation.

Forced regression



Definition: progradation driven by base-level fall. The coastline is forced to regress, irrespective of sediment supply.

Depositional trend: progradation with downstepping.

Stratigraphic surfaces subdivided by System Tract

---------- basal surface of forced regression **BSFR**

is the paleo-seafloor at the onset of forced regression and lies at the base of all marine deposits accumulated during relative sea-level fall.

——— regressive surface of marine erosion **RSME**

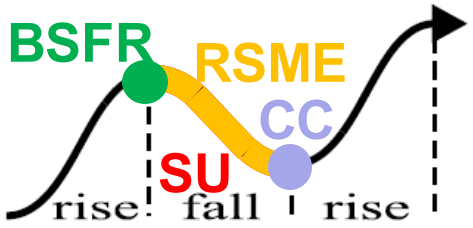
is cut by waves in the shoreface during relative sea-level fall, and marks the base of forced regressive shorefaces.

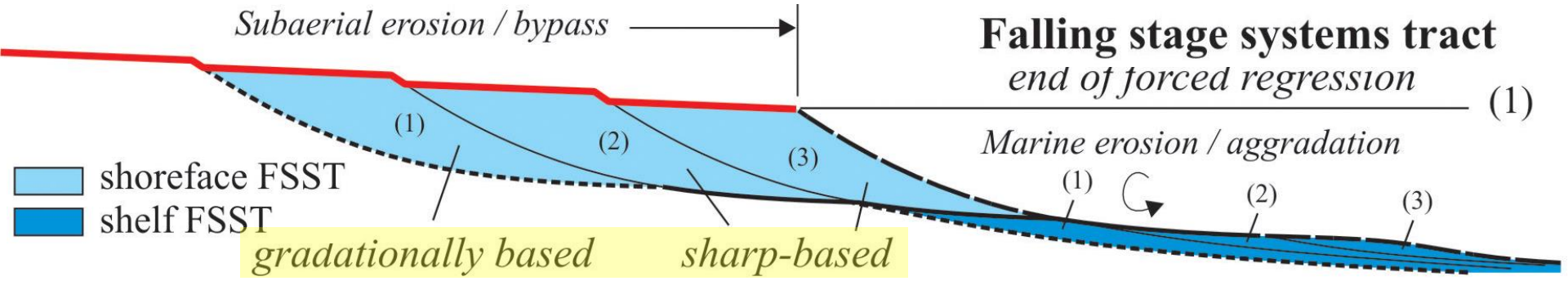
——— correlative conformity **CC**

corresponds to the seafloor at the end of relative sea-level fall and is connected to SU basinward termination.

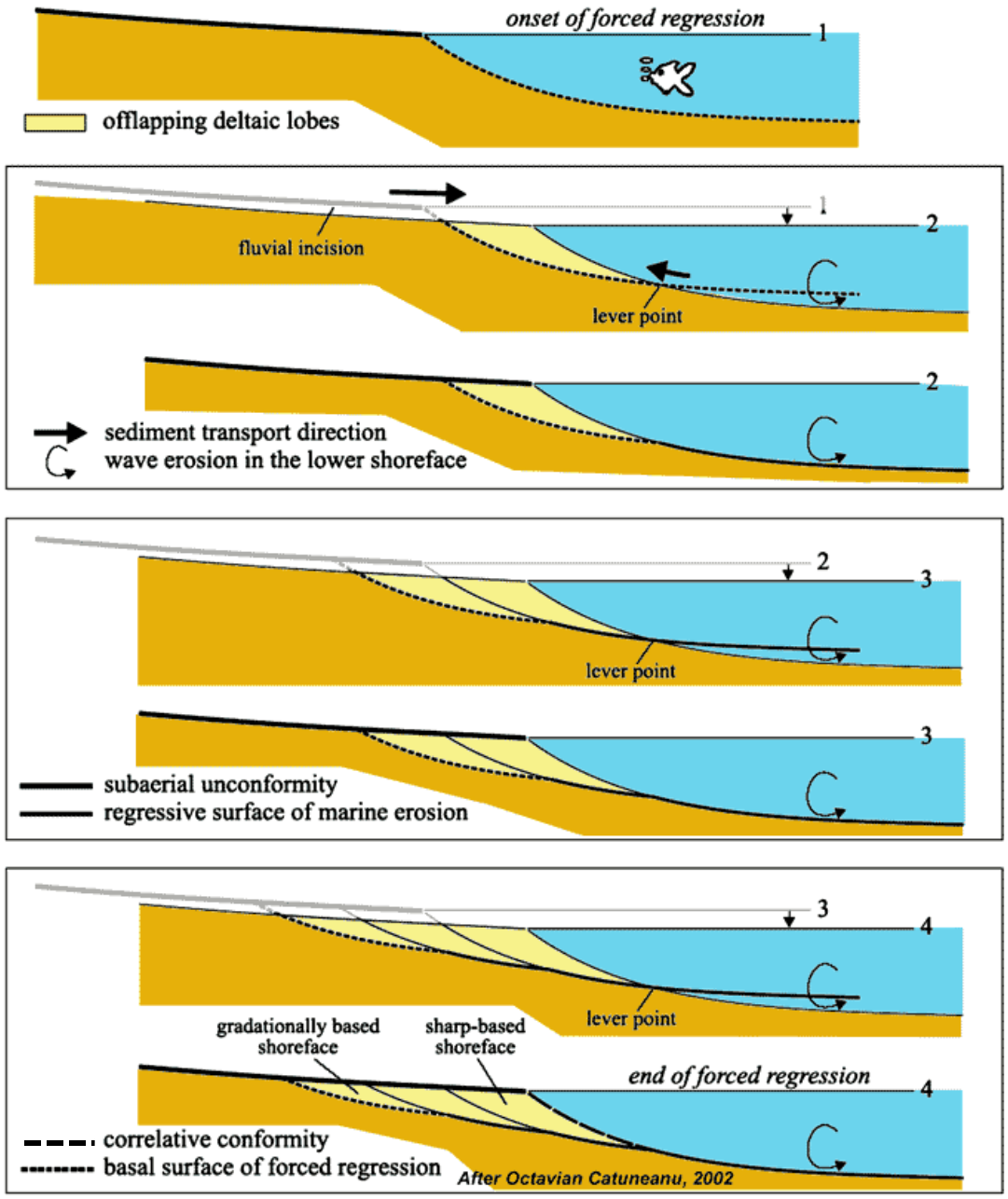
——— subaerial unconformity **SU**

develops during relative sea-level fall and progressively extends basinwards.



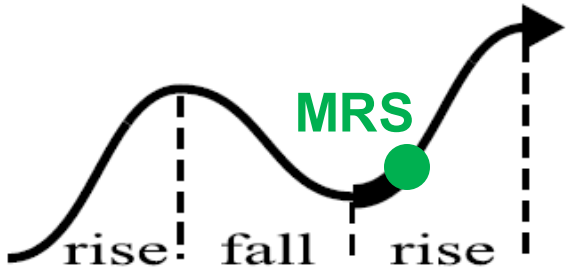


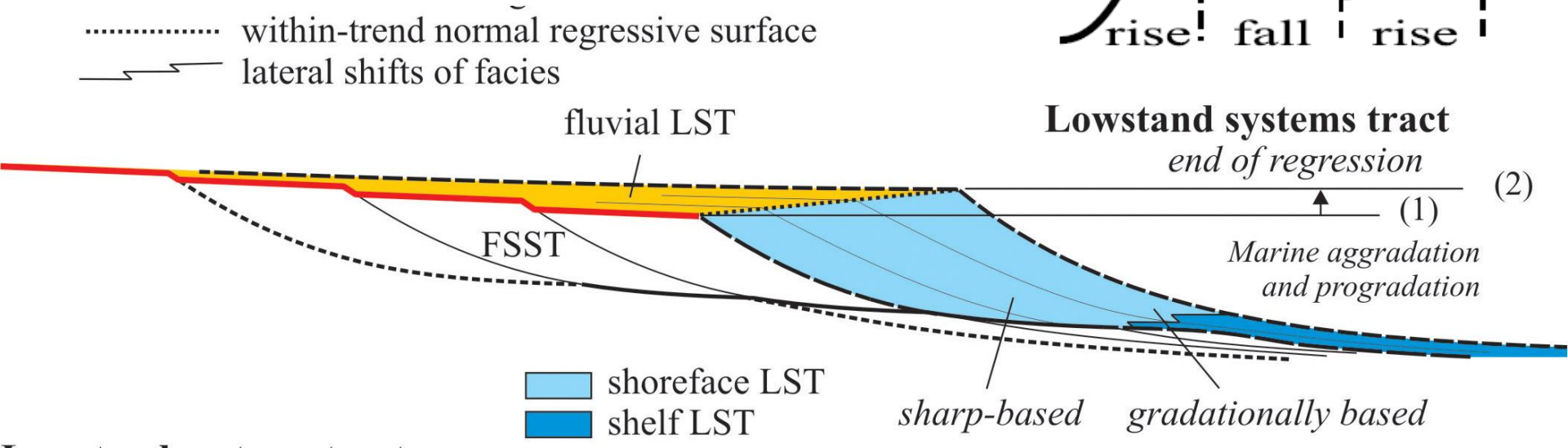
How the Regressive Surface of Marine Erosion reworks the Basal Surface of Forced Regression during the *Falling Stage System Tract*



maximum regressive surface **MRS** or Transgressive Surface, TS) marks the boundary bentween prograding (regressive) and subsequent retrograding (transgressive) deposits

It is formed when the increasing rates of accommodation creation (relative sea-level rise)
start to outpace the sedimentation rates.

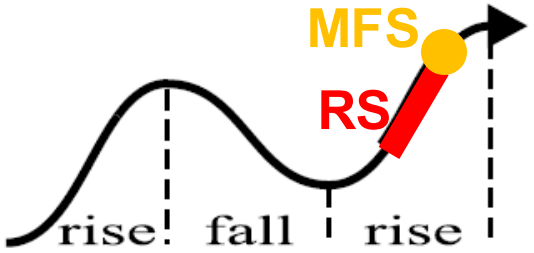


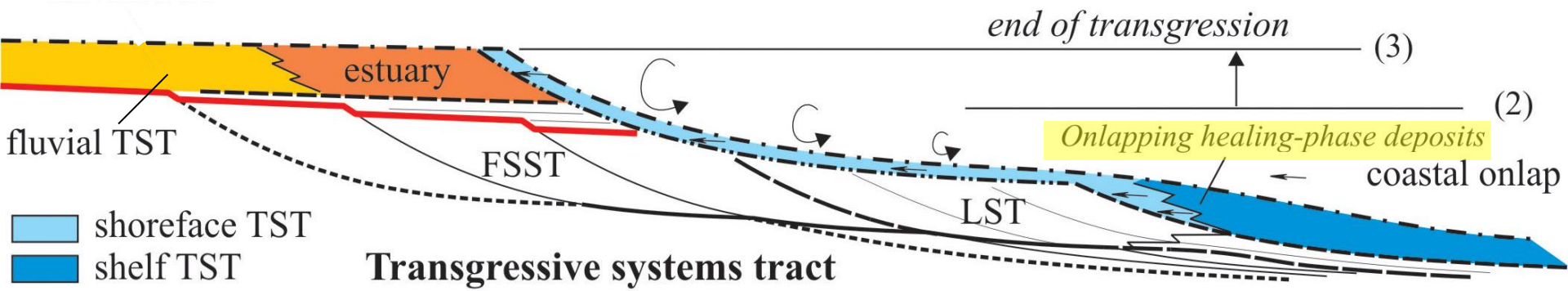


ravinement surface **RS** is a diachronous erosional surface cut by waves or tidal currents in the shoreface and coastal settings during transgression (RSL rise). It is associated with transgressive lags or condensed bioclastic deposits.

maximum flooding surface **MFS** marks the end of the shoreline transgression. It separates retrograding (transgressive) strata below from prograding (regressive) strata above. Commonly associated with a condensed section, it is a downlap surface in seismics.

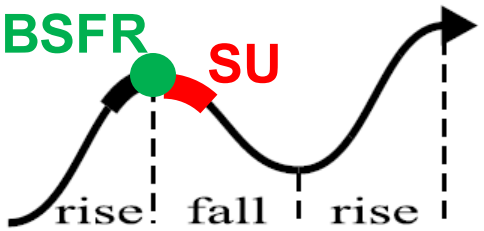
It is formed when the sedimentation rates start to outpace the rates of creation of accommodation (relative sea-level rise).

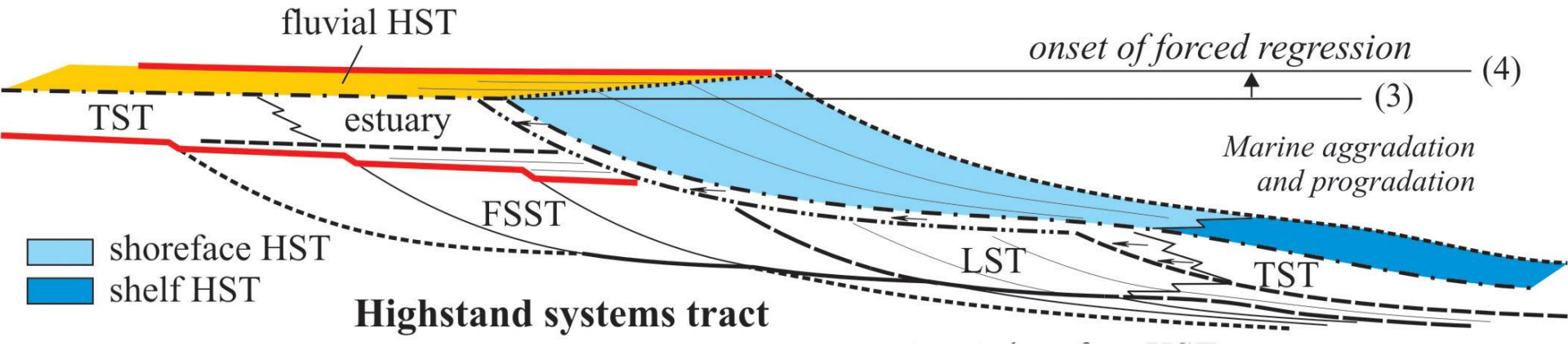




---------- basal surface of forced regression **BSFR** is to the paleo-seafloor at the onset of forced regression and lies at the base of all marine deposits accumulated during relative sea-level fall.

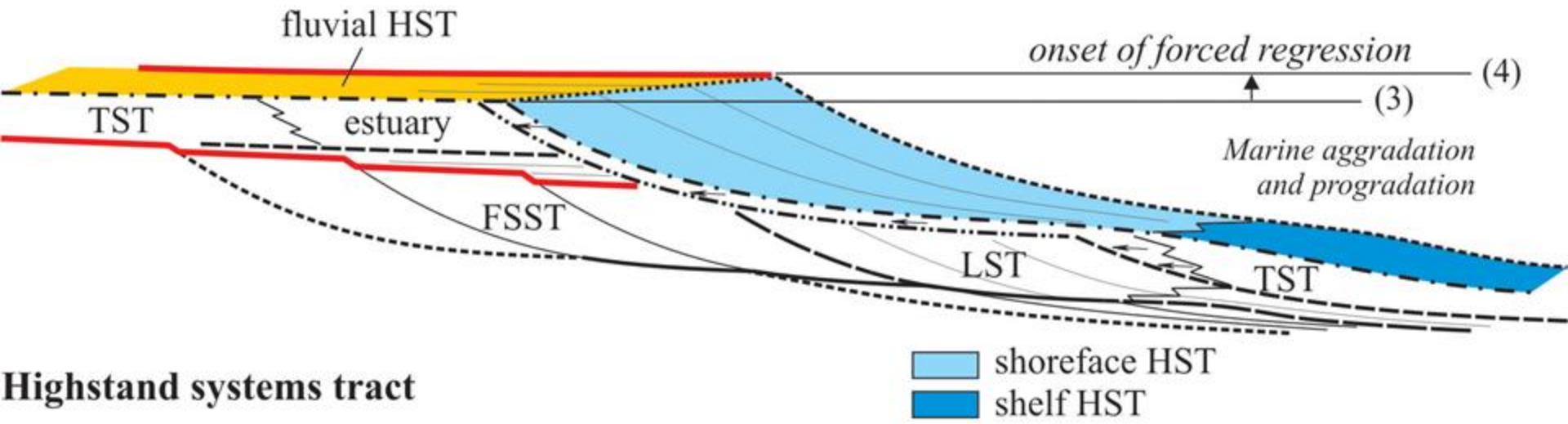
——— subaerial unconformity **SU** develops during relative sea-level fall and progressively extends basinwards.





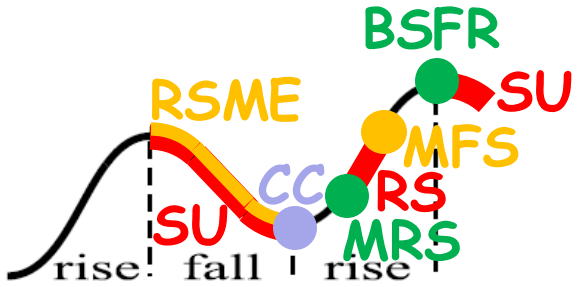
subaerial unconformity
correlative conformity
basal surface of forced regression
regressive surface of marine erosion
ravinement surface
maximum regressive surface
maximum flooding surface
within-trend normal regressive surface
lateral shifts of facies
coastal onlap (healing phase deposits)

Continuous succession of stratigraphic surfaces/ system tracts



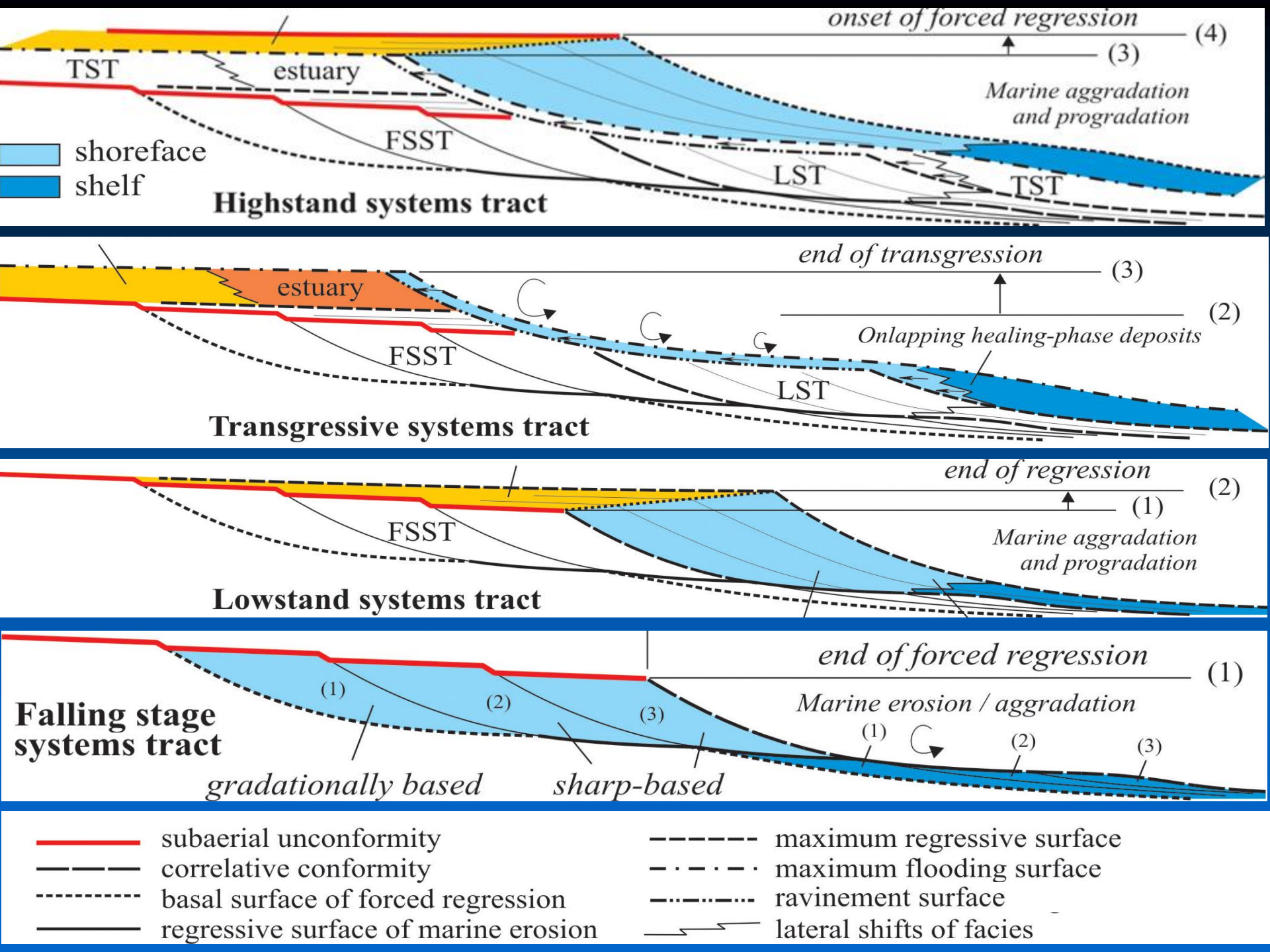
Highstand systems tract

System tracts & stratigraphic surfaces



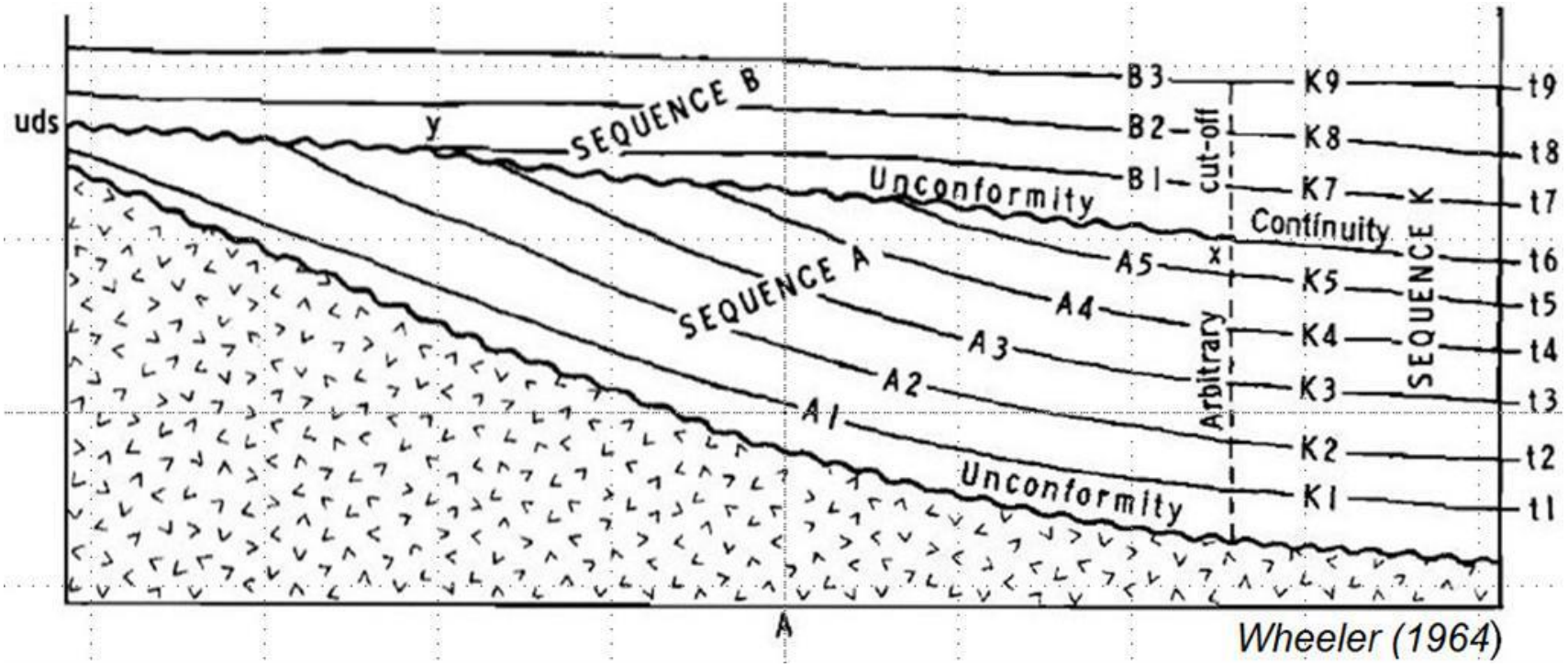
- subaerial unconformity
- correlative conformity
- basal surface of forced regression
- regressive surface of marine erosion
- ravinement surface
- maximum regressive surface
- maximum flooding surface
- within-trend normal regressive surface
- lateral shifts of facies
- coastal onlap (healing phase deposits)

All-in-one
Stratigraphic surfaces
& System Tracts

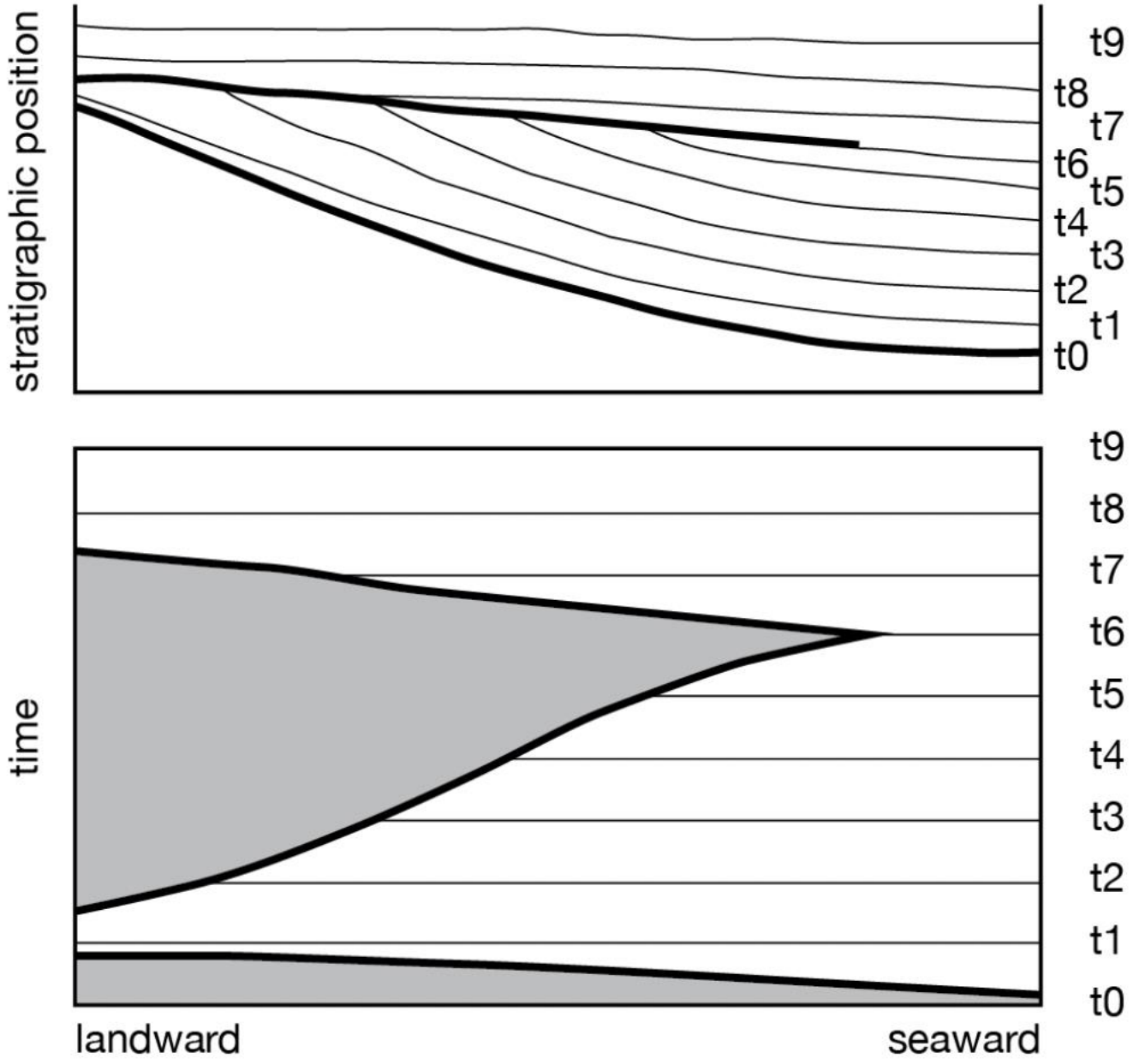

onset of forced regression
(4)
(3)
TST
estuary
Marine aggradation
and progradation
FSST
shoreface
shelf
LST
TST
Highstand systems tract
end of transgression
(3)
estuary
(2)
Onlapping healing-phase deposits
FSST
LST
Transgressive systems tract
end of regression
(2)
(1)
FSST
Marine aggradation
and progradation
Lowstand systems tract
end of forced regression
(1)
Marine erosion / aggradation
Falling stage
systems tract
(1)
(2)
(3)
(1)
(2)
(3)
gradationally based
sharp-based
subaerial unconformity
correlative conformity
basal surface of forced regression
regressive surface of marine erosion
maximum regressive surface
maximum flooding surface
ravinement surface
lateral shifts of facies

Hiatus

A cessation in deposition of sediments during which no strata form or an erosional surface forms on the underlying strata; a **gap in the rock record**. This period might be marked by development of a lithified sediment (hardground) or burrowed surface. A disconformity (surface that represents a time of nondeposition, possibly combined with erosion) can result from a hiatus.

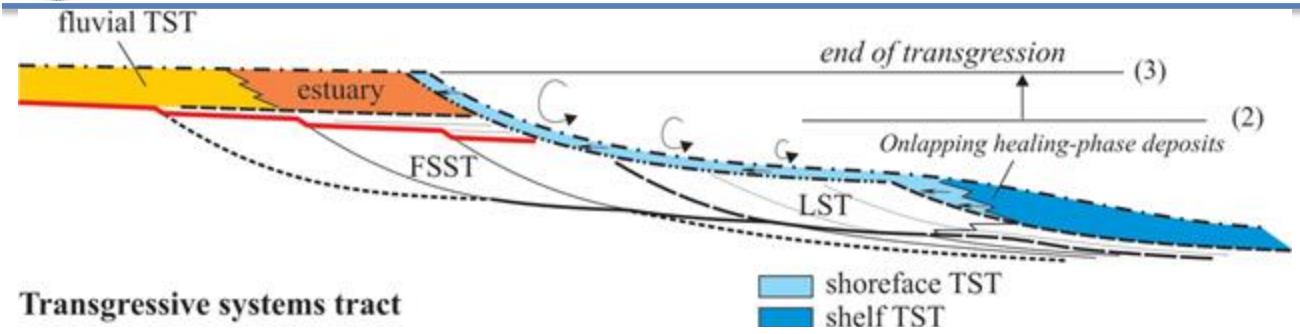


Wheeler diagram

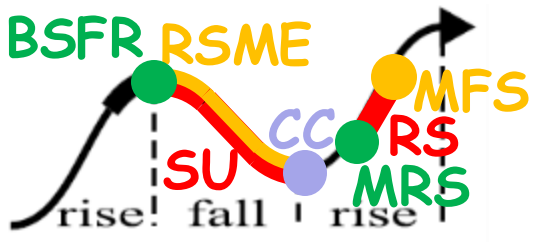


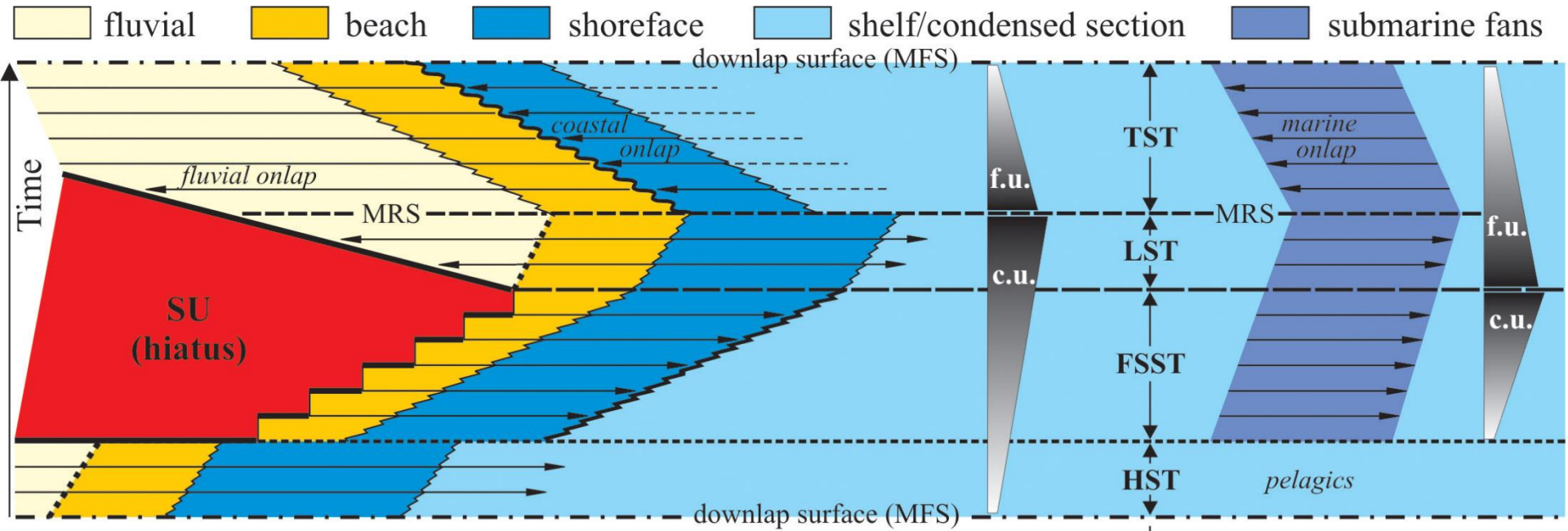
Stratigraphic cross-section (upper) and chrono-stratigraphic (Wheeler) diagram lower, illustrating the chrono-stratigraphic potential of a subaerial unconformity

Wheeler diagram of stratigraphic sequences



Transgressive systems tract





- subaerial unconformity
- correlative conformity
- regressive surface of marine erosion
- basal surface of forced regression
- onlap
- maximum regressive surface
- maximum flooding surface
- transgressive ravinement surface
- within-trend normal regressive surface
- downlap

First exercise

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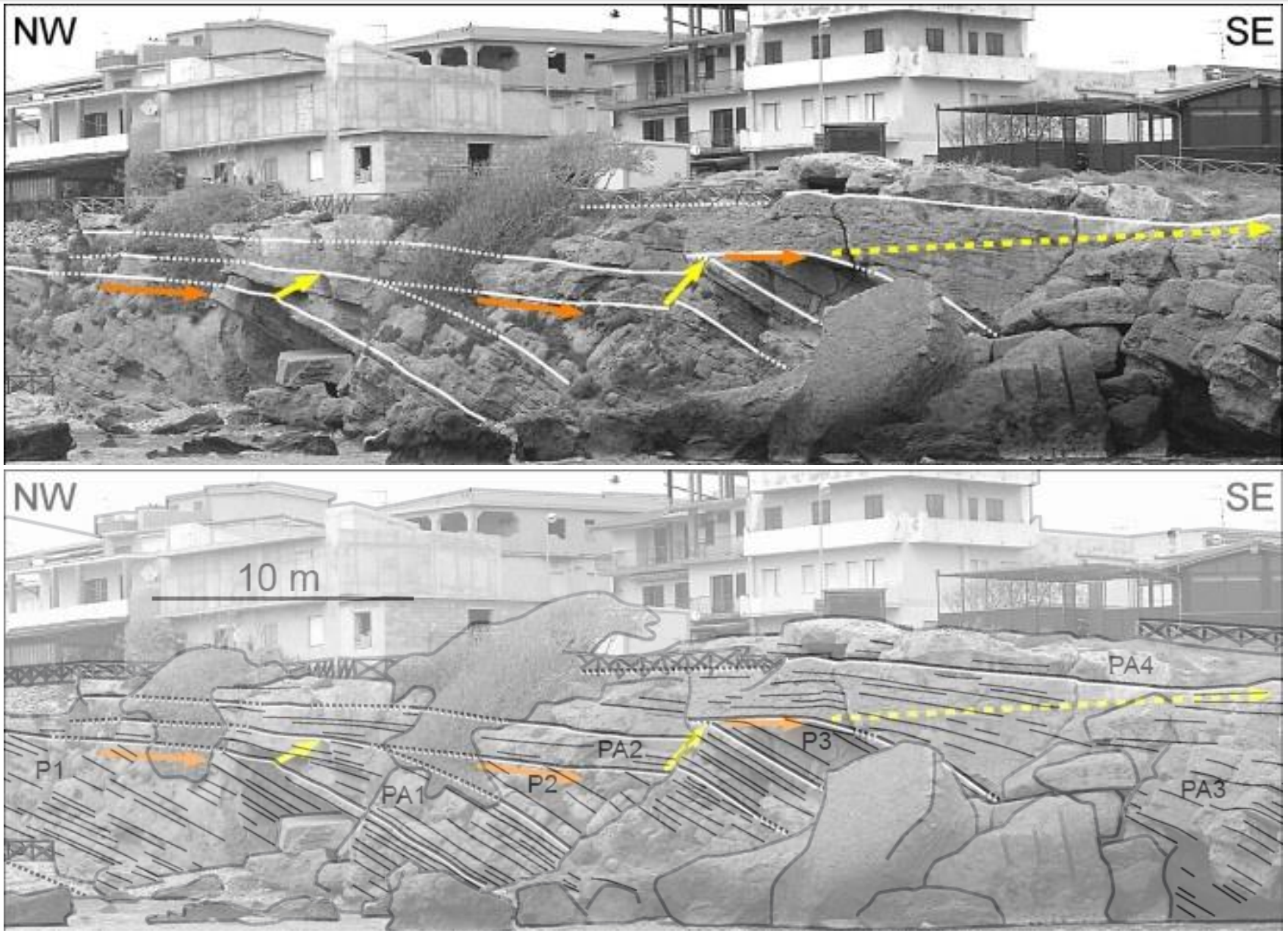
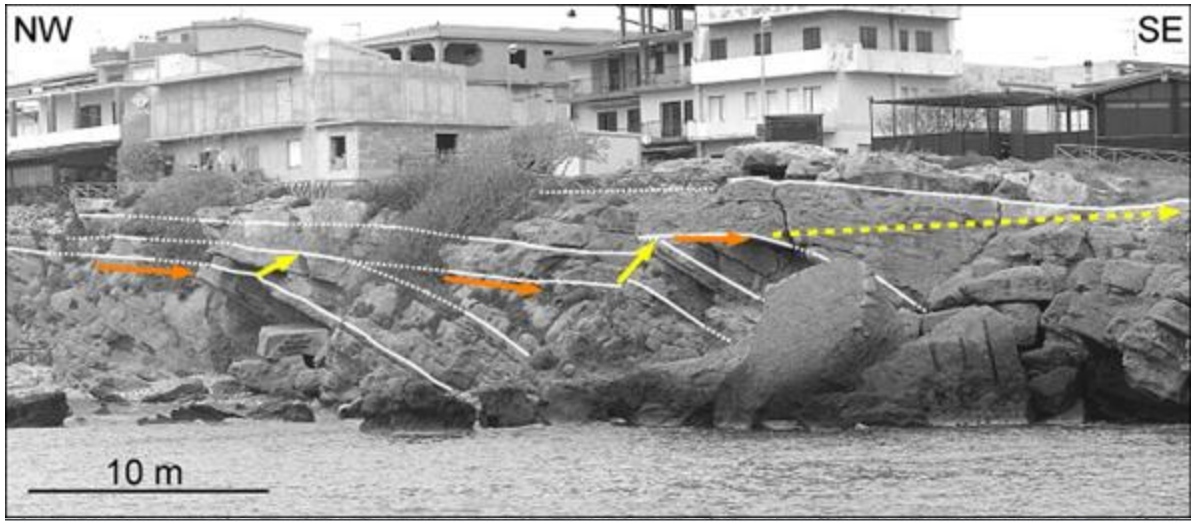
Natural example (exception)

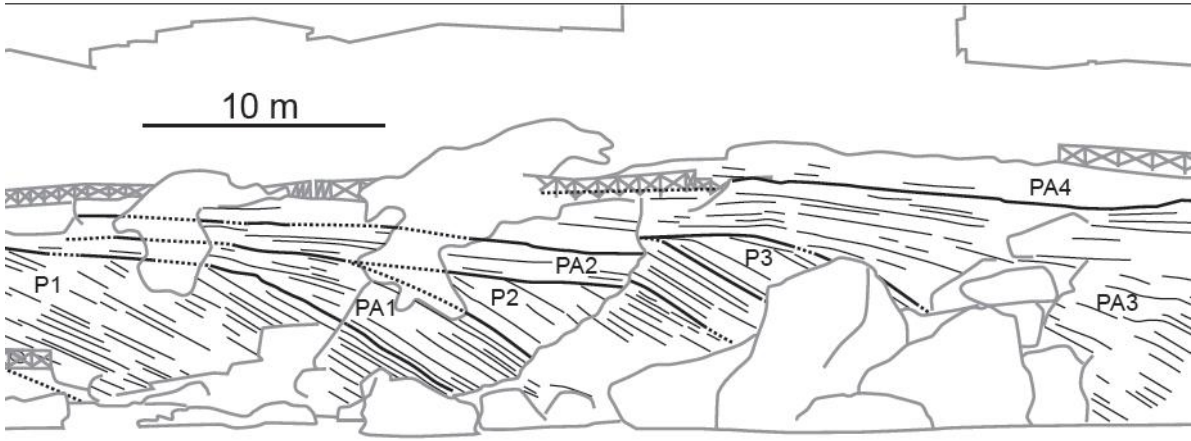


Normal and forced regressive deposits

Relative sea-level changes may be erratic/poorly predictable. The expected complete succession of systems tracts doesn't form in all cases.

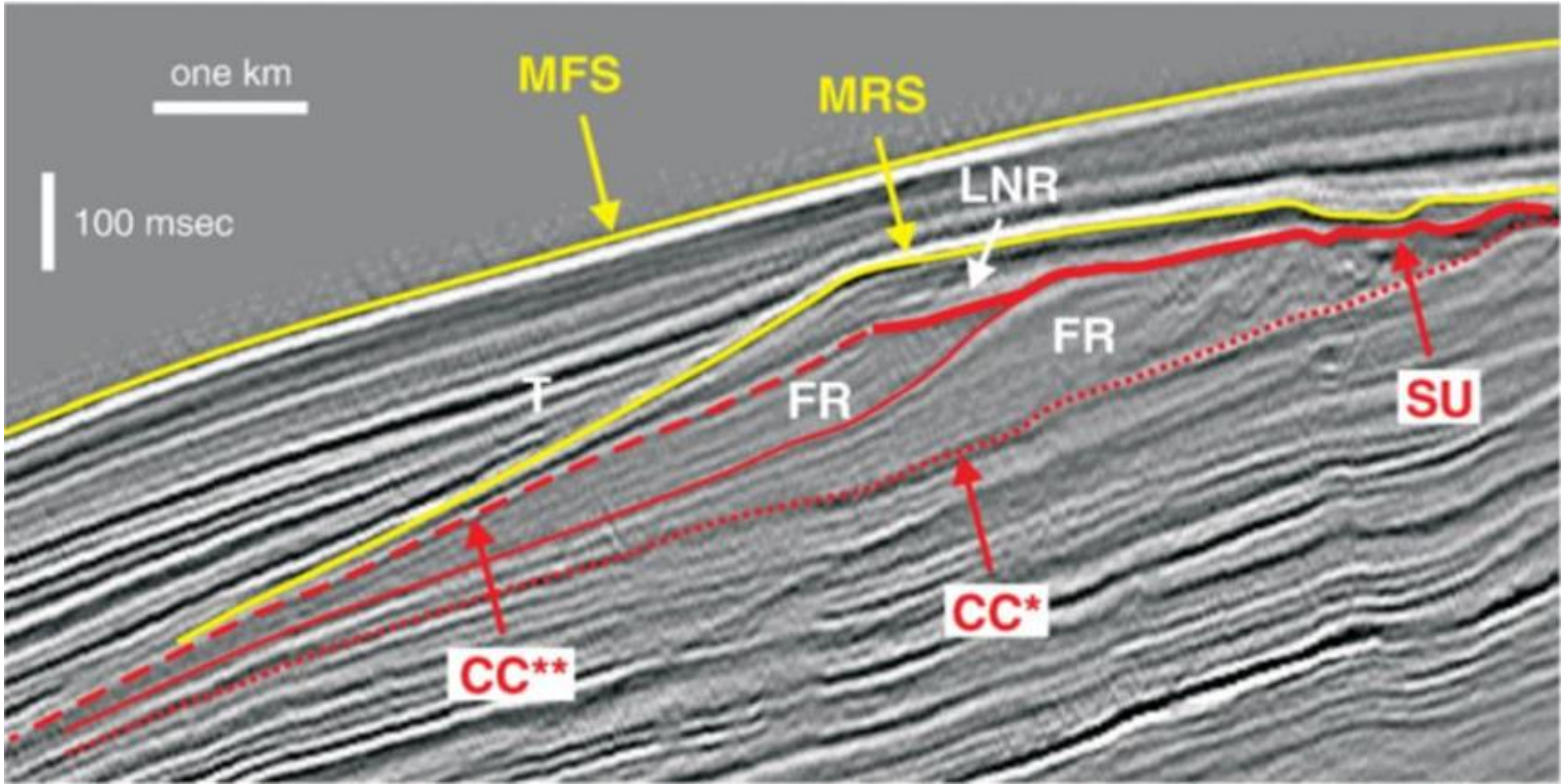
Zecchin et al., 2010. Le Castella clinoform. Sedimentary Geology. Alternating prograding and prograding/ aggrading elementary units, thought to be linked to high-frequency base-level changes during overall forced regressive conditions





Second exercise

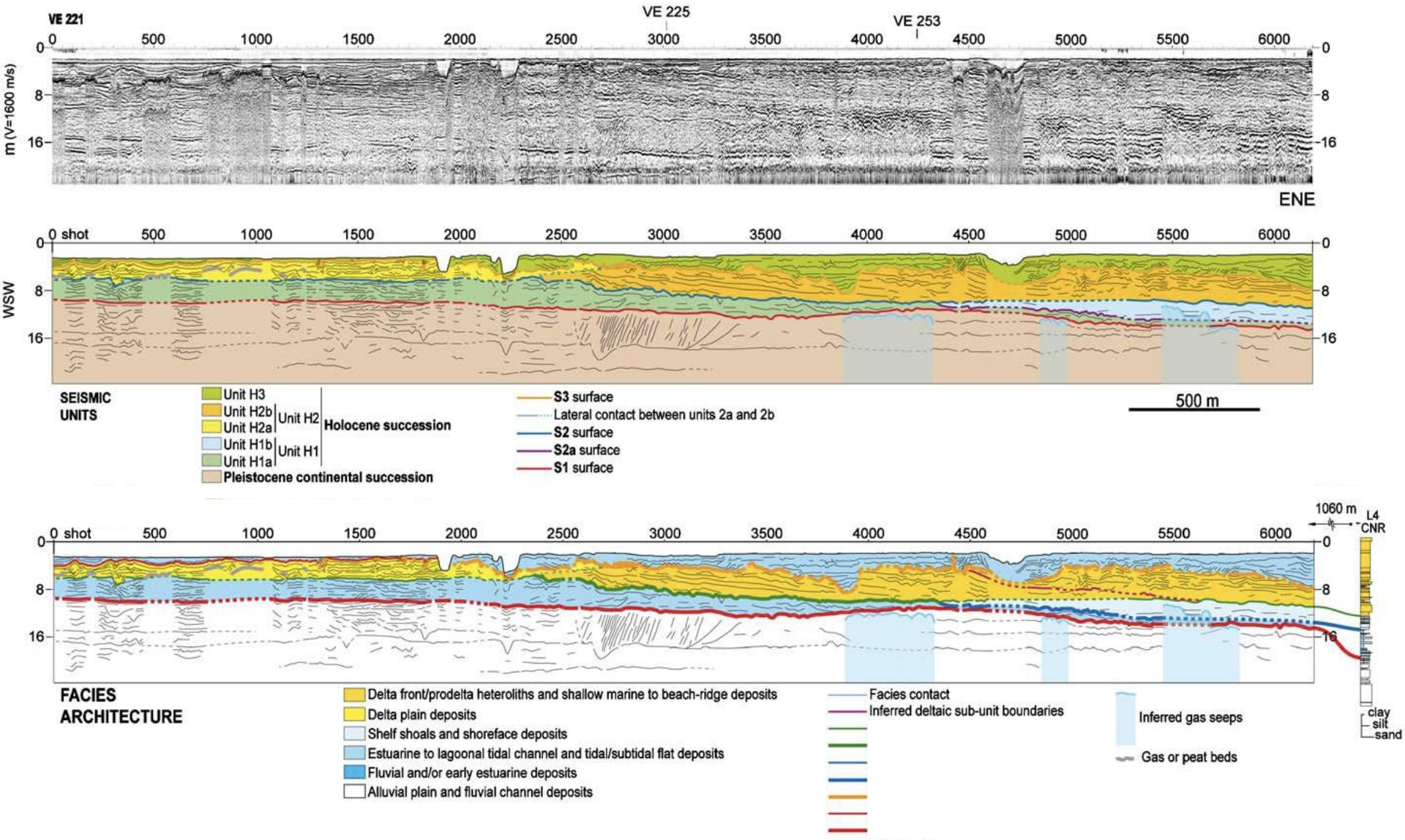
Exercise: try to identify the system tracts and to mark the stratigraphic surfaces

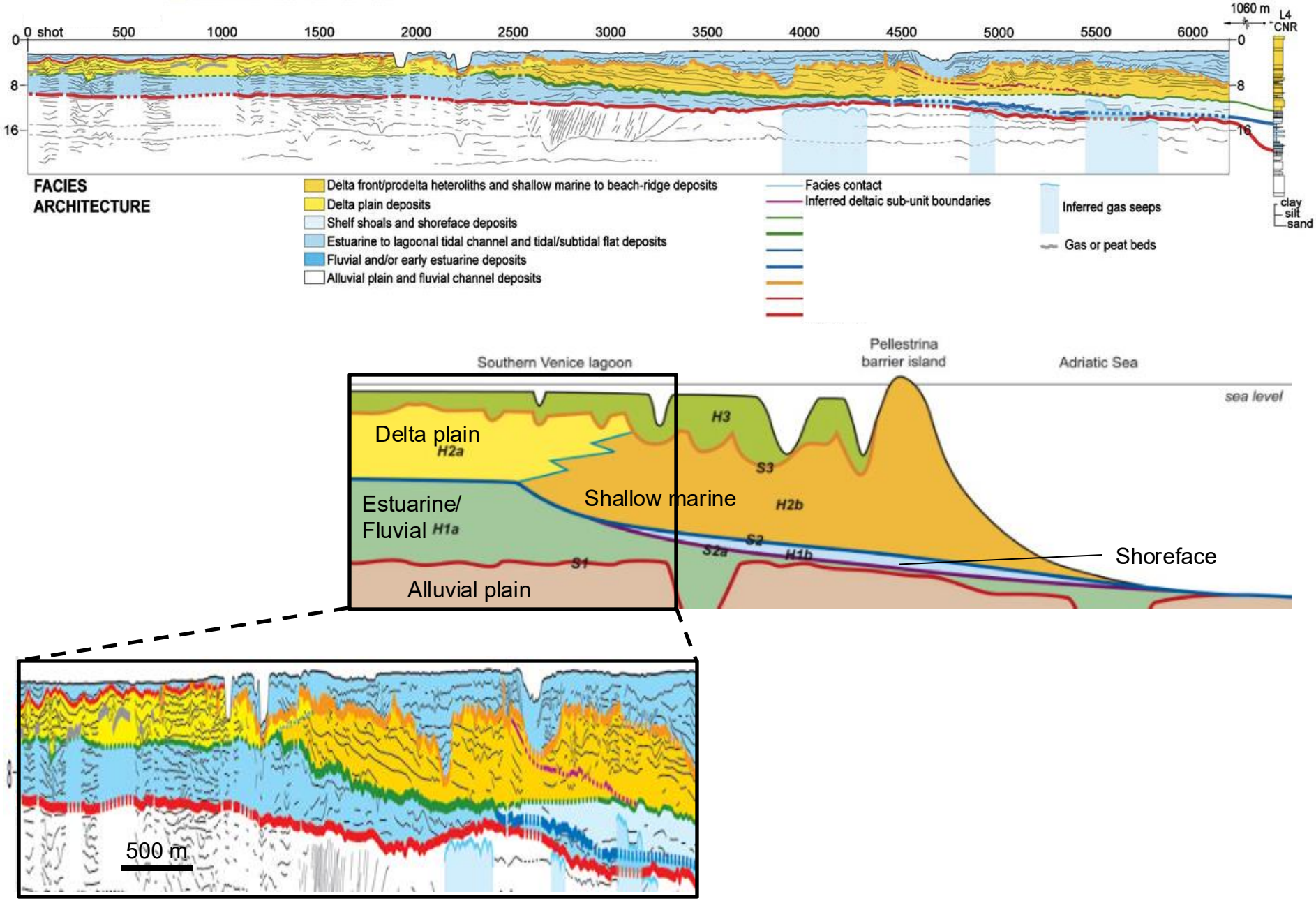


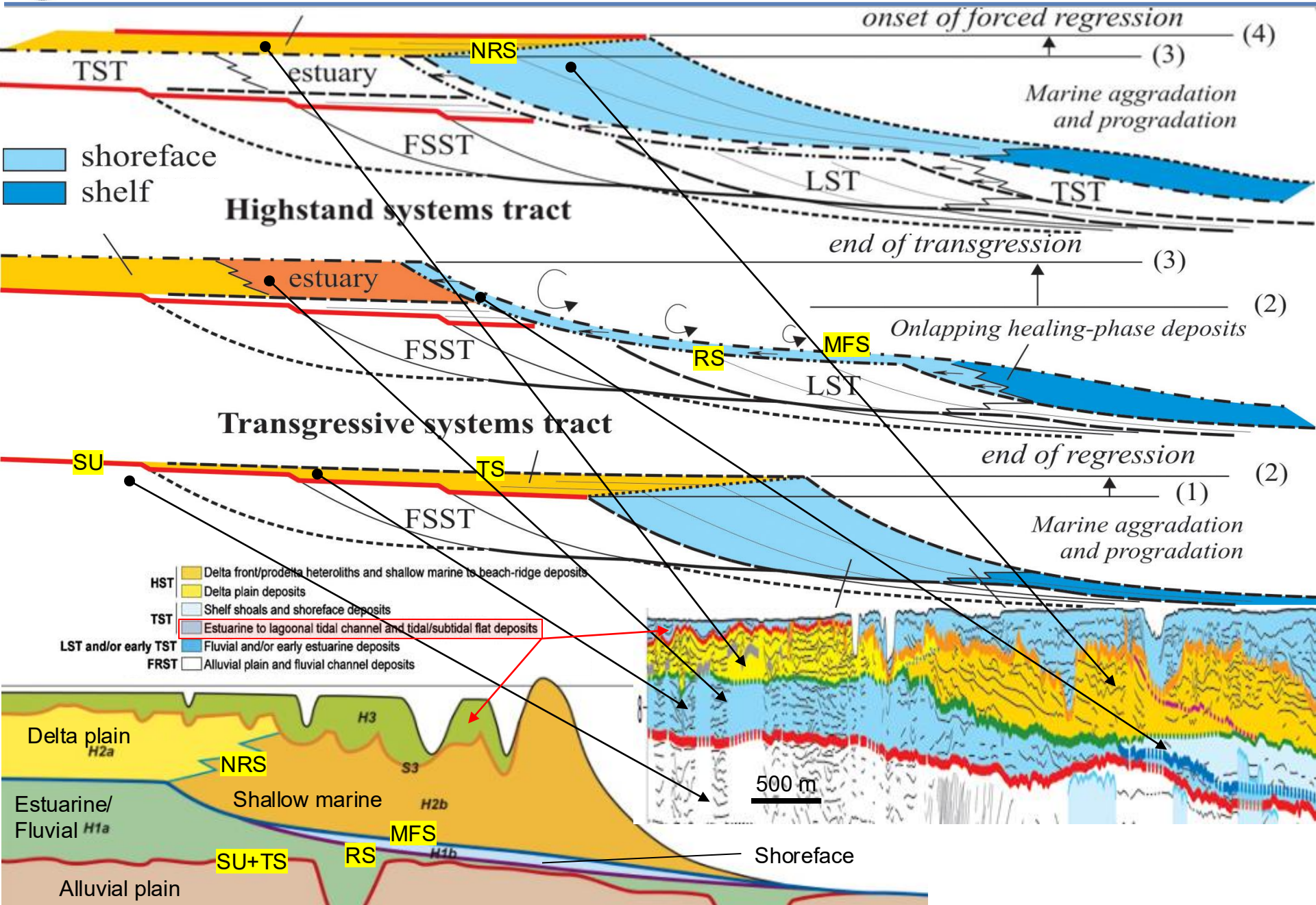
Third exercise

Guess the ST and surfaces!

From Zecchin et al. (2009) Venice lagoon. Continental Shelf Research 29, 1343-1359




0 shot
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
0
8
16
1060 m
L4
CNR
clay
silt
sand
FACIES
ARCHITECTURE
Delta front/prodelta heteroliths and shallow marine to beach-ridge deposits
Delta plain deposits
Shelf shoals and shoreface deposits
Estuarine to lagoonal tidal channel and tidal/subtidal flat deposits
Fluvial and/or early estuarine deposits
Alluvial plain and fluvial channel deposits
Facies contact
Inferred deltaic sub-unit boundaries
Inferred gas seeps
Gas or peat beds
Southern Venice lagoon
Pellestrina
barrier island
Adriatic Sea
sea level
Delta plain
H2a
H3
S3
Estuarine/
Fluvial H1a
Shallow marine
H2b
S2
S2a
H1b
S1
Alluvial plain
Shoreface
500 m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Delta plain deposits
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Shelf shoals and shoreface deposits
Estuarine to lagoonal tidal channel and tidal/subtidal flat deposits
LST and/or early TST
Fluvial and/or early estuarine deposits
FRST
Alluvial plain and fluvial channel deposits
500 m
Delta plain
H2a
H3
NRS
S3
Shallow marine
H2b
Estuarine/
Fluvial H1a
MFS
RS
H1b
SU+TS
Shoreface
Alluvial plain