PS The Demerara Marginal Plateau: A Case Study of a Distal Marginal Plateau Dominated by Contouritic Processes and Gravity Instability*

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Abstract

Mercier de Lépinay et al. published in 2016 an updated inventory of transform passive margins in the world. This inventory shows that those margins represent 30% of continental passive margins and a cumulative length of 16% of non-convergent margins. It also highlights the fact that many submarine plateaus prolong transform continental margins, systematically at the junction of oceanic domains of different ages. In the world, we identified twenty of those continental submarine plateaus (Falklands, Voring, Demerara, Tasman, etc.). The understanding of the sedimentary evolution of those marginal plateaus has many scientific and economic issues.

The Demerara marginal plateau located off French Guiana and Surinam belongs to this category of submarine provinces. It is potentially fed by sediments from the Amazon, Orinoco, Maroni, and Oyapock rivers. The GUYAPLAC (2003), IGUANES (2013), MARGATS (2016), and DRADEM (2016) cruises allowed mapping the distal Demerara plateau with multibeam bathymetric data and acquiring high and very high resolution seismic data including chirp data. 20 piston cores were also collected during the IGUANES cruise that allowed to ground-truth and characterize deep sediments.

This dataset has been analyzed at different scales. The seismic analysis of the dataset shows that the distal plateau evolves through three evolutionary stages: (1) a “pre-contourite phase” from late Albian to early Miocene with depocenters highly influenced by the structure of the Northern transform-derived border of the plateau. Major unconformities record the Cretaceous/Tertiary re-suspension event, and the Paleocene/Eocene Thermal Maximum (PETM); (2) a transition period from middle Miocene to early Pliocene during which a major unconformity possibly records major changes in oceanic circulation and during which major gravitational events affected sediments down to Paleocene strata; and (3), a “contourite phase” during which strong bottom-currents shape the distal Demerara plateau. In particular, the

NADW (North Atlantic Deep Water) follows an older slope failure headscarp that is regularly and locally eroded during the Plio-Pleistocene. A contourite Depositional System made of a longitudinal moat and a drift has been mapped. Some pockmarks develop within this drift that is expressed at the scale of recent sedimentation on Chirp data. The analysis of current meter data recorded in the study area in a 8 month time period shows that the NADW is flowing parallel to the bathymetric contours at speeds reaching 32 cm/s. Core data allowed confirming the importance of contourite and mass-wasting processes in the recent (last 120-250 kyr) sedimentary evolution of this domain. Sedimentary sequences are clearly impacted by the variations of the NADW intensity and associated winnowing effect during glacial/interglacial cycles. In addition, in this area, periods of intense winnowing are marked by glauconitic neoformation. We suggest that the presence and degree of maturity of glaucony might be used as an effective proxy to study current variations depending on climatic oscillation. The next step of our program will be to better assess the sediment source – probably exclusively transported from the North by the NADW as illustrated by preliminary results.

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The Demerara marginal plateau: a case study of a distal marginal plateau dominated by contouritic processes and gravity instability

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1. Defining marginal plateaus and presentation of the Demerara plateau

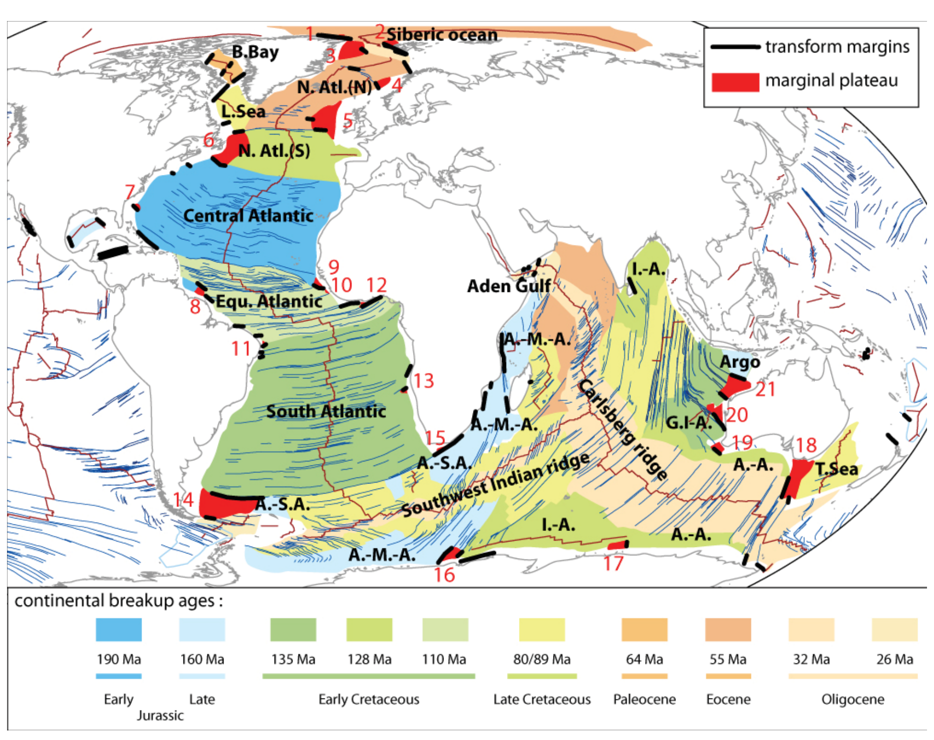


Figure 1: Worldwide distribution of Marginal plateaus. Transform margins (thick black lines), marginal plateaus (colored in red, , and break-up ages. The identified marginal plateaus are: 1: Morris Jesup Rise; 2: Yermarck plateau; 3: North East Greenland margin; 4: Vøring plateau ; 5: Rockall Plateau; 6: Newfoundland plateau; 7: Black Spur; 8: Demerara plateau ; 9: Guinea plateau ; 10: Sierra Leone; 11: Sergipe; 12: Côte d'Ivoire-Ghana; 13: Walvis; 14: Falklands plateau; 15: Gunnerus Ridge; 16: Bruce Rise; 17: Tasman plateau ; 18: Naturaliste plateau; 19: Perth margin ; 20: Exmouth plateau. 21: Argo=Argo abyssal plain; T.Sea=Tasman Sea. Indian-Madagascar-Antartic separation domains are from Marks and Tikku (2001) and Indian-Australia-Antarctic separation ages are from Gibbons et al. (2013). Central Atlantic break-up age comes from Labails et al. (2010) and Davison (2010).

Mercier de Lépinay et al. published in 2016 an updated inventory of transform passive margins in the world (Figure 1). This inventory shows that those margins represent 30% of continental passive margins and a cumulative length of 16% of non-convergent margins. It also highlights the fact that many submarine plateaus prolong transform continental margins, systematically at the junction of oceanic domains of different ages (Figure 1). In the world, we identified twenty of those continental submarine plateaus (Falklands, Voring, Demerara, Tasman, etc).

The understanding of the sedimentary evolution of those marginal plateaus has many scientific and economic issues.

The Demerara marginal plateau located off French Guiana and Surinam belongs to this category of submarine provinces. It is potentially fed by sediments from the Amazon, Orinoco, Maroni and Oyapock rivers.

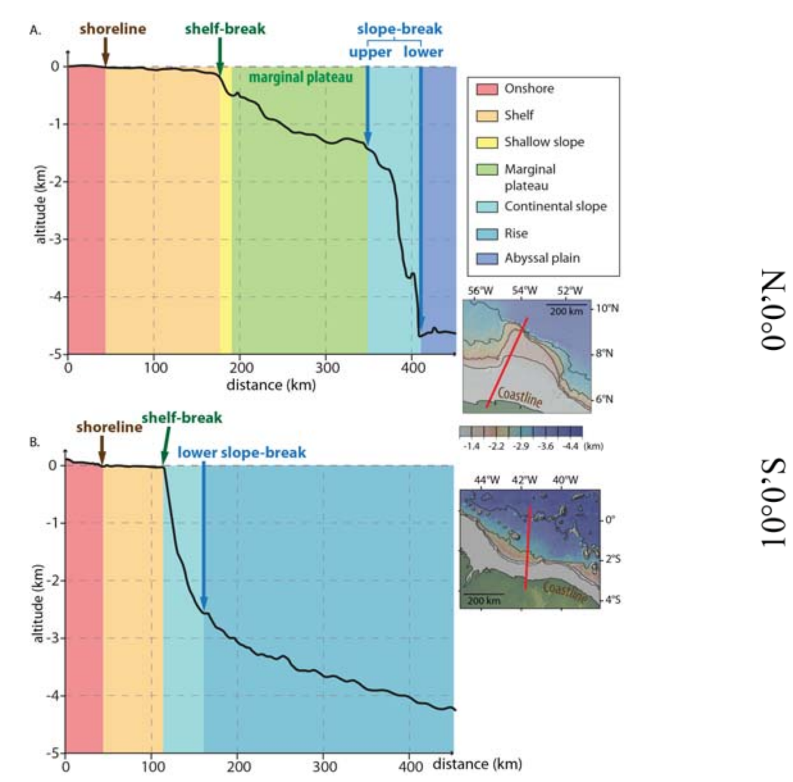


Figure 2: Bathymetric profiles of transform margins A) Demerara plateau, offshore Suriname, B) Ceara transform margin, offshore Brazil. In the case of the Demerara marginal plateau, two slope domains (the shallow slope and the continental slope) separate the marginal plateau from the shelf and abyssal plain, respectively

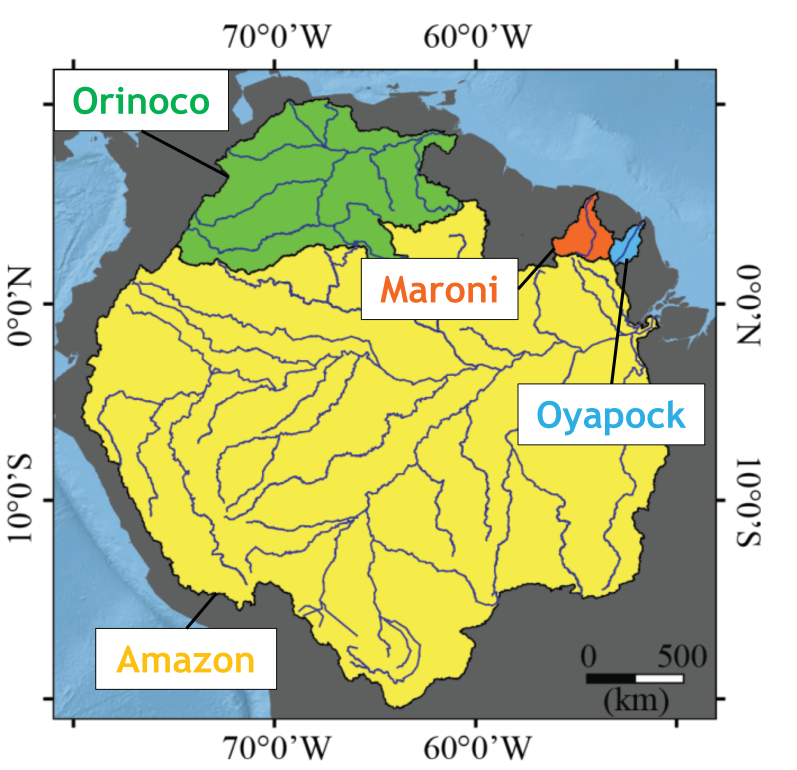


Figure 3: Location of the Demerara marginal Plateau, off French Guiana and Surinam, showing the main rivers surrounding the study area (i.e. Amazon, Orinoco, Maroni and Oyapock Rivers) and their watershed.

2. Available Dataset and hydrodynamic conditions

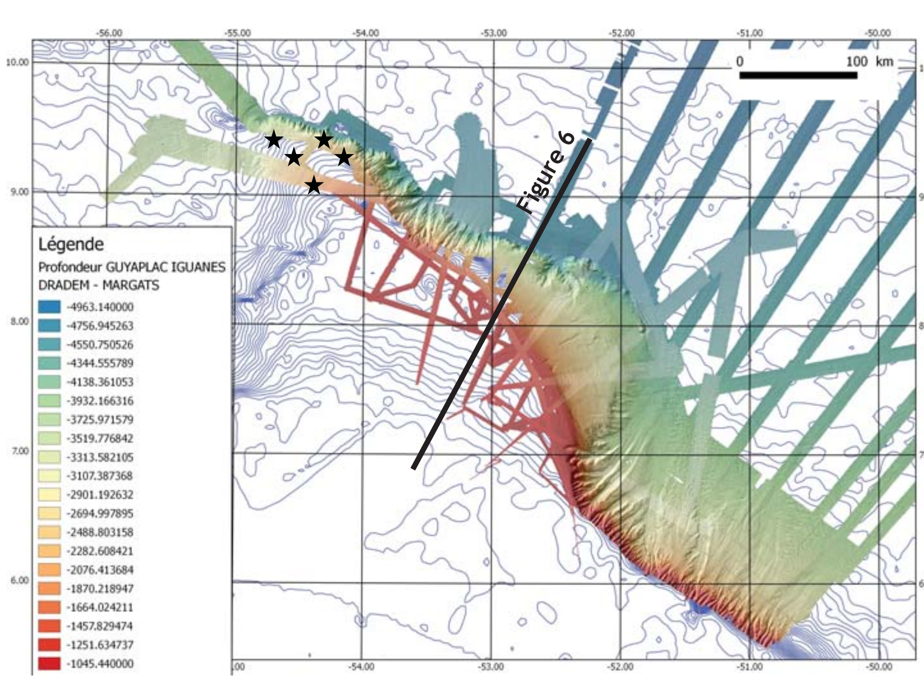


Figure 4: Bathymetric compilation of GUYAPLAC data (2003, Ifremer), IGUANES (2003 - Chief Scientist: L. Loncke), DRADEM (2016 - Chief Scientist: C. Basile), MARGATS (2016, Chief Scientist: D. Graindorge). The black stars refer to the location of ODP 207 drill sites (Mosher et al., 2007)

The GUYAPLAC (2003), IGUANES (2013), MARGATS (2016) and DRADEM (2016) cruises allowed mapping the distal Demerara plateau with multibeam bathymetric data and acquiring high and very high resolution seismic data including chirp data. 20 piston cores were also collected during the IGUANES cruise that allowed to ground-truth and characterize deep sediments.
This dataset has been analyzed at different scales.

The plateau is crossed by different water masses: The AAIW flowing to the North and **NADW flowing to the south** (Figures 5 and 6).

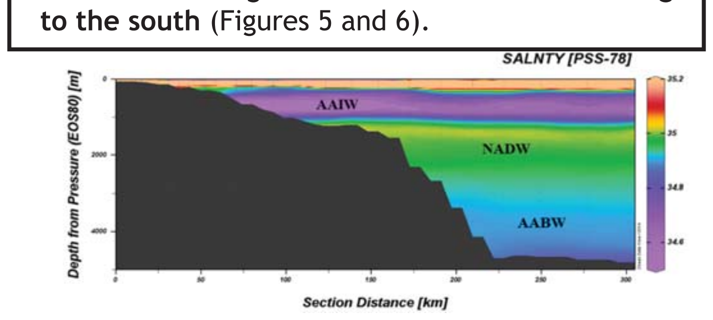


Figure 5: Hydrographic section (WoceAtlas, section A20) illustrating the distribution of water masses on the Demerera plateau. Sction located on figure 4.

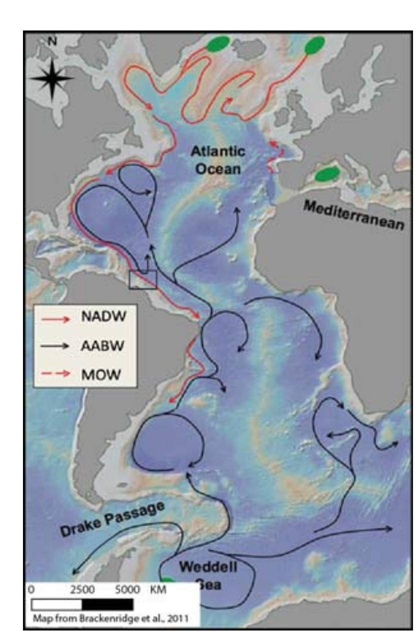


Figure 6: Map of the Atlantic illustrating the general circulation of the main deep-water masses (based on Brackenbridge et al., 2011). NADW: North Atlantic Deep Water; AABW: Antarctic Bottom Water.

3. Results

The bathymetric data (Figure 7) allows to identify different outstanding features: (1) a more than 250 km long linear slope failure headscarp that follows the edge of the plateau, (2) hundred of elongated depressions (Figures 7 and 9), (3) hundreds of linear sedimentary ridges that develop parallel to the NADW.
At the scale of Chirp and high resolution seismic data, sediment distributions are longitudinal evidencing the presence of a Contourite Depositional System (Figure 8). Some pockmarks develop within this drift that is expressed at the scale of recent sedimentation on Chirp data (Figure 8). The analysis of current meter data recorded in the study area in a 8 month time period shows that the NADW is flowing parallel to the bathymetric contours at **speeds reaching 32 cm/s.** Core data allowed confirming the importance of contourite and mass-wasting processes in the recent (last 120-250 kyr) sedimentary evolution of this domain. Sedimentary sequences are clearly impacted by the variations of the NADW intensity and associated winnowing effect during glacial/interglacial cycles. In addition, in this area, periods of intense winnowing are marked by glauconitic neoformation. We suggest that the presence and degree of maturity of glaucony might be used as an effective proxy to study current variations depending on climatic oscillation (Figure 10).
A huge destabilized complex also characterize the outer Demerara plateau (Figure 11) and fluid ascents are suspected (Figure 12). Pattier et al., 2013 ane 2015 suggest that fluid overpressure may have occured in depth.
In any case, the interplays between contourites, mass-wasting and fluid processes are complex and need additional data to be clearly understood.

Elements of A contourite Depositional System

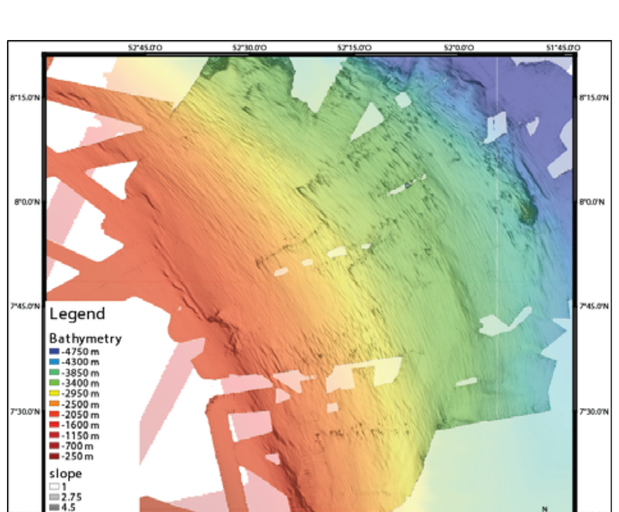


Figure 7: IGUANES bathymetric DTM showing the distal Demerara plateau and hundreds of elongated depressions on the seafloor (Loncke et al., 2016)

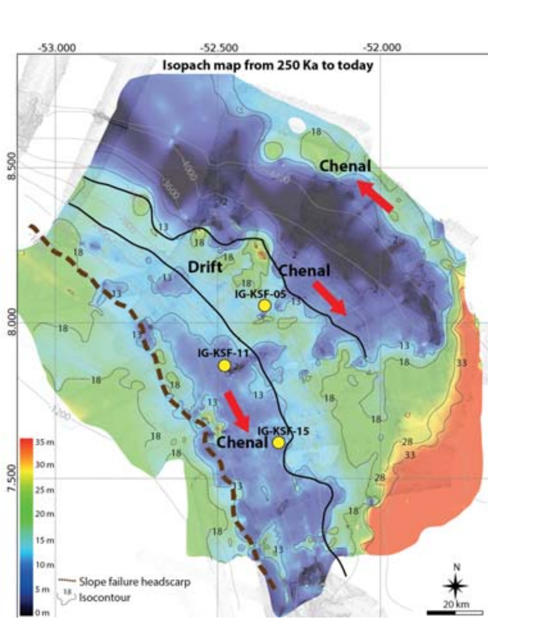
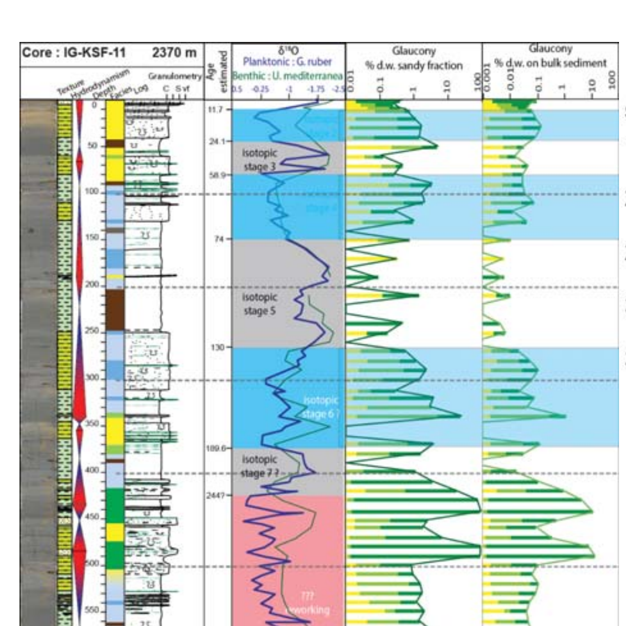


Figure 8: Isopach map of recent series showing longitudinal sediment distributions typical of contourite Depositional Systems (Tallobre et al., 2016)



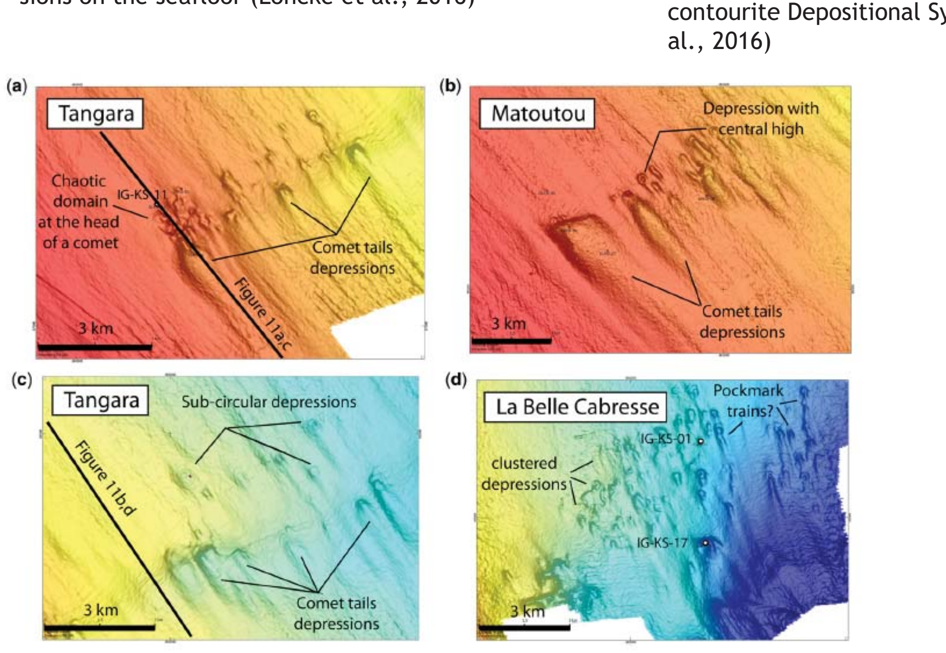


Figure 9: bathymetric details (a, b, c, d, e, f) showing the comet-tails that develop on the seafloor as a result of interactions between the North Atlantic Deep Water current and sedimentary highs (MTD blocks? authigenic carbonates?) (Loncke et al., 2016, Tallobre et al., 2016).

	Facies	Winnowing	Accumulation rates
F1	Carbonate facies		
F2	Glauconite facies		
F3	Foraminifera sandy facies		
F4	Foraminifera bearing Muddy facies		
F5	Muddy facies		

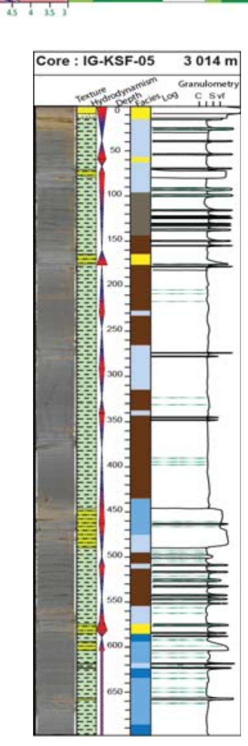


Figure 10: Cores KSF11 and KSF05 collected respectively in the moat and the drift of the Contourite Depositional system related to the NADW.
Typical succesions of positive and negative graded sequences attest of winnowing variations. Glaucony only occur during high winowing periods.

Interplay with slope instability and Fluid ascents

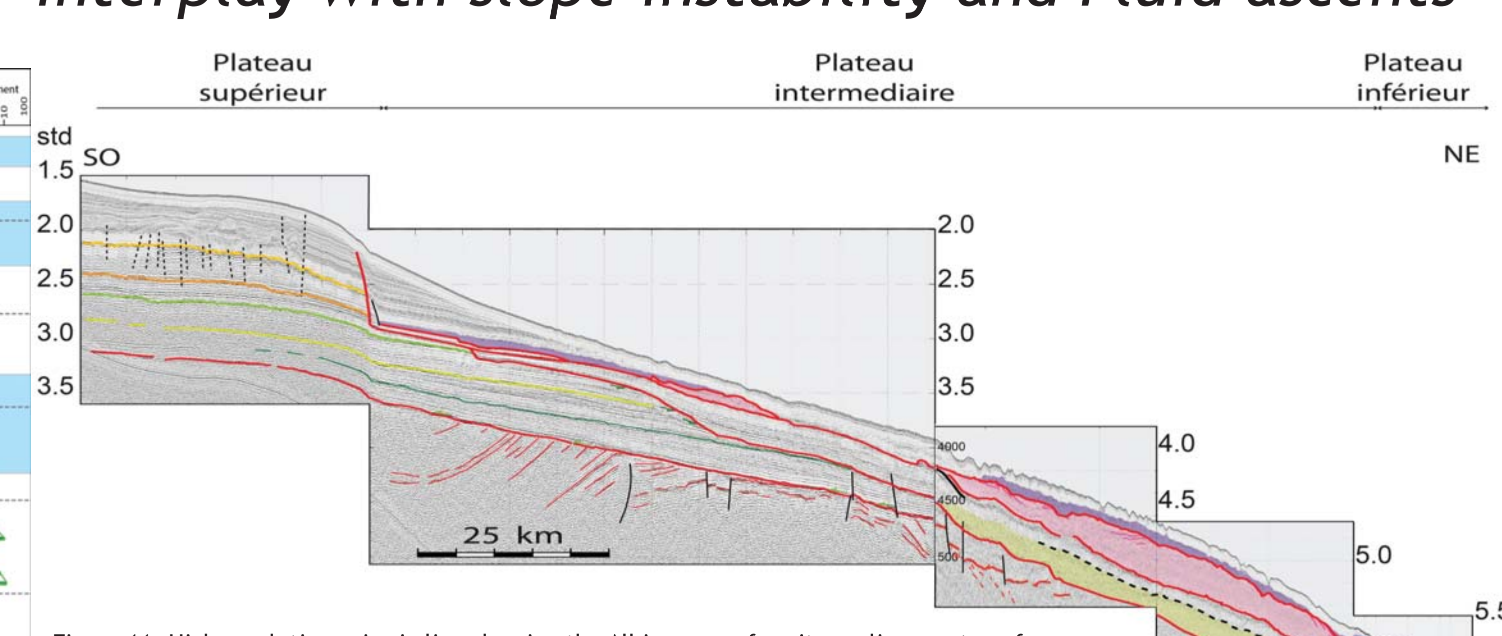


Figure 11: High resolution seismic line showing the Albian unconformity sealing syn-transform deformations (in red), post-Albian series higlhy deformed by wide slides ans associated mass-wasting deposits (Loncke et al., 2016).

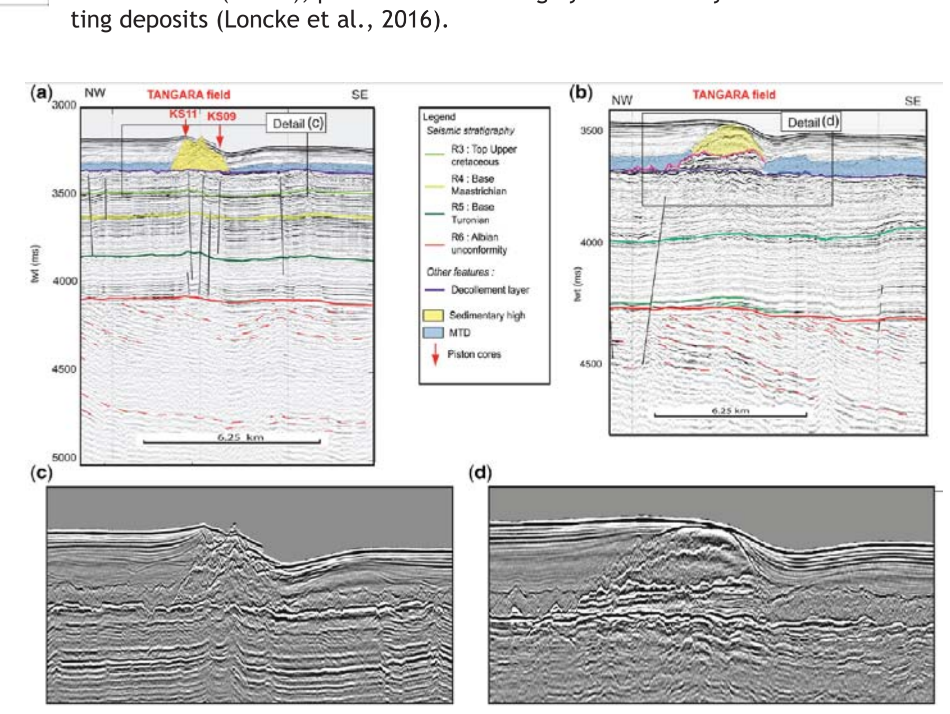


Figure 12: High-resolution 72-trace seismic lines focused on comet-tail alignments: (a) Profile showing that the comet-tail visible on the seafloor locates downslope an outcropping sedimentary high of unknown origin (stacked MTD? authigenic carbonates? Coral mound?...), (b) Profile showing that comet tail alignments occur on top of a sedimentary high made of stacked transparent MTDs.

Several questions remain:
- Are there some fossil evidence of active or recent fluid releases on the seafloor?
- How do sediment ridges develop parallel to the NADW direction?
- How do the comet tails develop? Above MDACS? Deep water corals? MTDS?
> Need of in-situ observations and measurements

And in the future? Nautile and AUV dives in 2019?