Deep Structure of the Demerara marginal plateau from MARGATS cruise academic wide-angle and multi-channel seismics, insights on the origin of the plateau

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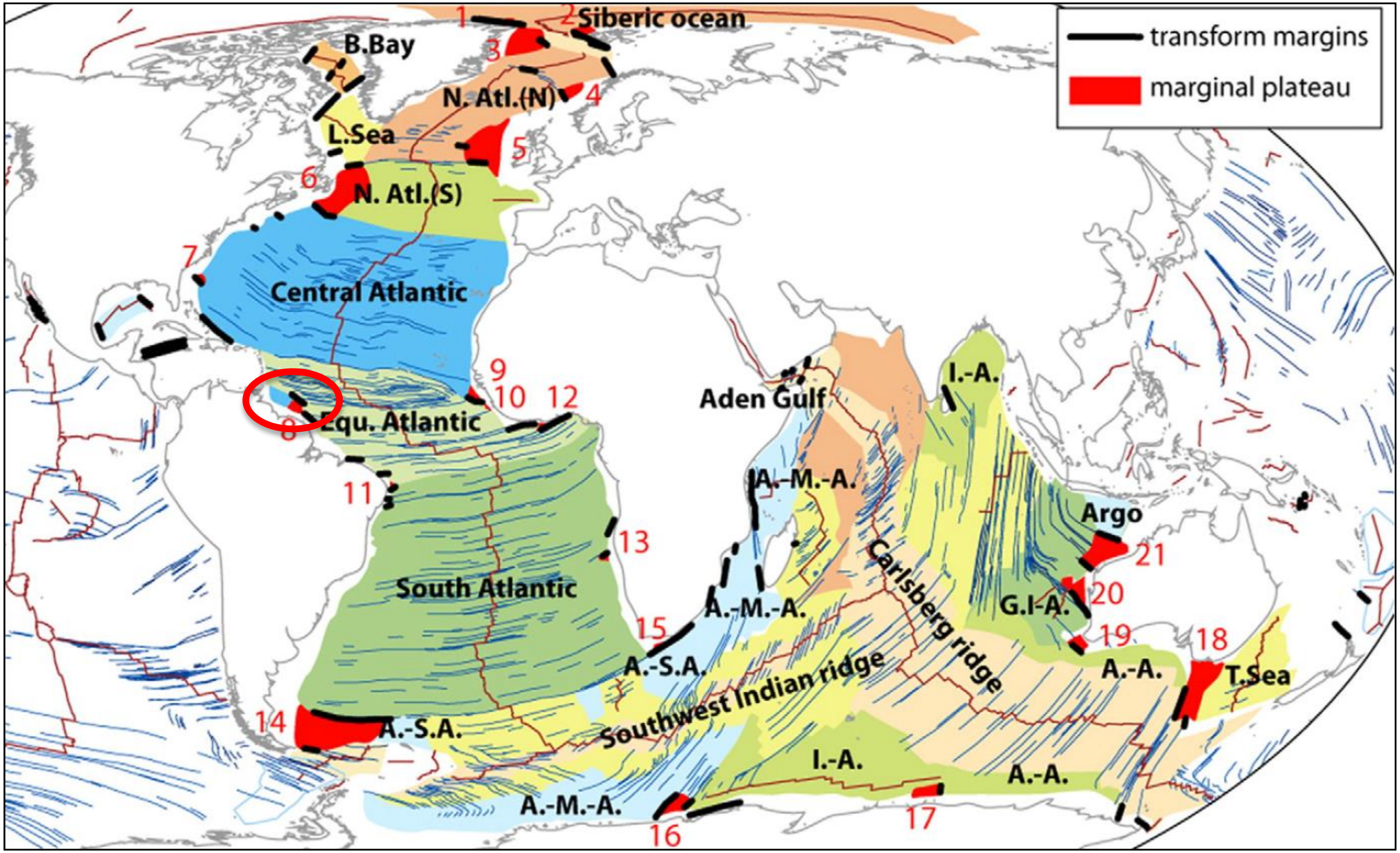
Plan

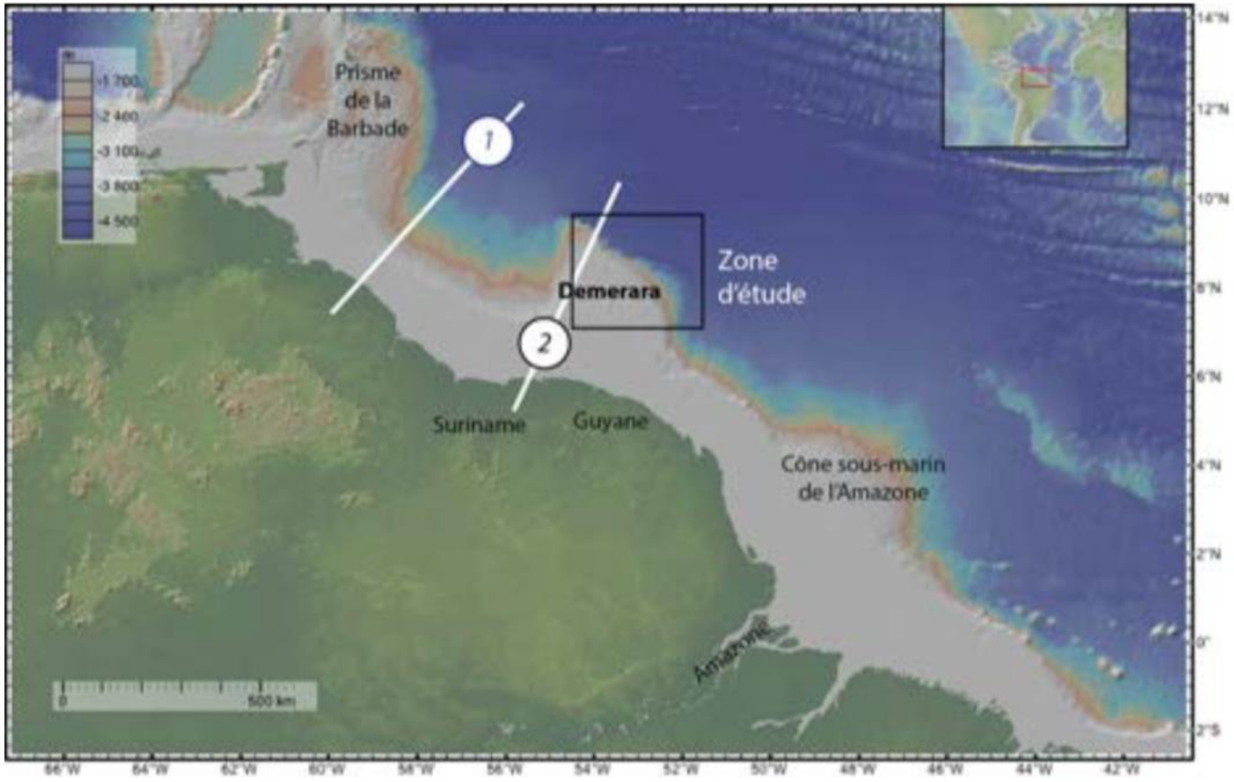
- Introduction
- Developments on the Demerara plateau
- MARGATS cruise
- Methodology
- Results and interpretation: Evidence for volcanic material
- Conclusions

Transform margins and marginal plateaux at a global scale

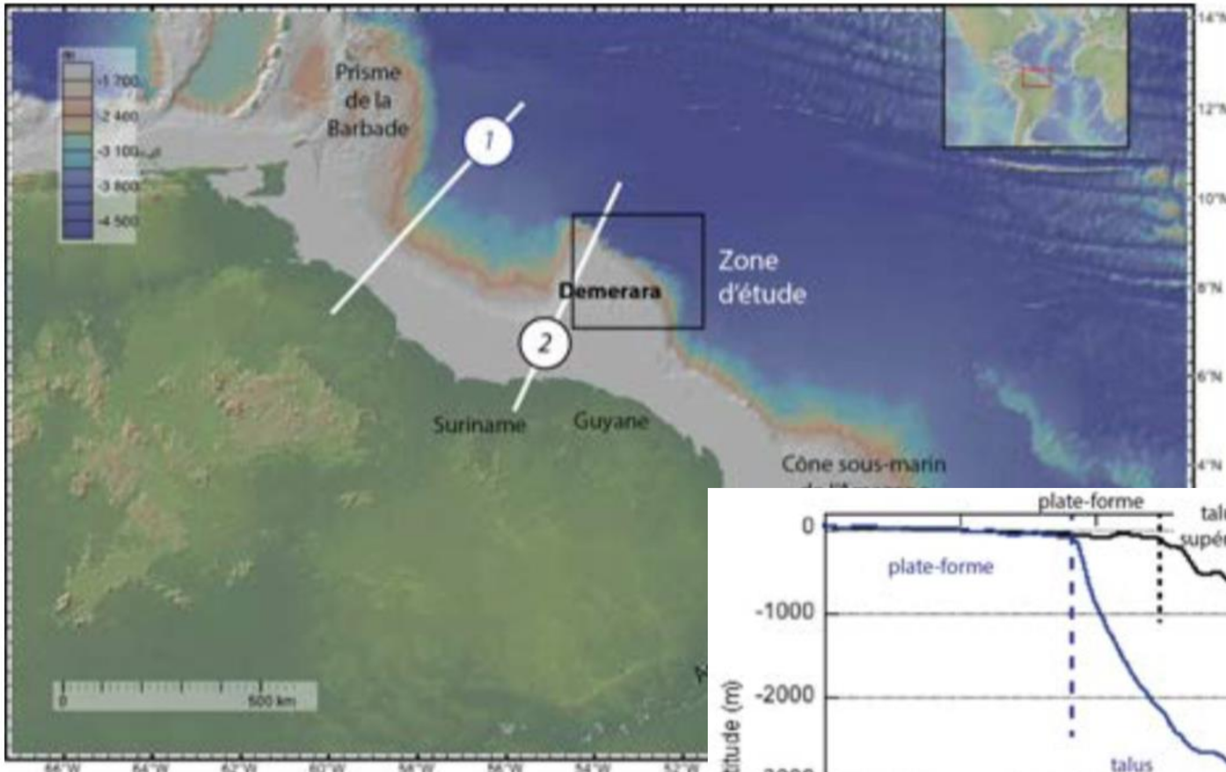


From Mercier de Lepinay et al., (2016)

The Demerara plateau

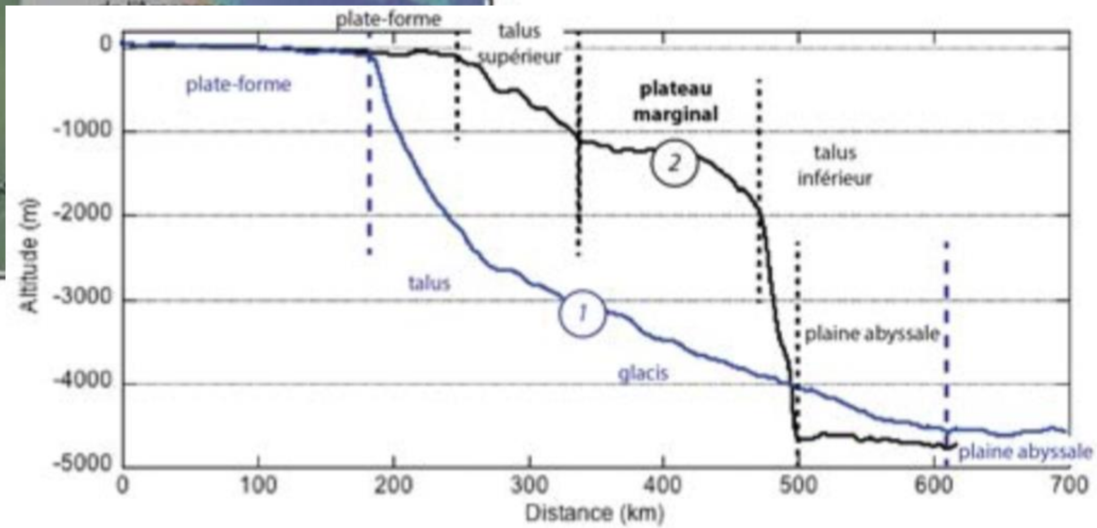


The Demerara plateau

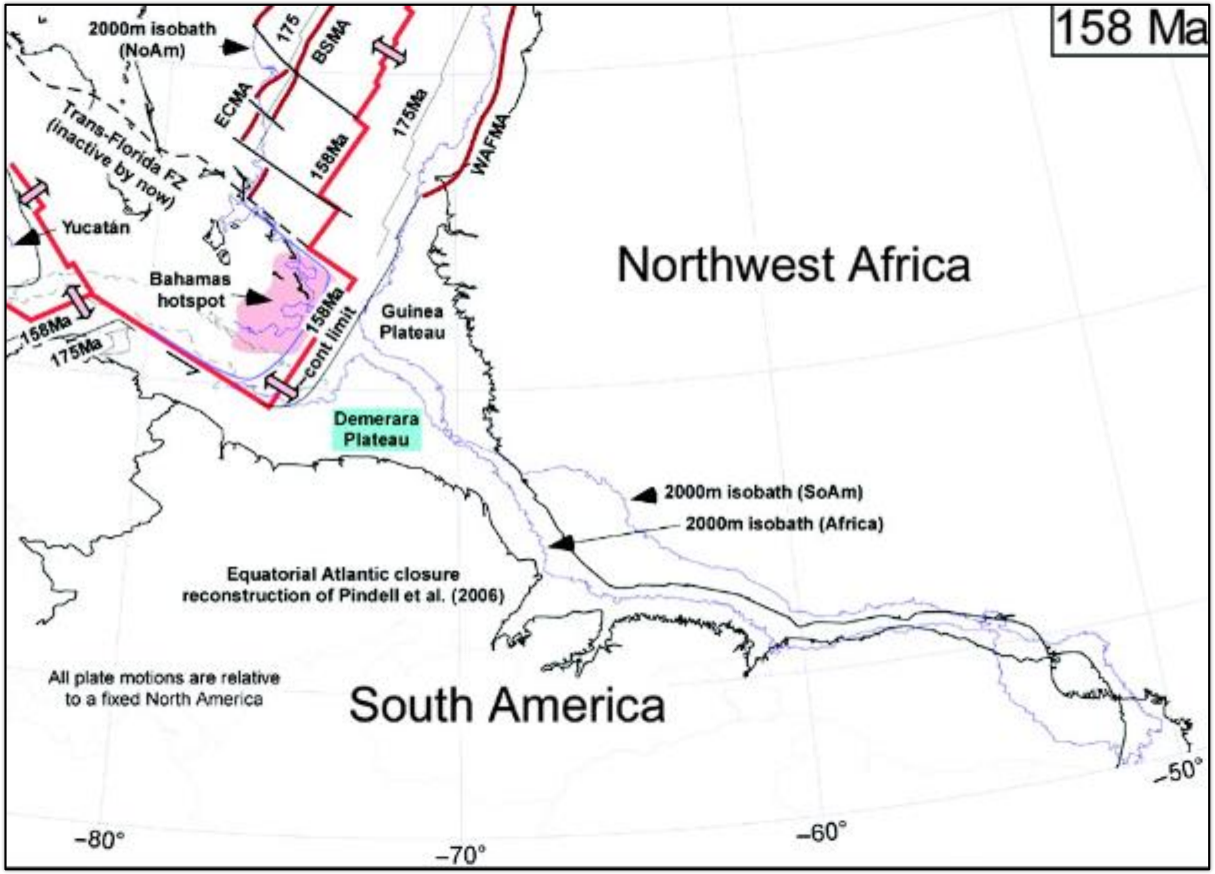


From 1200 m depth on the submarine plateau to 4800 m depth on abyssal plain.

The northern edge is very steep: reaching 60° in places.



Jurassic event



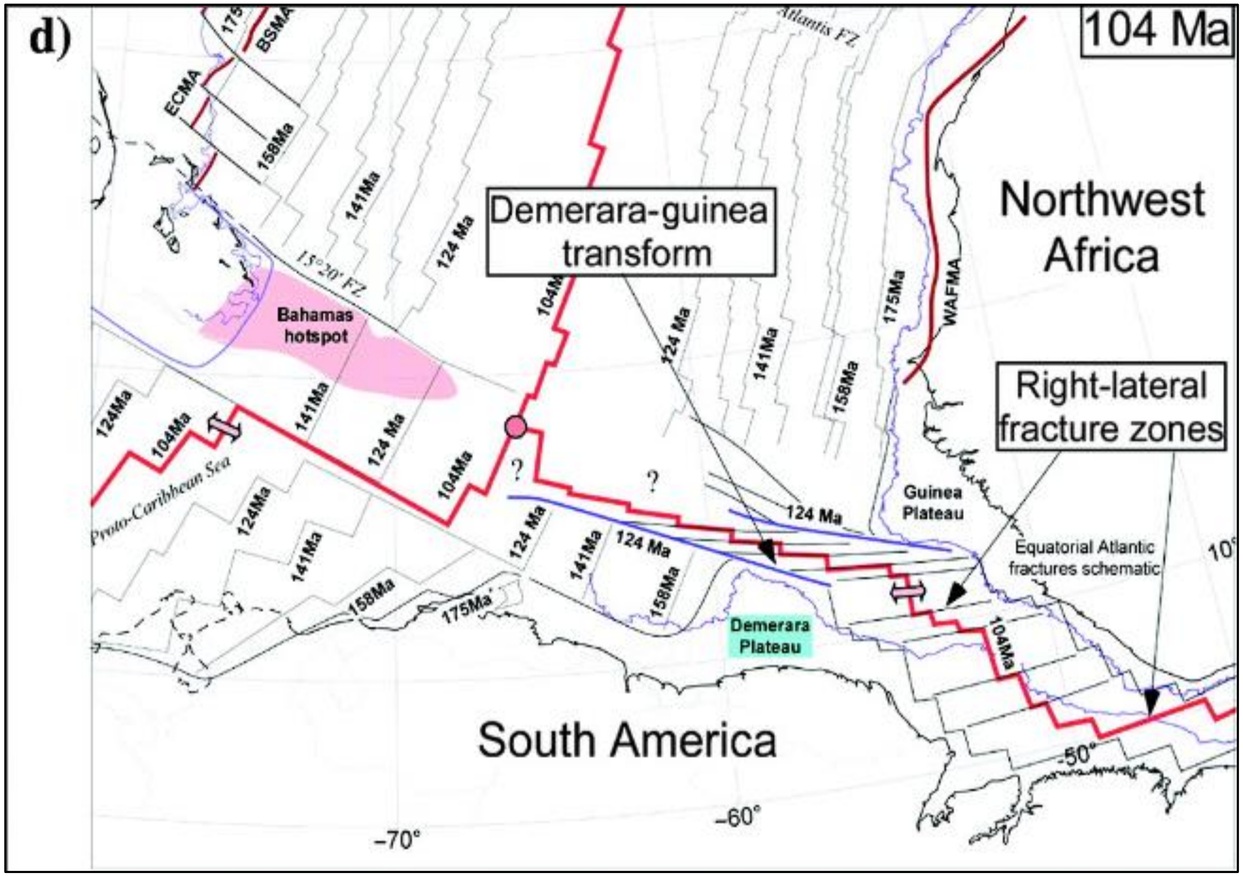
From Reuber et al., (2016)

A rifting phase occured during the Jurassic, with the opening of the Central Atlantic Ocean.

This created the western edge of the Demerara plateau.

The precise dating of this event is debated.

Cretaceous event



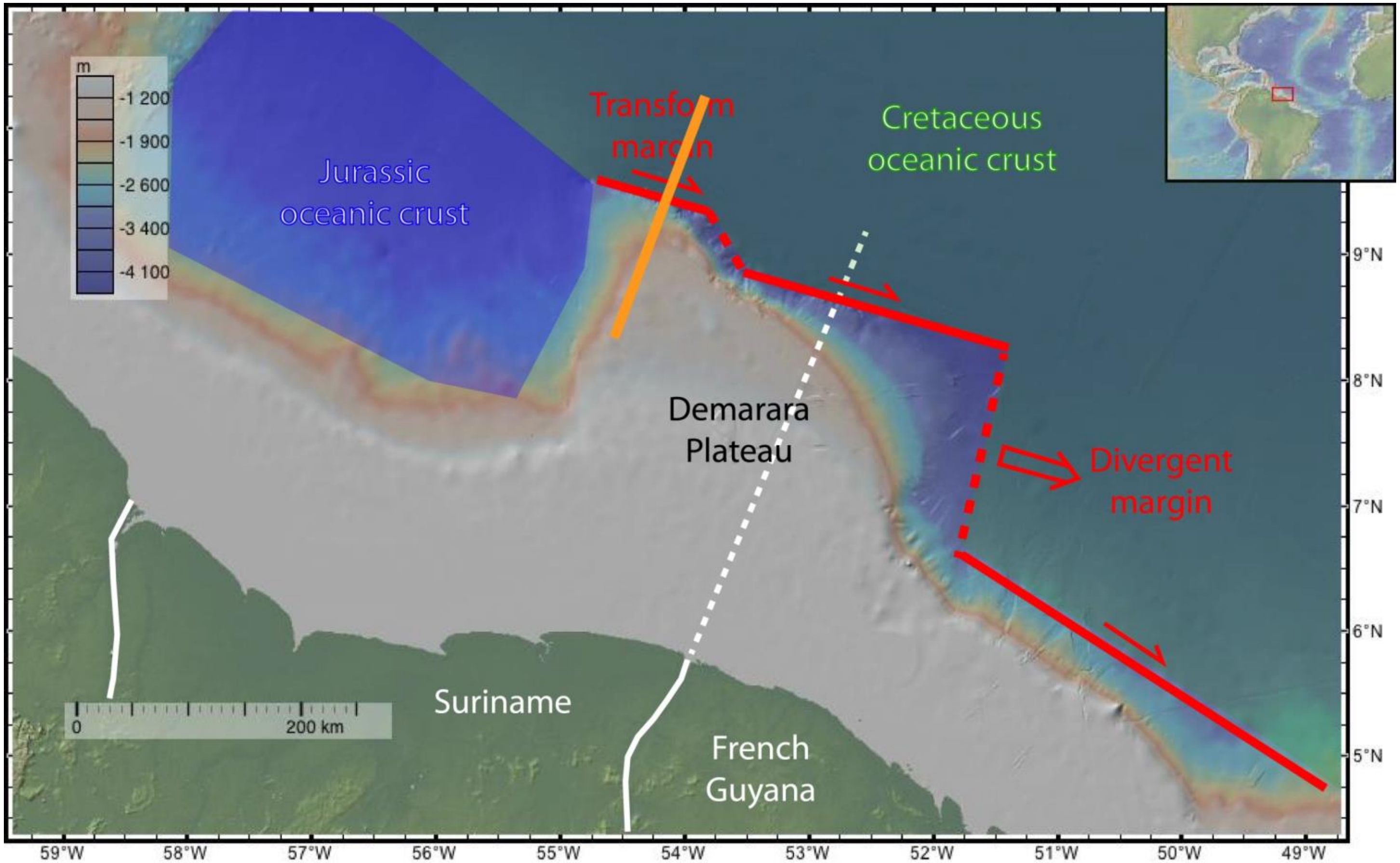
From Reuber et al., (2016)

Second rifting phase leading to the opening of the Equatorial Atlantic Ocean.

Separation between the Demerara Plateau and its conjugate margin: the Guinea Plateau.

This event forms the northern (transform) and the eastern (divergent) borders.

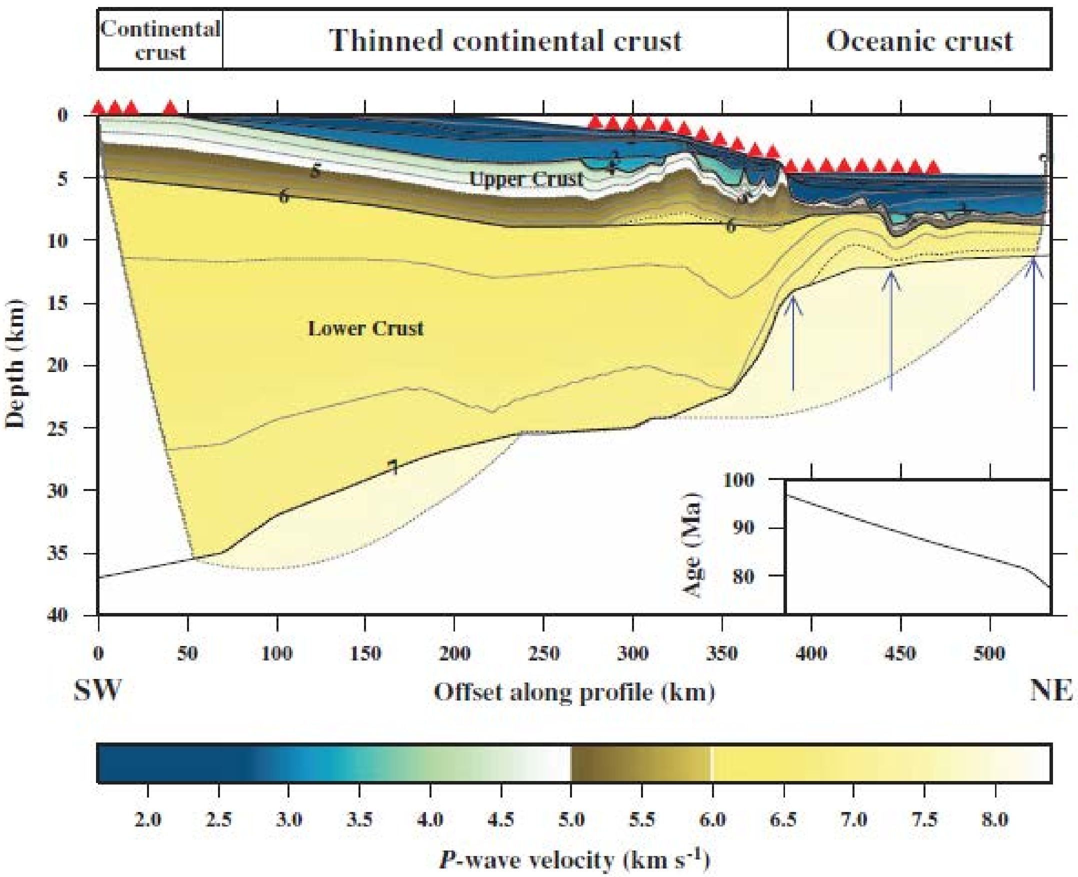
Two tectonic phases



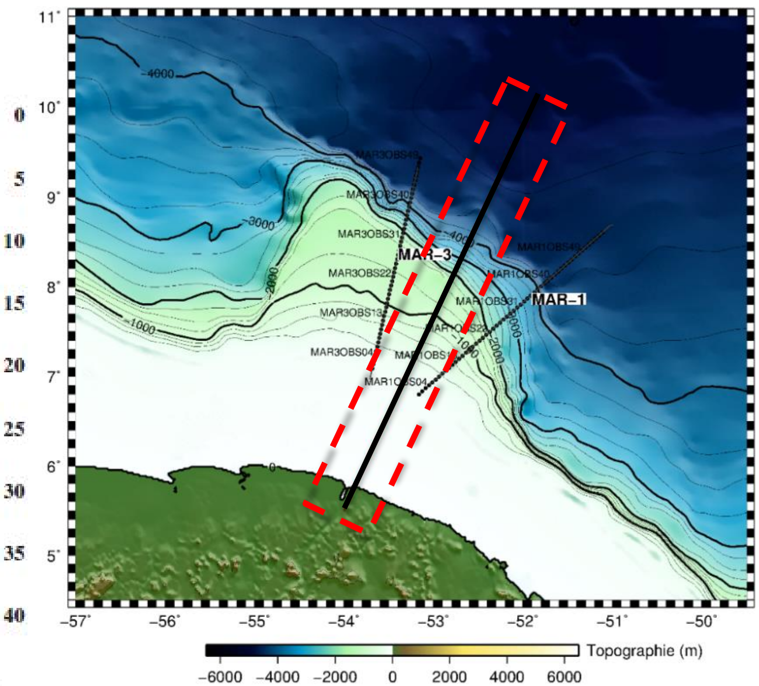
The two tectonic phases led to the formation of:

- A transform margin at the north.
- Divergent margins at the western and the eastern edges.

Nature of the crust: Continental affinity ?

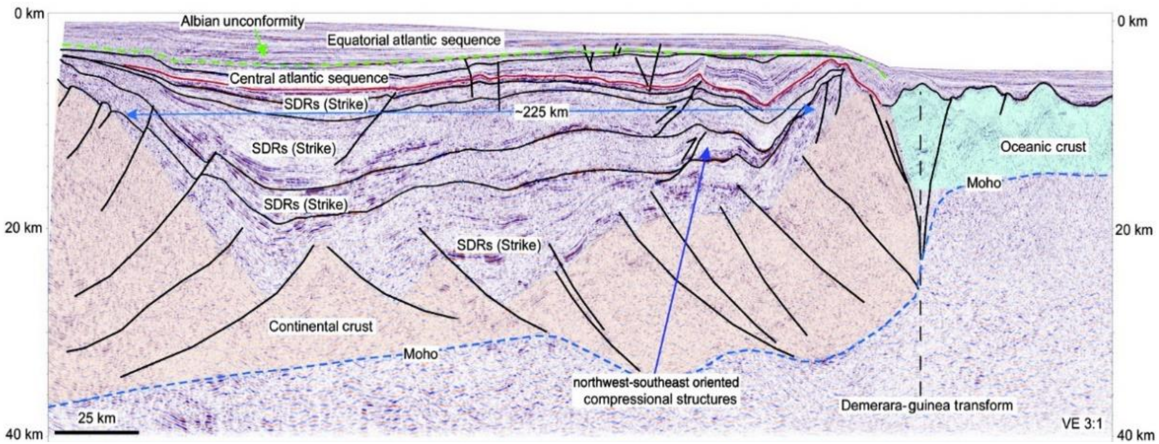


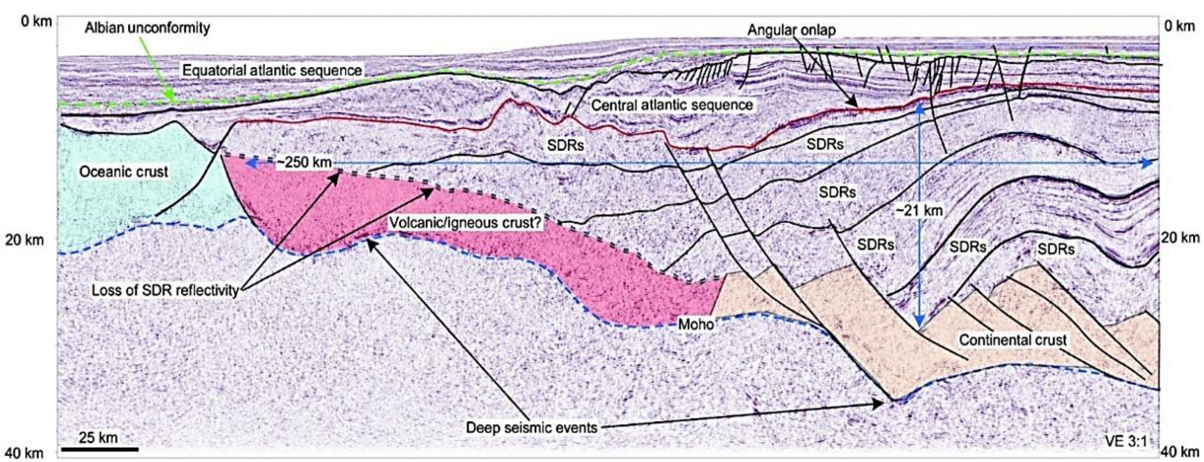
From Greenroyd et al. (2008)

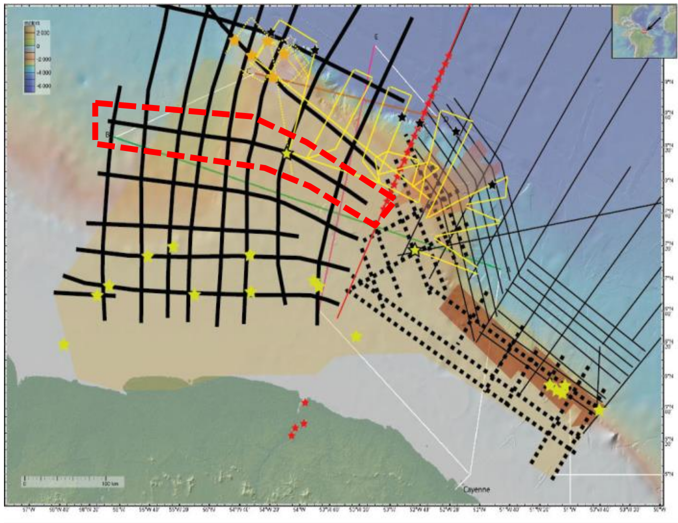


The deep part of the model is poorly constrained, with few picks.

Nature of the crust: Volcanic products ?

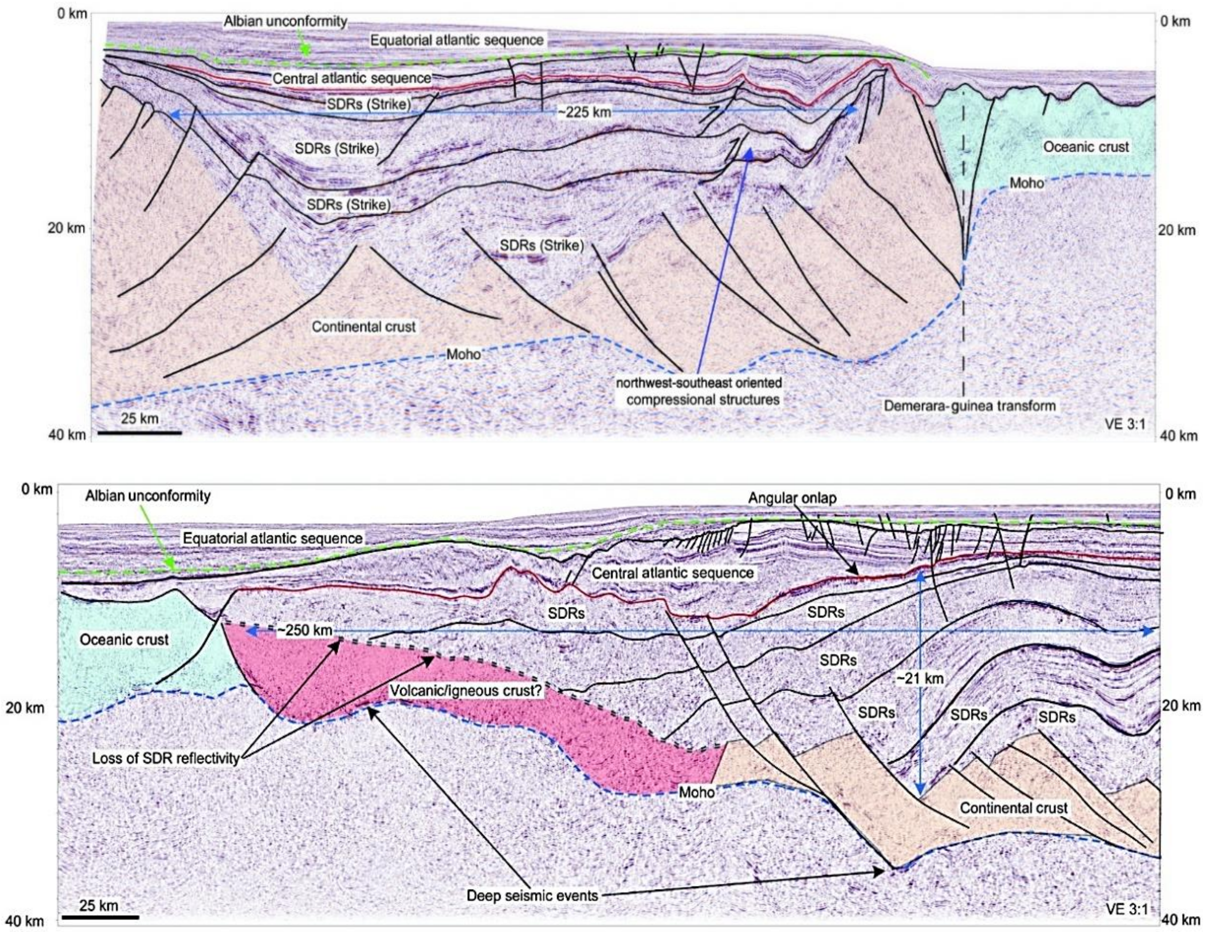






From Reuber et al. (2016)

Nature of the crust: Volcanic products ?

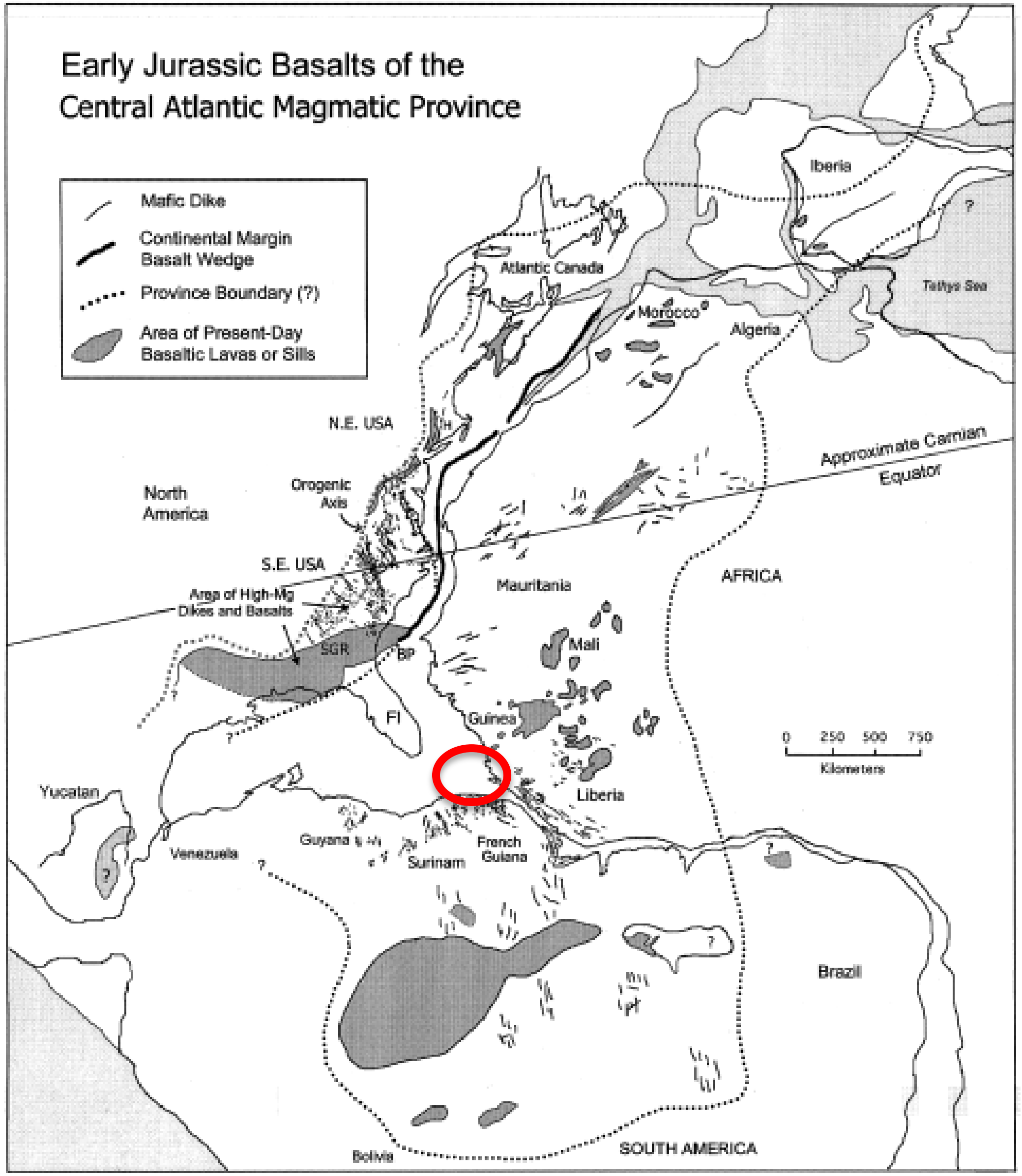


From Reuber et al. (2016)

Reuber et al., (2016) suggest the presence of a SDR (Seaward Dipping Reflector) complex.

Underneath the volcanic products, there would be a volcanic/igneous crust or a continental crust.

The maximum depositional thickness of the SDR complex would be located at the Western margin and its thickness would decrease towards the East.



From McHone et al., (2000)

Evidence for volcanism

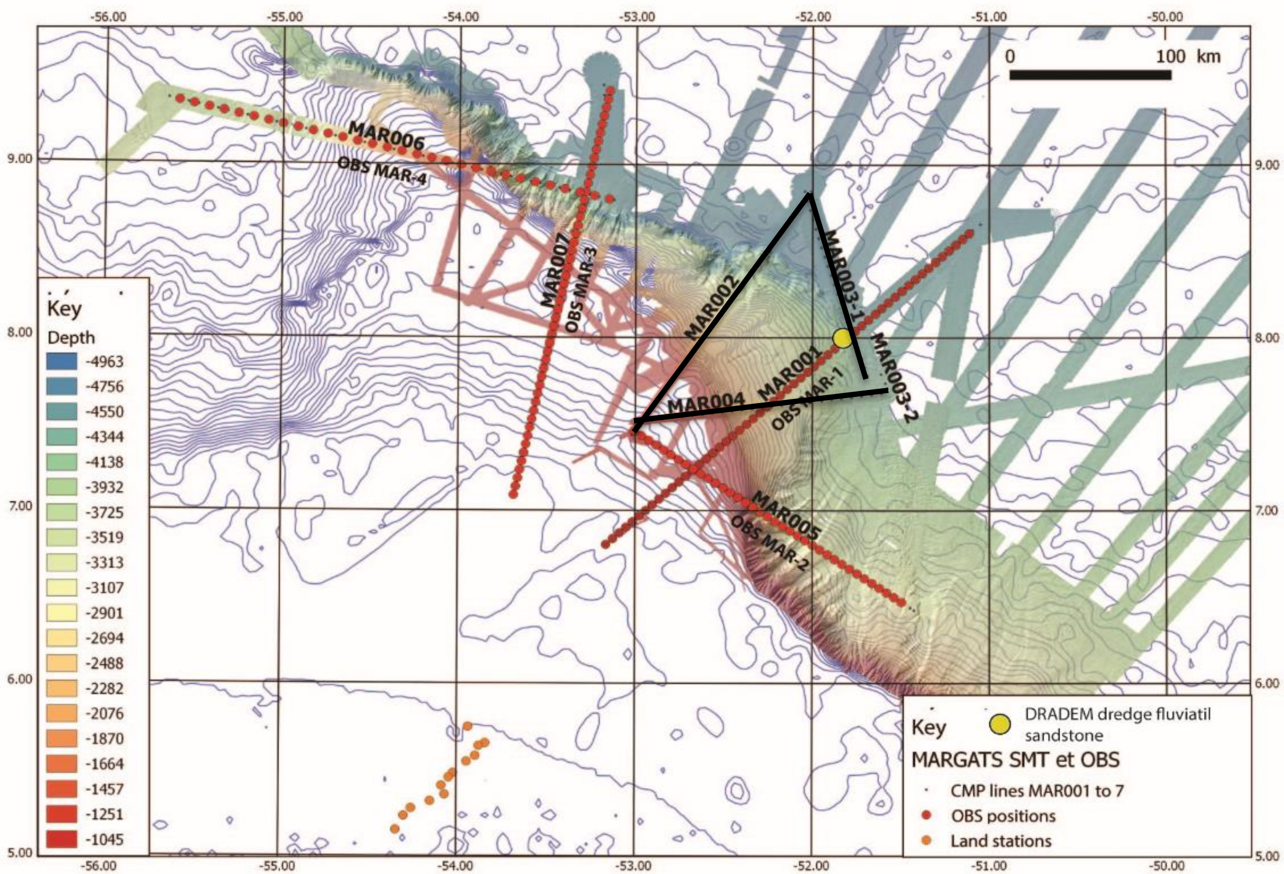
The Central Atlantic Magmatic Province (CAMP) is one of the largest igneous provinces on Earth, with ~2-3 x 10^6 km^3 of volcanic products.

Dikes, sills, lavas were found in a large area around the paleo-center of the Central Atlantic Ocean (Early Jurassic).

CAMP: 200 My, dated from many samples.

Occured before the first opening.

MARGATS cruise



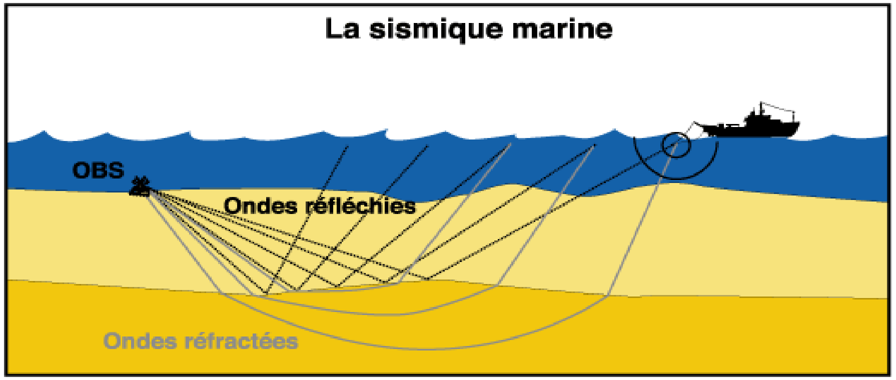
From October 20th to November 16th 2016 on the R/V L'Atalante.

171 OBS deployments along 4 combined wide-angle and reflection seismic profiles as well as 3 additional MCS profiles.

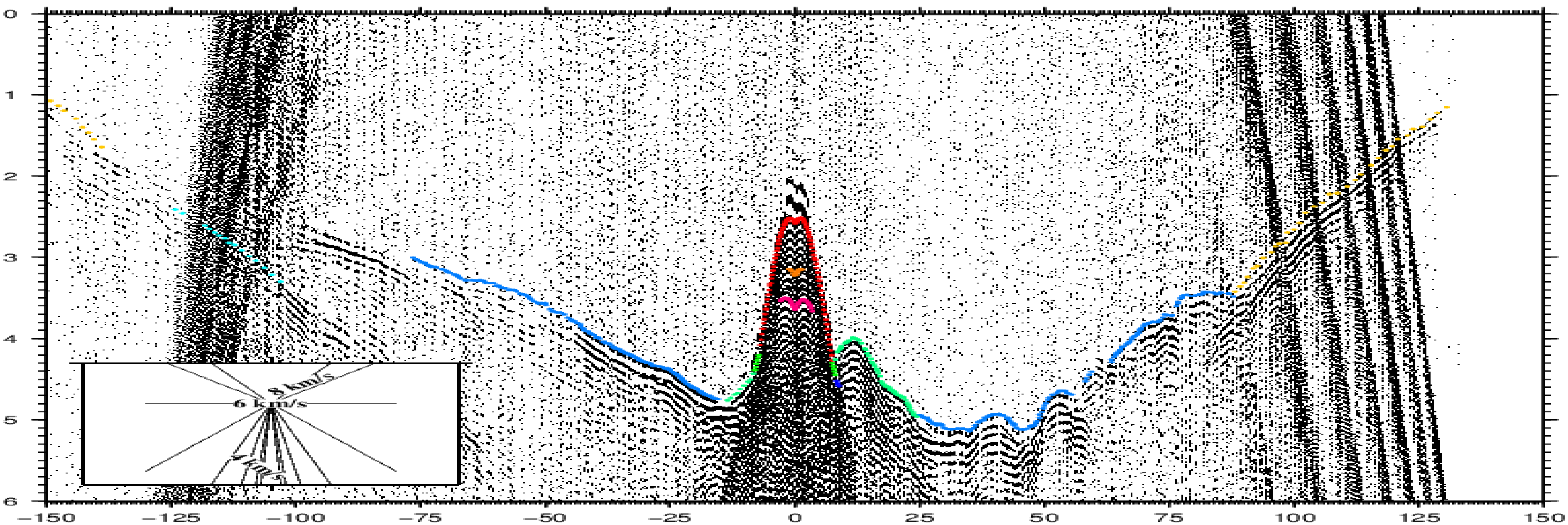
MARGATS cruise: objectives

- Image the deep structure of the plateau.
- Determine the heritage of the two rift events.
- Constrain the nature of the crust along the profiles.
- Enhance the knowledge of the evolution of the marginal plateaus.

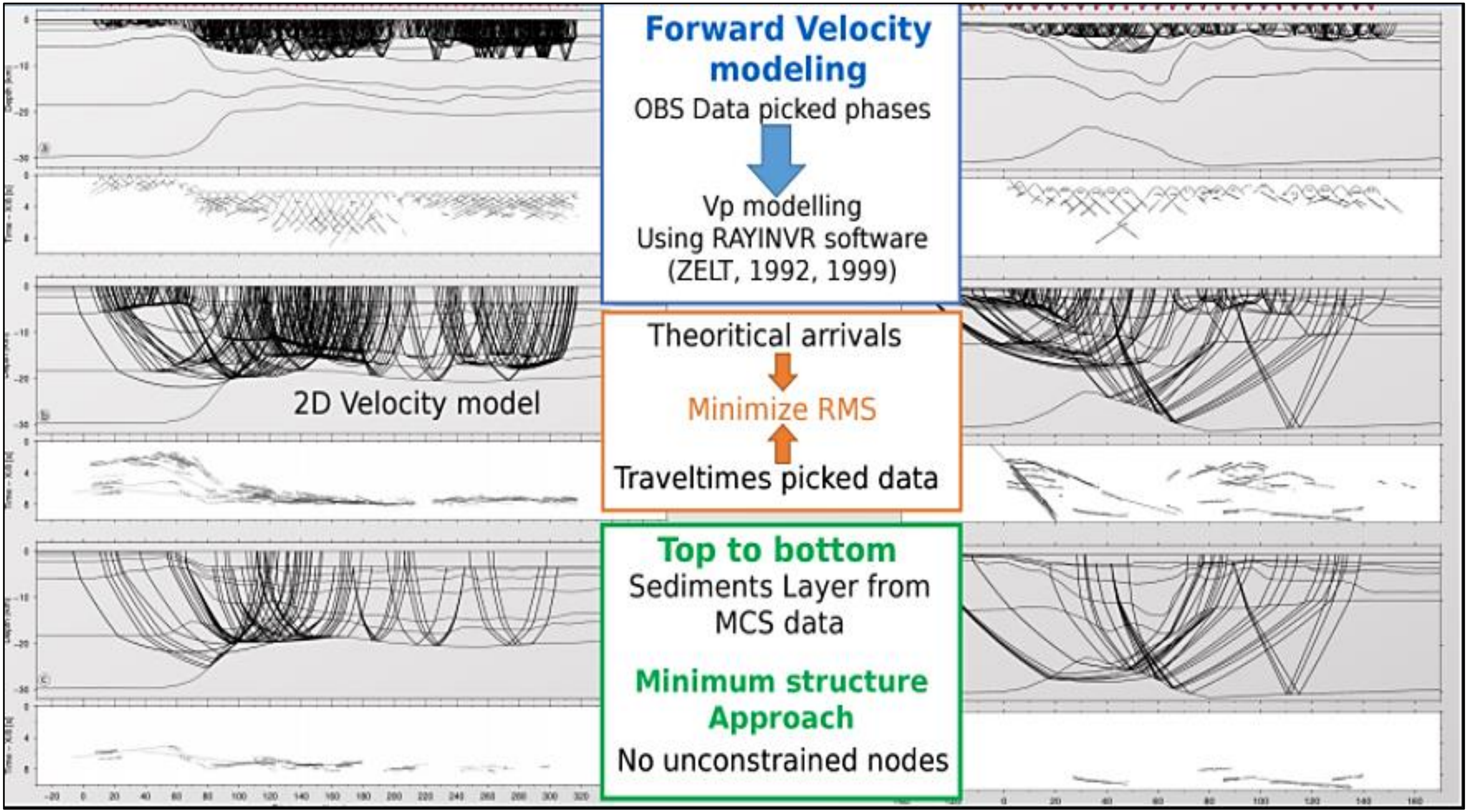
Methodology: wide-angle seismic



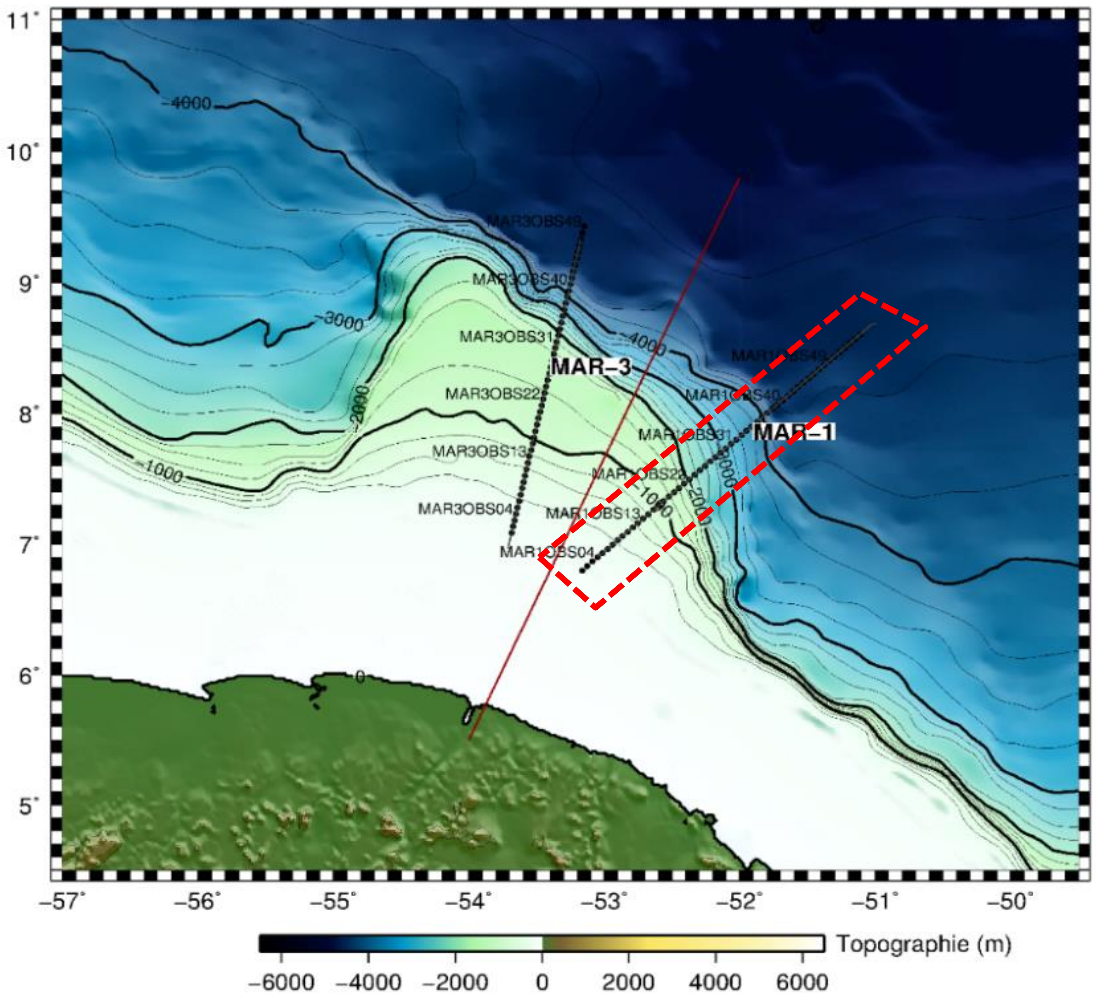
Different slopes correspond to different phases, distinguished by their velocity.
Initial step: Pick these different phases.



Modelling: Trial and error method



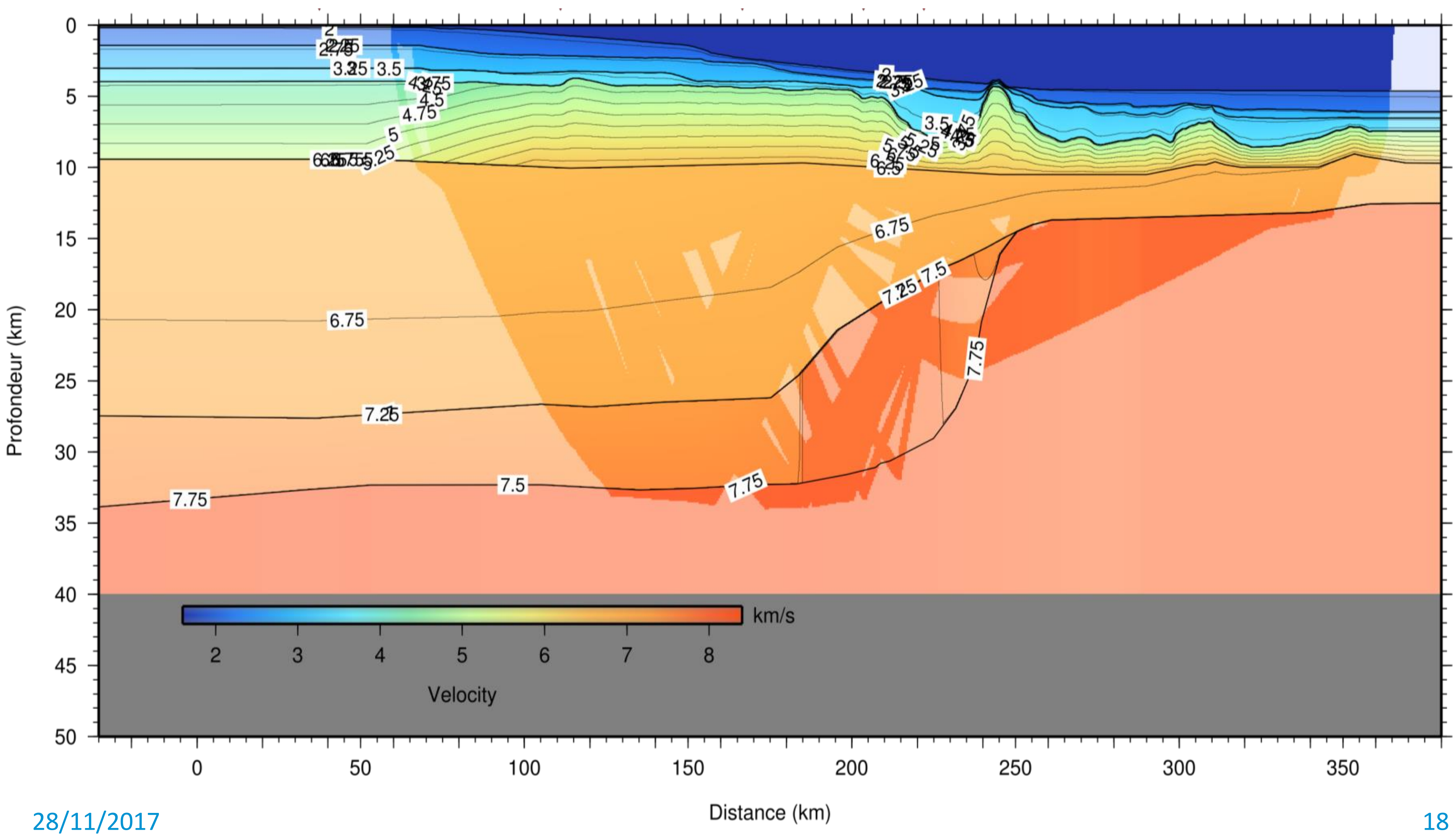
Results



One wide-angle profile has been modelled.

55 OBS. Crossing the border of the plateau at the limit between transform margin and divergent margin.

A preliminary model



Evaluate the quality of the model

	Nombre de points utilisés:			11553
	Temps de trajet RMS résiduel:			0,109
	Chi²:			3,29
N° Phase	Nom Phase	Nb Points	Temps RMS	Chi²
1	Fond de l'eau	3729	0,066	4,896
2	Sédiment 1	1091	0,144	5,787
3	Sédiment 2	426	0,092	2,373
4	Sédiment 1 réfléchies	764	0,05	0,689
5	Sédiment 2 réfléchies	699	0,059	0,968
6	Croûte sup	1739	0,082	0,83
7	Croûte sup réfléchies	205	0,104	1,34
8	Croûte intermédiaire	2359	0,129	2,071
9	Pn	343	0,295	10,786
10	Pmp	198	0,197	4,824

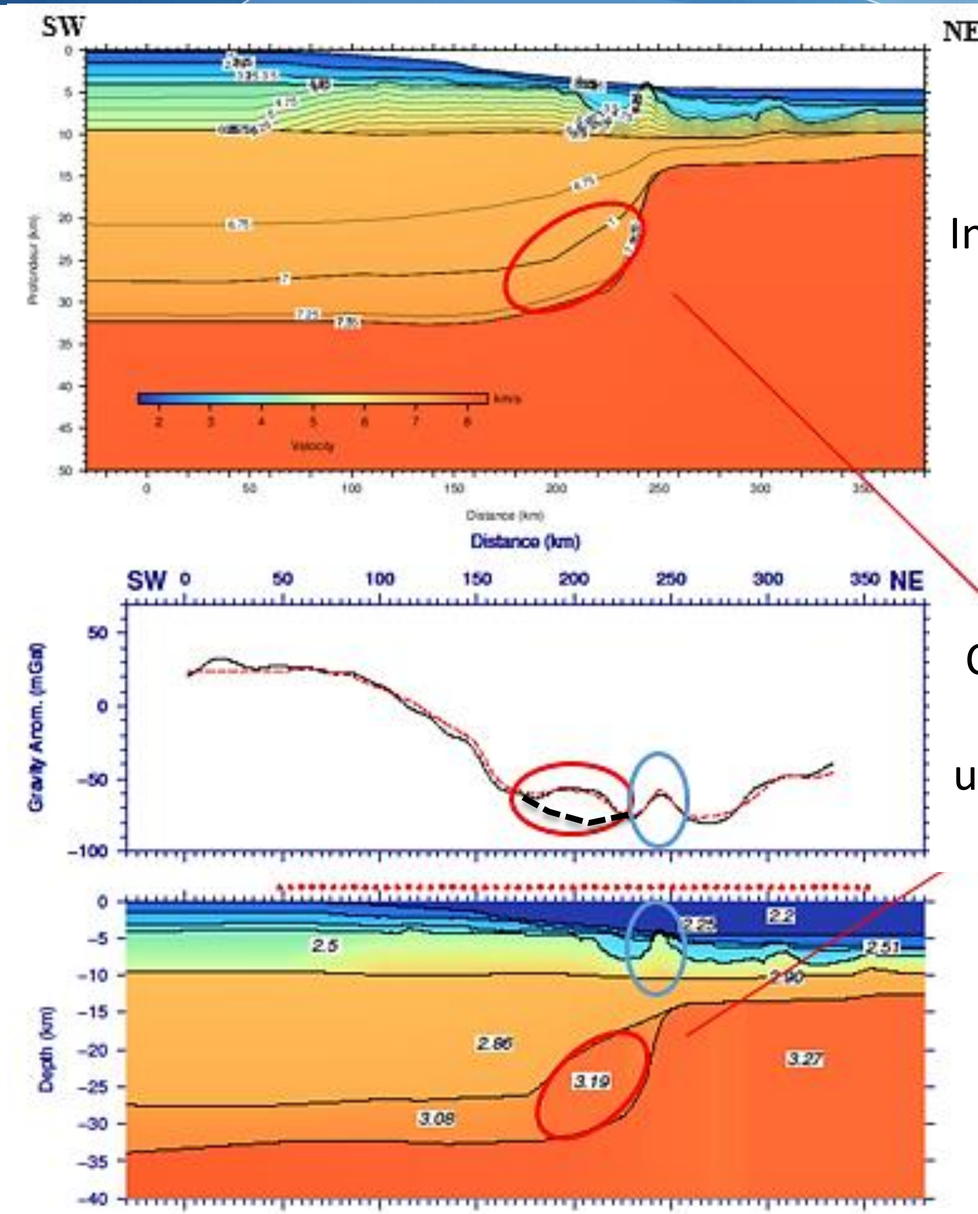
RMS error: Difference (in arrival time) between the recording and the modelled waves in our model.

<u>And other methods:</u>

- Comparaison with the synthetics
- Resolution grid
- Monte-carlo model
- Gravimetry

The objective: Try to reduce the error.

Gravity modelling



Initial model

Correction in the unconstrained area

Corrected model

Gravity anomaly from shipboard data

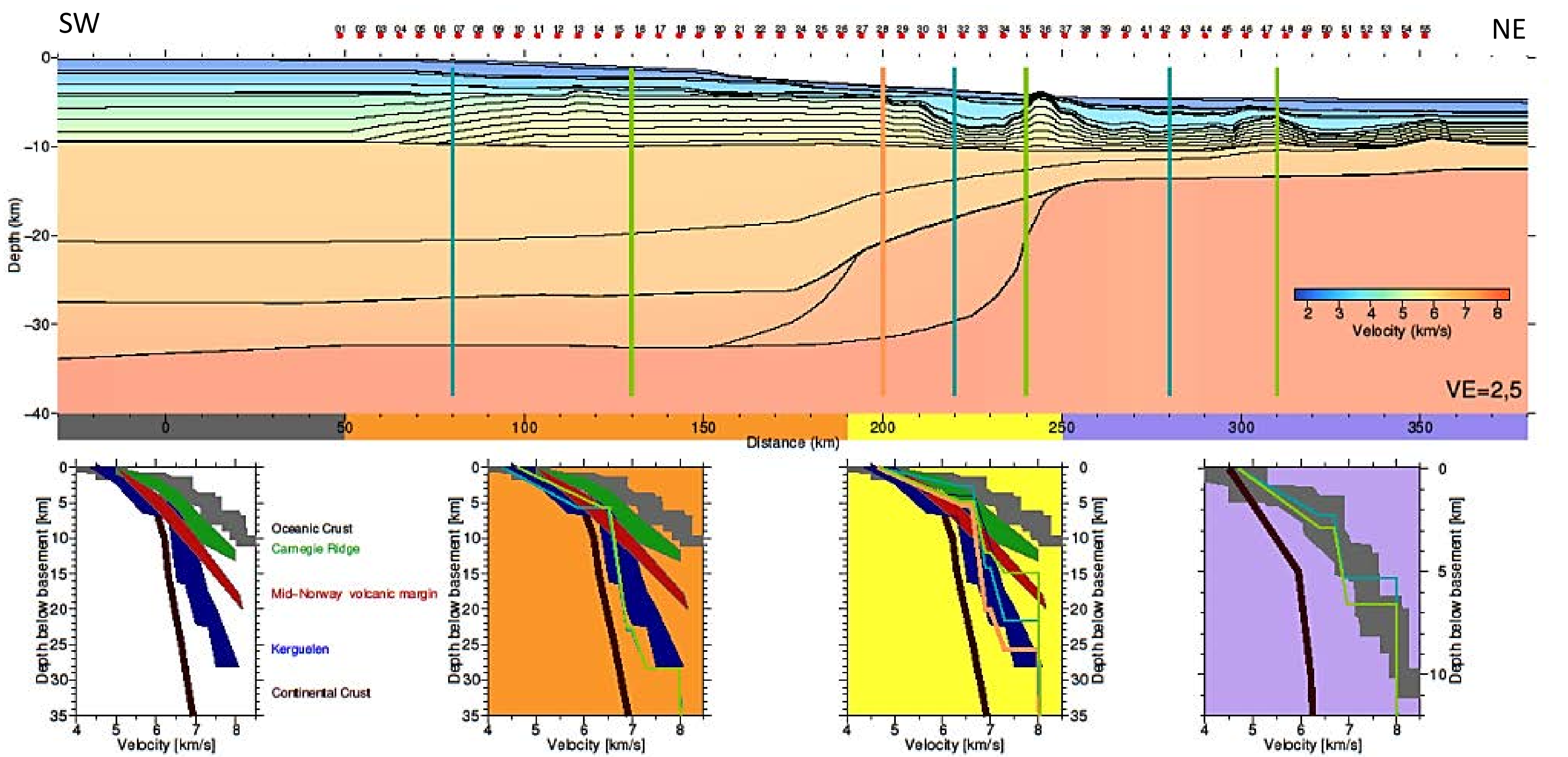
Predicted anomaly from velocity model converted to density

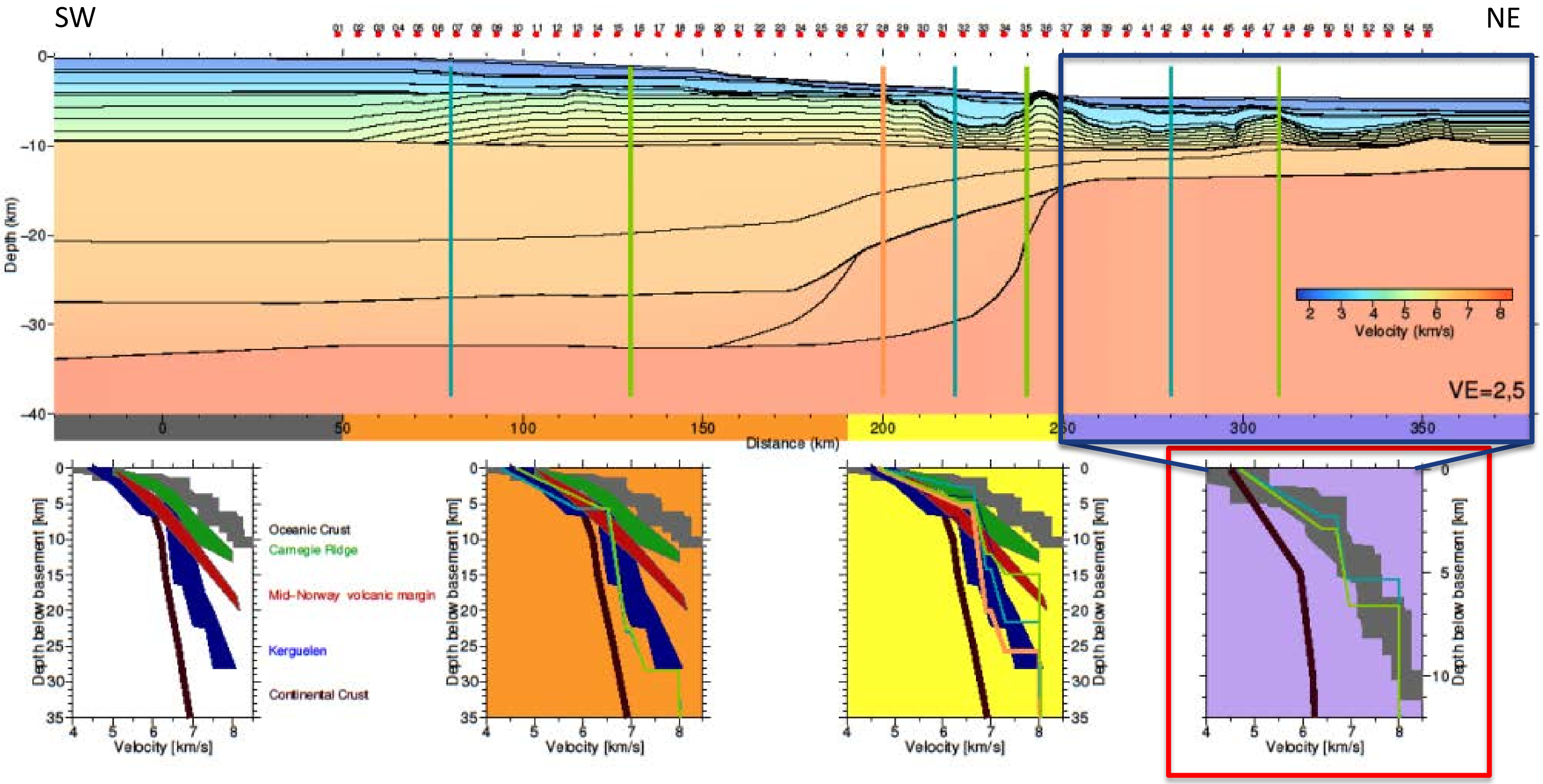
<u>The objective: Fit the two curves.</u>

The red anomaly was not explained in the initial model. Two solutions:

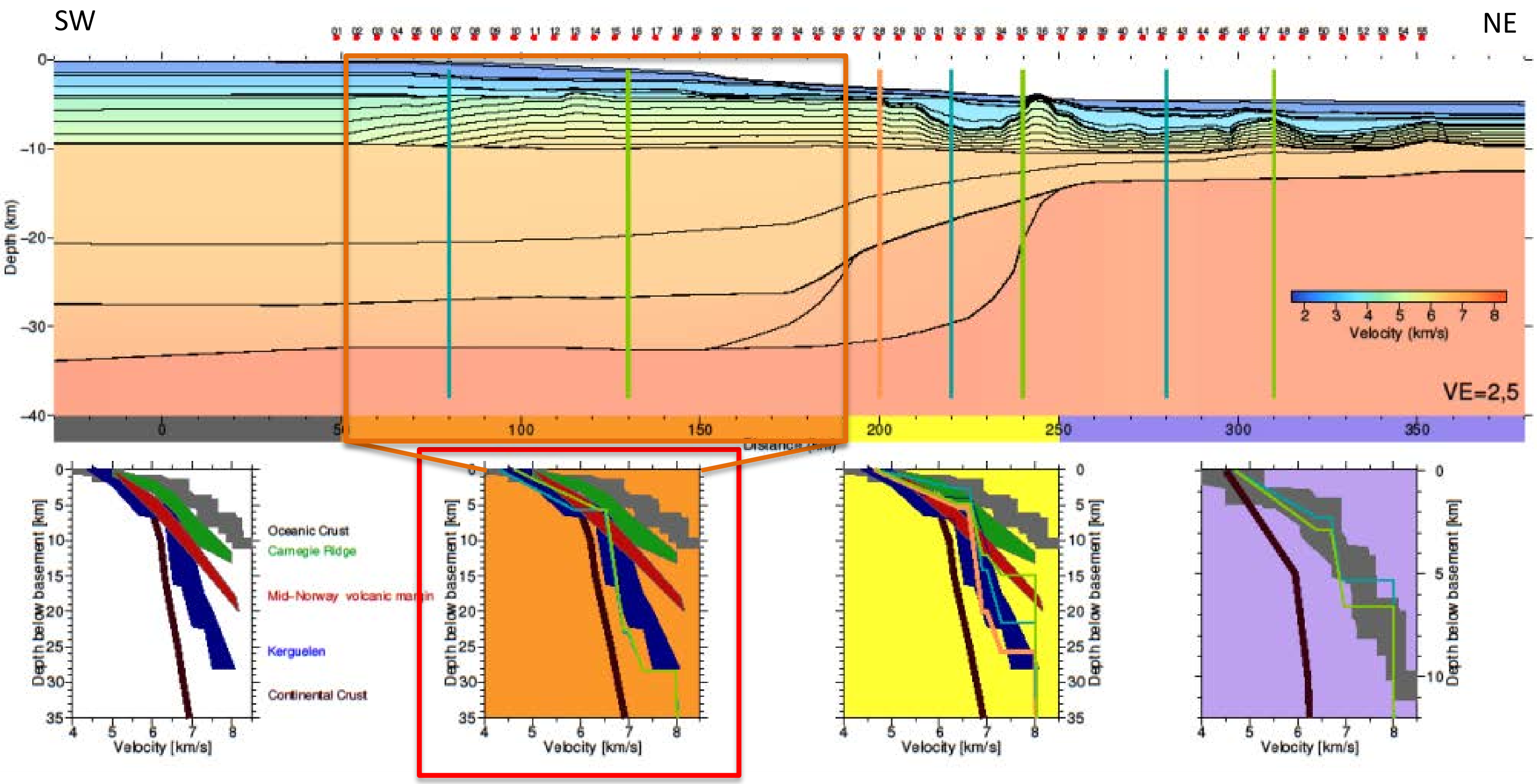
- Change the velocity in the mantle.
- Change the velocity in the unconstrained area.

Final model

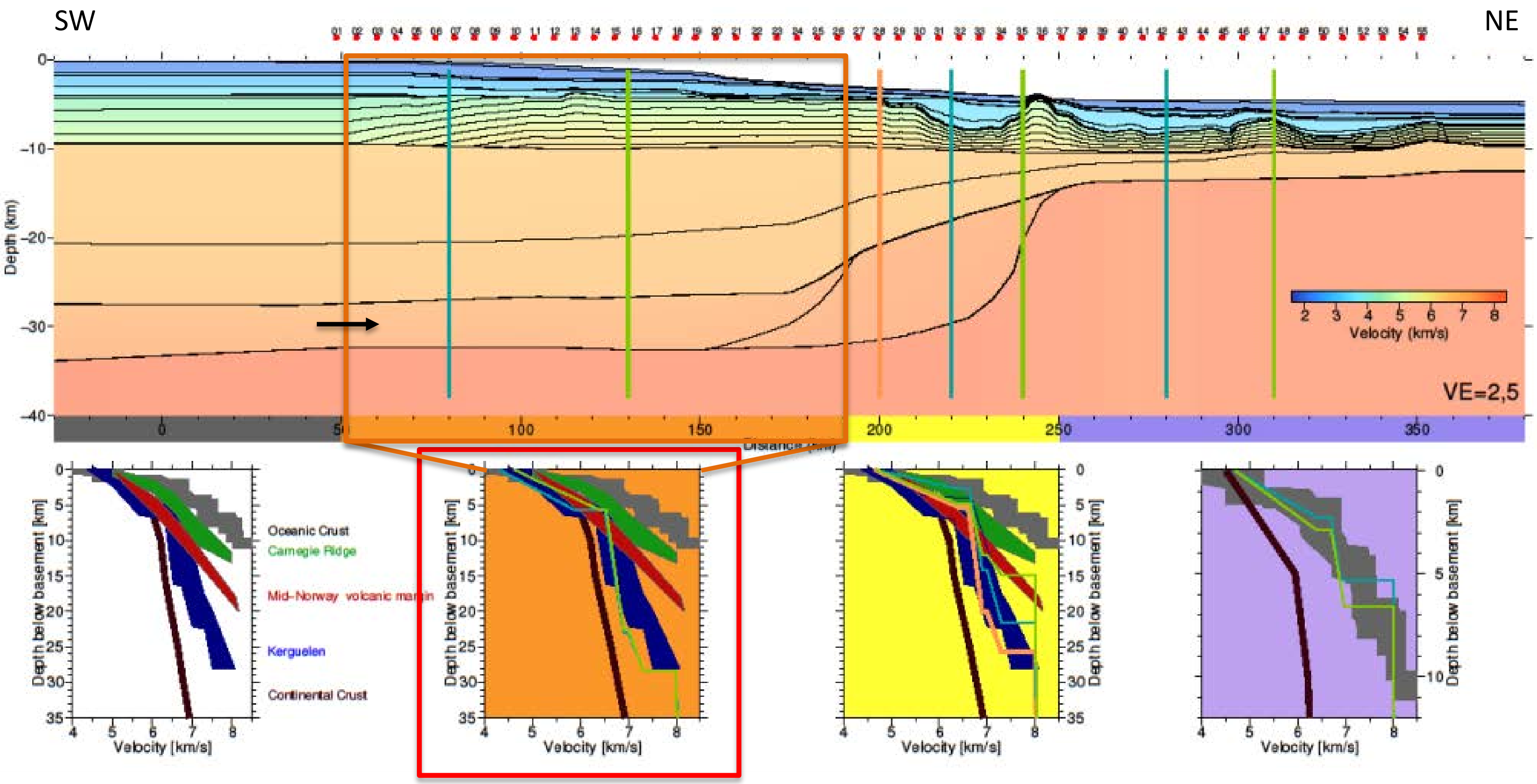

SW
NE
Depth (km)
VE=2,5
Velocity (km/s)
Distance (km)
Oceanic Crust
Carnegie Ridge
Mid-Norway volcanic margin
Kerguelen
Continental Crust
Depth below basement [km]
Velocity [km/s]



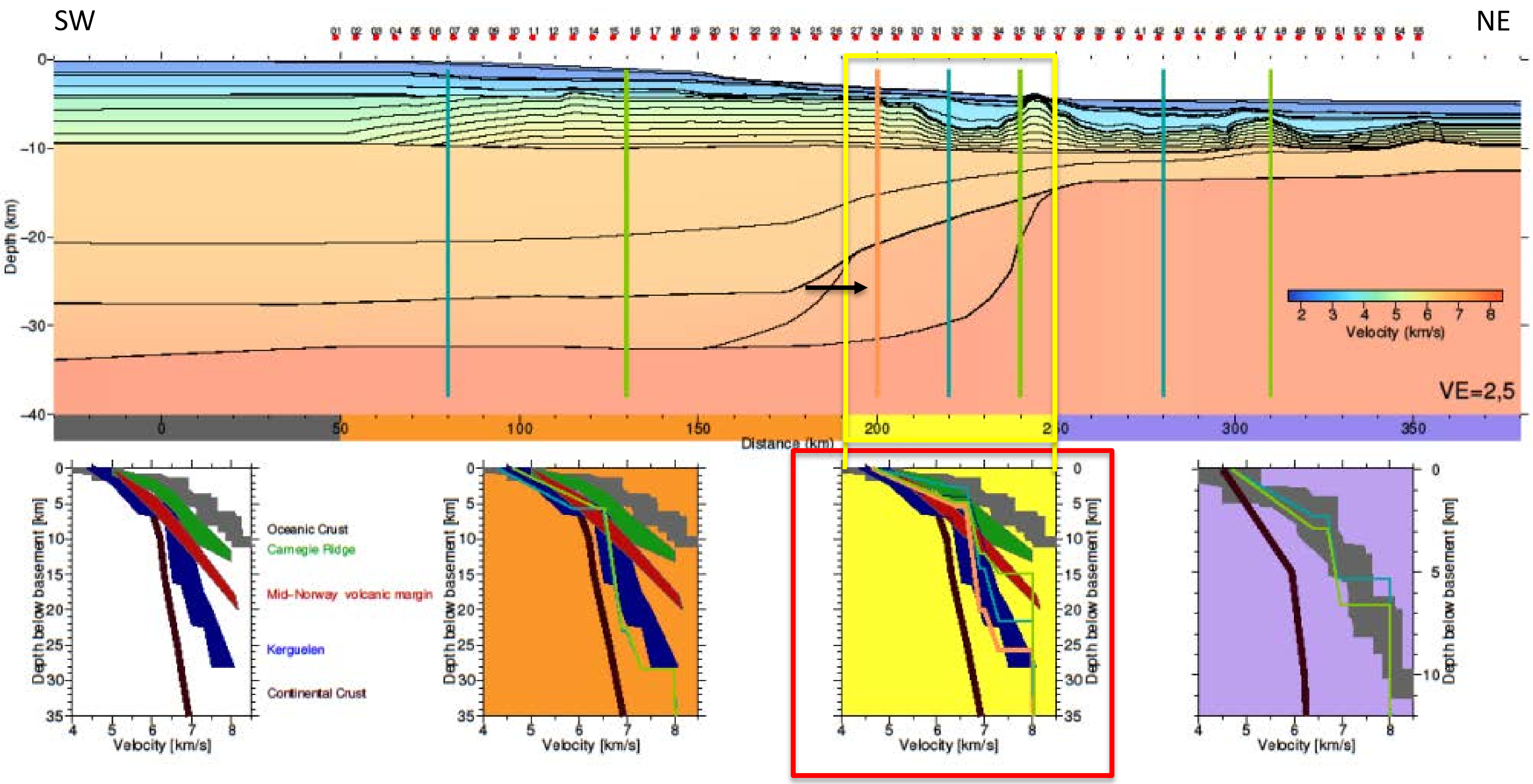
Oceanic part of the profil: Good fit between velocities from modelling and standard oceanic crustal velocities.



In the region of the Plateau : No clear correlation between modelled velocities and classic continental crust velocities (in brown). Best fit with volcanic plateau LIP-type (in blue).



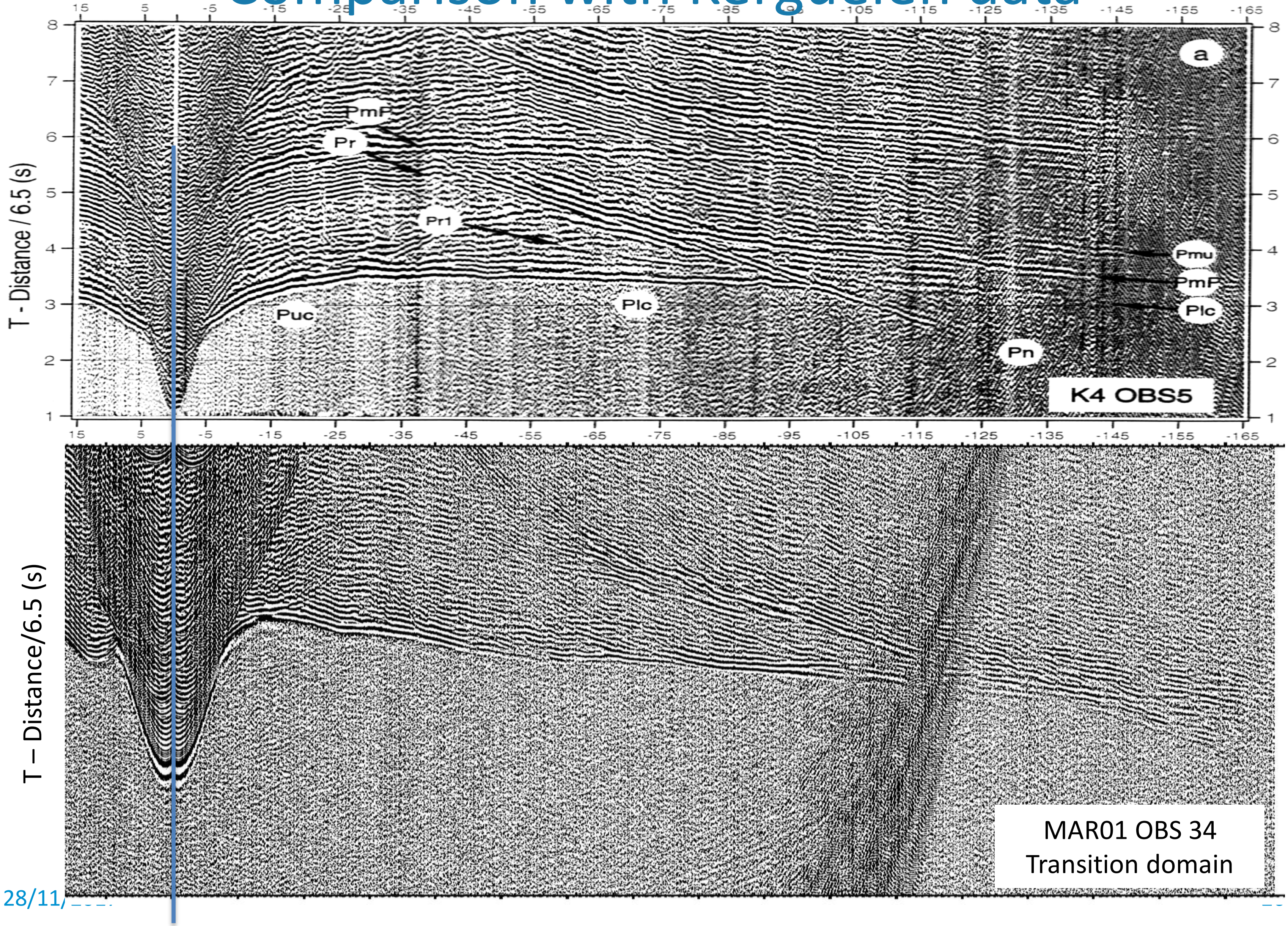
In the region of Plateau : No clear correlation between modelled velocities and classic continental crust velocities (in brown). Best fit with volcanic plateau LIP-type (in blue). Enigmatic crust just above the mantle: very high velocities (7.1-7.3 km/s). →



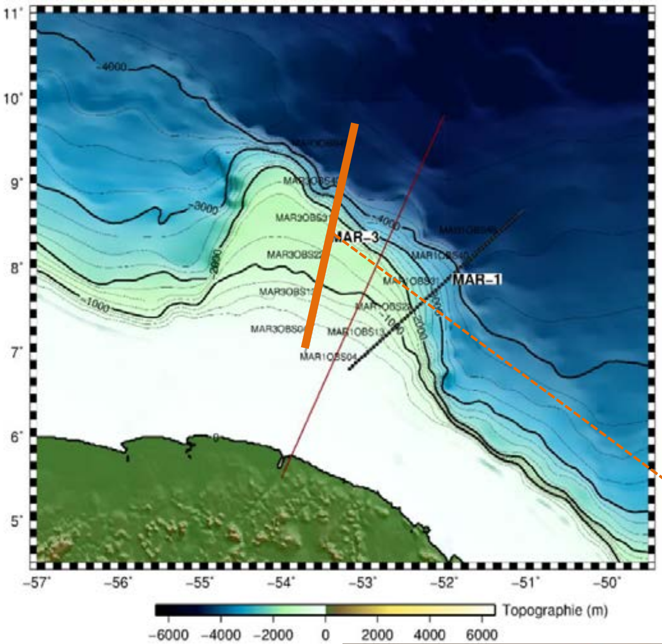
In the transition part: Globally the same as the previous slide: best fit with volcanic plateau LIP-type (in blue). The velocities are higher at depth than in the Plateau part.

There is an enigmatic crust, with velocities (7.6-7.7 km/s) near from mantle velocities. It could be an underplated body. $\boxed{\longrightarrow}$

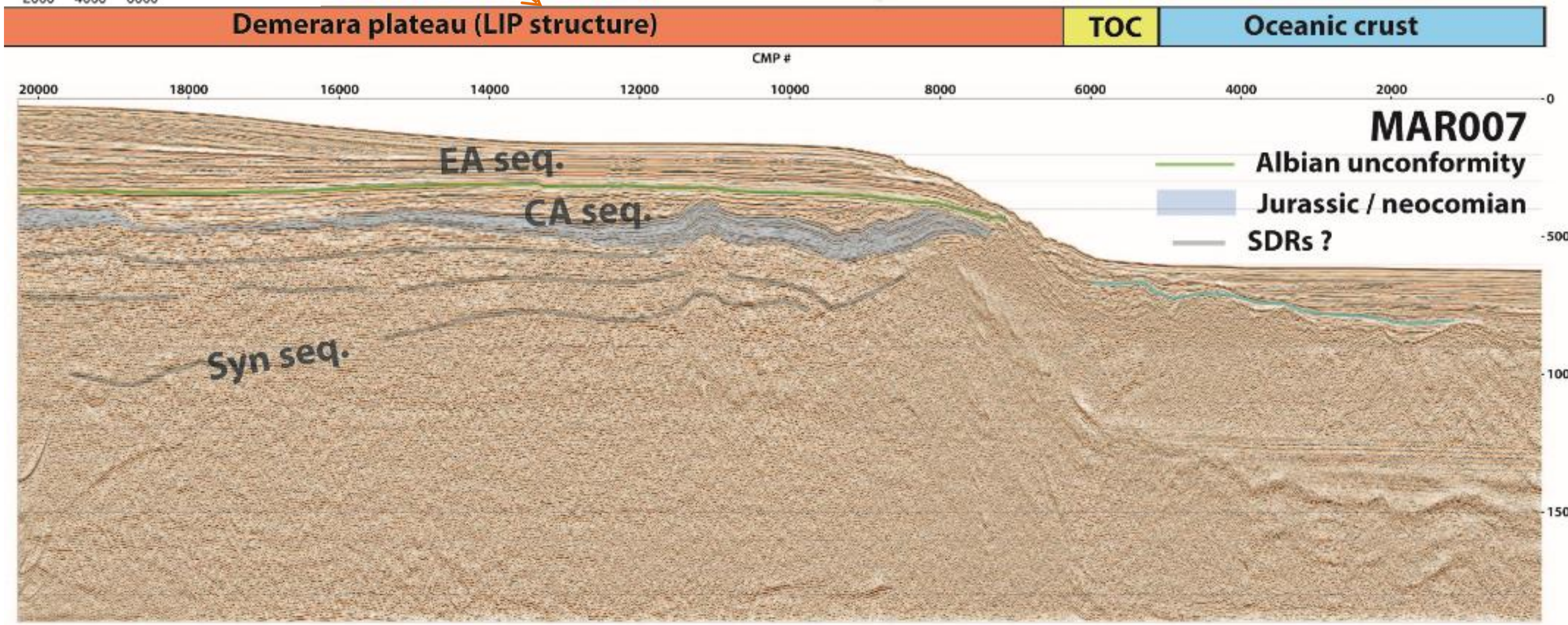
Comparison with Kerguelen data



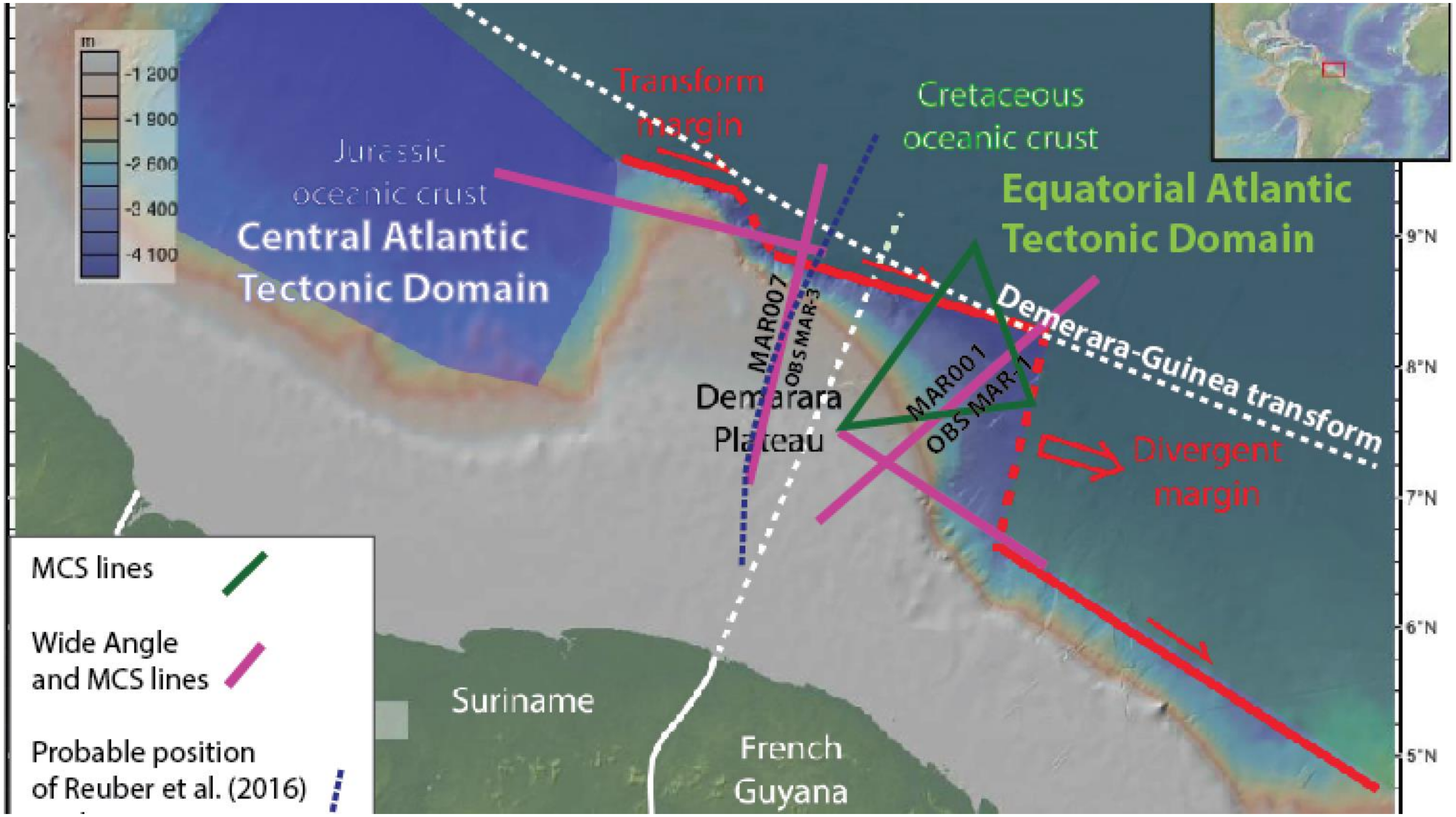
Exploitation of other data



An other MCS profil has already been further processed since the cruise to place.
Below the sedimentary sequences, we observe a geometry which could correspond to a SDR complex.



Future work



A wide-angle profil crossing the western border.

- Theorical location of the SDR maximum thickness.

A wide-angle profil crossing the eastern border.

- Learn more about a possible underplating during the Cretaceous.

Conclusions

- Based on the high velocities, the nature of the crust appears more like that of volcanic plateau (LIP-type) rather than continental crust. Moreover, the model contain a high density body in order to fit the gravity anomaly. This body is interpreted as underplating by volcanic products.
- This work suggests the presence of volcanic matter. Its formation could result from two volcanic events: during the Jurassic (creation of SDRs) and during the Cretaceous (underplating in the eastern margin).
- The dating, the chronology and the geometry are center parameters which we need to learn more about.
- The exploitation of additional data could clarify certain of these actual questions related to the Demerara Plateau.