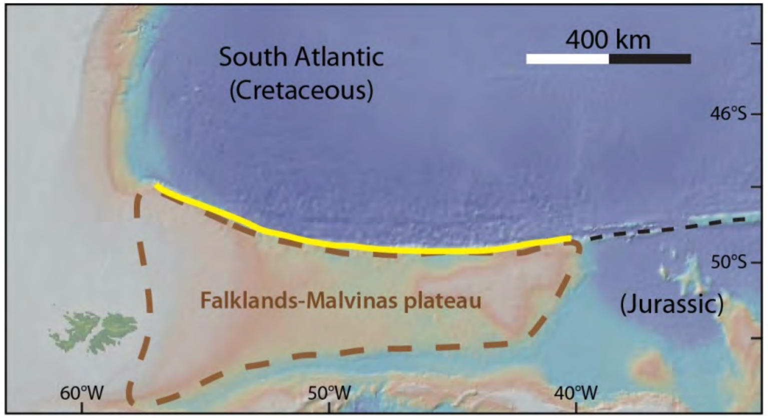
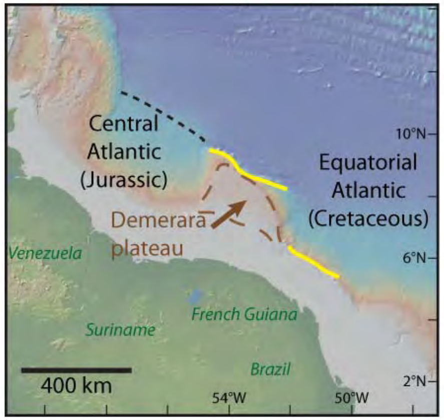
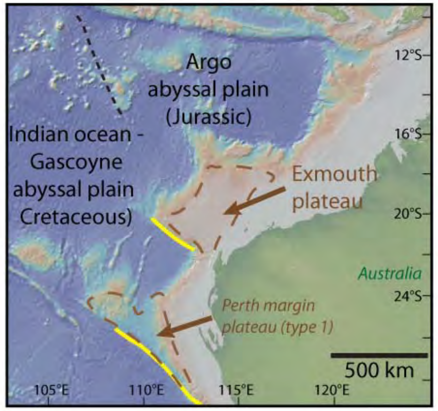
Marginal plateaus: Definition and scientific challenges

Loncke L., *Basile C., Roest W., Mercier de Lépinay M., Maillard A., Patriat M., Graindorge D., Fanget AS.*



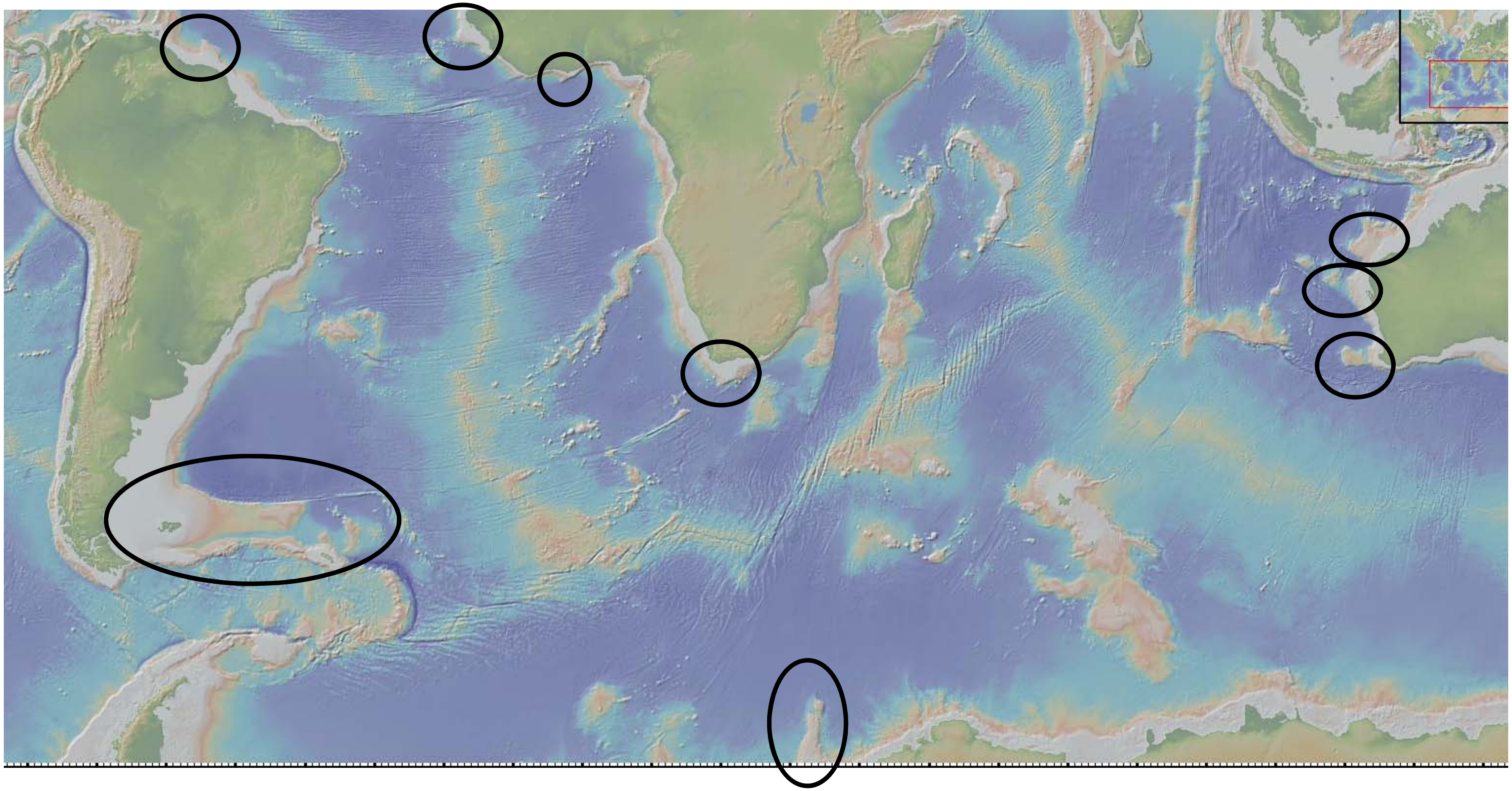




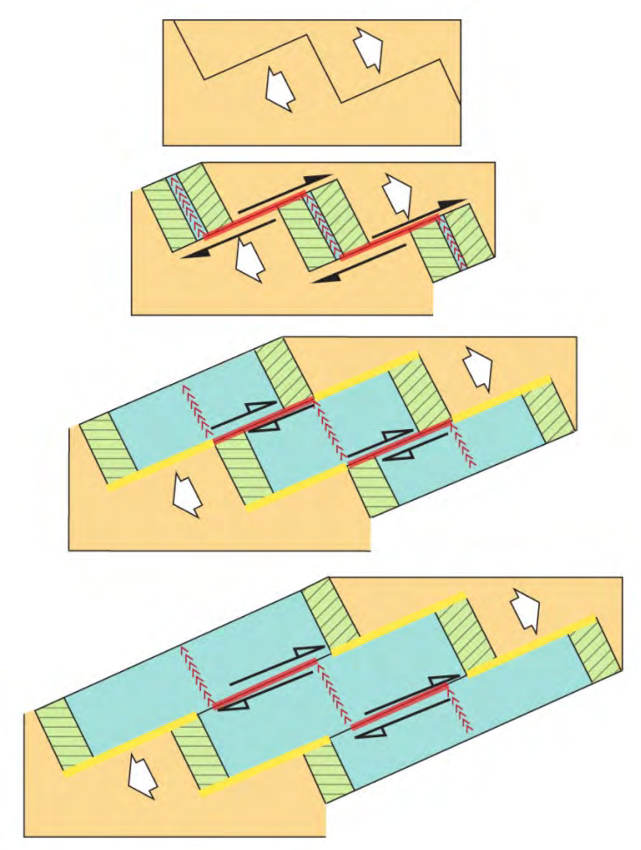
Outline

1/ Definition of marginal plateaus
2/ The Demerara Case study
3/ Volcanism and Contourites
4/ Main scientific Challenges

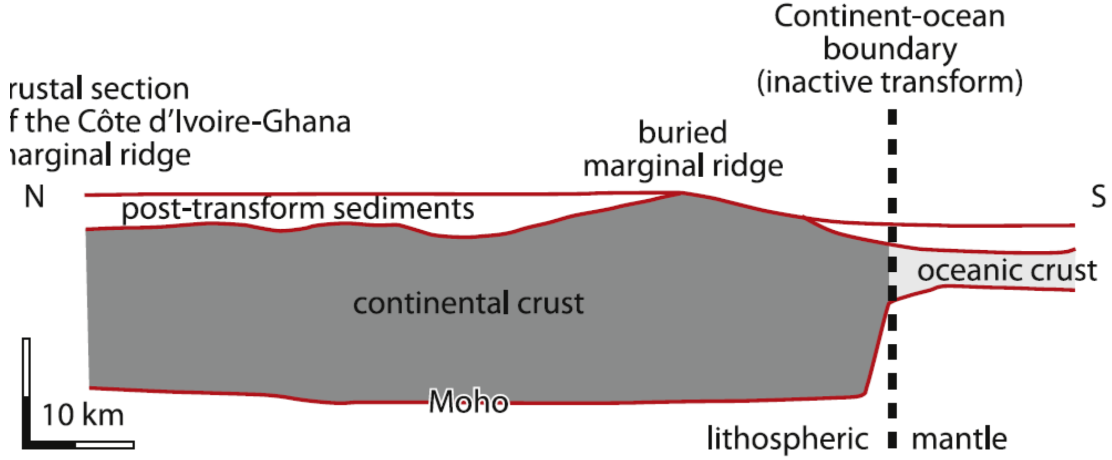
1. What do we call a marginal plateau?



This notion derives from a systematic cartography of transform margins



Modified From Mascle et Blarez, 1987



Basile, Tectonophysics, 2015

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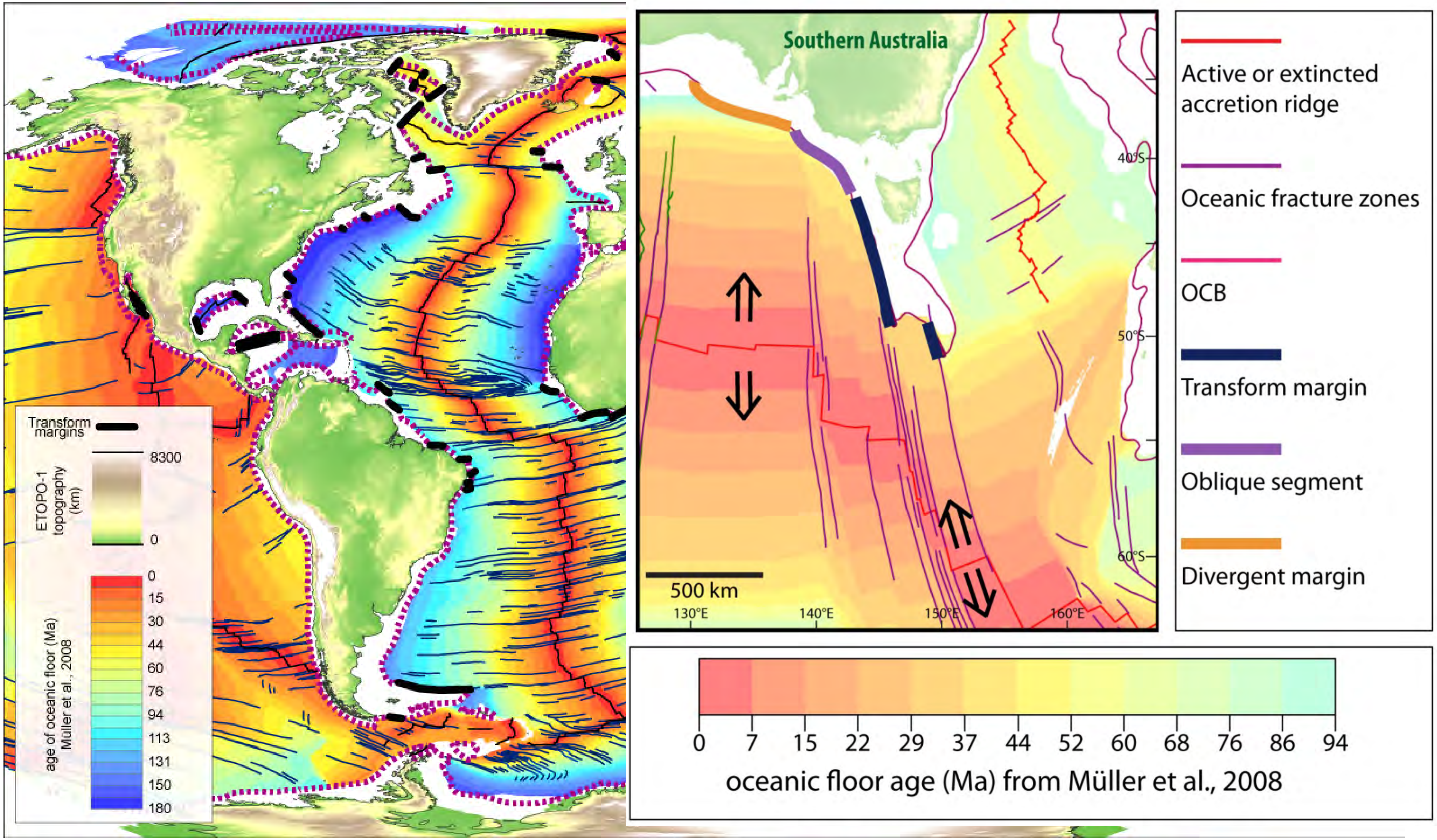
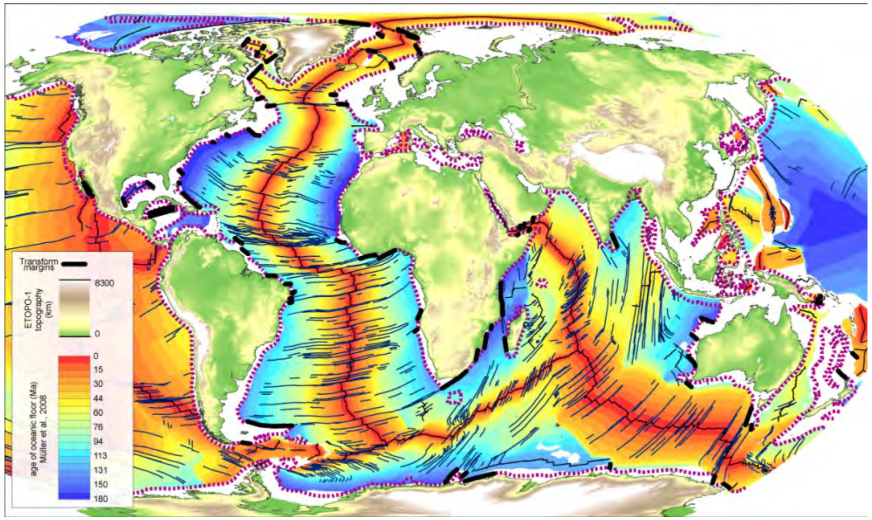


Mercier de Lépinay, Tectonophysics, 2016

The main results of this approach



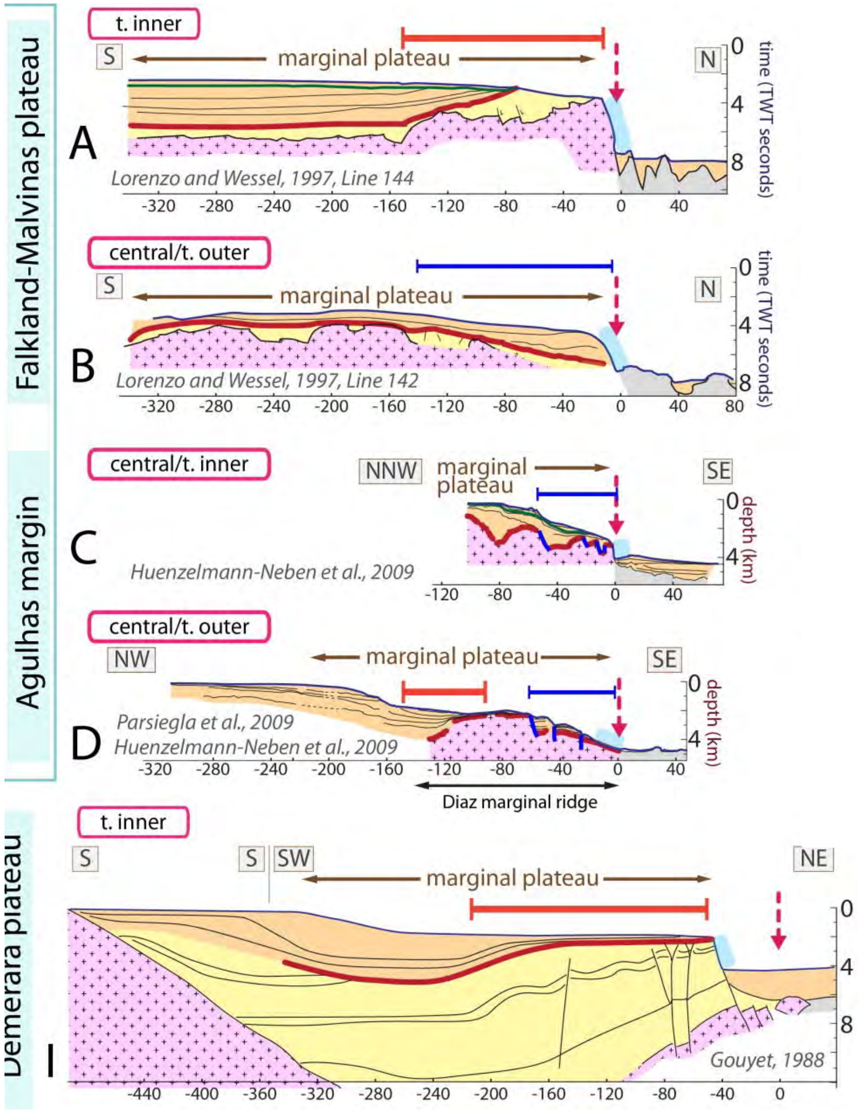
Mercier de Lépinay et al., 2016

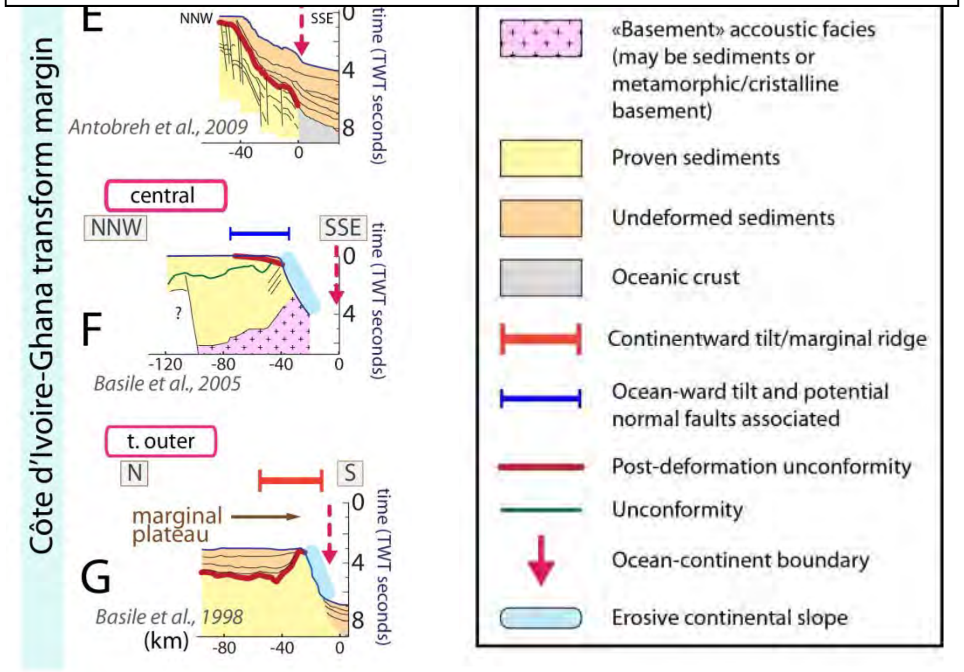
- **The inventory increases the number of identified transform margins from 29 to 78**
- **They represent 16% of continental margins with a cumulative length of 31% of non-convergent margins**

⇨ **This new database allows systematic comparisons**

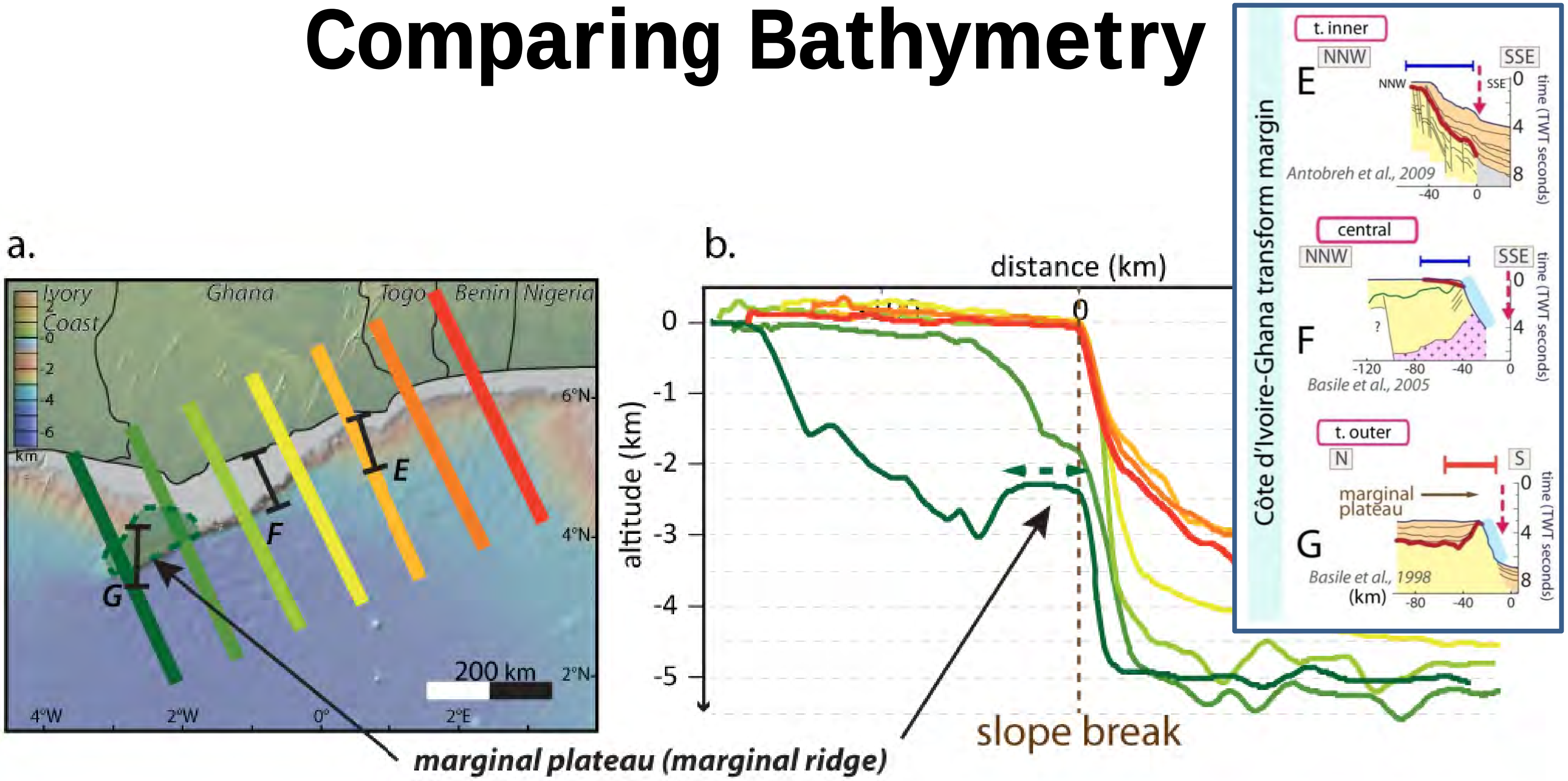
Comparing Upper Crustal Structures

- **A great diversity of structures**
- **Sharp Continent to Ocean transitions and eroded slopes**
- **Presence of numerous deep-sea plateaus**





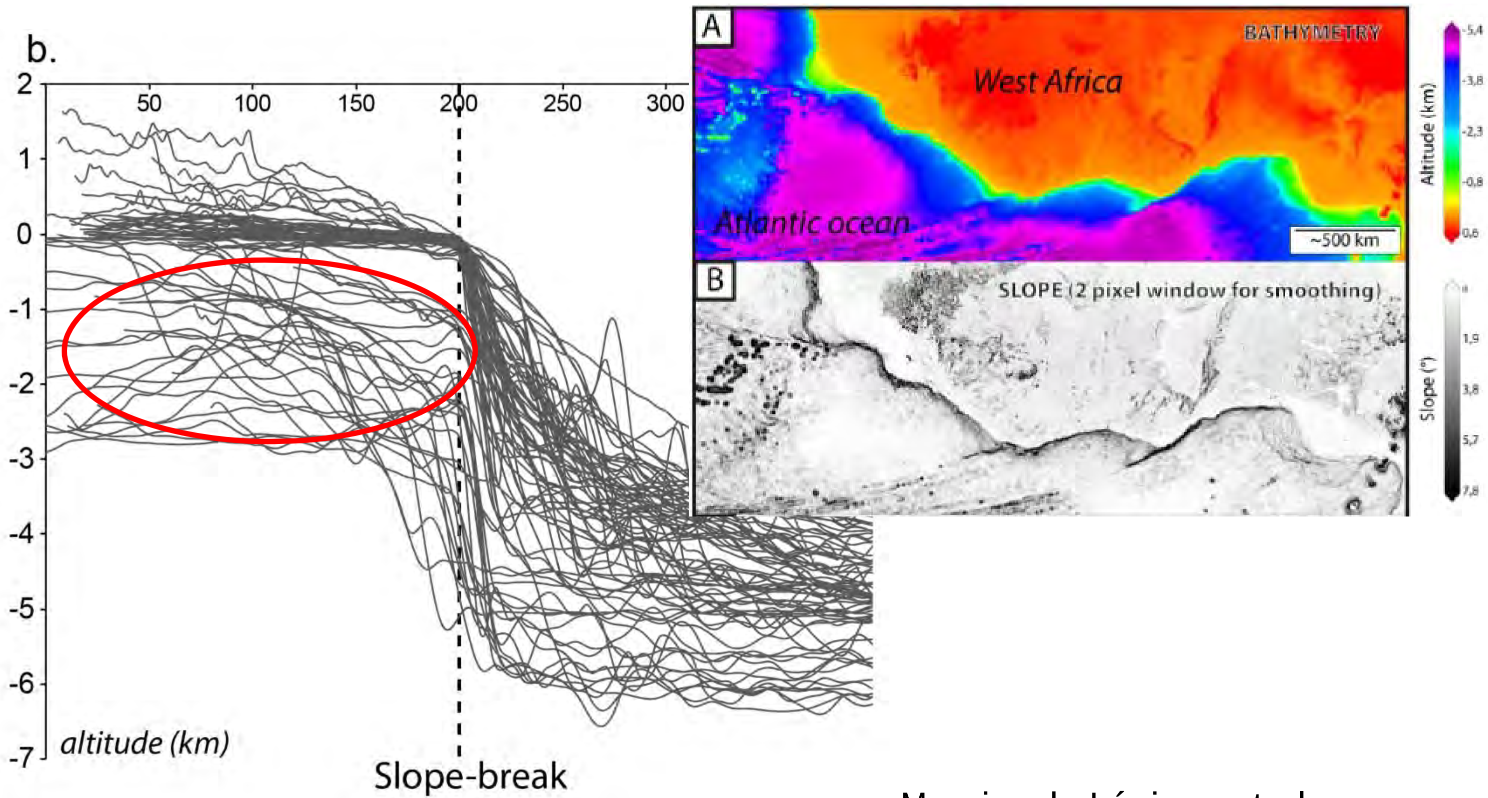
Comparing Bathymetry



Mercier de Lépinay et al,
Tectonophysics, 2016

Variability along a same margin reflecting lateral structural variations in the deep structure of the margin

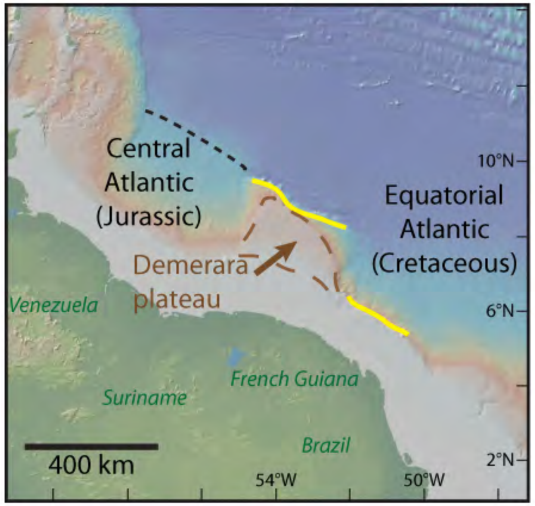
Comparing Bathymetry of all transform margins

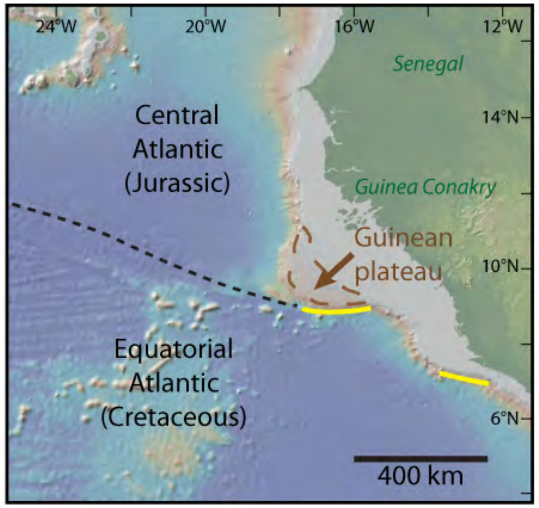


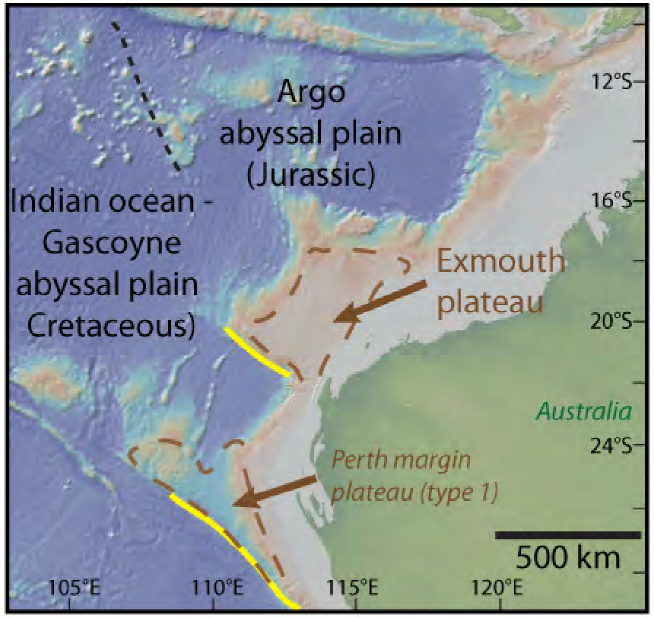
Mercier de Lépinay et al, Tectonophysics, 2016

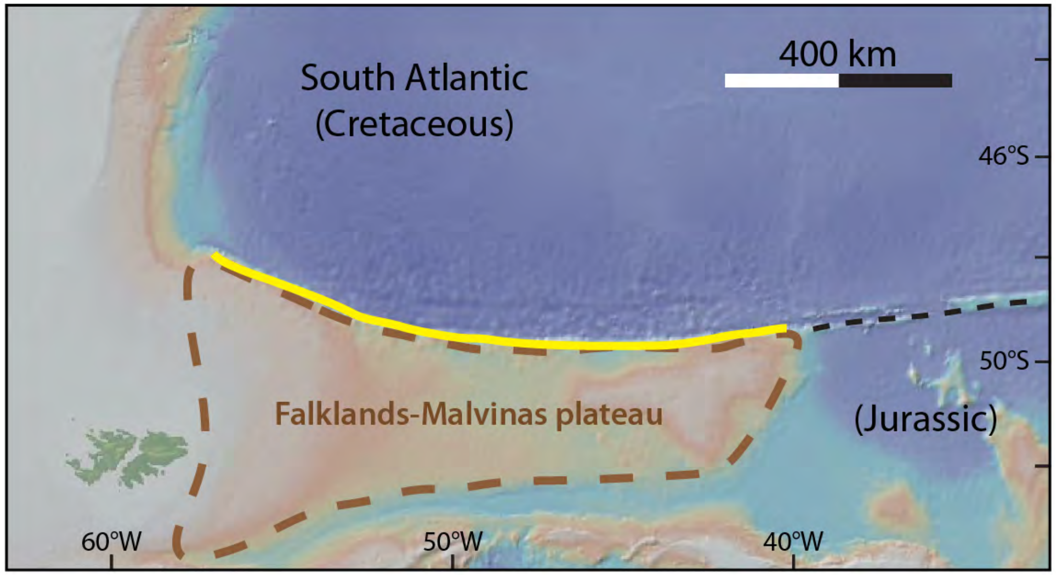
- **Continental slope is in average slightly steeper (4°) than for rifted margins (3°)**
- **Deep planar reliefs exist for 30% of margins**

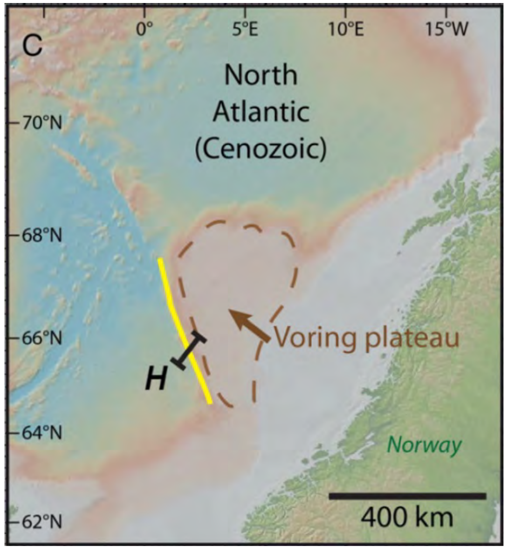
Those planar reliefs correpond to plateaus bounded by a transform COB



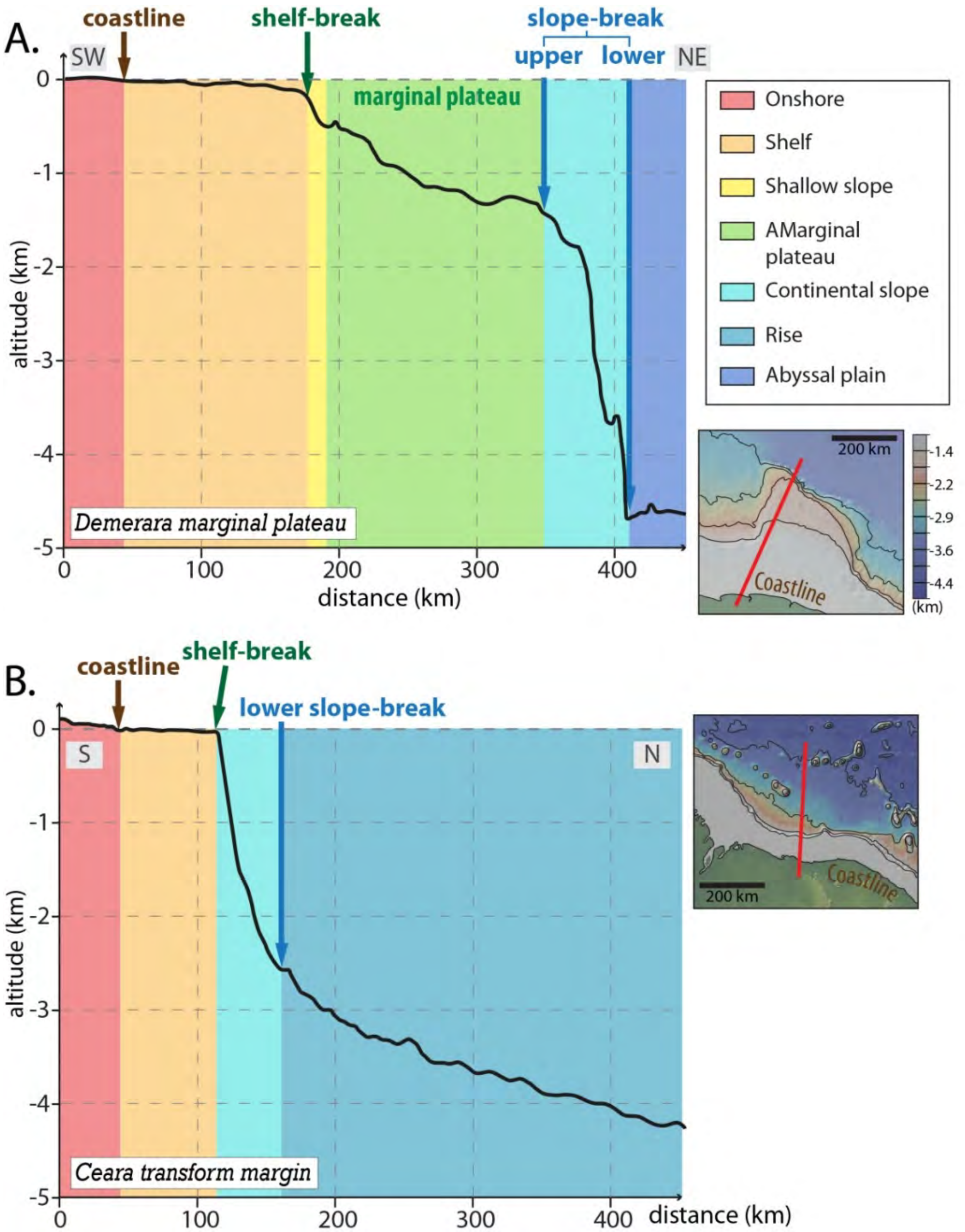








Bathymetric characteristics



- **Depths**

100 to 3400m

(Average:1250m)

- **Slopes**

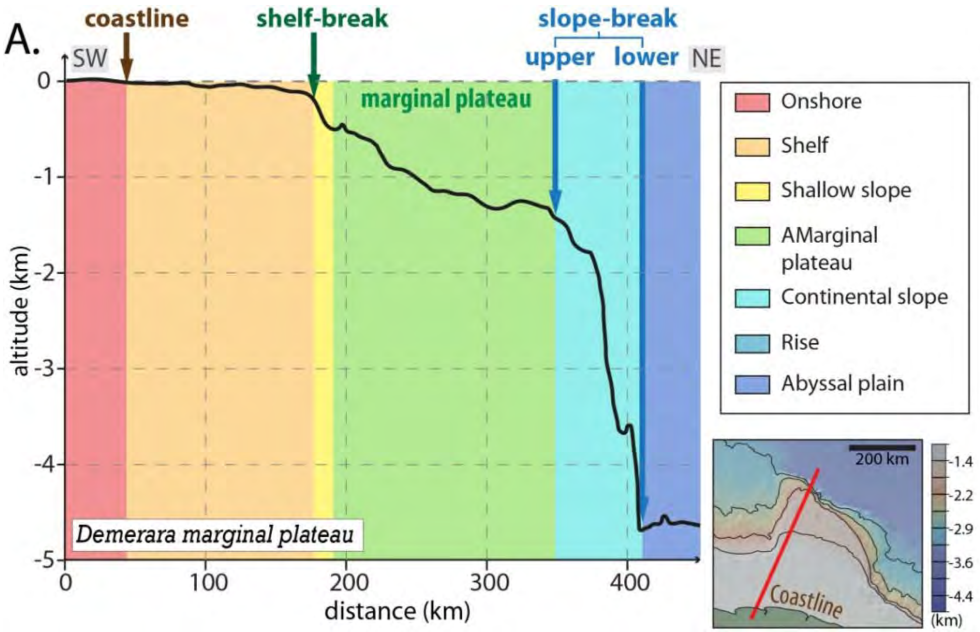
0 to 2°

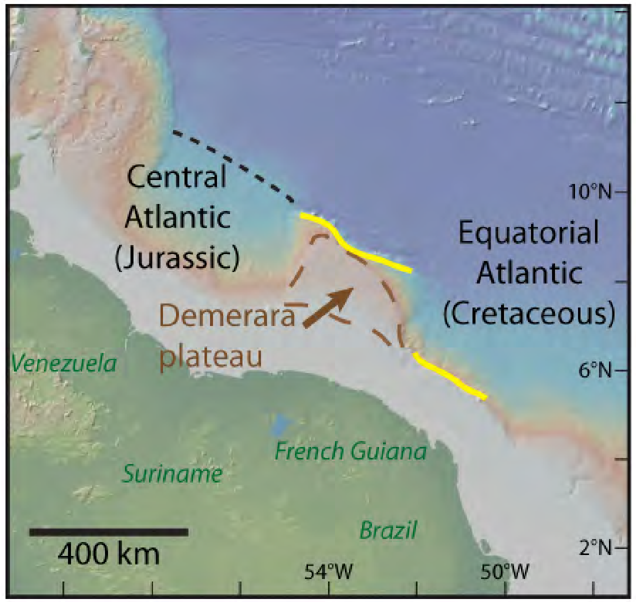
(Average: 0,3°)

- **Total surfaces on seafloor:**

1 213 750 km²

Definition of a Marginal plateau

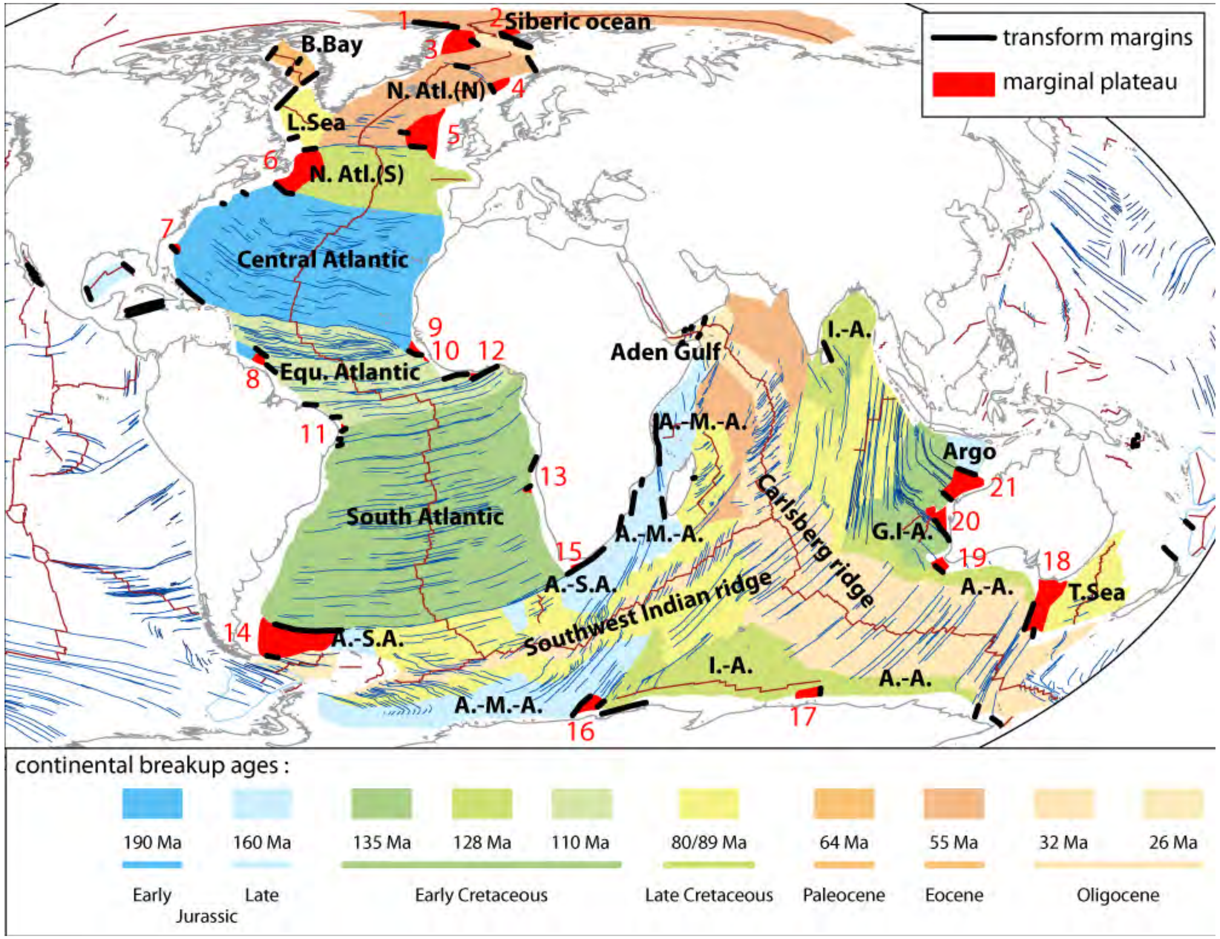




- **Deep planar and sub-horizontal plateaus located between continental shelf and continental slope.**
- **Bounded on one of their side by a transform margin**

> Therefore called MARGINAL plateaus

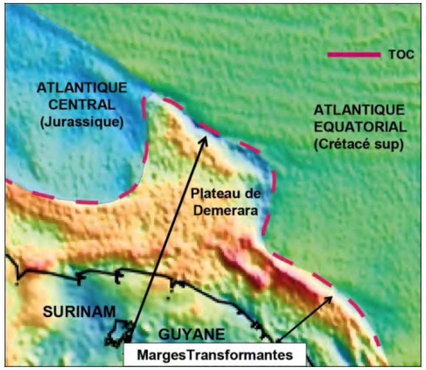
Worldwide distribution



Mercier de Lépinay et al., 2016, TectonophysicsC

- **21 marginal plateaus around the world**
- **Located in majority at the intersection of oceanic domains of different ages**

Three types of situations

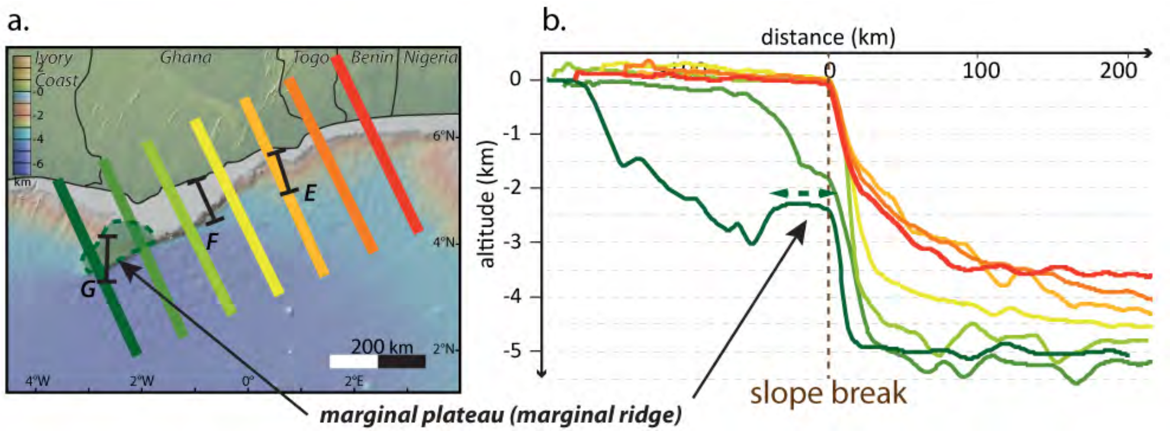


1. **At the junction of two oceanic domains of contrasted ages (transform border always toward the youngest ocean)**

Ex: Demerara

2. In domains that underwent several rift episodes before transform-dominated oceanic opening

Ex: Voring



3. Along outer transform margin corners at the intersection with divergent margins

Ex: CIG

To summarize

We defined marginal plateaus as flat deep-sea elevations bounded by a transform COB

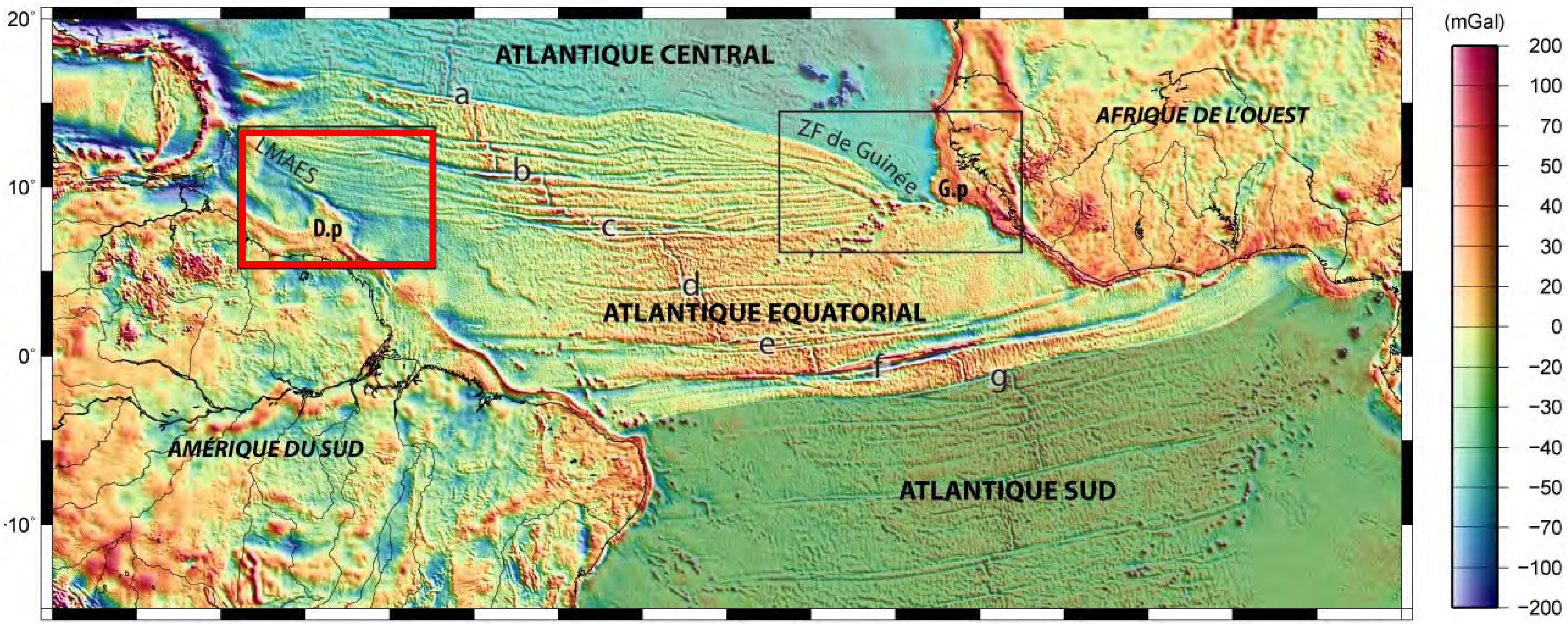
All marginal plateaus share a multi-stage evolution, with at least one period of rifting prior to transform formation;
MP = thinned continental crust domains later reworked by transform movements?

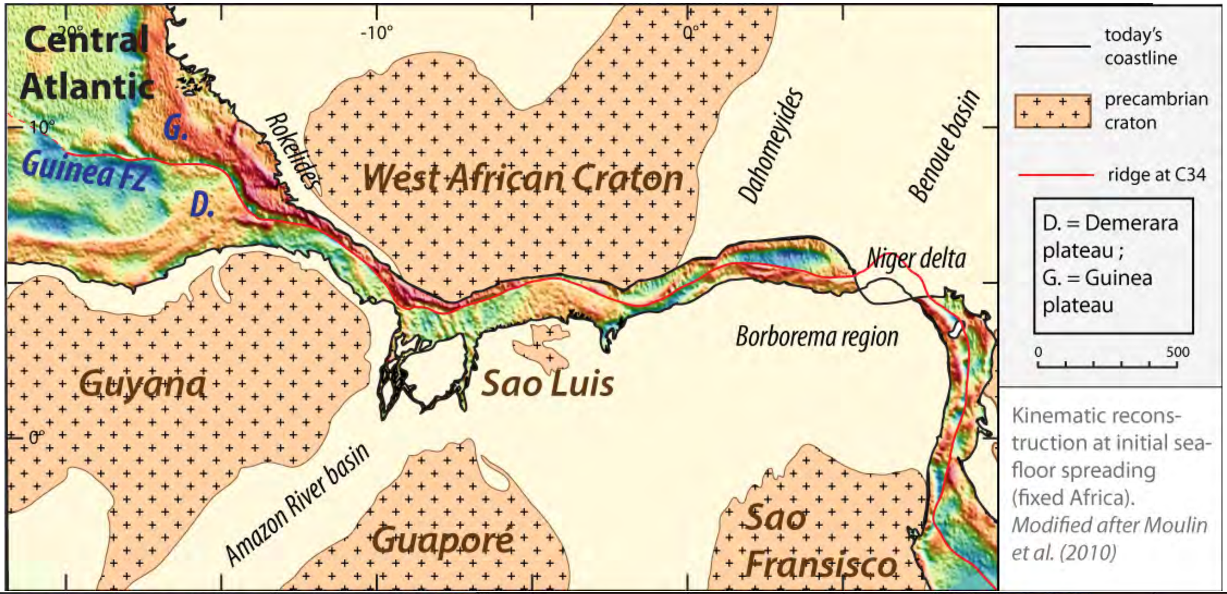
Table 3
Time lapse between two successive oceanic openings that occurred on different sides of marginal plateaus.

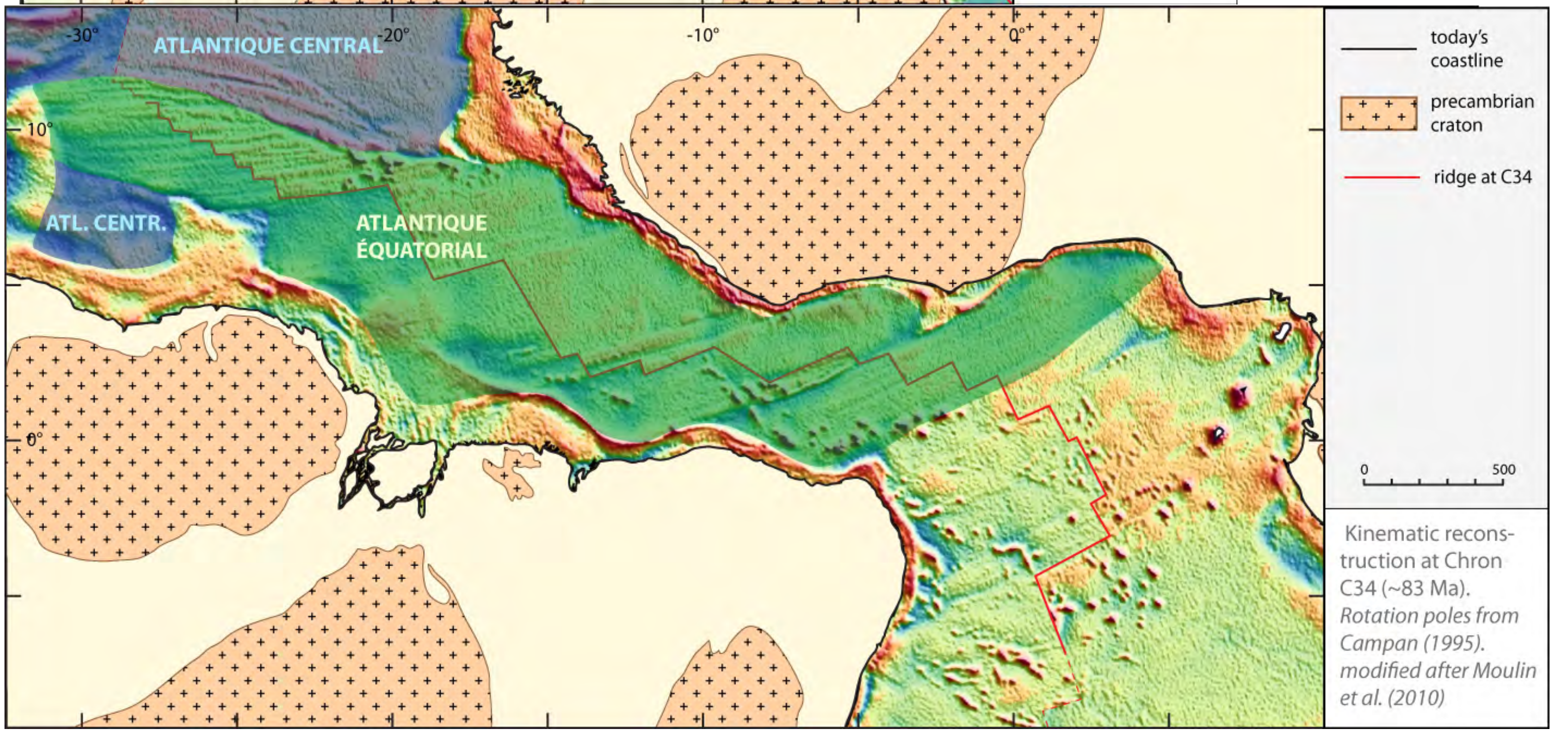
Marginal plateau	Duration between two oceanic openings
Brazil offshore (Maceio)	10
Walvis	15
Rockall Tough	20
Exmouth plateau	20
Morris Jesup Rise	30
Northeast Greenland	30
Outeniqua	30
Gunnerus Ridge	30
Bruce Rise	35
Tasman plateau	40
Naturaliste plateau	40
Newfoundland plateau	50
Demerara plateau	65
Guinea plateau	65

The age gap between the two oceanic openings that individualized MP varies from 10 to 65 My

2. The Demerara case study



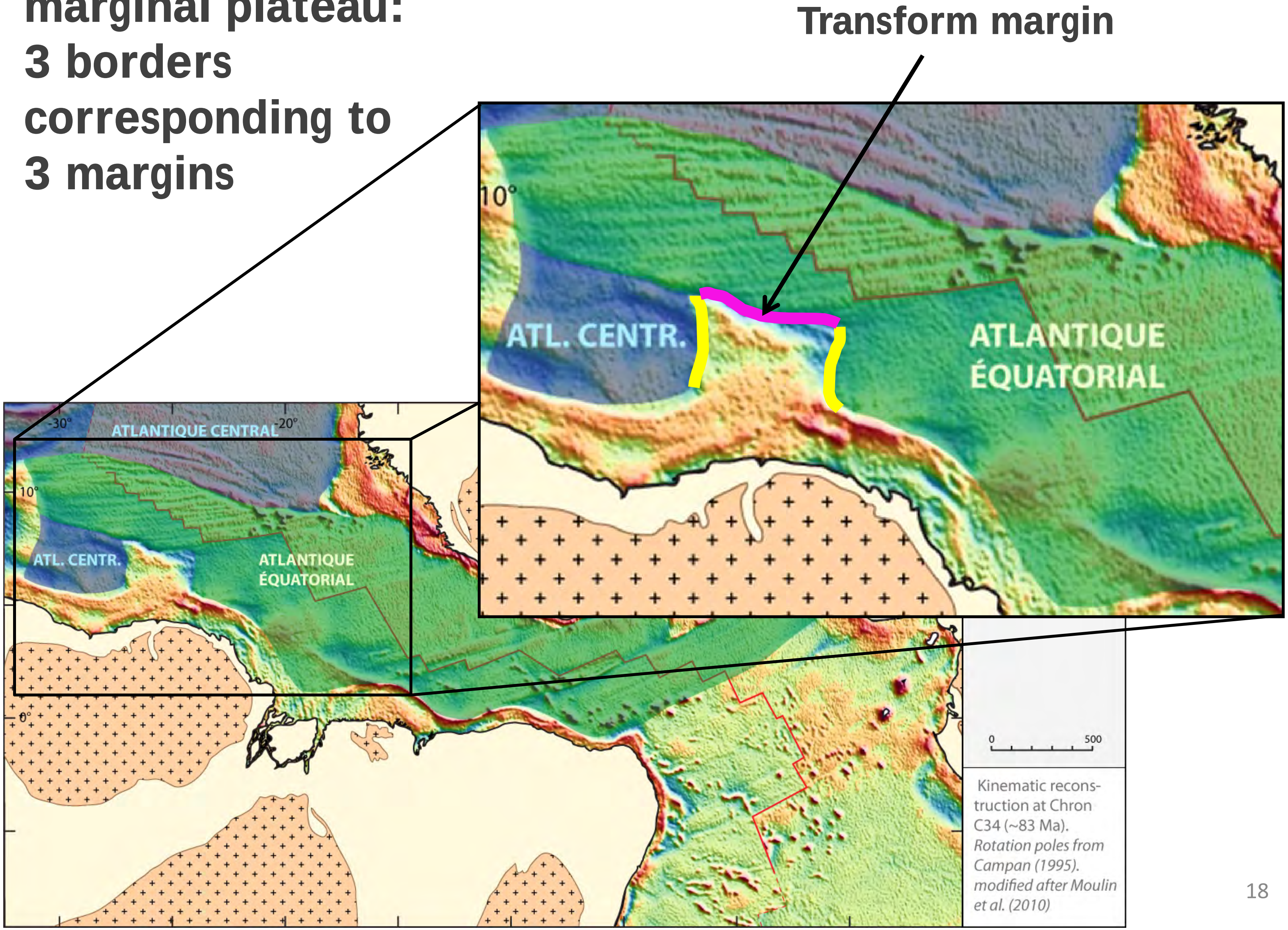




Demerara individualized through a polyphased opening history

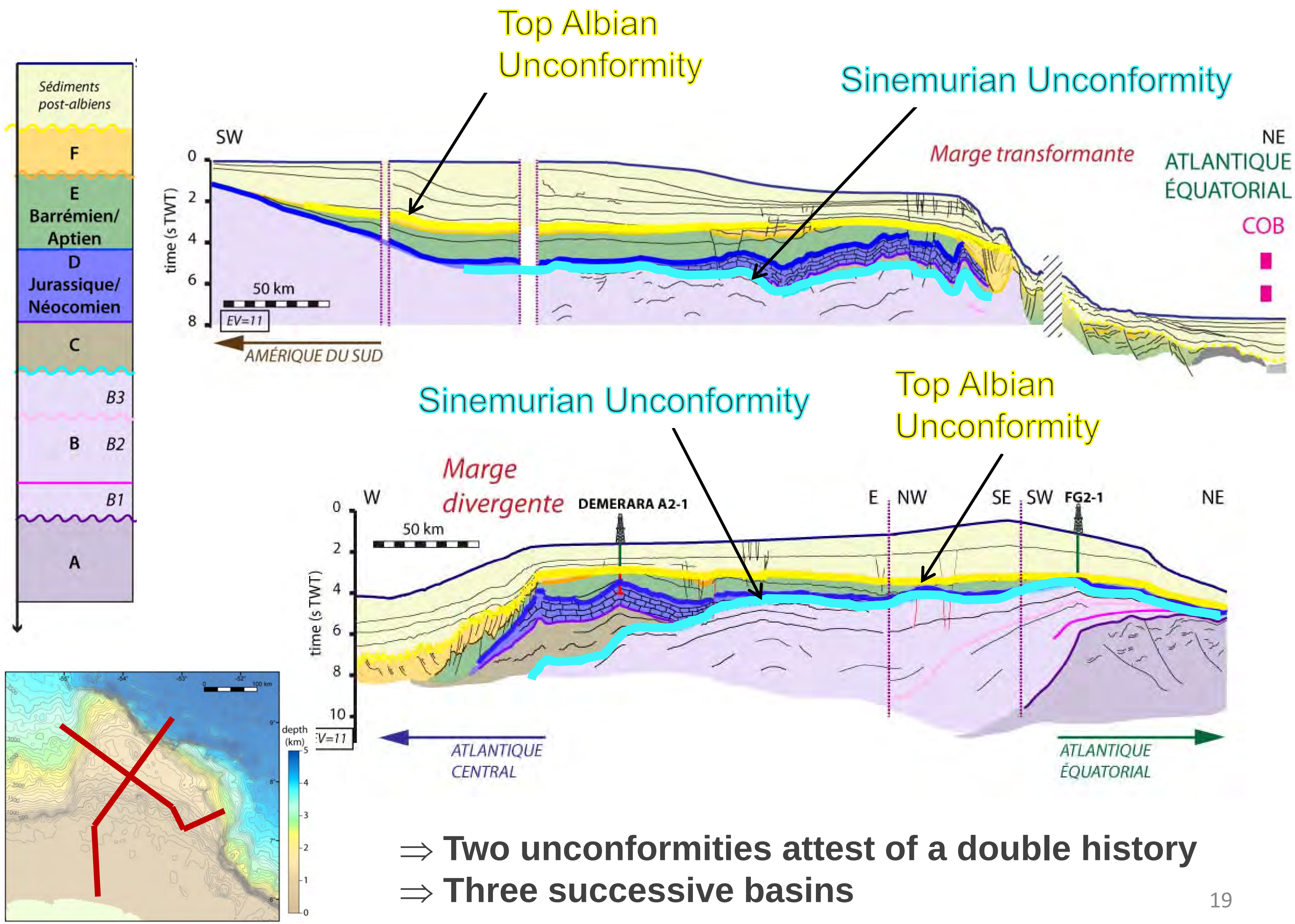
Modified from Moulin et al., 2010

=> Demerara marginal plateau: 3 borders corresponding to 3 margins



Kinematic reconstruction at Chron C34 (~83 Ma). *Rotation poles from Campan (1995). modified after Moulin et al. (2010)*

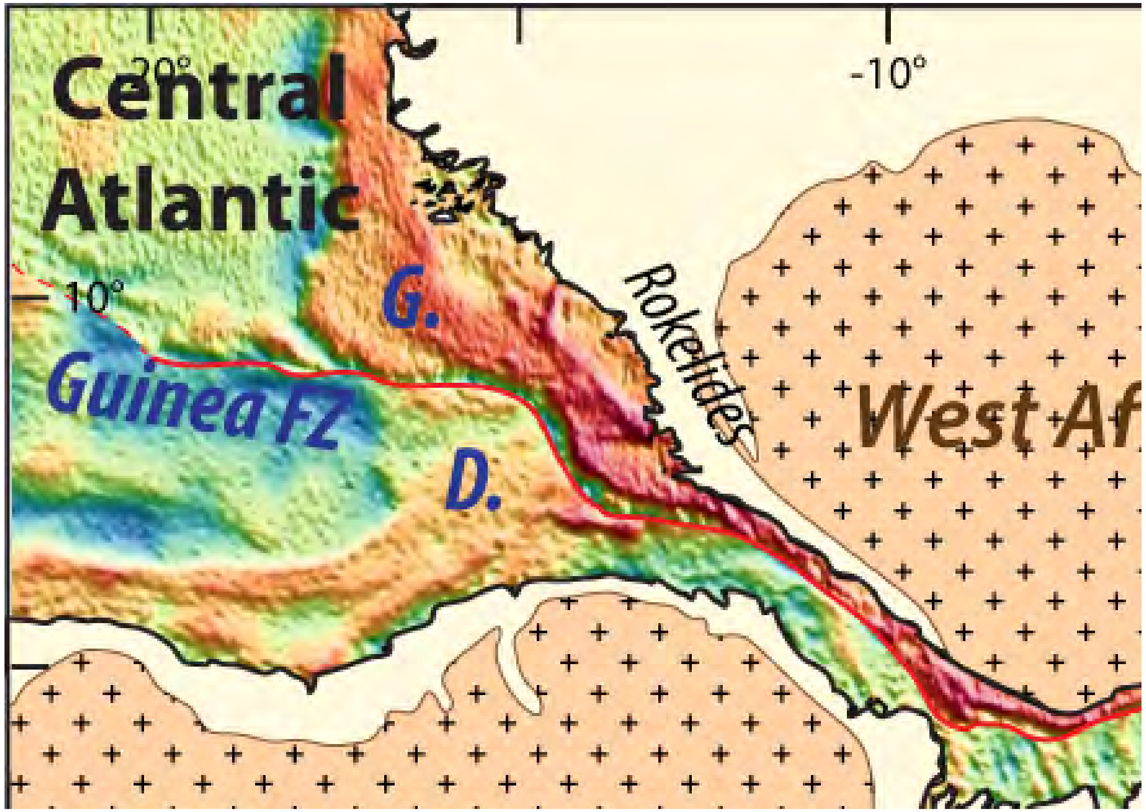
Regional cross sections



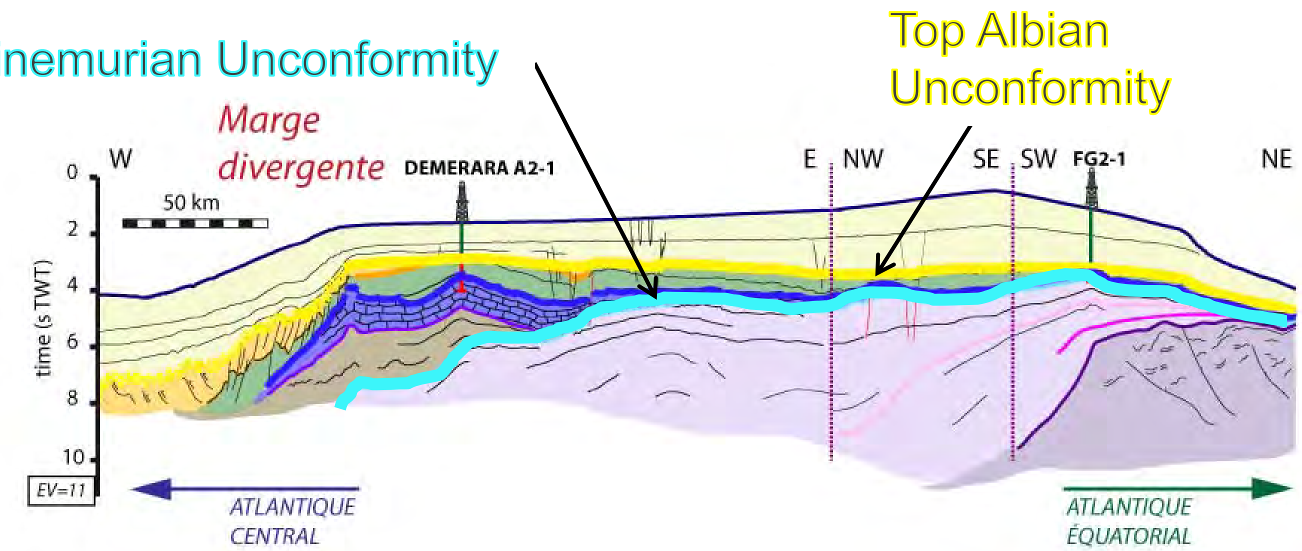
⇒ **Two unconformities attest of a double history**

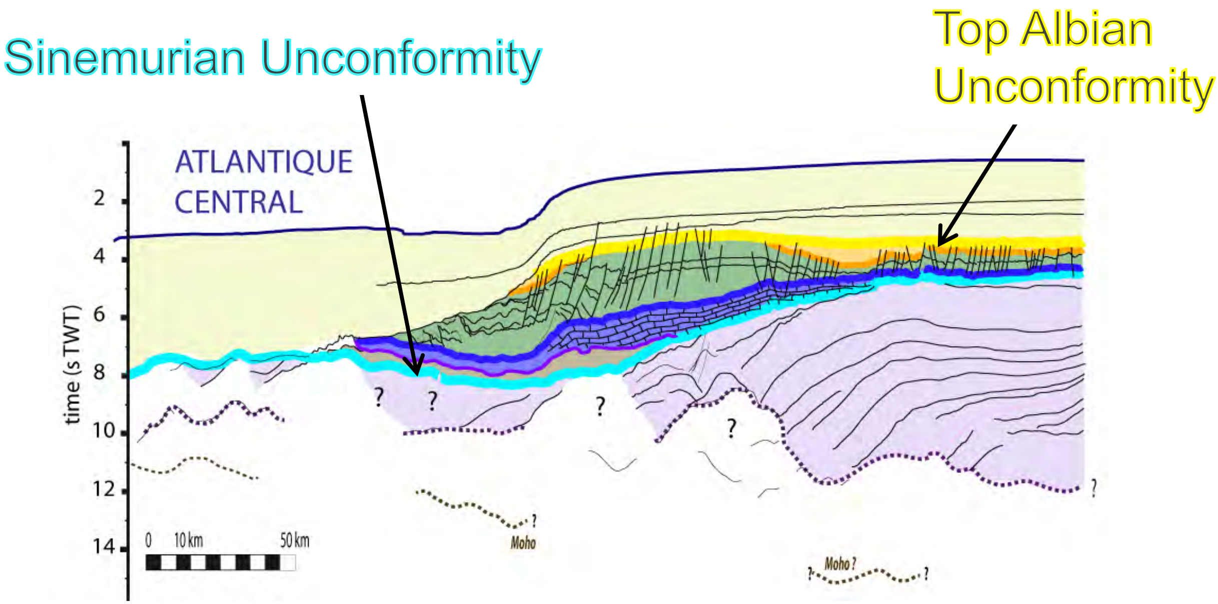
⇒ **Three successive basins**

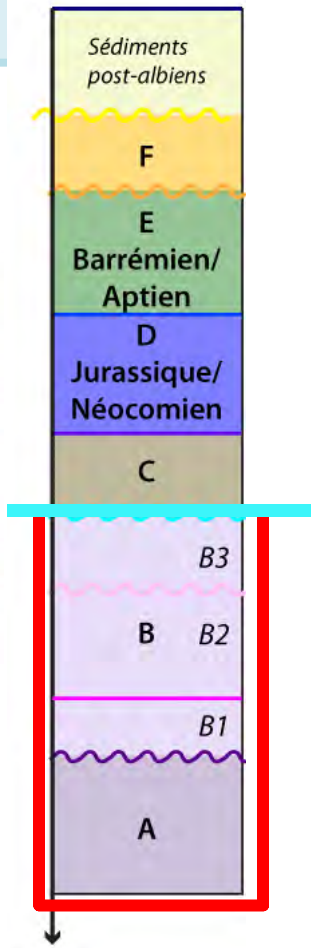
First phase: Central Atlantic opening

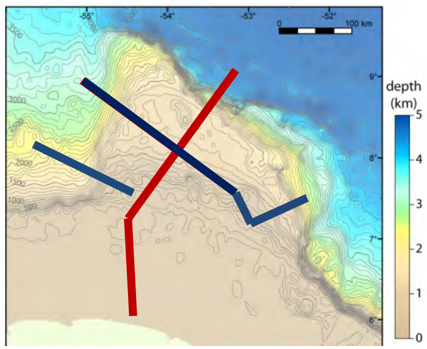


Jurassic uniconformity underlain by SDR's



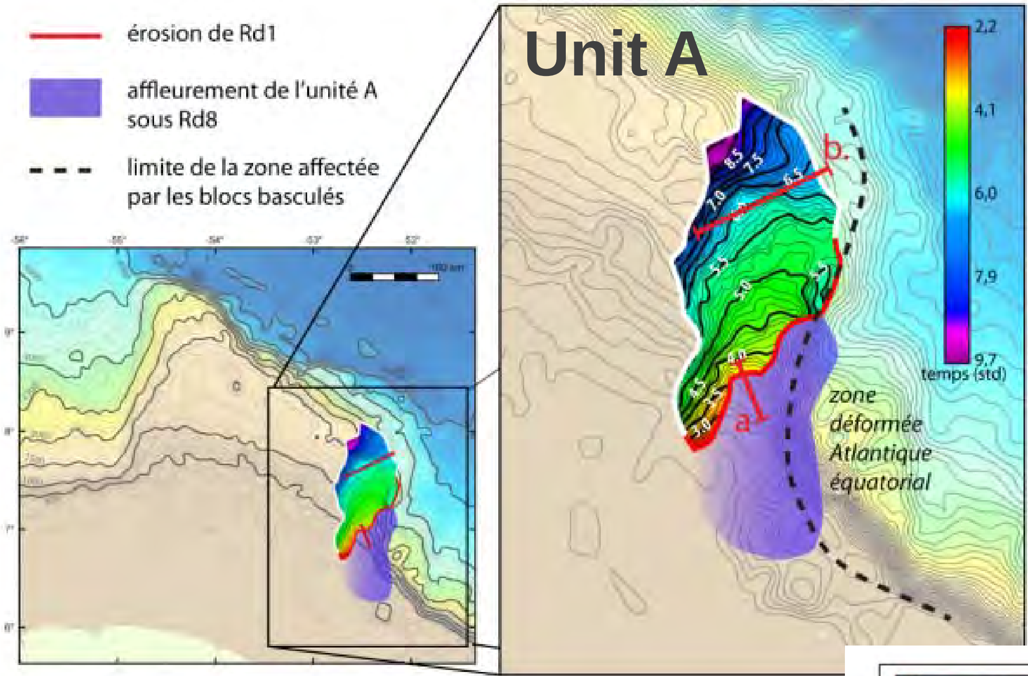


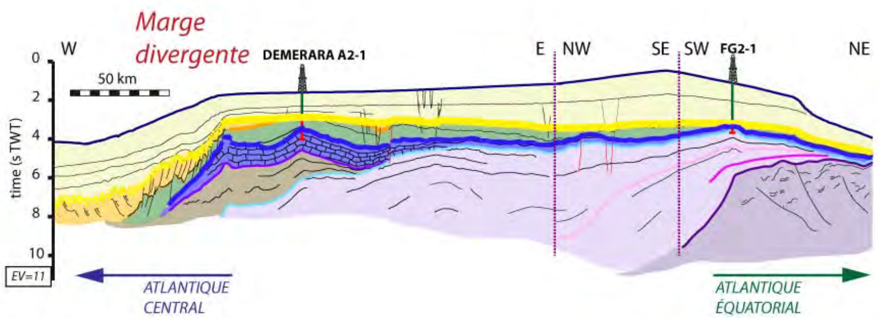




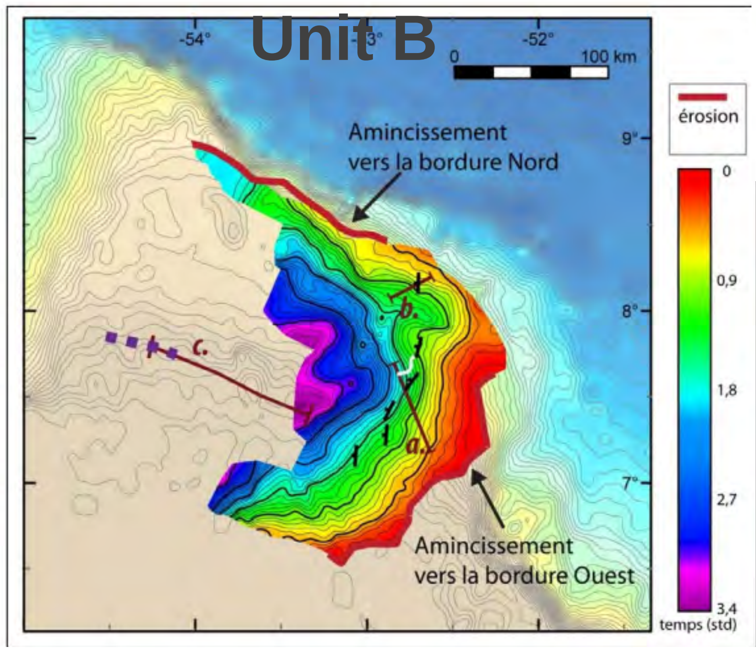
In map view

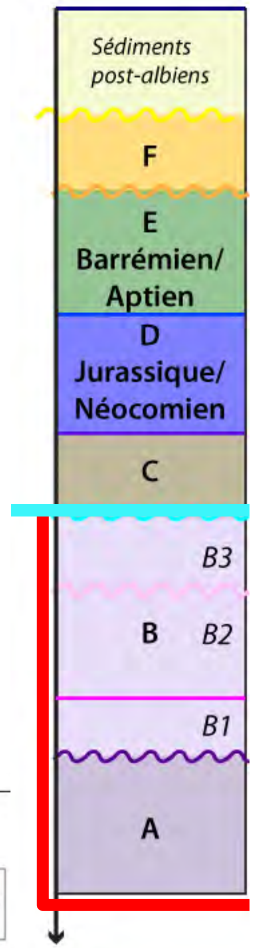
Unit A





Unit B

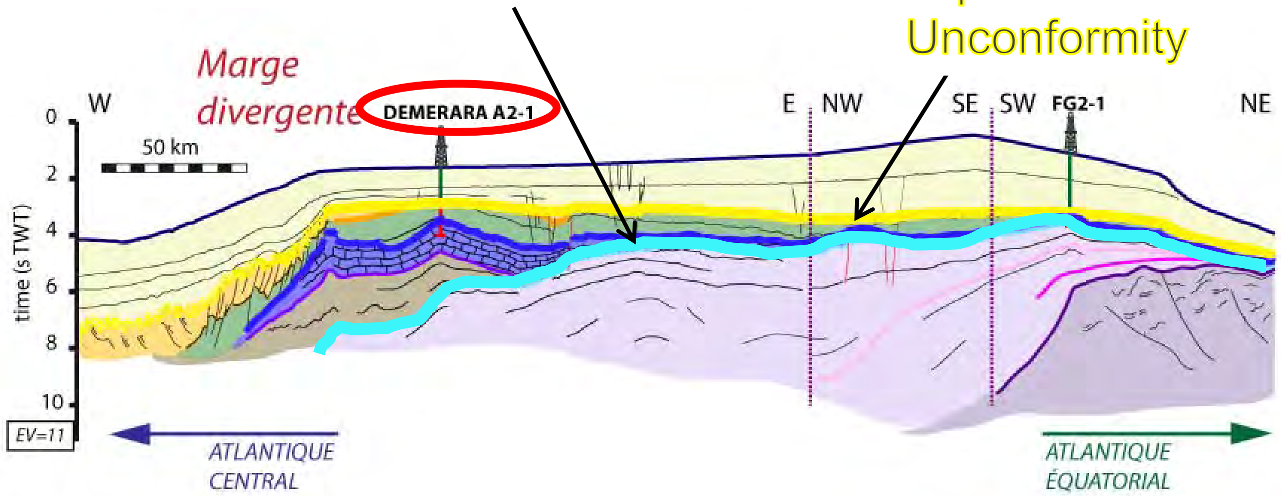


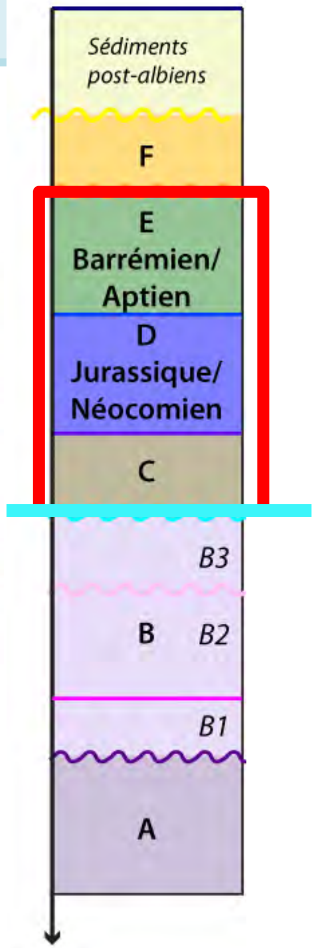


Post-rift carbonate ramp and deep-sea fan

Sinemurian Unconformity

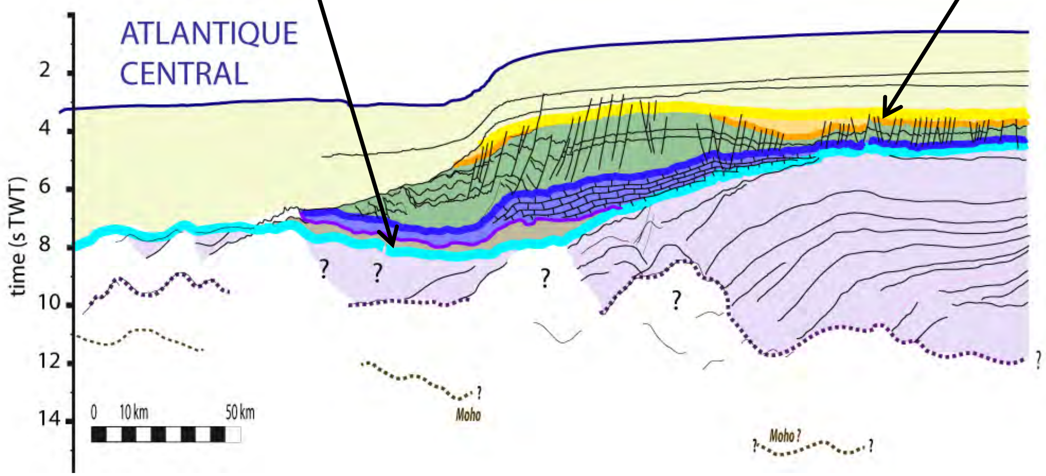
Top Albian Unconformity





Sinemurian Unconformity

Top Albian Unconformity

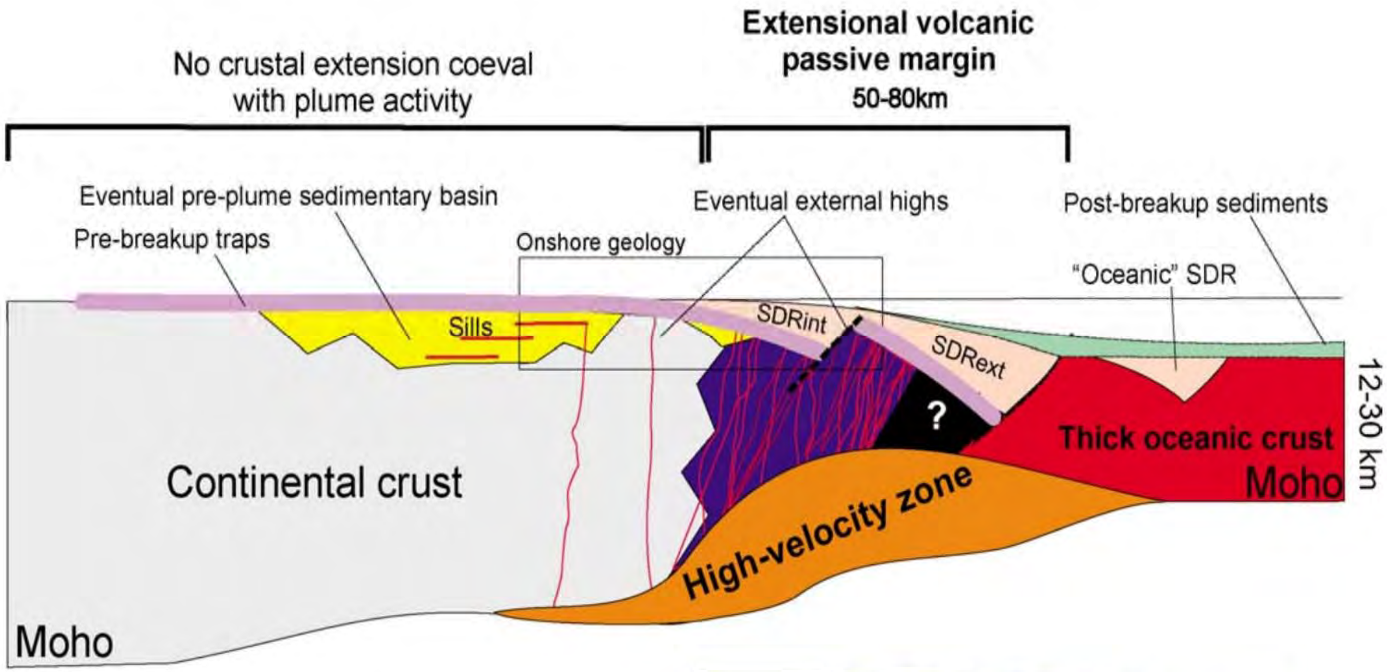


D: Carbonate platform

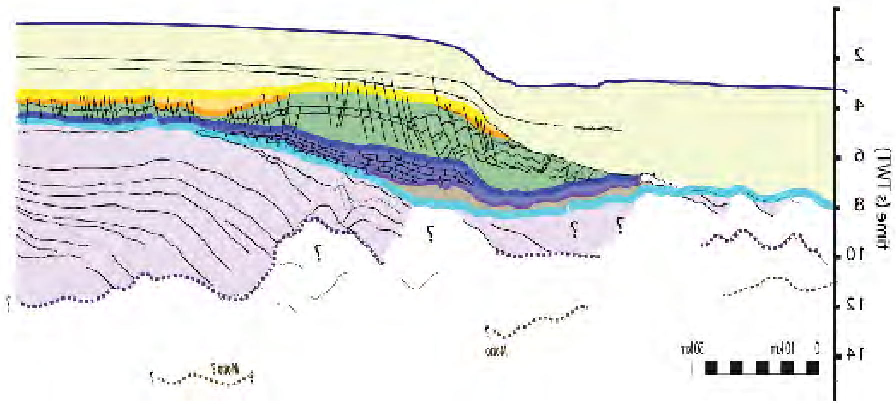
E: Terrigenous sediments

- ➢ A deep-sea fan affected by gravity tectonics

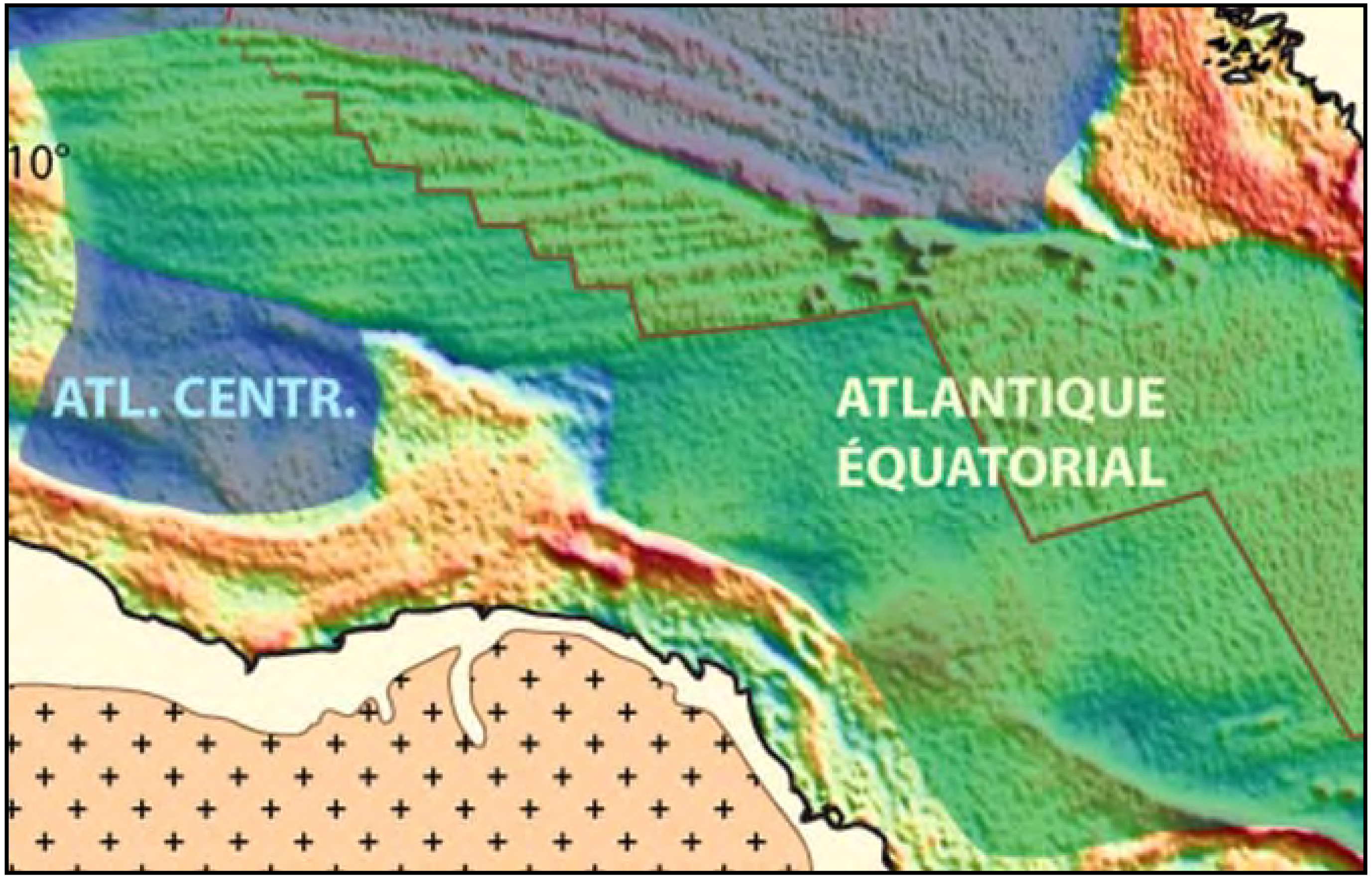
To conclude:
The Demerara plateau probably structured first as a volcanic margin (see presentations of Museur, Basile, Roest et al.)



Geoffroy et al., 2005

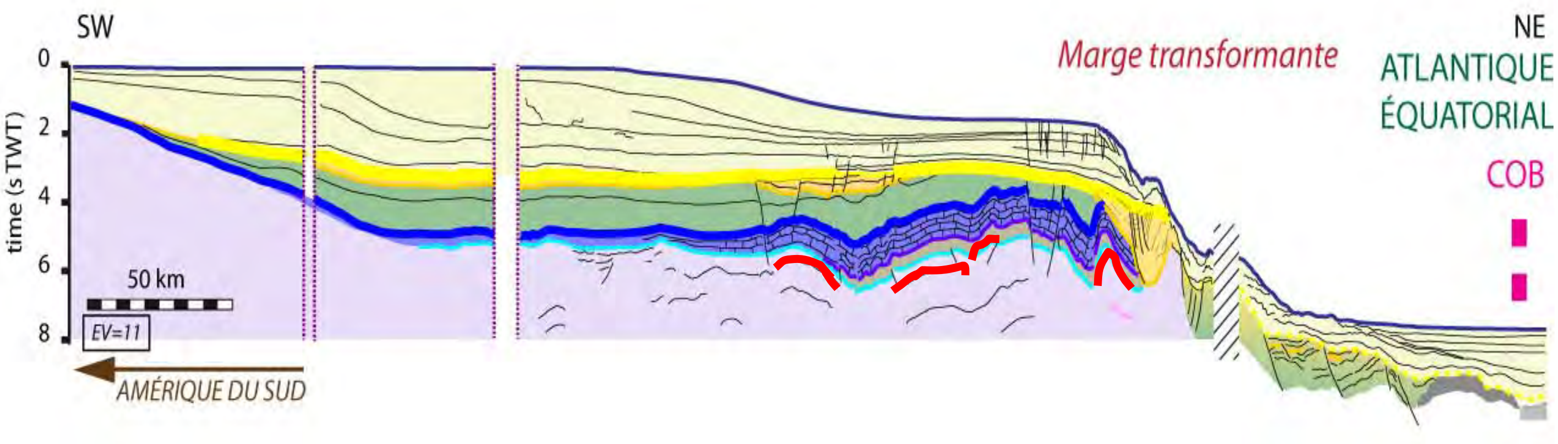


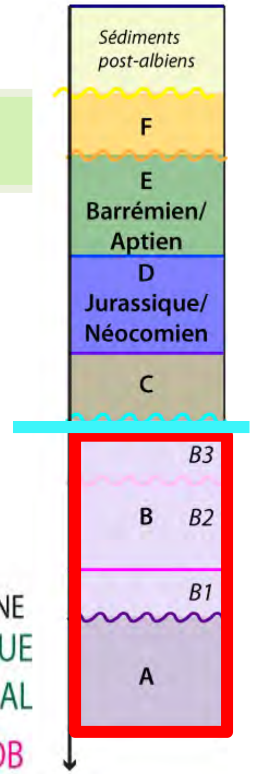
Second phase: Equatorial Atlantic

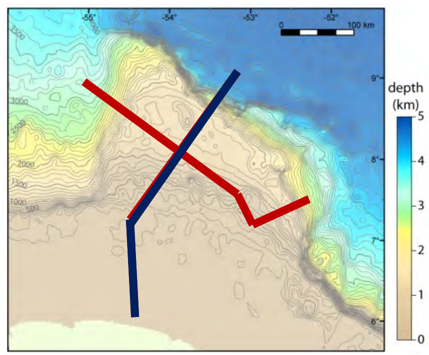


1) Deformations

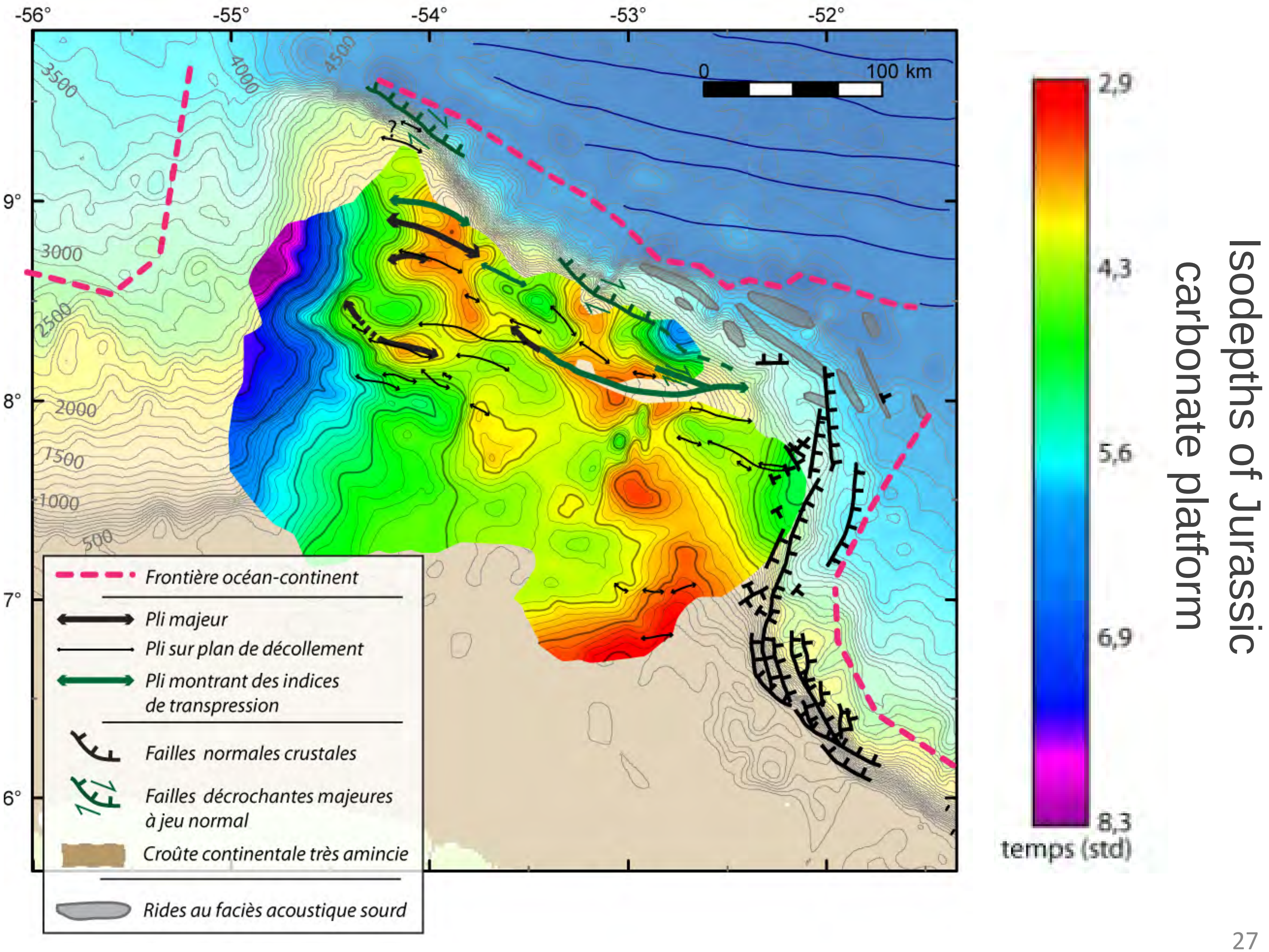
Deformations intensifying
Toward transform border



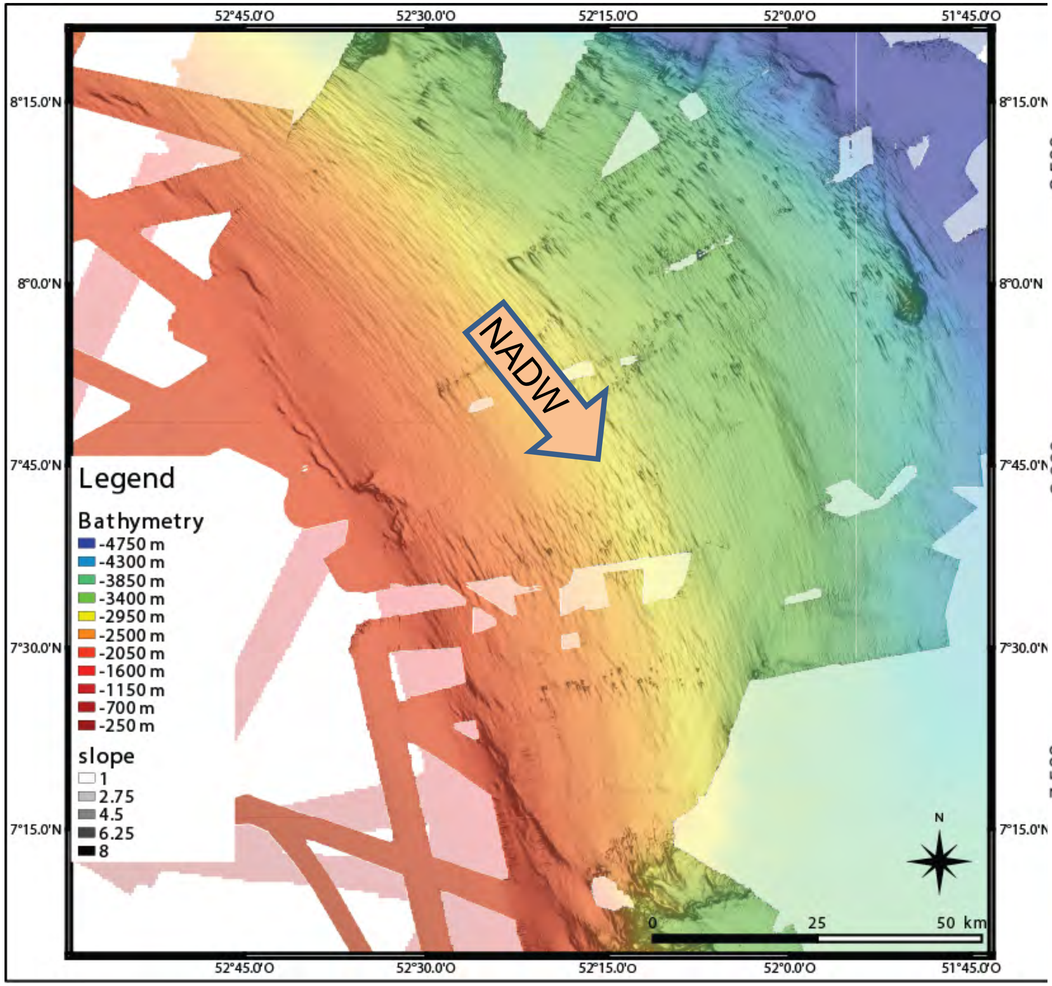


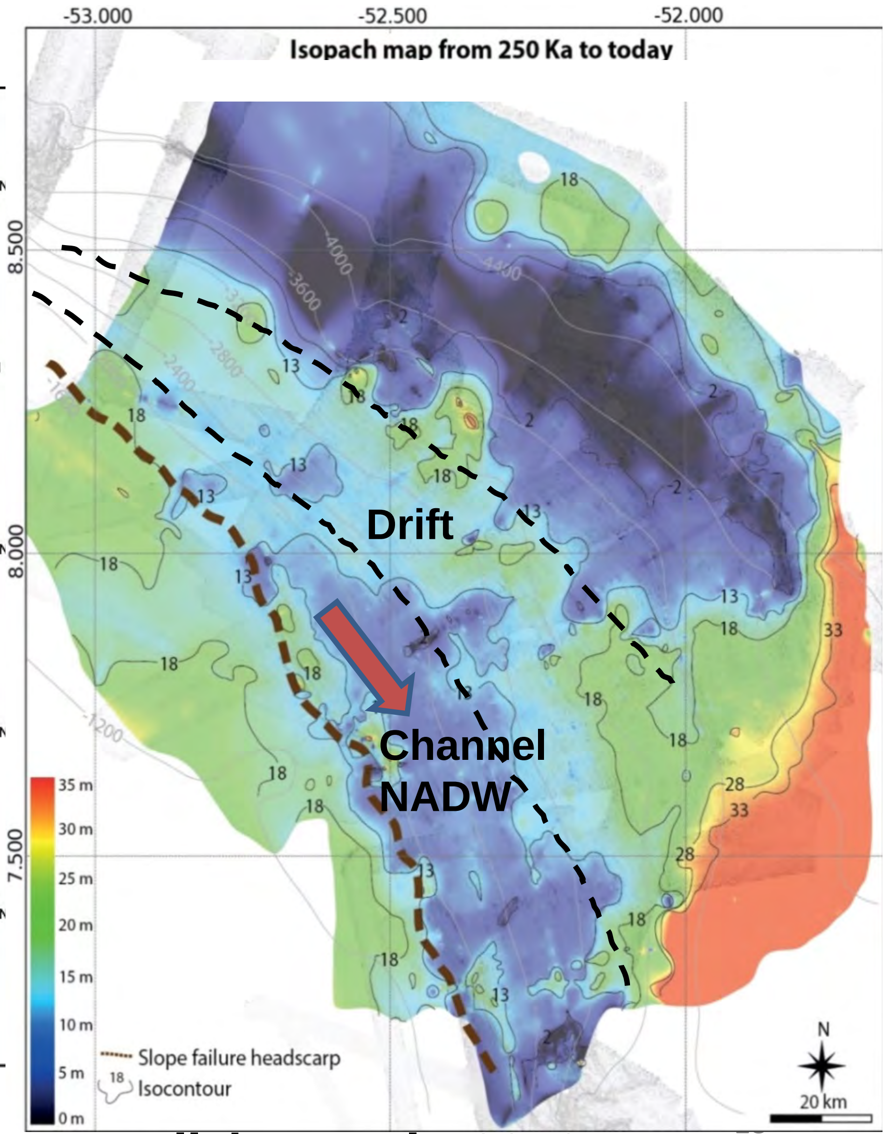


Structural map



Last phase: Post-Albian sedimentation > Fanget et al.





Tallobre et al., 2016

To summarize

The Demerara plateau architecture and sedimentation reccord a two-step evolution: Two breakup unconformities and 3 very different basins

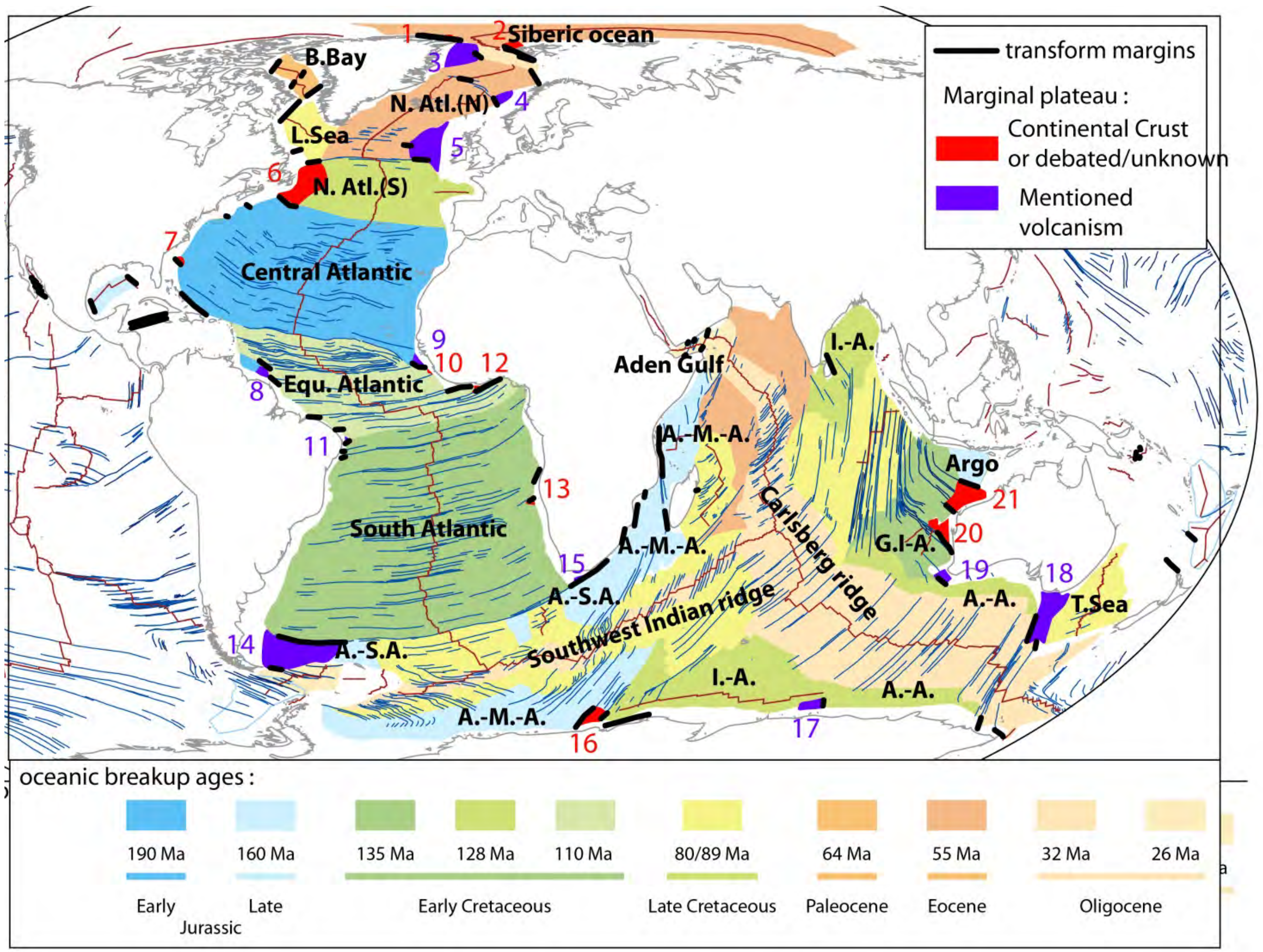
Recent data reveals that this plateau underwent strong volcanism probably related to the CAMP hotspot
<u>This changes our vision of the nature of the plateau…</u>

This plateau forms a gateway between Africa and America that seems to localize important contour currents when oceanic circulation initiates

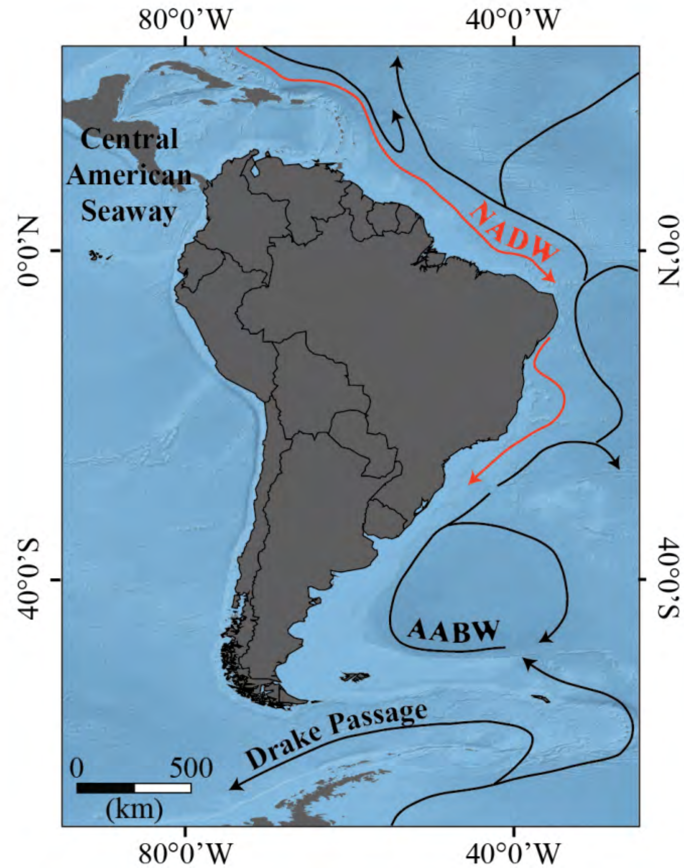
3. New issues

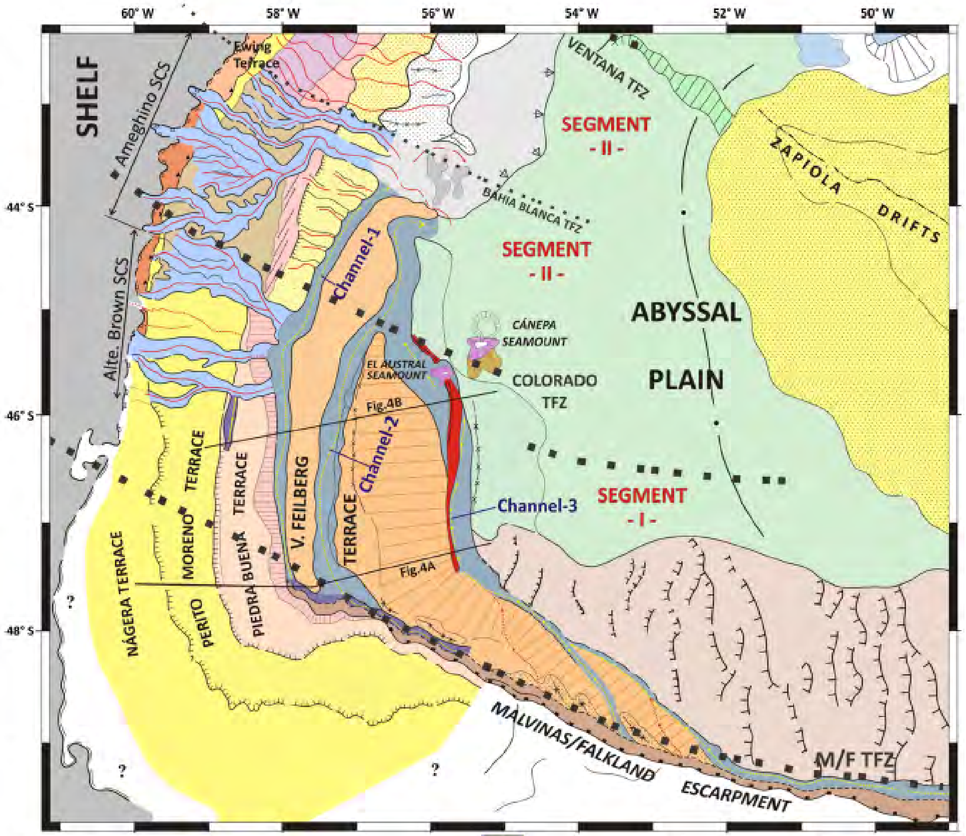
What about volcanism for other plateaus? The Demerara plateau, an isolated case?

What about contourites on other plateaus?



- **For 52% of MP, volcanism occured before, during or after transform motion**
- **For 16% of MP, the crust is continental**
- **For the resting 38%, the nature of the crust is unknown or debated (thinned CC, thick OC, volcanic plateau)**





Hernández-Molina et al. (2009).

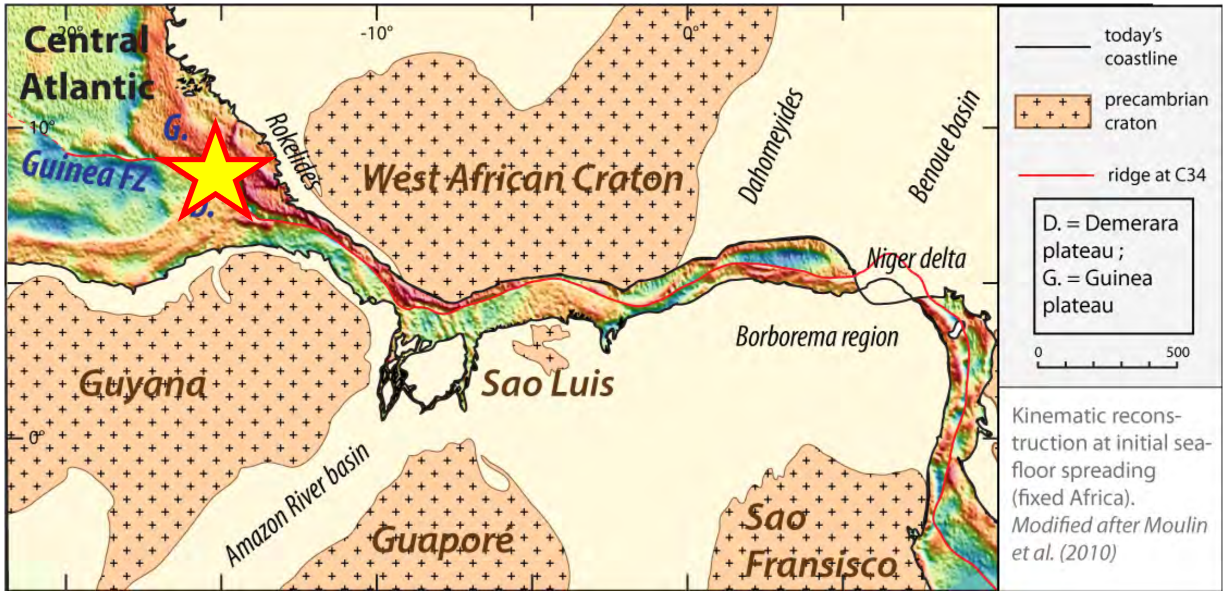
For most of the MP, contourites have been described revealing that those marine elevations are probably key areas to study oceanic circulation initiation and deep current oscillations as a function of climate variations

4. Main scientific challenges

PLATE TECTONICS

Those plateaus clearly emplace at complex geodynamic nodes. Their geodynamic significance has to be better understood in the future: relation with mantellic activity and hotspots?

Modified from Moulin et al., 2010



Specific lithospheric fabrics and thermal evolutions controlling transform emplacement?

NATURE OF THE CRUST

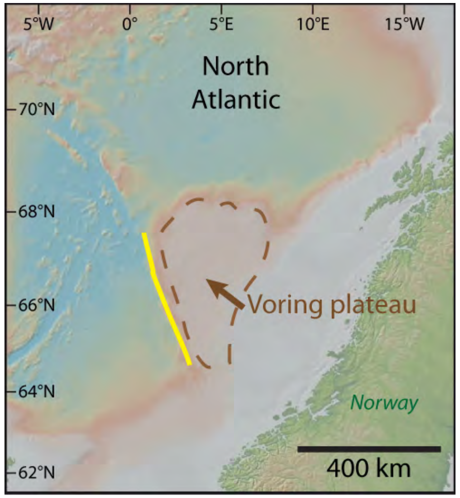
Thinned continental crust? Thickened oceanic crust? Underplated and intruded continental crust? What are the associated thermal evolutions and vertical movements?

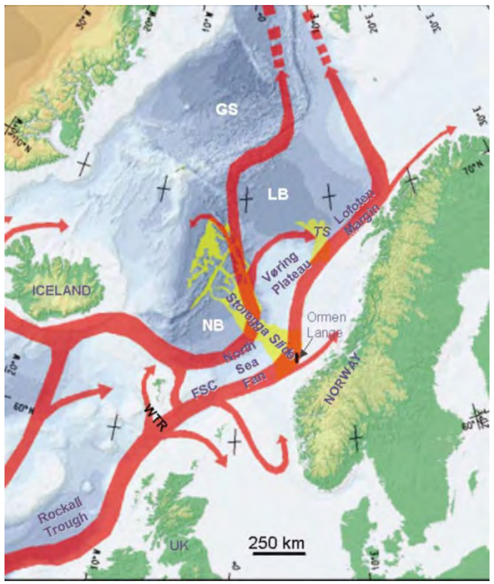
BASINS AND ASSOCIATED NATURAL RESOURCES

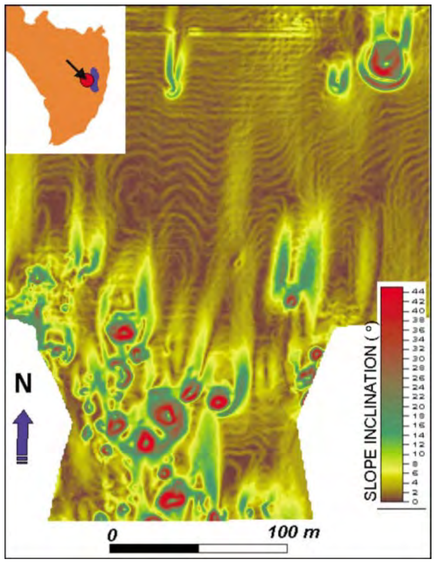
They probably host specific basins that record complex polyphased histories. Possibility to have access to original long-term tectono-sedimentary records? Associated resources?

SPECIFIC SEDIMENTARY PROCESSES

Those plateaus are emplaced nearby continent to ocean transition domains, but forming spurs at the scale of 50 to up to 1000km. Where and how do turbidites accumulate on those low slope gradients proximal plateaus? What kind of sediments reaches the distal part of those plateaus? Role of contourites?







Bryn et al., 2005

SUBDUCTION, COLLISION AND CRUST RECYCLING

Finally, what happens when those plateaus are involved in subduction and collision?