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*

Leslie Eliuk1

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1Earth Sciences, Dalhousie University & GeoTours Consulting, Halifax & Lunenburg, NS, Canada (geotours@eastlink.ca)

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 pinacles (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-coraline 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.

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Selected References

Chave, K.E., 1967, Recent carbonate sediments; an unconventional view: Journal of Geological Education, v. 15/5, p. 200-204.


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Leslie Eliuk
Dalhousie Earth Sciences – GeoTours Consulting
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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’

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

ABENAKI
Nova Scotia
Baltimore Canyon

Reefs & oolites

Siliceous sponge reef belt

L.Eliuk talk 2007
Krautter et al
PALEOGEOGRAPHY - LOCATION
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
PROBLEM – OPPORTUNITY

Sable Island Delta ‘point source’

*Lateral changes in carbonates of margin and reefs away from delta*
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 MICROBIALITES
Southwest  

OOIDS  

Northeast

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ABENAKI OOLITES
Abenaki Margin Facies Association

-Geometry

OOLITIC SHOALS OF INBOARD BANK FLEXURE

VARIED REEFS-MOUNDS OF OUTER FLEXURE

SLOPE-BASIN

EnCana Seismic
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

Discovery well 1998/1999

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

G-32 Projected in
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 Sable 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 complex; top place with carbonate-encased pinnacles and forereef beds dipping ‘landward’
7- Buildups don’t have to be porous or even carbonate! BC sponges
8. Amplitude 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

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

Figure 2.55: Deep Panuke Trap
L.Eliuk talk 2009
Margaree F-70 carbonate-encased pinnacle & slope
Deep Panuke
1998 >> 2010

Neptunian dyke red geopetal

3 – Dark sponge beds over Red Fe ooids

Coral Reefs
Baltimore Canyon
DIP SEISMIC LINE (time)

0336

0337

0317 projected

Oolite capped deltaic beds

Sponge MOUNDS

PINNACLE REEFs

PROGRADING OR INTERIOR REEFs

Slope microbial mud mound
Fraser Delta Sponge Reef

Vancouver BC Canada Winter Olympics

mound
ridge

Seismic profile
VE X10

Multibeam images

Location-Fraser Ridge

Sponge Mounds

Aphrocallisthes vastus siliceous sponges in shale matrix

Conway, Barrie and Krautter 2004

L.Eliuk talk 2007
PANUKE

Oceanic Cap

Major Delta

Sponge Beds

Slope/Microbes

FeO

Neptunian dyke

Late Jurassic Deformation Areas

Atlantic Ocean - Late Jurassic Sea

Late Jurassic Major Depositional Areas:
- Carbonate Bank
- Prograding Carbonate Ramps
- Upper-Middle Shoreface/Deltaic
- Lower Shoreface-Deep Lagoon ("Moat")

Main turbidite deposition limit

Well control

Modern shelf edge

in part after EnCana (Hogg & Dolph 1999)
Diachronous sedimentation:
Proximal increasing clay-sand-turbidity-nutrients-less oxidizing (along slope?)

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

Distal continued carbonate sedimentation & even slope highly oxidizing

Sable Island Delta 'point source'

Eliuk 1998
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

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Deep Panuke

Red Microbial Mounds

Sponge reefs

DELTA SILICICLASTICS

< 700km >

Eliuk 1978
‘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

- Reef complex (debris from reef)
- Sponge reef ‘drowning’ & Shale ‘plug’
- Capping prodelta
- Burial Φ/dolomite (fracture-fault conduits = migration)
- Burial-cemented platform = lateral seal
- Prodeltaic lignitic-humic material

Abenaki Formation
Deep Panuke
Sable Island PaleoDelta
Biscaro Bank-Artimon Sponge beds

Misaine Shale – MFS maximum flooding surface
700 km Strike Section

SW NE

Thank you Leslie Eliuk