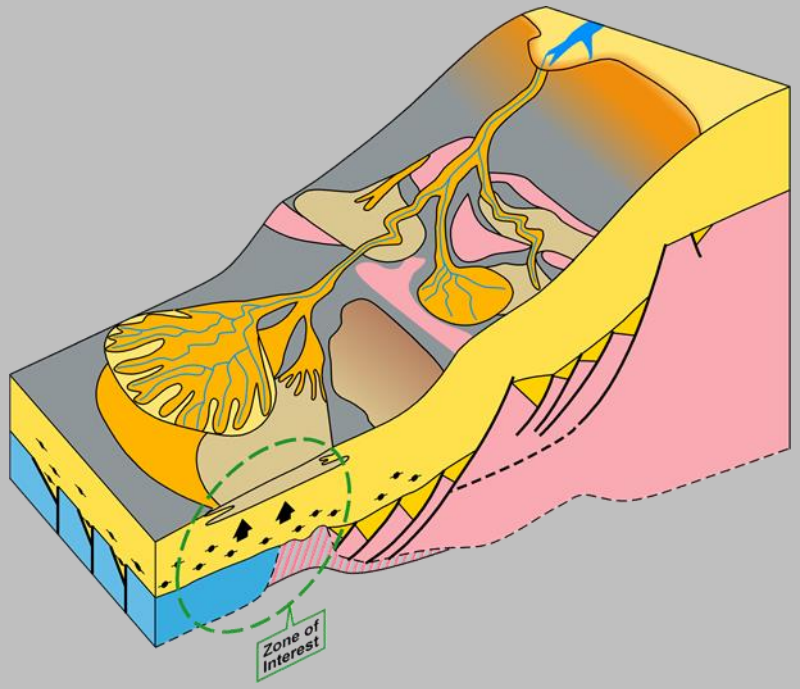
Oceanic Crust Exploration Project

OCEP – 'West Africa': Source Rock Occurrence & Maturity in the West African Distal Domain

Project Outline (September 2019)



SUBSURFACE RESOURCE CONSULTING

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INTEGRATED GEOCHEMICAL INTERPRETATION
IGI

Oceanic Crust Exploration Project
Aims and Objectives

As exploration extends into deeper waters there is an ever increasing need to improve our understanding of the sedimentary, tectonic and thermal conditions operating on oceanic crust. The SRC/IGI/Bridgeporth **Oceanic Crust Exploration Projects** are designed to answer the key questions surrounding exploration on oceanic crust viz. source rock occurrence, thermal history and structural development.

The first of these projects is aimed at the West African passive margin of the South Atlantic (**OCEP – 'West Africa': Source Rock Occurrence & Maturity in the West African Distal Domain**).

Oceanic Crust Exploration Project
Aims and Objectives

The initial phase of work on **OCEP – 'West Africa'** has already been completed and is available for licensing. This has included fieldwork and a thorough literature review and database compilation exercise as follows:

- Review of biostratigraphy of 15 DSDP/ODP sites
- Review and databasing of geochemistry data from 30 DSDP/ODP sites
- Review of thermal history and thermal calibration using DSDP data
- Examination and sampling/analysis of Mesozoic sections exposed on Fuerteventura (Canary Is.) and Maio (Cape Verde Is.)

Oceanic Crust Exploration Project
Technical Database

The research has included a review and re-evaluation of data from selected DSDP/ODP boreholes along the West African margin between Morocco and South Africa. *All sites are located in the 'Distal Domain' and most are on oceanic crust*. In addition, field visits have been undertaken to the islands of Fuerteventura and Maio where oceanic crust is exposed.

While DSDP/ODP data are in the public domain, the compilation and databasing of all analytical results in this project has been a major undertaking and the original data have been substantially re-evaluated, leading to significant new information on the habitat of source rocks on oceanic crust.

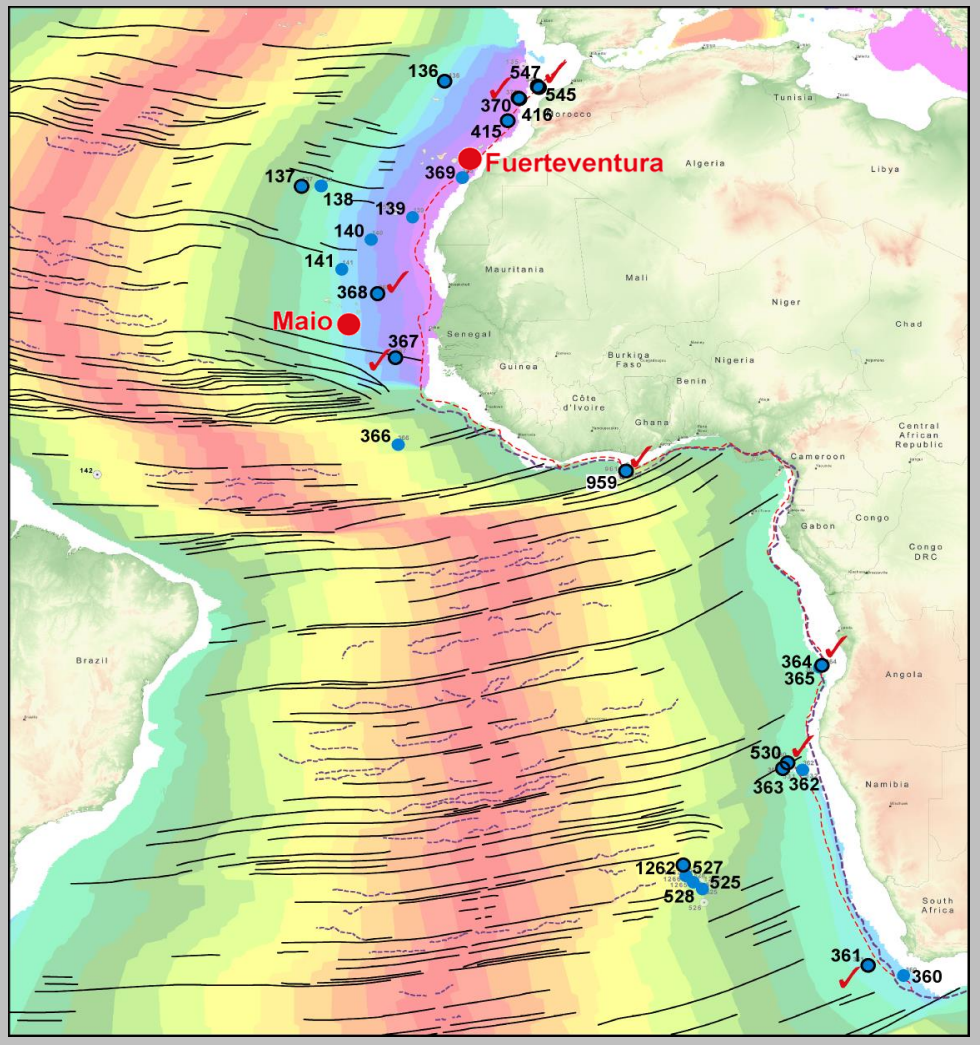
Seismic data and potential field data (public domain and provided by seismic contractors / government agencies) are now being used to extend the research away from DSDP/ODP borehole control in the distal domain to the proximal continental margin.

Oceanic Crust Exploration Project
Technical Database

Field visits, sampling and analytical work – Fuerteventura and Maio

DSDP/ODP sites selected on basis of:

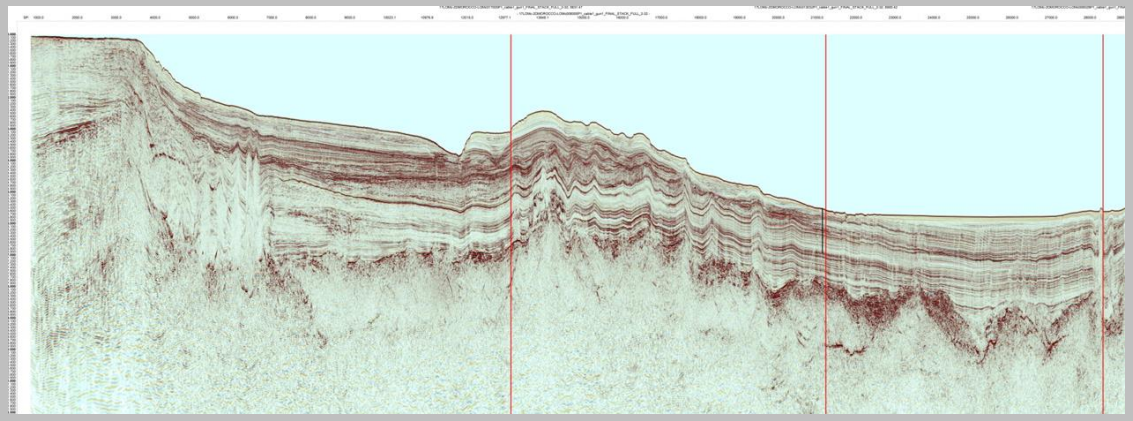
- Significant Mesozoic section penetrated
- Geographic spread
- Occurrence of recognised organic intervals



Oceanic Crust Exploration Project Technical Database

Seismic database has been established, using:

- Modern MC2D data (Geoex, discussions ongoing with other companies)
- Government Agencies (ongoing discussions with Sonangol, Petroleum Commission, Namcor, PASA)
- Published and Academic data (NOAA, UNCLOS, IEDA, etc)



OECP West Africa
Summary Work Schedule

2014 | 2017-18 | 2019 | 2020

Database creation and management

- Biostratigraphy
- Geochemistry (p:IGI)
- 1D Model calibration
- Seismic (Kingdom)
- GIS (ESRI)

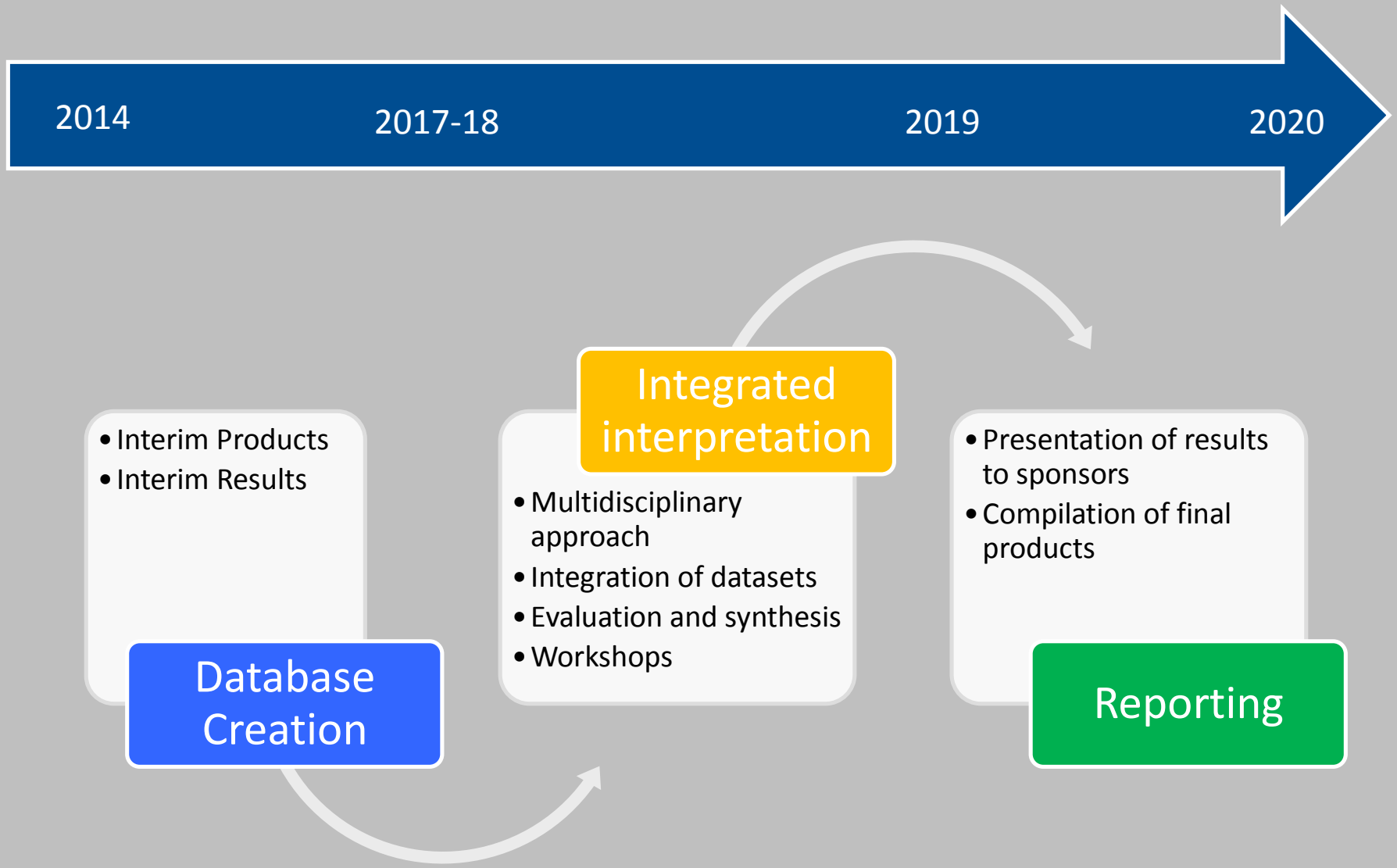
Data evaluation and modelling

- 1D and 2D basin modelling
- 2D and 3D potential field modelling
- Seismic interpretation

Final Reporting

- Integrated Technical Report
- Technical Database

OECP West Africa
Summary Work Schedule



OECP West Africa

Interim Deliverables Currently Available

- Review of biostratigraphy of 15 DSDP/ODP sites
- Review and databasing of geochemistry data from 30 DSDP/ODP sites
- Preliminary Geochemical Interpretation and 1D Thermal/Basin Modelling
- Review of thermal history and thermal calibration using DSDP data
- Examination and sampling/analysis of Mesozoic sections exposed on Fuerteventura (Canary Is.) and Maio (Cape Verde Is.)

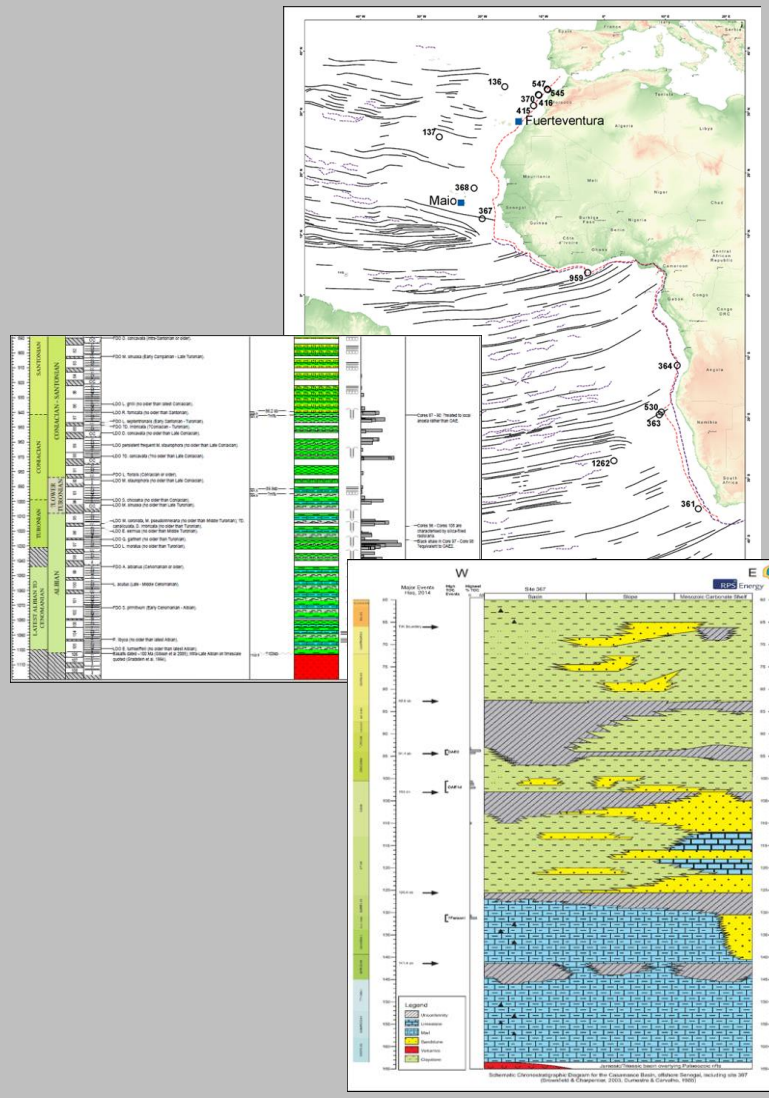
OECP West Africa
Biostratigraphic Review and Database

Biostratigraphic Review completed for 15 sites.
Data/disciplines reviewed: Macropalaeontology (ammonites, bivalves), Micropalaeontology (foraminifera, radiolaria and calpionellids), Nannofossils, Palynology (dinocysts and miospores) and Lithologies.

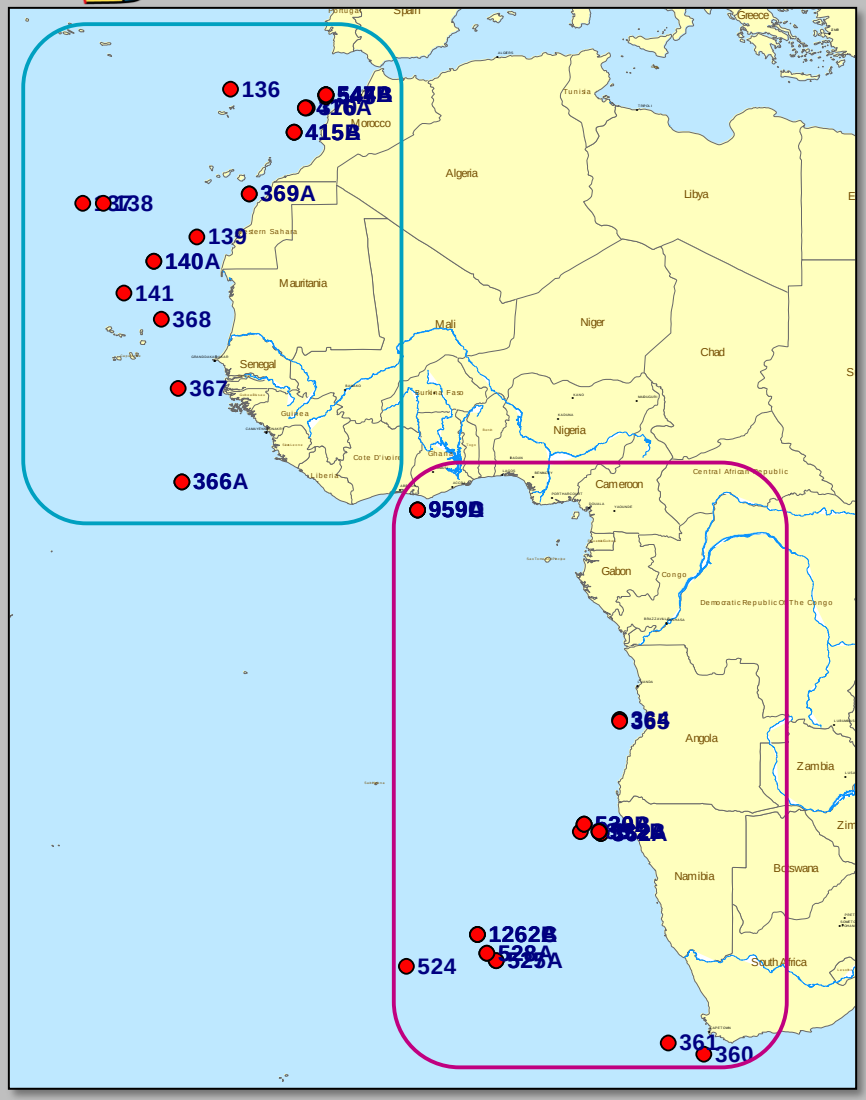
Revised Stratigraphy for each site.

Technical Report plus, for each site, large-scale summary charts and smaller A3 summaries are provided, which show:

- Core distribution against depth of penetration
- Core lithologies and any sedimentary structures
- Original and updated stratigraphic breakdowns
- Major stratigraphic breaks/unconformities – usually related to major sequence boundaries
- TOC values from the geochemical database



OECP West Africa Geochemical Database



Northern sector

Leg 14: Sites 136, 137, 138, 139, 140, 140A, 141
Leg 41: Sites 366, 366A, 367, 368, 369, 369A, 370
Leg 50: Sites 415, 415A, 415B, 416, 416A
Leg 79: Sites 544A, 544B, 545, 547, 547A, 547B

Southern sector

Leg 40: Sites 360, 361, 362, 362A, 363, 364, 365
Leg 73: Site 524
Leg 74: Sites 525A, 527, 528, 528A
Leg 75: Sites 530, 530A, 530B, 532, 532A, 532B
Leg 159: Sites 959, 959A, 959C, 959D
Leg 208: Sites 1262A, 1262B, 1262C

Key sites

Underlined sites are defined as '**key sites**'. These are DSDP/ODP boreholes for which a new evaluation of biostratigraphic data has been completed. This results in an improved resolution and age revision for chronostratigraphic divisions in each of the sites.

A bibliography of all sources used to collect raw data for the DSDP/ODP geochemical database is available as a separate word document

Geochemical data were obtained from DSDP/ODP online database and various literature sources

OECP West Africa
Geochemical Database

Shipboard geochemical data (TOC & Rock Eval pyrolysis) from DSDP & ODP online datasets and pdfs of Initial Reports volumes
Additional geochemical data from other publications, either in DSDP/ODP volumes (Scientific Results) and papers published elsewhere
Data for: **7600 samples from 30 DSDP/ODP sites** (Morocco to South Africa)

Data types:	Total Organic Carbon content	7052 samples
	Rock Eval pyrolysis	>1300 samples
	Vitrinite Reflectance	102 samples (& 90 TAI)
	Kerogen stable carbon isotopes	533 samples (& 245 extracts)

Geochemical database

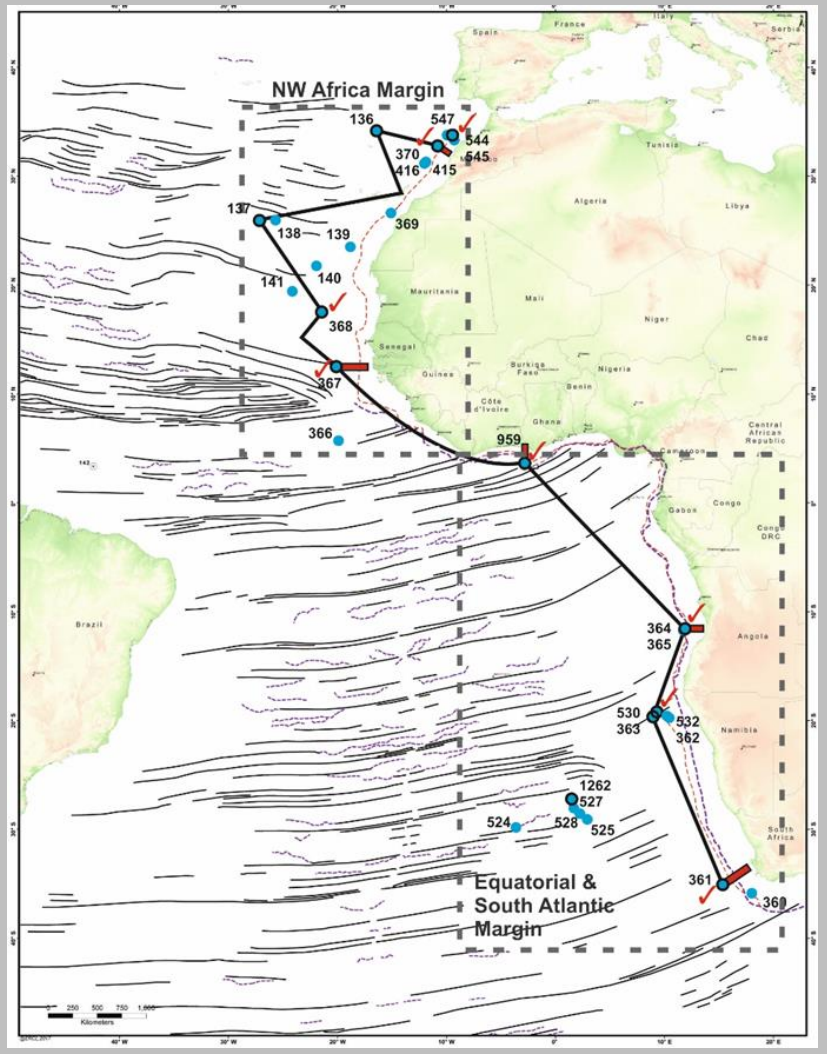
- p:IGI-3 & Excel formats
- Technical notes on database compilation
- Database bibliography (data sources)

PowerPoint overview

OECP West Africa

Preliminary Geochemical Interpretation and 1D Thermal/Basin Modelling on Oceanic Crust - Calibration

- 7 DSDP and 1 ODP sites were selected, capturing the wide range of tectonic settings and thermal regimes along the margin.
- The litho-stratigraphy of the well models is based on the revised stratigraphy, and the source rocks defined in agreement with the geochemistry interpretation.
- The setup of the thermal models took into account the available regional constraints, which include the structure of the crust/lithosphere and Heat Flow
- The available constraints for the geothermal gradients at the drill sites (i.e. temperature and maturity data) are scarce, and in most places non-existent.
- Plausible tectonic/thermal scenarios were tested at each location and the model predictions compared with published heat flow data.



OECP West Africa - Interim Project Deliverables Currently Available

Project delivered in electronic format on DVD or USB stick

Available now - delivery immediate upon signature of a standard non-exclusive data licence agreement with SRC.

Section 1	**Report Introduction**
Section 2	**Introduction to Oceanic Anoxic Events**
Section 3	**Biostratigraphy**
Section 4	**Technical Notes on Geochemistry Database**
Section 5	**Geochemical Interpretation**
Section 6	**Thermal History and Basin Modelling**
Appendix	**Geochemistry Database (in p:IGI and Excel formats)**

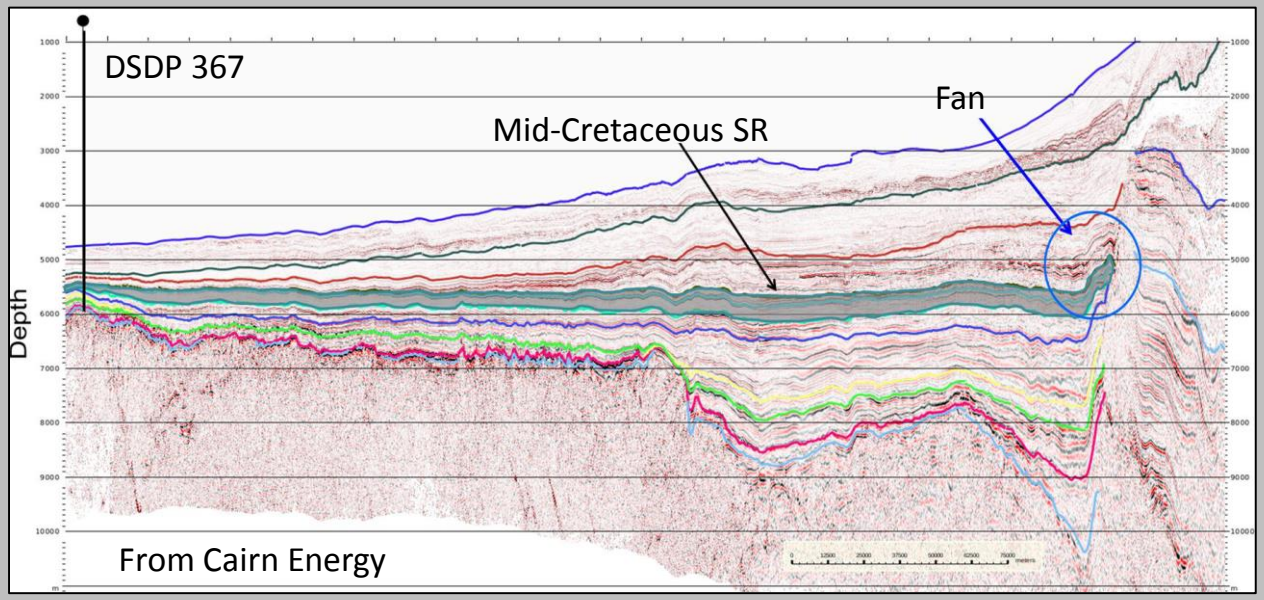
OECP West Africa
Ongoing Research Work

The ongoing interpretation phase of the project will use the results from the database build and review and will incorporate the interpretation of public domain geophysical data (potential field and seismic) to:

- ✓ Synthesise the stratigraphy of the Distal Domain to ascertain the context of organic-rich intervals (ORIs)
- ✓ Evaluate the geochemistry of the ORIs as commercial source rocks
- ✓ Investigate lithospheric/crustal structure to provide critical control for structural interpretation and basin modelling
- ✓ Determine thermal (maturity) history of source rocks by 1D and 2D basin modelling

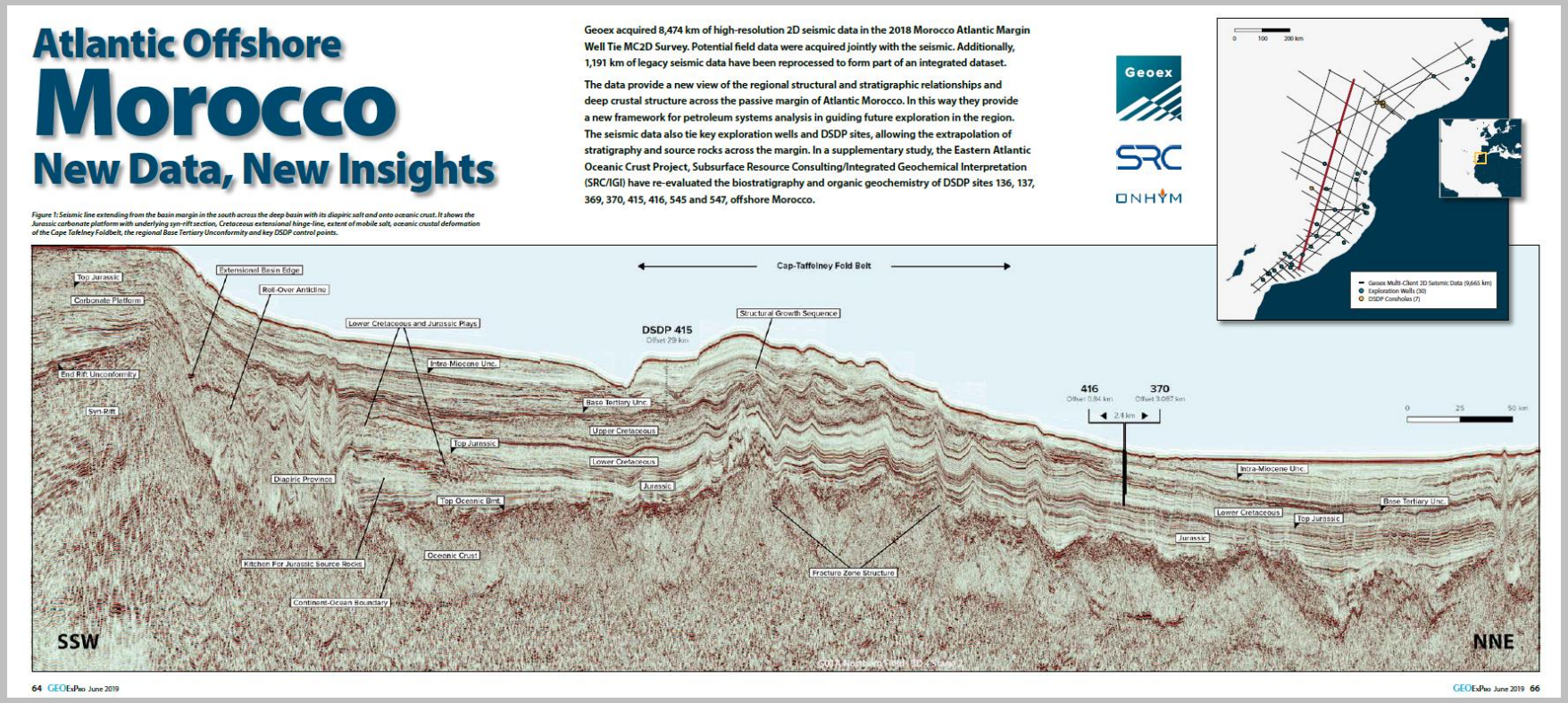
OECP West Africa
Source Rock Extrapolation

- Interpret stratigraphy of ‘Distal Domain’ as framework for correlation of ‘drift’ ORIs/potential source rocks.
- Seismic stratigraphic interpretation for extrapolation of ORIs/potential source rocks.
- 10 regional sections envisaged



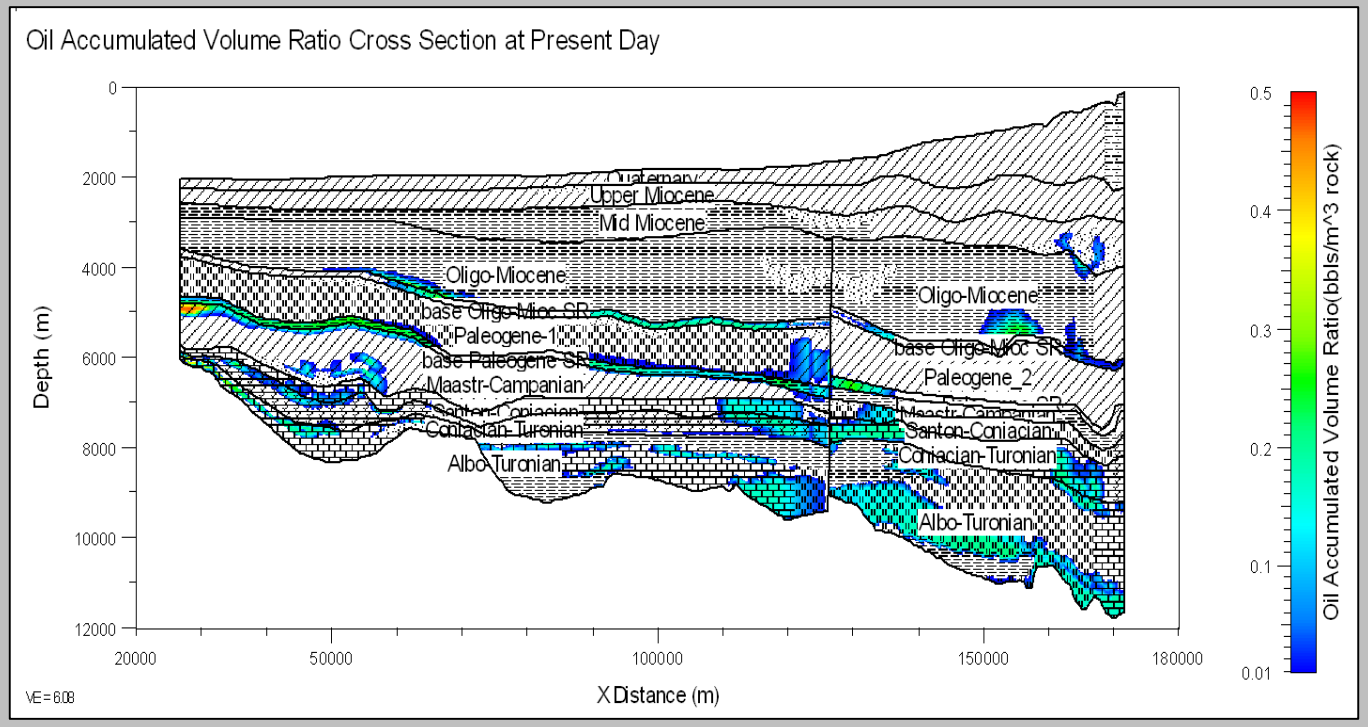
OECP West Africa
Structural Interpretation

- Interpretation of crustal structure/architecture, and 'reactivation structure'
- Potential field modelling (2D and 3D models)



OECP West Africa
Maturity Extrapolation

- Constrain 1D and 2D basin modelling from the control points towards the LLOC.
- 10 transects envisaged for modelling



Future Project Deliverables
Results of Ongoing Interpretation & Research

Project to be delivered in electronic format on DVD or USB stick

Subject to signature of a standard non-exclusive data licence agreement with SRC.

The research final deliverables will include:

Section 1	**Introduction**
Section 2	**Seismic Structural and Stratigraphic Interpretation, Source Rock Extrapolation, ORI Development and Extent**
Section 3	**Structure and Architecture of the transitional-to-oceanic crustal zone**
Section 4	**Geochemical Interpretation and Synthesis of Source Rocks in Distal and Proximal Domain**
Section 5	**Maturity Modelling and Mapping**
Section 6	**Integration of Studies**
Section 7	**Summary and Conclusions**

Oceanic Crust Exploration Project Accompanying Technical Notes

Here we provide a flavour of the ongoing research investigations into oceanic crust exploration being undertaken by SRC, IGI and Bridgeporth and early results obtained:

- **Source Rocks**

- Thick ORIs are developed in DSDP core-holes in the Jurassic, Aptian, Albian, Cenomanian-Turonian and Coniacian not restricted to OAEs.

- Geochemistry indicates that ORIs are dominantly oil-prone and represent good commercial source rocks.

Oceanic Crust Exploration Project
Accompanying Technical Notes

➢ Thermal History

- Source rocks can be thermally mature on oceanic crust despite perceived ‘cool’ history. DSDP data show anomalously high maturity levels at several locations.

- DSDP data show evidence for ‘hotter in past’ thermal history on oceanic crust. This can be attributed to anomalously high heat flow and/or additional burial (now ‘missing section’). We are investigating this scenario offshore Morocco by obtaining new thermal history data (AFTA/VR) from DSDP 415, 416 & 370 and in the eastern Gulf of Guinea where there is an extensive thermal history database. Results will be presented at the PESGB-HGS Africa Conference in October 2019

Oceanic Crust Exploration Project
Accompanying Technical Notes

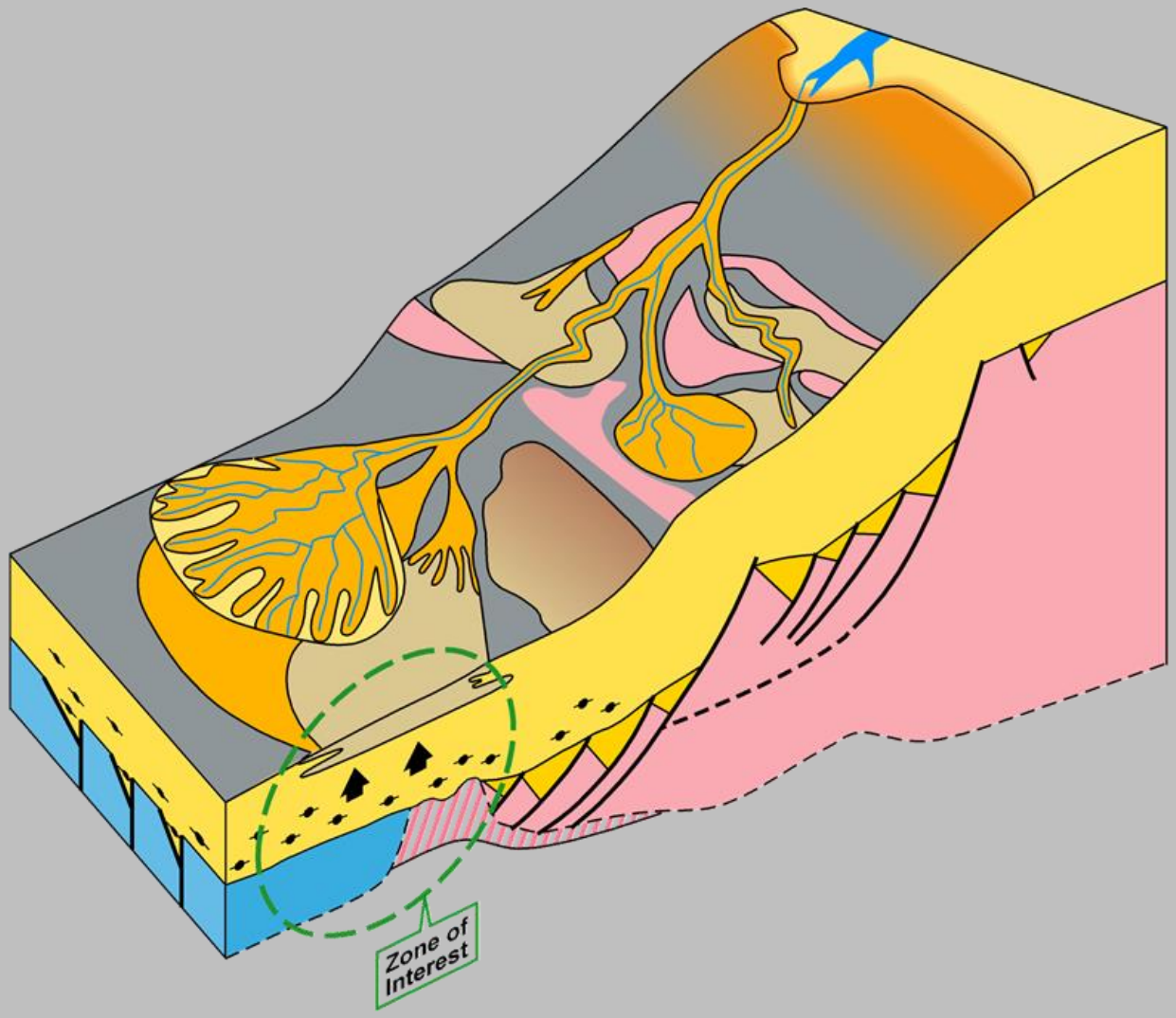
➢ Structural Development/Tectonic History

- Cretaceous and Tertiary post-break-up uplift has been demonstrated along vast tracts of the West African margin. New evidence suggests that uplift has extended into deep-water over transitional and oceanic crust offshore Morocco and eastern Gulf of Guinea.

- Sub-lithospheric processes dominate current thinking on the thermal and deformational history of oceanic crust despite growing evidence for lithospheric deformation involving re-activation of oceanic crustal fabric.

- We are investigating a tectonic explanation for deformation and uplift using new seismic data offshore Morocco and studies on Fuerteventura and Maio. These ideas will be presented at the PESGB-HGS Africa Conference in October 2019.

Eastern Atlantic Oceanic Crust Project



September 2019