#### Geochemical Assessment of Basins Along the Western South Atlantic Margin

Craig Schiefelbein<sup>1</sup>, Carlos Urien<sup>2</sup>, William Dickson<sup>3</sup>, and John Zumberge<sup>4</sup>

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#### **Abstract**

A super-regional review of detailed geochemical data from 1000+ crude oil samples has been applied to extend inferences about hydrocarbon kitchens from the better-known basins of the Brazil margin down to the Patagonian Toe. Multivariate statistical analyses were employed to separate the oils into four broad groups according to source environment that ranged from lacustrine to transitional to marine. Compositional attributes shared by crude oils allowed clustering into smaller sub-groups possibly indicating genetic relationships. Of particular interest is a large cluster of oils whose compositional features suggest an origin from similar mature source rocks deposited in lacustrine fresh to brackish water environments. These oils are distributed from Austral-Magallanes, San Jorge, Neuquen, and Cuyo basins of Argentina to basins offshore and onshore Central Brazil extending north to Para Maranhao. Source age for these oils varies from Triassic/Jurassic in the south to Jurassic/Neocomian in Central Brazil to Aptian in the Equatorial Margin basins of Brazil. Despite limited well coverage (<160 wells) in the shallow waters of the San Jorge, Austral - Malvinas (500,000 km<sup>2</sup>) and Colorado-Salado (300,000 km<sup>2</sup>) basins, continental - marine reservoir intervals have been identified. Three plays were selected for further analysis according to their proven, probable and possible petroleum systems: Colorado-Salado Type: NW-SE-trending basins with Paleozoic structural control roughly coast-orthogonal with superimposed coastparallel structuring related to later South Atlantic opening. Structural trends containing organic-rich intervals include pre-rift Permian and possible syn-rift lacustrine, Tithonian to Barremian facies, buried and sealed by marine Cretaceous high-stand systems tract units. Patagonian Margin toe: Elongate depocenters of Early Cretaceous lacustrine and Valanginian marine intervals tapering to thin condensed sections beneath the shelf from more than 6 km of sediments below the lower slope and rise. Malvinas/Austral: Proven oil sourced in Late Jurassic rifts and Neocomian shallow marine sequences. Similar transgressive Oxfordian age sequences were observed in DSDP-330/Ewing Bank and Tithonian-aged facies have been drilled in the Malvinas basin. These hypotheses were tested against reprocessed seismic (which revealed stratigraphic detail) and advanced potential field compilations which jointly illustrated basin architectures that influenced or even controlled oil family distributions.

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<sup>&</sup>lt;sup>1</sup>Geochemical Solutions Intl., Houston, TX, United States (info@geochemsol.com)

<sup>&</sup>lt;sup>2</sup>Urien & Associates, Buenos Aires, Argentina

<sup>&</sup>lt;sup>3</sup>Dickson Intl. Geosciences, Houston, TX, United States

<sup>&</sup>lt;sup>4</sup>Geomark Research Inc, Houston, TX, United States



# Geochemical Assessment of Basins Along the Western South Atlantic Margin

Craig Schiefelbein/GSI
Carlos Urien
William Dickson/DIGs
John Zumberge/GeoMark

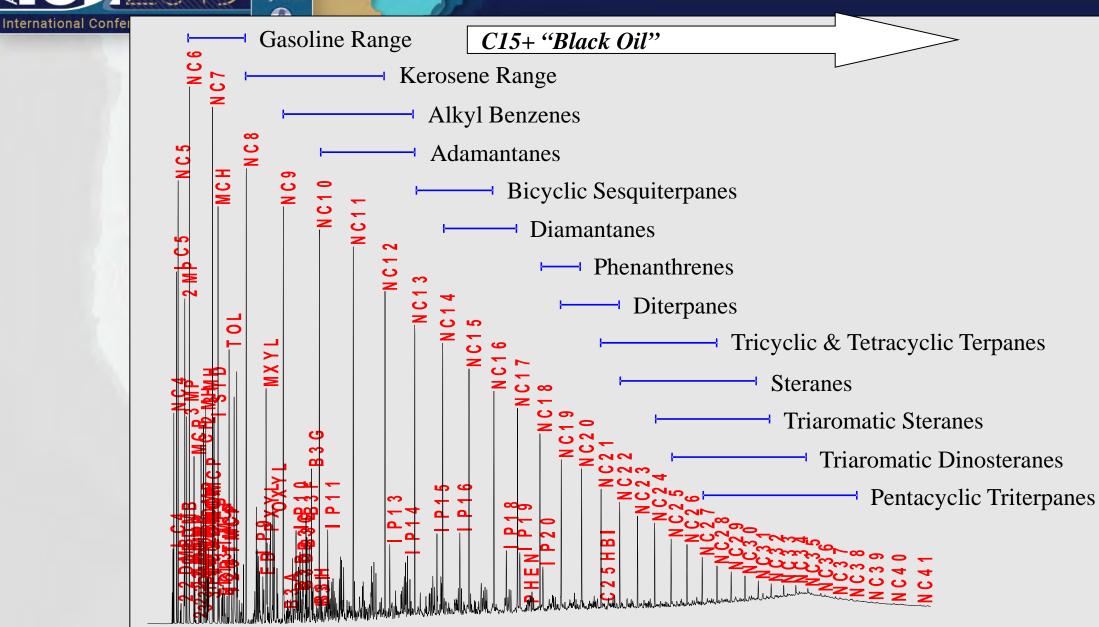


## Objective(s)

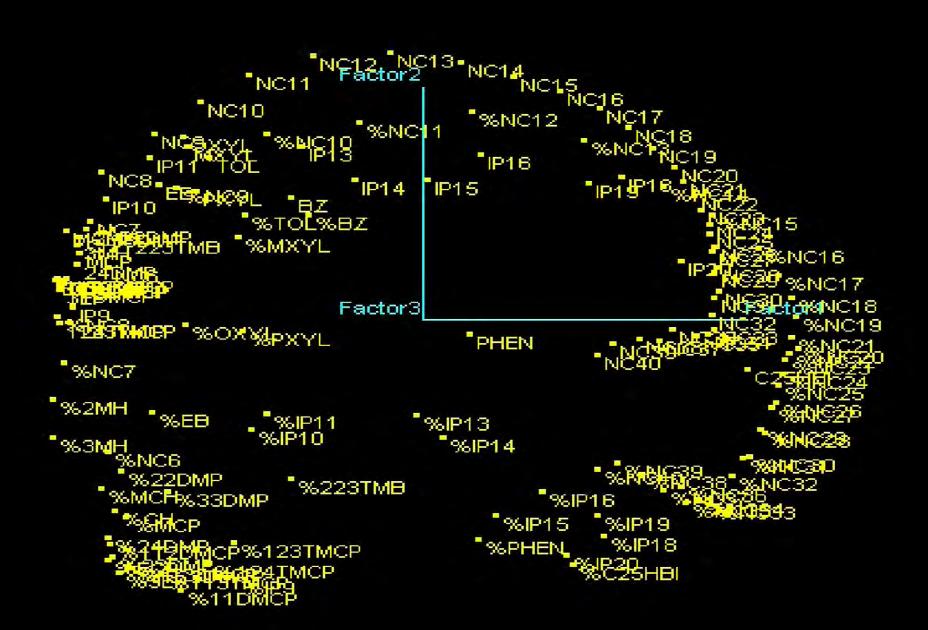
- Utilize chemical composition data & multi-variate statistics to separate crude oils into compositionally similar groups by source depositional environment & likely age/event
- Acquire & organize "black oil" data: 1130 crude oil samples, western South Atlantic margin, multiple nonexclusive sources
- Iterate on multivariate statistical techniques using hierarchical cluster and principal component analyses
- Winnow sample set, excluding 182 for high maturity, biodegradation, contamination, duplication, and/or other post-generative processes
- Focus on fourteen source dependent parameters for remaining 958 samples
- Check outliers to ensure data integrity, then map, repeat and ultimately integrate and interpret within a multi-disciplinary framework



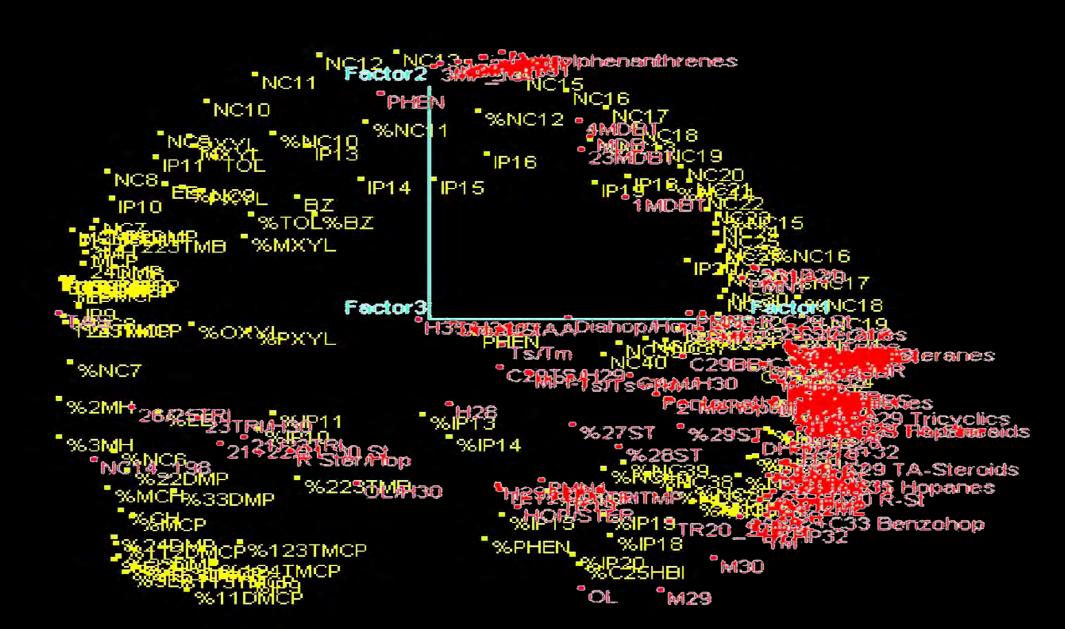
## Whole Oil Gas Chromatogram



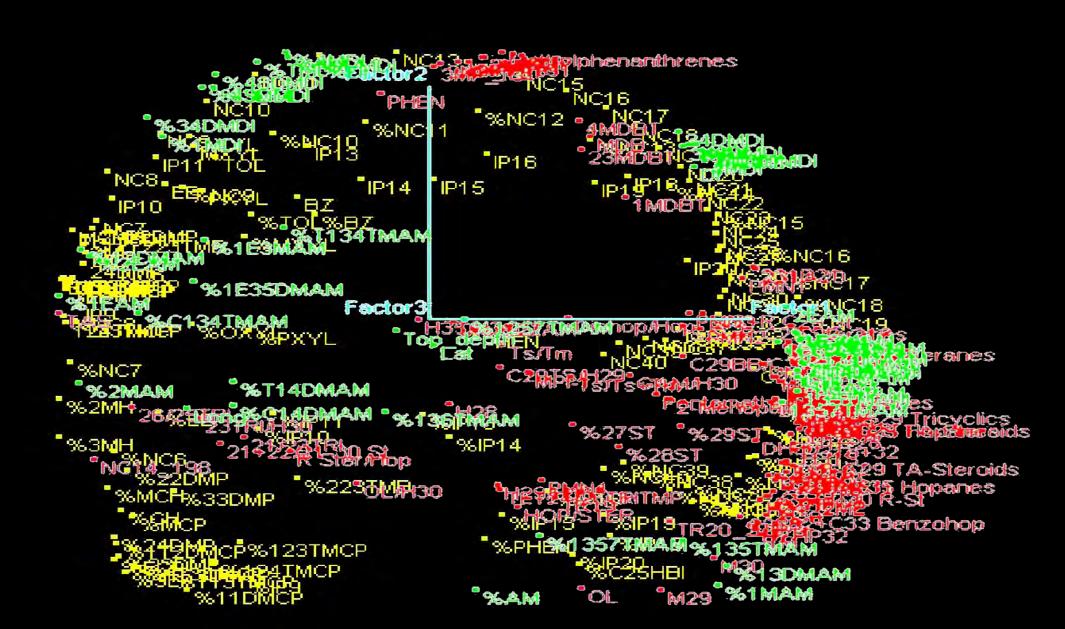
## PCA Loadings – All (Ideal World) Data



## PCA Loadings – All (Ideal World) Data



## PCA Loadings – All (Ideal World) Data





#### **Genetic Classification of Oils**

Applying an approach similar to that used in DNA paternity tests:

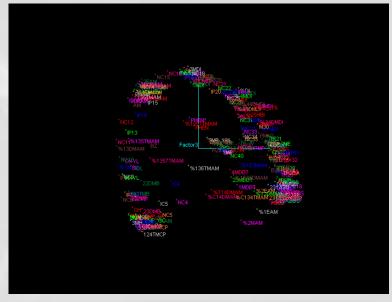
Parent -- sibling

But using quantitative compositional data to link:

Oils -- source rocks

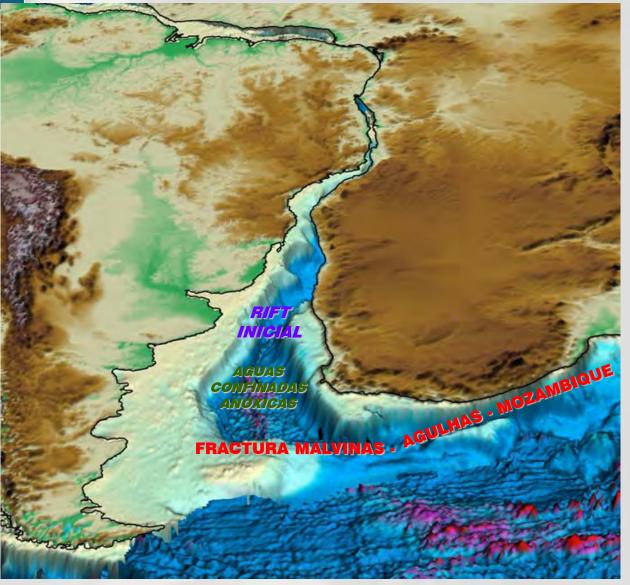


DNA
Double
Helix



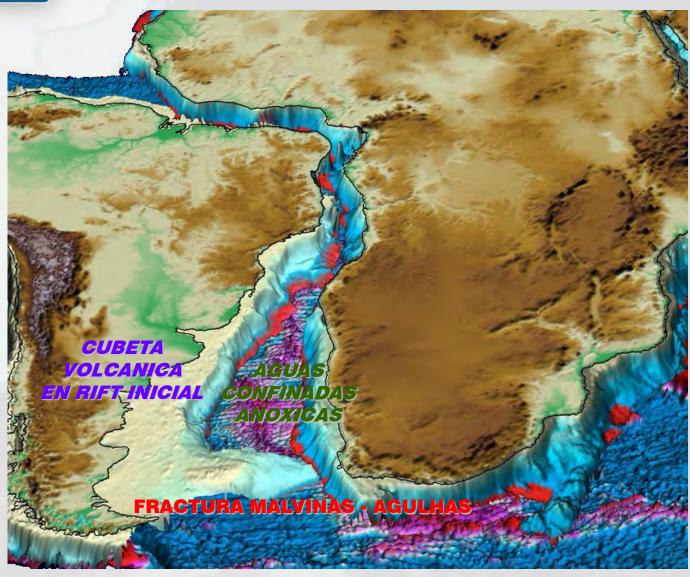


#### **UPPER JURASSIC - NEOCOMIAN**





## VALANGINIANO - BARRENIANO MOVILIZACIÓN ENTRE ÁFRICA Y AMÉRICA DEL SUR





#### **COVERAGE**

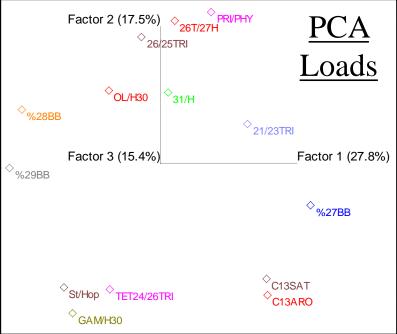
- •1130 Crude Oils
  - 997 Brazil
  - 116 Argentina
  - 9 Chile
  - 5 Suriname
  - 4 Guyana



#### STUDY AREA

- Coastal Basins
  - Guyana
  - Suriname
  - Brazil
  - Argentina
  - Chile



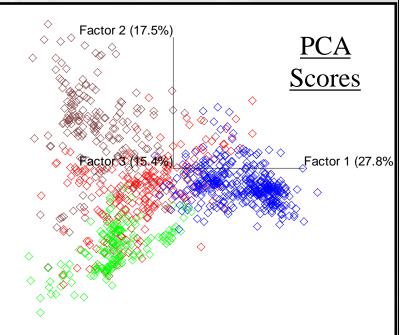


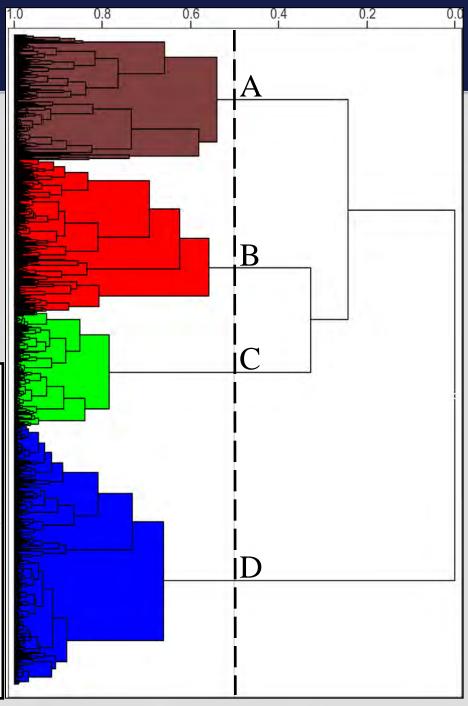
#### **PCA Results**

- 60%/PC3
- •77%/PC5

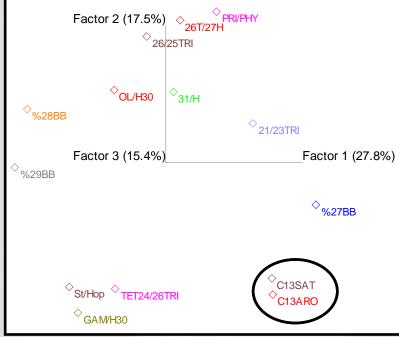
#### **HCA** Dendrogram

- 1130 Oils
- •182 Excluded
- 958 Oils Used
- •14 Parameters

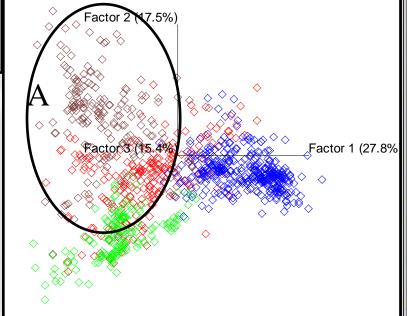


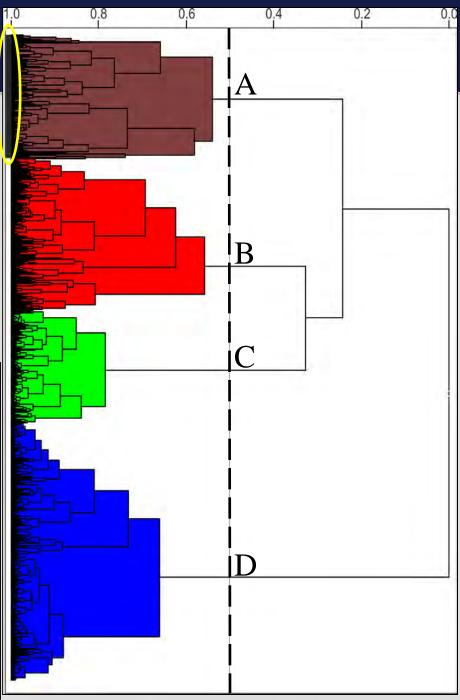






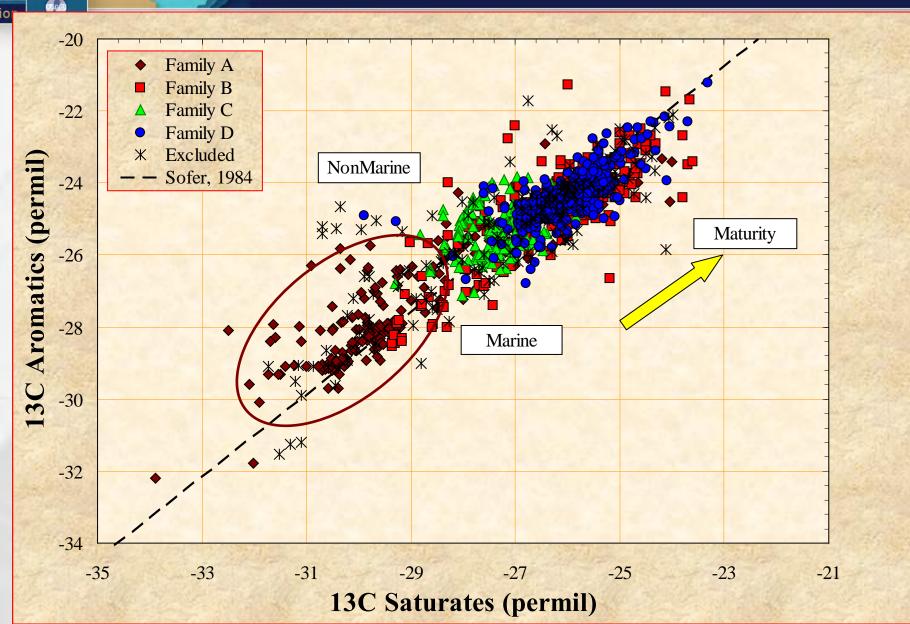
Family A (184 Oils)







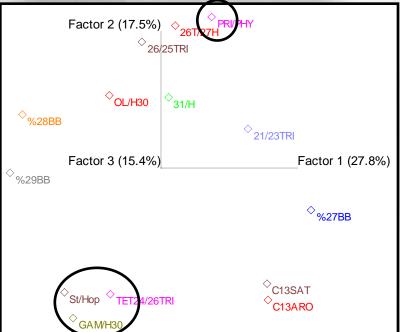
#### Family A



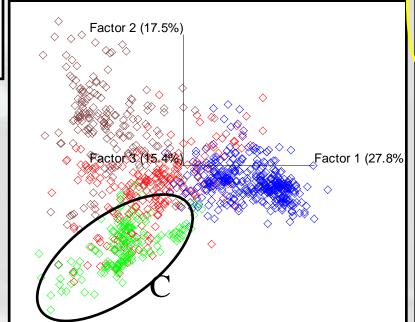


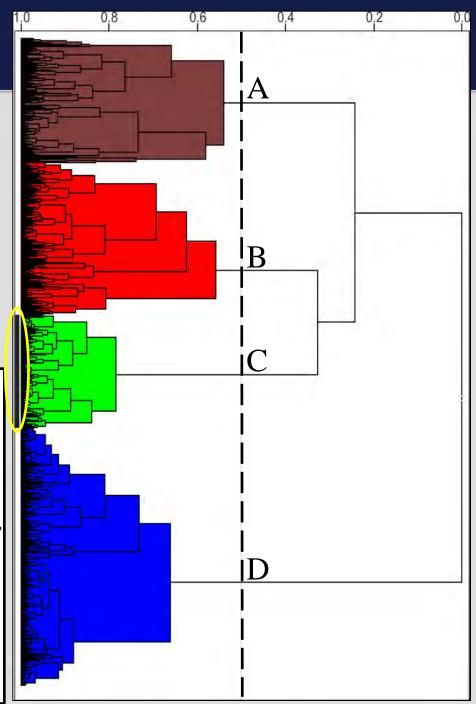






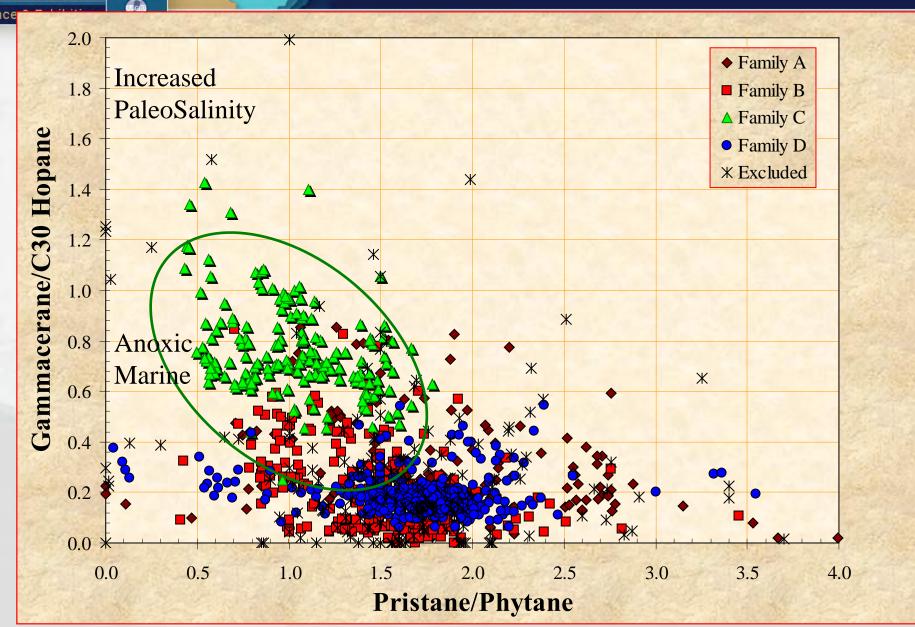
Family C (167 Oils)







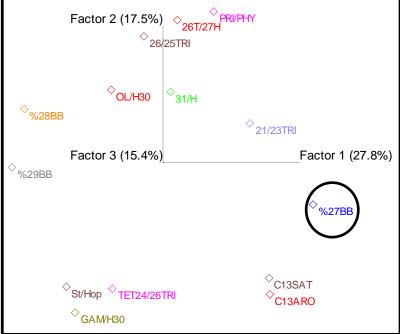
### Family C



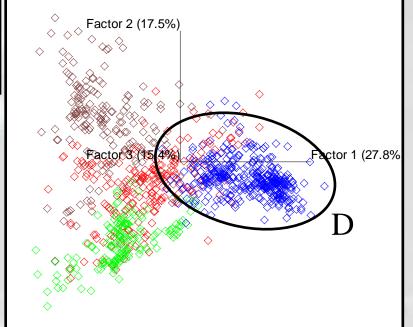


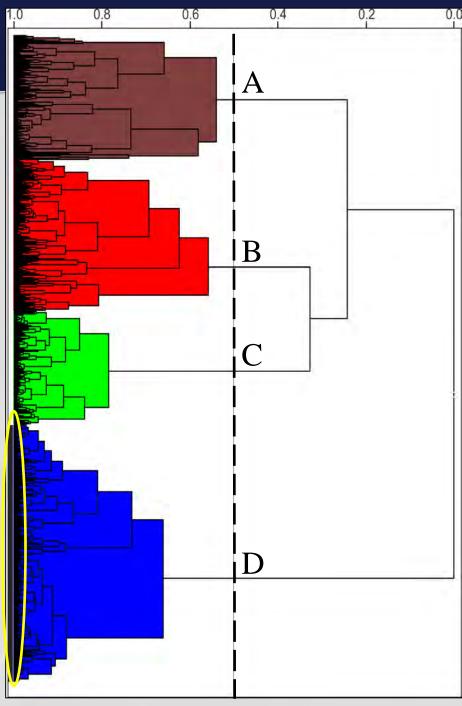






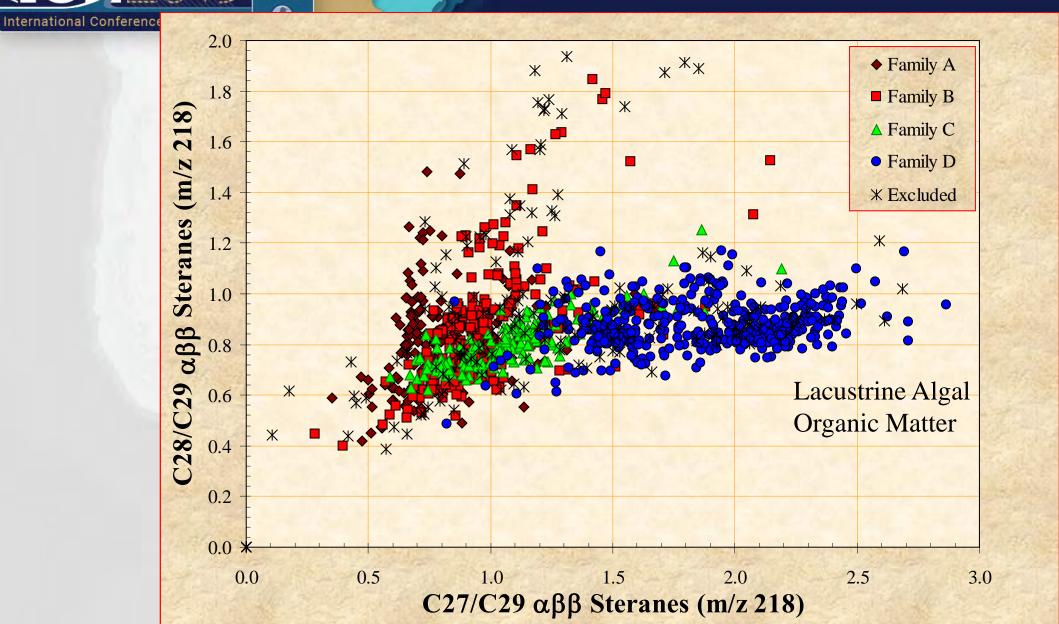
Family D (382 Oils)



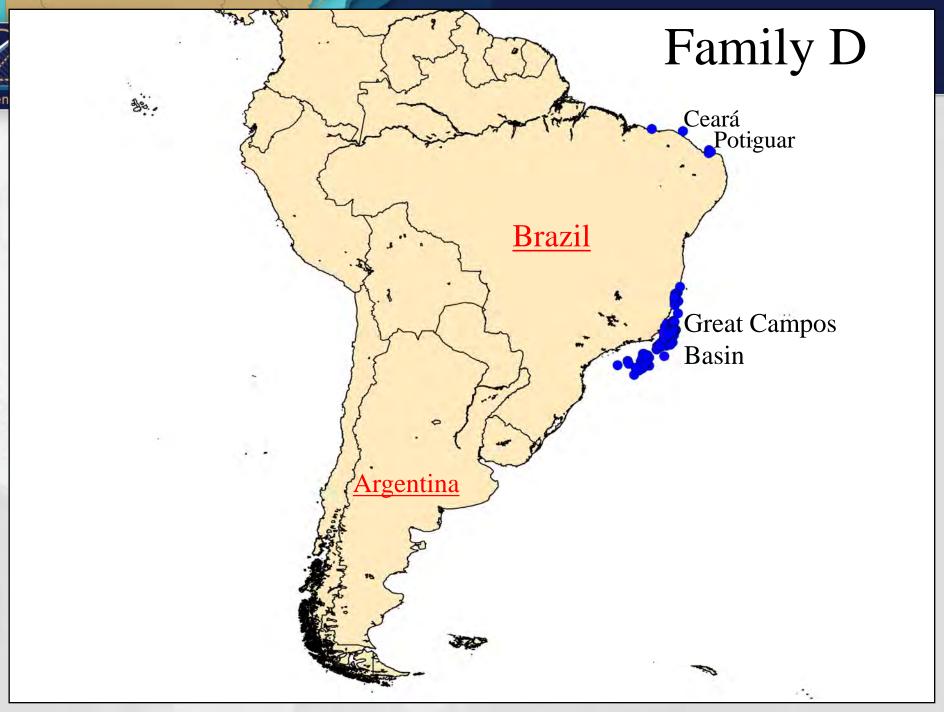




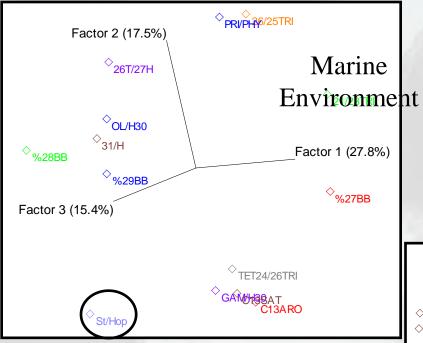
#### Family D





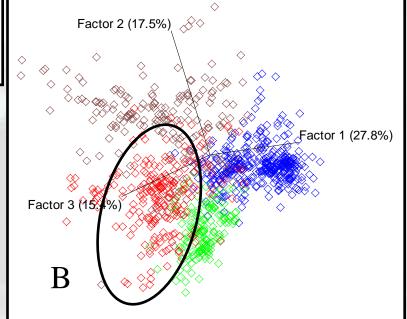


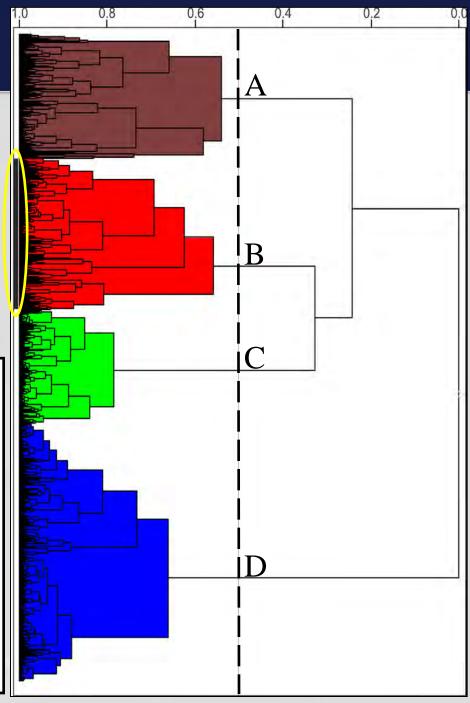




Family B

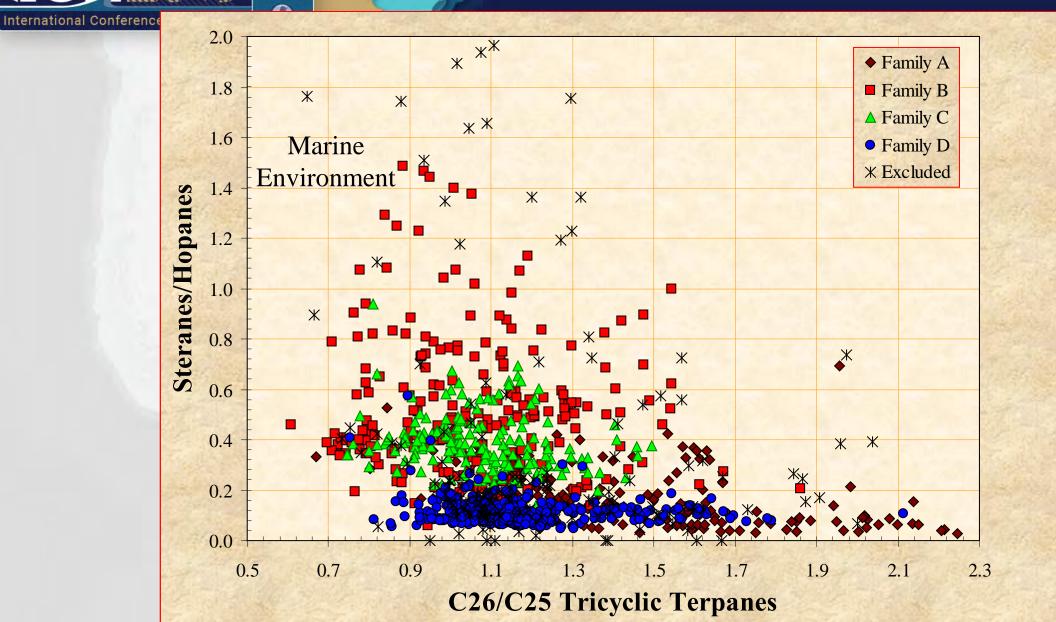
(225 Oils)







## Family B



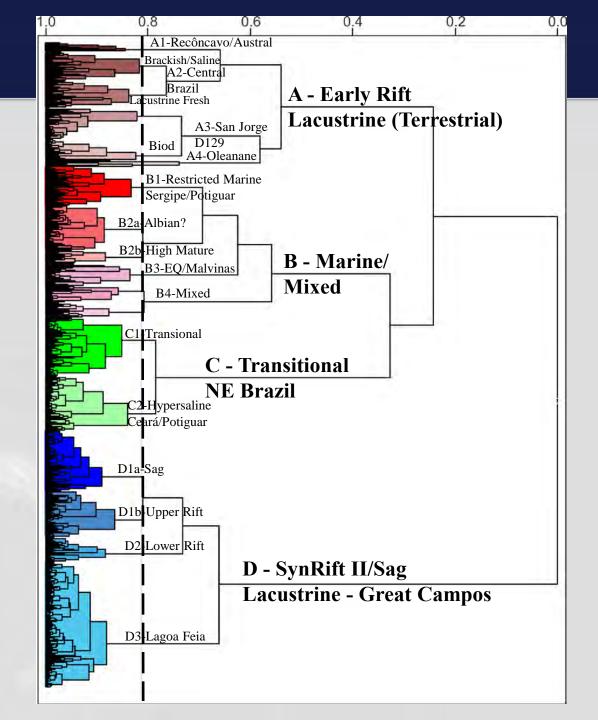




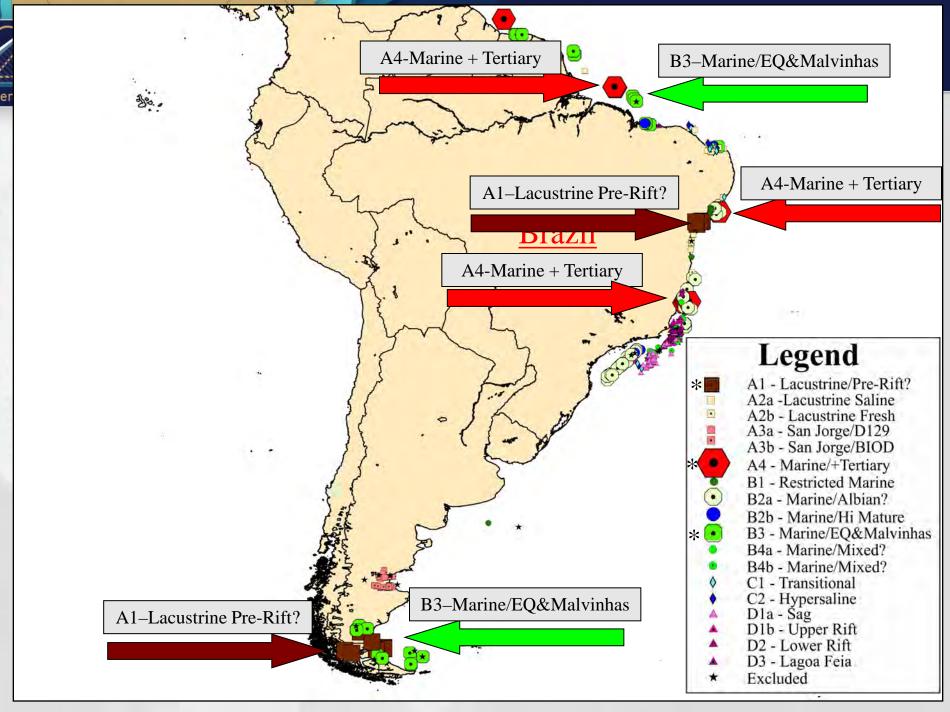


#### HCA Dendrogram @ 0.8

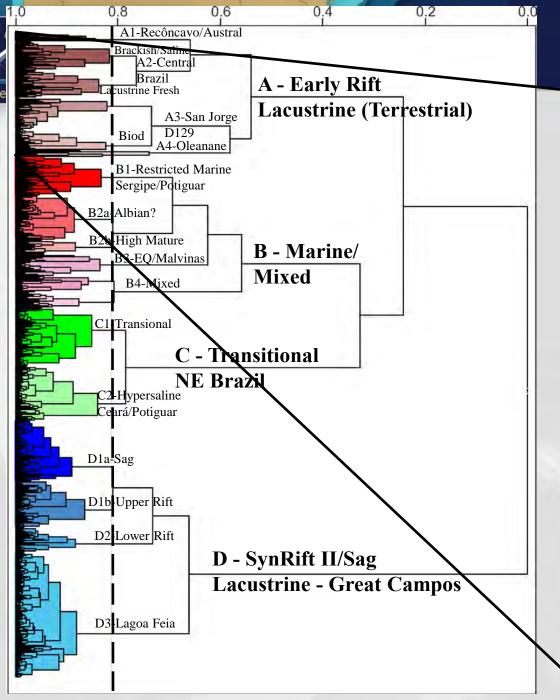
- 1130 Oils
- 182 Excluded
- 14 Parameters
- 60%/PC3
- 77%/PC5
- 18 Sub-Families at 0.812



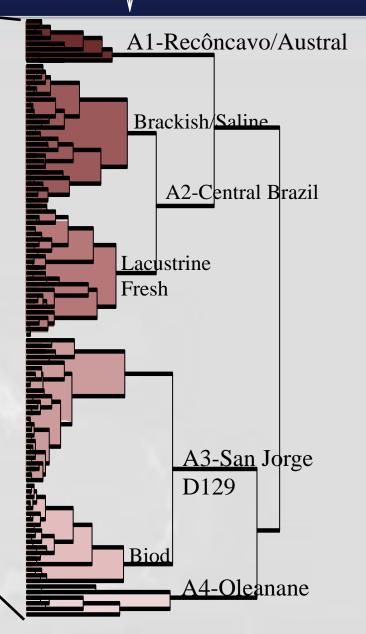


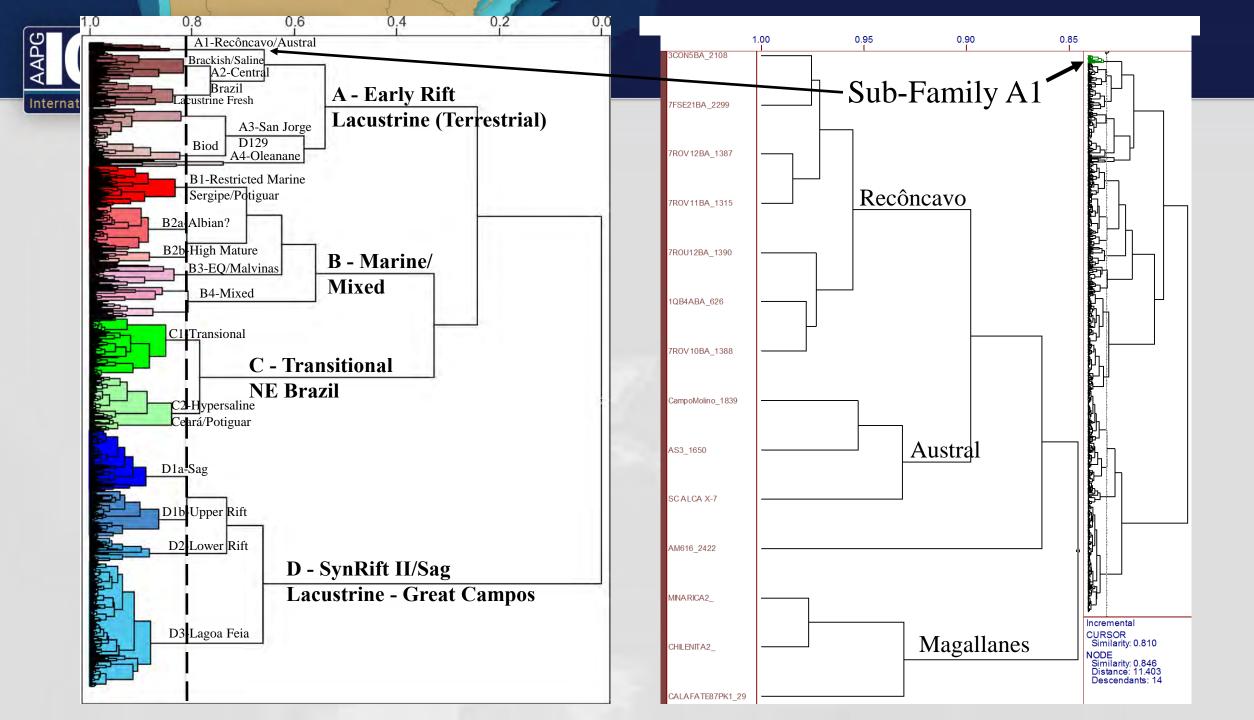






## Family A – Early Rift

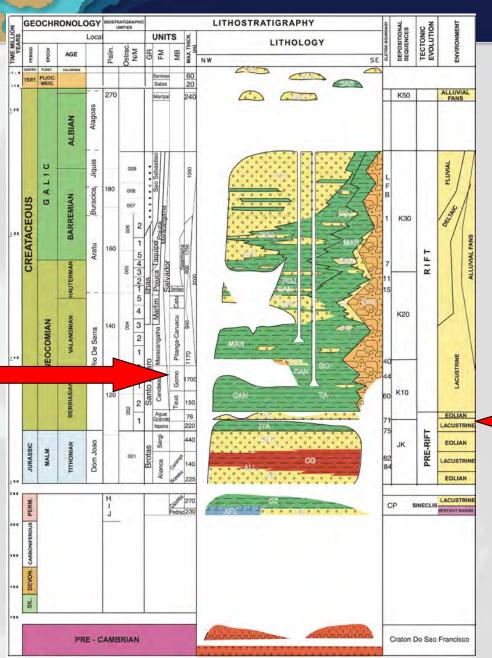






Candeias Fm; Gomo Mbr is Primary Source Unit (A2)

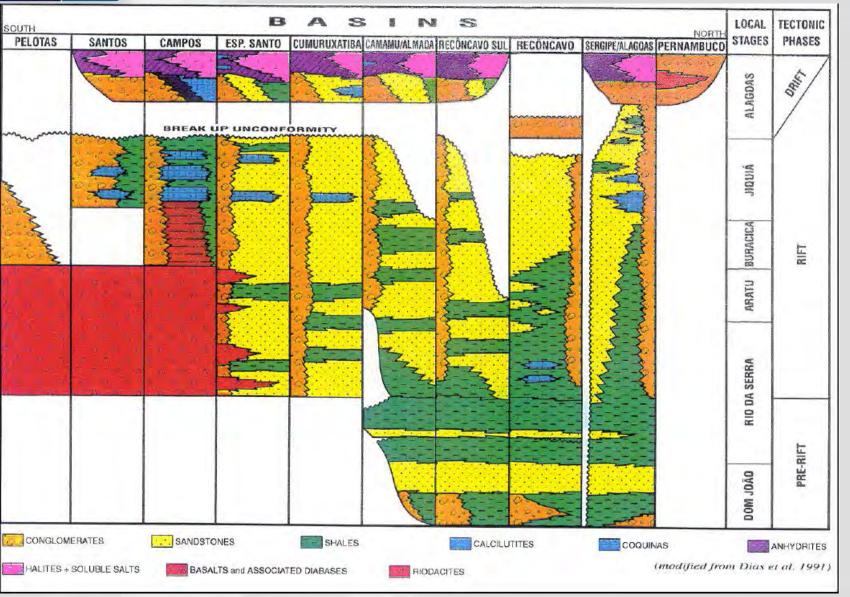
#### Recôncavo Basin Schematic Stratigraphic Chart



Pre-Rift Source for A1 oils?

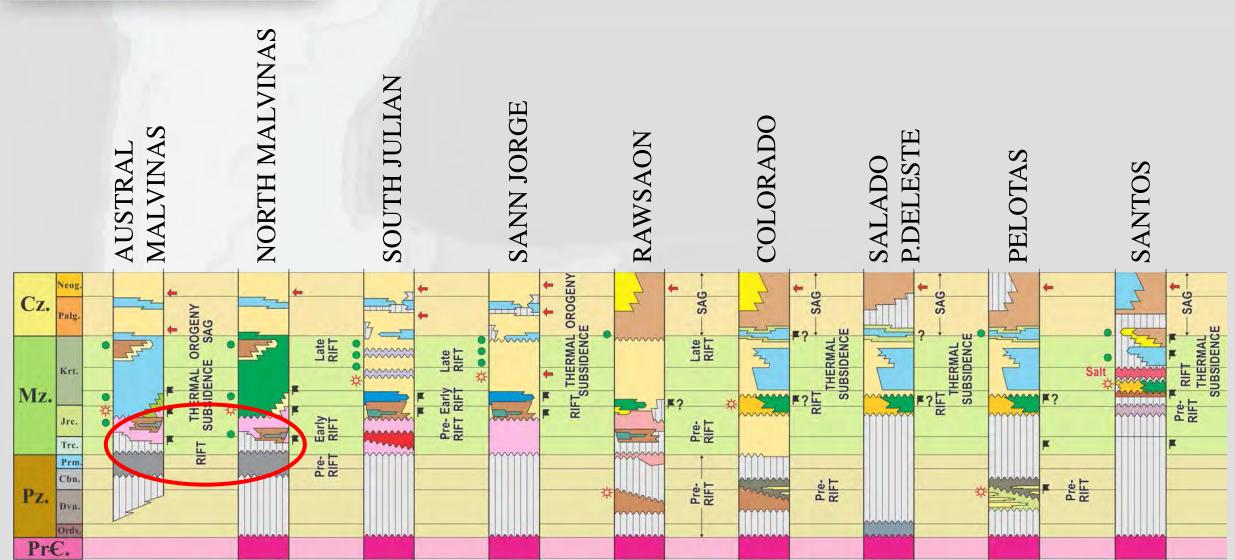


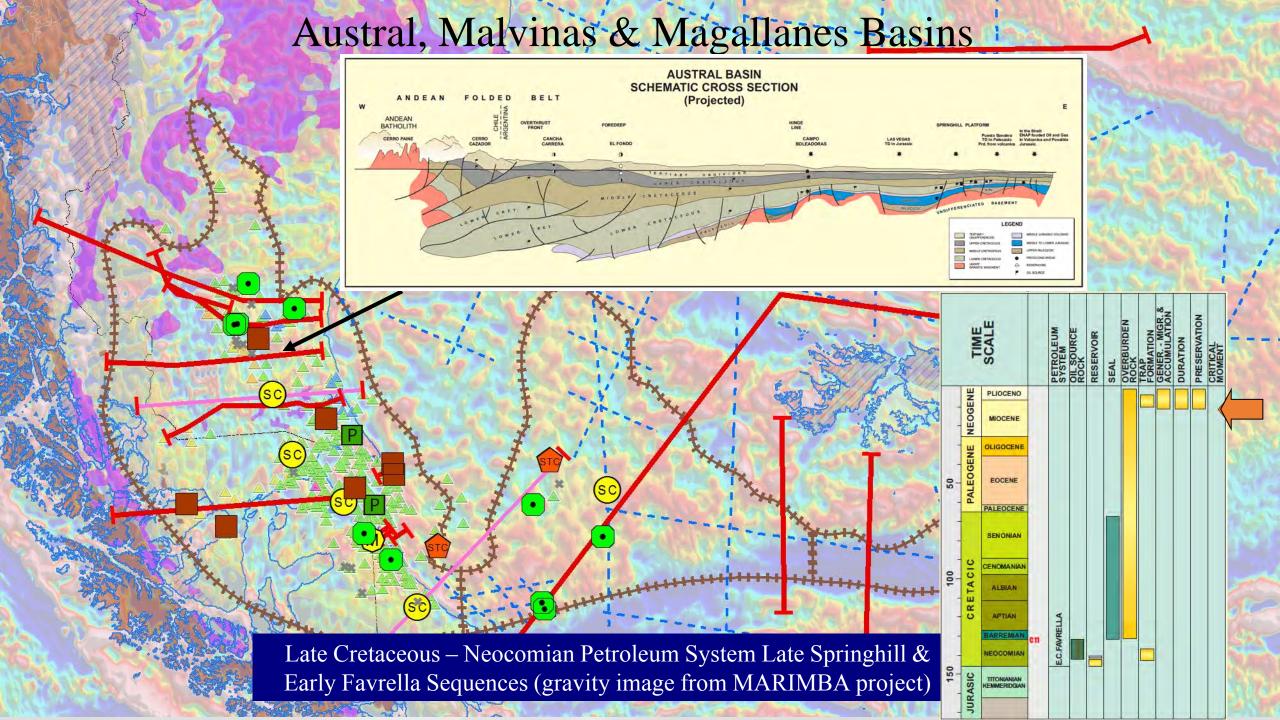
# Simplified Lithologic and Chronostratgraphic Chart in the Brazilian Basins of the South American Rift

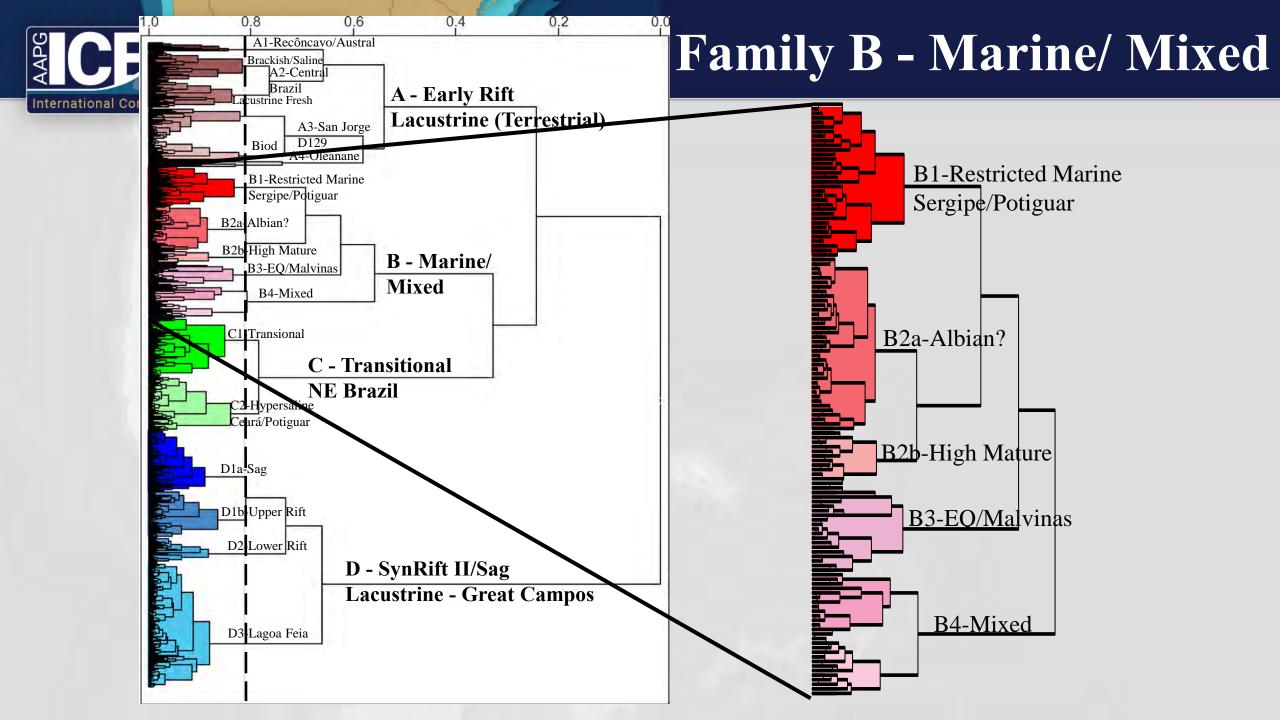


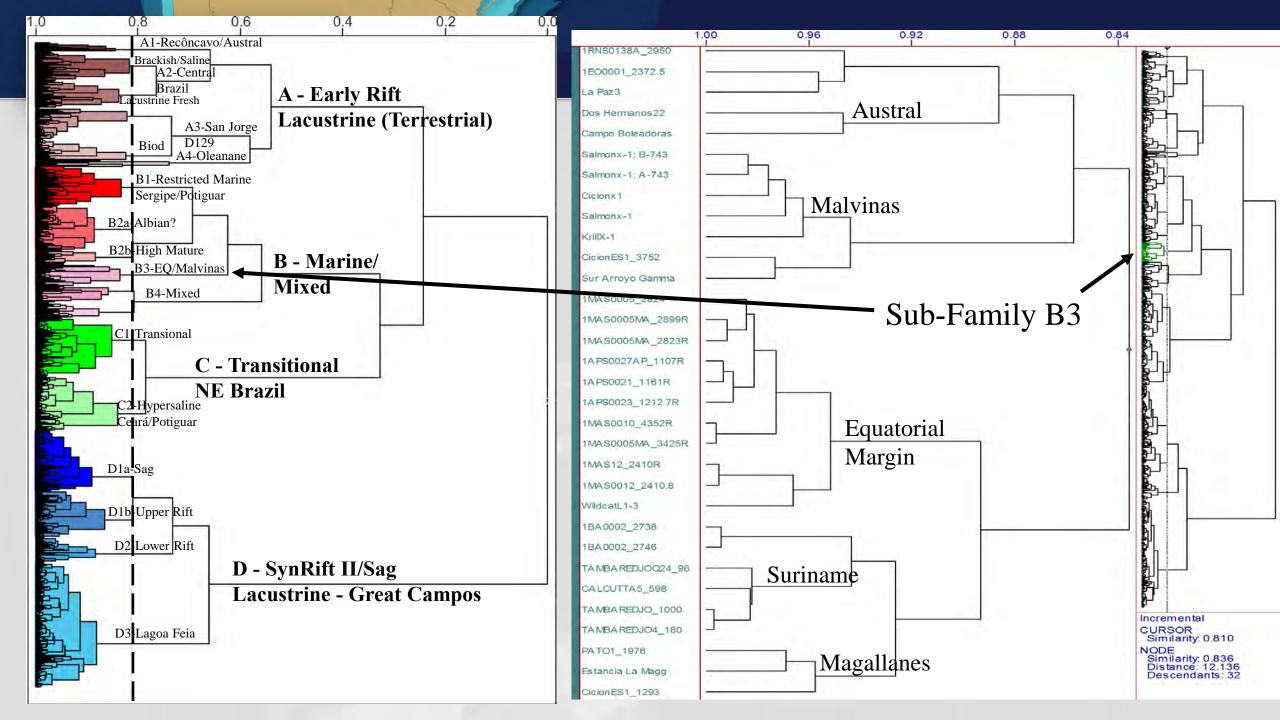


# Simplified Lithologic and Chronostratgraphic Chart in the Argentine Basins of the South American Rift











#### SCHEMATIC STRATIGRAPHIC CHART - PARA MARANHAO BASIN

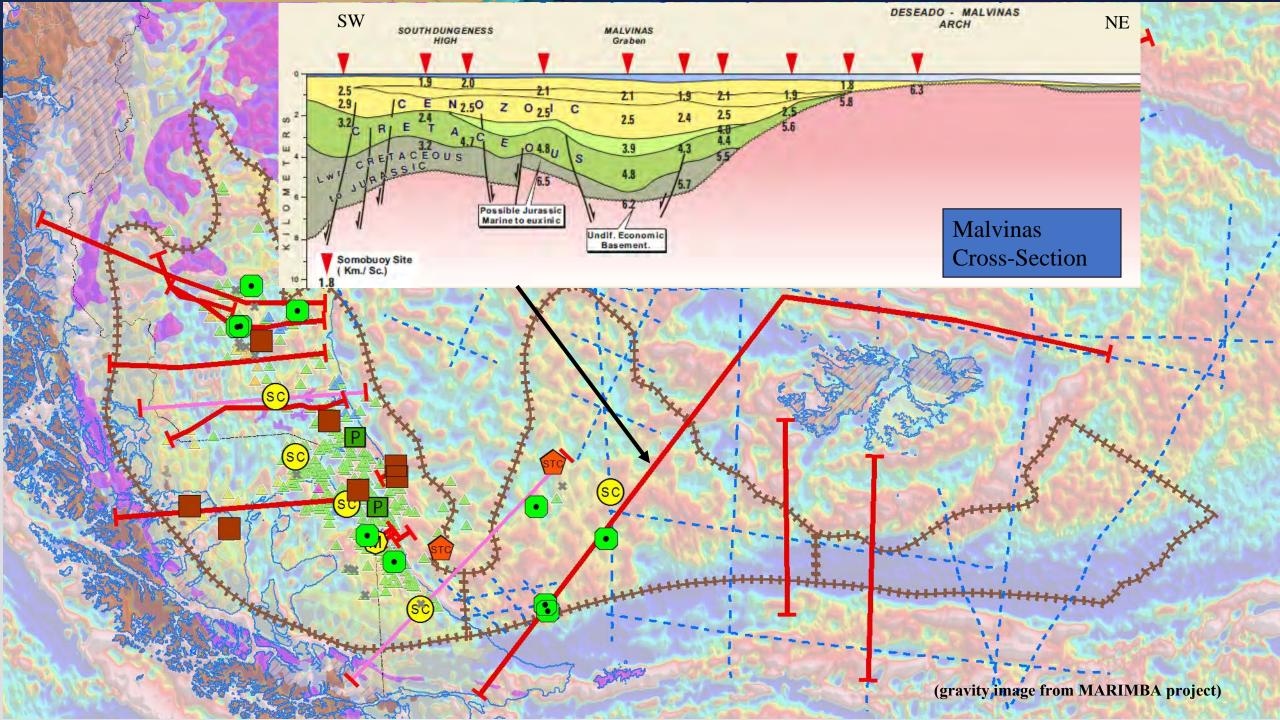
1 AADC

NO	GEOCHRONOLOGY BIOSTRAT, UNITS								LITHOSTRATIGRAPHY				NON	JNAL
YEARS	PERIOD		AGE	Local	Foram.	Nanof.	Palin.	GR.	FM	Max Thick (m)	LITHOLOGY		TECTONIC	DEPOSITIONAL ENVIRONMENT
	A R Y	Miocene Plicene 2	Zanciean Messinian Tortonian Serrayalian Langhan Burdigelian		Myogypsina Amphistebina		810		Areinhas	566	ANT TRA	T50 - T60	Z	NERITIC
	-	Eocene Oligocene	Acutanian Chairlian Rupeilan Priabonian Bartonian Lutetian Ypresien		220 W 340 350 3 W	6 450 6 440 6	30 30 310 320 320	erto De Campos	Arei	4348	Ante 9 TRA	T20 - T40	VE MARG	BATHYAL
	S	Senonian Paleccene	Danian  Danian  Maastrichtian  Cempanian  Santonian  Coniacian  Turchian			320	30 -70 -20 -30 -30 -30 -30	Humberto	Travosas	1900		K90 K100 K100 K110	PASSIV	ABYSSAL
	0 0		Cenomarian			3	90	Caju		311		-K80	NOILIS	TIC
)	CE	Galic	Albian		110.1	-	330	Canarias	•	1880	CHI	K60	RIFT	NERITIC FLUVIO/DEL' LACUSTRI
	ETA	9	Aptian	Alagoas		2	70							
0	CR		Barremian	Jiquia										
)														
		P	ROTE	RO	Z	OIC	2							

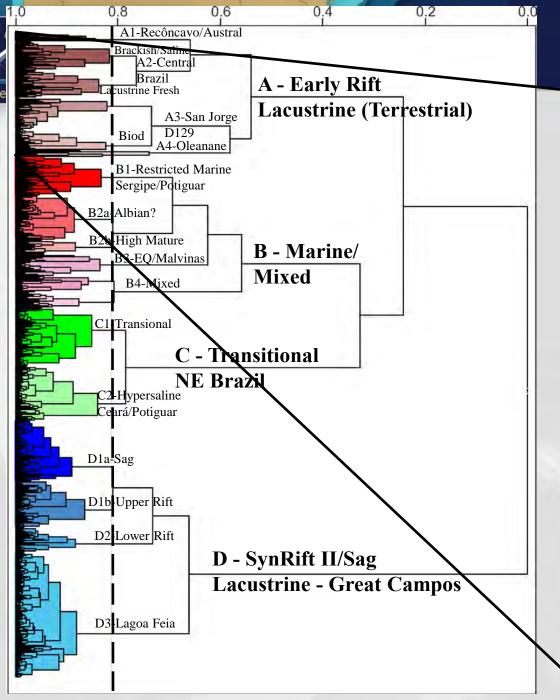
#### MALVINAS BASIN Stratigraphic Column

ERA	b	EPOCH	LITHO- LOGY	НС	FORMATION/ LITHOLOGY	DEPOSITIONAL ENVIRONMENT	PHASE
	QUAT	TERNARY	0 = _A_				
ERTIARY	PLIOCENE				SILTSTONES+ MUDSTONES	Neritic	
	MIOCENE OLOGOCENE			0	greenish gry	Marine neritic to Bathyal	FORELAND TROUGH
	,	OLIGOCENE	7				
TE		EOCENE	مممم		CLAYSTONES	Bathyai	LATESAG
16		PALEOCENE		Ð	GLAUCONITICO Ss fine- md grn	Marine offshore Nertic - Bathyal	
ous	UPPER	MAASTRICHTIAI TO CONIACIAN	Z-2		SANDSTONES GN GRY Fine - md gm. Upper INOCERAMUS SHALES + MARLS	Marine Outer Neritic	MIDDLE SAG
ACE		TURONIAN CENOMANIAN TO			Mid. INOCERAMUS Fm. MARGAS VERDES Fm.	Marine Nearshore	
CR	ER	ALBIAN		'	LWR INOCERAMUS Fm. ORGANIC RICH SHALES	Marine Anoxic	
0	LOWER	APTIAN TO BERRIASIAN	7.3	Φ	SPRINGHILL Fm. BASAL CLASTICS	Shallow Marine to Continental	EARLY SAG
ASSIC		UPPER	4		TOBIFERA FM	140 2000	SYN-RIFT
JURAS	LOWER		V - 11 V		Bedded Tuffs * Volcanics	NON MARINE VOLCANO CLASTICS	
PRE	144	URASSIC			BASEMENT		PRE - RIFT

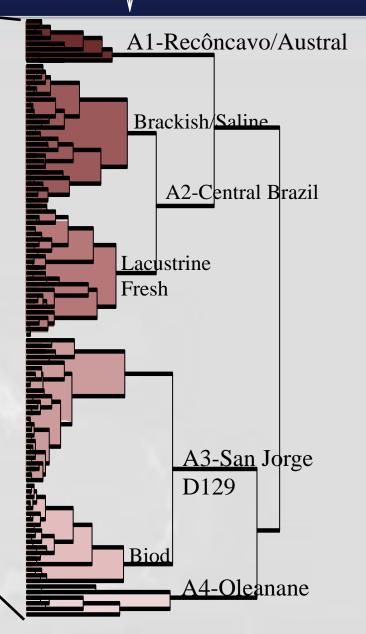
POTENTIAL SOURCE ROCK HORIZON







## Family A – Early Rift





#### CONCLUSIONS

- Statistical evaluation of chemical data for 1130 oils from eastern South America allows for separation into four broad groups or families according to source depositional environment and age
- Four groups include oils derived from lacustrine source rocks deposited during early (A) and late rift (D) lacustrine and/or sag, transitional (C) and marine (B) environments
- Results suggest a possible Pre-Rift lacustrine source in Recôncavo (?) that is similar to early rift source active in Austral Basin (Late Springhill & Early Favrella Sequences)
- Albian (Caju Fm) derived oils from Foz do Amazonas and Para Maranhão that are broadly related to marine-derived (Margas Vertes; Lower Inoceramus) oils from Austral and Malvinas, appear to be genetically related to oils from Cote d'Ivoire
- Evidence of input from younger Tertiary terrestrial-influenced (oleanane; angiosperms) source rocks is found offshore Guyana, Foz do Amazonas, Espírito Santo and Sergipe