Seismic Sedimentology of Incised Valley, Lowstand Delta, and Slope Fan Systems in the Eocene Wilcox Group, Central South Texas Coast*

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Abstract

Tectonic and stratigraphic architecture of the Wilcox Group along the central coastal plain of Texas defines a series of growth-fault-controlled subbasins similar to those in the Frio Formation in South Texas. A seismic sedimentologic study was performed to map fourth- and fifth-order systems tracts in a 2,500 km^2 3D seismic survey in Bee and Goliad counties. Guided by third-order sequence-stratigraphic correlations from seismic and sparse wireline-log data, we prepared stratal-slice maps to reveal high-resolution (10 m scale) sediment-dispersal patterns and associated systems tracts in a relative geologic-time domain, particularly in lowstand subbasins.

The integration of core, wireline-log, and seismic-geomorphologic patterns in stratal slices makes it possible to identify three types of depositional systems in a typical third-order lowstand systems tract: (1) incised valleys and associated fluvial systems on an exposed shelf, (2) lowstand prograding deltaic systems composed of strike-oriented and lobate deltaic sandstone bodies at the shelf edge, and (3) fault-controlled, off-shelf slope fans best characterized by point-sources, fan-like channel/levee systems or line-sourced, complex mudslide/gully systems. Sand-dispersal patterns are controlled primarily by accommodation resulting from rollover topography associated with growth faulting. Sandstone thickness and dispersal patterns can be predicted by integrating wireline-log measurements and seismic amplitude patterns.

The high quality, large 3D seismic data set provides a rare opportunity to visually inspect spatial relationships between incised valleys, self-edge deltas, and slope fans in a high-resolution stratigraphic framework. A sequential display of stratal slices reveals how the depositional systems respond to accommodation controlled by gravity tectonics.

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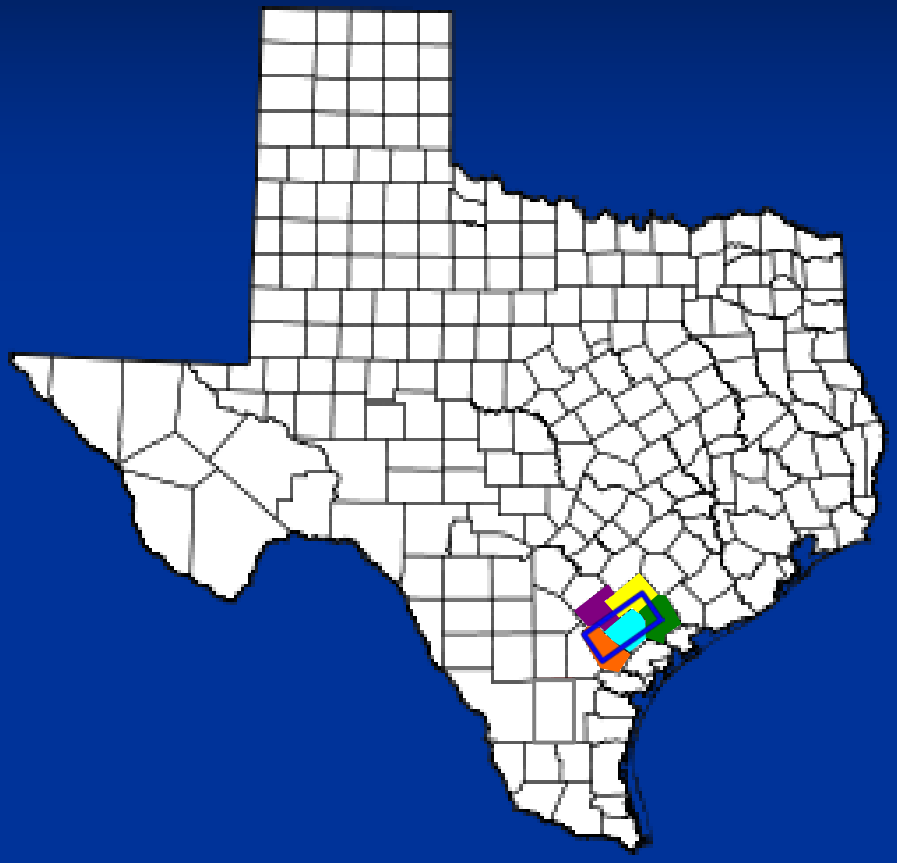
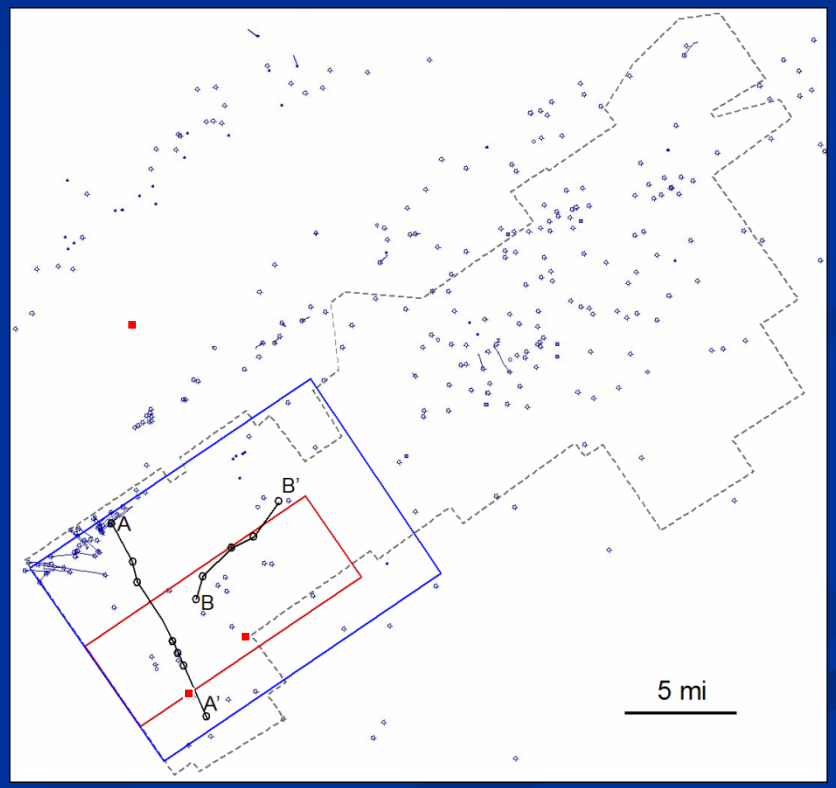
January 27, 2015

Study area in Bee/Goliad region

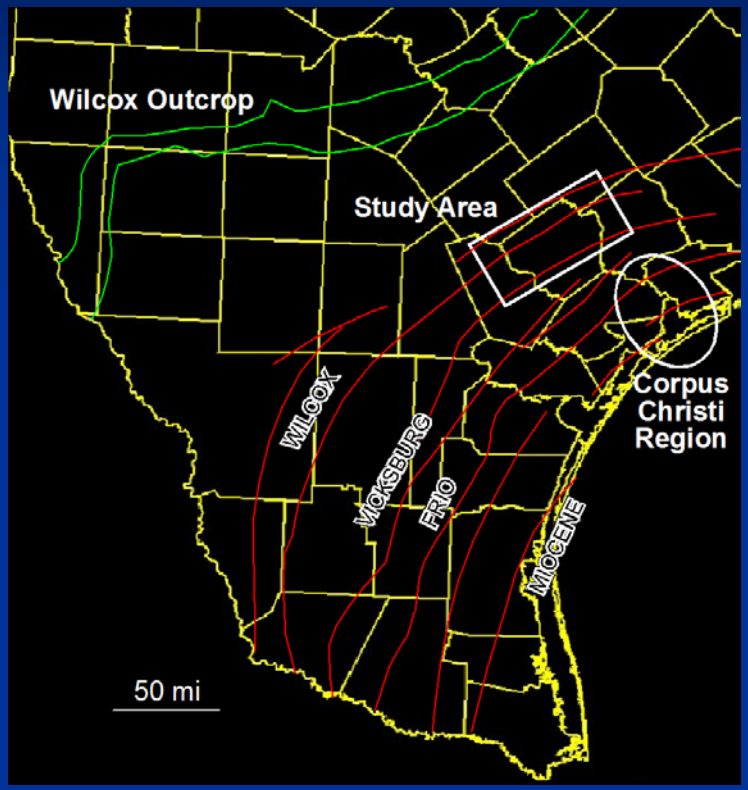


2800 sq. km



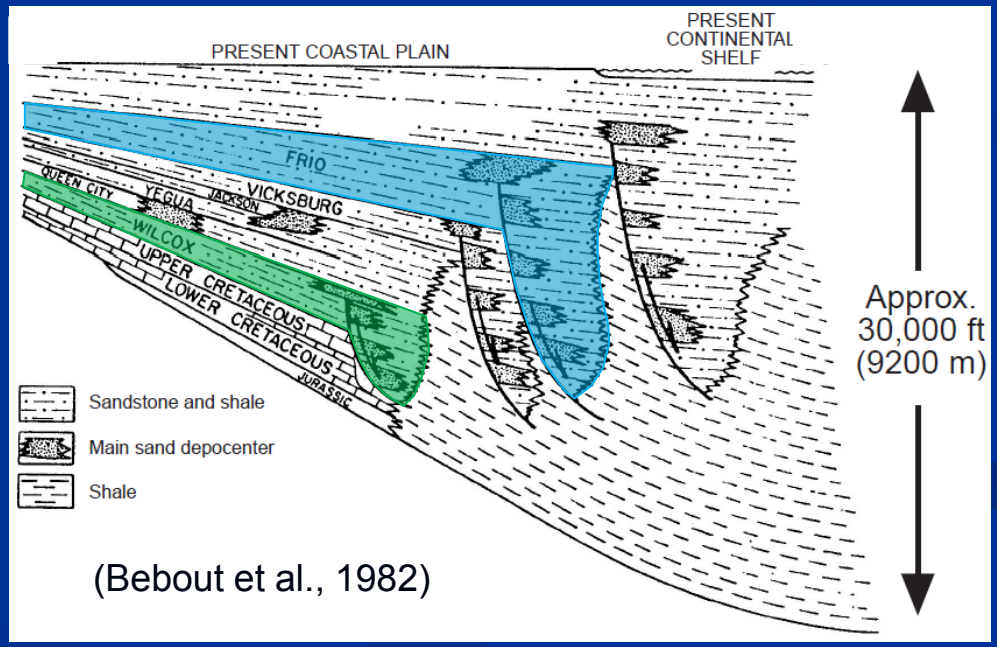
- A case study in south central Texas coast;
- Large 3D survey;
- Used seismic, logs and core.

Tertiary faults and stratigraphy



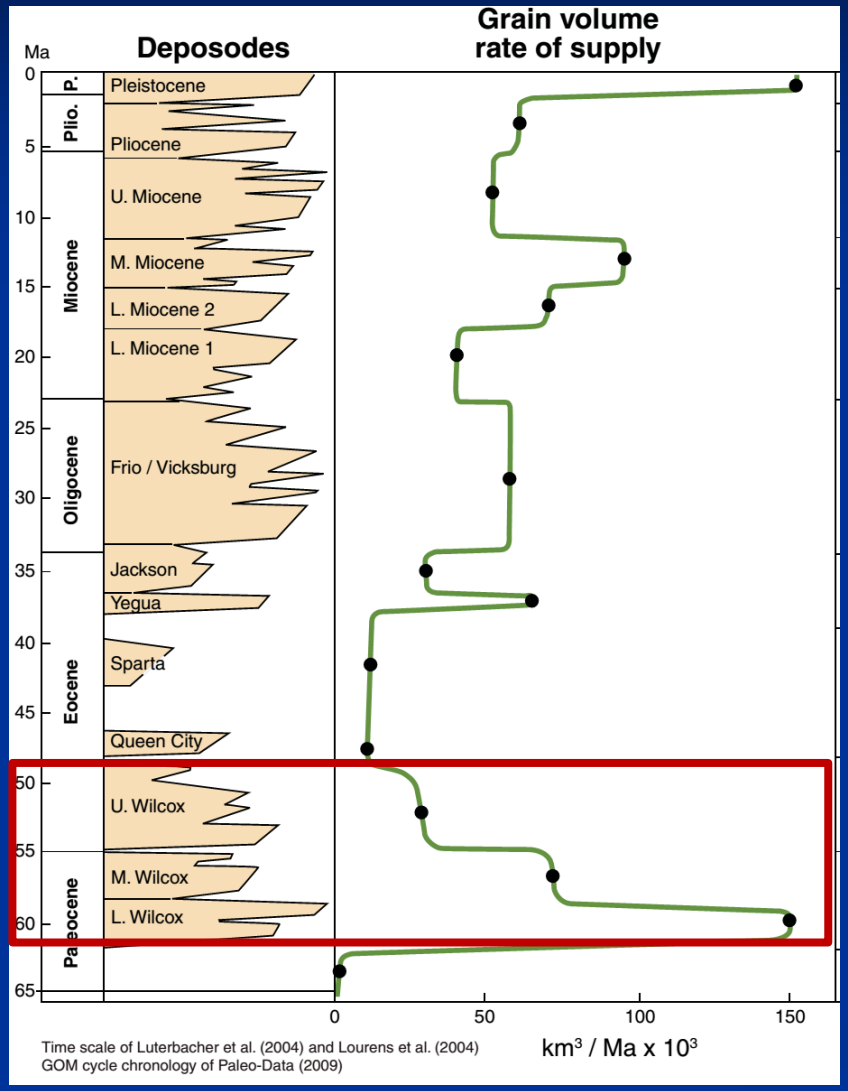
(Modified from Montgomery, 1997)

- A series of Tertiary growth faults;
- Fio fault subbasins are better studied;
- Faults controlled Tertiary stratigraphy;
- Wilcox is study interval.

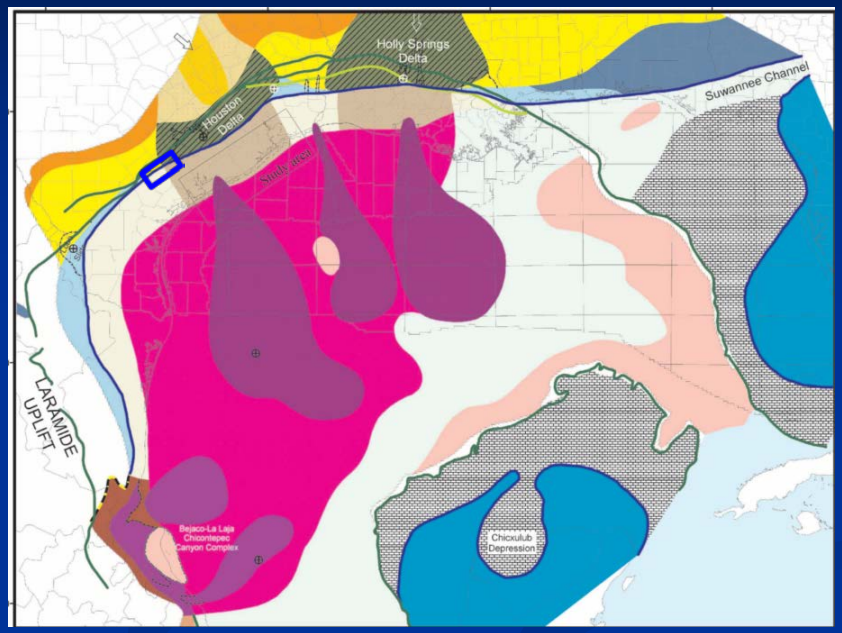


(Bebout et al., 1982)

Wilcox sediment dispersal pattern



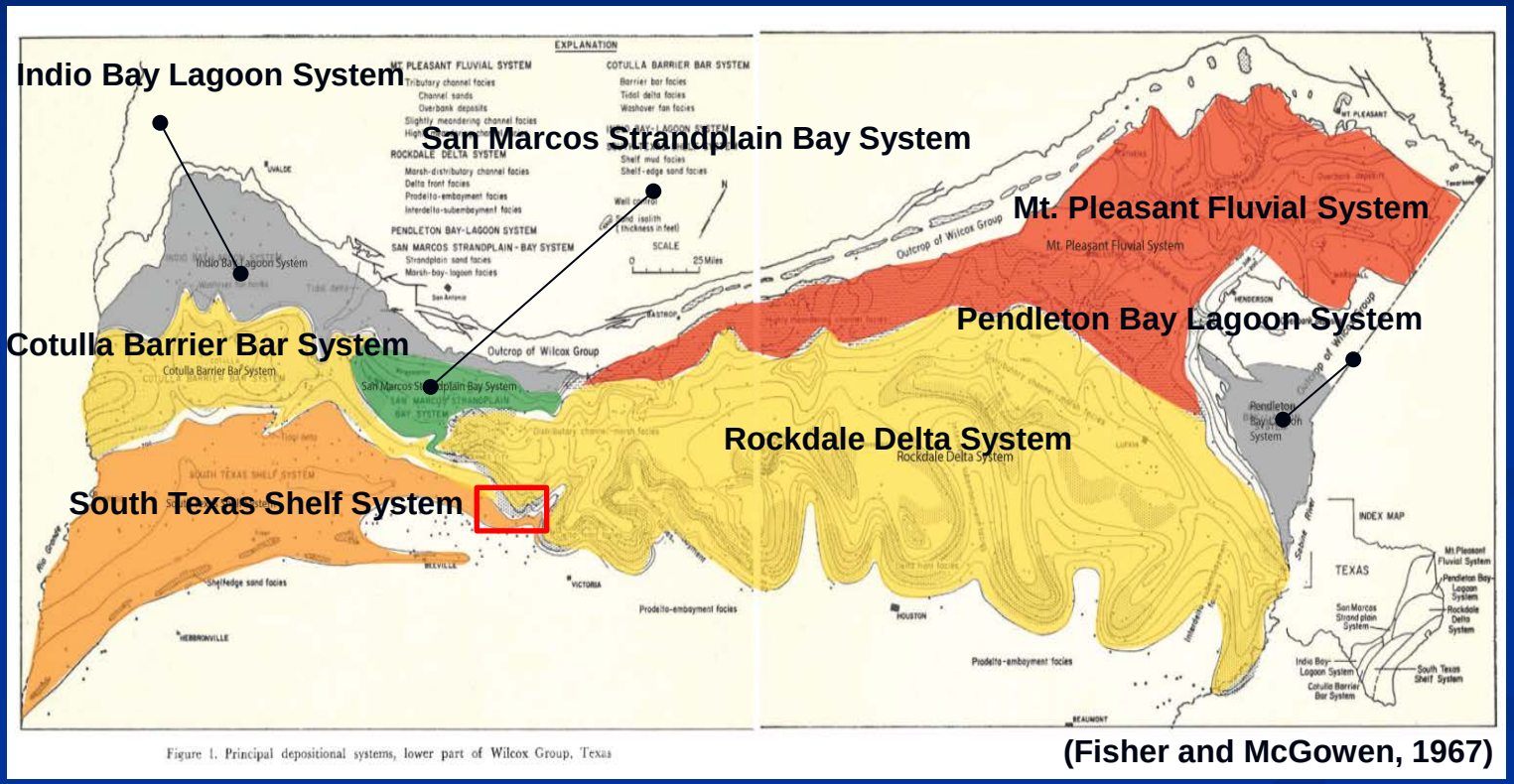
(Galloway et al., 2011)



(McDonnell et al., 2008; after Galloway et al., 2000)

- First Cenozoic depositional episode;
- Large and thick deepwater fans;
- Different depositional style in onshore area.

Wilcox deltaic system

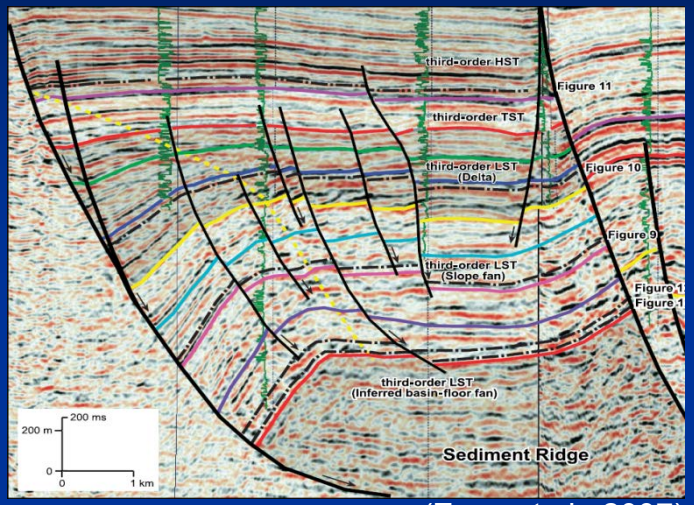


(Fisher and McGowen, 1967)

- Huge deltaic systems developed in Wilcox;
- Study area is part of Rockdale deltaic system;
- Also linked to deepwater system in a unique fashion (will show).

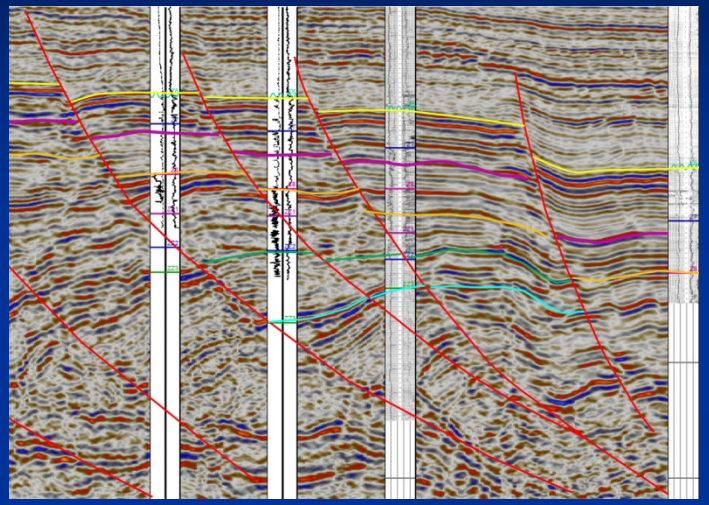
Motives

Frio, Corpus Christi region



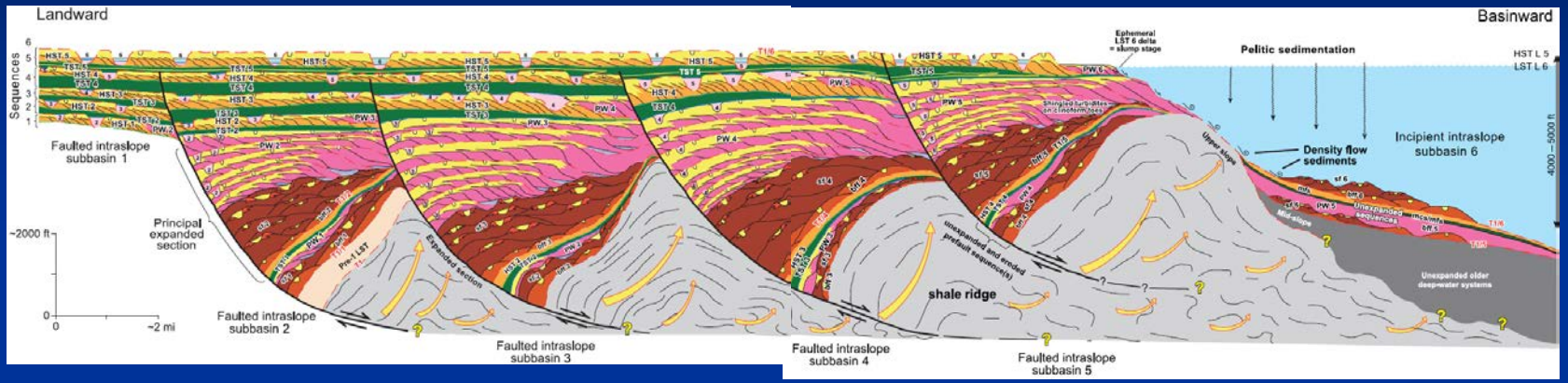
(Zeng et al., 2007)

Wilcox, Bee/Goliad region



1. Wilcox is similar to Frio in shale tectonics, growth fault-controlled sequence framework, and depositional model;
2. Wilcox in Bee/Goliad region has rare showing of on-shelf IVFs that are correlated to off-shelf, lowstand wedges and deep-water slope fans;
3. Sponsor provided large 3D seismic survey with necessary core and wireline-log calibration.

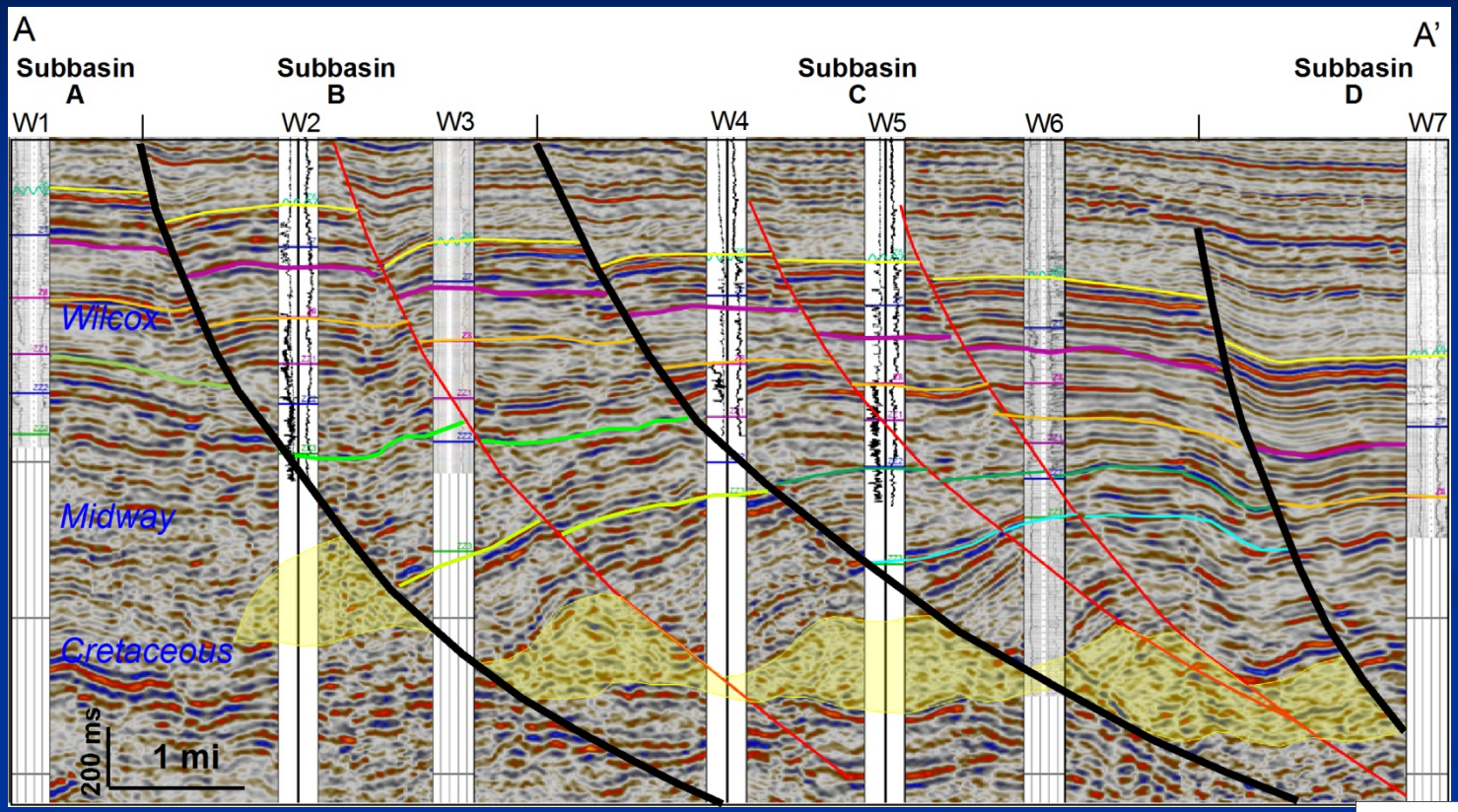
Growth-fault controlled Frio subbasins



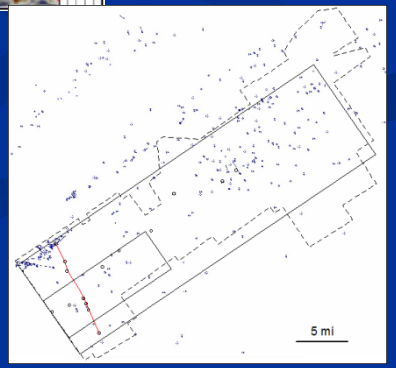
(Brown et al., 2004)

- Controlled by interaction between sea level change, growth faulting, and shale-ridge activity;
- Multiple faults, each controls a 3-rd order lowstand subbasin;
- Dischronous stratigraphy across the subbasins.

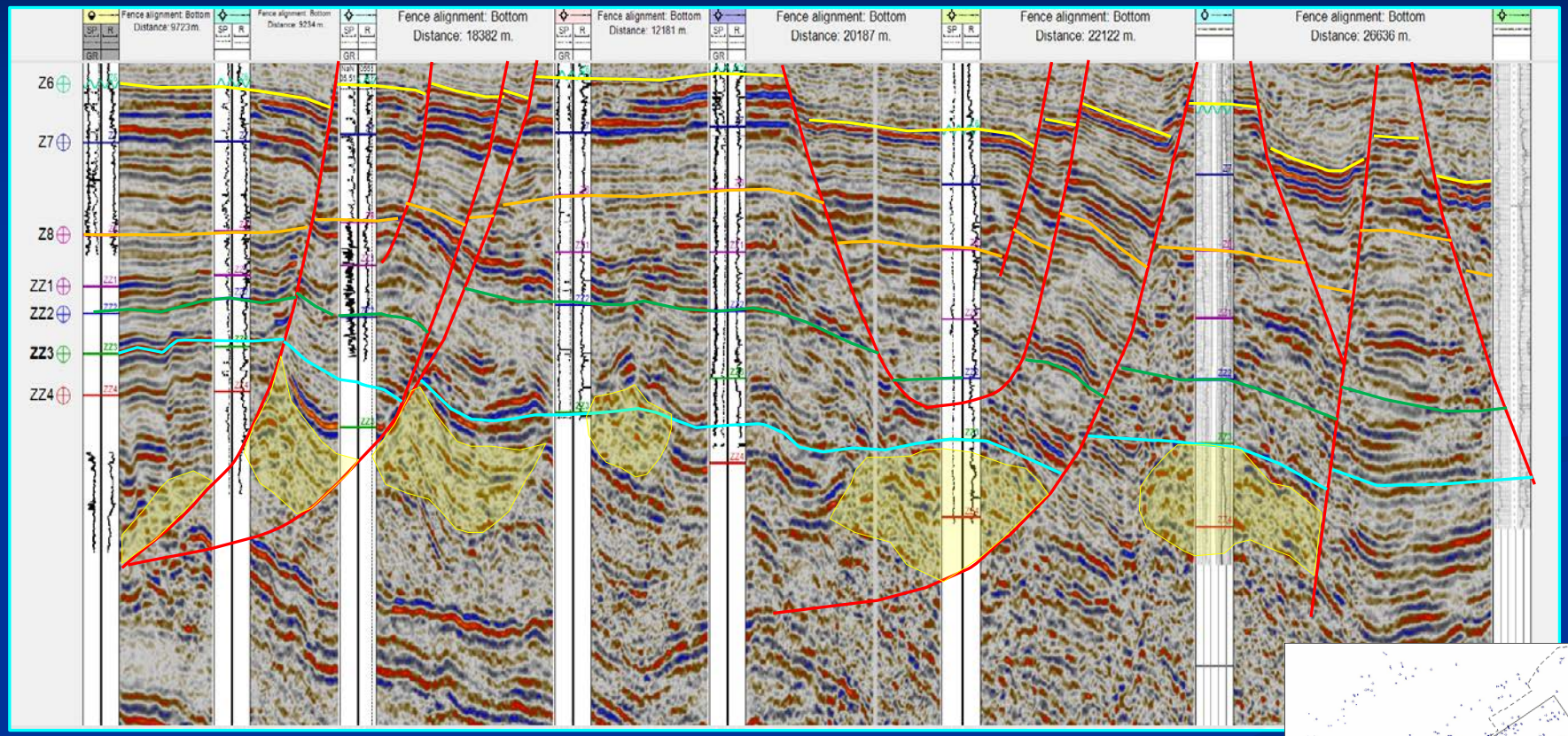
Dip well-seismic section of Wilcox subbasins in Bee/Goliad region

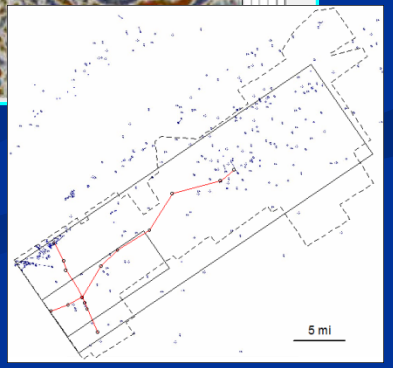


- Subbasins are separated by major growth faults;
- Roll-over anticlines in downthrown sides;
- Multiple shale ridges with chaotic reflection patterns;
- Formation is difficult to correlate between subbasins.



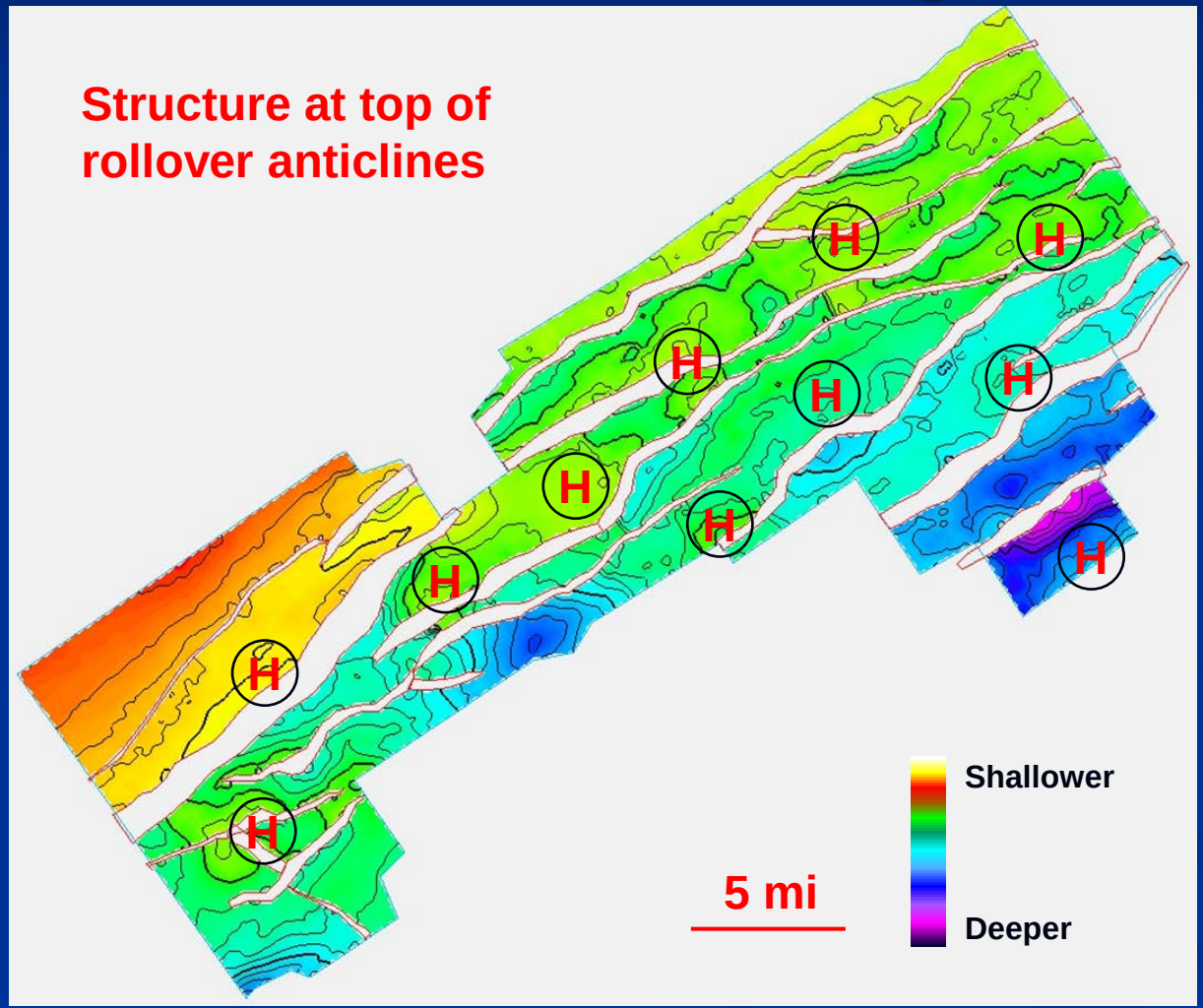
Strike well-seismic section





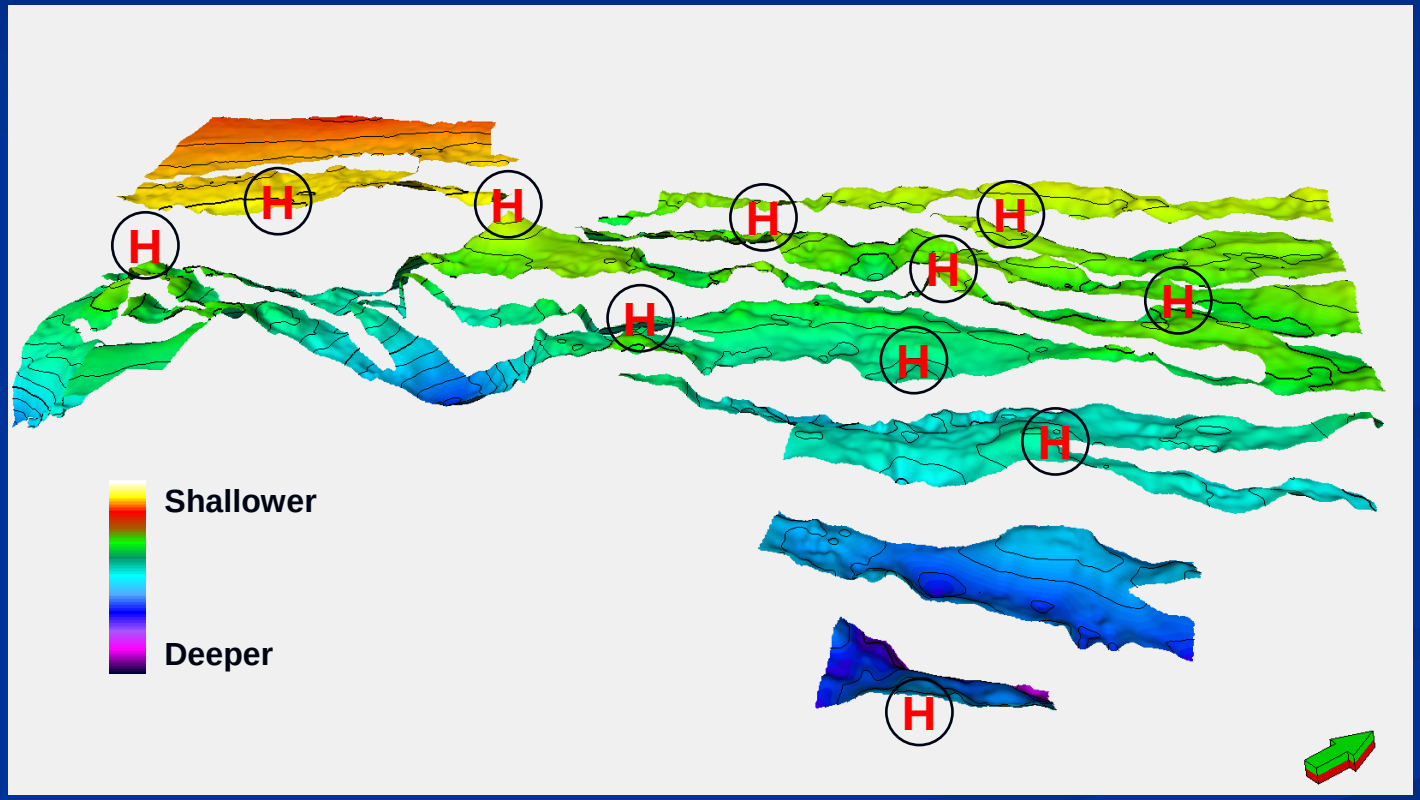
- Even more complex in strike sections;
- Cross multiple subbasins;
- Sequences are difficult to define and correlate.

Distribution of growth faults, rollover anticlines, and shale ridges



- Multiple growth faults;
- Many co-exist with rollover anticlines.

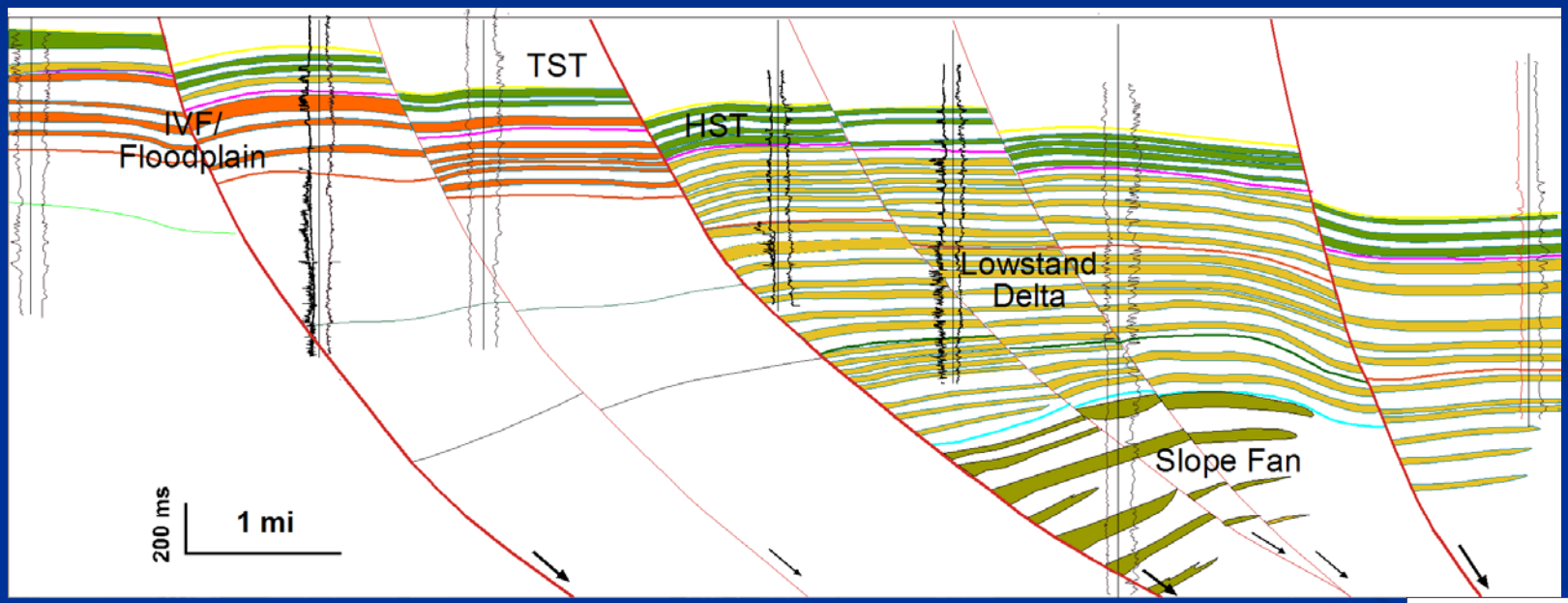
Distribution of growth faults, rollover anticlines, and shale ridges



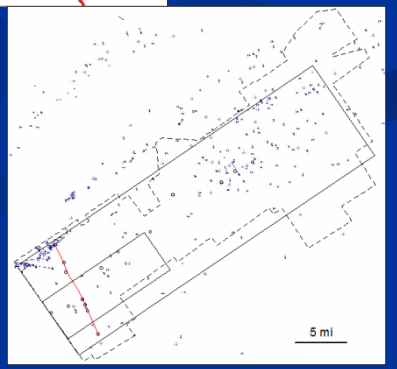
- Subbasins are deeper and younger downward/basinward;
- Rollover structures are at most active segments of faults.

Wireline-log correlation of Wilcox structure and sequence stratigraphy

Subbasin C



- Three 3rd order lowstand systems tracts;
- Log patterns are different across the boundary fault and are hard to correlate;
- Core calibration is very limited.



Core description showing wave influence on a lowstand deltaic system

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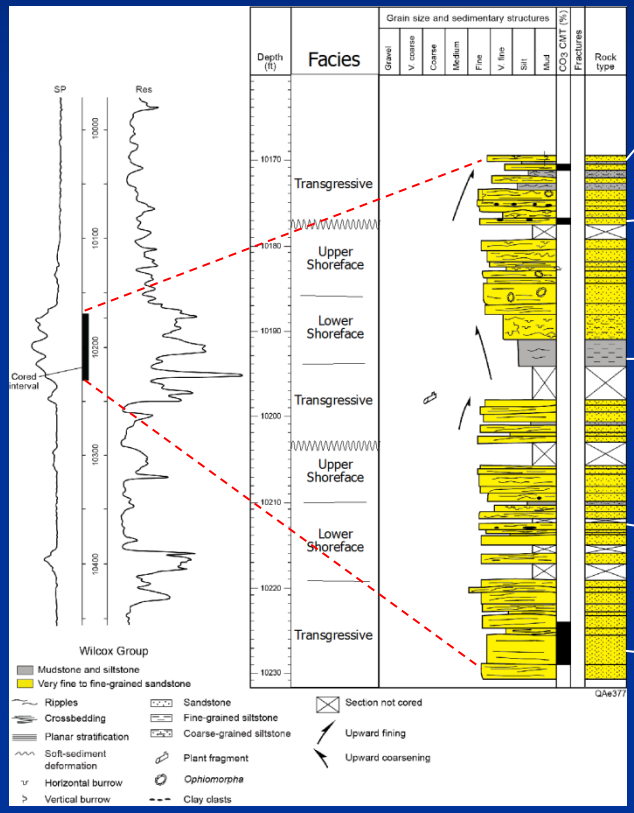
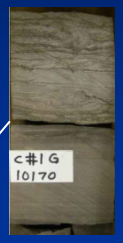
JACKSON SCHOOL OF GEOSCIENCES

Well Carl #1 Gillette

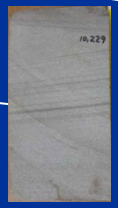




Washover fan

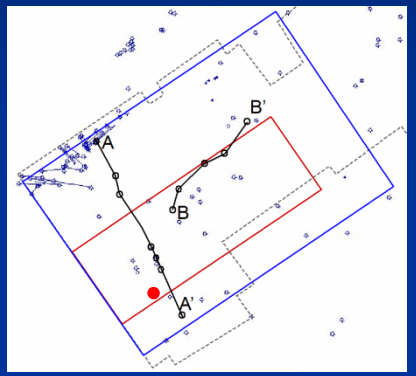
Wave-ravinement surface

Minor flooding surface



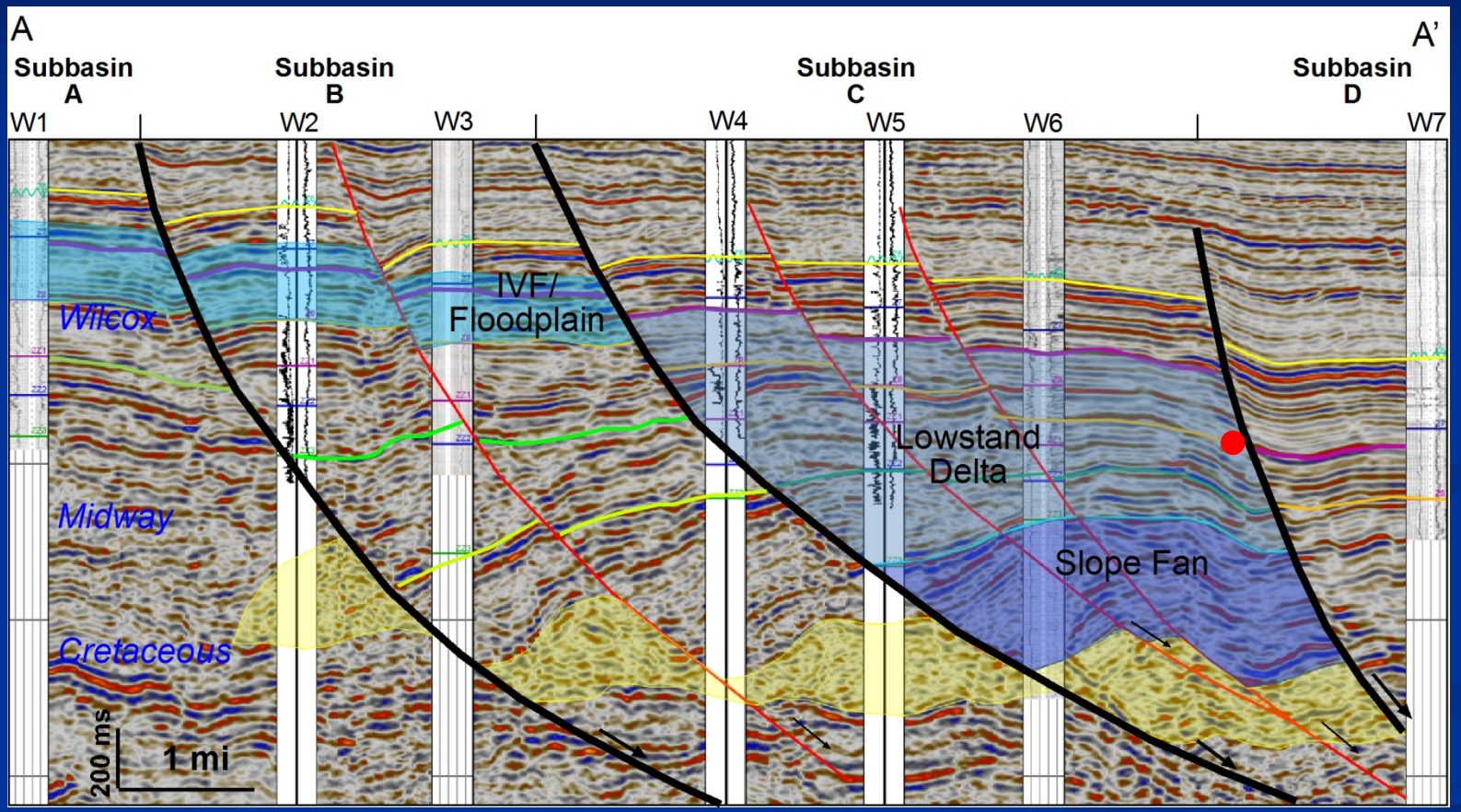
Crossbedded Upper shoreface

Ripple-stratified Lower shorface



- Deltaic sediments;
- Thin and fine-grained;
- Wave modification.

Seismic expression of 3rd-order systems tracts in Subbasin C



- Core is part of the lowstand deltaic system;
- Integrated interpretation of three systems tracts;
- Low resolution.

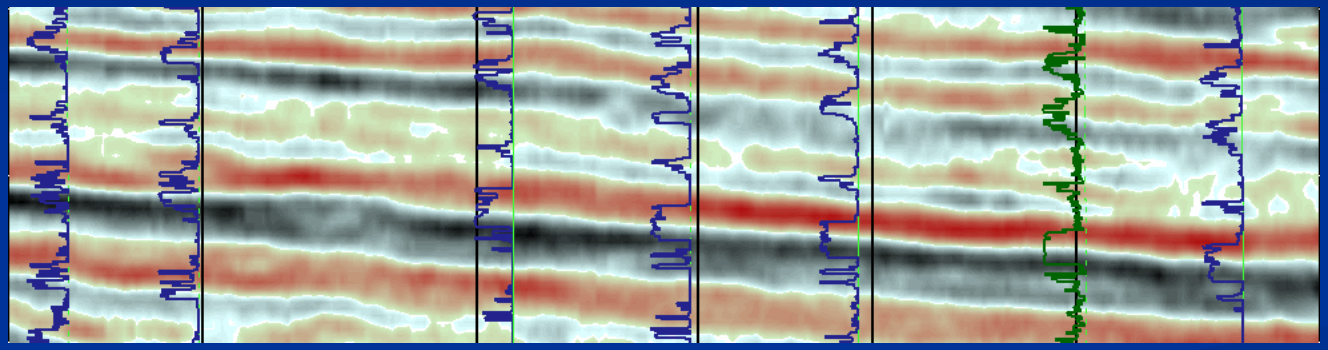
● Cored well

Seismic sedimentology for identifying lithology and sedimentary geomorphology in high-resolution

- Definition: combined use of seismic lithology and seismic geomorphology (Zeng & Hentz, 2004);
- Seismic lithology: link seismic attributes (amplitude and polarity) to lithology (sandstone and shale);
- Seismic geomorphology: link horizontal attribute patterns on stratal slices to depositional systems (fluvial, deltaic, fans, etc.);
- All in high-resolution (10-30 m, 4^{th} to 5^{th} order sequence).

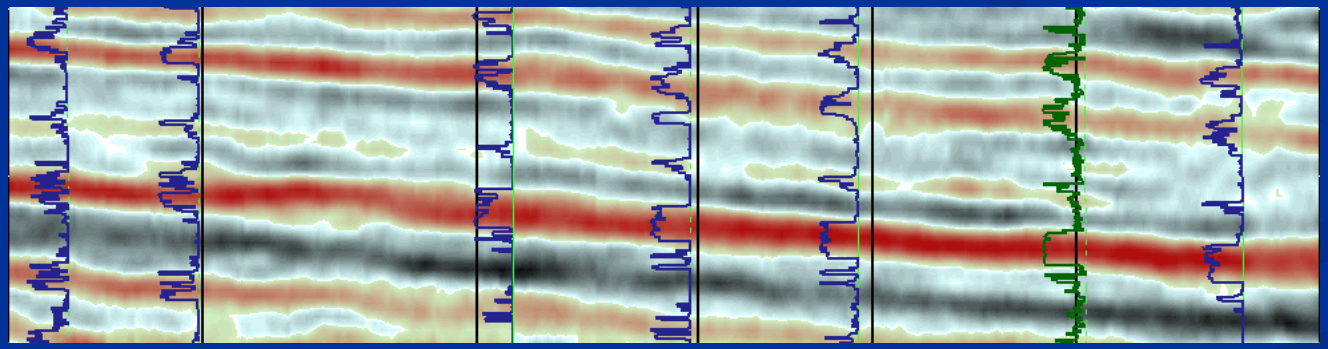
Seismic lithology: use of 90° data as relative AI for sandstone identification

0°



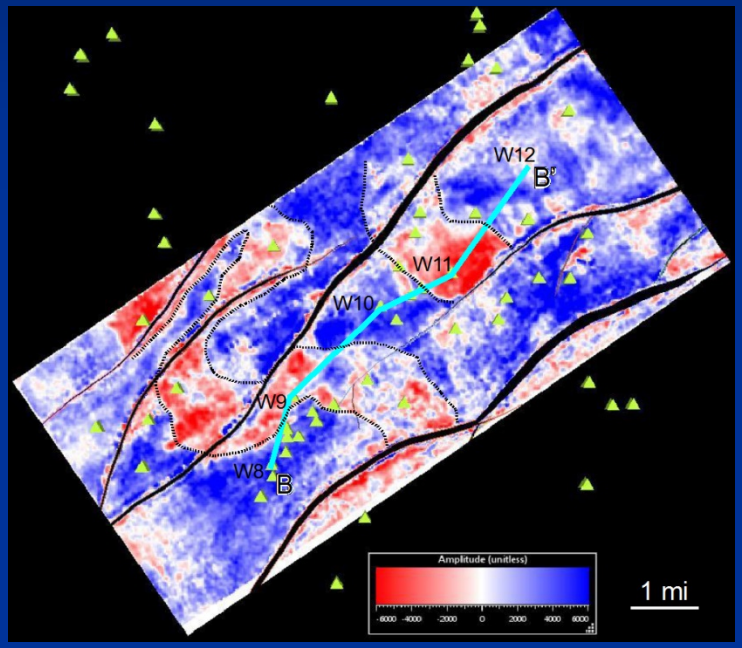
Event ≠ sand

90°



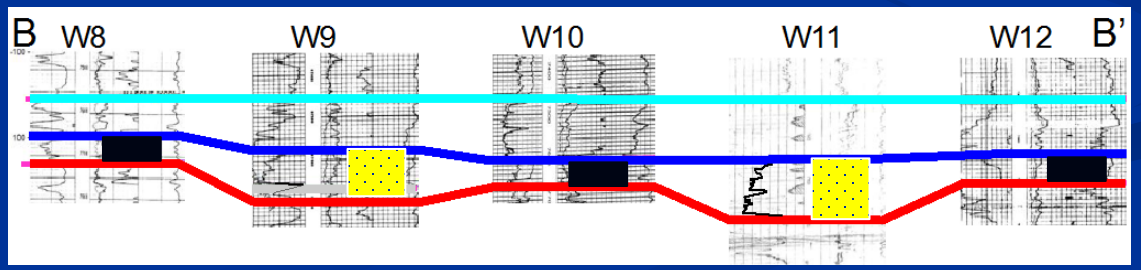
Event = sand

Amplitude (90°) as an indicator of sandstone and shale

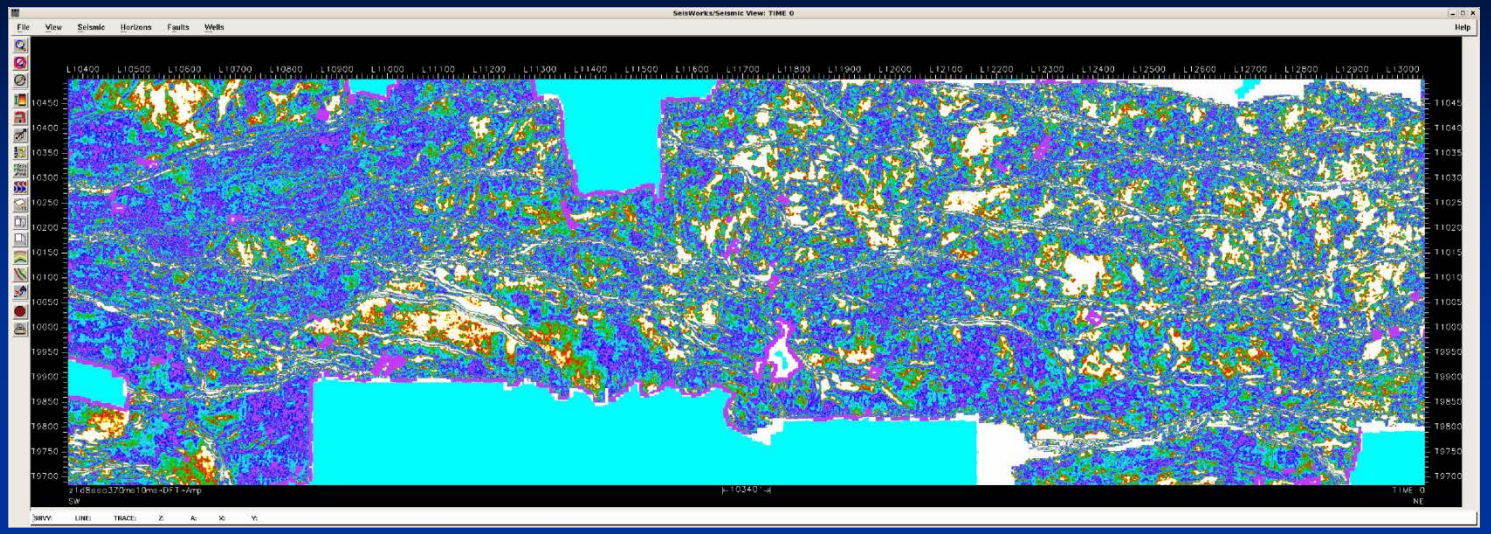


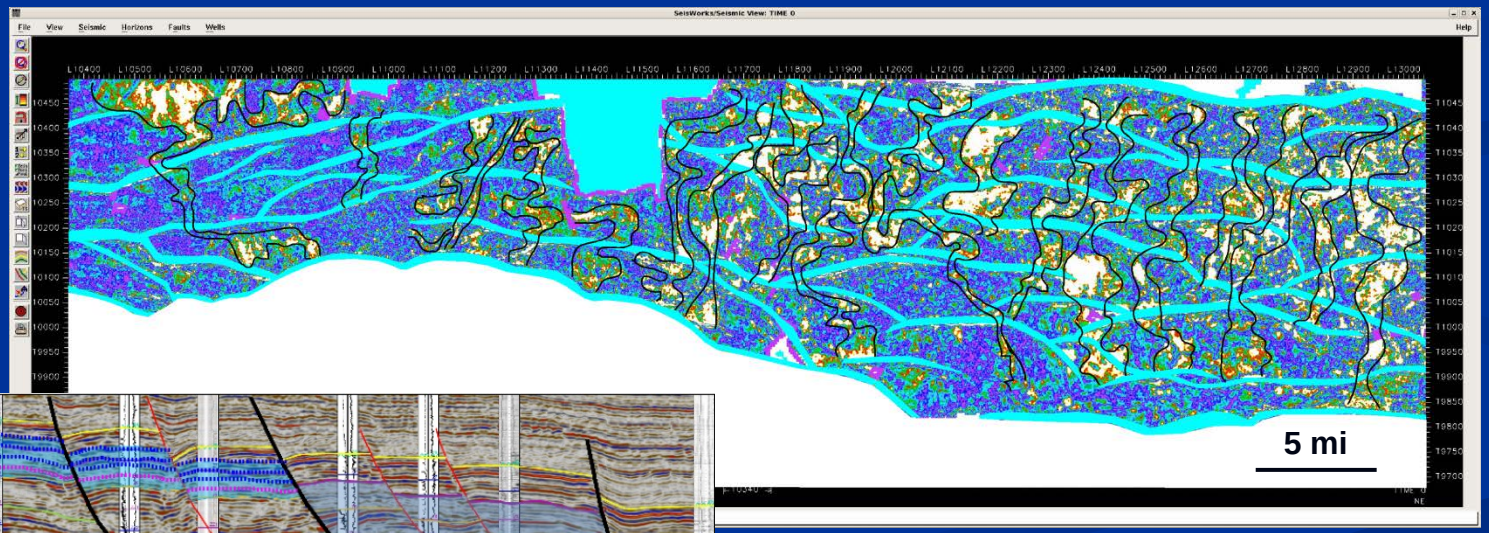
Stratal slice with IVF images

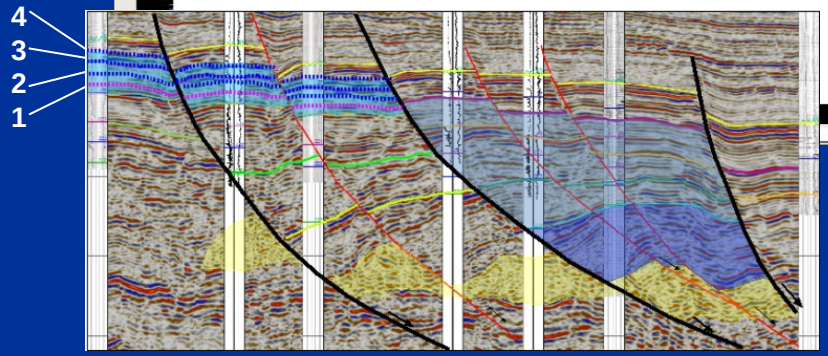
Wireline-log correlation



Seismic geomorphology: IVFs (episode 1)

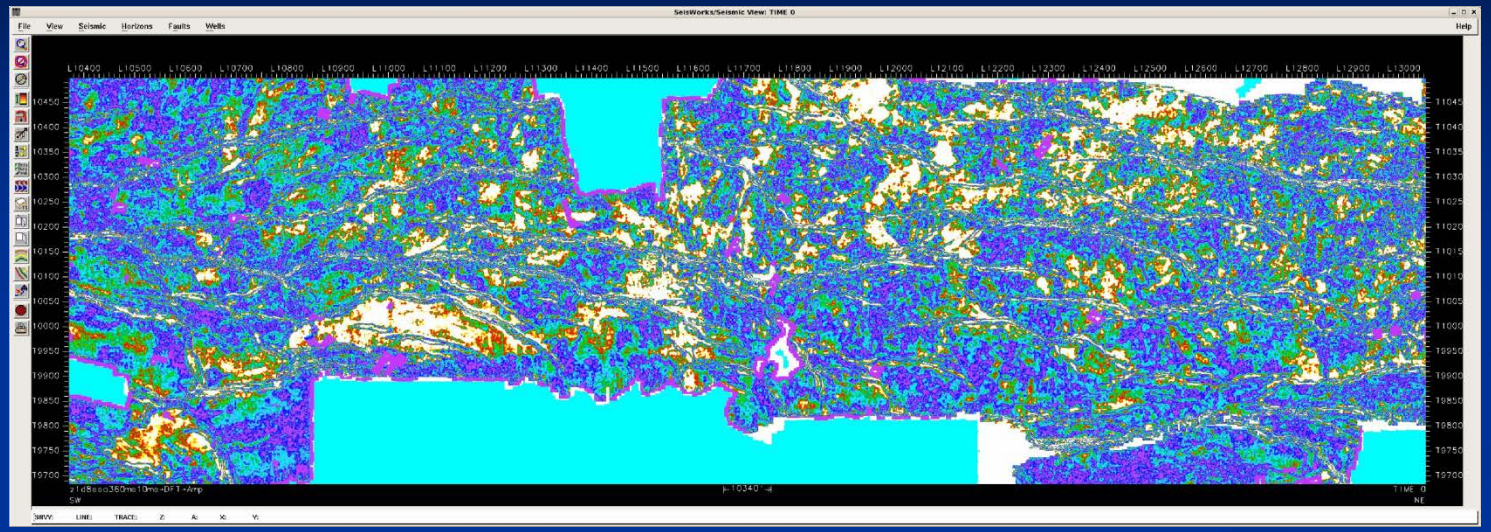


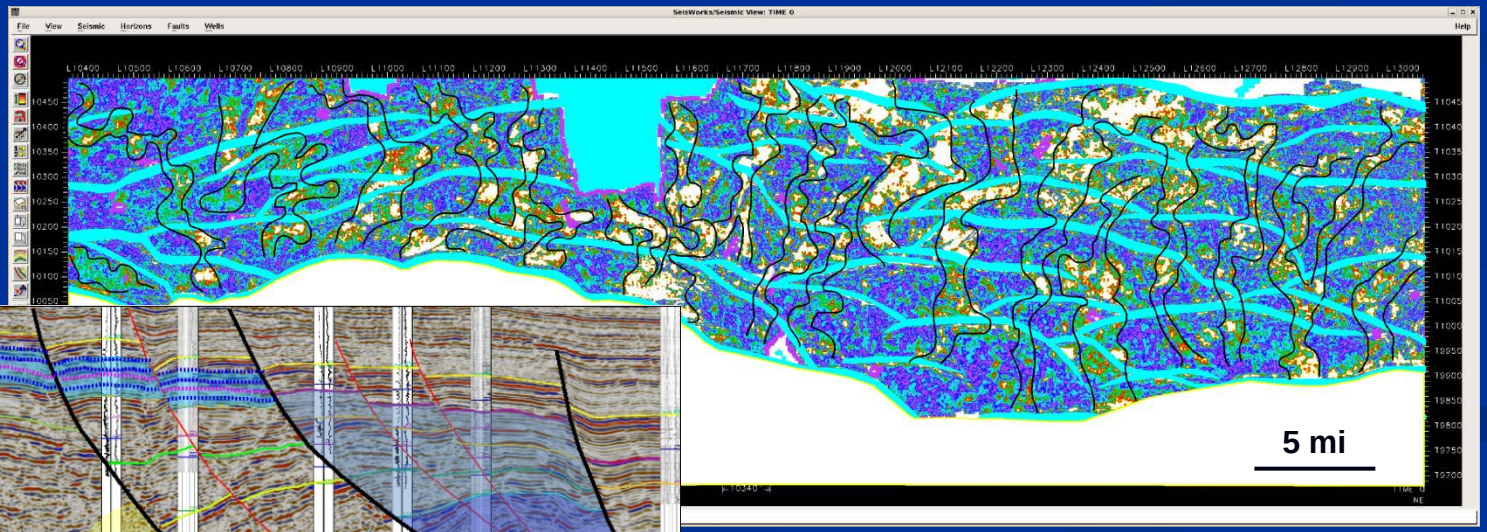




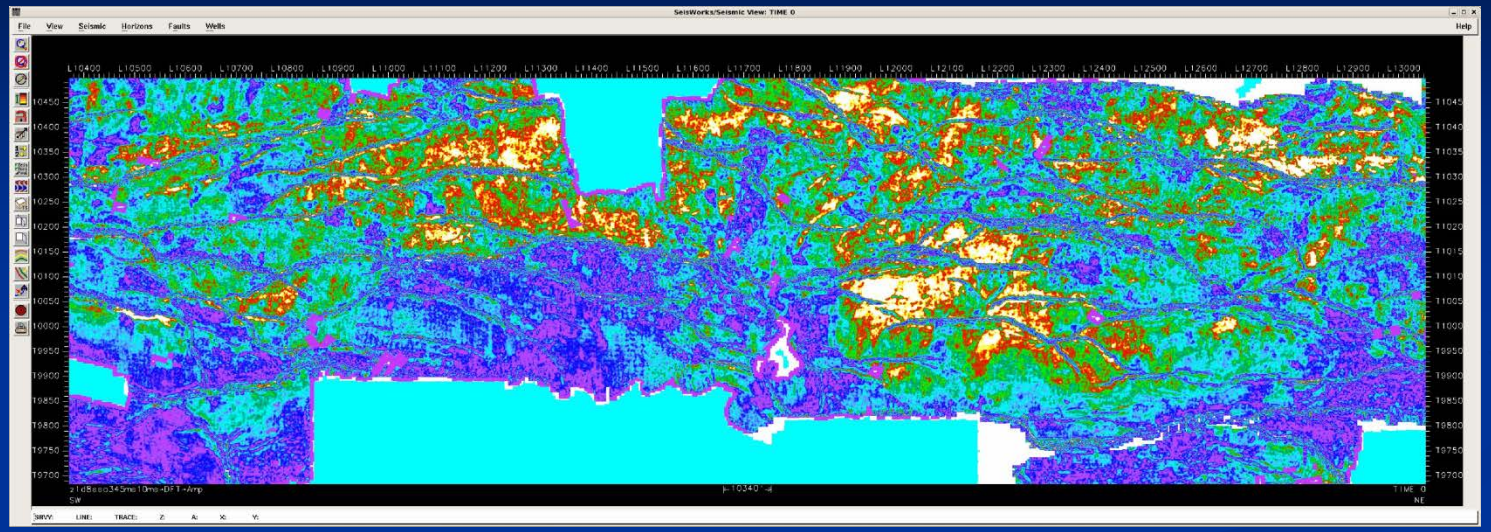
- On-shelf and off-shelf sliced separately;
- Highlight faults and see clearer patterns;
- Dip-oriented, sinuous channels;
- All stopped at shelf edge.

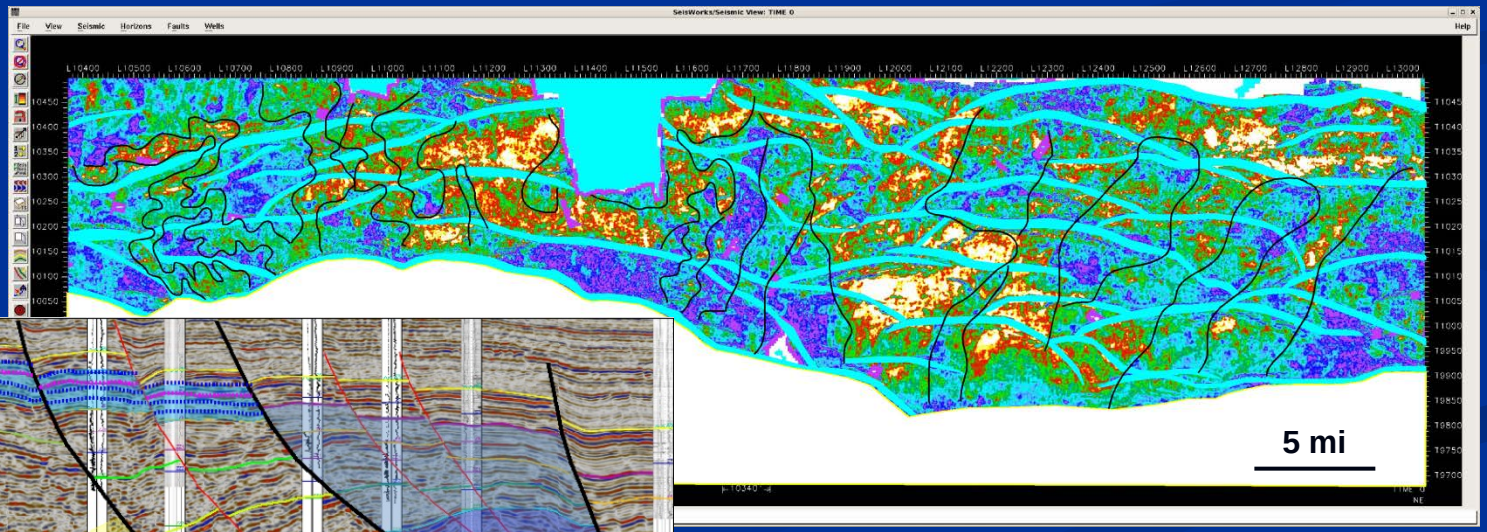
IVFs on exposed shelf (episode 2)



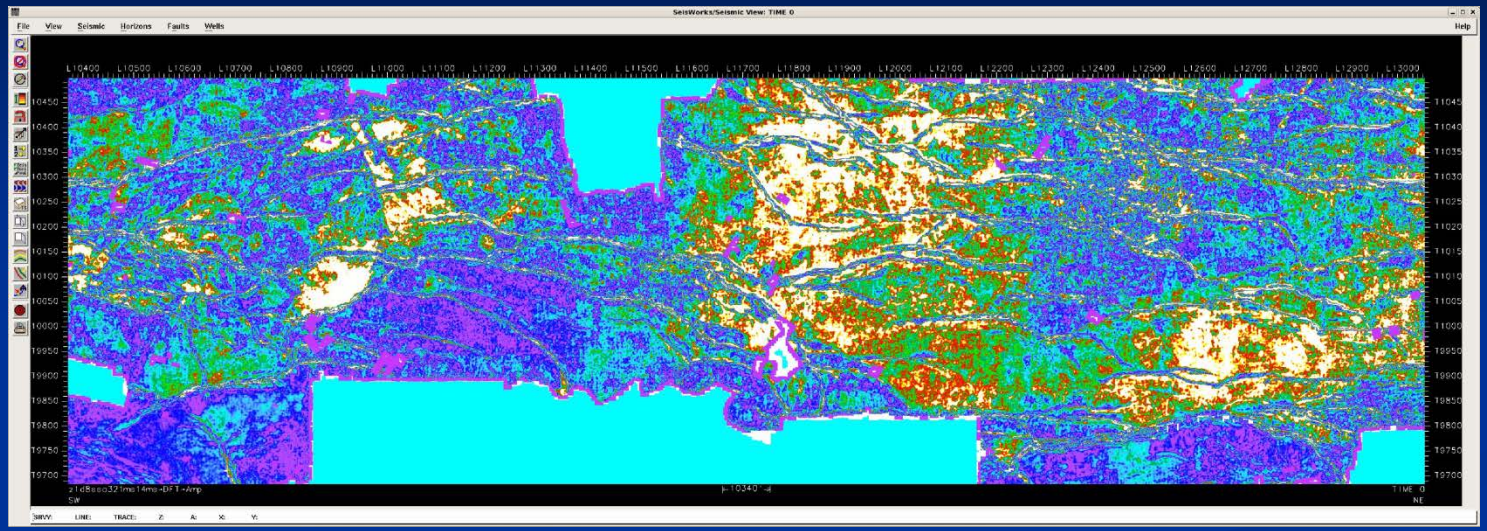


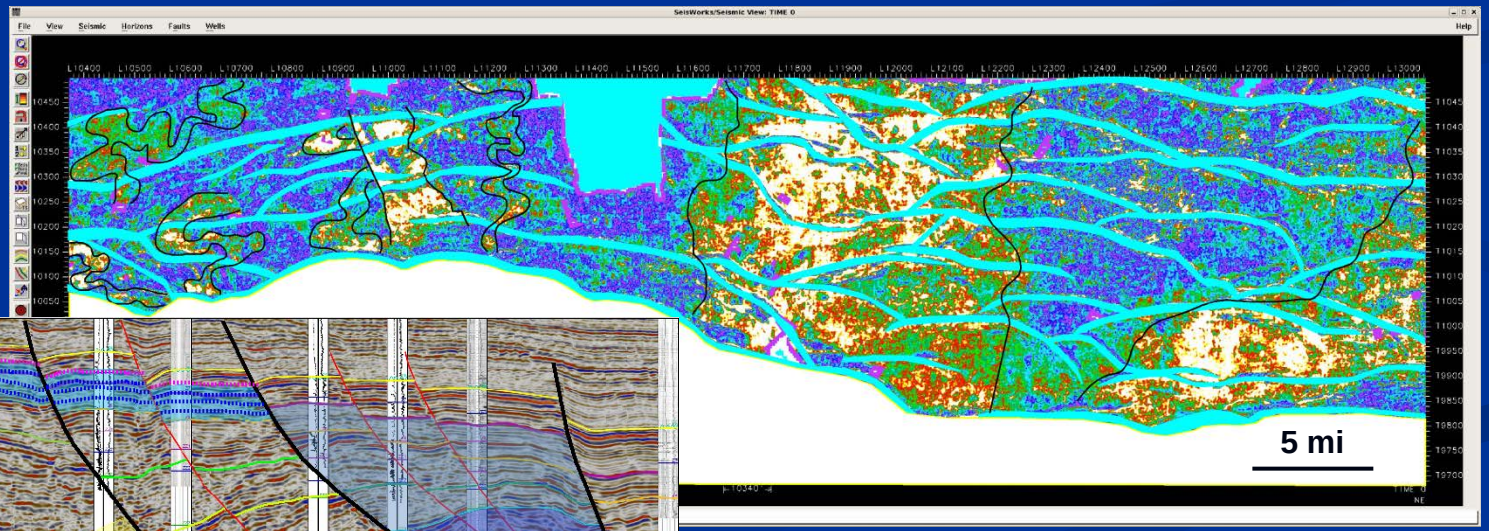
IVFs on exposed shelf (episode 3)



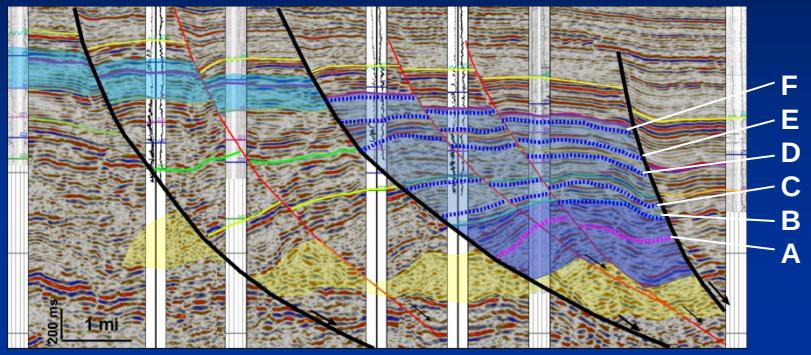


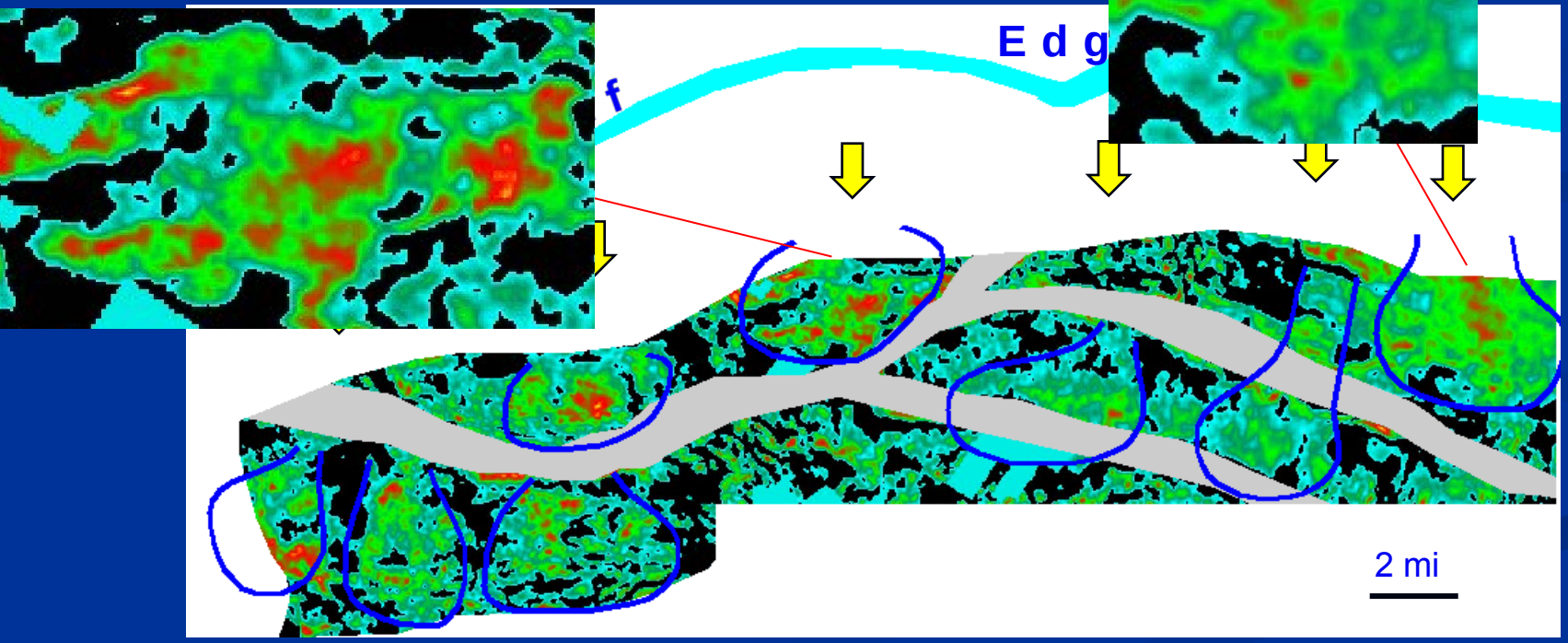
IVFs on exposed shelf (episode 4)





Slope fans (Subbasin C)





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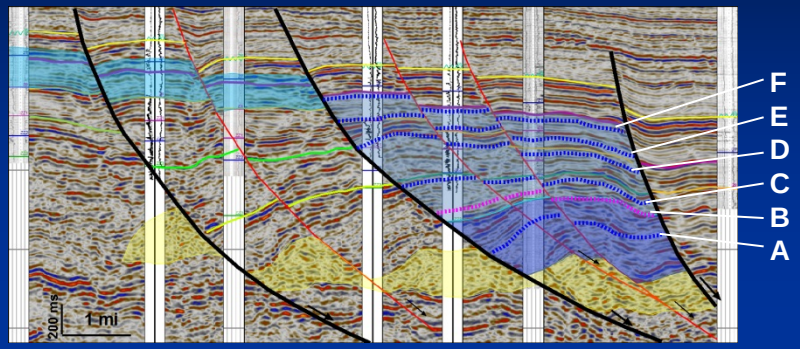
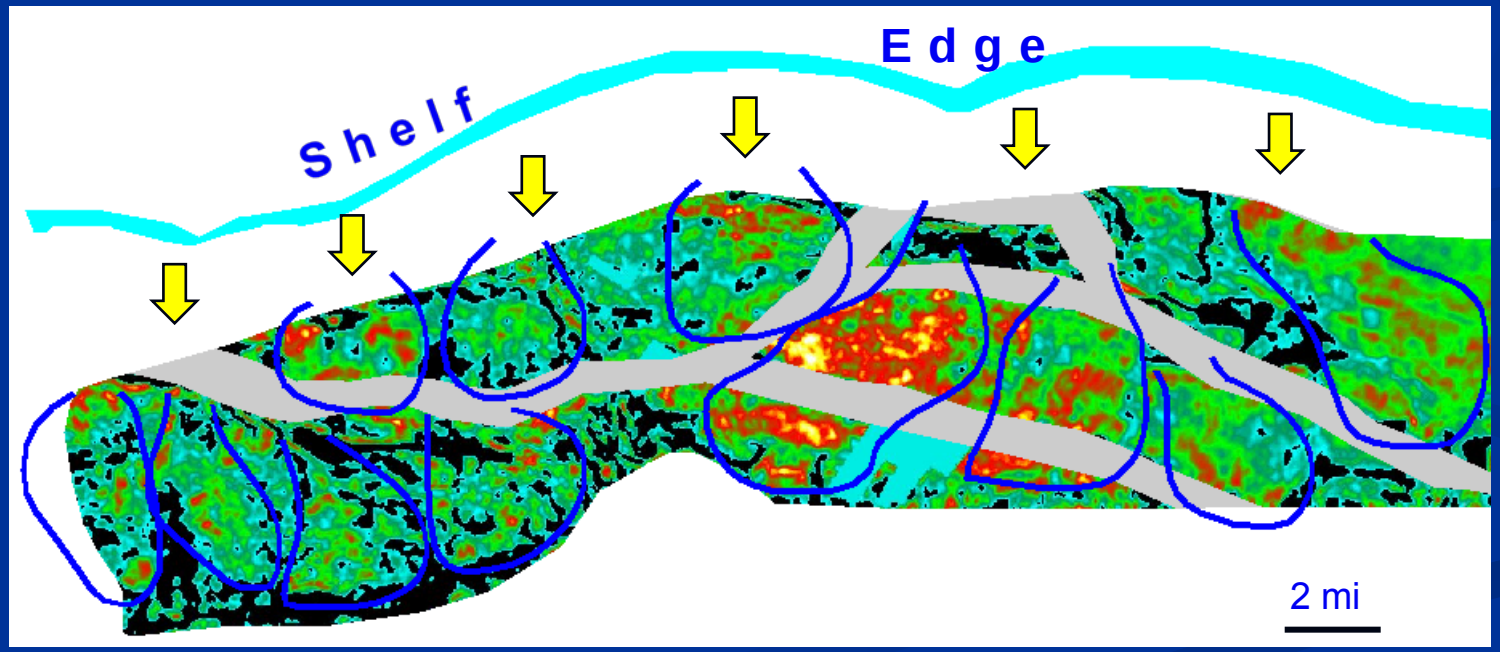
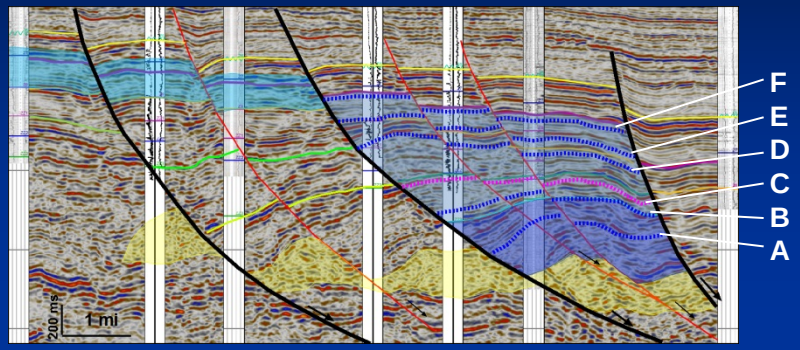
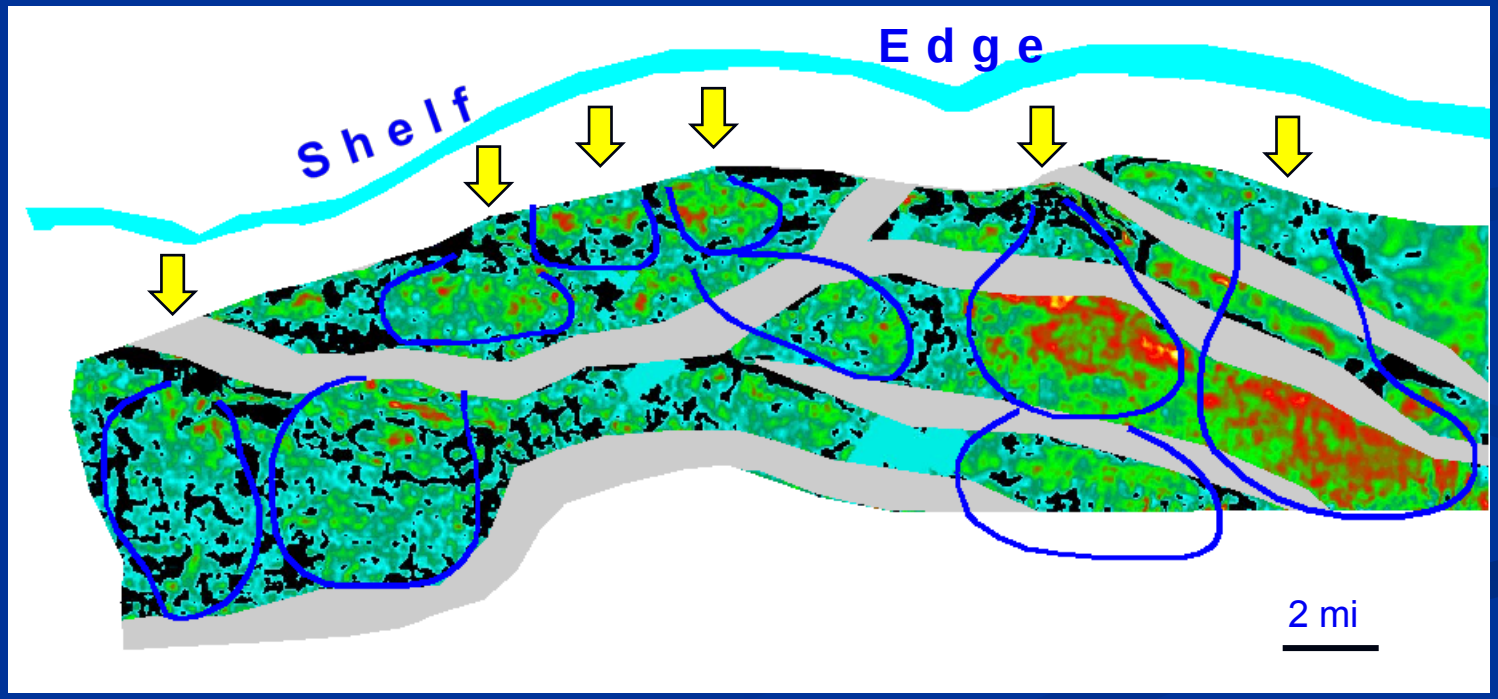


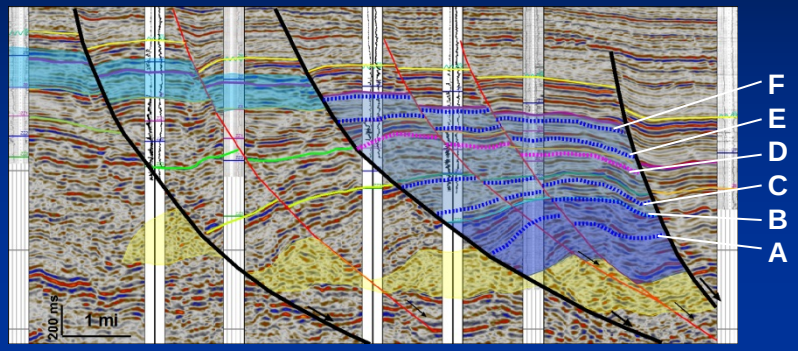


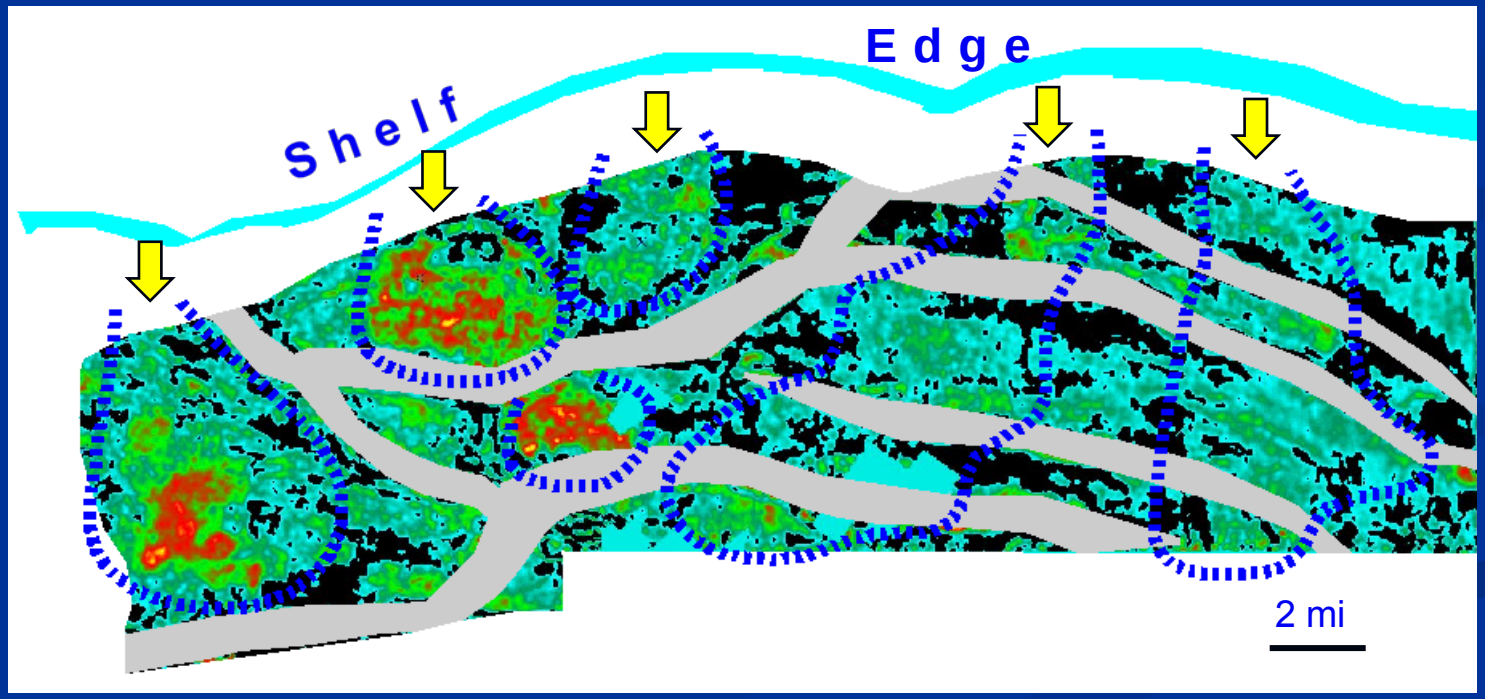
Slope fans (Subbasin C)



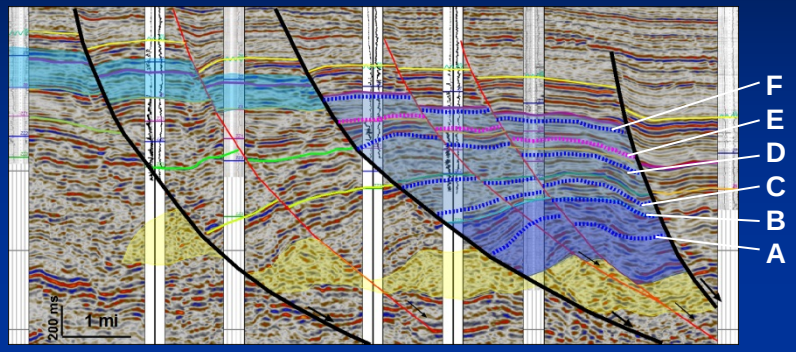


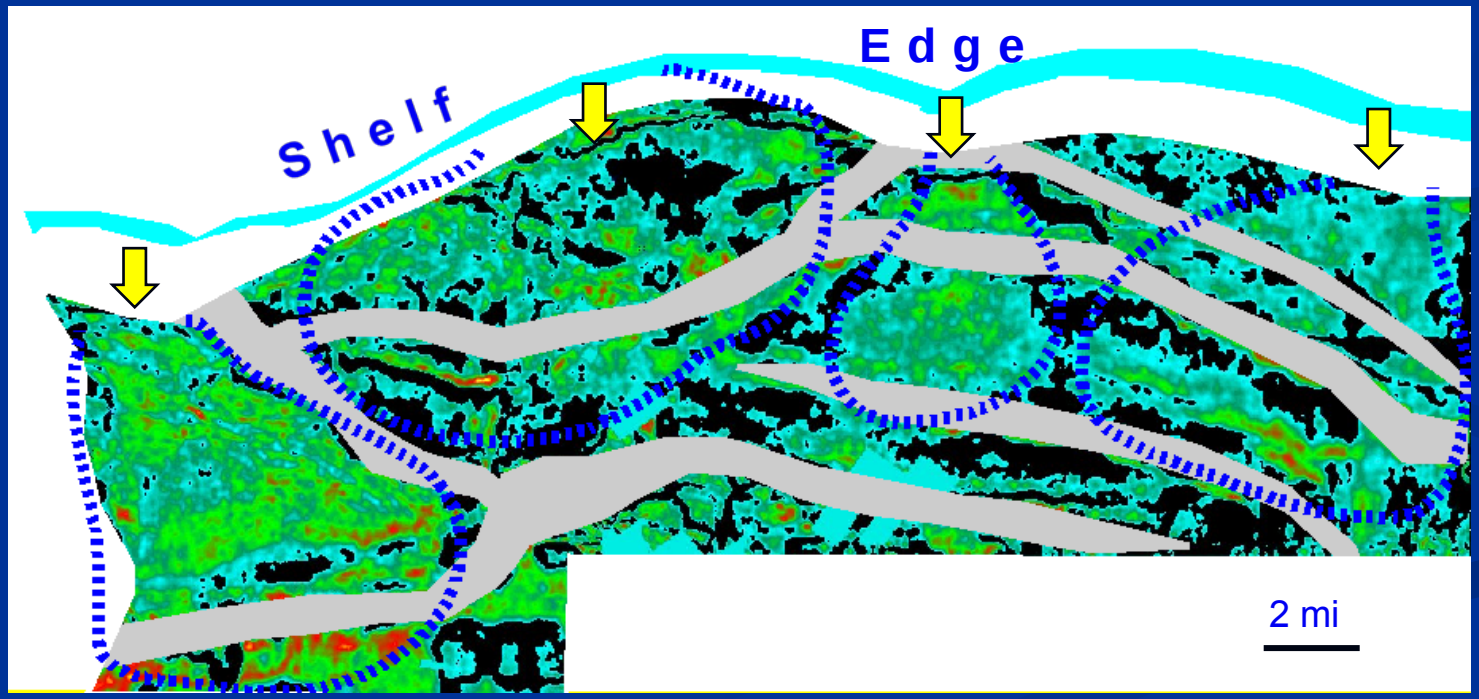
Lowstand deltas (Subbasin C)



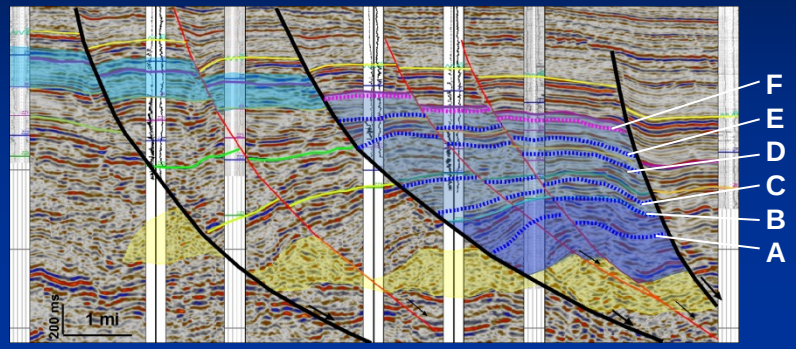


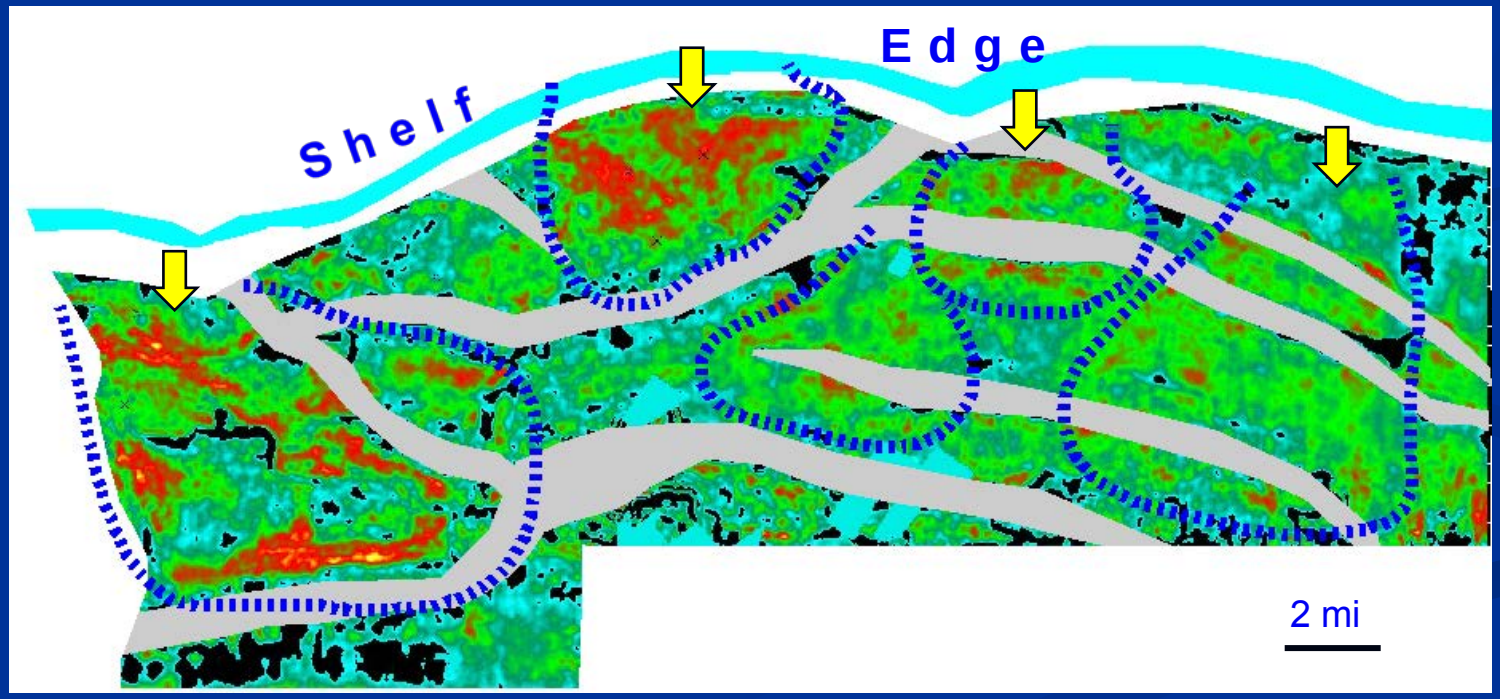
Lowstand deltas (Subbasin C)



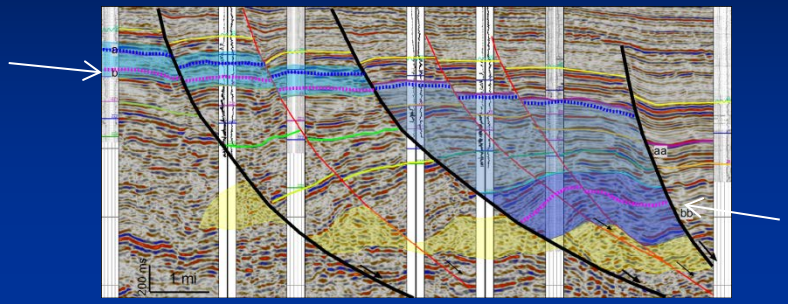


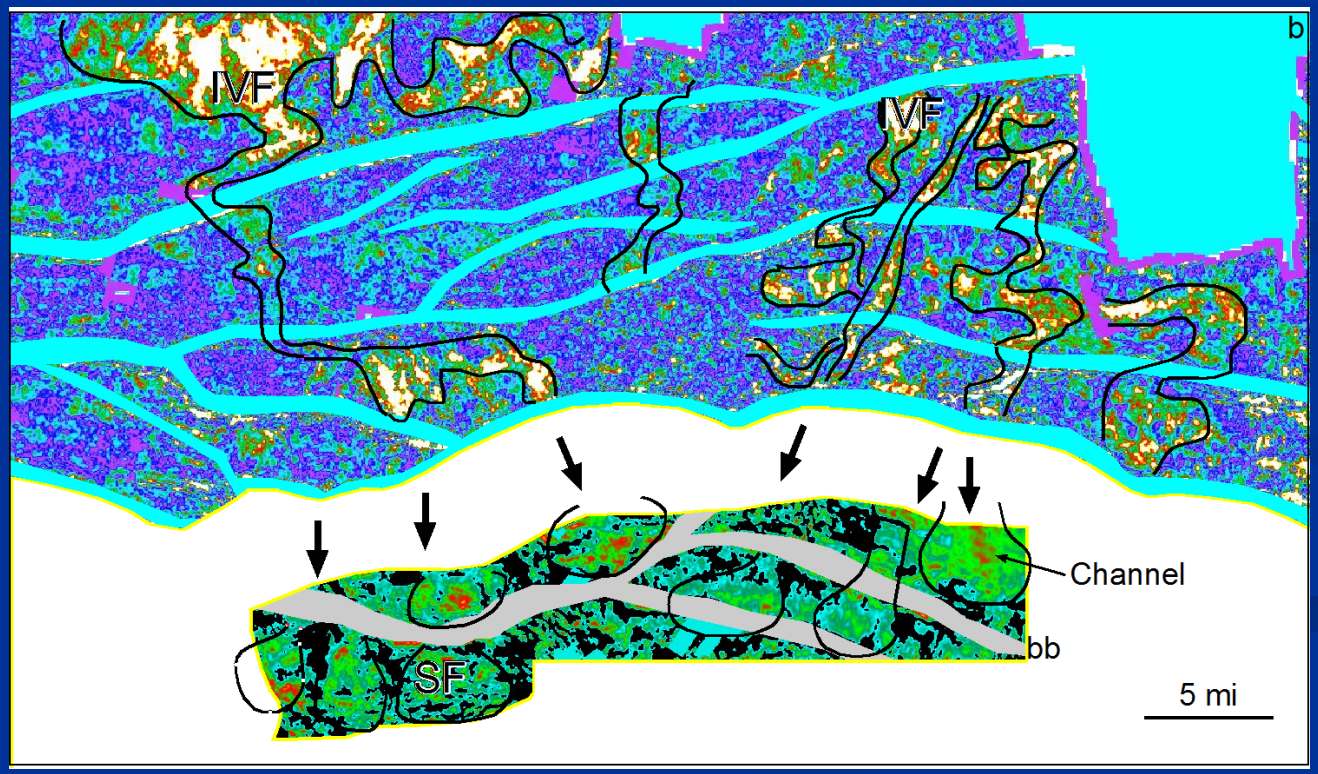
Lowstand deltas (Subbasin C)



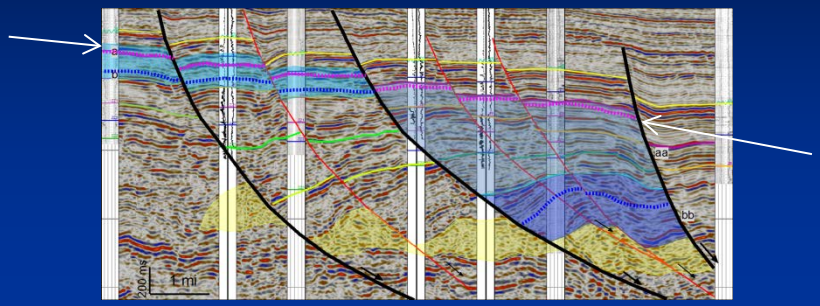


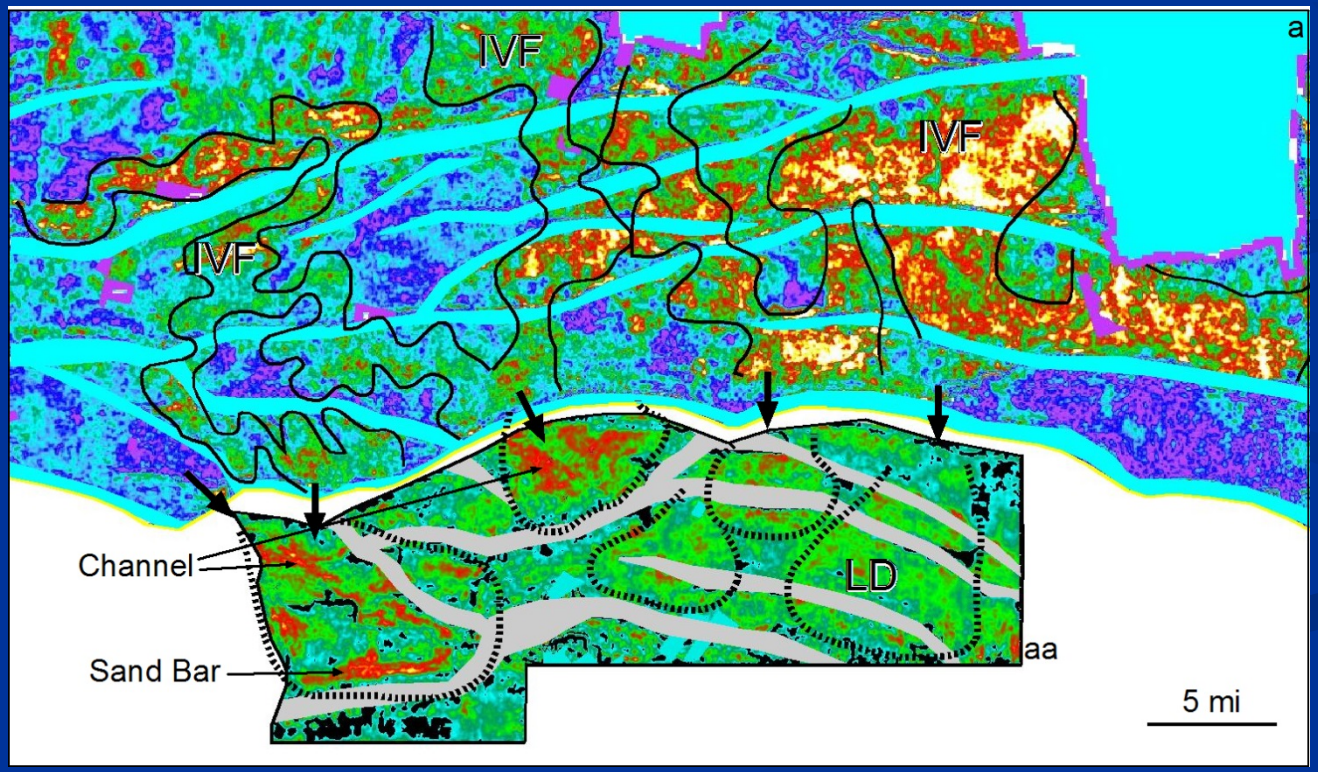
Slope fans correlated to IVFs (Subbasin C)





Lowstand deltas correlated to IVFs





Application to exploration

1. Wilcox off-shelf slope fans and lowstand prograding wedges have huge potential of deep gas (mostly deeper than 10,000-ft and up to 3000-ft thick).
2. Wilcox on-shelf IVF sandstones are matured exploration targets yet still have potentials (small stratigraphic and combined traps).

Conclusions

1. Wilcox in Bee/Goliad region is similar to Frio in Corpus Christi region in shale tectonics and depositional style.

2. There are multiple laterally dischronous Wilcox subbasins developed during 3-rd order lowstand.

3. Multiple episodes of incised valleys on exposed shelf transported plentiful sediments to subbasins, forming thick, deep-water slope fans and shallow-water lowstand deltas.

4. Deep-water slope fans and shallow-water lowstand deltas in the area have huge deep-gas potential.

Acknowledgments

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3. Excellong, Inc., provided well and seismic data.

4. Landmark Graphics provided conventional seismic-interpretation software.