

Regional Setting of the Late Jurassic Deep Panuke Field, Offshore Nova Scotia, Canada – Cuttings Based Sequence Stratigraphy and Depositional Facies Associations - Abenaki Formation Carbonate Margin*

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*Adapted from oral presentation at AAPG Convention, New Orleans, Louisiana, April 11-14, 2010. Please see closely related article, [“Large Scale Mixed Carbonate-Siliciclastic Clinoform Systems: Three types from the Mesozoic North American Atlantic Offshore”](#), S&D article #30132.

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Abstract

Deep Panuke, discovered in 1998, is the only carbonate gas field in the eastern North America continental shelf. Several recently published studies (Weissenberger et al., 2006; Wierzbicki et al., 2005, 2006; EnCana 2006) give details on the hydrothermally-dolomitized reef margin gas field itself. Expanding on those studies using mainly cuttings and core data, Panuke is placed in a larger context between the northeast contemporaneous major Sable Island paleodelta prograding ramp shelf and the southwest thicker cleaner carbonate platform.

Wells can be grouped based on geometry and position relative to the shelf margin as follows: prograding ramp margin (only a few of the numerous wells in the Sable Island paleodelta are included), margin slope, margin with full shoaling sequence, margin with paleohighs and encased pinnacles (typical of Deep Panuke area), margin inboard flexure with shoals, interior platform oolitic shoals, interior platform shaly lagoon and ‘moat’, and near-shore ridge/siliciclastic-rich. The large-scale (second order?) vertical full-shoaling stratigraphic sequence is seen in nearly all margin wells. It comprises a basal transgressive oolite usually, then forereef with microbial mud mounds, then shallow coral-coralline sponge reefs, then oolites and two types of capping beds - either oolites (with or without sandstone interbeds) or lithistid sponge-rich beds. Only Deep Panuke does not show this pattern. Laterally there is a curious pattern to the argillaceous sponge-rich cap beds in being flanked by wells with oolite caps both nearer the delta and south-westward of the Panuke area wells. There is also a regional trend in the color from darker to lighter (and finally even red in the slope beds) away from the Sable Island paleodelta. These facies trends relative to the Sable Island delta and the associated early, deep prodeltaic burial are key factors that contributed to Deep Panuke’s possibly unique hydrocarbon system of reservoir, trap, seal and charge properties

Selected References

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**Regional Setting of the Late Jurassic
Deep Panuke field, offshore Nova
Scotia, Canada – cuttings based
sequence stratigraphy and depositional
facies associations –
Abenaki Formation carbonate margin**

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Dalhousie Earth Sciences – GeoTours Consulting



THANKS

EnCana

Shell Canada

Ammonite Nova Scotia, El Paso Canada

CNSOPB & Dalhousie Earth Sciences

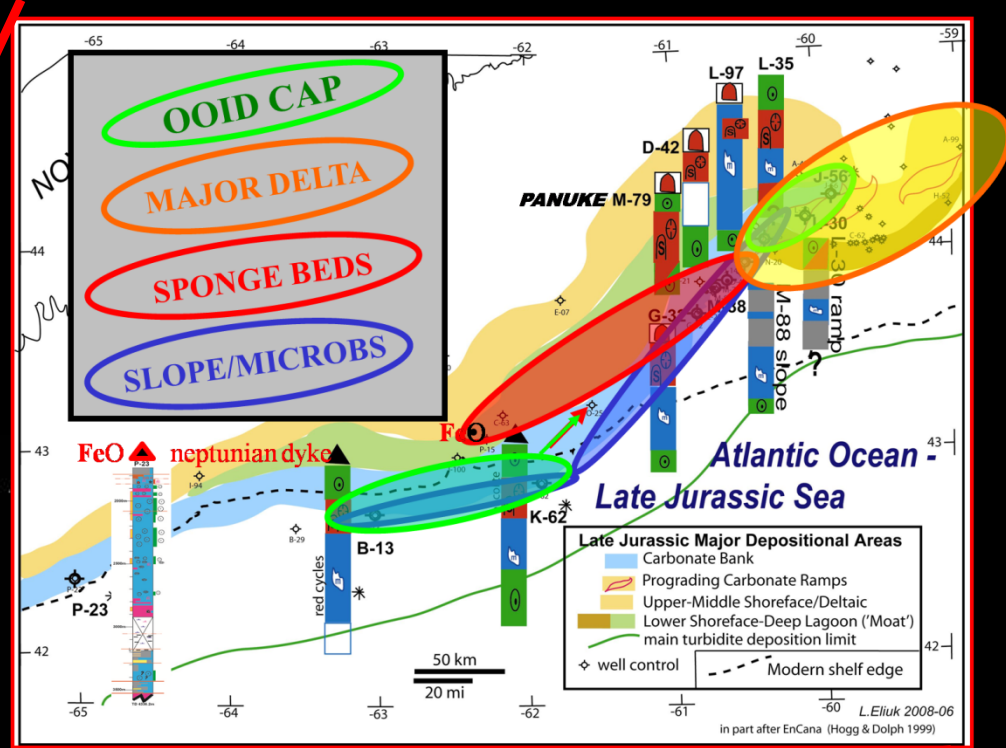
OETR and Grant Wach

All my co-authors, co-workers (google

PDFs) particularly Rick Wierzbicki & Nancy

Harland

Where we are going

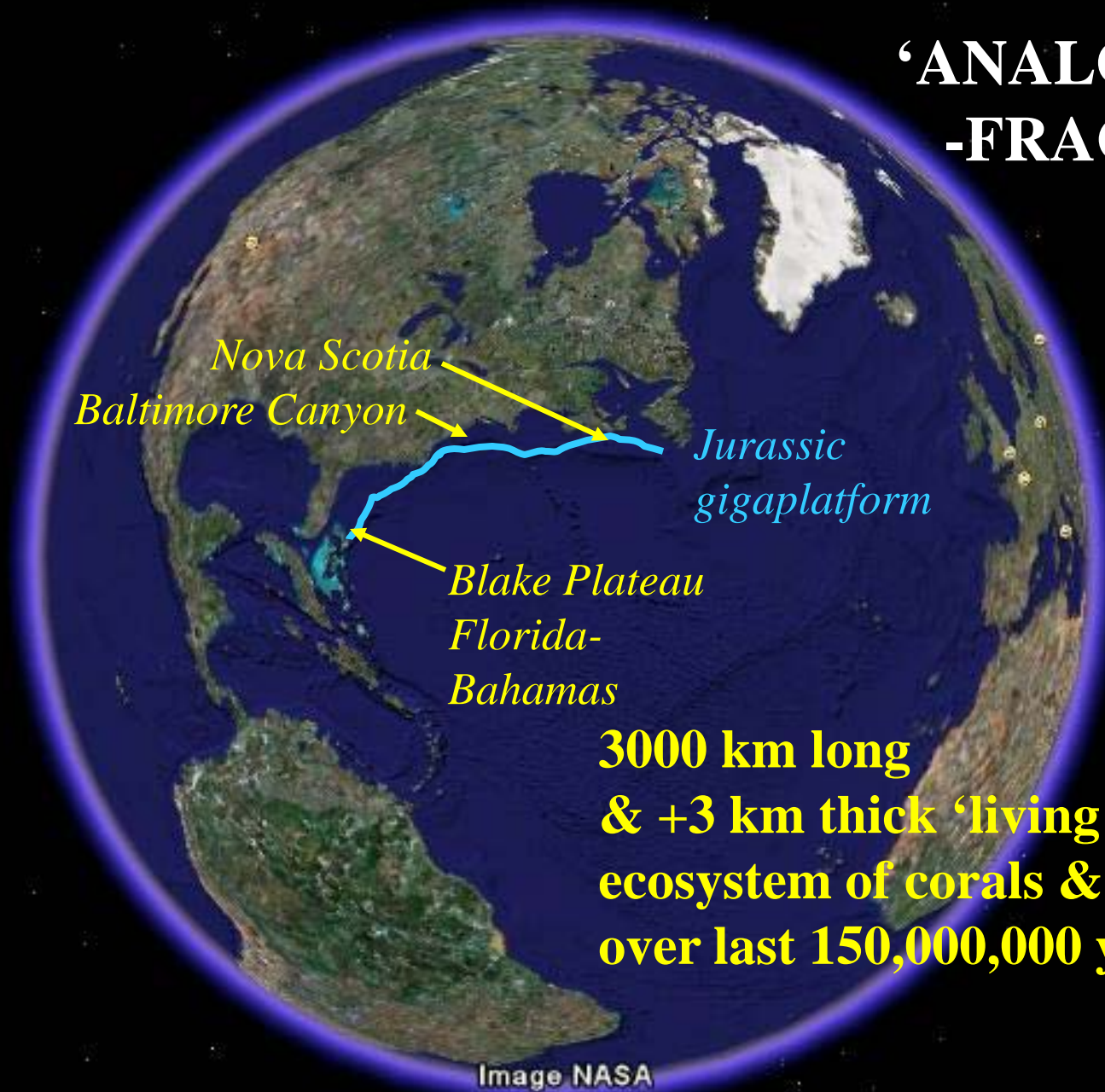


...in case I don't get through it all



North America-Atlantic

‘ANALOGUE
-FRACTAL’



Nova Scotia
Baltimore Canyon

*Jurassic
gigaplatform*

Blake Plateau
*Florida-
Bahamas*

**3000 km long
& +3 km thick ‘living fossil’
ecosystem of corals & algae
over last 150,000,000 years**

Image NASA

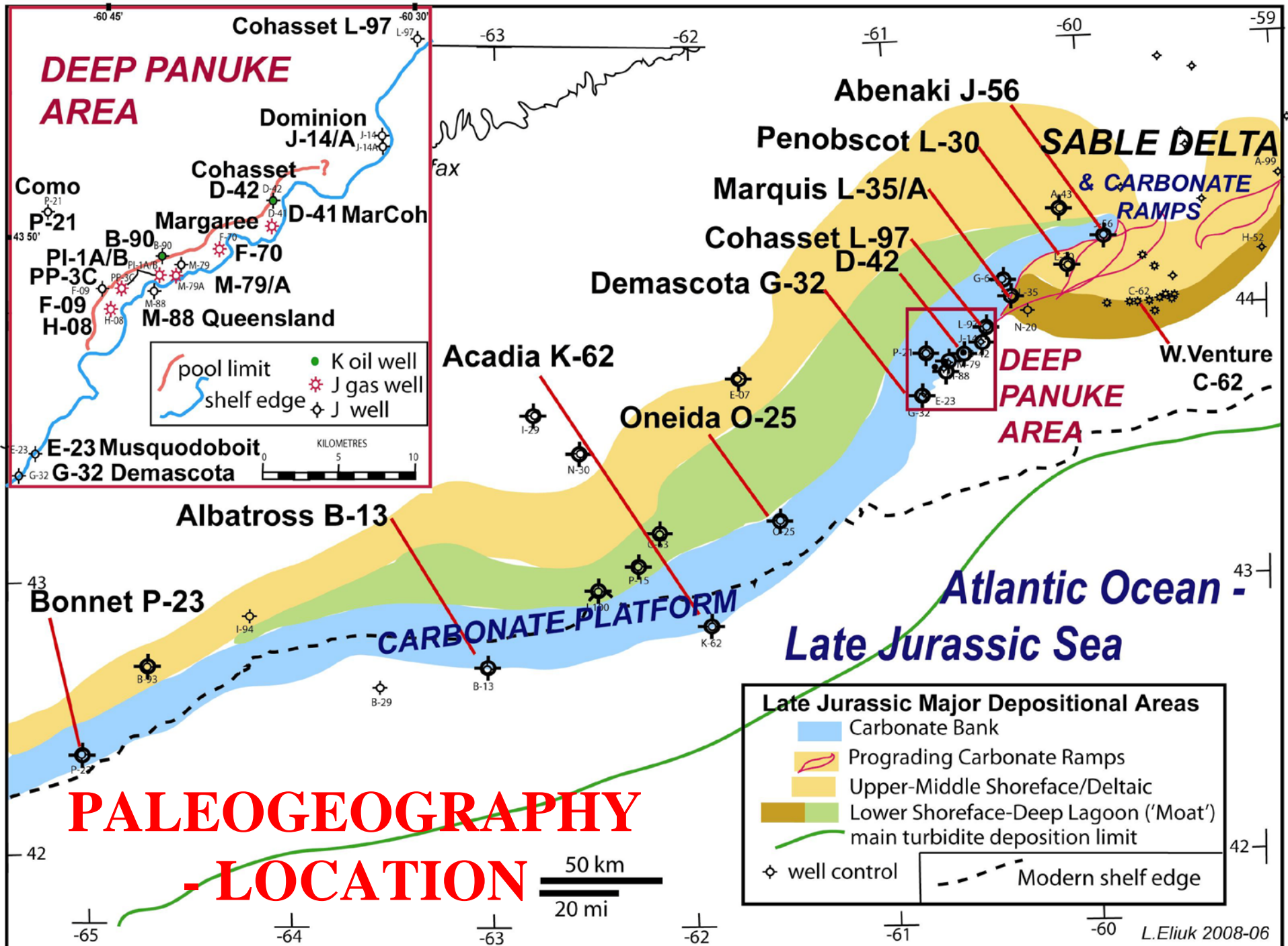
Upper Jurassic

ABENAKI
Nova
Scotia
Baltimore
Canyon



Siliceous sponge
reef belt

Reefs &
oolites



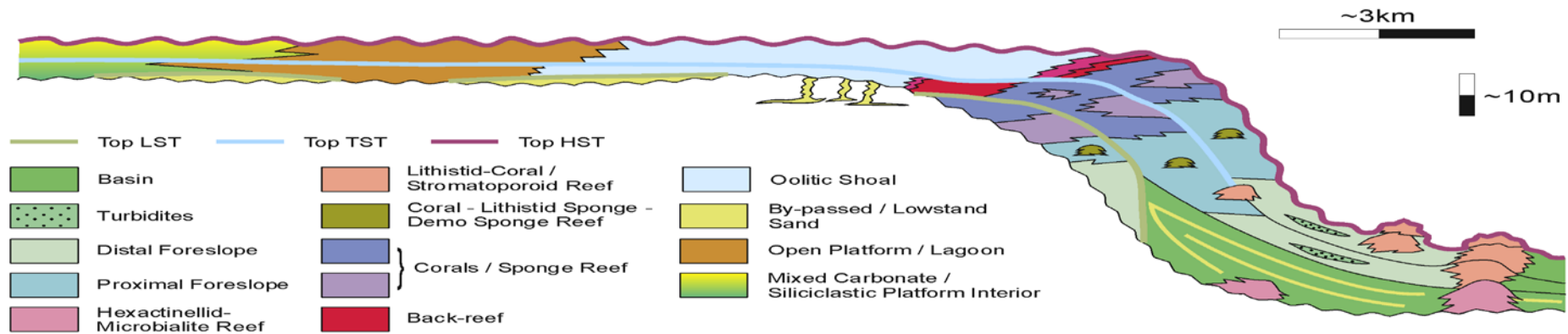
RESEARCH PROBLEM

Does a large siliciclastic delta have identifiable and significant influence on the margin and reefs of an adjacent large carbonate platform

“rivers, not temperature, organisms or chemistry appear to control the distribution of carbonates”

Chave 1967

ABENAKI DEPOSITIONAL MODEL – Panuke Trend



Depositional Sequence Model (idealized 4th order) Modified from Wierzbicki, Harland & Eliuk 2002

CARBONATE FACIES TEMPLATE

James Lee Wilson

(1974; Shell Canada <1969)

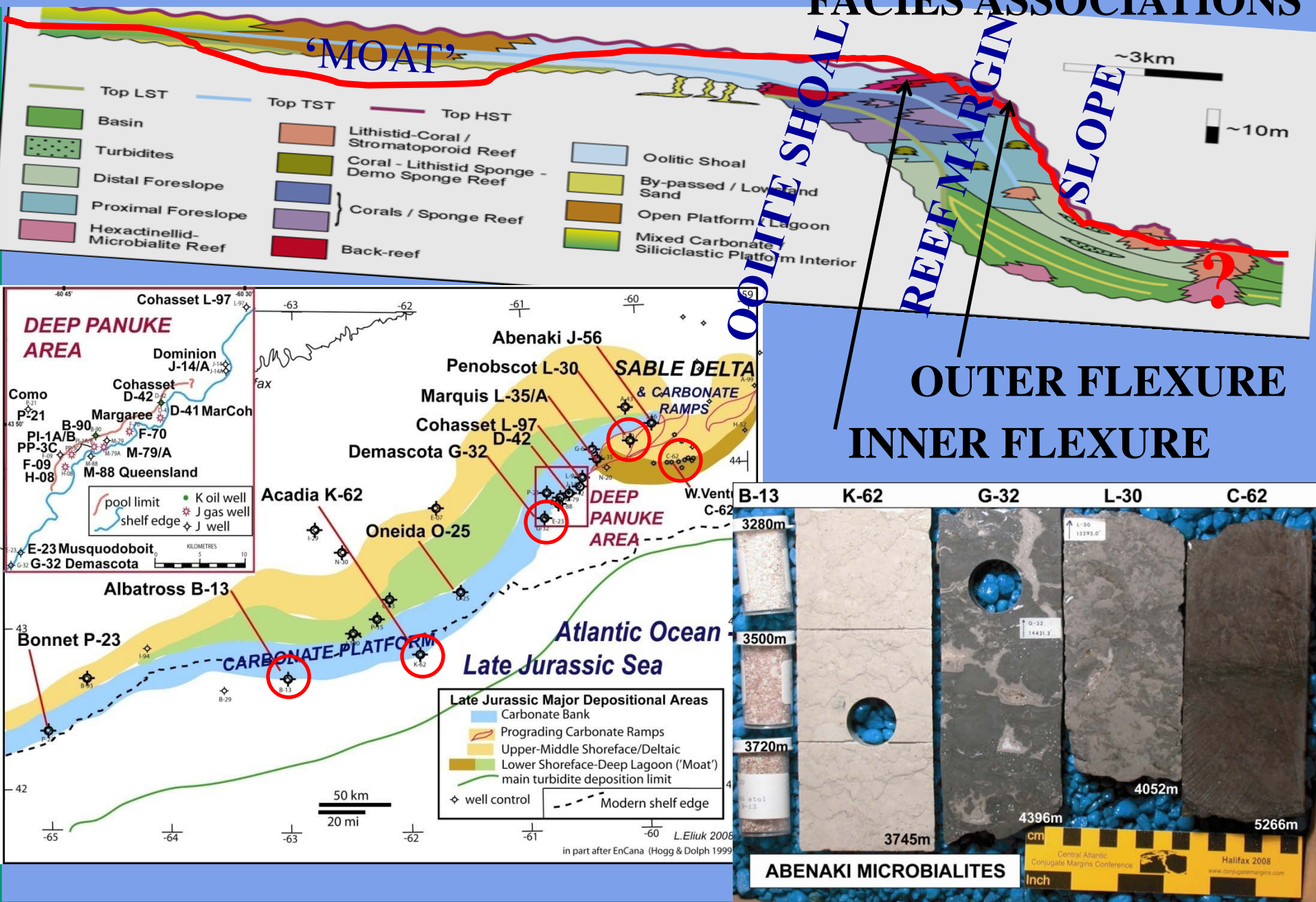
Comment on types of geologic colors:

“Dark, light and red”

J.L.Wilson 1975 classic text

ABENAKI DEPOSITIONAL MODEL – Panuke Trend

FACIES ASSOCIATIONS



Southwest **MICROBIALITES** Northeast

B-13

K-62

G-32

L-30

C-62

3280m

3500m

3720m

3745m

4396m

4052m

5266m

ABENAKI MICROBIALITES

cm

Central Atlantic
Conjugate Margins Conference

Inch

Halifax 2008

www.conjugatemargins.com

Southwest

Ooids

Northeast

B-13

F-09

M-79

L-30

2517m

3521m

3536m SS

3633m

3724m

3786m

3956m

4052m

ABENAKI OOLITES

cm

Central Atlantic
Conjugate Margins Conference

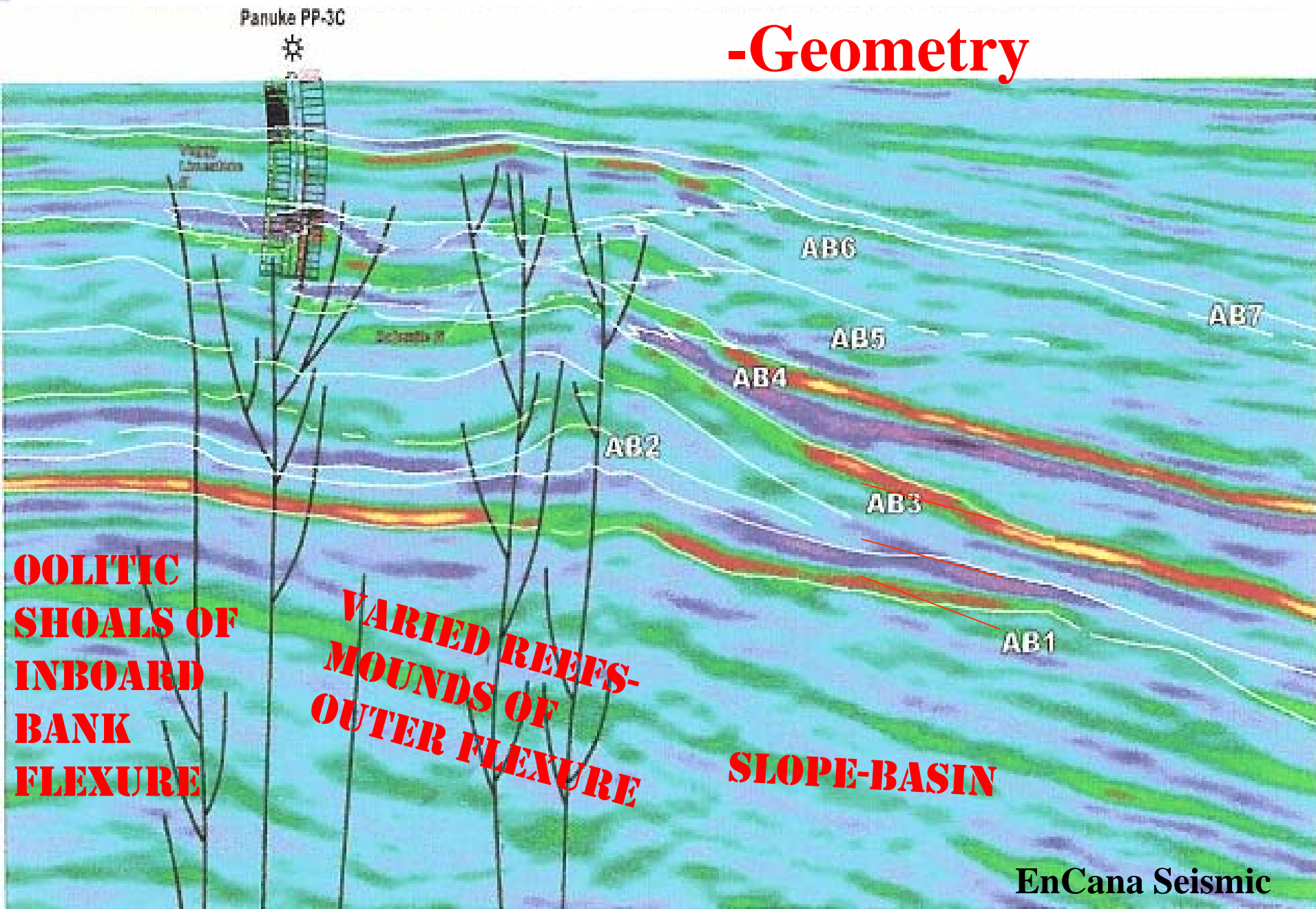
Inch

Halifax 2008

www.conjugatemarkins.com

Abenaki Margin Facies Association

-Geometry



Exploration Opportunity

(with some problems)

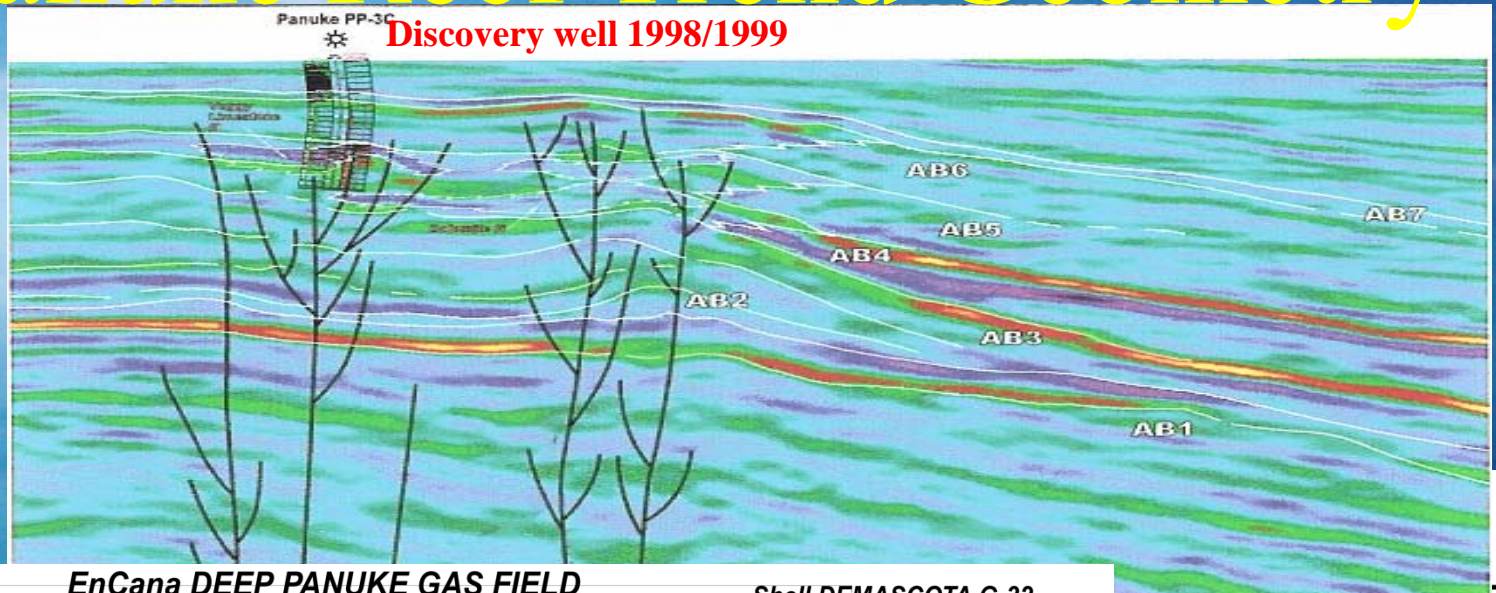
**Does a large siliciclastic delta
have identifiable and significant
control on the location of a reef
margin gas accumulation?**

“Imagination is more important than facts”

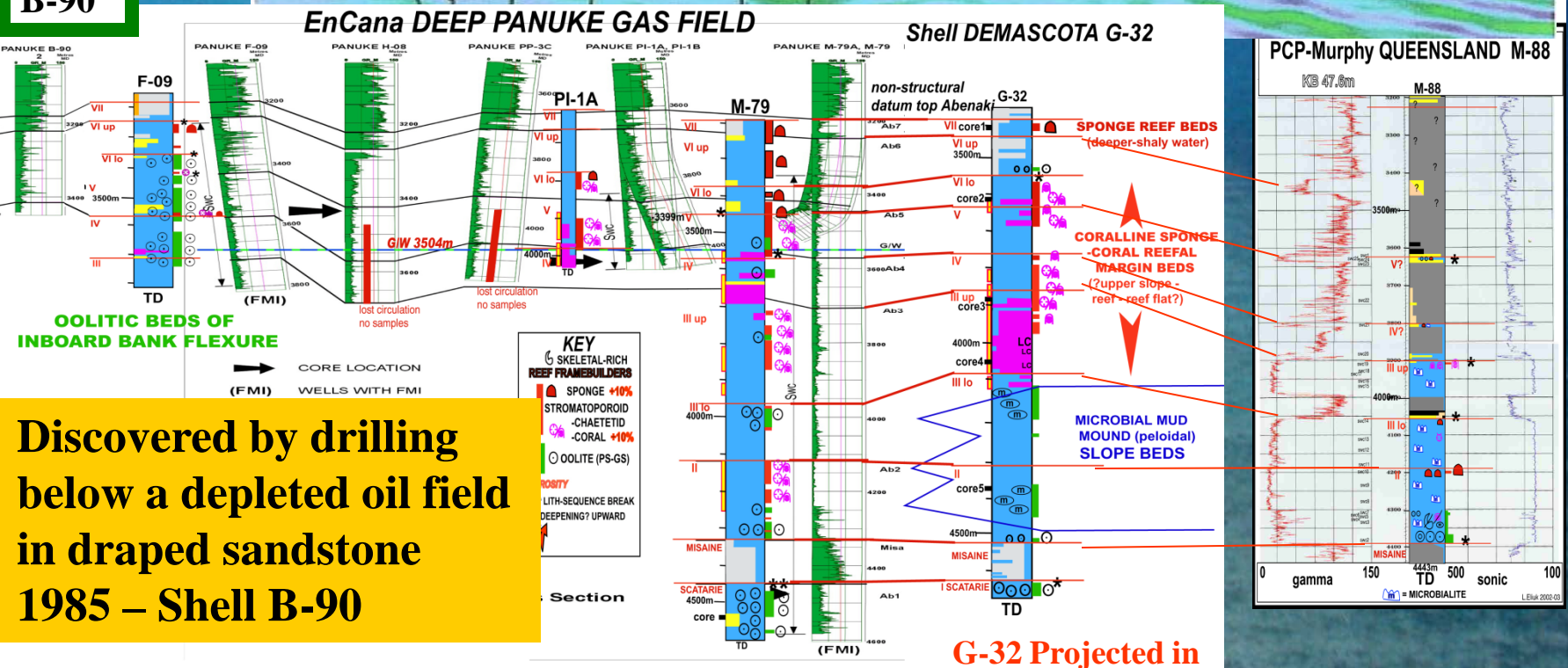
Einstein

*But never forget gas is found **by** drilling
... **with** imagination and seismic*

Panuke Reef Trend Geometry

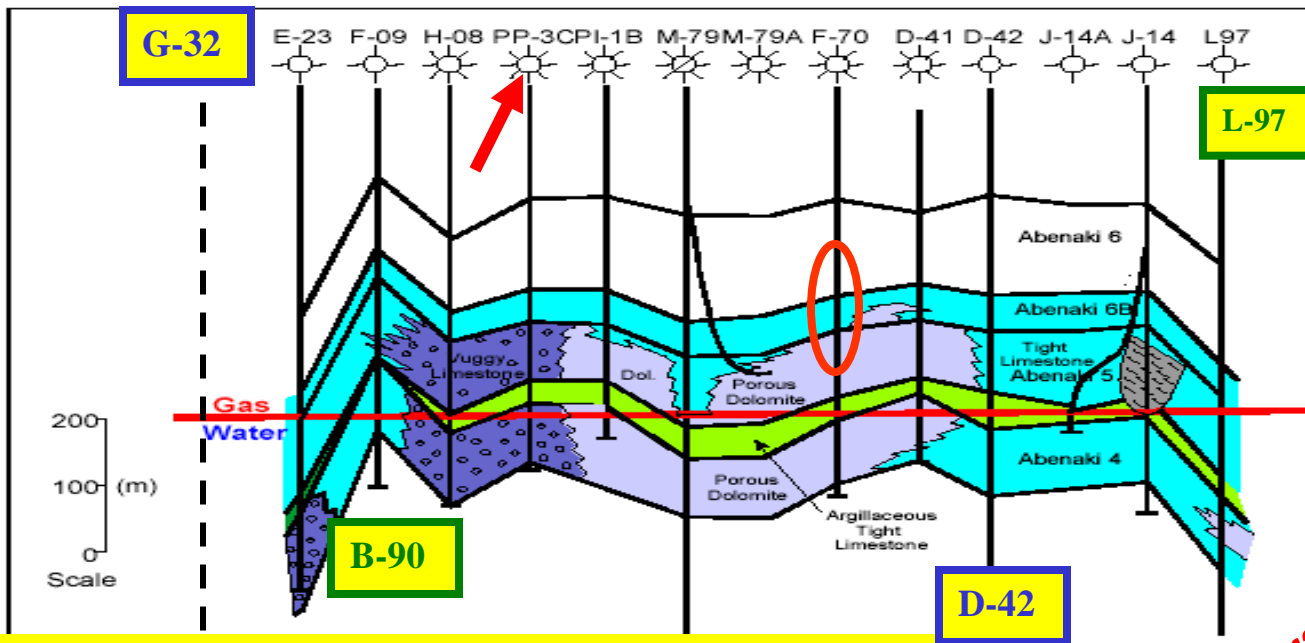


B-90



**Discovered by drilling
below a depleted oil field
in draped sandstone
1985 – Shell B-90**

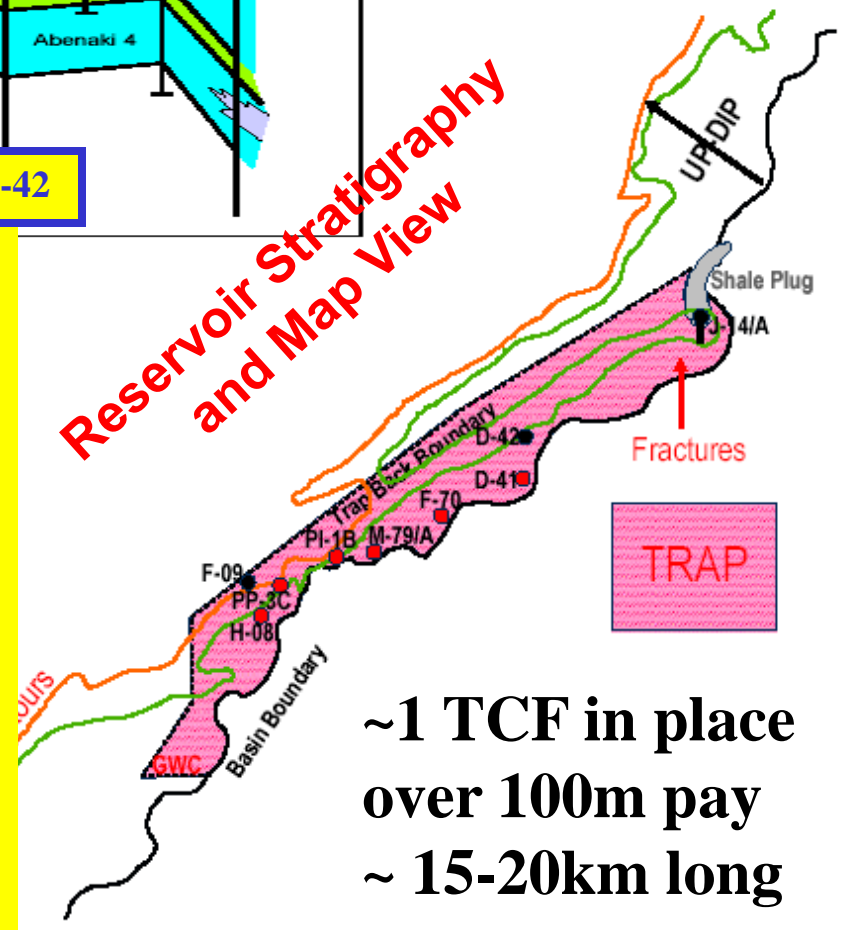
Deep Panuke – EnCana Plan 2006-11



PARADOXES of UJ Reefs and Deep Panuke

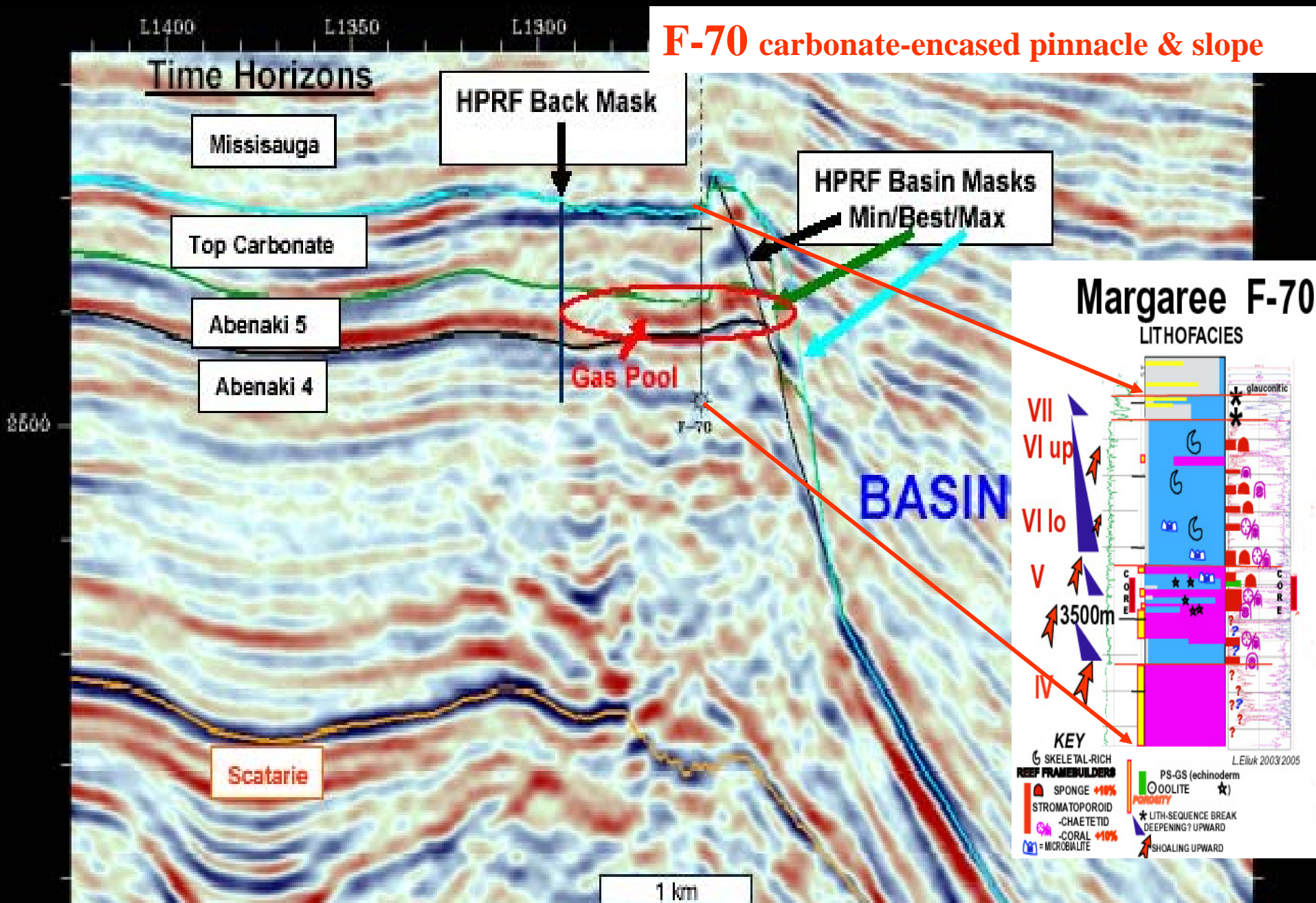
- 0- Drowned reefs and carbonate platforms – Schlager 1981
- 1- Lots of reefs ; lots of HC's ...BUT not in same place!
- 2 - Few HC-bearing reefs not close analogues ... ALL different!
- 3- Oolitic grainstones on shelf tight near Sabie Island paleodelta
- 4- Trap in deeper-margin reefs not platform shoals updip = strat trap
5. Top of carbonates not top of reservoir or major sequence
6. Margin complicated place with carbonate-encased pinnacles and forereef beds dipping 'landward'
- 7- Burial traps don't have to be porous or even carbonate! BC sponges
8. Ammonite anomalies do not have to be HCs or even porosity
- 9- Dolomites mostly evaporite-associated; Abenaki humid
- 10- Thick carbonate platform cut by big delta

Reservoir Stratigraphy
and Map View



~1 TCF in place
over 100m pay
~ 15-20km long

Figure 2.55: Deep Panuke Trap

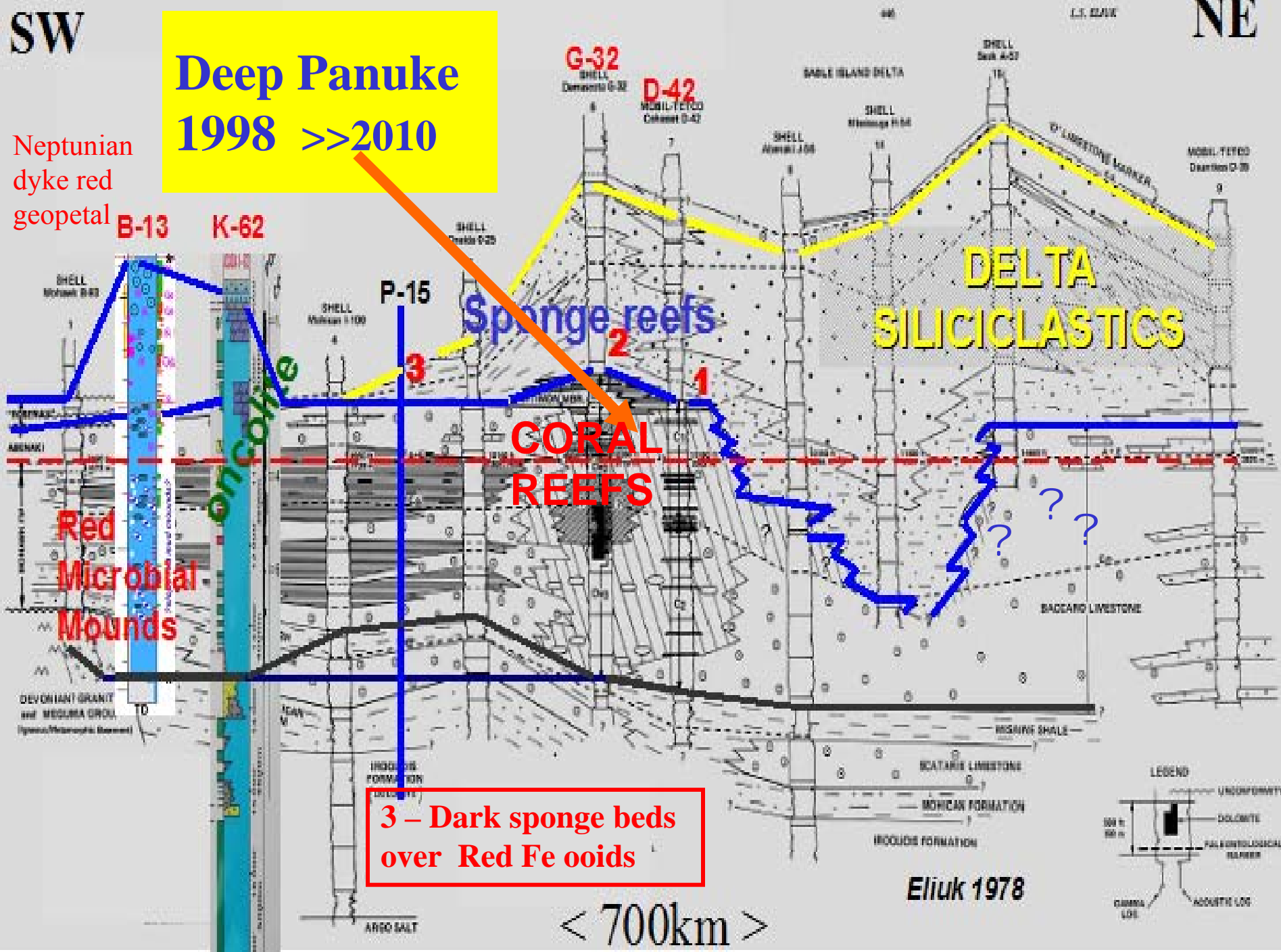


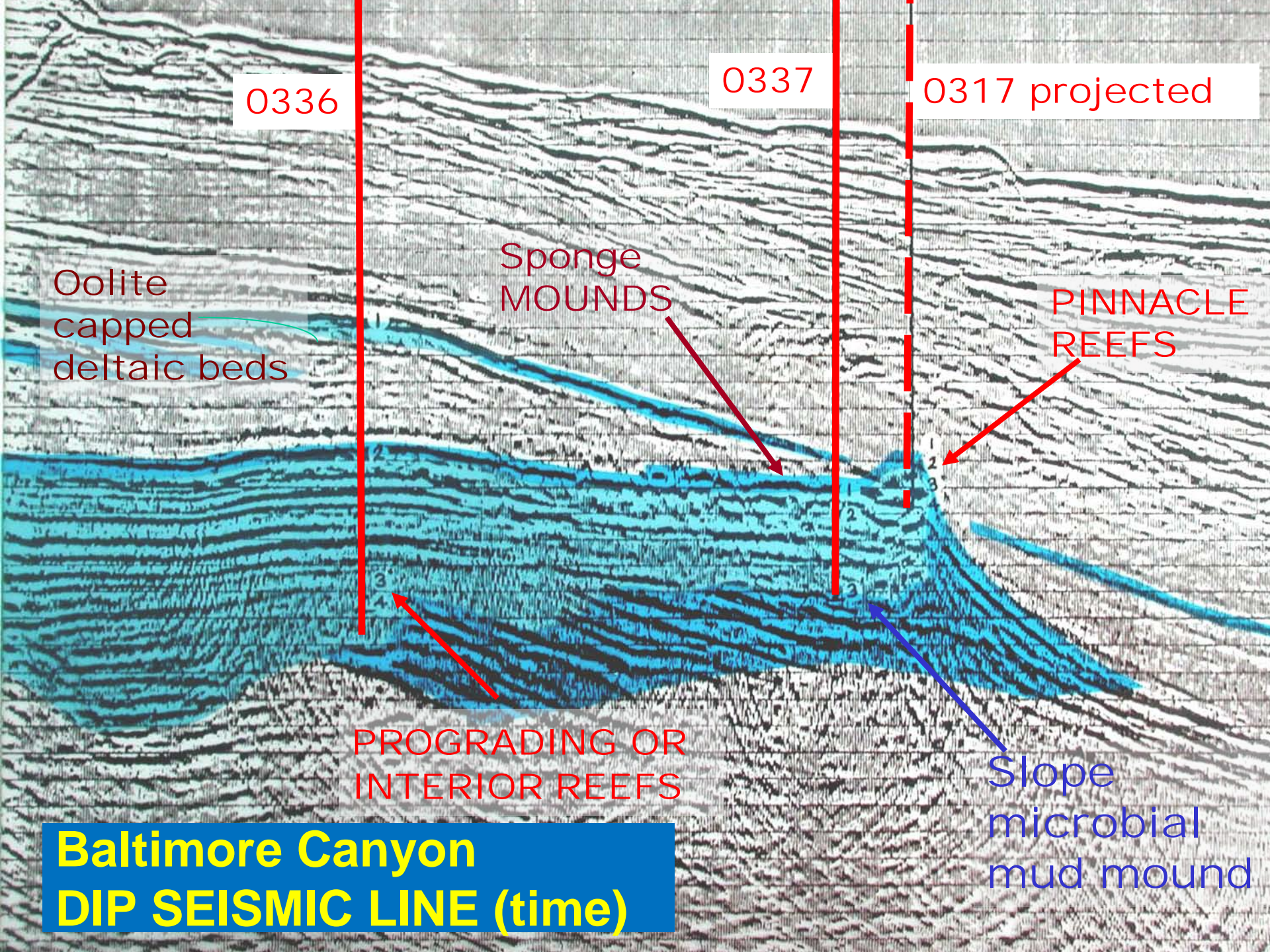
Margaree F-70 Seismic **Encana - Deep Panuke Report 2006**

Deep Panuke

1998 >>2010

Neptunian
dyke red
geopetal





0336

0337

0317 projected

Oolite
capped
deltaic beds

Sponge
MOUNDS

PINNACLE
REEFS

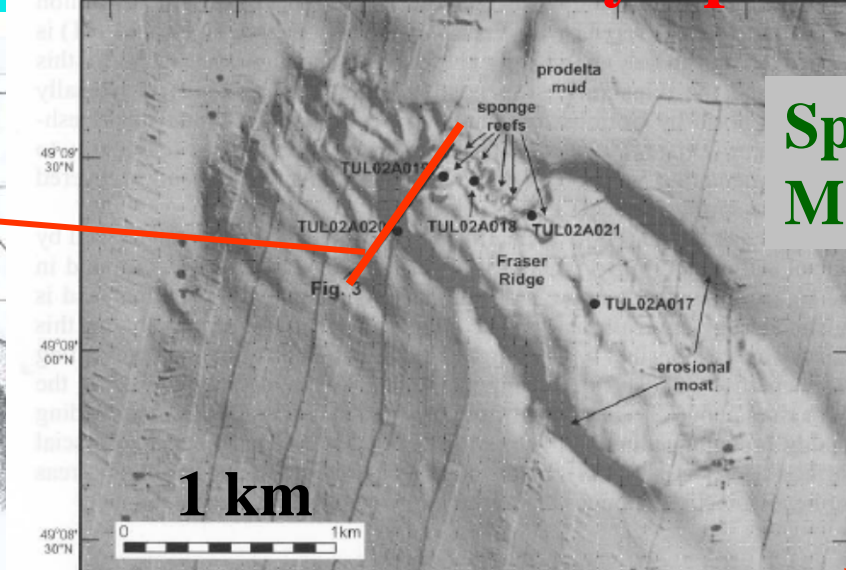
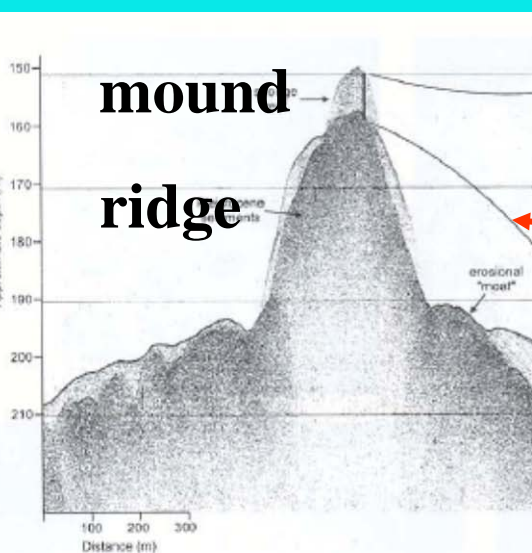
PROGRADING OR
INTERIOR REEFS

Slope
microbial
mud mound

Baltimore Canyon
DIP SEISMIC LINE (time)

Fraser Delta Sponge Reef

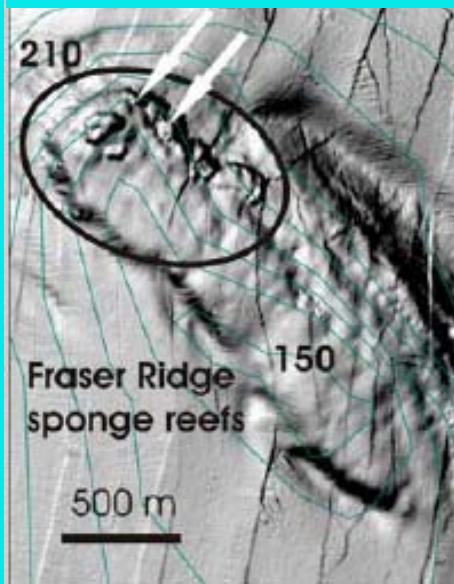
Vancouver BC Canada Winter Olympics



Seismic profile
VE X10

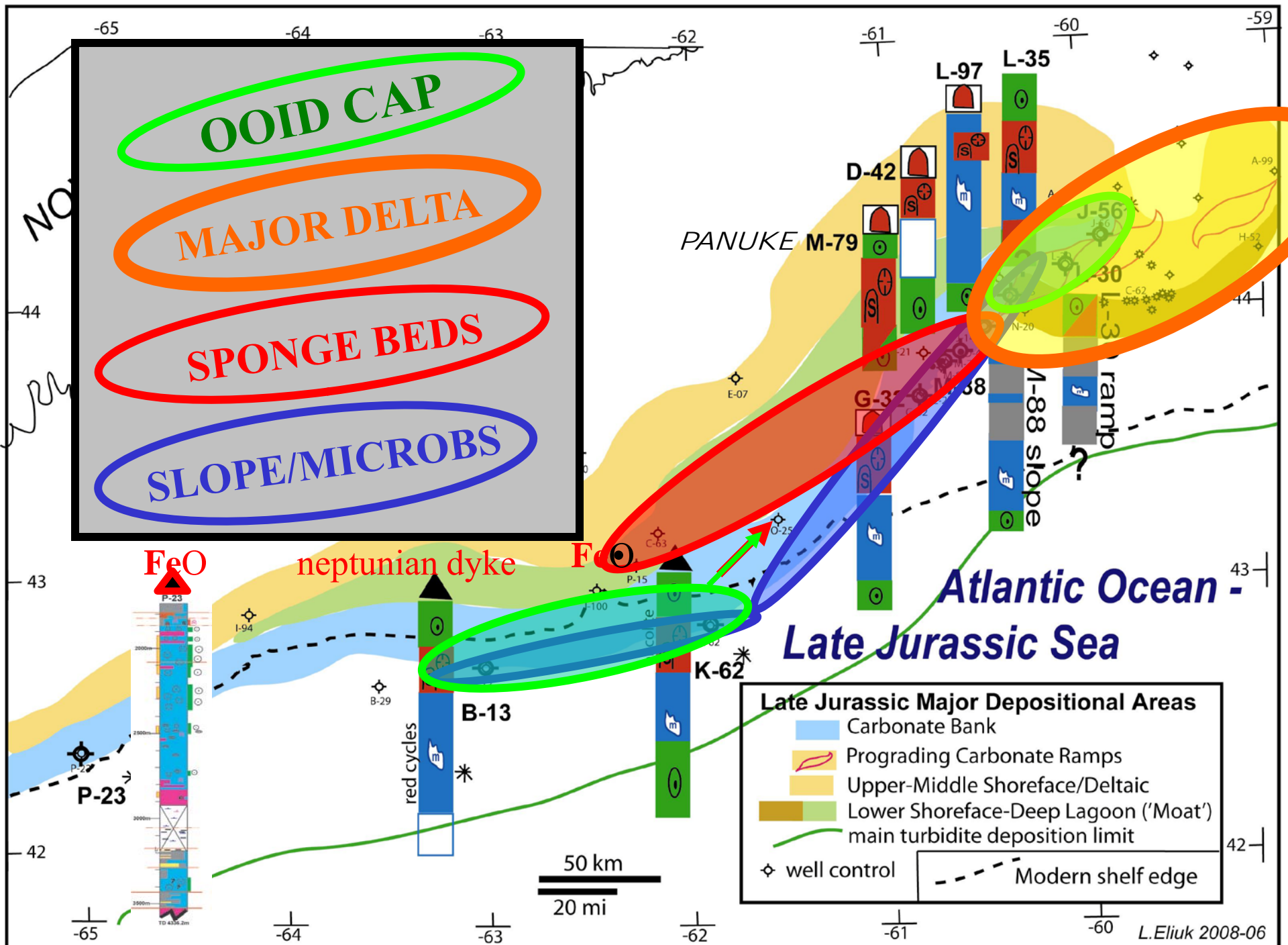
Conway,
Barrie and
Krautter
2004

Multibeam images



Location-Fraser
Ridge

*Aphrocallistes
vastus* siliceous
sponges in
shale matrix



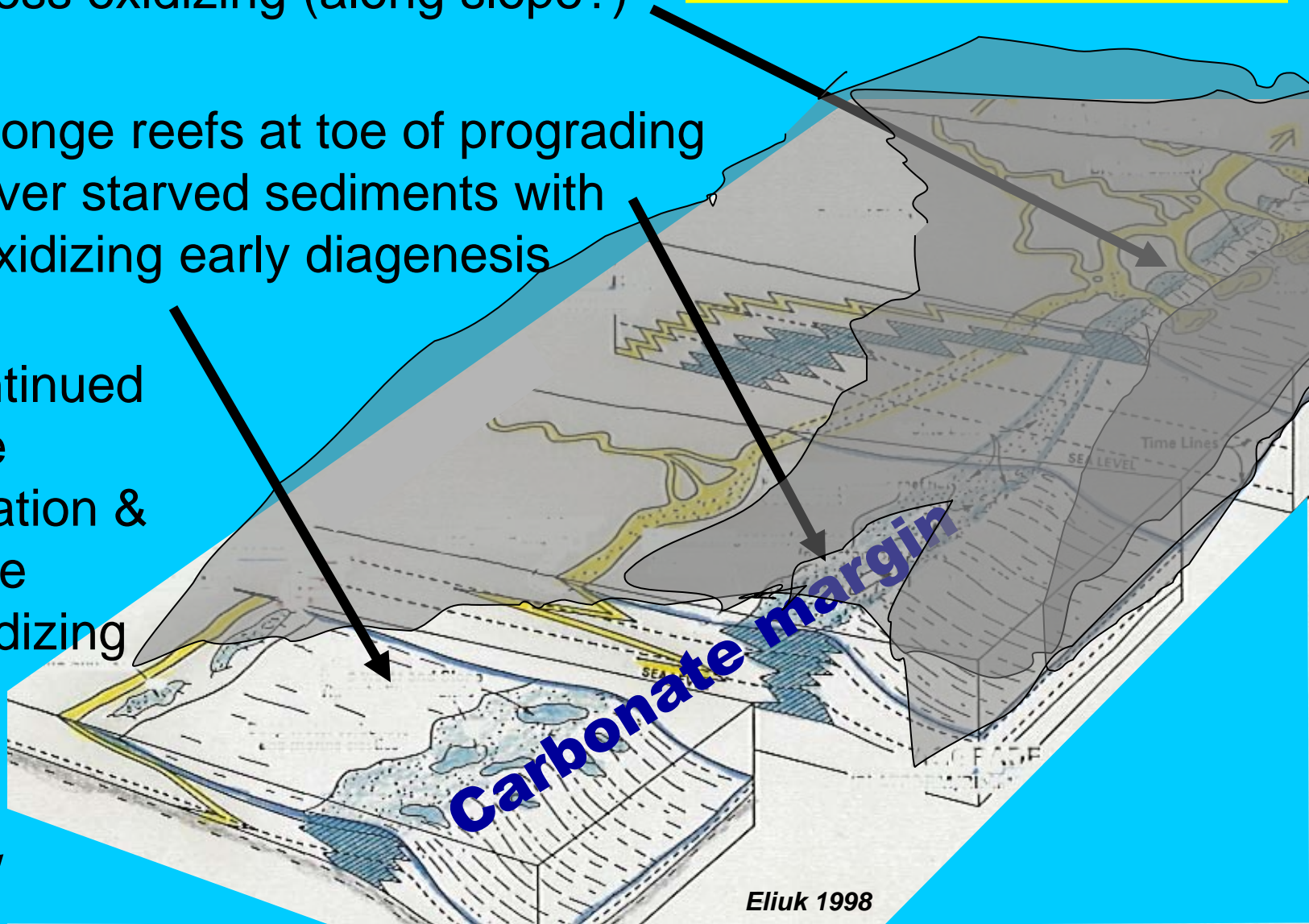
Diachronous sedimentation:

Proximal increasing clay-sand-turbidity-nutrients-less oxidizing (along slope?)

***Sable Island Delta
'point source'***

Medial sponge reefs at toe of prograding prodelta over starved sediments with seafloor oxidizing early diagenesis

Distal continued carbonate sedimentation & even slope highly oxidizing



Deep Panuke Hydrocarbon System

Trap & Reservoir 1 – reef complex (debris from reef)

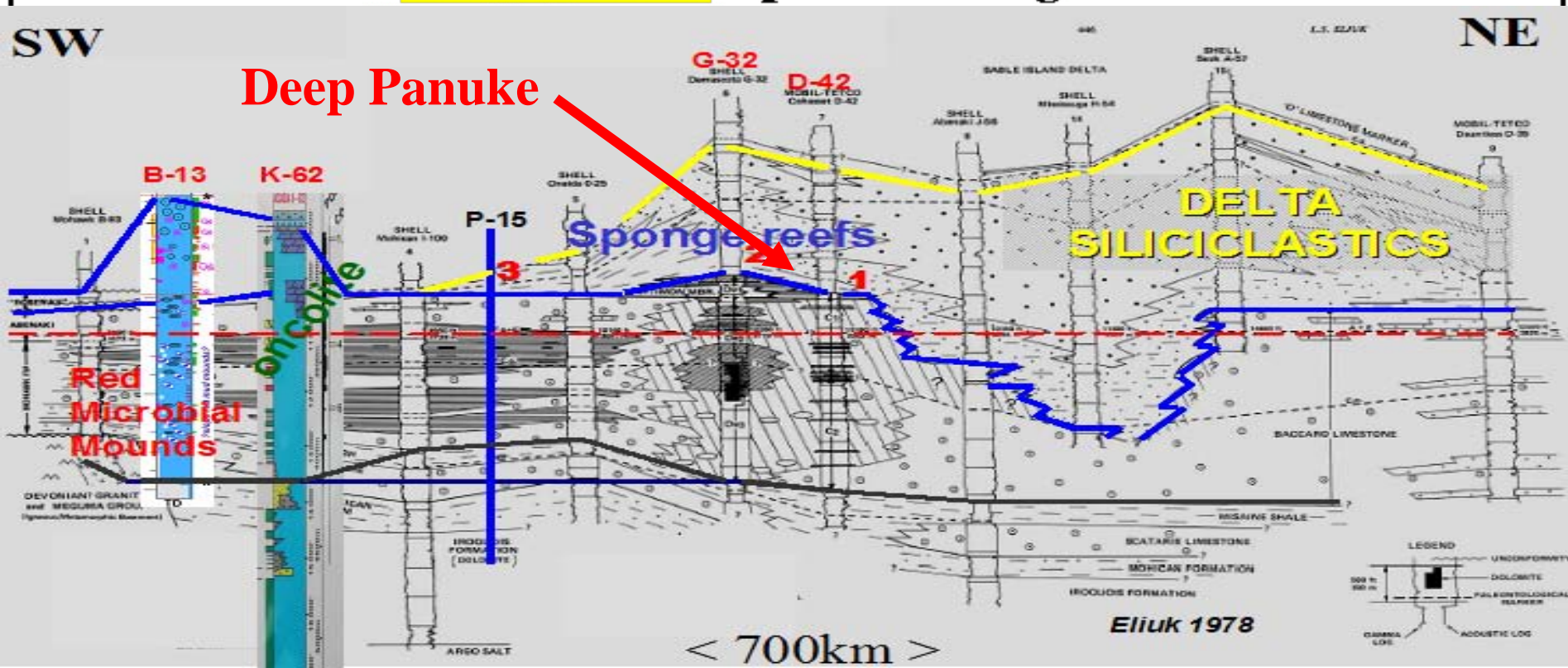
Seal 1 – Sponge reef ‘drowning’ & Shale ‘plug’

Seal 2 – Capping prodelta

Reservoir 2 – burial Φ /dolomite (fracture-fault conduits **migration**)

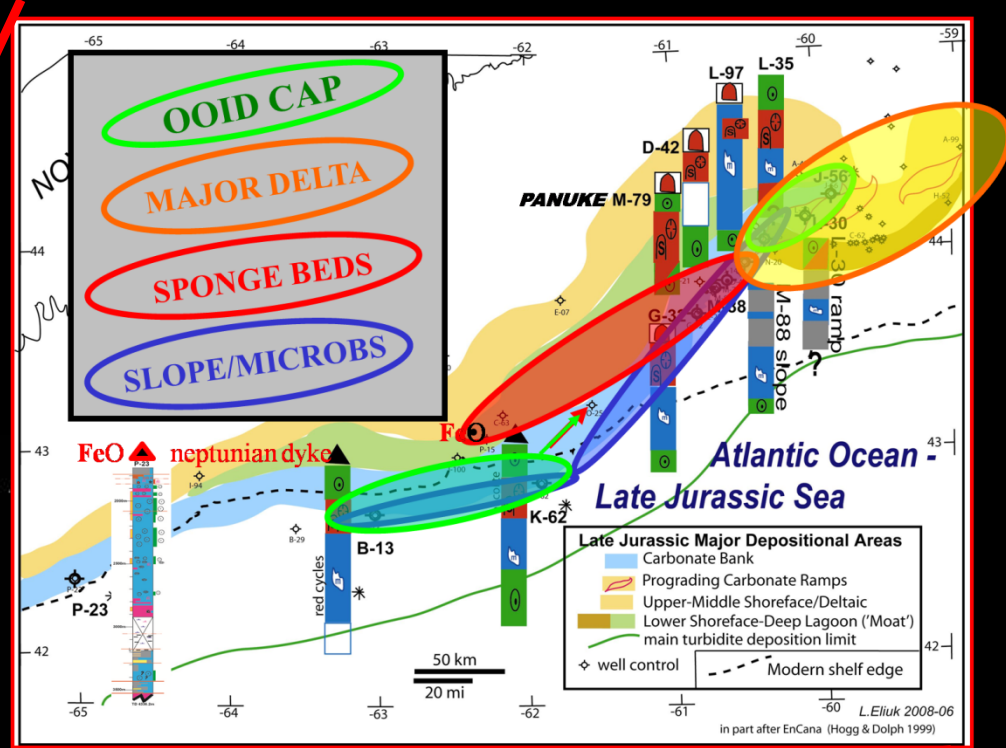
Strat’ Trap & Seal 3 – burial-cemented platform = lateral seal

Source Rock – prodeltaic lignitic-humic material



‘take-aways’---

-think laterally of
analogue-fractals



-diagenesis may
‘eat your lunch’ or make
it; but **deposition** (&
early seafloor alteration)
sets the table

Deep Panuke Hydrocarbon System

Trap & Reservoir 1 – reef complex (debris from reef)

Seal 1 – Sponge reef ‘drowning’ & Shale ‘plug’

Seal 2 – Capping prodelta

Reservoir 2 – burial Φ /dolomite (fracture-fault conduits **migration**)

Strat’ Trap & Seal 3 – burial-cemented platform = lateral seal

Source Rock – prodeltaic lignitic-humic material

Abenaki Formation

Deep Panuke

O Lst

Sable Island PaleoDelta

Barre Bank–Artimon Sponge beds

Misaine Shale – MFS maximum flooding surface

SW

700 km Strike Section

NE

THANK YOU

Leslie Eliuk