

Ecological Accommodation: A Key to the Interpretation of Carbonate Platform Architecture Variability*

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Abstract

The complex spectrum of heterogeneous facies architectures of carbonate platforms includes: 1) low-relief carbonate ramps that match a shelf-equilibrium profile and are composed of either loose, fine-grained sediments produced in shallow areas but shed downdip, or sediment mostly produced and accumulated in the deeper part of the depositional profile, 2) open shelf platforms involving large-skeleton metazoans with moderate capacity to build above the shelf-equilibrium profile, 3) platforms with biotic components capable of building up to sea level with a maximum ecological accommodation, and 4) platforms with steep, massive and thick marginal slopes.

The depositional order of the basic accretional units (sequences, cycles, parasequences, and/or beds), their geometry and stacking patterns provides a template for the interpretation of each platform succession. The interpretation rebuilds each platform in terms of its distinctive and unique response to geotectonic setting and the physical, chemical and biological conditions at deposition, expressed in terms of changes in both physical and ecological accommodation. Physical accommodation relies in basin floor conditions and hydrodynamics, while ecological accommodation relies on the potential to build upward. Changes in ecological accommodation depend on biological evolution, changes in ecological conditions and on the temporal/spatial evolution of the depositional settings.

Each succession has a distinct depositional profile, facies belt distribution, and platform architecture that guides the analysis of the inferred character of the ecology of ancient biota and reduces the uncertainty of interpretation. This system formulates new questions leading to realistic interpretations and enhanced predictions of lithofacies heterogeneities.

Ecological Accommodation: a Key to the Interpretation of Carbonate Platform Architecture Variability



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Premise: Stratal patterns and facies architecture develop in response to **sediment flux** and **accommodation space**

However: in lithoclastic systems sediment flux and accommodation space are **independent**

In carbonate systems:

- sediment flux & accommodation are **interdependent**
- multiple kinds of sediment flux (production)
- accommodation **is two fold: physical & ecological**

Our objectives are ...

- to analyze the variability in carbonate platforms through the Mesozoic & Cenozoic, and
- to discern the key factors in controlling the wide spectrum of platform types and their internal architectures

Accommodation:

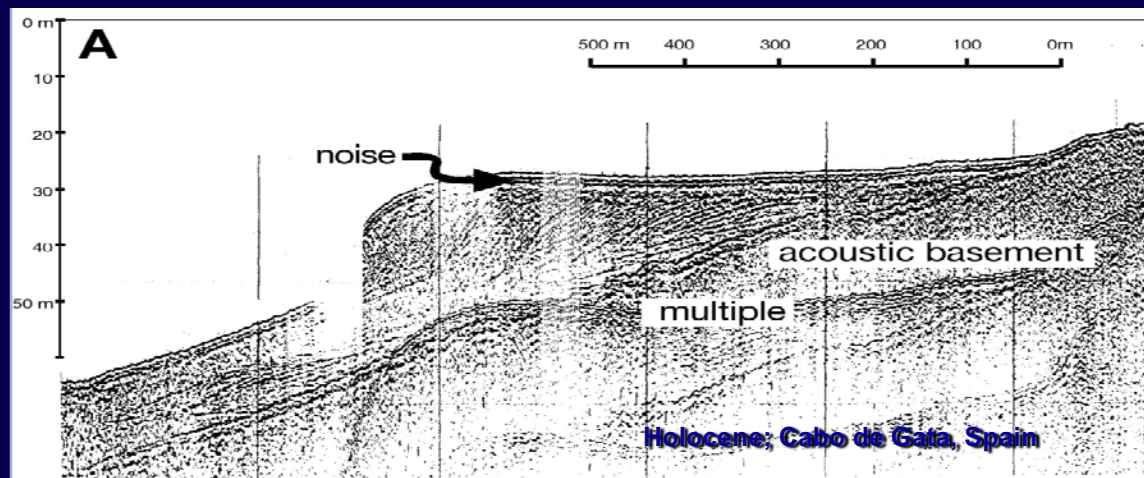
the space available for sediment accumulation

(Jervey, 1988; Vail et al. 1991; Posamentier and James, 1993)

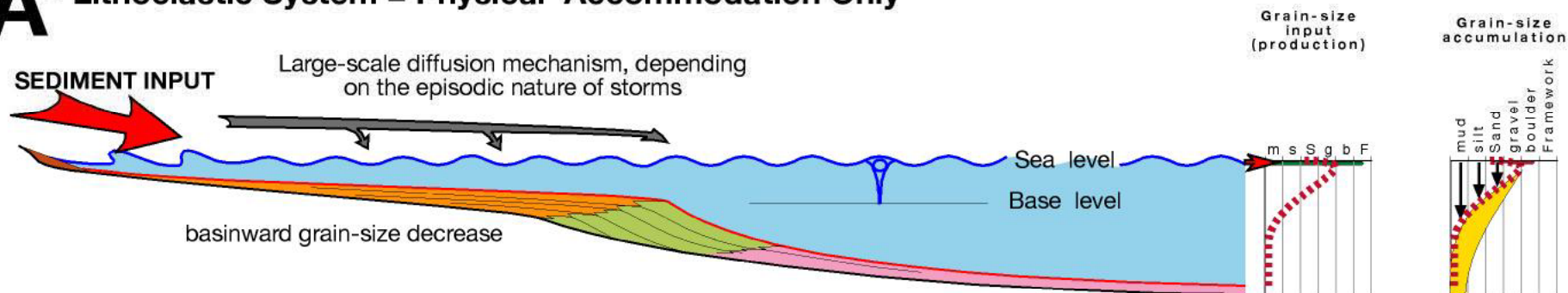
In **lithoclastics**, this is the space between **sea floor** and **base level**.

The “**base level**” for sediment accumulation tends to match the “**shelf equilibrium profile**”, the depth at which sediments are stirred by waves and currents (Swift and Thorne (1991).

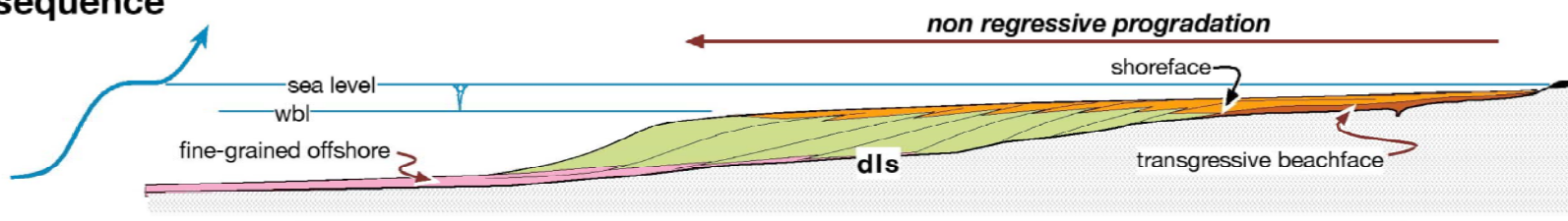
This is the physical accommodation



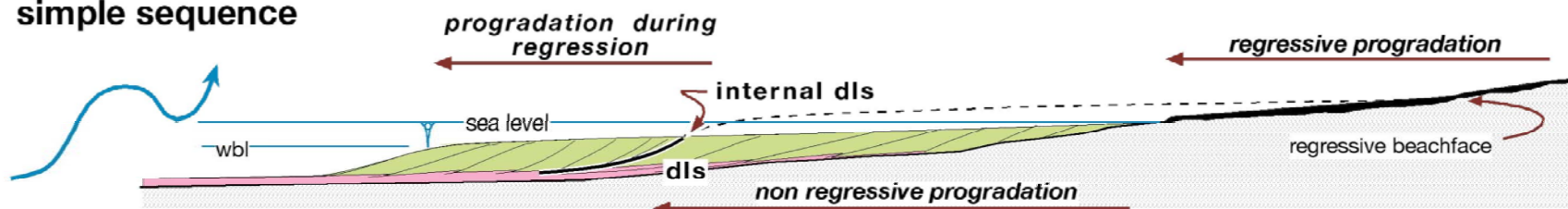
A - Lithoclastic System = Physical Accommodation Only



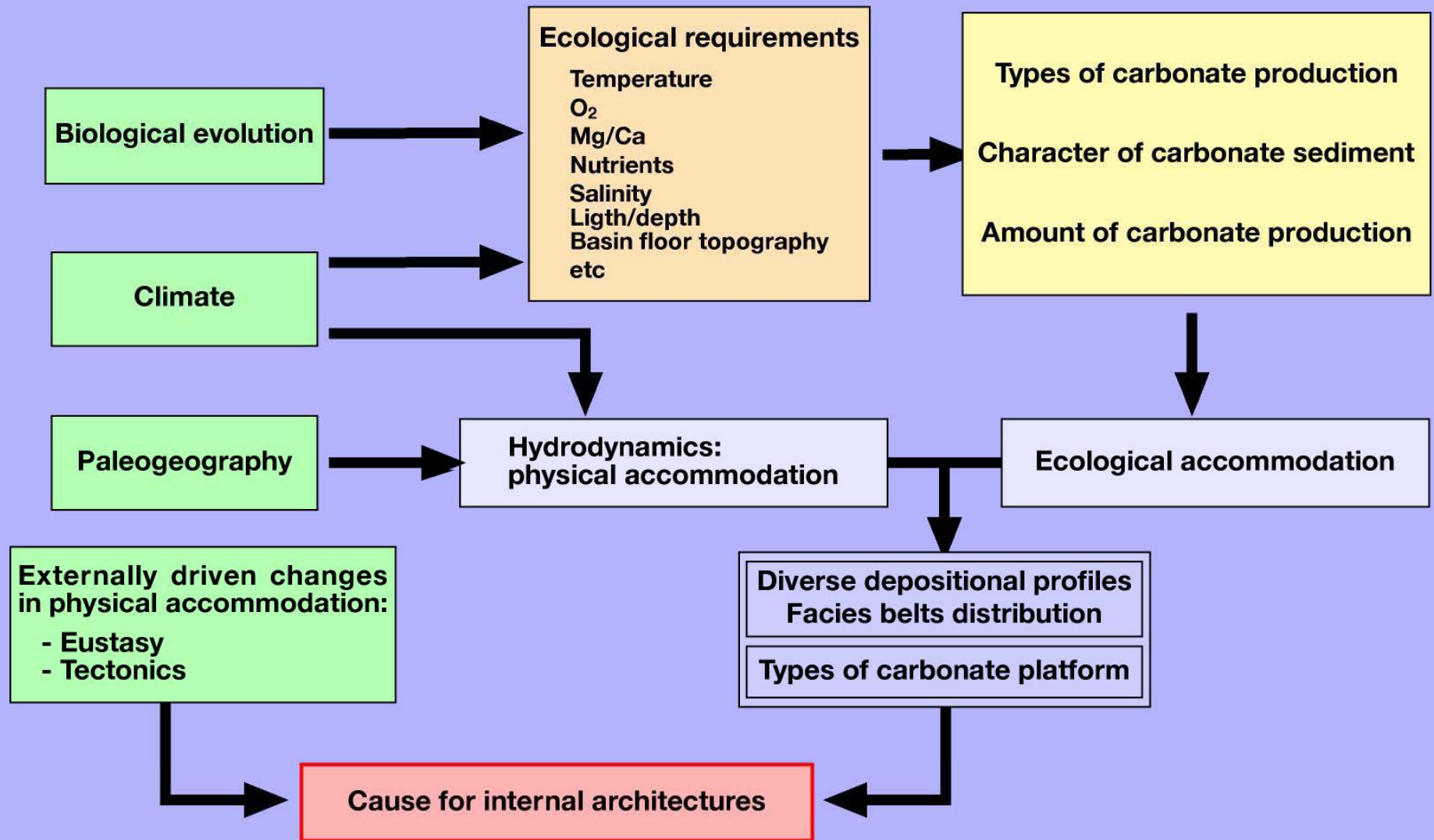
parasequence



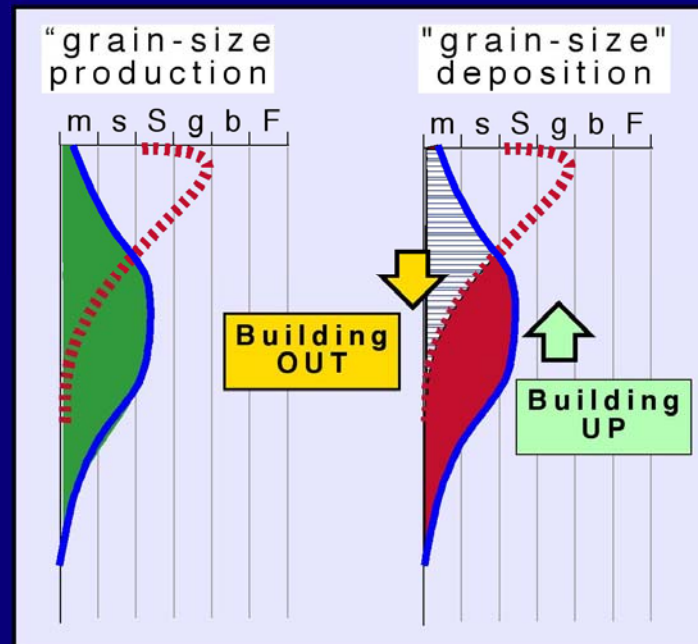
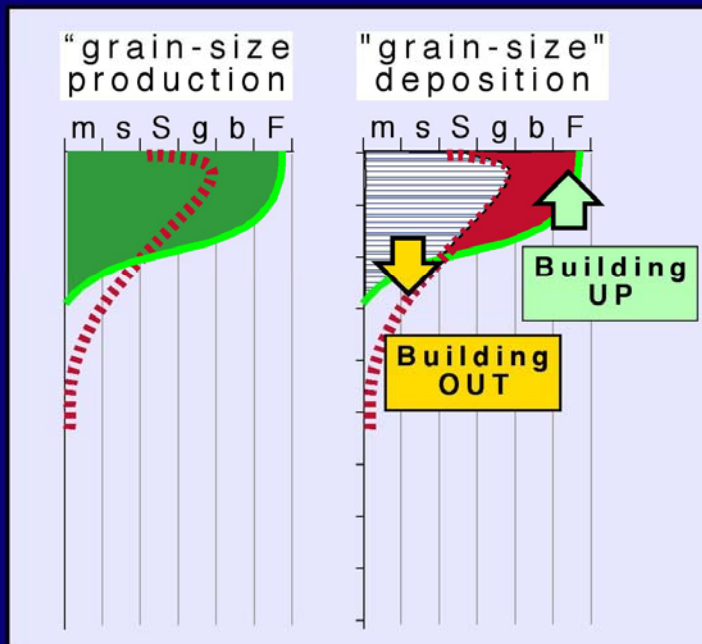
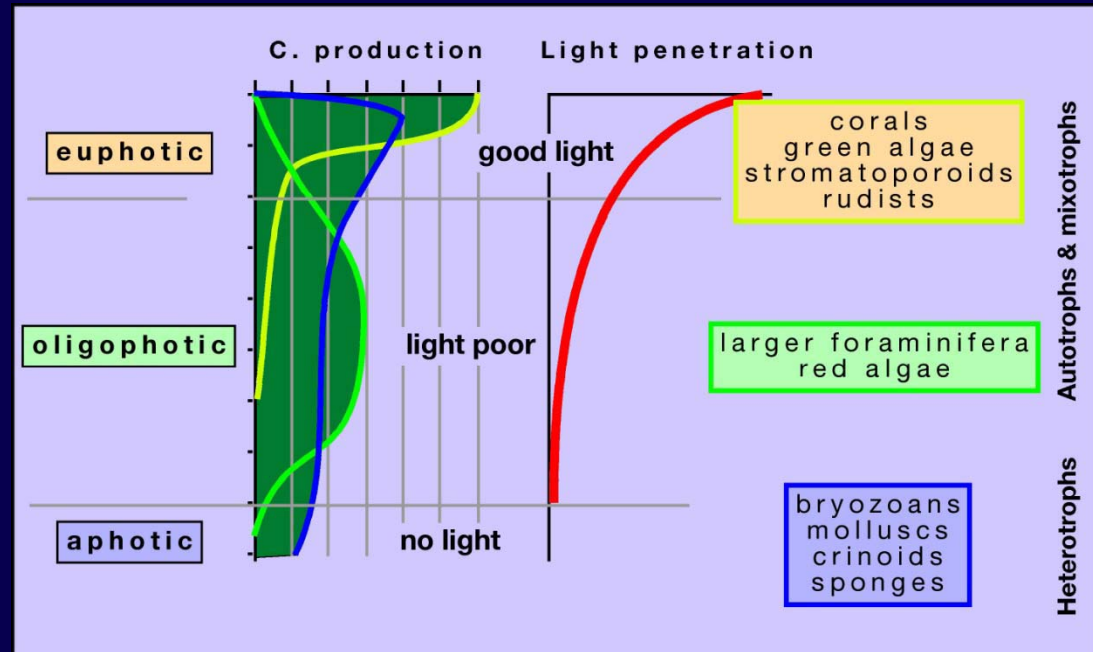
simple sequence



In carbonate systems, however, many controls exist



Sediment input



Sediment dispersal

And these differences result in the wide spectrum of platform types

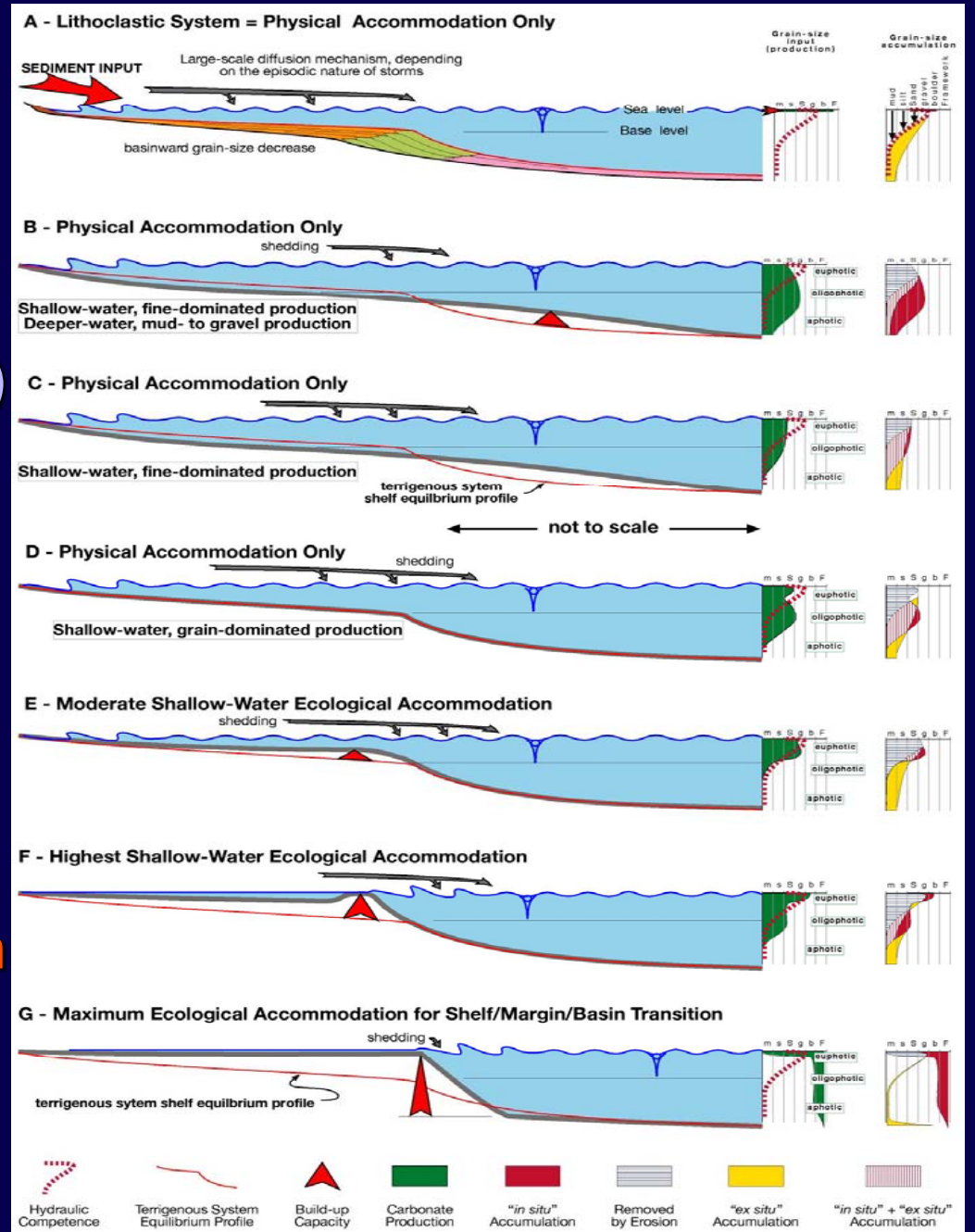
physical accommodation
(hydrodynamic conditions)

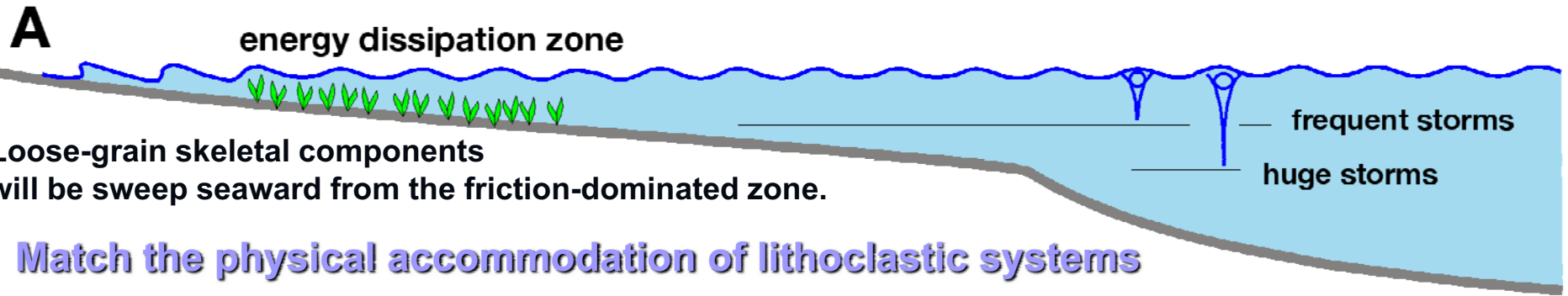


and

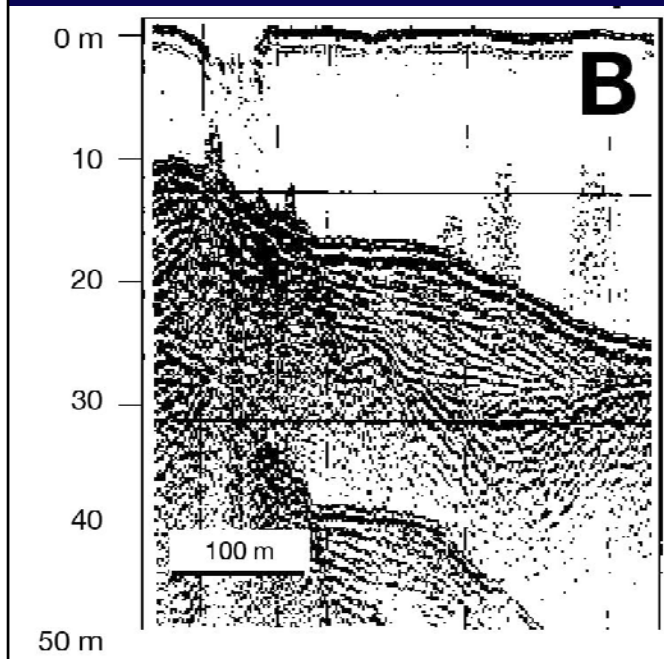


ecological accommodation
(building-up competence)

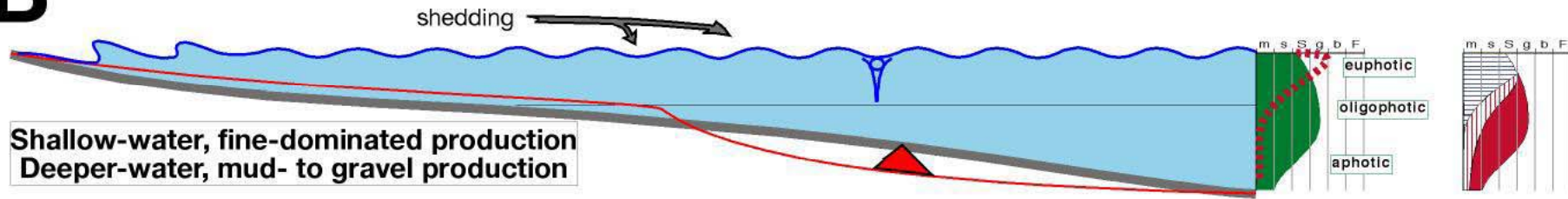




Holocene; bioclastic system, Balearic Islands

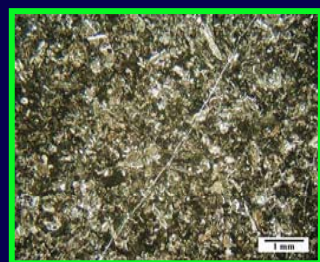


B - Physical Accommodation Only



Enhanced carbonate production in the aphotic zone

Middle Miocene, Central Apennines, Italy

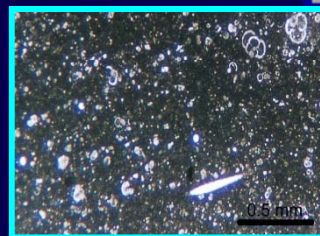


Echinoid/foraminifera
packstone

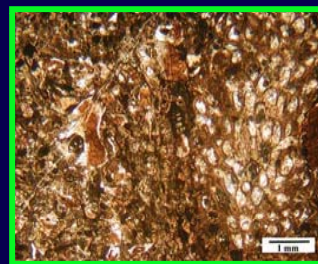
16-15 Ma

17.5 Ma

21-19 Ma

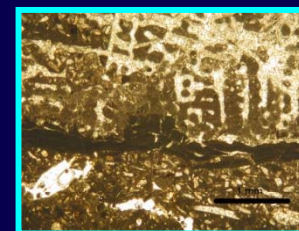
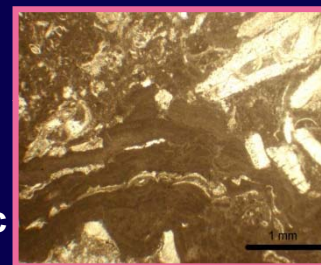


Spic-Plank.
Foram. Pkt.



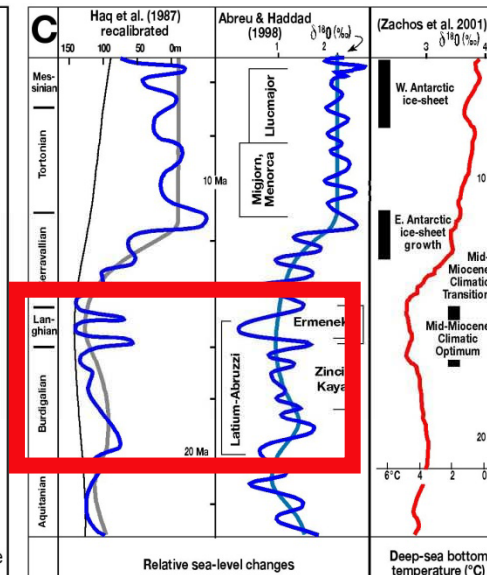
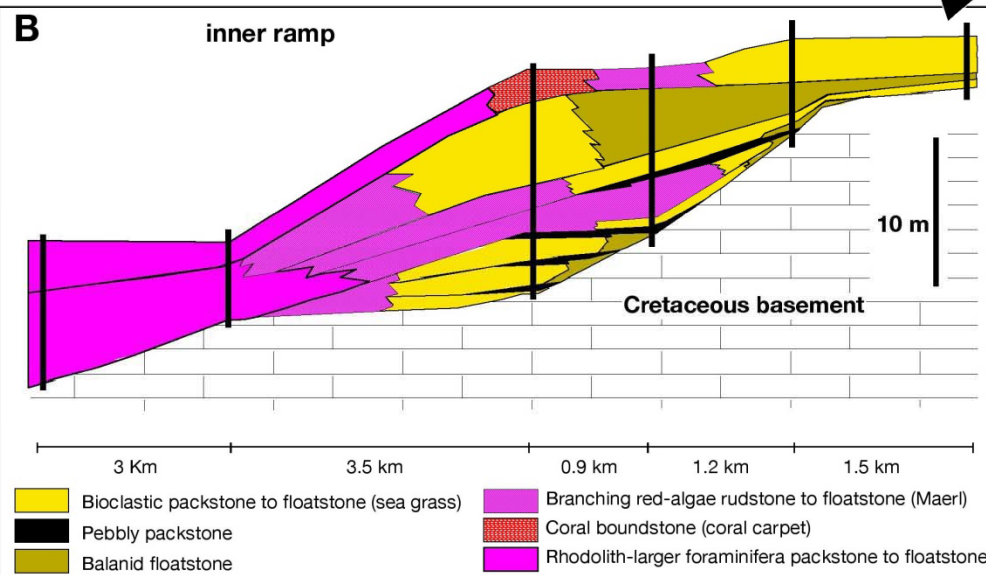
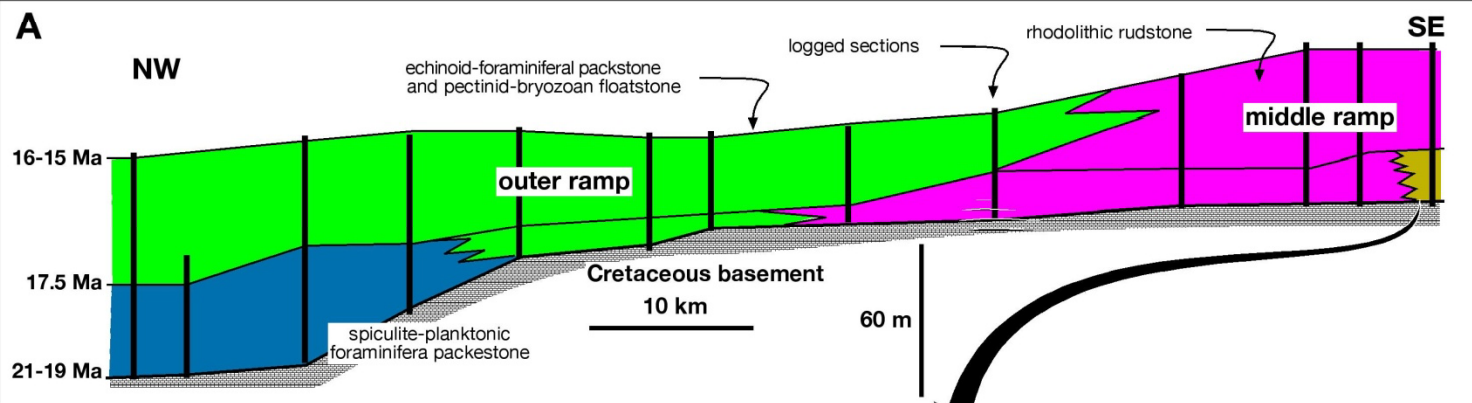
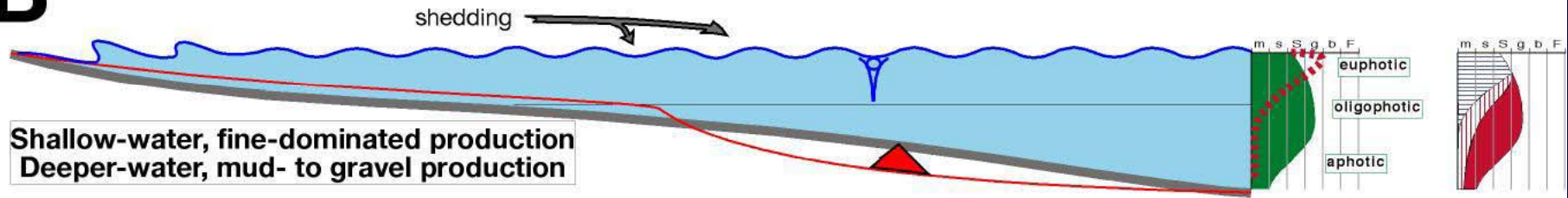
Bryozoan
floatstone

Rhodolitic
mudstone



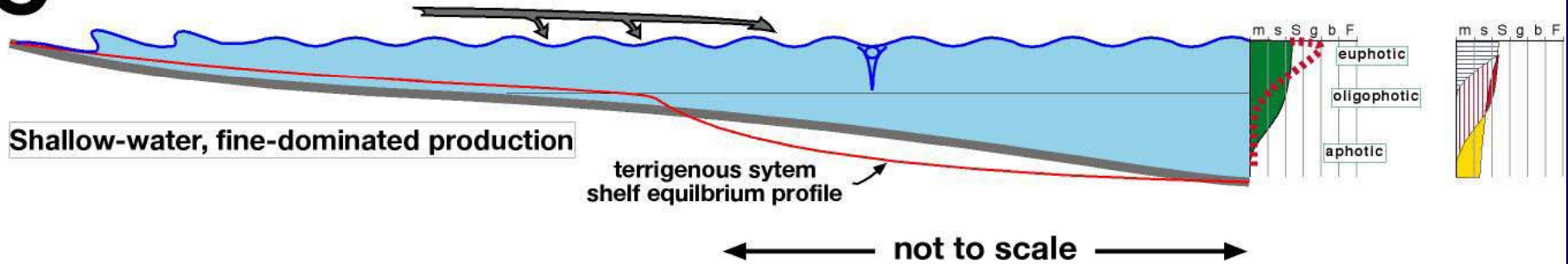
(Brandano, 2001)

B - Physical Accommodation Only



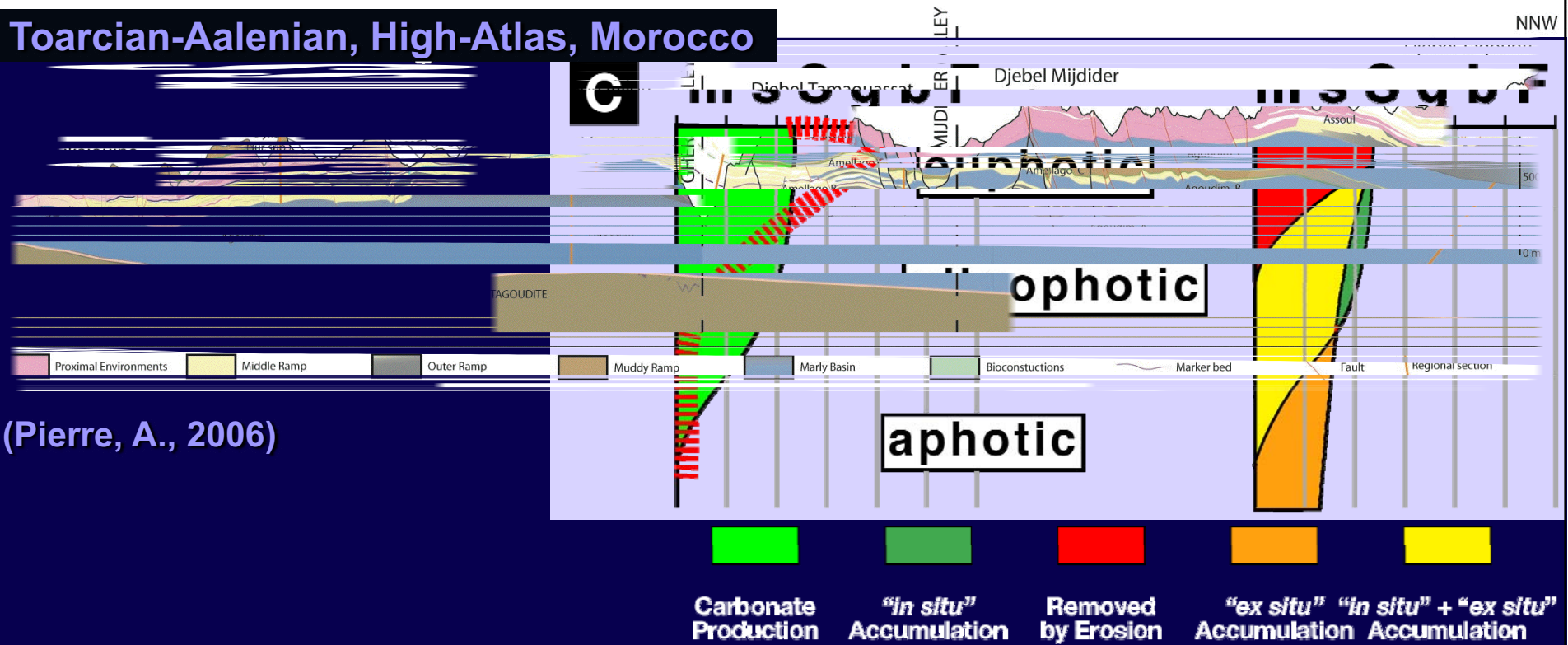
(Brandano, 2003)

C - Physical Accommodation Only

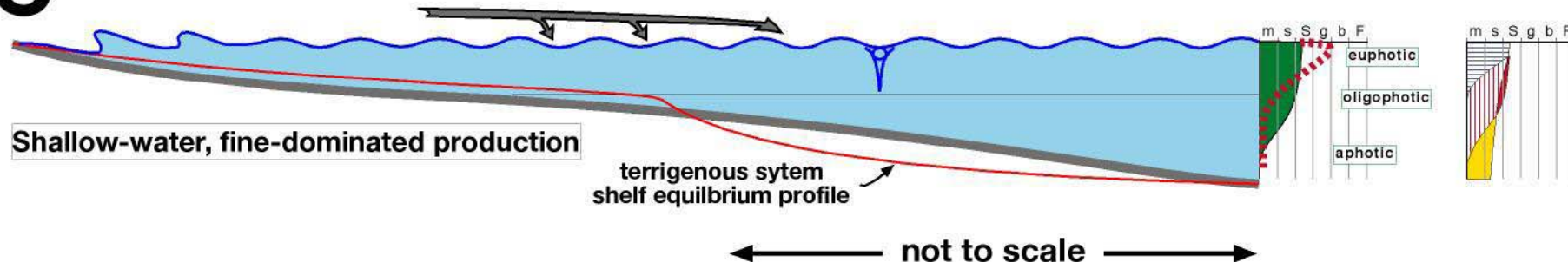


Downslope resedimentation processes

Toarcian-Aalenian, High-Atlas, Morocco

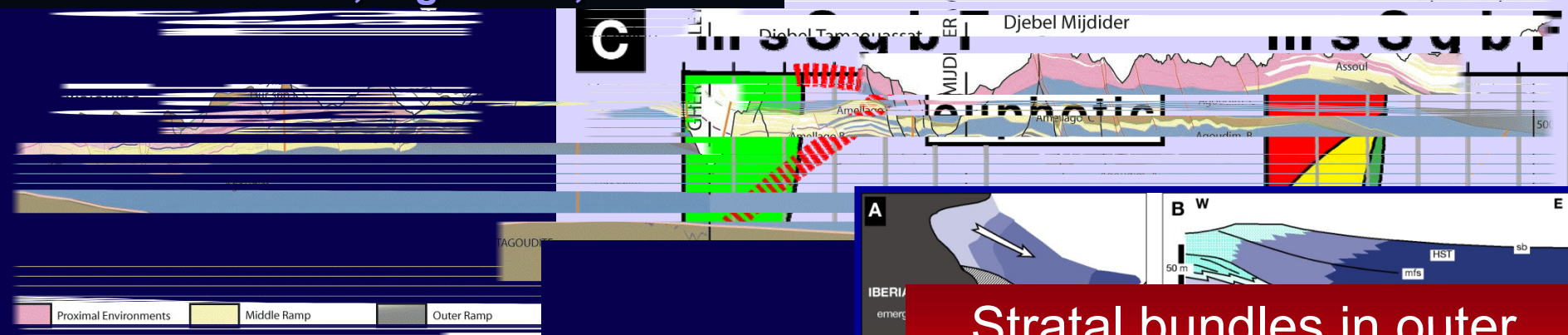


C - Physical Accommodation Only



Downslope resedimentation processes

Toarcian-Aalenian, High-Atlas, Morocco



(Pierre, A., 2006)

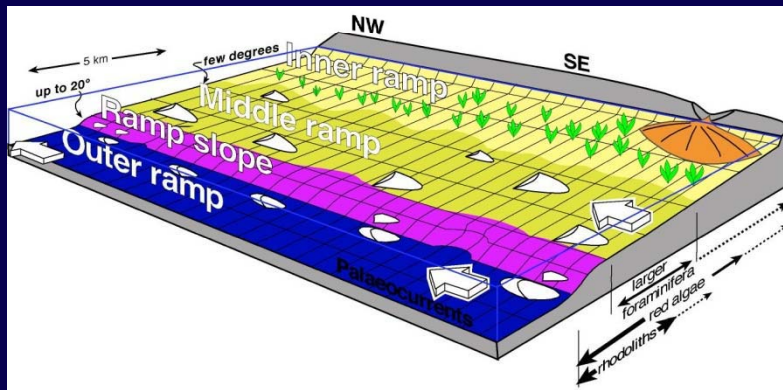
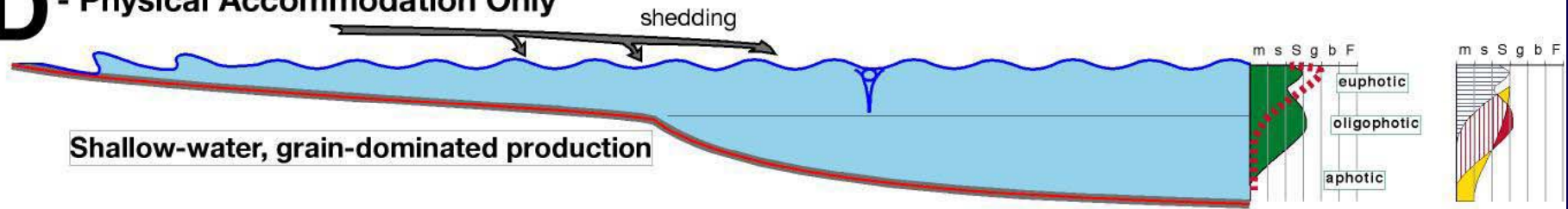
Kimmeridgian, East Iberia

(Bádenas et al, 2005)

Stratal bundles in outer ramp settings reflect 20 ka cycles, and sets of bundles the 100 ka frequency (Bádenas et al. 2003).



D - Physical Accommodation Only

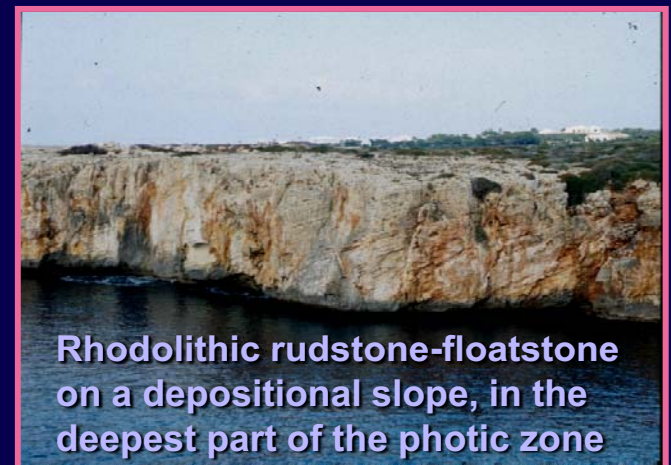


Lower Tortonian,
distally steepened ramp,
Menorca

Fine-grained laminated
packstones/wackestones

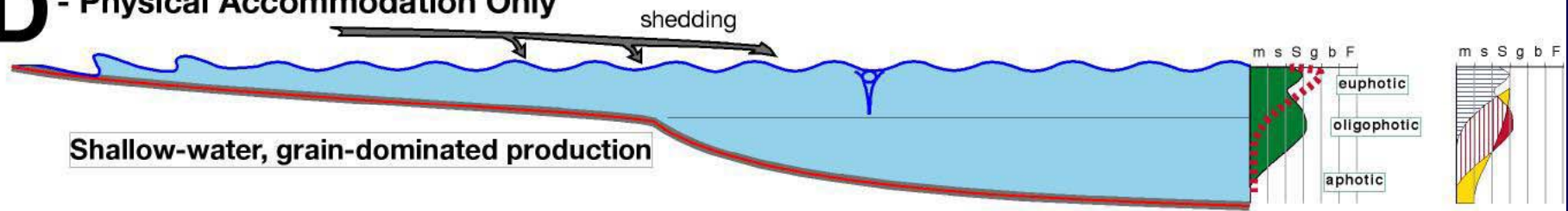


Subhorizontal,
bioturbated
packstones

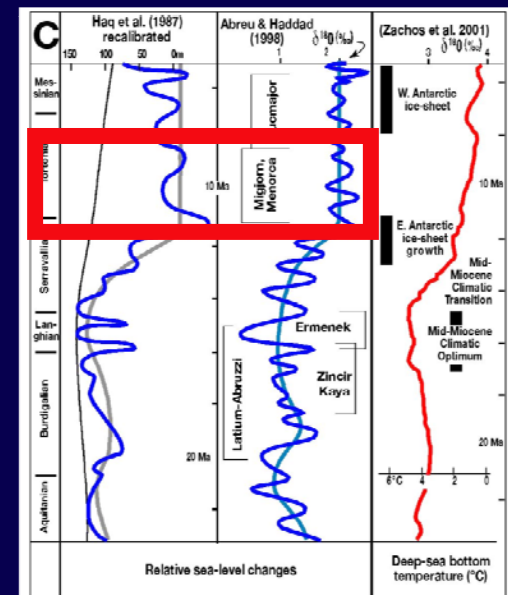
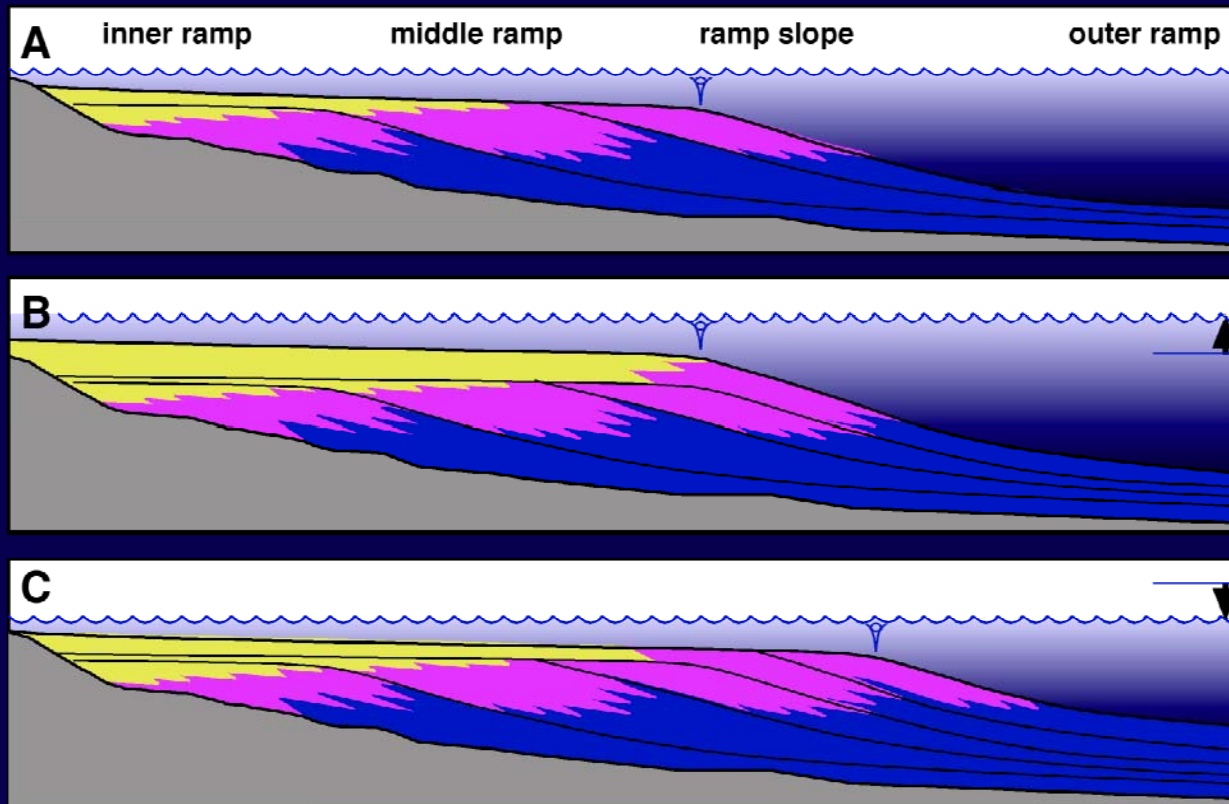


Rhodolitic rudstone-floatstone
on a depositional slope, in the
deepest part of the photic zone

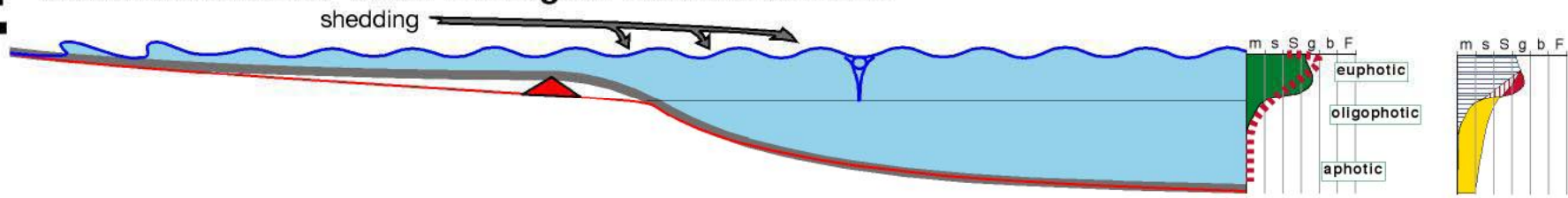
D - Physical Accommodation Only



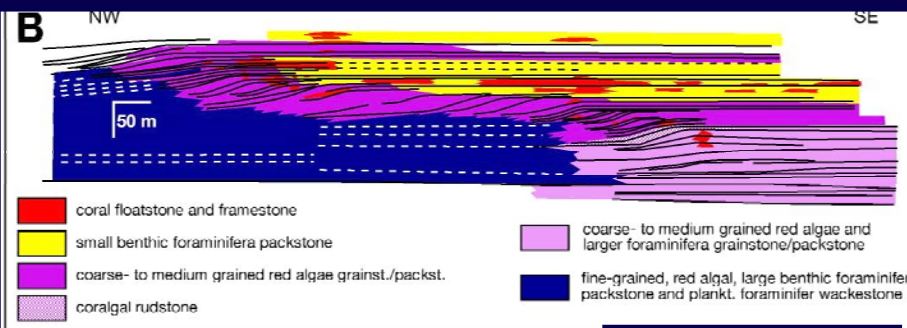
Enhanced carbonate production in the oligophotic zone



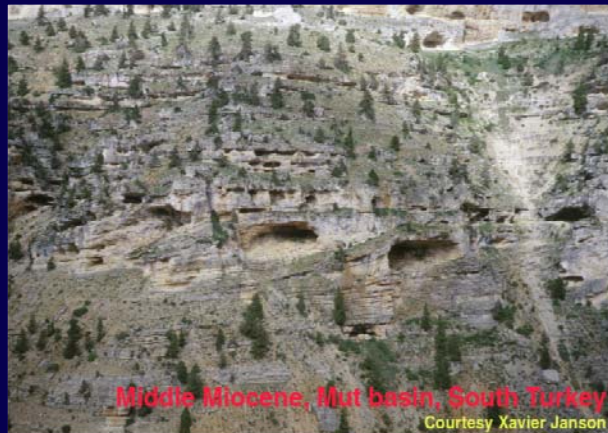
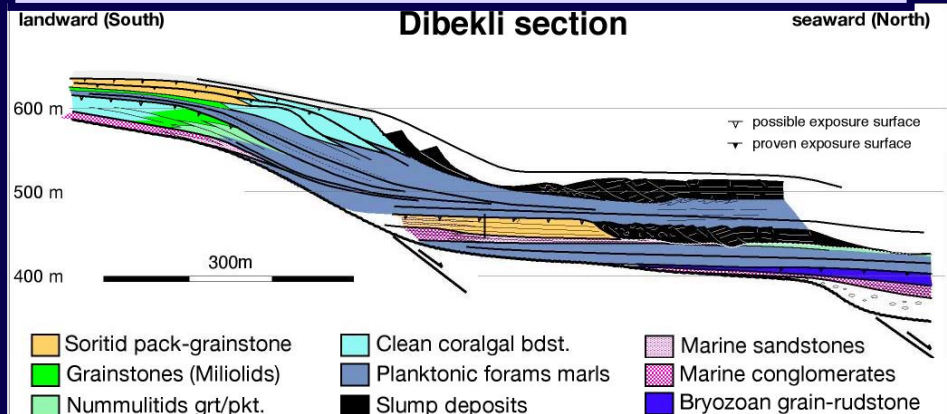
E - Moderate Shallow-Water Ecological Accommodation



Langhian, Ermenek platform, Turkey



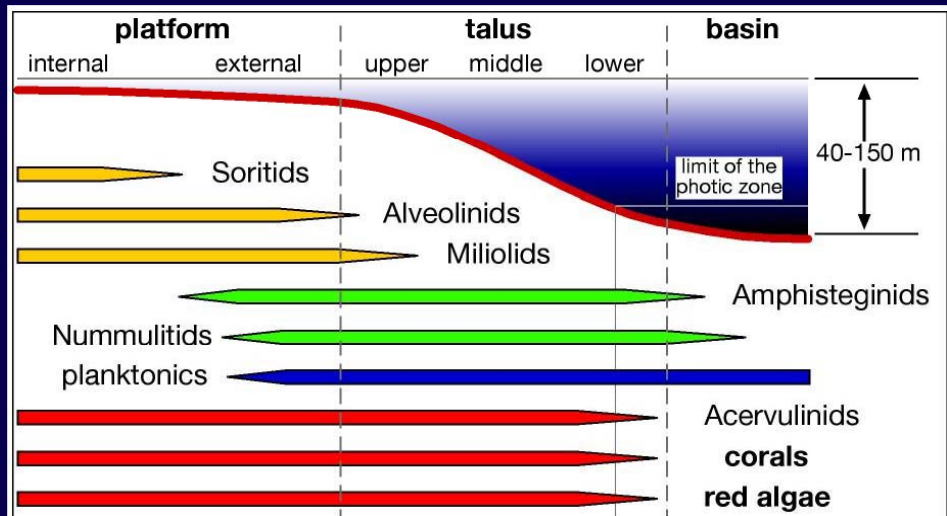
Burdigalian, Mut Basin, South Turkey



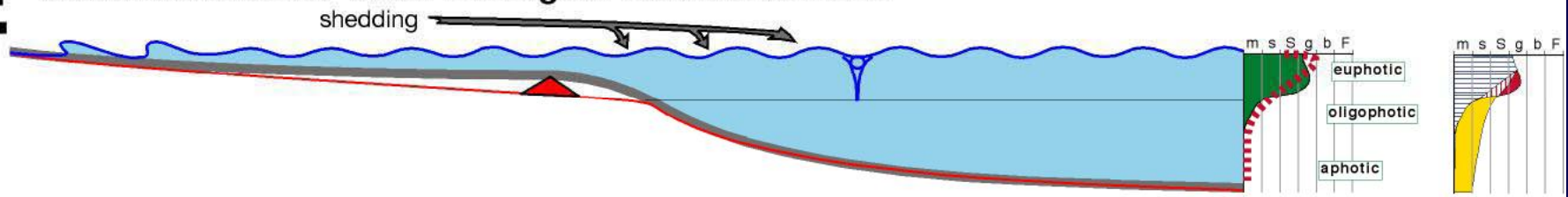
(X. Janson, 2002)

Carbon
Product

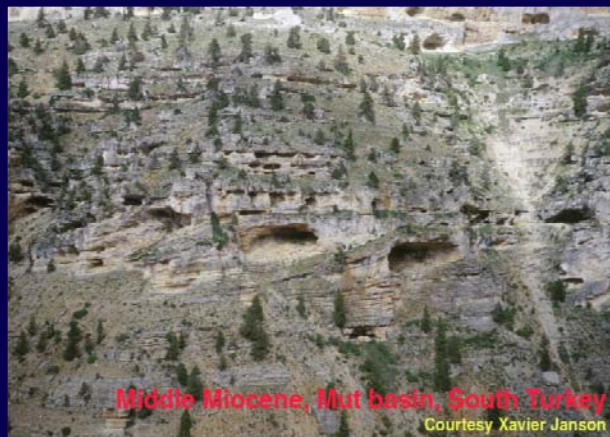
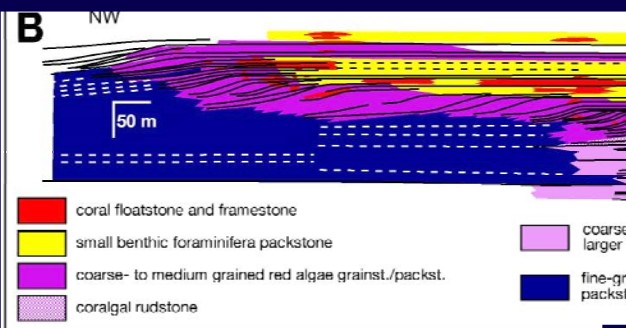
(P. Bassant, 1999)



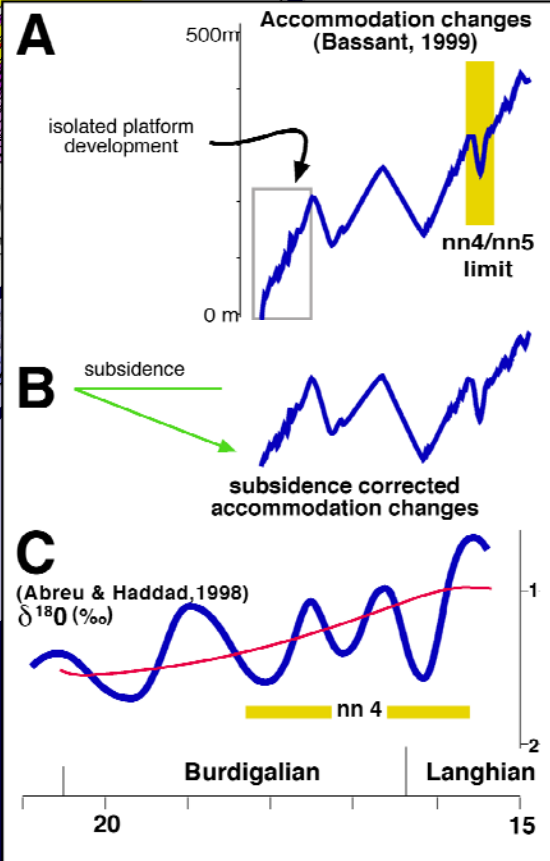
E - Moderate Shallow-Water Ecological Accommodation



Langhian, Ermenek platform, Turkey

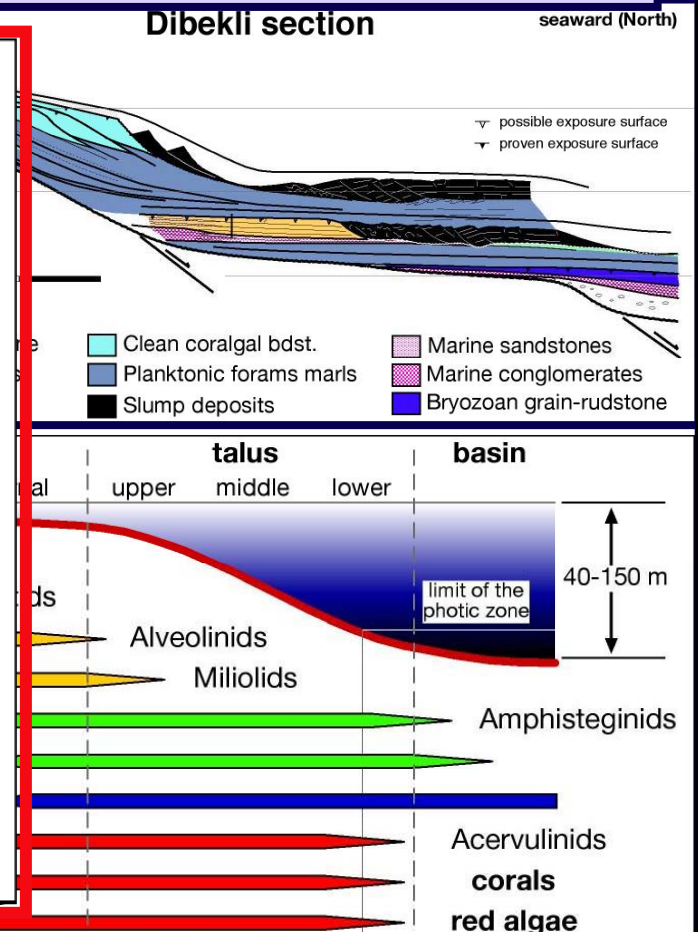


Burdigalian, Mut Basin, South Turkey

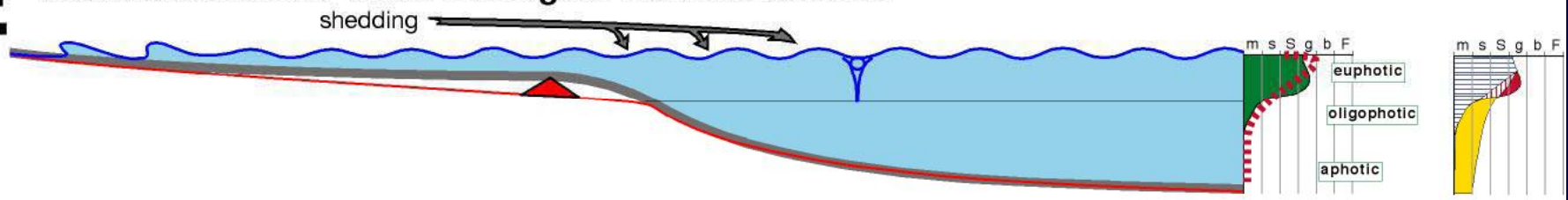


(P. Bassant, 1999)

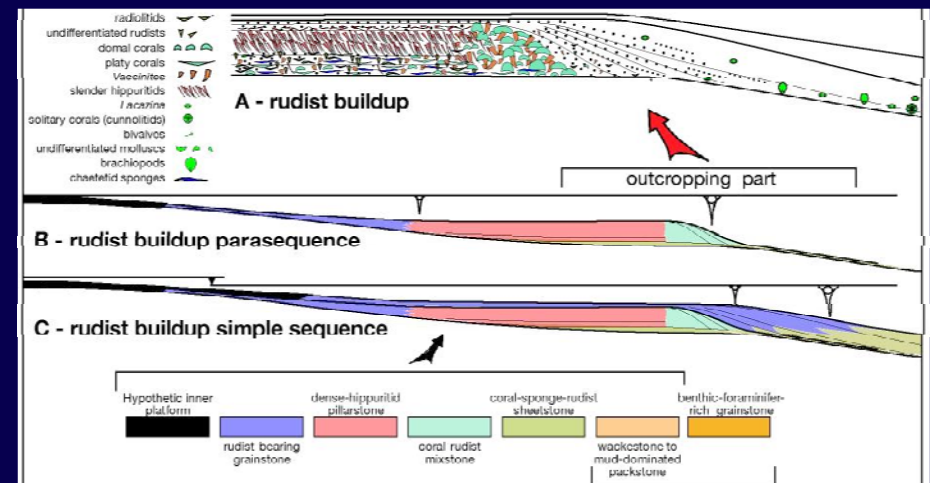
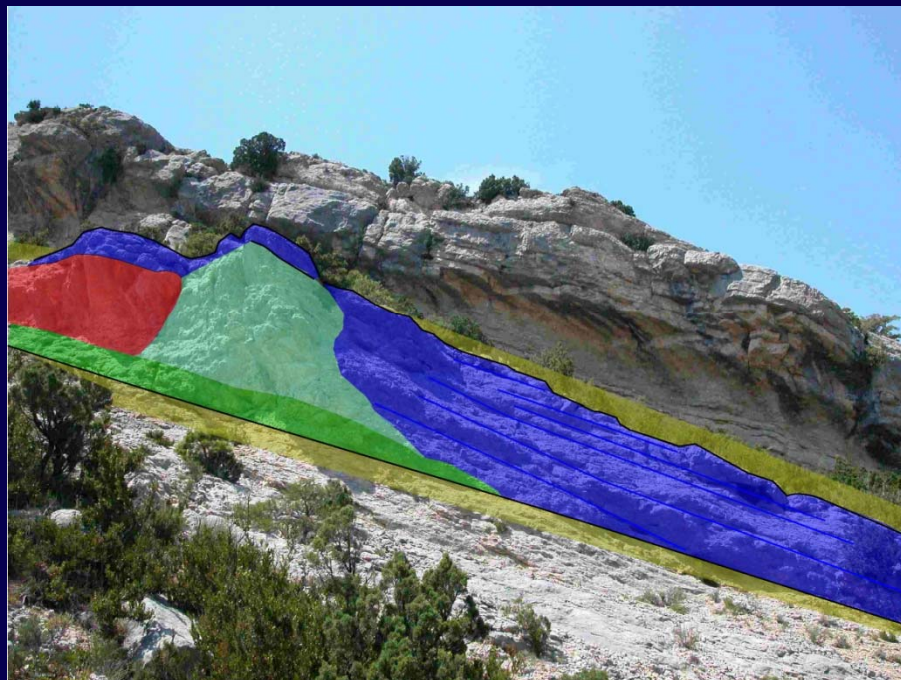
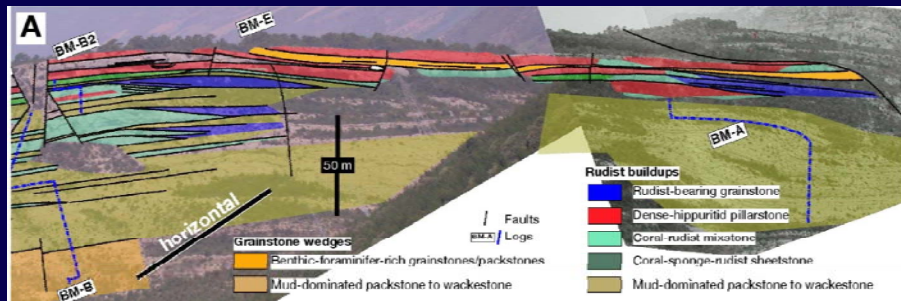
Dibekli section



E - Moderate Shallow-Water Ecological Accommodation

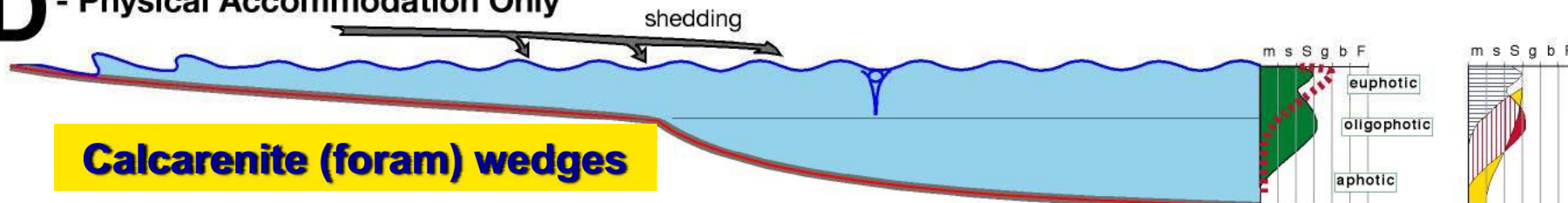


Upper Cretaceous, Pyrenees



D - Physical Accommodation Only

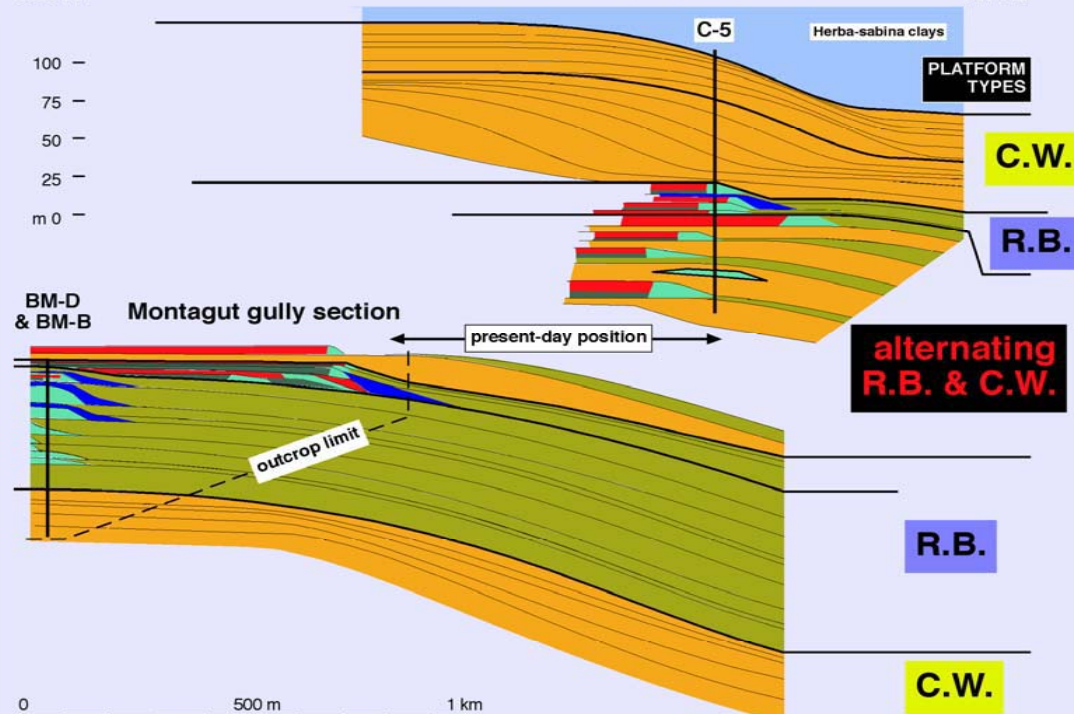
Calcareenite (foram) wedges



SSW

Carreu-river section

NNE

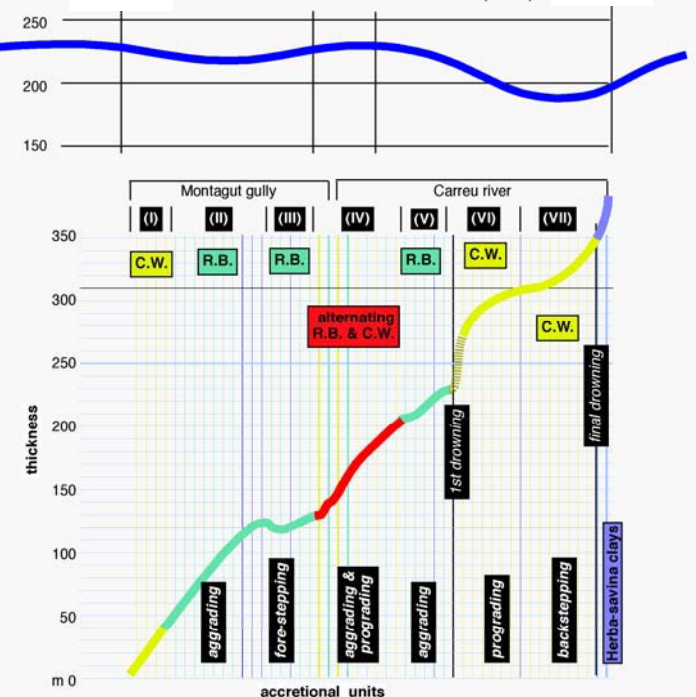


SANTONIAN

85.8

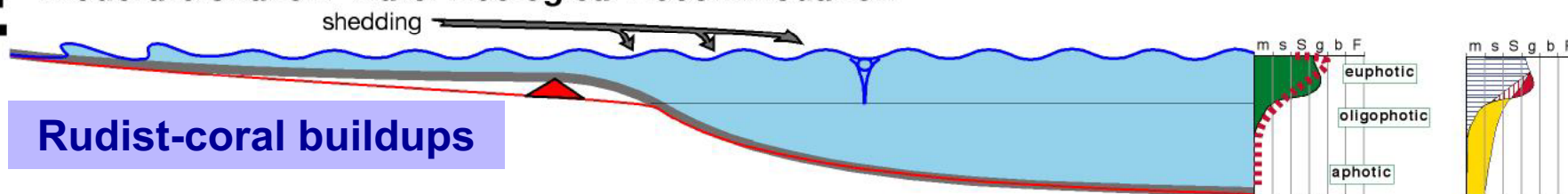
Eustatic curve Hardenbol et al. (1998)

83.5

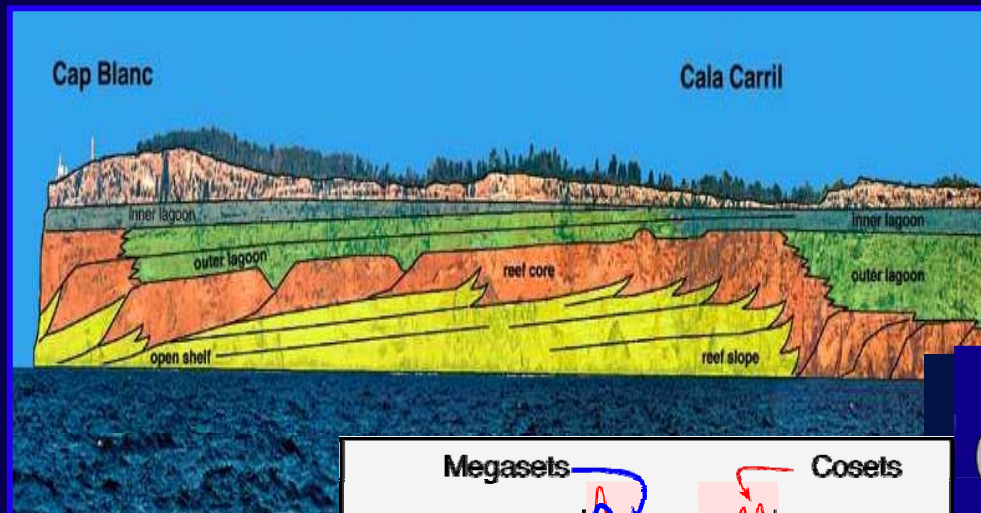
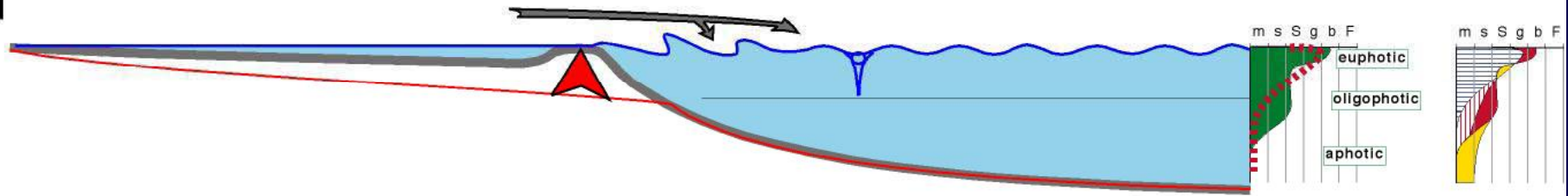


E - Moderate Shallow-Water Ecological Accommodation

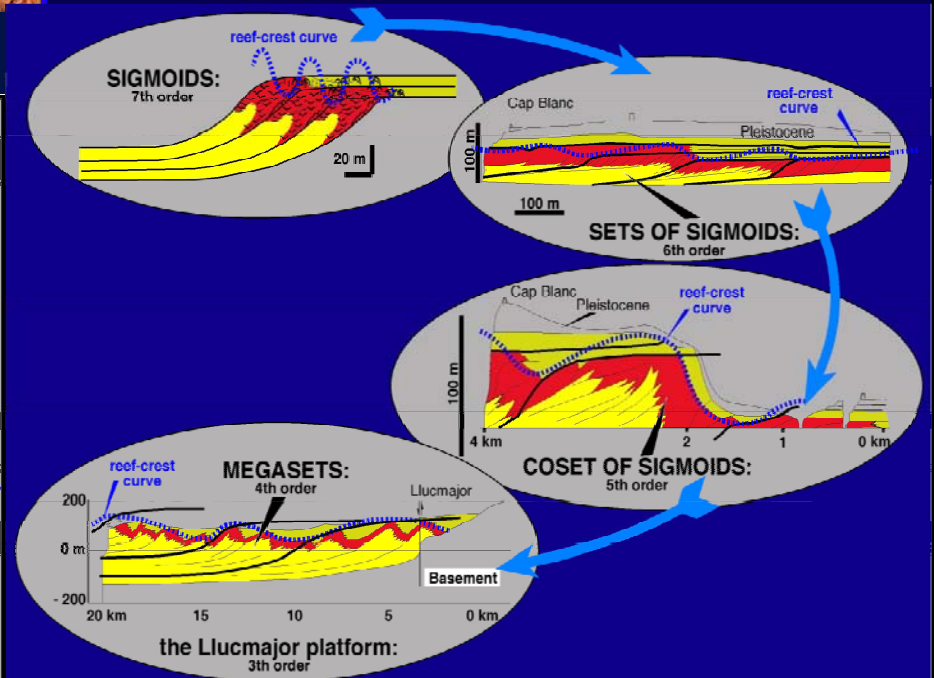
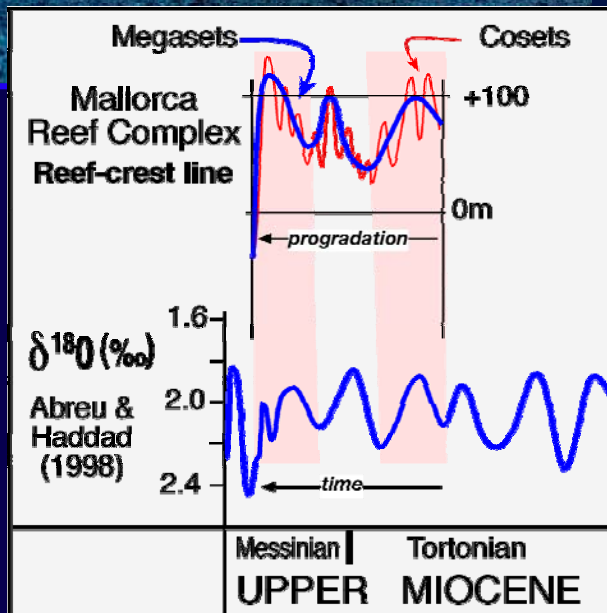
Rudist-coral buildups



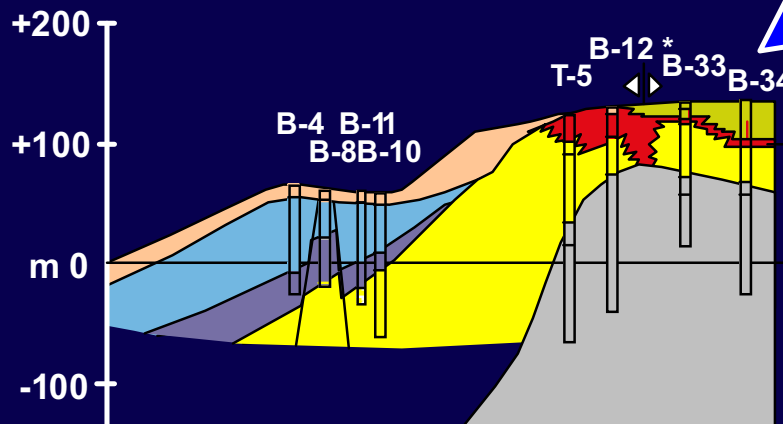
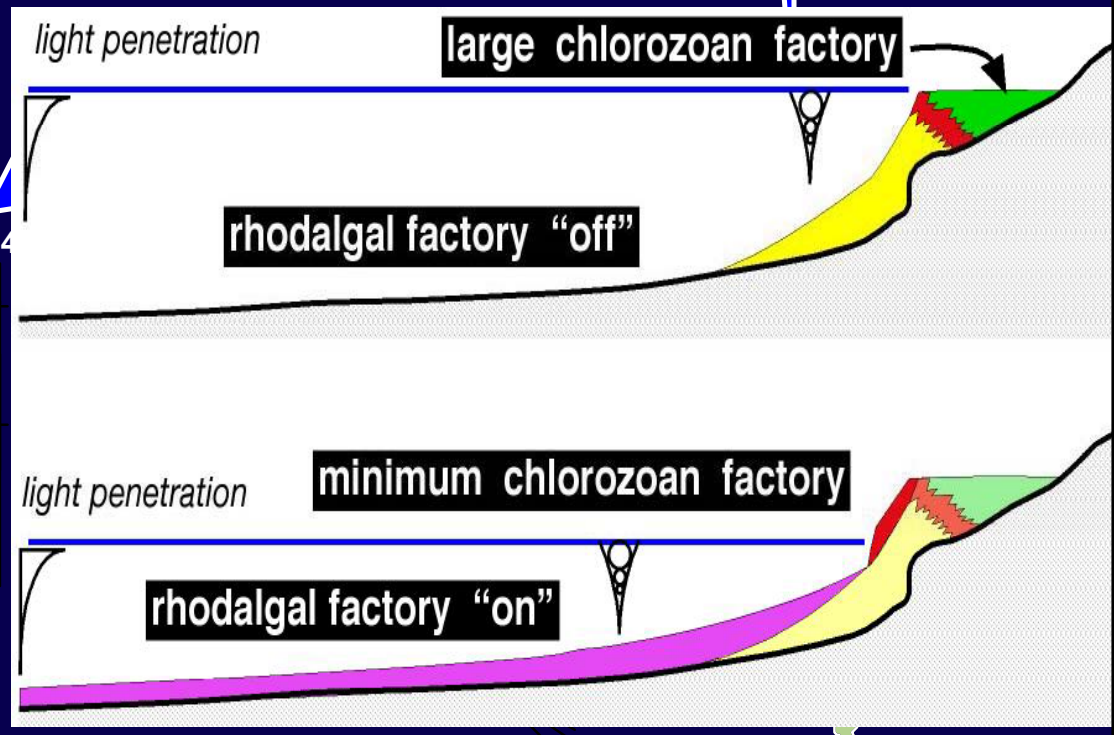
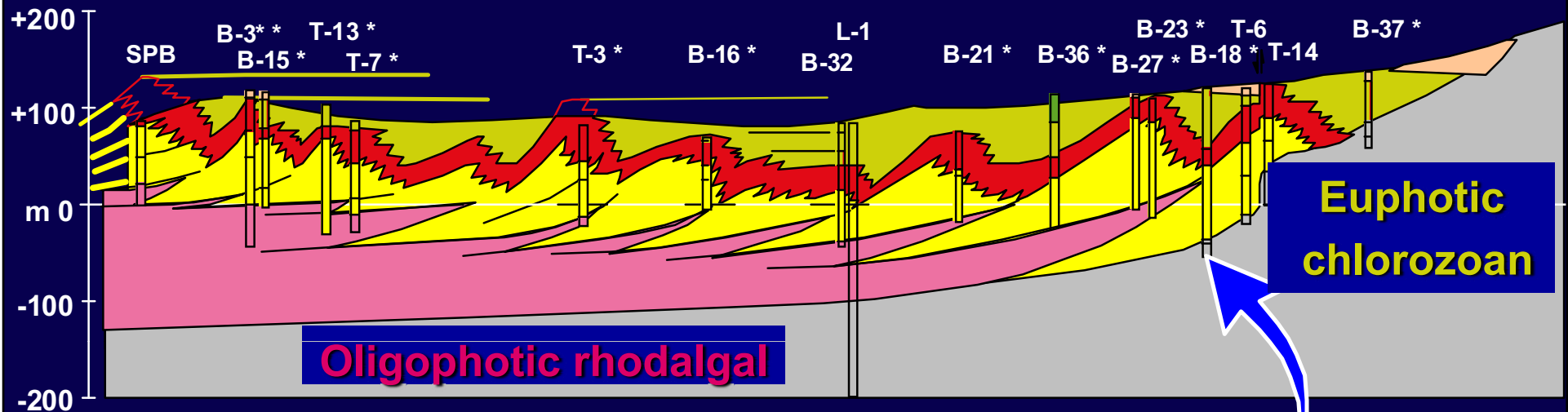
F - Highest Shallow-Water Ecological Accommodation



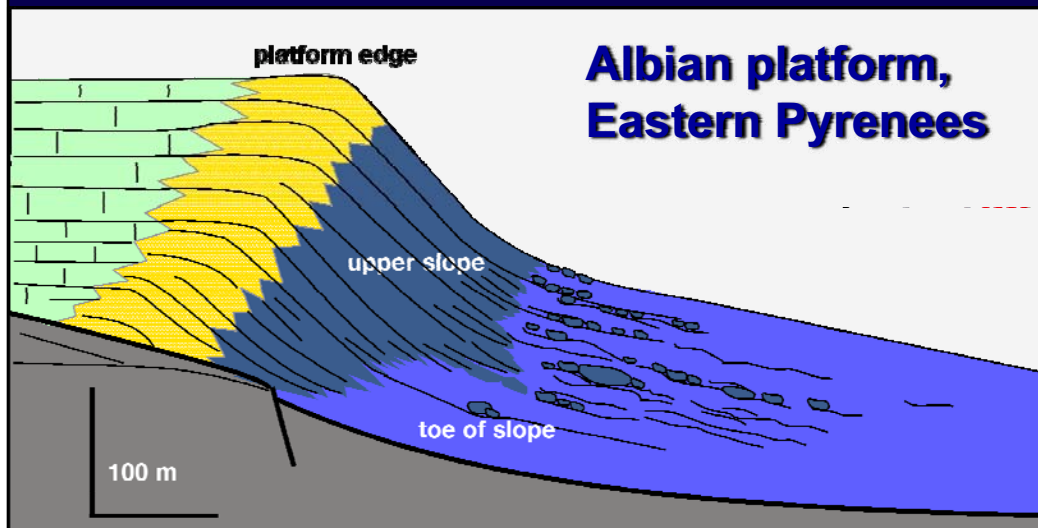
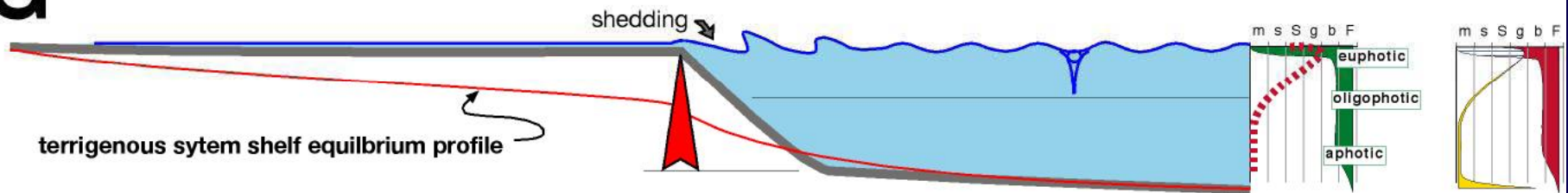
Upper Miocene, Mallorca, Spain



Two types of factories & basement control



G Maximum Ecological Accommodation for Shelf/Margin/Basin Transition



(from Gomez-Perez et al., 1998)



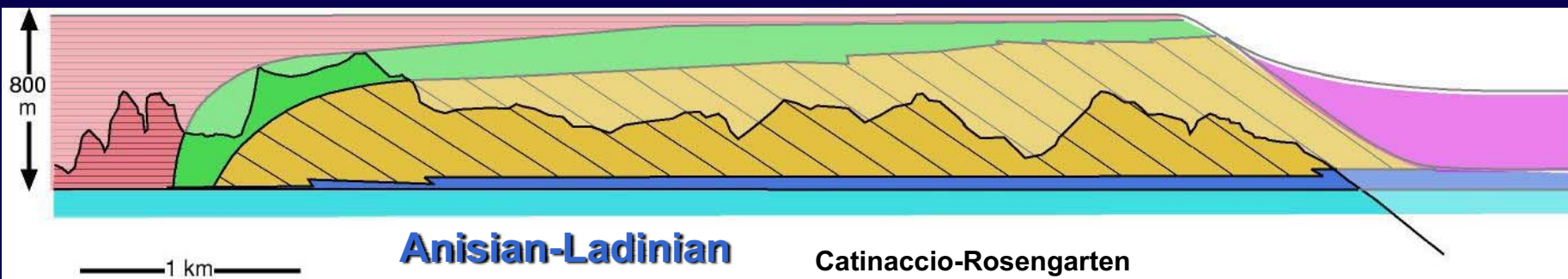
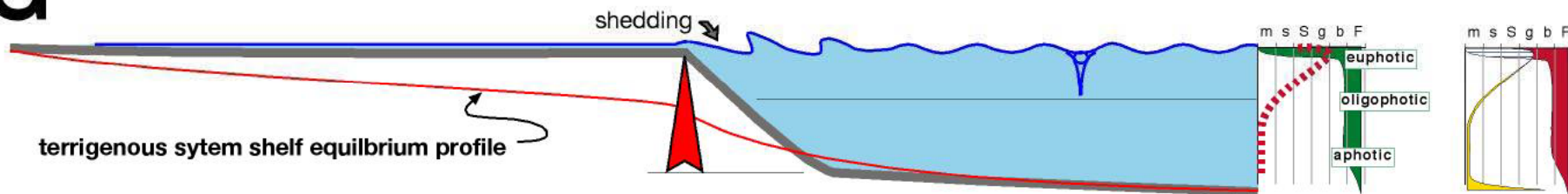
Steep and massive fore-reef upper-slope

created by

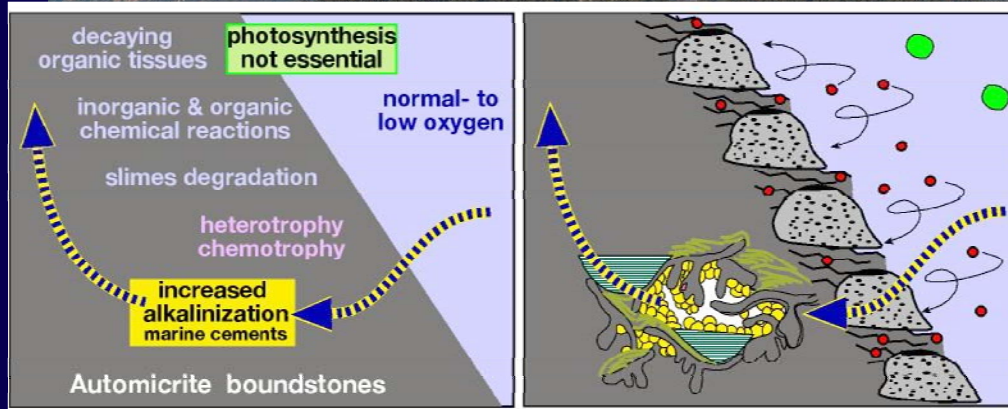
- auto-micrite precipitation,
- certain degree of frame-binding

early cementation on the

G · Maximum Ecological Accommodation for Shelf/Margin/Basin Transition

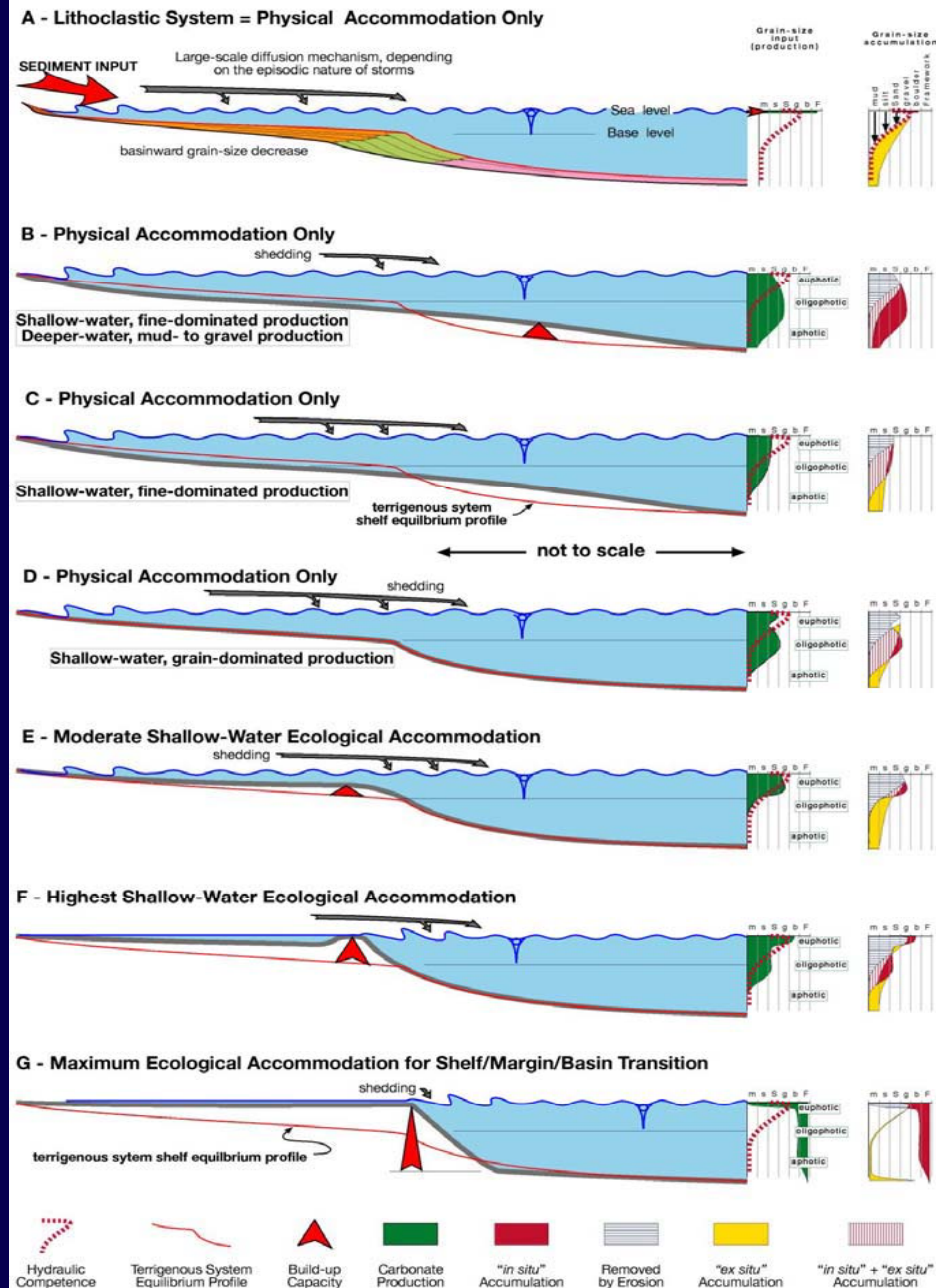


Pale de San Lucano. 1000m-thick slope



Courtesy: P. Gianolla

Conclusions



in carbonate systems
accommodation
is two fold:

physical accommodation
(hydrodynamic conditions)

&

ecological accommodation
(building-up competence)

both, along with
tectonics & global relat. sea-level,
determine

facies distribution,
depositional profile, &
platform architecture

Conclusions

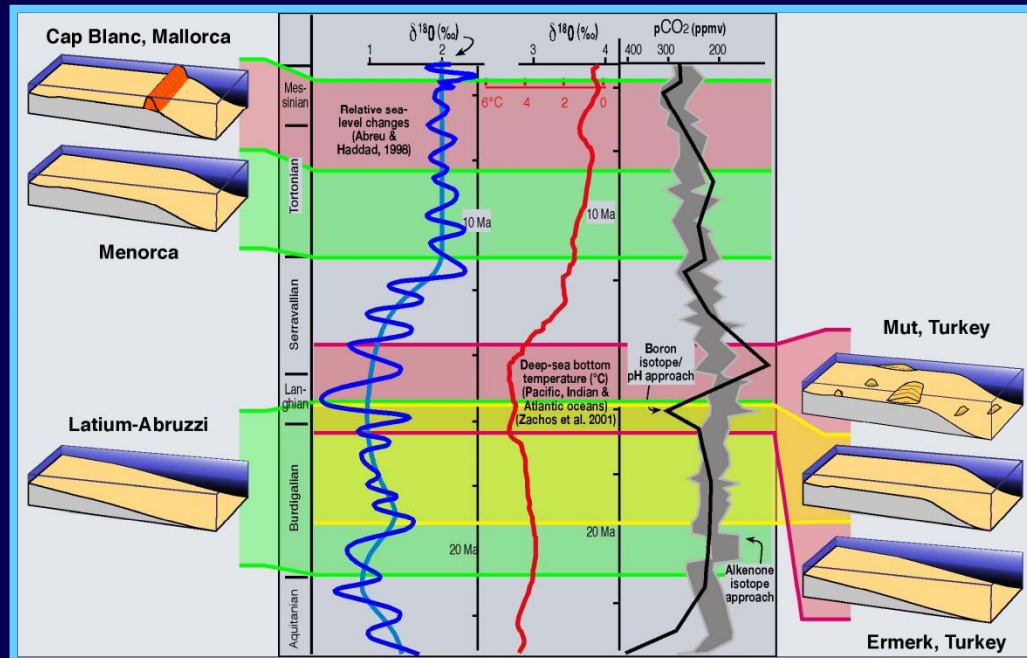
The impact of high-frequency sea-level changes in producing internal platform heterogeneities depends on ecological accommodation

accretional units	carbonate factories	examples
up to 7th order	euphotic	Late Miocene Llucmajor, Mallorca, Spain
5th-6th order	oligophotic	Kimmeridgian, East Iberia Toarcian-Aalenian, High-Atlas, Morocco
4th order ?		Upper Cretaceous, Southern Pyrenees
2th order	aphotic	Late Burdigalian to Serravallian, Southern Italy Lower Tortonian, Menorca, Spain Middle Miocene, Latium-Abruzzi, Italy Lower Aptian Gorbea, Eastern Pyrenees, Spain Upper Triassic, Southern Alps, Italy

**Susceptibility
to record
high-frequency
sea-level cycles**

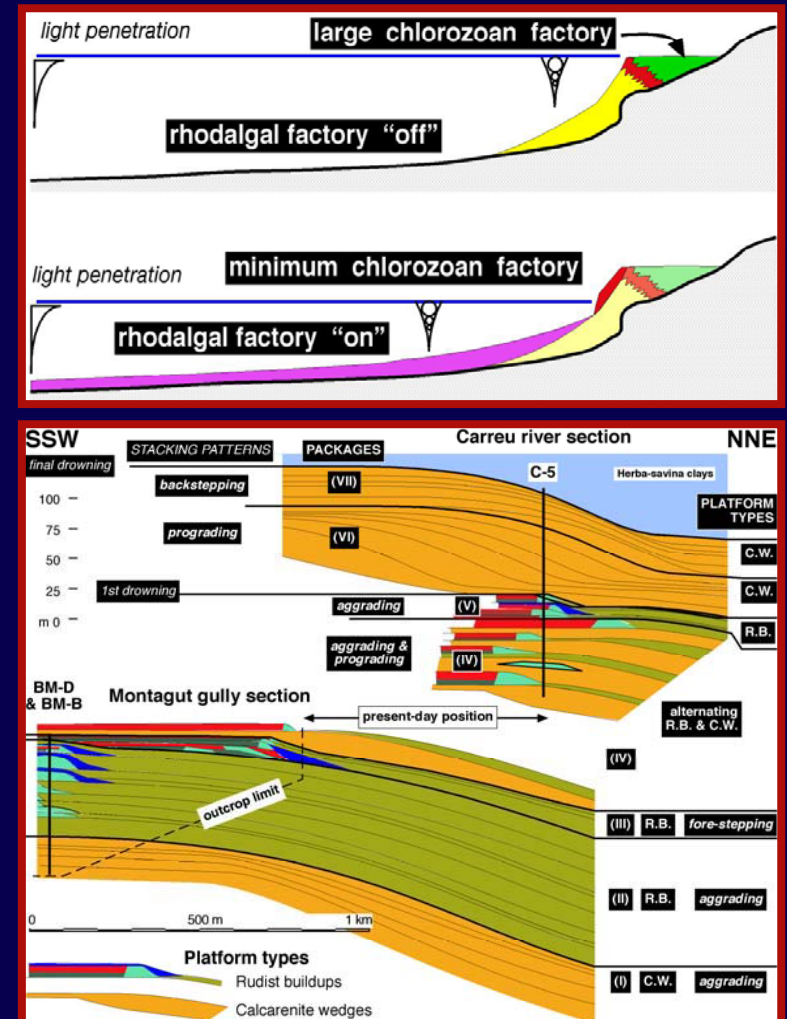
Conclusions

Changes in platform type may occur over short time intervals,



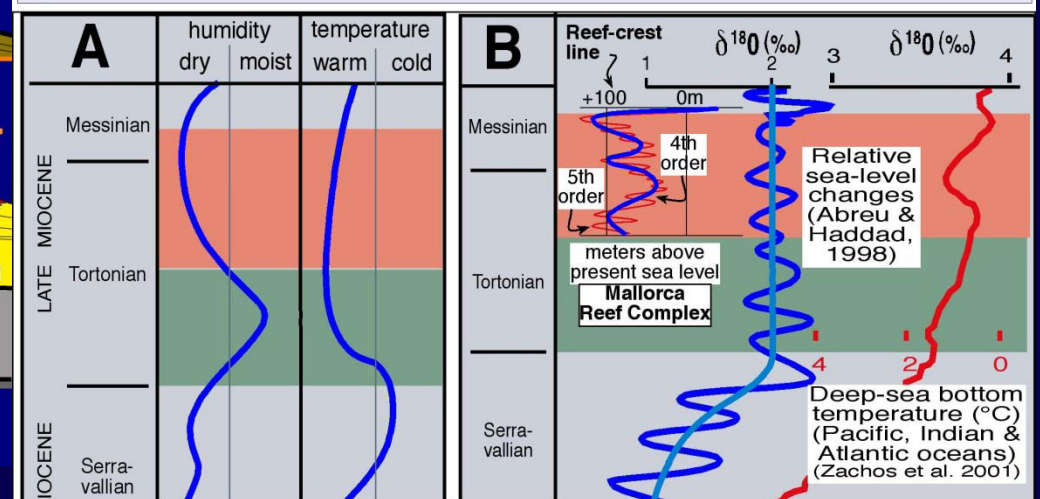
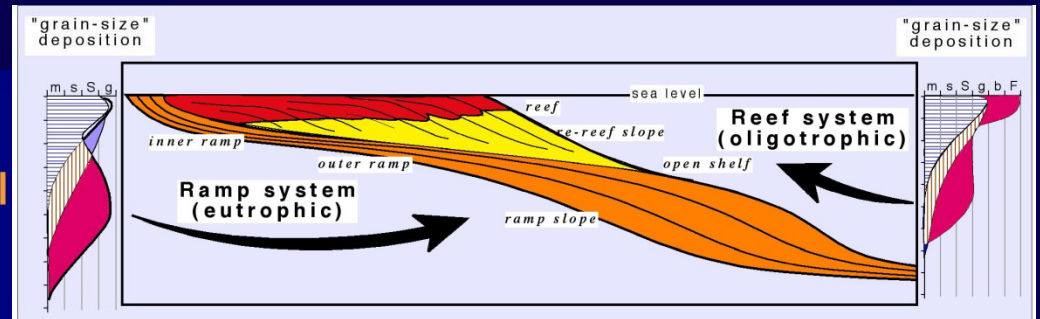
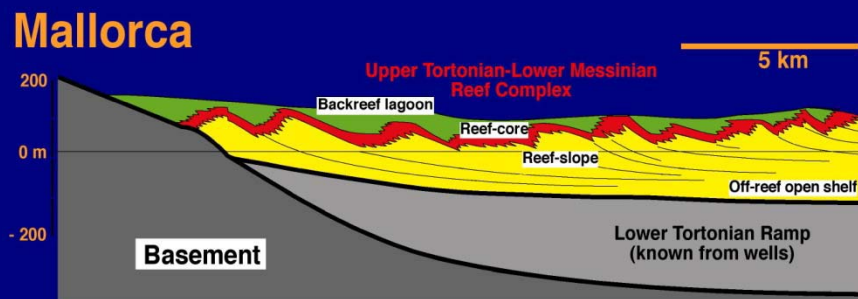
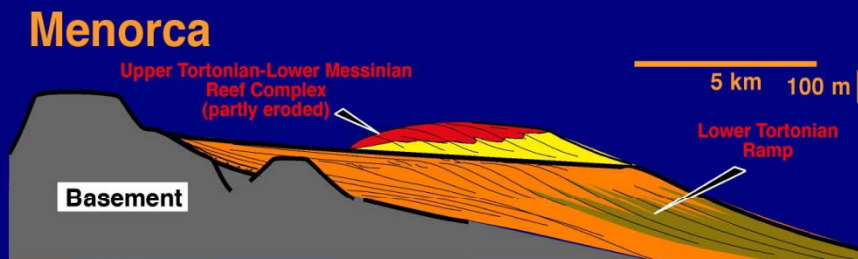
Different platform systems **may coexist**

and they can **alternate**,
in phase, or independently
of sea-level changes



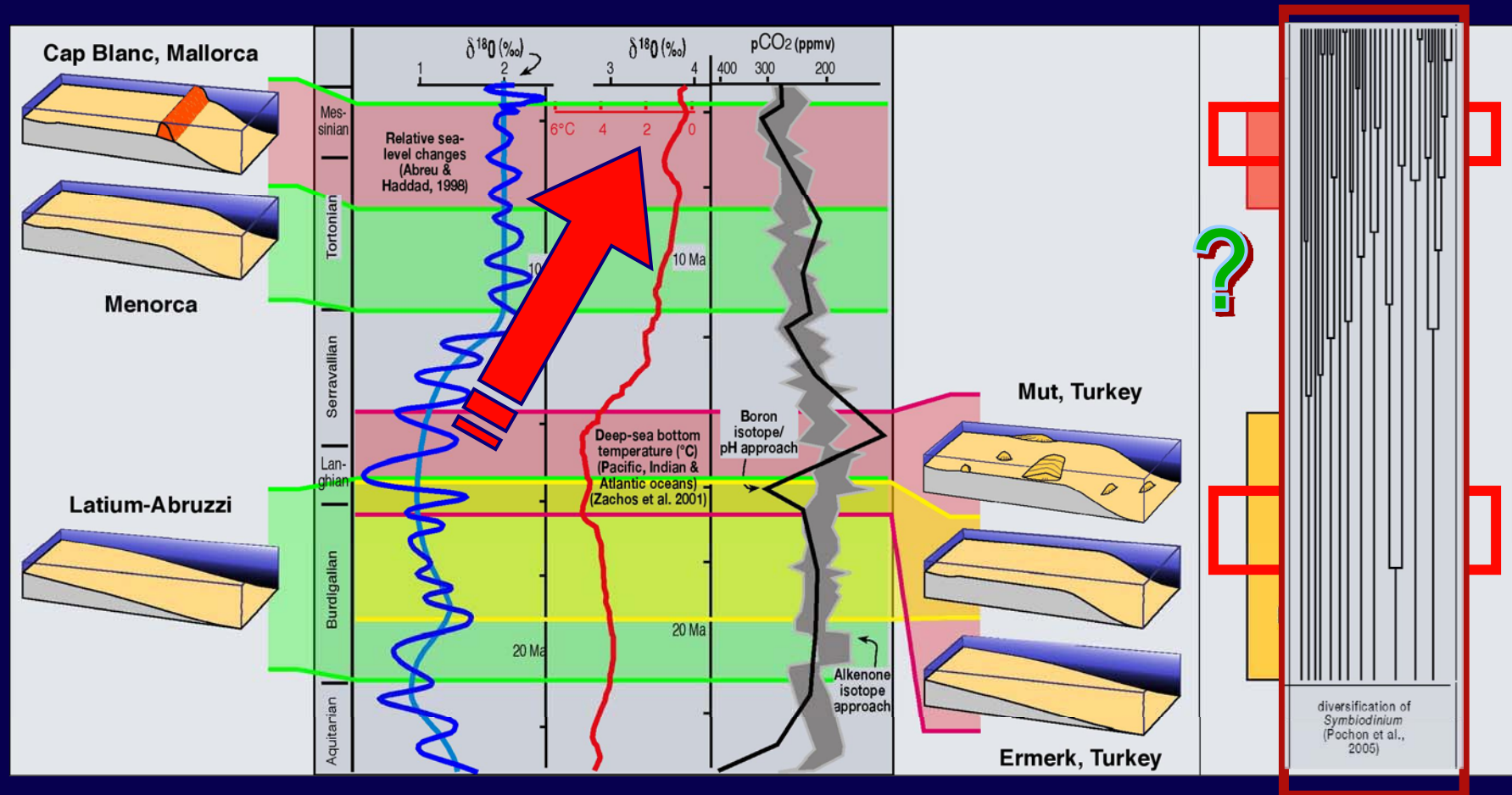
Conclusions

changes on paleoceanographic conditions may produce stronger impact on stratal patterns and facies architecture than relative sea-level changes if they affect the biological system



Conclusions: during the Miocene

Symbiodinium
diversification



✓ Corals changed from the oligophotic to the euphotic zone

✓ Why?

cooler -->> shallower
symbiont change

Conclusions: final remarks

Variability in carbonate platforms through the Mesozoic and Cenozoic, results from a multi causal interaction:

- ✓ Biological evolution & ecological requirements
- ✓ Tectonic settings -> Available space for the biota to thrive
- ✓ Global to local climate
- ✓ Global to local paleocenographic conditions

The diversity in platform architecture and the complexities in the stacking patterns can be better recognized as the products of the interaction of changes in both:

- ✓ ecological accommodation and physical accommodation

A mix of cautiously applied uniformitarianism associated with process/product relationships provides clues for improving **uncertainties evaluation** so these can be applied in **sub-surface interpretations**.

Simultaneously it initiates **new questions** that drive the attention of the interpreter to look **for new answers**.

Selected References

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