CCS Potential on the Scotian Shelf, Offshore Nova Scotia

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Sable Island from the west, 44 km long, ~ 175km offshore
https://www.dal.ca/sites/hydro/SableResearch.html

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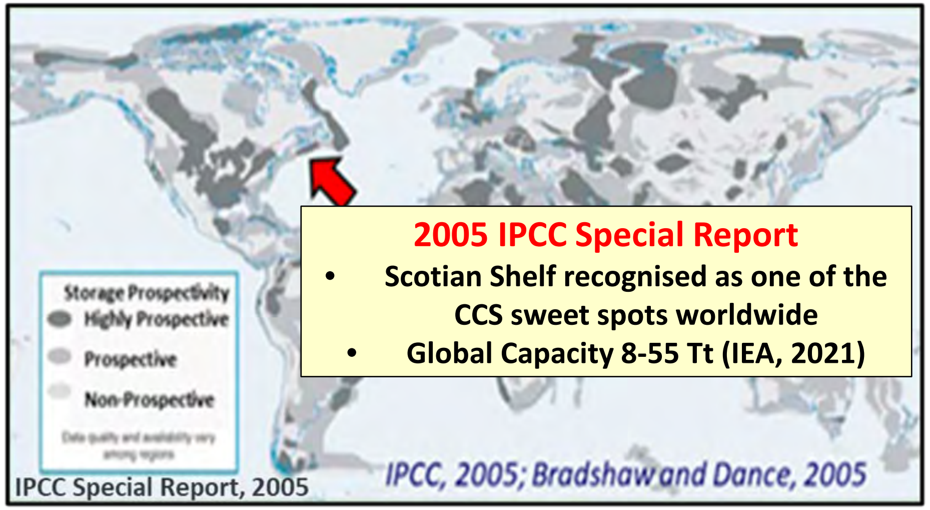
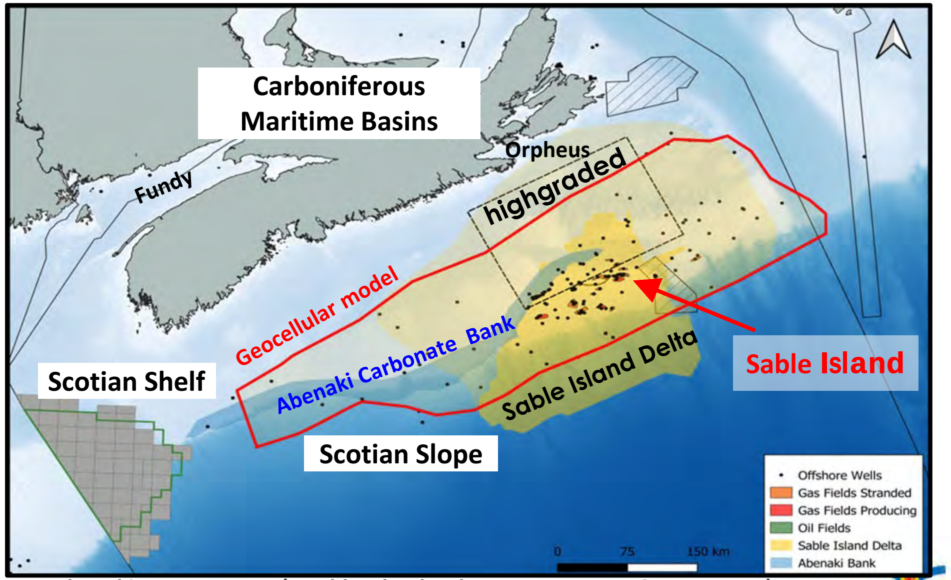
Key Points & Outline

- 2005 Scotian Shelf identified as highly prospective (IPCC)
  - Incorporates screening & ranking of Canadian Basins (Bachu, 2003)
- 2010 Nova Scotian Basins qualitatively screened for CCS (Wach et al)
  - **Low potential in Carboniferous basins and Scotian Slope** (1 slide each here)
    - 2014 CCS1 well drilled near Sydney airport: low effective PHI-K
    - CCS potential limited to salt caverns and coal seams
  - **Some potential in Fundy Basin** (1 slide) & Orpheus Graben (not assessed here)
  - **High potential on Scotian Shelf** (bulk of this talk)
- 2021 Assessments of Scotian Shelf: DNRR, Dal., & EAGE student comps.
  - Prompted by published atlases worldwide – used similar methodologies
  - **World-class deep saline aquifers: 100-200 Gt, >1000 Tt upside; 3% E**
  - **Modest capacity in 8 depleted & 15 stranded gas fields: total ~200 Mt; 75% E**
- 2022 Ranked fields & preliminary dynamic modeling of highgraded area
  - **Understanding entire plumbing system & pressure regime is critical**
- 2023 Recommend expert static & dynamic modeling; rock physics for 4D monitoring; project screening (pilot ➔ regional ➔continental)





Abenaki CNSOPB, 2005), Sable Island Delta CNSOPB, 2012 & SOEI, 1995)

* E = Storage Efficiency. Mt = 10^6 tonnes, Gt = 10^9 tonnes. Tt 10^{12} tonnes.

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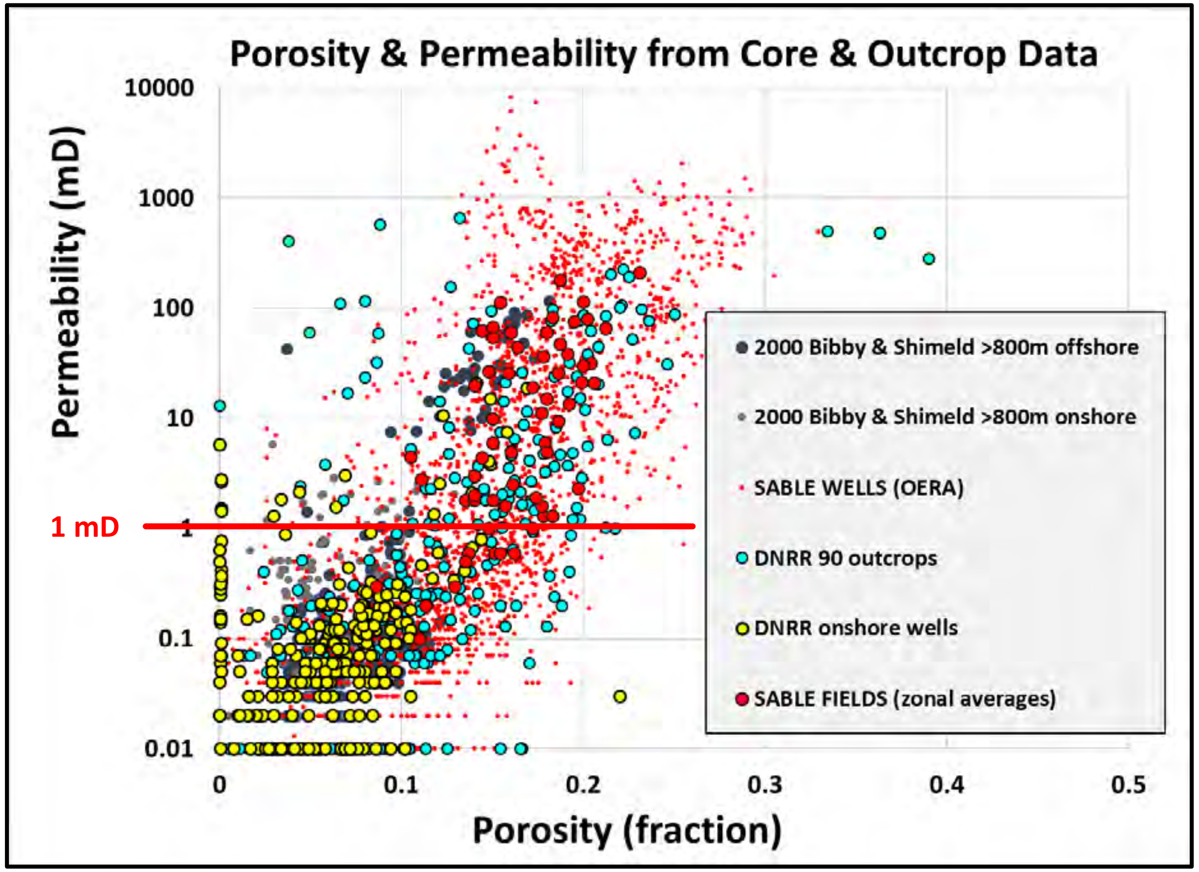
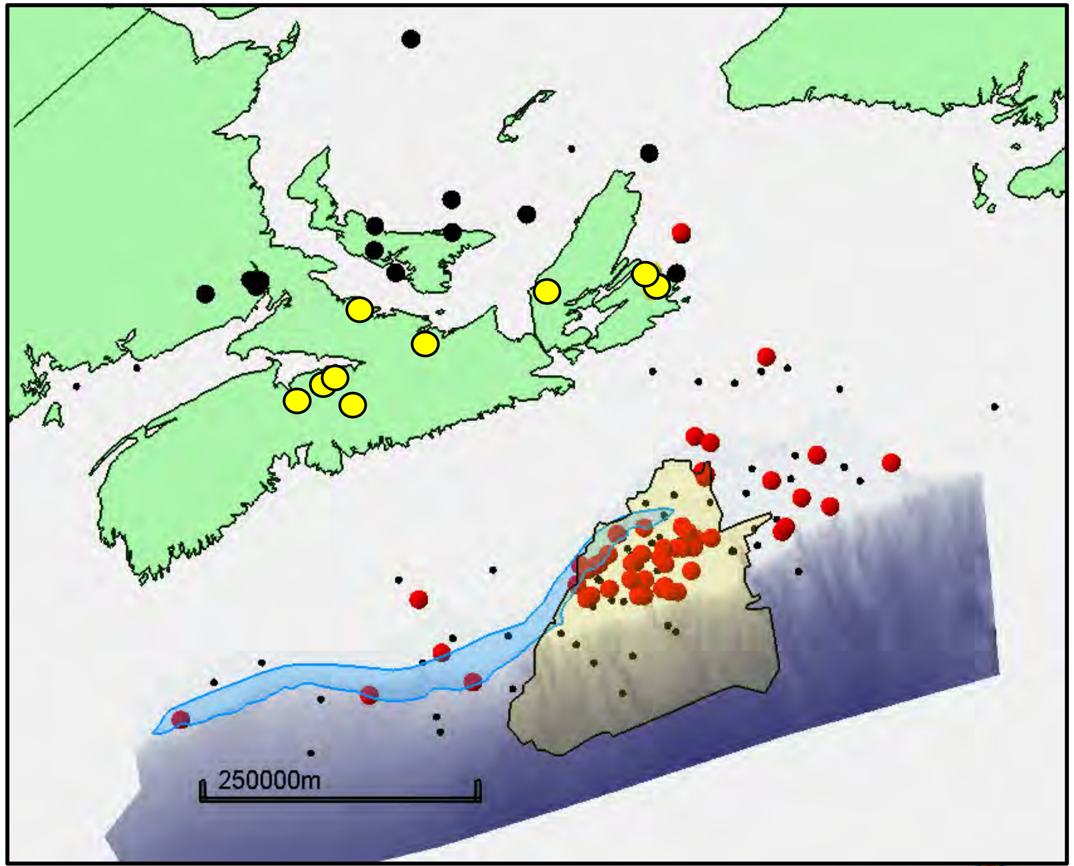
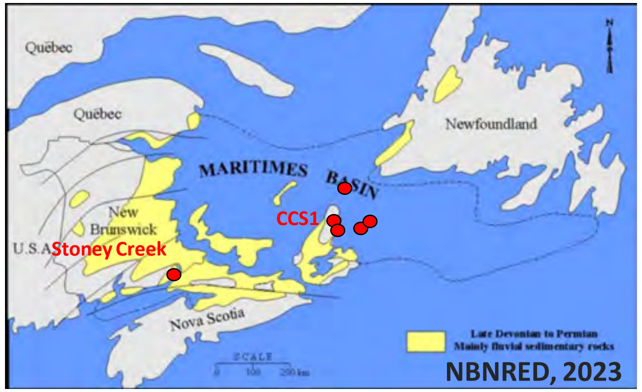
Nova Scotian Basins - Effective Porosity-Permeability (PHI-K) Lab Data from core

- Scotian Shelf (Red): High quality subsurface reservoirs / aquifers. Excellent for CCS.
- Onshore Carboniferous Basins (Yellow): Low quality. Poor CCS targets.
- Onshore outcrops (light blue): alluring but misleading. Weathered and/or not at subsurface conditions.



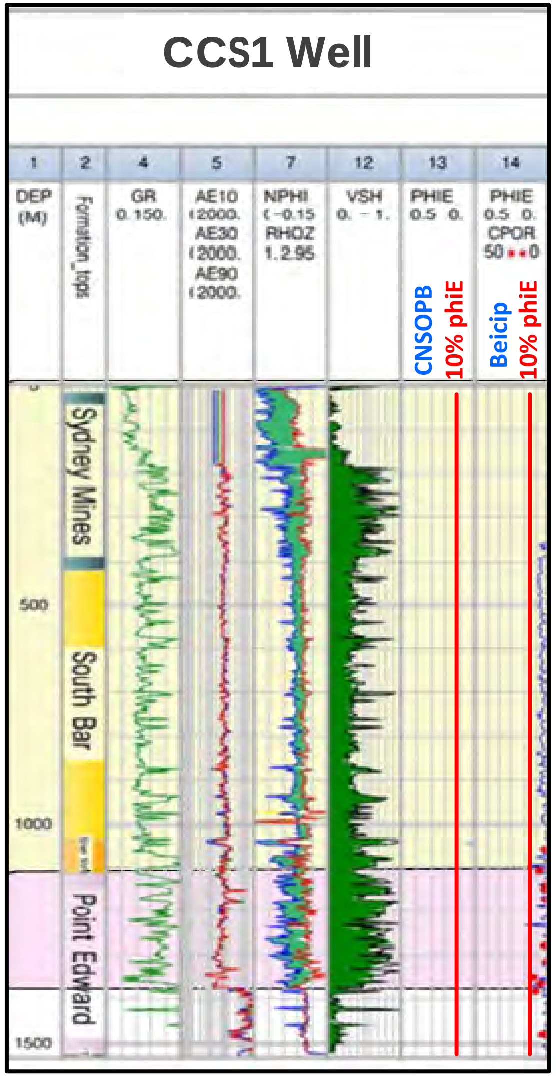


Maritimes Basins: Sydney Basin 2017 PFA; New Brunswick production



- 2017 Sydney Basin PFA (Westphalian: Cumberland - Mabou)
  - 5 wells: CNSOPB Avg.effective porosities 0.1 - 3.3%
  - Beicip-Franlab Avg. effective porosities 0.6 – 2.7%

	PHIE values from CNSOPB petrophysical interpretation		PHIE values from BF petrophysical interpretation		PHIT values from BF petrophysical interpretation		
Formation	Max	Avg	Max	Avg	Min	Max	Avg
Pictou	10%	0,5%	10%	0,8%	5%	21%	6,1%
Sydney Mines	10%	0,3%	10%	1,0%	1%	23%	6,4%
Waddens Cove	10%	0,4%	10%	2,7%	2%	19%	6,4%
South Bar	10%	0,3%	10%	2,7%	1%	19%	5,7%
Silver Mines	10%	0,1%	10%	0,8%	2%	17%	6,5%
Point Edward	10%	0,0%	10%	1,5%	0%	24%	5,7%
Cape Dauphin	0%	0,0%	6%	0,6%	2%	9%	6%
Woodbine Road	0%	0,0%	10%	1,2%	1%	13%	6%
Meadows Road	8%	3,3%	10%	1,4%	0%	14%	4,4%
Sydney River	10%	0,1%	9%	2,6%	0%	12%	6,2%



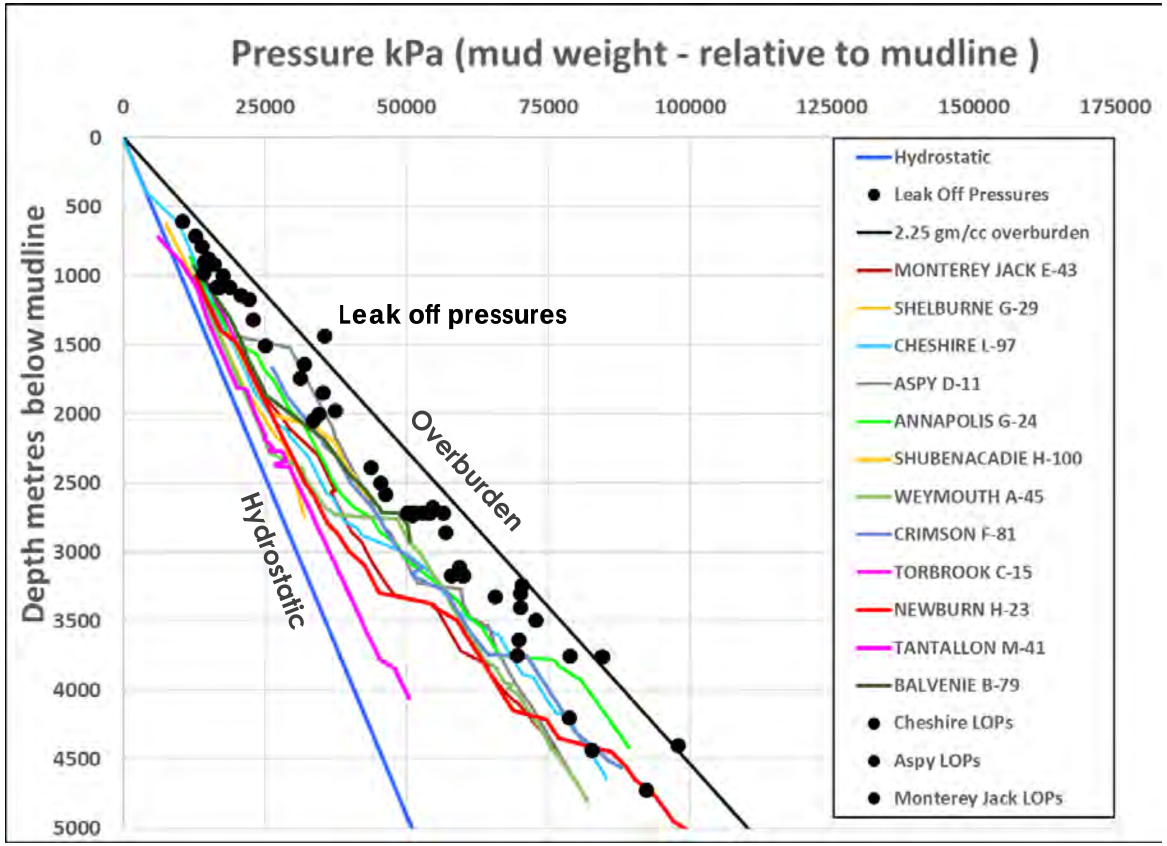
- HC fields in New Brunswick
  - Tournaisian: Albert / Horton
  - Hydraulic fracking at McCully
  - Nitroglycerine at Stoney Creek
  - Log porosities 4-8%
  - In situ permeabilites < 0.1 mD (LeBlanc et al, 2011)

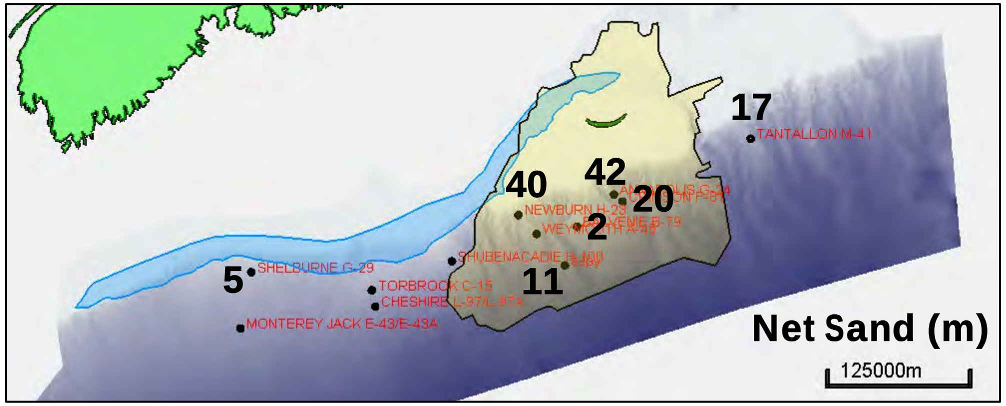
St Peter, 2000 (Fracturing Stoney Creek Field well with nitroglycerin, circa 1940).

New Brunswick first well 1859 – same year as Colonel Drake (Ontario dug well – Tripp - got oil in 1854/5)

Scotian Slope

- **Storage capacity limited by:**
  - **Lack of effective porosity and permeability**
  - **Overpressure (via mud weights – limited tests)**





Net sand reported by CNSOEB						
Name		**RT(m)**	**WD(m)**	**TD(m)**	**Net Sand (m)**	**NTG**
Annapolis	G-24	35.5	1711	6182	42	0.0095
Aspy	D-11/A	31.0	2771	7400	11	0.0024
Balvenie	B-79	25.0	1803	4750	2	0.0007
Cheshire	L-97/A	31.7	2142	7068	0	0.0000
Crimson	F-81	21.4	2092	6676	20	0.0044
Monterey Jack	E-43	31.7	2118	6692	0	0.0000
Newburn	H-23	24.0	977	6070	40	0.0079
Shelburne	G-29	25.0	1154	4005	5	0.0018
Shubenacadie	H-100	24.1	1477	4200	0	0.0000
Tantallon	M-41	24.0	1516	5602	17	0.0042
Torbrook	C-15	25.0	1675	3600	0	0.0000
Weymouth	A-45	25.0	1690	6520	0	0.0000
		323	21123	68765	137	0.0029

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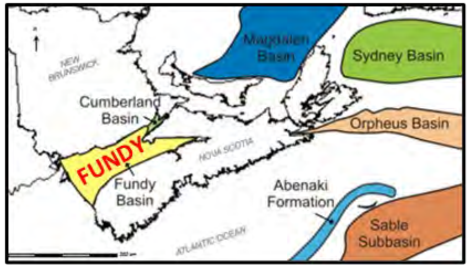
Fundy Basin: Scoping volumes, based on John Wade et al 1996 (maps; 2 wells)

- Wolfville Clastics – projecting well parameters basin-wide (typical clastic storage efficiency E) .

	Length	Width	Area	Cumulative Net Thickness			NRV	Average Porosity	NPV	Storage Efficiency	Storage Volume	Dens	Storage Capacity
	km	km	$10^9 m^2$	m			$10^9 m^3$	fraction	$10^9 m^3$	fraction	$10^9 m^3$	gm/cc	Gt
Wolfville - Cape Spencer Well	180	60	10.8	100			1080	0.2	216	0.03	6	0.75	4.9
Wolfville - Chinampas Well	180	60	10.8	280			3024	0.1	302	0.03	9	0.75	6.8



Wach et al, 2009

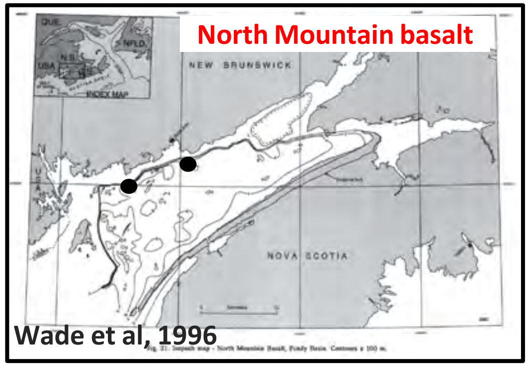
- N. Mountain Basalt : Storage resource, caprock or neither? Phi from groundwater study. (E is a guess)

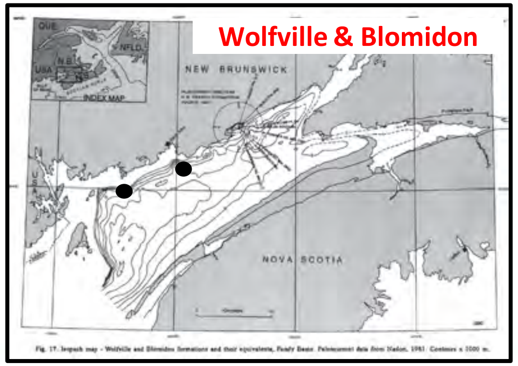
	Length	Width	Area	Average Thickness	GRV	Average NTG	NRV	Average Porosity	NPV	Storage Efficiency	Storage Volume	Dens	Storage Capacity
	km	km	$10^9 m^2$	m	$10^9 m^3$	fraction	$10^9 m^3$	fraction	$10^9 m^3$	fraction	$10^9 m^3$	gm/cc	Gt
North Mountain Basalt	180	60	10.8	300	3240	0.6	1944	0.07	136	0.05	7	0.75	5.1
North Mountain Basalt	180	60	10.6	300	3180	0.4	1272	0.05	64	0.03	2	0.75	1.4
North Mountain Basalt	180	60	10.6	300	3180	0.2	636	0.03	19	0.01	0	0.75	0.1

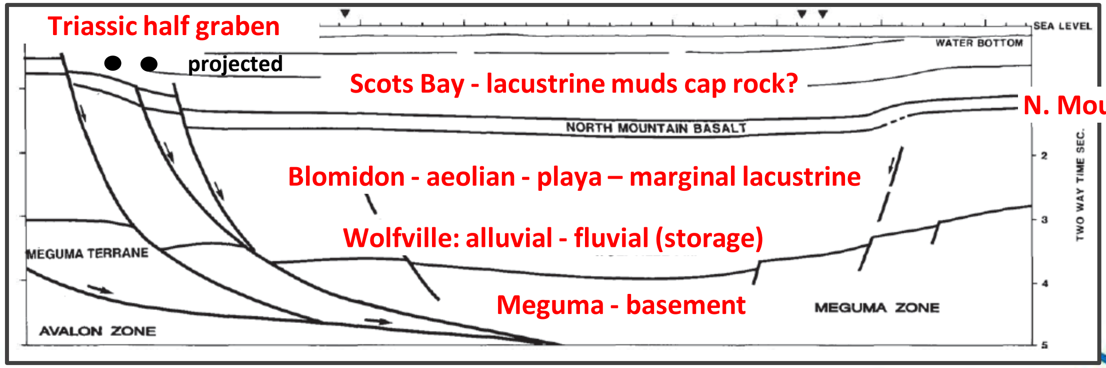
Geological unit	Hydraulic conductivity (K, m/s)	Porosity (n, %)	Specific storage (S_s, m^{-1})
North Mountain Fm.	10^{-7}	5	10^{-5}
Blomidon Fm.	10^{-5}	11	10^{-5}
Wolfville Fm.	5×10^{-5}	28	10^{-4}
Tills	10^{-7}	20	10^{-3}
Glaciolacustrine deposits	10^{-7}	15	10^{-3}
Glaciofluvial deposits	10^{-5}	35	10^{-2}
Colluviums	10^{-5}	35	5×10^{-3}

Gauthier et al, 2009

- Reasonable ~ 5 Gt potential in Wolfville. Speculative in basalt (much older than Icelandic basalts).
- Containment & environmental may be issues – currently building a geocellular model.







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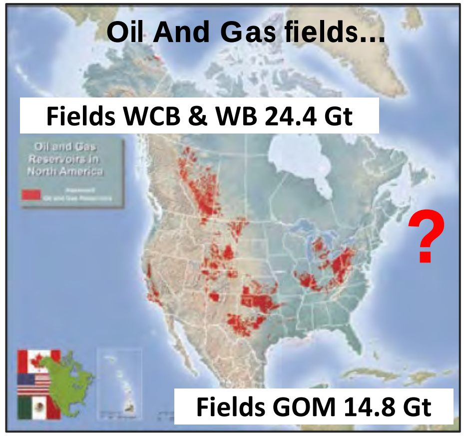
Background: CCS Atlases

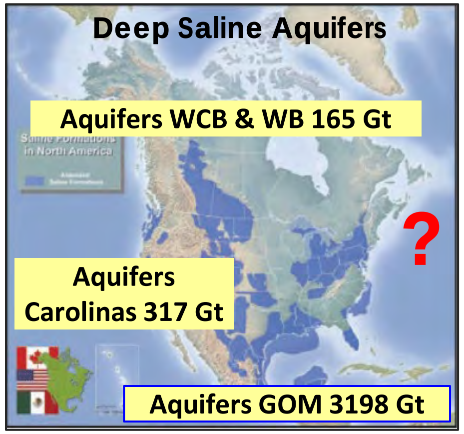
- ➢ **N. American & European atlases stimulated the 2021 assessments**
- ➢ **Major Scotian Shelf potential in deep saline aquifers**

Base Case CCS Capacity (Gt)			
Area	**Aquifers (Gt)**	**Fields (Gt)**	**Source**
GOM	3198	14.8	2012 USDOE, NRC, SdE
NE USA	479		2019 Batelle
Carolinas	317		2012 USDOE, NRC, SdE
Scotian Shelf	100-200	0.1	2021 DRR, Dalhousie
WCB & WB	165	24.4	2012 USDOE, NRC, SdE
UK	70	8	2014, Bentham et al
Norway	45	13	2021, NPD

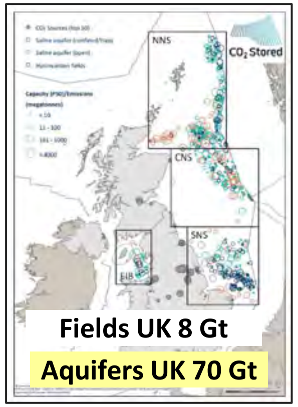
- ➢ **Modest potential for fields– due to low HC endowment**
  - **Will address**

N.America 2012 (US DOE, NRC, Secretaria de Energia)





UK (Bentham et al, 2014)



Norway (NPD)

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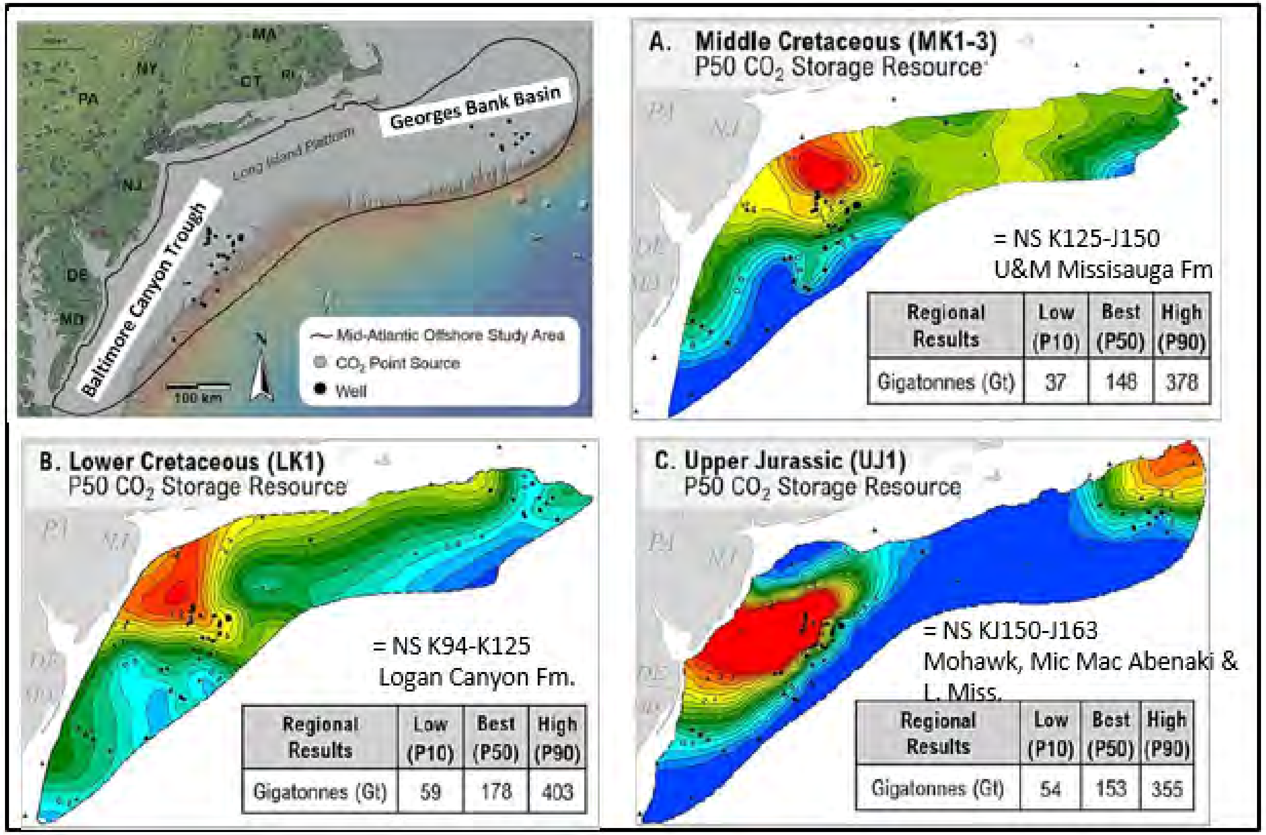
Background: NE USA Batelle 2019 CCS Study (US DOE, Gupta et al 2019)

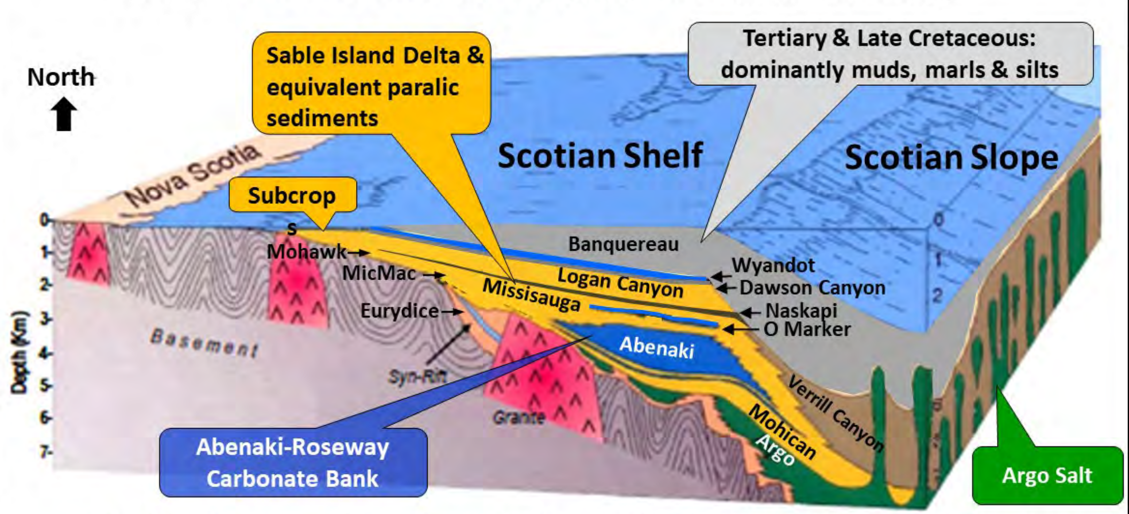
- **Became aware of this study after the 2021 assessments**
- **Same geologic intervals as Scotian Shelf**
- **Similar approach**
- **Less conservative E, depth range & PHI cut-off**
- **150-479-1136 Gt**



Scotian Margin: CCS Play Elements related to Regional Geology

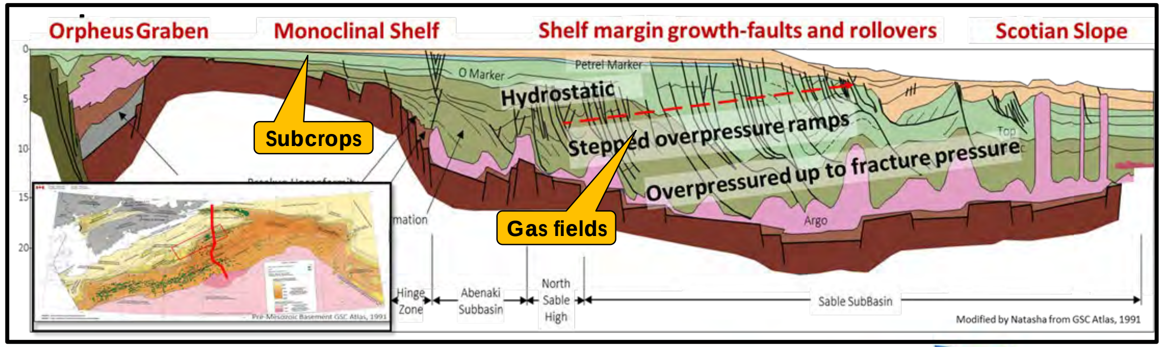
- **Low latitude rift-passive margin**
  - Massive hydrostatic, monoclinal shelf aquifers (storage) below a regional marl / mud-prone wedge (ulitmate containment)
- **Best opportunities are in U. & M. Missisauga fluvio-deltaic sandstones**
  - Below Naskapi Shale (sub-regional containment)
  - Above & below oolitic "O" Marker (local containment)
- **Aquifer subcrops are good news (hydrostatic systems) and bad news (risk of leakage via fluvio-deltaic conduits due to over- injection)**
  - Requires expert static & dynamic modeling & new data
- **Overpressure is the "enemy" for geomechanical risk**
  - Fortunately mostly confined to mud-prone slope and lower parts of shelf-margin expansion trends - act as "release valves" to the hydrostatic shelf
- **Injectivity**
  - Venture 1 well set record gas production rate in Canada (>100 MMCFPD)
  - Well-known permeability / transmissibility from tests, production and cores

Perspective View Scotian Margin (~ 700 km x ~ 200 km)



Modifed from OERA, 2011 (after J. Wade, modified Grant, 1986)

Hydrostatic shelf – Transitional shelf-margins – Overpressured Slope



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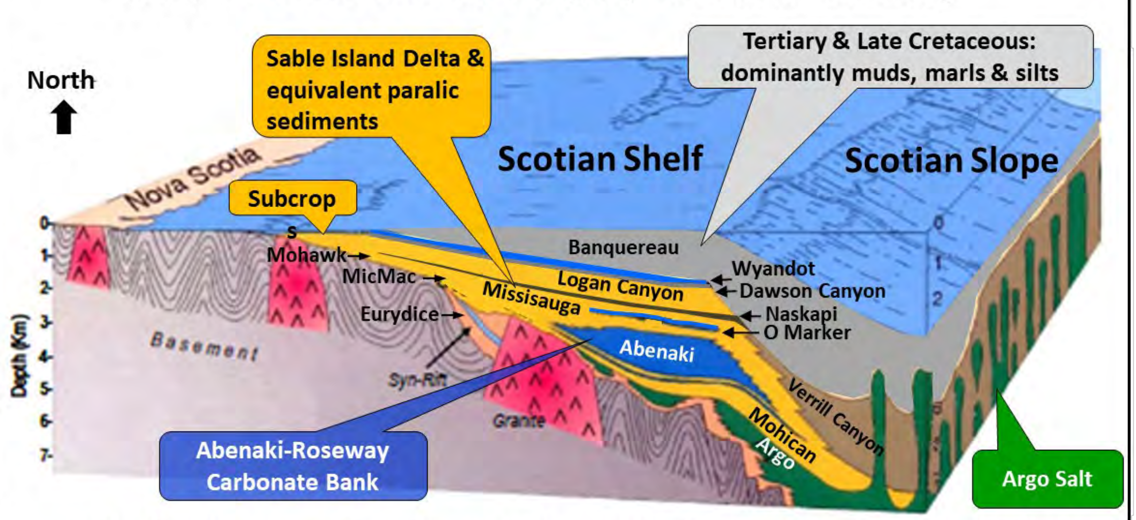

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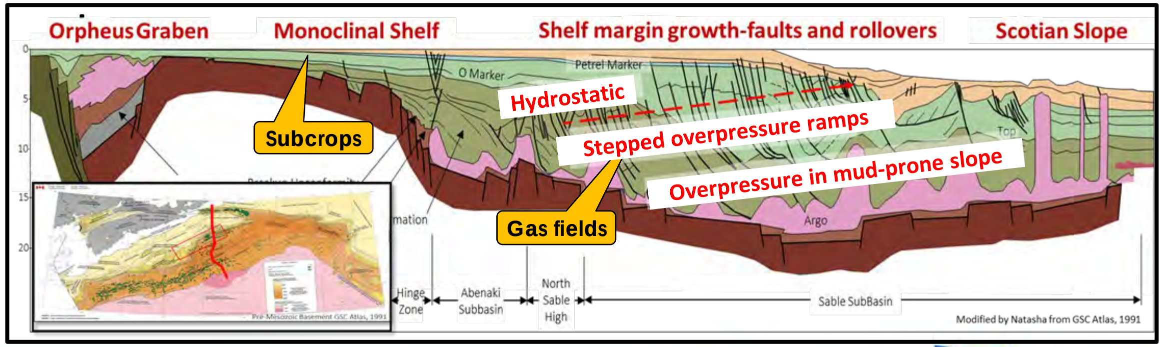


Why is the Scotian Shelf HC endowment so small? (& depleted field CCS)

- **Important to understand the whole plumbing system – and underlying geologic controls**

- **Proven resource ~4 TCF recoverable gas (~2 TCF produced); ~60 MBO (~45 produced)*.**
- **No issue with underfill – 2011 OERA PFA has ~1000 TCF generated within ~100 km of Sable Is.**

- **Sable max. column heights (~200m) are much less than JdA & MD (~600m+) for two key reasons:**
  - **No 2nd & 3rd phase tectonics & with long term high sediment supply seals are relatively thin**

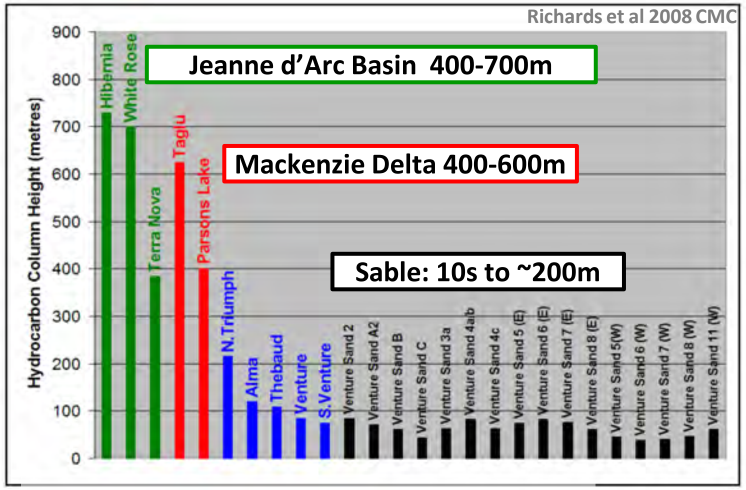
- **Shelf-margin rollover anticlines (18 of 25 fields) have limited dip closure heights (10-200m)**
  - **Fine balance between reservoir thickness, seal thickness & extensional crestal fault offsets**
  - **Immobile residual gas in breached traps – same mechanism as CCS in deep saline aquifers**

- **No stratigraphic traps discovered on the Scotian Shelf**
  - **Clastic reservoir quality improves updip (proximally) & carbonate bank "dips wrong way"**
  - **Opposite to WCB foreland basin – e.g. updip shale-out of clastic shorelines & carbonates**

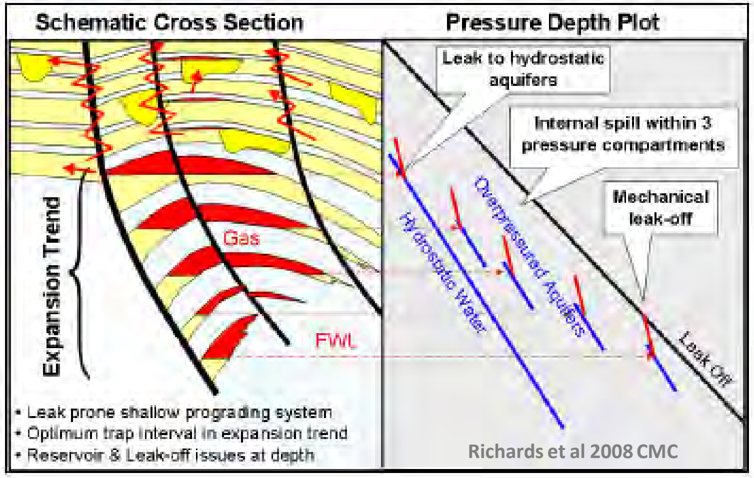
- **No Cenozoic reservoir influx like North Sea or Mackenzie Delta / GOM (Laramide tectonics)**
  - **Again related to lack of late tectonics in hinterland**
  - **Good news for CCS topseal**

- **Bad news is that we may find unexpected hydrocarbon traps updip (probably oil)**
  - **Fluvio-estuarine channel traps – like Glauconitic channel play in Alberta**
  - **Regional biogenic subcrop traps – like Kern River in California or Athabasca anticline**

Comparison of Maximum Hydrocarbon Column Heights



Schematic X-section - Venture Field expansion trend



*CNSOPB: Cumulative Production + 2014 SDL study P50 resources * Fortune Bay, White Rose, Nautilus, Richards Shale

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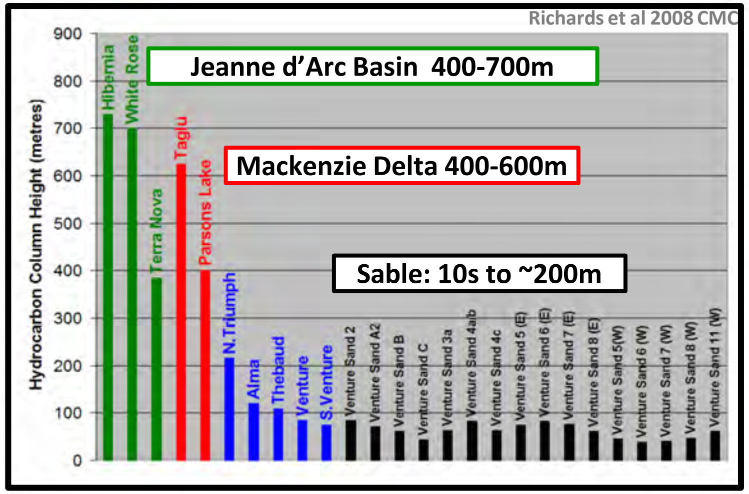

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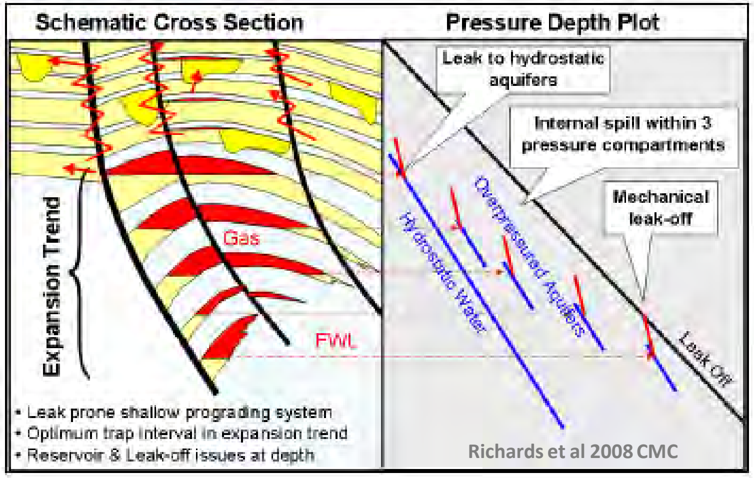

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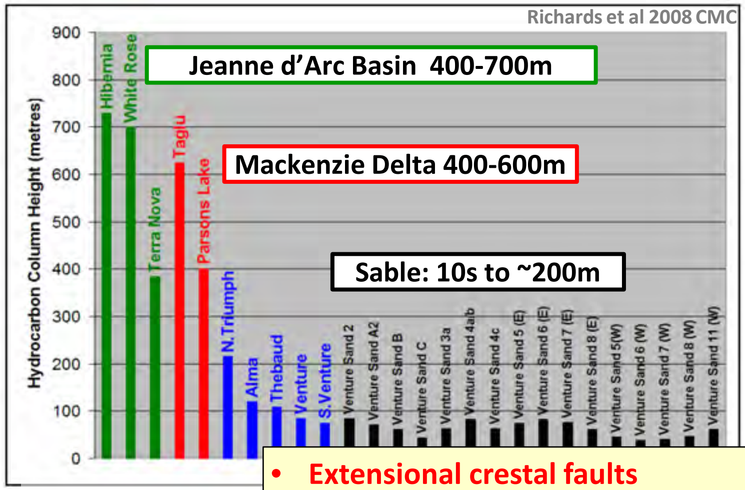
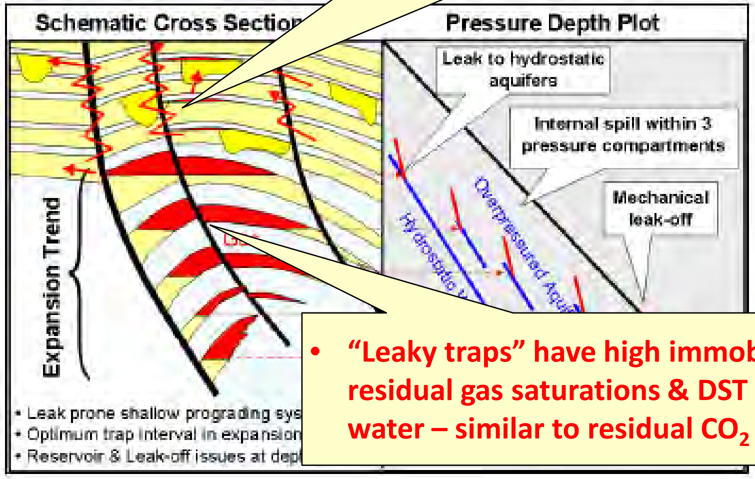


- Extensional crestal faults
- Offsets are critical to trap integrity

Schematic X-section



- "Leaky traps" have high immobile residual gas saturations & DST water – similar to residual CO_2

Scotian Shelf: Schematic distribution of fields & CCS play elements

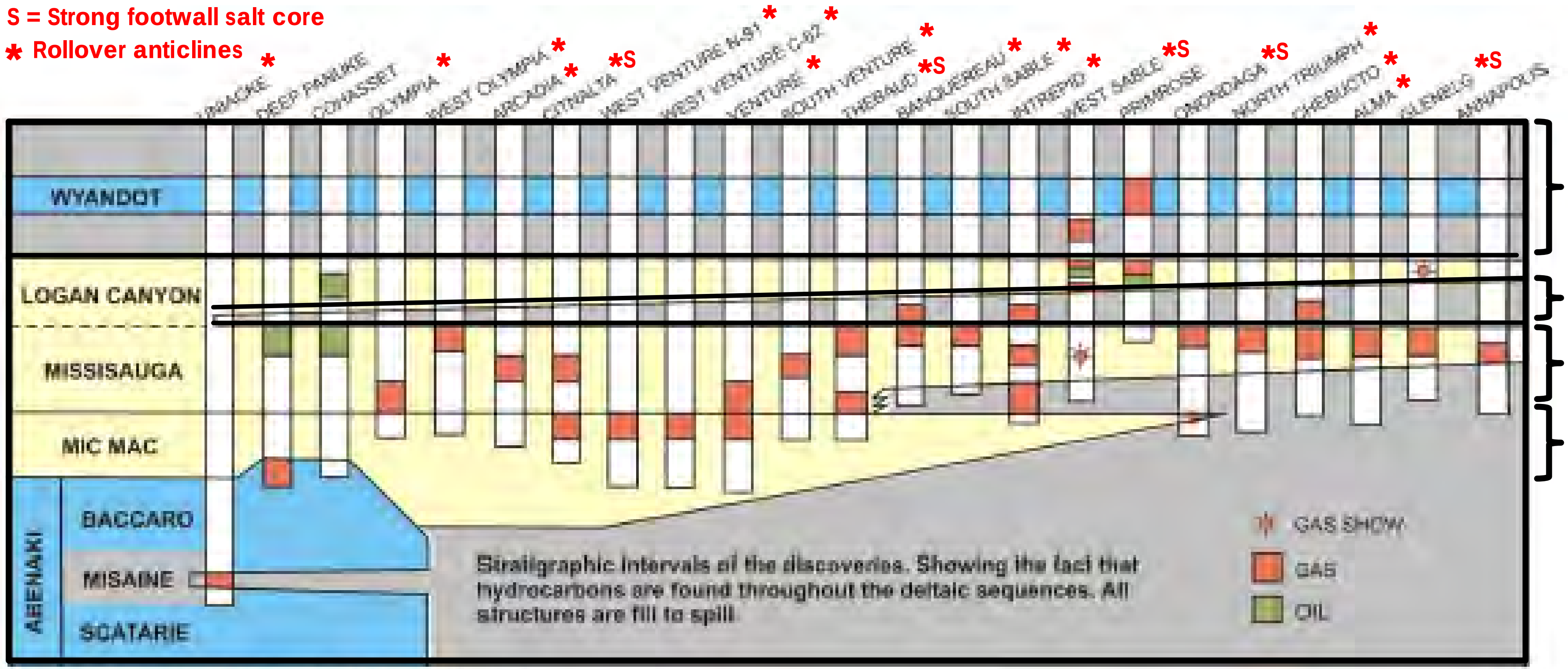


Figure 3: Stratigraphic distribution of discoveries.

Modified from OERA PFA, 2011

CCS Play Elements

Wyandot – Banquereau
- Regional containment

Naskapi Shale
- Containment

U. & M. Miss.
- Storage & Injectivity

Mic Mac & L.Miss
- Overpressured: geomechanical risk

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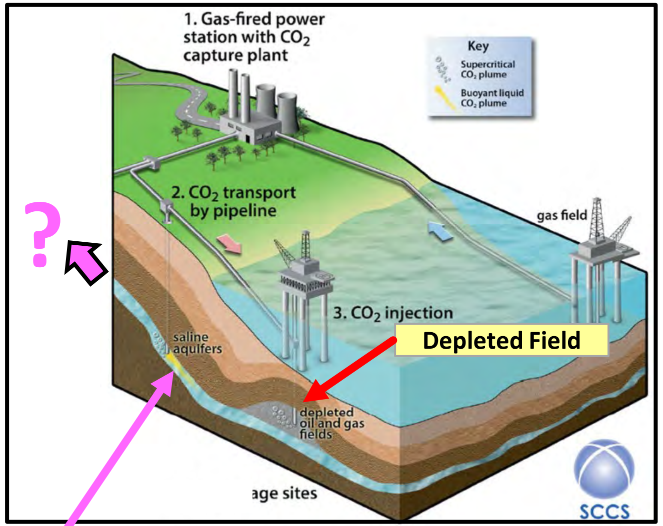
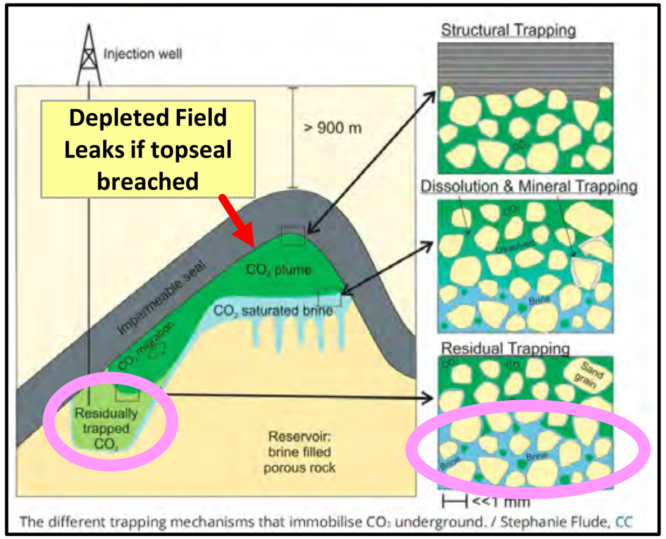
Deep Saline Aquifers Vs Structural Traps

https://energypost.eu/how-underground-ccs-works-low-leakage-risk-2/



Injection into deep saline aquifers
Are you crazy? Where does it go?

Like watering a sloping lawn – OK if you don't over-do it



The different trapping mechanisms that immobilise CO_2 underground. / Stephanie Flude, CC

CO_2 is dispersed as isolated microbubbles
Will not move – even if topseal is breached

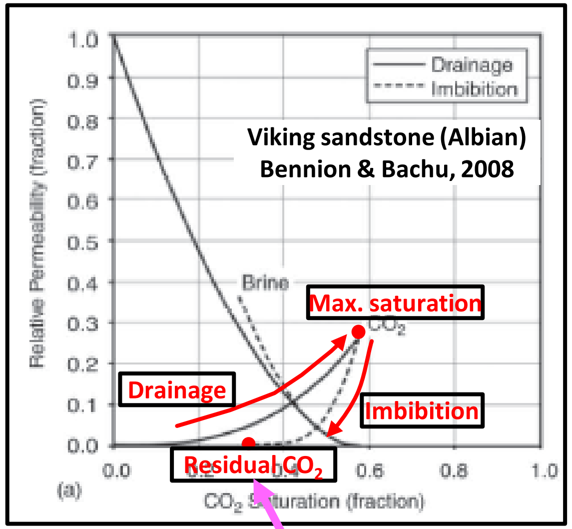
- Insufficient buoyancy to exceed capillary entry pressure to next pore

Structurally trapped CO_2 is **mobile** if seal is breached

Dissolution trapped CO_2 is **mobile** if water flows

Mineralogically trapped CO_2 is **immobile**

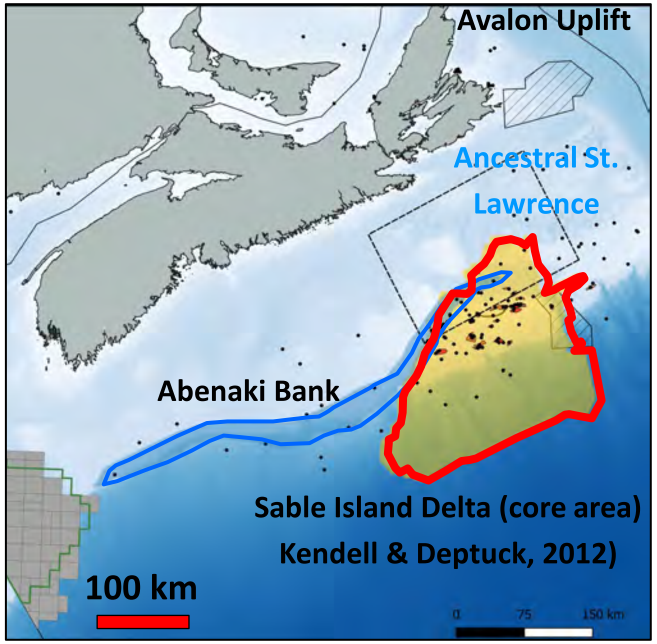
Residual CO_2 is trapped and **immobile** even if seal breached

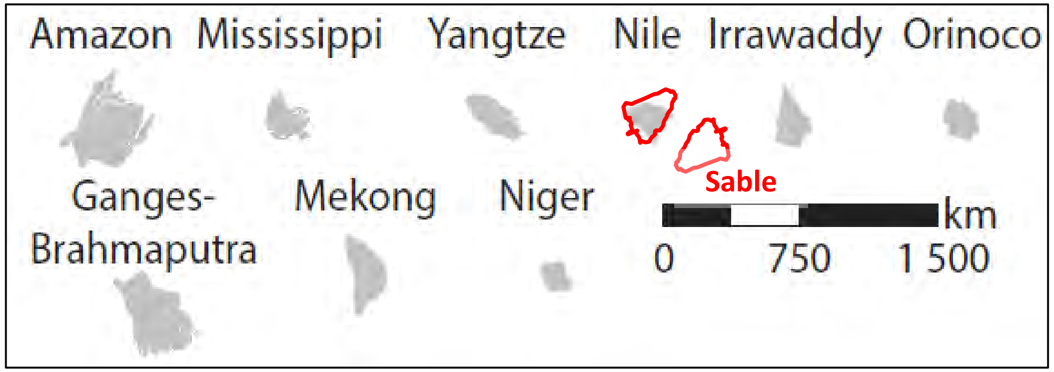


Zero relative permeability at residual saturation

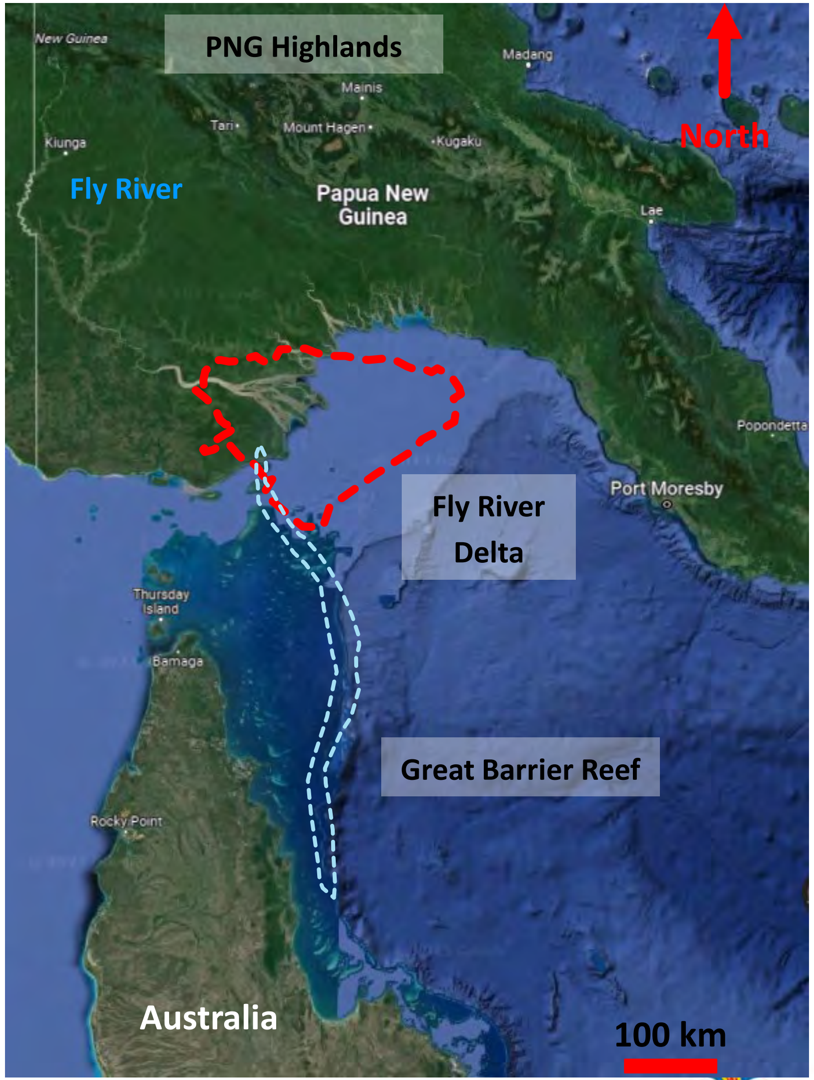
Scale of Sable Island Delta – and deep saline aquifers on Scotian Shelf

- **Late.Jur.- Early Cret. delta (~ 65 m.y. duration)**
- Sourced from the North
- Progressively overwhelmed and interfingered with the underlying Abenaki-Roseway Carbonate Bank
- **Comparable area to major modern deltas**
- **Analogue – Fly River Delta/ Great Barrier Reef**

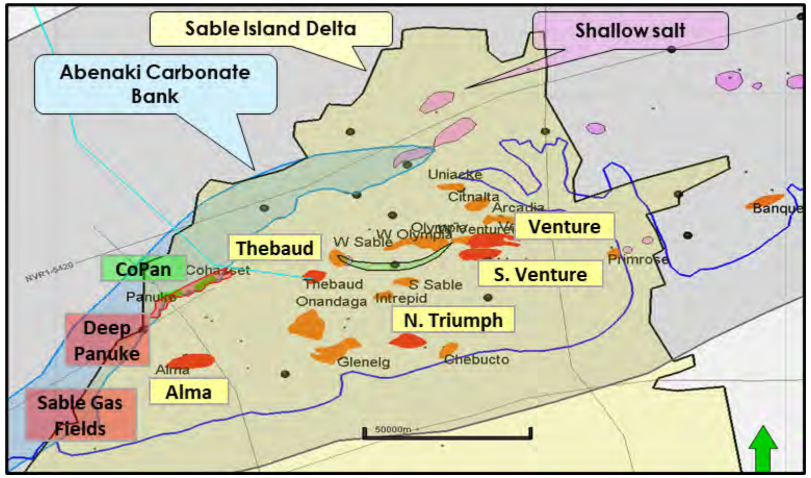




Major deltas: comparison of surface area (Klausen et al, 2019)



Scotian Shelf: Storage in Depleted and Stranded Fields (Ranked by size)



- 3 Decommissioned projects & 15 stranded fields
- Material Balance Approach
  - Storage Capacity = Production * 1 / FVF * E * Density
  - Storage Capacity = P50 Resource * 1 / FVF * E * Density
  - Storage efficiency factor (E) from 2009 IEA GHG report
- Need probabilistic assessment

5 Sable Gas Project Fields

Abenaki Projects

Depleted fields	CNSOPB published cumulative production.		Estimated weighted FVF (Estimated from Dev. Plans)	CO_2 Storage Density=0.7 E= 75%
	BCF / MB0	10^3 sm3	sm^3/rm^3	Mt CO_2
Alma	516	14,612,931	250	30.7
Venture	494	13,977,451	350	21.0
Thebaud	501	14,194,298	360	20.7
S.Venture	315	8,908,194	285	16.4
North Triumph	292	8,273,692	300	14.5
Sub-Total	2118	59,966,566		103.2
Deep Panuke	147	4,170,559	400	5.5
CoPan	44	7,066,810	0.8	4.6
Total	2265	131,170,500		113.4

Stranded Fields > 5Mt

Stranded Fields < 5Mt

Stranded Gas Fields (if depleted)	CNSOPB SDL Report (2014) P50 Resources		Estimated weighted FVF (Estimated from report)	CO_2 Storage Density=0.7 E= 75%
	BCF	10^9 M3	sm^3/rm^3	Mt CO2
Glenelg	508	14.4	270	28.0
Onondaga	304	8.6	250	18.1
Primrose	127	3.6	160	11.8
Banquereau	170	4.8	280	9.0
Citnalta	172	4.9	290	8.8
West Sable	93	2.6	170	8.1
Olympia	143	4.1	350	6.1
Arcadia	158	4.5	400	5.9
Chebucto	66	1.9	275	3.6
Intrepid	54	1.5	260	3.1
West Venture N-91	68	1.9	385	2.6
West Olympia	30	0.8	330	1.4
West Venture C-62	31	0.9	375	1.2
Uniacke	20	0.6	405	0.7
South Sable	8	0.2	265	0.4
Total	1952.0	55.3		108.8

NS Power plants ~ 7Mt/year NS & NB Power plants & refineries ~ 12 Mt /year

Deep Panuke and CoPan (Cohasset- Panuke)

- **Short HC columns - low volumes – low potential**

- **Deep Panuke**
  - Closure <30m in carbonate raised-rim
  - Complex reef-front diagenesis – low K lagoon
  - Watered out early with a ~15% recovery factor
  - Recovered 145 BCF

- **Panuke & Cohasset**
  - Multiple low relief (<20m) clastic drapes over raised-rim
  - Recovered 44.5 MBO
  - 46% Recovery Factor

Seismic line & schematic section over Deep Panuke (Weissenberger et al, 2000)

Chaotic reflections = dolomitised margin
Watered out early 15% Recovery

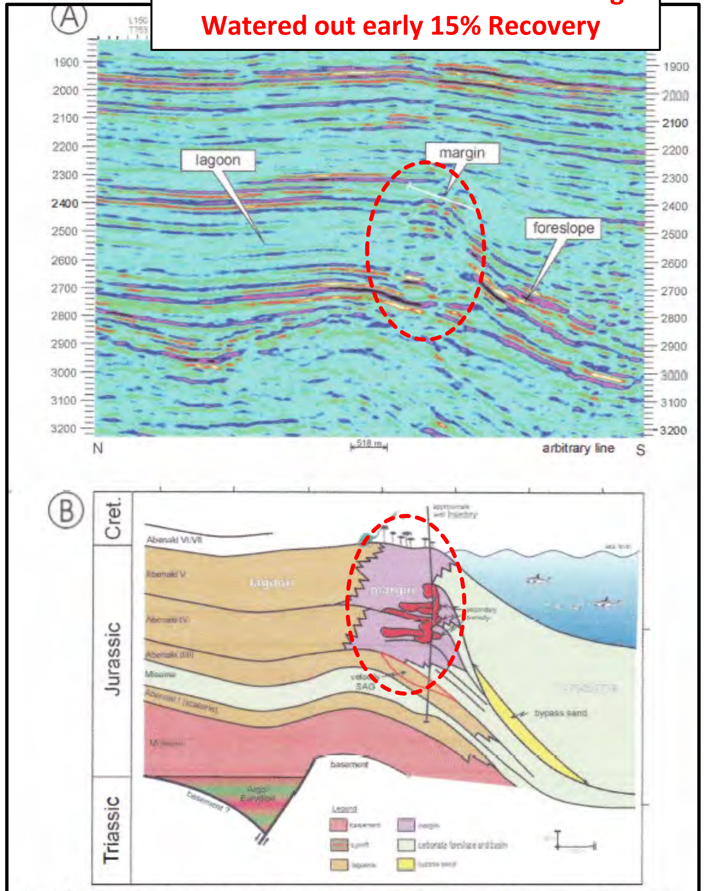
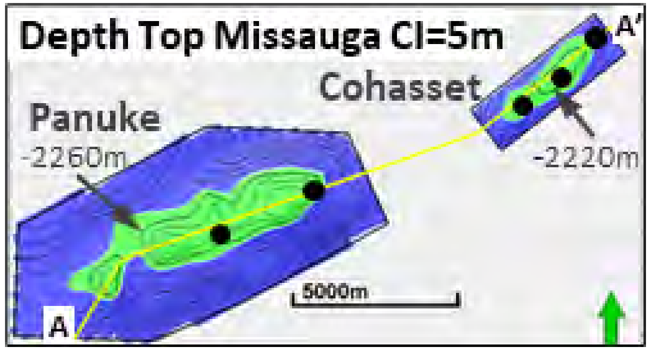
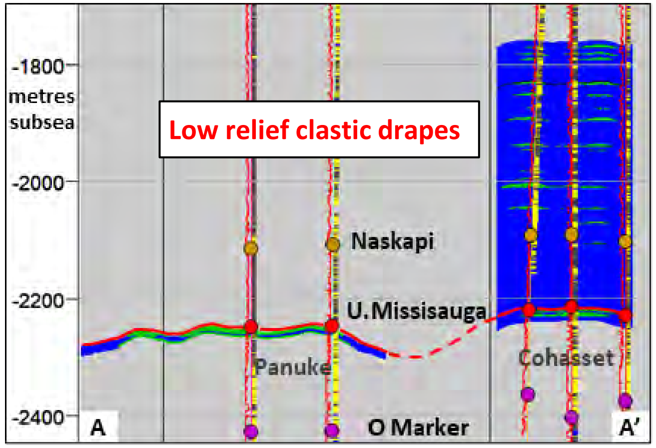


FIGURE 22 Arbitrary dip line from the Panuke 3-D seismic survey (A) and schematic interpretation of the same, illustrating the end of the Abenaki sequence V (B). Interpretation after G. Sylonyk.

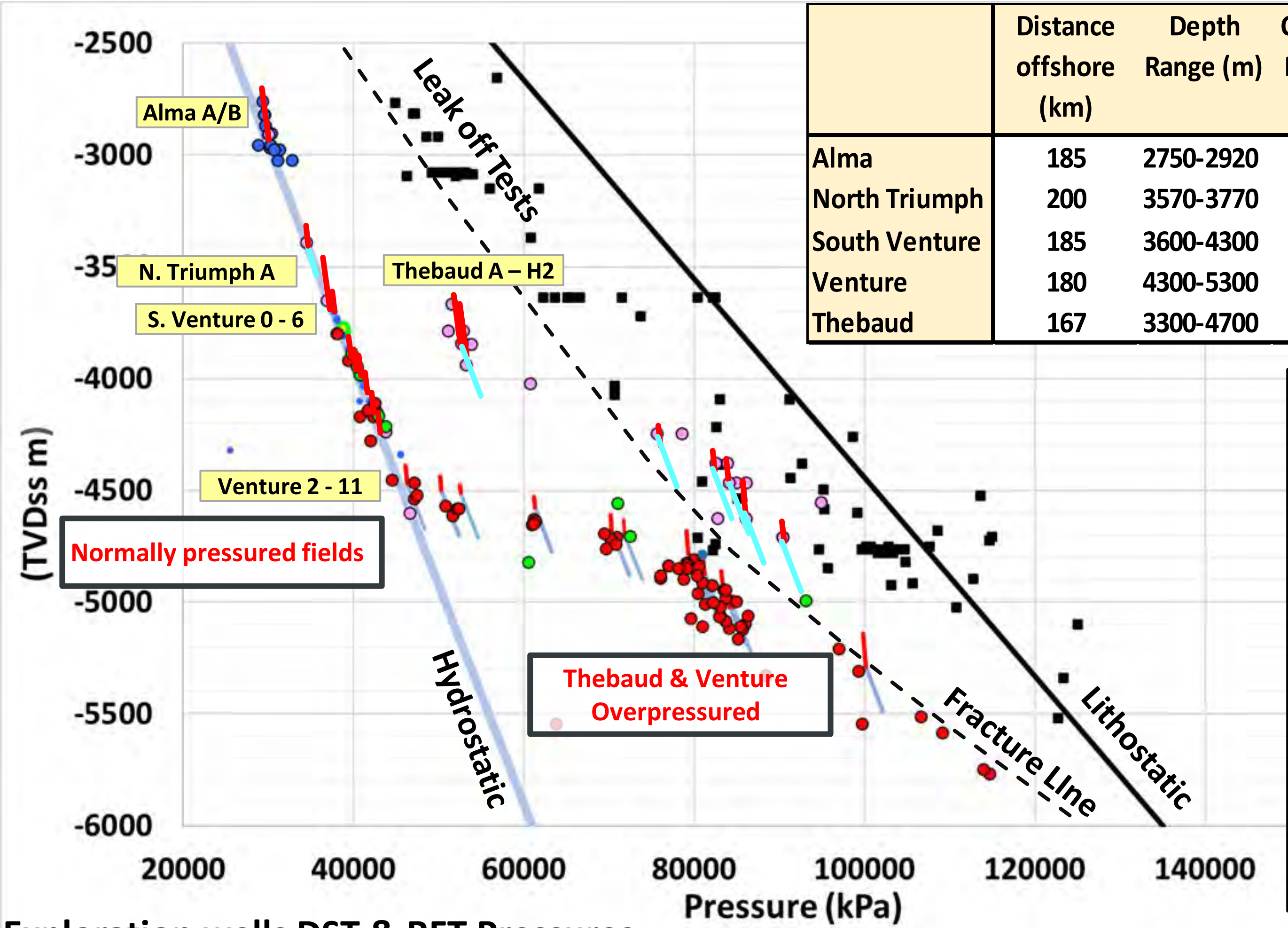
Static models of Panuke-Cohasset (via Lasmo development plan – Dalhousie)





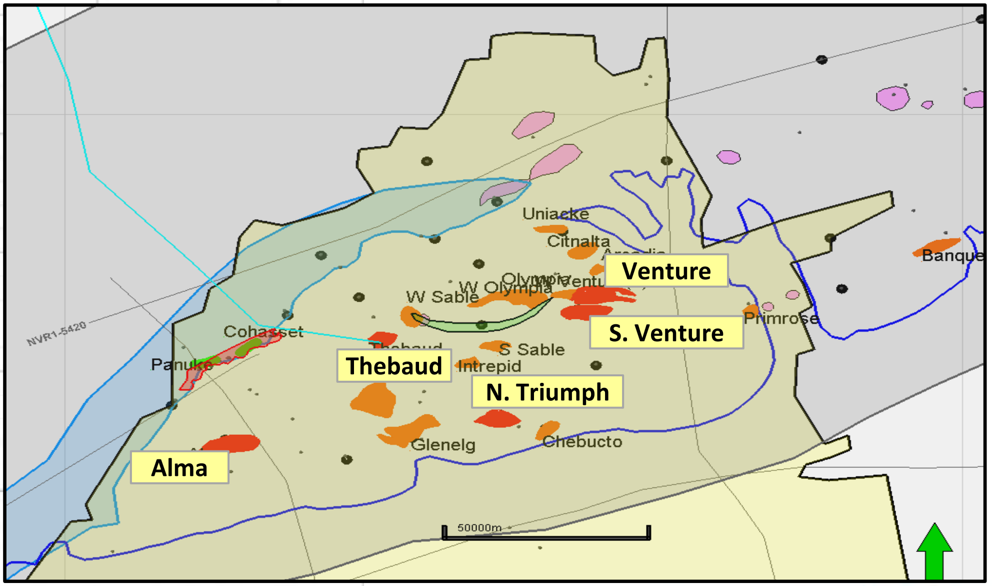
Depleted Sable Gas Fields: CCS Ranking

➢ **Alma & N. Triumph are ranked best: shallow, hydrostatic, single reservoir fields. Thebaud and Venture overpressured.**



Exploration wells DST & RFT Pressures.

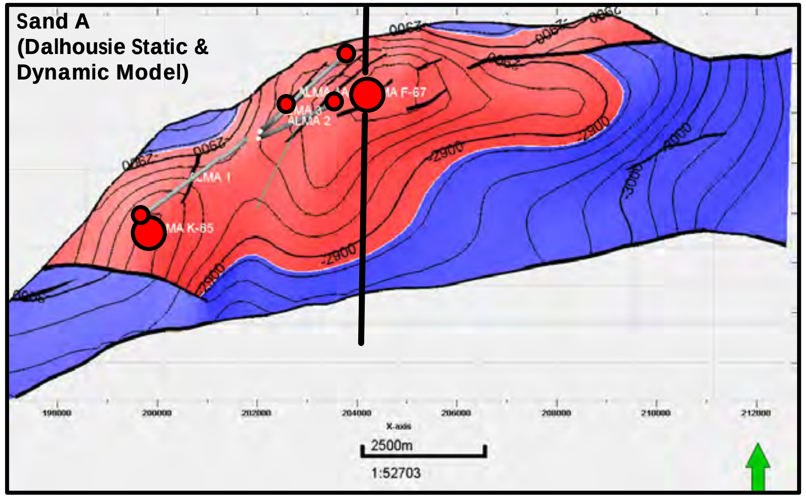
	Distance offshore (km)	Depth Range (m)	Cumulative Production (BCF)	Storage Capacity (Mt)	# Pools developed	Pressures (Developed Pools)	Comments
Alma	185	2750-2920	516	30.7	1	Hydrostatic	U.Missisauga
North Triumph	200	3570-3770	292	14.5	1	Hydrostatic	U.Missisauga
South Venture	185	3600-4300	315	16.4	7	Hydrostatic	Low Relief Pools
Venture	180	4300-5300	494	21	7	Hydrostatic-Leak off	Sand 2 potential
Thebaud	167	3300-4700	501	20.7	6	OP-Leak off	Hydro pools not dev.



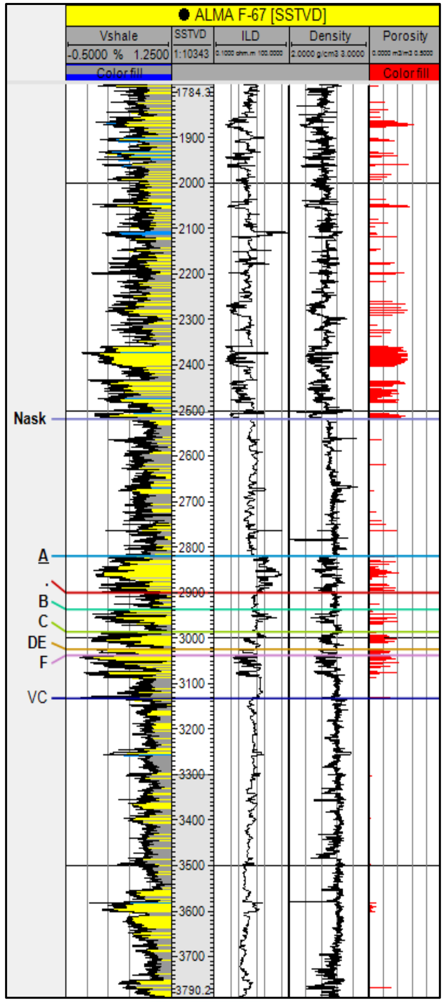
Alma, & South Venture Fields (Hydrostatic)

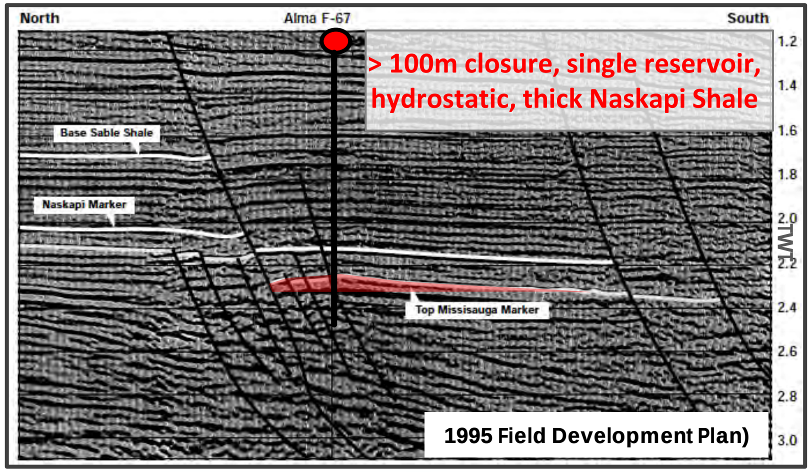
Alma Field: U Missisauga reservoir, ~2900m

- ➢ Good candidate for CCS: 31 Mt in one reservoir (North Triumph similar)



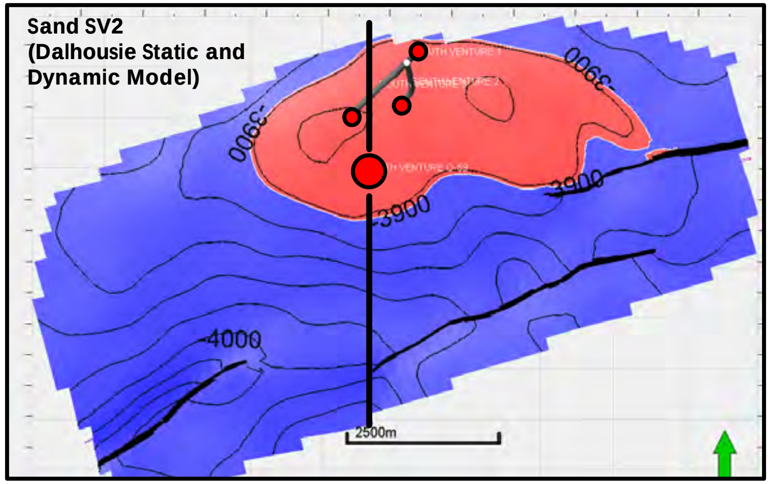
Sand A

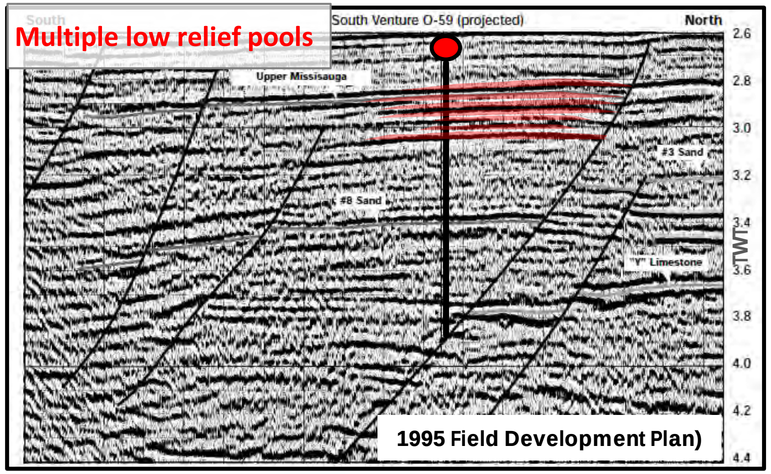


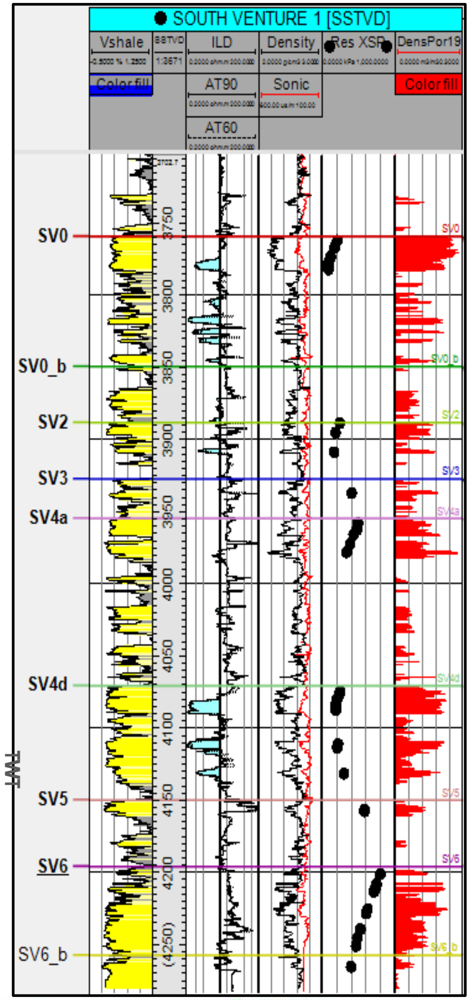


South Venture: L-M Missisauga reservoirs, ~3600-4300m

- ➢ 16 Mt in multiple low relief pools - hard to contain for CCS



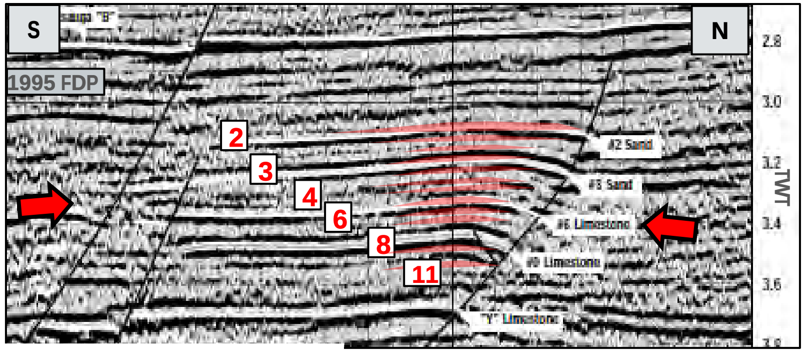




Venture Field

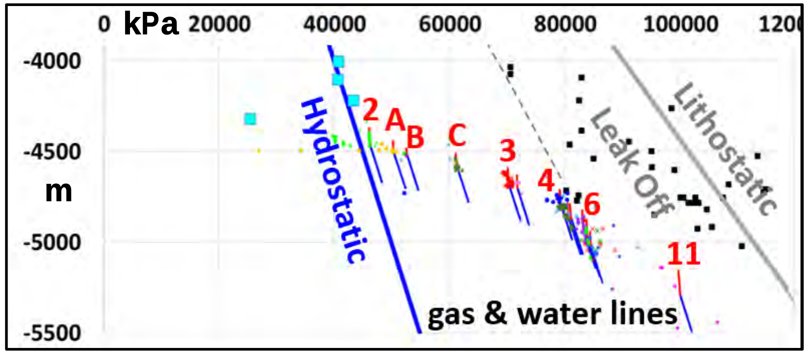
- Complex depletion pressures & overpressure issues for drilling and CCS
- Expansion trends are "pressure valves" between overpressured slope & hydrostatic shelf

- Dip line: stacked gas in hanging wall "sand traps"
- Pressure & gas influx from adjacent blocks

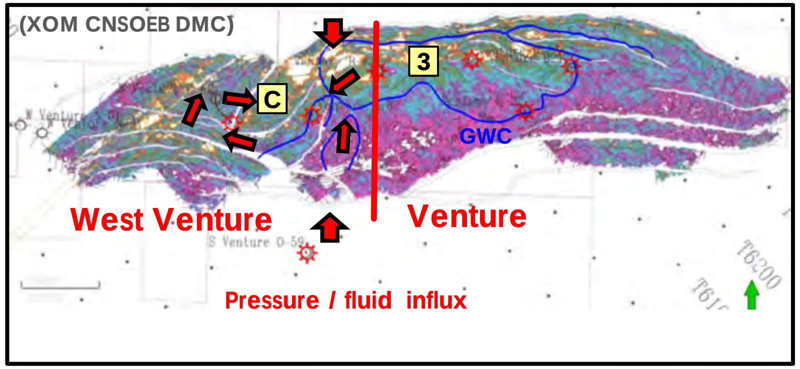


1995 Field Development Plan

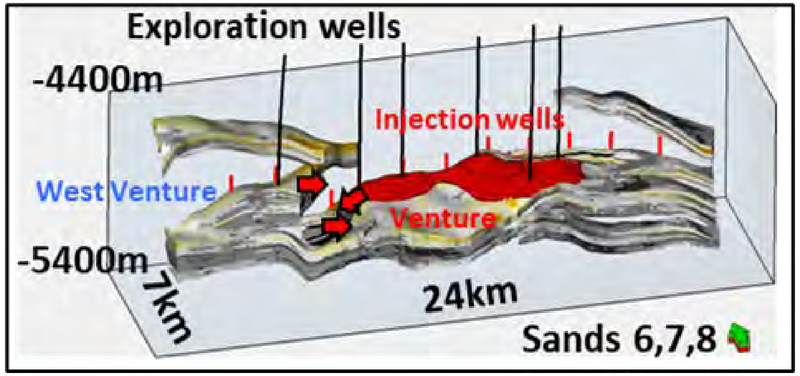
- Have to explain "stepped" overpressures from "leak off" ➔ "hydrostatic"



- Venture Sand 3: high amplitude near bounding fault
- Gas influx and cross-fault outflux at West Venture

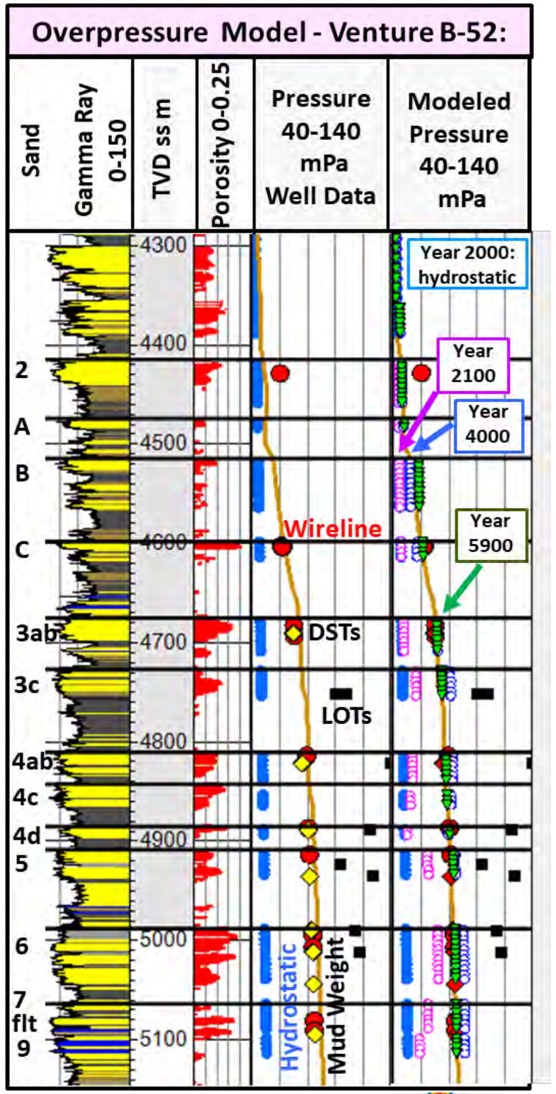


- Modeled by gas injection into sands 6,7,8
- Matched overpressures during inflation & deflation



Well Logs Pressures

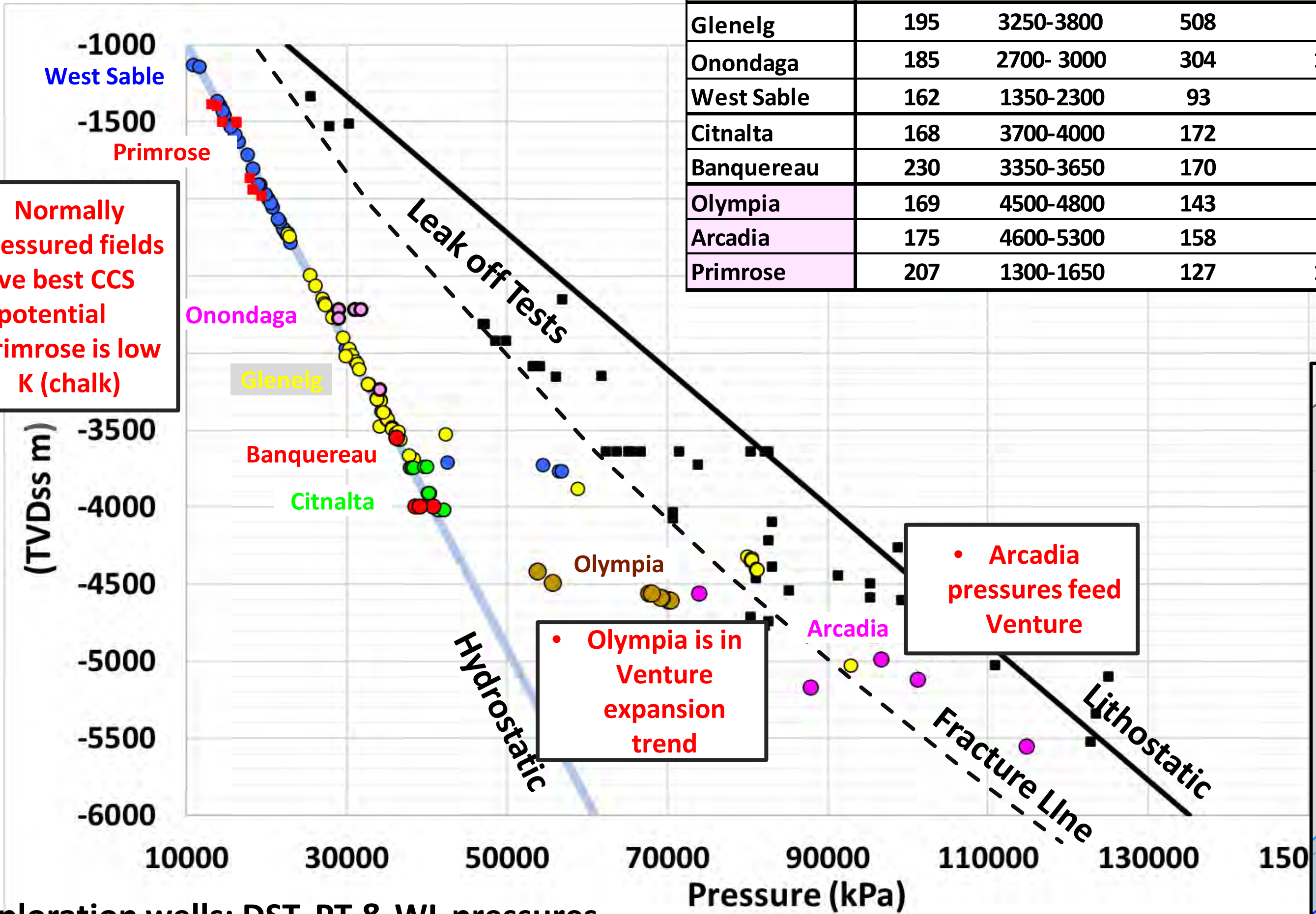
Observed Modelled



Stranded Sable Gas Fields (SDLs): CCS Ranking (> 5 Mt $scCO_2$)

	Distance offshore (km)	Depth Range (m)	P50 Resource (BCF)	Storage Capacity (Mt)	HC	Pressures	Comments
Glenelg	195	3250-3800	508	28	Gas	Hydrostatic	>20 U.Miss. pools. Multiple fault blocks
Onondaga	185	2700- 3000	304	18.1	Gas	Hydrostatic	2 U. & M. Miss gas zones. 3 fault blocks
West Sable	162	1350-2300	93	8.1	Gas, cond, oil	Hydrostatic	> 30 DC, LC, Miss. pools. Multiple fault blocks
Citnalta	168	3700-4000	172	8.8	Gas	Hydrostatic	5 L.Miss. reservoir zones (simple 4 way closure)
Banquereau	230	3350-3650	170	9	Gas	Hydrostatic	3 Naskapi & U.Miss. gas zones
Olympia	169	4500-4800	143	6.1	Gas	Overpressured	4 L.Miss. gas zones - short columns
Arcadia	175	4600-5300	158	5.9	Gas	Overpressured	6 Mic Mac reservoir zones
Primrose	207	1300-1650	127	11.8	Gas	Hydrostatic	Wyandot gas (low K) , minor LC gas and Iroquois oil)

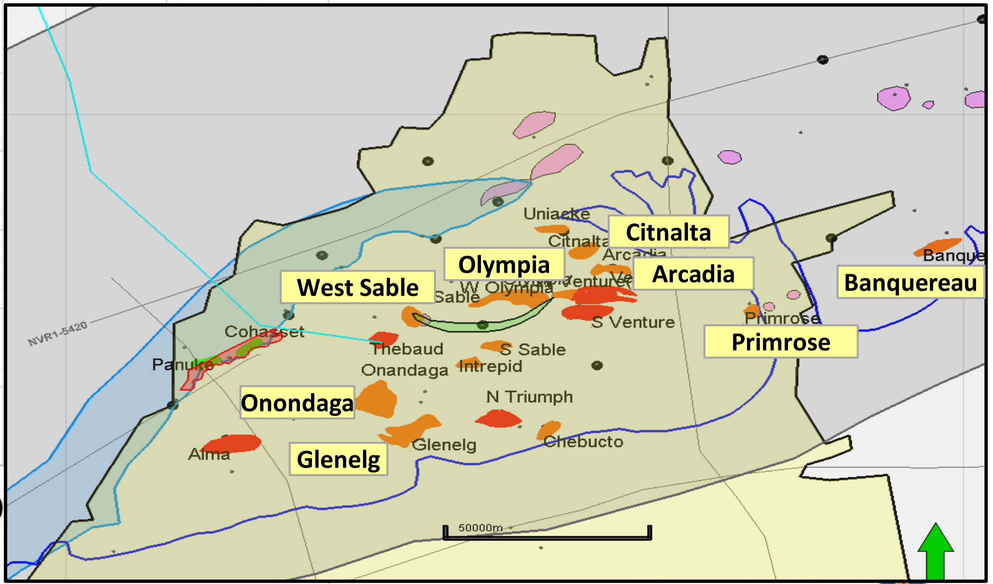
- Normally pressured fields have best CCS potential
- Primrose is low K (chalk)



- Olympia is in Venture expansion trend

- Arcadia pressures feed Venture

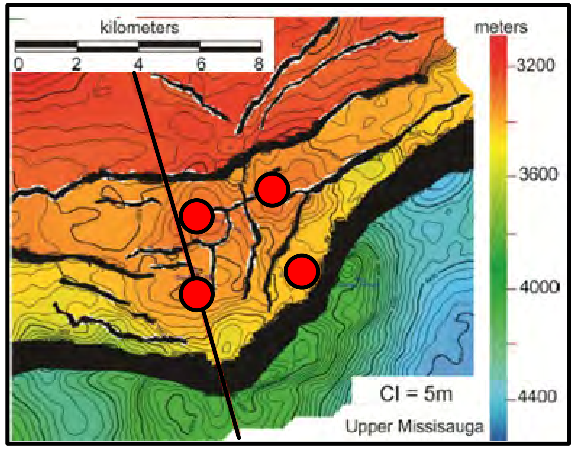
Exploration wells: DST, PT & WL pressures

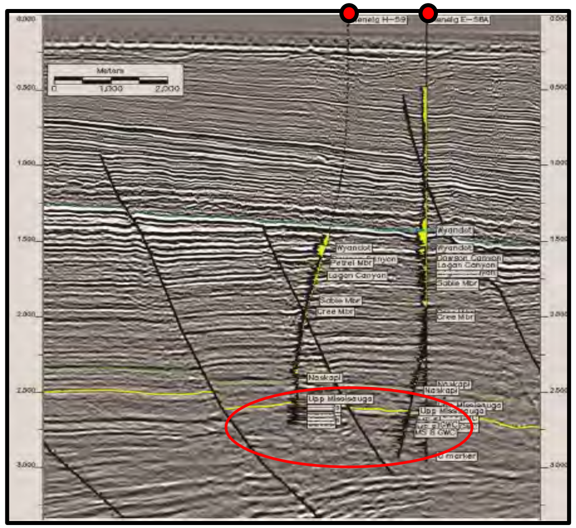


Stranded Sable Gas Fields (SDLs): Glenelg, West Sable & Citnalta (CNSOPB,2014)

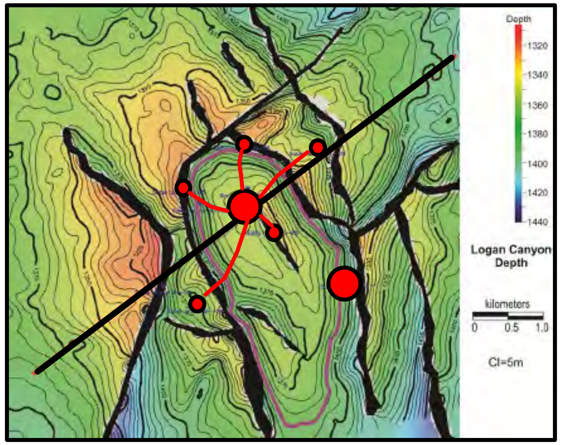
- Shallow, hydrostatic reservoirs look good – but footwall diapirs and stacked multiple compartments create complications

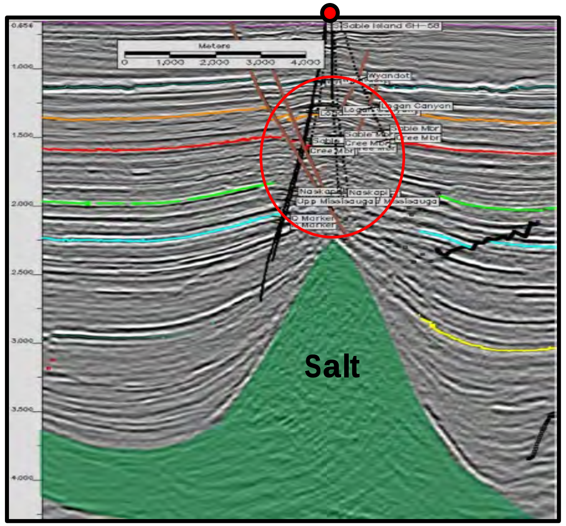
- Glenelg: ~3250-3800m



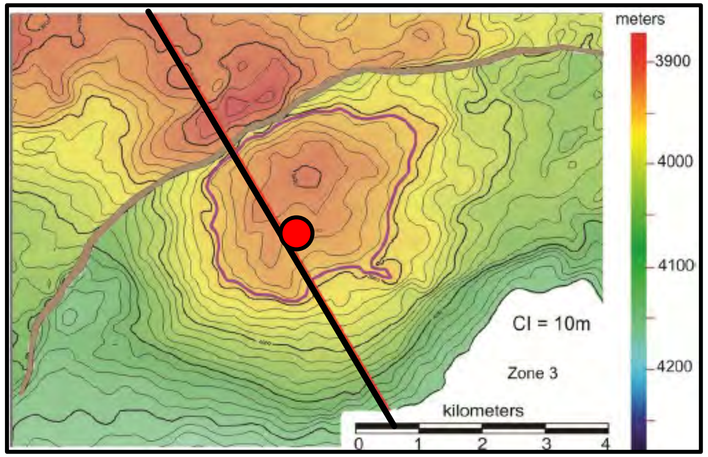


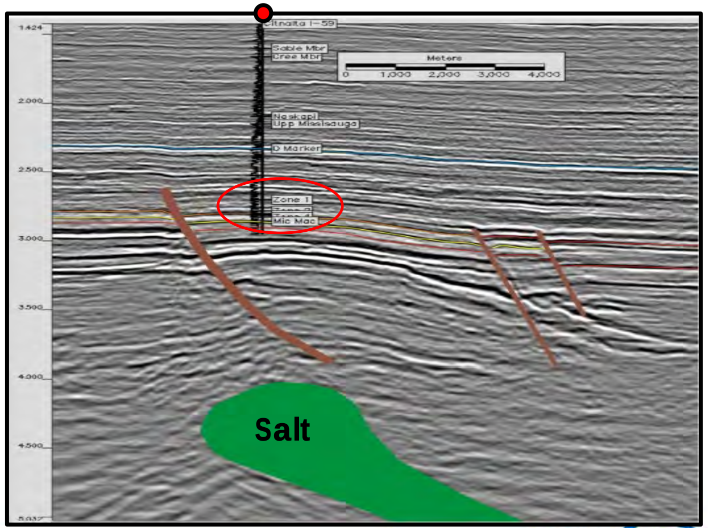
- West Sable: hydrostatic, ~1350-2300m





- Citnalta: hydrostatic, ~3700-4000m





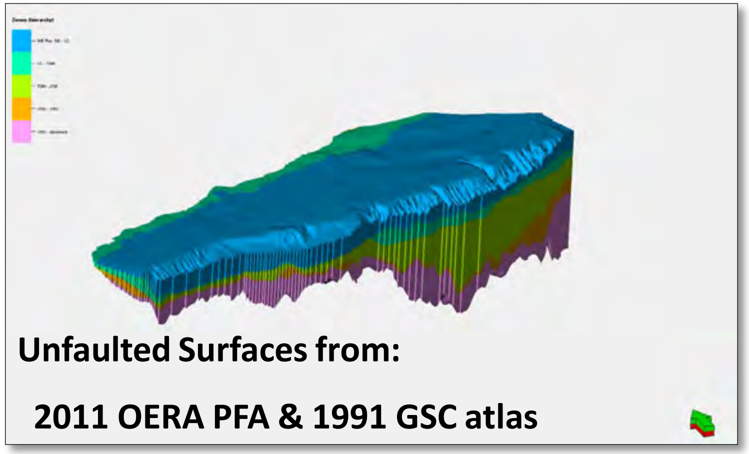
Scotian Shelf: Deep Saline Aquifers – Scoping assessment

	Length 10^6m	Width 10^6m	Interval m	m	Shape factor	GRV 10^9m^3	NTG	Phi	NPV 10^9m^3	1-SWirr	CO_2 gm/cc	Storage Efficiency	CO_2 Storage Gt (10^9 tonnes)
ML	650	150	-800	-4000	0.5	78,000	0.5	0.18	7,020	0.90	0.7	0.04	177
Low	550	100	-1000	-3000	0.4	22,000	0.4	0.14	1,232	0.85	0.65	0.02	14
High	750	180	-800	-5000	0.6	170,100	0.6	0.22	22,453	0.95	0.75	0.08	1280

Storage Capacity = GRV * NTG * PHI * E * Density sCO_2

- **Gross Rock Volume** (GRV=Area * Thickness * Shape Factor)
- **Net-to-Gross** (NTG=net porous thickness / gross thickness)
- **NPV =Net Pore Volume**
- **Storage efficiency factor** (E=Stored CO_2 / Pore Volume)
  - Typical ranges are published in CCS atlases

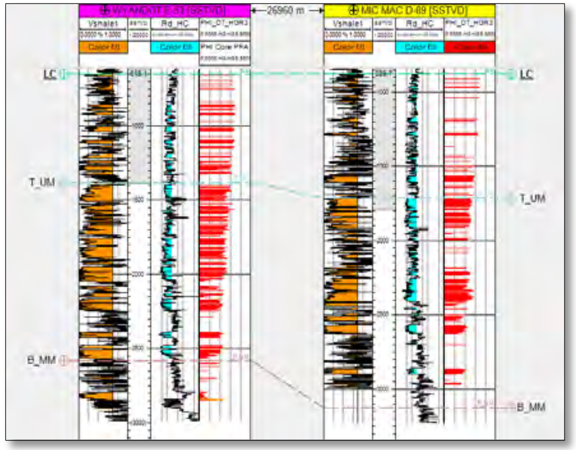
Scotian Shelf: Deep Saline Aquifers – Petrel Workflow



Unfaulted Surfaces from:

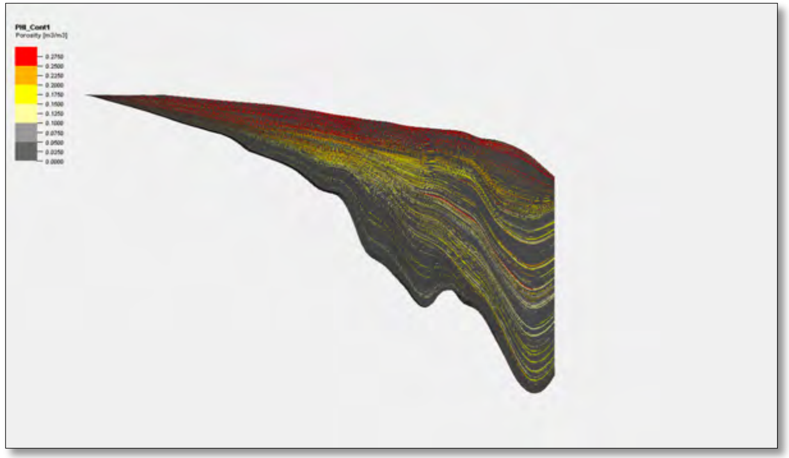
2011 OERA PFA & 1991 GSC atlas

7 horizons / unfaulted 6 zone framework
(Pillar Gridding - Make Horizons - Make Layers)



Sonic Porosities with Vshale cutoffs

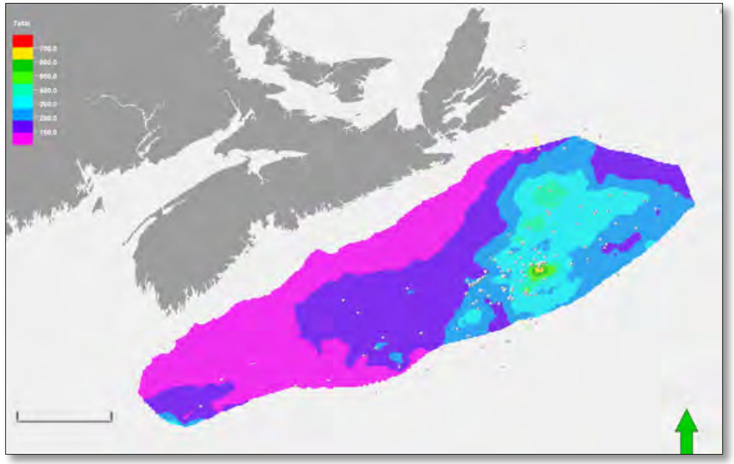
- 80 wells (of 210 on the margin)



Porosity Model
Layered, Scaled up well logs and populated model (Property Modeling – SGS etc)

Algorithm	Storage Efficiency	Low Vsh<30%	Med Vsh<50%	High Vsh< 70%
Moving Average	E=5%	77	250	588
	E=3%	46	150	353
	E=1%	15	50	118
SGS	E=5%	125	257	483
100km, 200km, 10m	E=3%	75	154	290
72 degrees	E=1%	25	51	97
SGS	E=5%	187	353	618
640km, 400km, 30m	E=3%	112	212	371
72 degrees	E=1%	37	71	124

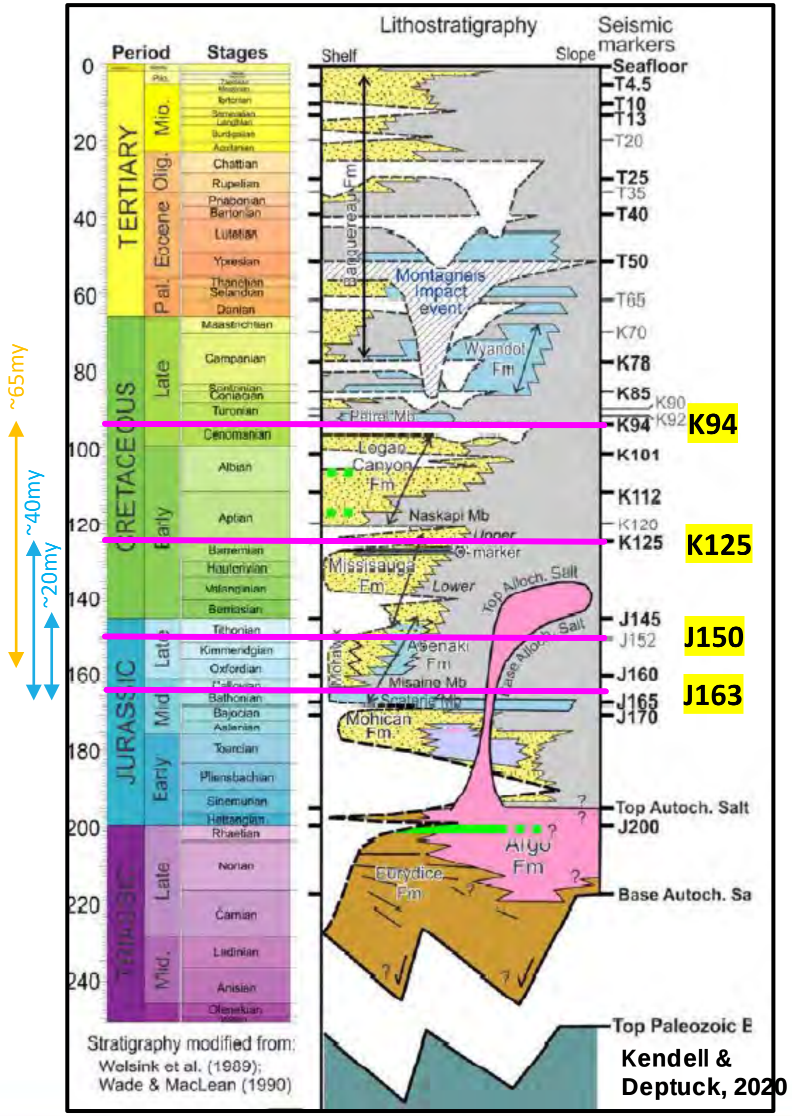
Set depth limits and areas
Calculated NPV & Storage Capacity



QC with porosity-metre maps by zone (Quality Assurance)

NOVA SCOTIA

Deep Saline Aquifers: Structural Framework

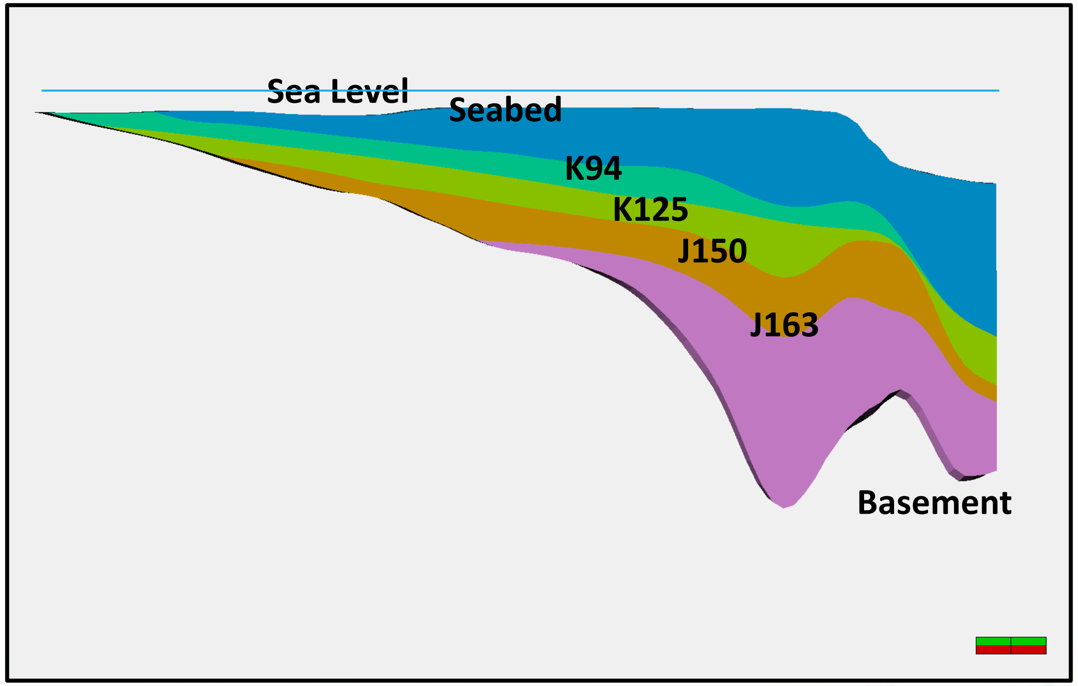


Logan Canyon

U. & M. Misssisauga

Mohawk, L. Miss., Mic Mac, Abenaki

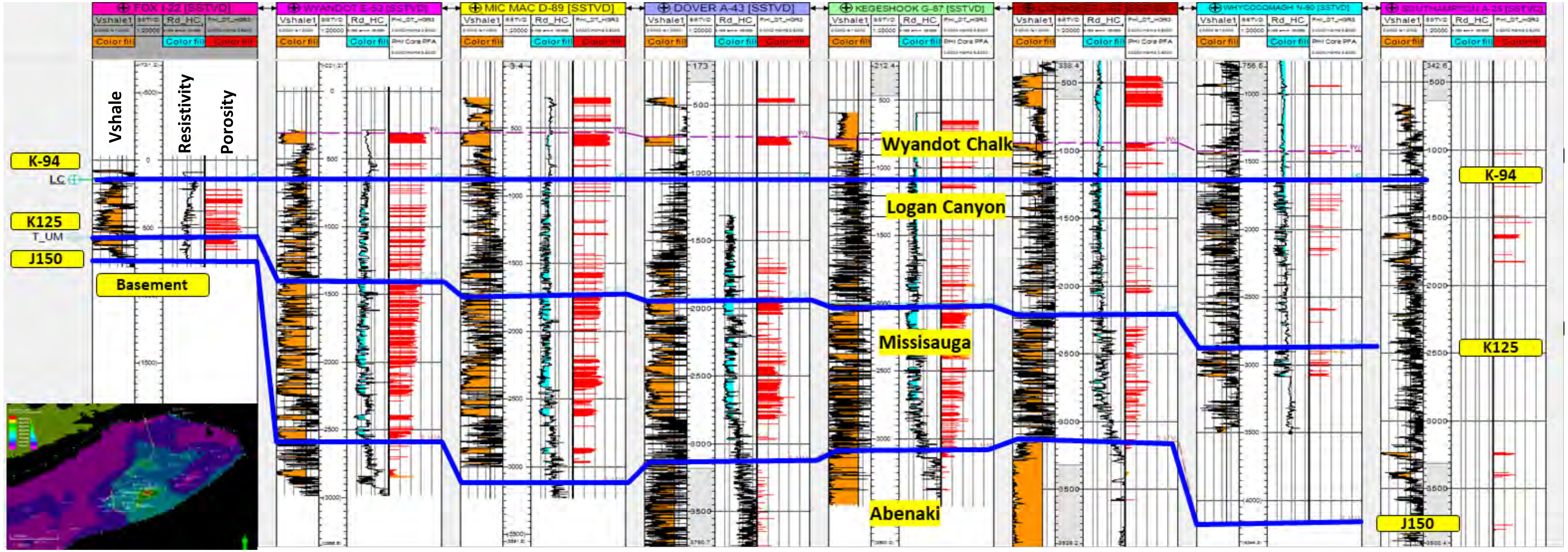
- **Structural Data: from the 2011 PFA and the 1991 Cant GSC Atlas (online)**
  - Unfaulted horizons are fine for static model – need faults for dynamic modeling
  - 7 horizons, 6 Zones – 3 of which are populated with porosity
  - Area: ~600*150 km
  - 2 x 2 km grid; 1500 layers; 67 million cells



Deep Saline Aquifers – Porosity Calculation (Petrel Calculator)

Porosity (80 wells, of ~210 on the margin)

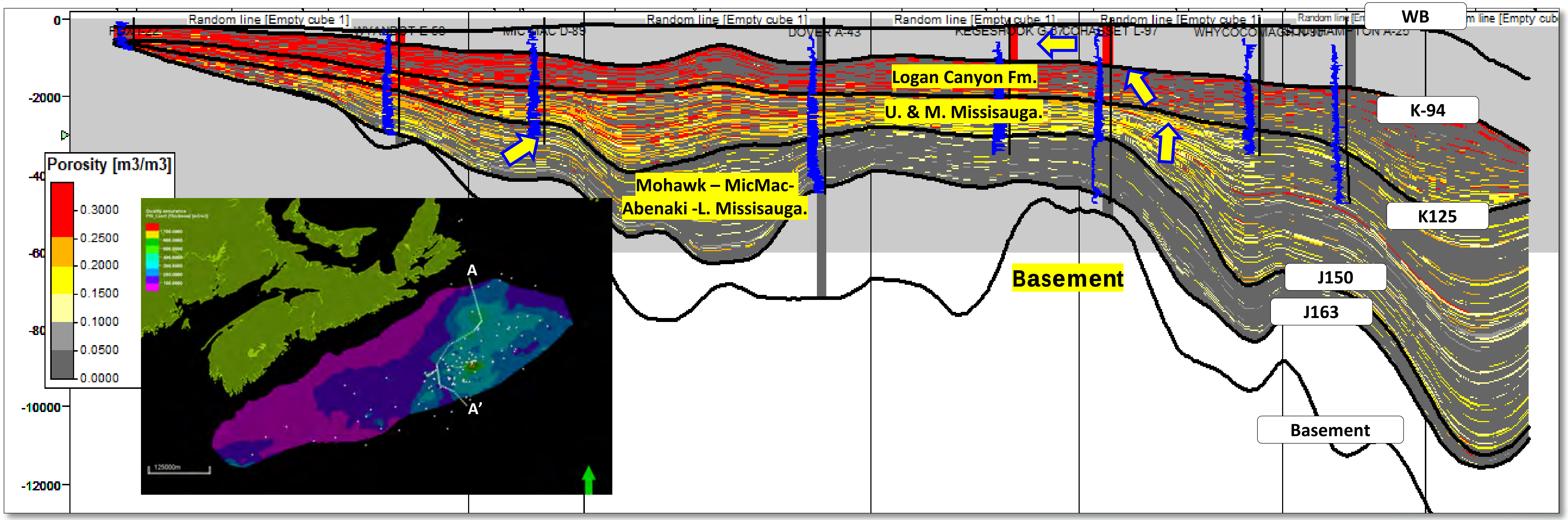
- Vshale from Gamma Ray
- Sonic Porosity >10%, matched to core data, with 30, 50, & 70% Vshale cutoffs



Deep Saline Aquifers – Property Modeling

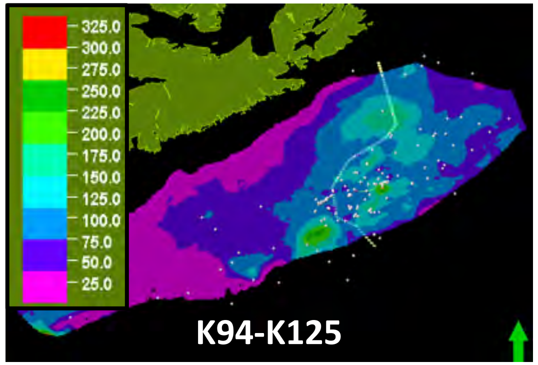
Porosity Model

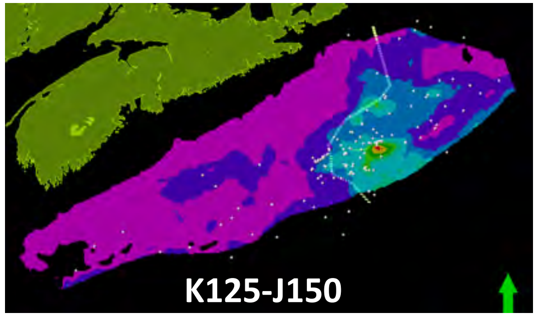
- **Scaled up porosity and propagated porosity throughout the model**
  - Sequential Gaussian Simulation with 72 degree azimuth. Anisotropy: 150km major & 100km minor axes, 30m vertical
  - Can see shelf-margin trajectories & large-scale progradational, aggradational, retrogradational stacking patterns

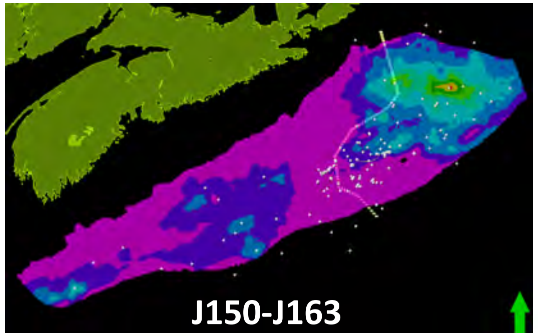


Deep Saline Aquifers – QC, Volume Calculations & Comparison to NE USA

Porosity Thickness (Phi-m)







- **QC via Quality Assurance Maps**
- **Storage Capacity (Gt) with a range of algorithms, storage efficiencies & Vshale parameters**
  - Depth Range 800-4000m subsea; Phi cut off 10% ; Density 700kg/m^3

Algorithm	Storage Efficiency	Low Vsh<30%	Med Vsh<50%	High Vsh< 70%
Moving Average	E=5%	77	250	588
	E=3%	46	150	353
	E=1%	15	50	118
SGS	E=5%	125	257	483
100km, 200km, 10m	E=3%	75	154	290
72 degrees	E=1%	25	51	97
SGS	E=5%	187	353	618
640km, 400km, 30m	E=3%	112	212	371
72 degrees	E=1%	37	71	124

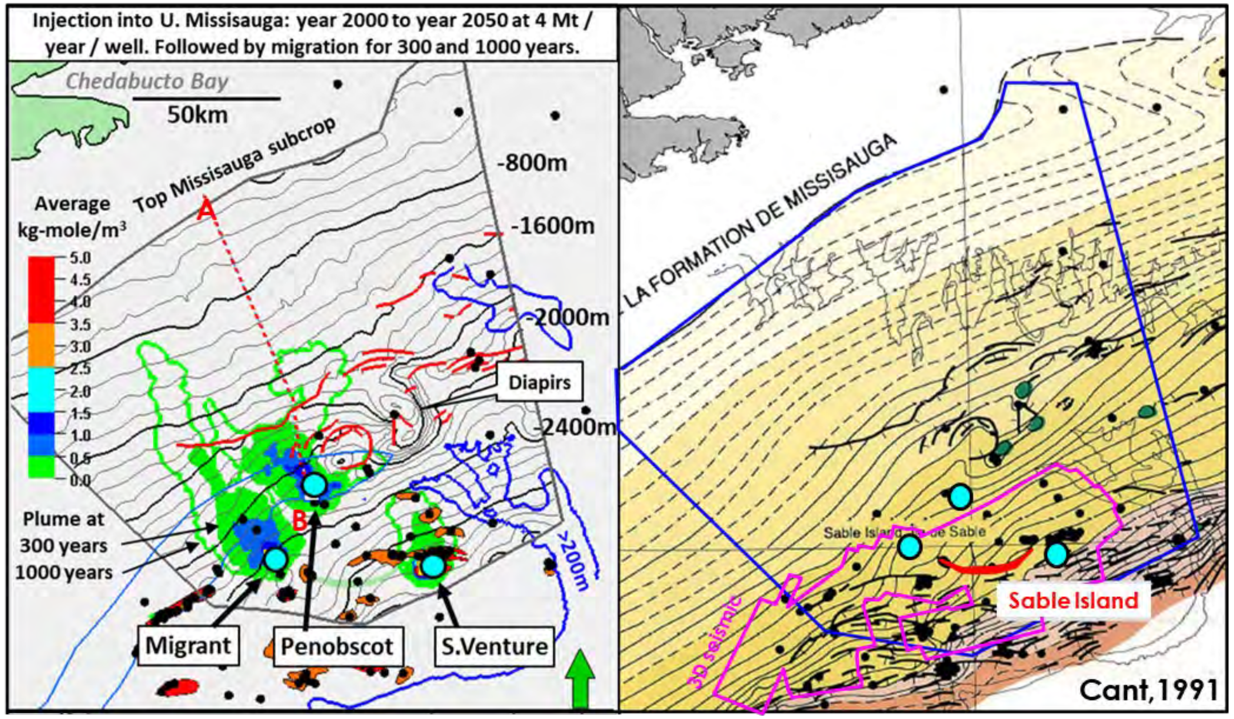
- **Base Case Comparison to Batelle study (NE USA Atlantic margin)**
  - Significant variations in CCS ranges are normal – even within the same organisations (Kearns et al. 2017)

US NE Margin				
	NPV (km^3)	E	Density	Gt
MK1-3	3,668	0.05	0.815	149
LK1	4,635	0.05	0.809	187
UJ1	6,511	0.03	0.796	155
	14814			492

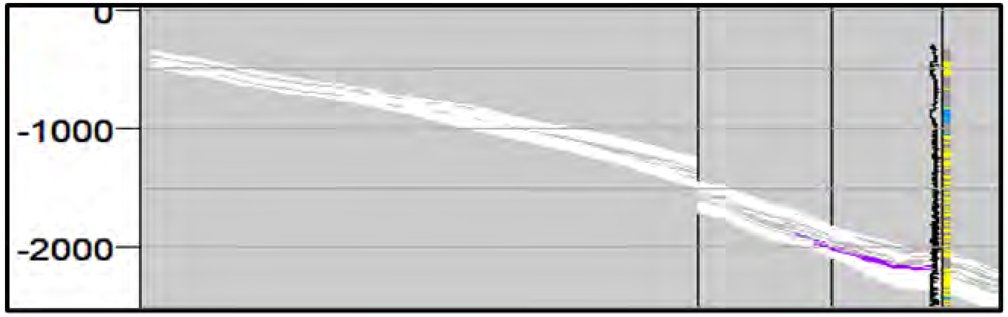
Scotian Shelf (800 to 4000m)				
	NPV (km^3)	E	Density	Gt
K94-K125	2148	0.03	0.7	45
K125-J150	3369	0.03	0.7	71
J150-J163	1683	0.03	0.7	35
	7200			151

NOVA SCOTIA

Preliminary Dynamic Modeling of Highgraded Area (Dalhousie)

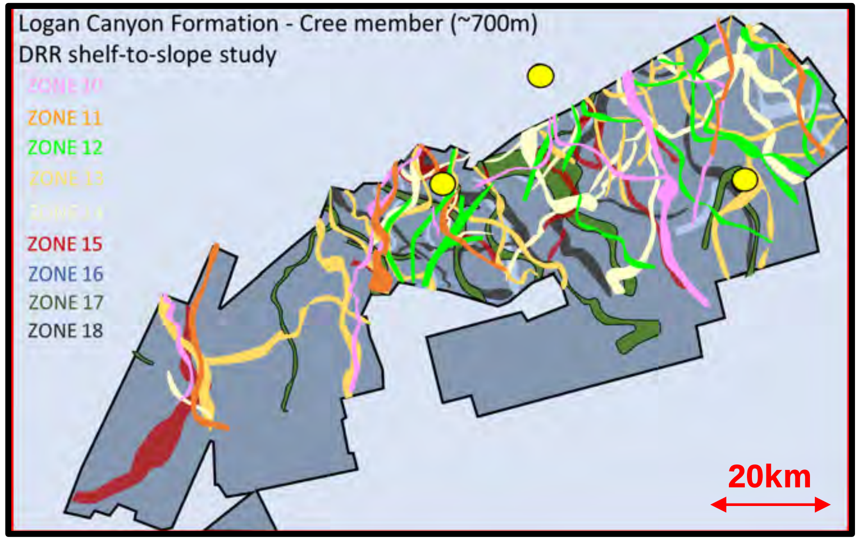


A



B

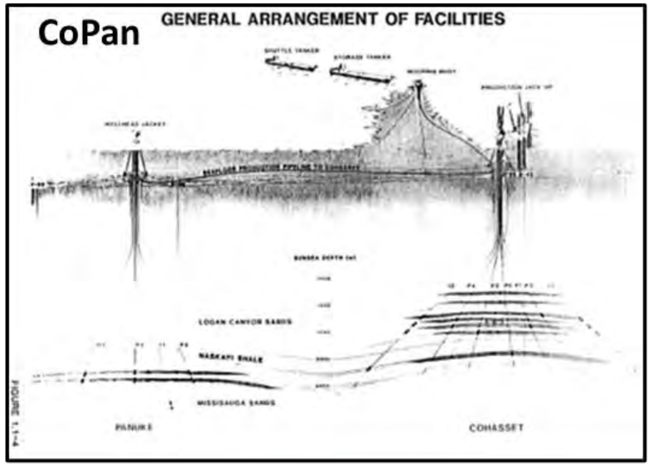
- ➢ **3 * 4 Mtpa injected below Naskapi Shale for 50 years**
- ➢ **Plumes reach residual saturations after ~1000 years**
- ➢ **Model needs imbibition curves & channel architecture known from 3D seismic data**

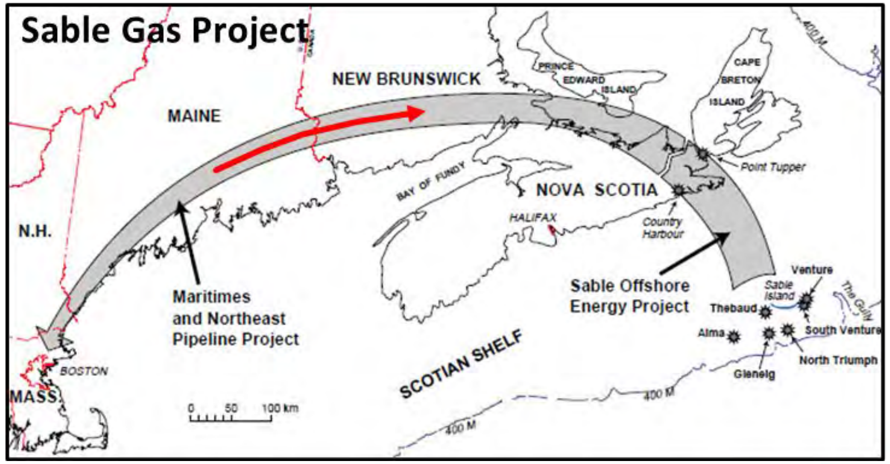


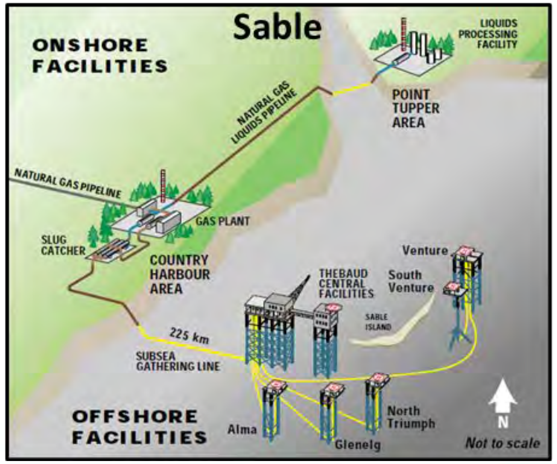
Logan Canyon Stacked Channels (RMS Interval Amplitudes)
~ 30 well penetrations, all high phi-k channel sands

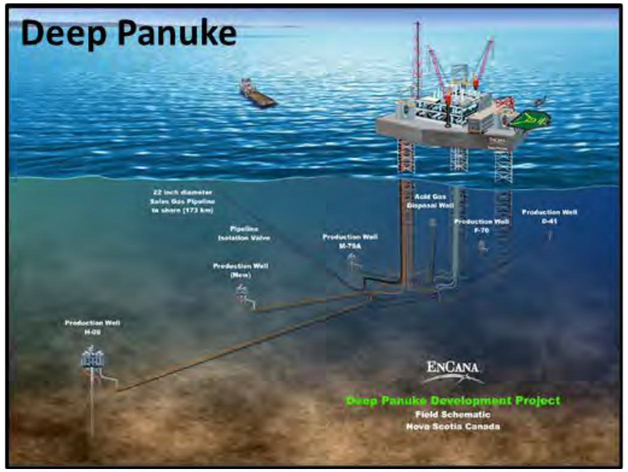
Historical Infrastructure (from field development plans)

- **Decommisioned fixed & floating facilities.**
- **2 abandoned offshore pipelines in place (useable?). Onshore pipeline reversed**
  - **CoPan: Lasmo, 1992-1999; 44.5 MBO 5 BCF**
    - Two steel jackets, subsea flowline with a jack-up drilling unit.
    - Production via an FPSO and shuttle tankers.
  - **Sable: Exxon Mobil, 1998-2018: 2.1 TCF**
    - Fixed platforms removed: pipeline from Thebaud to mainland abandoned in-place, unclear if re-useable (?). Maritimes and NE pipeline gas flow has been reversed
  - **Deep Panuke: Encana, 2015-2018, 147 BCF**
    - Jack-up platform with subsea tiebacks. Pipeline still in place (?) Useable (?)









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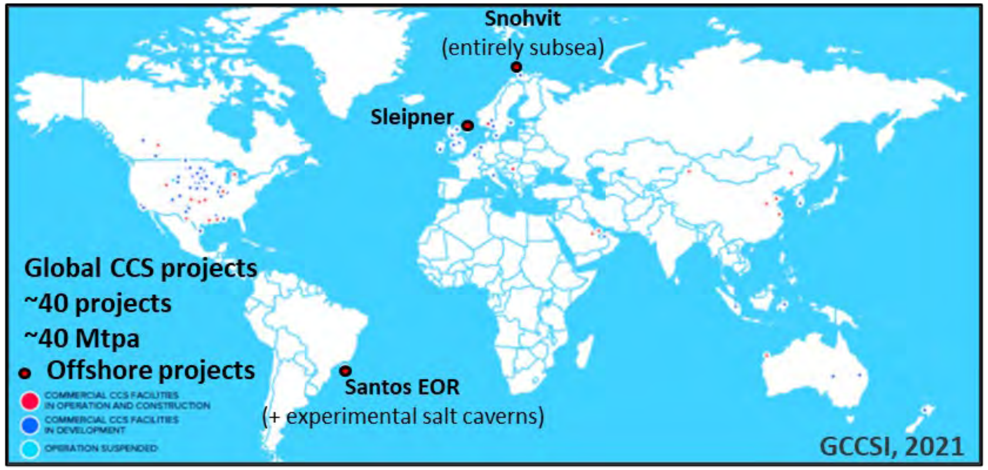
Offshore CCS Considerations

- **Some idea of costs from a 2021 Rutgers study – NE & Midwest USA**
  - Offshore CCS ~ $60/t all-in from coal-fired power plants (Schmelz et al, 2021)
- **Sable CCS wells could have twice the revenue of historical Sable gas wells**
  - 0.7 Mtpa, 30 years, $100/t credit ➔ ~ $2 billion
  - 100 BCF Sable Gas well at 10/MCF ➔ ~ $1 billion (22 wells, 2.1 TCF cum.)
- **Looking at a huge drilling investment if we want to take AGW seriously**
  - <u>7 Gtpa target (IEA 2DS 2050)</u> requires >10,000 x 0.7 Mpta injection wells (Ringrose & Meckel 2019)
  - <u>Drilling Cost $500 B at $50M</u> per well (maybe cheaper with economies of scale)
- **But an even bigger anticipated market - $4T CCS by 2050 (XOM)**
  - Planned clusters in Europe and N. America with pore-space land-grabs in GOM
- **Offshore CCS ready to take off**

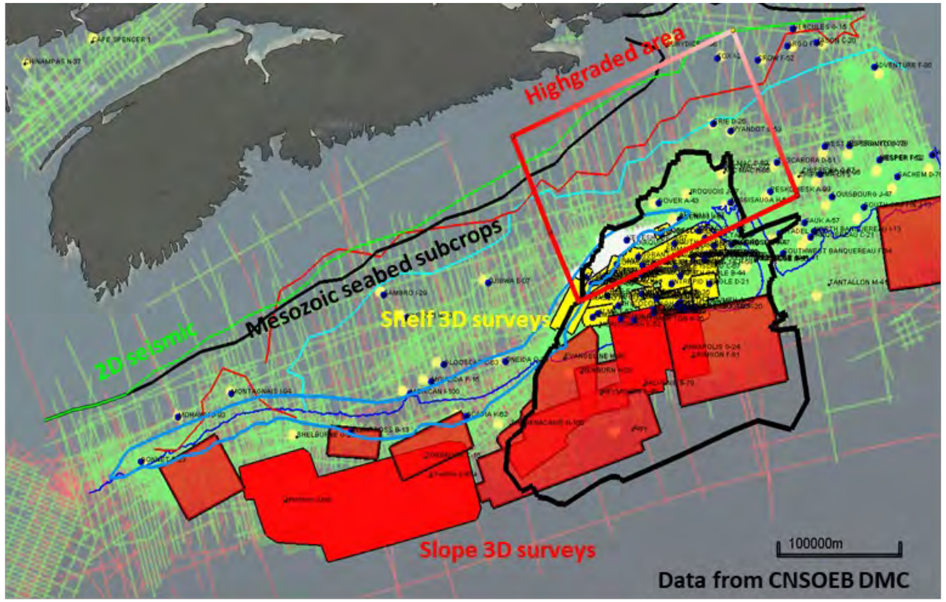


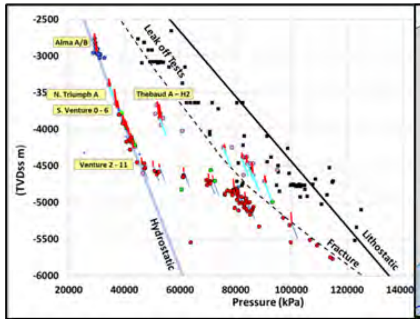
- Currently 3 operational offshore CCS projects
- Current Global emissions ~40 Gtpa; Storage ~40 Mtpa
- Global storage capacity ~ 8-55 Tt (IEA, 2021)
- Emissions since 1750 >1.7 Tt* Canada 2%, USA 24%, EU 21%, China 14%

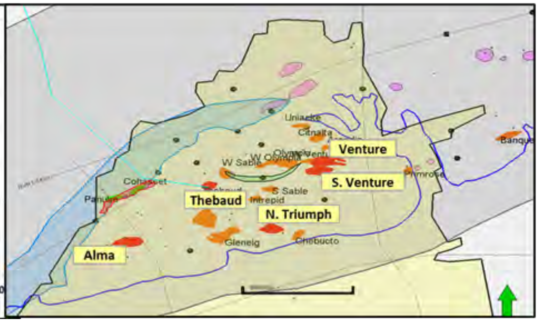
*https://ourworldindata.org (Oxford University ed.) USA 24%, EU 21%, China 14%, Russia 7%., Canada 2%

Conclusions and Next Steps

- **Excellent geologic and strategic attributes**
  - **Storage, containment, injectivity – access to USA & Europe**
- **~100-200 Gt resource in deep saline aquifers**
  - **Highgraded area**
  - **Requires "next-level" expert static & dynamic modeling & potential new data acquisition**
    - Geo-spatial modeling; core analysis; rock physics; 3D / 4D seismic
    - Probablistic assessments & a static resource atlas
- **~100 Mt resource in depleted fields**
  - **"Best" depleted fields are Alma & N. Triumph**
- **Potential for multiple phased commercial strategies**
  - **1-4 well pilot projects (similar to Snohvit or Aurora)**
  - **Regional (5-100 wells)**
  - **Intercontinental (100 + wells)**
  - **Integration with "Energy Corridor" (Dusseault & Wach, 2021)**







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Battelle Project Number – 100068380
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https://www.osti.gov/biblio/1566748 **(full report)**

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Department
Publications
Videos

NSDOE OFR 2017-05 - Cumberland Basin Lower Carboniferous Source Rock Project

- Cumberland Basin Lower Carboniferous Source Rock project pdf 2,749 KB
- Appendix 1 - Sample Images pdf 894 KB
- Appendix 2 - Palynofacies counts pdf 340 KB
- Appendix 3 - Palynomorph occurrence table per sample pdf 511 KB
- Appendix 4 - Pyrolysis resuls per sample pdf 3,475 KB
- Appendix 5 - Taxa illustration pdf 2,365 KB
- Appendix 6 - Raw data and histograms of the measured vitrinite relectance per sample pdf 811 KB
- Disclaimer txt 2 KB

NSDOE OFR 2017-06 Seismic Interpretation in the Windsor Basin

- Seismic Interpretation in the Windsor Basin pdf 21,708 KB
- Appendix 1 - Maps pdf 2,009 KB
- Appendix 2 - Cross sections pdf 1,670 KB
- Appendix 3 - Composite Lines pdf 8,347 KB
- Appendix 4 - Well Ties pdf 2,485 KB
- Disclaimer txt 2KB

NSDOE OFR 2017-07 Schedule of 2D Seismic Data, Onshore Nova Scotia

- Schedule of 2D Seismic Data, onshore Nova Scotia - Part 1 - Cape Breton region pdf 101,119 KB
- Schedule of 2D Seismic Data, onshore Nova Scotia - Part 2 - Cumberland region pdf 154,462 KB
- Schedule of 2D Seismic Data, onshore Nova Scotia - Part 3 - Windsor region pdf 61,901 KB
- Appendix 1 - List of seismic lines pdf 75 KB
- Appendix 2 - List of seismic surveys pdf 64 KB
- Disclaimer txt 2KB

NSDOE OFR 2017-08 Schedule of Petroleum Wells, Onshore Nova Scotia

- Schedule of Petroleum Wells, onshore Nova Scotia - Part 1 - Cape Breton region pdf 3,168 KB
- Schedule of Petroleum Wells, onshore Nova Scotia - Part 2 - Cumberland region pdf 4,045 KB
- Schedule of Petroleum Wells, onshore Nova Scotia - Part 3 - Windsor region pdf 3,168 KB
- Disclaimer txt 2 KB

NSDOE OFR 2017-09 Preliminary petroleum well log database, onshore Nova Scotia

- Preliminary petroleum well log database, onshore Nova Scotia - Part 1 - Cape Breton region zip (LAS files) 4,724 KB
- Preliminary petroleum well log database, onshore Nova Scotia - Part 2 - Cumberland region zip (LAS files) 15,773 KB
- Preliminary petroleum well log database, onshore Nova Scotia - Part 3 - Windsor region zip (LAS files) 43,353 KB
- Disclaimer txt 2KB

NSDOE OFR 2017-10 Preliminary petrophysics database, onshore Nova Scotia

- Preliminary petrophysics database, onshore Nova Scotia - Part 1 - Outcrop Data pdf 527 KB
- Preliminary petrophysics database, onshore Nova Scotia - Part 2 - Well Data pdf 568 KB
- Supporting notes pdf 81 KB
- Disclaimer txt 2 KB

NSDOE OFR 2017-11 Navigation data for 2D Seismic lines, onshore Nova Scotia

- Navigation data for 2D seismic lines, onshore Nova Scotia - Part 1 - Cape Breton region zip (shapefile) 1051KB
- Navigation data for 2D seismic lines, onshore Nova Scotia - Part 2 - Cumberland region zip (shapefile) 1909 KB
- Navigation data for 2D seismic lines, onshore Nova Scotia - Part 3 - Windsor region zip (shapefile) 274 KB
- Disclaimer txt 2KB

NSDOE OFR 2017-09 Preliminary petroleum well log database, onshore Nova Scotia

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NSDOE OFR 2017-10 Preliminary petrophysics database, onshore Nova Scotia

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- Preliminary petrophysics database, onshore Nova Scotia - Part 2 - Well Data pdf 568 KB
- Supporting notes pdf 81 KB
- Disclaimer txt 2 KB

Well_ID	Well Name	Sample_ID	Company	Year	Group	Formation	Depth_top (m)	Porosity	Permeability		
									K(max)	K(90)	K(vertical)
P-121	Milford Station #1		EOG Resources Inc.	2005	Horton		810.00	0.060	0.06	0.05	<.01
P-121	Milford Station #1		EOG Resources Inc.	2005	Horton		810.88	0.056	0.06	0.04	<.01
P-121	Milford Station #1		EOG Resources Inc.	2005	Horton		811.17	0.073	0.14	0.09	<.01
P-121	Milford Station #1		EOG Resources Inc.	2005	Horton		811.45	0.117	0.33	0.21	0.15

e.g.

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https://energy.novascotia.ca/oil-and-gas/offshore/play-fairway-analysis/analysis

The Analysis

Play Fairway Analysis Atlas

Below are the links to the current chapters of the Nova Scotia Play Fairway Analysis (PFA) Atlas. These chapters provide the results of the PFA. However, some are unfinished slides. Although scientifically accurate, the presentation will be polished over the coming weeks to provide improved context and readability.

Documentation of the Play Fairway Analysis is at an advanced stage. Interpreted material in digital format is also being prepared, which will enable interested parties to conduct due diligence and modify interpretations as desired. Our intention is to make digital material available in two forms:

1. Separate files containing
   1. Grid files for time, depth, isochron and isopach maps.
   2. Synthetic seismograms in SEG-Y format
   3. Seismic horizons
   4. Well tops
   5. Composite logs
   6. Geochemistry data, and
2. GIS database containing the above as well as various seismic and geological maps (GDE, CRS and seismic facies maps)It is expected that the individual file compilation will be available shortly. It is the expected that the GIS database will be completed by the end of the summer with the final version of the complete Play Atlas available on this website by the end of the summer.Due to the size of the images within the PFA, please expect long download times. If you are unable to download the files, please contact us for assistance or to request a DVD copy.

- Atlas Title – (421.4 KB)
- Executive Summary – (447.2 KB)
- Acknowledgements – (231.1 KB)
- Table of Contents – (116.5 KB)
- Chapter 1: Introduction – (40.7 MB)
- Chapter 2: Plate Tectonics – (12.2 MB)
- Chapter 3: Stratigraphy – (112.5 MB)
- Chapter 4: Petroleum Geochemistry – (10.9 MB)
- Chapter 5: Seismic Interpretation – (963.7 MB)
- Chapter 6: Tectono-Stratigraphic Evolution Petroleum Systems – (1.6 GB)
- Chapter 7: Basin Modeling – (39.6 MB)
- Chapter 8: Petroleum Evaluation – (228.4 MB)
- Chapter 9: Late Jurasic Carbonate Play Fairway Analysis – Addendum to Play Fairway Analysis – (862.7 MB)

Geophysical Data

- PFA ISOPACH Grids – (7.4 MB)
- PFA TVDSS Grids – (7.9 MB)
- PFA TWT Grids – (7.6 MB)
- Synthetics – (0.3 MB)
- Time Depth Data – (2.9 MB)
- 2D Seismic Interpretation (Note: This is a large .dat file. Please right-click the link and save it to your hard drive)
- 3D Seismic Interpretation

GIS Data

- ARC GIS Data – (266 MB)

Annex

- Annex 1: Well List Directory – (52.9 KB)
- Annex 2: Well Database for Workstations – (492.6 MB)
- Annex 3: Well Data Package – (1.0 GB)
- Annex 4: Well Log Results – (77.6 KB)
- Annex 5: Reservoir Properties – (117.1 KB)
- Annex 6: Petroleum Results – (470 KB)
- Annex 7: References and Bibliography – (248.2 KB)
- Annex 8: Report: Pe-Piper Sedimentology – (2.1 KB)
- Annex 9: Report: A. Karim, G. Pe-Piper, D.J.W. Piper Sedimentology – (260 MB)
- Annex 10: Report: Beaumont Salt Tectonics – (29.7 MB)
- Annex 11: Report: Hanley Fluid Inclusions – (1 MB)
- Annex 12: Report Kettanah Fluid Inclusions – (28.2 MB)
- Annex 13: Report: Sibuet Plate Tectonic Reconstruction – (54.1 MB)
- Annex 14: Report: Louden Refraction – (11.7 MB)
- Enclosures – (157.5 MB)

Annex-03_Well_Data_Package.zip
- Annex-03_Well_Data_Package
  - 01_DMC_well_collection_markers_original
  - 02_DMC_well_collection_masterlog
  - 03_Lithologies_from_85_wells_Rob_Fensome_composite_well_log
  - 04_Biostratigraphic_well_log_charts_Nov_2010_RPS
  - 05_PHI_K_core_analysis
  - 06_Well_Template_Xsect_lithostrat_2011_BF
  - 07_Well_Template_Xsect_bible_lines_2011_BF

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ComoP21.prn
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Core Analysis Data - All Wells.XLS
DauntlessD35.prn
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EagleD21.prn
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Etc.

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Backup

- **World-class offshore deep saline aquifers**
  - Size, strategic position, infrastructure, water depth, iceberg-free
  - Injectivity, capacity, containment
  - Low seismicity passive margin, hydrostatic aquifers
  - Data base, regional & field studies, offshore engineering experience

Infrastructure, reservoir-seal pairs & quality (Wach et al, 2010)

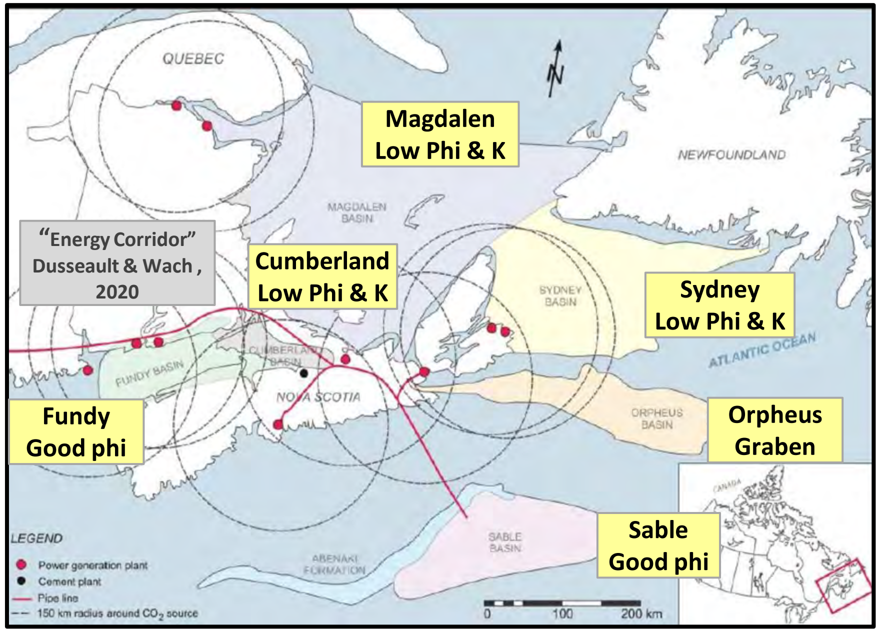

Table 4 : Geological Carbon Sequestration- Pros and Cons of the Maritimes and Scotian sedimentary basins.		
Maritimes	Pros	Cons
Fundy	Good Porosity	Farther from emission sites
Cumberland	Close proximity to emission site (Trenton)	Low Porosity and Permeability
Magdelen	Close proximity to emission site	Low Porosity and Permeability
Sydney	Close proximity to emission site	Low Porosity and Permeability
Scotian	Pros	Cons
Orpheus	Close proximity to emission site; potential for salt seal	Offshore pipeline and monitoring survey needed
Sable	Pipeline in place and good porosity	Far from emission sites
Abenaki	Pipeline in 2010; planned H2S injection site so some infrastructure	Far from emission sites

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Backup

Vidas, H., B. Hugman, A. Chikkatur, B. Venkatesh. 2012. U.S. OCS Study BOEM 2012 (ICF International)

Table 4 U.S. Offshore CO_2 Sequestration Potential

Gigatonnes

		Oil and Gas Fields			Saline			Coal Beds			Shale and Basalt	Total
		Low	High	Avg.	Low	High	Avg.	Low	High	Avg.		Avg.
Gulf of Mexico	Total	16.3	16.3	16.3	429	5,967	3,198	0.0	0.0	0.0	not assessed	3,215
	Depleted fields	14.8	14.8	14.8								14.8
	CO_2 EOR	1.5	1.5	1.5								1.5
Pacific Offshore	Total	0.2	0.2	0.2	14.9	201.5	108.2	1.4	3.1	2.2	not assessed	110.6
	Depleted fields	0.2	0.2	0.2								0.2
Atlantic Offshore		0.0	0.0	0.0	47.2	587.4	317.3	0.0	0.0	0.0	not assessed	317.3
Total	Total	16.5	16.5	16.5	491	6,756	3,624	1.4	3.1	2.2		3,643
	Depleted fields	15.0	15.0	15.0								15.0
	CO_2 EOR	1.5	1.5	1.5								1.5

Source: 2010 NATCARB Atlas with ICF allocations. The regional breakout was only partially documented in the NATCARB Atlas. The values for offshore saline potential in the Pacific and Atlantic are ICF estimates based upon analysis of the Atlas.

Table 2 DOE NATCARB Regional Assessment of North America CO_2 Sequestration Potential

Gigatonnes

Region	Non-EOR Depleted Oil and Gas	CO2 Enhanced Oil Recovery*	Coal Seams			Saline Formations			Assessed Total		
			Low	High	Calc. Midpoint	Low	High	Calc. Midpoint	Low	High	Calc. Midpoint
Williston Basin and Western Canada	24.4	0.6	1.0	1.0	1.0	165	165	165	191	191	191
Illinois Basin	0.9	0.1	1.6	3.3	2.5	12	160	86	15	164	89
Michigan and Appalachia	16.9	0.1	0.8	1.9	1.4	46	183	[illegible]	64	202	133
Gulf Coast, GoM, and Atlantic Offsh.	28.8	3.2	33.0	75.0	54.0	908	12,526	6,717	973	12,633	6,803
California, Pac. NW, Pac. Offsh., AK	2.8	1.2	10.0	23.0	16.5	82	1,124	603	96	1,151	624
S. Rockies, Mid-Cont.,West Texas	51.2	10.7	1.0	2.0	1.5	219	3,013	1,616	282	3,077	1,679
N Rockies, W. Montana	1.6	0.6	12.0	12.0	12.0	221	3,041	1,631	235	3,055	1,645
North America Total	126.6	16.5	59.4	118.2	88.8	1,653	20,212	10,933	1,856	20,473	11,164
Alaska	0.0	0.0	9.0	21.0	15.0	0	0	0	9	21	15
Canada	18.0	0.0	0.8	0.8	0.8	38	51	44	57	70	63
L48 Total	108.6	16.5	49.6	96.4	73.0	1,614	20,163	10,889	1,790	20,383	11,087
onshore	93.6	15.0	48.3	93.3	70.8	1,123	13,407	7,265	1,280	13,609	7,444
offshore	15.0	1.5	1.3	3.1	2.2	491	6,756	3,624	509	6,776	3,643

Sources: 2010 NATCARB Atlas for all except CO2 EOR, which is an ICF estimate based upon DOE assessments of EOR potential.

2015 NETL 5th Atlas

Alberta

Previou

CO_2 Stationary Source Emissions and CO_2 Storage Resource Estimates Summary*

State/ Province	CO_2 Emissions		Oil and Natural Gas Reservoirs Storage Resource			Unmineable Coal Storage Resource			Saline Formation Storage Resource			Total Storage Resource		
			Billion Metric Tons			Billion Metric Tons			Billion Metric Tons			Billion Metric Tons		
	Million Metric Tons Per Year	Number of Sources	Low Estimate	Medium Estimate	High Estimate	Low Estimate	Medium Estimate	High Estimate	Low Estimate	Medium Estimate	High Estimate	Low Estimate	Medium Estimate	High Estimate
Alabama	91	134	0.06	.09	0.12	1.92	2.98	4.37	120.22	307.34	689.67	122.20	310.41	694.16
Alaska	18	63				8.64	13.44	19.75				8.64	13.44	19.75
Alberta	137	182	0.60	1.49	3.57	0.03	0.03	0.03	38.17	76.74	140.30	38.80	78.26	143.90

UK North & Irish Sea P50	GT
CNS	40
SNS	15
NNS	14
EIS	6
Units under 20Mt	3
	78
O&G Fields	8
Aquifers	70

NPD.
Bentham.

Utsira Skade	15.8
Bryne/Sandness	13.6
Sonjefjord Delta East	4.1
Statfjord Fm. East	3.6
Gassum	2.9
Farsund	2.3
Johansen and Cook	1.8
Fislebank	1.0
Strod	0.1
Hugin East	0.1
	45.3
Fields	13.0
	58.3

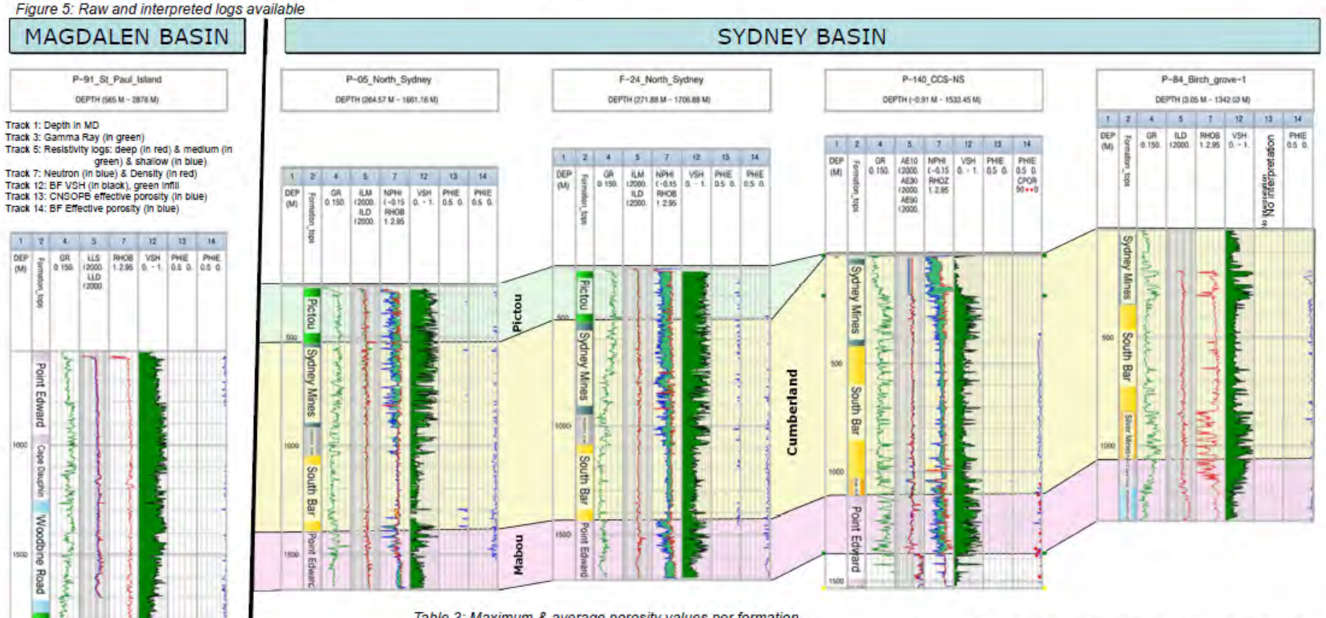
NOVA SCOTIA

Backup - 2017 Sydney Basin PFA Chapter 3

Porosity interpretation from CNSOPB (Track 13, Figure 5) in the Sydney Basin is close to 0%. An alternative porosity interpretation is provided by Beicip-Franlab (Track 14, Figure 5). The more optimistic porosity interpretation from Beicip-Franlab was conducted according to observations from NMR logs in well P-140 CCS-NS, while the porosity interpretation from CNSOPB is closer to the moveable fluid porosity. The representative porosity values per well and interval are shown in Table 3.

The basin petroleum system modeling requires a net-sand and a total porosity value per layer as well as an effective porosity value in reservoir layers. The values used in the basin petroleum system modeling will be chosen according to the petrophysical properties observed and gathered.

Figure 5: Raw and interpreted logs available



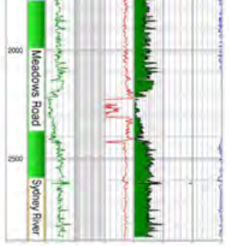


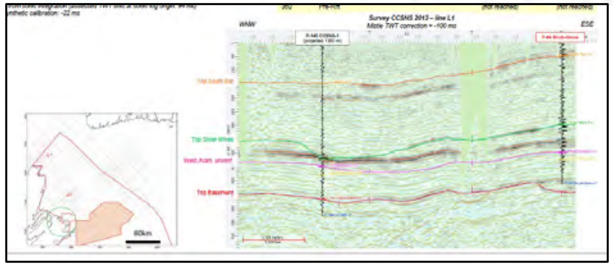
Table 3: Maximum & average porosity values per formation

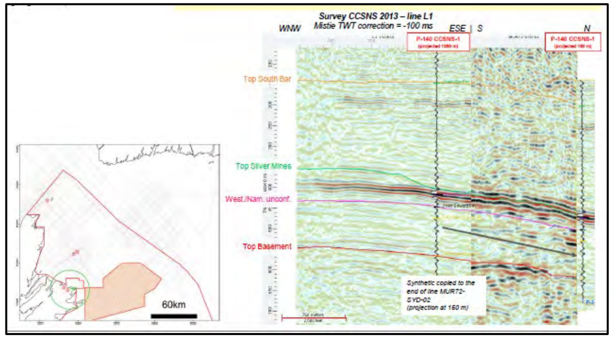
	PHIE values from CNSOPB petrophysical interpretation		PHIE values from BF petrophysical interpretation		PHIT values from BF petrophysical interpretation		
Formation	Max	Avg	Max	Avg	Min	Max	Avg
Pictou	10%	0,5%	10%	0,8%	5%	21%	6,1%
Sydney Mines	10%	0,3%	10%	1,0%	1%	23%	6,4%
Waddens Cove	10%	0,4%	10%	2,7%	2%	19%	6,4%
South Bar	10%	0,3%	10%	2,7%	1%	19%	5,7%
Silver Mines	10%	0,1%	10%	0,8%	2%	17%	6,5%
Point Edward	10%	0,0%	10%	1,5%	0%	24%	5,7%
Cape Dauphin	0%	0,0%	6%	0,6%	2%	9%	6%
Woodbine Road	0%	0,0%	10%	1,2%	1%	13%	6%
Meadows Road	8%	3,3%	10%	1,4%	0%	14%	4,4%
Sydney River	10%	0,1%	9%	2,6%	0%	12%	6,2%

Table 3: Maximum & average porosity values per formation

	PHIE values from CNSOPB petrophysical interpretation		PHIE values from BF petrophysical interpretation		PHIT values from BF petrophysical interpretation		
Formation	Max	Avg	Max	Avg	Min	Max	Avg
Pictou	10%	0,5%	10%	0,8%	5%	21%	6,1%
Sydney Mines	10%	0,3%	10%	1,0%	1%	23%	6,4%
Waddens Cove	10%	0,4%	10%	2,7%	2%	19%	6,4%
South Bar	10%	0,3%	10%	2,7%	1%	19%	5,7%
Silver Mines	10%	0,1%	10%	0,8%	2%	17%	6,5%
Point Edward	10%	0,0%	10%	1,5%	0%	24%	5,7%
Cape Dauphin	0%	0,0%	6%	0,6%	2%	9%	6%
Woodbine Road	0%	0,0%	10%	1,2%	1%	13%	6%
Meadows Road	8%	3,3%	10%	1,4%	0%	14%	4,4%
Sydney River	10%	0,1%	9%	2,6%	0%	12%	6,2%

Note:
- From Pictou to Point Edward Fm, statistics are derived from Sydney Basin wells
- From Cape Dauphin to Sydney River, statistics are derived from well P-91
- Minimum PHIE value is 0% for all formations and both interpretations





NOVA SCOTIA

DALHOUSIE UNIVERSITY — net-zero atlantic — Government of Canada / Gouvernement du Canada — NOVA SCOTIA

8:00-8:30	**Day 1, Wednesday April 19th, Registration & Breakfast**			**Lord Dalhousie Room**
8:30-9:30	**Opening Remarks (IT Briefing at 8:20)**			
	Setting the Scene – Carbon Neutrality	8:30-8:40	Grant Wach	Dalhousie University, Department of Earth and Env. Sciences
	Welcome to Mi'kma'ki	8:40-8:50	Catherine Martin	Dal. U. Director of Indigenous Community Engagement
	Welcome to the Workshop	8:50-9:00	Russell Dmytriw	Director of Research, Net Zero Atlantic
	Introduction to the Nova Scotia Perspective	9:00-9:10	Adam MacDonald	NS Dept Natural Resources & Renewables (NSDRR)
	Setting the Stage – NS Provincial Perspective	9:10-9:20	Karen Gatien	Deputy Minister, NSDNRR
	Setting the Stage – Federal Perspective	9:20-9:30	Drew Leyburne	Assistant Deputy Minister, NRCan
9:30-10:00	**Introduction to CCUS**			
	What is CCUS?	9:30-9:50	Carla Skinner	Geological Survey of Canada, NRCan Research Scientist
	Discussion	9:50-10:00	ALL	Speakers/Delegates
10:00-10:30	**Break**			**Lord Dalhousie Room**
10:30-12:00	**CCUS Opportunity**			
	Geostorage	10:30-10:50	Maurice Dusseault	University of Waterloo, Dept of Earth and Env. Sciences
	Opportunity for Canada	10:50-11:10	Robin Hughes	Manager Industrial Decarbonization, NRCan
	Opportunity for Nova Scotia – Offshore	11:10-11:30	Bill Richards	Consultant to NSDRR
	The Path Forward	11:30-11:50	Saviz Mortazavi	Deputy Director, CCUS and Hydrocarbon Production, NRCan
12:00-13:00	**Lunch and Group Photo**			**Lord Dalhousie Room**
13:10-14:50	**CCTS Regulation & Policy**			
	Carbon Transportation and Storage Regulations	13:10-13:30	Brian Bylhouwer	Associate, Environmental Science, Stantec, PEI
	Nova Scotia Policy and Priorities	13:30-13:50	Melissa Oldreive	Manager, Strategic Priorities, NSDRR
	Searcher's Datasets to Support C Neutrality	13:50-14:10	Karyna Rodrigues	Vice President, Global New Ventures, Searcher Seismic
	The Role of Industry	14:10-14:30	Patrick MacDonald	Director Sustainability, Can. Assoc. of Petroleum Producers
	Propelling Canada Past Other Jurisdictions	14:30-14:50	George Kovacic	Advisor, Searcher Seismic
15:00-15:30	**Break**			**Lord Dalhousie Room**
15:30-16:30	**Provincial Perspectives**			
	Quebec Perspective & Vision	15:30-15:50	Robert Symonds	Research Scientist, NRCan CanmetENERGY-0
	Newfoundland Perspective	15:50-16:10	David Corkey	Dir. Petroleum Engineering, NL Dept Industry, Energy & Tech.
	New Brunswick Perspective	16:10-16:30	Dave Keighley	Assistant Dean, Geology, University of New Brunswick
16:30-17:00	**Discussion & Closing Remarks**			
	The Path to Carbon Neutrality	16:30-16:50	Grant Wach	Dalhousie University, Department of Earth and Env. Sciences
	Thank You and Wrap Up Day 1	16:50-17:00	Russell Dmytriw	Director of Research, Net Zero Atlantic
17:00-18:00	**Reception – All Welcome**			**Lord Dalhousie Room**

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	Day 2, Thursday April 20th, Registration & Breakfast			**Lord Dalhousie Room**
8:30-10:00	**CO2 Issues & Lessons from Others**			
	Recap from Day 1	8:30-8:40	Grant Wach	Dalhousie University, Department of Earth and Env. Sciences
	Geotechnical Constraints - Achieving the 2030 deadline	8:40-9:00	Richard Jackson	Principal, Geofirma Engineering Ltd.
	CCS & Geostorage, Netherlands	9:00-9:20	Jaap Breunese	Principal Consultant, TNO Energytransition
	Northern Lights, Norway	9:20-9:40	Cristel Lambton	CCS Project Manager, Low Carbon Solutions, Equinor
	Acorn, UK Sector	9:40-10:00	Catherine Witt	Head of Subsurface, Storegga
10:00-10:20	**Break**			**Lord Dalhousie Room**
10:20-12:00	**CO2 Issues & Lessons from Others**			
	London Protocol	10:20-10:40	Michael Buckland-Nicks	Program Officer, Environment and Climate Change Canada
	Norwegian Continental Shelf 2030 Project	10:40-11:00	Ying Guo	Senior Advisor, CCUS-IOR, Norwegian Research Centre NORCE
	Workflow for Assessment (BC)	11:00-11:20	Brad Hayes	President, Petrel-Robertson Consulting Ltd.
	Pore Volume Assessment	11:20-11:40	Graham Simpson	Vice President, Geosciences, GLJ Engineering
	Oceans and CO2	11:40-12:00	Lesley James	Memorial University, Faculty of Engineering and Applied Science
12:00-13:00	**Lunch**			**Lord Dalhousie Room**
13:00-15:20	**CO2 Issues & Renewable Solutions**			
	Geothermal – Heat (Power)	13:00-13:20	Cathie Hickson	CEO, Alberta No. 1 / Terrapin Geothermics
	Boundary Dam, Sask	13:20-13:40	Erik Nickel	Chief Operations Officer, Petroleum Technol. Research Centre
	CCS in Alberta Basin	13:40-14:00	Mahendra Samaroo	Senior Engineer, Alberta Department of Energy
	Alberta Carbon Trunk Line	14:00-14:20	Jeff Pearson	President, Wolf Carbon
	Maritimes Energy Corridor	14:20-14:40	Grant Wach	Dalhousie University, Department of Earth and Env. Sciences
	Paleozoic Basins Potential	14:40-15:00	Trevor Kelly	Municipality of Cumberland
	Natural Gas & Hydrogen	15:00-15:20	Jordan MacNeil	Manager, Business Development, Eastward Energy
15:20-15:40	**Break**			**Lord Dalhousie Room**
15:40-17:00	**CO2 Issues & Renewable Solutions**			
	Socio-Economic Issues	15:40-16:00	Jennifer Winter	Dept Economics & Public Policy, University of Calgary
	The Role of Renewables	16:00-16:20	David Miller	Director, Clean Electricity NSDNRR
	Supporting CCUS in Development in Canada	16:20-16:40	Carl Landry	Canada Infrastructure Bank
	Closing Remarks	16:40-17:00	G. Wach/M. Dusseault	Dalhousie University / University of Waterloo
17:00-18:00	**Closing Reception**			**Lord Dalhousie Room**

https://www.dal.ca/sites/sustainable-energy/news---events/carbon-neutrality-forum/forum-review.html

Forum Review

Day I of the Carbon Neutrality Forum was a resounding success. Catherine Martin welcomed the delegation to Mi'kma'ki. This was followed by reviews of the federal and provincial