Marginal plateaus
Grenoble (France) November 28-29th, 2017

# CONTOURITE TERRACES vs MARGINAL PLATEAUS/ PLATFORMS: CONCEPTUAL IMPLICATIONS

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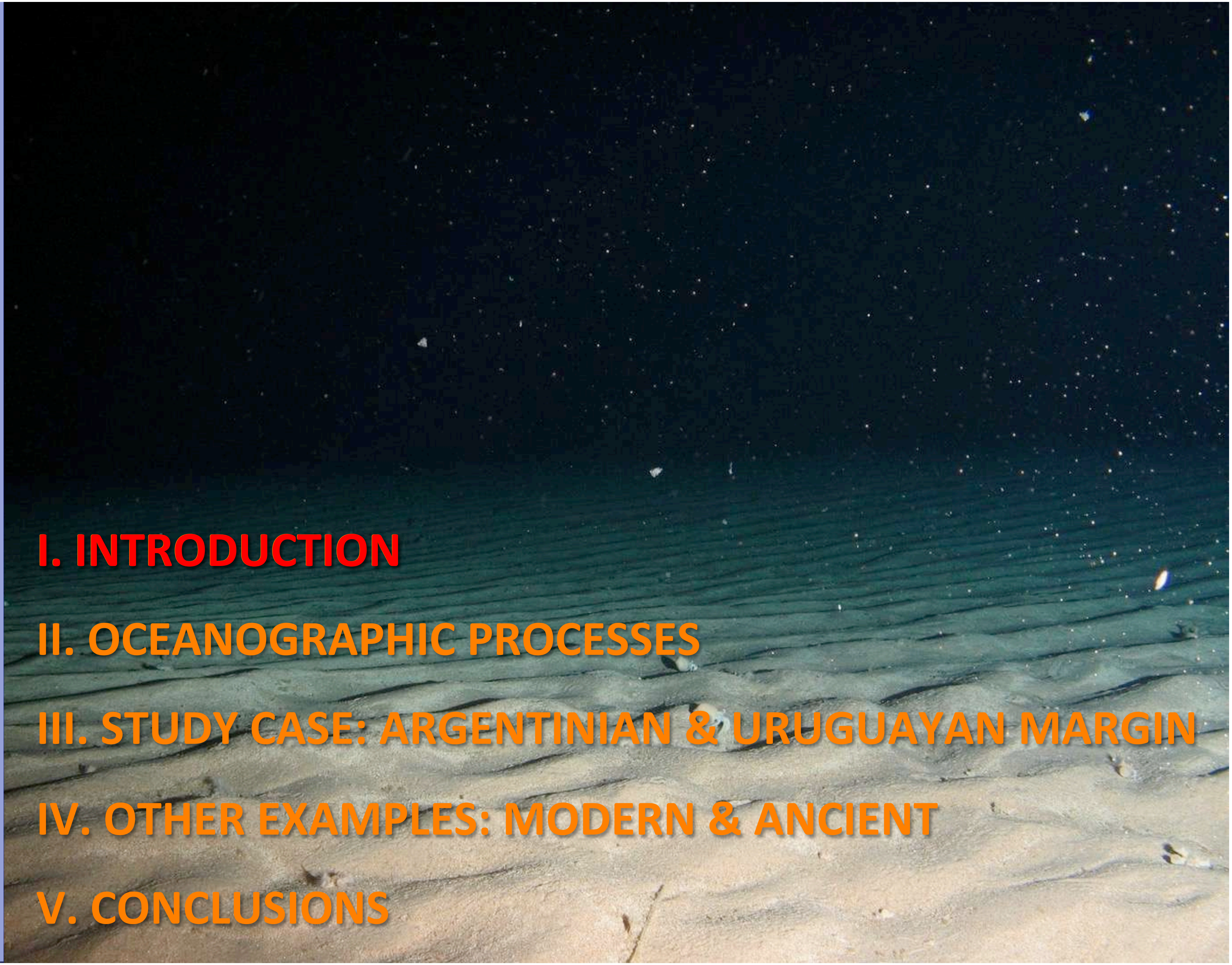
OUTLINE



I. INTRODUCTION

II. OCEANOGRAPHIC PROCESSES

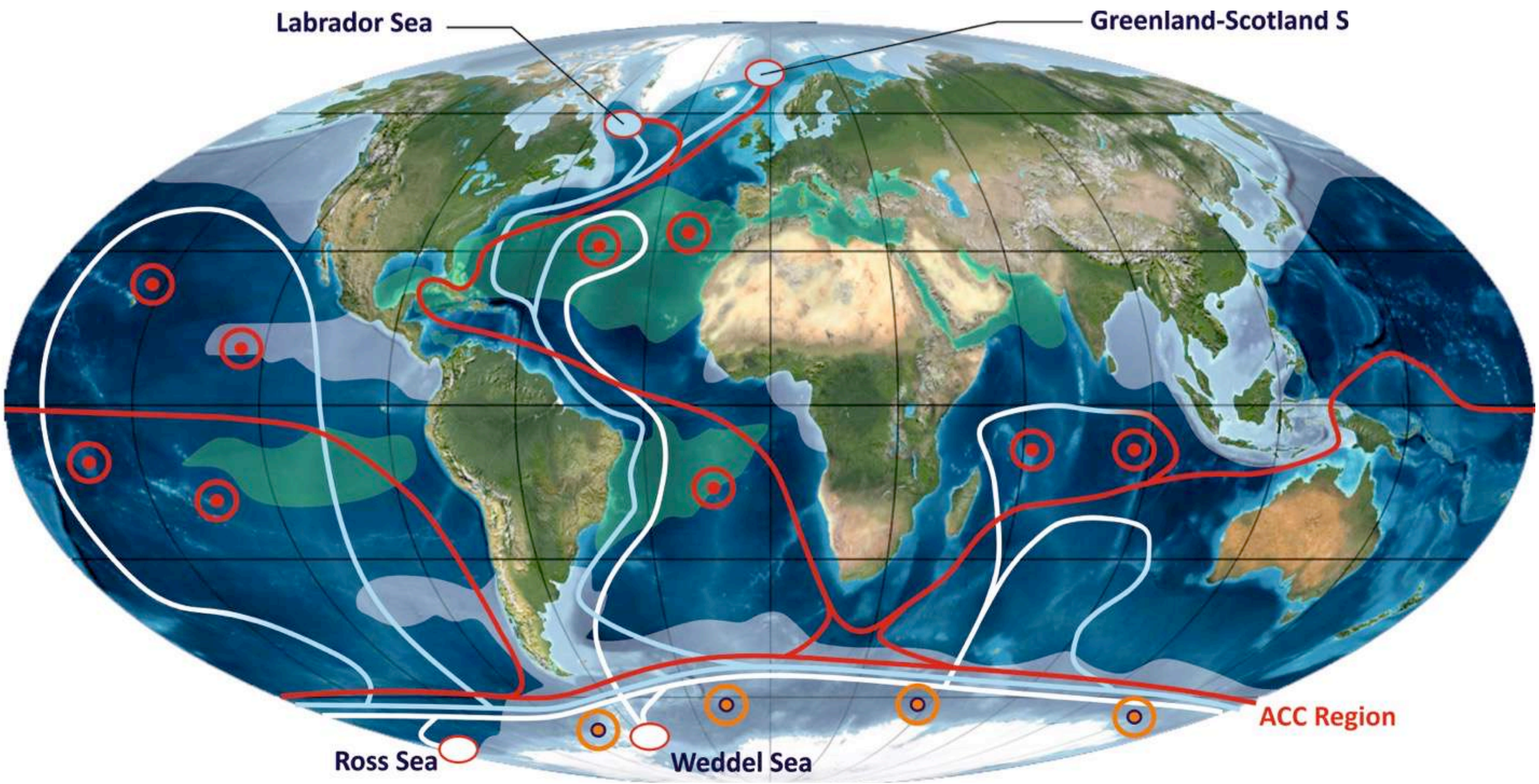
III. STUDY CASE: ARGENTINIAN & URUGUAYAN MARGIN

IV. OTHER EXAMPLES: MODERN & ANCIENT

V. CONCLUSIONS

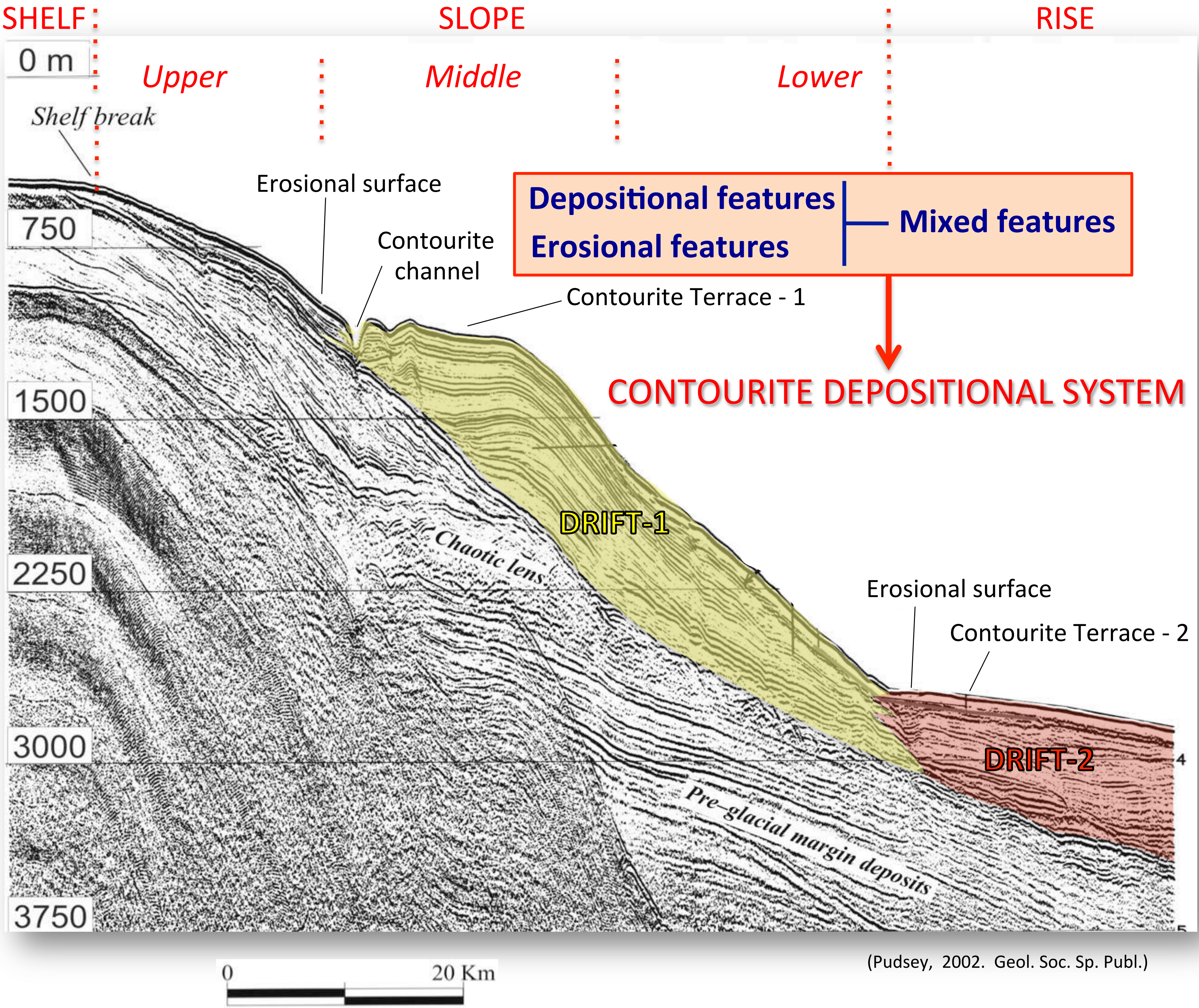
I. INTRODUCTION

Sediments deposited or substantially reworked by the persistent action of **bottom currents** (Stow & Faugères., 2008)



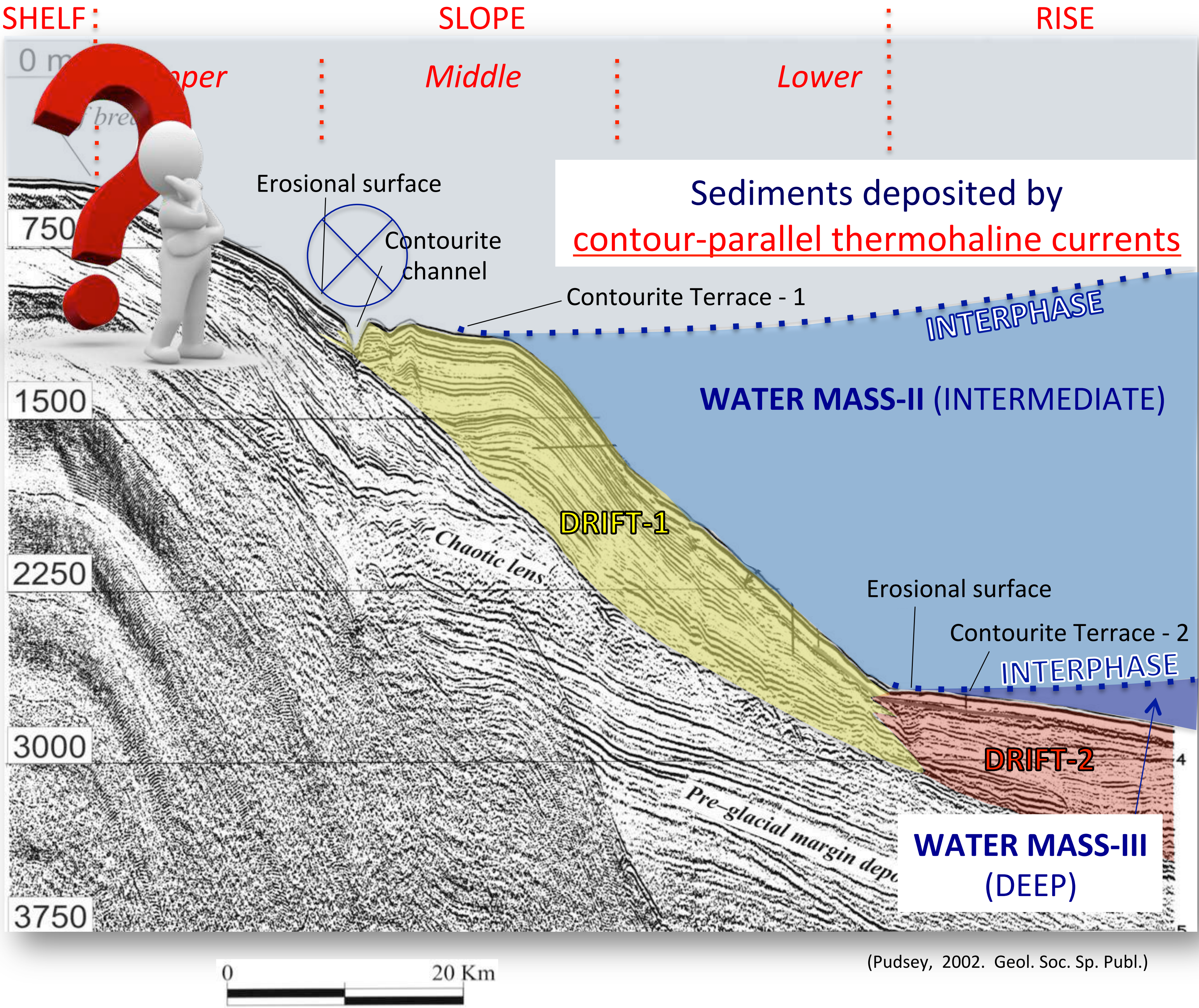

"Semi-permanent water-mass flows capable of eroding, transporting, and depositing sediments on the sea-floor"

# I. INTRODUCTION




(Pudsey, 2002. Geol. Soc. Sp. Publ.)

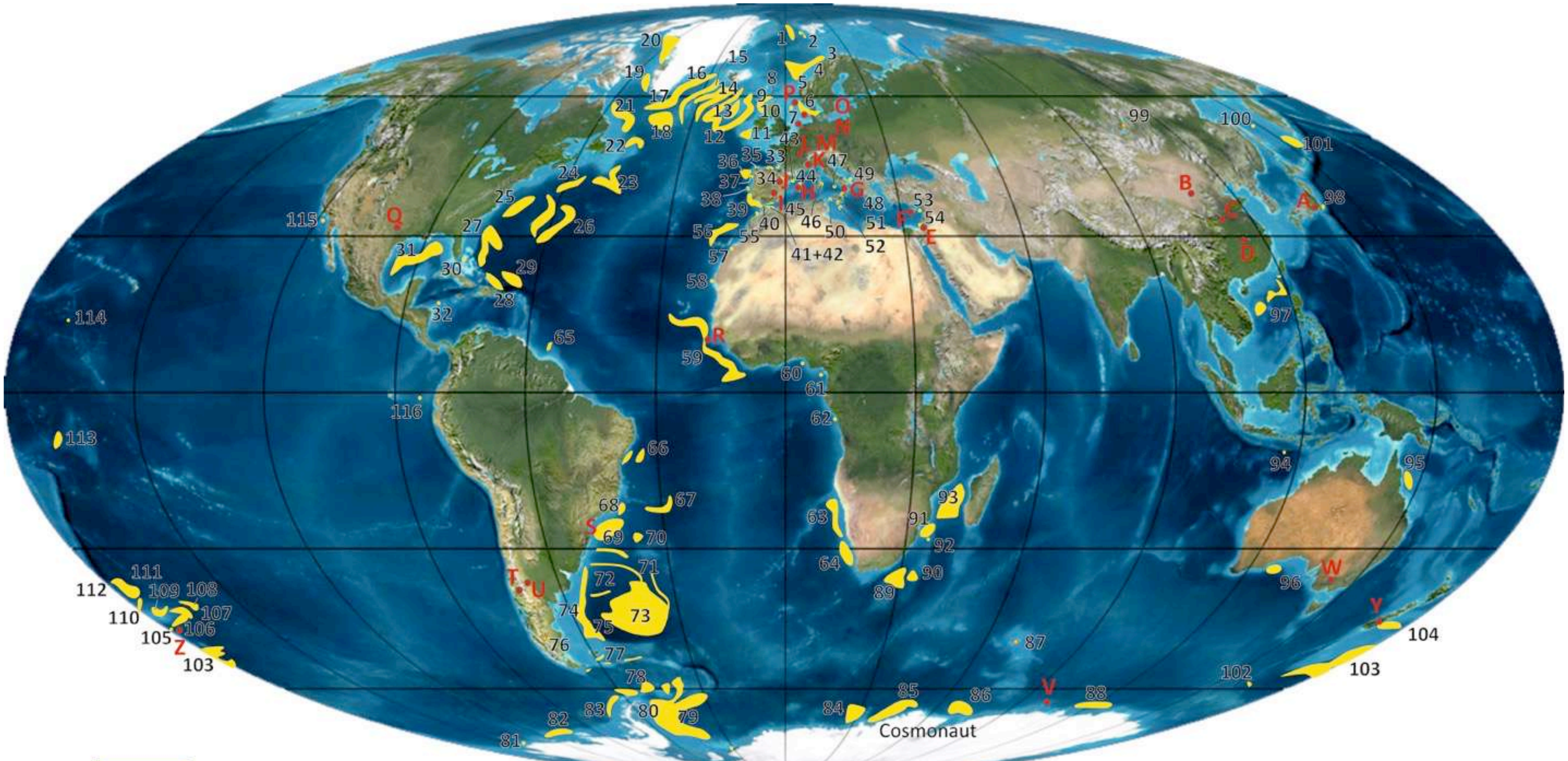
# I. INTRODUCTION




(Pudsey, 2002. Geol. Soc. Sp. Publ.)

# DEPOSITIONAL FEATURES

## Very frequent in present marine basins




Present / recent depositional features

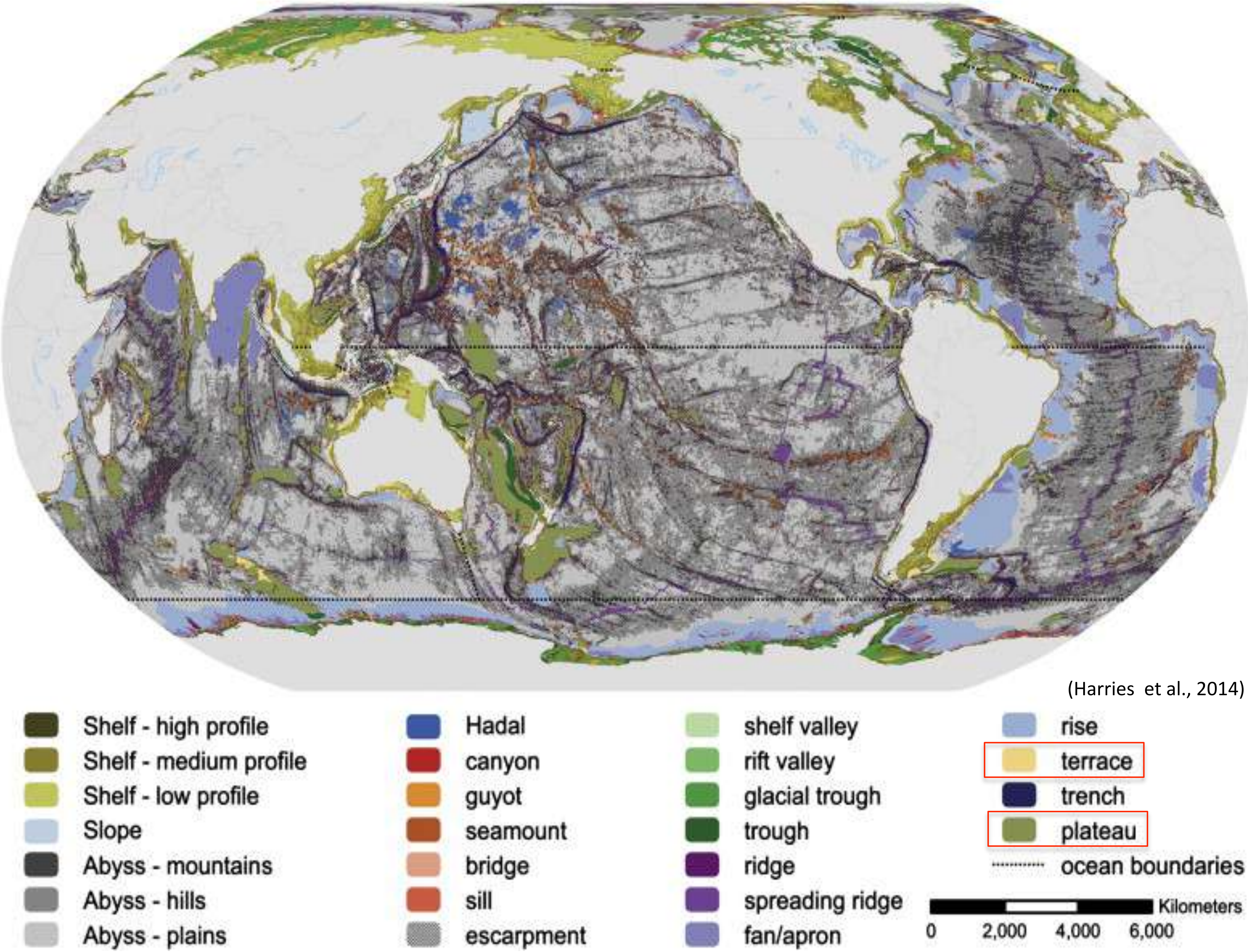
Depositional features in the ancient record

(Rebesco et al., 2014. Mar. Geol.)

Length = hundreds of km
Wide = tens of km
Thickness = 0.2-3 Km

I. INTRODUCTION

# TERRACES

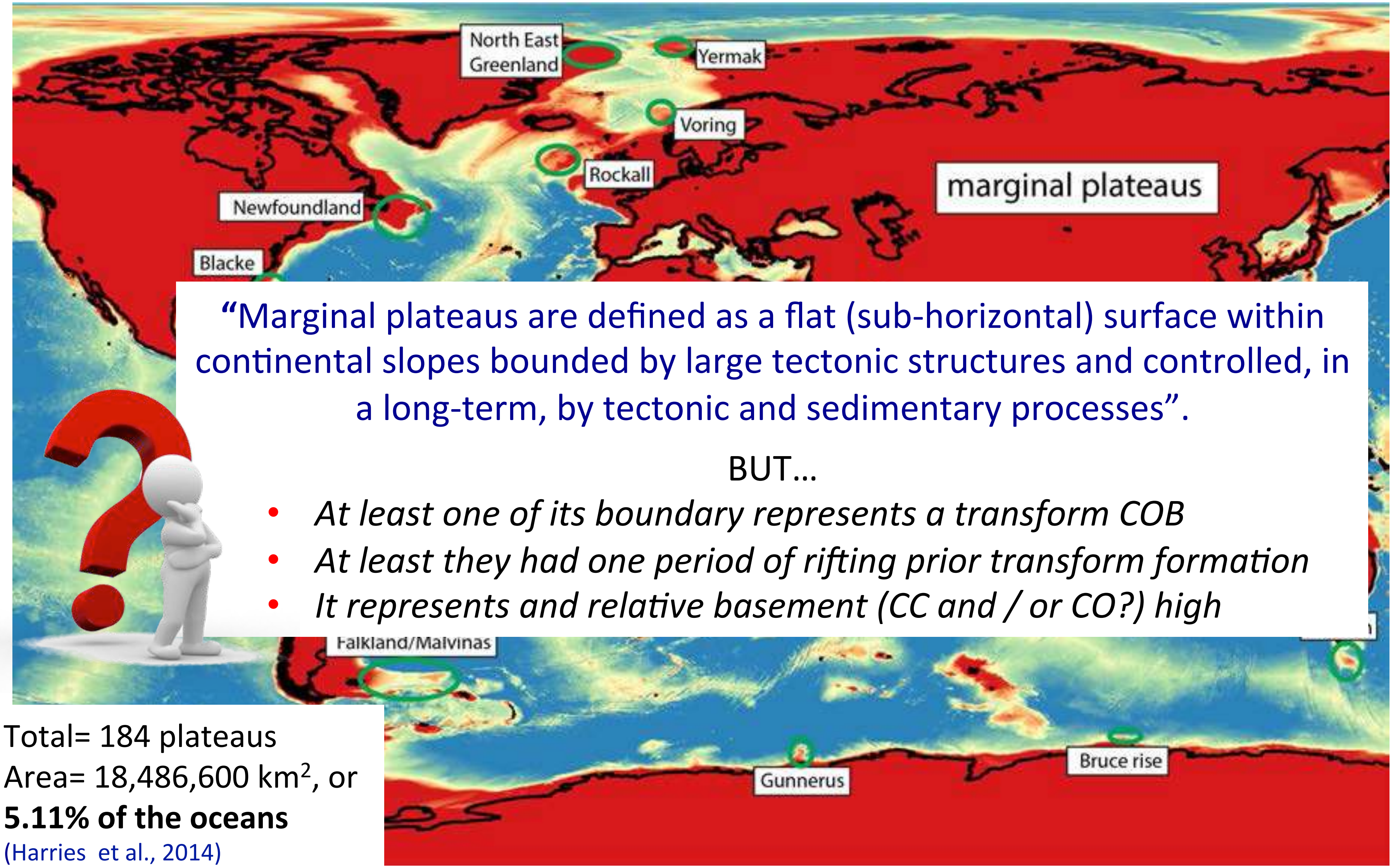



(Harries et al., 2014)

## PLATEAUS

"Marginal plateaus can be defined in the submarine morphology as flat (sub-horizontal) but deep (deeper than the shelf break) domains within the continental slope" (Mercier de Lépinay et al., 2016)

- Abut the margin
- Marginal plateaus (*separate from the slope and form isolated, raised platforms*)




"Marginal plateaus are defined as a flat (sub-horizontal) surface within continental slopes bounded by large tectonic structures and controlled, in a long-term, by tectonic and sedimentary processes".

BUT…

- *At least one of its boundary represents a transform COB*
- *At least they had one period of rifting prior transform formation*
- *It represents and relative basement (CC and / or CO?) high*

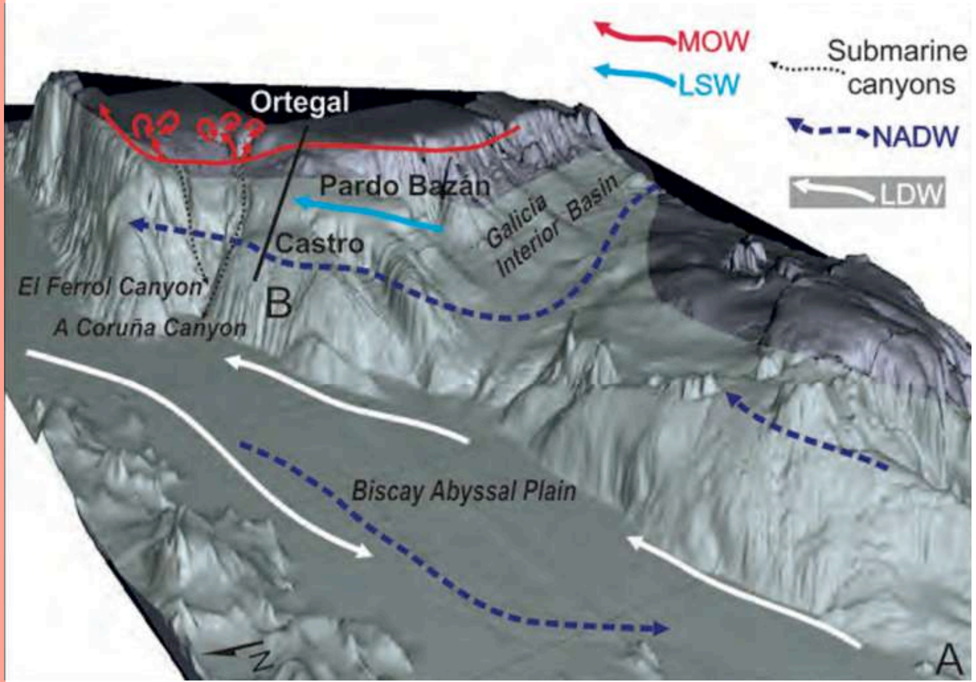
Total= 184 plateaus
Area= 18,486,600 km$^2$, or
**5.11% of the oceans**
(Harries et al., 2014)

(Courtesy from Christophe Basile, ISTerre, Université Grenoble-Alpes_2017)

I. INTRODUCTION

TERRACES

**"An isolated (or group of) relatively flat horizontal or gently inclined surface(s), sometimes long and narrow, which is (are) bounded by a steeper ascending slope on one side and by a steeper descending slope on the opposite side"** (IHO, 2008)




(Llave et al., submitted)

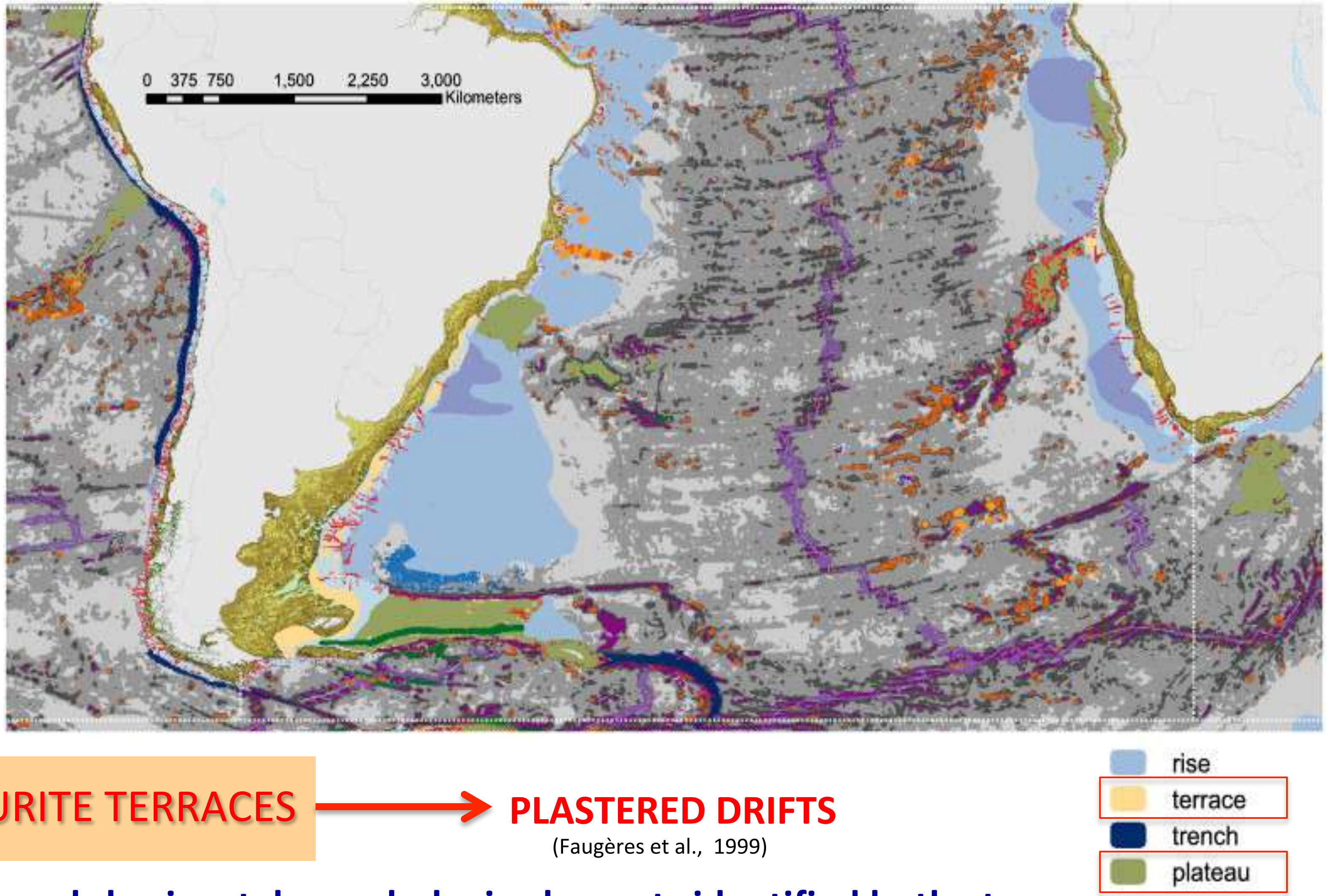
Total= 1230 terraces
Area= 2,303,490 km$^2$,
**0.64 % of the oceans**
**11.6 % of the continental slope** (Harries et al., 2014)

- Are most common on the slopes of the **Arctic** and **Indian Oceans** (> 21% of the continental slope)
- Occupy < 6% of the slope in the **Mediterranean** and **Black Seas**, the **North Pacific** and the **South Pacific Oceans**.
- The largest terrace is on the NW Shelf of Australia (104,470 km$^2$)

I. INTRODUCTION

TERRACES

**"An isolated (or group of) relatively flat horizontal or gently inclined surface(s), sometimes long and narrow, which is (are) bounded by a steeper ascending slope on one side and by a steeper descending slope on the opposite side" (IHO, 2008)**



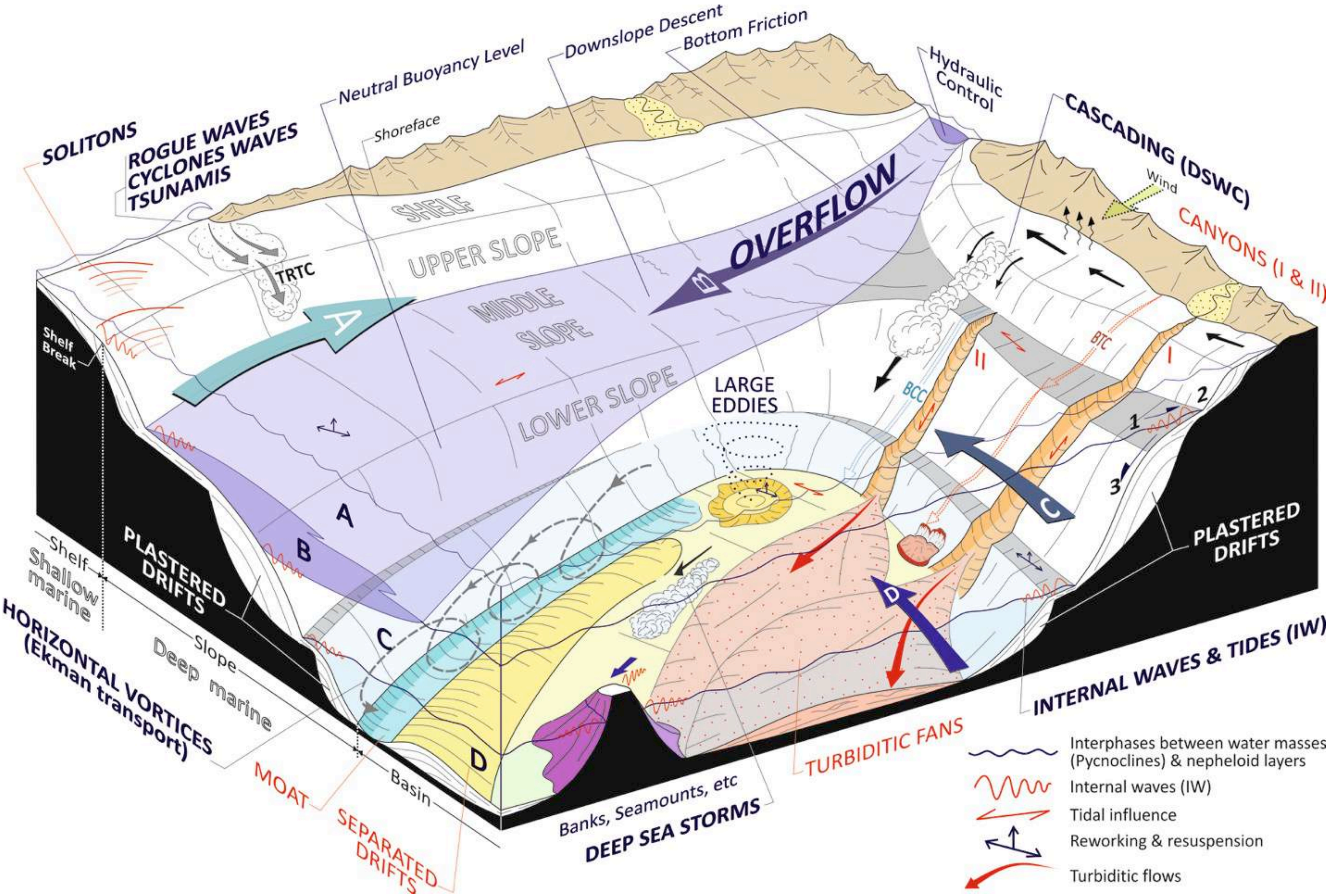

(Harries et al., 2014)

CONTOURITE TERRACES → **PLASTERED DRIFTS**

(Faugères et al., 1999)

**They are sub-horizontal morphologic elements identified both at the present sea-floor and in the sedimentary record, which have developed over time in constructional and erosive phases.**

# II. OCEANOGRAPHIC PROCESSES




(Rebesco et al., 2014. Mar. Geol.)

II. OCEANOGRAPHIC PROCESSES

# Deep water circulation is influence by a number of processes

PERMANENT

INTERMITTENT

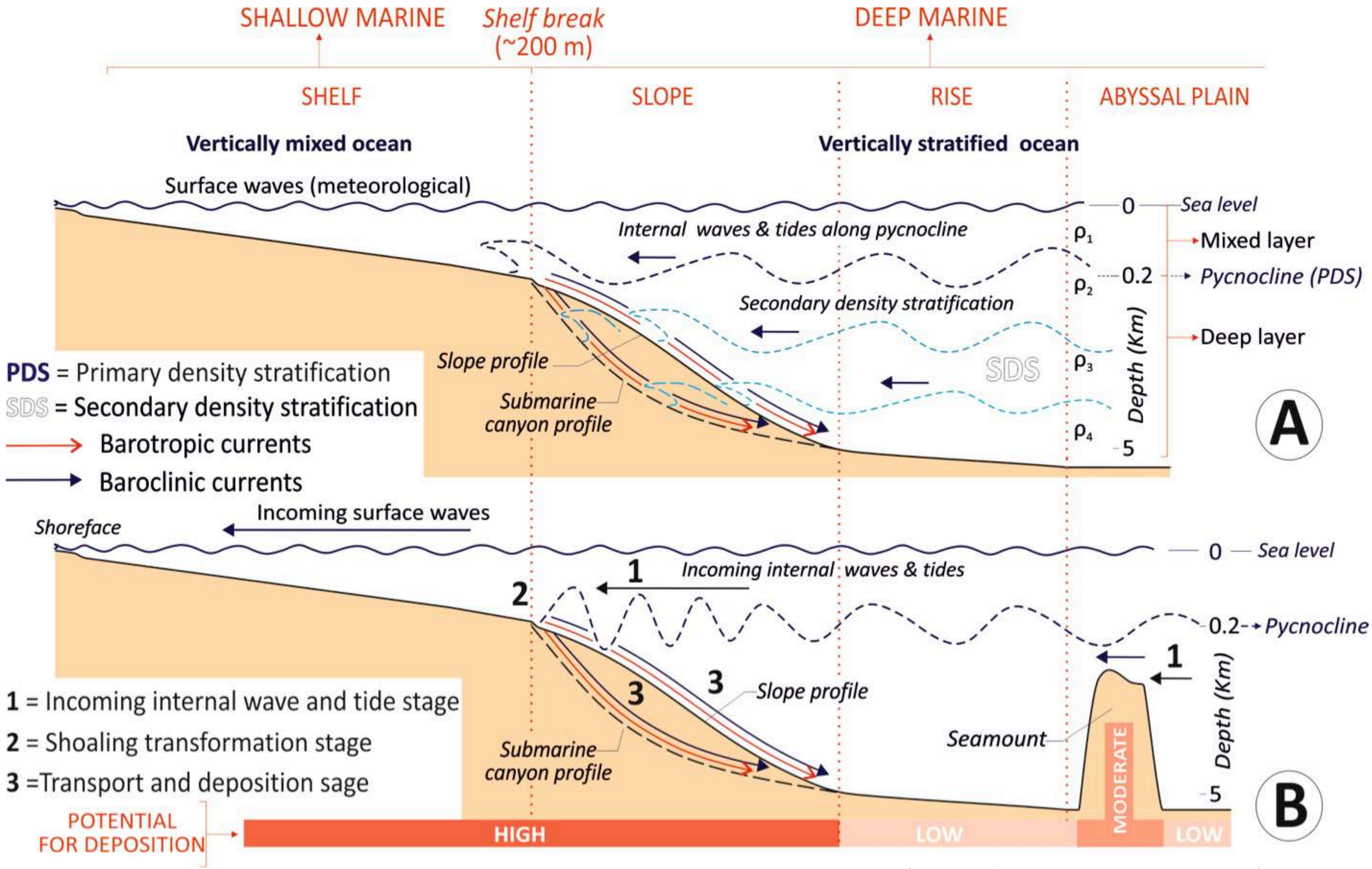
1. Bottom currents & thermohaline circulation → CONTOURITES
2. Overflows
3. Processes at the interface between water masses
4. Deep-water tidal & internal tides currents → TIDALITES?
5. Deep-sea storms
6. Eddies
7. Secondary circulation
8. Dense shelf water cascades
9. Internal waves & solitons → INTERNALITES?
10. Tsunami-related traction current
11. Rogue- & cyclone-related traction currents

*MODULE SPEED & INSTANTANEOUS DIRECTION*

BOTTOM CURRENTS DEPOSITS

DEPOSITS

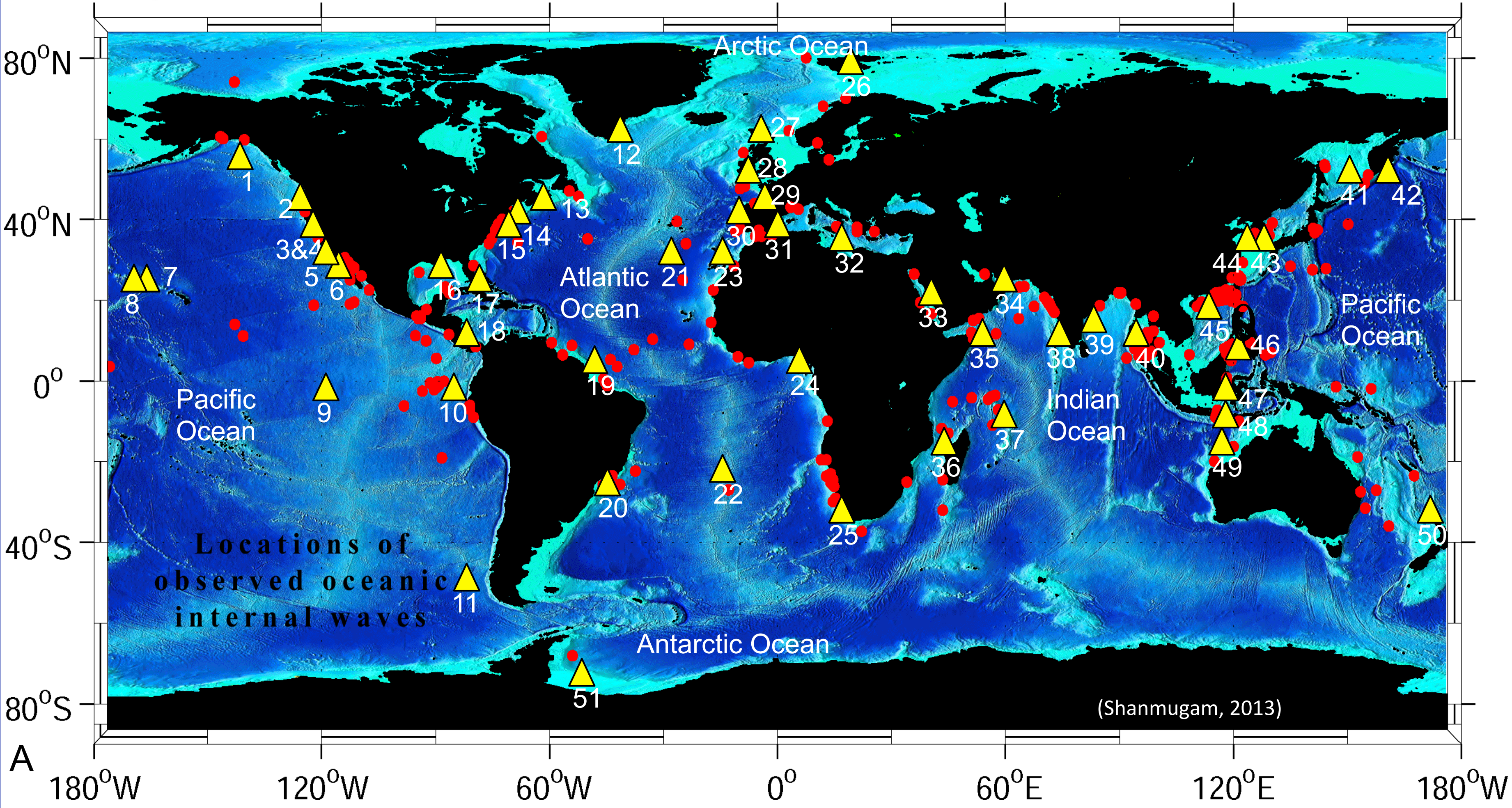
# Sub-surface waves associated to interphases between water masses with different density




(Adapted from Shanmugan, 2012, 2013)

II. OCEANOGRAPHIC PROCESSES

- *Very common in all oceans!*



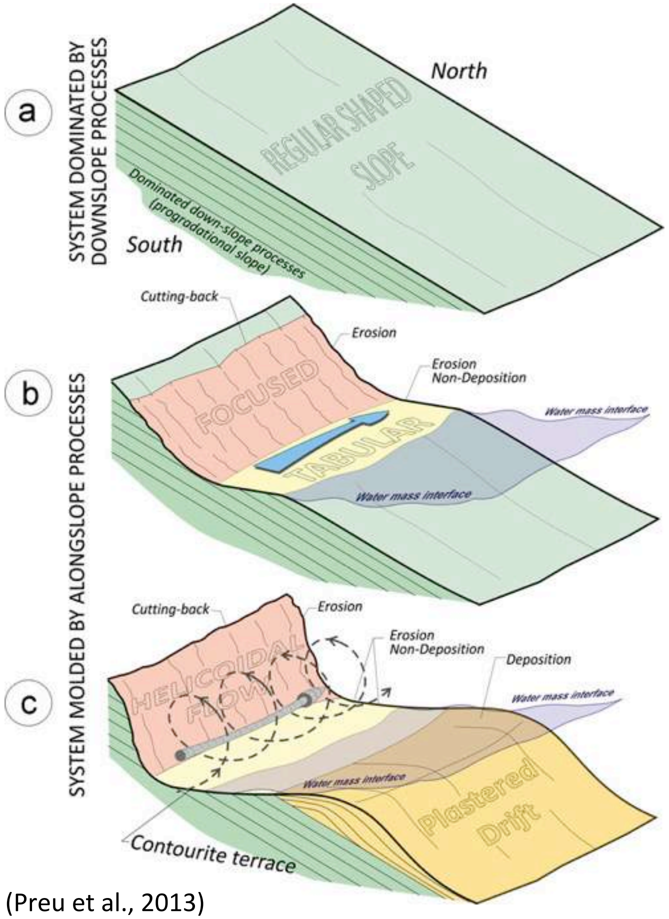

▲1 Location number and name

1. Gulf of Alaska. 2. Oregon shelf. 3. Monterey Bay, California. 4. Monterey Canyon, California. 5. Mission Bay, California. 6. Gulf of California. 7. Hawaiian Ridge. 8. Horizon Guyot. 9. Eastern Equatorial Pacific. 10. Galapagos Is. 11. Southeast Pacific. 12. East Greenland Shelf. 13. Nova Scotian Shelf Edge. 14. New England Shelf. 15. Mid-Atlantic (New York) Bight. 16. Gulf of Mexico. 17. Florida-Atlantic Coast. 18. Caribbean Sea. 19. Northern Brazil Basin. 20. Southern Brazil Basin. 21. Great Meteor Seamount. 22. Mid-Atlantic Ridge, Eastern Brazil Basin. 23. Moroccan Shelf. 24. Nigerian Shelf. 25. Southwest Africa. 26. Spitsbergen Is. 27. Faeroe-Shetland Channel. 28. Celtic Sea. 29. Bay of Biscay. 30. Iberian Peninsula.31. Strait of Gibraltar. 32. Strait of Messina. 33. Red Sea. 34. Gulf of Oman. 35. Somalia. 36. Mozambique Channel. 37. Mascarene Ridge. 38. Arabian Sea. 39. Krishna-Godavari Basin. 40. Andaman Sea. 41. Sea of Okhotsk. 42. Kamchatka Shelf. 43. Sea of Japan-Korea Strait. 44. Yellow Sea. 45. South China Sea. 46. Sulu Sea. 47. Makassar Strait. 48. Lombok Strait, 49. Australian Northwest Shelf. 50. Poor Knights Is. 51. Weddell Sea.

Locations (red dots) of observed oceanographic internal waves and tides in coastal seas and in the open ocean (*from* Apel, 2002; Jackson, 2004a).

II. OCEANOGRAPHIC PROCESSES

(Bruce Sutherland, 2013)




(Preu et al., 2013)

Breaking of internal waves on sloping surfaces creates episodic high-turbulence events and consequently erosion and transport of sediments

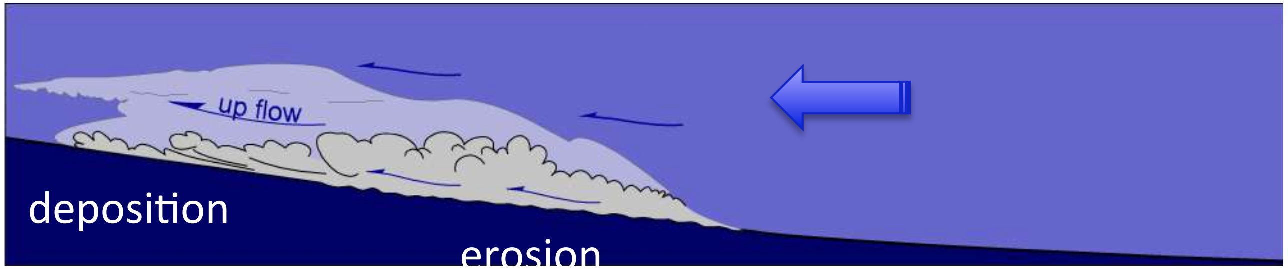
II. OCEANOGRAPHIC PROCESSES

# Impact in sediments: breaking internal waves

*based on laboratory experiments (Southard & Cacchione, 1973)*

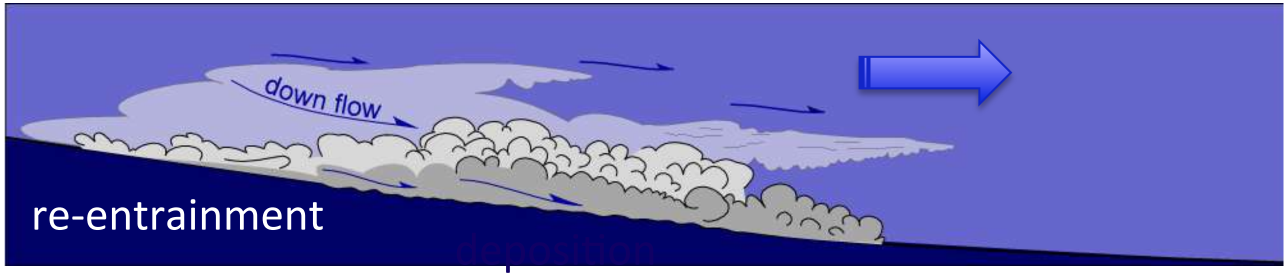
Upslope, partly in suspension

**SWASH RUN-UP**



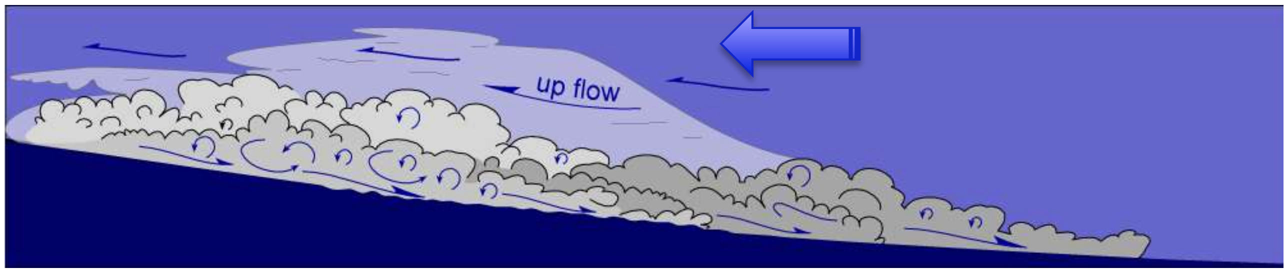

Downslope, as bedload

**BACKWASH**




Repetitive high energy events

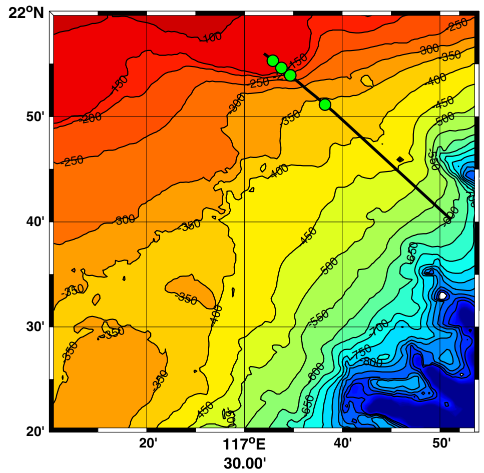
(Southard & Cacchione, 1973)

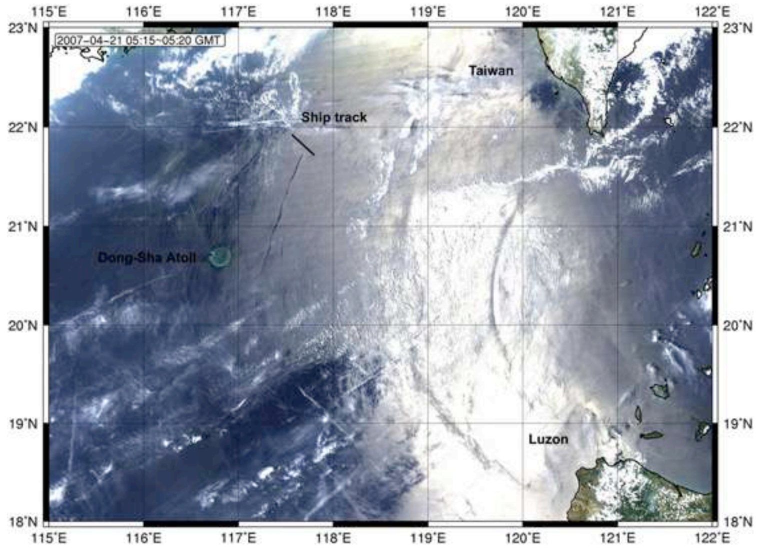


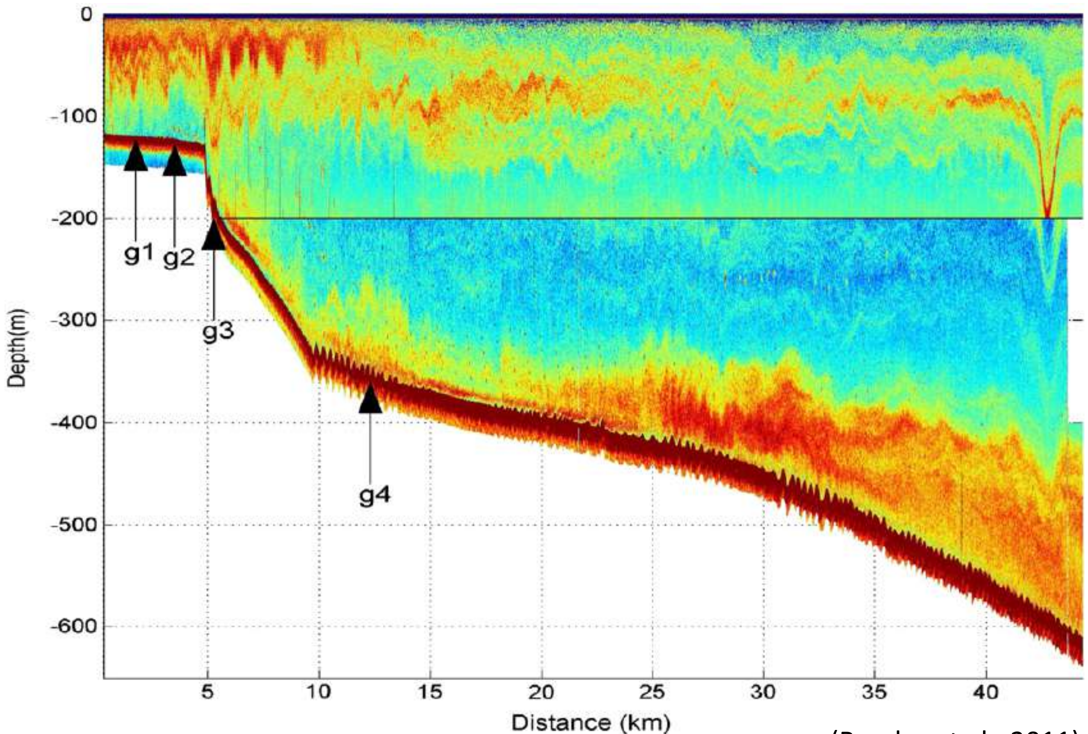

(Bádenas et al., 2011)

II. OCEANOGRAPHIC PROCESSES

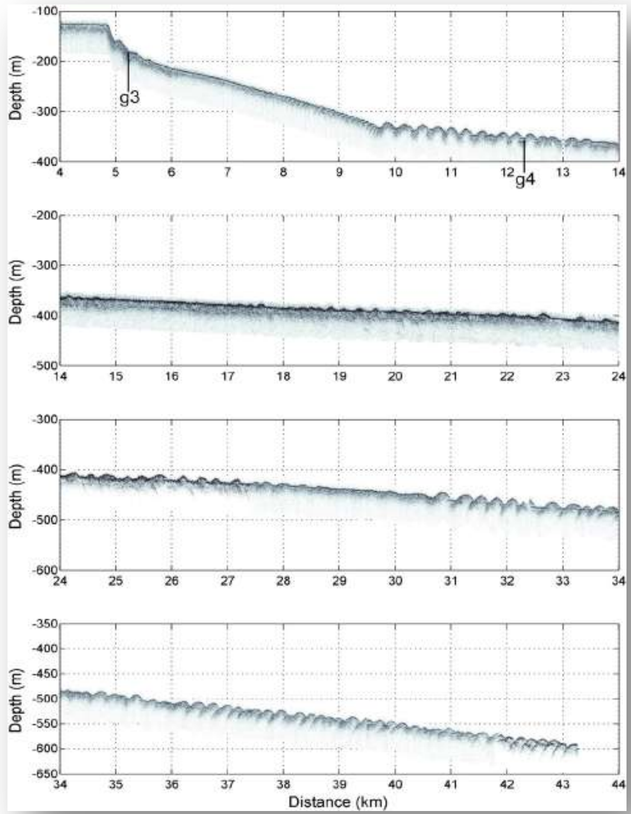
# SOUTH CHINA SEA



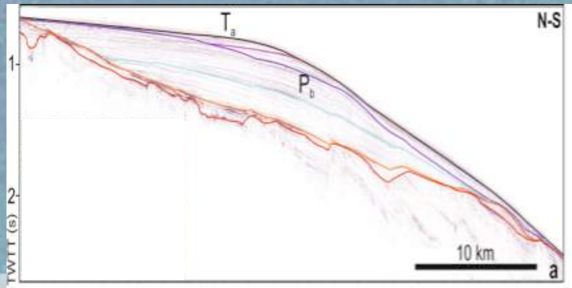




(Reeder et al., 2011)



# III. ARGENTINIAN & URUGUAYAN MARGIN

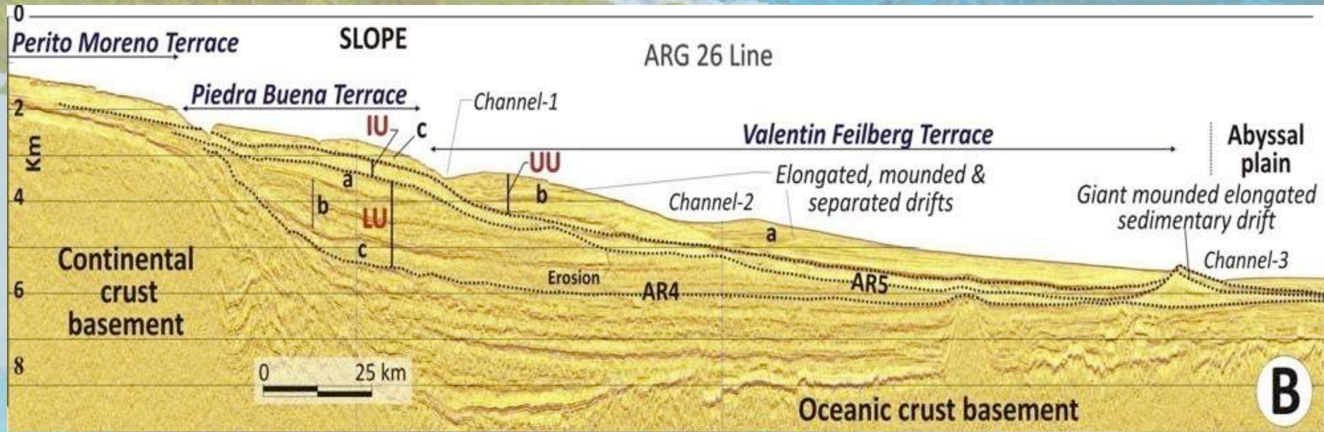
## OFF TIERRA DEL FUEGO




(Modified from Koenitz et al. 2008 in Pérez et al., 2015. GML)

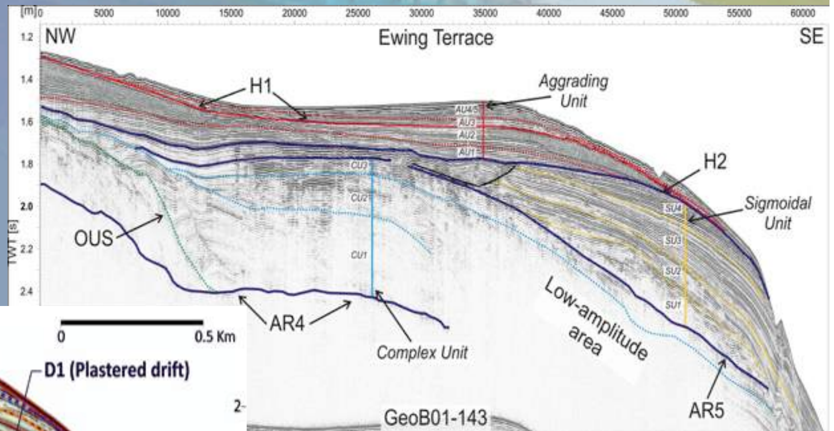
## PATAGONIAN MARGIN

H1 -> Late Pliocene (~3.2 Ma)
H2 -> Middle/Late Miocene
AR5 -> Middle Miocene (~17 Ma)
OUS -> Oligocene Upper Slope (~23 Ma)
AR4 -> Eocene/Oligocene (~32 Ma)



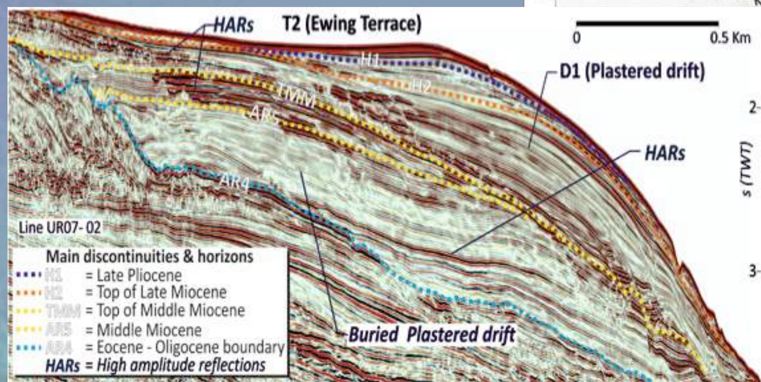

(Hernández-Molina et al., 2009. *Geology*)

## RÍO DE LA PLATA MARGIN



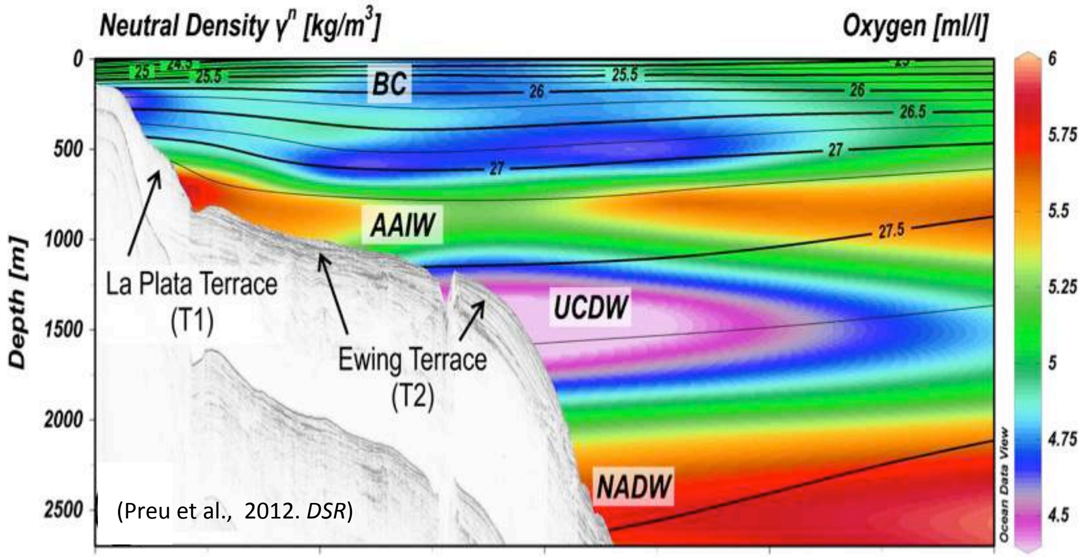

(Preu et al., 2012. *DSR*)

## URUGUAYAN MARGIN




(Hernández-Molina et al., 2016. *Marine Geology*)

# III. ARGENTINIAN & URUGUAYAN MARGIN

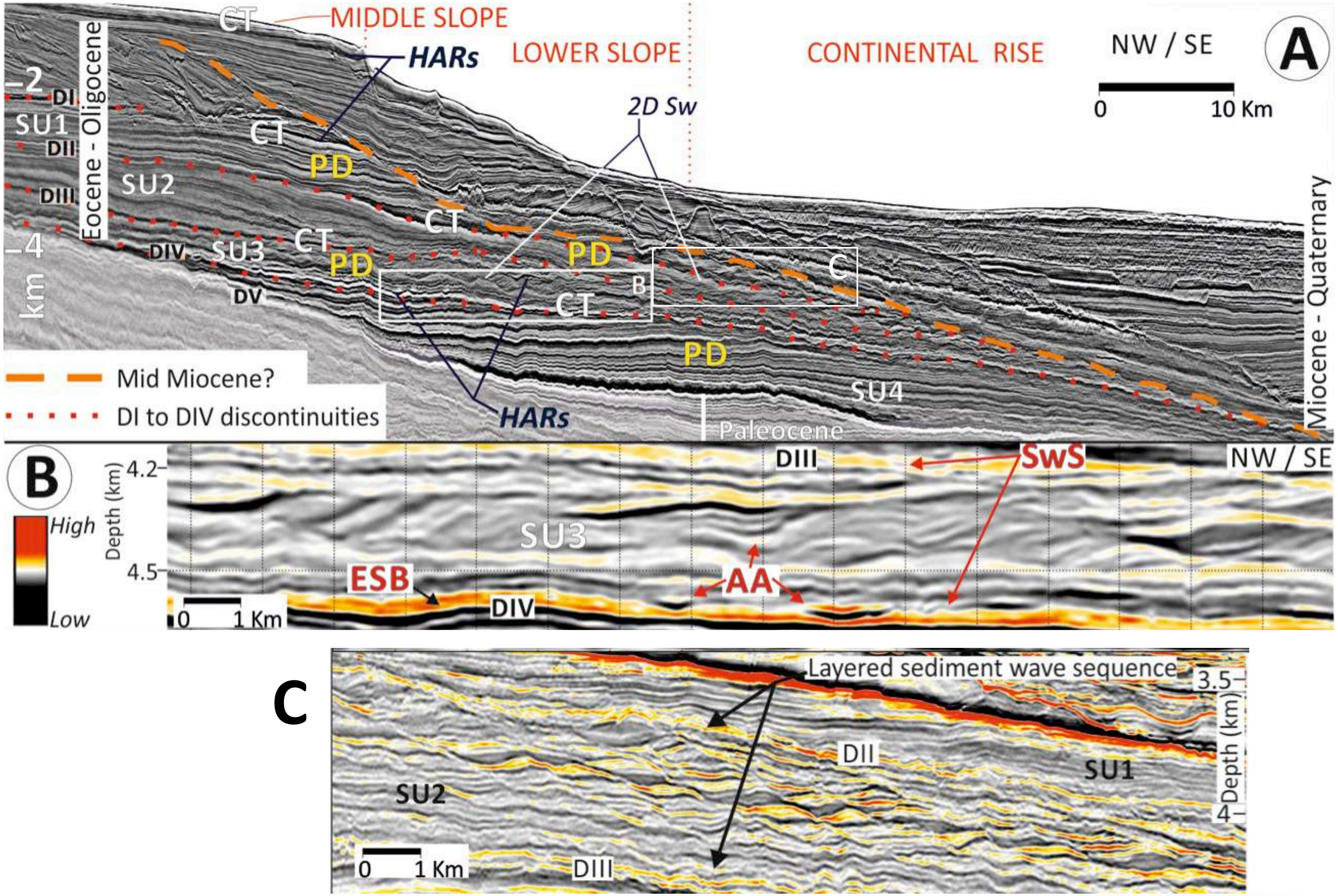


(Preu et al., 2012. *DSR*)

- Their location can be correlated with the main interfaces of regional water masses.

| ARGENTINE | | | | URUGUAY | | |
|---|---|---|---|---|---|---|
| Off Tierra del Fuego | | Patagonian margin | Rio de La Plata | | | |
| | | | | | | TW |
| | | | | 250 m | T0 | |
| | | | | | | SACW |
| Ta | 500 m | Nágera | T1= La Plata | 400 / 600 m | T1 | |
| | | | | | | R-AAIW |
| Tb | 1000 m | Perito Moreno | T2= Ewing | 1200 / 1300 m | T2=Ewing | |
| | | | | | | UCDW (NADW) |
| | 2500 m | Piedra Buena | T3 | 2500 m | T3 | |
| | | | | | | LCDW (NADW) |
| | 3800 / 3500 m | V. Feilberg | T4 | 3500 m | T4 | |
| | | | | | | AABW |

# III. ARGENTINIAN & URUGUAYAN MARGIN




BG GROUP

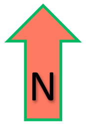
**AA** = Amplitud anomaly barchan "horns"
**BD** = Barchan dunes
**CT** = Contourite terrace
**DC** = Downslope channels

**ESB** = Erosional surface with barchan bedforms
**F** = Furrows
***HARs*** = High amplitude reflections
**PD** = Plastered drifts

**SAM** = Seismic amplitude map
**SR** = Sand ribbons
**Sw** = 2D sedimentary waves
**SwS** = Layered sediment wave sequence

(Hernández-Molina et al., 2017. *Geology*)

# III. ARGENTINIAN & URUGUAYAN MARGIN

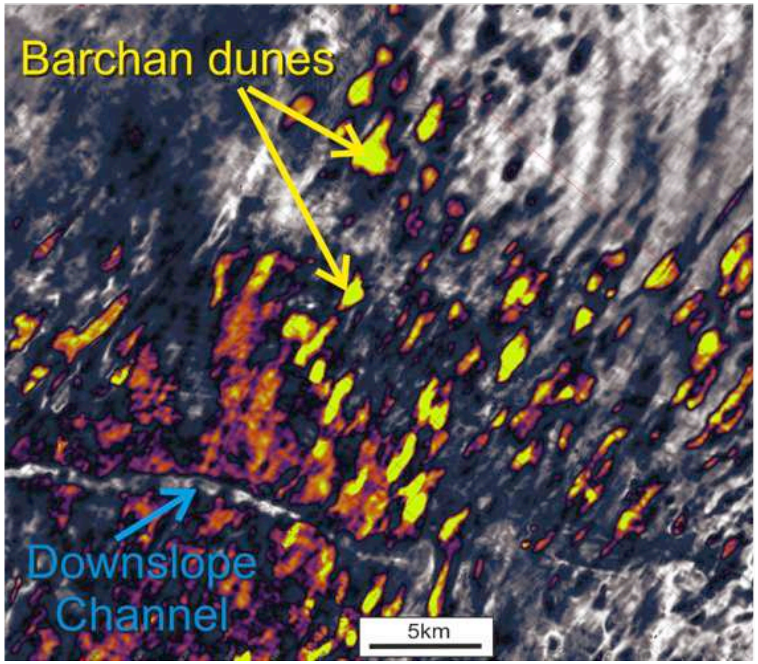



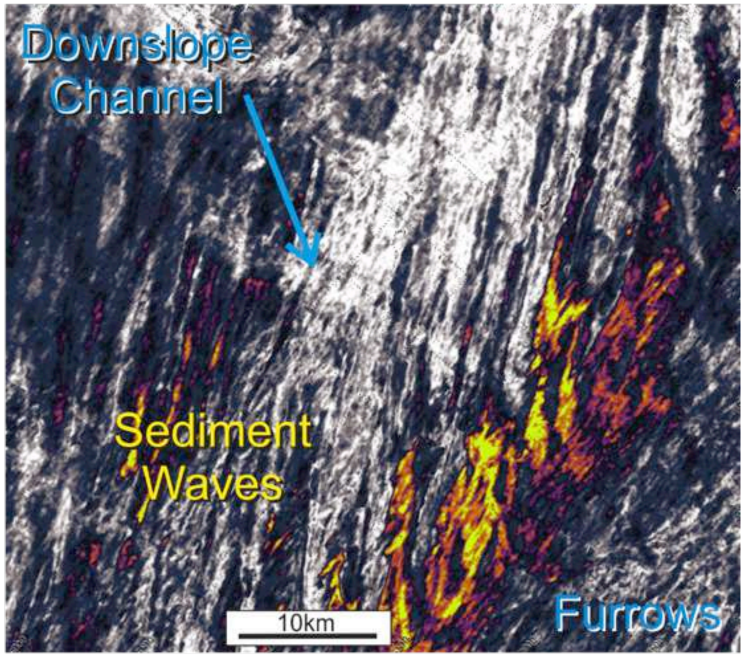

Erosional features:

*a) Regional discontinuities*
*b) Abraded surfaces*
*c) Contourite channels (& moats)*
*d) Furrows*
*e) Marginal troughts*
*f) Scours*

Depositional features:

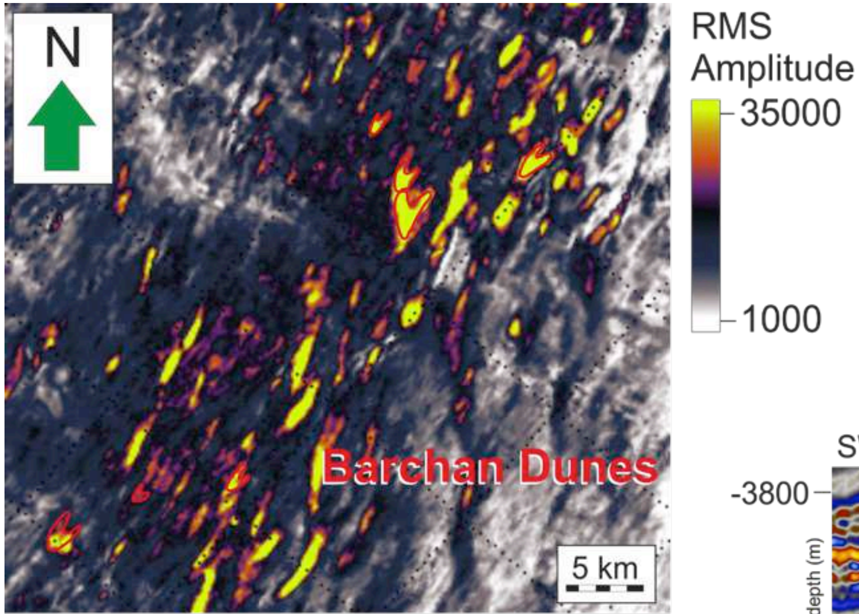
*a) 2D Sediment waves;*
*b) Barchanoid bedforms*
*c) Linear sand ribbons*

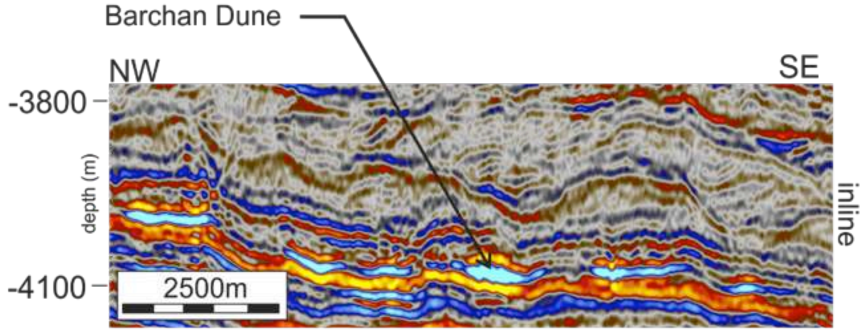


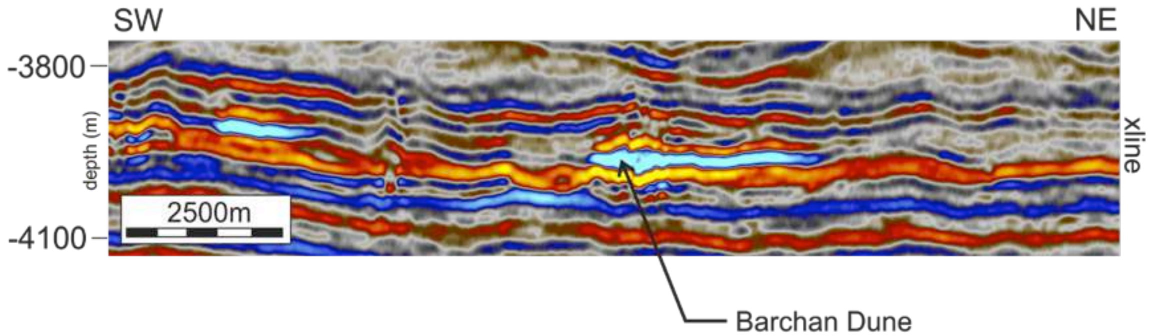



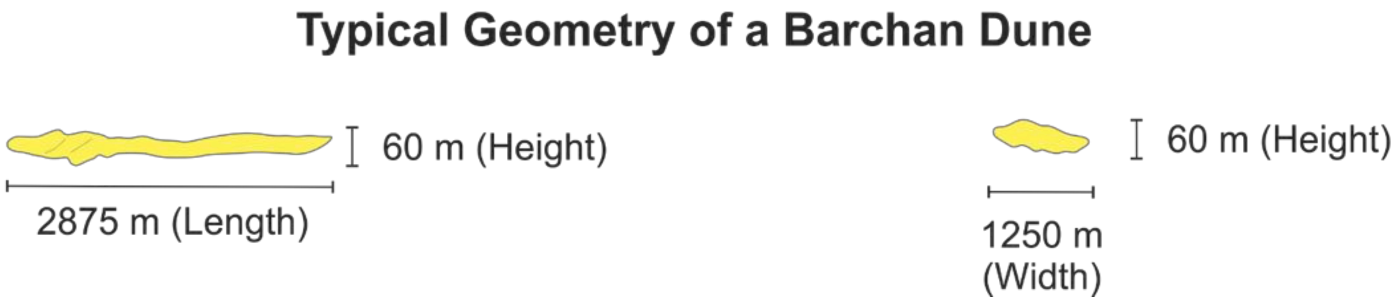

(Hernández-Molina et al., 2017. *Geology*)

- *Barchanoid bedforms* are convex to the SW with steep lee faces to the NW idicating a dominant NW-flowing current.
- They are typically around 1-4 km wide, 2.5-6 km long, and 14-60 m in height.



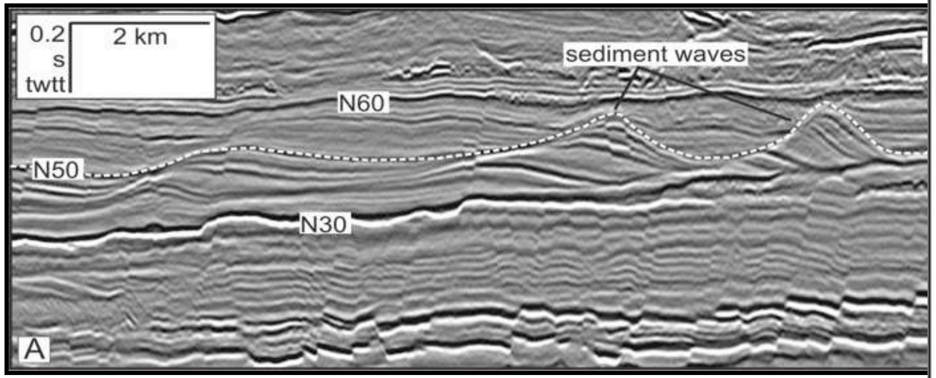



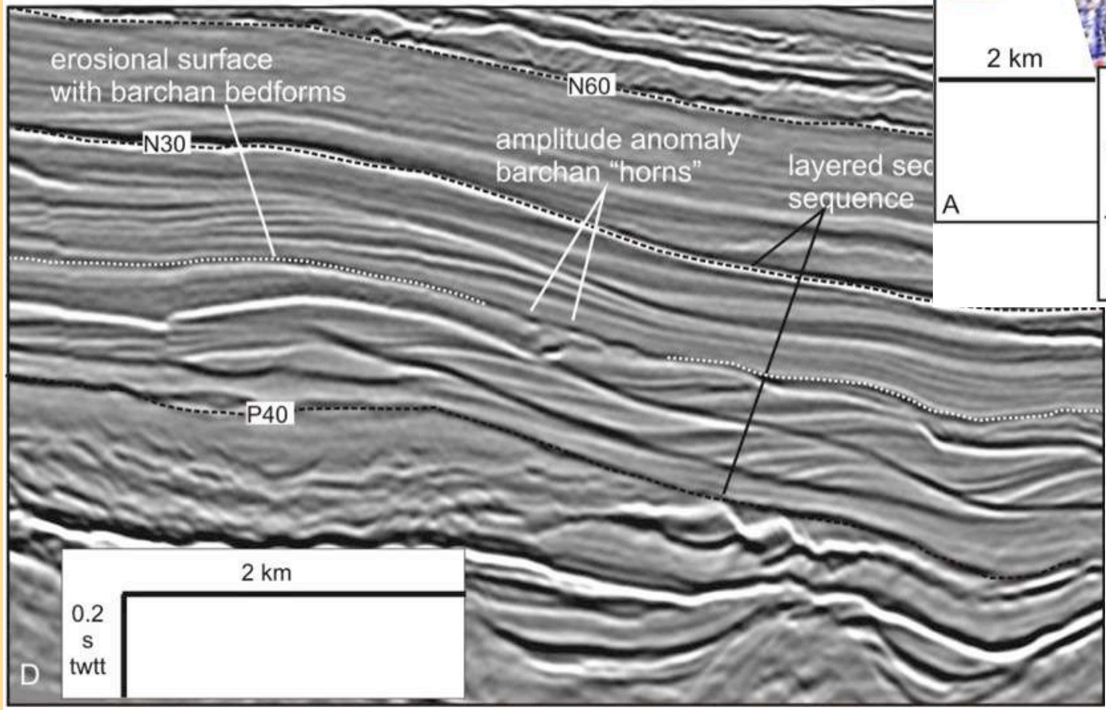



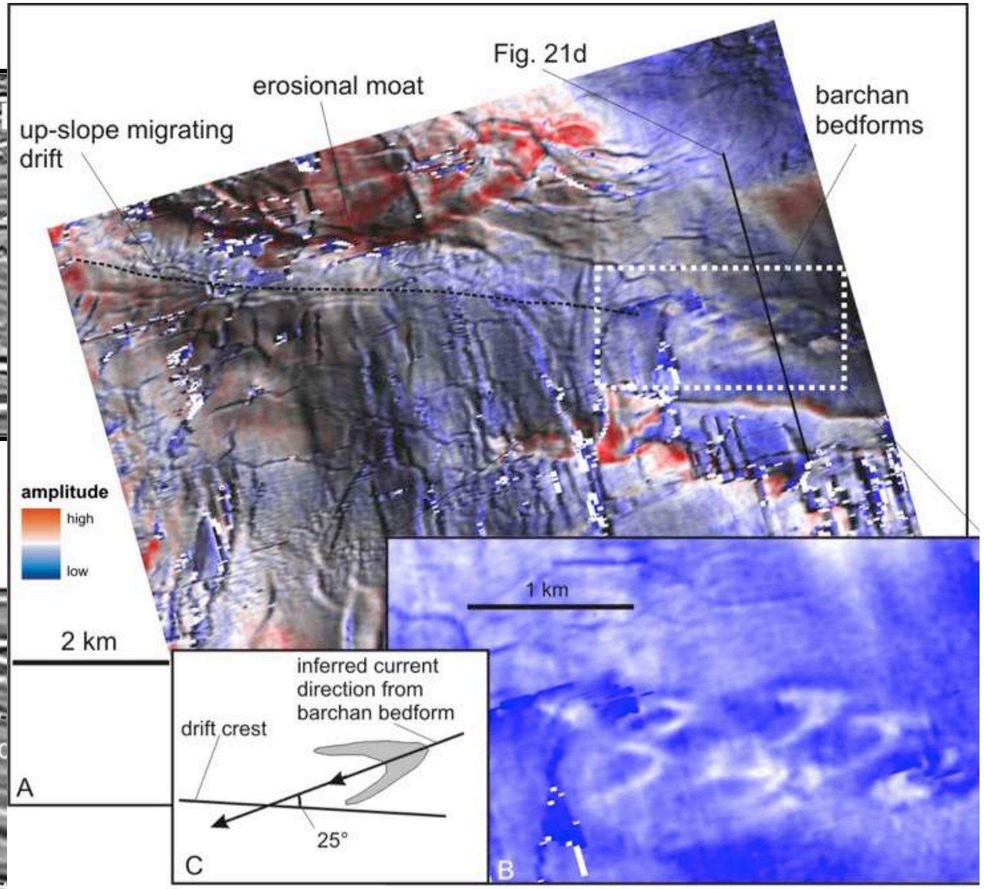

(Hernández-Molina et al., 2017. *Geology*)

# CANADIAN MARGIN




(Miocene)



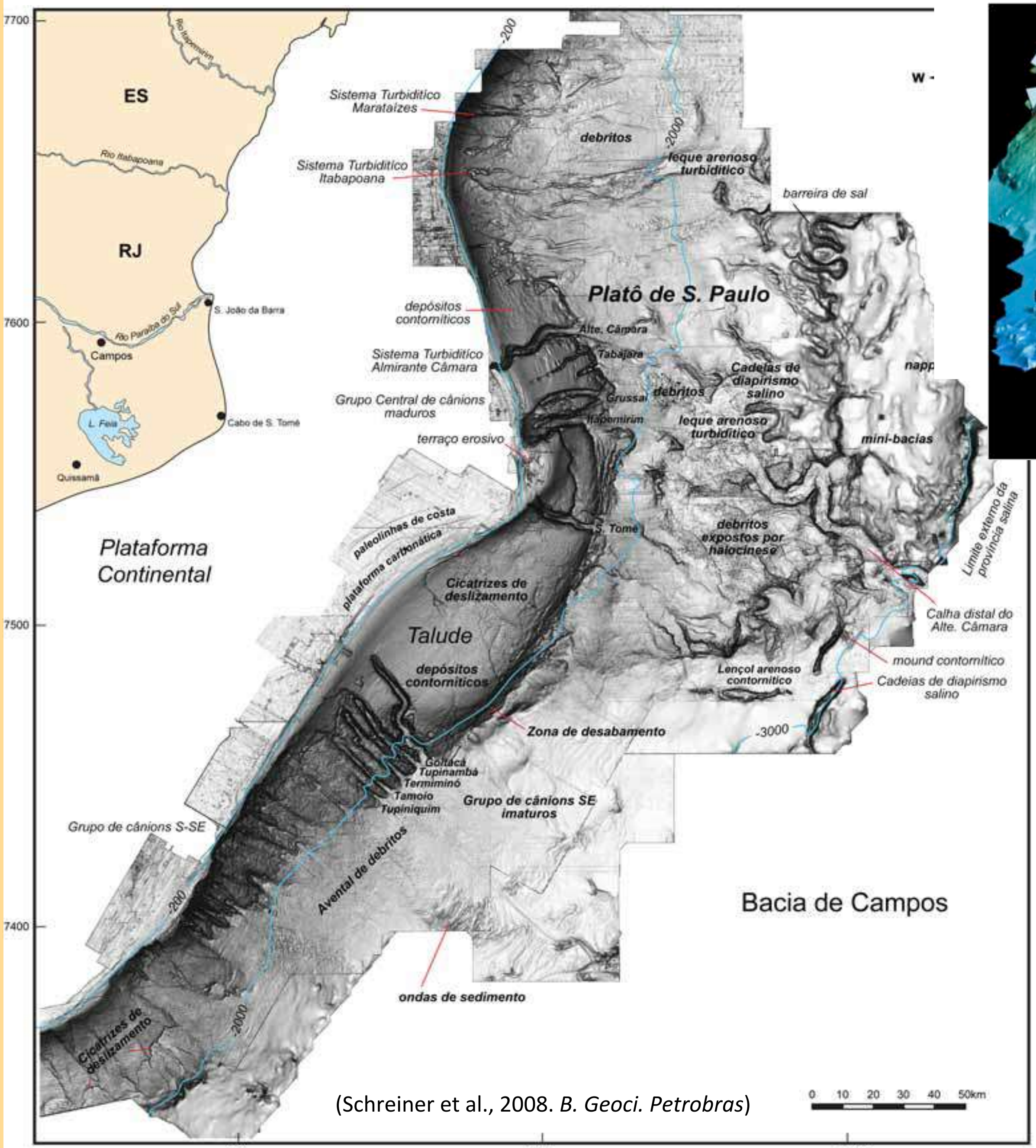




(Campbell & Mosher, 2016. Marine Geology)

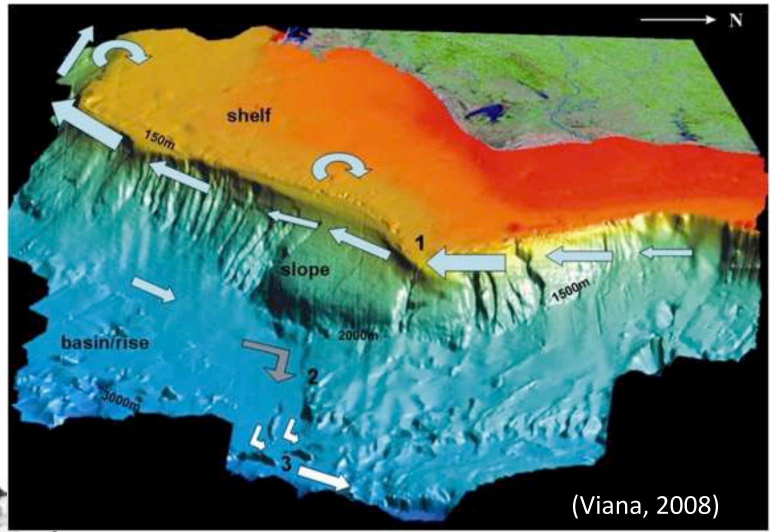
*Data EnCana Corp.*

# BRAZILIAN MARGIN

A. Viana

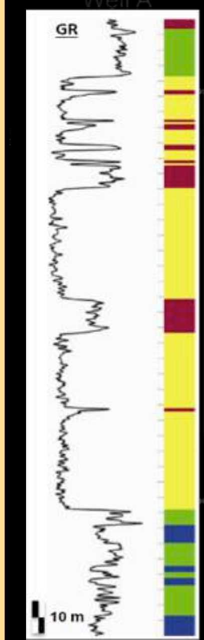


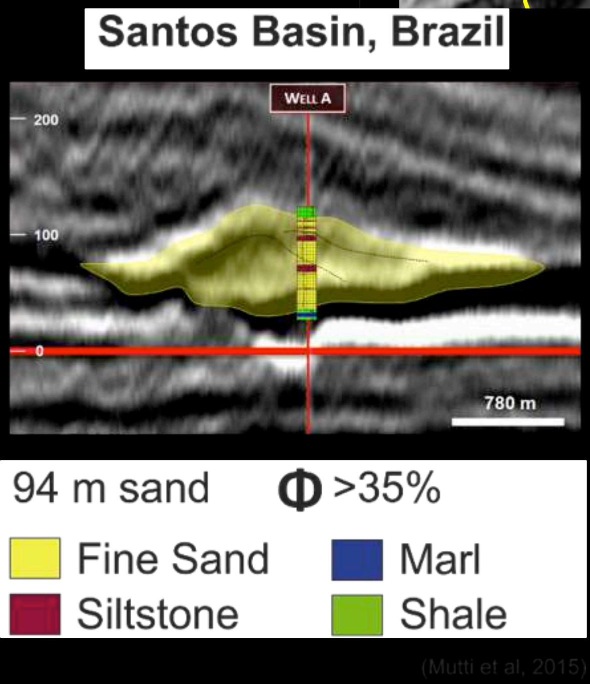

(Schreiner et al., 2008. *B. Geoci. Petrobras*)



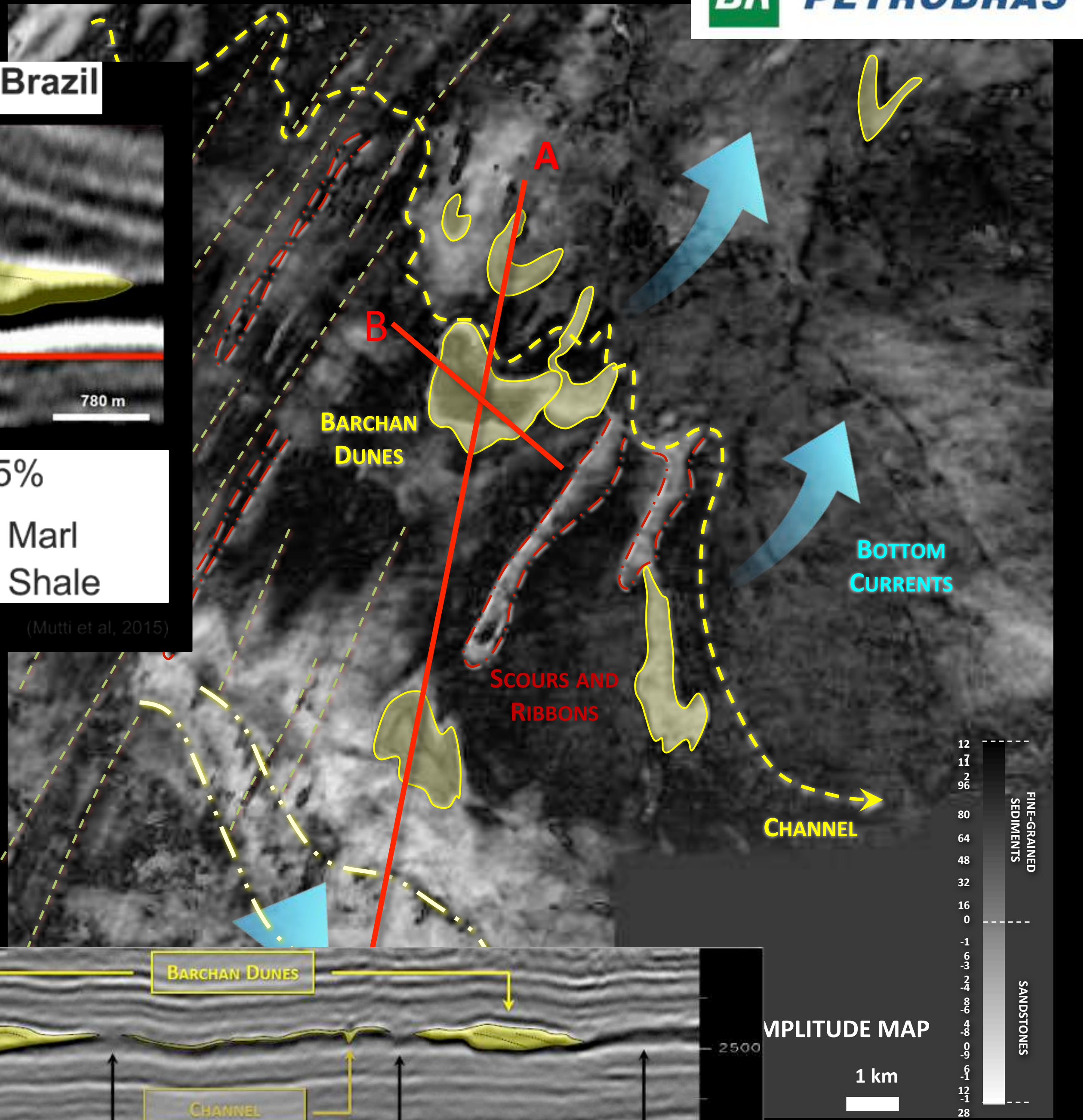

(Viana, 2008)

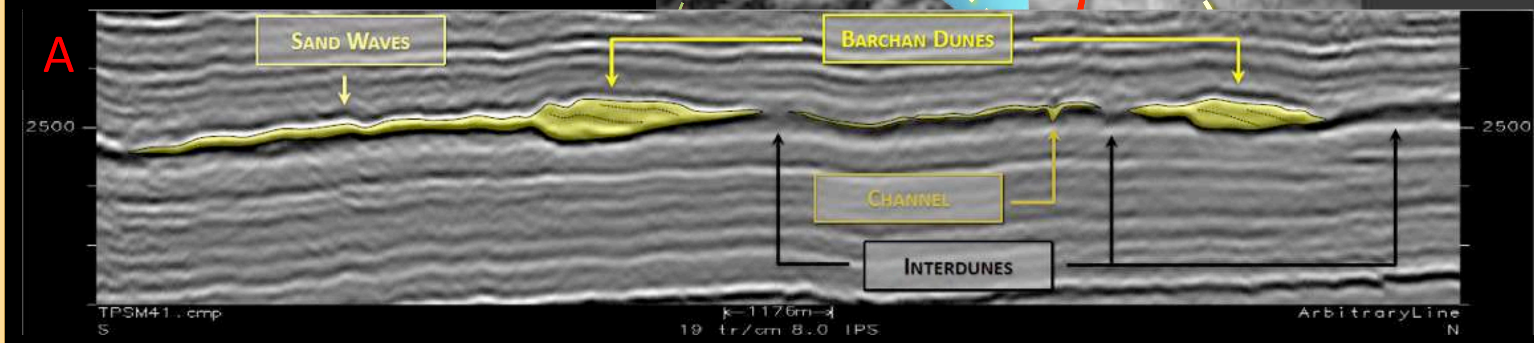
# IV. OTHER EXAMPLES: MODERN & ANCIENT




Geometry of barchan dune

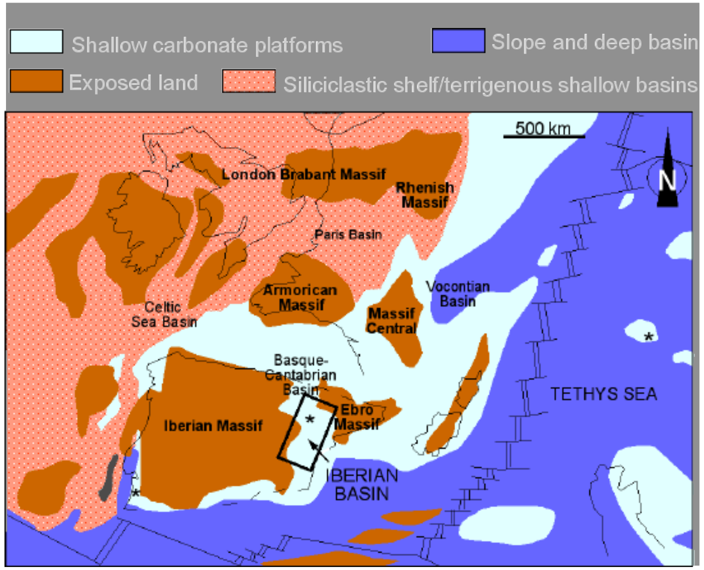



(Mutti et al, 2014)

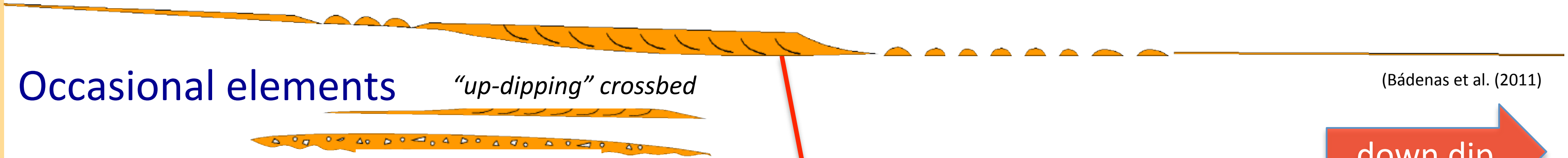
# • UPPER JURASSIC SANDY-OOLITIC EVENTITES (RICLA, SPAIN)

(Bádenas & Aurell, 2001; Bádenas et al., 2005; Bádenas et al. 2011; Pomar et al., 2012)




## Basic elements

thin sand lamina "down-dipping" crossbeds starved ripples thin sand lamina



## Occasional elements

*"up-dipping" crossbed*

*Intraclastic Rdt/Flt*

(Bádenas et al. (2011)

down dip

## • Jurassic - Cretaceous Kermanshah Radiolarite Complex, west of Iran

# CONCLUSIONS

The role of bottom water circulation and associated oceanographic processes in shaping the seafloor and controlling the sedimentary stacking pattern on passive continental margins <u>has to be seriously reconsidered in future decades</u>.