

Edwards (Stuart City) Shelf Margin of South Texas: New Data, New Concepts*

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Abstract

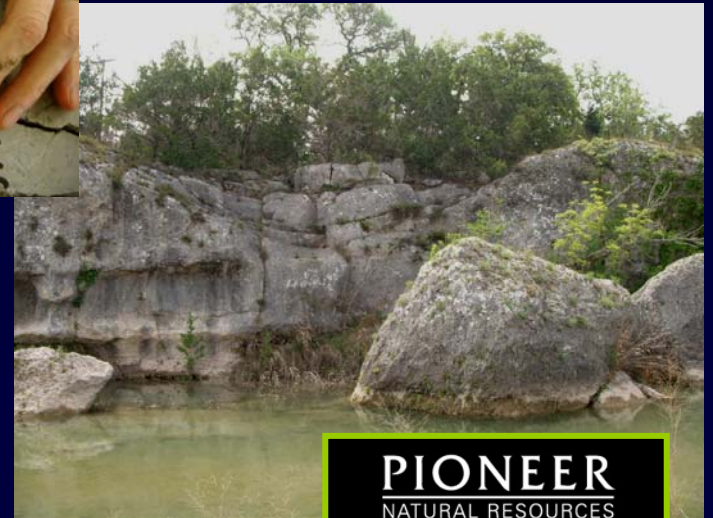
In 2005, Pioneer Natural Resources (PNR) embarked on an aggressive, 6-rig exploration and development drilling program within the middle Albian (Edwards Formation) portion of the Stuart City shelf margin of south Texas. As a result of this ongoing program, a new characterization of this economically important Tethyan shelf margin is beginning to emerge. The revised characterization draws upon an extensive pool of new geologic, geophysical, and engineering data sets, including modern wireline logs for over 80 deep pilot holes within the Stuart City margin, several new extensive Edwards Formation cores, drilling and production data for both horizontal and vertical wells, and approximately 1000 mi² (2600 km²) of high-fold 3D seismic complementing several hundred line miles of existing 2D seismic data. A number of new gas discoveries, including one significant accumulation (Moray Field, Dewitt County), have spurred further exploration and development and acquisition of additional data.

Previous characterizations of the Stuart City shelf margin have focused primarily on general depositional and diagenetic models, including a description of facies based on data from a relatively small number of wells. These studies have led to a “one model fits all” approach to characterize the entire 250+ mile-long (> 400 km) reef margin. The newly acquired PNR data set highlights key differences in depositional settings and reservoir quality of the trend along strike. Preliminary results indicate multiple geologic models are required to accurately characterize this complex and heterogeneous reef/bank margin system. Geologic heterogeneity along strike appears to be fundamentally controlled by deep structure related to basement configuration and faulting and salt-related tectonics. Important secondary controls include the physiographic forms of the Edwards and underlying Sligo shelf margins and the nature and timing of subsidence of the Edwards margin related to development of isolated fault blocks along various portions of the margin. In addition, recognition and correlation of the Regional Dense Marker Bed (RDMB), an important middle Albian stratigraphic datum within the massive Edwards shelf margin succession, have been crucial to understanding changes within the Stuart City margin along strike and in the development of area-specific geologic models.

Edwards (Stuart City) Shelf Margin of South Texas: New Data, New Concepts



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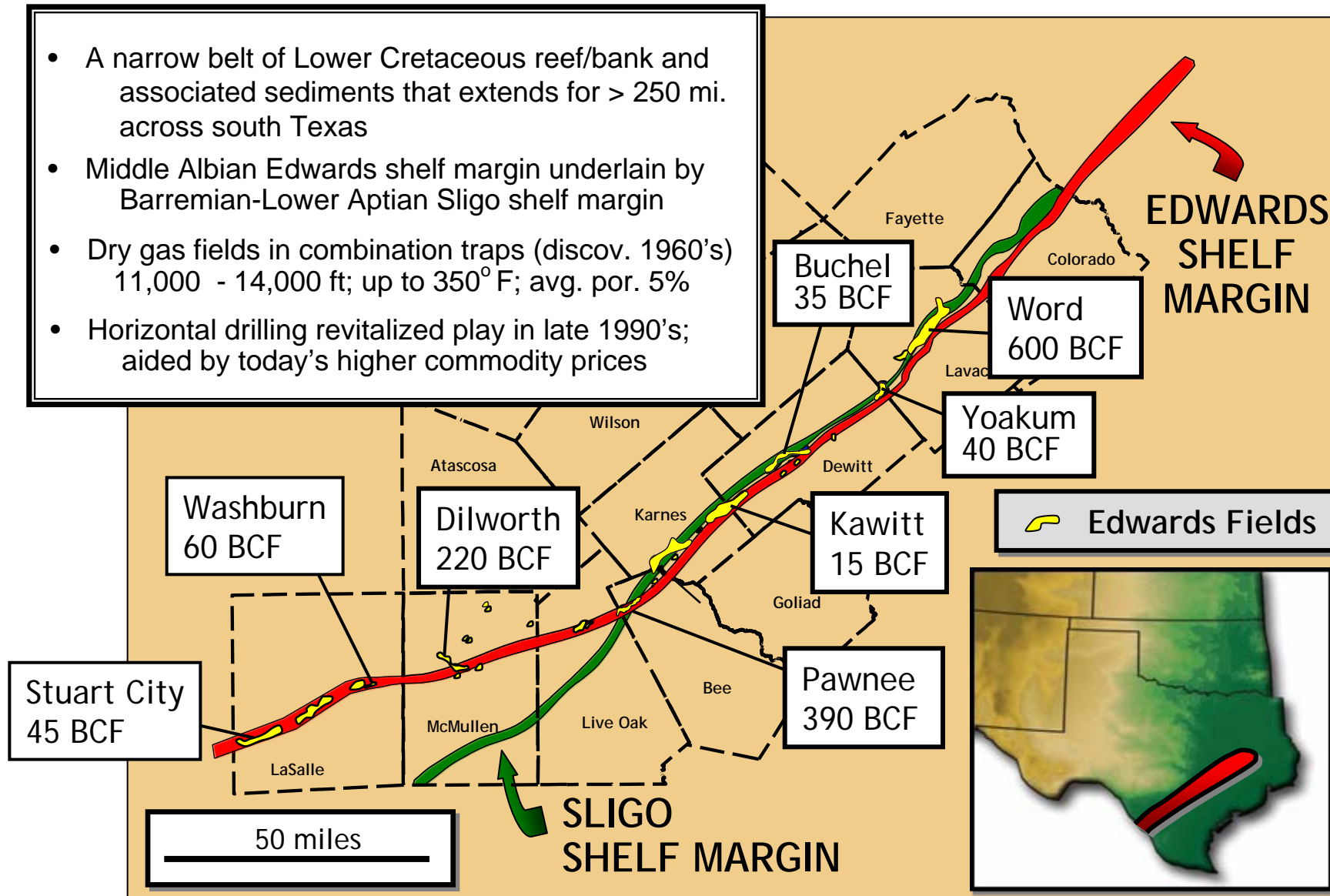
PIONEER
NATURAL RESOURCES

Outline

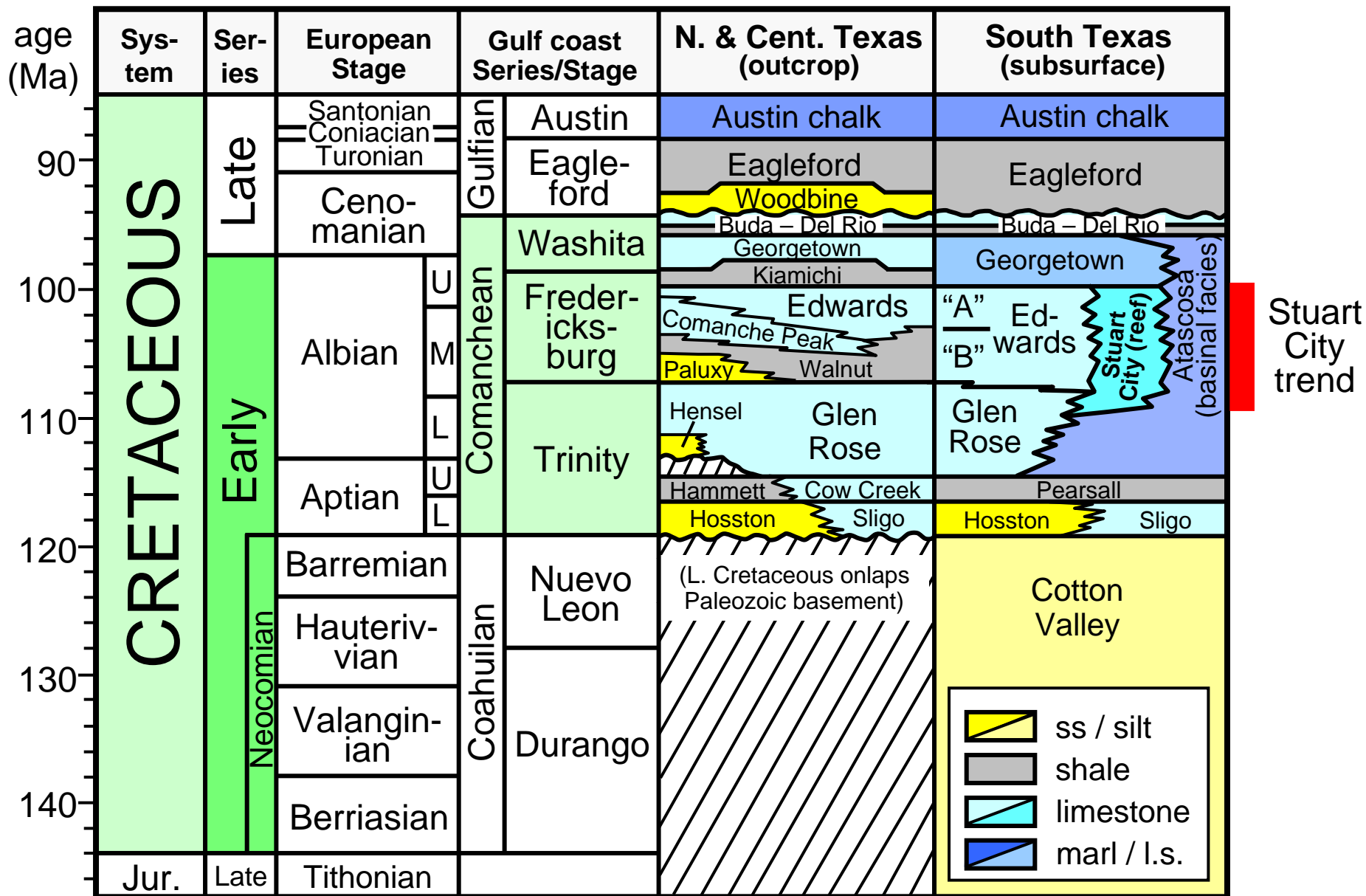
- Introduction to Stuart City trend and the Early Cretaceous world
- Stuart City shelf margin: previous work
- Description of the Pioneer Natural Resources (PNR) data set (2005 - present)
- New concepts and models
- Ongoing work and path forward

The Edwards (Stuart City) shelf margin trend

- A narrow belt of Lower Cretaceous reef/bank and associated sediments that extends for > 250 mi. across south Texas
- Middle Albian Edwards shelf margin underlain by Barremian-Lower Aptian Sligo shelf margin
- Dry gas fields in combination traps (discov. 1960's)
11,000 - 14,000 ft; up to 350° F; avg. por. 5%
- Horizontal drilling revitalized play in late 1990's; aided by today's higher commodity prices



General Stratigraphy & Facies



Early - mid Cretaceous world

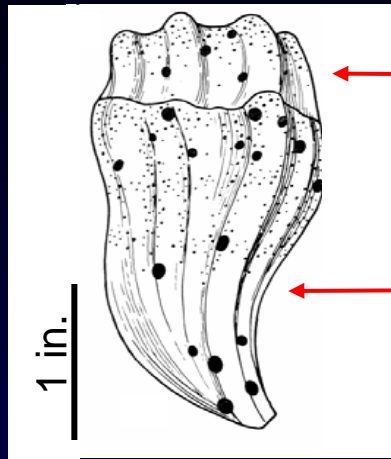
South Texas

- Post-Pangea breakup
- Opening of Tethys seaway
- Large % continental shelves in low (tropical) latitudes
- Greenhouse climate
- Low amp. high freq sea-level cycles during long-term rise
- Signif. global anoxic events in Albian, Turonian
- Rise of the rudist bivalves as main reef builders



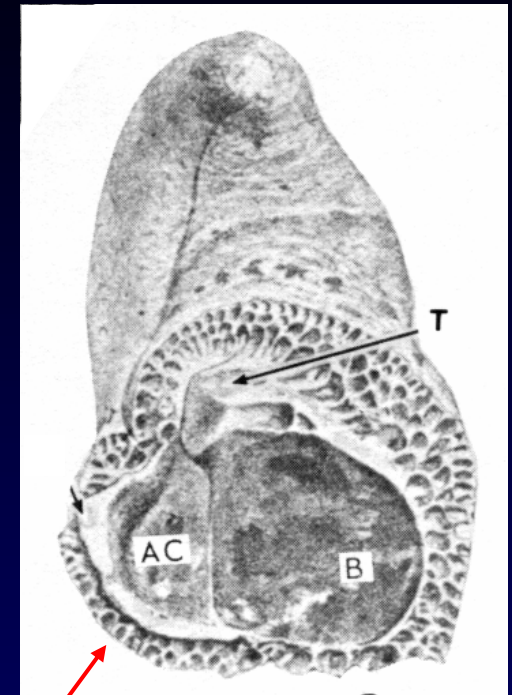
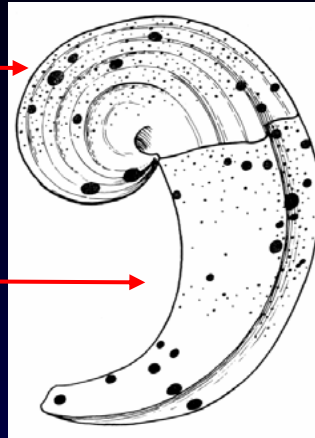
(see Markello et al., 2008)

The Rudists....Cretaceous bivalve reef builders

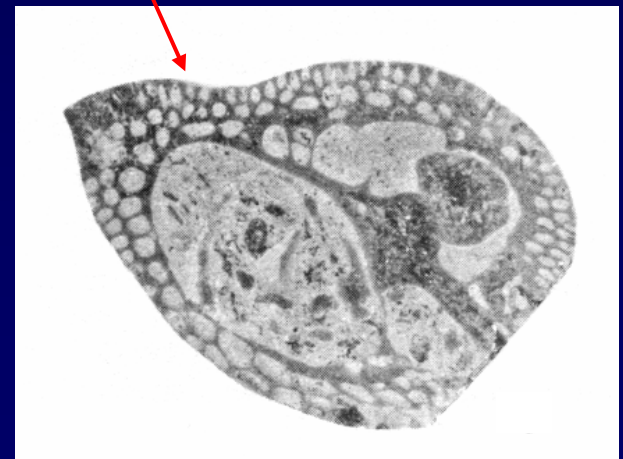
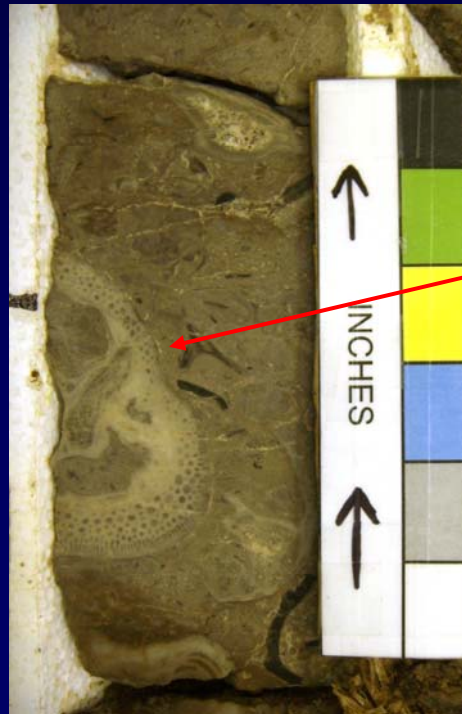


Upper valve

Lower valve

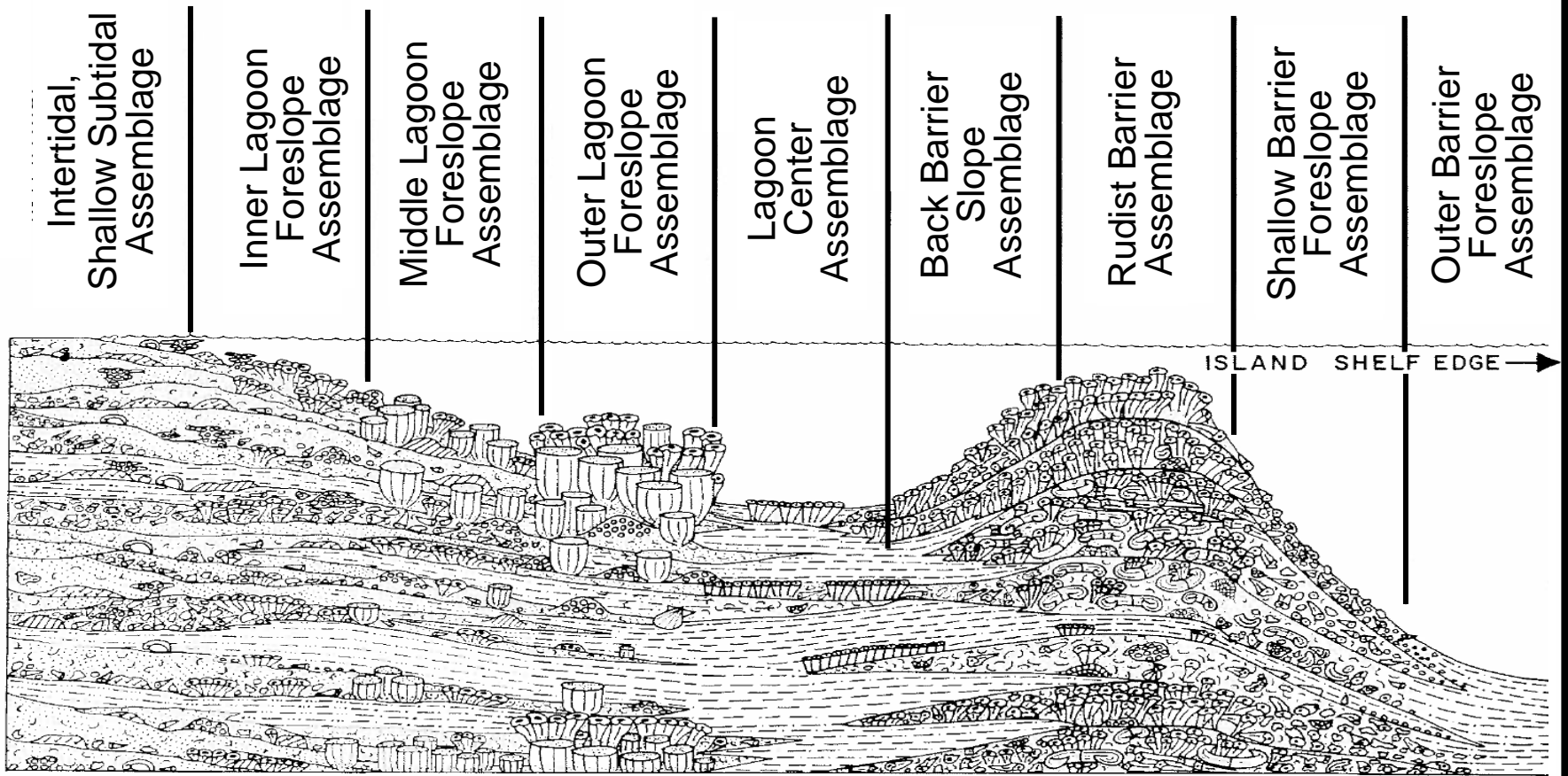


Distinctive shell wall



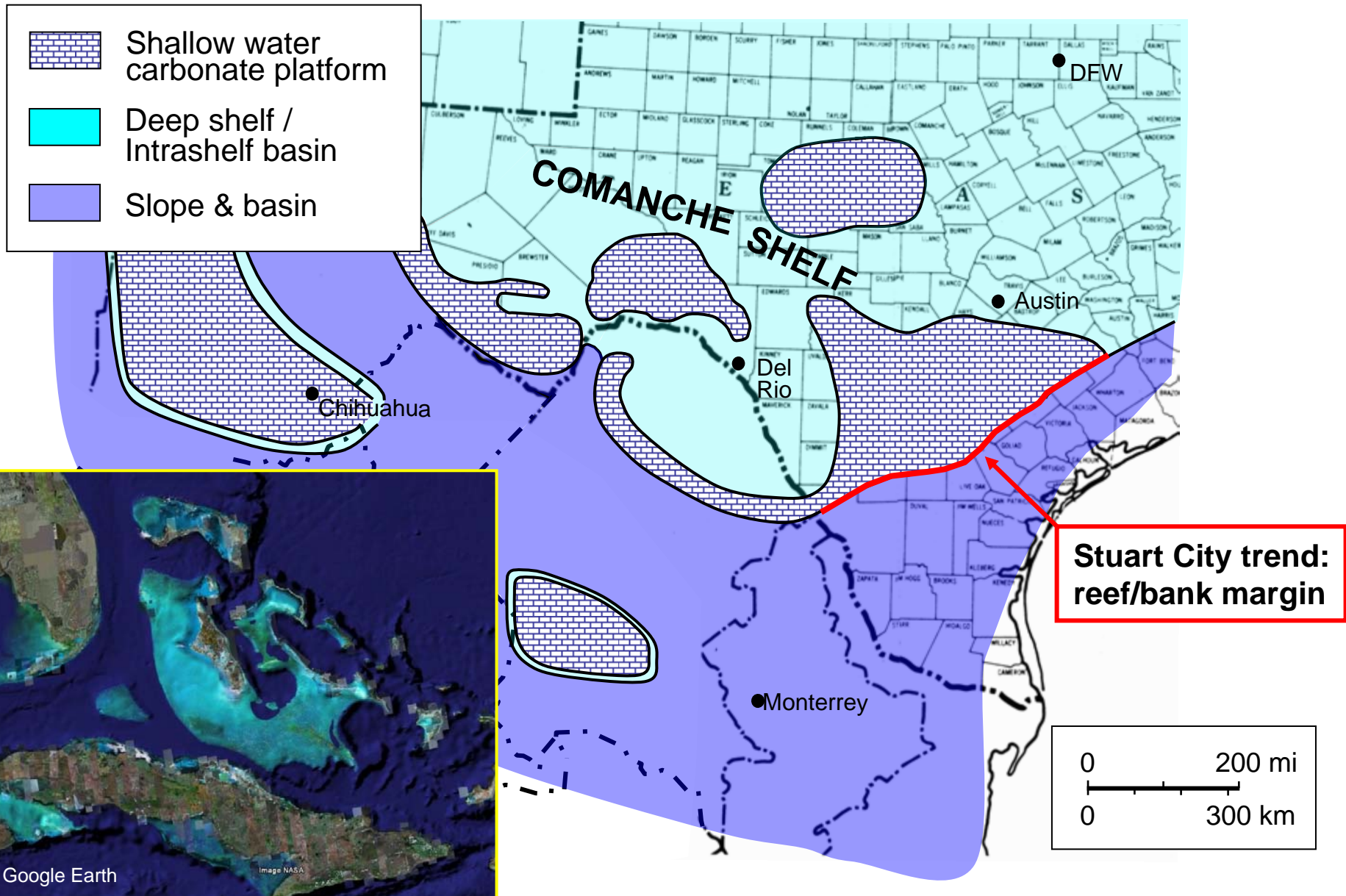
Rudist growth forms & reef models (Kaufmann and Sohl 1974)

MODEL OF CARIBBEAN RUDIST FRAMEWORK DISTRIBUTION



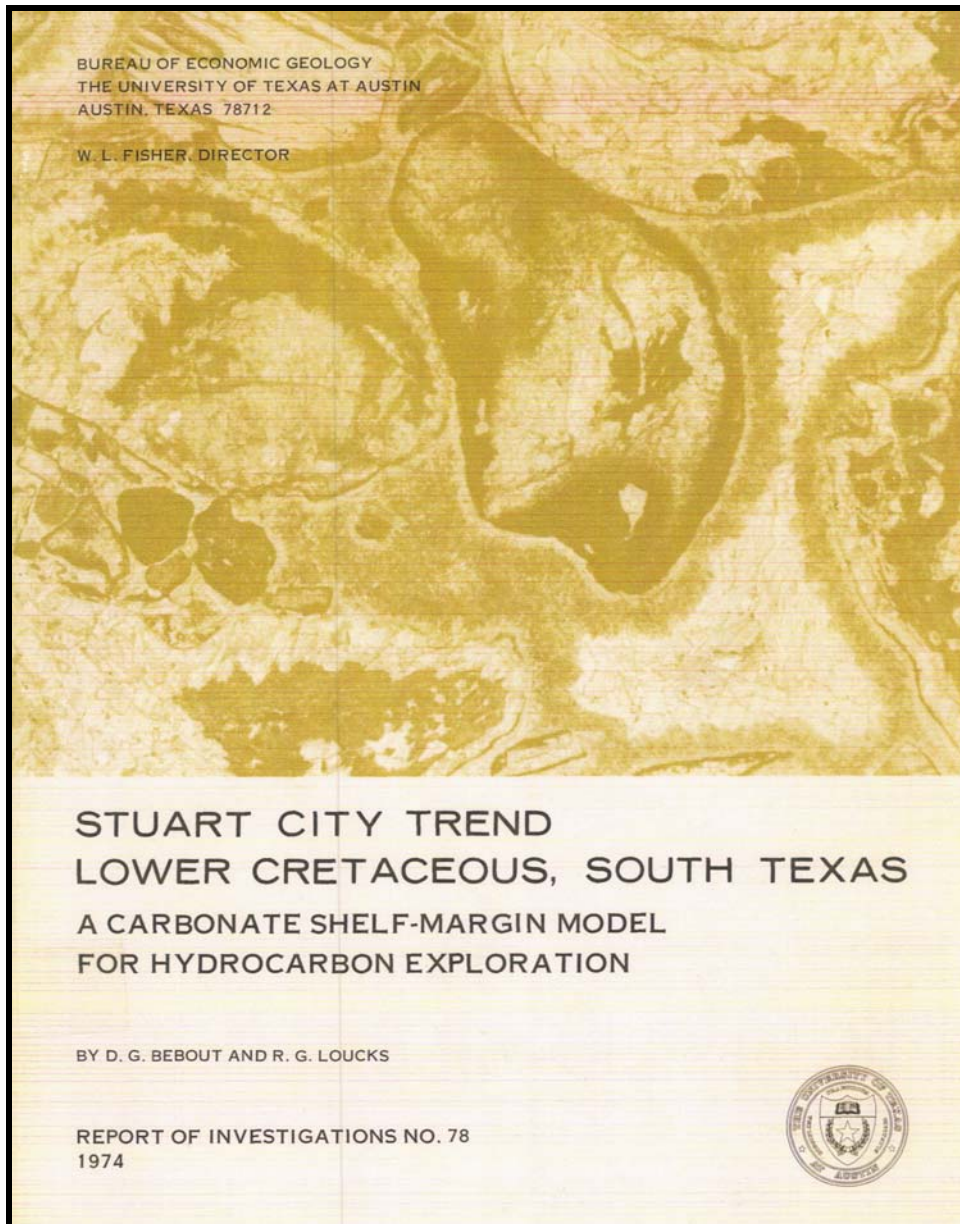
Mid-Late Albian Paleogeography

(from Kerans, 2002)



Outline

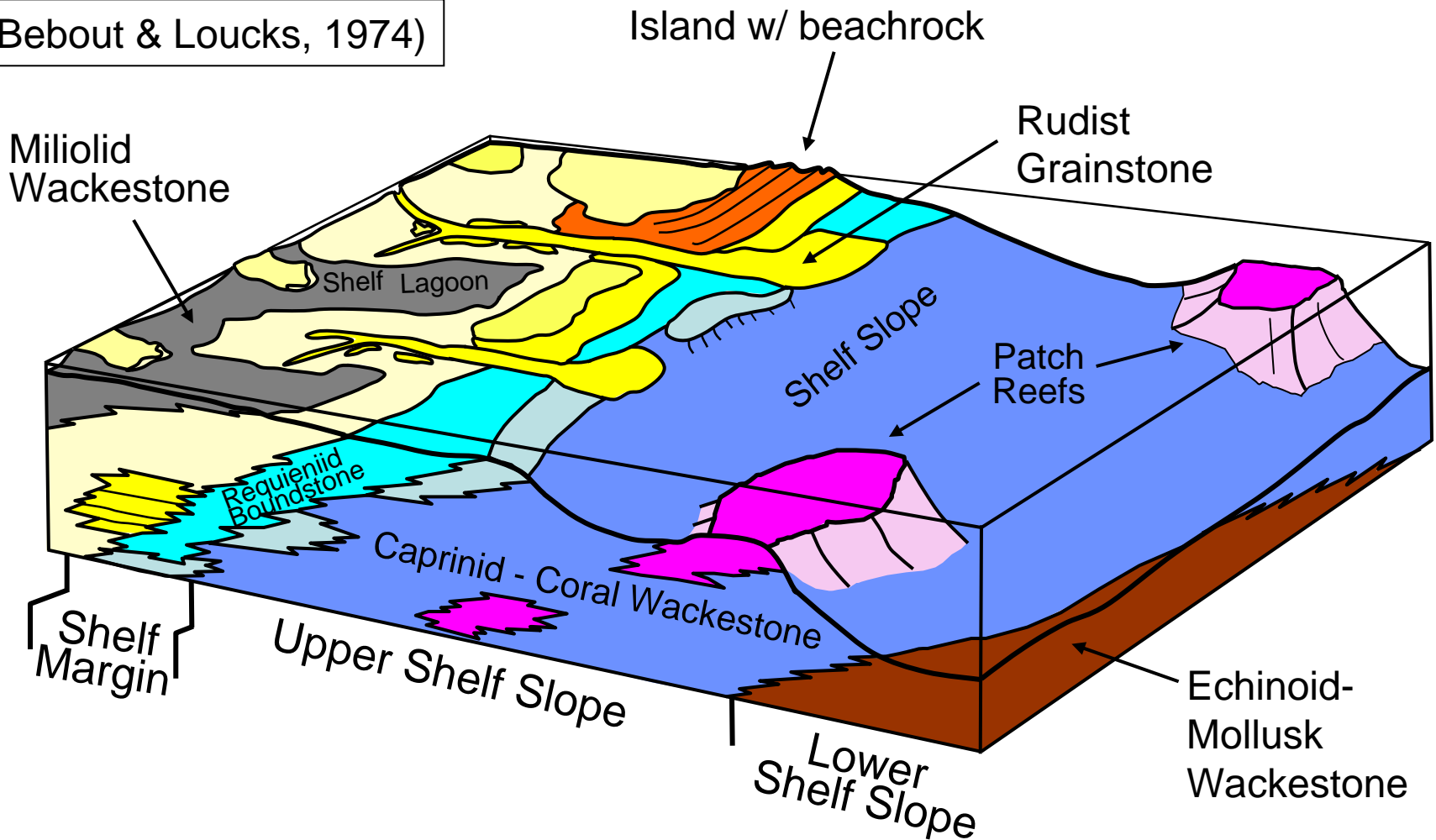
- Introduction to the Early Cretaceous world
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Bebout and Loucks (1974)

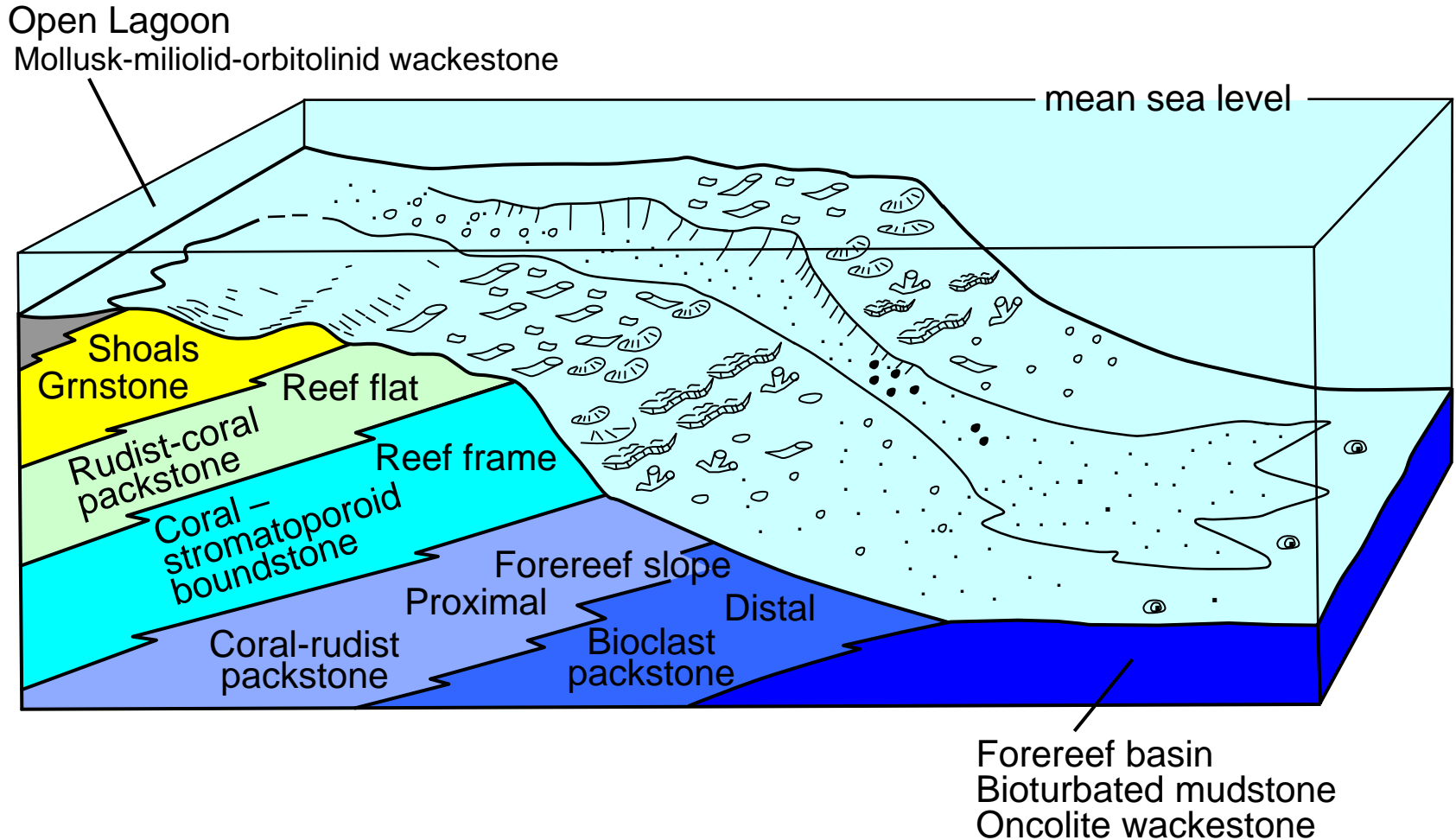
- 1st comprehensive description of Stuart City facies
- Based on analysis of >10,000 ft. of core from 20 wells along trend
- Recognized 5 major environments:
 - shelf lagoon
 - shelf margin
 - upper shelf slope
 - lower shelf slope
 - open marine (basin)
- Identified 14 separate depositional facies within the 5 environments
- Noted cement types, porosity types and distribution; commented on timing of diagenesis (early cementation)

(Bebout & Loucks, 1974)



- Shelf margin consists of progradational package of requeniid boundstones & caprinid-algal packstones
- Skeletal grainstones show evidence of brief subaerial exposure
- Note outboard margin: interpreted “patch reefs” on upper slope

Middle Albian Comanche shelf margin (Scott, 1990)



Caprinids

Toucasids

Massive corals

Branching corals

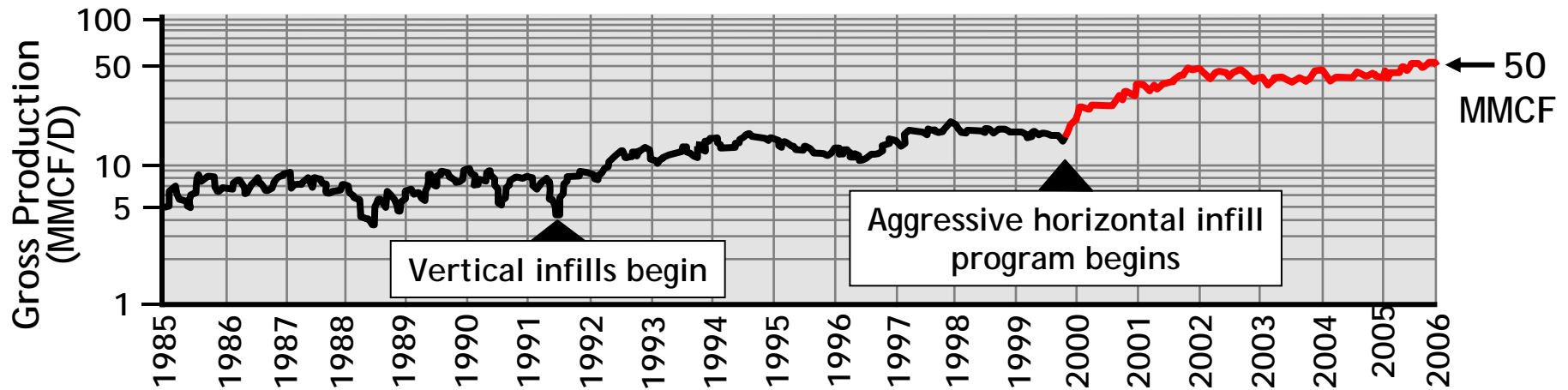
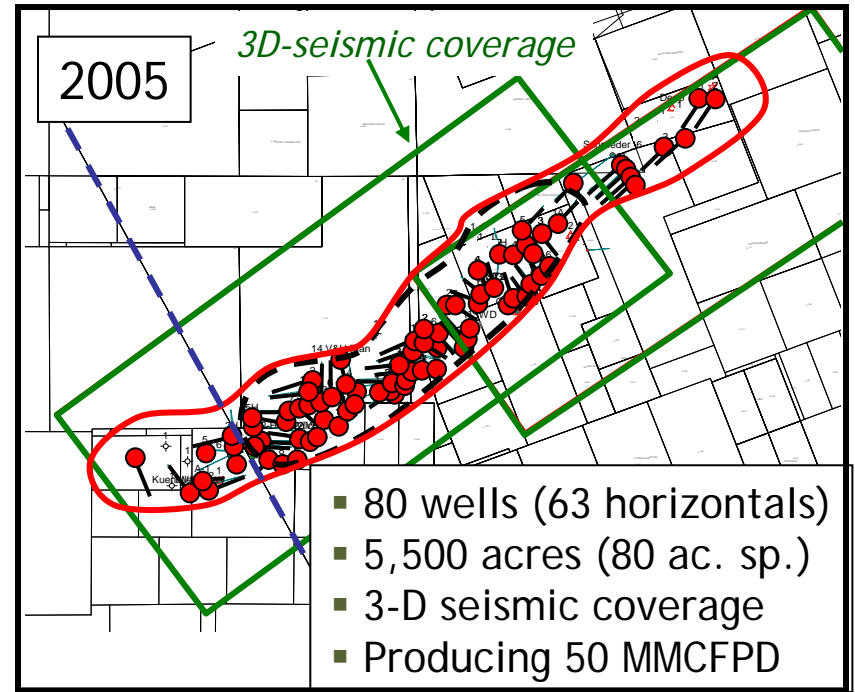
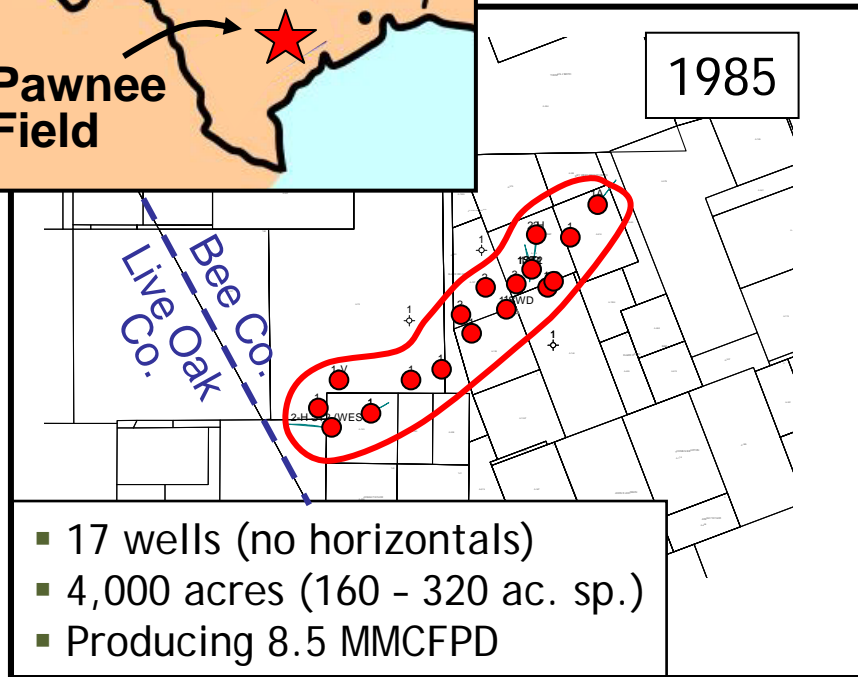
Laminar corals

Oncolites

Outline

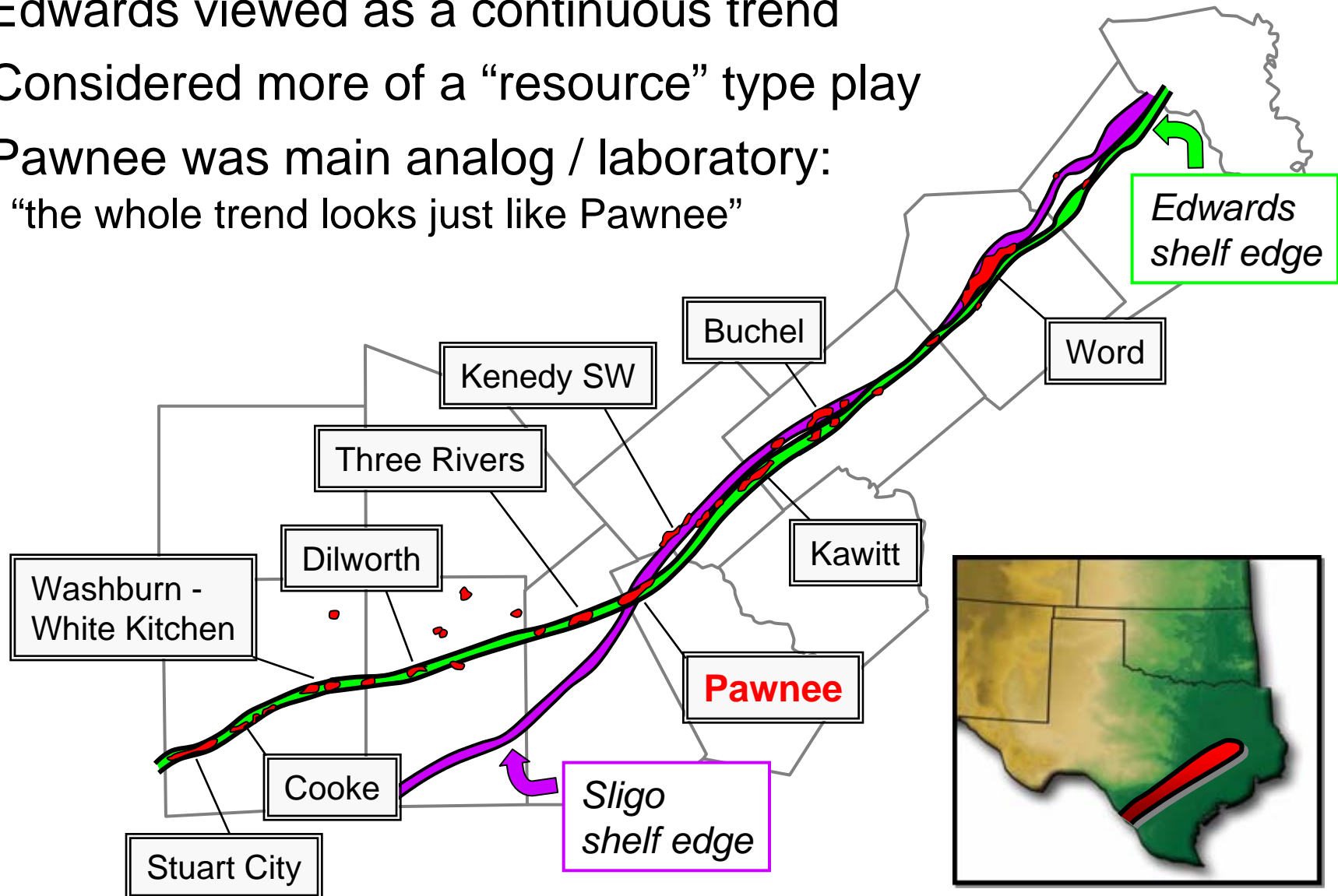
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Pawnee (Edwards reef) Field Bee & Live Oak Counties, TX



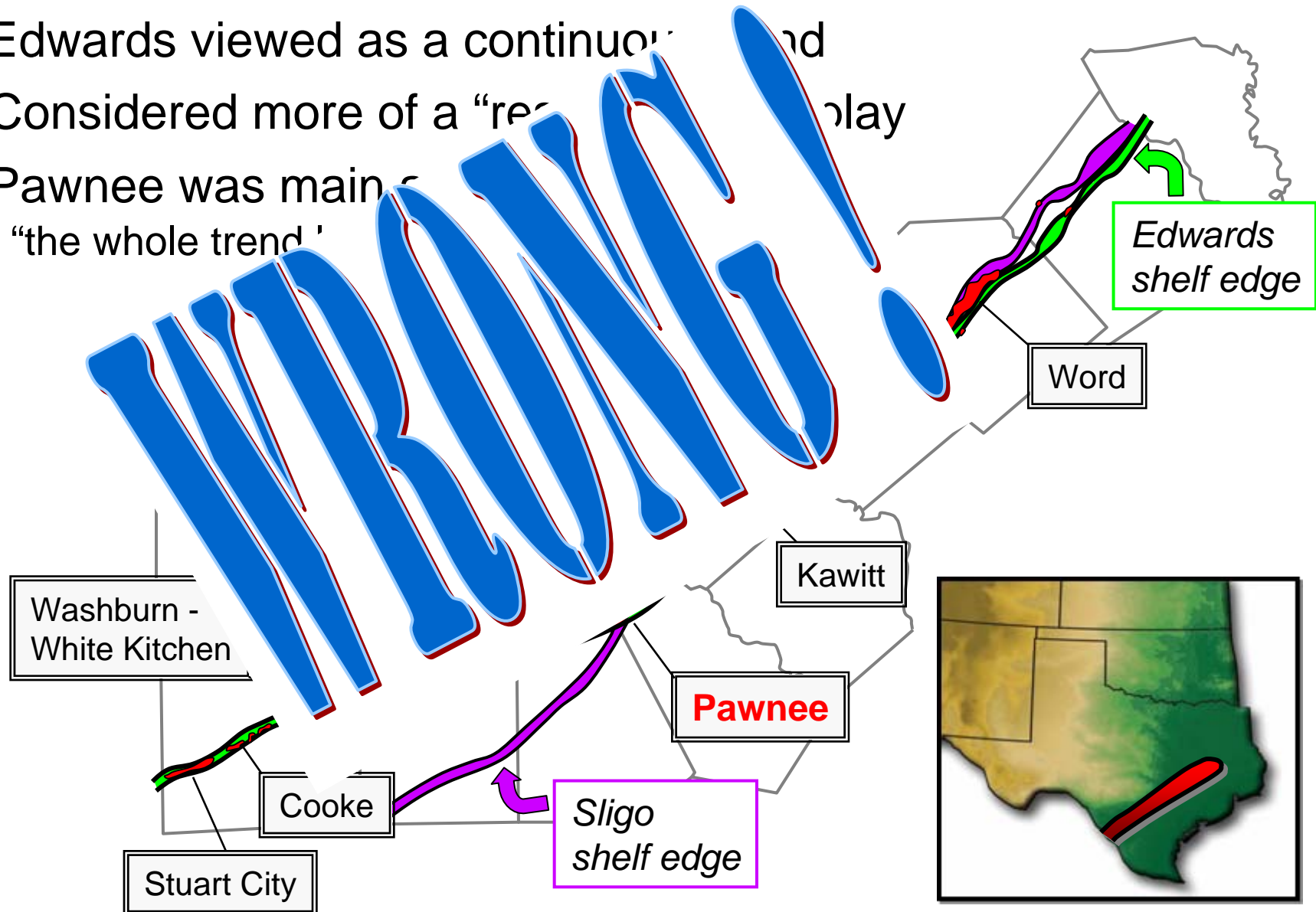
The PNR Edwards concept circa 2004

- Edwards viewed as a continuous trend
- Considered more of a “resource” type play
- Pawnee was main analog / laboratory:
“the whole trend looks just like Pawnee”



The PNR Edwards concept circa 2004

- Edwards viewed as a continuous trend
- Considered more of a “regional play”
- Pawnee was mainly “the whole trend”



PNR Edwards Trend data acquisition ('05 – '08)

- 10,000 line-miles of previously acquired 2D seismic
- > 300,000 acres under lease
- 85 (and counting) deep pilot holes w/ full log suites
- 7 new extensive conventional cores
- 1000 mi² of new 3D seismic (full fold across margin)
- Several new gas discoveries; one significant (Moray Field)
- Numerous production and engineering data
(por/perm, cap. pressure, production rates, decline rates, pressure, etc.)

PNR drilling activity, 2005-2008



NE Dewitt Co.

Moray & Sawfish Fields (new)

- 32 wells
- 4 cores

Karnes Co.

SW Kenedy Field

- 2 wells

Live Oak Co.

Three Rivers Field

- 14 wells

Lasalle Co.

Washburn Ranch Field

- 4 wells

Edwards shelf edge

Lavaca Co.

Word Field extension

- 13 wells
- 1 core

Central Dewitt Co.

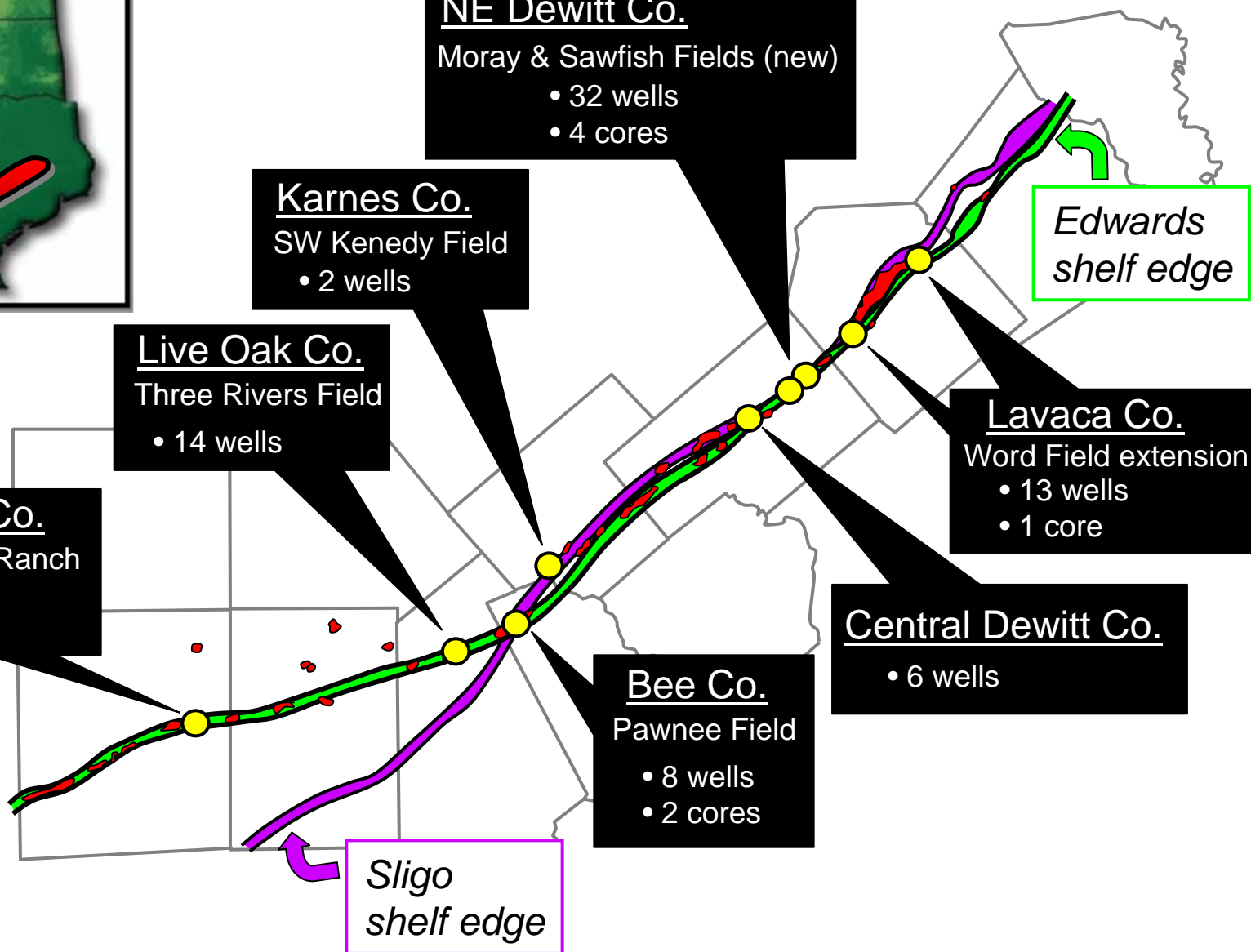
- 6 wells

Bee Co.

Pawnee Field

- 8 wells
- 2 cores

Sligo shelf edge

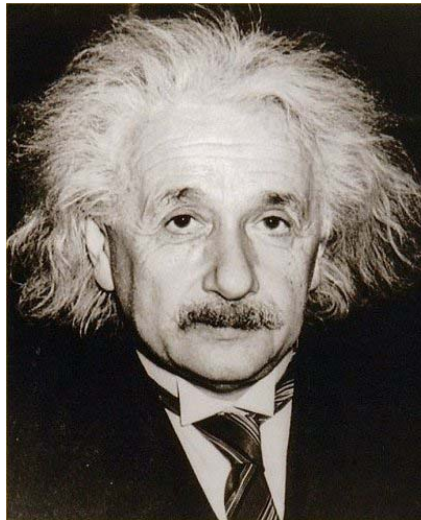


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SO...WHAT HAVE WE LEARNED ?

- A tale of two reefs: Edwards 'B' vs. Edwards 'A'
- Salt distribution, deep Jurassic / basement faults & Sligo margin: fundamental control on development of Edwards reef
- Edwards trend is not a “simple ribbon” nor is it a true resource play
- Very complex system -- “One model” does not fit all !
- Structure, facies, diagenesis are all important



“We must
make things
as simple
as possible...
but no
simpler”

- A. Einstein

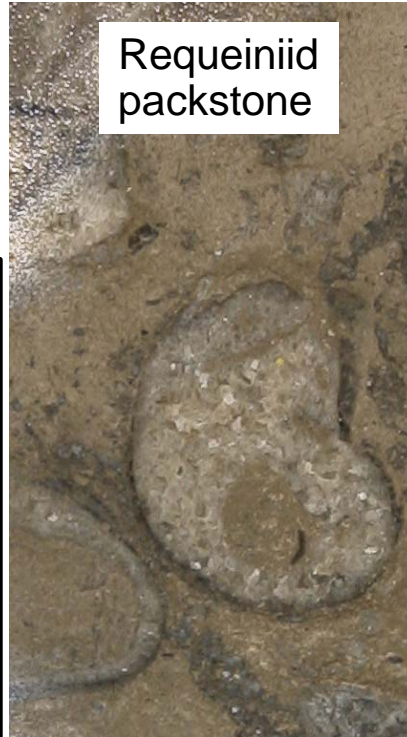
Edwards Stratigraphy

- Regional Dense Marker bed separates Edwards into 2 units: "A" and "B"
- "A" and "B" are two different reef types

Caprinid PS,
coated grains



Requeiniid
packstone



Regional Dense
Marker Bed:
shaly mudstone



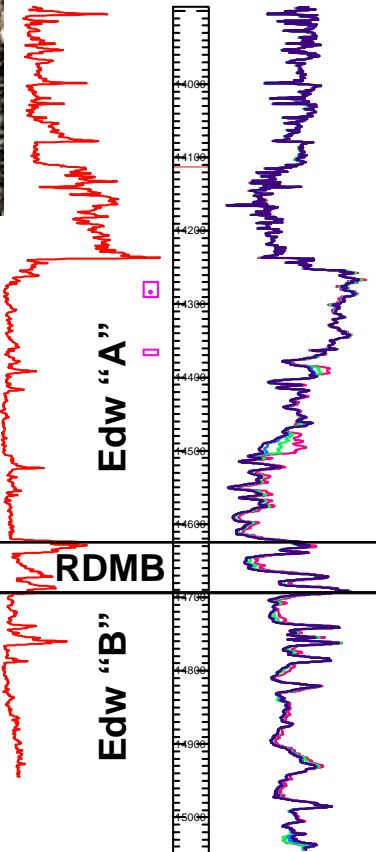
Rudist-coral-strom.
boundstone



Pioneer Nat. Res.
Dewitt Co.

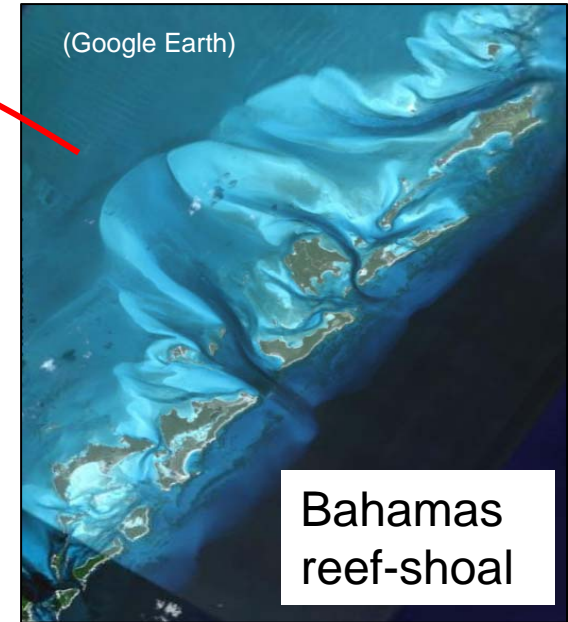
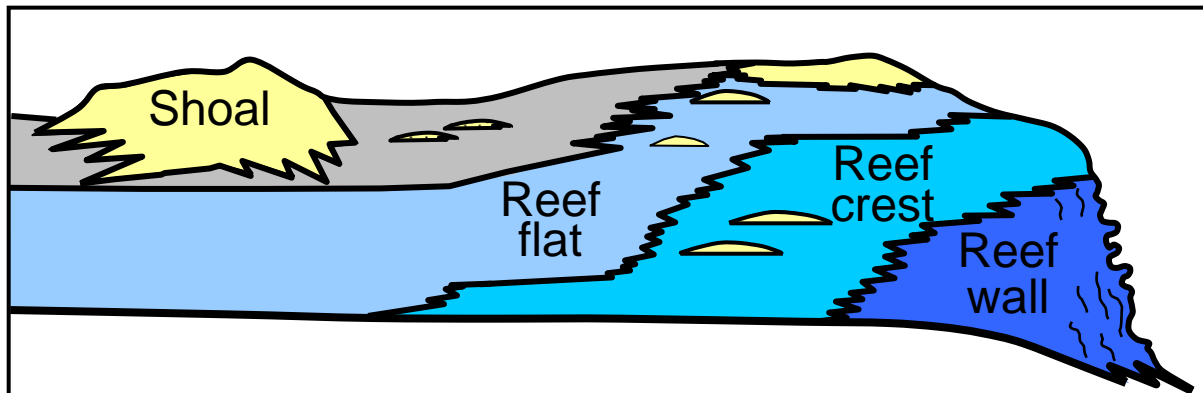
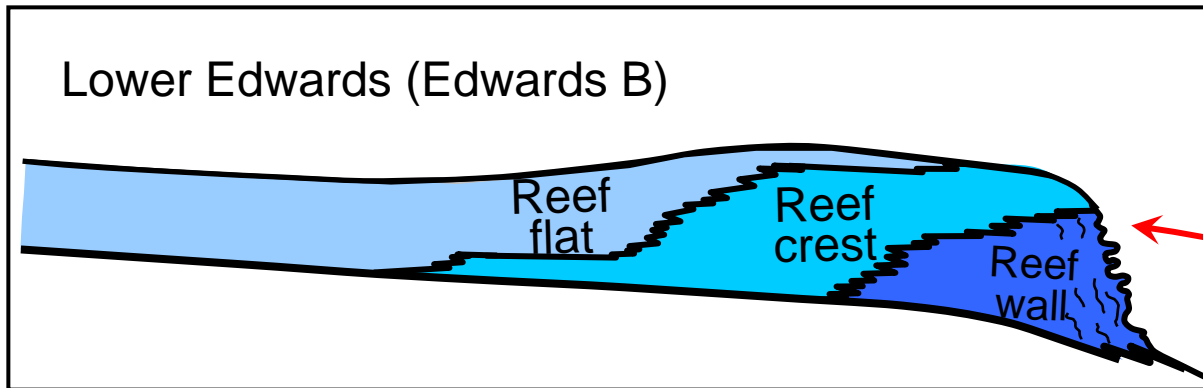
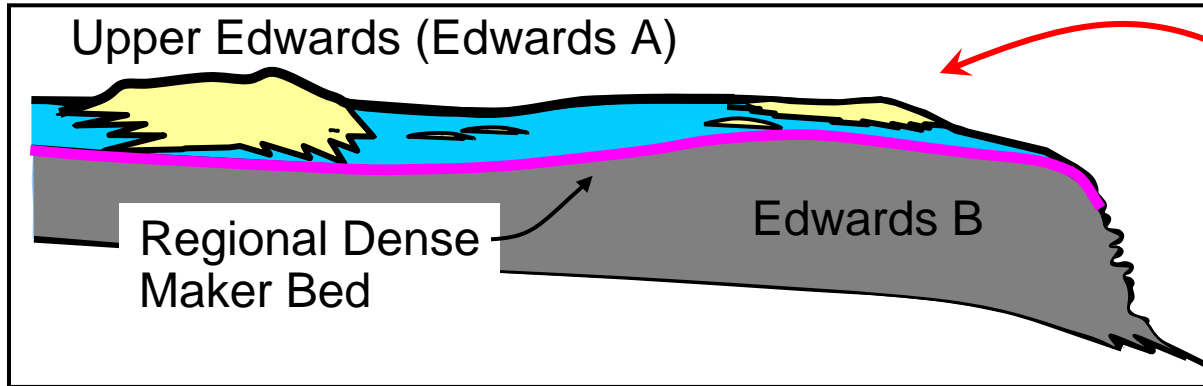


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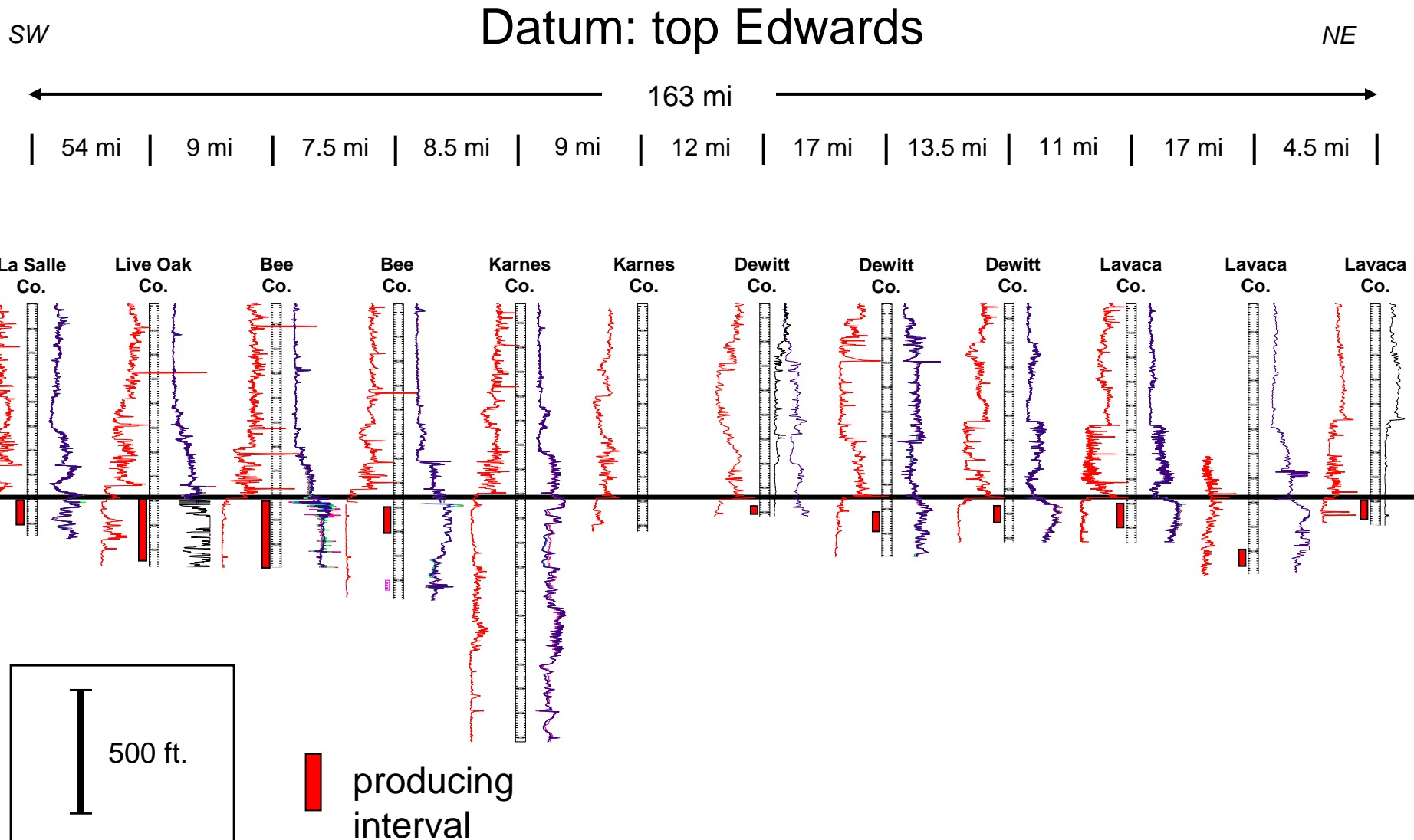


(see Waite et al., 2007)

A tale of two reefs : Lower vs. Upper Edwards



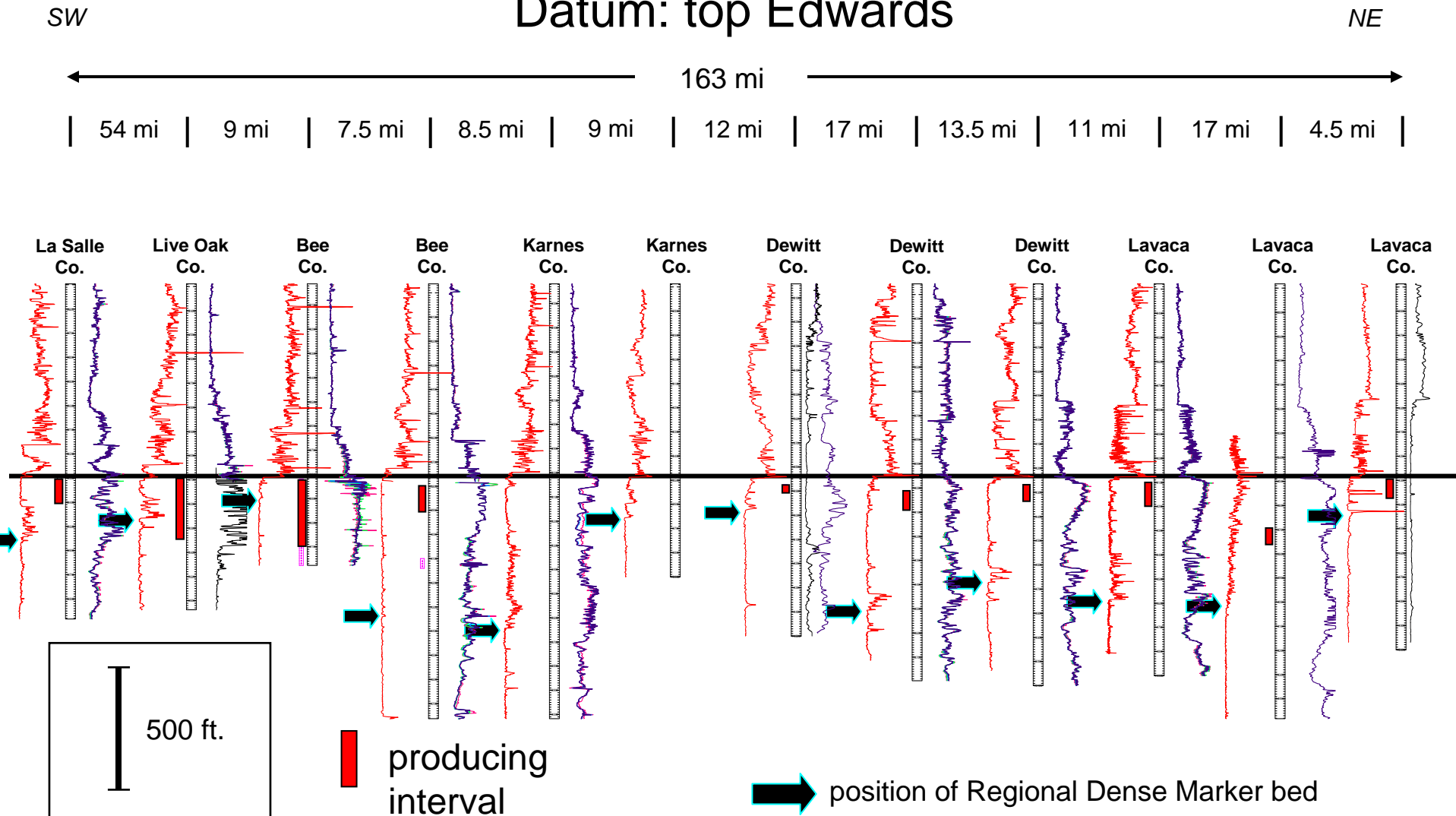
Regional strike section, Stuart City margin (Showing lack of deep well control)



Regional strike section, Stuart City margin

PNR deep pilot holes

Datum: top Edwards



Regional strike section, Stuart City margin PNR deep pilot holes

Datum: base RDMB/top Edwards "B"

SW

NE

163 mi

54 mi

9 mi

7.5 mi

8.5 mi

9 mi

12 mi

17 mi

13.5 mi

11 mi

17 mi

4.5 mi

La Salle
Co.

Live Oak
Co.

Bee
Co.

Bee
Co.

Karnes
Co.

Karnes
Co.

Dewitt
Co.

Dewitt
Co.

Dewitt
Co.

Lavaca
Co.

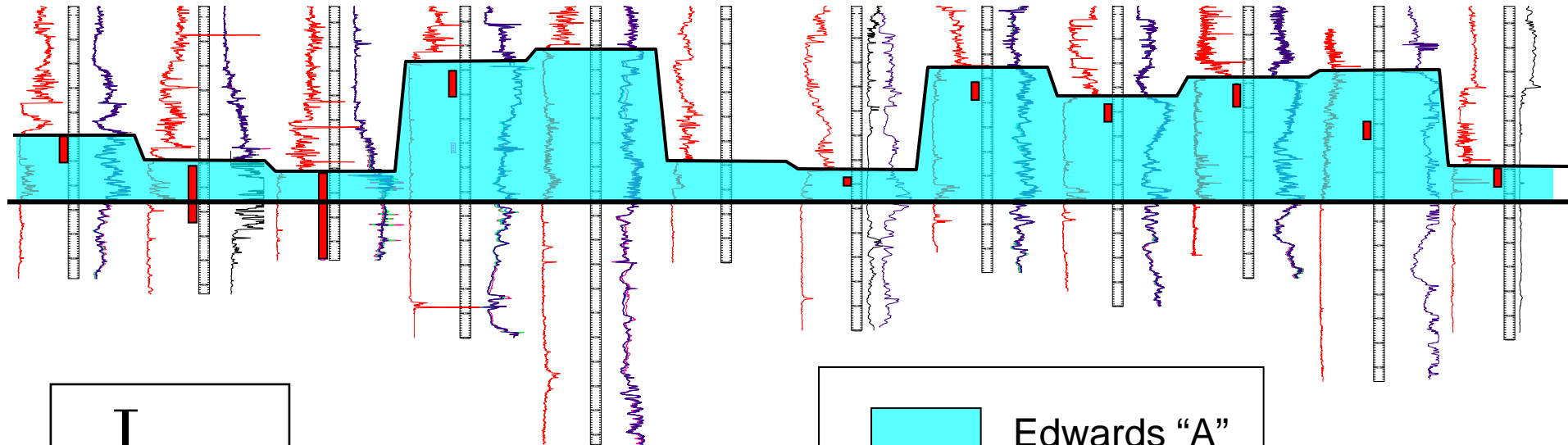
Lavaca
Co.

Lavaca
Co.

500 ft.

producing
interval

Edwards "A"



Tectonic/structural elements partition reef trend into 3 main provinces

Llano uplift

**Updip
limit of
Louann salt**

HOUSTON SALT BASIN

EDWARDS “MARGIN”

30 miles

**Updip
limit of
Louann salt**

Pearsall
arch



RIO GRANDE SALT BASIN

SLIGO SHELF MARGIN

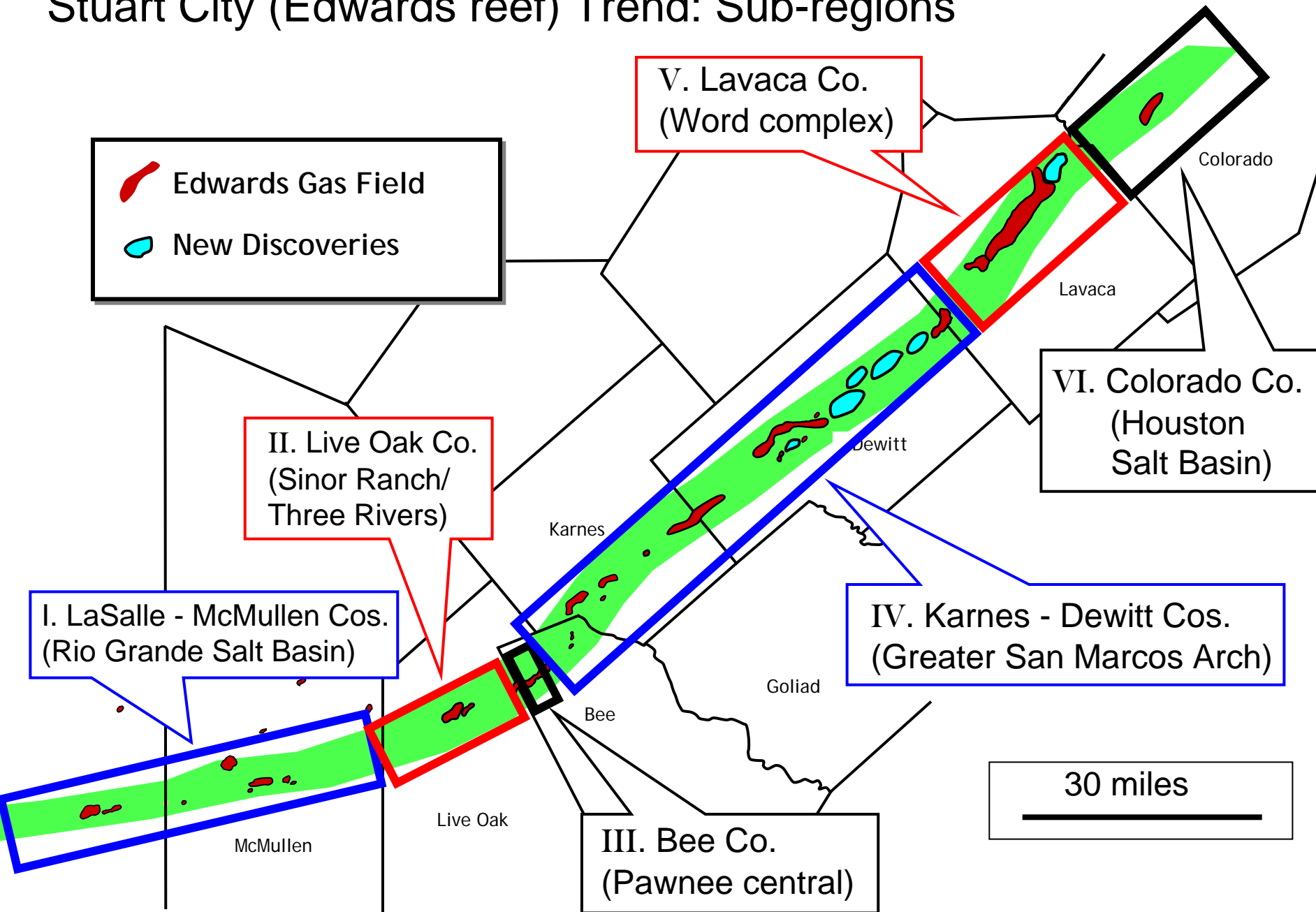
Continental Shelf

Continental Slope



Transitional Crust

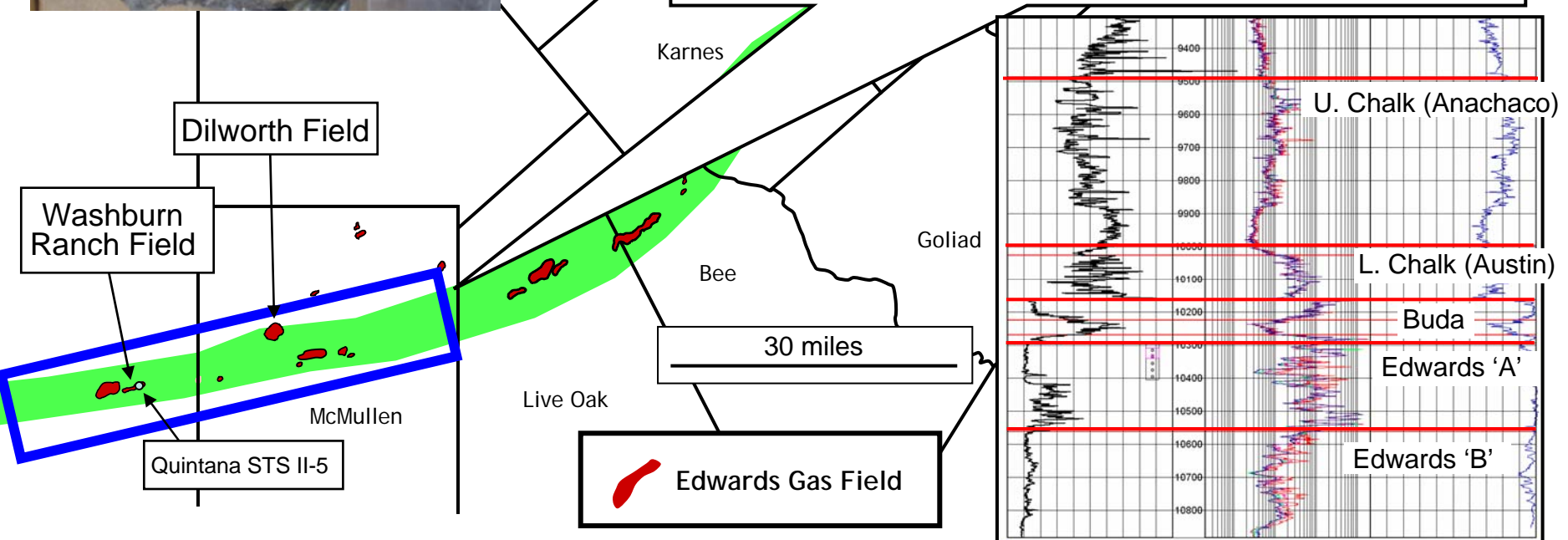
Stuart City (Edwards reef) Trend: Sub-regions



Key cores: Quintana STS II-5

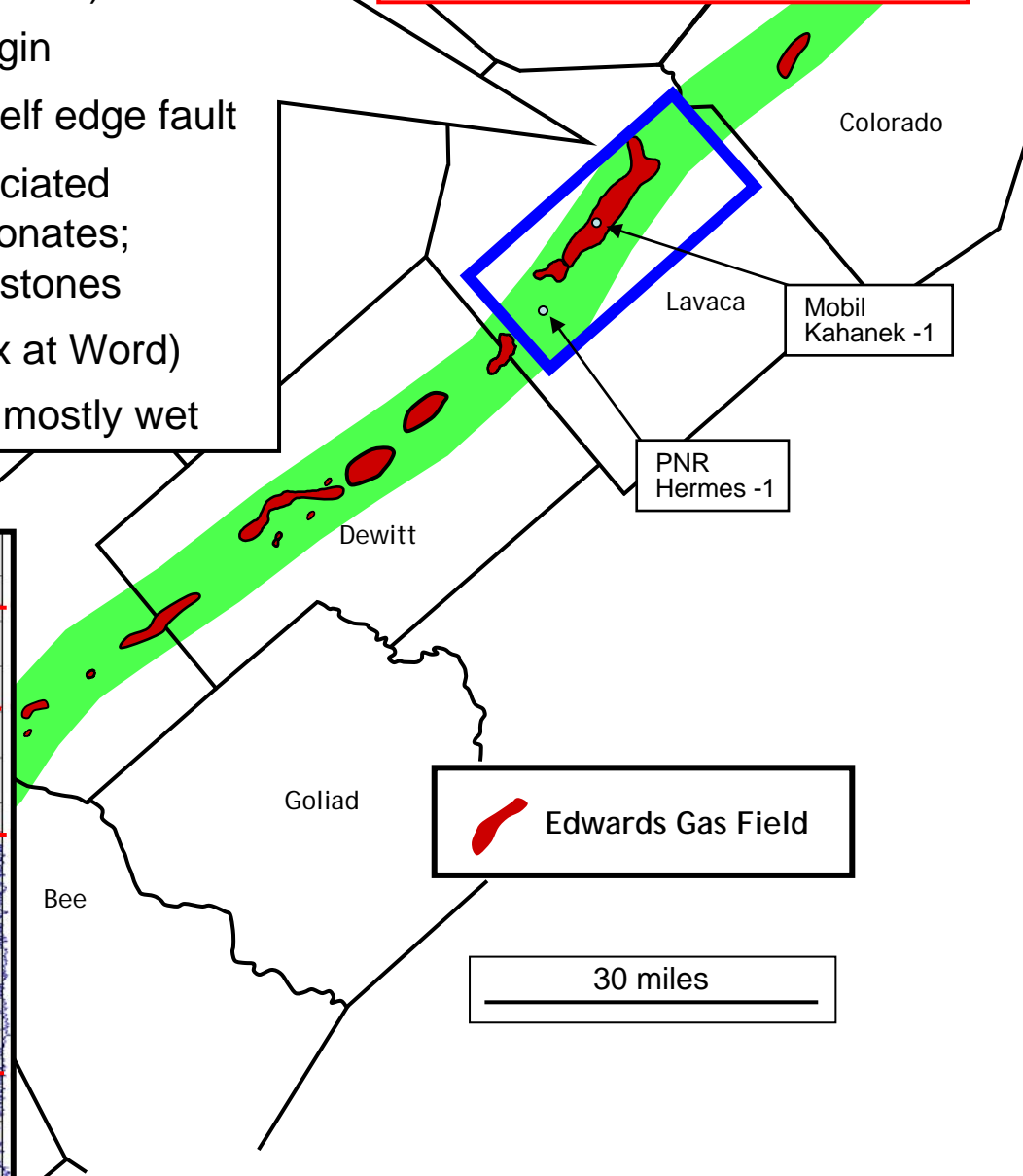
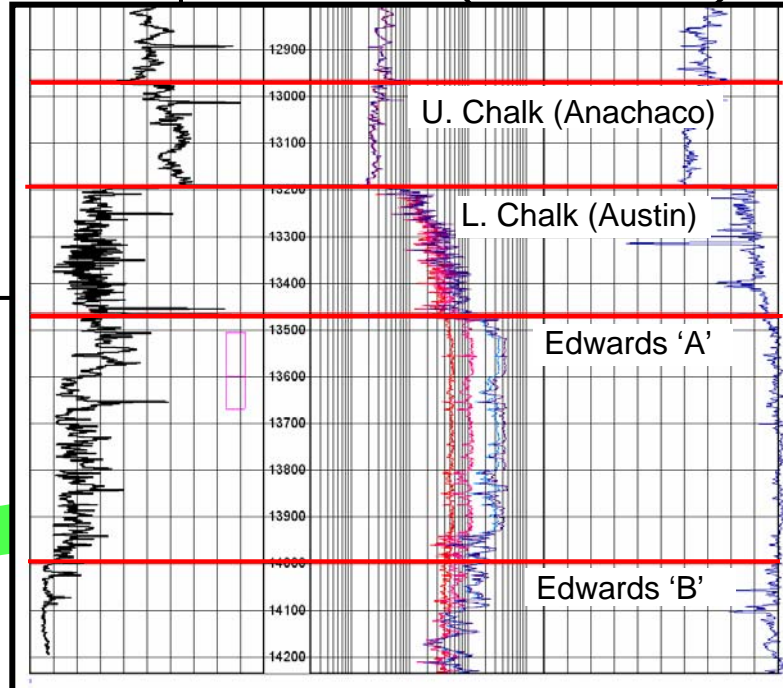
1. LaSalle - McMullen Cos. (Rio Grande Salt Basin)

- Center of the Rio Grande Salt basin
- Edwards relatively shallow (10 – 12, 000 ft)
- Sligo margin is far outboard of Edwards margin
- Pay section restricted to upper portion of Edwards 'A' (\pm 100 ft. of total gas column)
- Small bioherms with grainstone/packstone cycles
- High porosity and perm (interparticle, vuggy)
- Best wells on salt-related structural highs; depletion concerns in existing fields



5. Lavaca Co. (Word Field complex)

- Edwards relatively deep (13,500 – 14,100 ft)
- Edwards margin outboard of Sligo margin
- Thick Edwards 'A' landward of main shelf edge fault
- Island/tidal flat cycles (Word) and associated low-energy, open marine muddy carbonates; highest por-perm in microporous mudstones
- Thick gas columns in Edwards 'A' (max at Word)
- Outboard, massive Edwards 'B' reef is mostly wet



Summary of new insights

- Shelf margin reef is subdivided vertically into two portions
 - Lower Edwards ('B'): high relief, barrier-type reef margin
 - Upper Edwards ('A'): low relief bioherms
- Geology of Edwards shelf margin controlled in part by basement configuration and salt distribution
 - Rio Grande Salt Basin / Maverick Basin
 - San Marcos Arch
 - Houston / East Texas Salt Basin
- More than one geologic model is required to fully characterize the complexities of the reef margin along strike

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3D seismic coverage along the Stuart City margin



Existing (pre-2007)
200 sq mi

Runge
23 sq mi

Kenedy
18 sq mi

Sweethome
66 sq mi

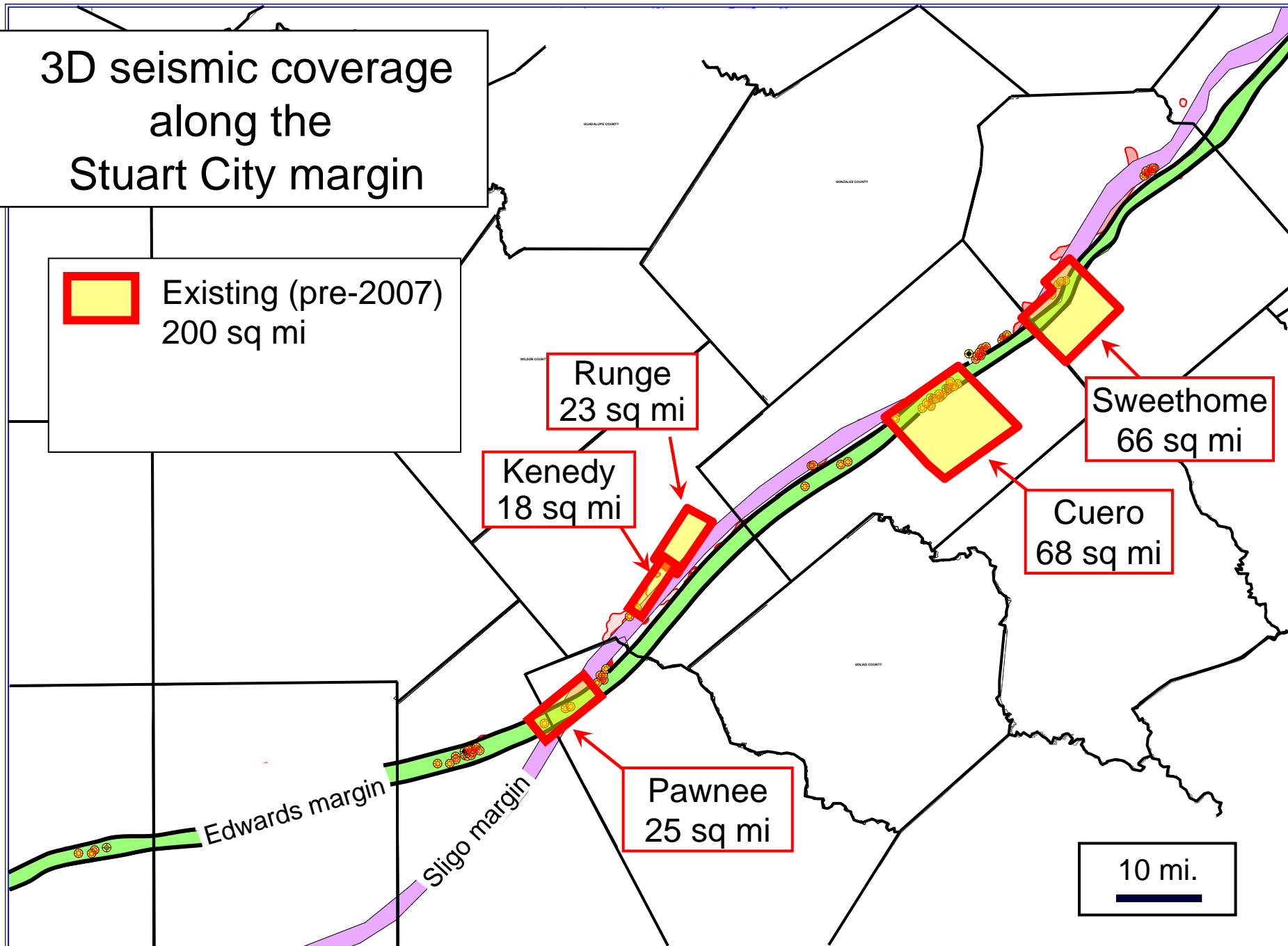
Cuero
68 sq mi

Pawnee
25 sq mi

Edwards margin

Sligo margin

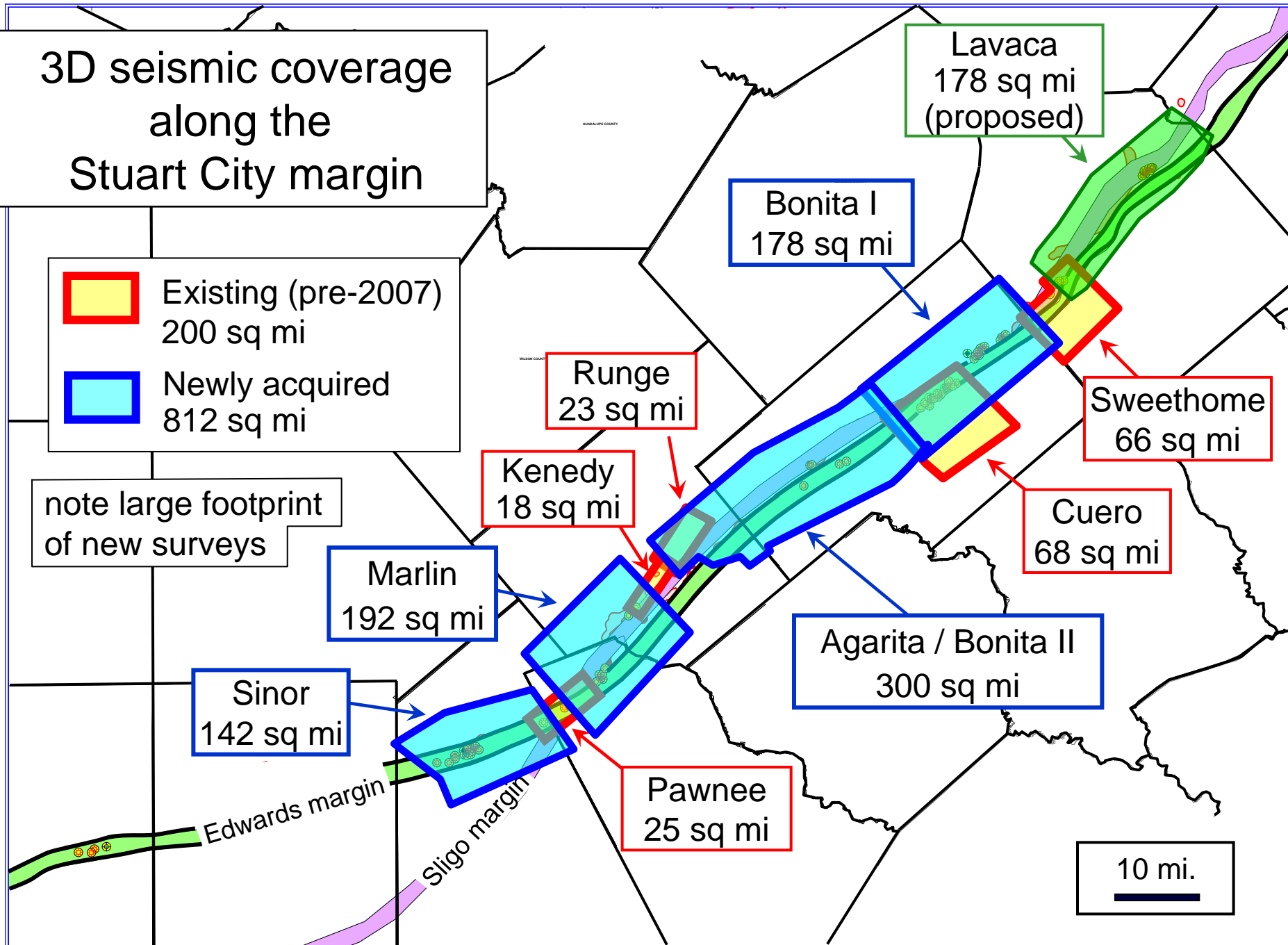
10 mi.



3D seismic coverage along the Stuart City margin

- Existing (pre-2007)
200 sq mi
- Newly acquired
812 sq mi

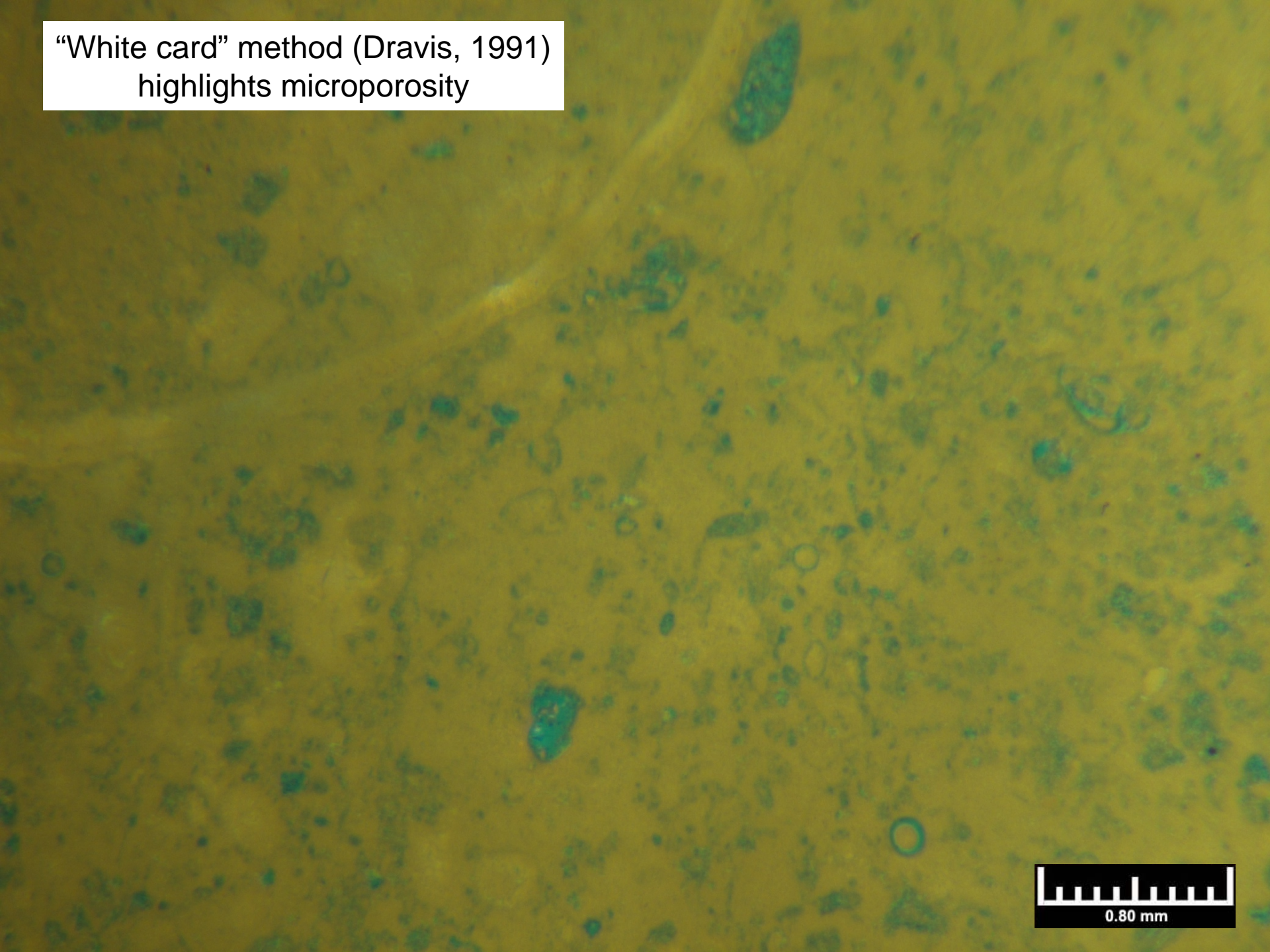
note large footprint
of new surveys



Where is the porosity ??



“White card” method (Dravis, 1991)
highlights microporosity



Closing remarks

- Deep Edwards gas play is challenging
- Conventional play with resource play elements
- Significant new gas discovery in NW Dewitt Co.
- Moving forward: 3D seismic, control costs
- One eye on the microscope, the other on commodity prices

Acknowledgments

- Dr. Robert W. Scott, Precision Stratigraphy and University of Tulsa, Tulsa, OK
- Mr. Walter Bloxsom, Consultant, Houston, TX
- Dr. Charles Kerans, University of Texas at Austin, Austin, TX
- Management of Pioneer Natural Resources, Irving, TX, and
and fellow co-workers, South Texas Asset Team



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