

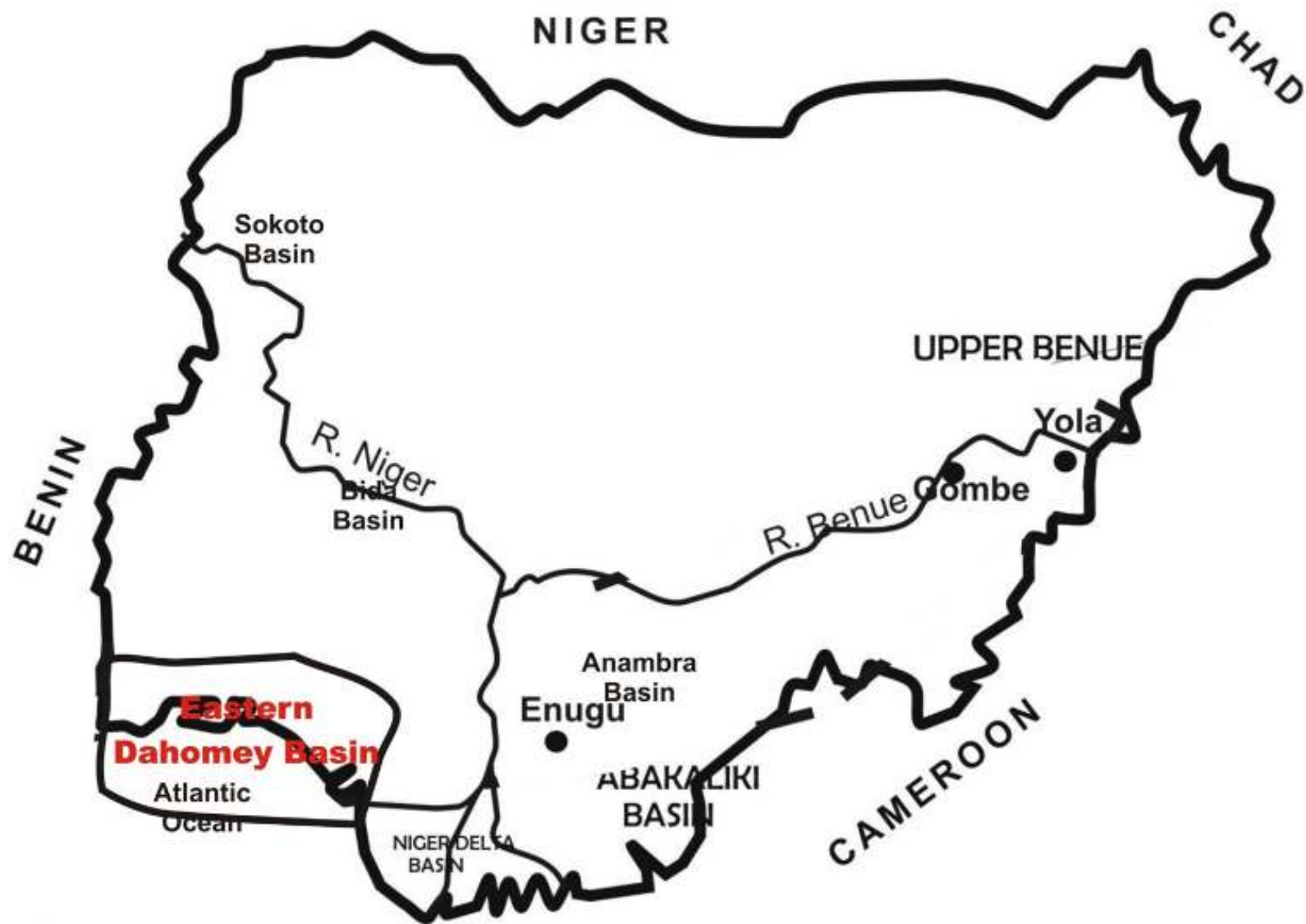
**Paleoenvironments and Organic Geochemical
Evaluation of the Cenomanian to Coniacian
Afowo Formation in the Dahomey Basin, Nigeria.**

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52nd Nigerian Mining and Geoscience Society (NMGS)
Annual International Conference and Exhibitions held at Ilorin, Nigeria.**

- 1. Introduction**
- 2. Objectives of the Study**
- 2. Basin Setting**
- 3. Methodology**
- 4. Results and Interpretations**
- 5. Conclusions**



Map of Nigeria

Goal: To identify potential Cretaceous petroleum system source rock within the Dahomey Basin

Objectives:

- Evaluate the thickness and distribution of potential source rock using lithostratigraphy and sedimentological data.**

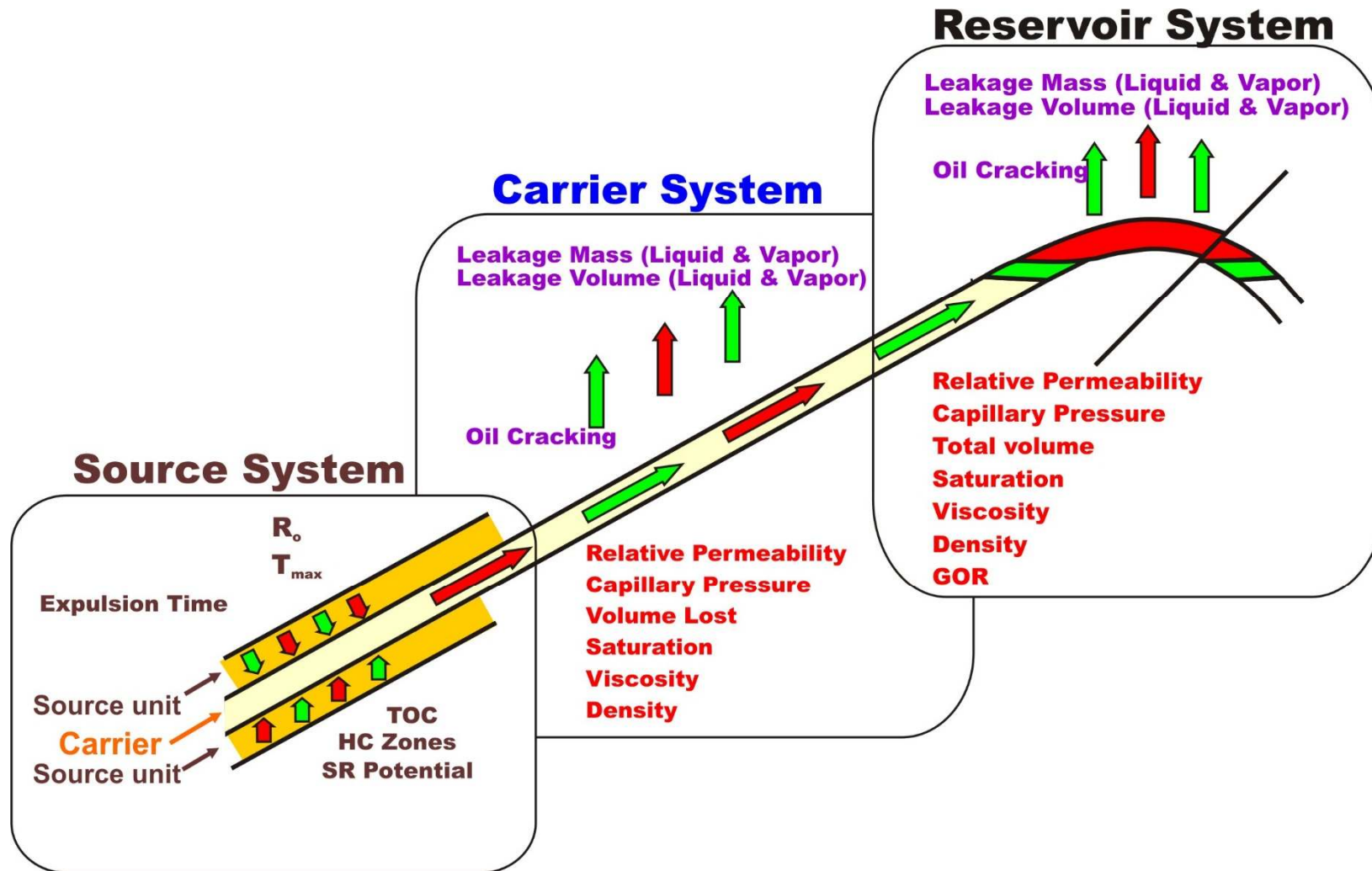
- Characterize the potential source rock through geochemical study**

- Establish the stratigraphic position and depositional environments of the source rocks through sedimentological, and foraminifera studies.**

- Construct a thermal history model of the basin to assess source rock(s) maturity using Petromod software**

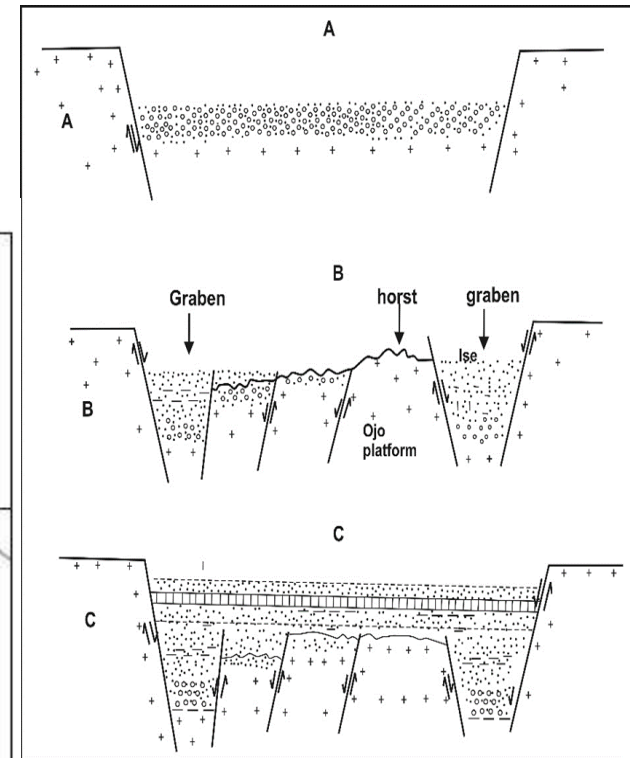
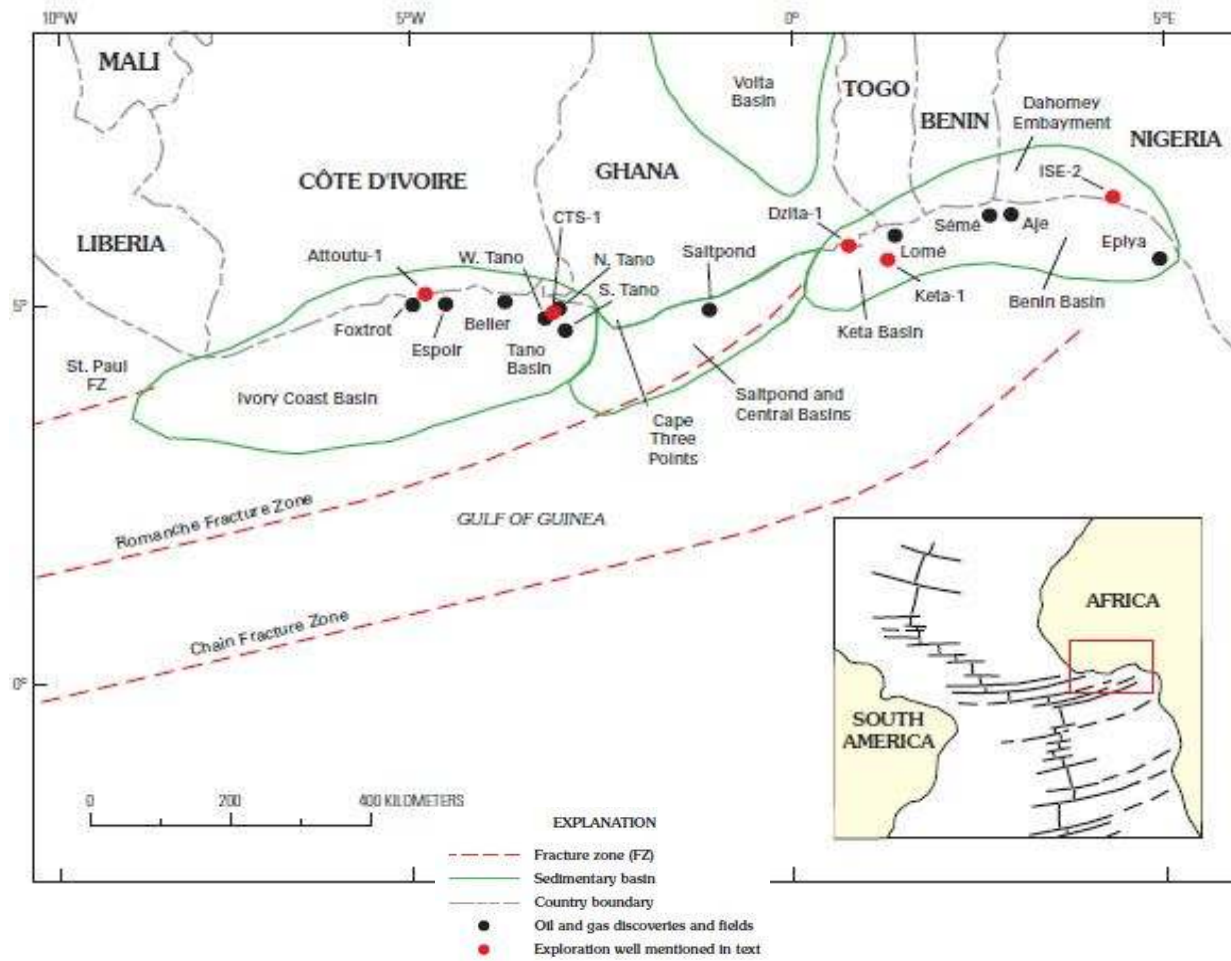
Petroleum System Evaluation- Elements and Processes

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Tectonic Settings and Evolution History of Dahomey Basin

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(Modified after Omatsola and Adegoke, 1981)

Brownfield and Charpentier, 2006

Stratigraphic Setting of Dahomey Basin

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AGE		FORMATION	
QUART.	PLEISTOCENE	BENIN Fm	
TERTIARY	EOCENE	ILARO Fm	
		OSHOSUN Fm	
	PALEOCENE	EWEKORO Fm	
CRETACEOUS	CAMPANIAN - MAASTRICHTIAN	ABEOKUTA GROUP	ARAROMI Fm
	TURONIAN - CONIANCIAN		AFOWO Fm
	BARREMIAN - CENOMANIAN		ISE Fm

After Omatsola and Adegoke, 1981

- Evolutionary history** (Adegoke et al., 1972, Billman, 1976, Omatsola and Adegoke, 1981, Adediran, , Ako et al., 1980 and Adegoke, 1987)

- Sedimentology** (Allix, 1983, Adekeye, 2005)

- Geochemistry** (Russ, 1924, Adekeye, et al., 2005, 2007)

- Paleontological** (Reyments, 1966, Adegoke 1972, 1977, Nwachukwu et al., 1992, Okosun 1990, 1996, 2000, Bankole et al., 2007, Gebhardt, 2010).

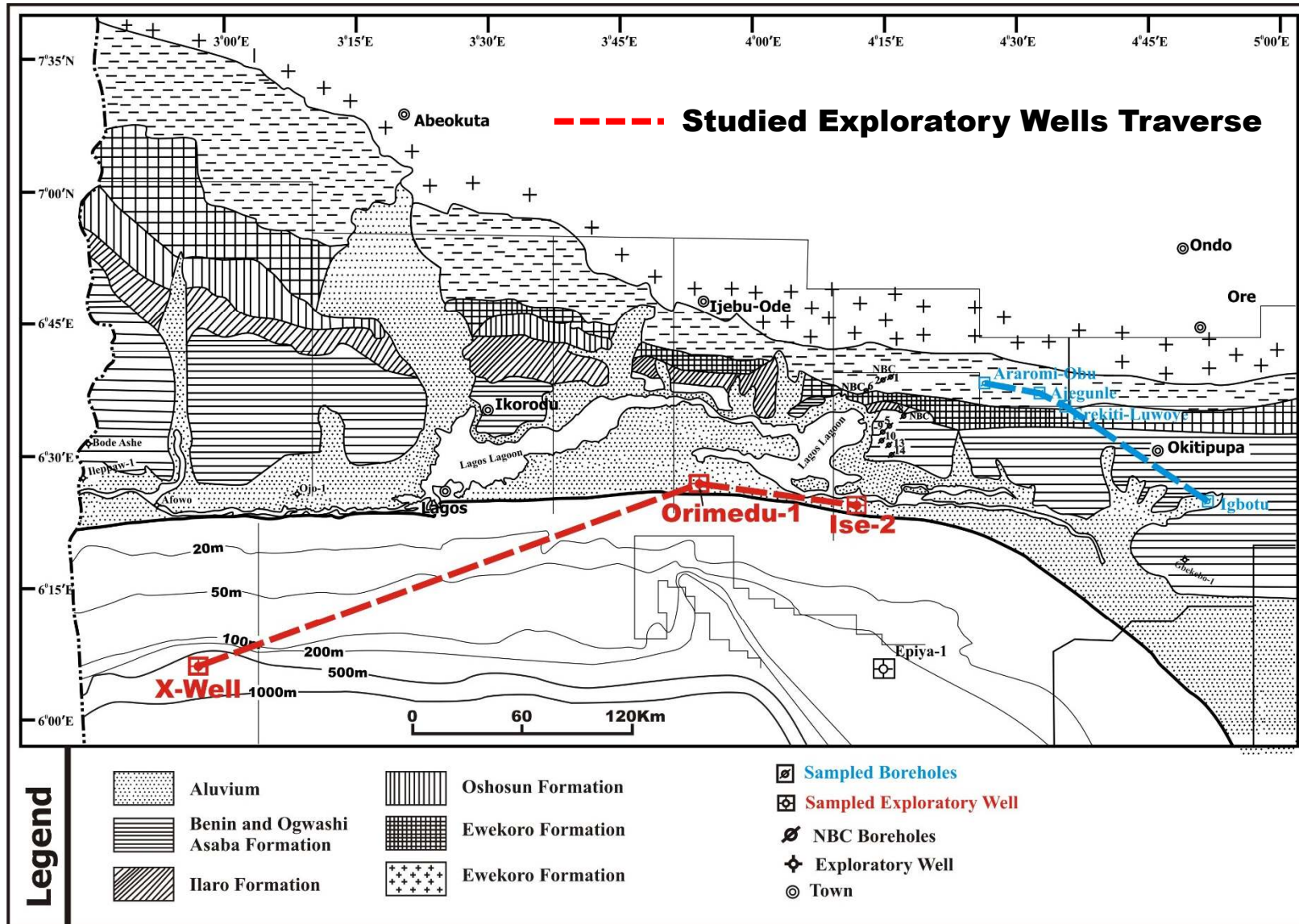
- Petroleum potential** (Ekweozor and Nwachukwu, 1989, Adekeye et al., 2004, 2006, Nton et al., 2005, Akande et al., 2010, 2012, Haack et al., 2000, Kaki et al., 2013).

- Field Data gathering**

- Laboratory Studies**
 - ✓ **Foraminifera Biostratigraphic Study**

 - ✓ **Geochemistry**

- Thermal history Modeling**



Geological Map of Dahomey Basin, SW Nigeria
 (Modified after Adekeye, 2005)

Lithostratigraphy

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X WELL

DEPTH (M)	LITH.	DESCRIPTION
1417		Black Shale
1493		
1554		Black Shale
1676		
1707		Black Shale
1807		Black Shale
1856		
1865		Carbonaceous grey Shale
1892		
1914		
1938		Calc. sandy grey Shale
1975		Carboaceous grey Shale
2005		
2024		Calc. sandy grey Shale
2048		
2130		Calc. grey Shale
2167		
2182		
2204		Missing interval
2240		
2256		
2286		
2304		Calc. sandy grey Shale
2356		
2368		Calc. grey Shale
2399		
2420		
2448		Calc. sandy grey Shale
2454		
2469		
2481		
2496		
2518		Calc. grey Shale
2536		
2554		
2566		
2585		

ORIMEDU-1 WELL

DEPTH (M)	LITH.	DESCRIPTION
0		Fossiliferous coarse grain Sandstone
61		
122		Fossiliferous Shale
183		
244		Medium grain Sandstone
305		Sandy Shale
366		Grey Shale
427		
488		Grey Shale
549		
610		Grey Shale
670		
731		Grey Shale
792		Medium grain Sandstone
853		
914		
975		Medium grain Sandstone
1036		Medium grain Sandstone
1097		Sandy grey Shale
1158		Shaly Sandstone
1219		Sandy grey Shale
1280		Medium grain Sandstone
1341		Medium grain Sandstone
1402		Sandy grey Shale
1463		Sandy grey Shale
1524		Sandy grey Shale
1585		Shaly Sandstone
TD 1612		

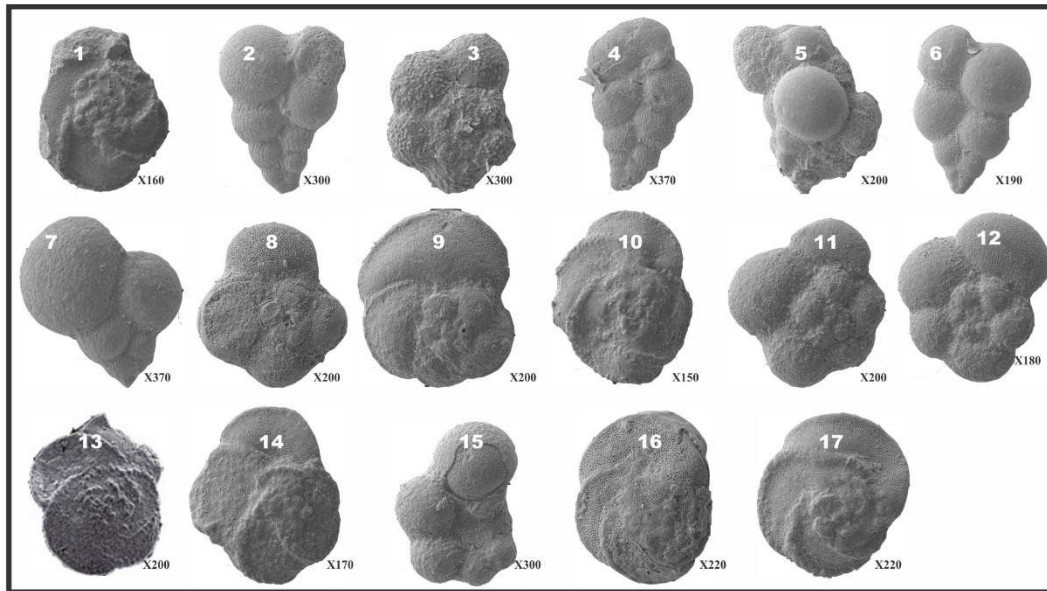
LITH.= Lithology
 TD= Total Depth
 1cm = 200m

ISE-2 WELL

DEPTH (M)	LITH.	DESCRIPTION
0		Fossiliferous coarse grain Sandstone
300		Coarse grain Sandstone
600		Brownish Coarse grain Sandstone
900		Coarse grain Sandstone
1200		Medium grain Sandstone
1500		Very fine grain Sandstone Grey Shale
1800		Fine grain Sandstone
2100		Shaly light grey Sandstone
2400		Sandy light grey Shale
2700		Grey Shale
3000		Grey Shale
3300		Grey Shale
TD 3600		Fissile grey Shale
		Fissile grey Shale
		Fissile grey Shale
		Fissile grey Shale
		Sandy grey Shale Shaly fine grain Sandstone
		Fine grain Sandstone
		Fine grain Sandstone
		Shaly Sandstone
		Sandy grey Shale
		Shaly Sandstone
		Shaly Sandstone
		Fine grain Sandstone
		Sandy grey Shale
		Sandy grey Shale
		Shaly Sandstone
		Sandy grey Shale

LITH.= Lithology
 TD= Total Depth
 2.3cm = 300m

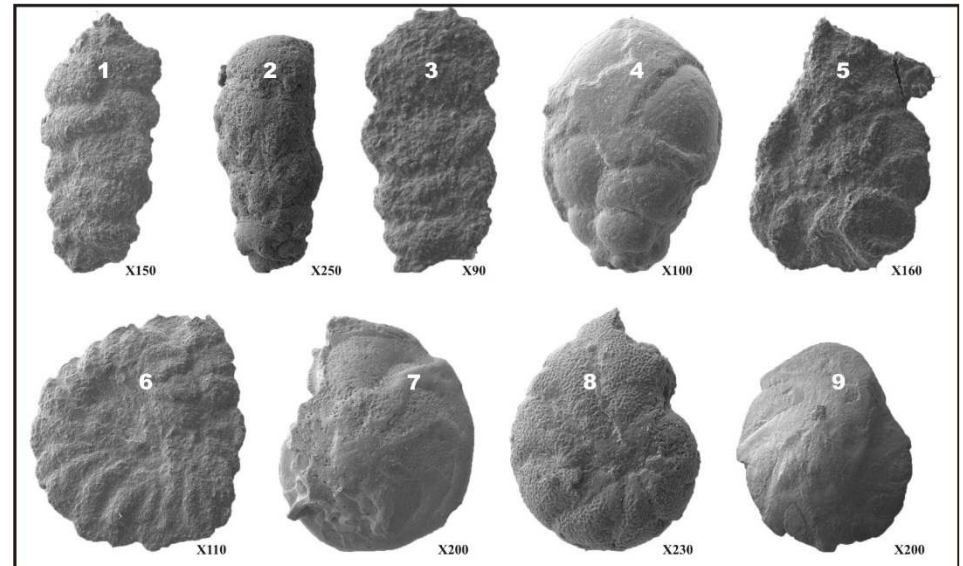
Biostratigraphy



Planktonic species

1. *Rotalipora greenhensis*, 2. *Heterohelix moremani*, 3. *Globotruncana* sp., 4. *Heterohelix pulchra*, 5. *Gumbelitarium* sp.
6. *Heterohelix globulosa*, 7. *Heterohelix reussi*, 8. *Praeglobotruncana stephani*, 9. *Whiteinella inornata*, 10. *Marginotruncana* cf. *Renzi*
11. *Whiteinella archaeocretacea*, 12. *Whiteinella baltica*, 13. *Globotruncana aegyptica*, 14. *Dicarinella primitive*, 15. *Hedbergella simplex*
16. *Marginotruncana* cf. *pseudolinneiana*




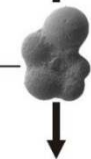




Benthic species



1. *Textularia*, 2. *Afrolivina*, 3. *Reophax*, 4. *Gabotina*, 5. *Ammobaculites*,
6. *Haplophragmoides*, 7. *Planulina*, 8. *Gavelina*, 9. *Lenticulina*

Index Fossil for Biostratigraphy Zonation

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STAGES		PLANKTIC FORAMINIFERA INDEX FOSSIL RECOVERED FROM THE SOUTHERN AND NORTHERN TRAVERSE	
MAASTRICHTIAN		 <i>Globotruncana aegyptiaca</i>	 <i>Abathomphalus mayaroensis</i> Zone
CAMPANIAN		 <i>Globotruncana calcarata</i>	
CONIACIAN			
TURONIAN		 <i>Whiteinella archeocretacea</i> (Caron, 1985, Hardenbol et al., 1998, & Nishi et al., 2003)	 <i>Rotalipora greenhornesis</i> (Morrow, 1934 & Bandy, 1967)
CENOMANIAN		 <i>Praeglobotruncana stephani</i> (Bolli 1957a & Bandy, 1967 & Peryt, 1983)	 <i>Marginotruncana pseudolinneiana</i> (Nishi et al., 2003)
			 <i>Heterohelix moremani</i> (Bandy, 1967)

Morrow, 1934,

Bolli, 1957a

Bandy, 1967

Peryt, 1983

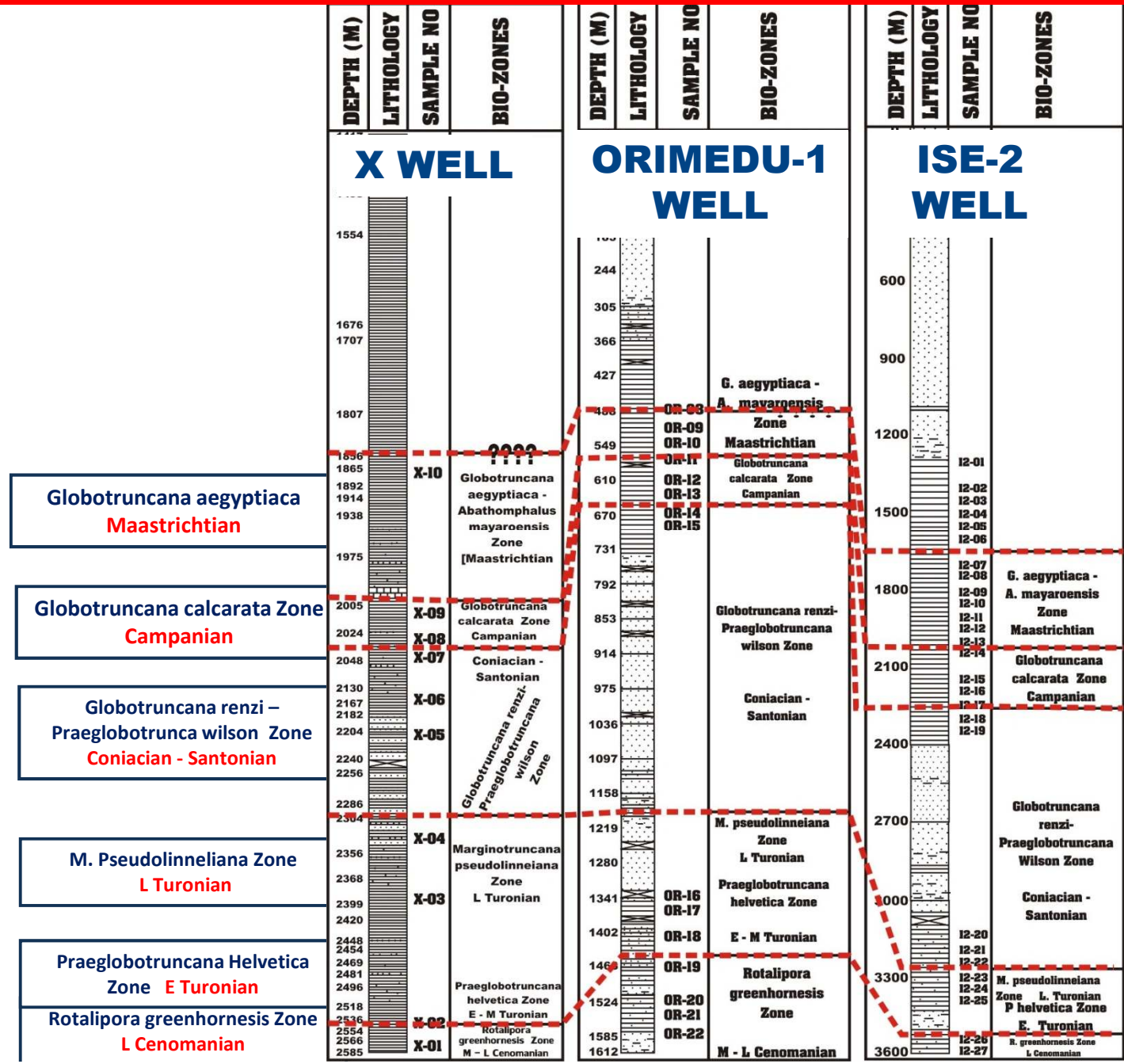
Caron, 1985

Hardenbol et al 1998 and

Nishi et al., 2003,

Biostratigraphic Zonation

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Present Study

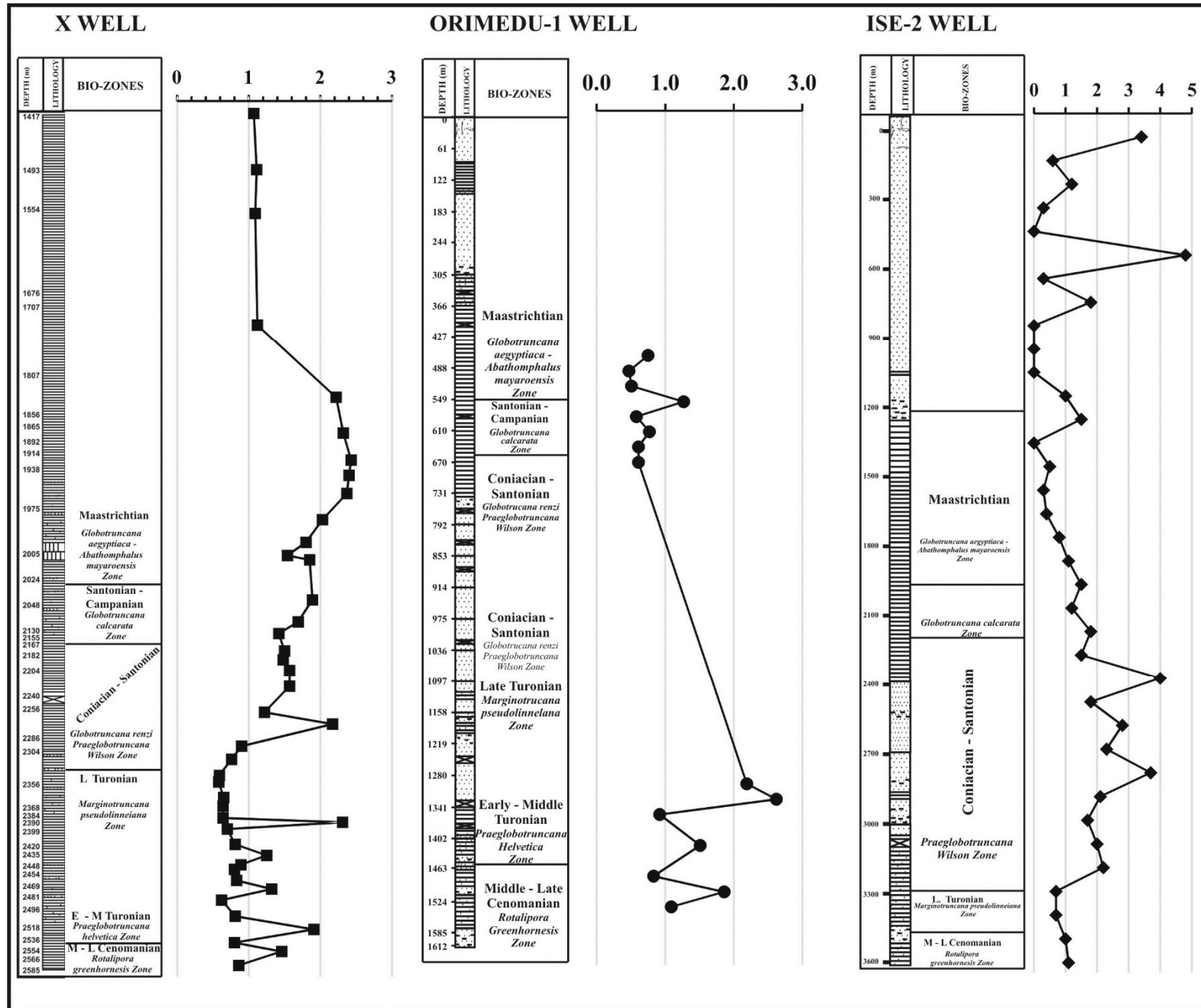
Cenomanian – Turonian Shale	V/Ni	V/(V + Ni)	Ni/Co	Interpretations
X-Well	3.3	0.8	2.7	Marine organic matter Oxic – dysoxic
Orimedu-1	1.2	0.5	3.7	Terrigenous organic matter More Oxic
Ise-2 Well	2.2	0.7	2.7	Mixed terrigenous and marine More Oxic

References

S/N	Trace Elements Ratios	Values and Interpretation	Authors
1.	V/Ni	> 3 Reducing Environment, Marine organic material 1.9 – 3 Mixed terrigenous and marine	Barwise (1990), Galarraga et al. (2008)
2.	V/(V + Ni)	0.69 – 0.76 Dysoxic	Adegoke et al., 2014
3.	Ni/Co	> 5 Dysoxic – Anoxic < 5 Oxic	Jones and Manning, 1994

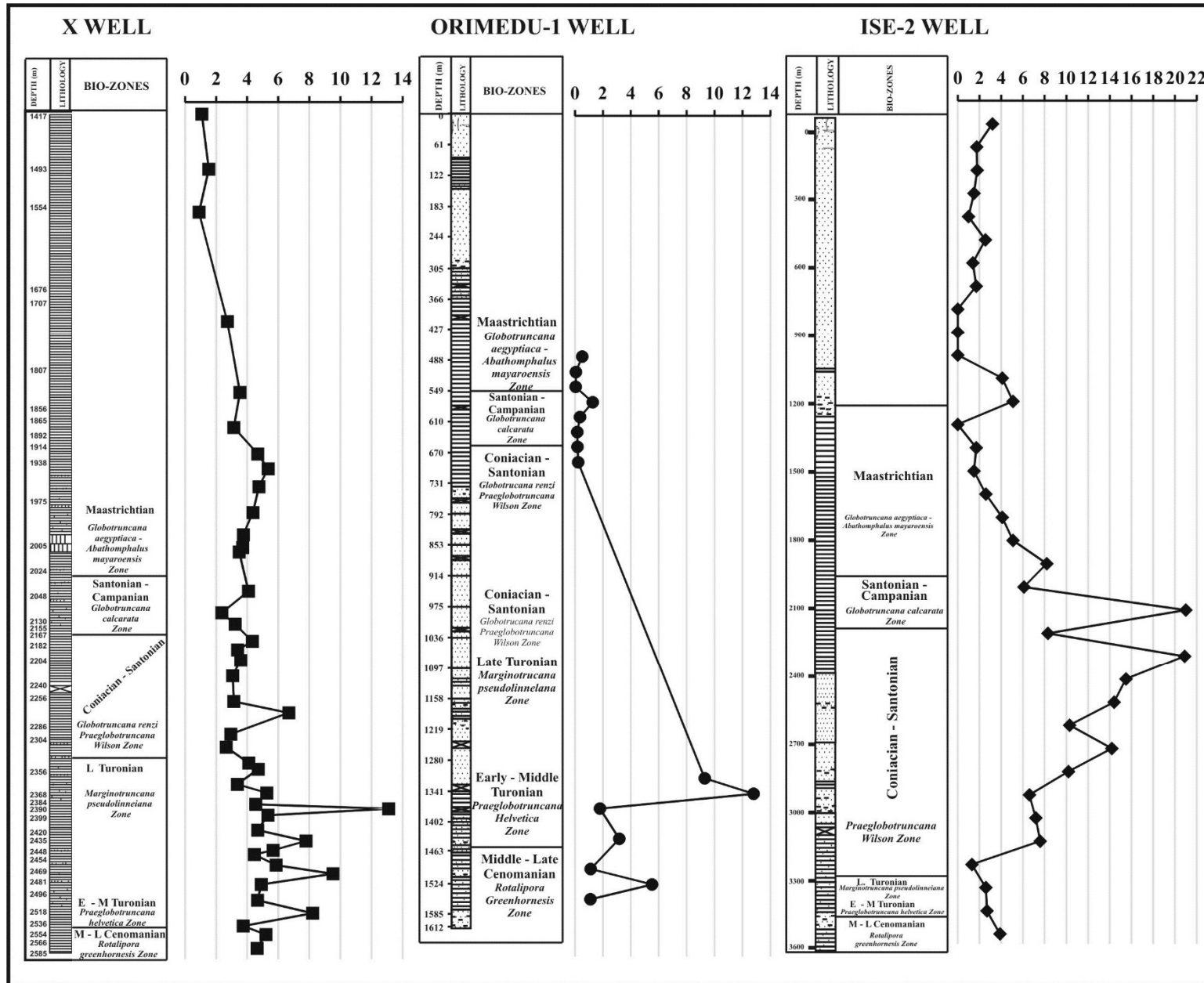
Total Organic Contents TOC (wt%)

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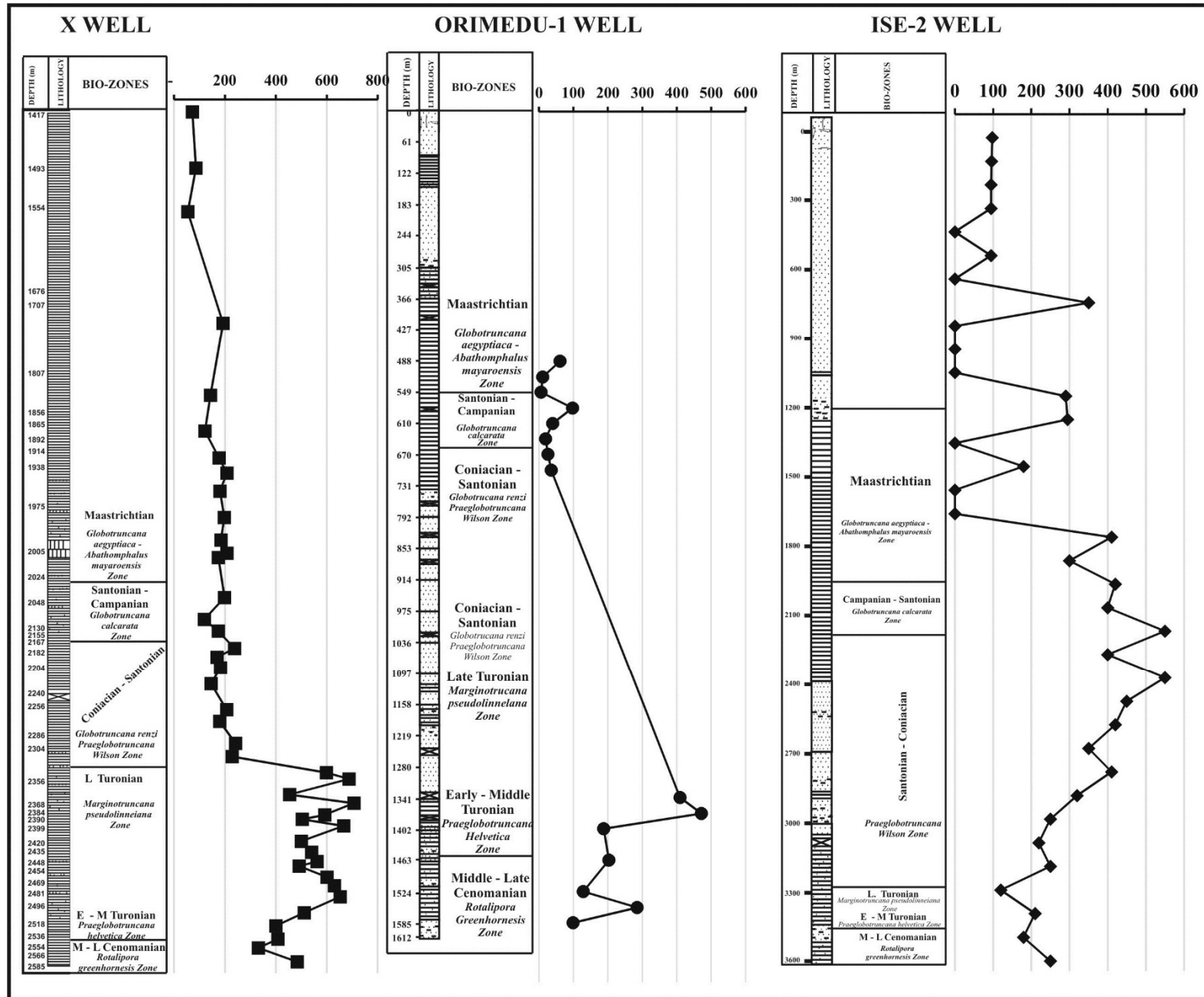
Source Potential ($S_1 + S_2$)

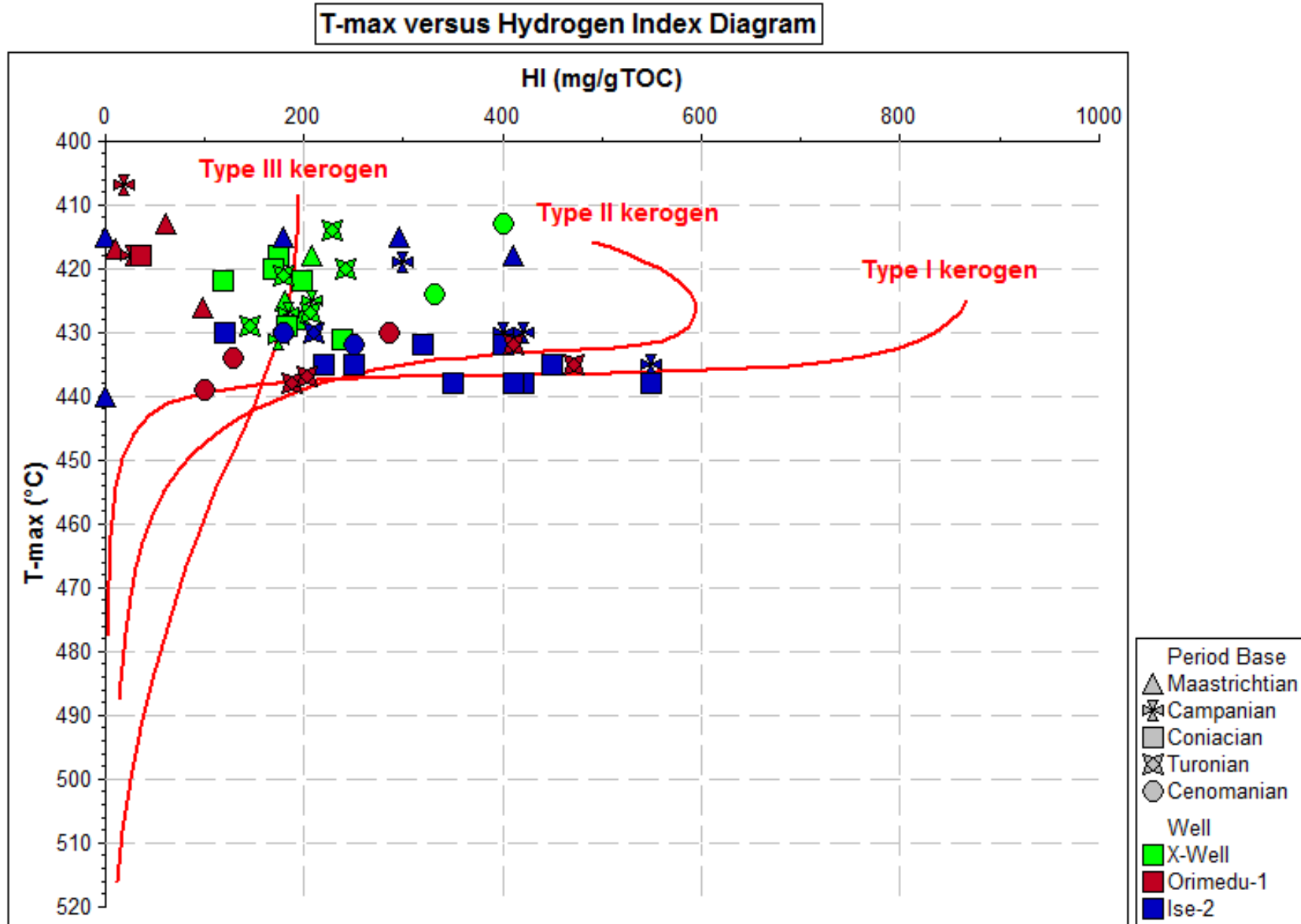
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Hydrogen Index (HI) mgHC/gTOC

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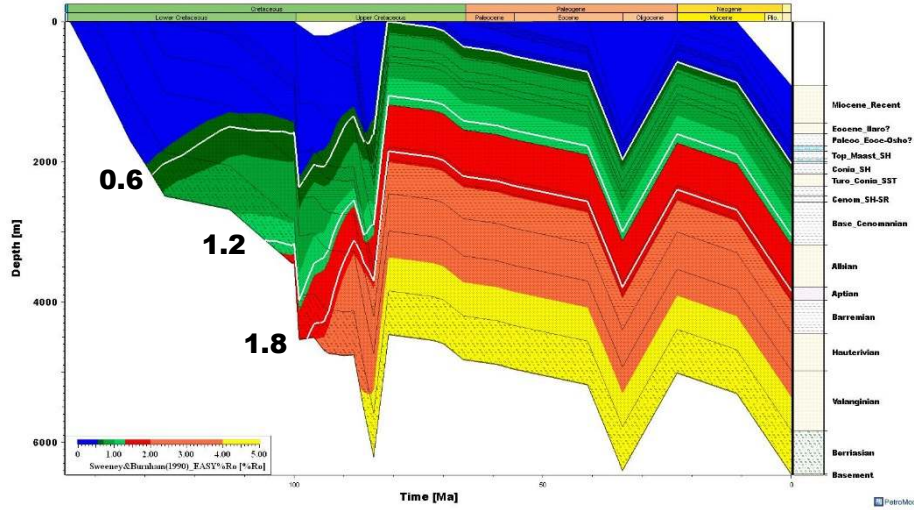




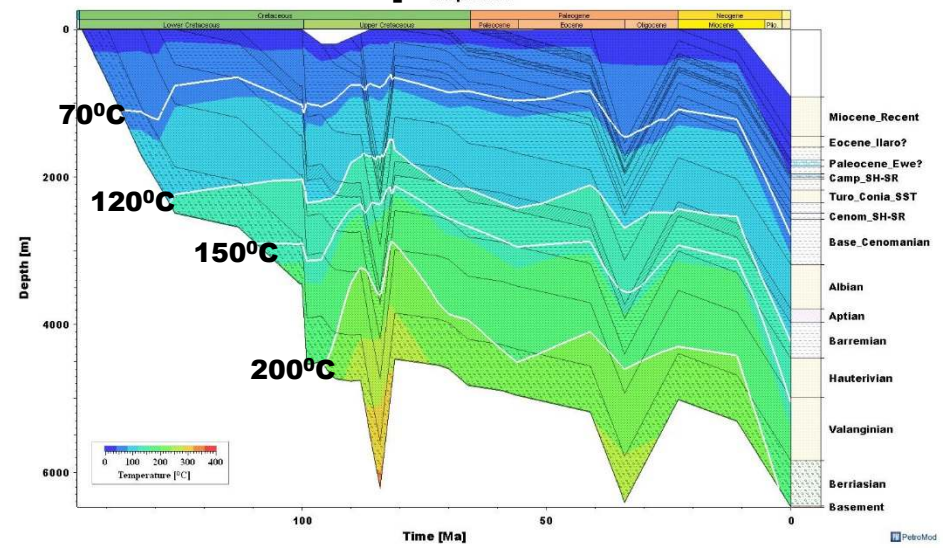
HI/Tmax plots of shales in the exploratory wells (IGI Software)

Thermal History

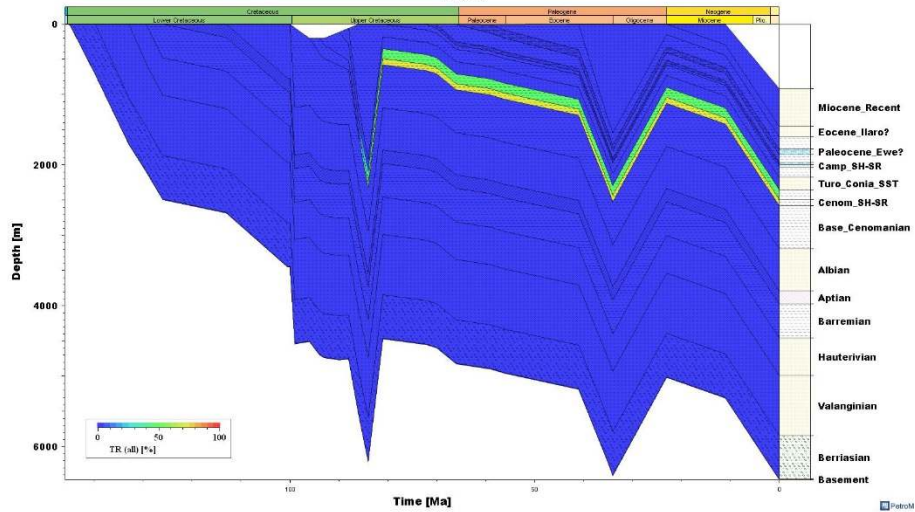
Vitrinite Reflectance



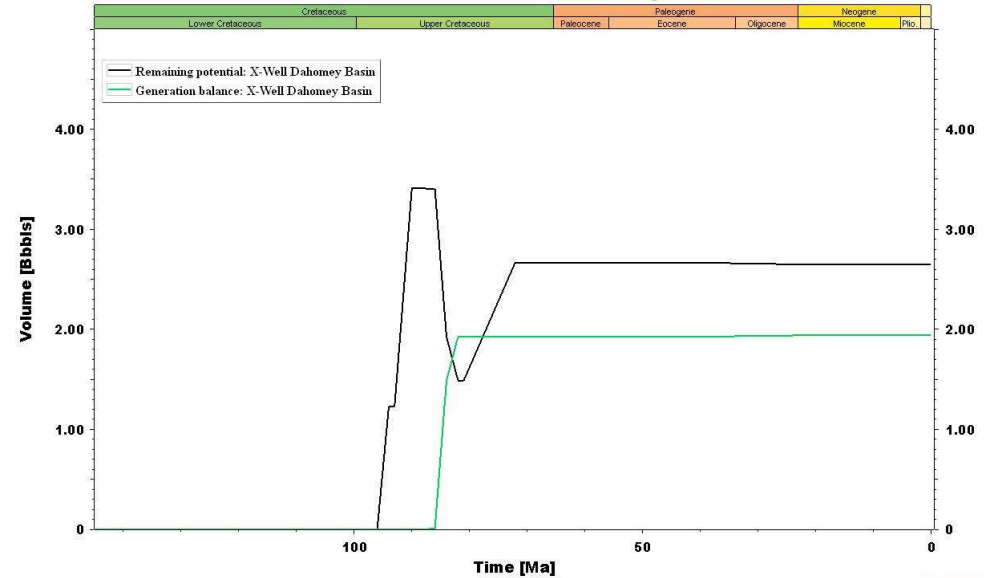
Temperature



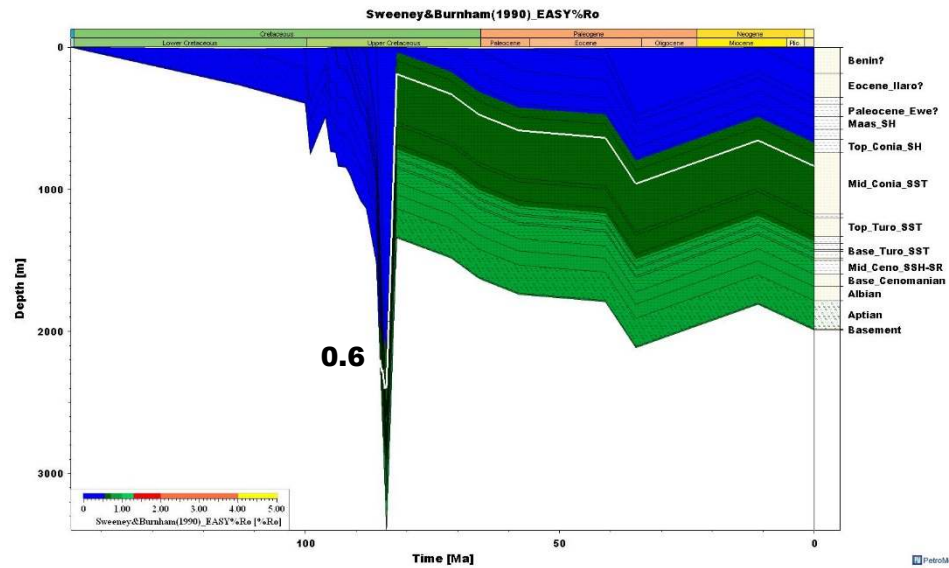
Transformation Ratio



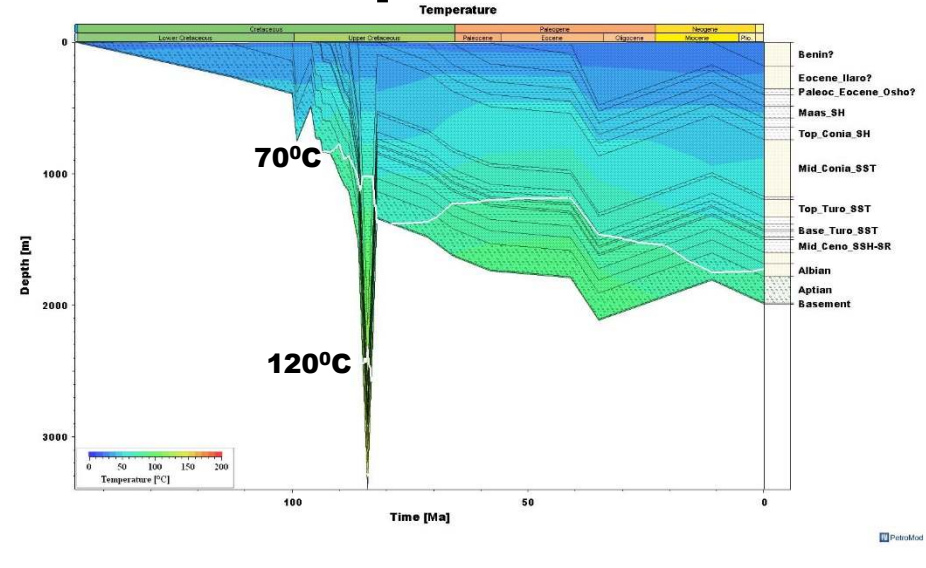
Generated & Remaining Potential



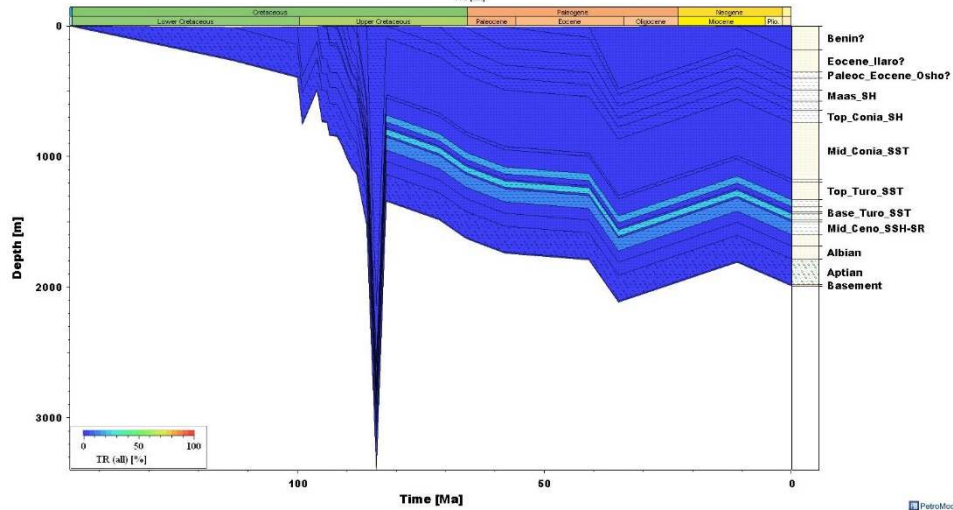
Vitrinite Reflectance



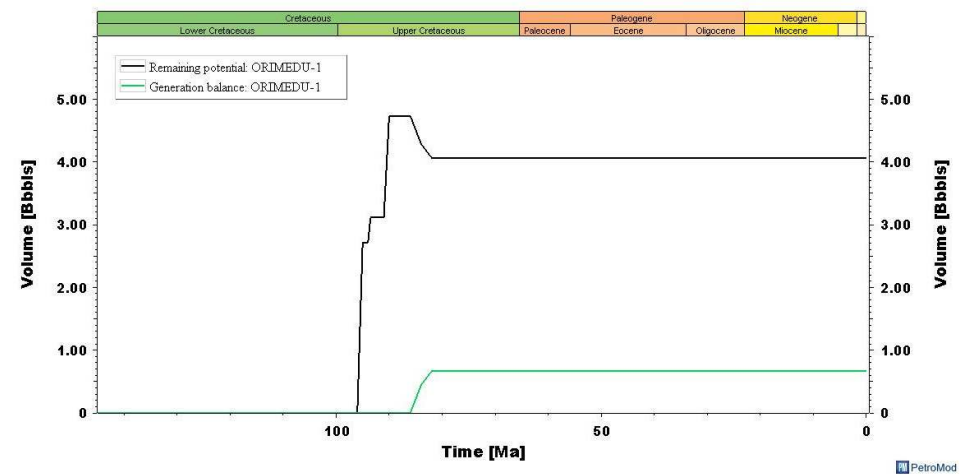
Temperature



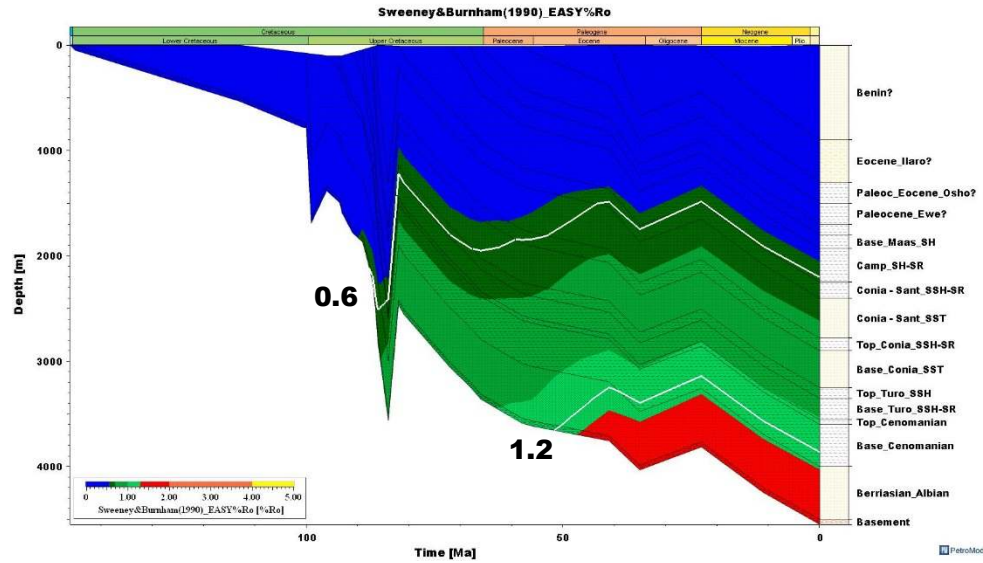
Transformation Ratio



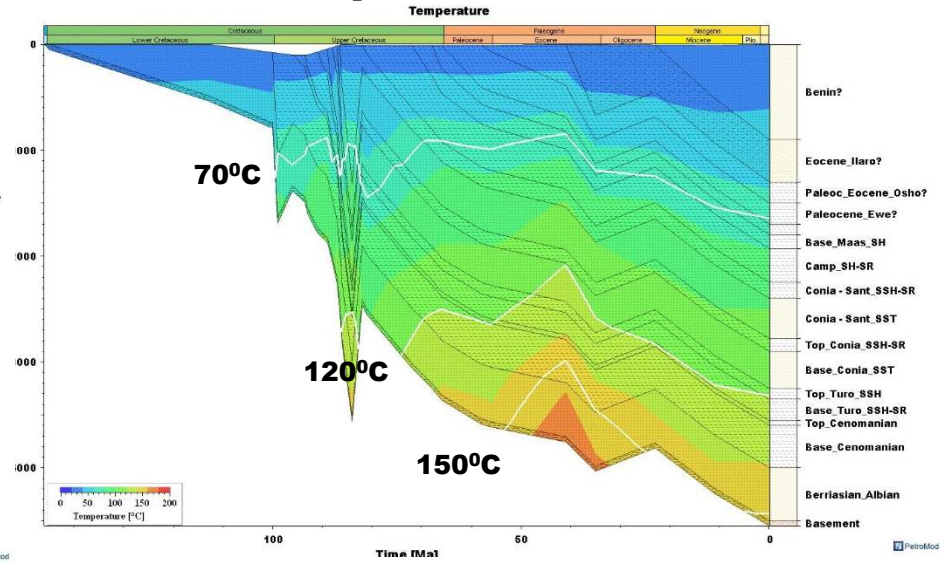
Generated Volume with time



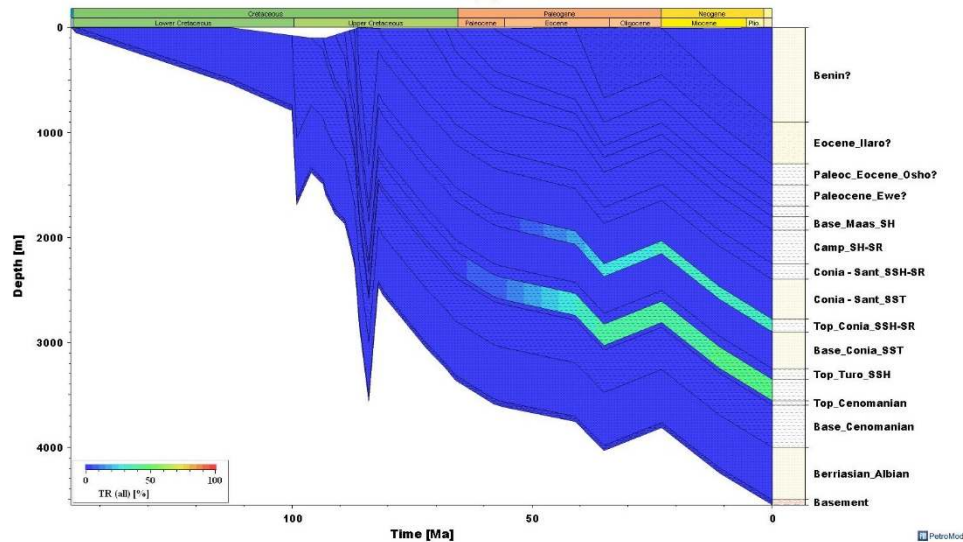
Vitrinite Reflectance



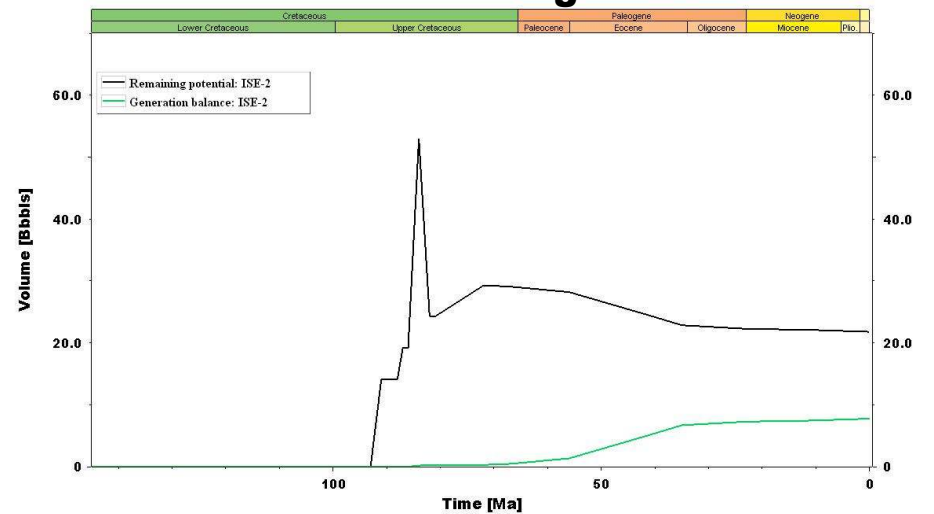
Temperature



Transformation Ratio



Generated & Remaining Potential



Conclusions

Conclusions

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S/NO	PARAMETERS	CHARATERISTICS
i.	Source Rock Facies	Shale
ii.	Age	Cenomanian – Turonian
iii.	Paleowater Depth	< 250m (upper Bathyal) to < 100m (middle - outer Neritic e.g Open shelf)
iv.	Depositional Environments	Marine
v.	Organic Matter Type	I, II, II/III
vi.	TOC	Good to Excellent
vii.	Maturity	Mature
viii.	Transformation	Begins in Upper Cretaceous in X and Orimedu -1 Well and Paleocene in Ise-2

Tano and Ivory Coast basins have Albian to Coniacian petroleum system while Dahomey basin have Cenomanian to Turonian Petroleum Source rock.

Acknowledgements

- ❑ Petroleum Technology Development Fund (PTDF)**
- ❑ Weatherford Laboratories, Houston Texas, USA**
- ❑ University of Frankfurt, Germany**
- ❑ Technical University Berlin, Germany, ZELMI**
- ❑ Schlumberger - SIS NGA**

Thanks for Listening