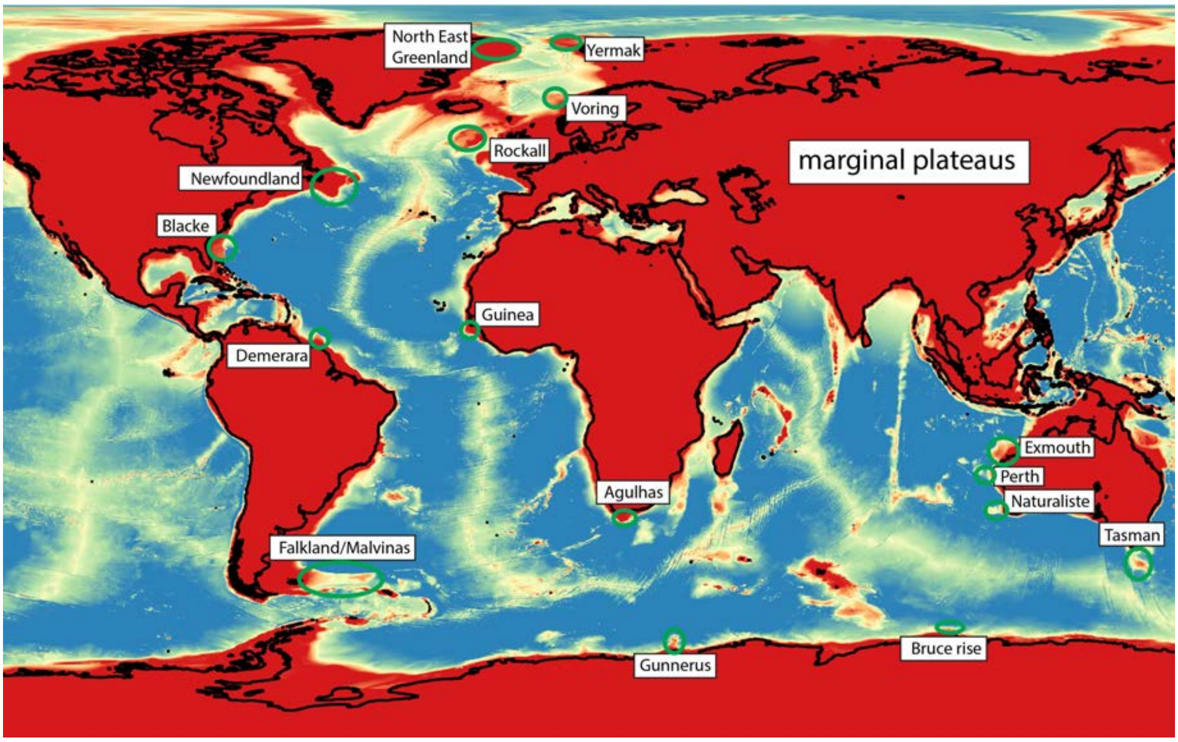
WORKSHOP
Grenoble (France) November 28-29th, 2017

Marginal plateaus:

from magmatic divergent margins to transform margins, and from the continental shelf to the pelagic and contouritic setting

Program and abstracts



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ISTerre, Amphi Kilian, 1381 rue de la piscine, St Martin d'Hères

Schedule, Tuesday November 28th

9h Welcome

9h25 **Christophe Basile** Introduction and practical informations

9h30 **Lies Loncke** University of Perpignan
Marginal plateaus: definition and scientific challenges

10h15 **Asbjørn Breivik** University of Oslo
Why is the Vøring Plateau a plateau?

11h00 coffee break

11h20 **Gavin Elliott** Lukoil
An overview of the Hatton-Rockall plateau

12h05 **Dave McCarthy** British Geological Survey
The Falkland plateau

12h50 lunch

14h00 **Walter Roest** Ifremer
An overview of the scientific exploration of the Demerara plateau

14h45 **Thomas Museur** University of Brest
Deep structure of the Demerara marginal plateau from MARGATS cruise academic wide-angle and multi-channel seismics, insights on the origin of the plateau

15h30 coffee break

15h50 **Christophe Basile** University Grenoble-Alpes
Where was the CAMP hotspot, and how it controlled the opening of the Central and Equatorial Atlantic oceans around the Demerara plateau

16h35 **Nicolas Coltice** University of Lyon
Thermal fluctuations beneath continents

17h20 Discussion

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Schedule, Wednesday November 29th

8h45 **François Chauvet** Sedisor
Recent concepts on volcanic passive margins

9h30 **Scott Bryan** Queensland University of Technology
Large ignous provinces, continental break-up and marginal plateaus

10h15 coffee break

10h35 **Christophe Basile** University Grenoble-Alpes
Transform margins along marginal plateaus

11h20 **Thierry Dumont** CNRS
The Briançonnais fossil marginal plateau, Western Alps: identification of the early stages of inversion and implications for its restoration

12h05 lunch

13h15 **Javier Hernandez-Molina** Royal Holloway University
Contourite terraces vs marginal platforms: conceptual implications

14h00 **Anne Sophie Fanget** University of Perpignan
The Demerara Plateau: a case study of the initiation and evolution of a contourite depositional system on a marginal plateau

14h45 Final discussion

16h00 End of meeting

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Poster session

Frédérique Eynaud et al. University of Bordeaux

The Bay of Biscay and the Capbreton canyon as key sedimentary contexts to decipher Holocene sea-surface hydrography of the boreal Atlantic

Estefania Llave et al. Instituto Geológico y Minero de España

From marginal platforms to contourite terraces: a study case from NW Iberia

Walter Roest et al. Ifremer

Multidisciplinary scientific program of investigation of the structure and evolution of the Demerara marginal plateau

David Graindorge et al. University of Brest

The enigmatic deep structure and margins of the Demerara Plateau: the MARGATS cruise seismic data together with dredges,kinematic reconstructions and magnetic data reveal a complex and polyphased magmatic history

Igor Girault et al. University Grenoble-Alpes

The outcropping basement of the Demerara marginal plateau (French Guiana-Surinam): results from DRADEM dredges

Lies Loncke et al. University of Perpignan

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

Cédric Tallobre et al. Université du Littoral – Côte d'Opale

Formation and evolution of a glauconite-rich contourite depositional system on the marginal Demerara plateau (French Guiana, Surinam)

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Oral presentation

with David GRAINDORGE, Walter ROEST, Frauke KLINGELHOEFER, Lies LONCKE, Igor GIRAULT, Jean Louis PAQUETTE, Arnaud AGRANIER, Arnauld HEURET

Where was the CAMP hotspot, and how it controlled the opening of the Central and Equatorial Atlantic oceans around the Demerara Plateau

Emplaced 200 Ma ago, the Central Atlantic Magmatic Province (CAMP) appears to be genetically linked to the opening of the Central Atlantic Ocean. Magmatism related the CAMP is widespread from Bolivia to France, especially in the Guyana craton, West Africa and along the East Coast of the United States. Seaward Dipping Reflectors (SDR) along the Central Atlantic margins can also be related to the CAMP. This magmatism is currently proposed to be related to a mantle plume. However, continental traps are missing, and the trace of the expected hot spot related to the CAMP is still not clearly identified.

From industrial seismic lines, it has been recently proposed that the Demerara and Guinea plateaus are not remnants of thinned continental crust, but consists mainly in thick magmatic stacked SDRs. Data from the dredging cruise DRADEM and from the seismic cruise MARGATS confirm the magmatic nature of the basement of the Demarara plateau. Geochemical analysis of the few recovered samples unambigously point out an Ocean Island Basalt (OIB) signature, and U/Pb dating of magmatic zircons indicates crystallization at 173.4±1.6 Ma.

Based on these new petrological and geophysical data, we propose a kinematic model where a single hot spot can both be the source of the CAMP and take into account the dated magmatic occurrences in the area of Demerara plateau and conjugated Guinea plateau since 200 Ma. In this model, the opening of the southern part of the Central Altantic followed the hot spot track during the Lower Jurassic. During the Toarcian, the Gondwana plate is stable above the hot spot located below the Demerara plateau, leading to a very thick magmatic crust. Subsequent displacements of the Gondwana plate moved the hot spot away from Demerara from Middle Jurassic to Lower Cretaceous, but the hot spot was in the close vicinity around 120 Ma at the time of the opening of the Equatorial Atlantic. The same hot spot that controlled the Jurassic western margin of Demerara is thought to have controlled again the formation of the northern and eastern Cretaceous margins of Demerara. At the end of Lower Cretaceous, the hot spot track passed below the mid-oceanic ridge and formed the Sierra Leone Rise, before leaving several magmatic structures offshore Guinea. The Cenozoic track of the hot spot started south of the Guinea plateau, and is thought to end at the present day at the southern edge of the Sierra Leone Rise.

This kinematic reconstruction has huge implications on the nature of the basement, the mechanisms of rifting and the evolution of both heat flow and vertical displacement (uplift and subsidence) during the Jurassic and Cretaceous history of the Demerara area.

Christophe BASILE Oral presentation
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with Lies LONCKE, Marion MERCIER DE LEPINAY, Walter ROEST

Transform margins along marginal plateaus

Transform continental margins are not restricted to marginal plateaus, but marginal plateaus correspond to very peculiar settings that can greatly improve our understanding of how transform margins appear and evolve.

Marginal plateaus are always bounded on one side by a transform margin, and inherited from a two stages rifting history. The transform margin appears during the second stage, pointing out the question of how the structures inherited from the first rifting phase influence the location and formation of the transform margin. This question will be theoretically discussed in the frame of partitioning in divergent plate setting.

Recent data from the Demerara Plateau suggest that the northern transform margin may be the first ever identified magmatic transform margin, i.e. a transform margin that appeared above a hot spot. It suggests that the thermal structure of the lithosphere may be the main cause of the localization of the transform fault, instead of inherited tectonic structures such as suture zones.

Vertical motions along transform margins are the second topic that can benefit from marginal plateaus studies. Both subsidence and uplift were described on transform margins, and both were related to coupling or uncoupling of continental and oceanic lithospheres across the transform fault. Because of the their peculiar elevation by far deeper than sea level, marginal plateaus provide a setting where remnants of these vertical displacements (sedimentation and erosional surfaces) can be preserved. Recent data from the Demerara Plateau allow to demonstrate that the vertical motions evolved with time, with a first stage of flexural uplift and erosion when the margin was an active transform margin, followed by a second stage of flexural subsidence when the margin became passive. Relating these two stages with the kinematic evolution along a given transform margin allow to understand why and how vertical displacements vary laterally.

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Oral presentation

with Jan Inge FALEIDE, Rolf MJELDE, Ernst R. FLUEH, Yoshio MURAI

Why is the Vøring Plateau a plateau? Origin of the Vøring Plateau, offshore Norway – Interplay between timing of rifting and emplacement of plume material

The Vøring Plateau was part of the Northeast Atlantic igneous province (NAIP) during early Cenozoic crustal breakup, located at the outer edge of the Iceland Plume influence (Fig. 1). Crustal breakup at the Vøring Plateau occurred marginal to the deep Cretaceous basins on the shelf, and with less extension of the crust than in the older event. Intrusive magmatism and oceanic crust up to three times normal thickness caused a period of sub-aerial magmatism around breakup time. The transition from the plateau to the Lofoten Margin deep-water plain is rapid (Fig. 1). Still, there is some excess magmatism north of this transition, where early oceanic crustal thickness is reduced to half of that of the Vøring Plateau ~150 km away (Breivik et al., 2009). Our estimates of the earliest seafloor spreading rates using new ship-track magnetic profiles on different margin segments offer a clue to what caused this rapid transition, which is not associated with a margin offset (Breivik et al., 2006, 2009, 2012). While crustal breakup occurred within the magnetic polarity C24r in other parts of the NAIP, there is a delayed breakup for the Lofoten/Vesterålen margin. Modeling of the earliest seafloor spreading with geomagnetic reversals, indicate a breakup within C24n.3n (anomaly 24b), approximately 1 m.y. later. Both old wide-angle seismic models (from Ocean Bottom Seismometers) off southern Lofoten and a newly published profile farther north show a strongly extended outer margin. Applying early seafloor half-spreading rates (~30 mm/y) obtained from other NAIP margin segments for 1 m.y. can account for 30 km extra extension, giving a factor of three crustal thinning, and a high strain rate of ~$3.2 \cdot 10^{-14}$. Crustal breakup at the magma-poor Iberian Margin occurred at a low strain rate of $4.4 \cdot 10^{-15}$ (based on Whitmarsh et al., 2001), which allowed the ascending mantle to cool, causing tectonic extension and upper-mantle serpentinization to be favored over magmatism. However, similar low strain rates are found within the main Ethiopian Rift, but the rift process there is highly magmatic and crustal separation is now dominated by dike injection (Bastow et al., 2011). Mantle tomography models show an exceptionally low seismic velocity below the area interpreted as an unusually hot upper mantle, the probable cause for the excess magmatism. Based on this comparison, it is likely that the transition from the Vøring Plateau to the Lofoten Margin is governed by the presence or absence of hot mantle plume material under the margin segments during rifting. Initial breakup-related extension on the Lofoten/Vesterålen Margin was strong and rapid without apparently causing much magmatism. Only close to crustal breakup time did a minor amount of plume material reach the Lofoten/Vesterålen margin to cause some elevated but short-lived excess magmatism there. Plume material appears to have been present at the Vøring Plateau earlier, where crustal extension caused much magmatism which led to extensive intrusions, low tectonic extension, and rapid crustal breakup, much as seen in the Ethiopian Rift. A combination of magmatic growth and lower tectonic extension of the crust created the shallow Vøring Plateau, both related to the presence of plume material during onset of rifting.

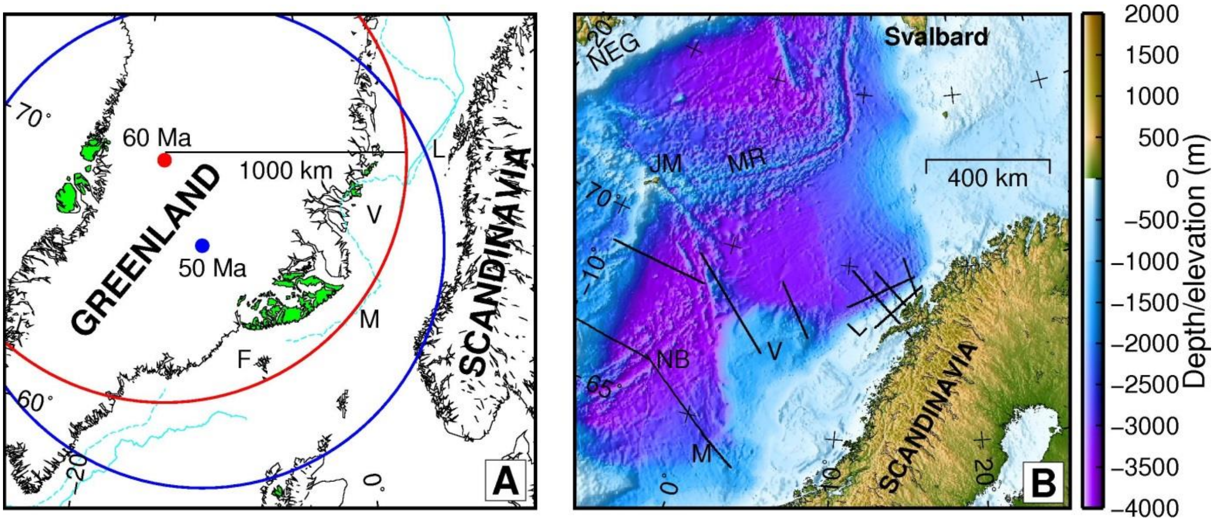

Figure 1. A: Continental reconstruction between Europe and Greenland back to opening based on spreading pole by Gaina et al. (2009). Green shading indicates early Cenozoic onshore flood basalts (Noble et al., 1988). The reconstructed 2000 m bathymetry contours are shown in cyan lines, solid from the Greenland side, and dashed from the Eurasian side. Iceland plume positions at 60 Ma (red) and at 50 Ma (blue) are from Lawver and Müller (1994), each enclosed by a 1000 km radius circle. B: Regional map with outer margin wide-angle seismic lines from 2000 and 2003 surveys. F: Faeroes, JM: Jan Mayen, L: Lofoten Margin, M: Møre Margin, MR: Mohn Ridge, NB: Norway Basin, NEG: North-East Greenland Margin V: Vøring Plateau. Figure is modified from Breivik et al. (2017).

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Scott BRYAN Oral presentation
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With Luca FERRARI

Large Igneous Provinces, Continental Break-Up and Marginal Plateaus

A key feature of the break-up of the supercontinent Pangea is that virtually each successive break-up phase was marked by a Large Igneous Province (LIP) event. This LIP-related break-up of Pangea and of earlier supercontinents produced volcanic rifted margins, new and large (up to 10^8 km^2) ocean basins, and new, smaller continents that underwent dispersal and ultimately, reassembly (e.g., India). As much as 90% of the present-day rifted continental margins are volcanic rifted margins, with only a few margin segments characterized as being unusually magma-poor. The time it takes to successfully break-apart continents is generally between ~20 and 40-50 Myrs, with the youngest examples of continental rupture - the Gulf of California and Red Sea - have both taken ~25 Myrs. Syn-rift magmatism and dyke intrusions play an important role in rift evolution where large magma volumes can facilitate continental rupturing, but at the regional scale, magmatism can thicken and strengthen the crust via magmatic underplating. Crustal rupturing is also recognized as an important process in the oceanic realm. Propagation of mid ocean ridge spreading centres and ridge jumps break-up oceanic LIPs soon after the termination of LIP magmatism as recorded by a number of plateau fragments (e.g., the Ontong Java–Manihiki and Hikurangi plateaus; Kerguelen and Broken Ridge). However, not all continental LIPs lead to continental rupture, and the controls on which LIPs lead to break-up remain poorly understood. This is despite all Mesozoic to Cenozoic continental LIPs being emplaced into regions of either prior or coeval extension. One factor that may prevent continental rupturing is whether an adjacent continental margin is undergoing subduction such that any contractional forces are transmitted into the overriding plate. However, evidence for upper plate contraction at the time of LIP emplacement is poorly documented, and the relative distance of LIP magmatism to the active plate boundary (often >500 km), coupled with evidence for crustal extension suggest plate boundary forces are not strongly controlling the ability of the lithosphere to rupture at the site of LIP magmatism.

Asymmetry is a fundamental feature of continental break-up. Conjugate margins are produced that are very different in character in terms of: 1) syn- and post-rift magmatic histories; 2) present-day elevation and uplift/subsidence histories; 3) structure and extensional history; and 4) continental shelf width and architecture of the continent-ocean boundary. Detailed studies of rifts and rifted margins since early 1980's have shown that continental rifting involves large horizontal motions along flat-lying or strongly rotational normal faults (i.e. low-angle detachment faults). Detachment fault geometry affects the gross rift architecture, and width of zone of uplift, including areas of more distributed extension or wide rift modes. Rift asymmetry can also switch along rifted margins across major crustal lineaments or transform faults.

The East Australian volcanic rifted margin exhibits the most asymmetry of all present-day rifted margins with asymmetry occurring both across the rift and between the conjugate margins, as well as along strike of the rifted margin. The southeastern Australian margin is characterised by a relatively unstructured margin, a lack of rift magmatism preserved onshore, a narrow continental shelf (<80 km width, mostly <50 km), and the highest elevations along the passive margin mountain range (up to 2.2 km ASL). In contrast, the northeastern margin is much more structured with several margin-parallel syn- to post-rift transtensional basins occurring within a wider zone of extension, and has a much wider continental shelf (>100 km and in places >200 km) providing the platform for more extensive development of the Great Barrier Reef, but a lower relief passive margin mountain range (up to ~1 km elevation). The LIP event heralding break-up (Whitsunday Silicic LIP) is preserved along this margin segment, and large marginal plateaus (e.g., Queensland and Marion; >150,000 km^2) are still attached to the continent. This may be a more general feature as marginal plateaus commonly occur offshore from rifted margins with wide continental shelves and lacking elevated passive margin mountain ranges onshore. Marginal plateau development along the northeastern Australian margin was promoted by the northward propagating seafloor spreading system of the Tasman Basin stepping eastward into the Cato Trough and then establishing further north in the Coral Sea. Seafloor spreading in the Cato Trough and Coral Sea occurred from ~63 to 50 Ma, but operated under a transtensional regime from ~58 Ma. The Darling River Lineament defines the boundary between the very different northeastern and southeastern rifted margins, and is a NE-striking, crust-penetrating, cross-orogen structure thought to have initially developed during the break-up of Rodinia. The Darling River Lineament acted as transform boundary during seafloor spreading and defines the southern margin to the marginal Marion Plateau.

The Gulf of California is one of two sites on Earth recording young continental rupture. Today, the Gulf is an ~1500-km-long, active oblique rift separating the Baja California peninsula from mainland Mexico, with the Baja California microplate being progressively dragged to the northwest by the Pacific Plate. Several short, NE-striking spreading axes are linked by long NW-striking transform faults through the Gulf. Extension began ~30 Ma during the first pulse of the Sierra Madre Occidental Silicic LIP. Extension and magmatism initially occurred in a wide rift mode (up to 500 km wide) until the pace and breadth of extension changed ~20–18 Ma, switching to a narrow rift mode (~80 km wide) with extension and magmatism focused on the future site of the Gulf. A number of NW-striking rift basins occupied this narrow rift belt including the now submerged Foca-Cerralvo and San Blas Basins but which became isolated or dismembered after ~12.5 Ma, when the kinematics of rifting became oblique. The Foca-Cerralvo and Tamayo Banks are two small (~3000 km^2) marginal plateaus developed within the last 20 Myrs in the southern Gulf and now separated by spreading in the Alarcon Basin. Thermochronology on intrusive rocks exposed in fault scarps bounding the marginal plateaus records rapid tectonic exhumation of syn-extensional magmatism as a result of the extending crust undergoing ~100% thinning between 18 and 12 Ma. Tectonic activity of the marginal plateaus largely ceased following the change to a dextral transtensional regime at ~12.5 Ma.

In summary, the architecture of rifted margins reflects an interplay of: 1) pre-existing structures and deformational history such as cross-orogen faults that can partition deformation, 2) syn-extensional processes, in particular the geometry of large-scale detachment faults inducing asymmetry to the rift, and LIP magmatism that can thicken and strengthen crust and drive surface uplift through magmatic underplating, as well as facilitating the rupturing process with magma lining faults, and 3) the evolution of stress regimes from orthogonal extension to more transtensional regimes where early formed rift basins become abandoned and new locations of crustal rupture are developed. Marginal plateaus developed at a variety of scales along rifted margins are being increasingly recognised and their formation appears promoted by: wide rift modes and the relocation or focussing of rifting when the rift mode changes to narrow, detachment fault geometries, and transtensional regimes overprinting earlier orthogonal extension.

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Oral presentation

The Falkland plateau

The Falkland Plateau forms a critical element of Gondwana reconstructions because it sits at the juncture of Southern Africa, South America and East Antarctica. Although the basin has received significant interest in terms of hydrocarbon exploration over recent years, a fully constrained tectonic framework is yet to be constrained. Not only does this limit our understanding of the true fit of the southern continents (Southern Africa, South America and East Antarctica), it also means that the complex tectonic evolution of the region remains enigmatic. The plateau rifted from the South Africa by the early Jurassic (190 Ma) accompanied with extensive volcanism. The mechanism for initial displacement is still widely debated, and was accommodated either by oblique extension of South America and clockwise rotation of the Falkland Islands, or a simpler strike-slip rifting with the Falklands Plateau firmly attached to the South American plate. This initial rifting is thought to have completed by 165 Ma, with further extension and volcanic activity due to the opening of the Weddell Sea. The opening of the South Atlantic occurred at 130 Ma, accommodated by oblique extension focused largely along the Agulhas Falkland Fracture Zone, one of the largest and most significant transform faults on the planet. Additional uncertainty and debate includes the nature of the Falkland Plateau, whether it is composed of extended continental crust or oceanic crust has been generated. This contribution will present a review of the most controversial debates regarding the plateau, and provide insights based on mapping of the onshore geology and the wide range of offshore exploration data.

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Oral presentation

with Laurent GEOFFROY, Marie BIDAULT, Huixin GUAN, Evgenii BUROV, Philippe WERNER, Laurent ARBARET, Charles AUBOURG

Recent concepts on volcanic passive margins

Two distinct types of passive margins are recognized, volcanic (VPMs) and non-volcanic. Basing ourselves on field surveys and interpretation of deep seismic profiles, we review the distinctive characteristics concerning VPMs architecture and development. We specially focus on the tectonic coupling between upper crust and high-velocity lower crust and on the ways magma interacts with the lower crust during extension.

VPMs are associated with lithosphere extension coeval with mantle melting. In contrast with non-volcanic margins, VPMs are characterized by syn-magmatic continentward-dipping detachment faults accommodating crustal necking at both conjugate volcanic margins. Those faults bound the inner-SDRs. They root in a deformed middle-crust (LC1) that appears to be sill-injected and ductile. This middle crust seems to flows over a deeper and thinner layered lower crust down to the Moho (LC2). Both LC1 and LC2 are probably exhumed up to the bottom of the outer-SDRs at the outer parts of the margin.

Thermo-mechanical modeling suggests that strengthening the deep continental crust during early magmatic stages provokes a divergent flow of the ductile lithosphere away from a central continental block (Block C), which becomes thinner with time due to the flow-induced mechanical erosion acting at its base. Pure-shear type deformation affects the bulk lithosphere at VPMs until continental breakup, and the geometry of the margin is closely related to the dynamics of an active and melting mantle. Syn-magmatic lower crust dynamics at conjugate VPMs and related inner-SDRs are best explained by an outward gravity collapse of the continental lithosphere from apart the buoyant Block C, denudating the lower crust along the major brittle crust/ductile crust decoupling level. In a way, the dynamics of VPMs presents some similarities with gravity collapse in the latest stages of orogeny.

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Oral presentation

Thermal fluctuations beneath continents

Continents drift at the surface of the Earth's mantle for billions of years. While they slowly evolve, the mantle beneath constantly evolves. Therefore, the temperature below the continental lithosphere changes with geodynamic context and natural fluctuations of a convective system. Substantial volumes of melts are consequences of these deep processes. I will present how geodynamic models provide a framework to improve our understanding on the origin of large igneous provinces. Analytical and numerical models allow to link the nature, the tectonic context and the extent of the melts erupting at the surface with the dynamic origin of the thermal anomalies, either related to plumes, small-scale convection or large-scale heating following supercontinent aggregation. I will discuss a non-plume model for the origin of the Central Atlantic Magmatic Province, invoking the dynamic warming up of the mantle beneath Pangea after its aggregation.

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Oral presentation

The Briançonnais fossil marginal plateau, Western Alps: identification of the early stages of inversion and implications for its restoration

The Briançonnais nappes stack found in the internal zones of the western Alpine arc is classically interpreted as issued from a distal part of the European palaeomargin of the Tethys. It is characterized by a specific Mesozoic sedimentary record showing an erosional and non-depositional gap of variable amplitude. This was caused by syn-rift uplift and emergence of the whole Briançonnais plateau, with an increasing amplitude towards the rift breakup. The end of this gap corresponds quite precisely with the age of Adria-Europe oceanic breakup, provided by either paleontological or geochronological evidences. The subsequent drowning fits well with an expected thermal subsidence effect, despite some interference with the more recent Iberia-Europe rifting may occur (Claudel & Dumont, 1999). Later on, the Briançonnais submarine plateau received extremely starved sedimentation likely due to bypassing and/or sea floor currents distribution.

Due to Alpine thin-skinned inversion processes, favoured by the occurrence of several detachment layers within the sedimentary sequence, the best preserved elements of this marginal plateau analogue are upper Paleozoic to Cenozoic cover nappes, which are moderately affected by HP metamorphism. Their origin and their relationships with polymetamorphic basement of the Internal cristalline massifs are still debated, and their pre-Alpine restoration is critically constrained by the knowledge of Alpine deformation which is polyphased. Unfolding this buildup perpendicularly to the most prominent structures, that is E-W or NE-SW in the Grenoble and Briançon areas, is inefficient because the western Alpine arc was formed during Oligocene lateral extrusion, by indentation and distorsion of the initial (Eocene) orogenic wedge (Dumont et al., 2012). This is demonstrated by structural analysis of superposed deformations between the Maurienne and Ubaye valleys, showing that the internal nappes initially propagated towards the N to NW, before beeing overprinted by either pro- or retro-deformation associated with the formation of the arc. The Briançonnais marginal plateau has thus a southeastern origin, and was located by the present Ligurian sea or further south. Consequently, it included thick late Paleozoic peri-Gondwanan basins which played a key role during Alpine inversion. It can be regarded as an eastward extension of the Iberian microplate, probably bordering on three sides oceanic or attenuated lithosphere but not directly connected with the Dauphiné-Helvetic realm, to which it is presently juxtaposed.

The cause of syn-rift uplift of this non-volcanic marginal segment is still debated, either compatible or not with hyperthinning. It is likely that the latter feature affected only the most distal, so-called Prepiedmont domain of the margin, close to the continent-ocean transition. If so, the major syn-rift uplift of the plateau would be better explained by isostatic rebound close to the necking zone. A similar event occurred at the northern edge of the Iberian plate in the western Pyrenees (Dumont et al., 2015).

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Oral presentation

An overview of the Hatton-Rockall plateau

The Hatton-Rockall Plateau is one of a chain of submarine plateaus located along the hyperextended North East Atlantic margin extending from offshore Ireland to the Arctic. This remote (> 450 km from West of UK & Ireland) oceanic plateau comprises a series of Mesozoic rift basins hosted within Paleozoic metamorphic crystalline basement. The details of the deep geology of the Hatton-Rockall area are largely unknown due to the presence of a thick succession of Cenozoic extrusive igneous rocks which mask the deeper geology of the area. The remoteness of the plateau has also meant that it has been isolated from major clastic input over the majority of the Cenozoic with only a thin sedimentary cover. This thin sediment cover provides an ideal natural laboratory to examine geological processes without the presence of large sedimentary succession. Over 40 years of multi-discipline research has revealed much about its deep structure, the sedimentary basins hosted on it, the igneous evolution of its magma-rich western flank, the evolution of polygonal fault systems and the interaction of variable bathymetry on both alongslope and downslope sedimentation.

The Hatton-Rockall Plateau consists of two structural highs, the Rockall Bank in the East which consists of metamorphic basement with igneous intrusions and the Hatton Bank to the West which has a series of Mesozoic rift basins. The Hatton Basin separates the two highs and comprises stretched continental crust with a Mesozoic to recent sedimentary succession that has also been intruded by a number of large igneous centres. The western flank of the Hatton Bank which borders the oceanic Iceland Basin was one of the first volcanic rifted margins investigated with DSDP drilling in the late 1970's sampling the seaward dipping reflection (SDR) events imaged on seismic data and proving their volcanic nature. Up until the 2000's the alongstrike variability of the volcanic margin remained unclear but integration of modern seismic reflection data with multibeam bathymetry allowed the margin to be divided into segments. The distribution of SDR packages is not uniform with the central portion of the margin comprising of a single SDR package and an undeformed continental block. To the north, a wider region of SDRs was mapped than to the south with numerous volcanic cones. The variations in the distribution of the SDRs along the margin indicate that the break-up process was not a uniform process along-strike with gravity lineaments suggesting crust of different thickness and affinity influenced the Eocene aged break-up style (presence or absence of SDR) and also the presence of post break-up volcanism.

Following the onset of seafloor spreading to the west of the Hatton Bank, the margin became tectonically quiescent and hemipelagic sedimentation dominated from the Eocene to the recent. Vigorous bottom currents redistributed the hemipelagic sediment leading to the build-up of sediment drifts, erosional scours and moats whose distribution has been controlled by the underlying shallowly buried structural template which focused currents promoting erosion in some areas and deposition in others. Throughout the Cenozoic the Hatton Bank Basin received little shelf-edge derived sediment supply thus remaining sediment starved with only hemipelagic sedimentation that allowed the development of polygonal fault populations that exist not only in the sedimentary succession but also at the modern day seabed. Multibeam bathymetry data show 10 m deep and 200 - 600 m wide troughs at the seabed that connect to each other forming polygons that cover almost 37,000 km^2.

The build-up of the contourite drifts along the flanks of the Hatton and Rockall Banks was not a purely aggradational process with large-scale slope failures occurring along the eastern flank of the Rockall Bank. The Rockall Bank Mass Flow (RBMF) is a large, multiphase submarine slope failure complex located where the Feni Drift impinges upon the eastern flank of the Rockall Bank. Slope failure scarps cover ~ 6,100 km^2 with individual scarps reaching up to 22 km long and 150 m high, lies upslope of a series of mass flow lobes that cover at least 18,000 km^2 of the base of slope and floor of the Rockall Trough. A deep erosional moat linked to the onlapping contourite complex bisects the region of failed slope and differential sedimentation and erosion associated with the moat may have promoted slope instability. A Late Pleistocene age for the slope failure is likely but the RBMF is unusual in that it records the large-scale collapse of a contourite body on a margin where there was little overloading by offshelf glacial sediment.

The western flank of the Hatton Rockall Plateau influenced the development of the Maury Channel, a 1200 km long deep-sea sediment transport system that extends from Icelandic plateau to the Charlie-Gibbs Fracture Zone. DSDP Site 115 sampled a volcaniclastic turbidites of unequivocal Icelandic provenance. The volcaniclastic turbidity currents were discharged from Iceland as result of sub-glacial volcanic eruption producing massive outflow events. These massive outflow events were discharged into the Iceland Basin transforming into turbidity currents which travelled southeast prior to being deflected by the Hatton Bank and funnelled along the base of the Hatton Bank where they encountered the Miocene to recent Gardar Drift. The drift appears to have initially acted as a barrier to the flows and formed a large submarine fan. Continued sediment supply from Iceland eventually led to the overspilling of the Gardar Drift resulting in the initiation of the Maury Channel.

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Poster

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The Bay of Biscay and the Capbreton canyon as key sedimentary contexts to decipher Holocene sea-surface hydrography of the boreal Atlantic

The Bay of Biscay is a semi-enclosed basin from the north-eastern Atlantic Ocean bounded by French coasts to the east and Spanish ones to the south. This triangular portion of the western European margin extends from the Galician Finisterre Cap at 44°N to the Goban Spur at 50°N. The Bay of Biscay provides rare sedimentological archives which permit to study at an exceptional decadal time resolution the boreal Atlantic paleohydrography over the Holocene and thus to test regional connections with known modes of the Atlantic Meridional Overturning Circulation (AMOC) component.

Such archives are the product of sediment focusing and especially lie at the margin interface in atypical contexts of accumulation mainly forced by the interplay of geostrophic, gravity currents and hemipelagic sedimentation.

This study aggregates the results obtained on two long Calypso piston cores: the MD03-2693 (1.663; 43.654) retrieved at 431 m water depth (by the RV *Marion Dufresne* in 2003 during the SEDICAR-PICABIA cruise) and the PP10-07 one (2.228; 43.677) retrieved at 1472 m water depth (by the RV *Pourquoi pas ?* in 2010 during the SARGASS cruise).

These cores display very high sedimentation rates over the last 10 ka of respectively 1.2 cm/yr and 0.2 cm/yr with a normal decreasing trend over a cross-shore E-W gradient (longitudinal distance from the shore of 15 km for core MD03-2693, and of 58 km for core PP10-07).

Here we will present past Holocene hydrographical data reconstructed after an ecological transfer applied to planktonic foraminiferal assemblages. These sea-surface reconstructions are compared to additional sedimentary data and also to a set of boreal North Atlantic Holocene records in order to highlight the coherency of the European margin sedimentary response to climatic forcings over the subtropical to subpolar band.

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The Demerara Plateau: a case study of the initiation and evolution of a contourite depositional system on a marginal plateau

The Demerara marginal Plateau, part of the Surinam-French Guiana transform passive margin, is located at the western edge of the Equatorial Atlantic Ocean, close to the junction with the Central Atlantic Ocean. In order to better characterize the structural and sedimentary evolution of the Demerara Plateau that are closely linked to the opening history of the Atlantic Ocean, this prominent marginal plateau has been intensively surveyed for several years with four multidisciplinary cruises (i.e. GUYAPLAC (2003), IGUANES (2013), DRADEM and MARGATS (2016)). Interpretation of a large set of seismic data (including 24 and 72-channel seismic profiles) provides a refined image of the post-transform architecture of the Demerara Plateau and a better understanding of the intricate relations between topography, bottom currents activity, and slope instabilities that influence sedimentation on the plateau.

From Late Albian to Early Miocene, the evolution and sedimentary infill of the Demerara Plateau have been strongly controlled by inherited structural topography. Indeed, the difference of structure and morphology between the transform and divergent segments directly influences through differential subsidence the distribution pattern of post-transform deposits. Despite the first modifications in oceanic circulation in the Atlantic during this phase, no clear evidence of large-scale overturning circulation has been observed along the Demerara Plateau, possibly erased by the regular mechanical destabilization of the plateau that has been occurring since the Late Cretaceous. Only the Cretaceous-Tertiary boundary and the Paleocene-Eocene Thermal Maximum are expressed as erosive events.

The transition between the pre-contourite phase and the active contourite phase is associated with a major slope failure event that erodes sediments down to Paleocene strata. The basal *décollement* layer of this mass transport deposit correlates with an erosion surface that peneplains the distal plateau and is Middle Miocene in age. It is interpreted as the result of major changes in oceanic circulation throughout the Atlantic linked notably to the progressive closure of the Central American Seaway that has induced the onset of a modern and intensified in strength Atlantic Meridional Oceanic Circulation.

The establishment of a persistent deep-water circulation in the Atlantic leads to the development of current-controlled sedimentary features during Late Miocene and Plio-Quaternary times. Thus, under the influence of the North Atlantic Deep Water (NADW), a contourite depositional system (CDS) builds up along the Demerara marginal Plateau. The NADW seems to be guided by the main Miocene slope failure headscarp that localizes an abrupt incision interpreted as a contourite moat. Within the CDS, giant fossil depressions (hydrate pockmarks?) and small pockmarks are observed, and could reflect fluid escape mechanisms. Several peculiar bedforms develop parallel to the NADW flow: longitudinal depositional bedforms forming migrating sedimentary ridges on the drift and hundreds of giant comet tails that represent erosional bedforms. The repartition of these current-controlled structures seems to be governed by the presence of mass transport deposits that developed, until recently, down the main slope failure headscarp.

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Poster

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The outcropping basement of the Demerara marginal plateau (French Guiana-Surinam): results from DRADEM dredges

At the connection between the Central and the Equatorial Atlantic, the Demerara marginal plateau is a continental margin that resulted from both Jurassic and Cretaceous rifting. The northern edge of the plateau is a steep transform margin, where the basement was expected to outcrop. The DRADEM cruise (2016) dredged this continental slope on seven sites from 4700 to 3500 m depths.

Three dredges recovered magmatic rocks, six dredges recovered sedimentary rocks. All samples were analysed using optical and electronic microscope and X-ray diffraction. Magmatic rocks were also analysed for major and trace elements. Zircons were separated from three sedimentary rocks, in order to date their cristallisation from U/Pb isotopes and their cooling from fission tracks.

In two adjacent dredges, magmatic rocks correspond to fresh basalts and rhyolites belonging to a calc-alcaline, Ti-rich suite. Zircons in rhyolites were dated at 173,4 ± 1,6 Ma. In a third dredge, magmatic rocks are trachy-basalts and basaltic trachy-andesites. All samples share similar patterns in trace elements. They are Light Rare Earth-enriched, and present positive anomalies in Nb, Ta, Zr and Hf, indicative of Ocean Island Basalt magmas, and consequently an hot spot-related magmatic origin.

The trachy-basalts were altered, eroded, and sedimented in a carbonate platform forming clasts in a bioclastic and lithoclastic rudstone. Large aragonitic shells were dissolved, and the moldic porosity is partially filled by vadose silts, indicating post-sedimentation outcropping above sea-level. The other sites recovered sandstones : either coarse, or from a delta shoreface, or from an oolithic platform.

Cooling ages of detrital zircons from three sites indicate in each site three main peaks dated lower Cretaceous, Trias to lower Jurassic and Paleozoic (ranging from 101 to 145, 190 to 242 and 288 to 434 Ma, respectively). Those peaks are interpreted as cooling ages of the detrital sources. They roughly coincide with, respectively: (1) the lower Cretaceous Equatorial Atlantic rifting, (2) the Central Atlantic Magmatic Province event at the Trias-Jurassic boundary and the subsequent Central Atlantic Rifting and (3) the Panafrican exhumation, possibly in the Hercynian orogen. Cristallisation ages inferred from $^{206}Pb/^{238}U$ dating of detrital zircons are mainly distributed around 650 Ma and may indicate detrital source from the Panafrican belt in West Africa, prior to the opening of the Equatorial Atlantic.

These findings allow to discuss the subsidence of the northern edge of the Demerara plateau, and to propose new relationships between the formation of the Demerara Plateau and the Central Atlantic Magmatic Province, based on a magmatic nature and Mesozoic age of the Demerara basement.

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Poster

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The enigmatic deep structure and margins of the Demerara plateau: the MARGATS cruise seismic data together with dredges, kinematic reconstructions and magnetic data reveal a complex and polyphased magmatic history

Many transform margins have associated intermediate depth marginal plateaus, which are commonly located between two oceanic basins. The Demerara plateau is located offshore Surinam and French Guiana. Plate kinematic reconstructions show that the plateau is located between the central and equatorial Atlantic in a position conjugate to the Guinean Plateau. In the fall of 2016, the MARGATS cruise acquired geophysical data along the 400 km wide Demerara plateau. This cruise is part of a program dedicated to the deep geological investigations of the margin, including the Demerara plateau, following the GUYAPLAC (2003), IGUANES (2013) and DRADEM (2016) cruises. The aim of MARGATS was to image the internal structure of the Demerara plateau and its different margins using coincident deep penetrating wide angle refraction and Multi Channel reflection Seismic (MCS) methods. During the MARGATS experiment 171 Ocean Bottom Seismometers (OBS) were deployed distributed along 4 wide-angle lines. Along each wide angle line we also recorded coincident MCS data using a 3 km-long 480 channels streamer. The dataset was completed by three MCS lines along the eastern part of the Demerara plateau. MCS MAR007 line which is coincident with line OBS MAR-3 was extended on land by a set of 13 land stations deployed along the Maroni River. This line, together with MCS MAR001 and the coincident OBS MAR-1 line reveal the highly homogeneous deep structure of the internal part of the plateau. MCS MAR005 line, which is coincident with OBS MAR-2, MCS MAR006 line coincident with OBS MAR-4, MCS MAR002, MCS MAR003 and MCS MAR004 help to elucidate the structural complexity of the northern transform margin and the eastern divergent margin of the plateau. These new datasets are highly complementary to the DRADEM dredges results which provide evidences of mid Jurassic volcanic rocks along the plateau and huge vertical displacements along the transform margin. A compilation of magnetic data from the MARGATS and 3 previous cruises shows high amplitude magnetic anomalies along the plateau thereby strengthening the hypothesis of an volcanic origin of at least part of the structure. These results together with the wide-angle and MCS results allow to interpret the plateau as the remains of a amazingly thick Jurassic volcanic divergent margin in the southern part of the Central Atlantic ocean. This margin broke again during the Cretaceous opening of the Equatorial Atlantic ocean as an highly oblique margin to the north and a divergent margin to the east. This meeting will be a great opportunity to reveal the exceptional quality of the seismic data after the initial processing steps and the subsequent results.

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Oral presentation

Contourite terraces vs marginal Plateaus/platforms: conceptual implications

Over the last decade, numerous bottom current-controlled depositional (drift), erosional and mixed features (contourite terraces) have been recognized in deep-water settings of the world's oceans, providing diagnostic evidence for modern and ancient bottom water circulation patterns and sedimentary processes. The present talk provides a detailed analysis of these contourite terraces and associated large bedforms interpreted to be sand-rich based on their morphology and seismic facies. Contourite terraces have good lateral continuity and have been described at different depths along continental slopes and rises. They are sub-horizontal morphologic elements associated to plastered drifts and identified both at the present sea-floor and in the sedimentary record, which have developed over time in constructional and erosive phases. Their location can be correlated with the main interfaces of regional water masses. Contourite terraces occurrence condition a remarkable change in the slope morphological profile different to those defined as "Plateaus", "Marginal Plateaus", or other "Terraces" along continental margins. Therefore, bottom water circulation and associated processes are shaping the seafloor and controlling the sedimentary stacking pattern on continental margins. These features pose questions about our fundamental understanding of margin processes, morphologies, stratigraphic context and bedform development in deep marine environments. Consequently, new perspectives should be evaluated, given that these deposits are of great scientific and economic significance.

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From marginal platforms to contourite terraces: a study case from NW Iberia

Three marginal platforms (Ortegal, Pardo Bazán and Castro) comprise the NW Iberian continental margin related to the rifting of the North Atlantic and the opening of the Bay of Biscay spanning from the Mesozoic to the present. A morphological analysis of the seafloor has been carried out by means of interpretation of very high-resolution multibeam bathymetry, acoustic backscatter and ultra-high resolution seismic profiles data. This information were obtained during campaigns carried out under the framework of the *Spanish Exclusive Economic Zone* (ZEEE) *Programme*. Five main contourite depositional features have been differentiated comprising: *plastered and separated drifts, mixed deposits*, and *sediment waves*. Moreover two contourite erosive features have been described including *moats* and *abraded surfaces*. Their distribution coincides with depths presently under the influence of several bottom currents, as the North Atlantic Central Water (ENACW), Mediterranean Outflow Water (MOW), Labrador Sea Water (LSW) and North Atlantic Deep Water (NADW). This sector has been considered as a glacially influenced continental margin, where down-slope sedimentary processes should be dominant. This work confirm that slope failures and turbidity currents along submarine canyons are common, but in addition to that in the inter-canyons sectors there are commonly bottom currents features. That is the case of the marginal platforms, where bottom currents apparently have reworked and deposited deep-water sediment.

Moreover, a vertical variability of the contourite features is observed, with erosive features developed close to the interface depths, and depositional ones between the interface depths. This vertical upward/downward migration or expansion of the bottom currents imprints reflects that although tectonic processes triggered the emplacement of the marginal platforms and structural highs, the influence of bottom currents may have overprinted the tectonic signature. In this new scenario, the Ortegal, Pardo Bazán and Castro marginal platforms could be considered to constitute large *contourite terraces* where tectonism has constituted the first controlling factor on their onset and longer-term scale formation, whereas climate, sediment supply and oceanographic changes have played a major role on a shorter-term scale for their final morphology and sedimentary stacking pattern evolution.

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Marginal plateaus : définition and scientific challenges

During the last decade, a renewed attention has been paid to transform margins. Those margins, less studied than rifted and oblique margins, display numerous originalities that merit attention: diachronic oceanisation along a same margin, syn- and post-transform lateral variability in vertical movements, common association with polyphased oceanic opening. Moreover, important petroleum discoveries have been made at transform to rifted transition domains on high slope gradient continental slopes inherited from narrow continental to oceanic transform transitions typical of those margins.

Mercier de Lépinay et al., 2016, published in this context an updated inventory of transform passive margins in the world that uses worldwide compilations of the continent-ocean boundary and of fracture zones. In this compilation, transform margins are defined as continent-ocean boundaries superposed to active or previously active transform faults. This inventory shows that those margins represent 30% of continental passive margins and a cumulative length of 16% of non-convergent margins.

A systematic analysis of those transform margins allows to define for a quarter of them a deep, planar and sub-horizontal plateau located between the continental shelf and the lower continental slope. 21 submarine plateaus have been mapped, based on those criteria: they have rectangular or triangular shapes and are systematically bound on one of their sides by a transform continent-ocean boundary (examples of the Falklands, Vøring, Demerara, Tasman plateaus, etc. Figure 1). The widths of those plateaus vary from ca. 45 to 480 km and lengths vary from ca. 30 to 1100 km. Their depths range from 100 to 3400 m, with an average of 1250 m. We call those plateaus "marginal plateaus" because they occur landward of transform continent-ocean boundaries, display low slope gradients (average slope of 0.3°, maximum slope 2°) and intermediate depths between typical continental and oceanic provinces.

The majority of those "marginal plateaus" are located at the intersection of oceanic domains with different break-up ages and/or opening directions (Figure 1). They are always bounded by a transform margin along one side and by older transform or divergent margins along the other sides, which means that those plateaus underwent a polyphased evolution. Mercier de Lépinay et al., proposed that those specific elevations may relate to continental crust domains thinned by a least two rifting episodes.

In parallel, one marginal plateau has been particularly investigated the last decade: the Demerara plateau. Many analyses converge to the conclusion that this plateau may relate to a Jurassic volcanic margin (SDR on seismic data, high velocities from refraction data, discovery of volcanic rocks) that later individualized as a plateau during the Cretaceous transform-dominated opening of the equatorial Atlantic. This result led us to reconsider the hypothesis of a volcanic origin of those plateaus and to inventory marginal plateaus that underwent volcanism before, during or after transform motion. 52% of those plateaus are concerned by volcanism, which suggests that the nature of the crust in those domains may be continental to highly intruded by intrusions and related to hot spot activity. For 29 % of the plateaus, the nature of the crust is unknown or highly debated. For 19% of the plateaus, the crust is continental.

The understanding of the nature, origin, evolution and future of those elevations has important issues:

(1) Those plateaus clearly form at complex geodynamic nodes. Their geodynamic significance has to be better understood in the future: relation with mantle activity? Specific lithospheric fabric and thermal evolution controlling transform emplacement?

(2) They represent important surfaces at the continent to ocean transition and their nature is debated: Thinned continental crust? Thickened oceanic crust? Underplated and intruded continental crust? What are the associated vertical movements?

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

(4) Those plateaus are emplaced nearby continent to ocean transition domains, but forming seaward spurs at the scale of 50 to up to 1000 km. How do turbidites accumulate on those low slope gradients proximal plateaus? What kind of sediments reaches the distal part of those plateaus? Effect of those plateaus on deep-sea currents and deposition of contourites?

(5) What are the natural resources associated with marginal plateaus and their borders?

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

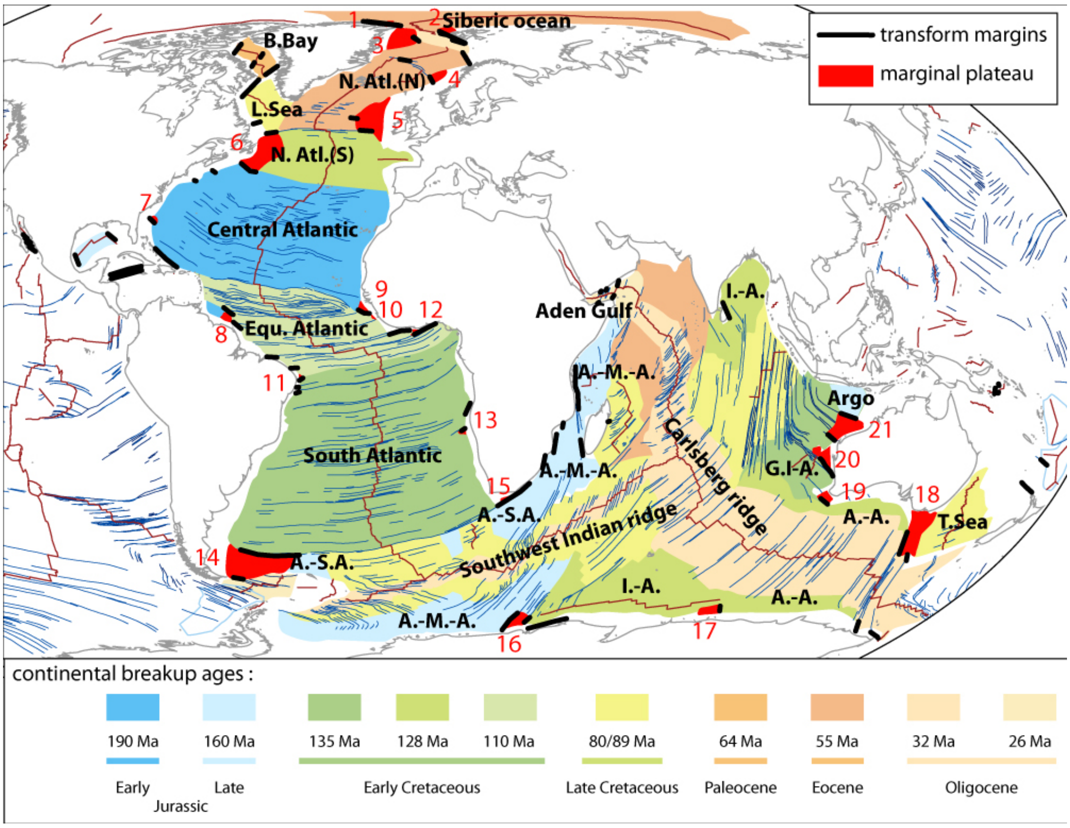

Figure 1: Transform margins (thick black lines), marginal plateaus (red), and break-up ages. 1: Morris Jesup Rise; 2: Yermarck plateau; 3: North East Greenland margin; 4: Vøring plateau; 5: Rockall Plateau; 6: Newfoundland plateau; 7: Black Spur; 8: Demerara plateau ; 9: Guinea plateau; 10: Sierra Leone; 11: Sergipe; 12: Côte d'Ivoire-Ghana; 13: Walvis; 14: Falklands plateau; 15: Aghulas; 16: Gunnerus Ridge; 17: Bruce Rise; 18: Tasman plateau; 19: Naturaliste plateau; 20: Perth margin; 21: Exmouth plateau. Domain abbreviations: B.Bay=Baffin Bay; L.Sea=Labrador Sea; N.Atl (N)=Northern North Atlantic; N.Atl(S)=Southern North Atlantic; Equ Atlantic = Equatorial Atlantic; A.-S-A=Africa-South America; A.-M.-A. = Africa-Madagascar-Antarctic; I.A.=India-Antarctic; A.-A.=Australia-Antarctic; G.I.-A.=Greater India-Australia; ; 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).

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

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

The MARGATS scientific cruise was carried out from October 20th to November 16th 2016 on board the R/V L'Atalante, offshore Suriname and French Guiana. This cruise is part of a program dedicated to the geological investigation of the continental margin, including the Demerara plateau, following the GUYAPLAC (2003), IGUANES (2013) and DRADEM (2016) cruises. The aim of MARGATS was to image the internal structure of the Demerara plateau and its different margins using coincident deep penetrating wide angle refraction and multi channel reflection seismic (MCS) methods. During the MARGATS experiment 171 OBS deployments were distributed along 4 wide-angle lines. Along each wide-angle line we also recorded coincident MCS data using a 3 km long 480 channels streamer. The dataset was completed by three MCS lines along the eastern part of the Demerara plateau. MCS MAR007 line which is coincident with line OBS MAR-3 was extended on land by 13 land stations deployed along the Maroni River. This line, together with MCS MAR001 and the coincident OBS MAR-1 line reveal the highly homogeneous deep structure of the internal part of the plateau. MCS MAR005 line, which is coincident with OBS MAR-2, MCS MAR006 line coincident with OBS MAR-4, MCS MAR002, MCS MAR003 and MCS MAR004 helps to elucidate the structural complexity of the northern transform margin and the eastern divergent margin of the plateau. These new datasets are highly complementary to the DRADEM dredge results which provide evidence for mid Jurassic volcanic rocks along the plateau and significant vertical displacements along the transform margin. These results allow to interpret the plateau as the remains of a huge jurassic volcanic divergent margin along the Central Atlantic ocean to the west, possibly remobilized during the cretaceous opening of the Equatorial Atlantic ocean as an highly oblique margin to the north and a divergent margin to the east in persistent presence of volcanism. This session will be a great opportunity to present the exceptional quality of the seismic data, after the initial processing steps and how these data are conditioning a new understanding of the Demarara plateau and its margins which implies the hypothetic role of a new hot spot shaping the complex polyphased history of the structure.

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Oral presentation

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An overview of the scientific exploration of the Demerara plateau

The recent scientific exploration of the Demerara plateau, located offshore French Guiana and Surinam, started with the Guyaplac scientific cruise in 2003. This cruise was conducted as part of the French EXTRAPLAC program, dedicated to the delineation of the continental shelf beyond 200 nautical miles (M) in the framework of the United Nations Convention on the Law of the Sea. Coastal States can extend sovereign rights over the natural resources of the Continental Shelf beyond 200 M if they can demonstrate that their continental margin, as a natural prolongation from the landmass, extends that far from the coast. Article 76 of the Convention defines the continental shelf and includes geomorphological and geological criteria that need to be satisfied in order to claim such a shelf beyond 200 M. In the case of French Guiana, a significant effort was employed in acquiring new marine geophysical and geological data, including multibeam bathymetry, multi channel seismics, magnetics and gravity. These data and their interpretation were presented to the UN Commission on the Limits of the Continental Shelf in 2007 and the outer limit of the shelf was fixed in 2009. Besides the use of these data to secure French sovereign rights, the data collected during the Guyaplac cruise led to new scientific questions and encouraged new and enhanced scientific collaboration between French government organizations and the academic community. A multidisciplinary research program involving new scientific cruises, one conducted in 2013 and two in 2017, has since explored the Demerara plateau and its margins from the surface to the mantle. Our work has addressed downslope and along slope sedimentary processes, including giant submarine landslides as well as contourite processes associated with the strong bottom currents observed along the continental slope. Most recently, multi-channel reflection and wide angle refraction methods were deployed to study the deep structure of the Demarara plateau, a submarine plateau that is similar to other plateaus found along many transform continental margins. Dredging along the northern slope of the Demerara plateau has found further evidence for its volcanic origin, and provides age constraints on its initial formation.

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Multidisciplinary scientific program of investigation of the structure and evolution of the Demerara marginal plateau

An updated inventory of transform passive continental margins in the world was published by Mercier de Lépinay et al. in 2016. This inventory shows that these margins represent 30% of passive continental margins and a cumulative length of 16% of non-convergent margins. The inventory also highlights the fact that many submarine plateaus are bounded by transform continental margins and are systematically located at the junction of oceanic domains of different ages. Globally, we identified twenty of these marginal submarine plateaus (Falklands, Voring, Demerara, Tasman, etc). These plateaus experience two phases of deformation: a first extensional phase and a second transform phase that allows the individualization of those submarine elevations appearing in bathymetry as seaward continental-like salients. Understanding of the origin, nature and evolution of those marginal plateaus has many scientific and economic implications.

The Demerara marginal plateau located off French Guiana and Surinam belongs to this category of submarine provinces. The French part of this plateau has been the locus of a first academic investigation in 2003 during the GUYAPLAC cruise dedicated to support the French delineation of the limits of the continental shelf beyond 200 nautical miles. This cruise was the starting point of a multidisciplinary scientific program dedicated to geological investigations of the Demerara plateau, sustained by different cruises and collaborations: (1) IGUANES (2013) completed the mapping of this plateau including off Surinam, allowed to better understand the segmentation of the Northern edge of the plateau, and to demonstrate the combined importance of contourite and mass-wasting processes in the recent sedimentary evolution of this domain (see poster session); (2) Collaboration with TOTAL (PhD thesis of Mercier de Lépinay) to better qualify the two main phases of structural evolution of the plateau, respectively during Jurassic times for its Western border and Cretaceous times for its Northern and Eastern borders; (3) DRADEM (2016) (see poster session) mapped the continental slope domain of the transform margin north of the Demerara plateau and was dedicated to the dredging of rocks outcropping on the continental slope, suspected to be Cretaceous in age and older; (4) MARGATS (2016) (see poster session) dedicated to the better understanding of the internal structure of the plateau and its different margins using multi-channel reflection and refraction seismic methods.

The combination of all those experiments allow us to paint an integrated portrait of the Demerara marginal plateau – that may be very useful in understanding the processes involved (1) in the individualization of such plateaus (volcanism, heritages, kinematics, …) (2) in their evolution (subsidence, mass-wasting processes, domains of deep-sea current acceleration).

The next steps of our research program include a better understanding of kinematic evolution in this region (based on new and existing observations including magnetic data) and a better knowledge of the geology of the slope domain by in situ observations with either a ROV or a manned submersible.

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Formation and evolution of a glauconite-rich contourite depositional system on the marginal demerara plateau (french guiana, surinam)

The Demerara plateau forms a promontory along the French Guiana and Surinam margin. It is defined as a marginal plateau related to a polyphased rifting history. This relief is composed by a continental shelf followed by a slowly deepening plateau between 200-3200 m of water depth. The distal part of this plateau is delimited by the continental slope deepening toward the abyssal plain. This relief is tought to influence the bottom current intensity and being at the origin of the contourites formation. The contourite deposits are recently described and it is generally constituted by about 24 % of clays, 70 % of silts and 6 % of foraminifer-rich sand. The very peculiar feature is the occurrence of glauconitic grains, which account in some samples to up to 13 % of the bulk sediment and 90 % of the sandy fraction, mainly found filling the foraminifer tests.

Inside those tests, neoformation of Fe-smectite and interstratified smectite/glauconite can occur during early diagenetic redox processes. During the first stage, thanks to a low sediment accumulation rate (induced by the winnowing effect), the formation of authigenic Fe-smectite leads to sequestration of iron and potassium. This process is faster for Fe than for K. If the grains stay during sufficiently long-time at the sea/sediment interface, seawater K continues to be incorporated, hence leading formation of interstratified Fe-smectite/illite (glauconite). The subsequent phases neoformation are also suggested by evolving pigmentation of glauconitic grains from light green to dark green. Both the degree of maturity of glauconitic grains and their chemical composition are likely related to the current intensity: high current intensity with high winnowing effect and low sedimentary accumulation favour glauconitisation. Thus, we suggest that the occurrence of glauconitic grains and their geochemical characteristics, when they are found in contourite sediments, might be an efficient tool for estimating the intensity of bottom currents that shape the oceanic deposits.

We have used this new approach for characterising the contouritic sediments of the Demerara plateau that are mainly under the influence of NADW with variable strength during global climate shifts (glacial and interglacial phases). In this area, the glauconite formation is allowed because of significant supply of elements such as Fe, favoured by strong continental leaching under the tropical conditions. Our results indicate that during glacial periods, the glauconitic formation and maturity is higher than during interglacial periods, suggesting an increase of the NADW intensity during ice periods along the French Guiana margins, inducing a strong bottom winnowing and, consequently, a strongly reduced accumulation rate.