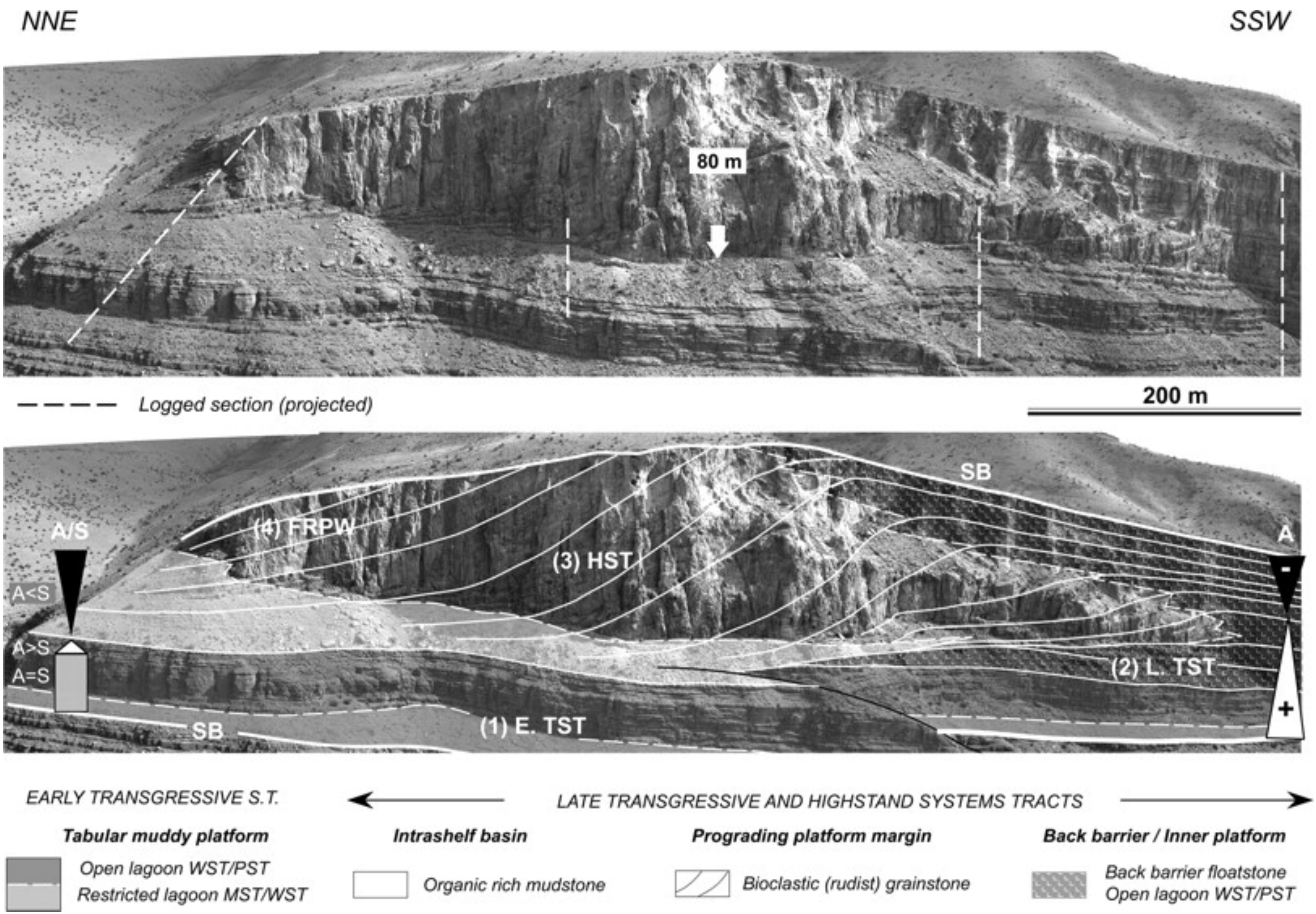
Sequence stratigraphy in the field



Sequence stratigraphy in the field

Describe & interpret **beds** (records of individual depositional events)

Describe **bedsets** (groups of beds with similar features, deposited by similar processes during similar depositional events)

Identify **parasequences** (based on shallowing upward successions or bedsets) and **flooding surfaces** (abrupt decrease in water depth)

Identify **stacking pattern** and **parasequence sets** (based on vertical trends in water depth among successive parasequences)

Recognize potential **sequence boundaries**:

- erosional truncation
- evidence of subaerial exposure
- abrupt basinward shift of facies

Recognize potential **condensed sections**:

- burrowed surfaces
- abundant diagenetic minerals (glauconite, phosphate, pyrite siderite, hematite, etc.)
- fossil concentrations
- closely spaced bentonites

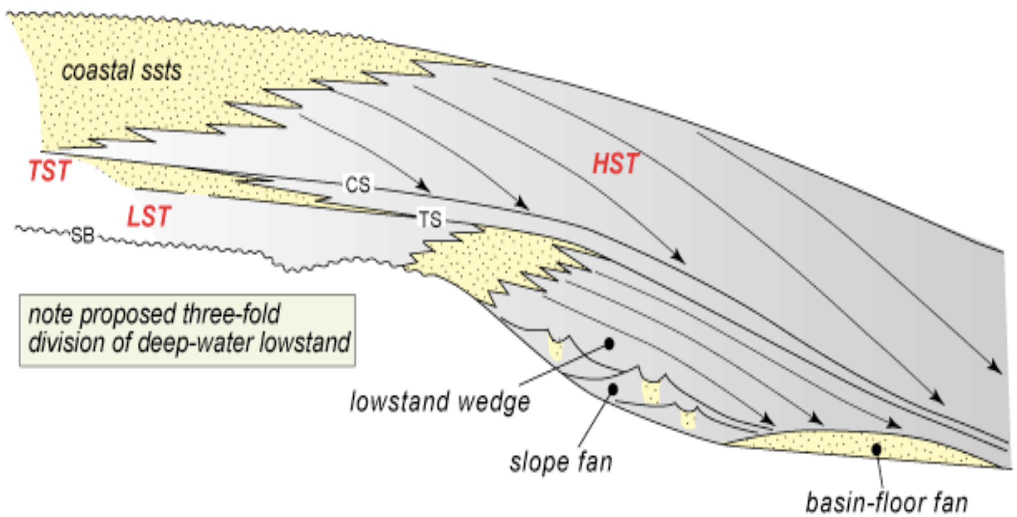
Identify system tracts (LST, TST, HST) and surfaces (SB, TS, MFS) based on stacking pattern and significant stratal surfaces

Sequence stratigraphy in deep-sea basins

Sequence stratigraphy defined for continental margins (shelf to continental slope) – not for deep-sea basins

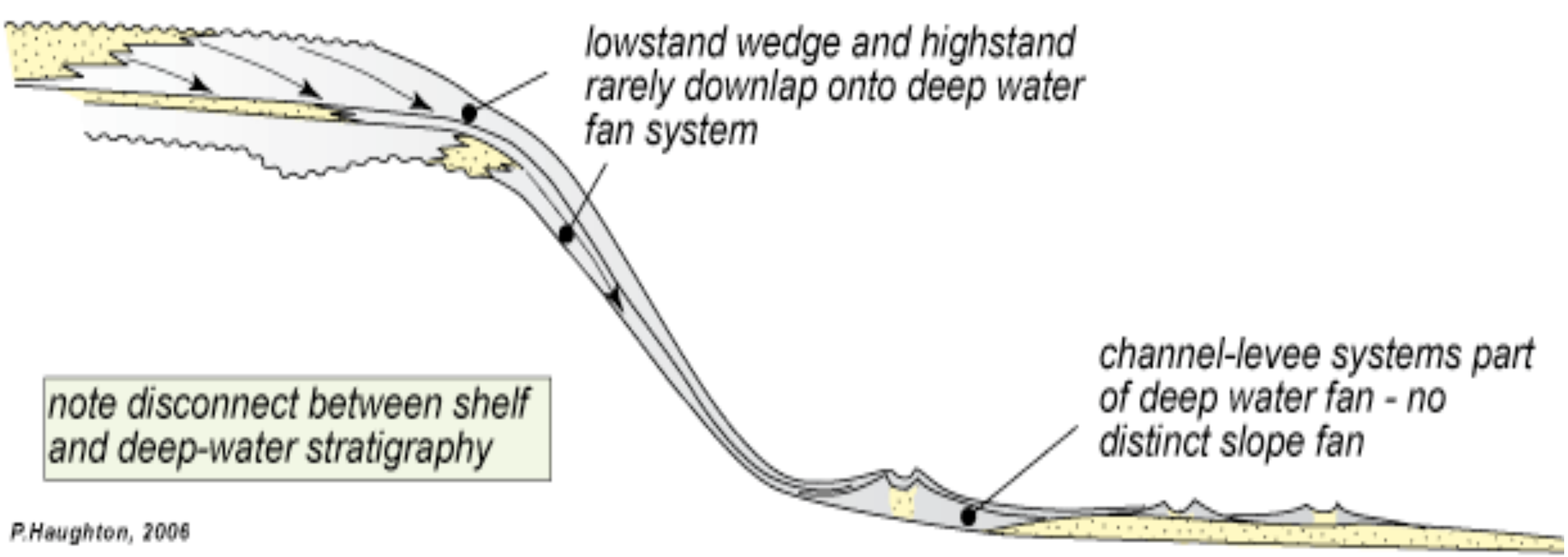
Deep-sea basin sequence stratigraphy focuses on identifying markers and detecting evidence of sea level change through lithologic indicators in the distal basin

Sequence stratigraphy in deep-sea basins

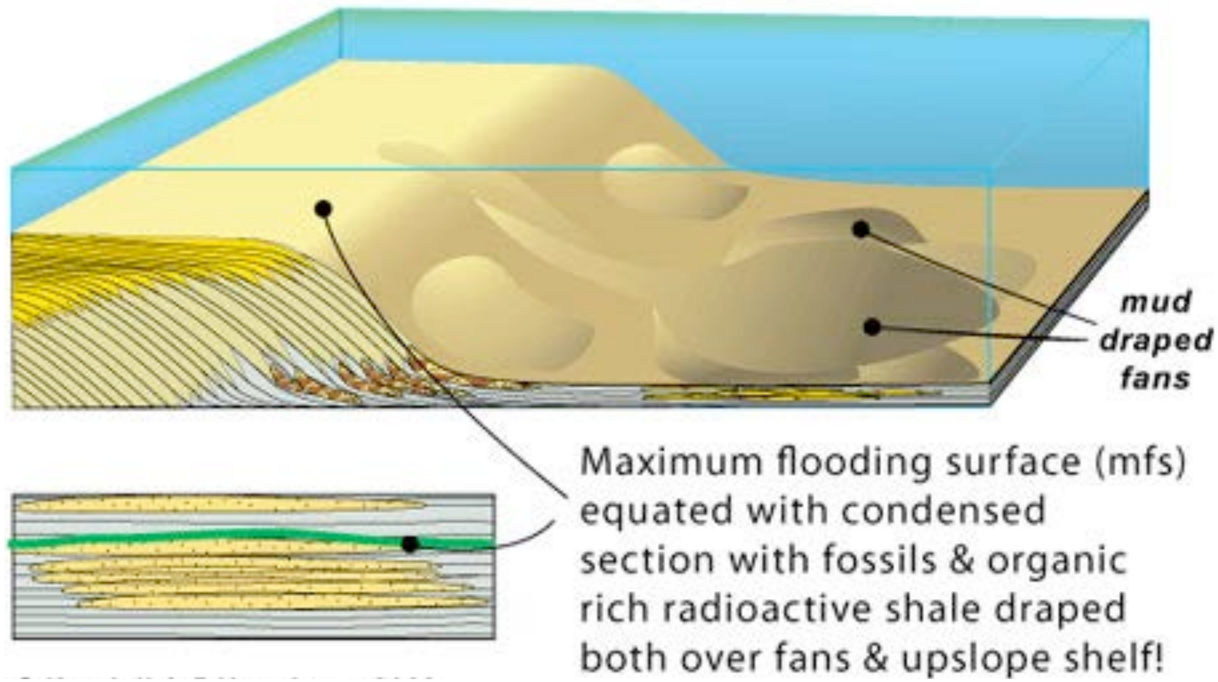


Basin floor sediments only part of the very proximal basin floor during LST

Basin floor sediments often disconnected from shelf succession



Sequence stratigraphy in deep-sea basins



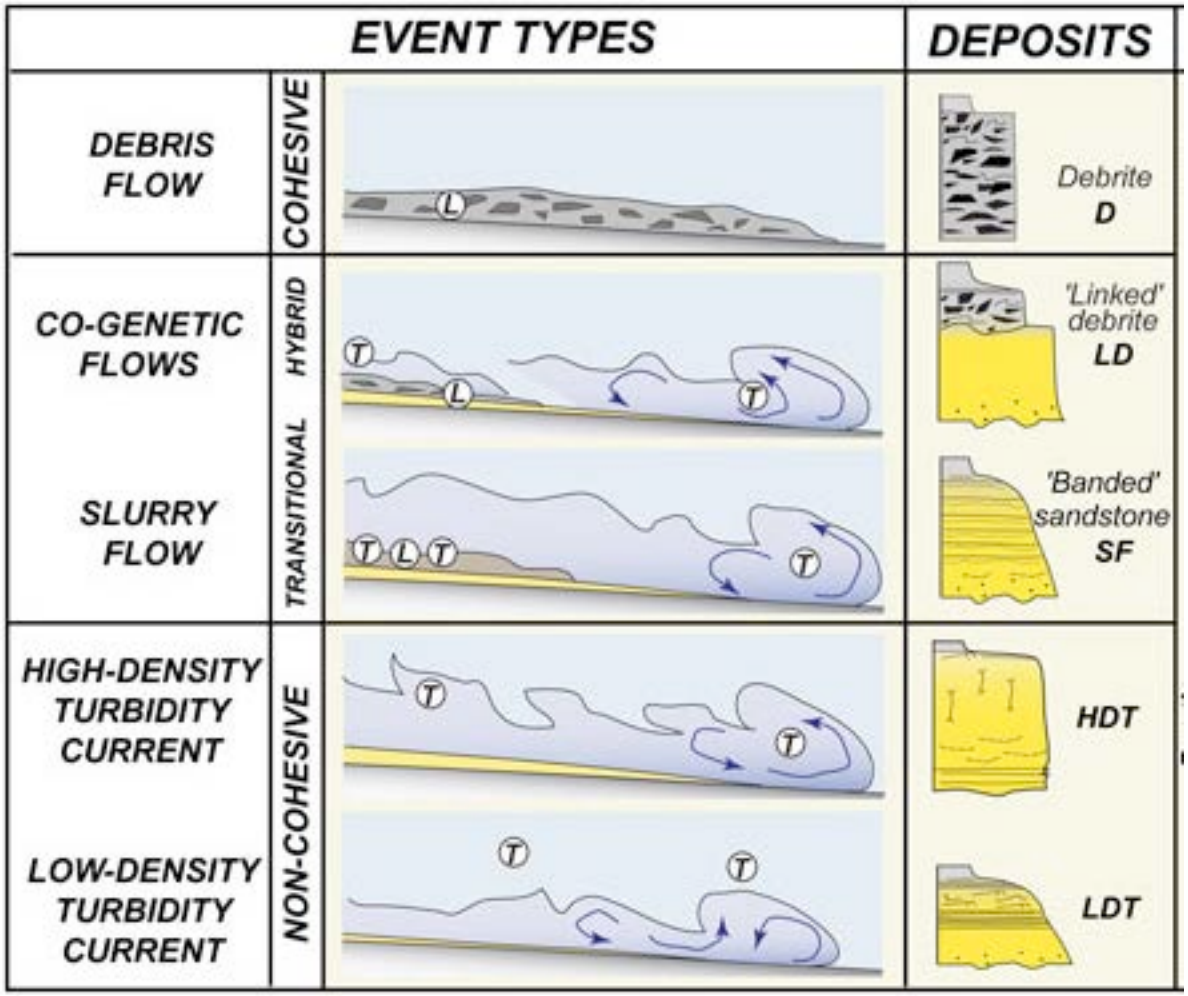
Basin floor sediments are mainly genetically conformable, unconformities are almost completely absent

Changes in relative sea-level are shown by cyclic changes in lithology and condensed sections (typical for mfs)

MFS is the most uselful sequence stratigraphic parameter, indicated by condensed sections - fossil and organic rich layers

Sequence stratigraphy in deep-sea basins

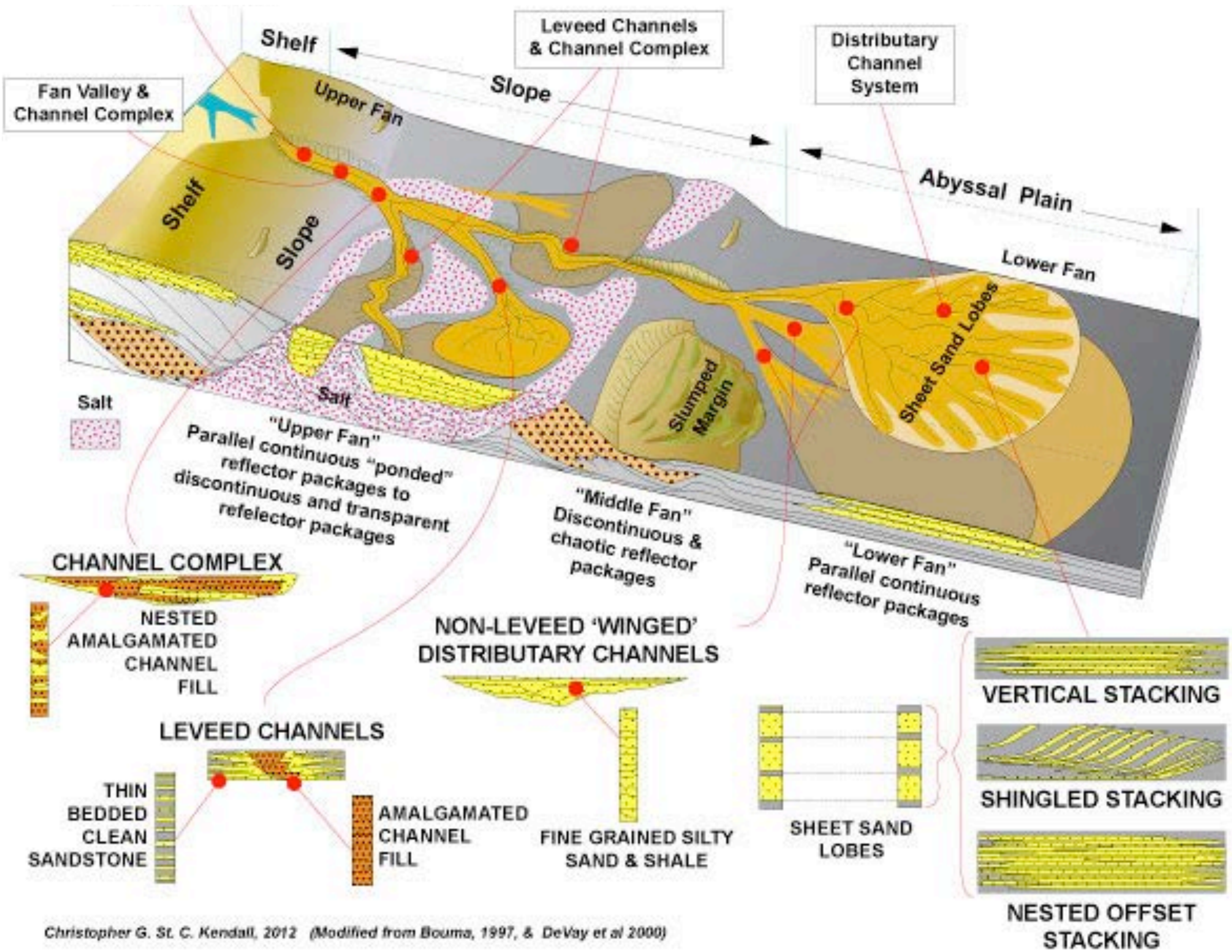
Lithological changes within the normal basin floor mud sediments are mostly sand-rich massflow sediments



Sedimentary composition and distribution depends strongly on flow type

Sequence stratigraphy in deep-sea basins

Cyclic changes in lithology due to redeposition of shelf sediments into the basin – lobes with sheeted sands and channel systems

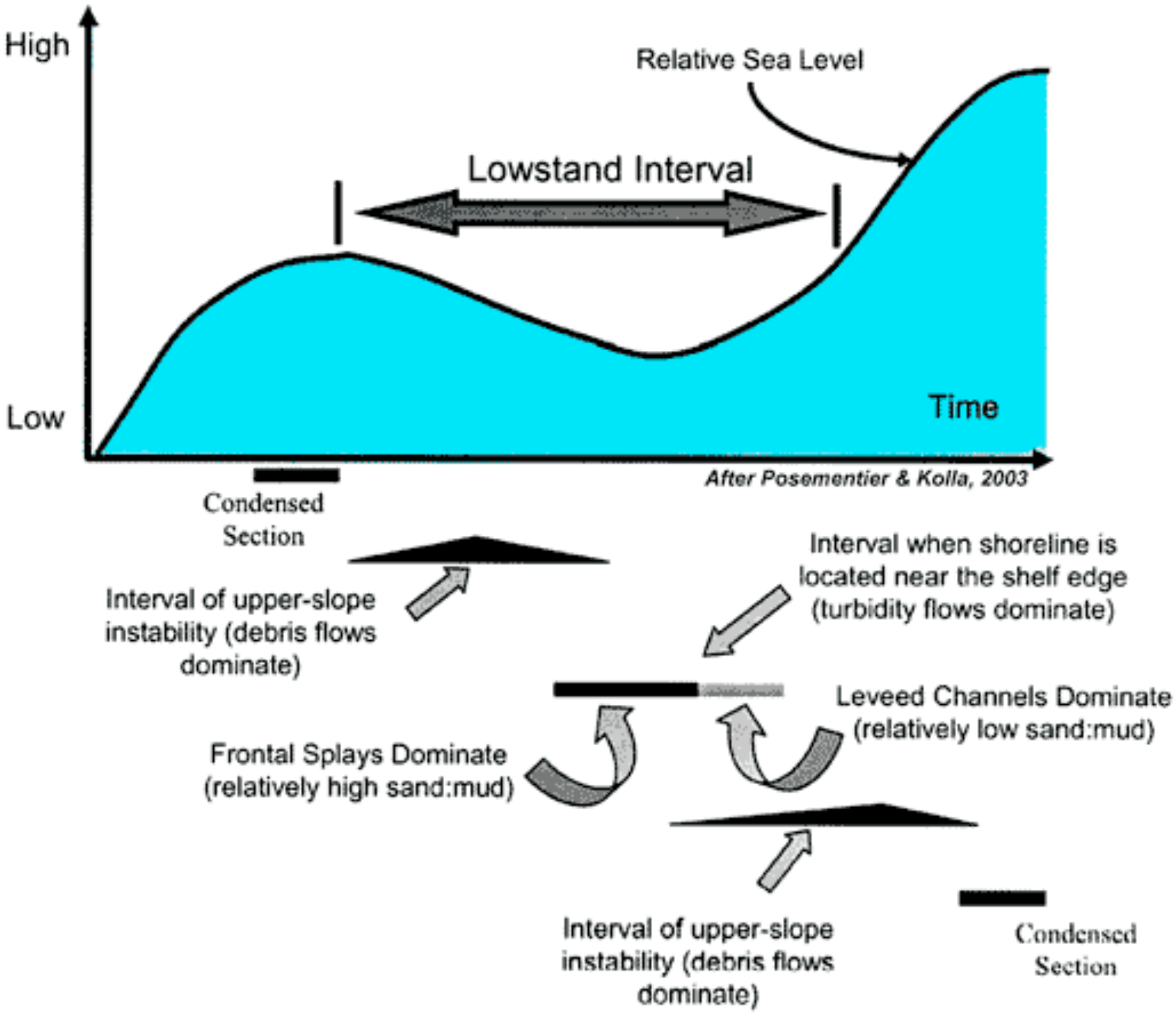


BUT –
most cyclic lithological changes are *autocyclic* = controlled by internal factors not by relative sea-level

Less litholgical changes are *allocyclic* = controlled by changes in relative sea-level

Sequence stratigraphy in deep-sea basins

Influences of relative sea-level changes on basin-floor sedimentation



Changes in dominating sedimentation types

but no clear sequence boundaries and surfaces are recognized

Best identified sequence stratigraphic surface is the **mfs**

Carbonate Sequence Stratigraphy

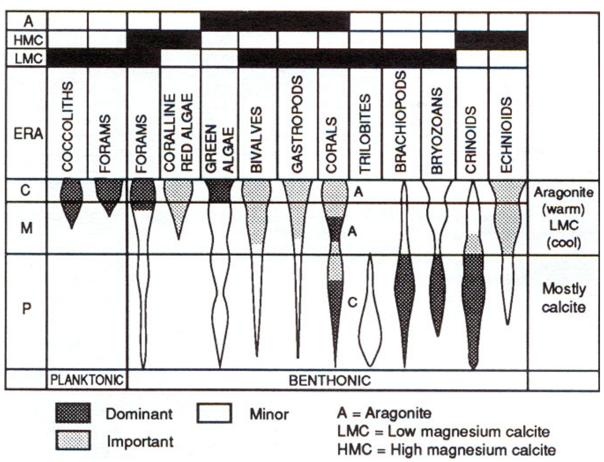
Carbonate sequence stratigraphy – carbonate shelfs

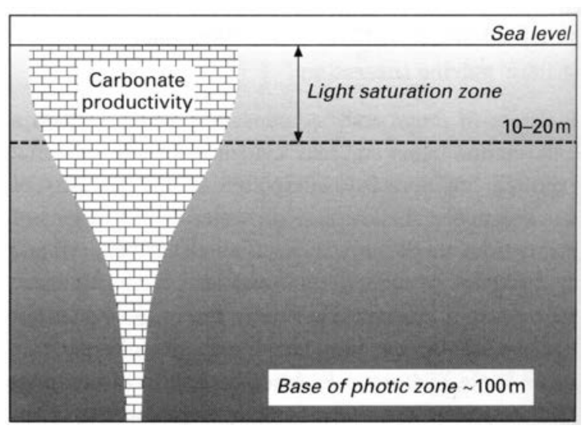
Carbonate sediments are mainly biogenic sediments:
primary sediment supply (production rate) and distribution is strongly controlled by biological and environmental parameters
secondary sediment distribution is controlled by hydrodynamic (physical) processes

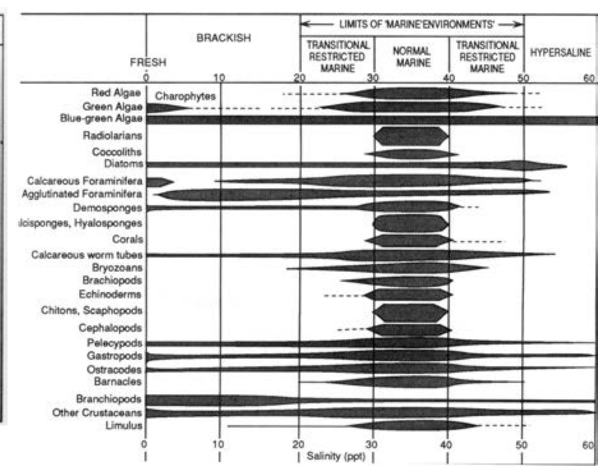
= major difference to siliciclastic shelfs, were sediment supply and distribution is controlled by hydrodynamic (physical) processes only

Carbonate production controlled by: water depth (light), temperature, salinity, oxygen

Carbonate production mainly at shallow marine shelfs (photic zone) in marine conditions (salinity, oxygen) in moderate to warm climates

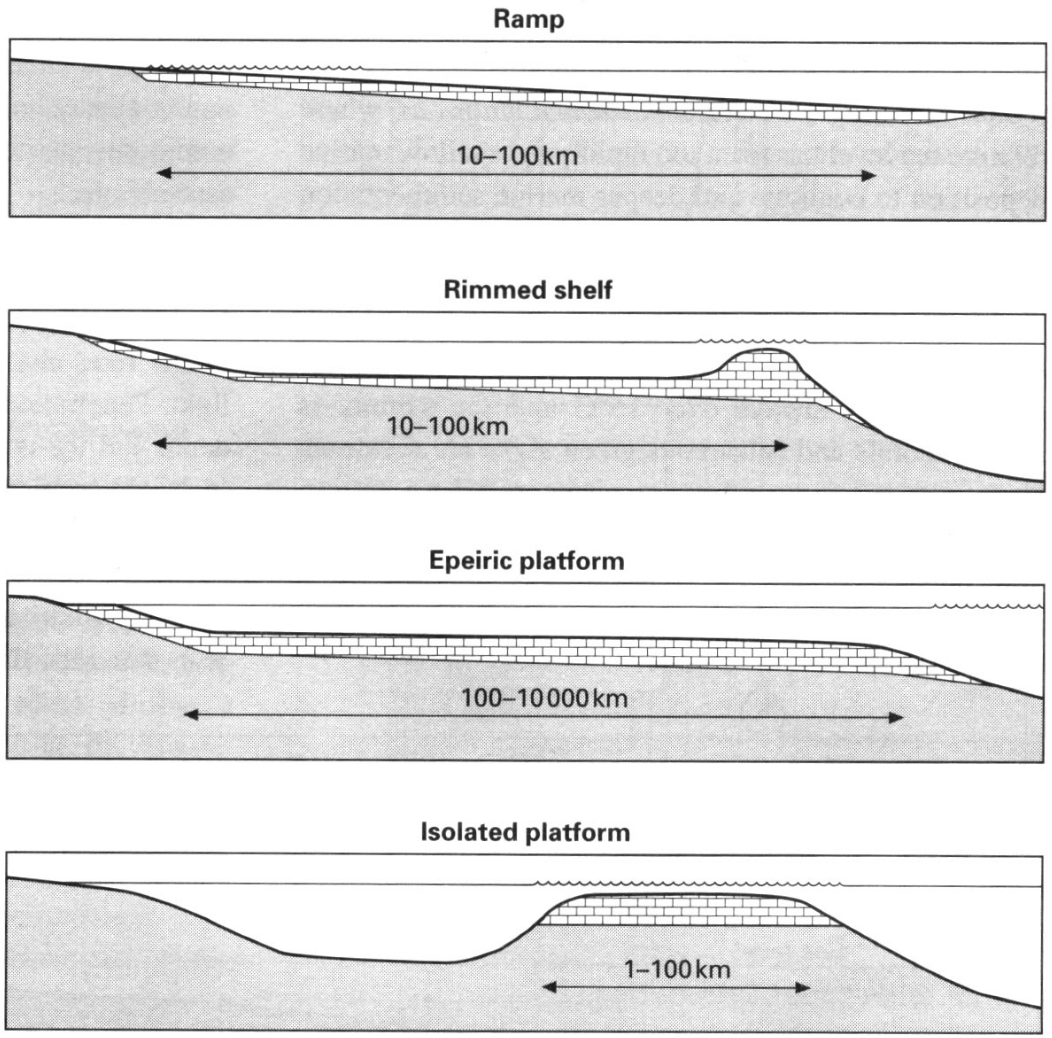






Carbonate sequence stratigraphy – carbonate shelfs

Different types of carbonate shelfs



3 major types of carbonate shelfs:

Ramp

Shelf (rimmed, unrimmed)

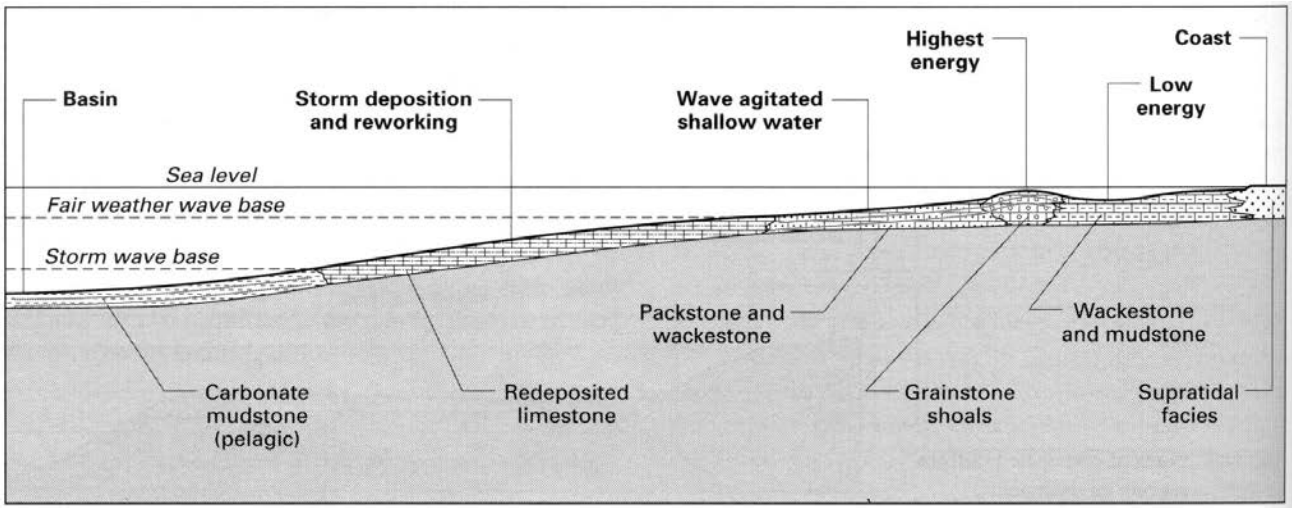
Platform (connected, isolated)

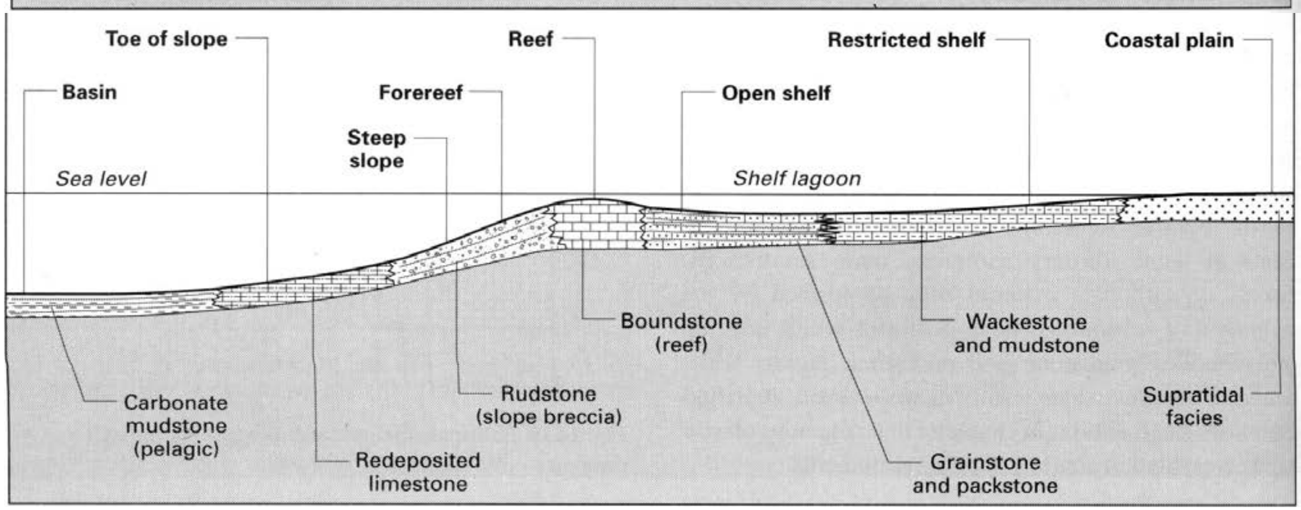
Relative sea-level change has different effect on different types of carbonate shelfs

Sequence Stratigraphic analysis differs in different carbonate shelfs

Carbonate sequence stratigraphy – carbonate shelfs

Facies distribution on carbonate shelfs





Different facies distribution in different carbonate shelf systems

Different effect of relative sea-level changes

Differences in Sequence Stratigraphic analysis

Carbonate sequence stratigraphy – carbonate shelfs

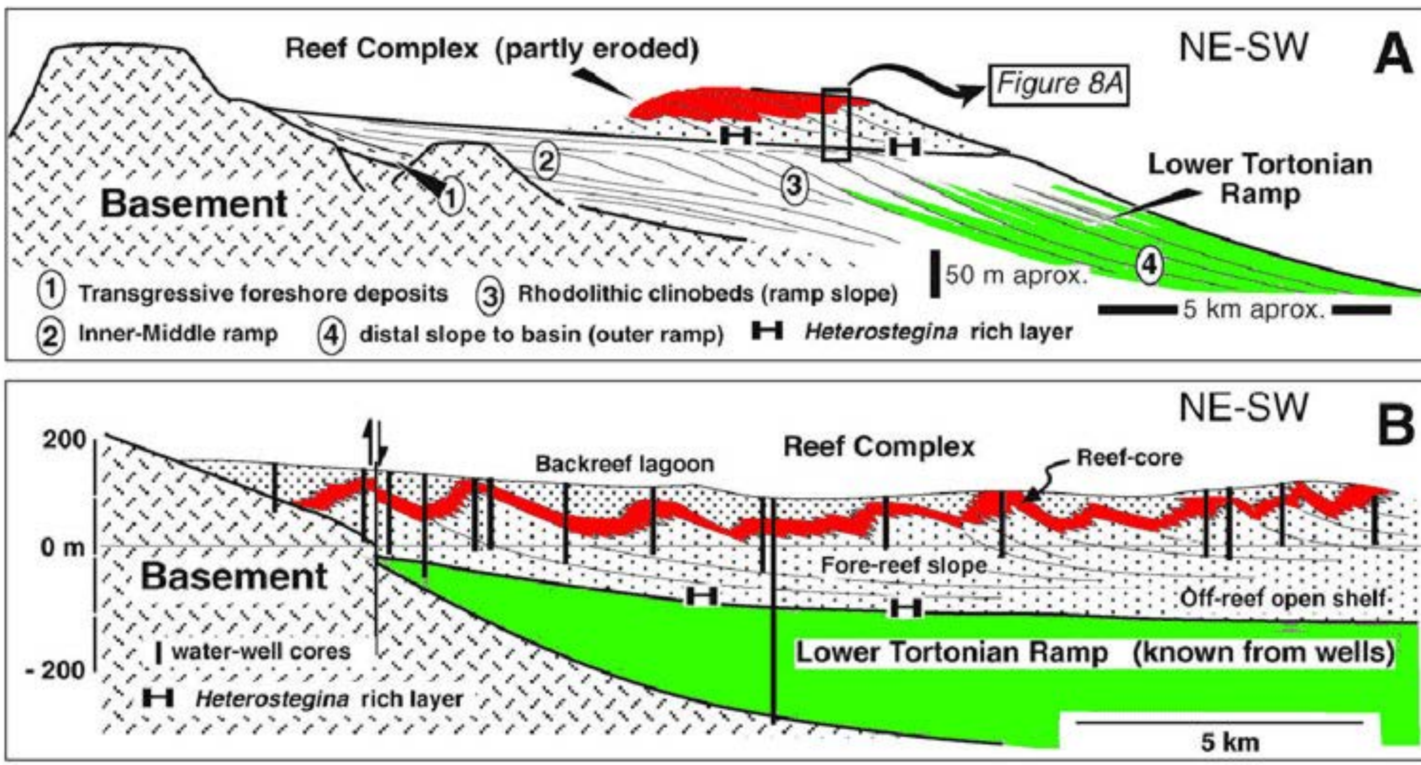
Carbonate and siliclastic shelf systems are marked by similar boundaries and surfaces (related to relative sea-level changes)

But – major difference in Sediment accomodation: Silicilclastic shelf: transport (physical) only

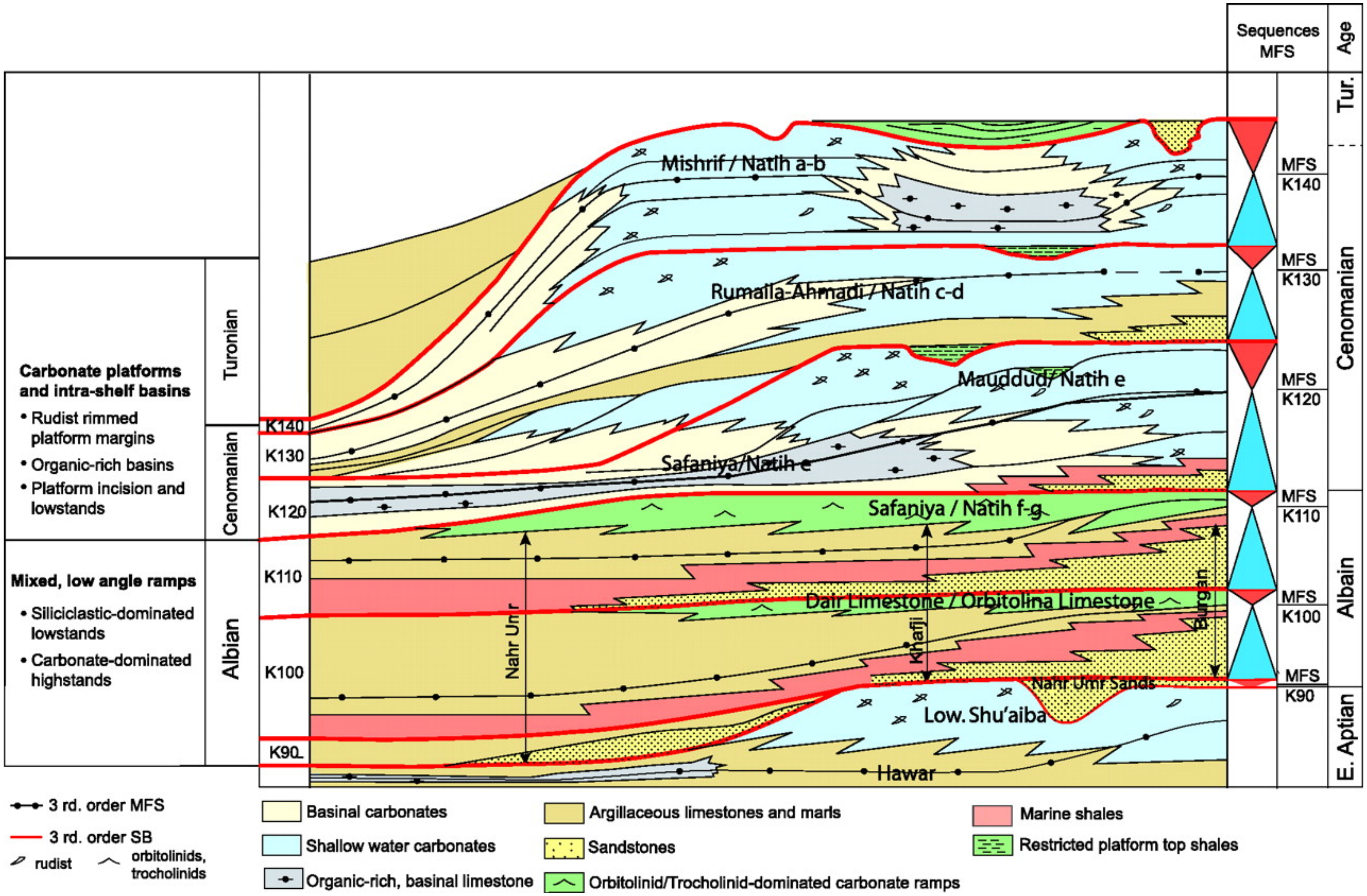
Carbonate shelf: in-situ production and transport (ecological & physical accommodation)

Balearic Archipelago: differences between physical & ecological accommodation

Lithofacies types: rhodalgal (green) vs. Coralgal (red)



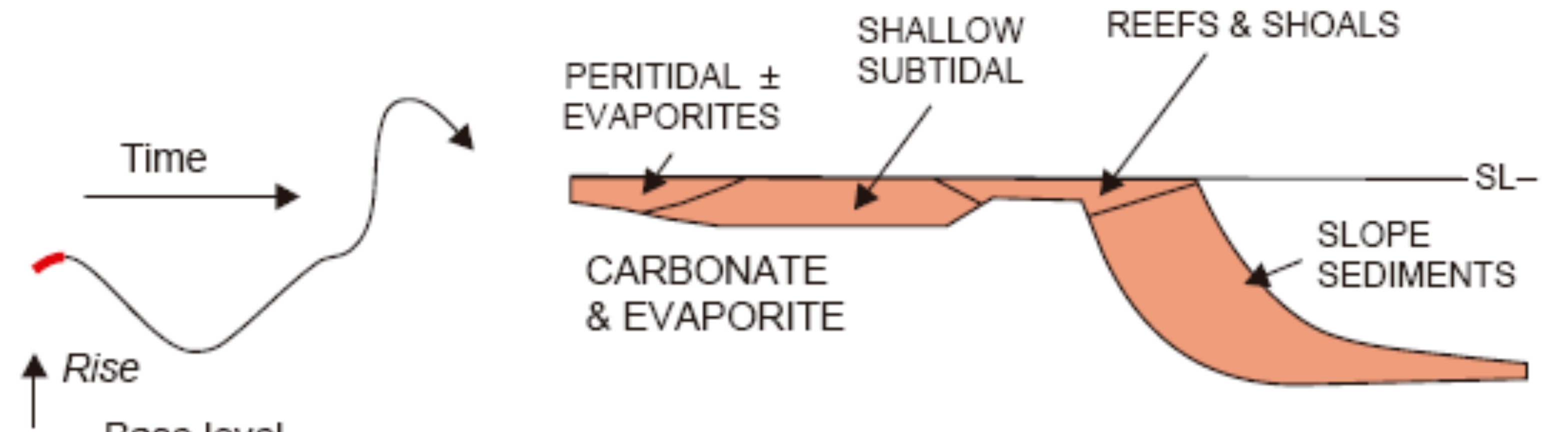
Carbonate sequence stratigraphy – carbonate shelfs



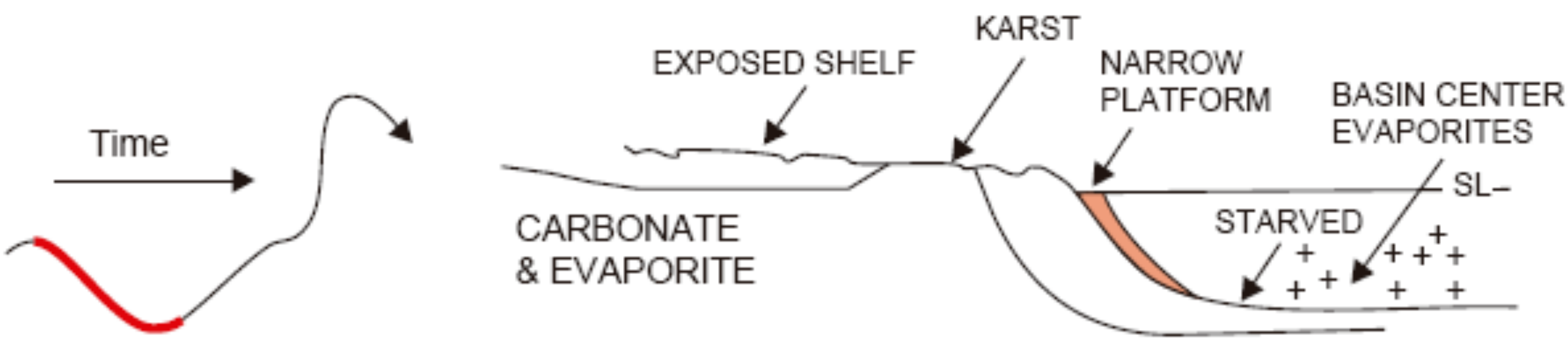
Geometric pattern and lithofacies changes within different sequences on a carbonate shelf – major difference between ramp and rimmed margin style

Carbonate sequence stratigraphy – sea-level cycle

Relative sea-level cycle on carbonate platform – *HST & FSST/LST*



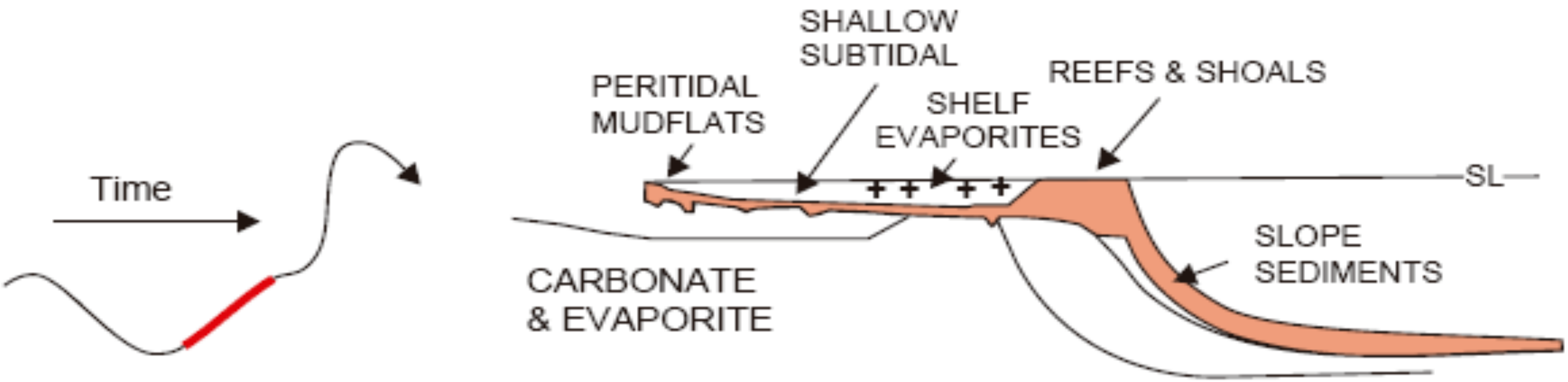
1. HST: *platform growth and progradation*



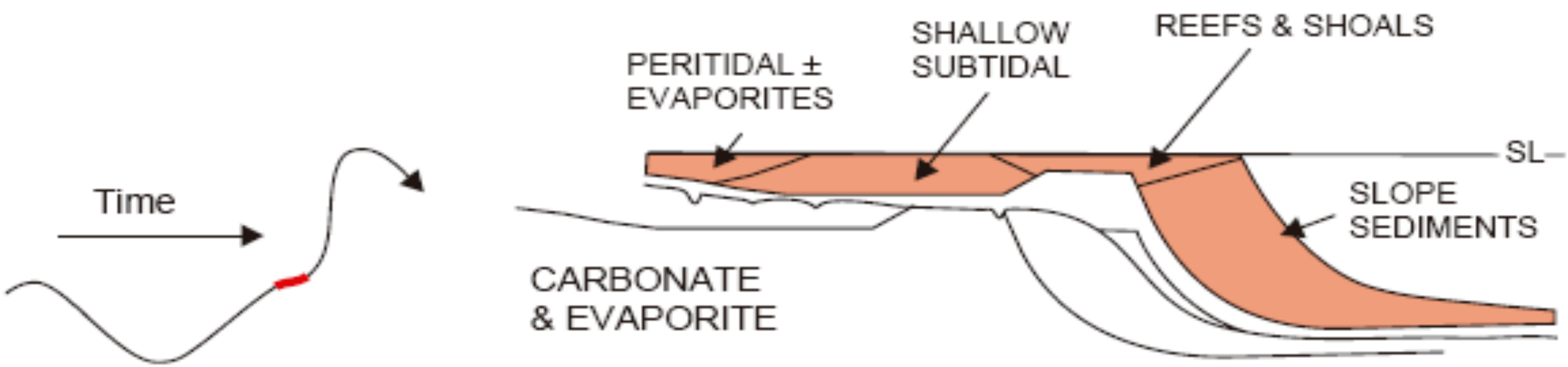
2. FSST - LST: *carbonate factory shut down*

Carbonate sequence stratigraphy – sea-level cycle

Relative sea-level cycle on carbonate platform – *TST & HST*



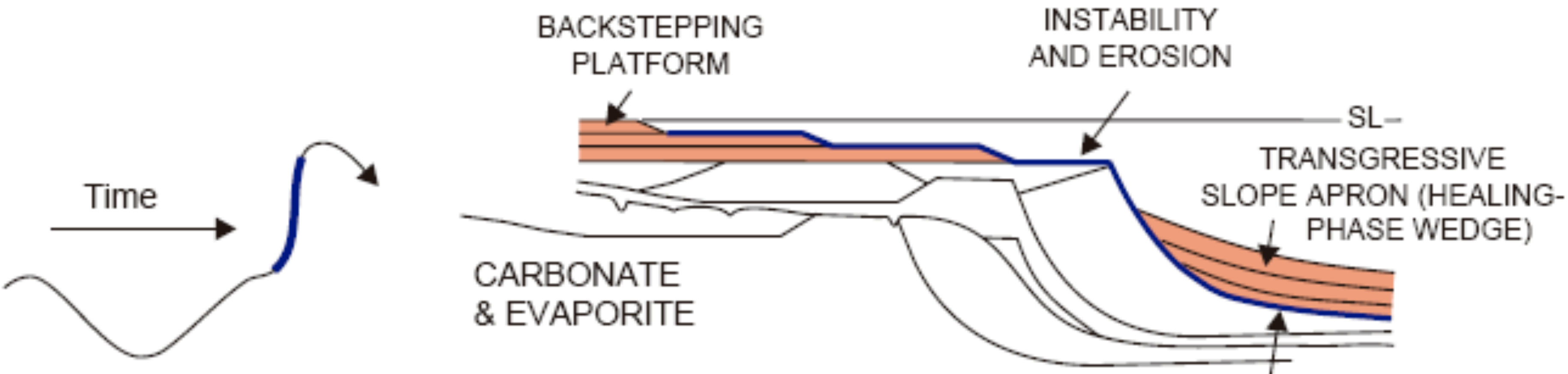
3. TST - slow transgression: *catch-up phase*



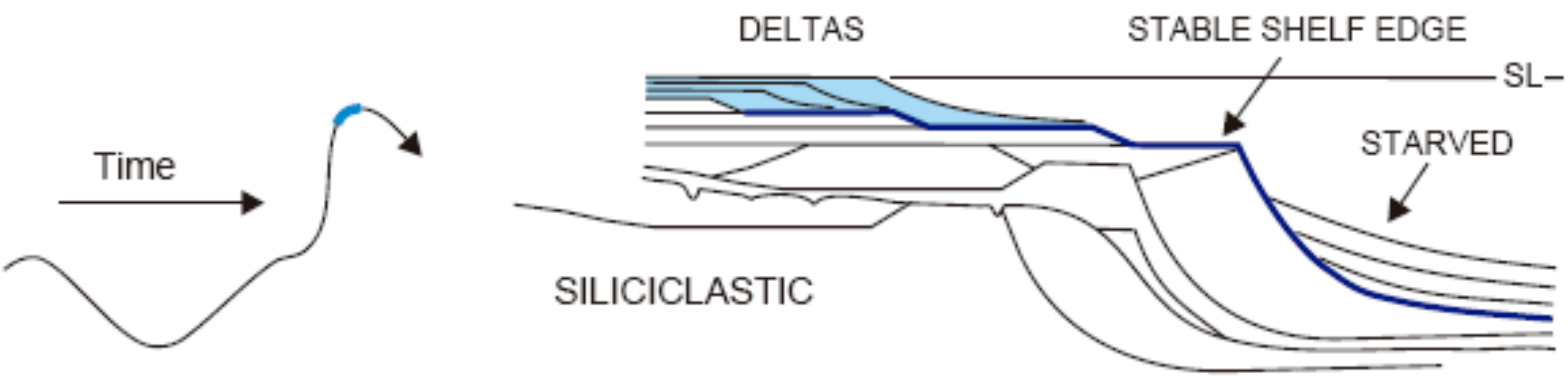
4. HST: *keep-up and progradation ('highstand shedding')*

Carbonate sequence stratigraphy – sea-level cycle

Relative Sea-level cycle on carbonate platform – *TST & HST*

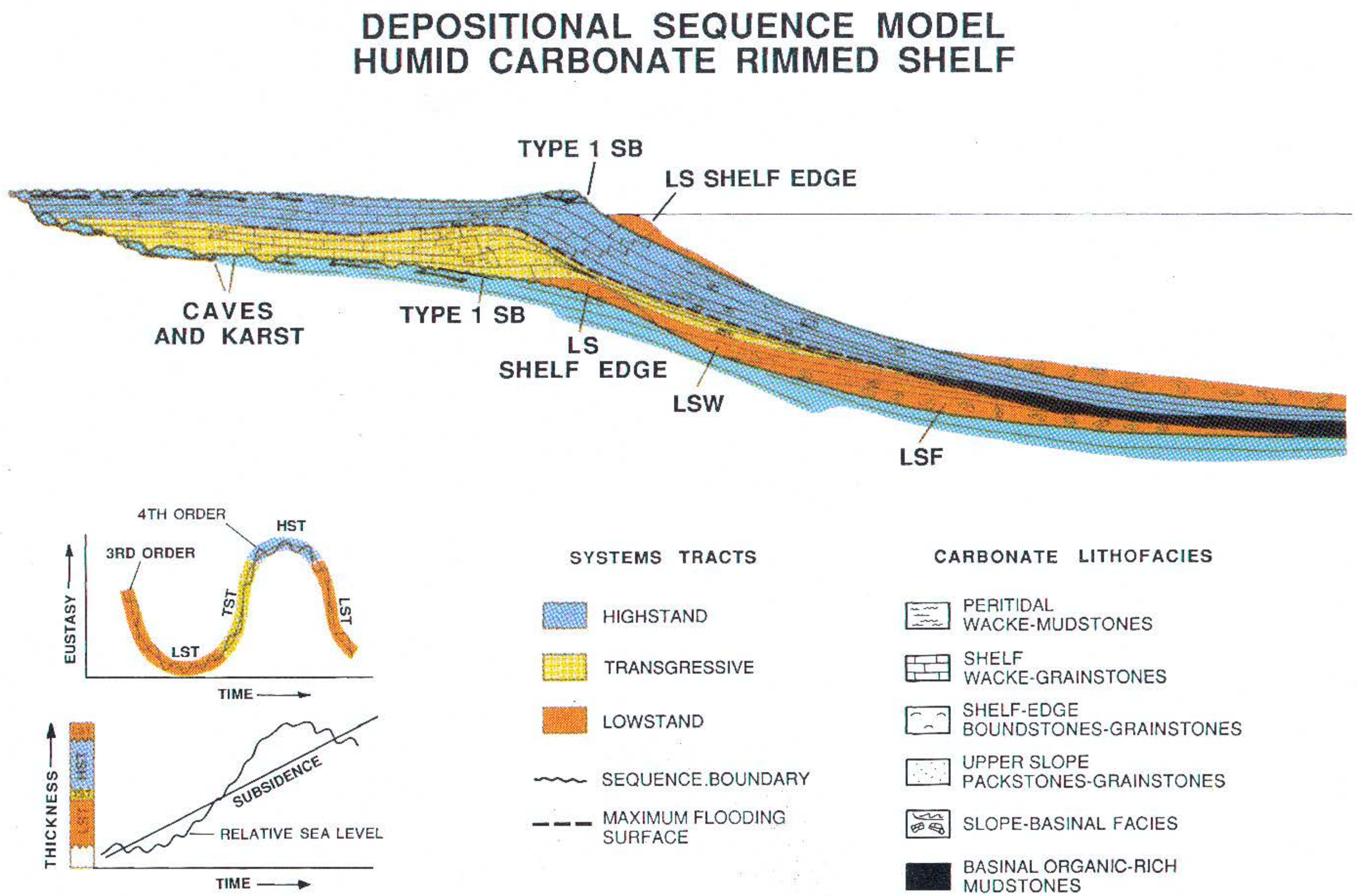


5. TST - rapid transgression: *drowning unconformity*



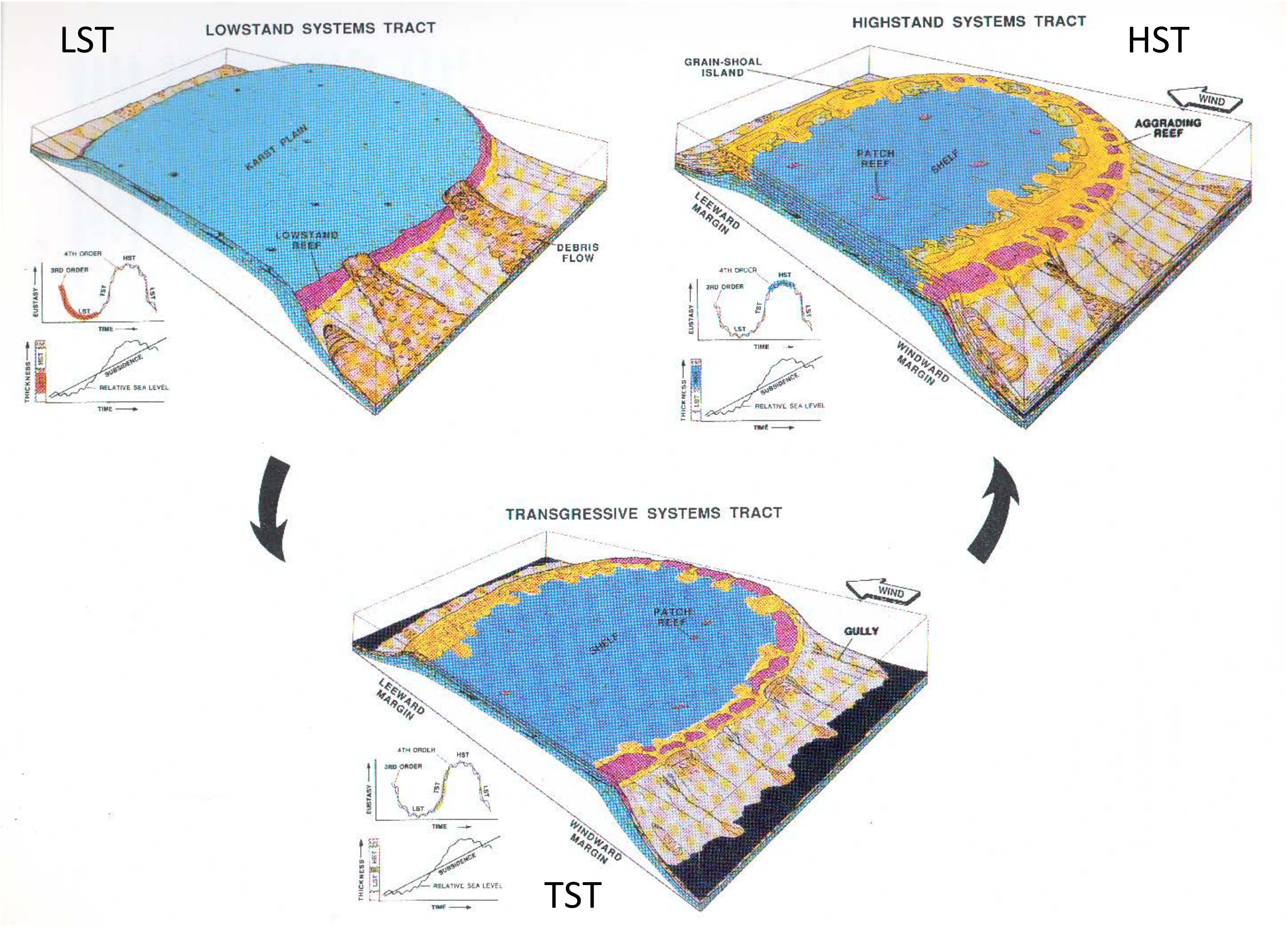
6. HST: *platform burial (siliciclastic progradation)*

Carbonate sequence stratigraphy – depositional sequence



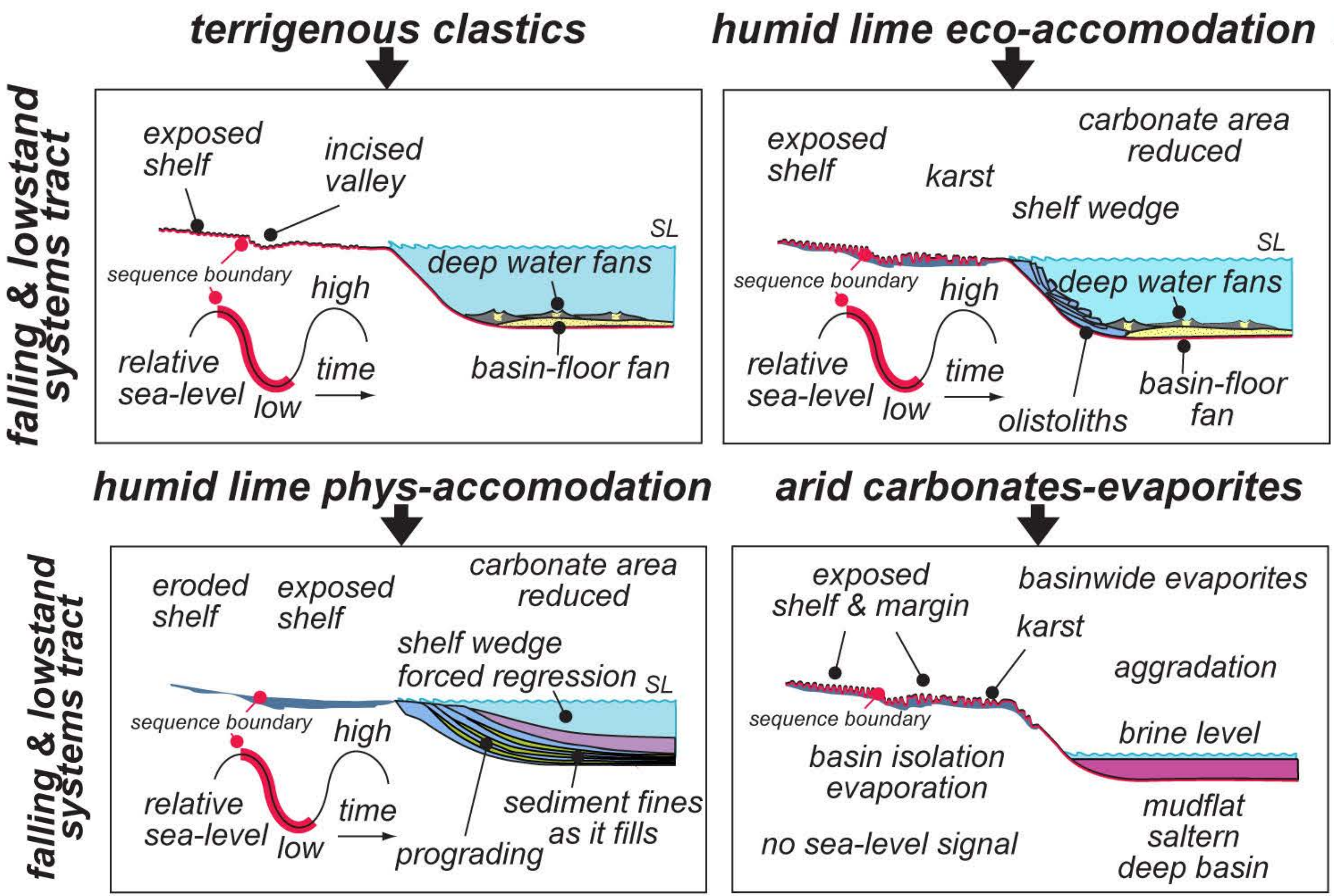
Carbonate sequence stratigraphy – depositional sequence

Depositional sequence of an isolated platform



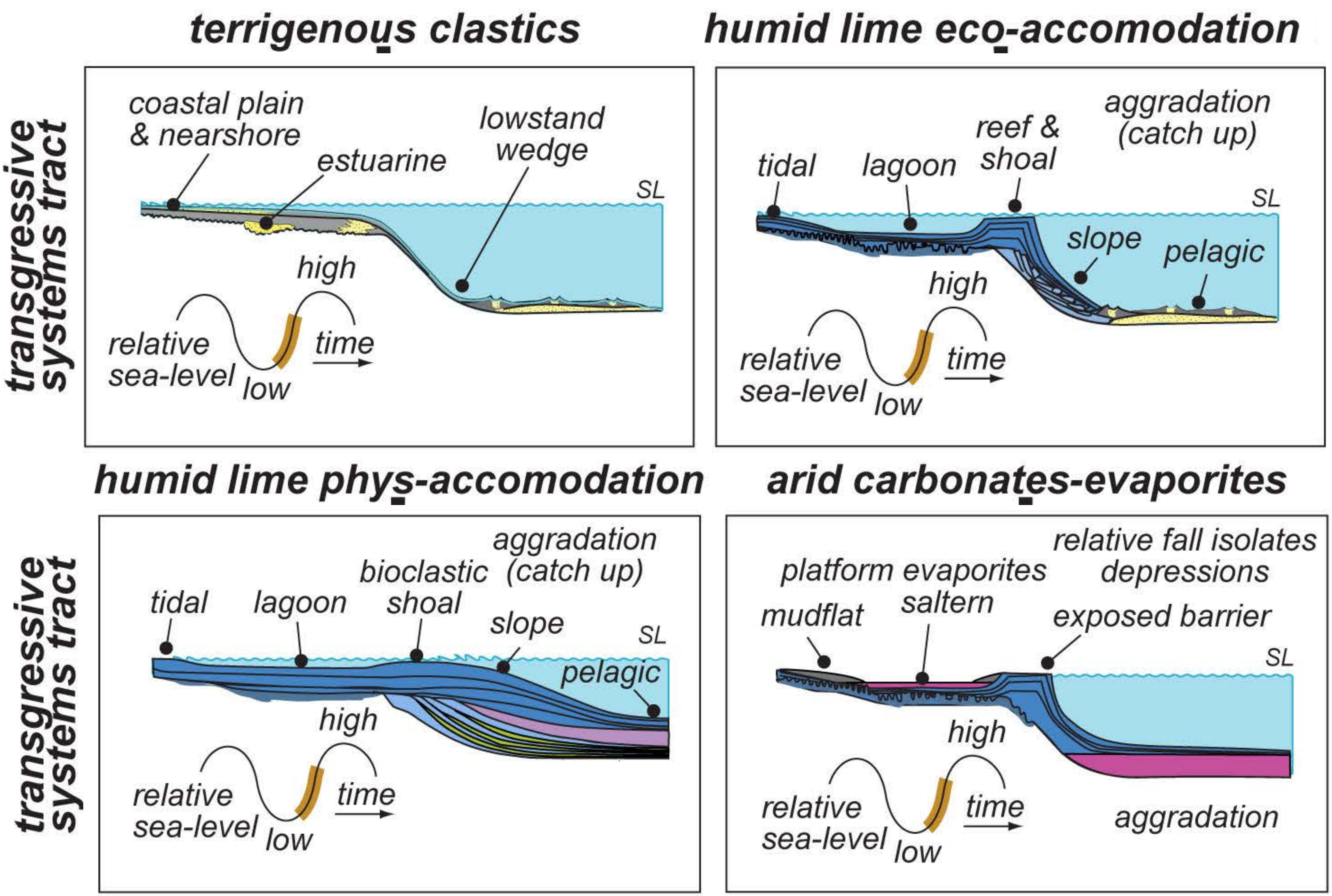
Carbonate sequence stratigraphy – depositional sequence

Depositional sequences related to different carbonate shelf environments



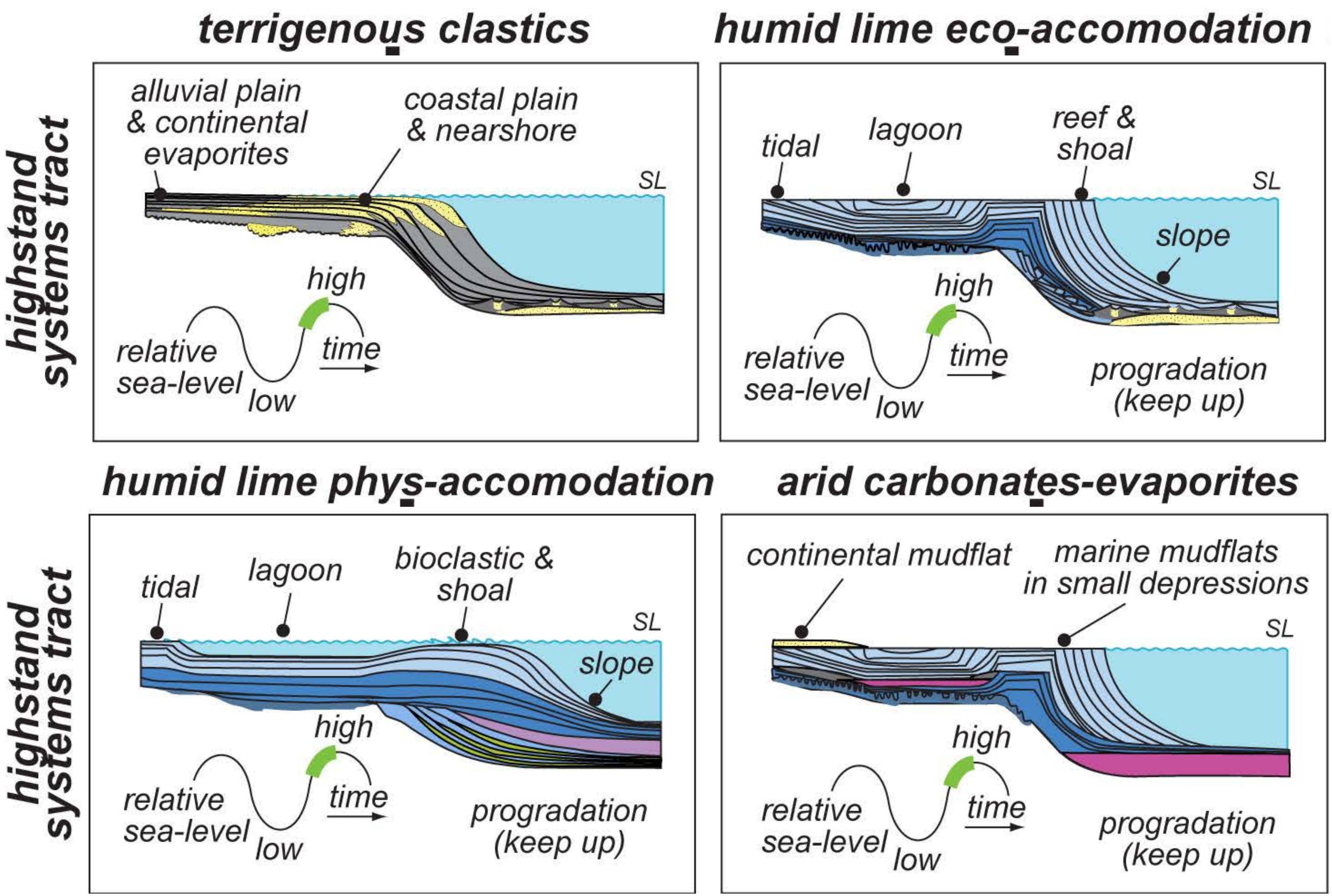
Carbonate sequence stratigraphy – depositional sequence

Depositional sequences related to different carbonate shelf environments



Carbonate sequence stratigraphy – depositional sequence

Depositional sequences related to different carbonate shelf environments



Sequence stratigraphy in seismic lines

Sequence stratigraphy of seismic lines

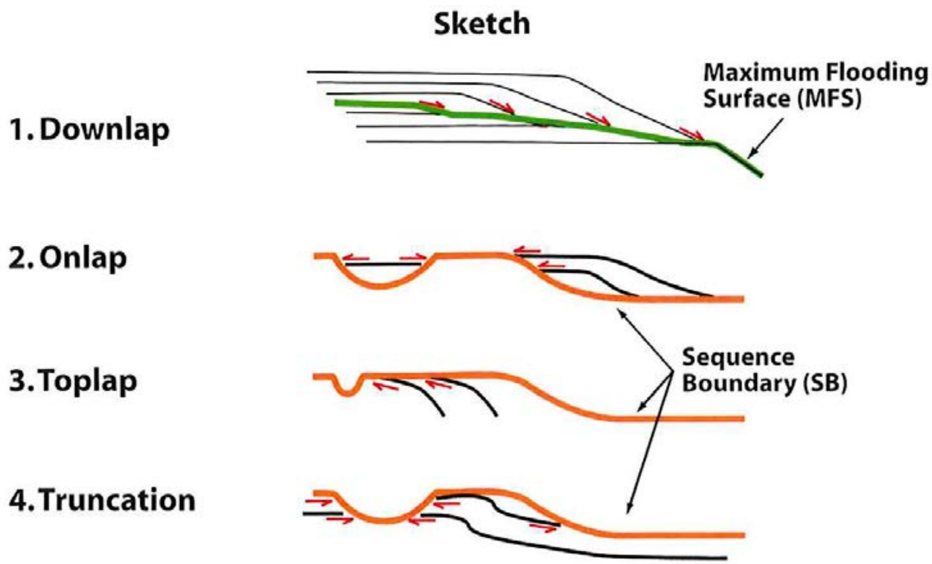
Main application for Sequence Stratigraphy is the interpretation of seismic transects

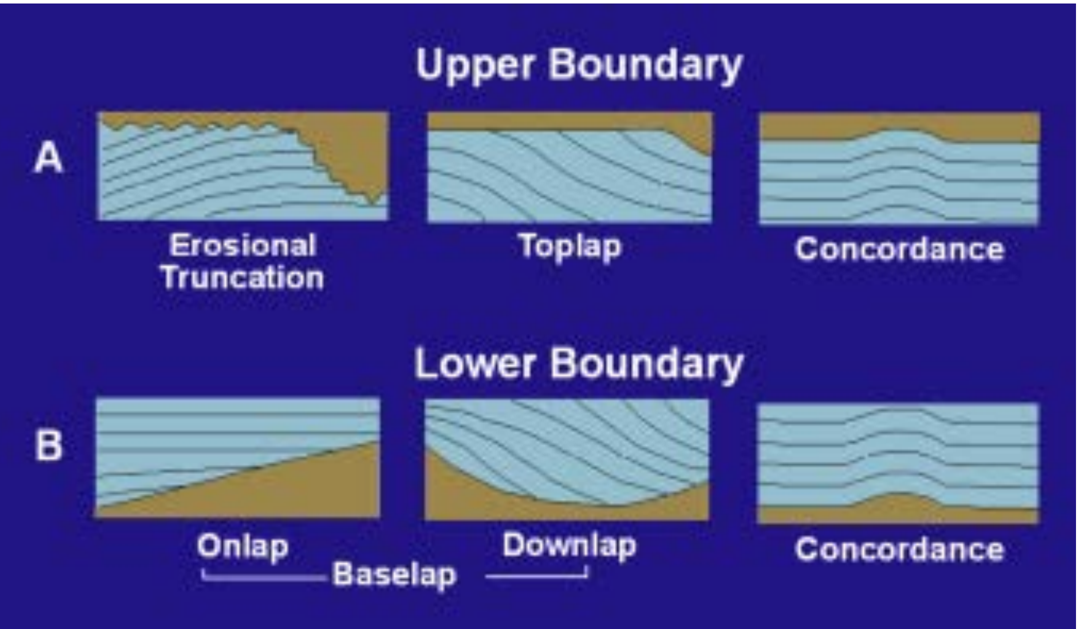
Geometrical features (terminations) observed in seismic section represent changes of physcal properties = lithological changes

Main features of Sequence Stratigraphy are terminations (time lines), boundaries and surfaces - all recognized in seismic sections

Sequence stratigraphy of seismic lines

Termination Types:

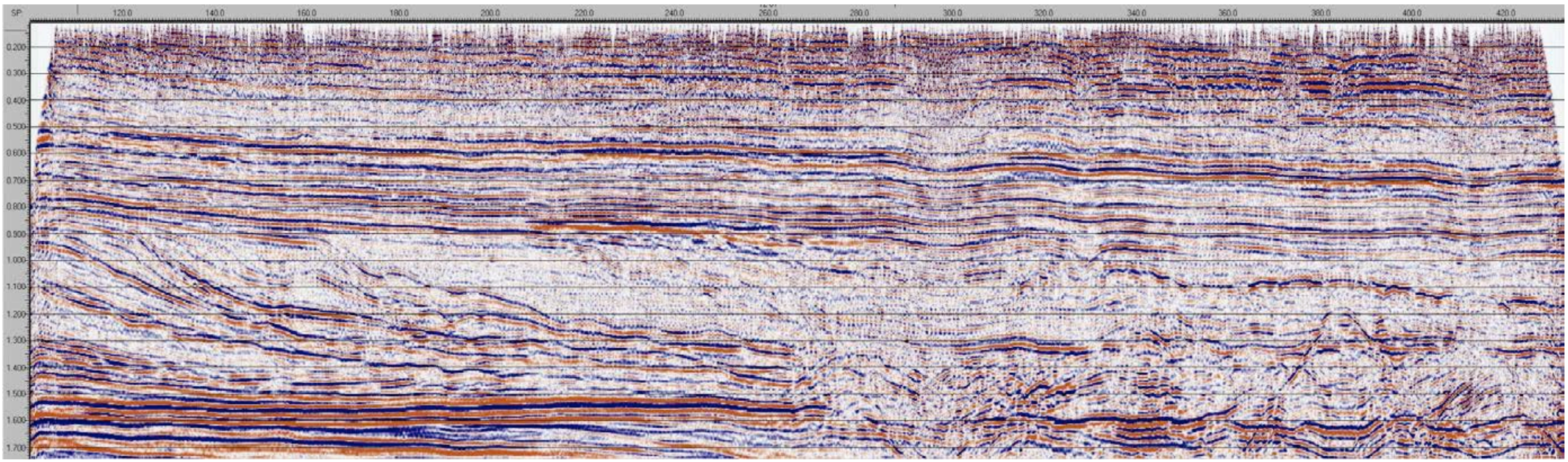


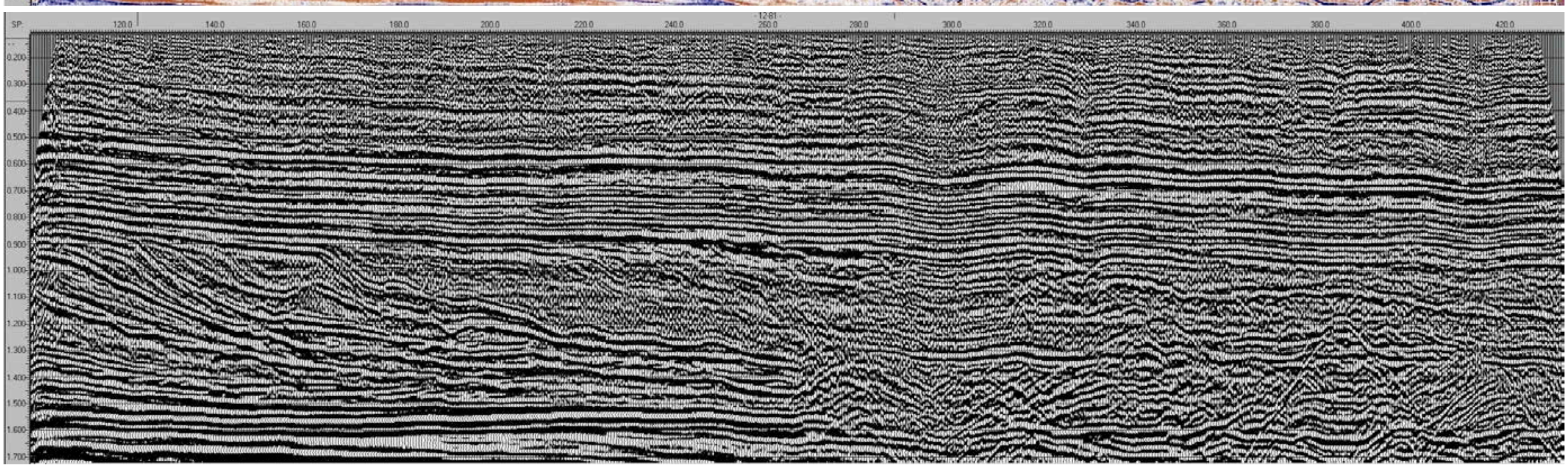


Geometric features in seismic lines

Initial idea of sequence stratigraphic analysis of seismic section was the Identification of sequences (bounded by unconformities) using terminations (seismic reflectors) to identify geometries and surface pattern

Different formats of seismic sections

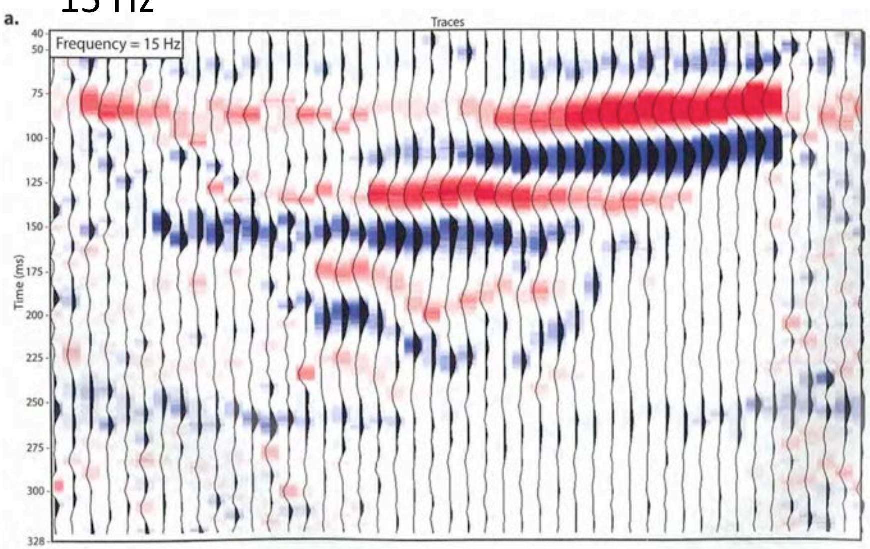




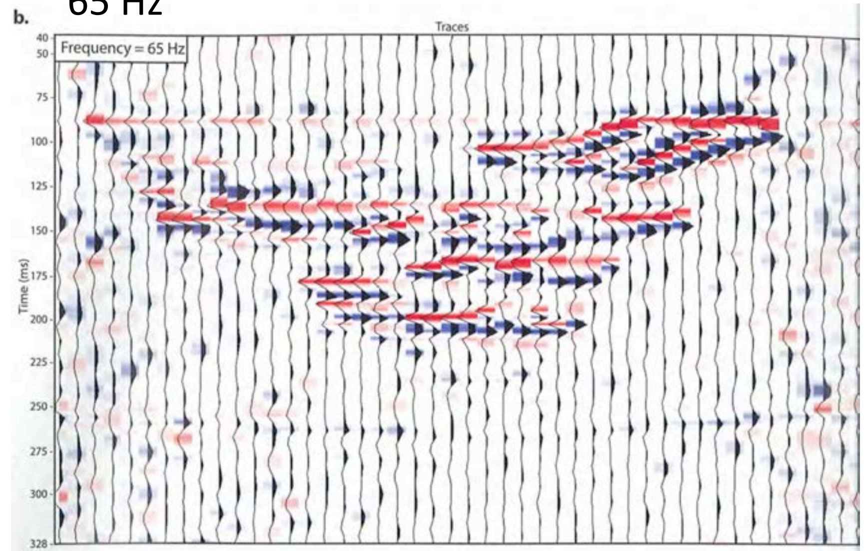
Sequence stratigraphy of seismic lines

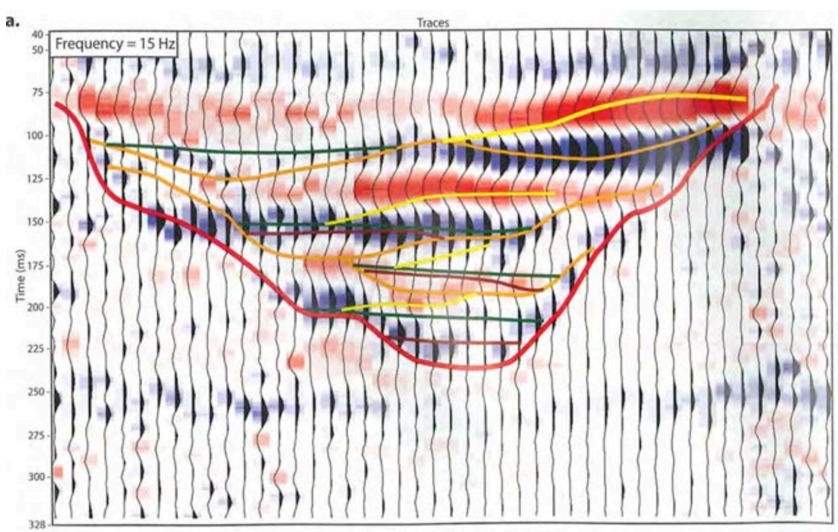
Seismic resolution limits the detail of sequence stratigraphy

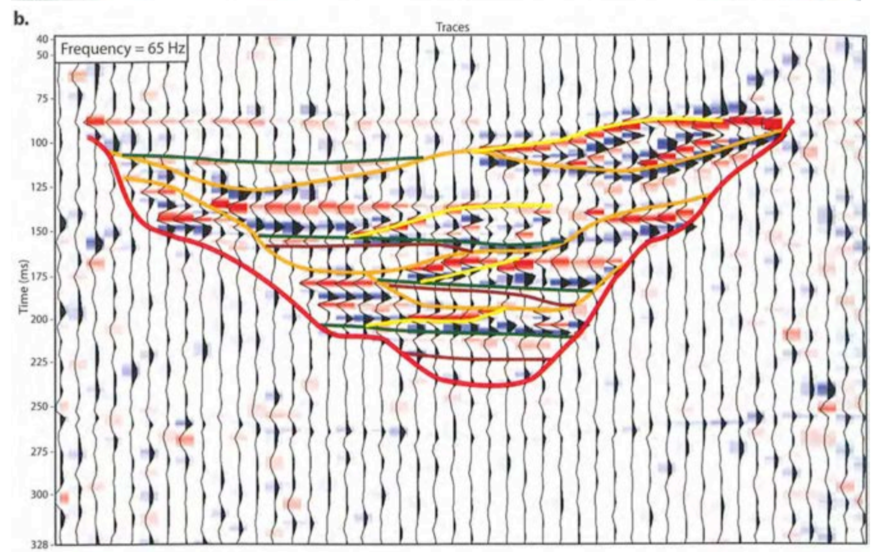
15 Hz



65 Hz







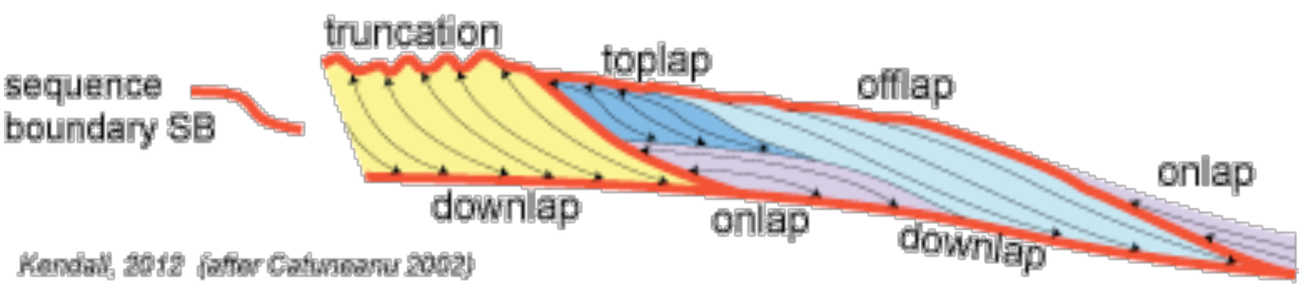
Sequence stratigraphy of seismic lines

Recommended procedures for seismic sequence analysis:

- Identifying the unconformities in the area of interest. Unconformities are recognized as surfaces onto which reflectors converge.
- Mark these terminations with arrows.
- Draw the unconformity surface between the onlapping and downlapping reflections above; and the truncating and toplapping reflections below.
- Extend the unconformity surface over the complete section. If the boundary becomes conformable, trace its position across the section by visually correlating the reflections.
- Continue identifying all unconformities in the remaining seismic section
- Identify the type of unconformity:

  Sequence boundary: this is characterized by regional onlap above and truncation below.

  Downlap surface: this is characterized by regional downlap.



Kendall, 2012 (after Catuneanu 2002)

Sequence stratigraphy of seismic lines

Recommended color codes:

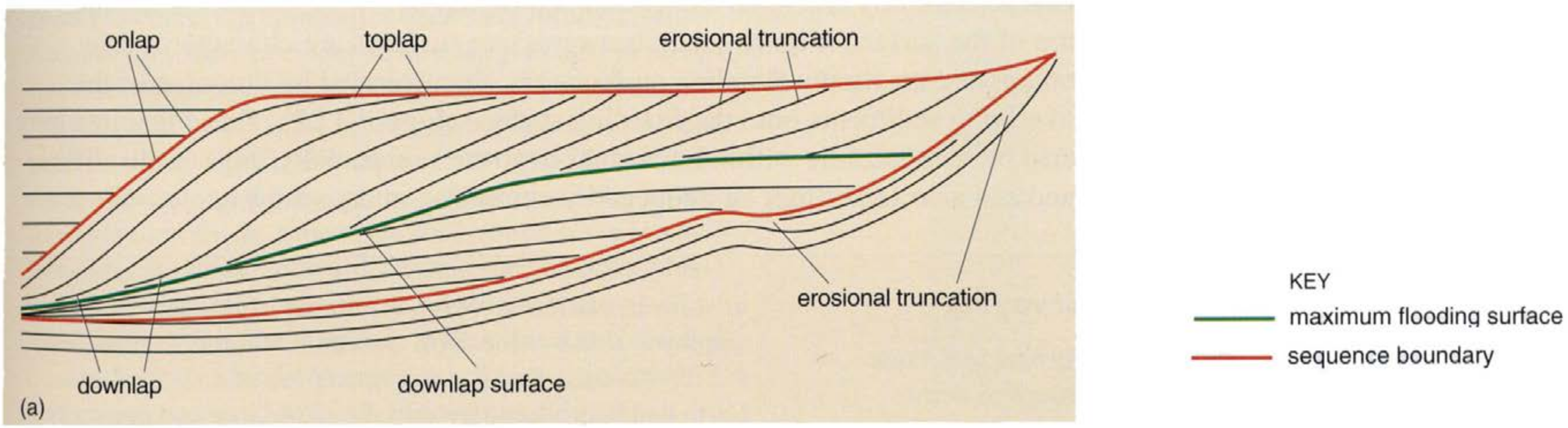
- Red: reflection patterns and reflection terminations.
- Green: downlap surface
- Blue: transgressive surface
- Other colors: sequence boundaries

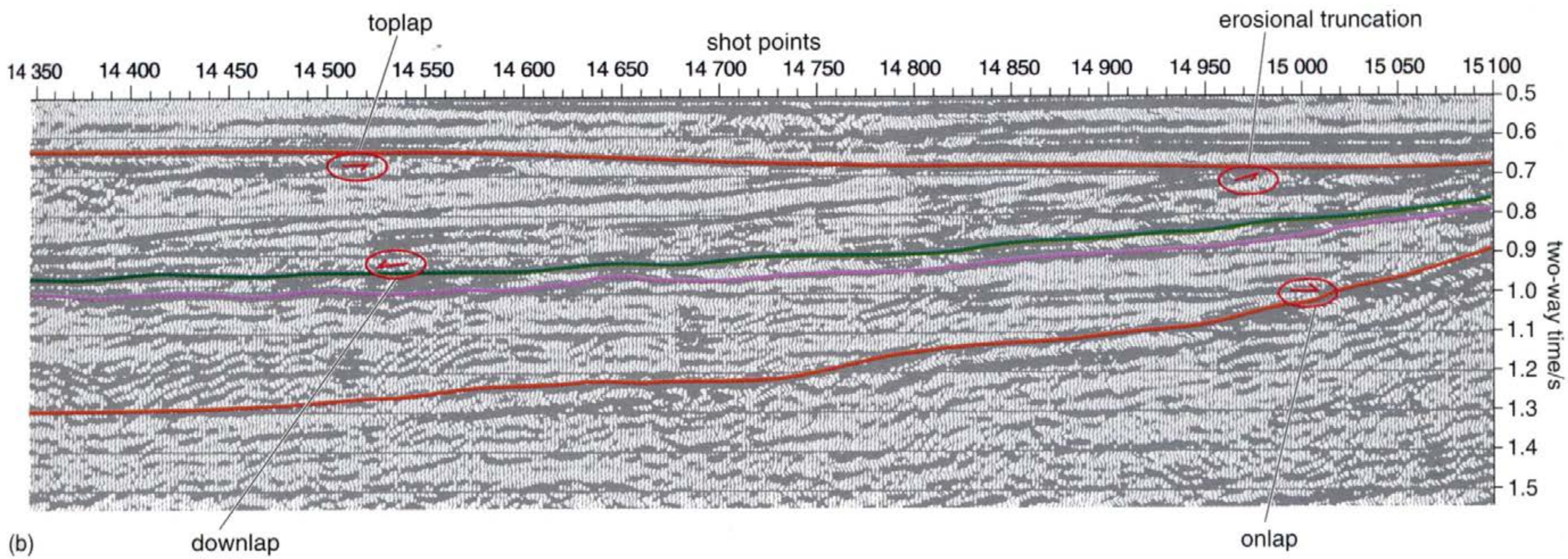
If using only black and white:

- Thin solid lines: reflection patterns
- Thicker solid lines: sequence boundaries
- Dashed lines: downlap surface
- Dotted lines: transgressive surface

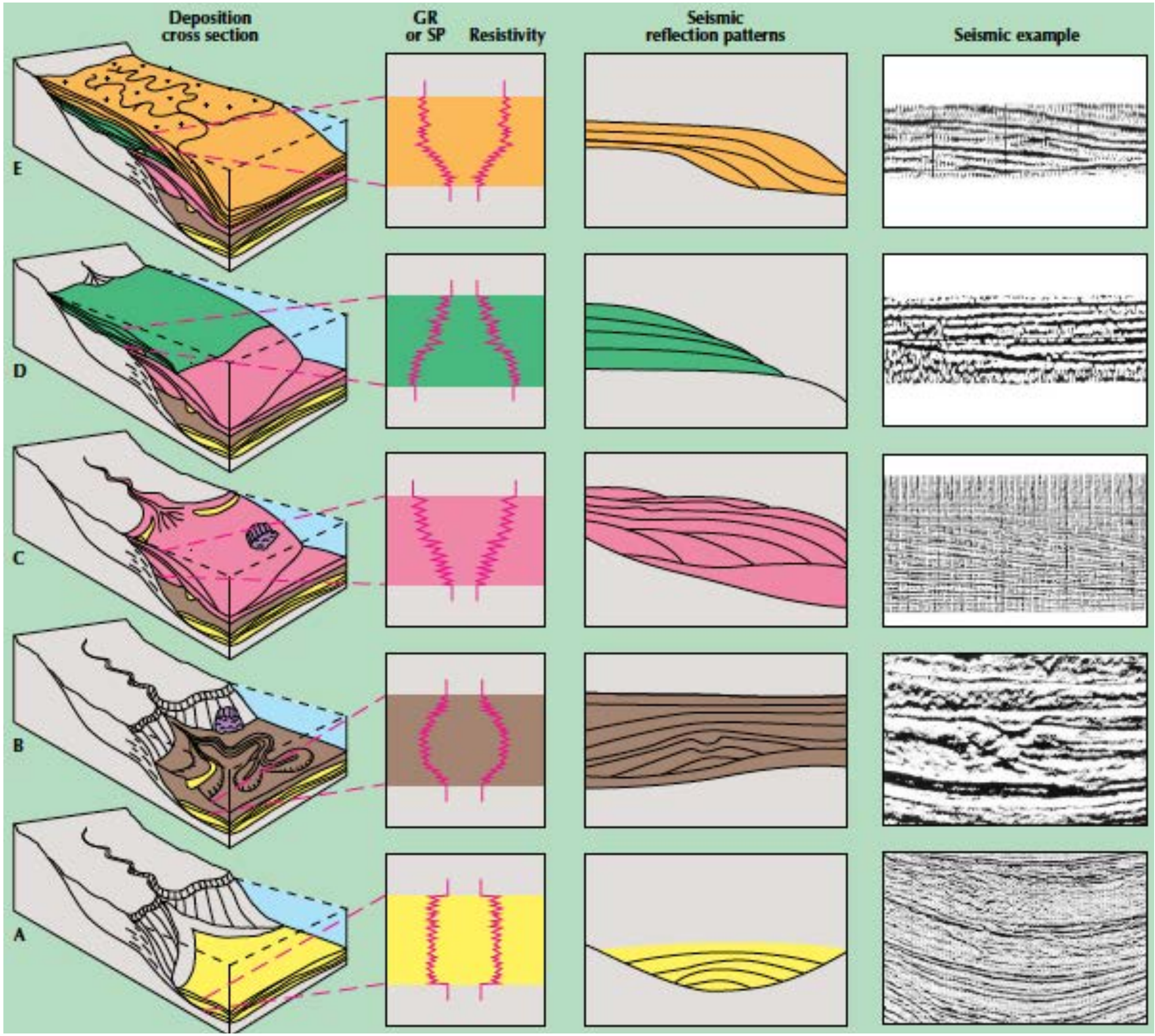
Sequence stratigraphy of seismic lines

Identification of surfaces





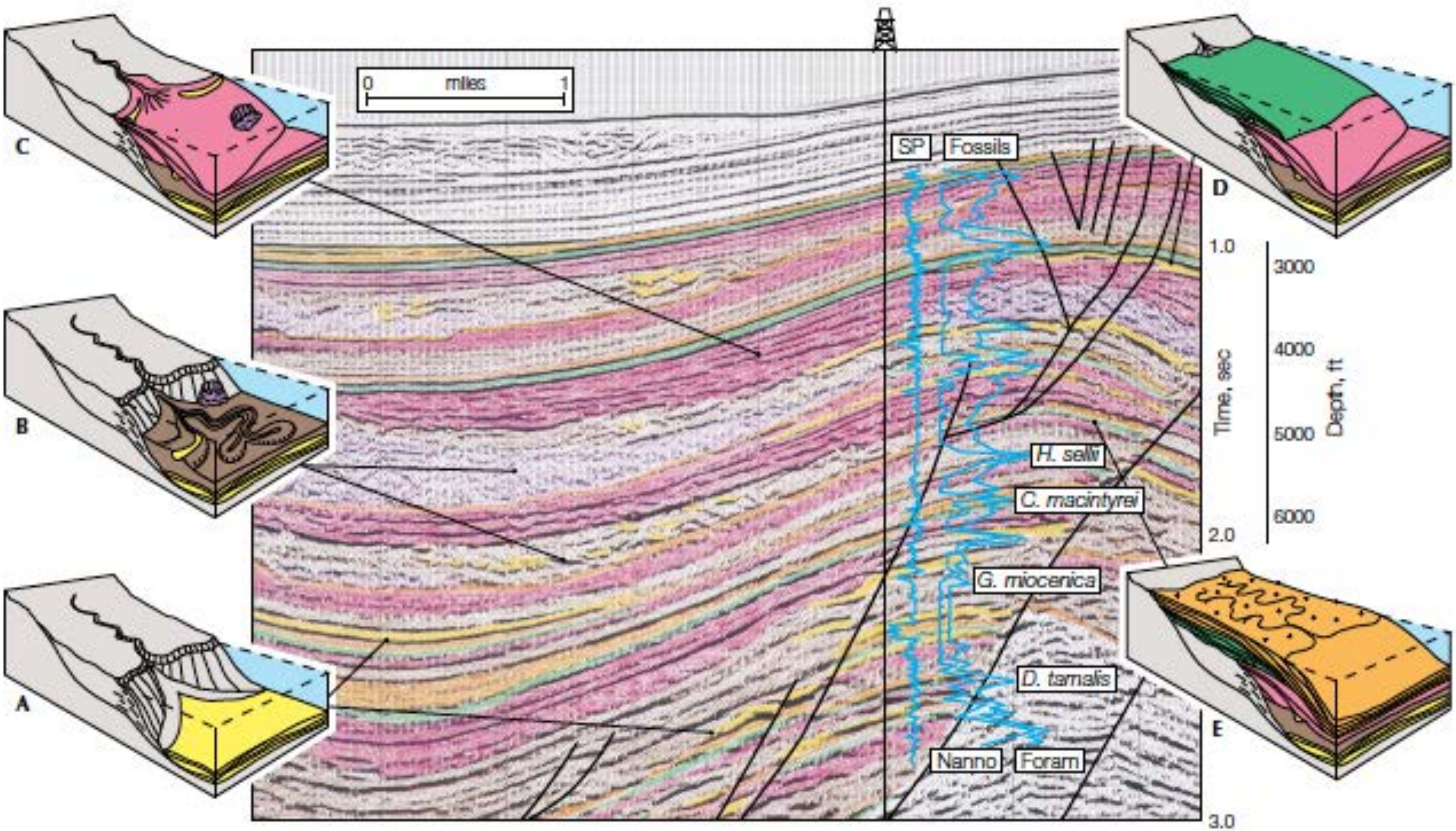
Sequence stratigraphy of seismic lines



Correlation of seismic pattern and well logs of different depositional settings, related to different system tracts

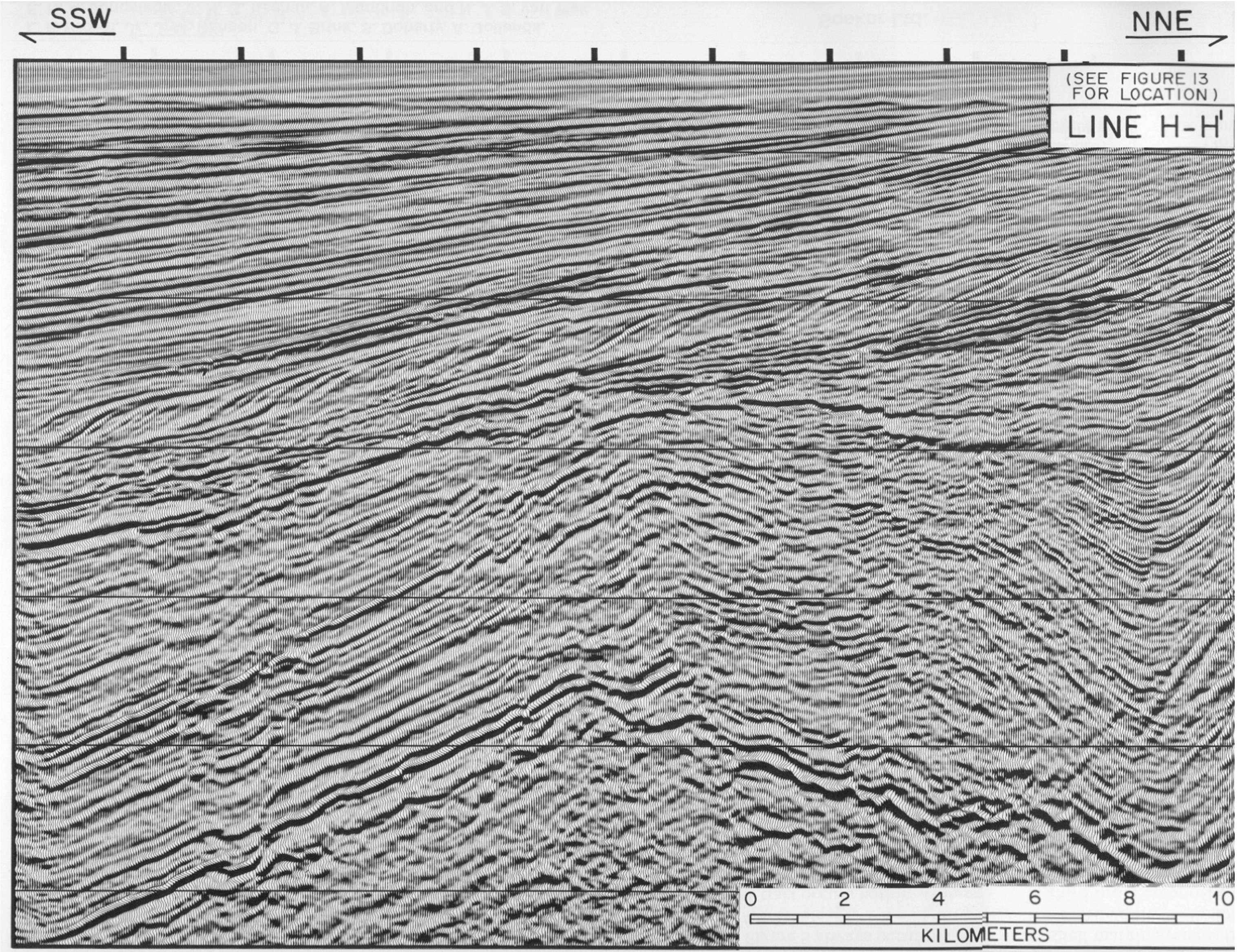
Sequence stratigraphy of seismic lines

Identification of of different depositional settings (related to different system tracts) in a seismic section



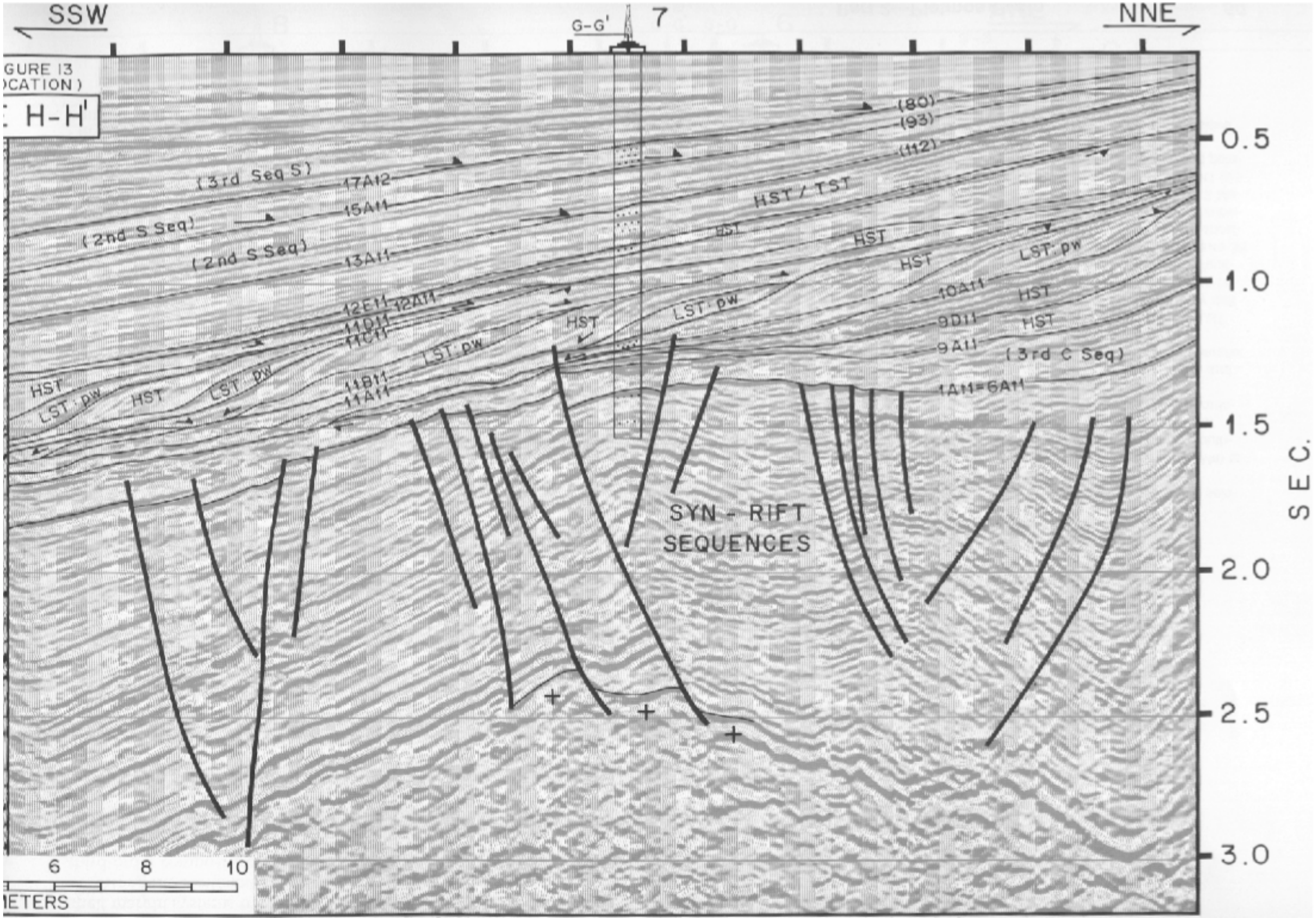
Sequence stratigraphy of seismic lines

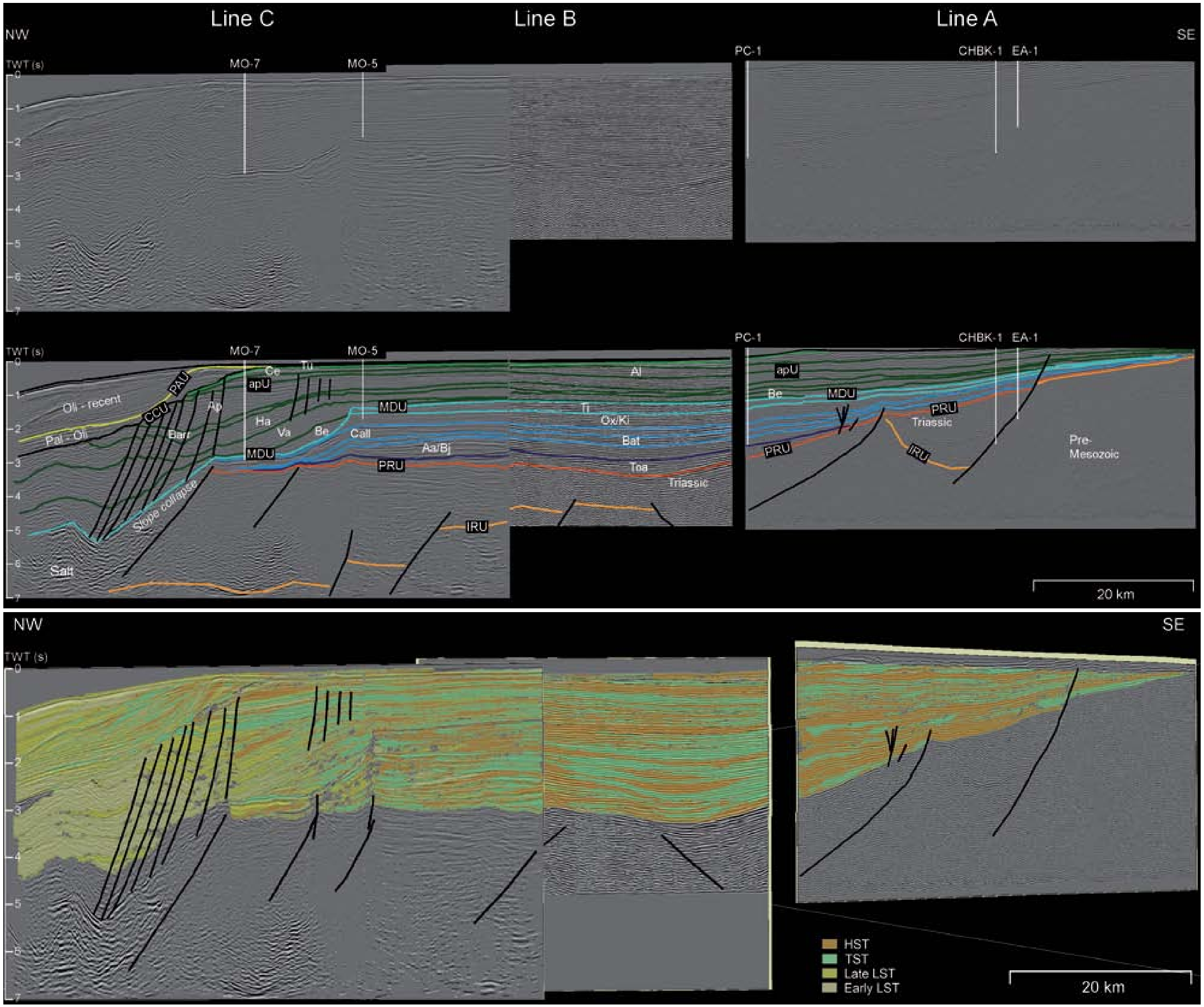
Analysis of all seismic terminations



Sequence stratigraphy of seismic lines

Analysis of all seismic terminations





Sequence stratigraphic analysis of seismic transect

1. identification of surfaces

2. definition of system tracts