Weakly Confined Minibasin Fill and Depositional Architectures: A Shallow Analog*

Heather Macdonald[1] and David McGee[2]

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[1]School of Earth and Environment, University of Leeds, Leeds, United Kingdom (heatheralexmacdonald@gmail.com)
[2]ConocoPhillips, Houston, TX (david.t.mcgee@conocophillips.com)

Abstract

Controls affecting the depositional style within intraslope minibasins include glacially-controlled sea-level fluctuatons (eustacy), the dynamic 3D movement of basin-confining salt (halokinetic), and the alternation between depocenters (autocyclic). In this study, three-dimensional seismic-data from minibasins of Western Green Canyon (northern Gulf of Mexico) record the interplay of eustatically and halokinetically controlled depositional processes.

The ~500 sq. mile study area comprises two salt-confined minibasins that are separated by an extensional fault. Six laterally extensive seismic surfaces interpreted as condensed sections were used to define intervals of stratigraphy up to 5 seconds. Interval analysis reveals the two minibasins to have previously behaved as one single, larger basin. This single-basin morphology was initially altered by salt emergence then subsequently by extensional faulting. These changes in basin morphology acted to divide the two minibasins. Both stages of salt emergence and extensional faulting affected resultant depositional architectures, and topographically steered basin-filling events.

Deposits observed within these intervals include mass-transport deposits (MTD), turbidite sheets, overbank accumulations, and hemipelagic drapes. We categorize the intervals as being eustatically and halokinetically controlled, and show how their period of deposition correlates to just 4 glacially controlled global highstands. Intervals identified as being eustatically controlled are punctuated by hemipelagic drapes, turbidite sheets, channelized regions, and mass-transport deposits. The absence of mass-transport deposits in one eustatically controlled interval may be due to the proximal location of the study area relative to the shelf edge. One interval identified as halokinetically controlled comprises widespread mass-transport deposits and turbidite sheets that accumulated during a

period of considerable fault movement. It is likely that the faulting was driven by salt dynamics, which also led to mass wasting on over-steepened basin margins at salt upwellings, thus creating high frequency mass-transport complexes.

Selected References

Gradstein, F.M., J.G. Ogg, and A.G. Smith, 2004, A Geologic Time Scale 2004: Cambridge University Press, Cambridge.

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Posamentier, H.W. and V. Kolla, 2003, Seismic geomorphology and stratigraphy of depositional elements in deep-water settings: Journal of Sedimentary Research, v. 73/3, p. 367-388.

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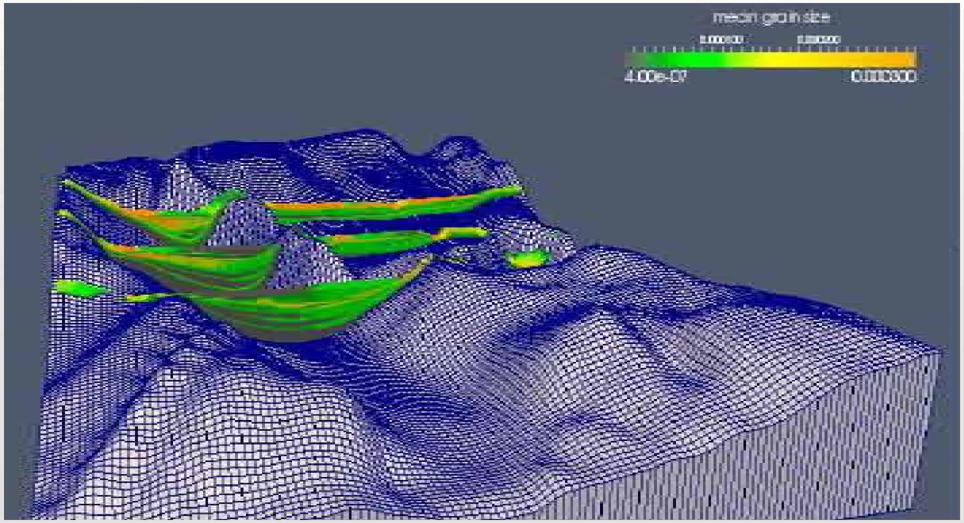
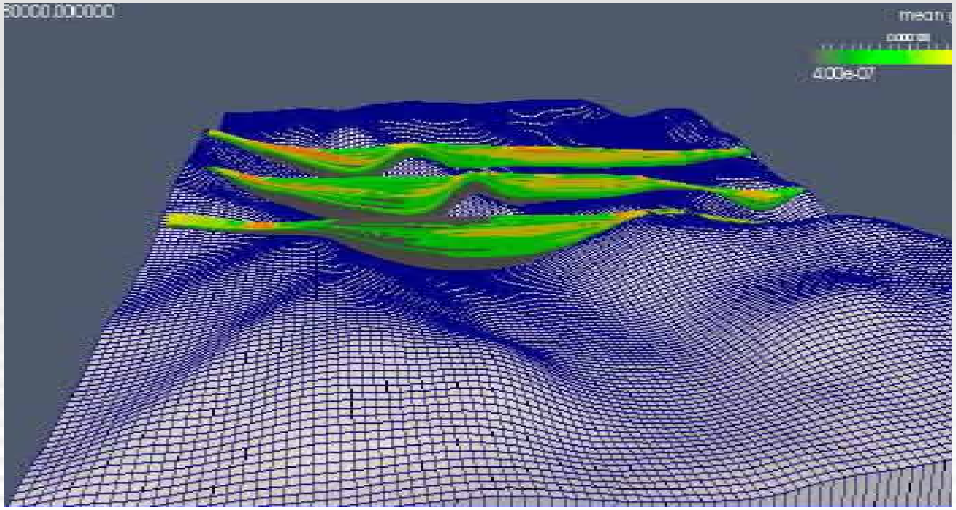


Heather Macdonald* and Dave McGee^



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^ConocoPhillips

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Objectives

Basin Introduction

Pleistocene Sea Level Fluctuations

Potential Controls on Depositional Style

Interval Descriptions

Conclusions

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Seismic data Courtesy of CGGVeritas Services (U.S.) Inc., Houston, Texas

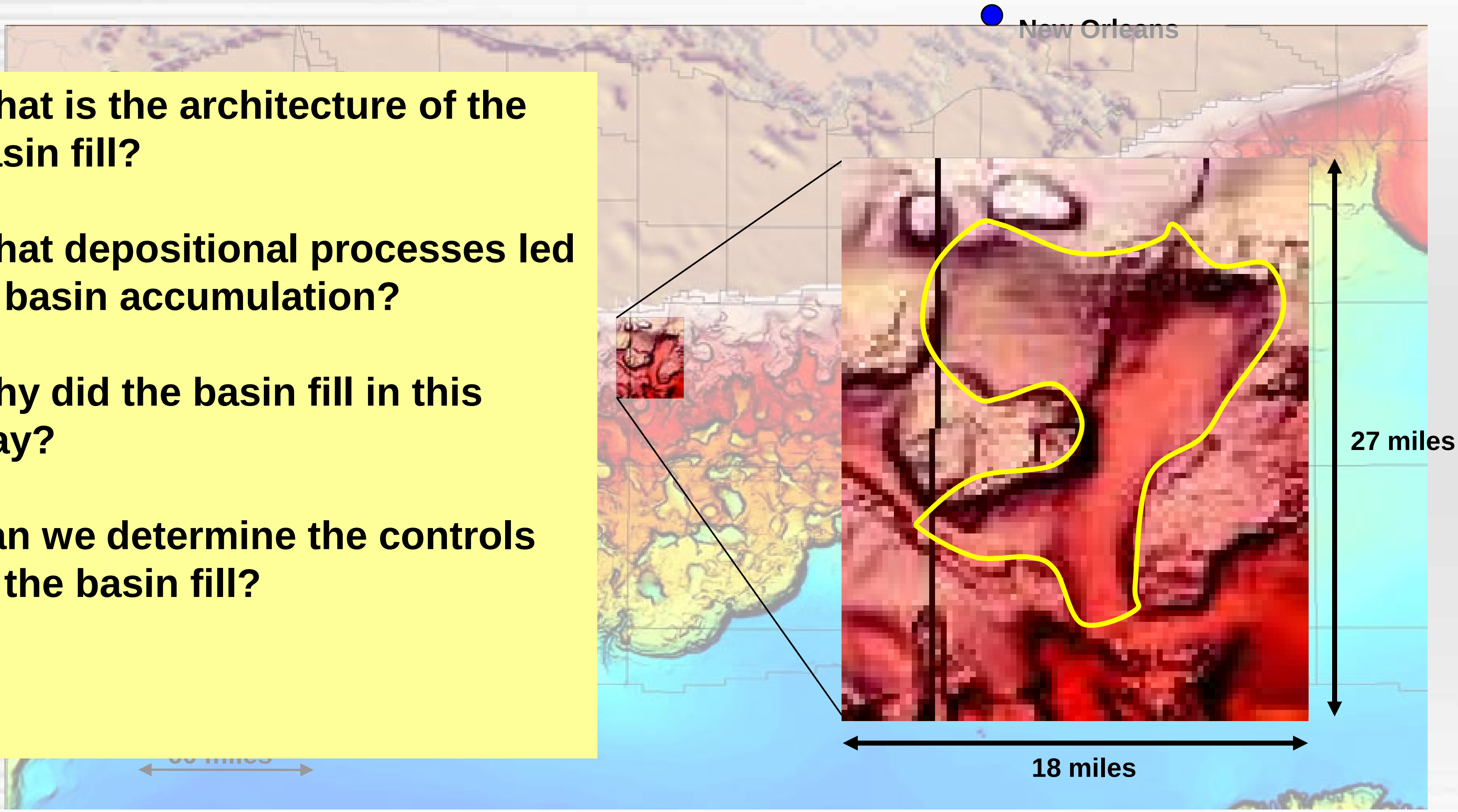
Northern Gulf of Mexico Bathymetry

What is the architecture of the basin fill?

What depositional processes led to basin accumulation?

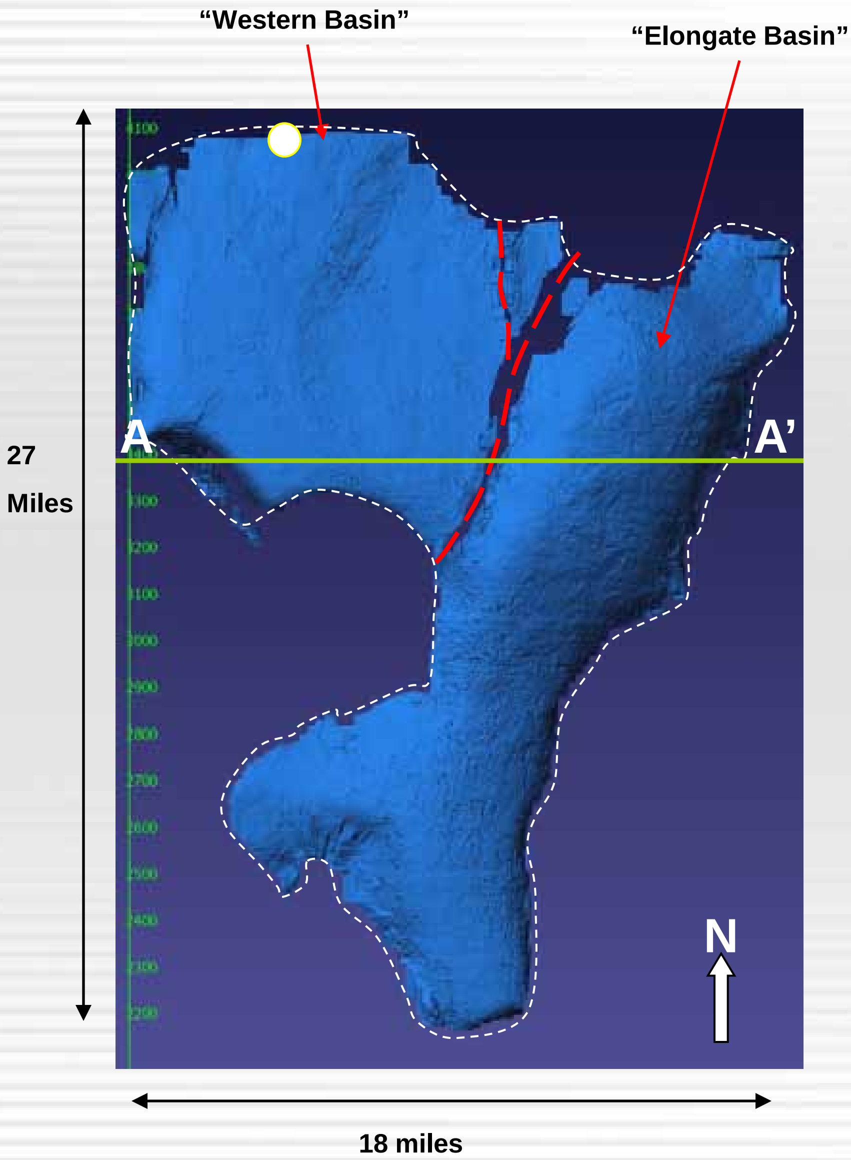
Why did the basin fill in this way?

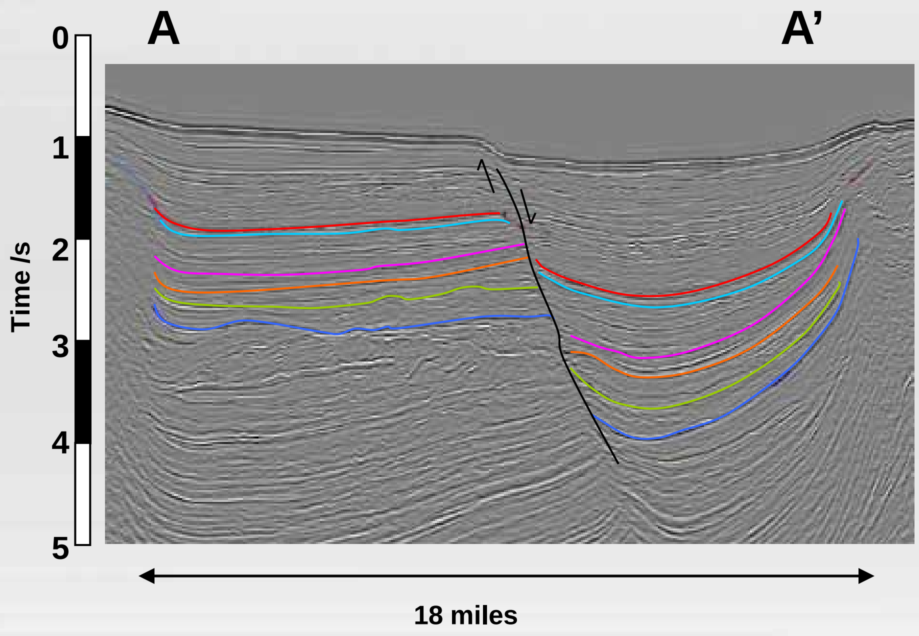
Can we determine the controls of the basin fill?



Presently, the basins are confined, but during deposition of the interval of interest, that was much less true

Basin Introduction





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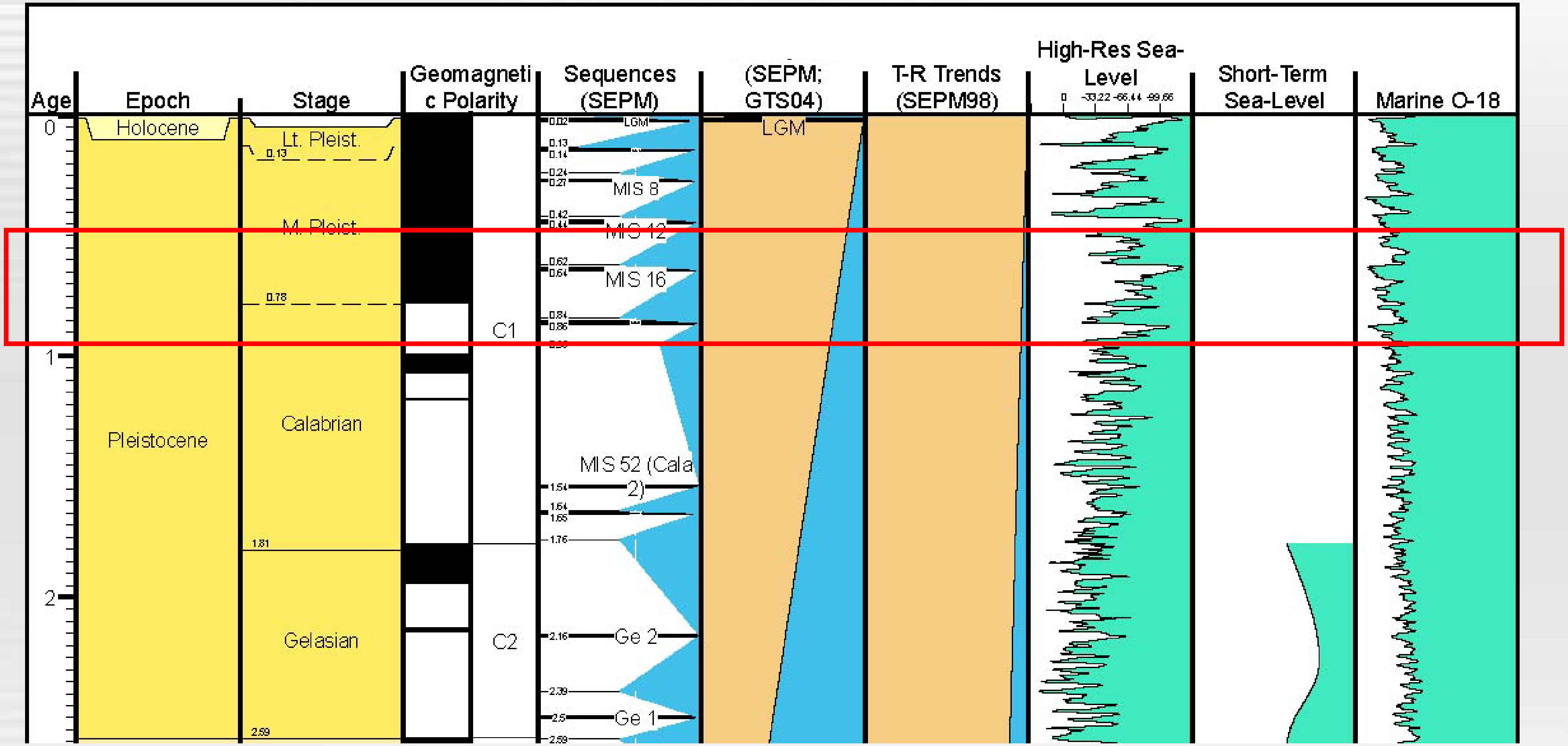
Pleistocene Sea Level Fluctuations

Oxygen Isotopic-based Global Sea-level Estimate



Redrawn from:

GTS 2004
Gradstein et al.., 2004

Miller et al., 2005

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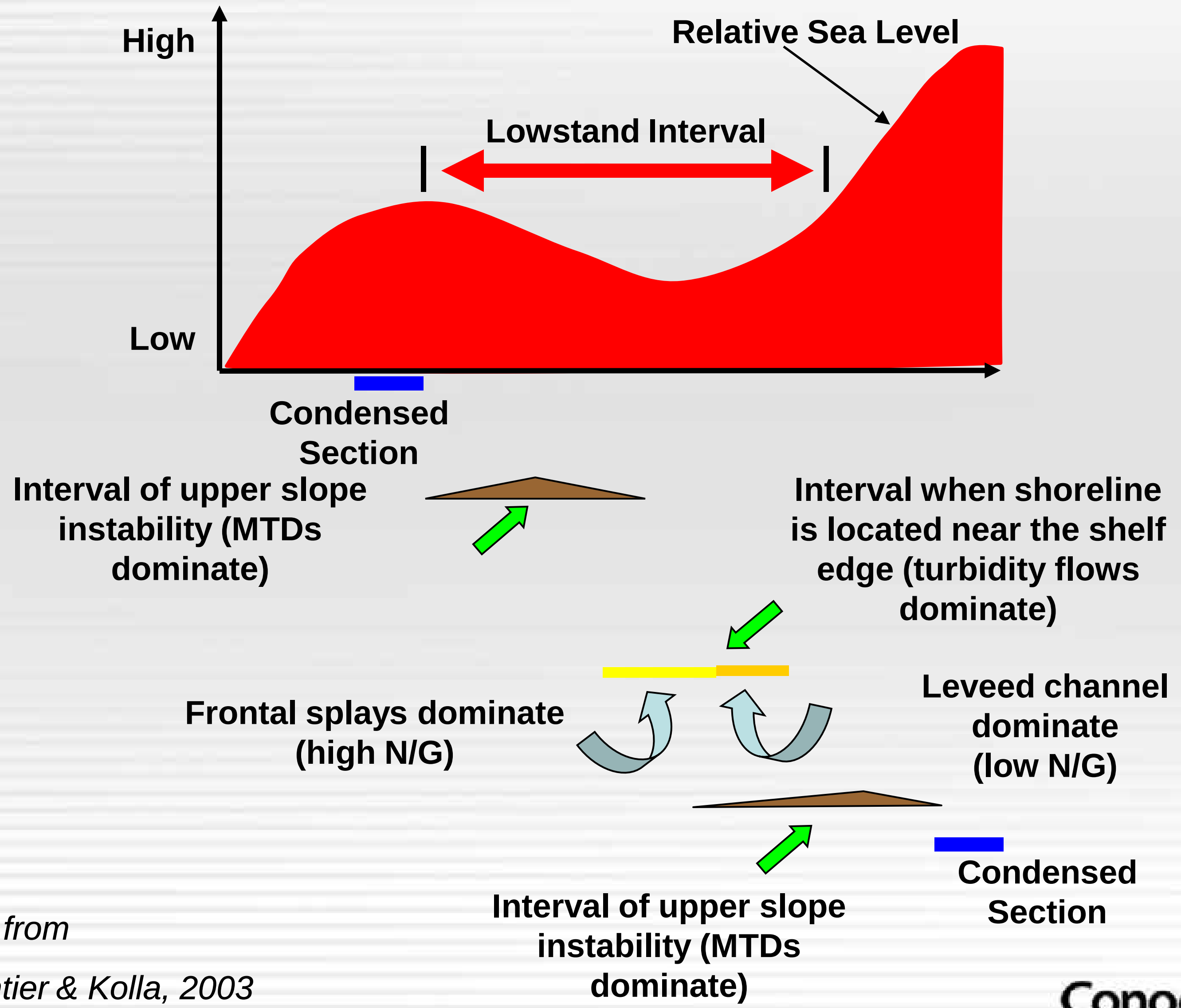
Controls on depositional style

1. Sea Level Change



Redrawn from

Posamentier & Kolla, 2003

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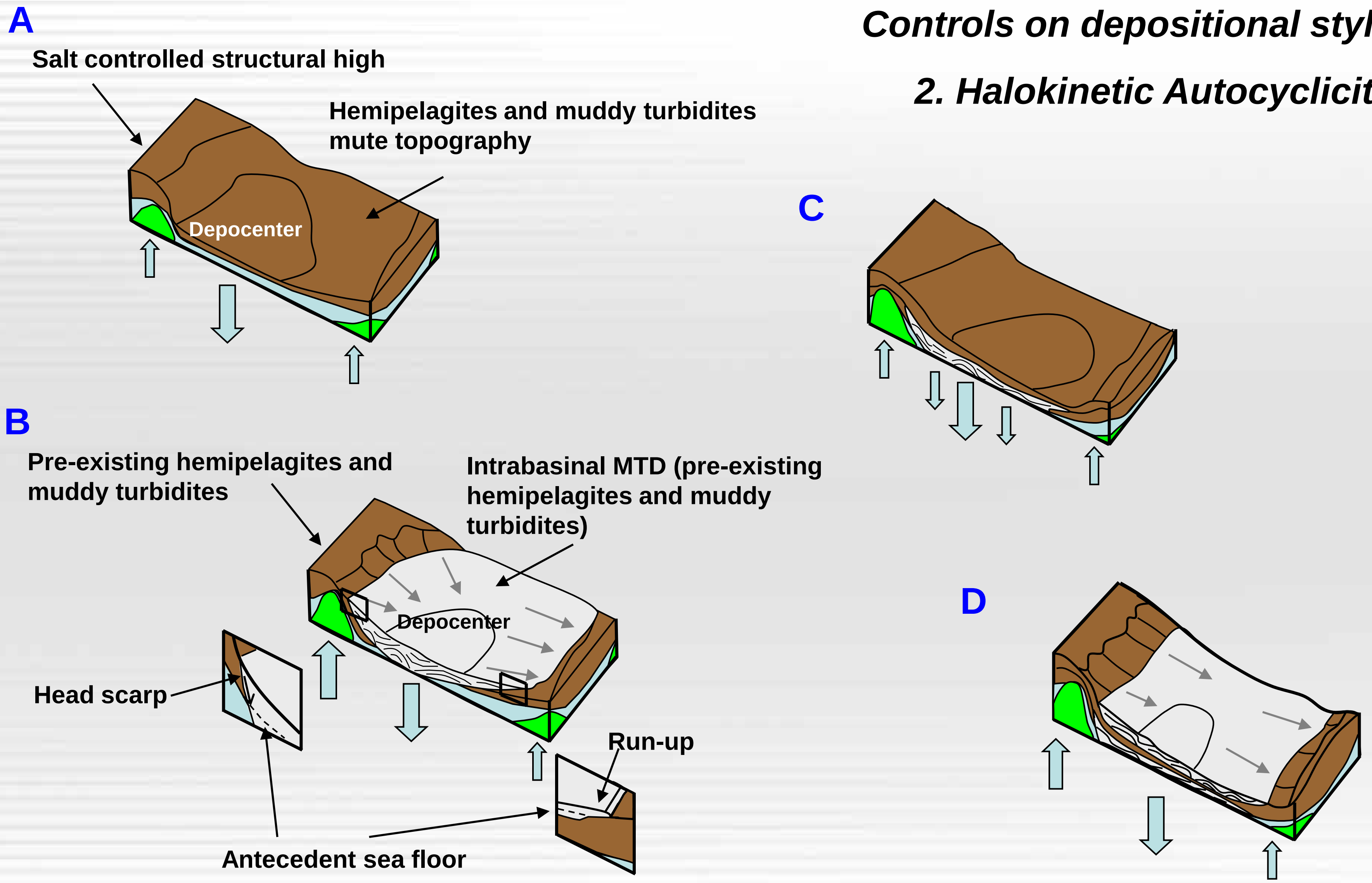
Controls on depositional style

2. Halokinetic Autocyclicity



Redrawn from Madof et al., 2009

Eustatic Control

Would expect to see alternating deposits punctuated by condensed sections:

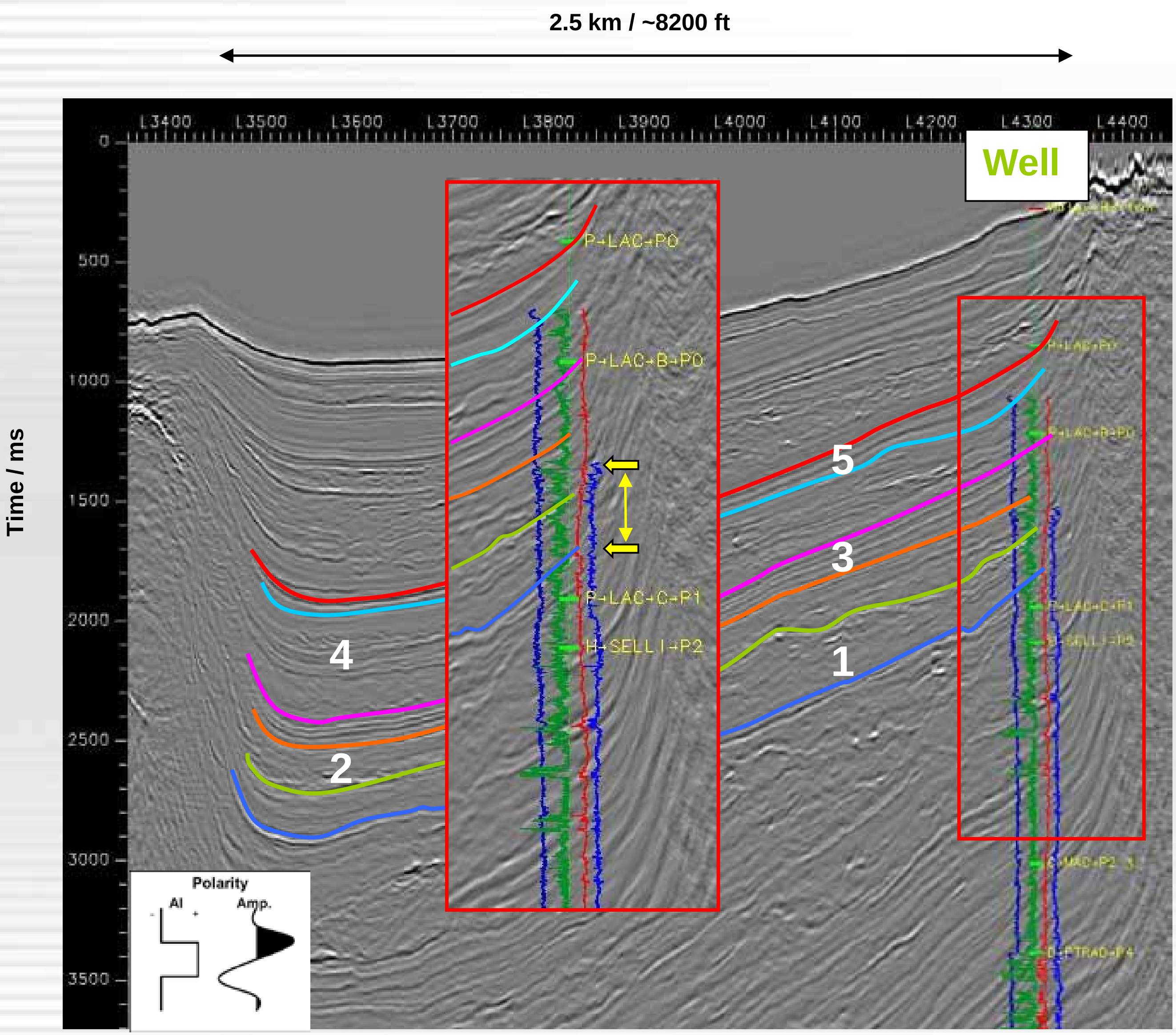
Condensed Section
MTD
Frontal Splay
Channel Complexes
MTD
Condensed Section

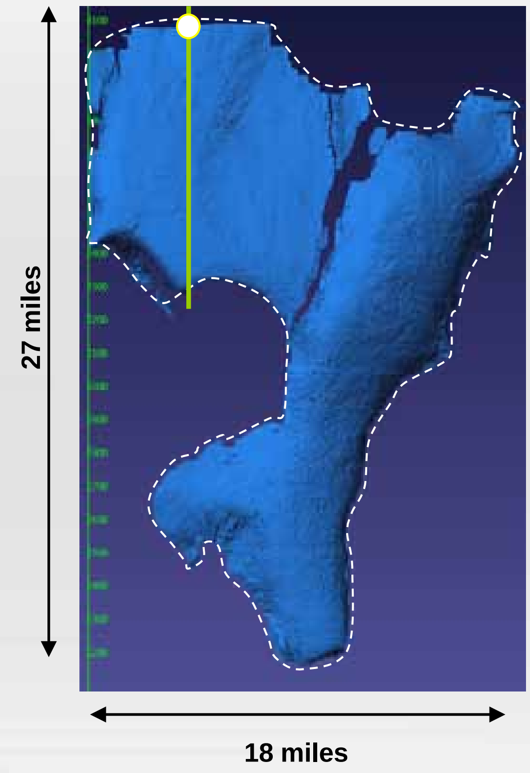
Halokinetic Control

Patterns of sedimentation governed by 3D motion of salt:

Hemipelagites & Muddy turbidites
Intrabasinal MTDs
Interbedded with organized turbidite systems

Horizon Selection





Not a particularly sandy section except intervals 1 and 2.

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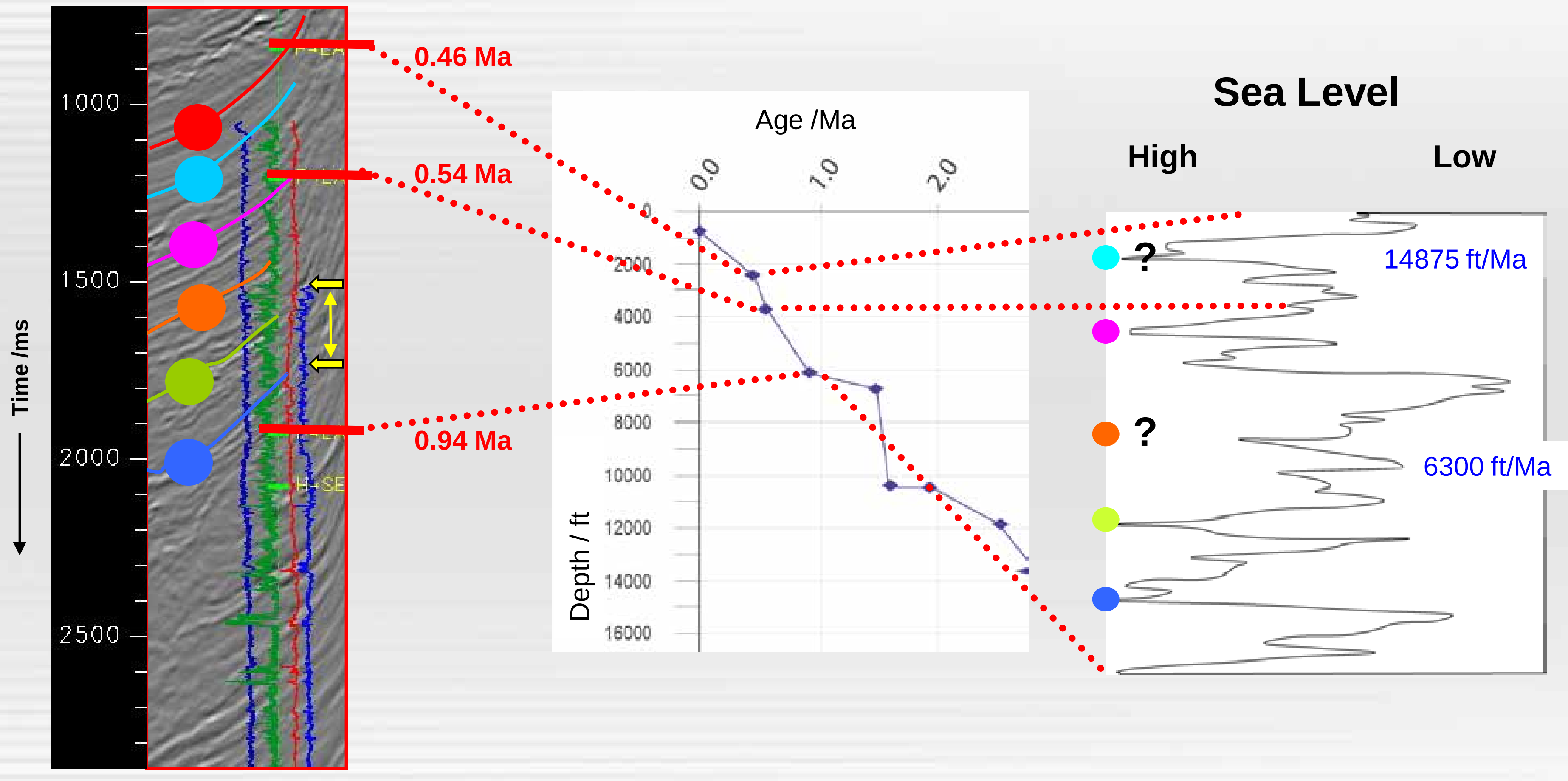
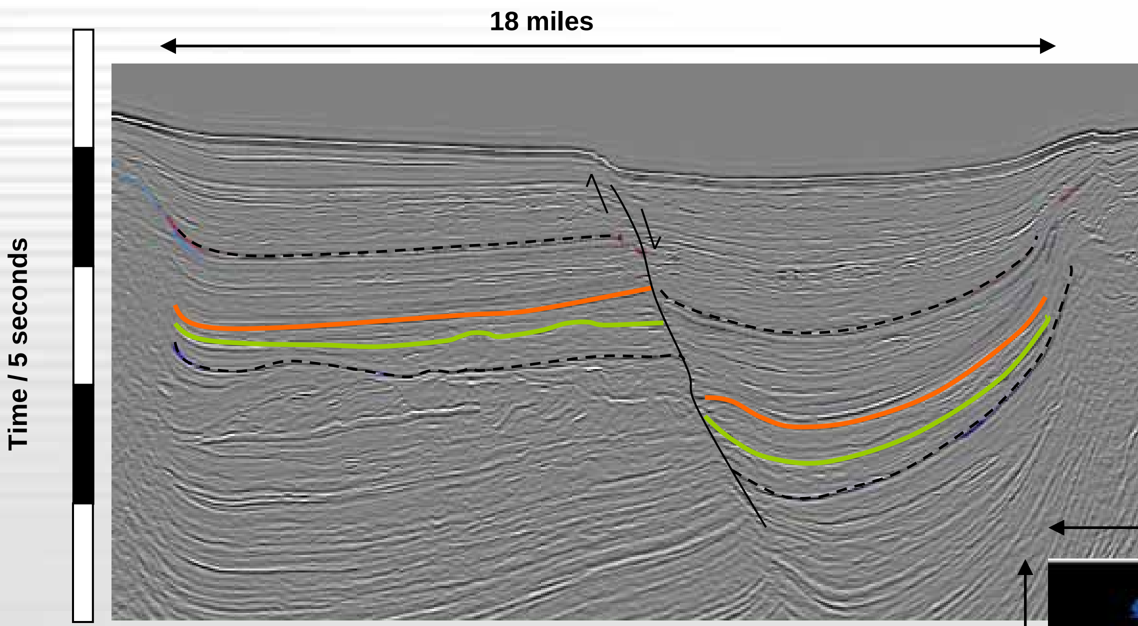
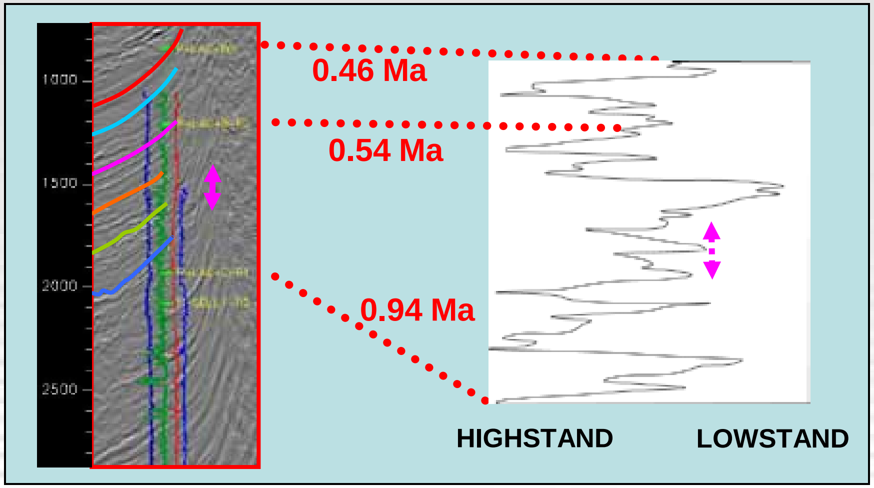
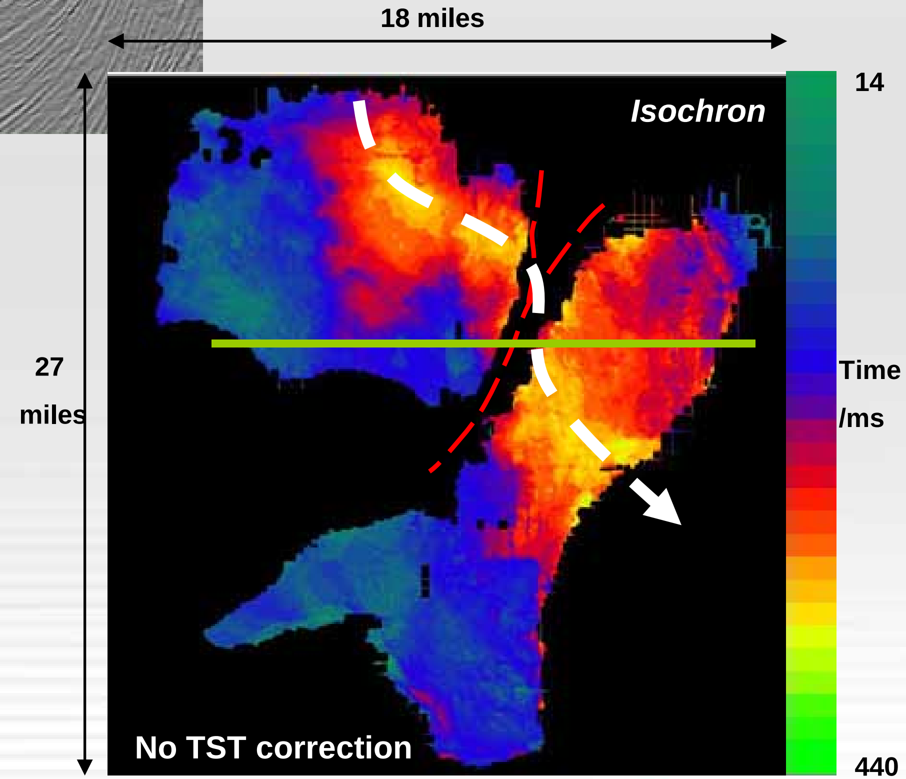
Interval Timing & Sedimentation Rates



Interval 2







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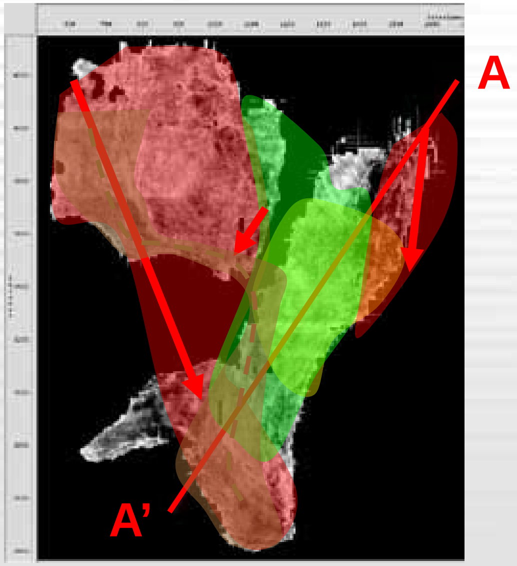
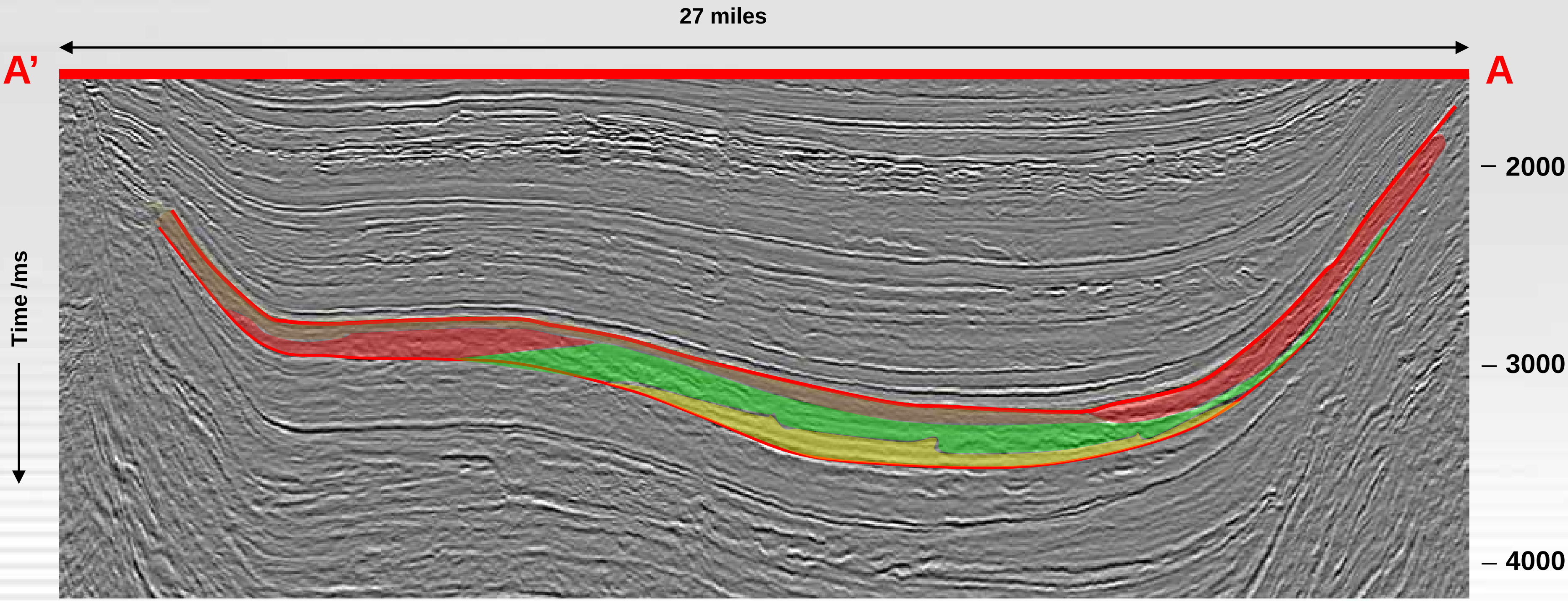
Interval 2: Sedimentary History

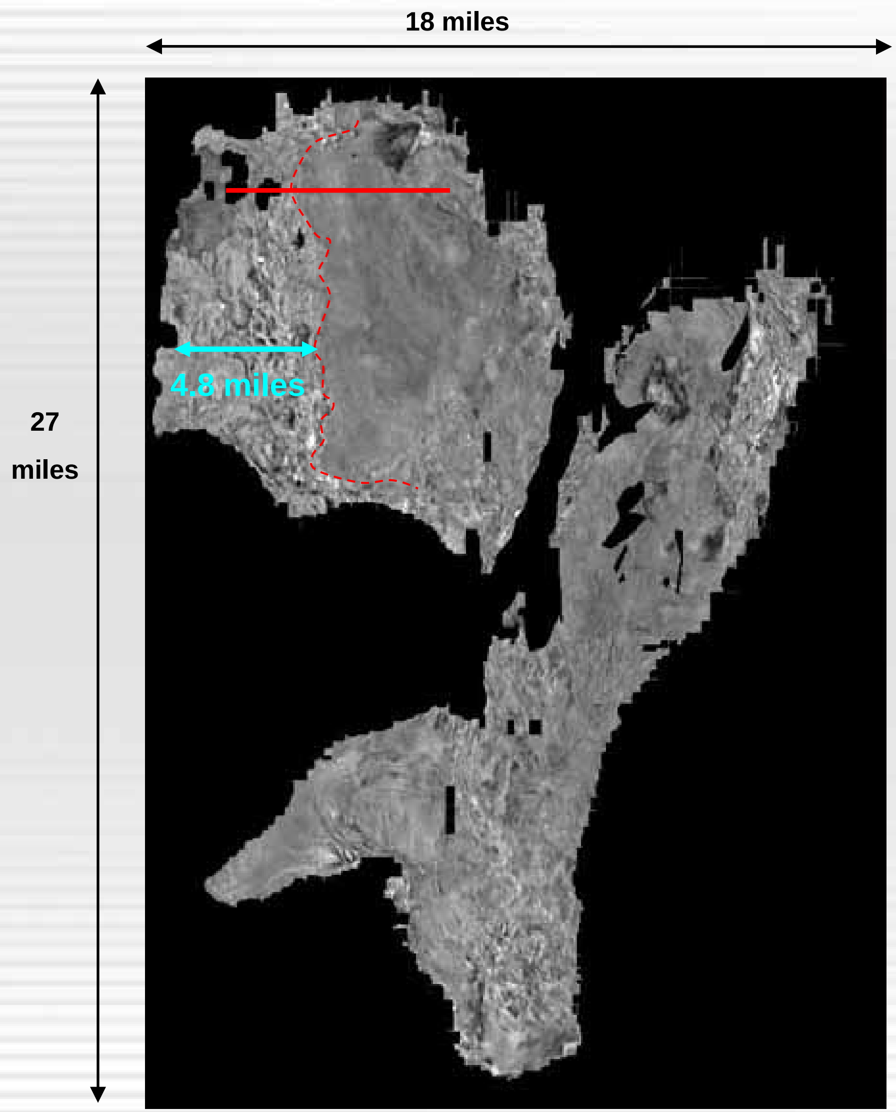


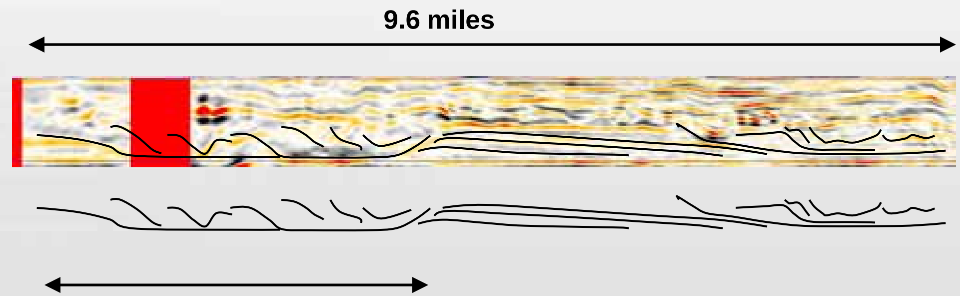
1. Ponded Sheets
2. MTD
3. Channel Complexes
4. Confined Sinuous Channel



Interval 2

Channel complexes





Chaotic

High reflectivity

Erosional Base

Channel complex: >4.8 miles width

Channel elements: 600 – 1300 ft width

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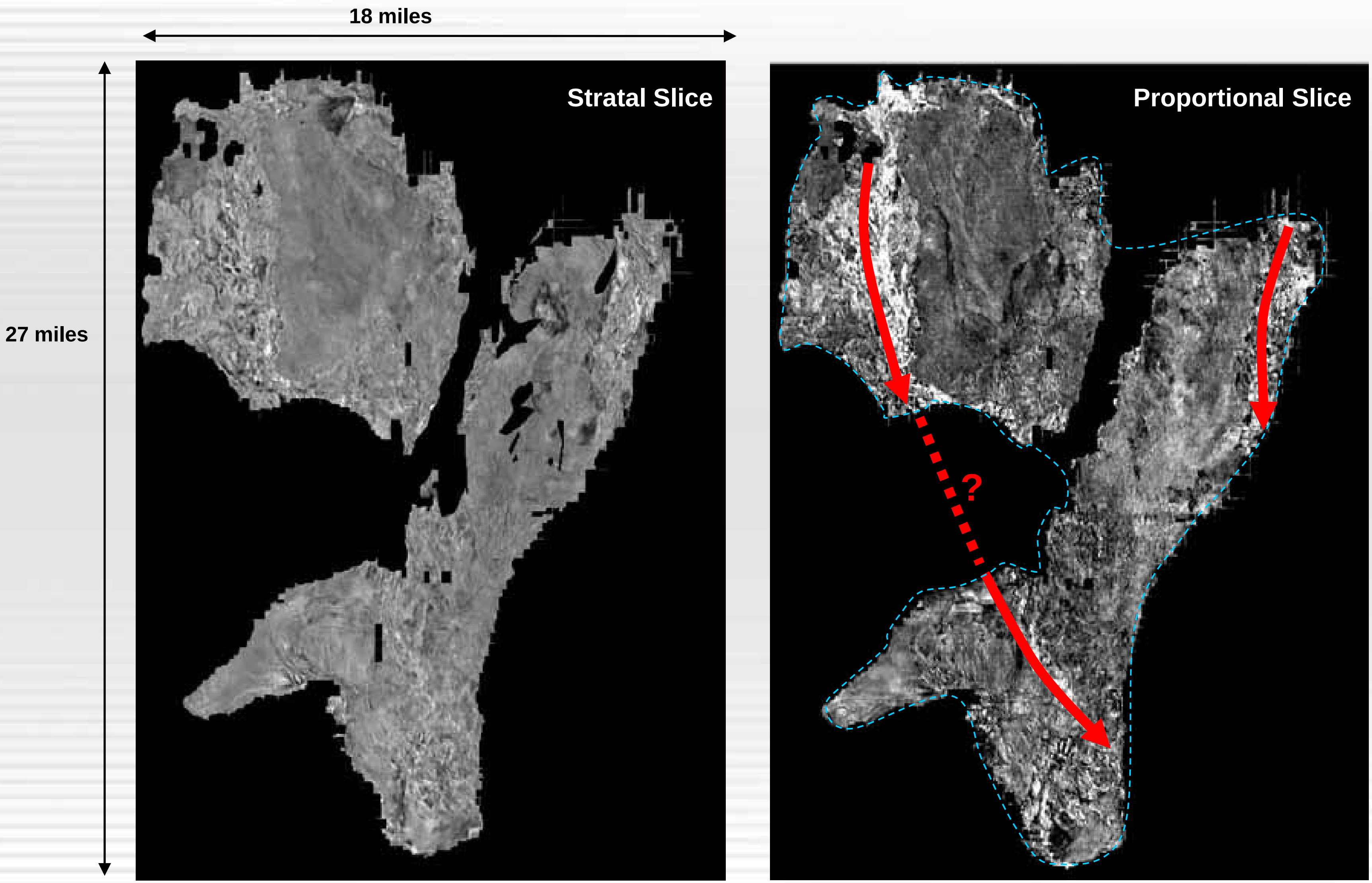
Interval 2 - *Channel complexes – pre-date salt dome*



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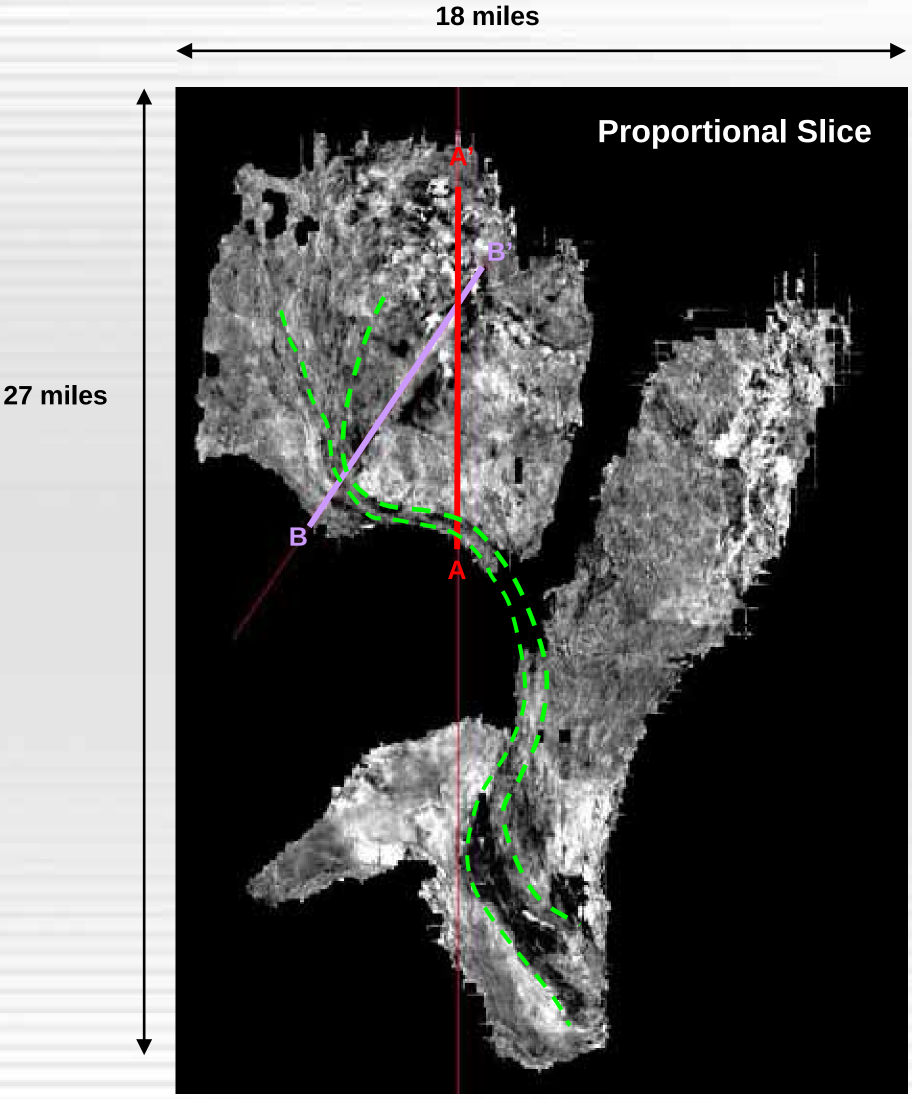
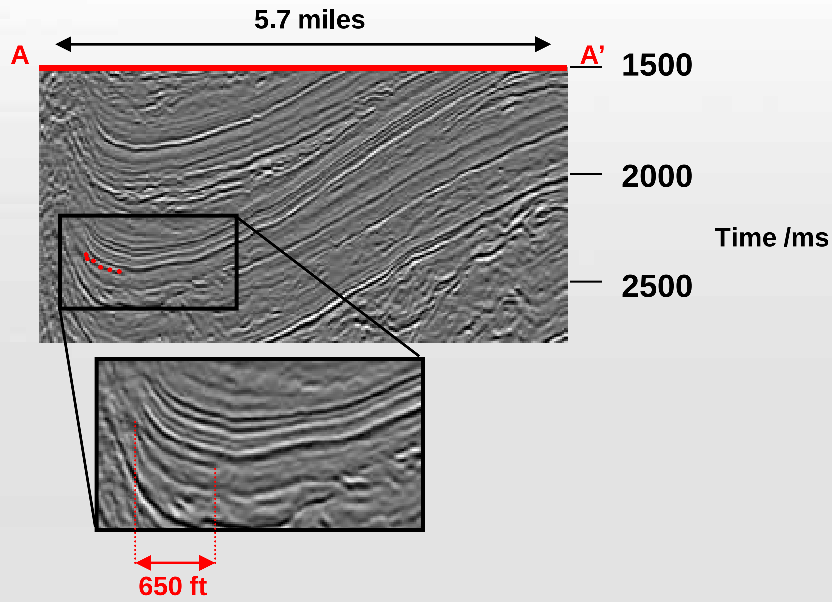
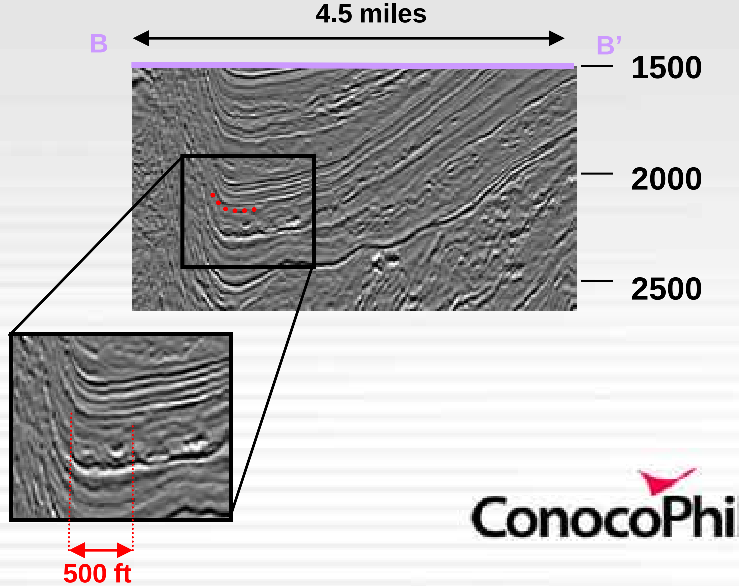
Confined Channel - *Evidence for salt emergence?*







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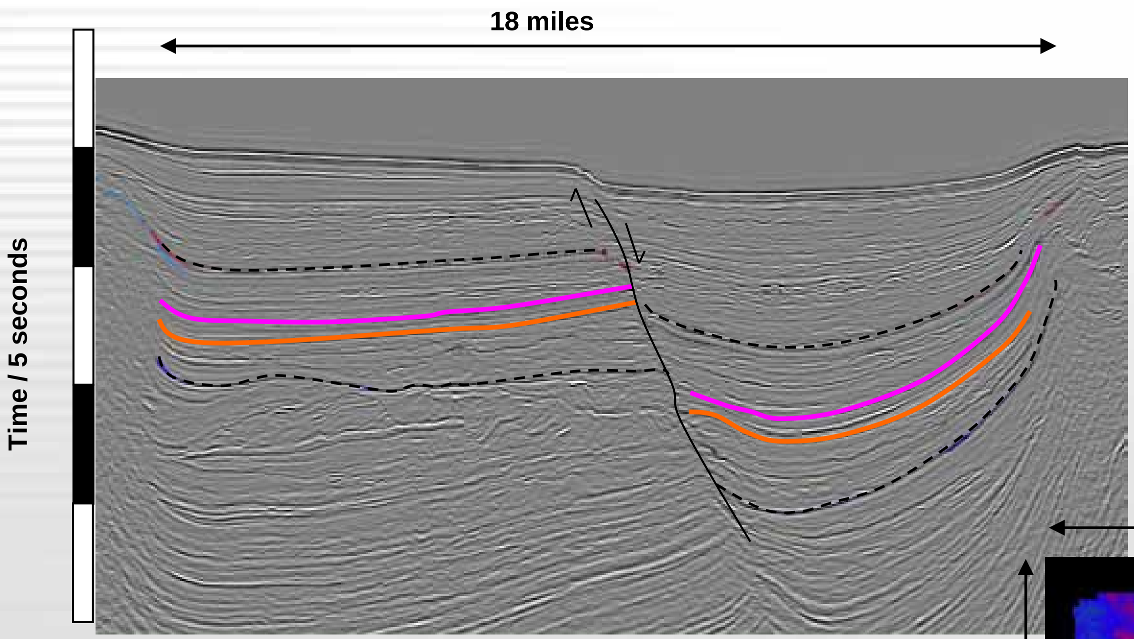
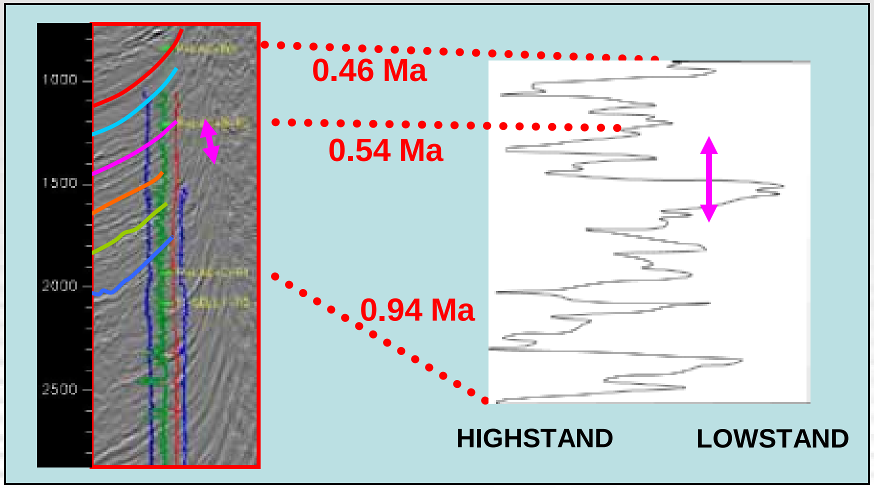
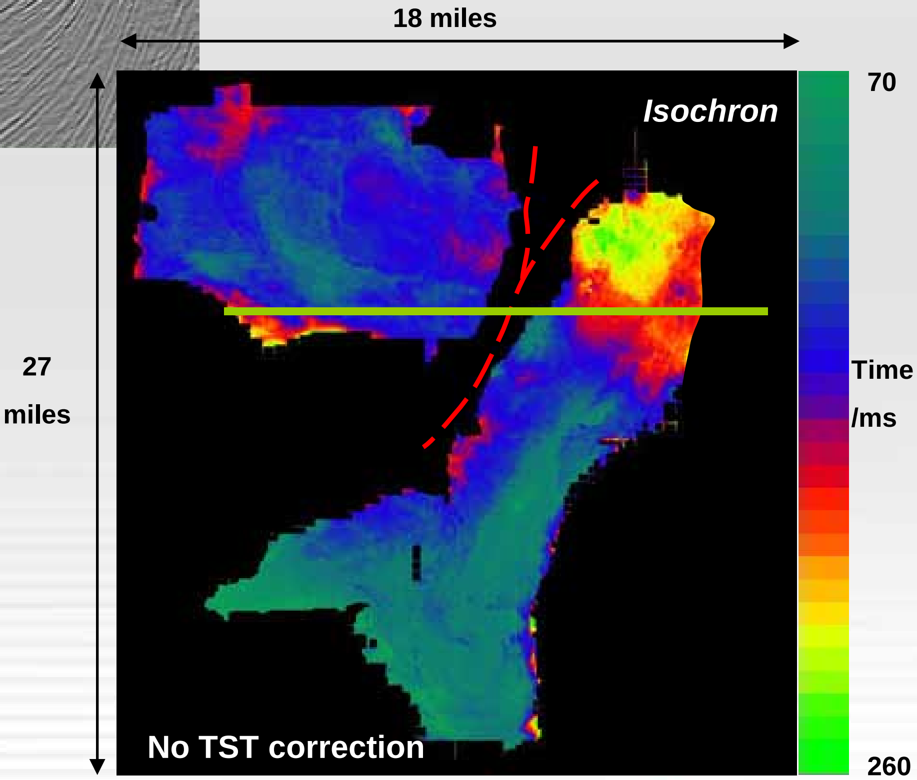
Interval 3







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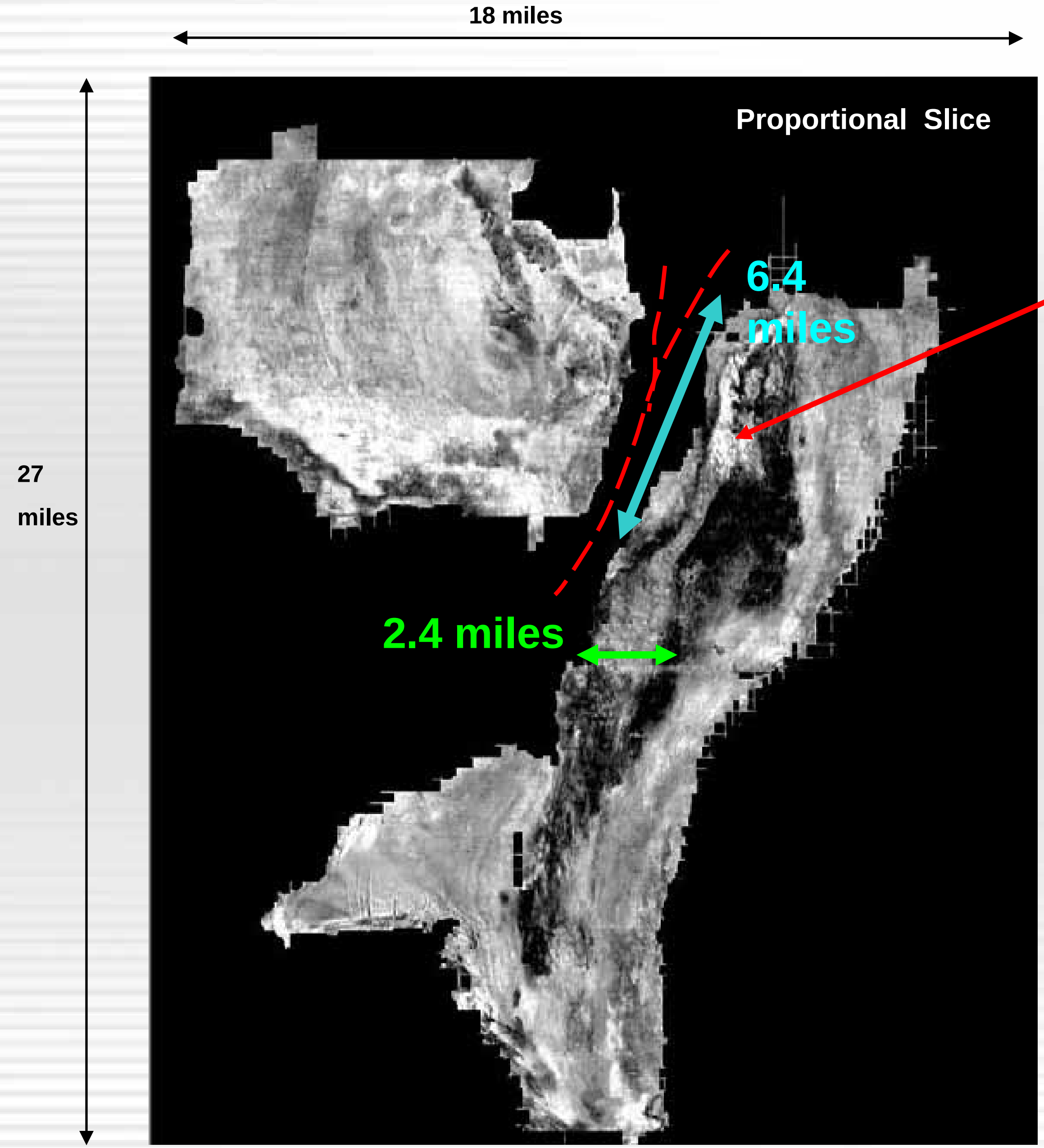
Interval 3 – Channelized region



1500 – 3000 ft width

Elements: 600 – 800 ft

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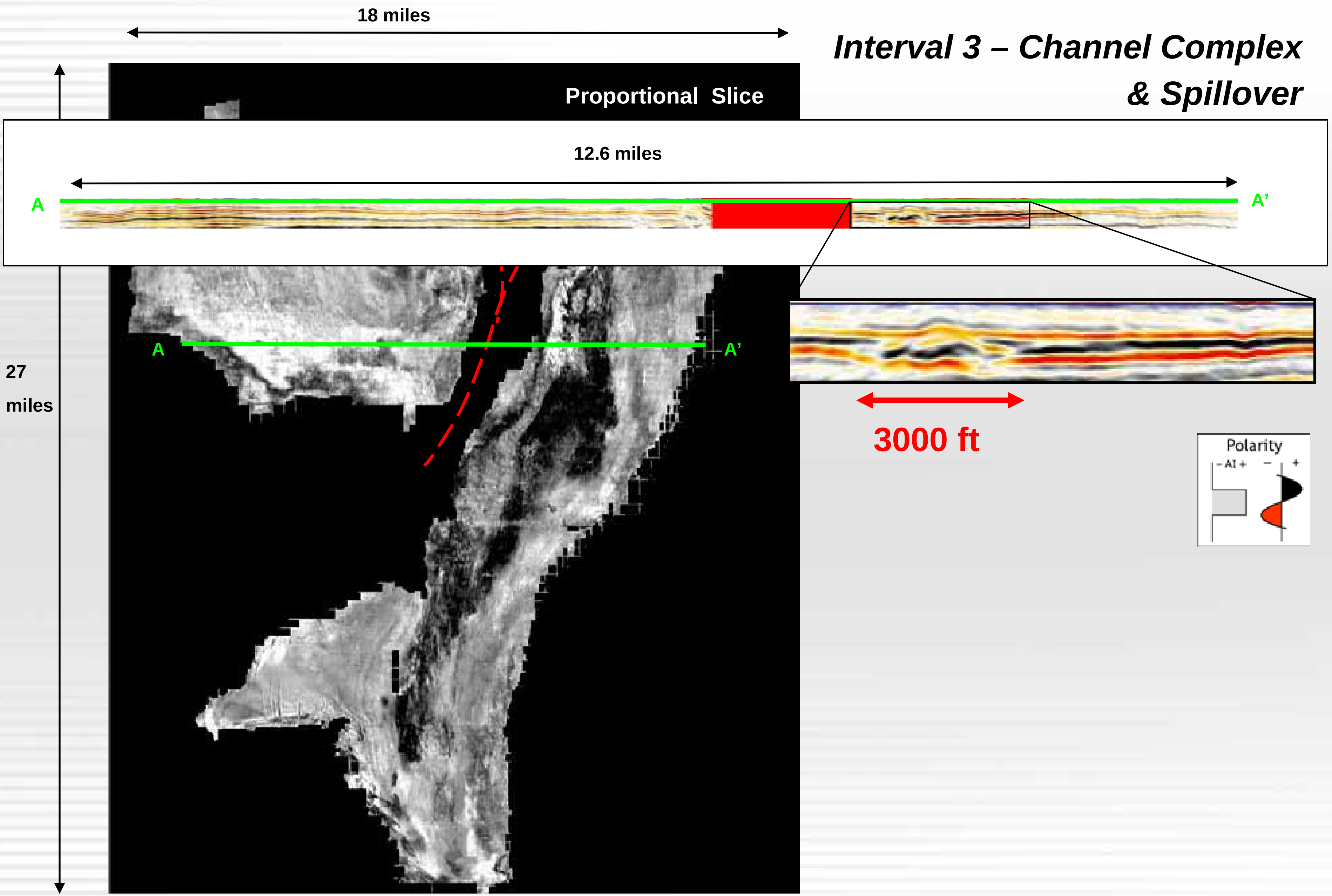
Interval 3 – Channel Complex & Spillover



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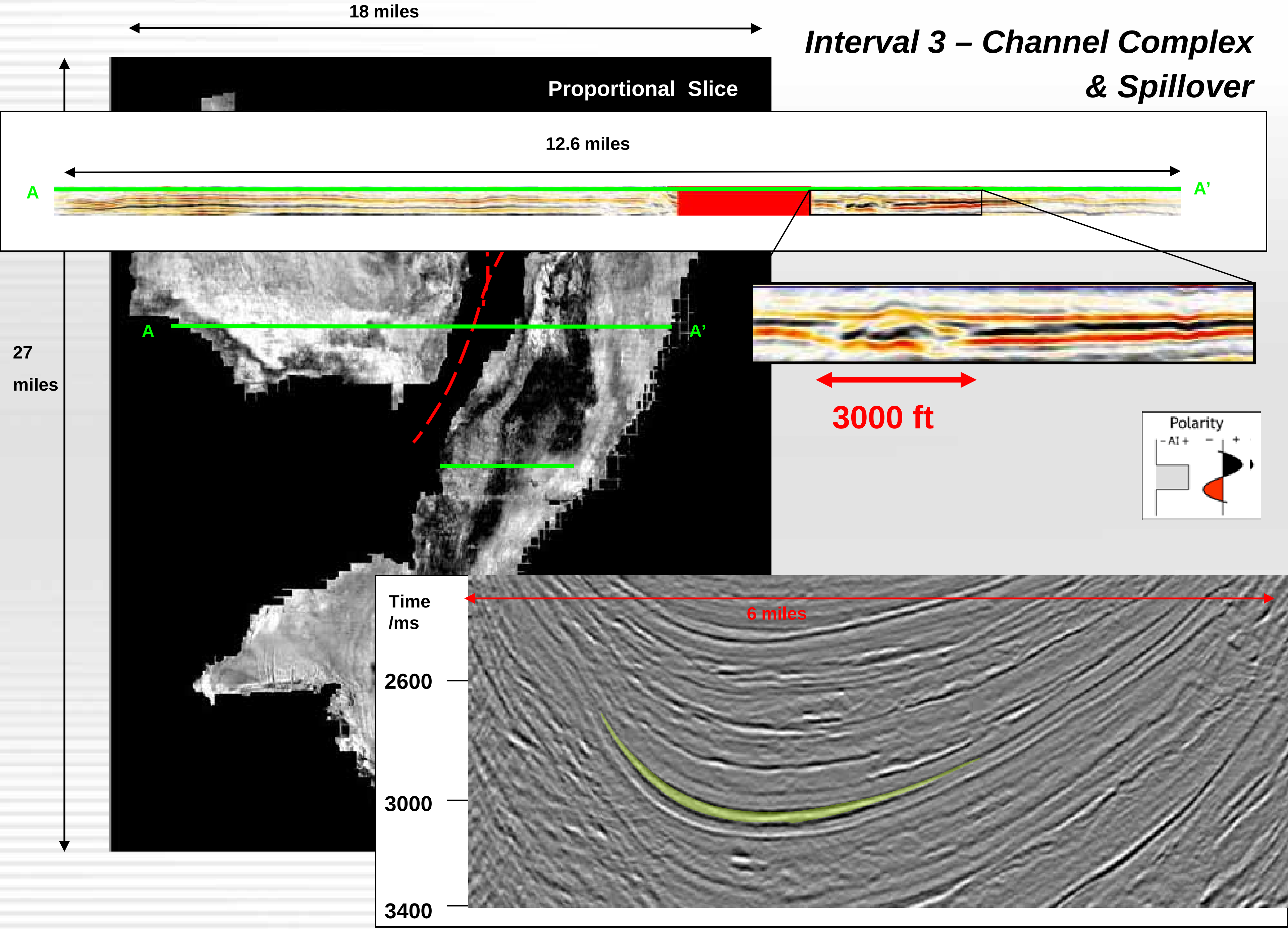
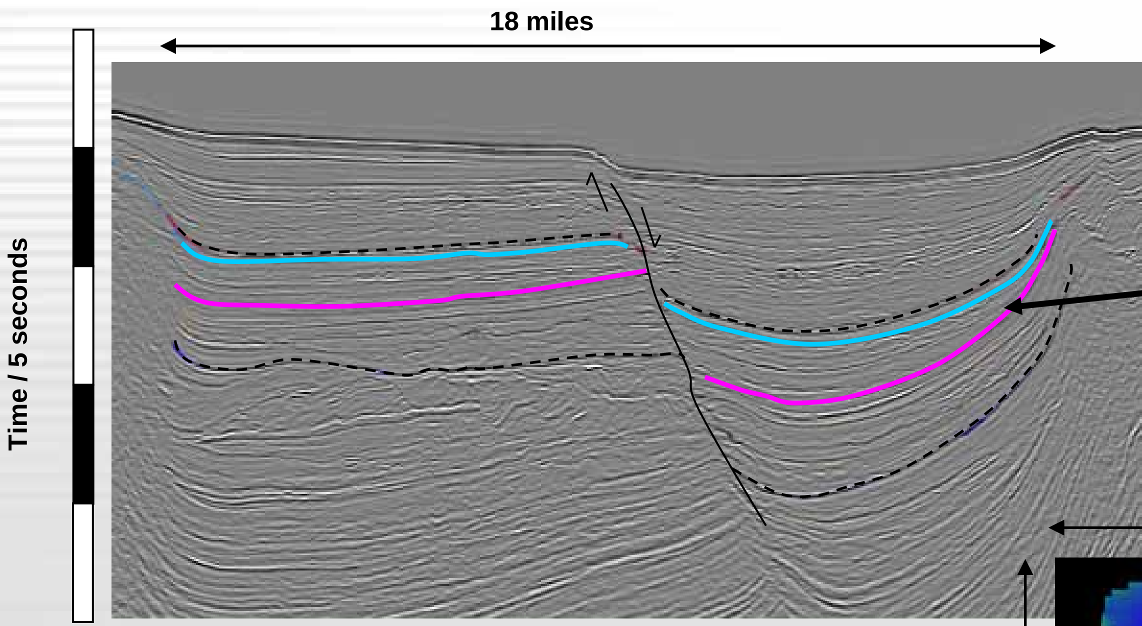
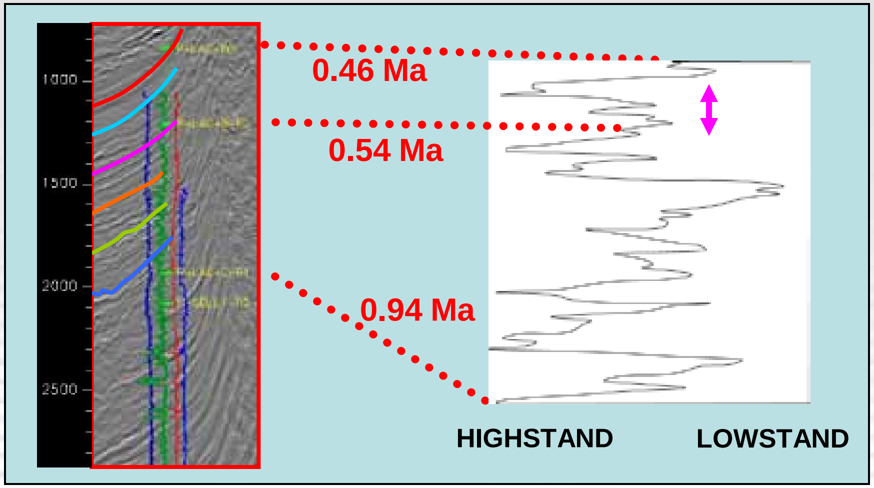
Interval 3 – Channel Complex & Spillover

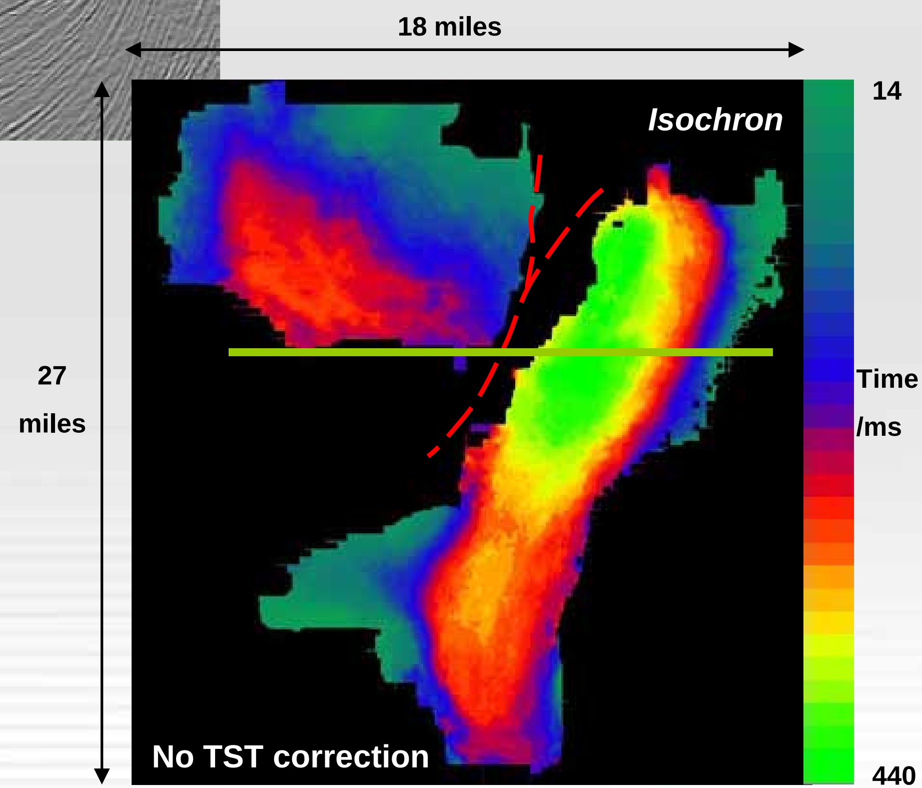


Interval 4



Elongate basin is confined





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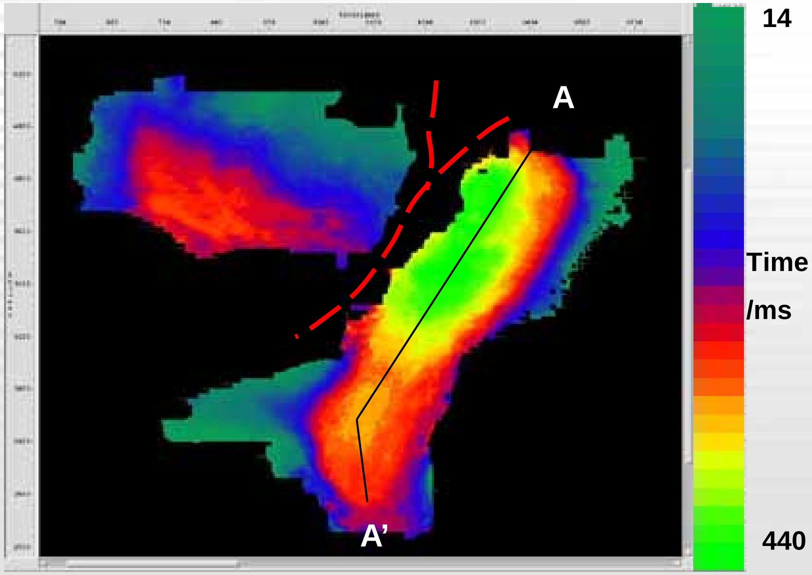
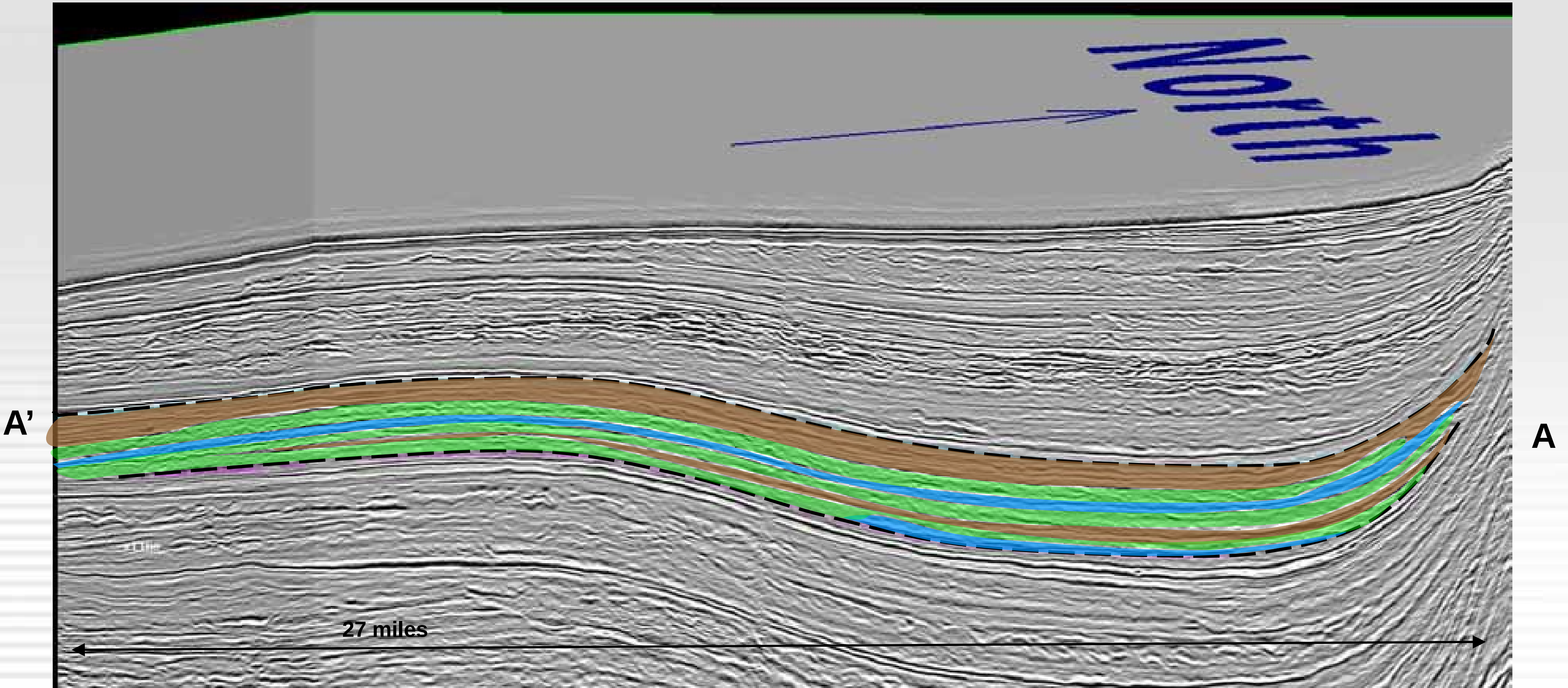
Interval 4



1. Muddy turbidites and HP
2. MTD
3. Sheets deposits with channels
4. MTD
5. Muddy turbidites and HP
6. MTD
7. Sheet deposits with channels



Summary of intervals

Interval 2 – Weakly Confined

Ponded sheets, MTDs, Channel complexes

Documents
- -Salt emergence
- -Increased channel confinement
- -No fault movement

Interval 3 – Intermediate ?

Draped sheet deposits, fault-steered channel complex

Documents
- -Continued salt emergence
- -Presence of fault
- -Fault movement negligible

Interval 4 – Confined

Alternating sheet and mass-transport deposits

Documents
- -Basin-wide deposition
- -Extreme cyclicity in deposits
- -Considerable fault movement

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Driving Mechanism Summary

Eustatic Control

1. Doesn't account for all condensed sections
2. Should ponded sheets be first phase of fill in all intervals?
3. Might explain why MTDs all apparently sourced from North?

Halokinetic Control

1. Accounts for sheet/MTD alternating deposits in interval 4
2. Also doesn't account for all interpreted condensed sections
3. Ties salt emergence to increased frequency of MTDs

Not surprisingly, we see both controls active in this basin during deposition of the studied intervals.

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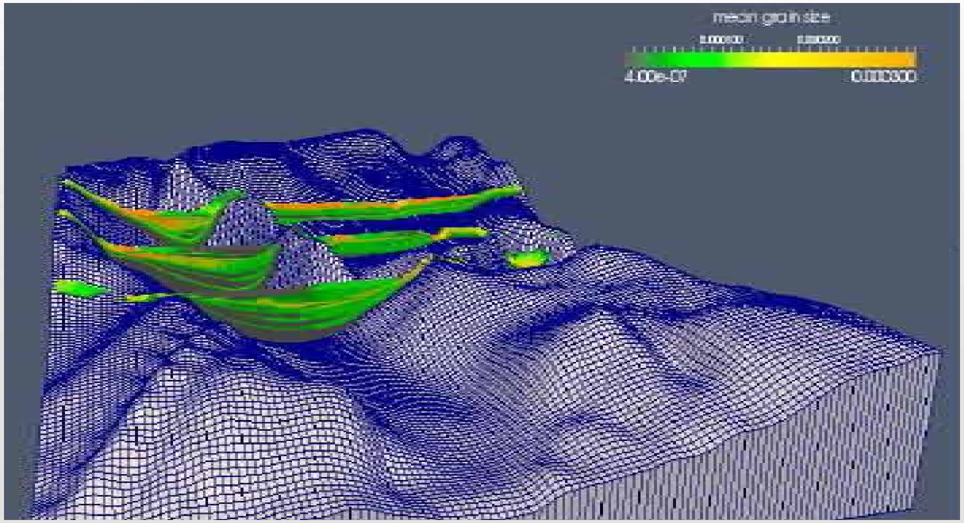
1. Basin fill comprises:

Unconfined Turbidites

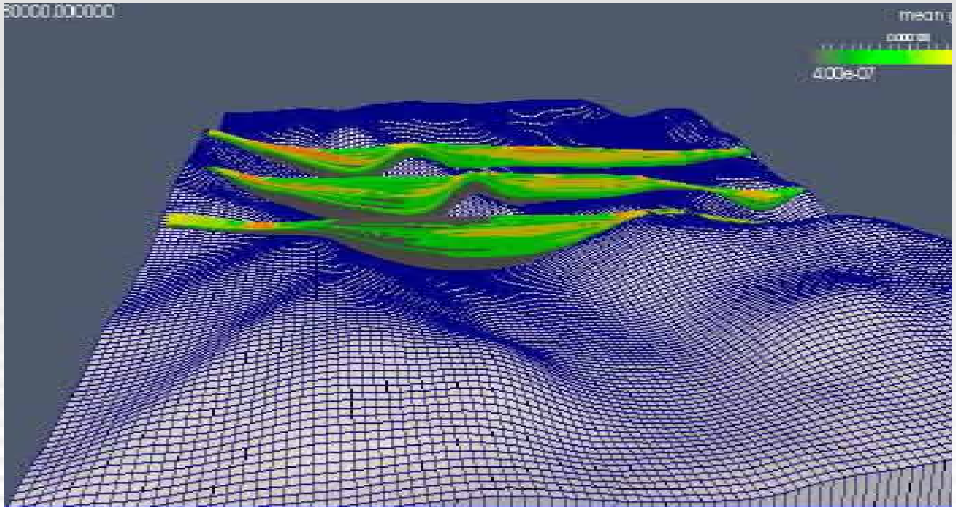
Channel Complexes

MTDs

Hemipelagite



2. The basin fill is cyclic in nature



3. Cyclicity is controlled by:

(i) salt interplay – dominantly?

(ii) glacially controlled sea level changes

Next Steps: Forward stratigraphic model basins

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