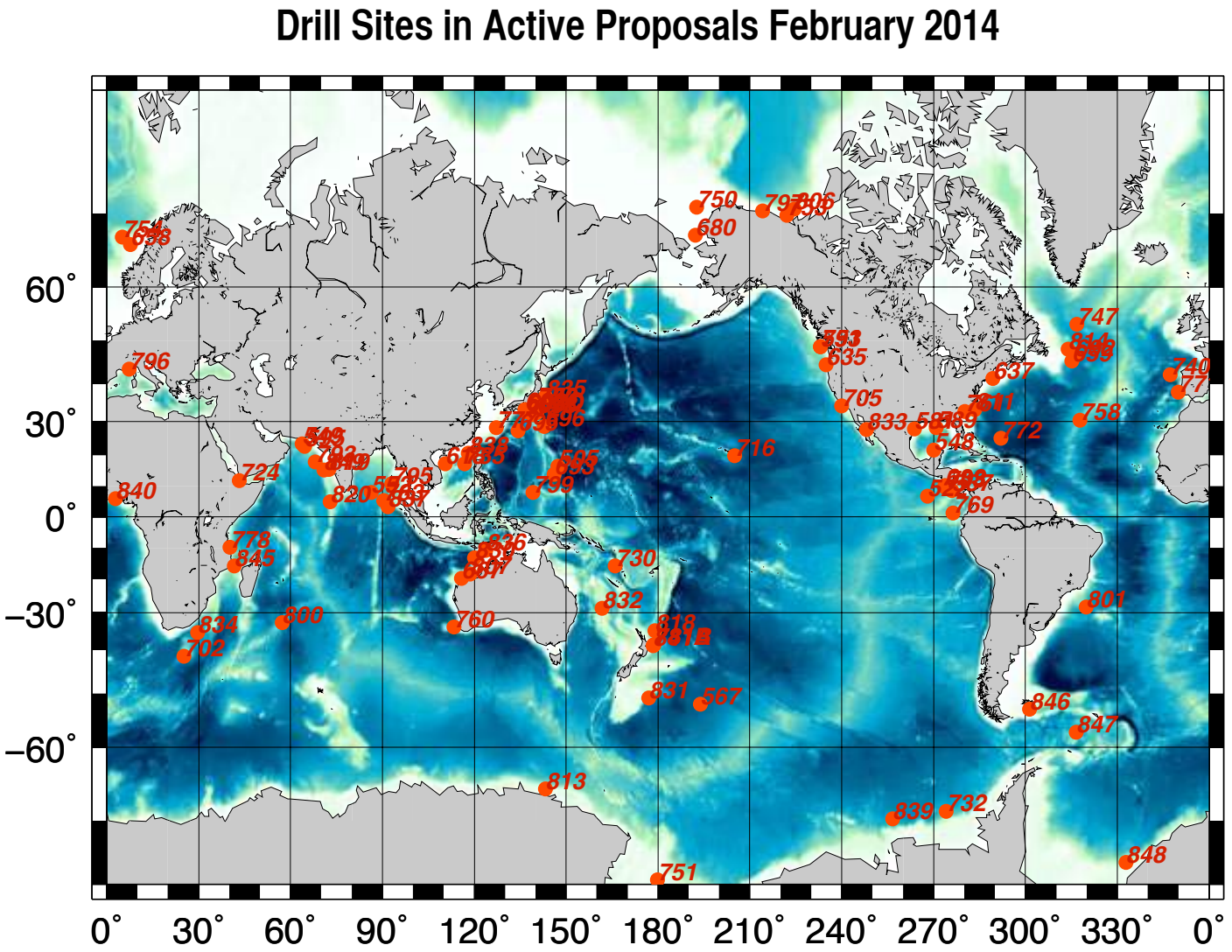
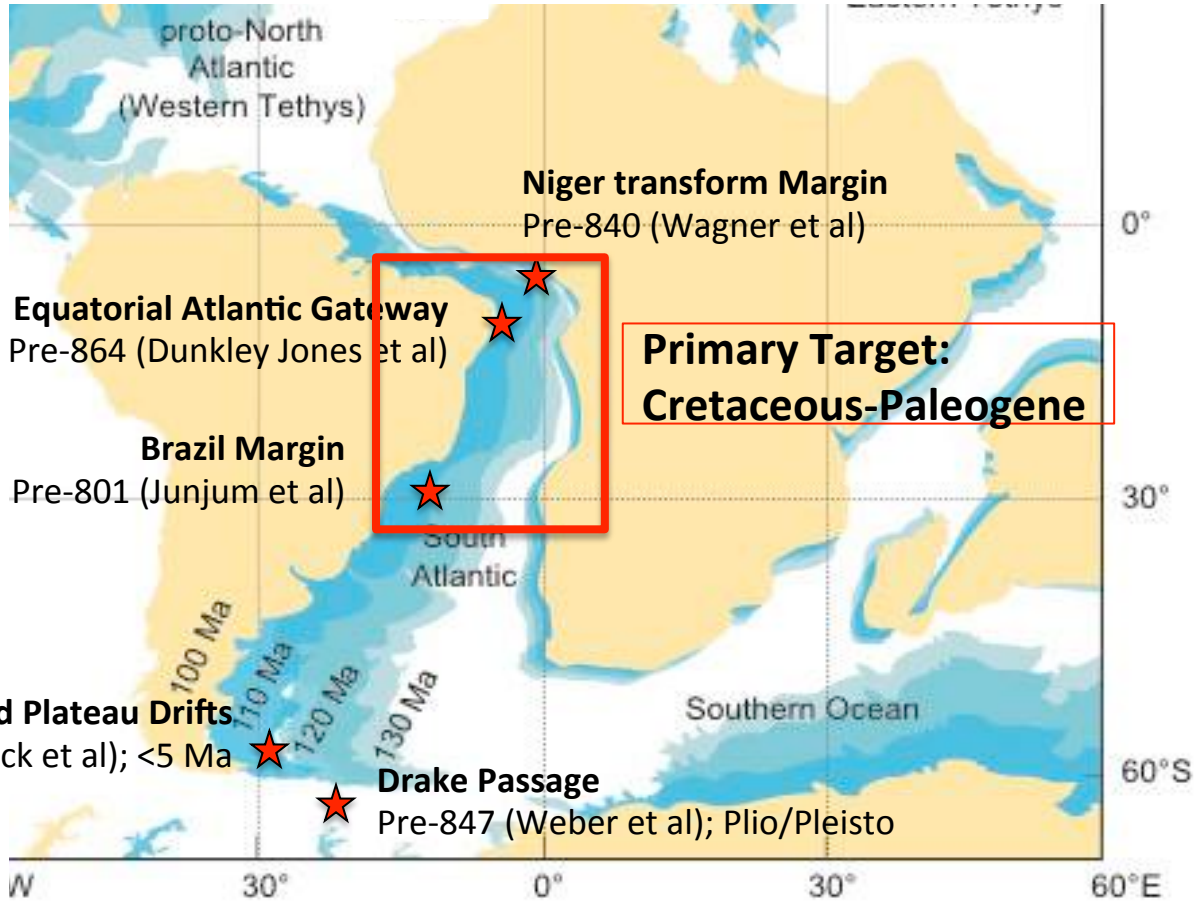
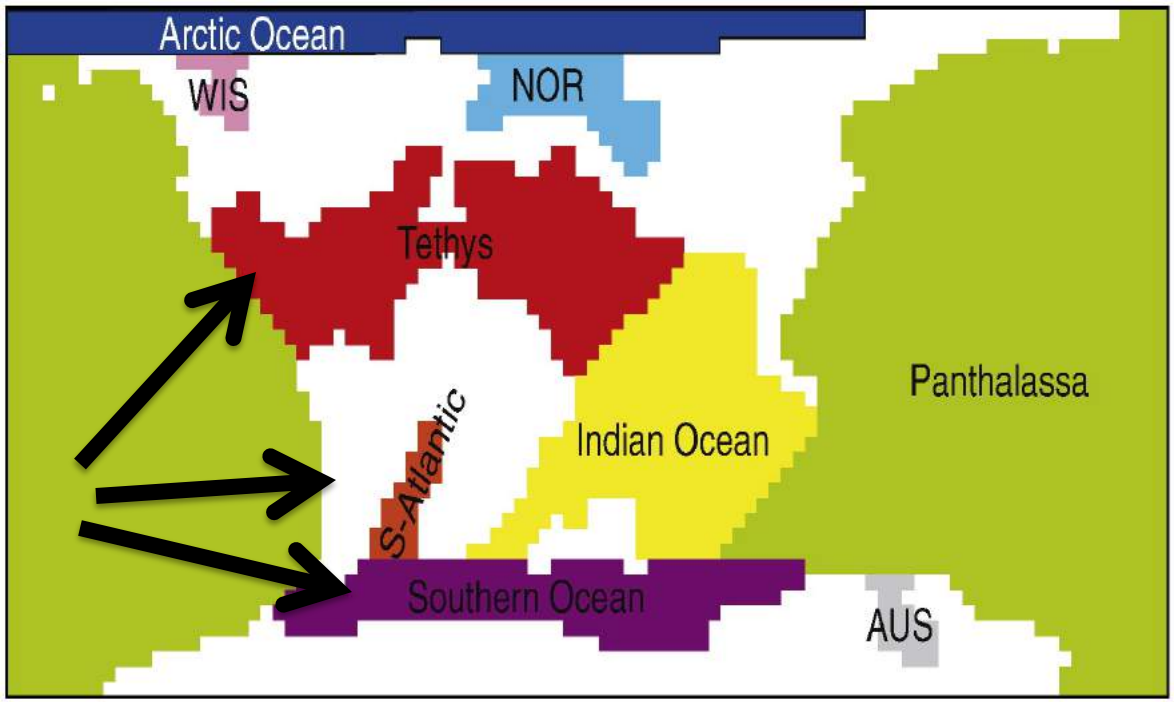
Drilling the South Atlantic



Active drilling proposals in the South Atlantic (Feb 2014)



Enhanced carbon burial in the Cretaceous: a modelling perspective

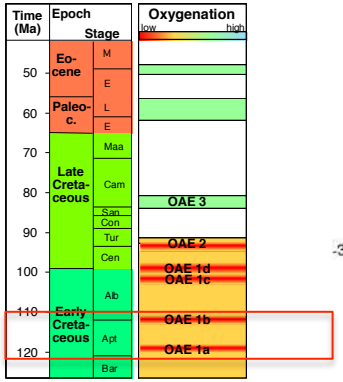


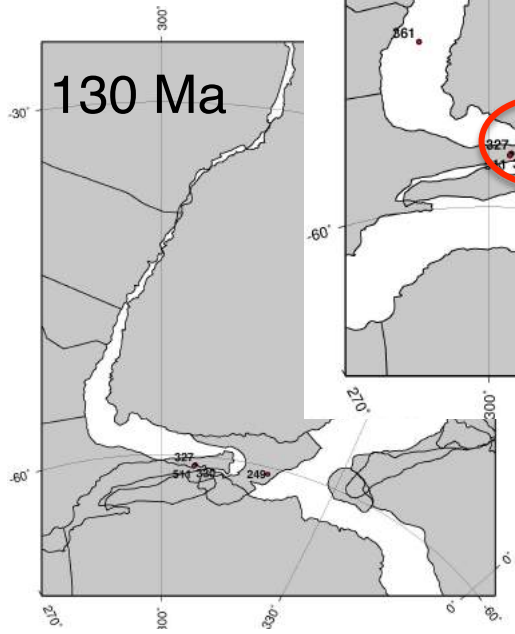
Excess carbon burial occurred preferentially in young ocean basins surrounding Africa and S-America (Gondwana break-up)

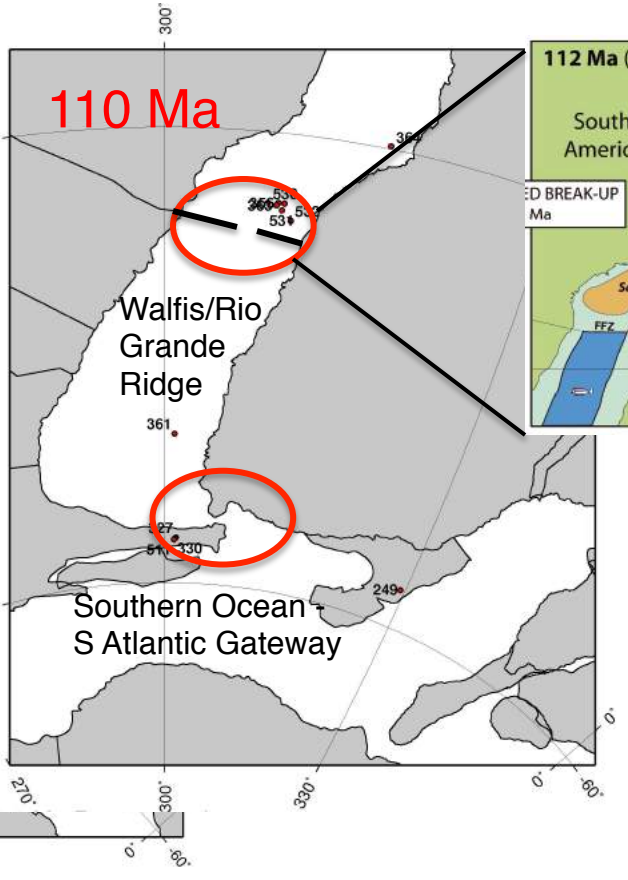
	Area of total ocean (%)	Fraction of global excess carbon burial (%)
Tethys	12	13
South Atlantic	1	16
Southern Ocean	4	19
	28	**48**

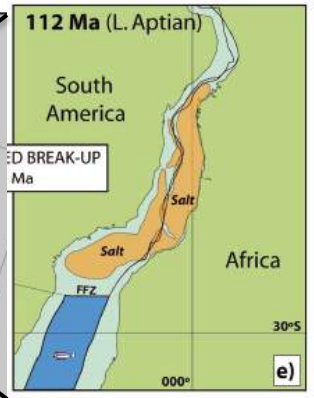
McAnena et al. 2013, *Nature Geosciences*
model from Flögel et al. (2011), *EPSL*

Opening of S Atlantic/Southern Ocean Gateway and initial flooding of northern sub-basin







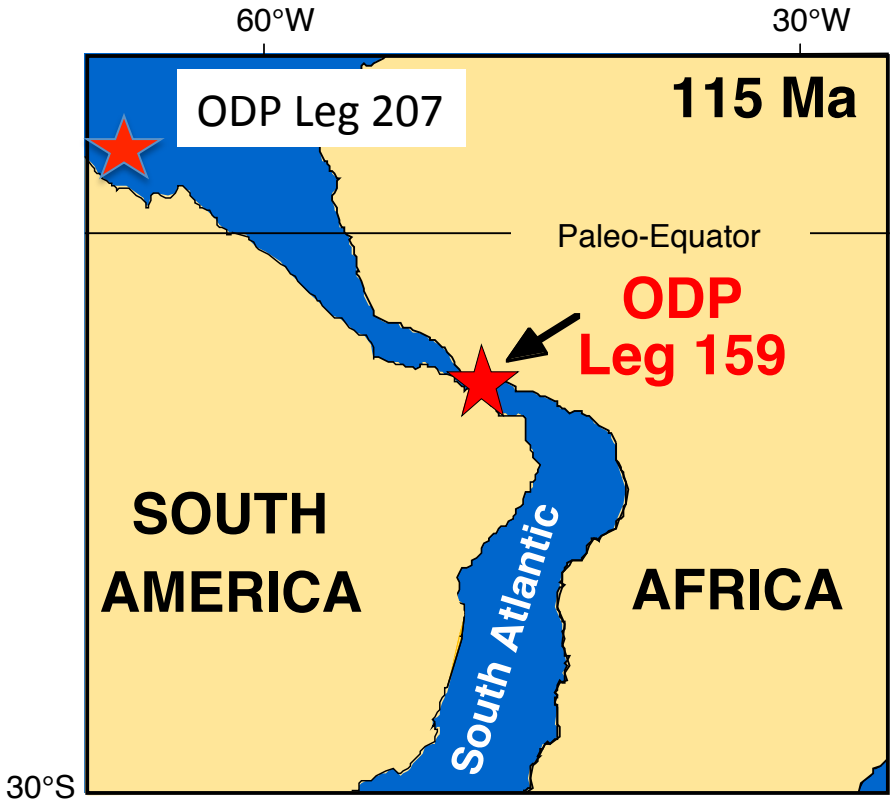


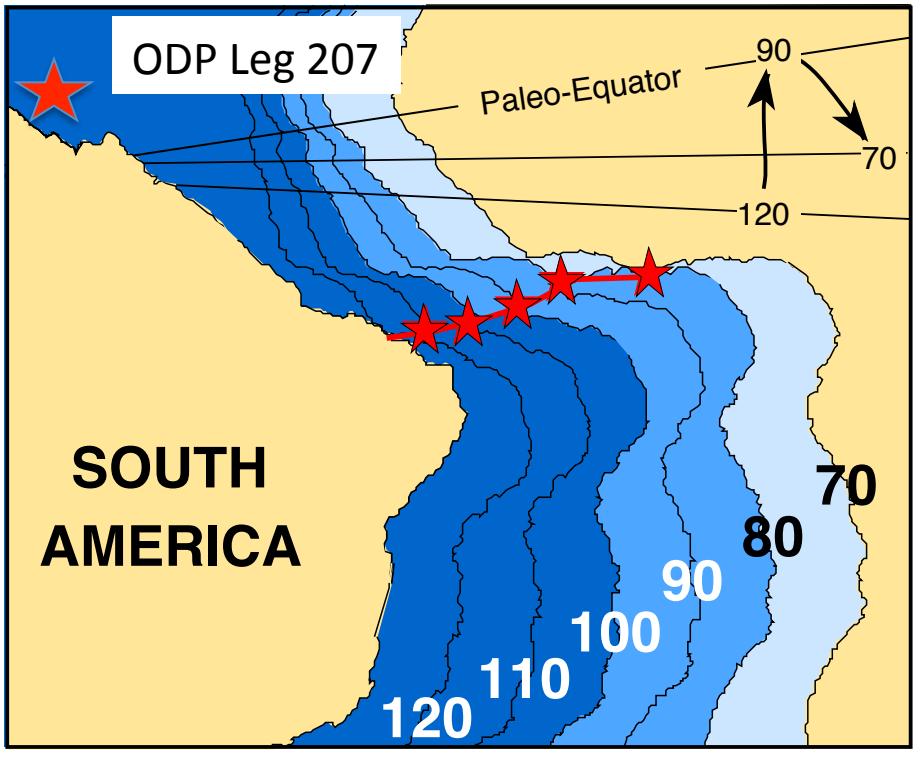
Torswick et al. (2009)

Palaeo-maps from odsn.de

Torswick et al. 2009 (Geophys J Int); Dalziel et al. 2013 (ESR)

Plate reconstructions for the Cretaceous opening of the Equatorial Atlantic





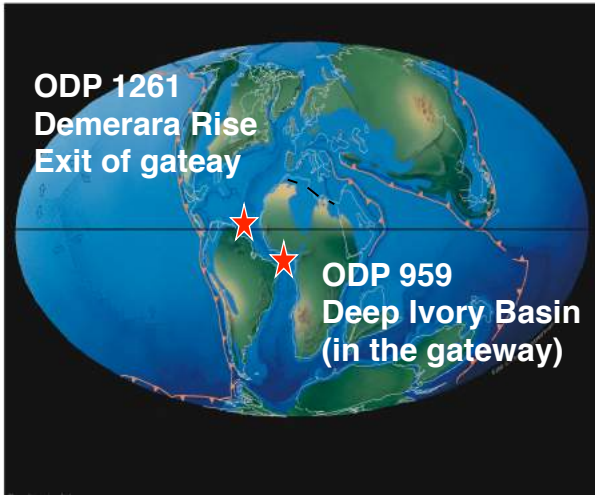
Crustal separation in the late Aptian (Gradstein et al. 1995 time-scale)

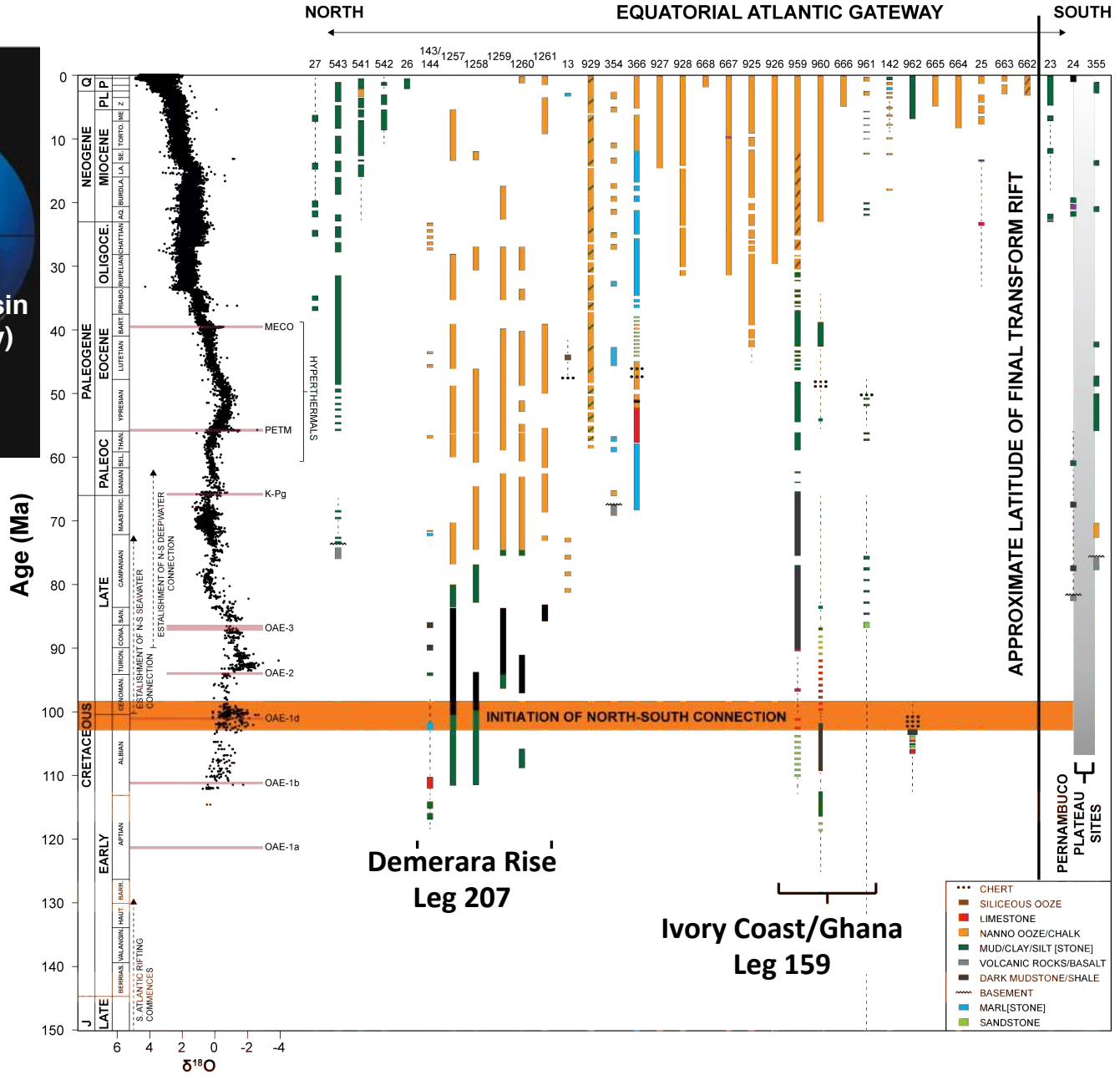
Probably still many obstacles to open circulation until late Albian-Cenomanian (100 Ma)

Interpolated plate motions (Hay et al., 2000)

No palaeomagnetic control within „Cretaceous Quiet Zone“ (120-80 Ma)

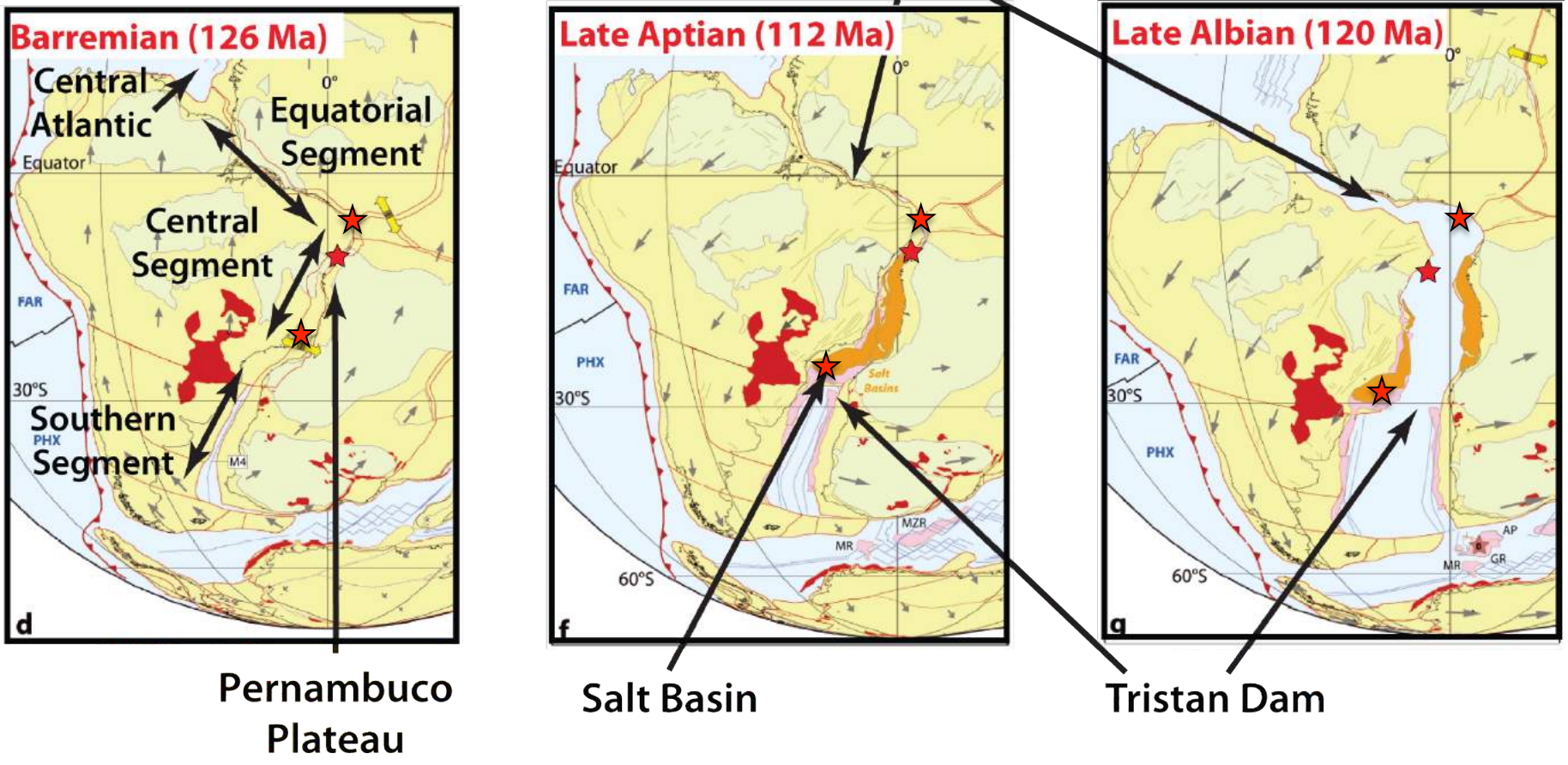
Wagner and Pletsch, 1999, Geological Society of London, Special Publication 153





Compilation from Dunkley Jones, Dickson, et al. (2014); IODP pre-864

South Atlantic Rift Gateway Evolution Scenarios



IODP Proposal Cover Sheet

Brazil Argentina Margin

801 - Pre

Title: Brazil Argentina Margin, Black Shales and Microbiology

Proponents: C. Junium, J. Biddle, A. Sluijs, J. Moura, R. Pancost, S. Shah, V. Edgecomb, K. Billups, H. Christopher, C. Chessi, M. Arthur,

Microbiology/paleocoeanography program that will access Mesozoic and Paleogene age

- Determine whether subsurface life is active or preserved through lipid, molecular and activity studies.
- Understand the usage of carbon by subsurface microbial communities, including organic rich layers of shale to understand how burial and usage coexist and if breakdown of shale influences the deep biosphere
- Enhance the understanding of the mechanisms and biogeochemical impacts of Oceanic Anoxic Events and deposition of organic matter-rich black shales.
- Reconstruct the evolution of the incipient South Atlantic basin from the perspective of the Brazil and Argentina margins.

Four sites, 2 new sites in the Argentine Basin and Margin and reoccupations of successful DSDP Sites in the Brazil Basin and Sao Paulo Plateau

IODP Proposal Cover Sheet

Brazil Argentina Margin

801 - Pre

Title	Brazil Argentina Margin, Black Shales and Microbiology
Proponents	C. Junium, J. Biddle, A. Sluijs, J. Moura, R. Pancost, S. Shah, V. Edgecomb, K. Billups, H. Christopher, C. Chessi, M. Arthur,

Scientific Objectives

1) Determine whether subsurface life is active or preserved through lipid, molecular and activity studies.
2) Understand the usage of carbon by subsurface microbial communities, including organic rich layers of shale to understand how burial and usage coexist and if breakdown of shale influences the deep biosphere
3) Enhance the understanding of the mechanisms and biogeochemical impacts of Oceanic Anoxic Events and deposition of organic matter-rich black shales.
4) Reconstruct the evolution of the incipient South Atlantic basin from the perspective of the Brazil and Argentina margins.

We propose a unique joint microbiology/paleocoeanography expedition that will access Mesozoic and Paleogene age sediments following a north-south transect of the Brazilian and Argentine Margins. This drilling area is of great paleooceanographic interest because it contains record of the opening of the South Atlantic Ocean basin, important geologic events such as Cretaceous Oceanic Anoxic Events and the opening of oceanic gateways during intervals of extreme global warmth. The area is also of interest for subsurface microbiology for two broad reasons. First, subsurface microbiology of the South Atlantic is presently unexplored, and second, deeply-buried organic-rich horizons may fuel a unique subsurface habitat. Organic rich margins have previously been shown to contain abundant subsurface Archaea, and recent results have suggested that archaeal signatures are correlated to total organic carbon content of sediments. However, this result is under scrutiny and new methods are available to use for the examination of new areas of seafloor. The Eastern Margin of South America has been relatively underexplored in the Ocean Drilling Era and has yet to be revisited during the ODP-IODP programs. We propose four sites, 2 new sites in the Argentine Basin and Margin and reoccupations of successful DSDP Sites in the Brazil Basin and Sao Paulo Plateau. In a departure from standard IODP practice we propose that each site be quadruple cored to ensure recovery sufficient for a complete stratigraphy and extensive sampling for microbiology. This proposal addresses Climate and Ocean Change and Biosphere Frontiers of the 2013-2023 IODP Science Plan.

840 –Pre Niger Transform Margin)

Cretaceous Gateway opening and modern deep biosphere dynamics of an active petroleum system

Proponents
Tom Wagner (Newcastle), Jennifer Biddle, Sascha Flögel, Ian Head; Peter Hofmann, Casey Hubert, Christopher Junium, Mark Leckie, Christian März, Ellen Martin, Dick Norris, Jeremy Owens, Julio Sepulveda, Sadat Kolonic and Eric Allison (Shell, Nigeria)

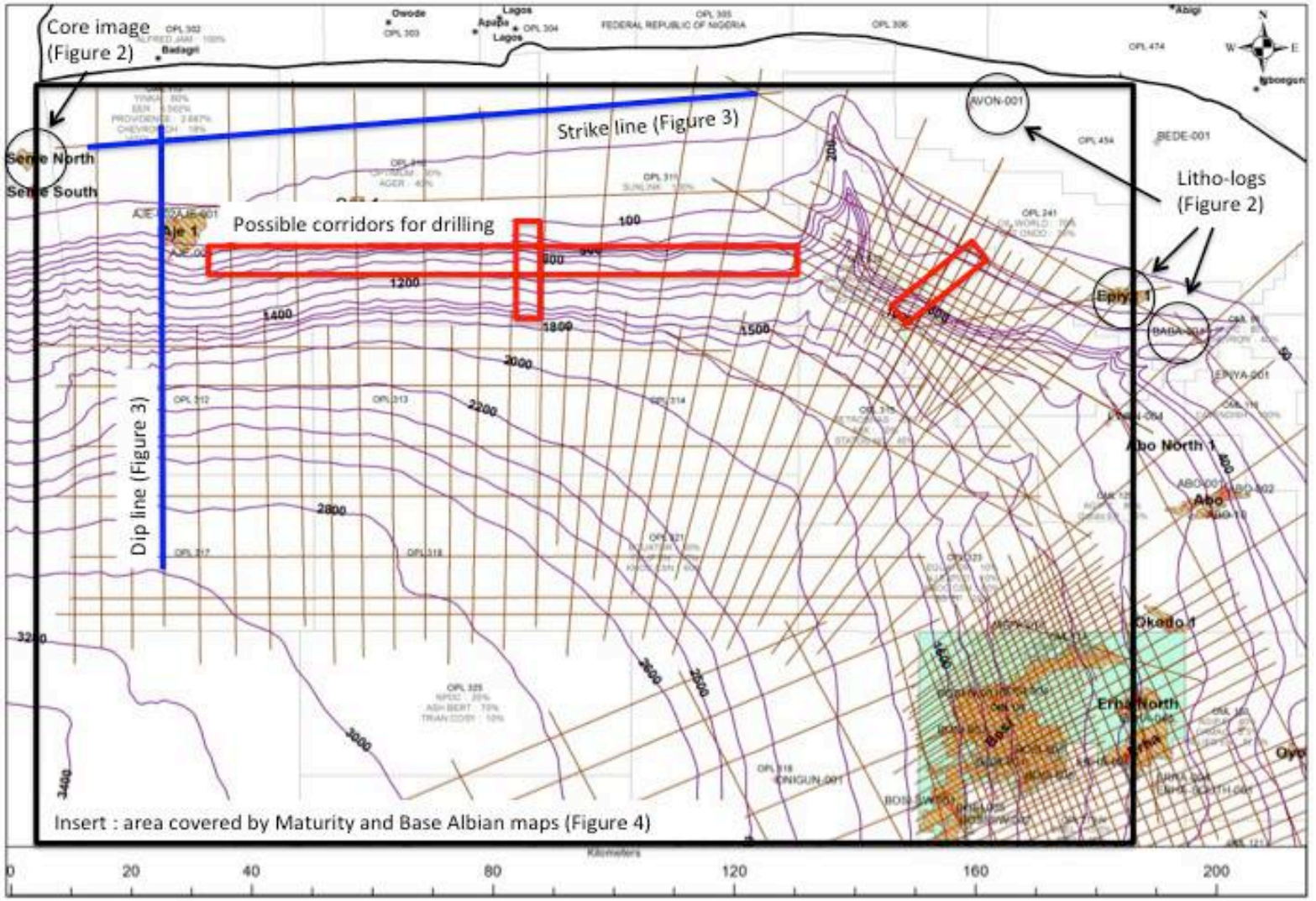
Primary science questions

- Linking paleo-environmental studies with cutting-edge research of an active petroleum system
  - Timing of the opening of the Cretaceous Equatorial Atlantic and the Rio Grande-Walvis Ridge gateways and their consequences for global biogeochemical cycles, black shale formation, tropical precipitation/weathering, and the evolution of marine biota.
  - Constrain the petroleum system deep biosphere by drilling immature Cretaceous (source) and Tertiary (reservoir) successions including fluid migration routes from deeper buried source units – thereby encompassing major components of an active petroleum system.

Secondary science questions

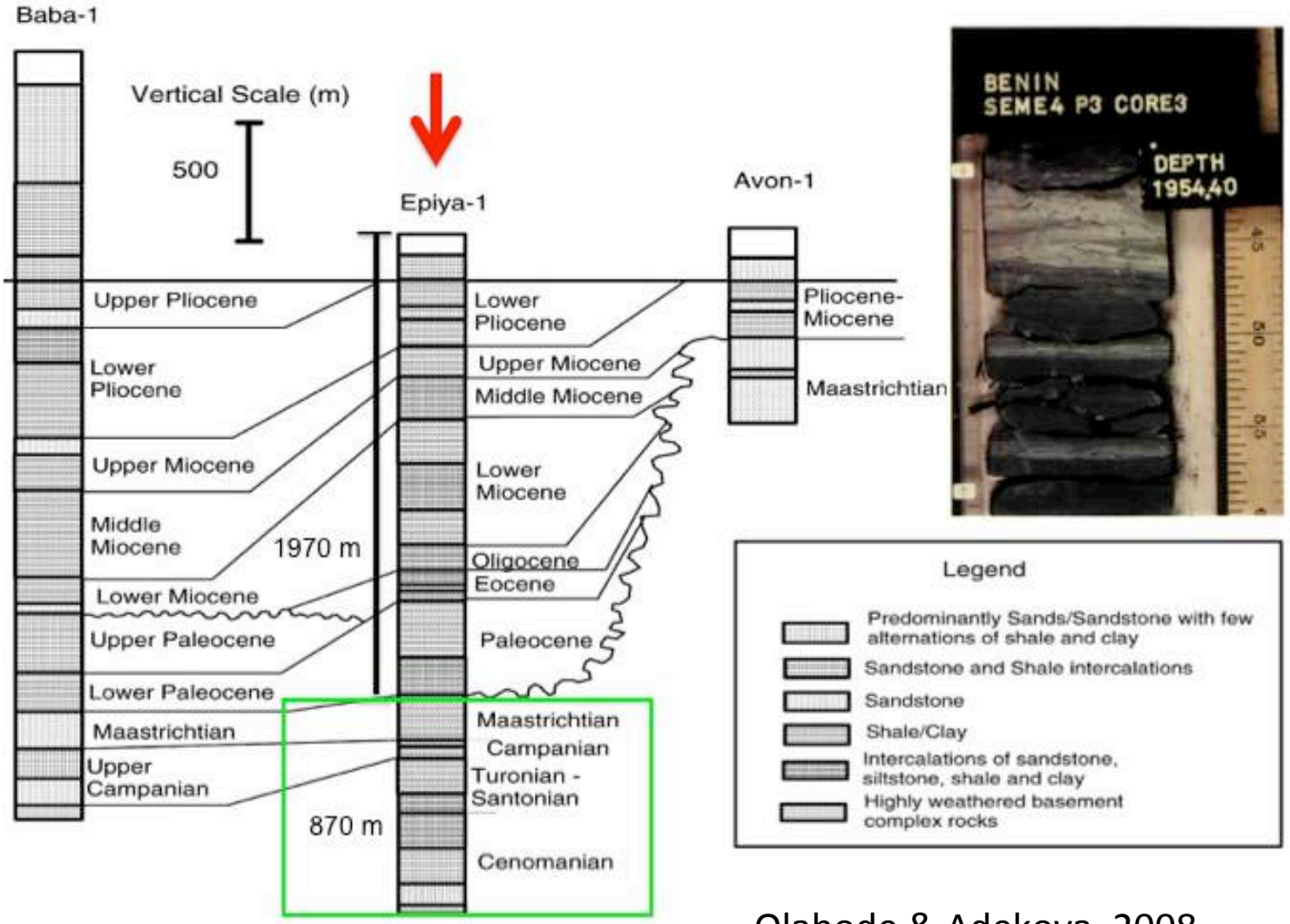
- Miocene-to-Modern sections to contribute to the earth system context for a tropical W-African perspective on
  - Evolution of equatorial upwelling
  - Hominin evolution (NRCs 'Around Africa' initiative: Understanding climate's influence on hominid evolution)

Proposed drilling area



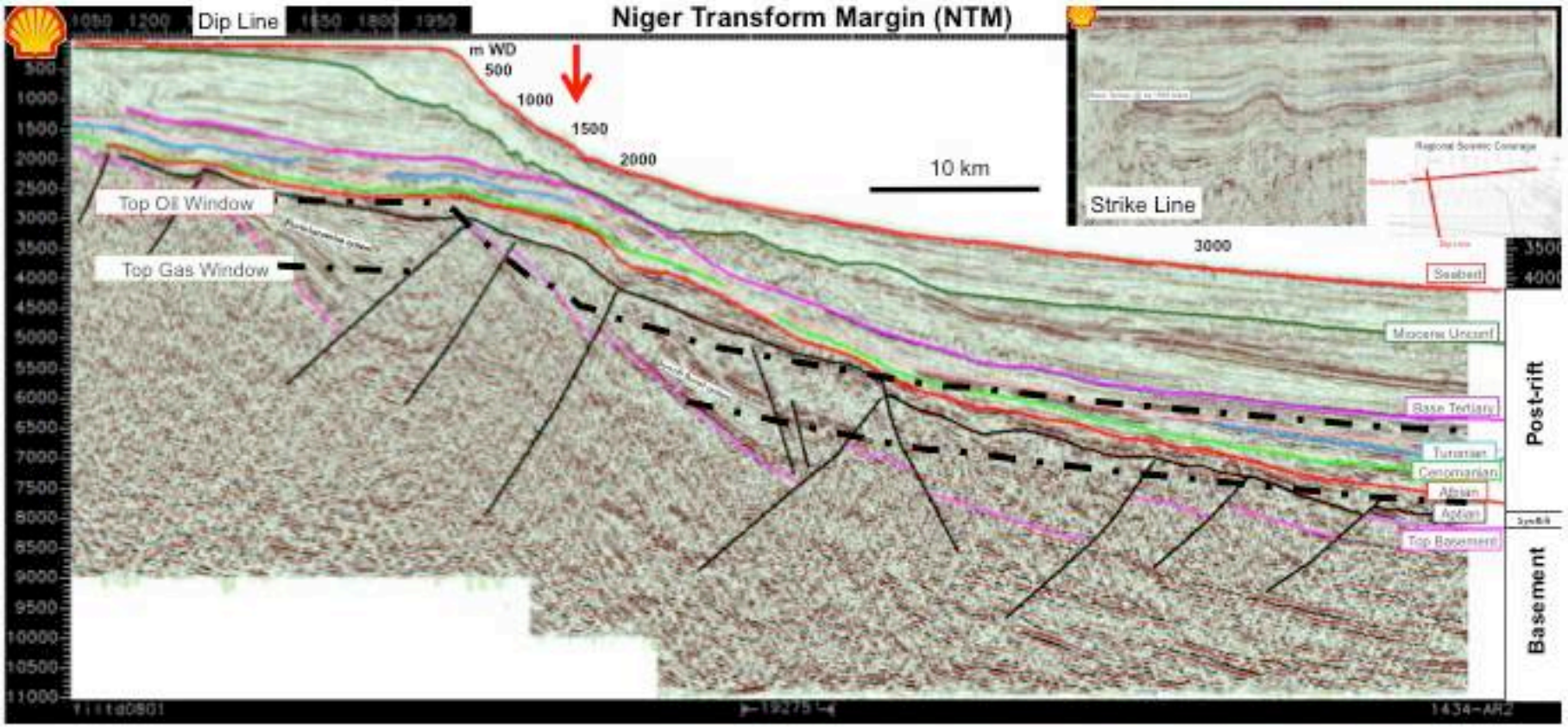
Shell, confidential information

Lithological logs from three wells of the Benin Basin



Olabode & Adekoya, 2008

Seismic dip and strike lines from western part of the Benin Basin



Shell, confidential information

840 –Pre
Niger Transform Margin

Milestones

- Pre-proposal developed in partnership with Shell Nigeria/ Nigerian DPR, in 2013
- Pre-proposal approved by PEP, end 2013
- Potentially identified to develop into a Complementary Project Proposal (CPP).
- Current status: MoU draft from Shell Nigeria ready to be forwarded to IODP; once approved, assessment of Shell database to identify precise drilling locations

Next steps:

- Submission of main proposal: April 2015 (targeted)

Pre-864 Equatorial Atlantic Gateway (*Pernambuco Plateau)*

Origin, Evolution and Palaeoenvironment of the Equatorial Atlantic Gateway

Lead Proponents
Tom Dunkley Jones (Birmingham), Alex Dickson (Oxford) as lead PIs

IODP Proposal Cover Sheet

Equatorial Atlantic Gateway

Pre-864

1 - Pre a

Title	The Origin, Evolution and Palaeoenvironment of the Equatorial Atlantic Gateway
Proponents	T. Dunkley Jones, T. Alves, S. Arndt, J. Bendle, D. Carmo, H. Coxall, A. Dickson, K. Edgar, G. Fauth, S. Fauth, S. Flgel, M. Giorgioni, S. Grimshaw, N. Hayman, S. Jones, L. Jovane, H. Mills, H. Mort, H. Plike, J. Pross, B. Kiel Reese, J. Savian, H. Scher, A. Svartman Dias, T. Wagner, J. Whiteside, J. Zachos,

This proposal seeks to answer first order questions about the tectonic, climatic and biotic evolution of the Equatorial Atlantic Gateway (EAG). We propose to target sequences of Late Cretaceous and Paleogene sediments in NE Brazil, just south of the theorized final opening point of the EAG. These sequences are accessible to conventional, non-riser drilling, on the Pernambuco Plateau, part of the northeastern Brazilian continental shelf. This region was chosen to satisfy two key constraints that other regions in Equatorial Brazil could not meet; first, the Pernambuco Plateau records the basal Cenomanian marine incursion into the South Atlantic at depths shallow enough to be recovered by non-riser drilling; second, Late Cretaceous and Paleogene sediments are close enough to the continental margin to provide both well-preserved organic biomarkers and calcareous microfossils for multi-proxy studies of greenhouse climate states. New records in this region will allow us to address scientific questions within four themes: (i) to determine the timing and oceanic-source (N. Atlantic v. Southern Ocean) of the South Atlantic flood event and use post-flood water-depth estimates to constrain models of depth-dependent lithospheric stretching; (ii) to generate multi-proxy records of tropical marine and terrestrial climates under conditions of extreme warmth; (iii) to test the resilience of tropical ecosystems and biotas to major environmental perturbations, including Oceanic Anoxic Events (OAE 2&3), the end-Cretaceous mass extinction, early Paleogene hyperthermals and the greenhouse/icehouse transition; and, (iv) to understand the processes controlling deep biosphere communities, especially in regions with extensive and deeply buried organic material.

Pernambuco Plateau - Main science questions

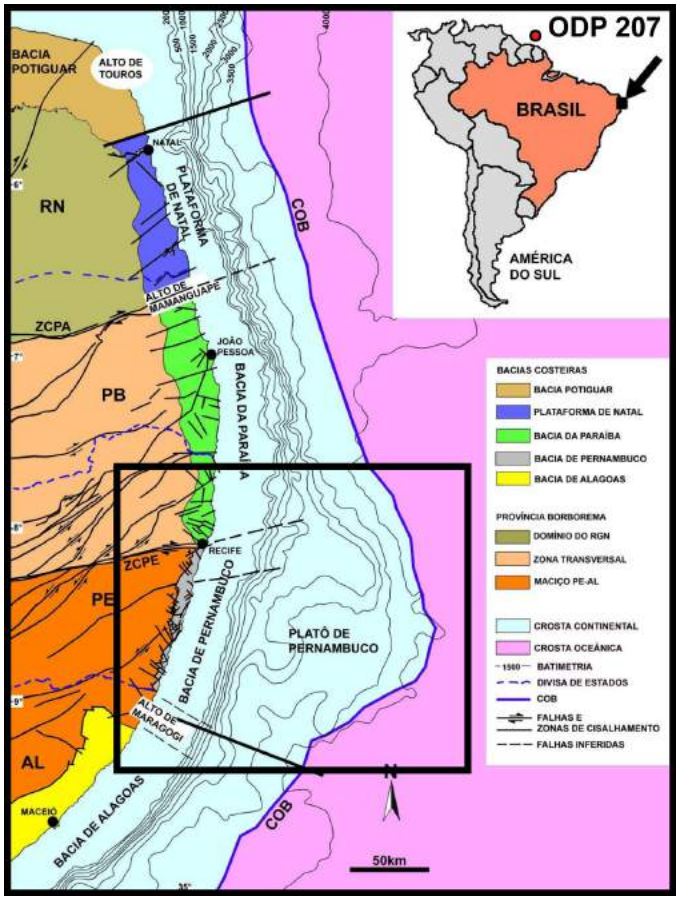
(i) Timing and oceanic-source of the South Atlantic flood event and use post-flood water-depth estimates to constrain models of depth-dependent lithospheric stretching;

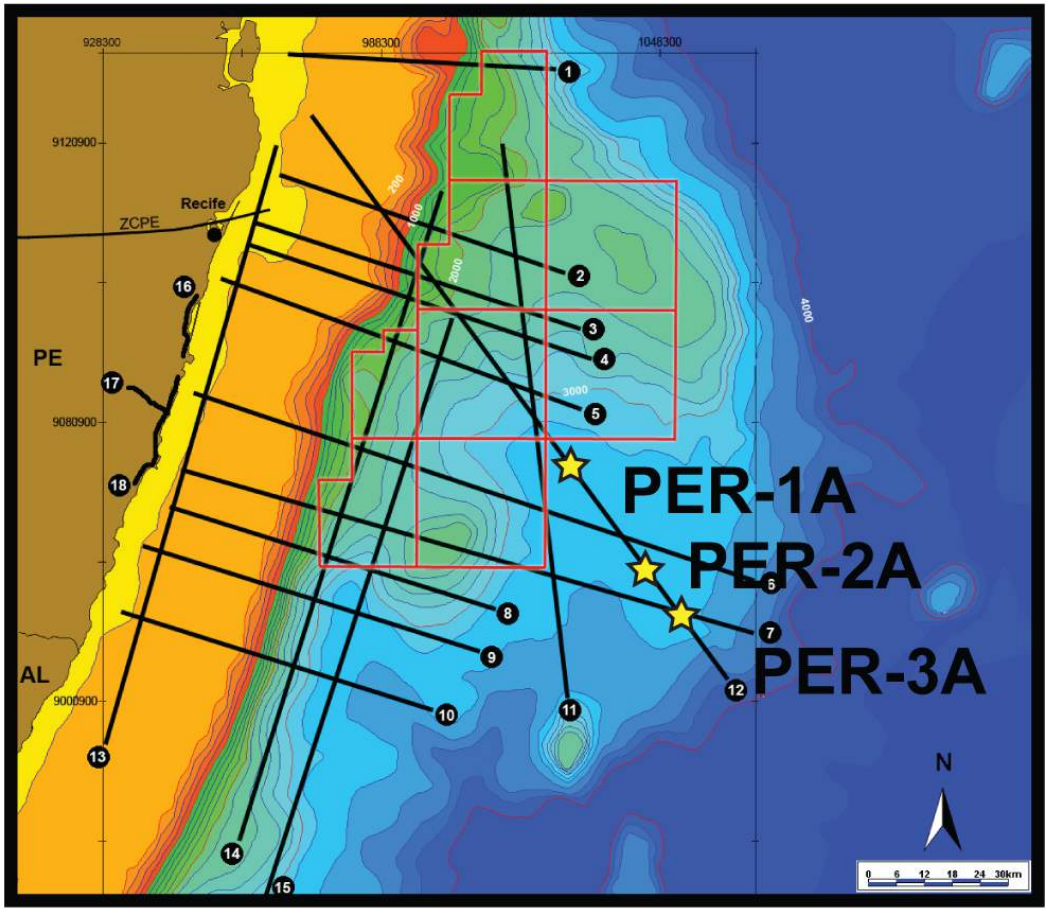
(ii) Multi-proxy records of tropical climates under conditions of extreme warmth;

(iii) Test the resilience of tropical ecosystems to major environmental perturbations (OAEs, K/Pg, PETM);

(iv) Deep biosphere communities in regions with extensive deeply-buried organics.

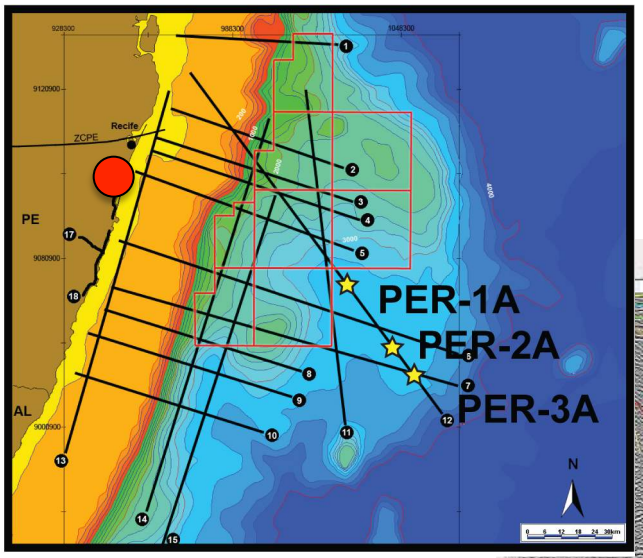
Pre-864 Pernambuco Plateau

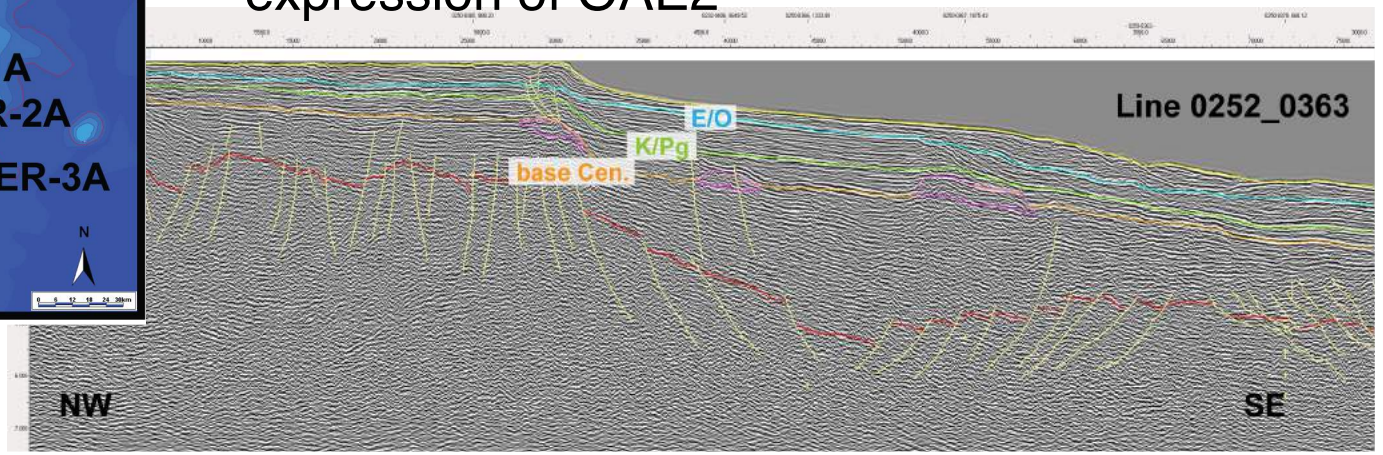




Pernambuco Plateau drilling targets:

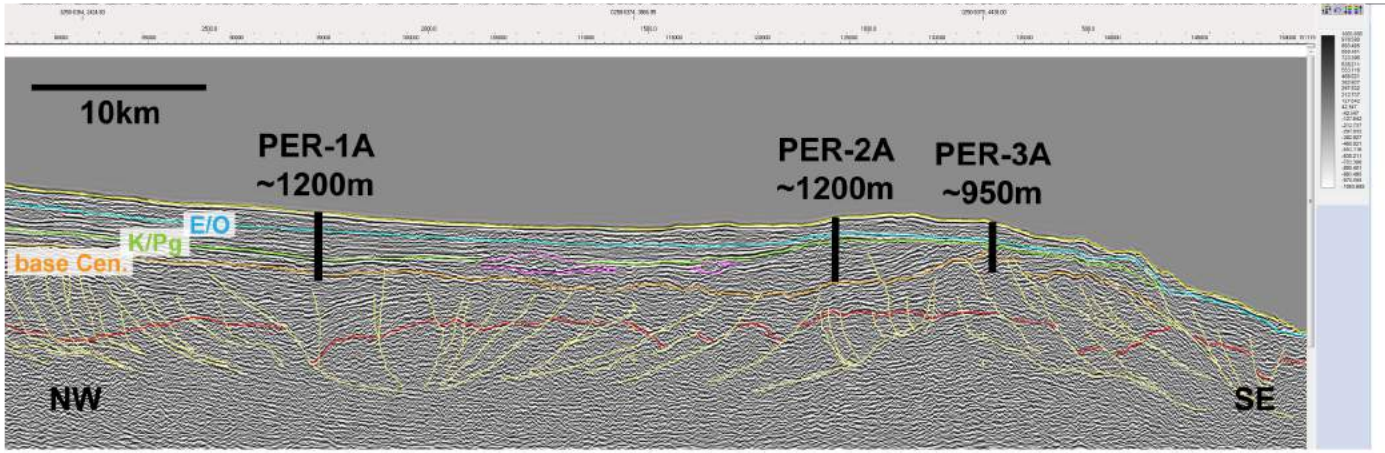
- Top Albian/base Cenomanian marine incursion
- Expanded Late Cretaceous and early Paleogene hemipelagic marls for multi-proxy climate record
- Microbiological, pore-water and sediment sampling down to and through eq. Atlantic expression of OAE2





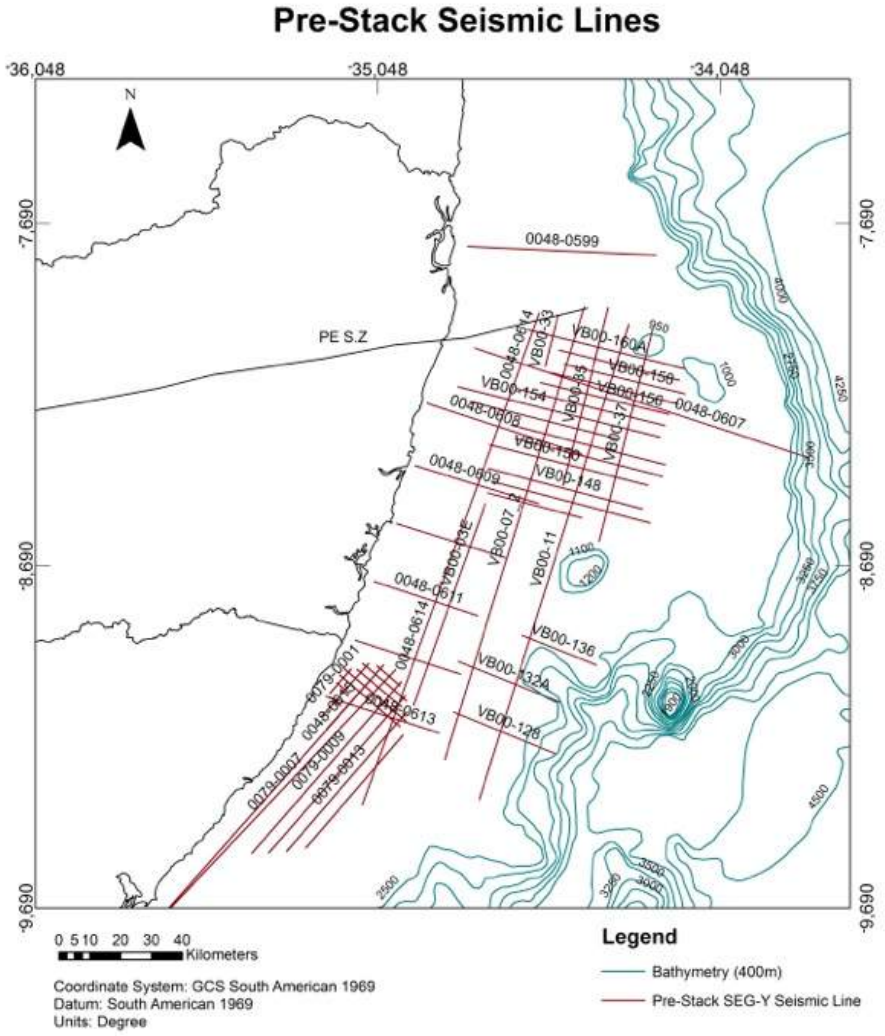
Main challenges:

- Correlation of confirmed lithological units to seismic lines;
- Industry supported needed !

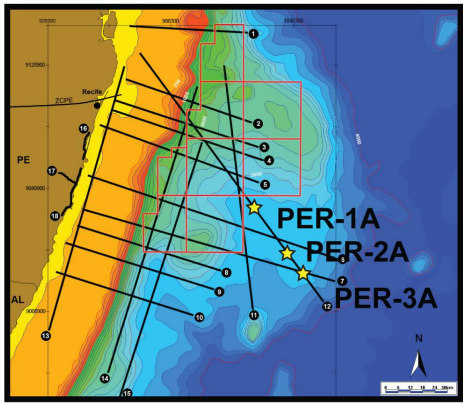


Pernambuco Plateau

Strong industry engagement secured



- National data repository (Bdep) providing historic seismic data;
- Recent ION GX survey of Pernambuco Plateau;
- Industry co-investment in site survey (spot coring), seismic acquisition, data integration and scientific drilling.



864 –Pre Pernambuco Basin

Milestones

- IODP-BEM workshop (Maresias – Sao Paulo, 4-6 Feb 2014)
- Pre-proposal developed April-May 2014 at Birmingham meeting , with strong BG Group contribution
- Pre-proposal recently submitted to IODP
- Identified as potentially Complementary Project Proposal (CPP)

Next steps:

- Pre-proposal to be assessed by PEP, end 2014
- Submission of main proposal: April 2015, depending on PEP feedback

What can we expect from these new South Atlantic proposals ?

- Better constrain (and predict) geological and climatic boundary conditions for source rock formation on the conjugate Atlantic continental margins
- High resolution records of tropical (monsoonal) and subtropical (trade wind) forcing during greenhouse conditions
- Improved understanding of internal heterogeneities of black shale units – critical variables of unconventionals (shale gas/shale oil)
- Linking deep biosphere, subsurface source rocks, and producing HC systems
- Testing Rift Scenarios for evolution of passive margins (depth-independent vs depth-dependent stretching models)

Drilling the South Atlantic Cretaceous is on a good way… but further detailed planning is essential to realize multiple drilling legs in 17/18

Industry support will be essential to realize this program