Click to view animation: Structural low accommodation

Tectonic Geomorphology of the Eastern Trinidad Shelf, Implications for Influence of Structure from Reservoir Distribution and Nature in Older Basin Fill*

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Search and Discovery Article #30063 (2008)
Posted December 30, 2008

*Adapted from oral presentation at AAPG Annual Convention, San Antonio, TX, April 20-23, 2008

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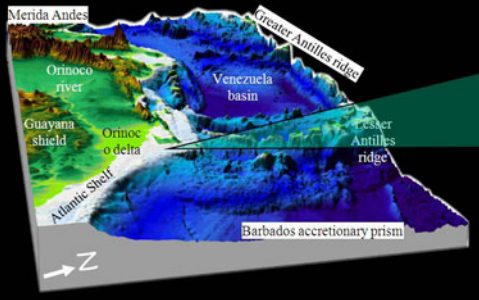
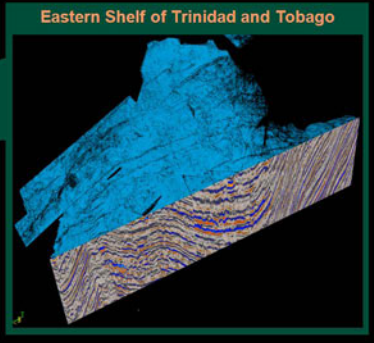
Abstract

Many deltaic systems have been described in passive shelf settings, but the narrow, eastern Trinidad shelf has been tectonically active throughout the late Tertiary and into the Quaternary, undergoing both extension and shortening. Paralic and shelf reservoir sand distribution and geometry have been significantly influenced by both structuring and strong offshore current activity, as well as large forced and unforced regressions. These deposits hold significant shallow gas across the region, but the complexity of their distribution and architecture is poorly understood. A large merged 3D seismic survey (~10,000 sq km) was integrated with well penetrations across the modern shelf to examine the near-modern basin fill and examine the influence of structuring on the morphology and architecture these systems. Key horizons mapped across the area allow attribute imaging of the modern sediments which preserve a record of shelf evolution. Of particular interest are the reservoir elements, such as channels and channel belts, tidally inundated interfluves, shelf delta topsets, interdistributary areas, and ridge and swale topography. The channels, which are ubiquitous across the shelf during lowstand times, show vivid patterns of avulsion and lateral migration. They range from 1-4 km wide to smaller channels of less than 100 meters in width. Several active listric faults interact with landward and basinward migration of shoreline during base level changes to influence depositional systems. Quantitative data on systems tract architectural elements, including spatial orientation and distribution, should significantly improve 3D modeling of these reservoirs and improve understanding of sand distribution and the processes of sediment transfer from proximal sources to shelf staging areas.

Tectonic geomorphology of the eastern Trinidad shelf: implications for influence of structure on reservoir distribution and nature in older basin fill

Tricia Alvarez & Lesli Wood





The University of Texas at Austin
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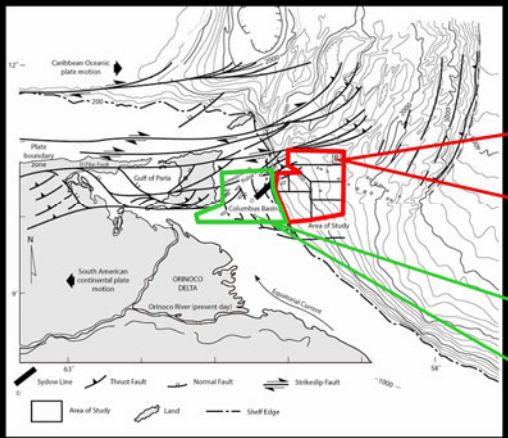
Talk Outline

- Regional Overview
- Area of Interest
- Previous Work
- Seismic Interpretation
- Structure Grids and Structure Maps
- Structural Interpretation
- Attribute Extractions
- Shelf Geomorphology
- Conclusions

3D Seismic Data – Offshore Trinidad

Location Map



Transpressive Margin – Caribbean and South American Plate
High Frequency Sea Levels Fluctuations during the Plio-Pleistocene
High Sedimentation Rates – Orinoco River and influence of Amazon River
Gas Hydrate Dissociation

Five 3D seismic data volumes merged into a continuous deep water volume
Total Area of coverage = 10,708 km2
Total Age of coverage = 2 million years
(Data images from 1.5 sec to 5 sec (TWTT))
Acquisition Parameters:
Bin spacing = 25 x 12.5 m
Vertical Sampling Rate = 4 ms
Average frequency content = 30 – 35 Hz
Approximate time-depth conversions at shallow depths are 1 ms ~ 0.75 m

Single large mega-merged seismic volume
Total Area of coverage = 9,200 sq km
Total Age of coverage = 500,000 yrs
(Data images from seafloor to 1 sec (TWTT))
Acquisition Parameters:
Bin spacing = varies
Vertical Sampling Rate = 4 ms
Average frequency content = 30 – 35 Hz
Approximate time-depth conversions at shallow depths are 1 ms ~ 0.75 m

Quantitative Clastics Laboratory IA

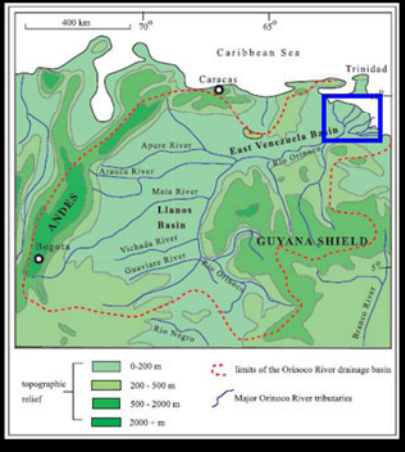
Cumulative (marine) oil production from 1955-2003: 1,666,425,203 barrels

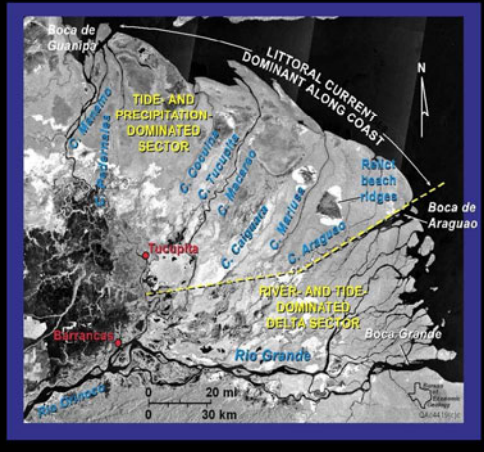
Cumulative gas production 1908-2003: 11,713,443,579 mscf

Source: Ministry of Energy & Energy Industries 28 April, 2003

Sediment Source: Orinoco Delta

- 3rd largest fluvial discharge (behind Amazon & Zaire)
- 11th largest in terms of sediment supply
- Mixed energy fluvial/tide & wave influenced shelf delta, fine grain sand, silts and clays.





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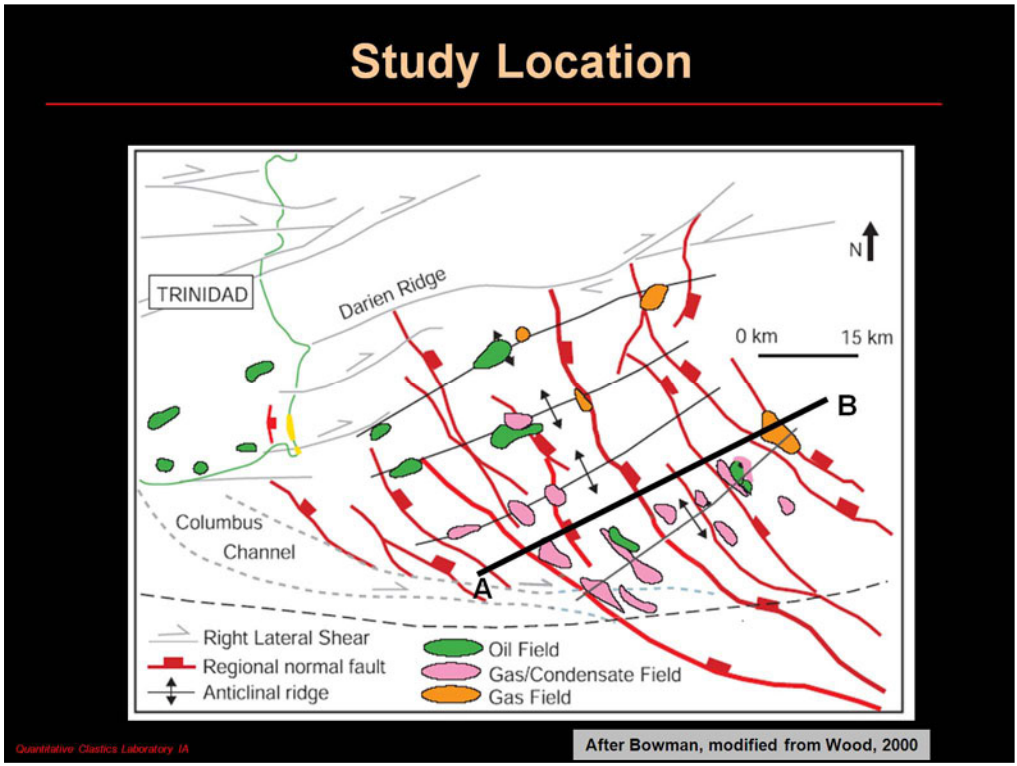
18 kabp, sea level was about 100 m lower than today

The North Brazil/Guyana littoral current has been active since 6.5 kabp



-my study area 78 km from shore, 150 km to the shelf edge,

-300-600 ft water depth

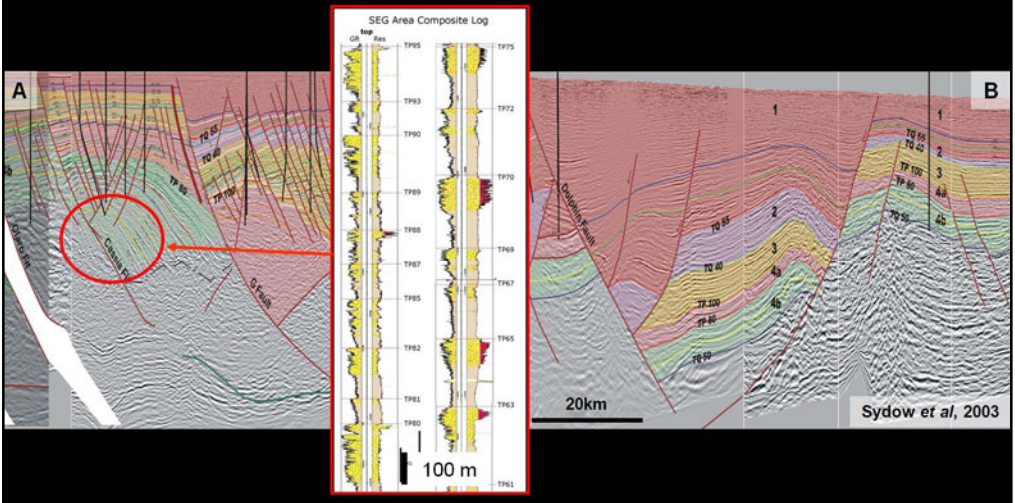
-all collected since 2000

-25 X 25 line/trace spacing; so resolution should be less than 75 m

-whole set was mega-merged by the companies before handing it over to us; so I don't have the finer details of how all the data went together.

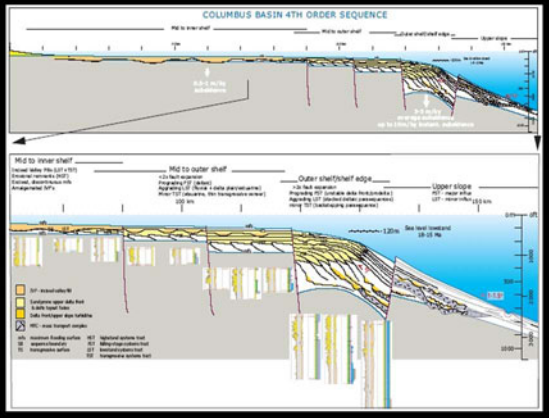
-COLOR SCALE 20-1000 CHANGING EVERY 156 ms

Structural setting



The Columbus Basin is probably the global end member high sediment supply/high subsidence deltaic setting: sediment accumulation rate ~10 m/Kyr

Previous Work



But very little work has been done on the more proximal paralic facies of the lowstand, transgressive and highstand systems.

Leonard (1983) classic synthesis defining the key structural and stratigraphic elements in the basin with respect to the hydrocarbon system.

Wood (2000) elaborated on the chrono & tectonostratigraphic framework describing an >12km Plio-Pleistocene clastic sequence; sourced from the wave-dominated Paleo-Orinoco, which can be split into 300-500 kyr megasequences

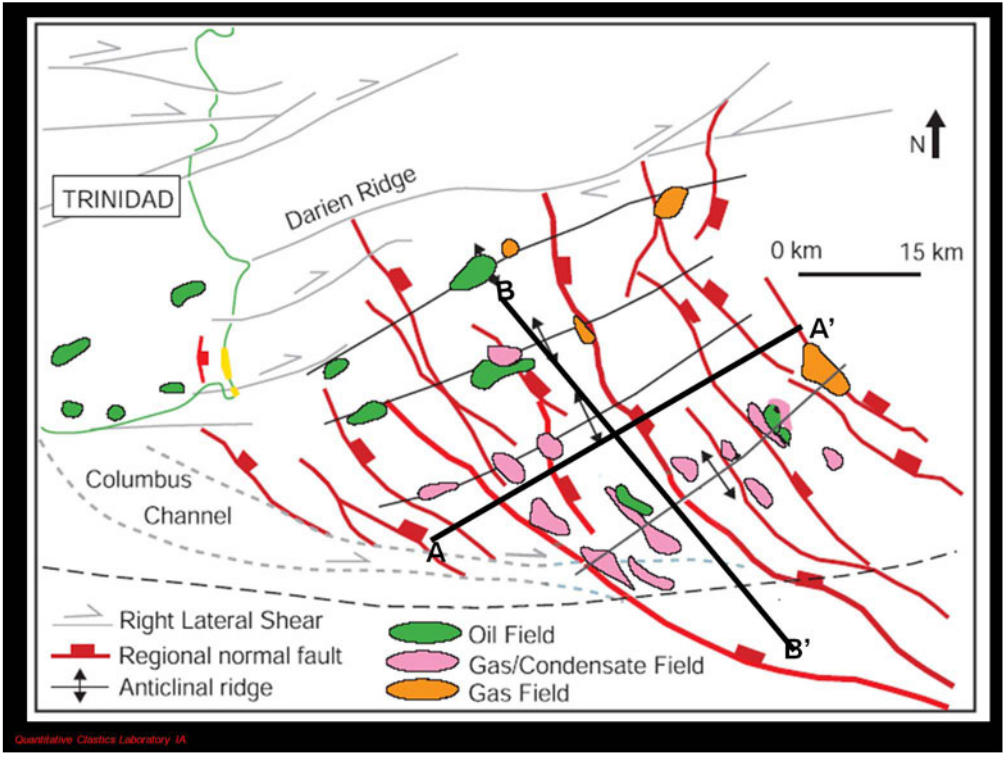
Sydow (2004) published a study of the Quaternary strata along the eastern shelf, examining the influence of structure on the thickness and morphology of shelf edge deltaic deposits.

Bowman (2004) an excellent dissertation on the Plio-Pleis. Section offshore and the older, but similar outcropping facies.

Key Questions

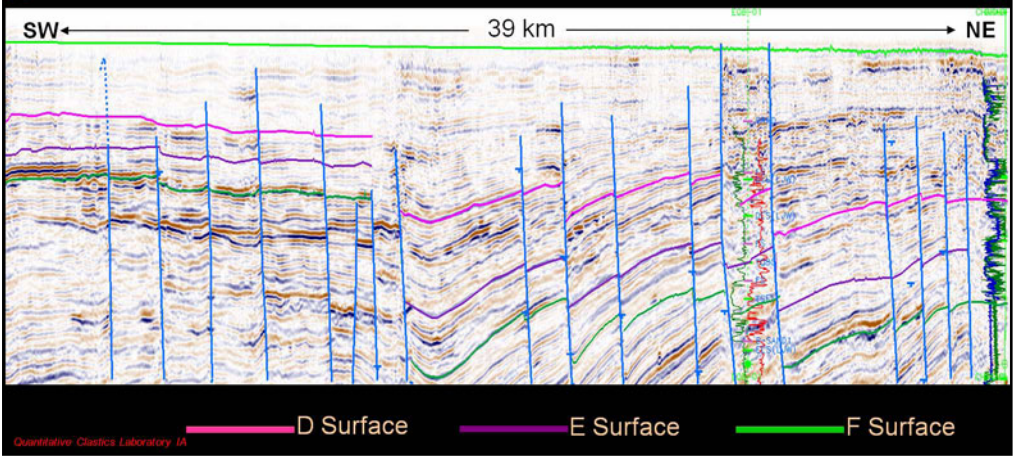
Answering several key scientific questions can lead to improved understanding of the clastic development of the eastern Trinidad shelf:

- 1.) What are the key structural elements on the shelf and what has been their history of activity?
- 2.) How do paralic, deltaic and marine shelf depositional systems interact with these structural elements to influence depositional architecture and morphology of key elements?
- 3.) Can we use the morphometrics of depositional elements in the lowstand, transgressive and highstand systems tracts to improve our understanding of prospectivity and recovery of gas in this prolific basin.


TRINIDAD
Darien Ridge
N
0 km
15 km
B
A'
A
B'
Columbus
Channel
Right Lateral Shear
Regional normal fault
Anticlinal ridge
Oil Field
Gas/Condensate Field
Gas Field
Quantitative Clastics Laboratory IA

Seismic Dip Section showing the extensional regional and counter-regional faults

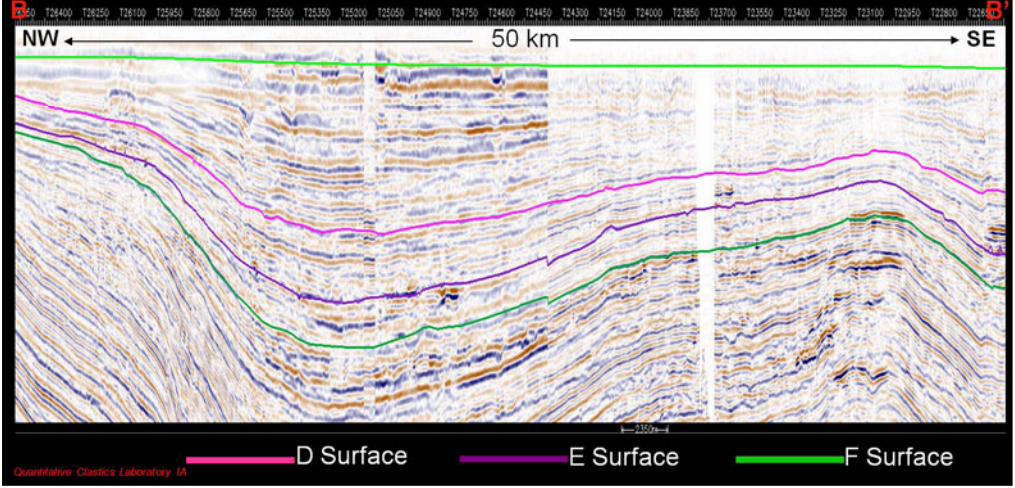
- Key surfaces were mapped across the extent of the data along with a number of faults in order to provide a framework within which to understand the timing and magnitude of structural movements and to frame morphological attribute imaging.
- Data is hammered by shallow gas and structurally complex
- Several well penetrations provide some lithologic and age control.



Trace 23244

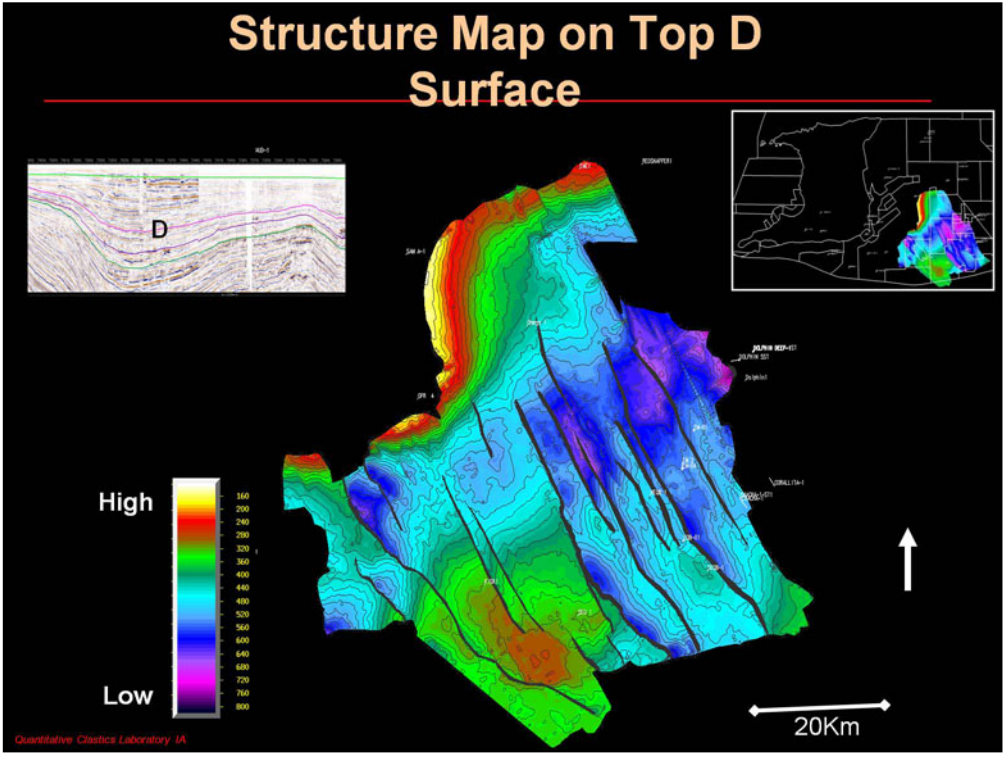
Seismic strike section showing continuity of horizons within individual fault blocks

- In contrast to the dip (west-to-east) lines, correlation along strike within a given fault block is well constrained
- The influence of active tectonics can be observed as sediments thin over the structural highs with a correlative thick sequences developed in the structurally constrained lows

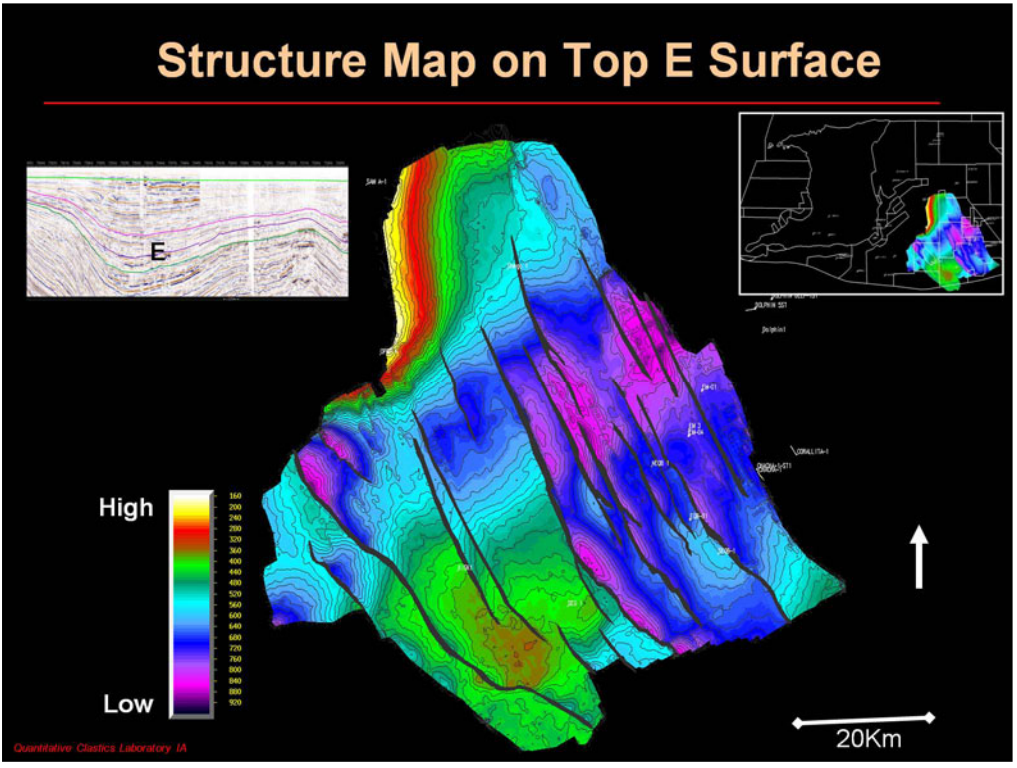


Line 22036

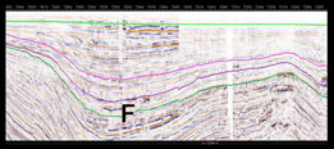
Structure Map on Top D Surface

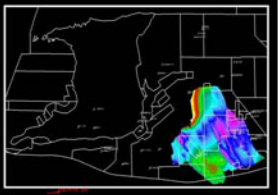


Structure Map on Top E Surface

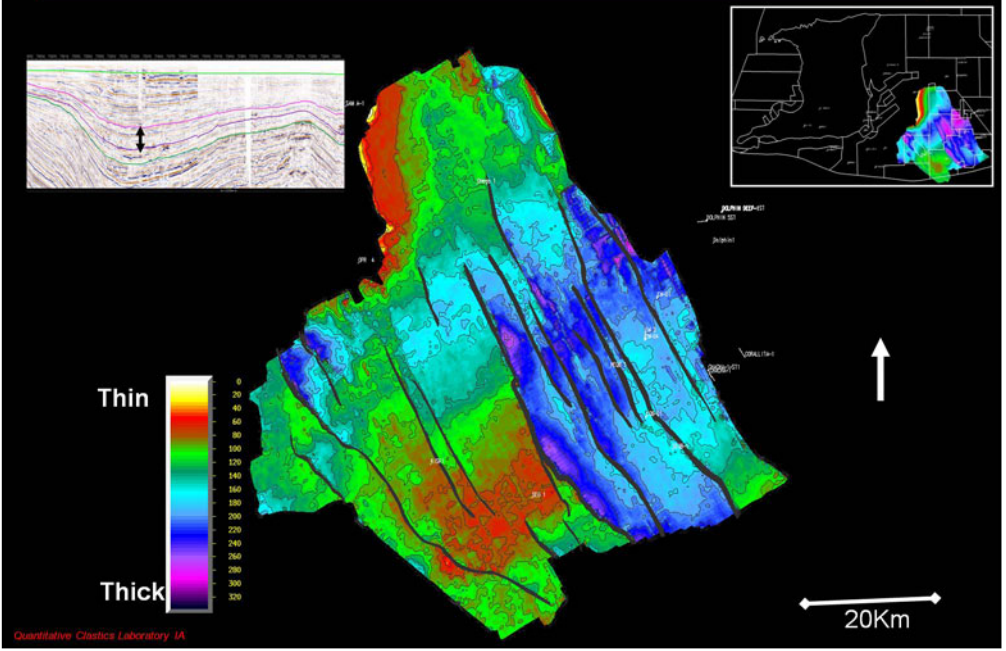


Structure Map on Top F Surface

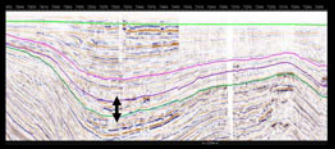


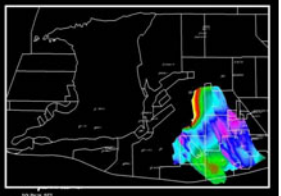


Isochron Map (Top D - Top E)



Isochron Map (Top E - Top F)





Thick, late Pleistocene trough of sediment accumulation

Thin

Thick

20Km

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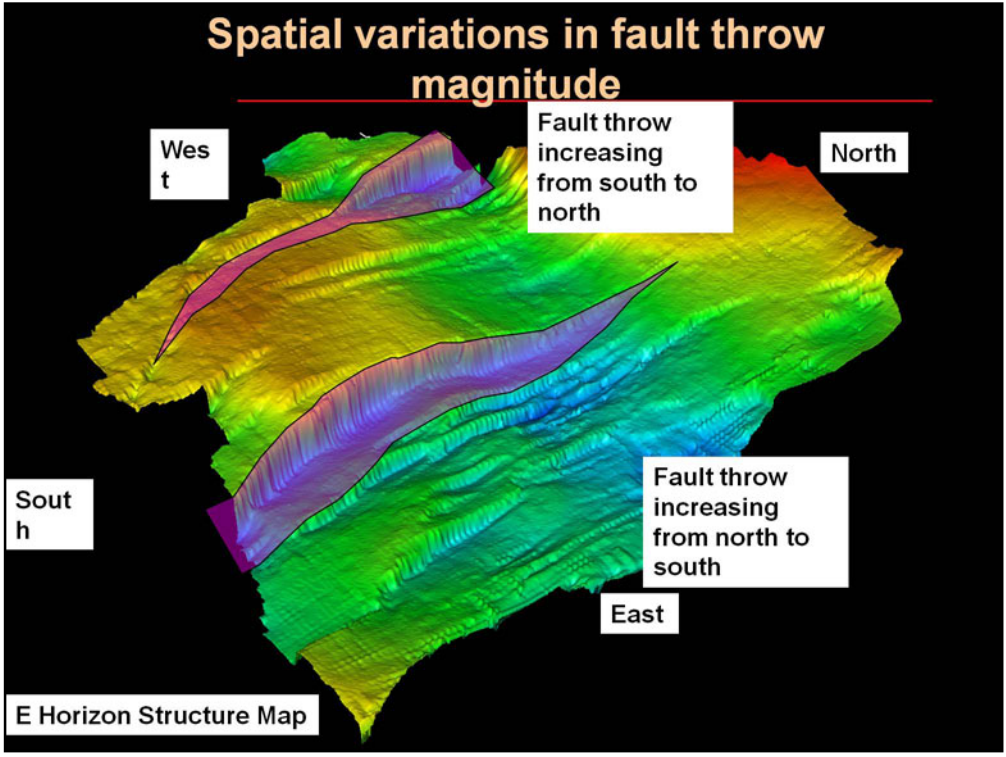
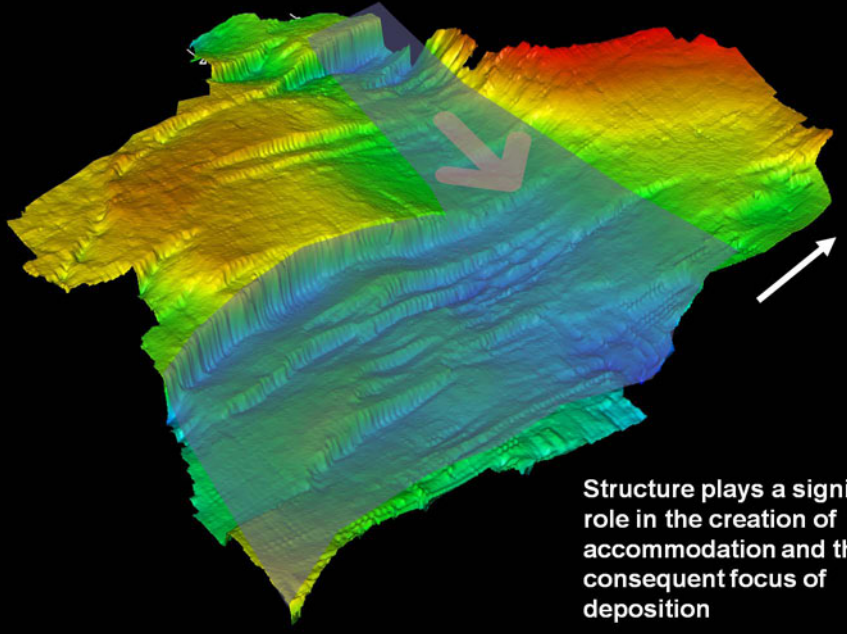
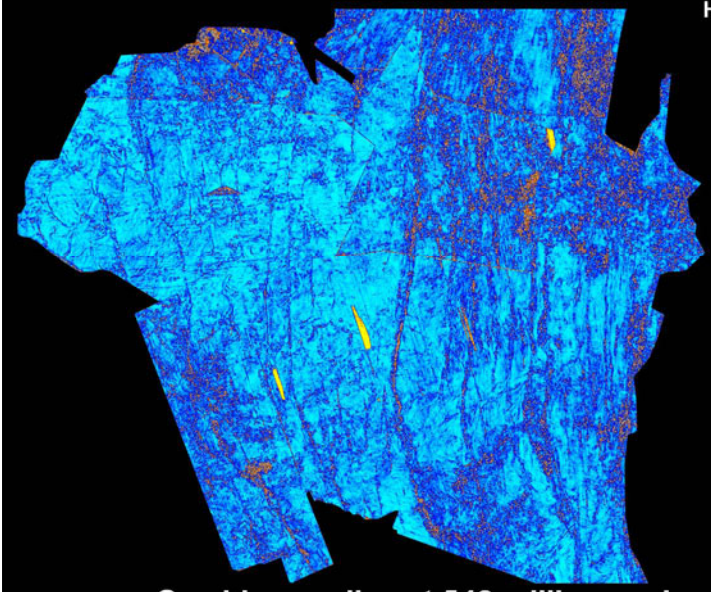

Spatial variations in fault throw magnitude
Wes t
Fault throw increasing from south to north
North
Sout h
Fault throw increasing from north to south
East
E Horizon Structure Map

Spatial distribution of accommodation



Structure plays a significant role in the creation of accommodation and the consequent focus of deposition

Imaging reservoir morphology



High density of faulting and shallow gas necessitate careful mapping of framework horizons prior to an attribute analysis

Several attributes were used to analyze imaging of reservoir scale morphology across this difficult region. Including:

- Proportional Slicing
- Semblance
- Maximum Interval Amplitude
- Root-mean squared amplitude

Semblance slice at 548 milliseconds

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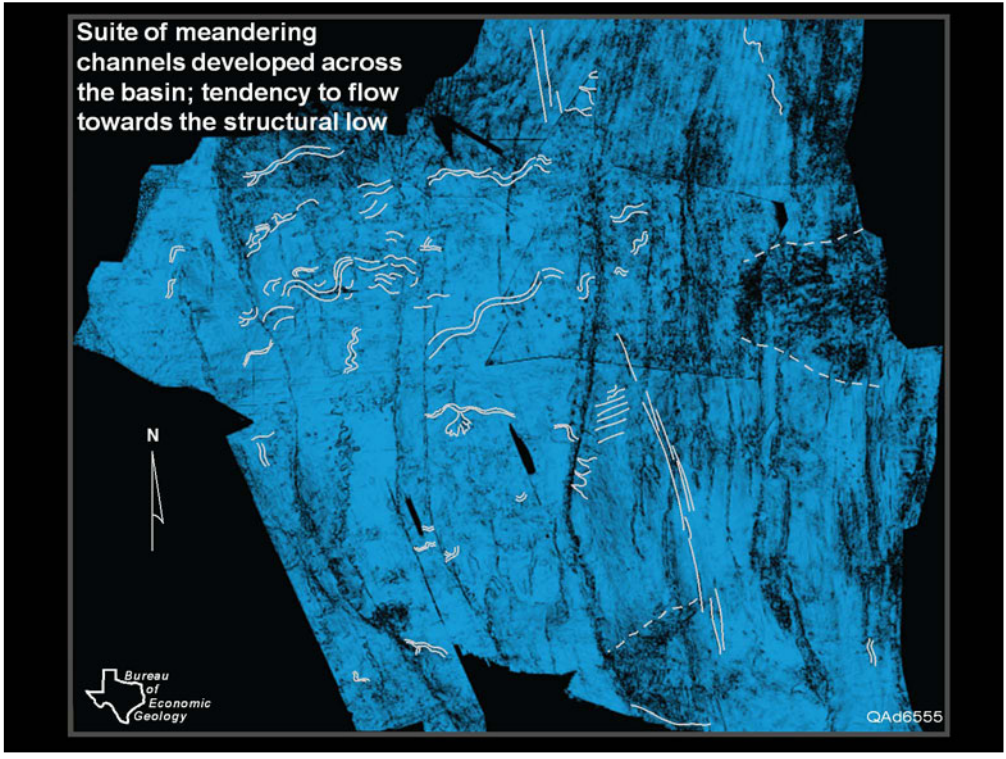
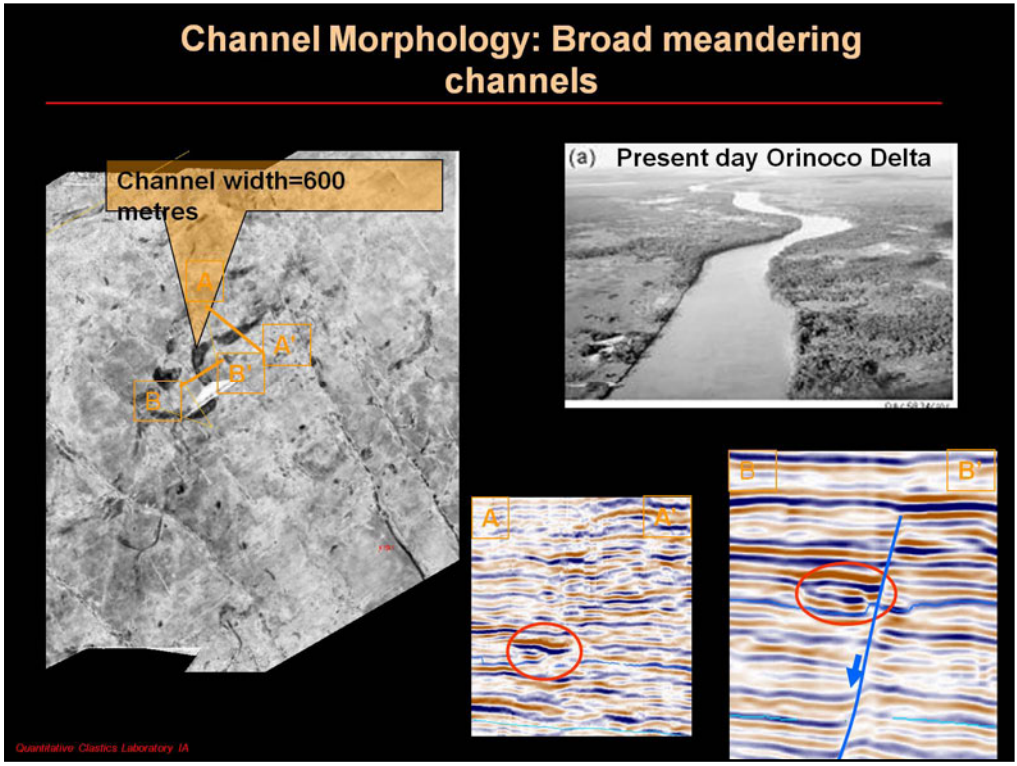
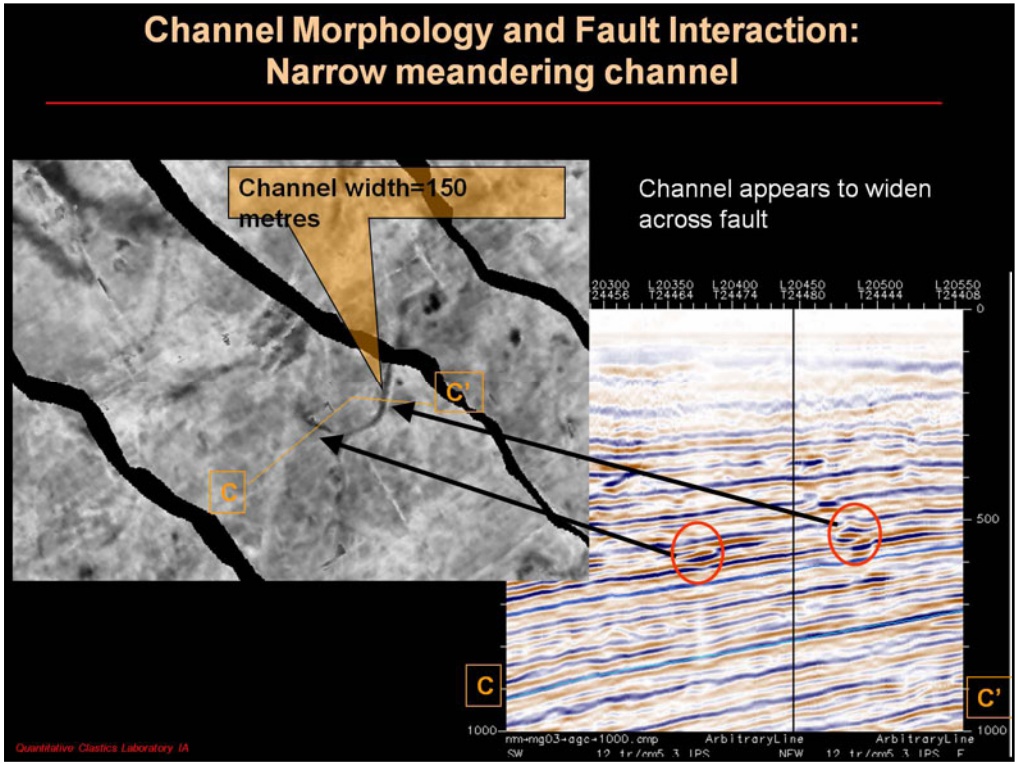
548ms



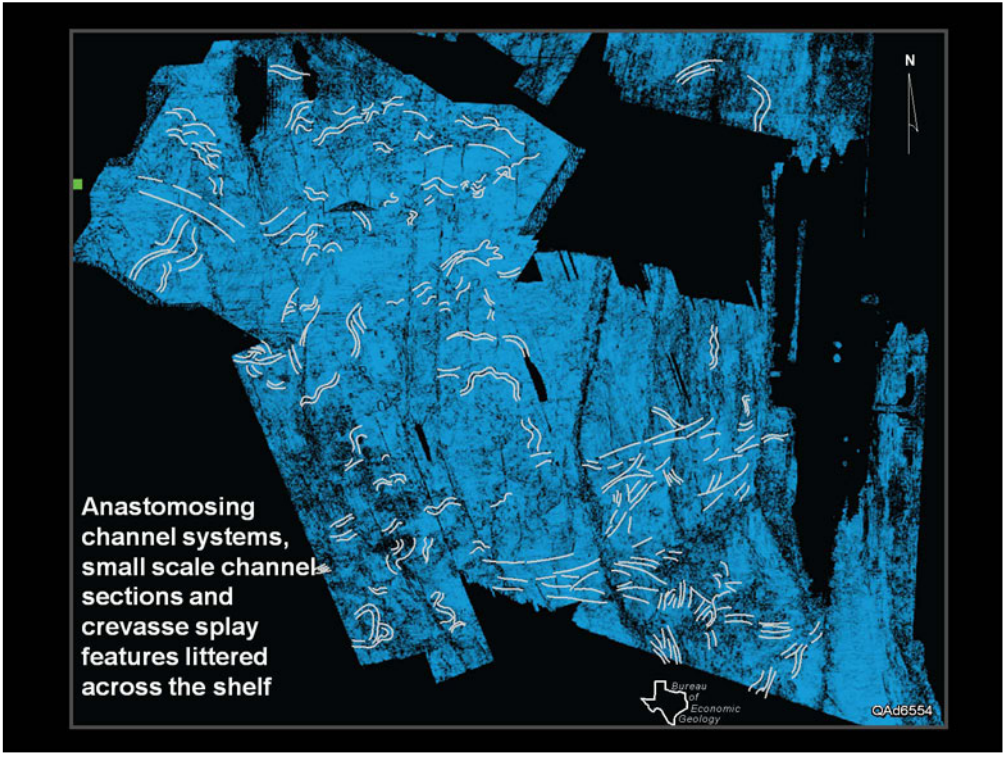
~636 30ms above surface F



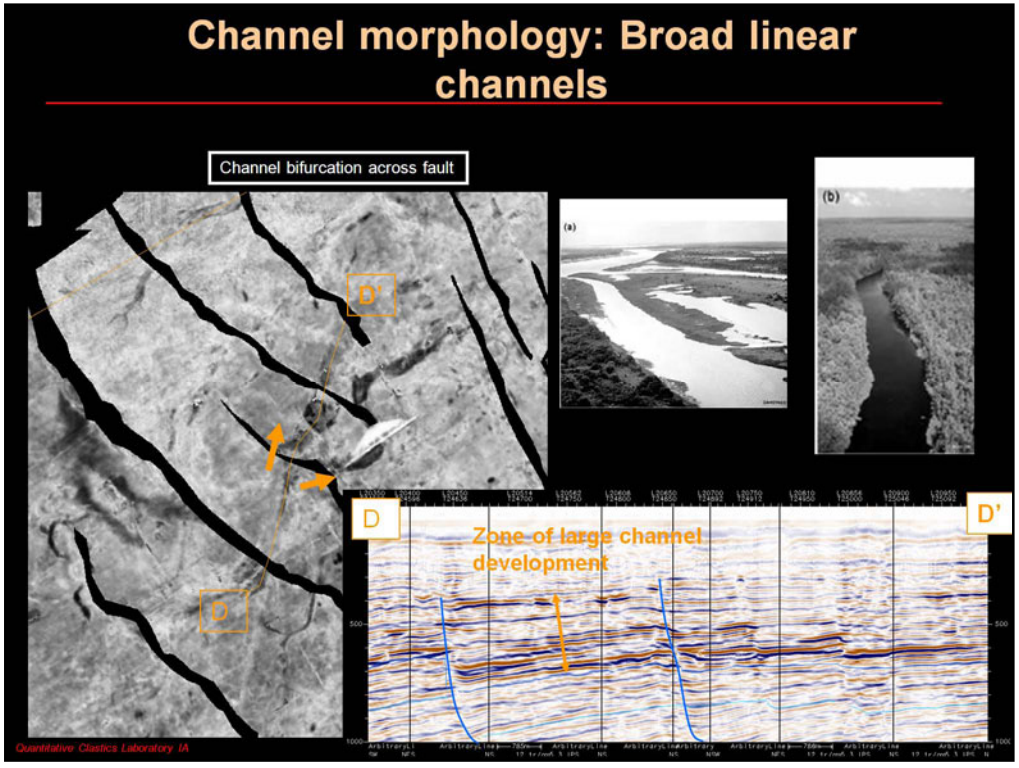
Arb line channels



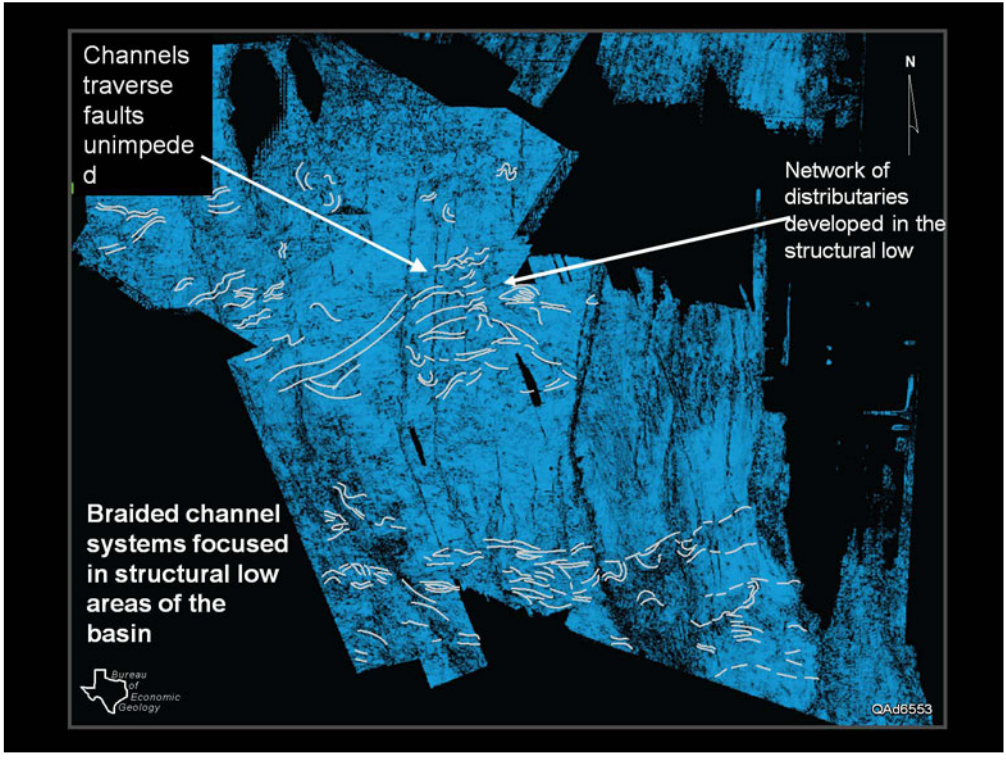
Small meandering channel



548ms just above ELS surface



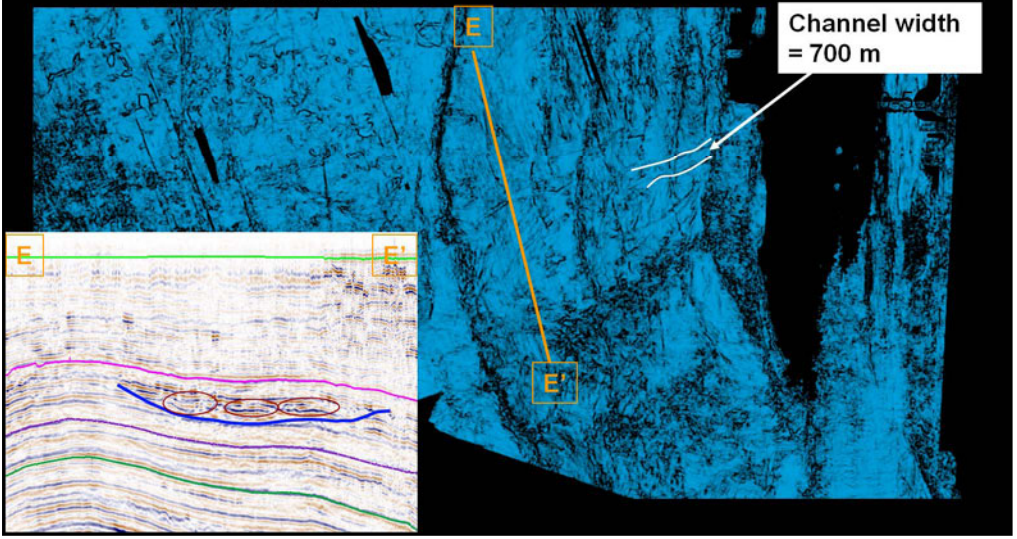
Across faults along broad channels

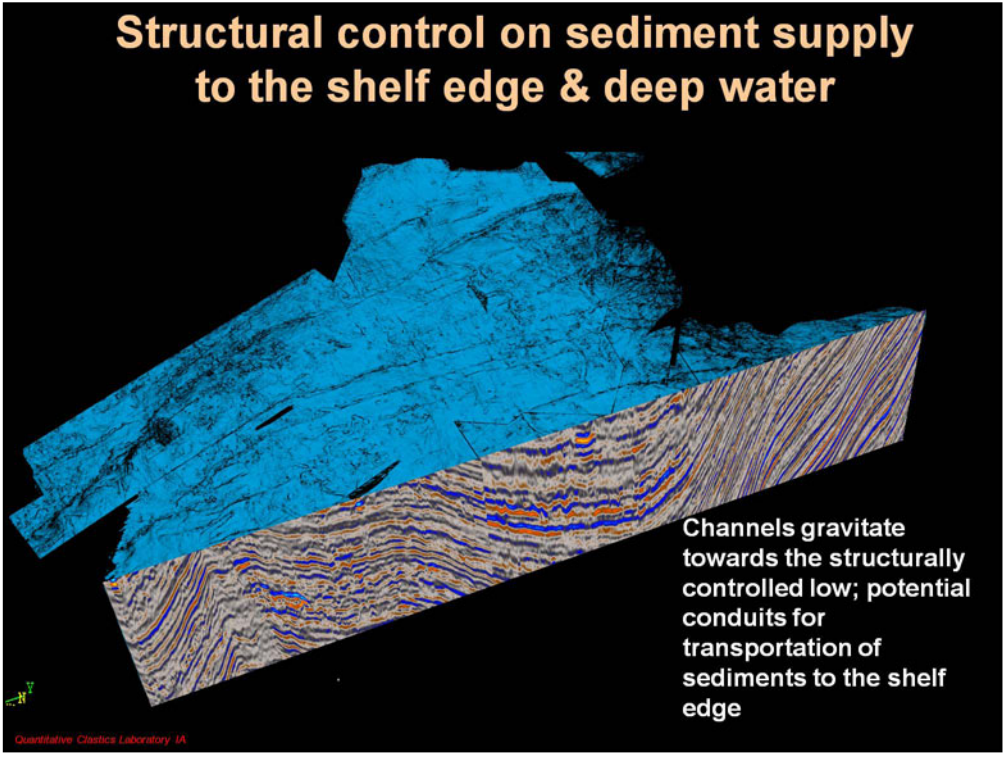


696ms 20ms below surface F

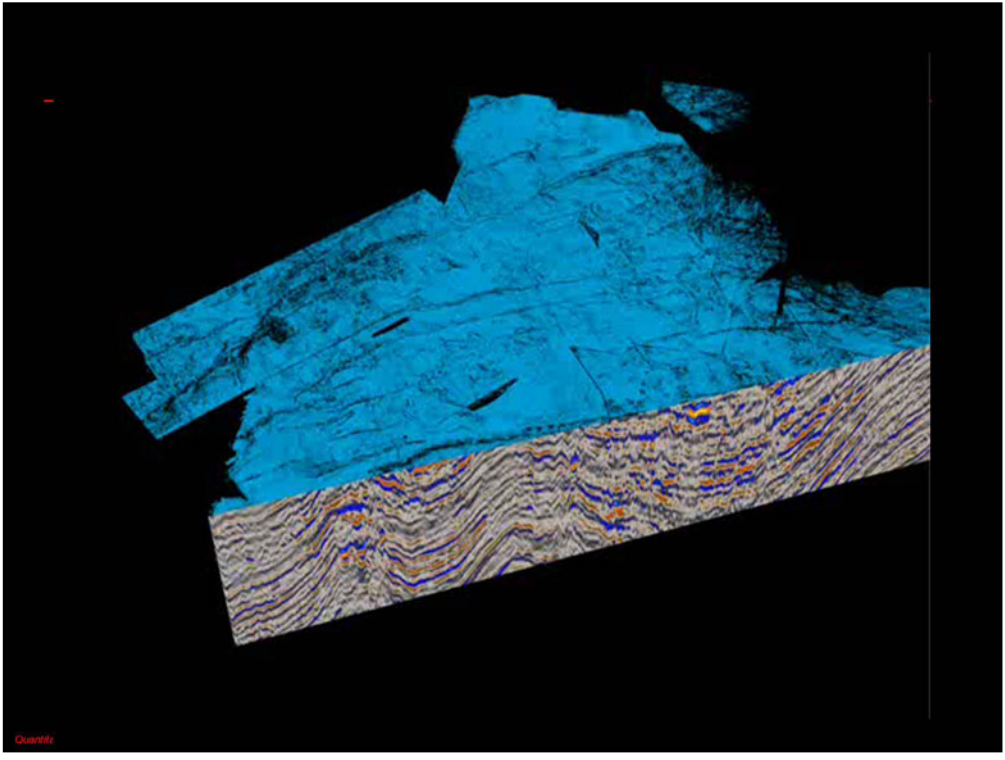
Geomorphology

- Braidplain distributary channels spilling basinward unimpeded capitalizing the accommodation created in front of the main fault.



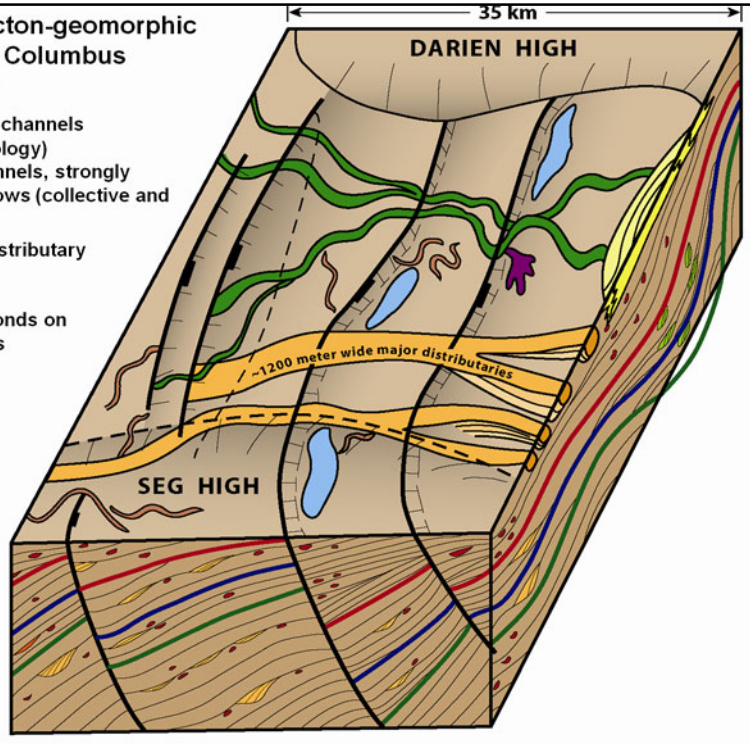

Structural control on sediment supply to the shelf edge & deep water
Channels gravitate towards the structurally controlled low; potential conduits for transportation of sediments to the shelf edge
Quantitative Clastics Laboratory IA

572 ms


Quantifi

Synthesis of tecton-geomorphic elements of the Columbus Basin, Trinidad

- Large distributary channels (distributive morphology)
- Medium scale channels, strongly seeking structural lows (collective and distributive)
- Small-scale interdistributary drainage channels
- Crevasse splay
- Interdistributary ponds on the low side of faults



Bureau of Economic

Conclusions

- The Columbus Basin shelf remains tectonically active into the Holocene as extension on the shelf is taken up by a series of northwest-southeast-trending listric faults.
- For the period represented by the strata between surfaces D and F there is a northwest-southeast trend of maximum fault throw across the shelf
- Regional tectonics play a significant role in the creation of accommodation and consequently the focus of sediment accumulation
- During lowstand intervals the Columbus Basin shelf is dominated by a suite of channels which appear to migrate laterally over time

Conclusions

- The preserved morphology reflects the preservation of some channels for a large proportion of the mapped area
- Numerous partially preserved (discontinuous) channel features; may be a function of the ability to image the features due to the nature of the channel fill or the preservation of complex amalgamated surfaces, reflecting multiple episodes of channel incision at a given location
- Channels appear to be indifferent to tectonic activity (applies to a range of channel sizes) over most faults on the shelf
- Channel relationships with the main fault appears to be more complex

Acknowledgements

- Funding provided by QCL Industrial Associates at the Bureau of Economic Geology, Jackson School of Geosciences, EOG Fulbright 2000, Chevron Fellowship
- Data courtesy of bpTT, BG Trinidad, Chevron Trindad, EOG Resources and the Ministry of Energy & Energy Industries Trinidad & Tobago
- Dallas Dunlap for software support
- Sean Sullivan & Lorena Moscadelli for technical contributions
- BEG Graphics & Administrative Staff

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