

Use of Biostratigraphy and 3D Seismic Data to Reinterpret Depositional Environments of the Lower Cruse in the Southern Basin of Trinidad*

Curtis Archie¹, Christopher Lakhan¹, and Nancy Gallai-Ragobar¹

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Abstract

In the Southern basin of Trinidad, about 60% of the hydrocarbons produced to date come from the Cruse Formation. The Cruse represents a progradational sequence of deep-water turbidites to shallow water (deltaic) sediments. The top of this sequence is marked by an unconformity that is overlain by the Forest Formation, which represents another progradational sequence of prodelta to shallow water deltaic sediments.

Sequence stratigraphic models previously placed upper bathyal Lower Cruse deposits in the lowstand systems tract, slope fans and basin floor fans of a third order cycle. This upper bathyal setting for Lower Cruse sedimentation extends for over 100 km from the Gulf of Paria in the West to the Maloney Field on the East Coast of Trinidad.

This sequence stratigraphic model has now been revised based on recent integrated work using paleobathymetries, log motifs, and seismic attributes where some middle neritic sediments previously interpreted to be Middle Cruse have now been identified as a slumped facies within the Lower Cruse. The Lower Cruse continues to be interpreted as lowstand deposits but the thick sand deposits have now been interpreted to have been deposited in mini-basins on the slope and constitute low stand slope fans. Regionally the Lower Cruse interval is dominated by claystones and occasionally by thick sands.

Spectral decomposition was used to further understand the stratigraphic setting of the Lower Cruse. Various tuning cubes were generated for the interval and it was observed that each frequency was tuned at a different thickness. A low frequency of 10 Hz and a time window of 100 ms illustrated a channelized system with a sand trend from SW – NE and source direction from the SW. Spectral decomposition was also used to calculate the thickness of the sand (513 feet) within the system. This value was in close comparison to the sand thickness derived from the geological model. A SW-NE trending progradational feature was mapped using seismic data, which internally exhibited bidirectional downlap that created potential closure in an up dip direction. An exploration well has been proposed to 12,500 ft to test the validity of this stratigraphic trap.

Selected References

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- Prather, B.E., J.R. Booth, G.S. Steffens, and P.A. Craig, 1998, Classification, lithologic calibration, and stratigraphic succession of seismic facies in intraslope basins, deep-water Gulf of Mexico: AAPG Bulletin, v. 82, p. 701-728.



Petroleum Company of Trinidad and Tobago Limited

**Use of Biostratigraphy and 3D
Seismic to Reinterpret Depositional
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the Southern Basin of Trinidad**

**Curtis Archie, Christopher Lakhan , Nancy Gallai-
Ragobar.**

Introduction:

In the Southern basin of Trinidad, about 60% of the hydrocarbons produced to date have come from the Cruse Formation.

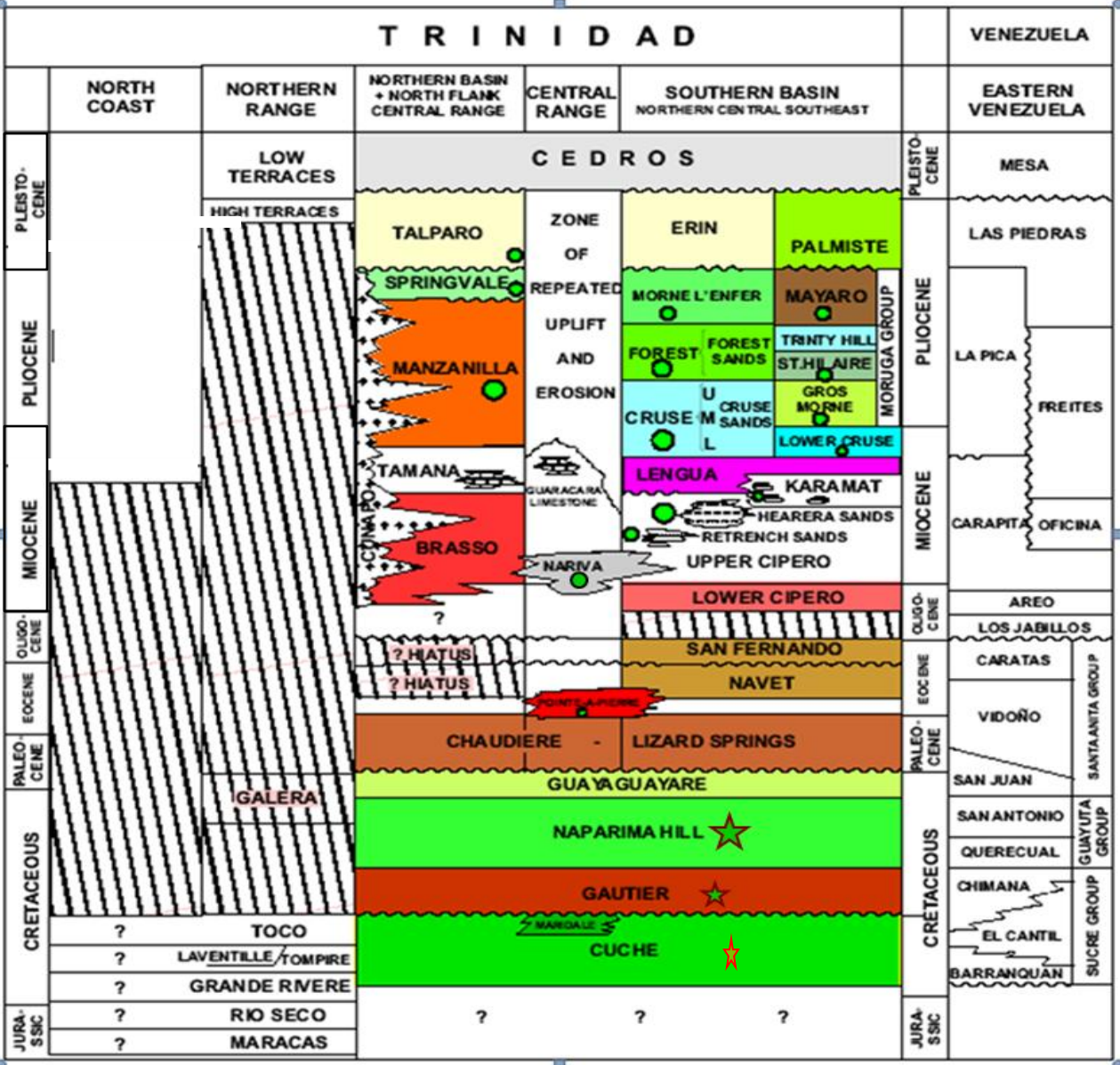
The Cruse represents a progradational sequence of deep water turbidites to shallow water (deltaic) sediments.

Traditional depositional models have interpreted the Lower Cruse interval as basin floor fans, with the claystone dominated intervals and sections with abundant reworked foraminifera being interpreted as 'mud flow'.

A large, faint, semi-transparent watermark of the Petrotrin logo is visible in the background. The logo consists of a stylized leaf or flame shape inside a circle, with the word "Petrotrin" written in a curved font below it.

Petrotrin

STRATIGRAPHIC CHART



After Carr-Brown & Frampton 1979

- Oil & Gas producing Reservoirs
- ★ Source Rocks

Lower Cruse - Biostratigraphy

The Lower Cruse is defined by Petrotrin as the last appearance datum (LAD) which is the first downhole occurrence of *Discamminoides tobleri* (Lit 1) .

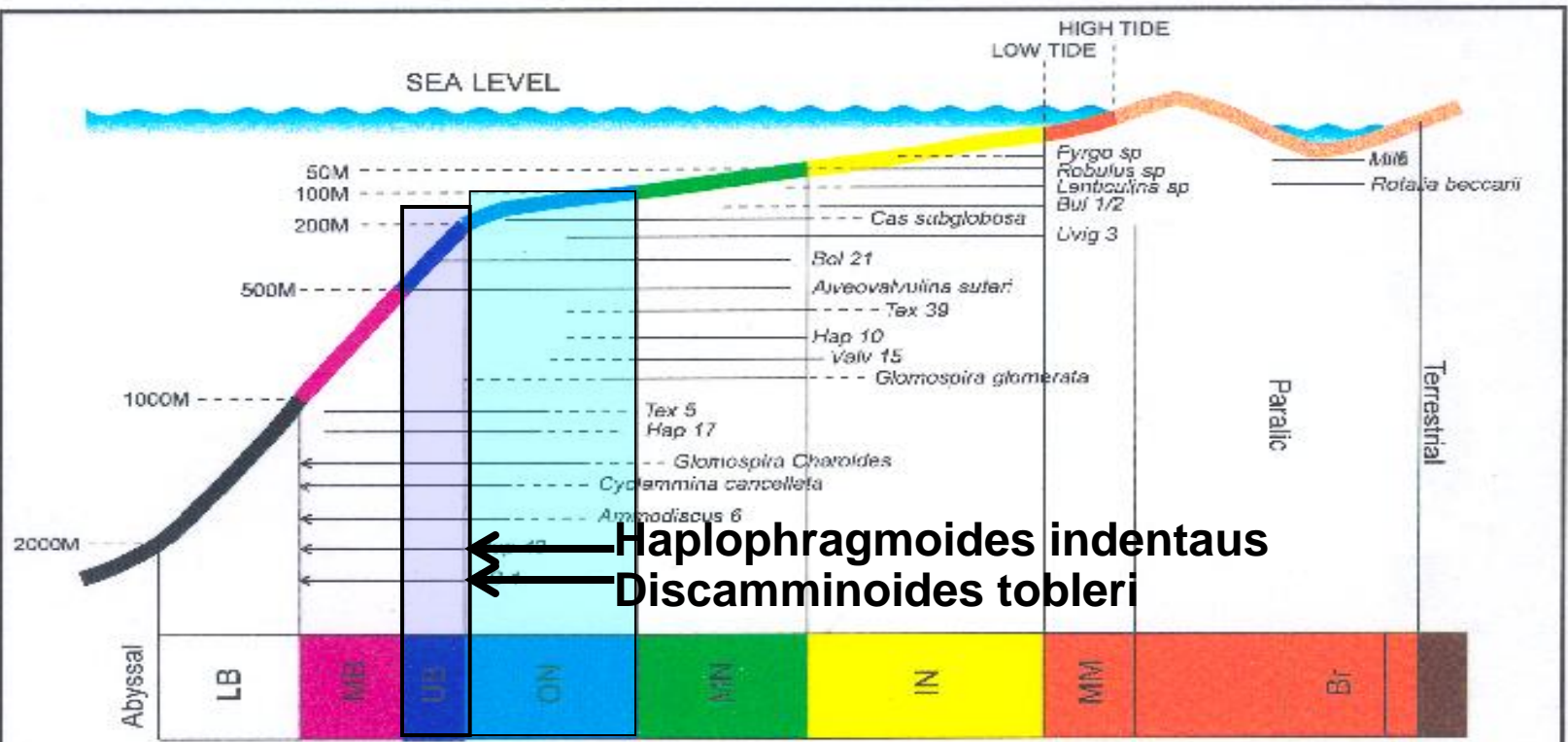


DISCAMMINOIDES TOBLERI Bronnimann, 1951

The Lower Cruse contains a rich and diverse upper bathyal faunal assemblage comprising primarily of arenaceous foraminifera.

This assemblage includes *Haplophragmoides indentatus* (Hap42), *Textularia notabilis* (Tex5), *Guppyella miocenica*, *Cyclammina cancellata*, *Trochammina pacifica*, *Recurvoides obsoletum*, *Ammodiscus incertus*, and *Glomospira charoides*

Paleobathymetry



Note: Vertical scale greatly exaggerated.

DIAGRAM OF THE DISTRIBUTION OF MODERN BATHYMETRIC ENVIRONMENTS SHOWN AT PRESENT-DAY HIGHSTAND OF SEA LEVEL (MODIFIED FROM HEDGPETH, 1957). STUDIES OF MODERN ORGANISMS WITH PRESERVABLE PATHS PROVIDE CRITERIA FOR RECOGNIZING EACH OF THE BATHYMETRIC ENVIRONMENTS WITHIN THE GEOLOGIC RECORD. THE LIMITS OF THESE DEPTH ZONES ARE RELATED TO REGION TO REGION, ALTHOUGH MOST WORKERS RECOGNIZE THE SAME CHARACTERISTIC FAUNAL ASSEMBLAGES.

Stratigraphic Column showing Formations and Microfossil Index Species

Fossil Definition	Formation / Member	Selected Microfossil Index Species	TLL(1951)	UBOT/SHELL(1951)	Kugler	Series
Defined by arenaceous Benthonics	Erin				4	Pleistocene 2.58Ma
	Upper Morne L'Enfer Sandstone				6a	Mid-Late Pliocene 3.6Ma
	Lot 7 Silt				6b	
	Lower Morne L'Enfer Sst				6c	
	Upper Forest Silt				6d	
	Lower Forest				8	Early Pliocene
	Upper Cruse				9a	5.33Ma
Lower Cruse				9b	Upper Miocene	
Defined by Planktonics	Lengua				lower 9b 10a	11.63Ma
	Karamat				10b 12a	
	Karamat /Cipero Herrera /Cipero				12b 14a	

Inaccurate Lower Cruse Pick

Tex 5 is a longer ranging benthic species and can occur above the LAD of Lit 1

True Lower Cruse Pick

Tex. 5

Hap 42

D. tobleri / Lit1

G. menardii

G. mayeri

G. fohsi robusta

G. acostaensis

Gr.56
Gr.55

Gg.7
/Gr.55

Gg.7

OU1

Gr.7a/Gg.7

ML4-1

ML4-2

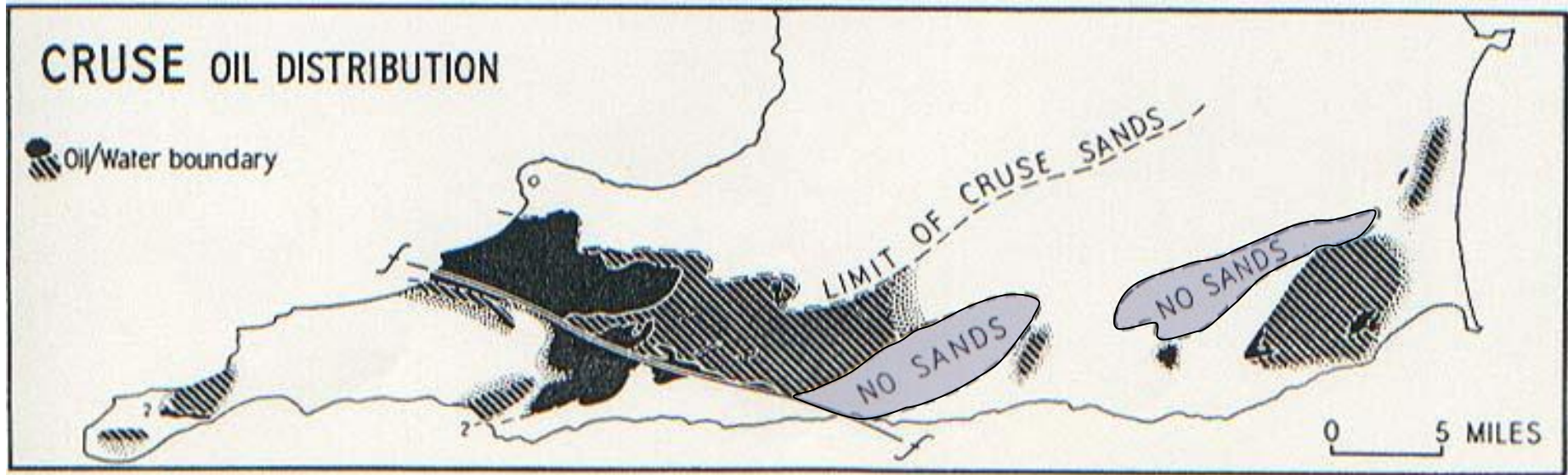
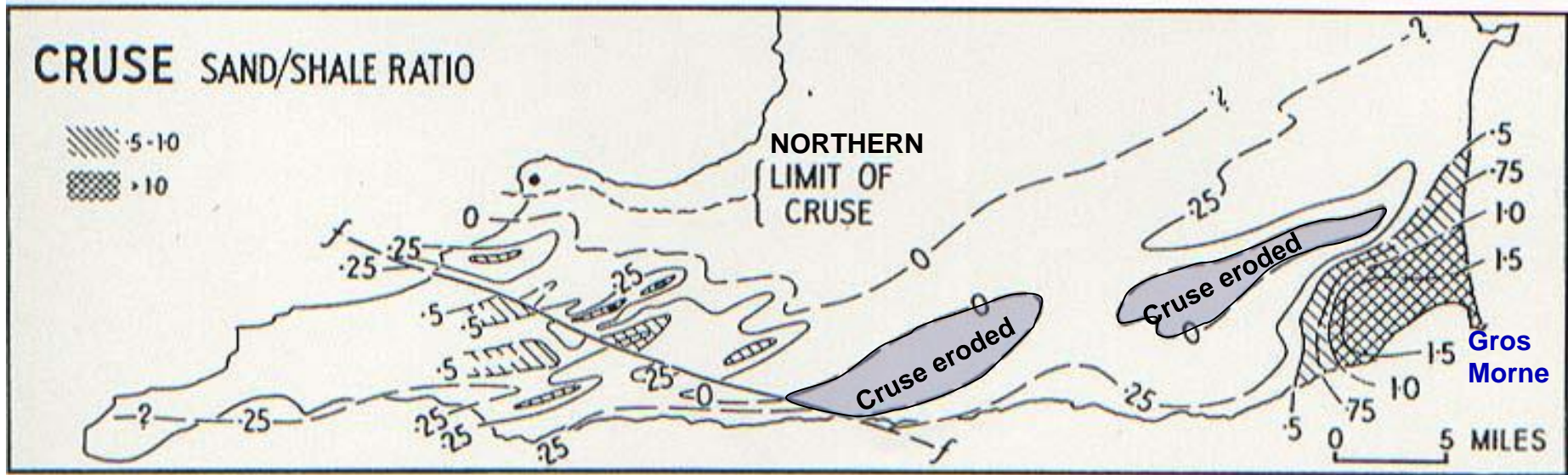
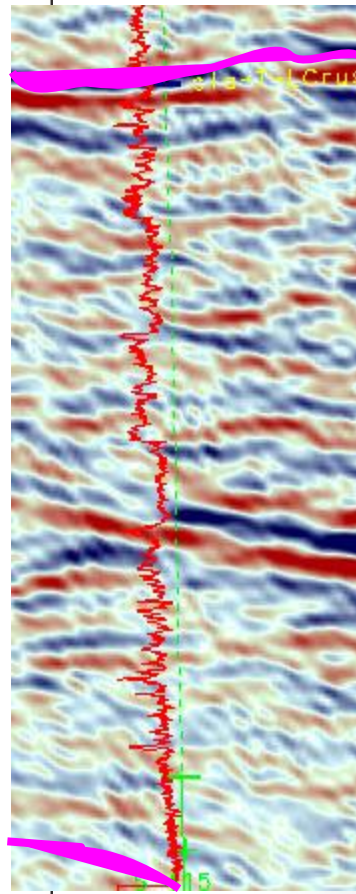
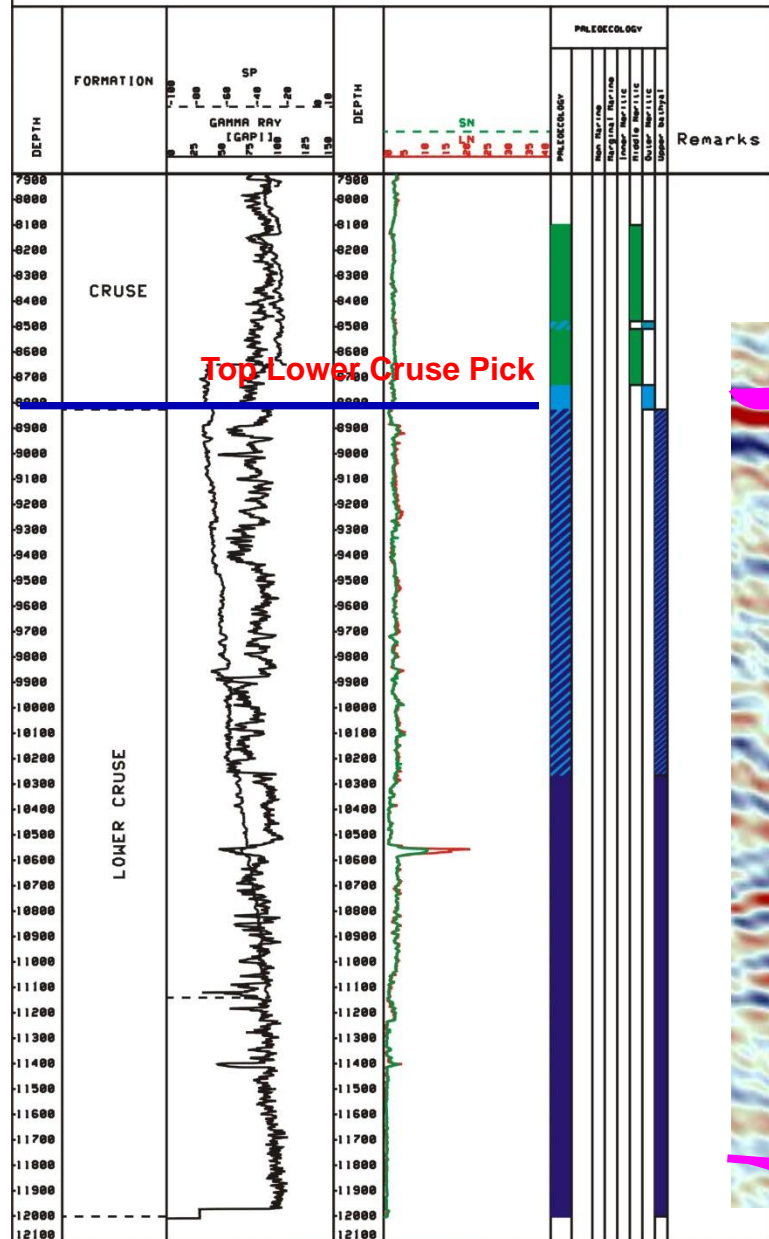


FIG. 7.—The Cruse cycle, showing sand/shale ratio (upper) and oil distribution (lower).

What does a Normal Succession of Lower Cruse look like?

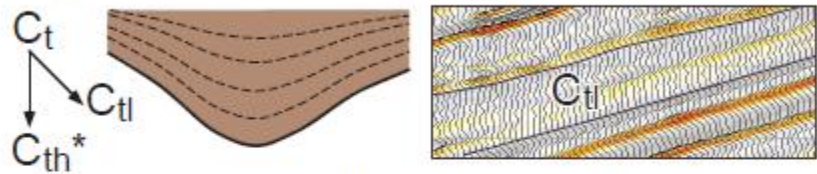
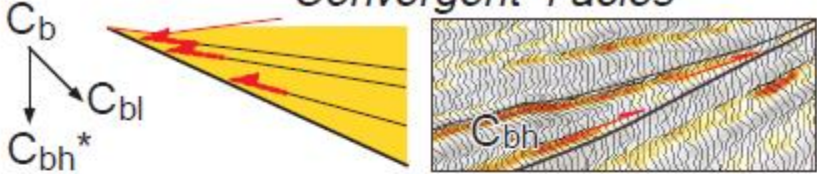


- L Cruse Biofacies is entirely Upper Bathyal
- No middle neritic fauna.
- No evidence of slumping

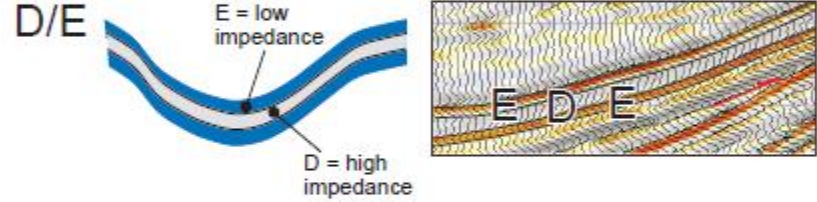


Turbidite Seismic Facies

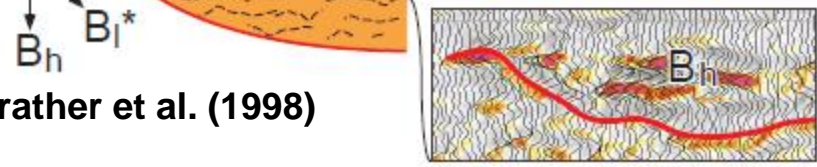
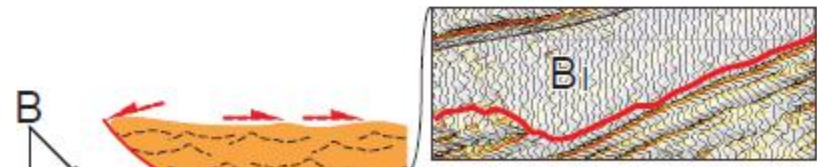
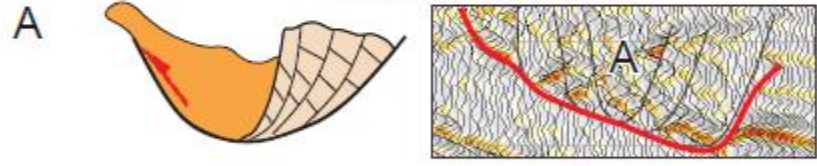
Convergent Facies



Draping Facies

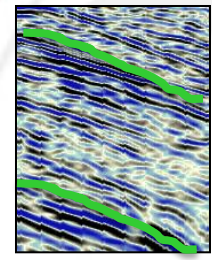
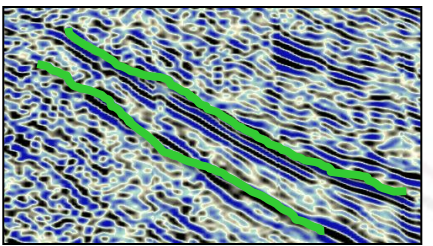
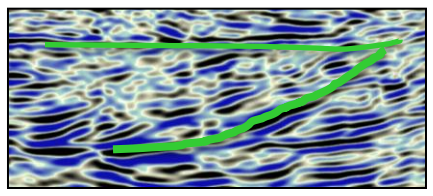


Chaotic Facies

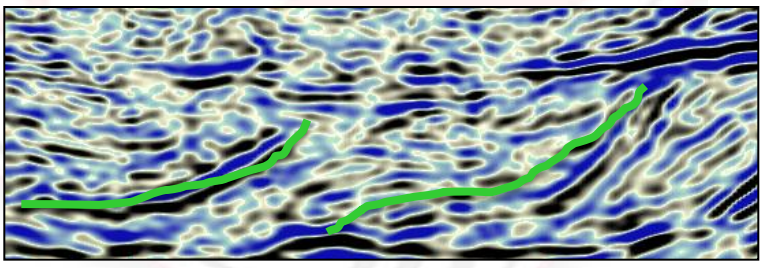


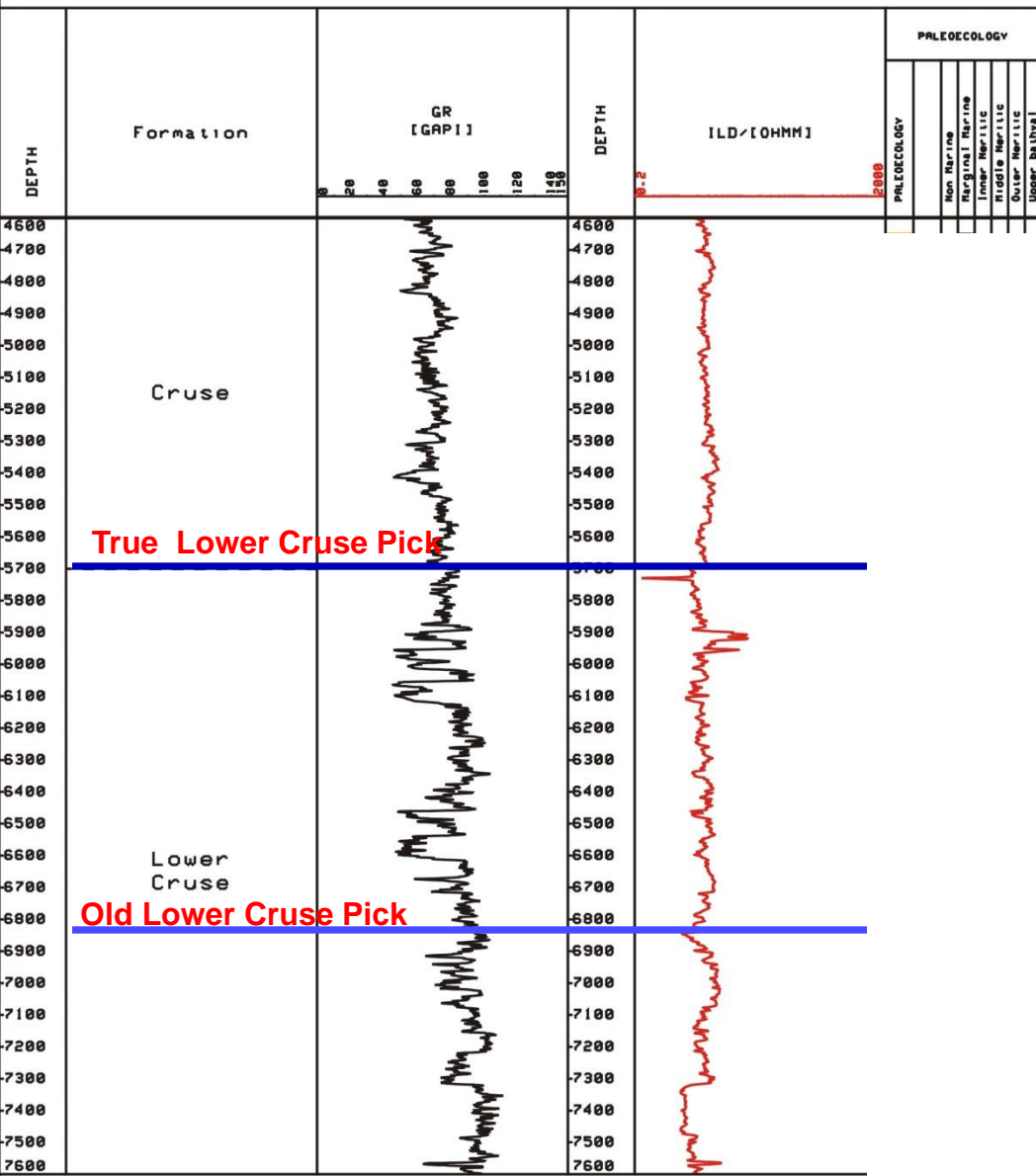
Prather et al. (1998)

Lower Cruse Seismic Facies



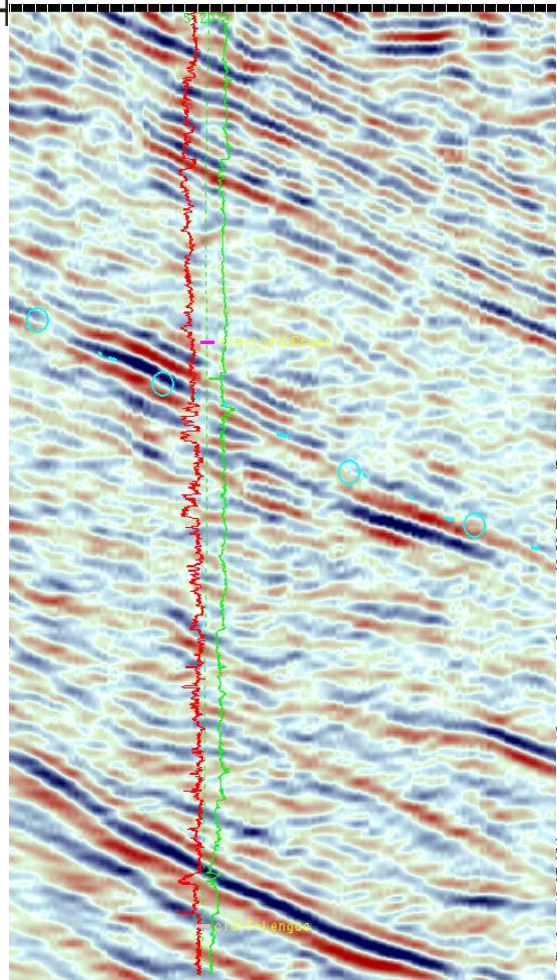
South West Soldado
PSDM





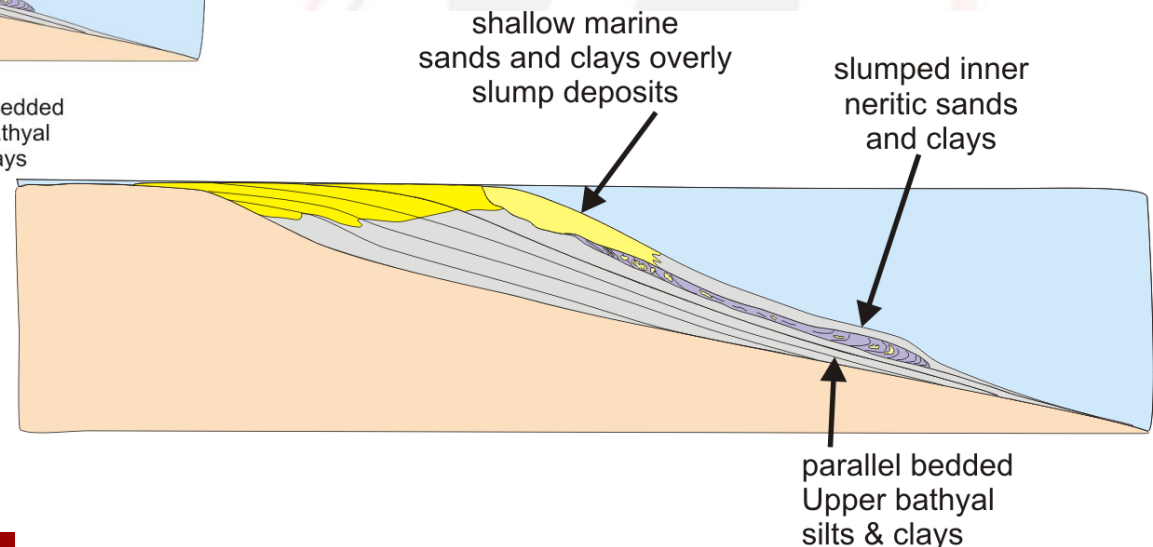
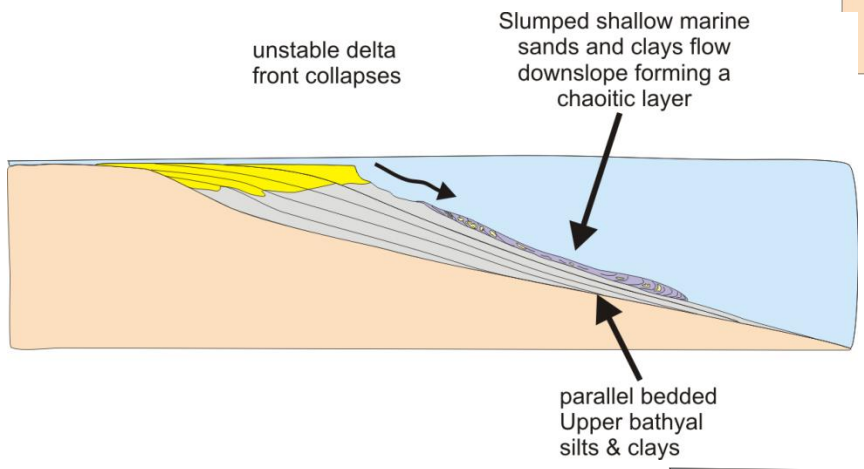
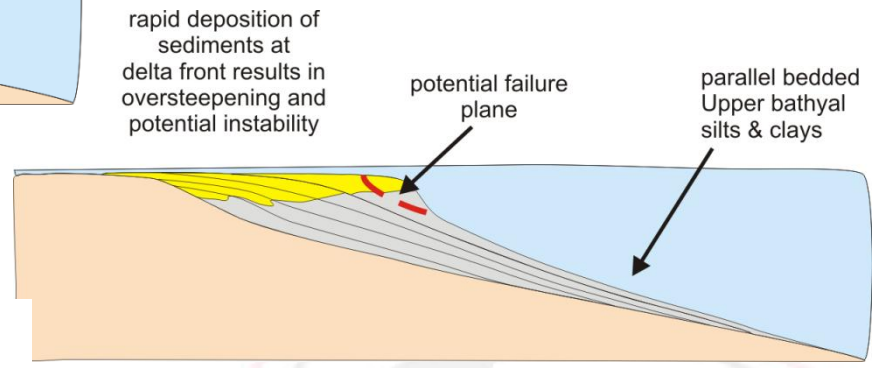
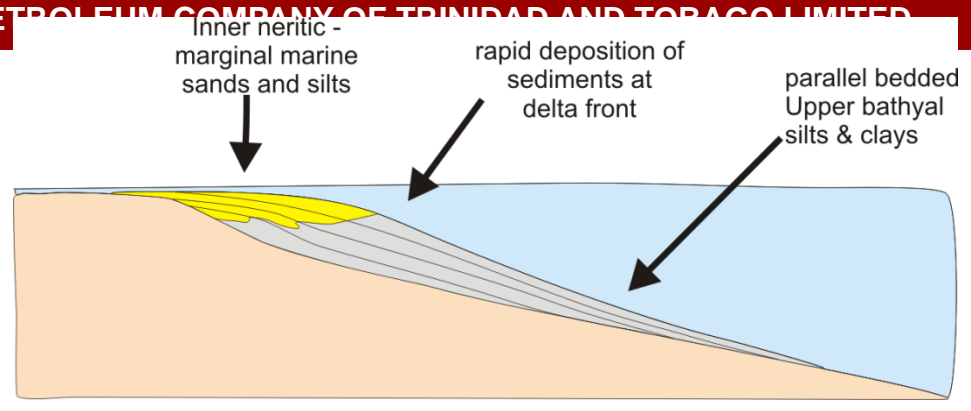
PALEOECOLOGY						
PALEOECOLOGY	Non Marine	Marginal Marine	Inner Neritic	Middle Neritic	Outer Neritic	Upper bathyal
0						
2000						

PALAEOBATHYMETRY

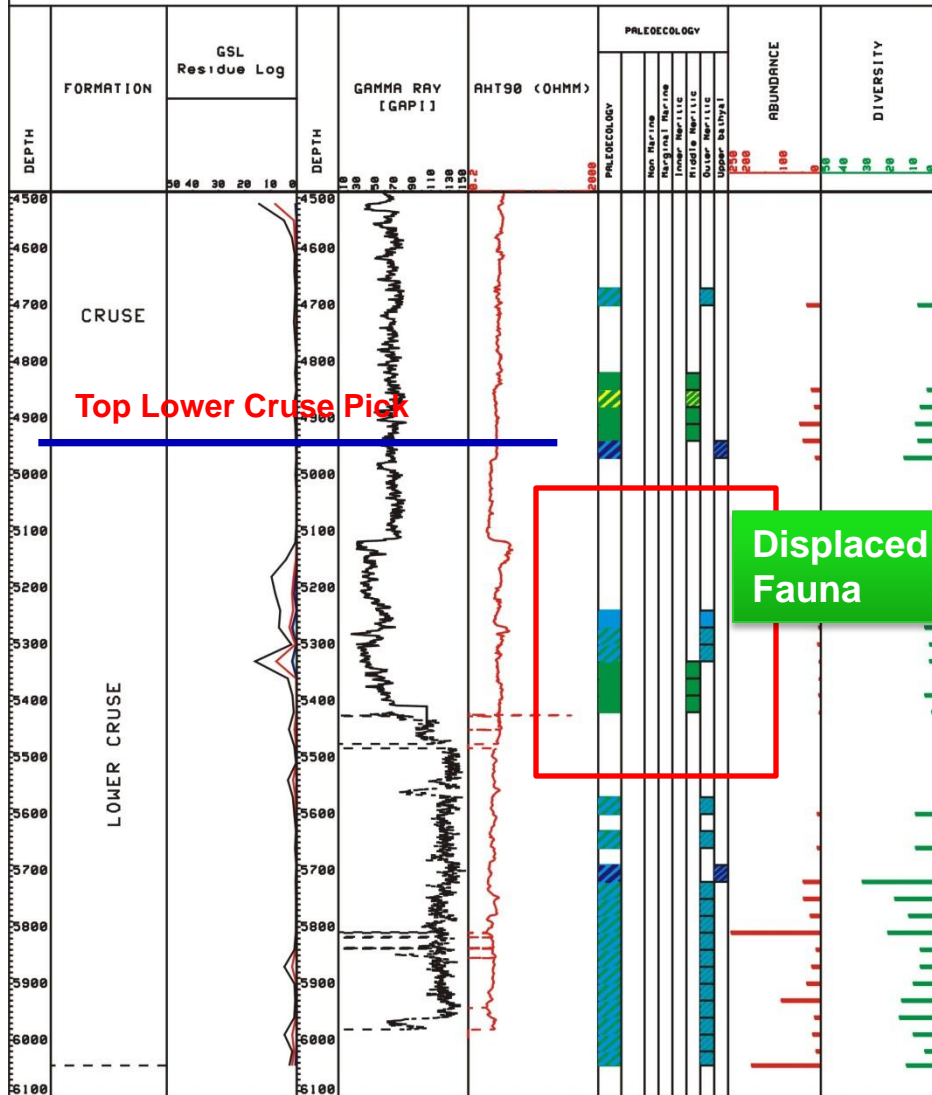


arrow) arenaceous fauna
 Valvulina 3 at intervals
 na, Kaplophragoidea 10
 be 6 at intervals between
 24 at 5840', Globi-
 na 1 at 5866',
 a specialised lower
 Lower Cruse (Middle-
 textularia 5,
 large Forams,
 at 6940', and rolled
 ng strongly calcareous
 Apatina 3, large
 Amphistegina with
 being more abundant
 lu 1, Globigerina 8
 bulina 3 at 9190',
 1, 2, Globigerina 11,
 ia 2, Sphaeroidinella 1,
 Globigerina 95 at 9470'; Globorotalia 1,
 Sphaeroidinella 2 at 9440'; Sphaeroidinella 1,
 Globulina 1 at 9470'.

Origin of displaced fauna on the slope

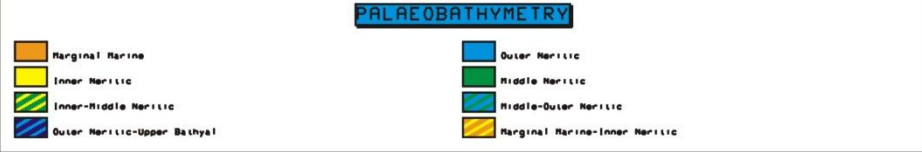
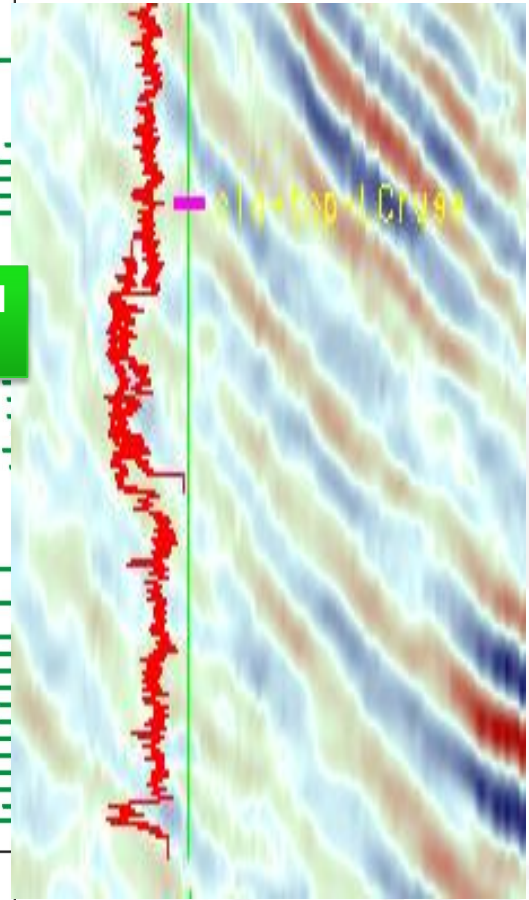


WELL : SOLDADO 874



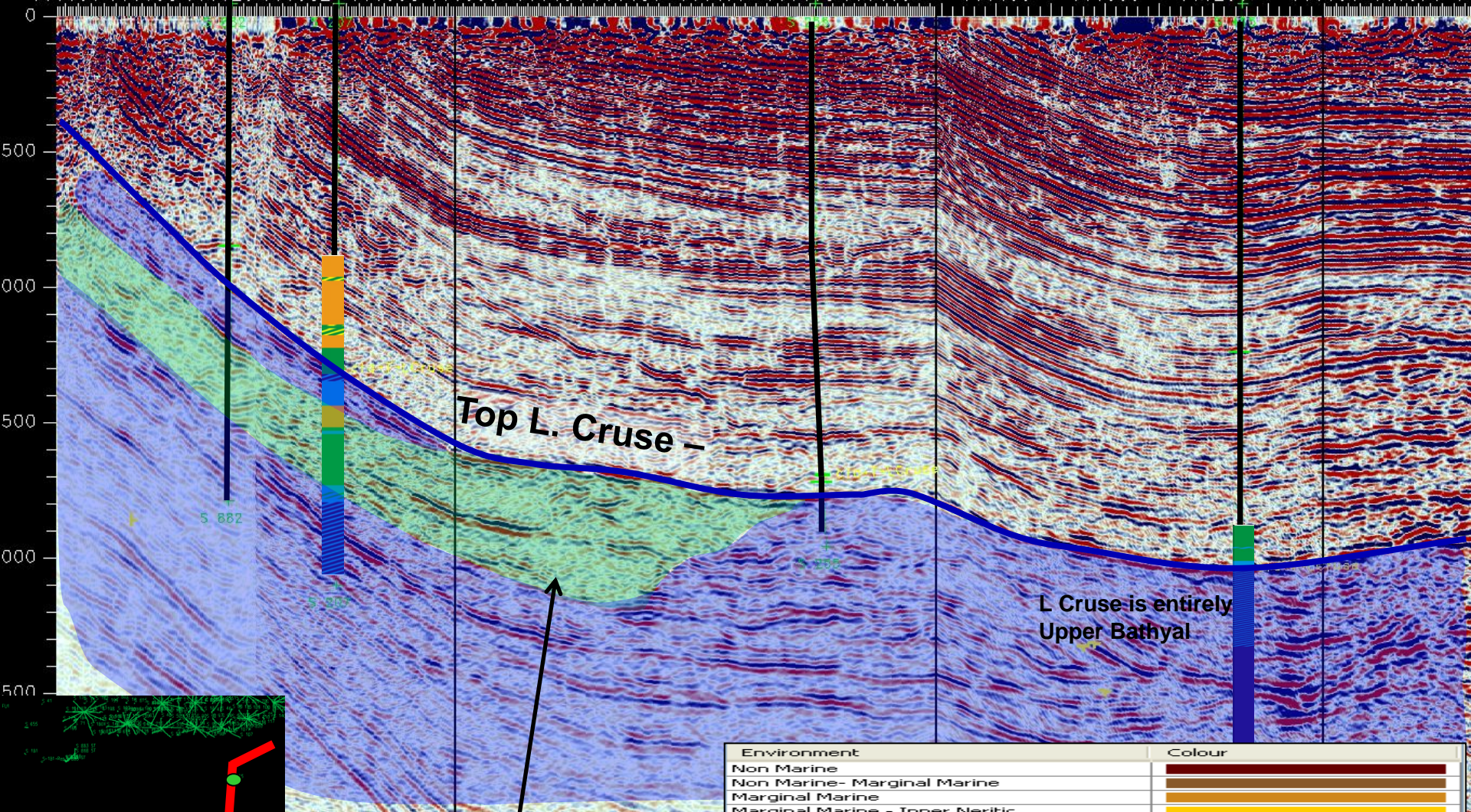
Top Lower Cruse Pick

Displaced Fauna



PALEOBATHYMETRY AND REWORKING

SW S-882 S-207 S-255 S-415 NE



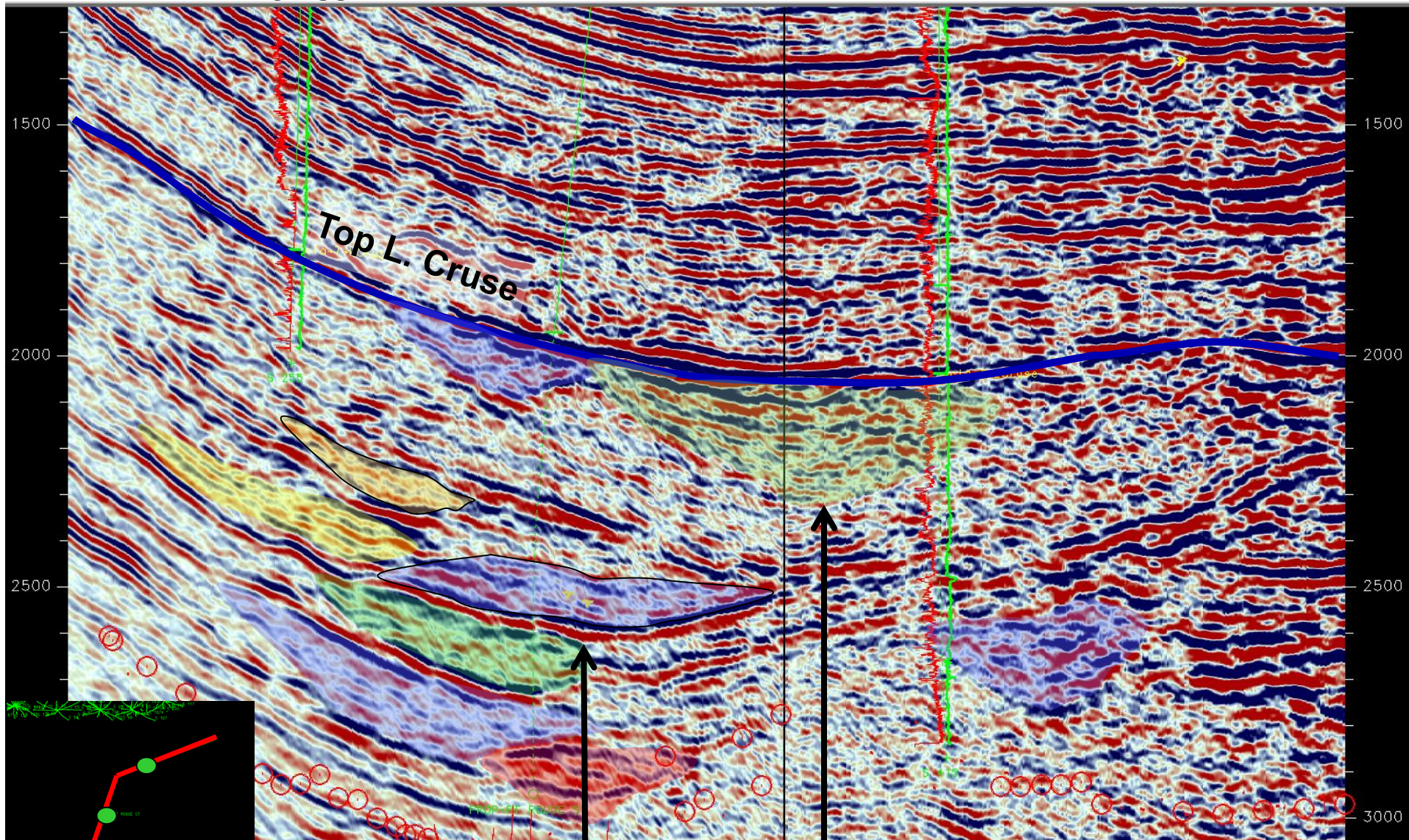
Top L. Cruse -

L Cruse is entirely Upper Bathyal

Chaotic seismic facies middle & inner neritic biofacies

Environment	Colour
Non Marine	Dark Red
Non Marine- Marginal Marine	Brown
Marginal Marine	Orange
Marginal Marine - Inner Neritic	Yellow
Inner Neritic	Light Green
Inner Neritic-Middle Neritic	Green
Middle Neritic	Light Blue
Middle Neritic- Outer Neritic	Blue
Outer Neritic	Dark Blue
Outer Neritic - Upper Bathyal	Dark Purple
Upper Bathyal	Light Purple
Upper Bathyal- Middle Bathyal	Very Light Purple

S-255 STRATIGRAPHIC FEATURES S-415



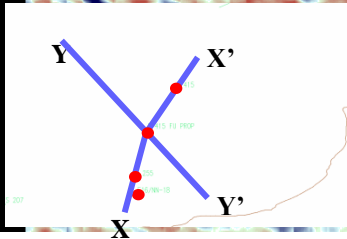
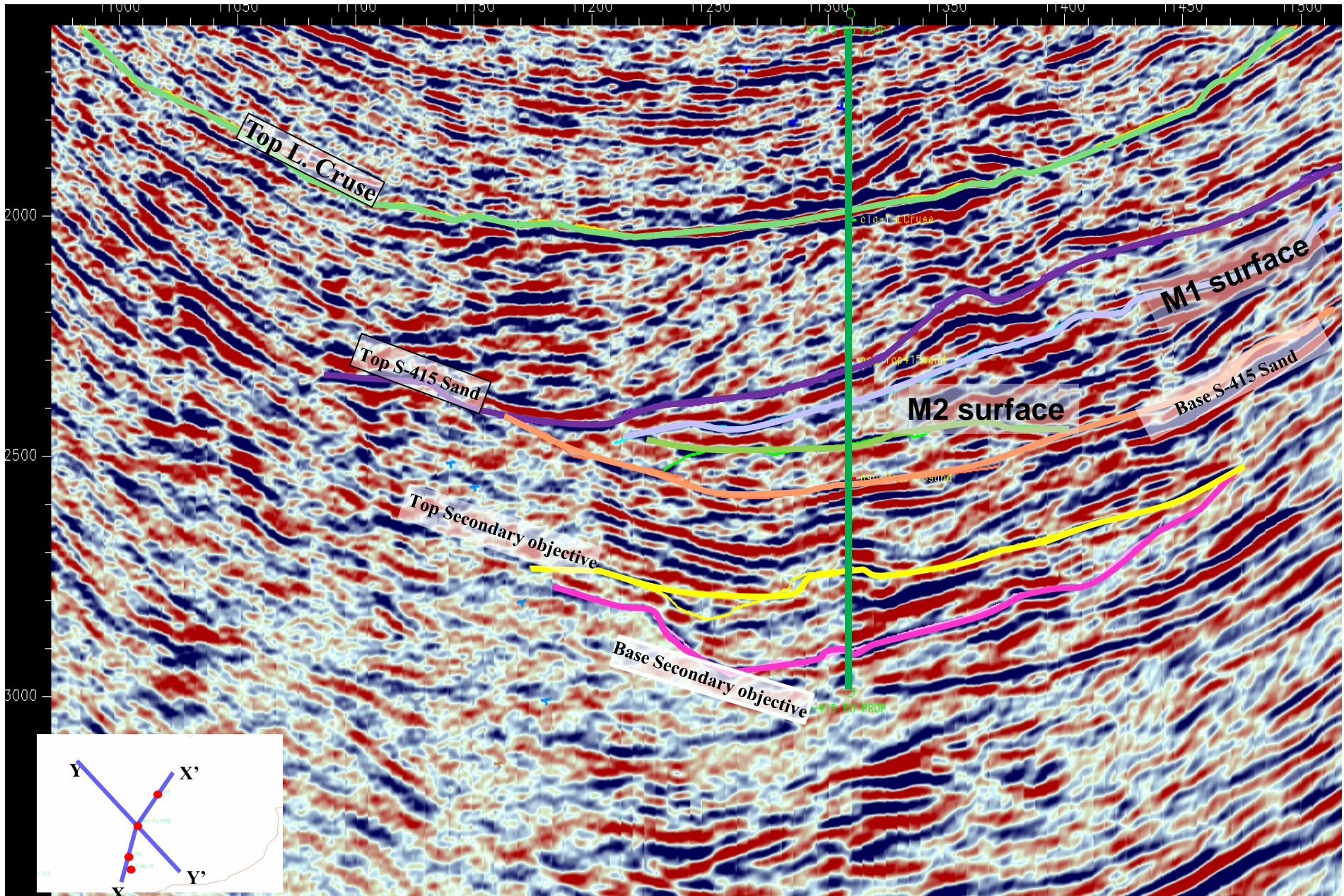
Within a weakly confined channel system on the slope within the Upper Bathyal setting/ slope



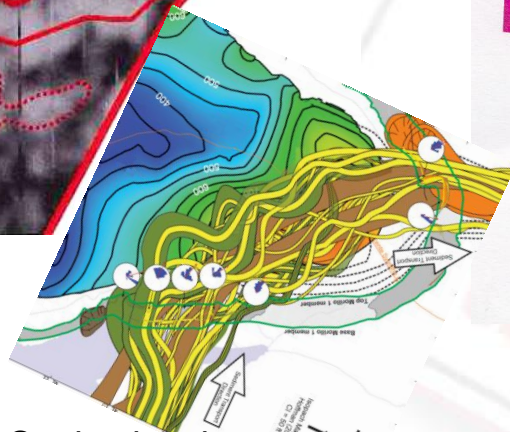
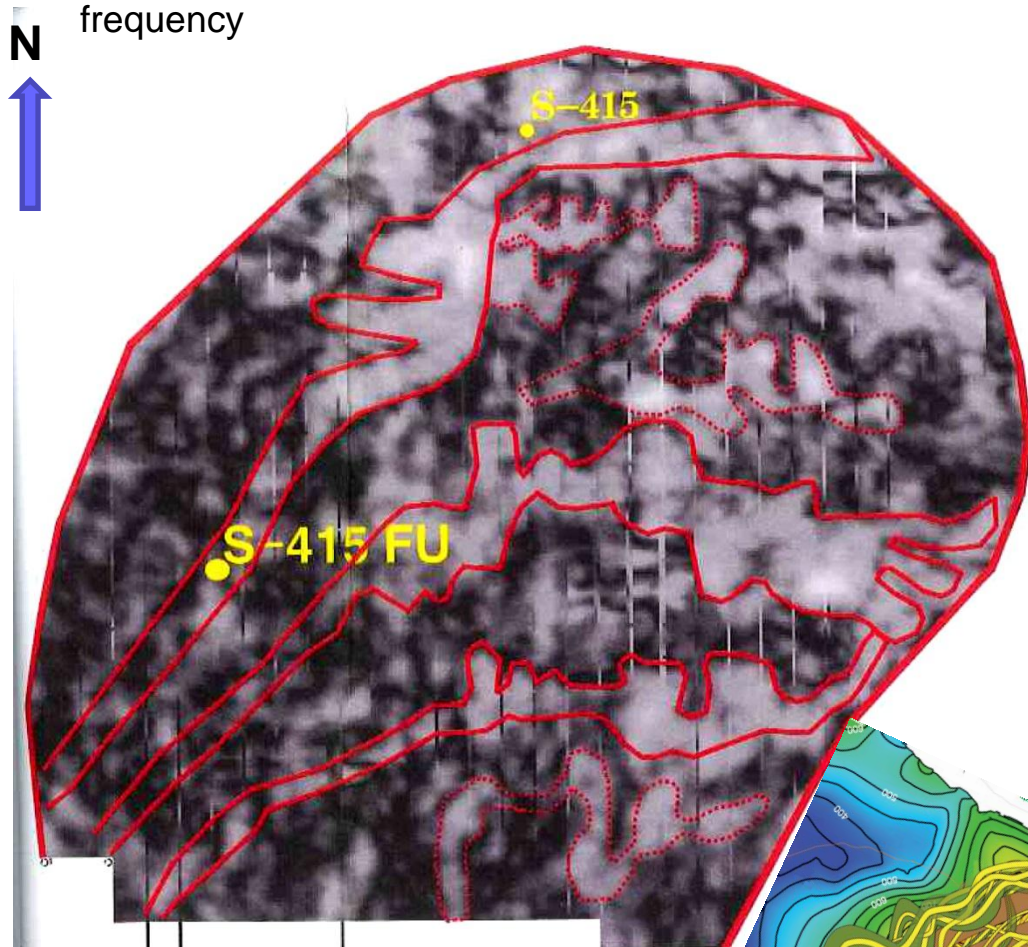
Y

Seismic Line Y-Y'

Y'

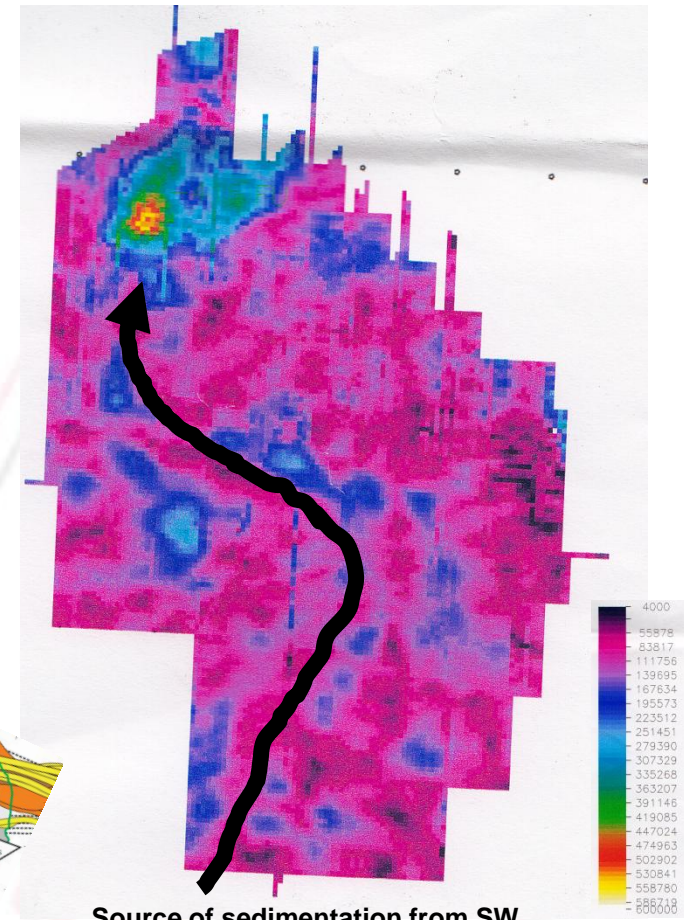


Spectral Decomposition :Using a 100ms window centered on the High Amp. Reflector at a 10hz frequency



Analogue from Spain showing Meandering & overlapping channels

RMS Amplitude horizon extraction from M2 – base of feature



Source of sedimentation from SW

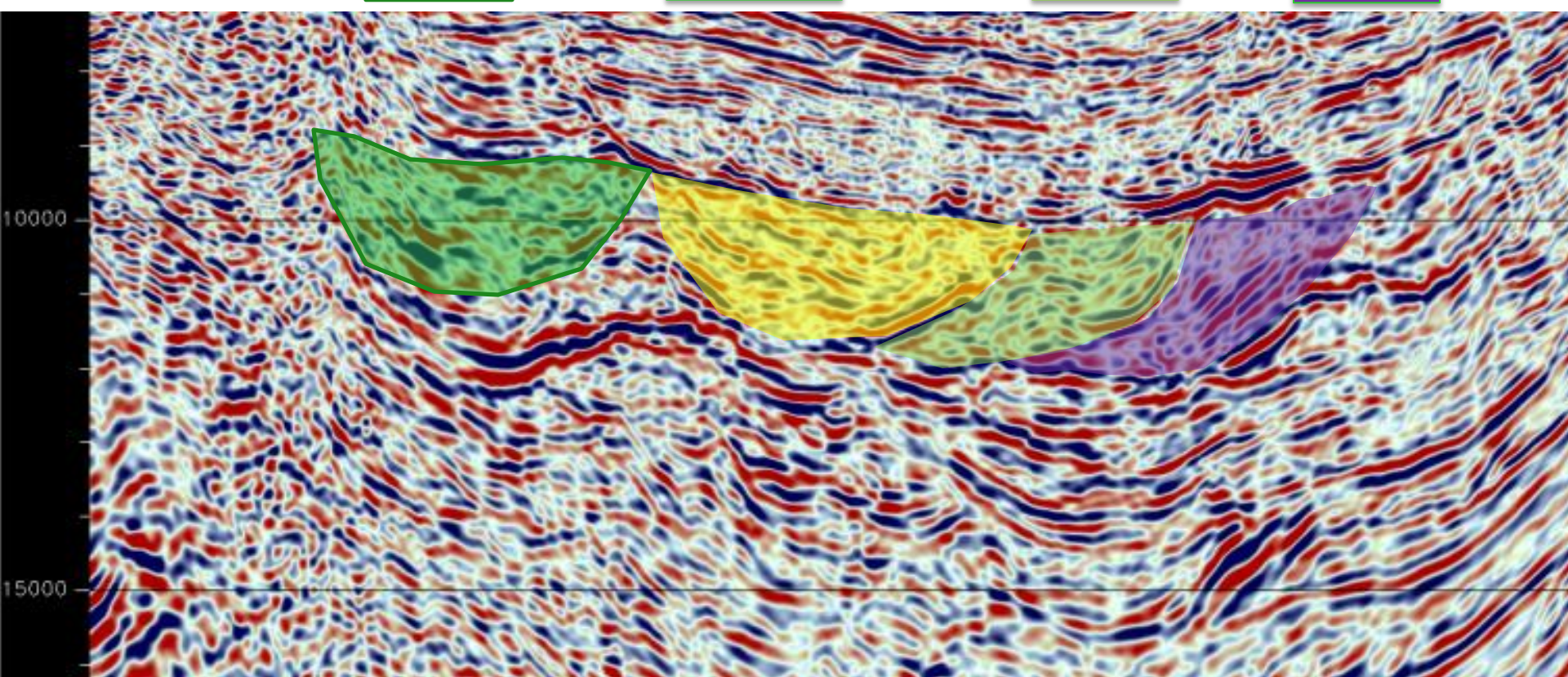
After Archie & Gallai 2013

ES Ch 1

ES Ch 2

ES Ch 3

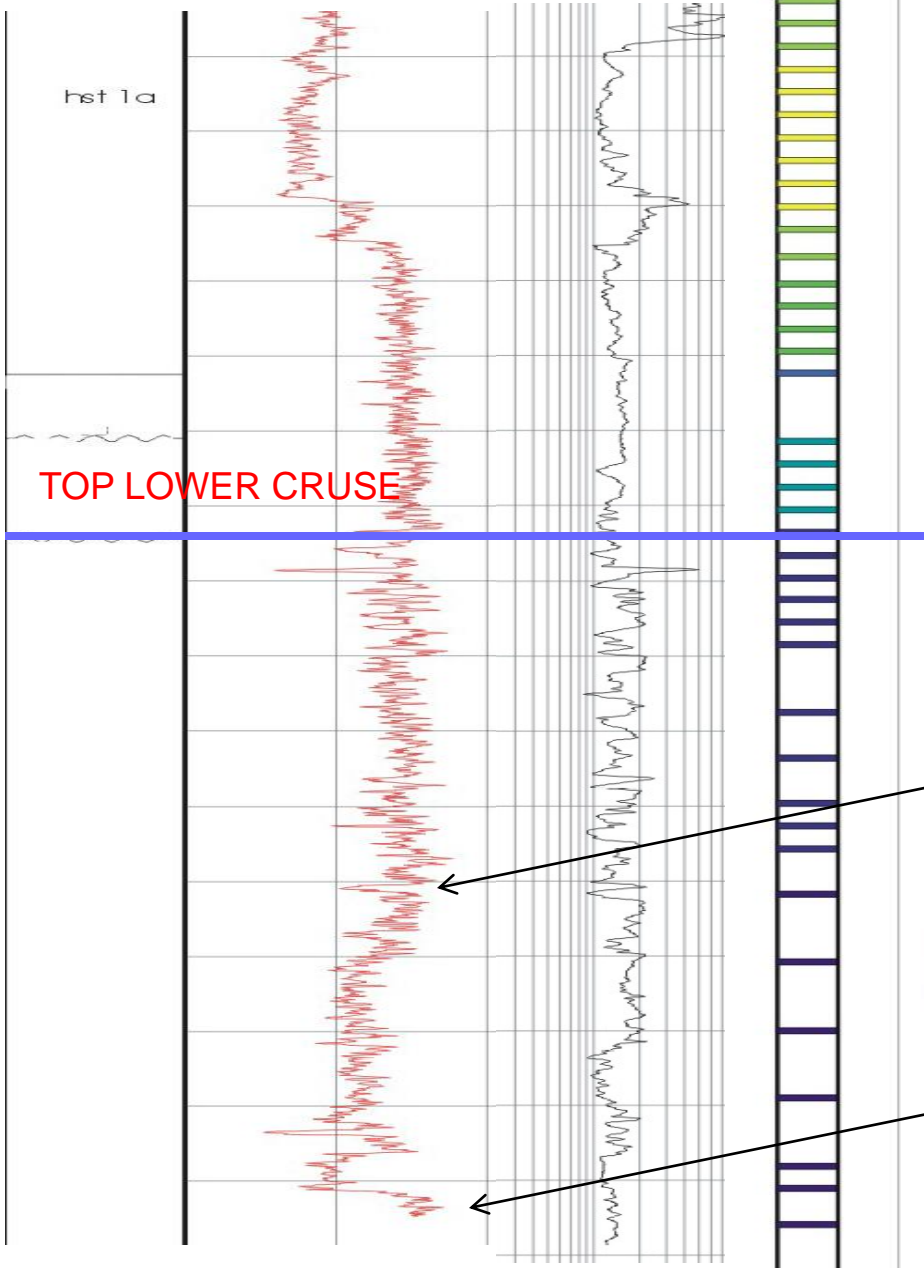
ES Ch 4



- **In onshore Trinidad, traditional depositional models have interpreted the Lower Cruse interval as basin floor fans with the claystone dominated intervals and sections with abundant reworked foraminifera being interpreted as ‘mud flow’.**
- **Detailed examination of the well data contradicts that interpretation.**
- **High resolution biostratigraphic analysis of wells with long claystone intervals have indicated a normal bio-stratigraphic assemblage.**
- **The intervals with reworked older fauna are thought to have been due to erosion of Mid Miocene highs. Erosion and re-sedimentation of older formations from these highs were incorporated into the Lengua and Lower Cruse Formations.**

A large, faint, semi-transparent watermark of the Petrotrin logo is visible in the background. The logo consists of a stylized leaf or flame shape above the word "Petrotrin" in a sans-serif font, all enclosed within a rounded rectangular border.

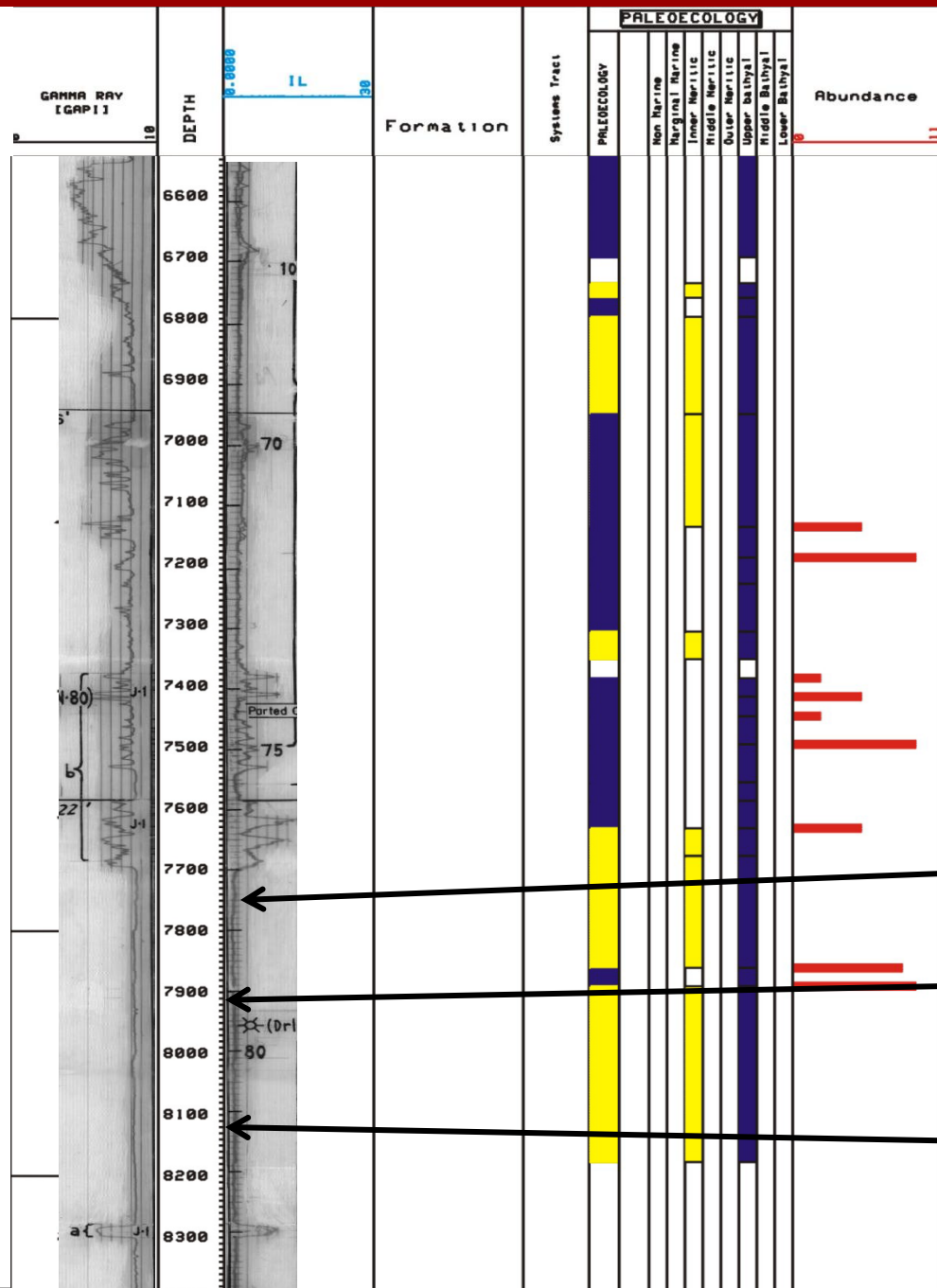
PARRYLANDS



Environment	Colour
Non Marine	Dark Red
Non Marine- Marginal Marine	Brown
Marginal Marine	Orange
Marginal Marine - Inner Neritic	Yellow
Inner Neritic	Light Green
Inner Neritic-Middle Neritic	Green
Middle Neritic	Teal
Middle Neritic - Outer Neritic	Blue
Outer Neritic	Dark Blue
Outer Neritic - Upper Bathyal	Dark Purple
Upper Bathyal	Light Purple
Upper Bathyal- Middle Bathyal	Dark Purple

Super Abundant fauna including Lower Cruse Assemblage with *Discamminoides toberi*. This samples also contains rich ? **Miocene** planktonic fauna ? Lower Cruse/Lengua

Superabundant fauna including Lower Cruse assemblage with *Discamminoides toberi*. This fauna is mixed with predominantly Late **Eocene**, Early Oligocene and less common Miocene fauna.



PALEOECOLOGY



FOREST RESERVE

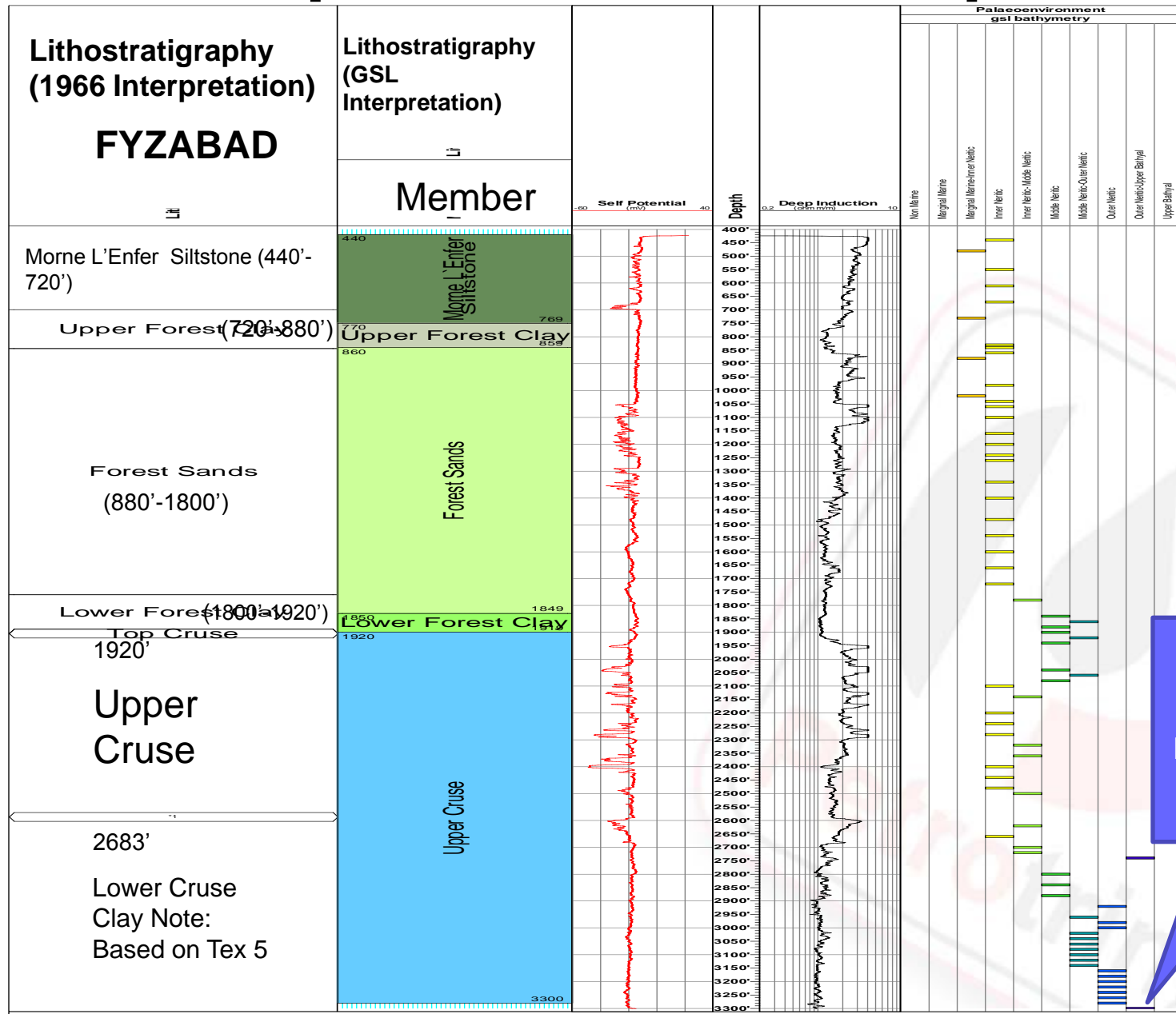
7767' **Fauna:** Arenaceous/calcareous fauna with *Textularia* 5, *Cyclammina* 2, 3, *Haplostiche* 3, *Haplophragmoides* 3, *Trochammina* sp., *Sphaeroidinella* 1, *Uvigerina* 3, *Buliminella* sp., *Gastropod* sp.

Strat. Det: Lower Cruse with shallow water facies influence.

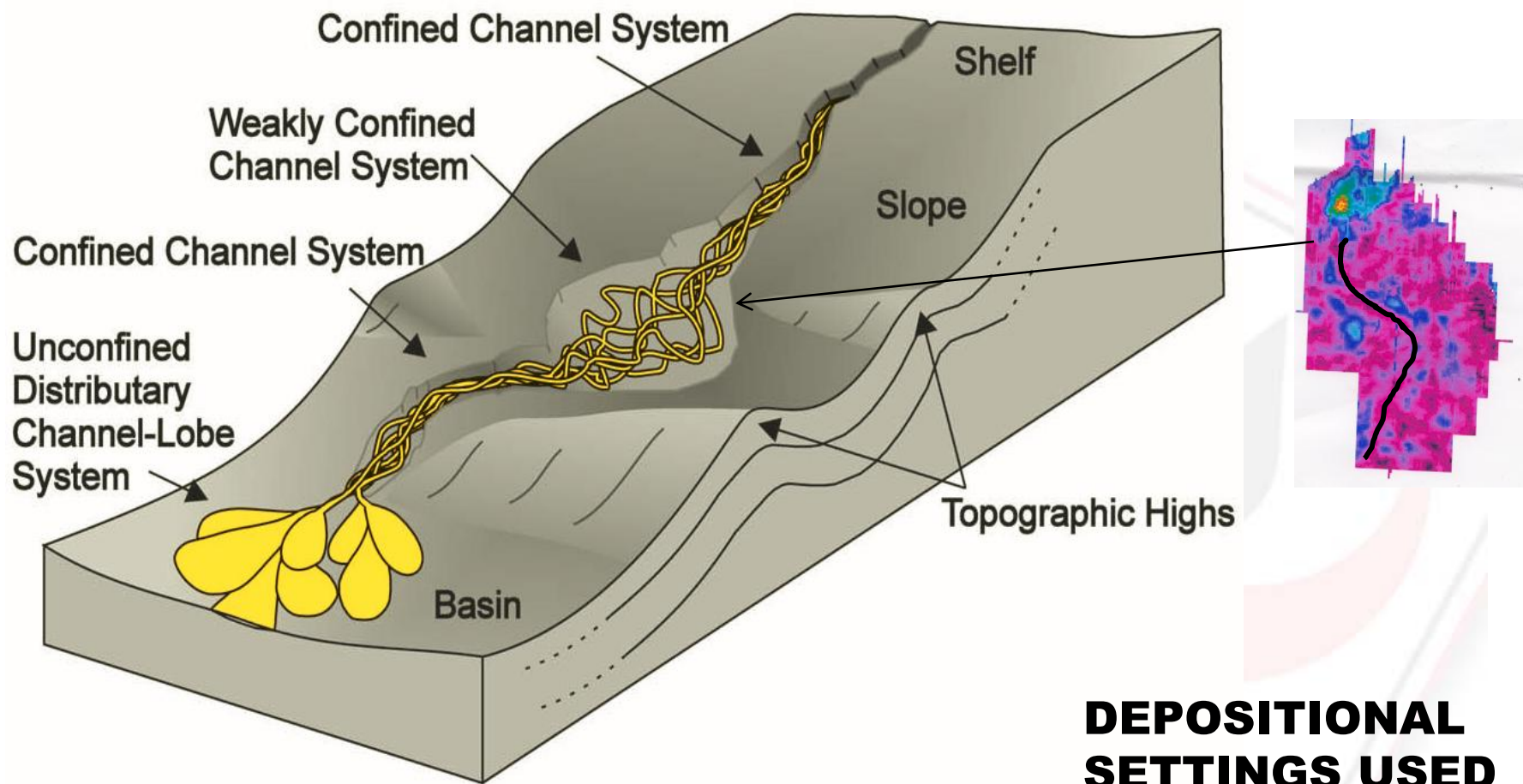
7920' **Fauna:** Mainly arenaceous fauna with *Textularia* 5, *Haplostiche* 3, *Valvulina* 3, 9, *Haplophragmoides* 3, *Lituotuba* 1, *Trochammina* sp., *Rhabdammina* sp., *Buliminella* sp.

8117' **Fauna:** Rich, mainly arenaceous fauna with *Cyclammina* 2, 3, *Haplostiche* 3, *Haplophragmoides* 3, 17, *Valvulina* 3, 9, *Textularia* 5, *Ammodiscus* 6, *Lituotuba* 1, *Buliminella* sp.

1966 Interpretation vs. 2014 Interpretation



(ON-UB)
LAD,
Haplophragmoides
aff., indentatus



MOODY ET AL 2012

**DEPOSITIONAL
SETTINGS USED
IN
INTERPRETATIONS**

CONCLUSIONS

- ❖ **The methodology for picking the top of the Lower Cruse has changed and we have been able to establish and improve ties between the seismic and Biofacies.**
- ❖ **Seismic facies within the Lower Cruse can be used to map stratigraphic events. No basin floor fans have been identified, however slumped facies, confined channels and mini basins with ponded sediments in a slope setting are common.**
- ❖ **Some wells previously interpreted as mud diapirs are currently interpreted as having reworked fauna with different provenances.**
- ❖ **Correct identification of the Top Lower Cruse gives rise to the opportunity to drill deeper, to fully evaluate the interval and allow correct placement of casing strings enabling wells to be drilled to the programmed TD.**

ACKNOWLEDGMENTS

SHAZANA GAZALIE

AVITA GOOLCHARAN

ALYSSA MARCANO

NAMELIA LUTCHMAN

ANN RAMSOOK



THE END

ANY

QUESTIONS

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