Shelf-Margin Trajectories: Significance for Sediment By-Pass*

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Abstract

Repeated sediment delivery across the shelf and onto the shelf margin, whether by accommodation- or supply-driven forcing of river deltas to the shelf edge, causes shelf-edge migration and large-scale accretion of margin sedimentary prisms. For margins of similar height, this accretion rate can be modest (few km/my) or fast (10s of km/my) depending mainly on the width of the shelf and the sediment flux across the shelf edge. Greenhouse margins, despite a likely weak accommodation drive, nevertheless can partition great volumes of sediment into deepwater areas likely favored by high rates of sediment yield during warmer climate and a tendency for deltas to remain near the shelf edge for long periods without floodback. In this setting there can occur both lowstand and highstand delivery of sand into deepwater areas. On icehouse margins we predict longer and higher frequency transgressive-regressive delta transits across the growing shelf-margin prism driven by glacio-eustatic sea-level fluctuations, with punctuated deepwater sand delivery at sea-level lowstands and thus the creation of conventional stratigraphic sequences.

The shelf-edge trajectory during the longer-term growth of many margins is commonly irregular, with alternating rising and flat segments that have a time scale of 0.5-2 my. These segments themselves, always consisting of stacked basic sequences, are useful predictors of alternating strong sediment storage on the shelf (for segments of rising trajectory) and strong bypass of sediment to deepwater areas (for segments of flat trajectory). The possible causes of shelf-edge trajectory segmentation are discussed with reference to a number of ancient shelf margin successions.

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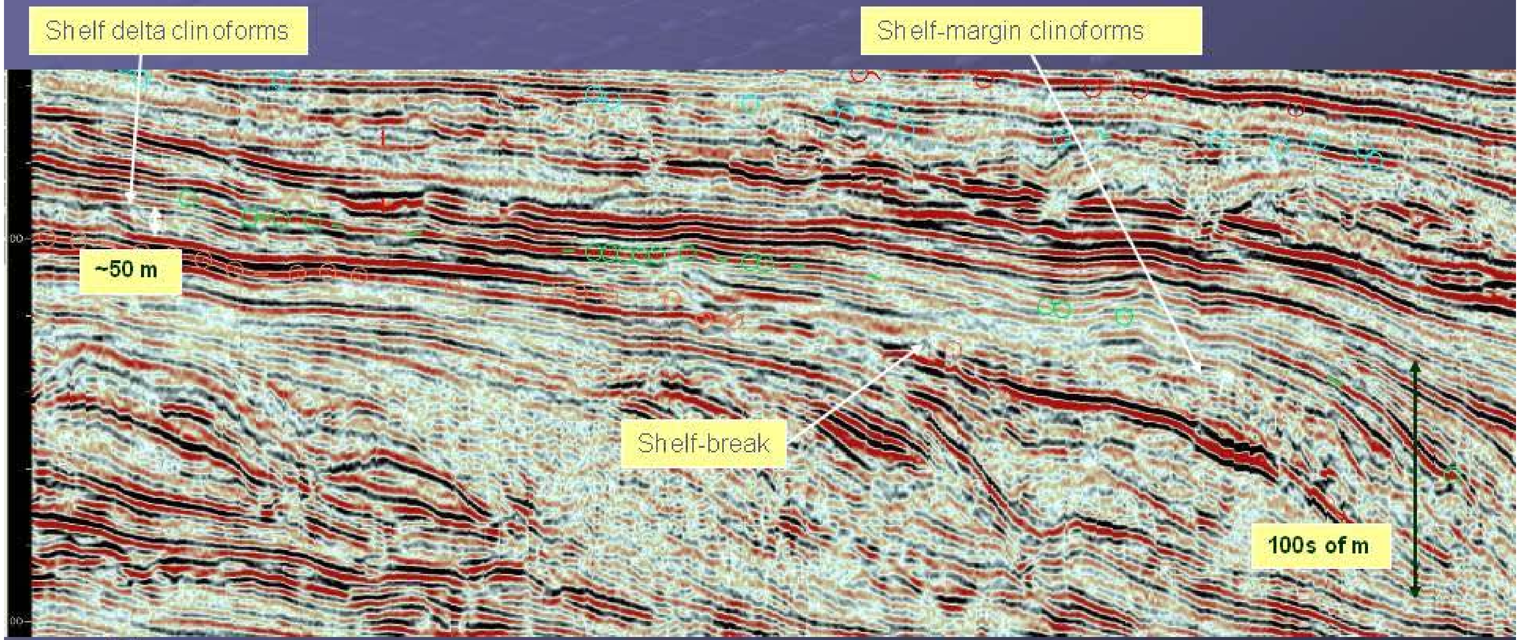
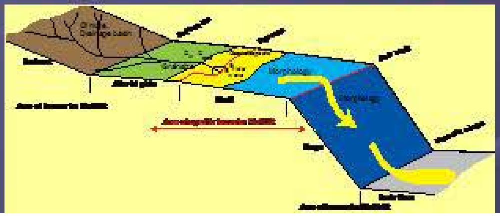
SHELF-MARGIN TRAJECTORIES: SIGNIFICANCE FOR SEDIMENT BY-PASS

R.Steel, C.Carvajal, C.Olariu, A.Petter, P.Plink-Bjorklund & C Sanchez

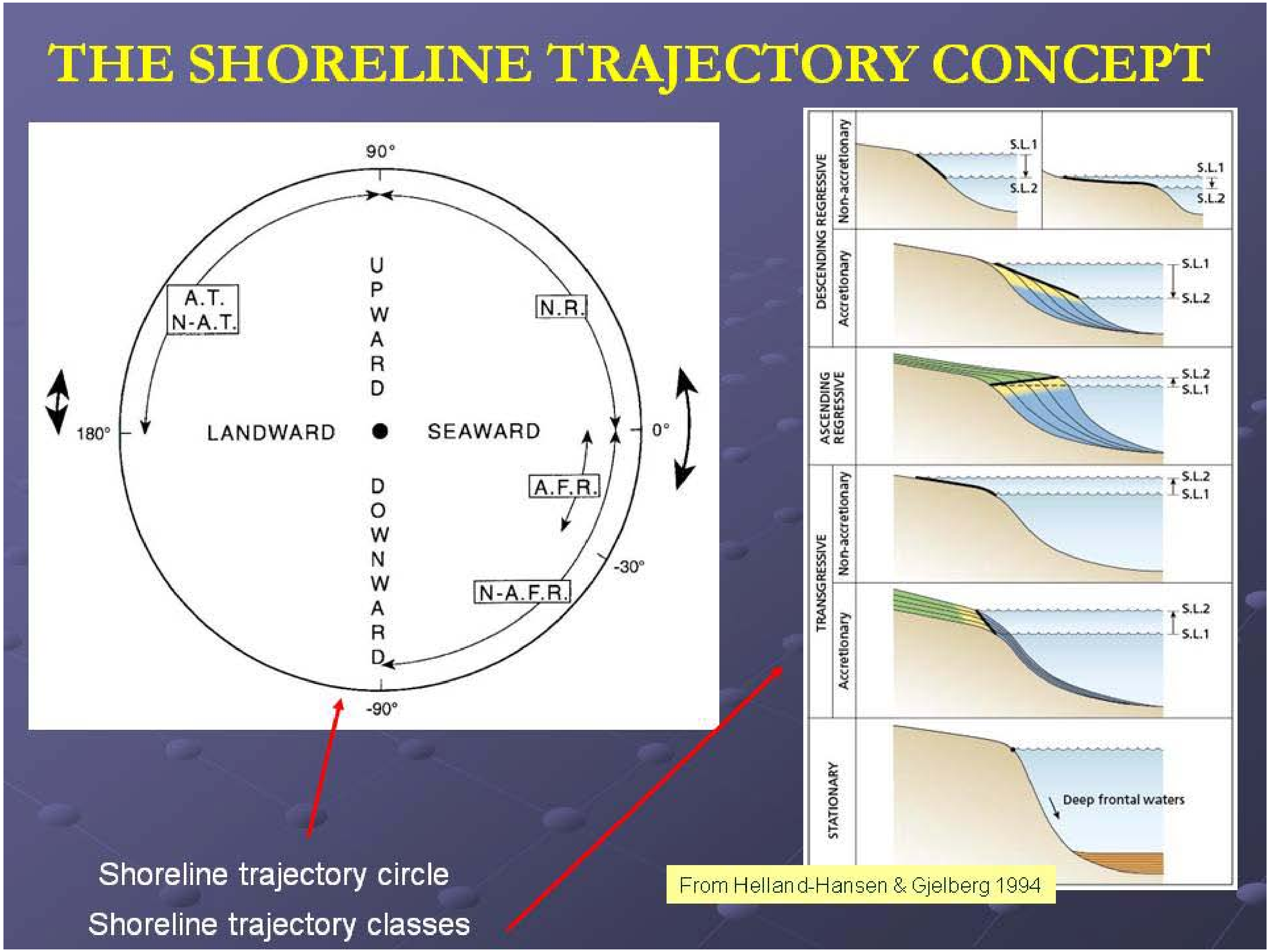




RioMAR
CSM-UT

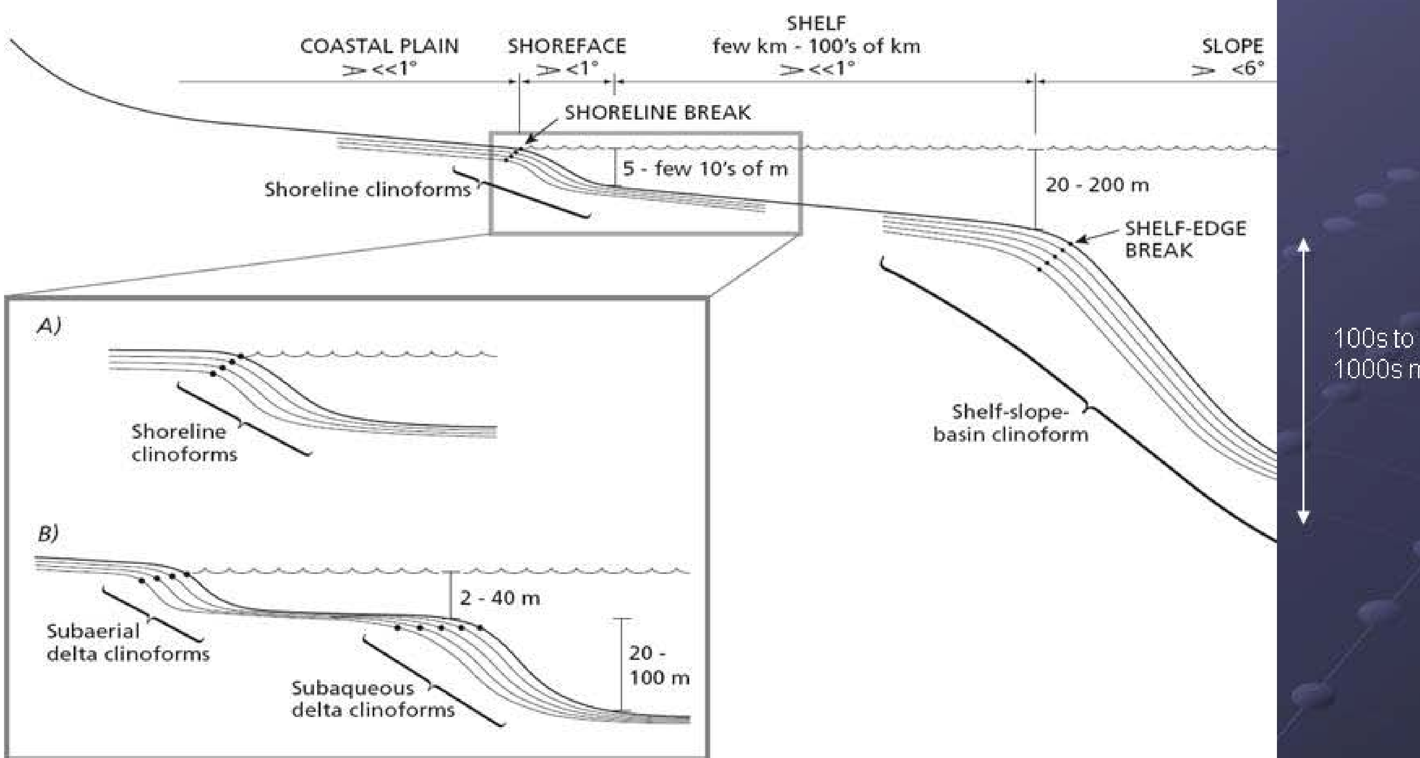
BP, BHP Billiton, BG-Group, Devon, ENI, PDVSA, Petrobras, Shell, Statoil

Notes by Presenter: In RioMAR work, we are interested in both processes and architectures at shelf edge, and also in the longer-term growth trajectory of the shelf margin.



Notes by Presenter: Trajectory concept was developed by Helland-Hansen for describing shoreline movement and as a dynamic element in sequence stratigraphy: then adapted as a descriptor for SE.

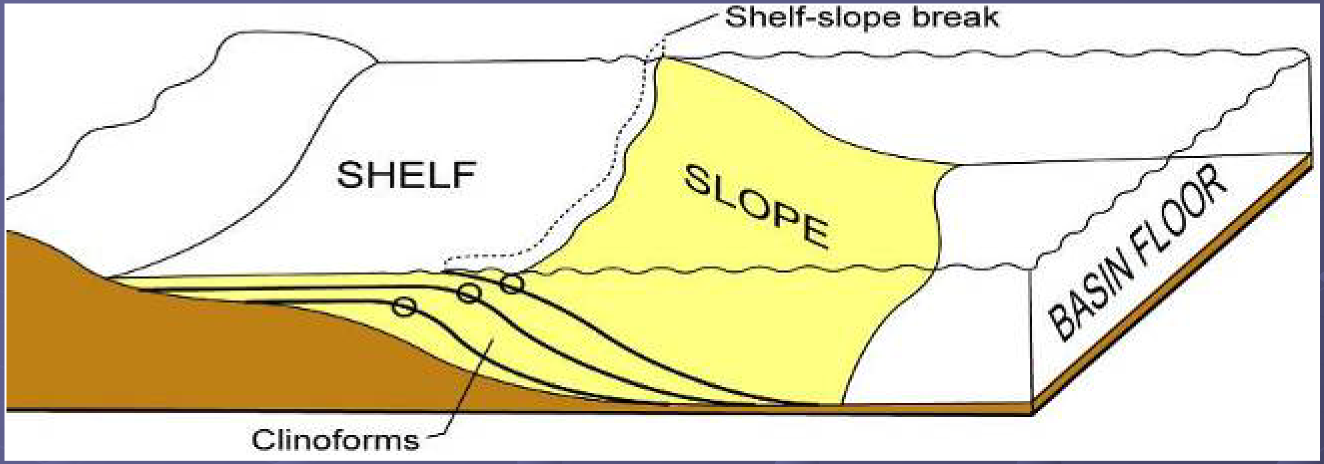
SHORELINE AND SHELF-BREAK TRAJECTORIES



Helland-Hansen & Hampson, 2009

Notes by Presenter: Note the scale difference between shorelines/deltas and shelf margins, though they merge at SE for brief time.

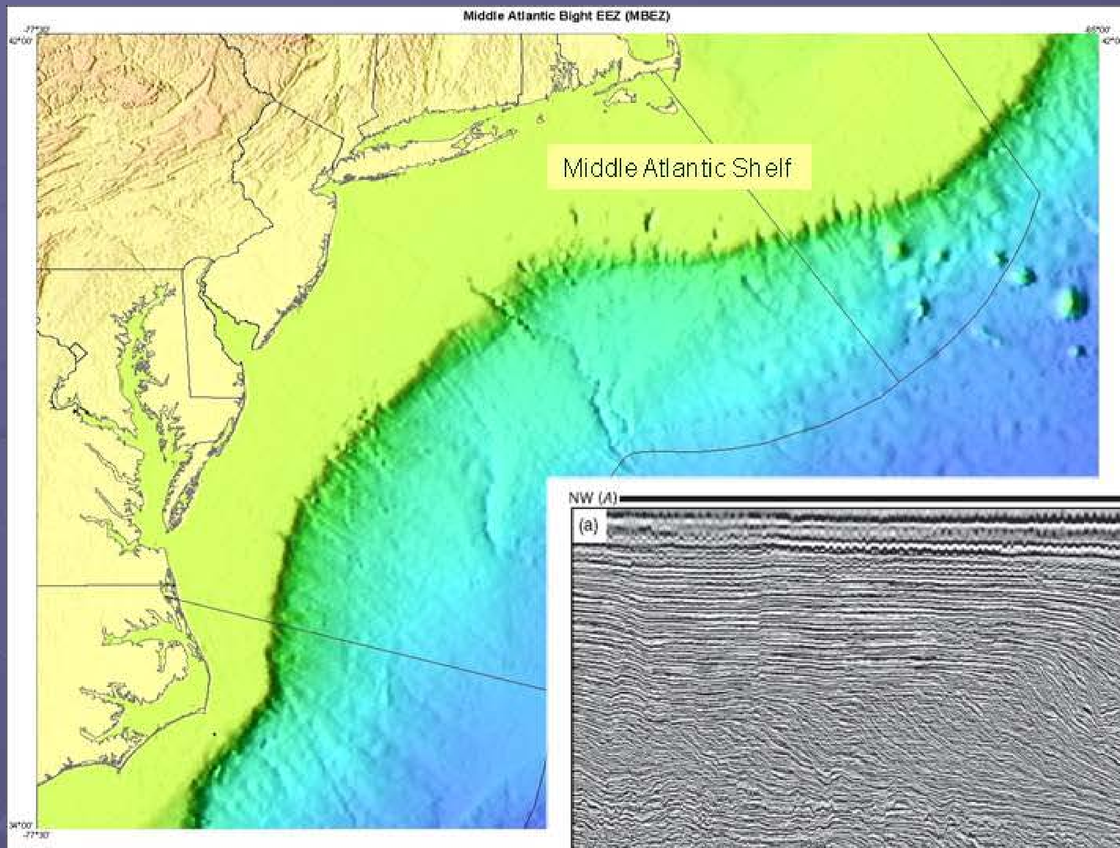
SHELF MARGINS

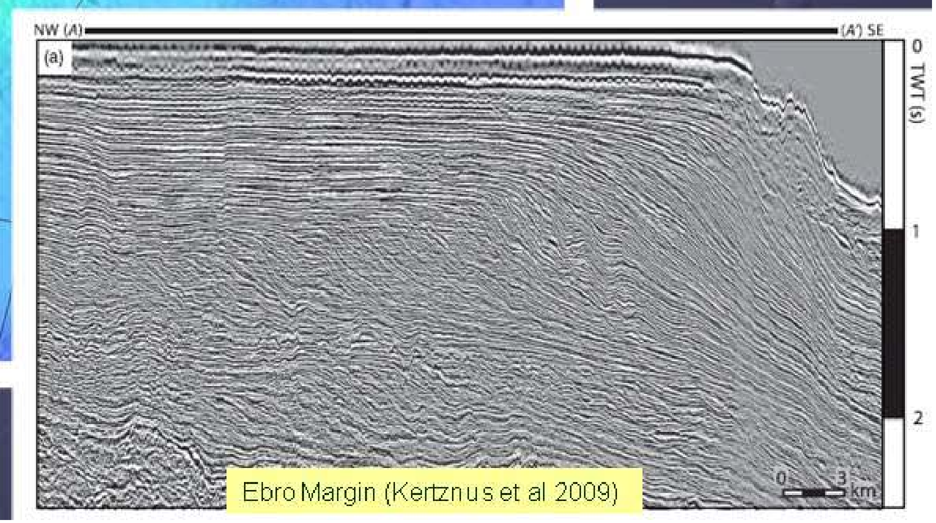


- Growth of margin prism
- Rates of growth
- Trajectory style
- Volume partitioning

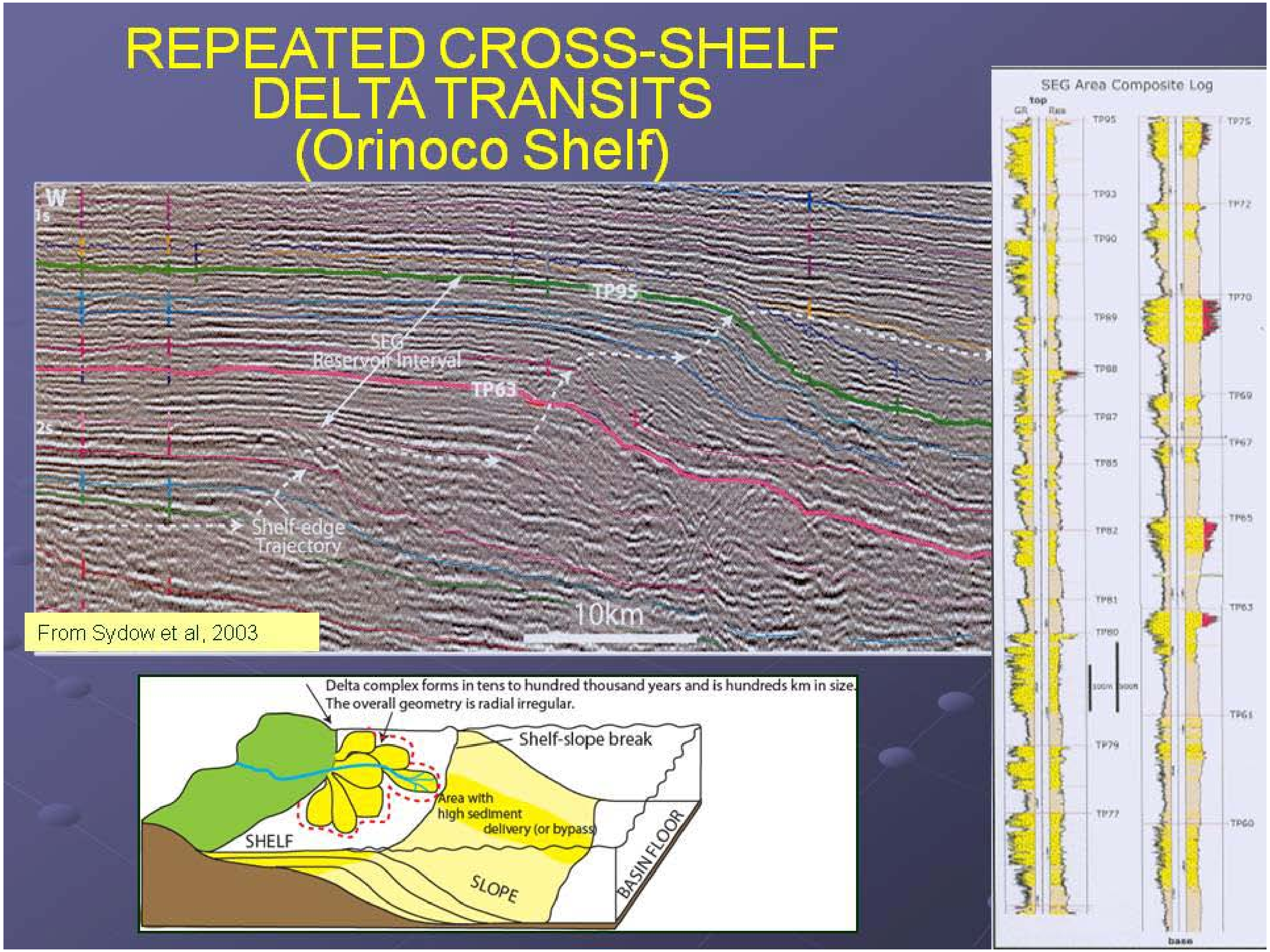
RioMAR CSM-UT

.........BUILT BY RIVER DELTA SYSTEMS: REPEATED EPISODES OF PROGRADATION



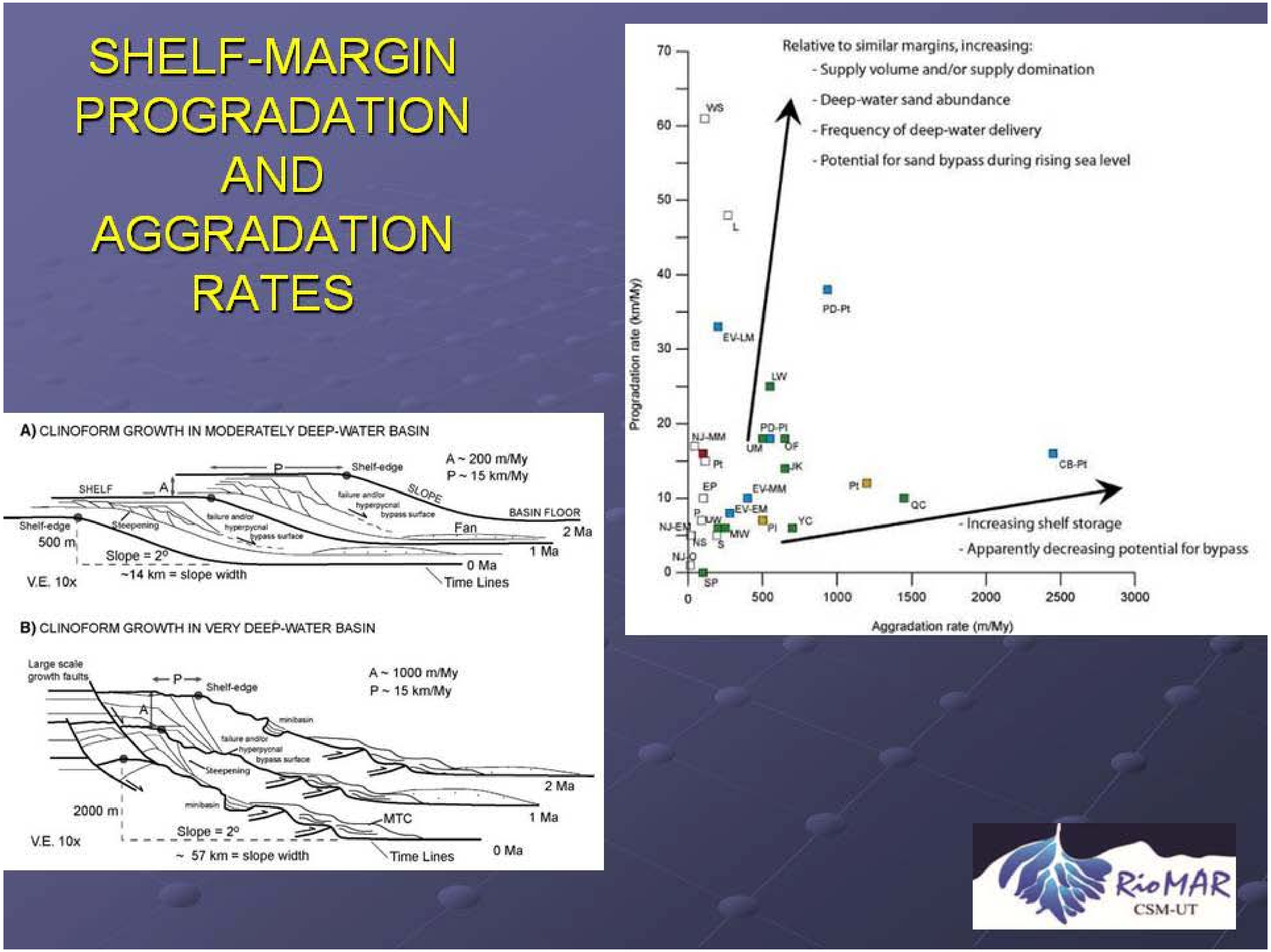


Notes by Presenter: Shelf-margin prism is gradually built out by repeated cross-shelf transits by shorelines. Note tramline character of topsets.



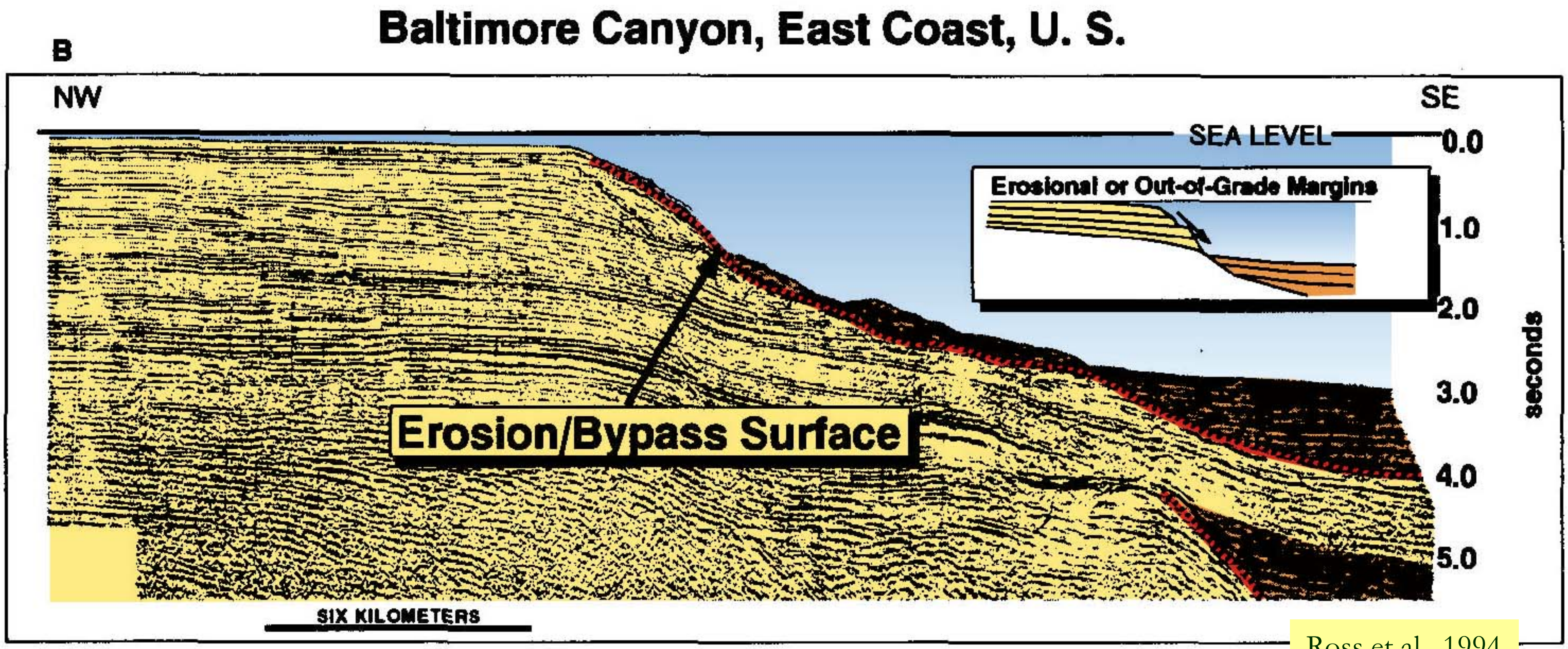
Notes by Presenter: There are both allogenic & autogenic components to shelf building. Icehouse causes longer transgressions, further enhancing the tramlines.

Notes by Presenter: Sand from delta transits is particularly well developed at shelf edge areas.



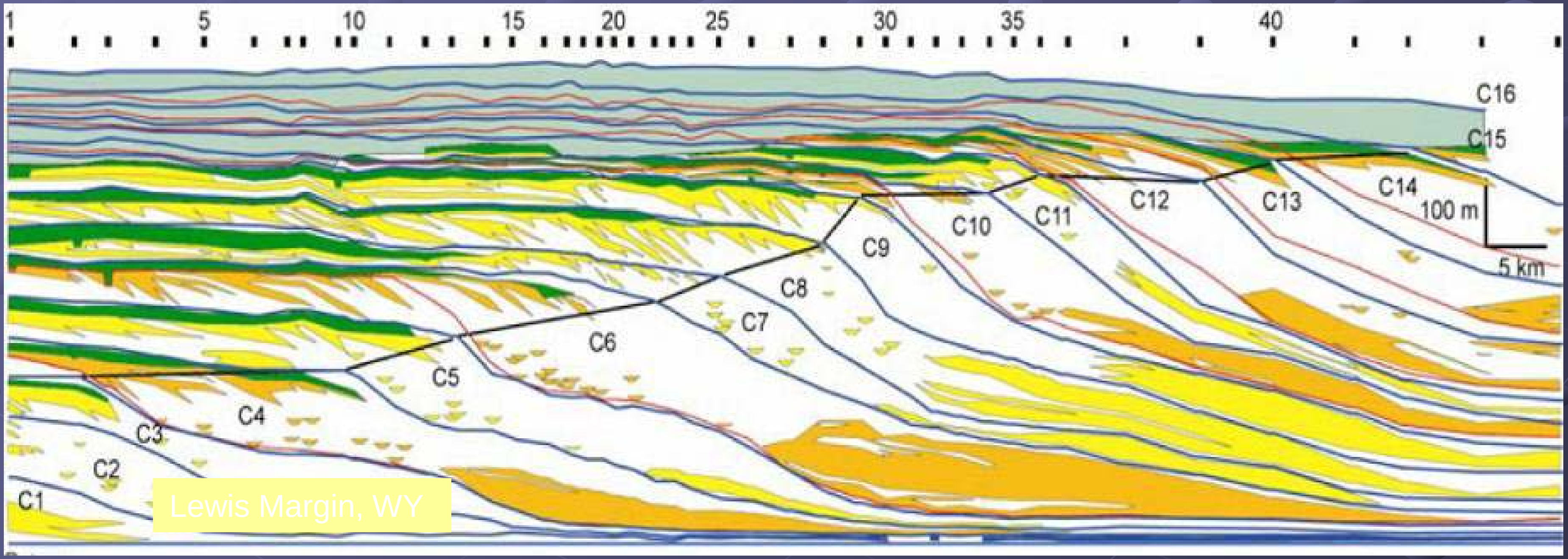
Notes by Presenter: High progradation rates favor reaching shelf edge faster and bypass; high aggradation rates favor more storage of sand on shelf.

....MARGINS CAN ALSO BE SIGNIFICANTLY EROSIONAL AT TIMES



Ross et al., 1994

SHELF-EDGE GROWTH: RISING AND CONVEX-UP



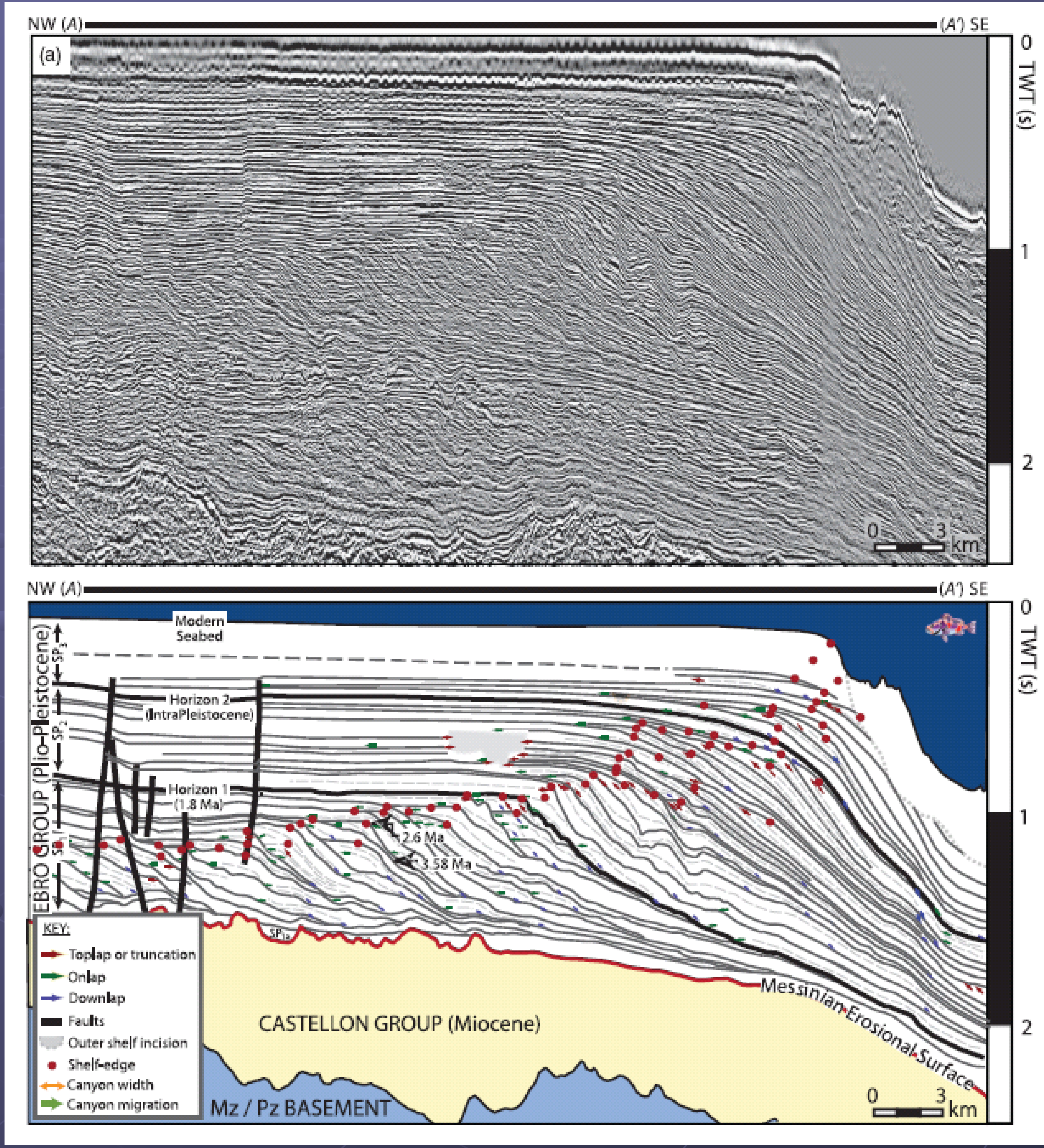
Carvajal & Steel 2006

Laramide Basin: trajectory controlled by increased sandiness & rate of sediment supply?

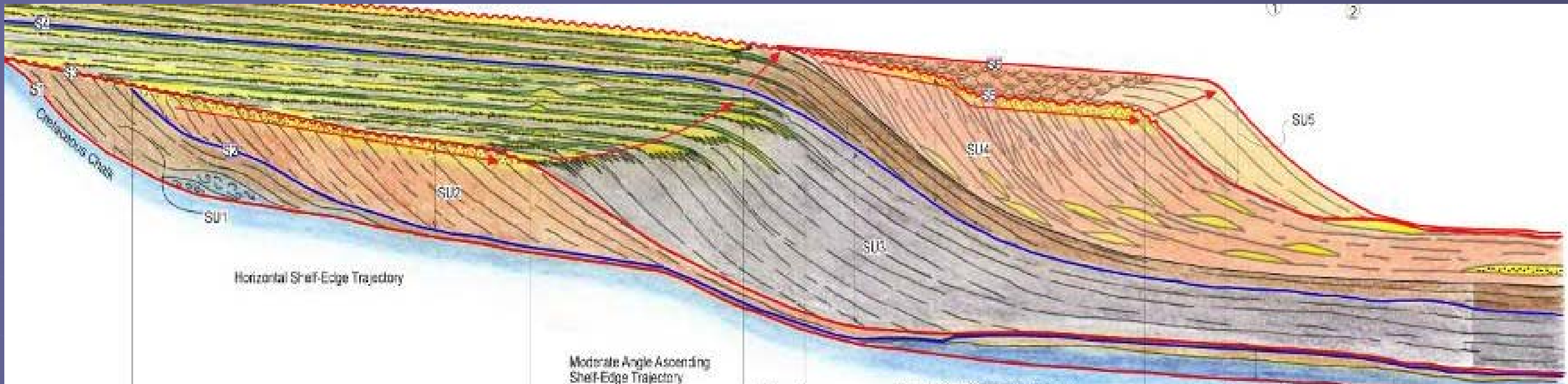
....RISING AND CONCAVE-UP

EBRO MARGIN

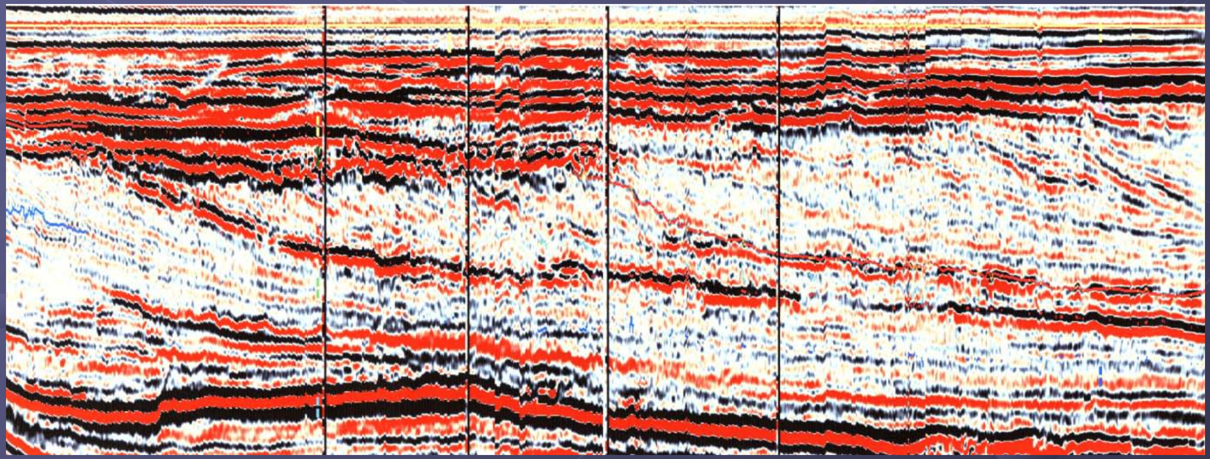
INTERPRETED AS SUPPLY INCREASE WITH ACCOMPANYING INCREASED LOADING AND COMPACTION
Kertznus et al 2009`



…..ALTERNATING RISING AND FALLING

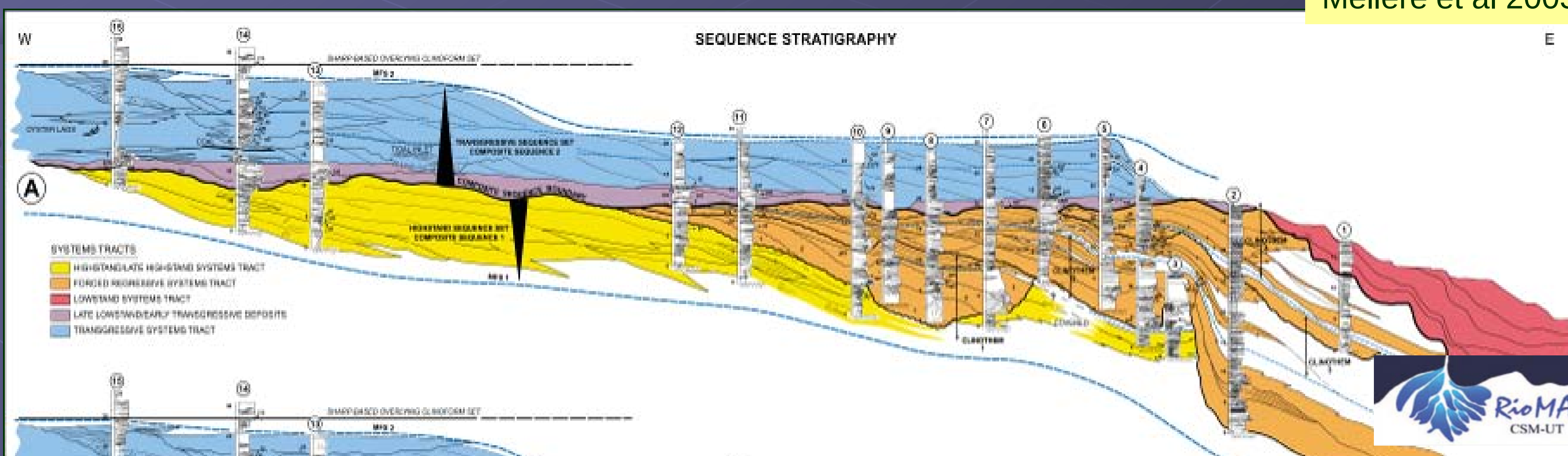


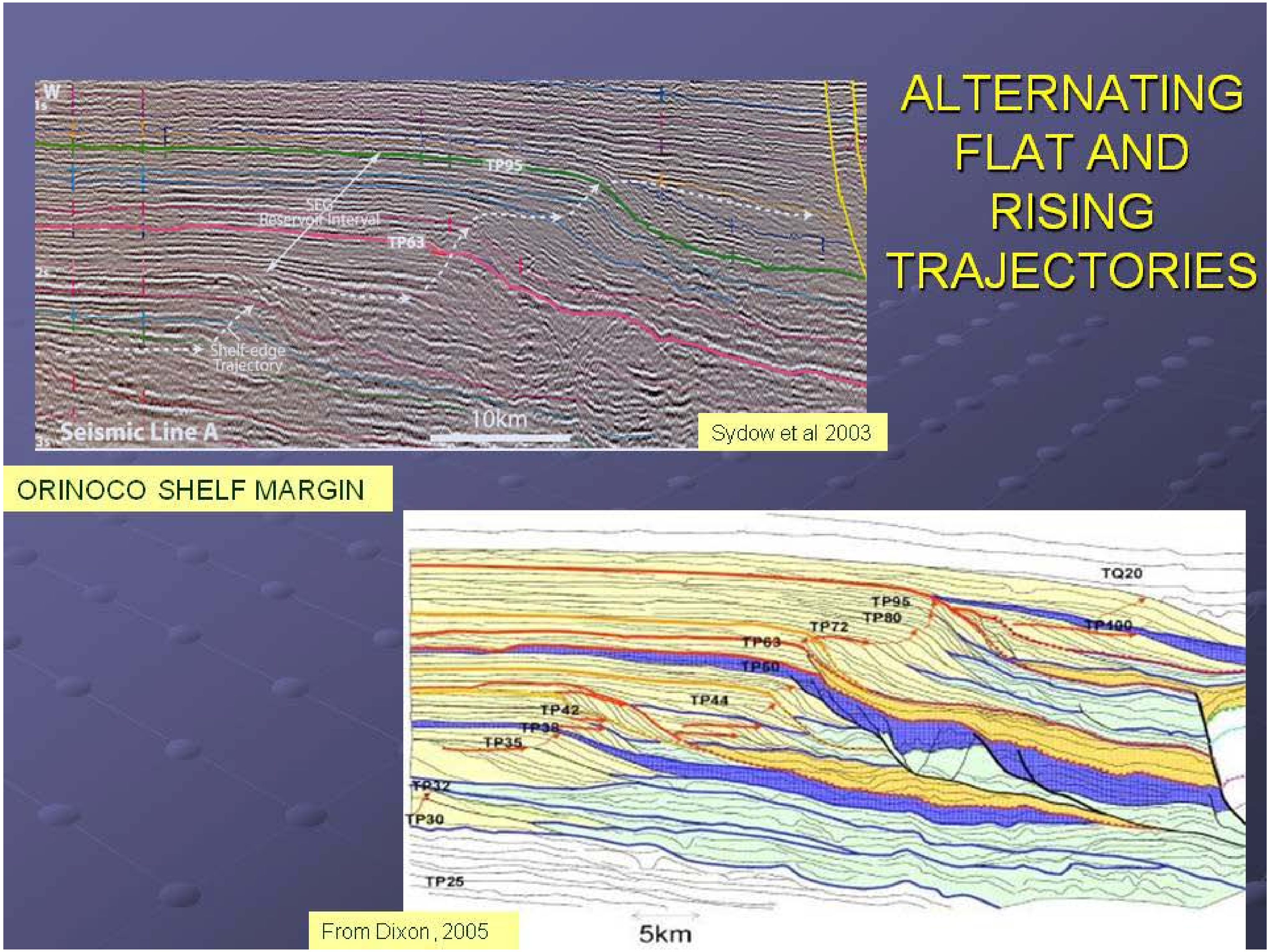
PORCUPINE MARGIN (from Ryan et al., 2009)



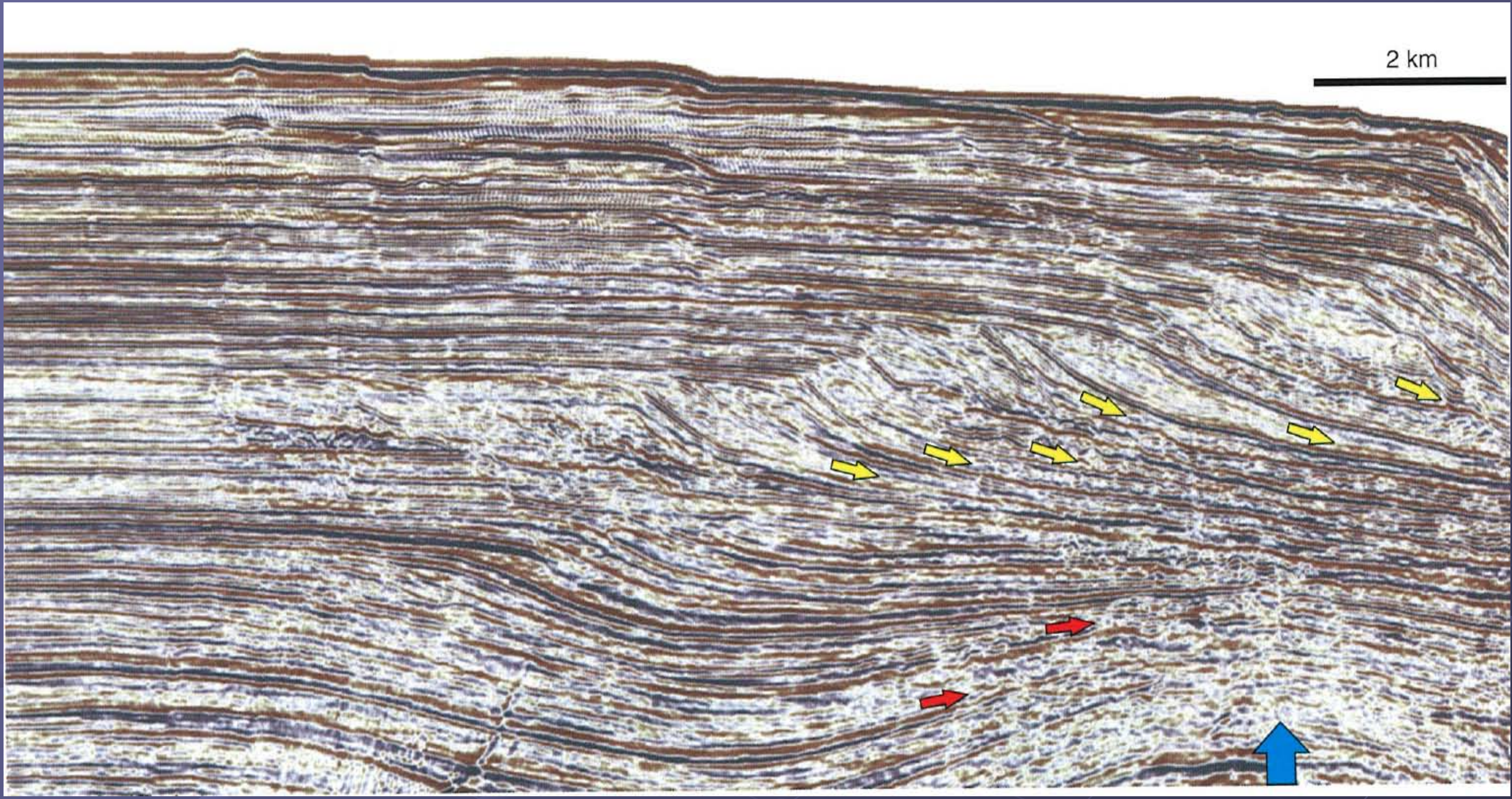
TOPLAP AND FLUVIAL INCISION IN OUTCROP…….

Mellere et al 2003





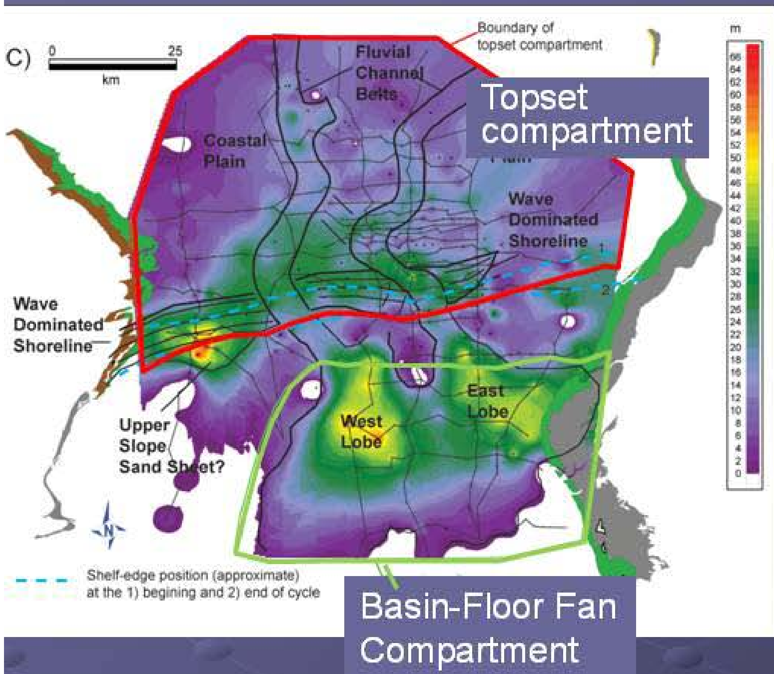
Notes by Presenter: Note the repeated tendency to flat-rising trajectory segments on time scale of 0.5-1 my.



Neogene Gulf of Mexico: Is salt growth the cause of the flatter trajectory?

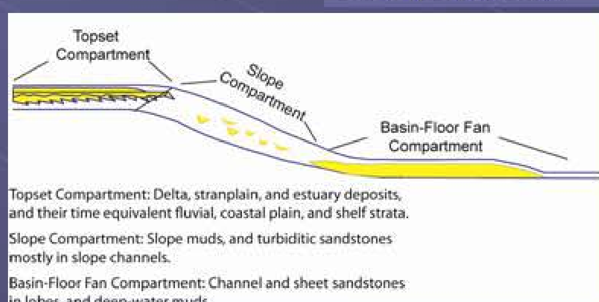
PEMEX/Catuneanu 2006

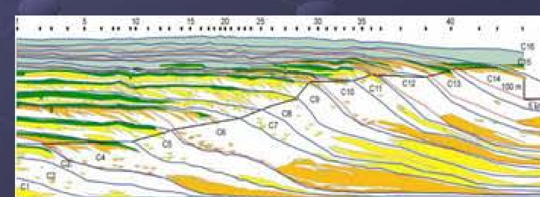
SEDIMENT VOLUME PARTITIONING – 1:1:1



Example:
Washakie Basin
Wy, Clinothem 9

- Topset/slope boundary
  - At the shelf edge in map view
- Slope/basin-floor fan boundary:
  - At approximately proximal end of fan
  - Some fans reach the lower slope, but they are included in the fan compartment

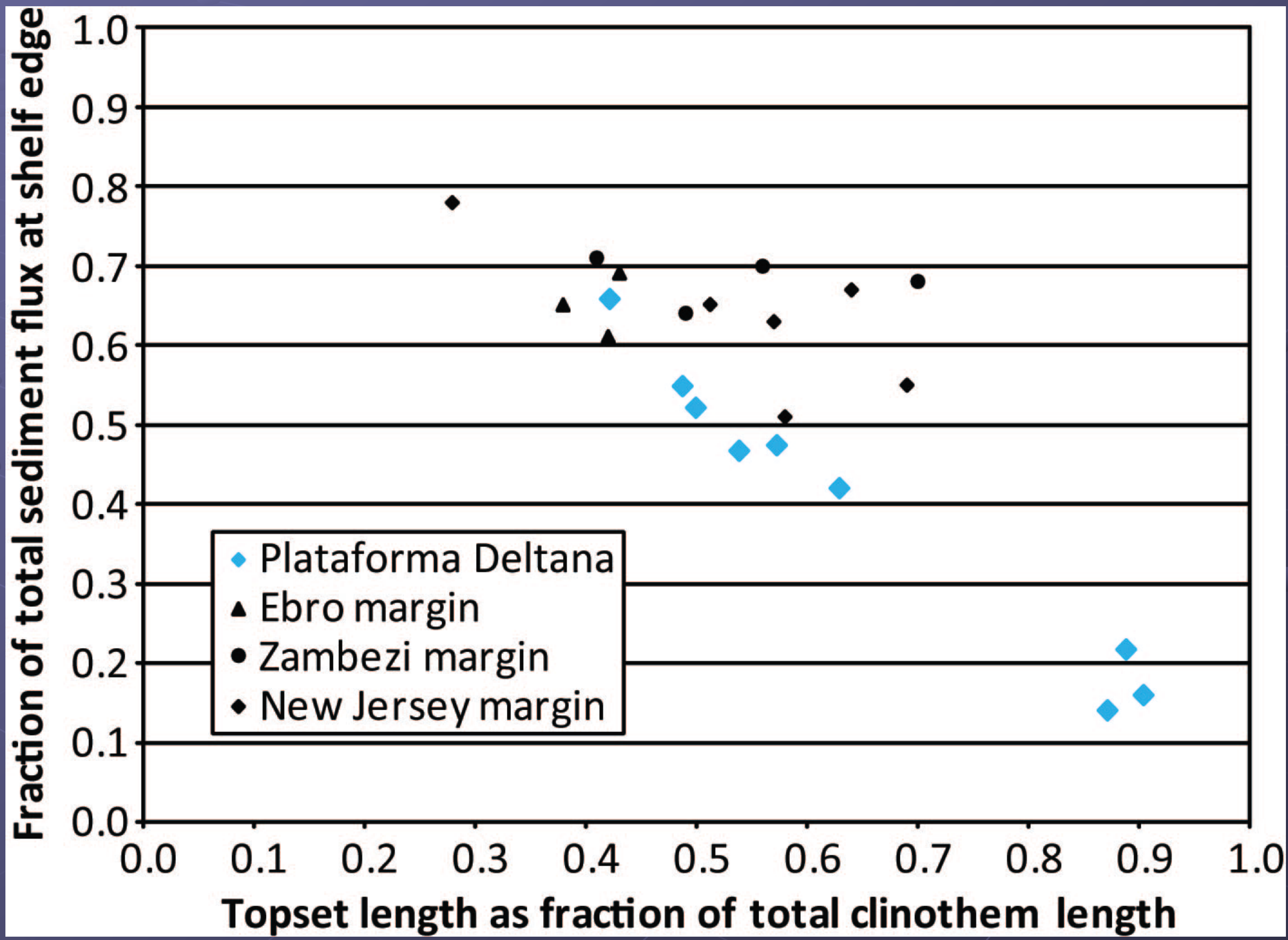




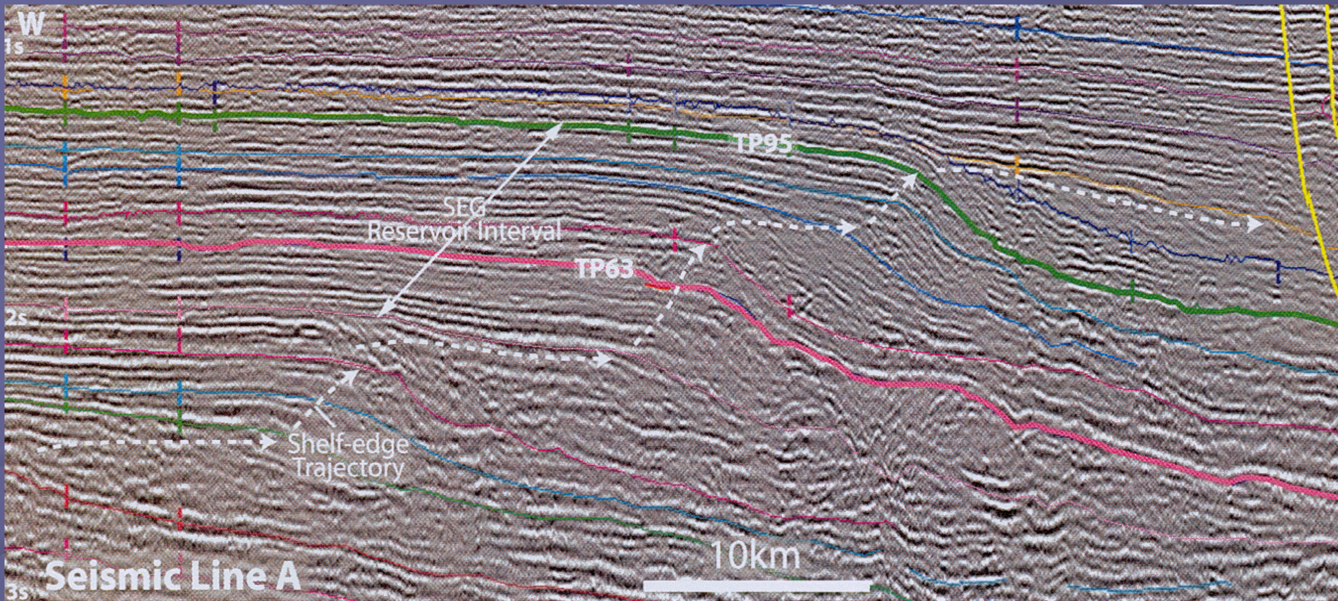
Notes by Presenter: Finally, looking at how sediment volumes are partitioned in the three compartments: Washakie-Great Divide Basin clinoforms were monitored in 3-D by tight well control, and it was found that the common partitioning was 1:1:1.

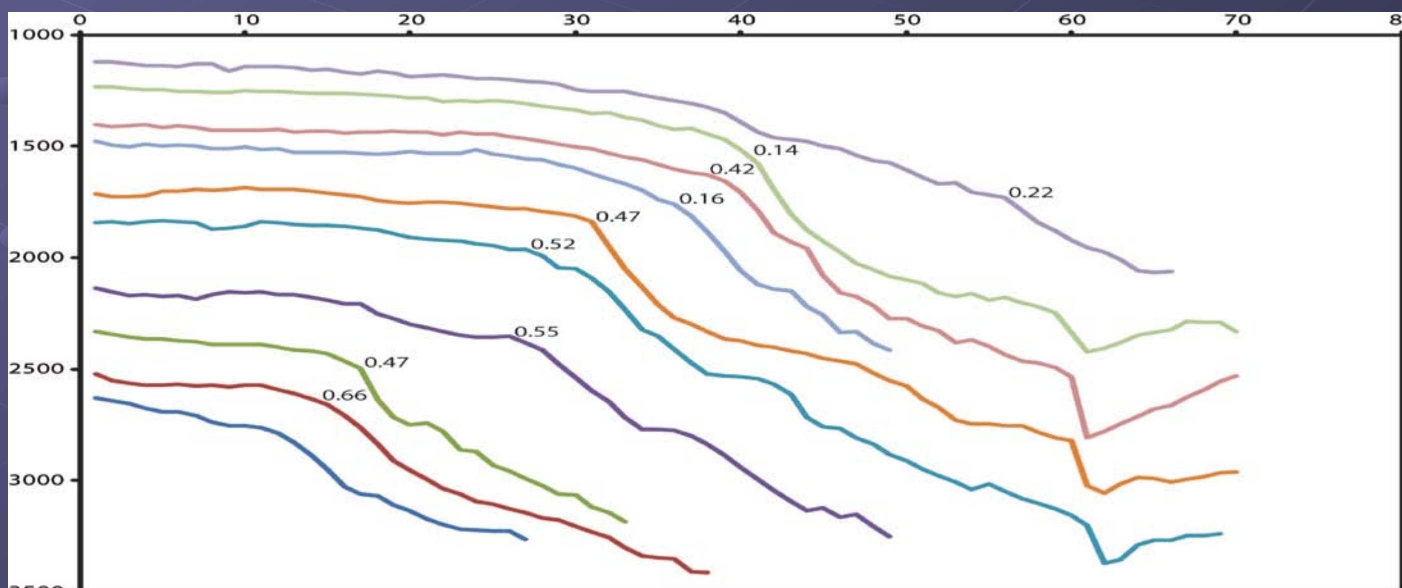
CONCLUSIONS

- Shelf-margin prism grows by the regressive and transgressive transits of delta systems
- Shelf increments of sediment appear to be allogenic in origin, especially in Icehouse climates with widespread transgressions; autogenic components spread the sediment on the shelf
- Shelf margins grow basinwards by rates varying from few km/my to 10s of km/my
- Trajectories of shelf-margin growth involve sediment supply factors (relief, climate, drainage) and sea-level factors; difficult to resolve without better dating
- Two-thirds of the total sediment budget for many clinoforms is commonly partitioned beyond the shelf edge; though this decreases on highly subsiding margins & increases across narrow shelves



Fraction of total sediment flux at shelf edge
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Topset length as fraction of total clinothem length
Plataforma Deltana
Ebro margin
Zambezi margin
New Jersey margin


W
1s
2s
3s
TP95
SEG
Reservoir Interval
TP63
Shelf-edge
Trajectory
10km
Seismic Line A


0
10
20
30
40
50
60
70
80
1000
1500
2000
2500
3000
3500
0.14
0.22
0.42
0.16
0.47
0.52
0.55
0.47
0.66