Shale Gas in Quebec's Sedimentary Basins*

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Editor's note: This presentation is an update, or sequel, to Search and Discovery Article #80073 (2009) ("Shale Potential of the Quebec Sedimentary Basins" by the same authors).

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Abstract

Keen interest for Shale Gas remains high in the Southern Quebec Lowlands. During 2009 to 2010, fifteen shale gas wells were drilled in the basin. The calcareous and organic-rich Middle Ordovician Utica Shale is the main target of this recent exploration effort. To date, most operations have been performed in the medium to deep depth thermogenic Shale gas play (1,000-2,000 meters), located in the central part of the Saint Lawrence Lowlands. With OGIP estimates ranging from 75 to 300 Bcf per section, the deep play is definitely considered to be promising. Publicly released information from the different tested areas in the basin expressed a potential gas-in-place over 200 Tcf (OGIP). After drilling exploration wells in order to delineate a "sweet spot", companies have now focused their effort on determining the highest gas-prone unit within the Utica. Discussions concerning pilot-test projects are also beginning.

While testing the deep shale potential, JUNEX also has begun to evaluate the potential of the other shale gas plays. Only over the last two years, Junex started the evaluation of gas potential in three other shales:

1. Shallow to medium depth thermogenic shale gas;
2. Overthrusted shale gas;
3. Intra-Appalachians sub-basin shale gas.

The three plays are described based upon the data available regarding the basin geology, shale mineralogy, organic matter type, gas geochemistry, structural style and infrastructure access. The characteristics of the plays, from a geological, geochemical, structural and geophysical perspective, are reviewed. With the addition of the acquisition of a large geoscience database, new exploration efforts undertaken by JUNEX include:

- Exploration well in the deep and shallow shale plays;
- Propane frac stimulation in the shallow shale play;
- Exploration in the new intra-Appalachian basin;
- Scheduled for fall 2010: two exploration wells in the overthrusted shale play.

Selected References

Aguilera, Roberto, 1978, Log Analysis of Gas Bearing Fracture Shales in the Saint Lawrence Lowlands of Quebec: SPE Annual Fall Technical Conference, 1-3 October 1978, Houston, Texas, SPE 7445-MS, Web accessed 1 March 2011, http://www.onepetro.org/mslib/app/Preview.do?paperNumber=00007445&societyCode=SPE

Castonguay, S., S. Séjourné, and J. Dietrich, 2003, The Appalachian structural front in southern Quebec: seismic evidence for complex structures and a triangle zone at the edge of the foreland thrust belt: Geological Society of America Northeastern Section, 38th Annual Meeting Abstracts with Programs v. 35/3, p. 86.

Chan, P., and J.R. Etherington, 2010, A process to evaluate unconventional resources: SPE Annual Technical Conference and Exhibition, 19-22 September 2010, Florence, Italy, SPE 134602-MS, Web accessed 1 March 2010, http://www.onepetro.org/mslib/servlet/onepetropreview?id=SPE-134602-MS&soc=SPE

Cluff, R., 2009, Shale gas: opportunities and challenges for independents or, What's in it for me?: SIPES Annual Meeting 2009, Hilton Head, South Carolina, Web accessed 1 March 2011. http://www.discovery-group.com/pdfs/2009%20SIPES%20Ann%20Mtg%20Shale%20gas%20opportunities%20and%20challenges.pdf

Comeau, F.-A , D. Kirkwood, M. Malo, E. Asselin, and R. Bertrand, 2004, Taconian mélanges in the parautochthonous zone of the Quebec Appalachians revisited: Implications for foreland basin and thrust belt evolution: Canadian Journal of Earth Science, v. 41/12, p 1473-1490.

Ferworn, K., J. Zumberge, J. Reed, and S. Brown, 2008, Gas character anomalies found in highly productive shale gas wells: GeoMark Research Technical Presentation, Houston, Texas, October 2008, 26 p.

Thériault, R., 2009, Variations Géochimiques, Minéralogiques et Stratigraphiques des Shales de l'Utica et du Lorraine: Implications pour l'Exploration Gazière dans les Basses-Terres du Saint-Laurent: Technical paper presented at the Quebec Oil and Gas Association Annual Meeting Montréal, Canada, October 19-20, 2009, 51 p.

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Shale Gas in Quebec's Sedimentary Basins

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Introduction : Exploring a large portofolio

- Created in 1999 & listed on the TSX Venture Exchange in June 2001 with a Quebec-based Management team & Board members (significant E&P, energy & business experience);
- First Mover in the St. Lawrence Lowlands Basin - built a strong land position >1.5 million acres from 2002 to 2005. Largest Landholder in the Utica Shale Gas Play - 1,064,644 gross acres in Utica Play (849,248 net acres) ;
- The first "pure play" shale gas partnership deal done in Quebec – JNX and Forest Oil in 2006 for the Bécancour Block;
- Significant exposure to all Shale Fairways (Utica Shallow, Deep & Structured, Appalachian Shales) ;
- JNX owns & operates two drilling rigs – better cost control & timely access to drilling equipment for its projects. JNX is largest E&P direct employer of Quebec residents : total of ~ 45 employees (15 office & ~ 30 field employees).

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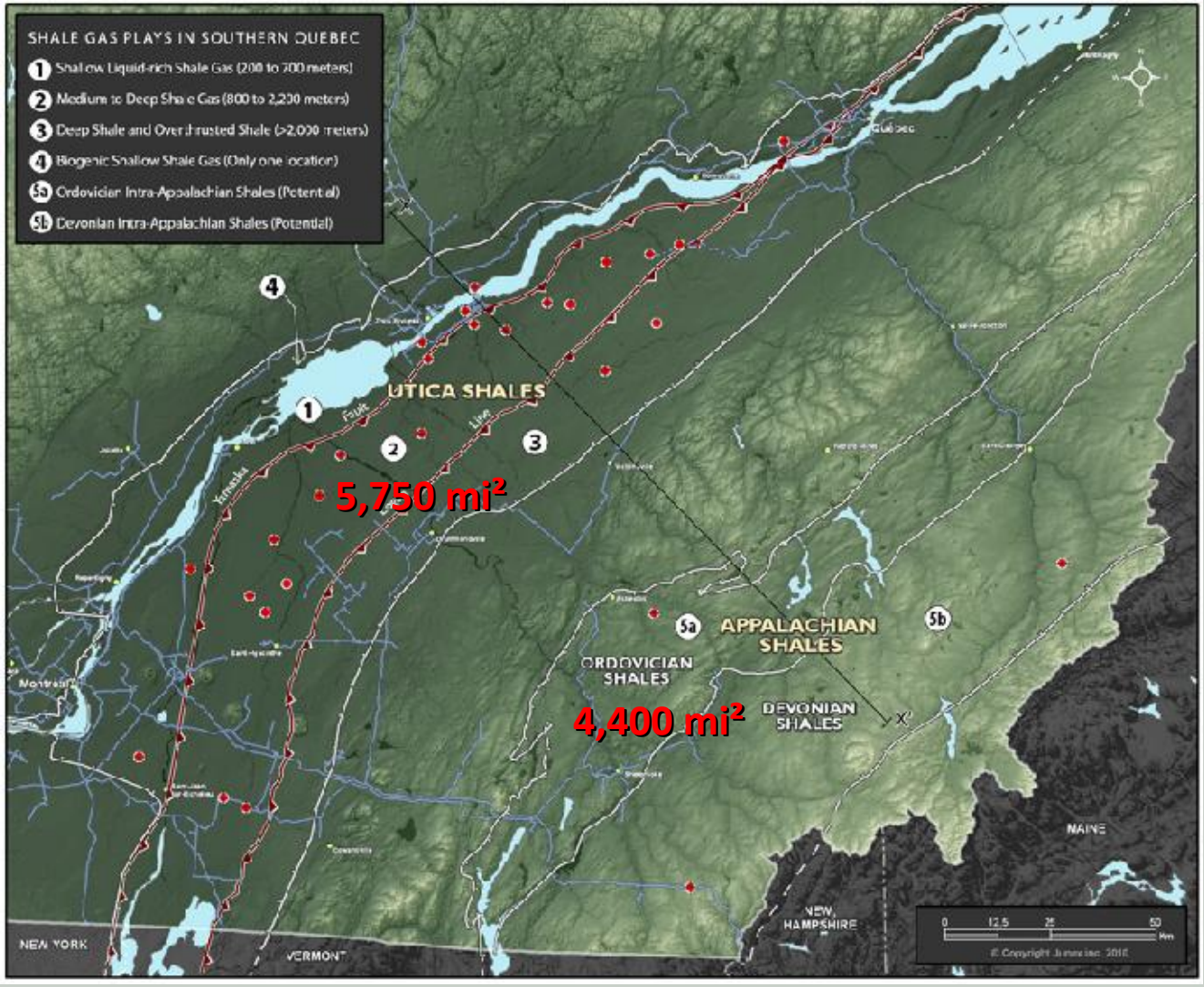
Southern Quebec Paleozoic Shale Gas

Geology and Play Types

- **Two shale basins :**
  - St. Lawrence Lowlands;
  - Appalachian.
- **Four potential shales :**
  - Utica Shales (Ord.);
  - Lorraine Shales (Ord.);
  - Beauceville Shales (Ord.);
  - St-Francis Shales (Dev.).



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Southern Quebec Shale Gas Plays

To date, most operations have been performed in the Play 1 - medium to deep depth Shale gas (1,000-2,000 meters) - located in the central part of St Lawrence Lowlands.

Play 1 : Medium to Deep depth thermogenic shale gas	Utica and Lorraine (500 to 2,500 m) - Thickness : 100 to 400 m TOC : 0.5 to 2.5% - Thermal Maturity : Condensate to Dry Gas Low deformation, moderate depth and with significant OGIP
Play 2 : Shallow to medium depth thermogenic shale gas	Utica and Lorraine (100 to 500 m) - Thickness : 100 to 200 m TOC : 0.5 to 3.0% - Thermal Maturity : Condensate to Dry Gas Lower Pressure & OGIP, Liquid-rich, Lower drilling & completion costs
Play 3 : Overthrusted shale gas	Utica and Laurier (500 to 3,000 m) - Thickness : 100 to 700 m (thrusted) TOC : 0.5 to 5.0% - Thermal Maturity : Condensate to Dry Gas Lowlands deformed zone, area with the highest OGIP and TOC
Play 4 : Appalachians shale gas	Beauceville and St-Francis (500 to 3,000 m) - Thickness : >500 m TOC : 1.0 to 5.0% - Thermal Maturity : Dry Gas Deformed zone, higher TOC, higher POR
Play 5 : Biogenic shale gas	Utica (100 m) - Thickness : 50 m TOC : ~2.0% - Thermal Maturity : Variable Very local, restricted to faulted zone area

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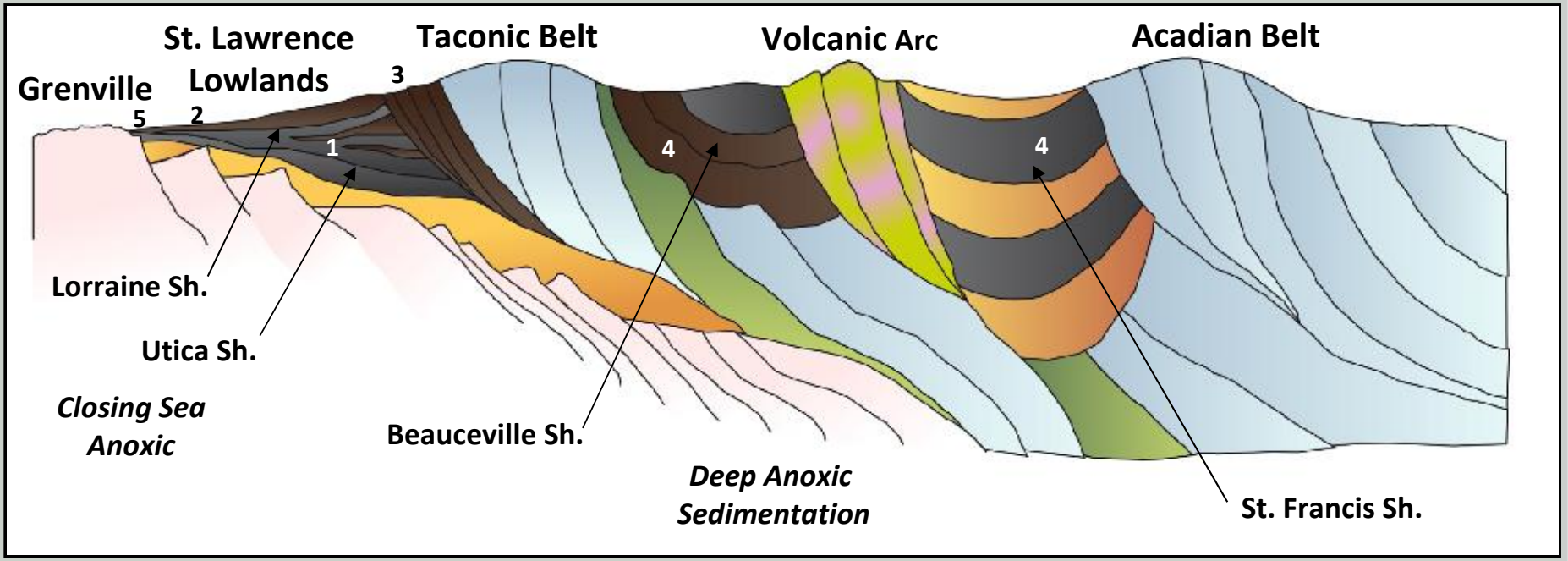
Schematic Cross-section



Play 1 : Medium depth to Deep Shale Gas
Play 2 : Shallow to Medium depth Shale Gas
Play 3 : Structured Shale (Overthrusted)
Play 4: Intra-appalachian Basin Shale Gas
Play 5 : Biogenic Shale Gas

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Strategy :

Explore to identify and evaluate the « Best » Zones

Building a large database

Historical Data	Review old wells data and vintage seismic
Basin geology	Regional-scale sedimentology model
Shale mineralogy	XRD, Thin-section, Shale Gas Log, Frac Fluid Sensitivity, Cap suction
Shale Petrophysics	Coring (Porosity, Permeability, Density), Well log for Shale Gas
Organic matter type	TOC/RE, Biomarkers, Kerogen thermal maturity
Gas geochemistry	Stable isotopes, Gas composition, Gas Origin
Reservoir	Initial pressure, Production test, DST, integrate RM and microseismic data
GIP	Core analysis (Canister Desorption & Adsorption Isotherms), GeoJar, TRAC
Geophysic	HRAM, FMI, Cat-Scan, New Seismic (2D, Swath, 3D)

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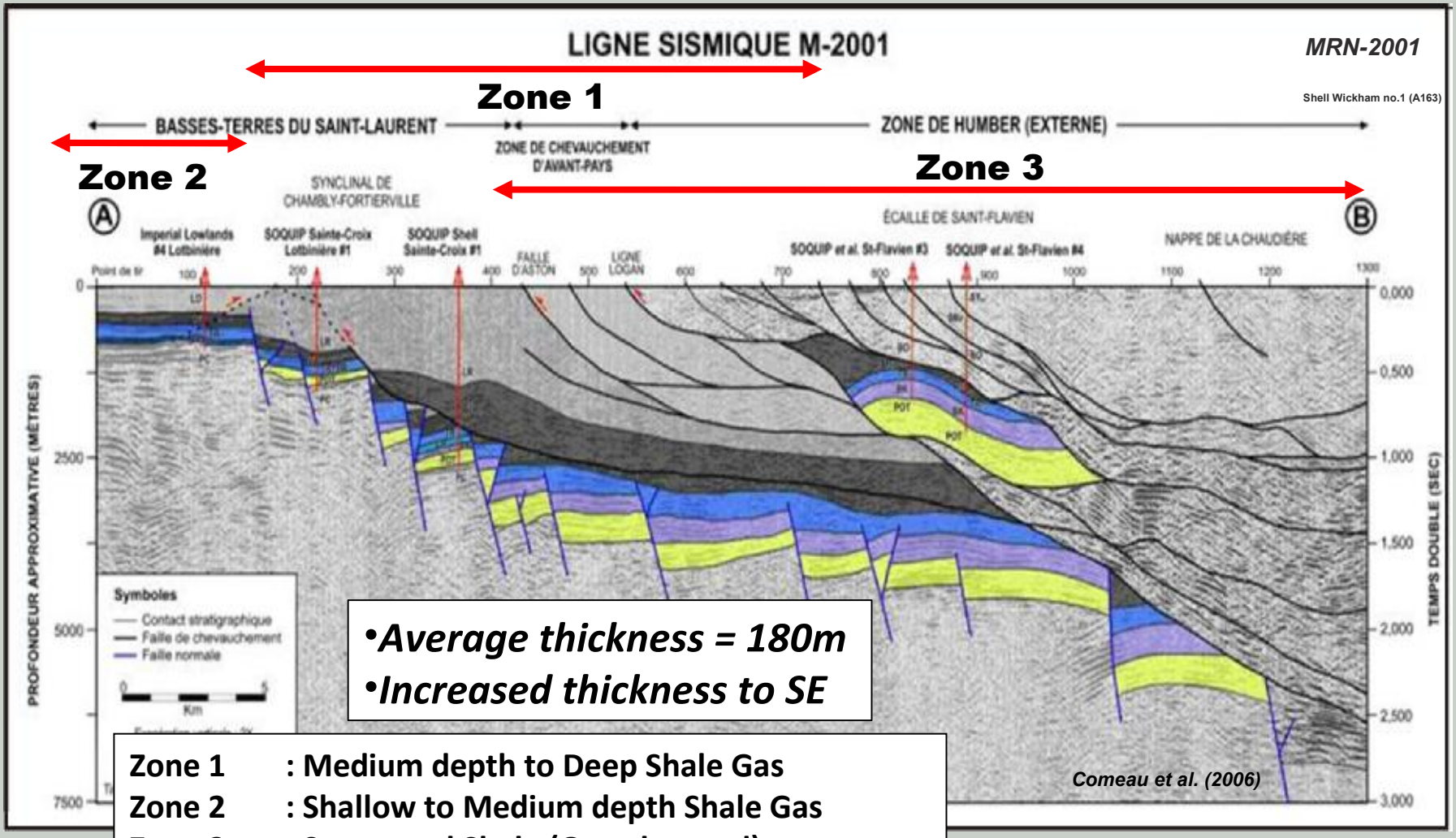
Three Shale Gas plays of the Quebec St Lawrence Lowland



Zone 1 : Medium depth to Deep Shale Gas
Zone 2 : Shallow to Medium depth Shale Gas
Zone 3 : Structured Shale (Overthrusted)

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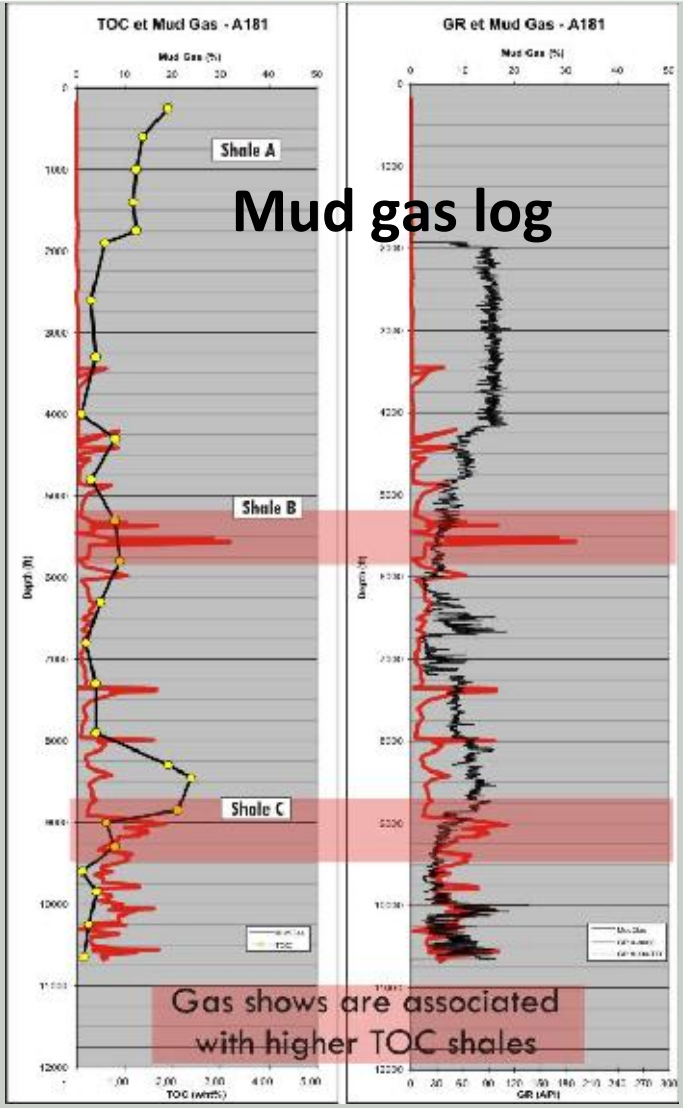
Utica Shale Gas
Where and when did it start?

Lower Lorraine and Utica Shales Gas

Gas in shales in the St. Lawrence Lowlands known for decades – however low gas prices, little infrastructure, and lack of pertinent technologies to "unlock" the gas precluded its development.

Dr. Roberto Aguilera, world-reknowned petroleum engineer, expert in fractured reservoirs & member of JNX's board, first published about the St. Lawrence gas shales in 1978 ("Log Analysis of Gas Bearing Fracture Shales in the Saint Lawrence Lowlands of Quebec," Paper SPE 7445 (1978))



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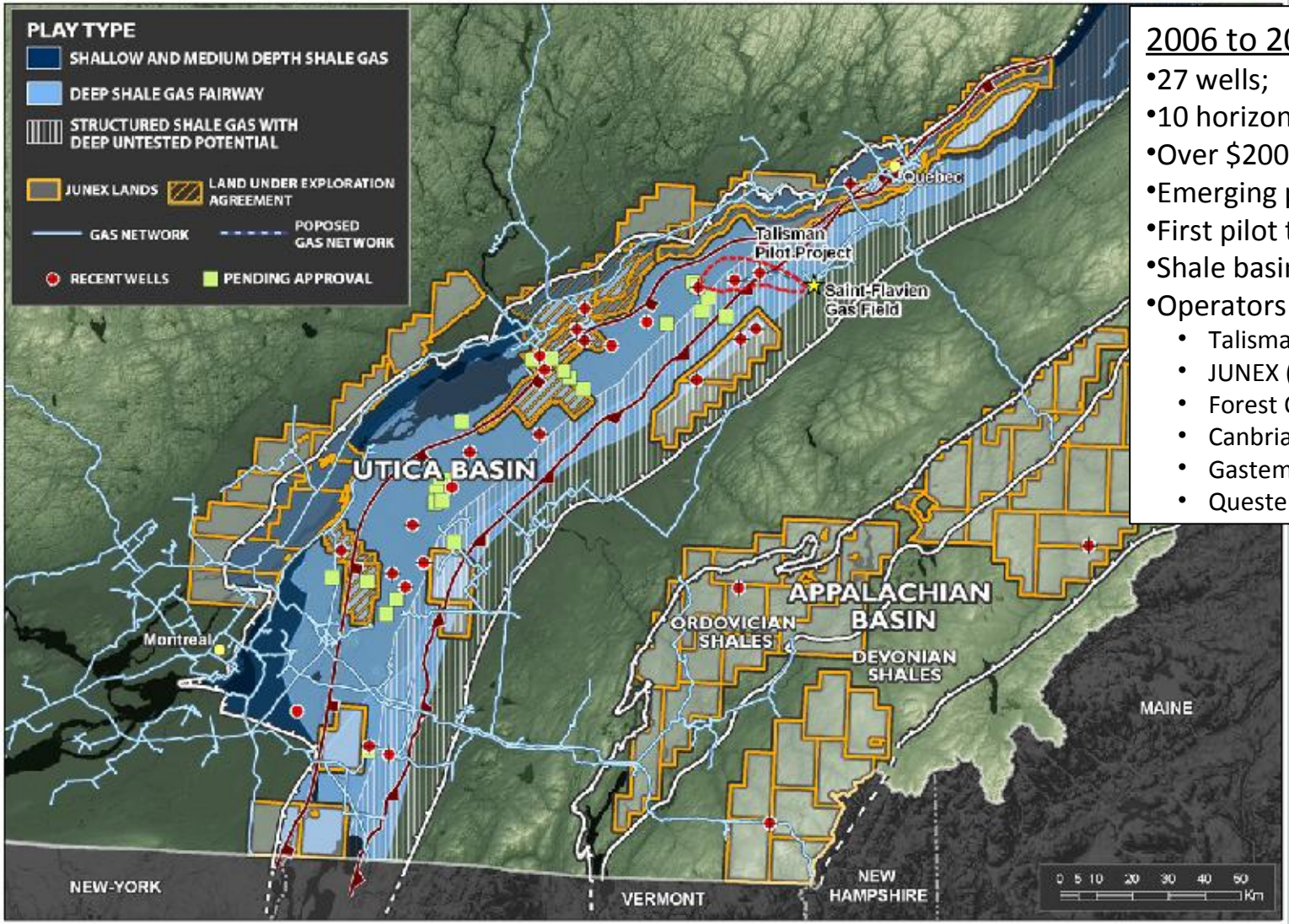
Quebec's Shale gas plays Exploration activities



2006 to 2010

- 27 wells;
- 10 horizontal;
- Over $200 million invested;
- Emerging play;
- First pilot to start in 2011;
- Shale basin : 5,750 mi²
- Operators :
  - Talisman (10 wells)
  - JUNEX (6 wells)
  - Forest Oil (2 wells)
  - Canbriam (6 wells)
  - Gastem (2 wells)
  - Questerre (1 well)

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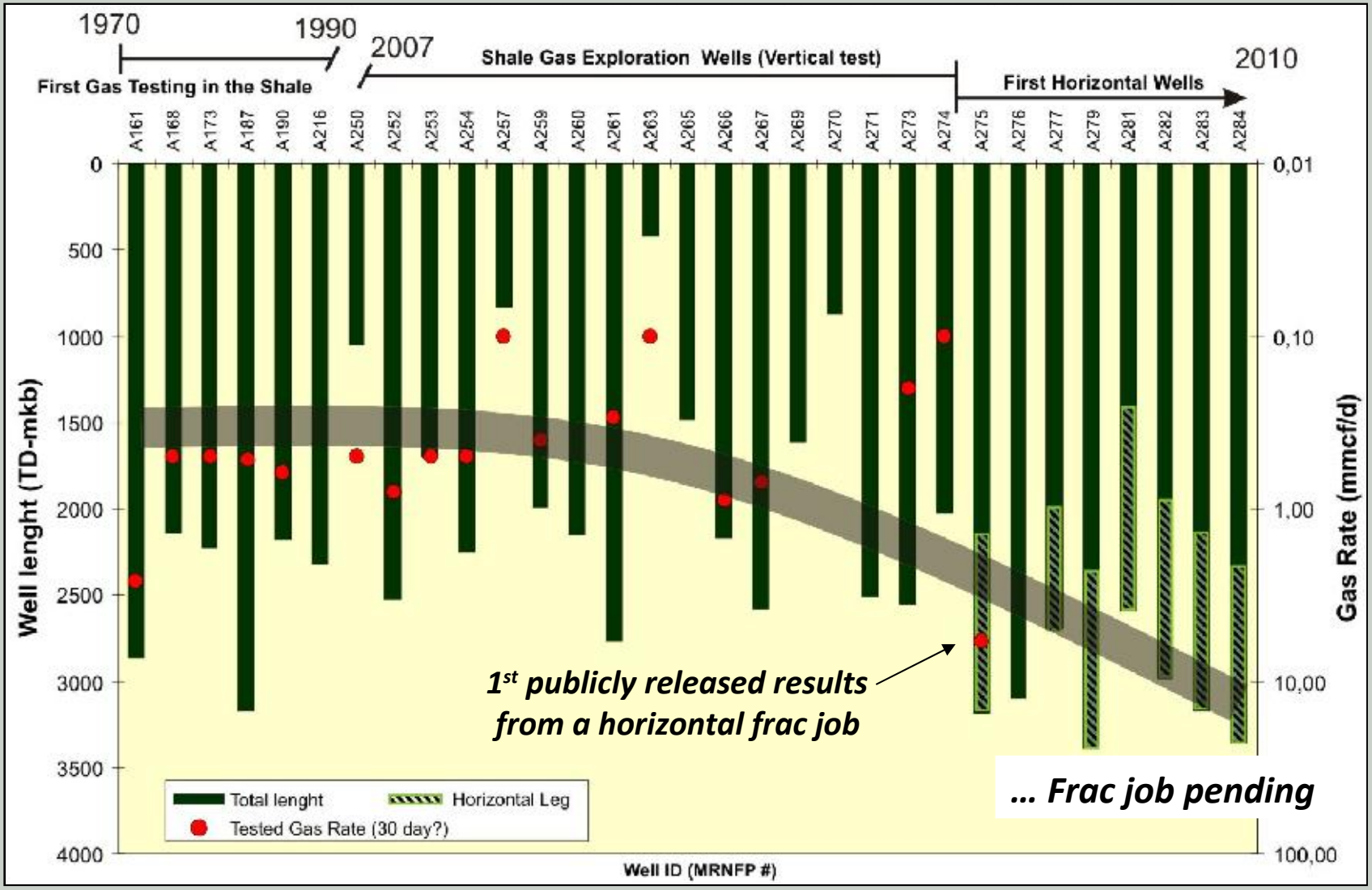
Quebec Shale gas play history

Exploration Drilling activities



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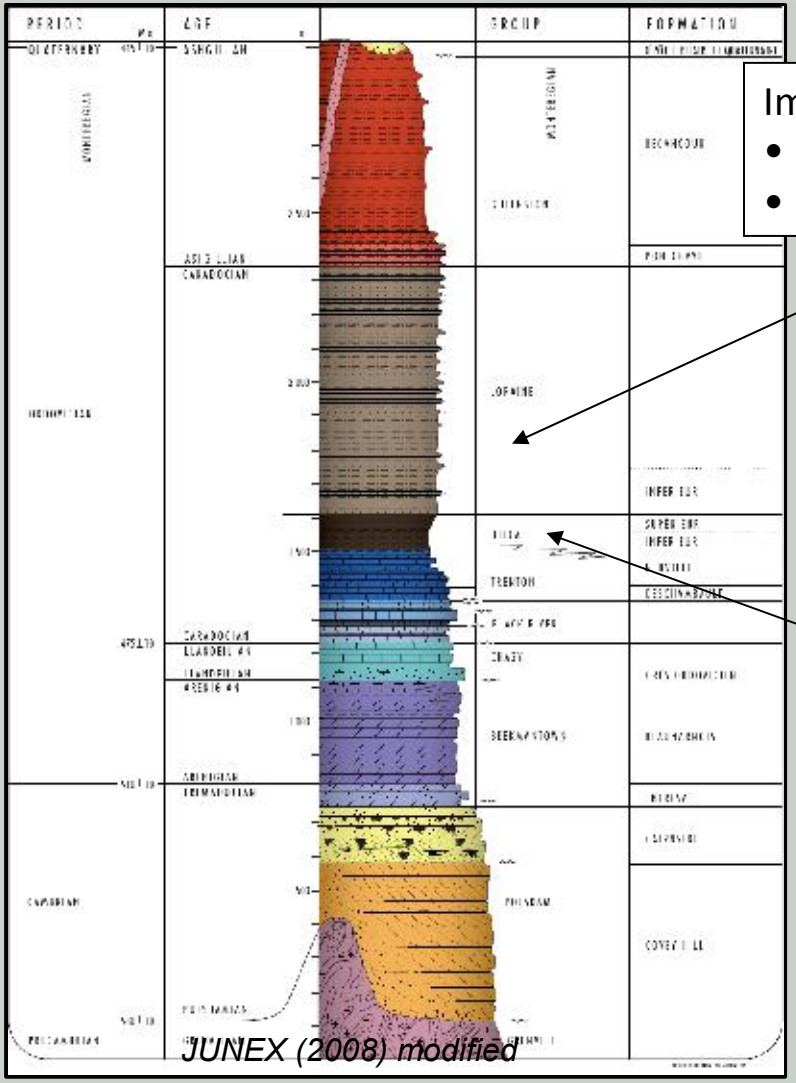
General Stratigraphy of St Lawrence Lowlands Basin



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Importance of mineralogy for:

- Geological setting;
- Fracability measurement.

Lorraine Shales :

600 to 2000 m

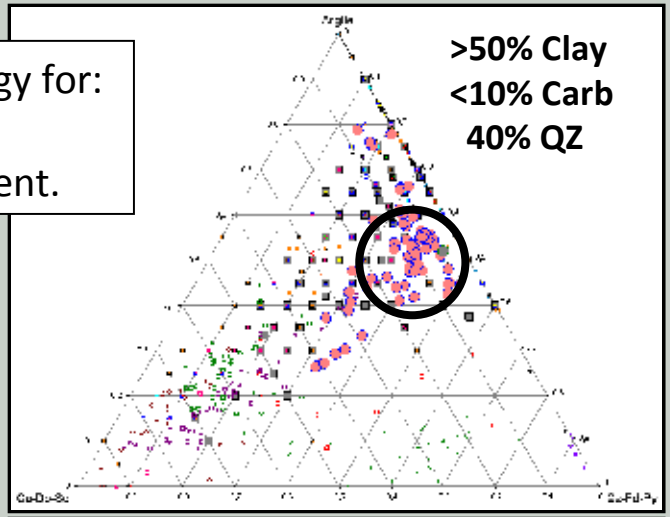
Arenaceous shales/<u>siltstones</u>

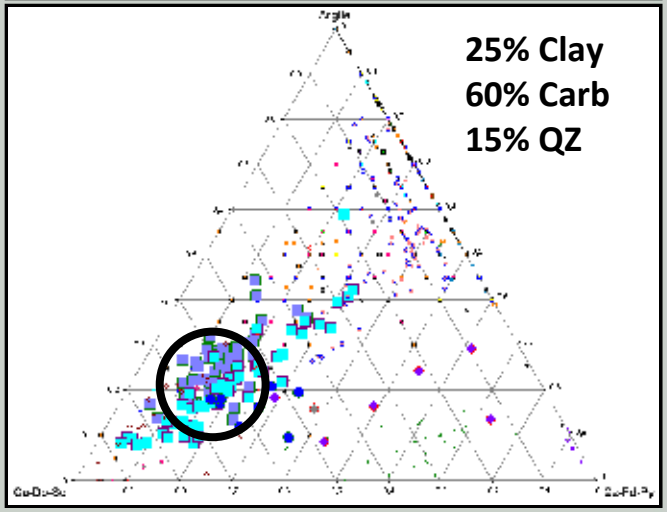
Sandstone interbed

Utica Shales :

100 to 500 m

Dark brown to black <u>calcarous shale</u>





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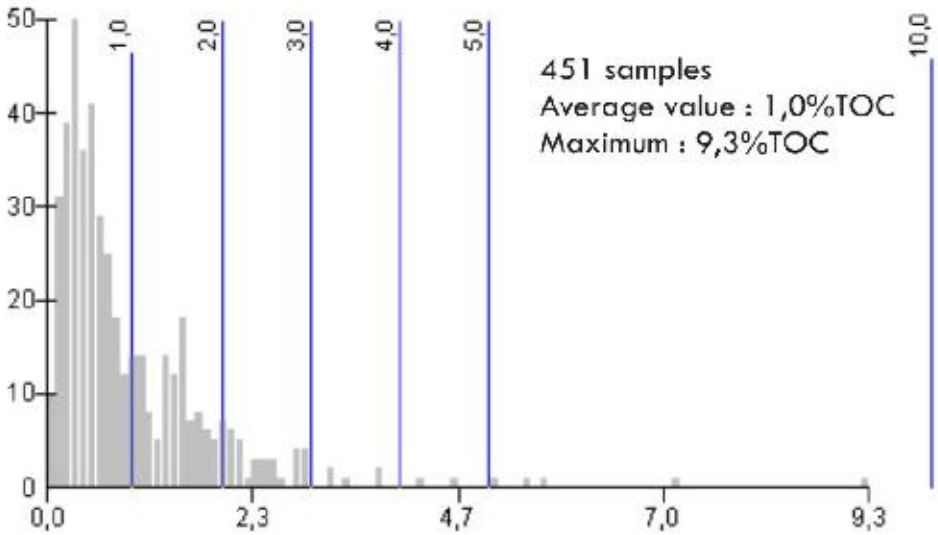
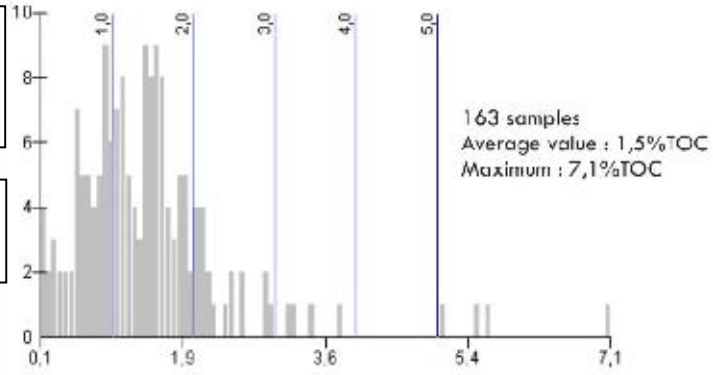
Geochemistry

Paleozoic Shales TOC variation

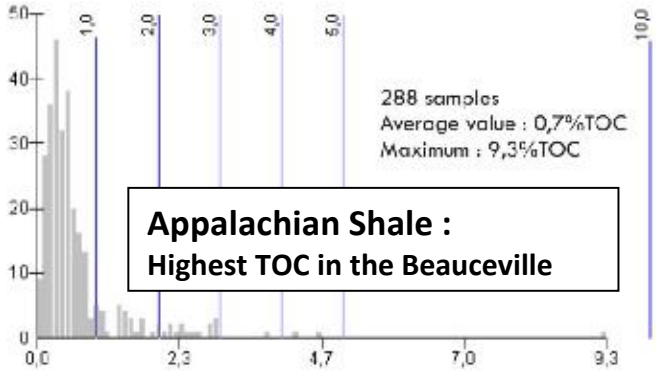
Analysis from Lowlands wells:
Results reported only for the Shale gas zone with the highest TOC



Northeastern Lowlands :
Utica with the highest TOC and Lower Maturity



Southwestern Lowlands :
Lorraine with the highest TOC



Appalachian Shale :
Highest TOC in the Beauceville

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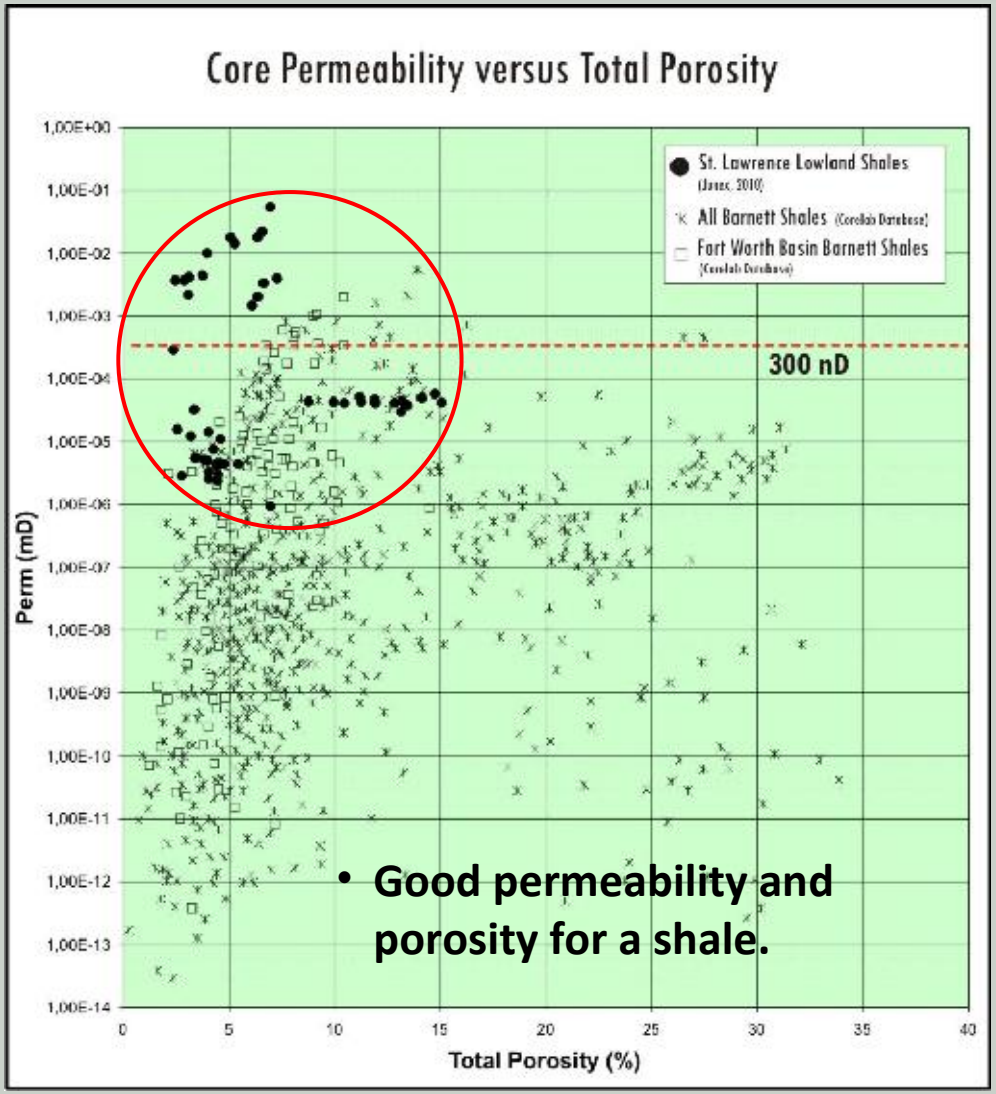
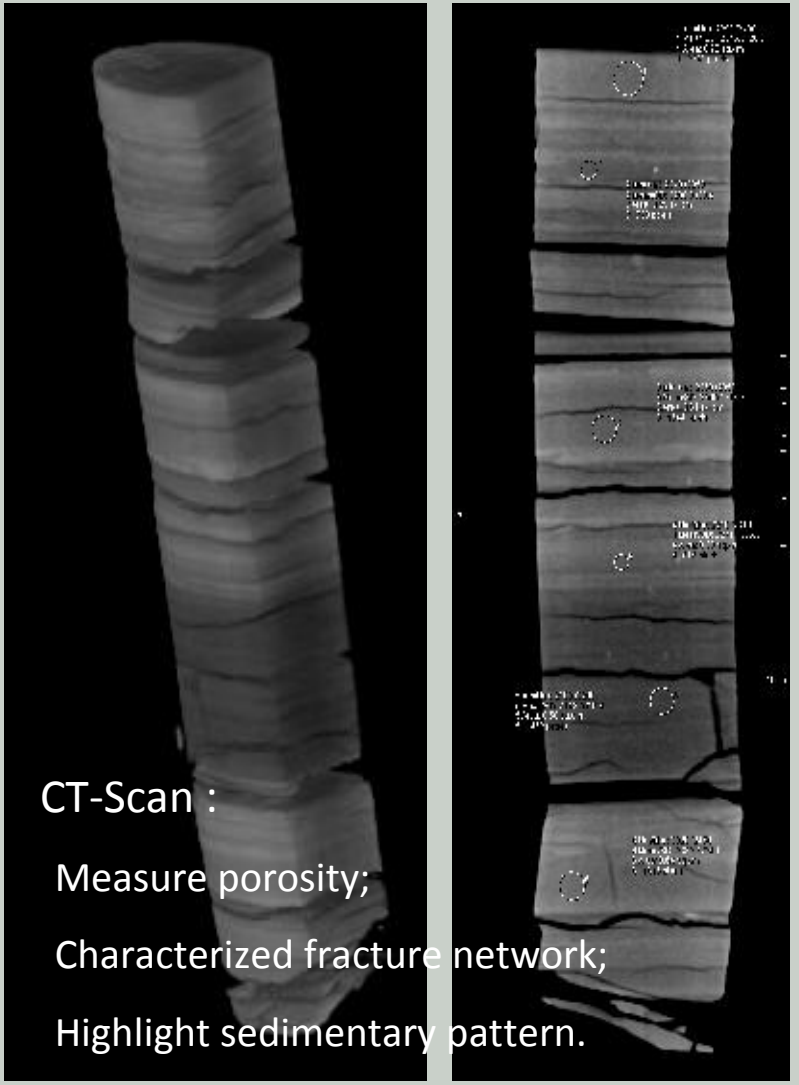
Permeability and Porosity



- **Good permeability and porosity for a shale.**



CT-Scan :

Measure porosity;

Characterized fracture network;

Highlight sedimentary pattern.

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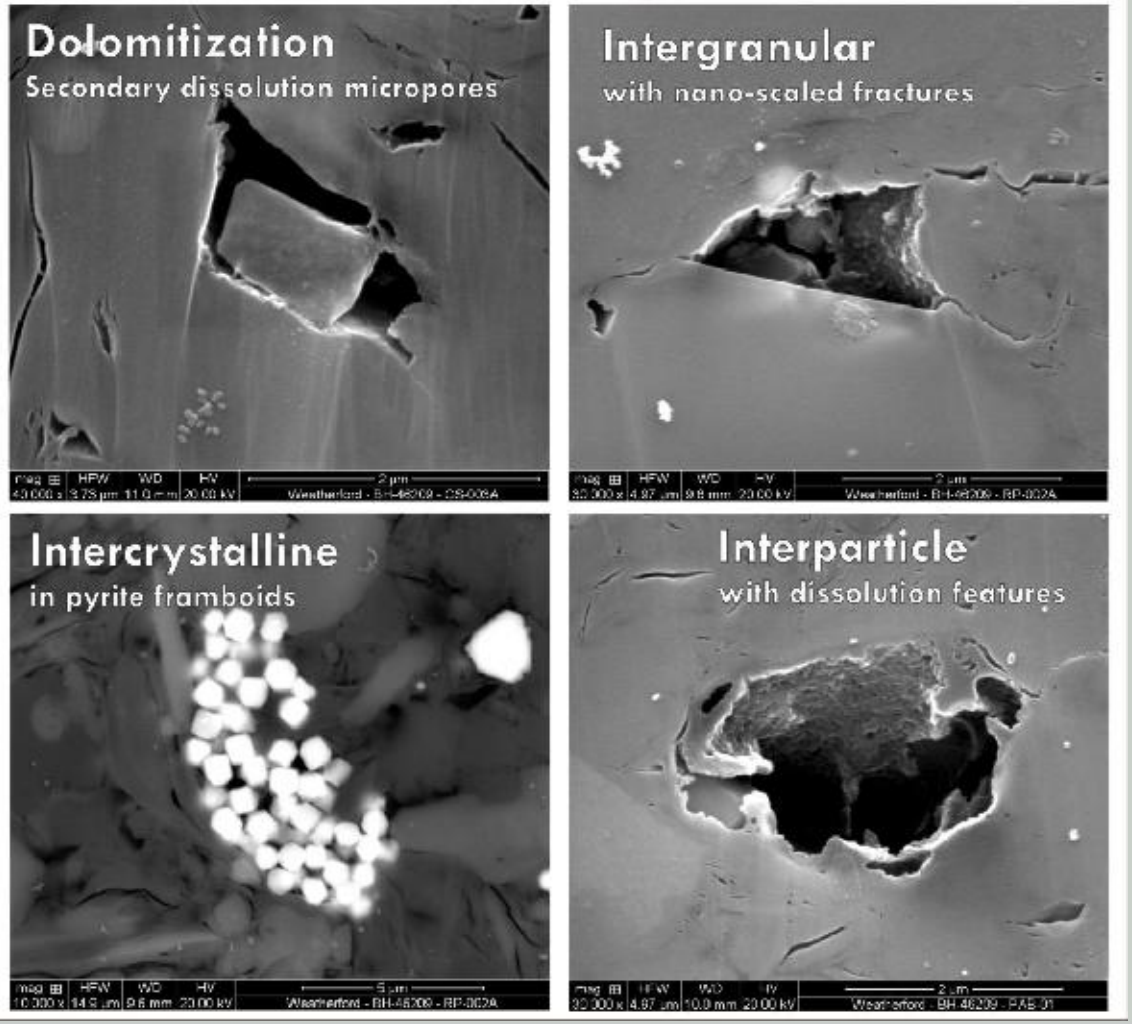
Permeability and Porosity

Utica Shale Microporosities



- Dissolution and dolomitization of calcite in Utica Shales will be a positive factor on porosity and permeability.

Meso-scaled fractures

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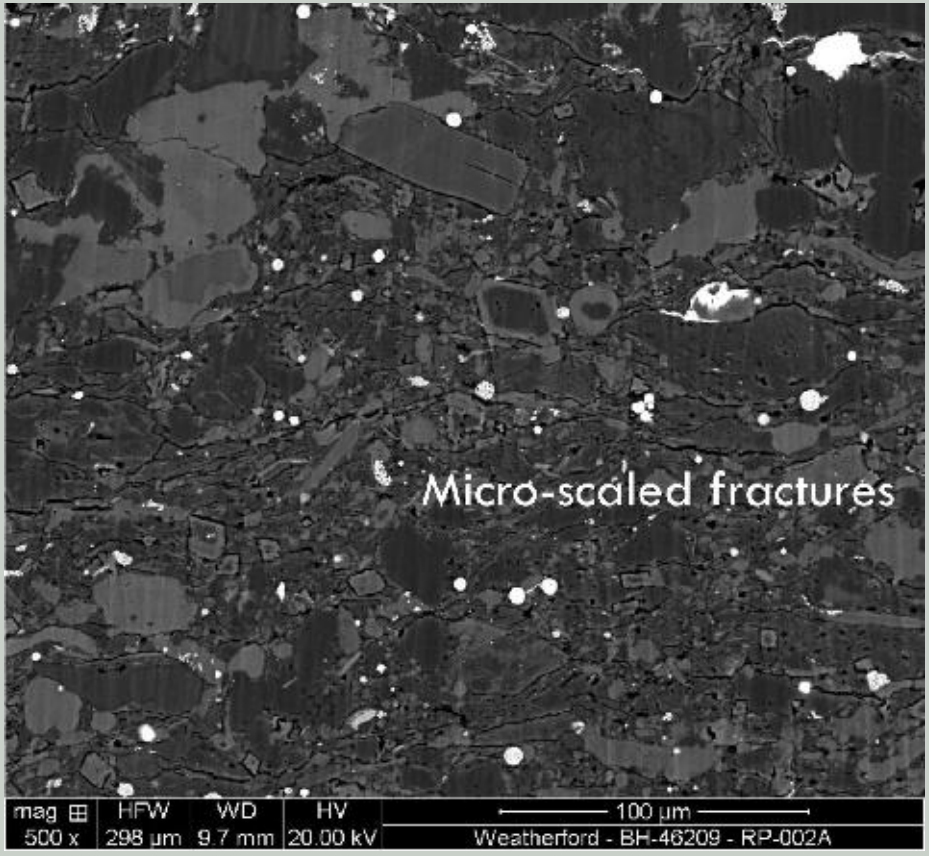
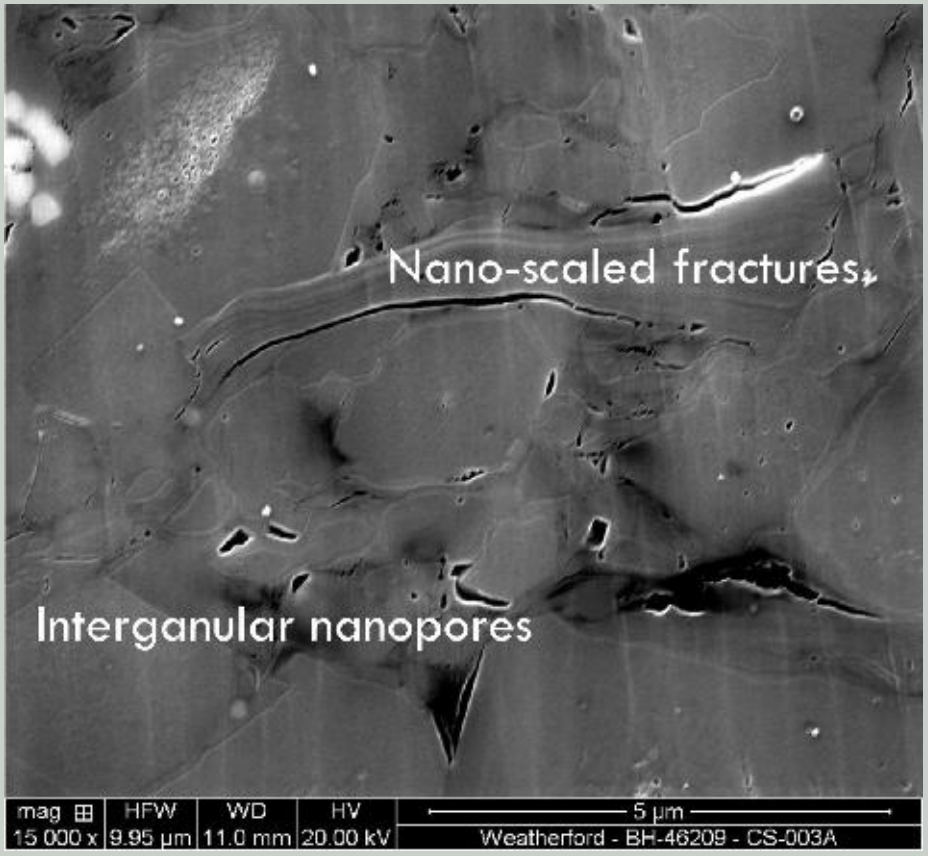
Permeability and Porosity

Brittleness of calcareous shale





- Micro-scaled fractures is possibly responsible for higher permeabilities in Utica Shales.

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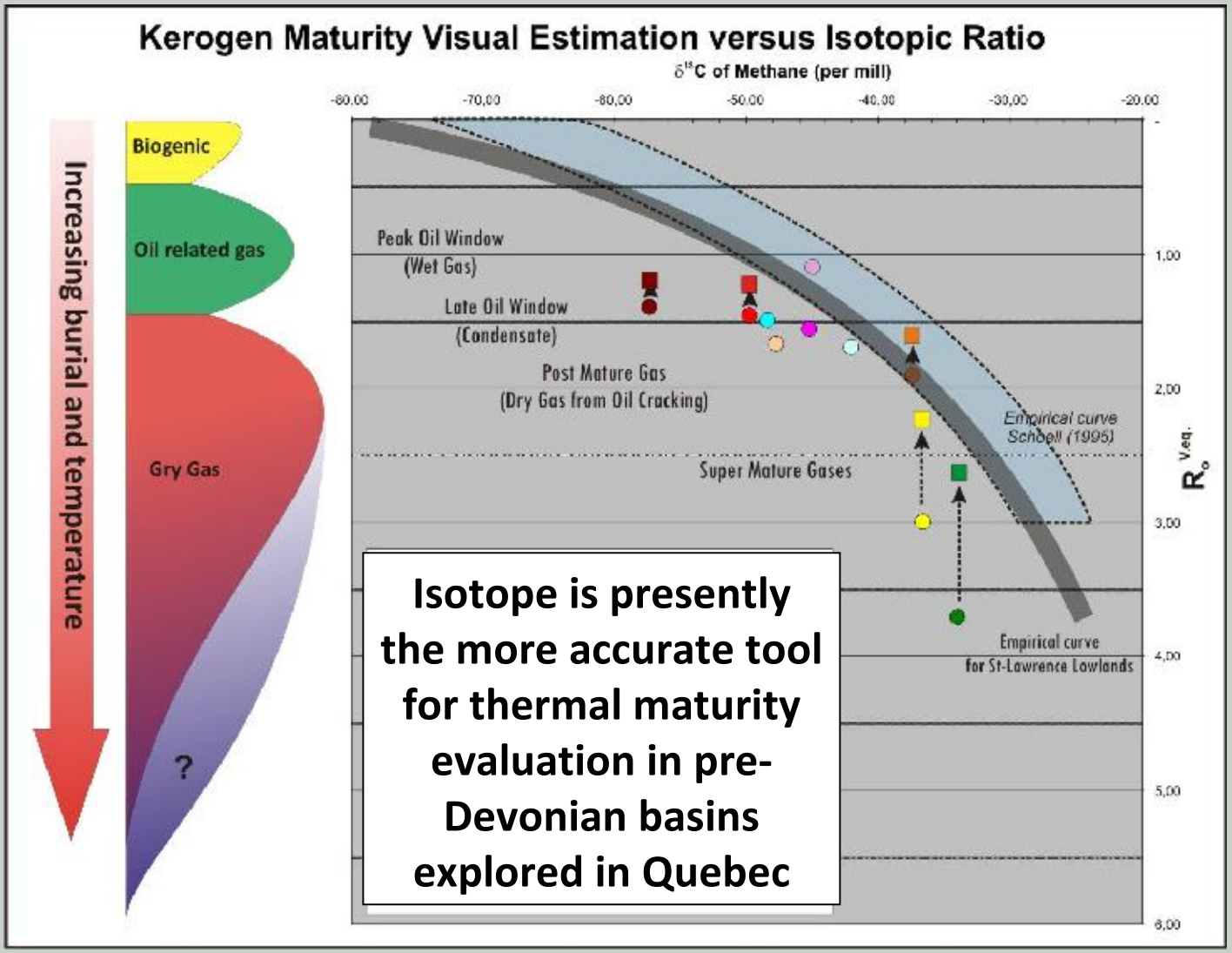
Shale gas type
Thermal Maturity Evaluation



- Calculation is made on pre-Devonian rock to find the Vitrinite Reflectance equivalent.

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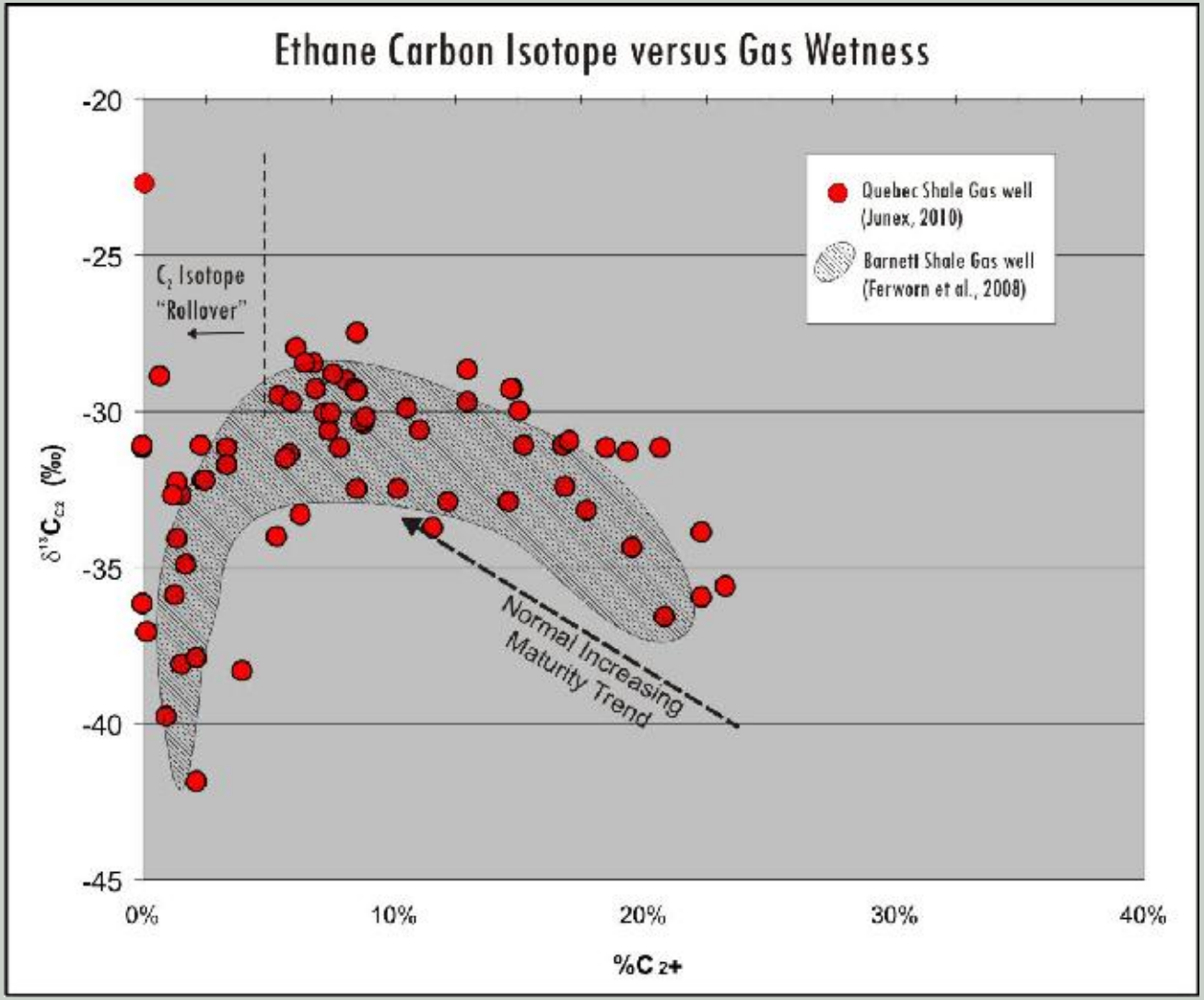
Gas Geochemistry

Ethane Carbon Isotope Rollover



- Ethane Isotope Rollover is characteristic of high production zone;
- Ethane Isotope Rollover mapping constrains the best potential zone.

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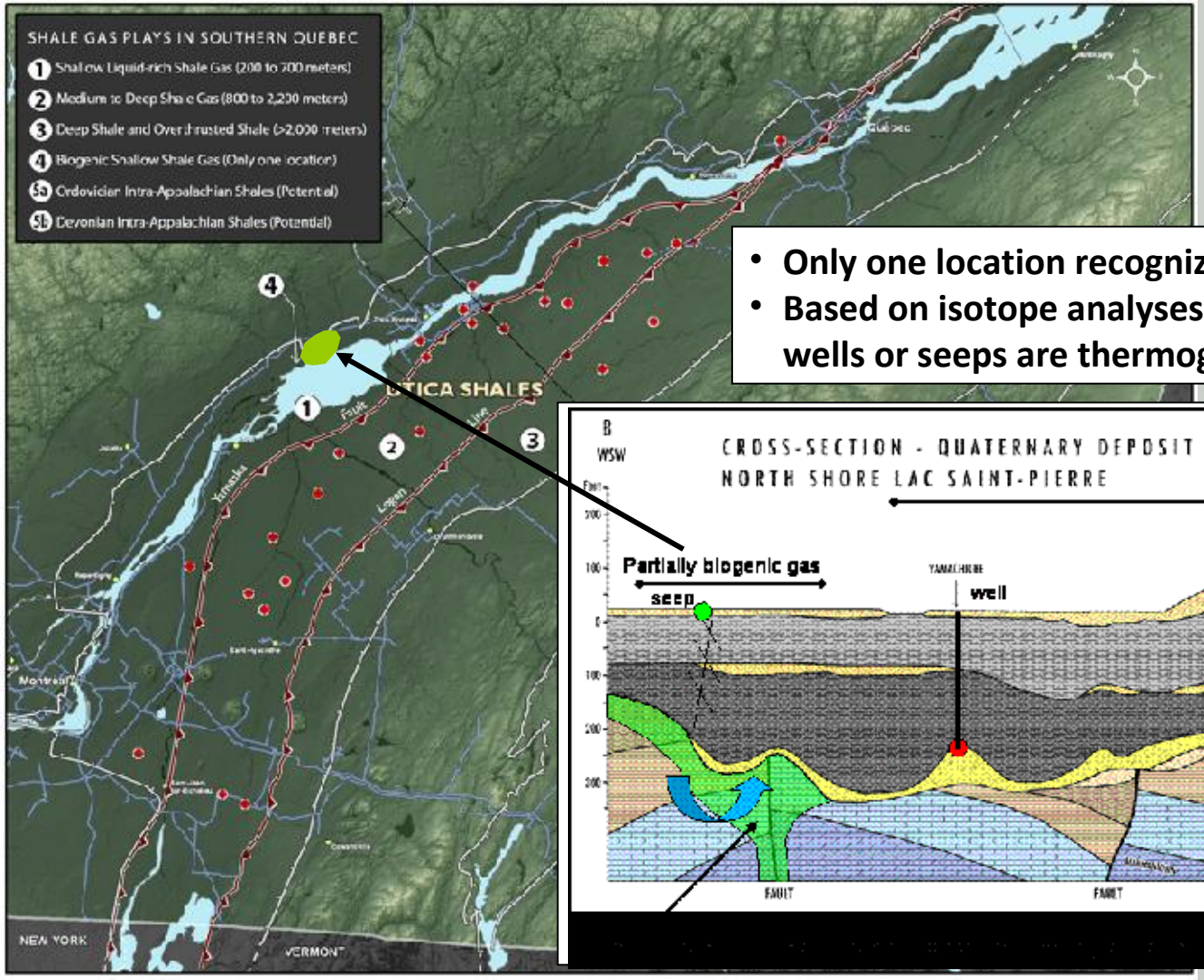
Biogenic Shale Gas



- **Only one location recognized;**
- **Based on isotope analyses, gas found in other water wells or seeps are thermogenic Utica shale sourced.**

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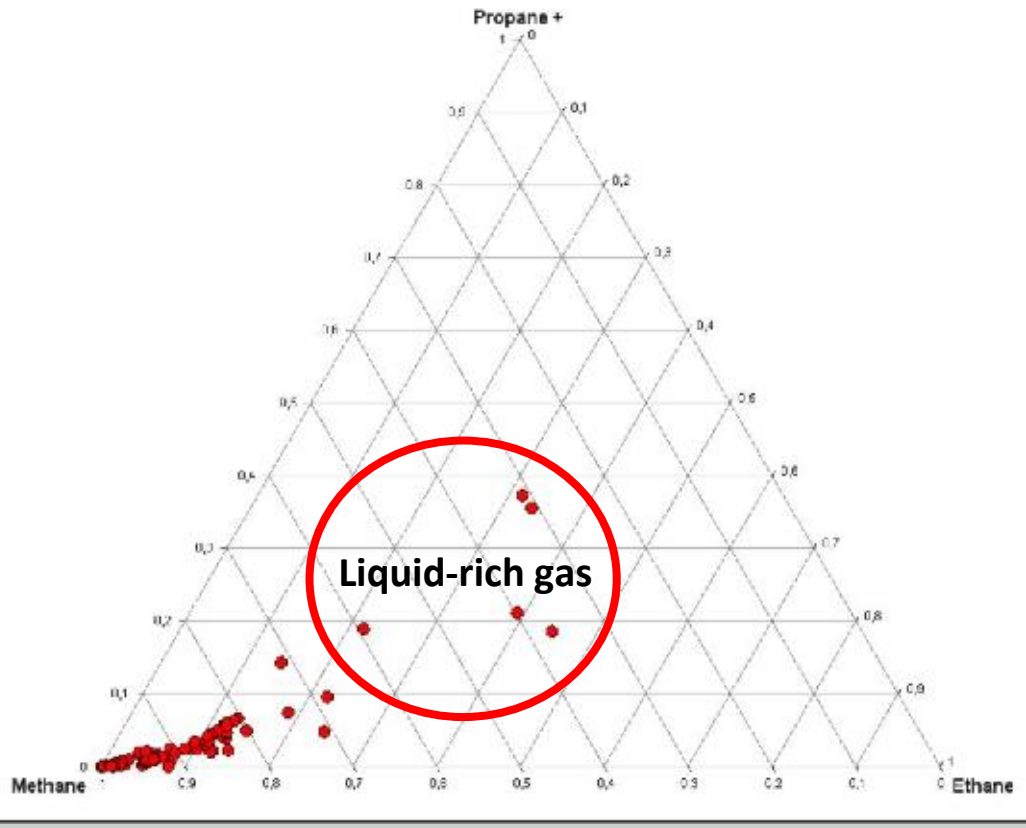
Gas composition

- **Mainly <u>Dry gas</u> with 80 to 98% methane;**
- **Liquid-rich gas found in the northeastern Lowlands area.**



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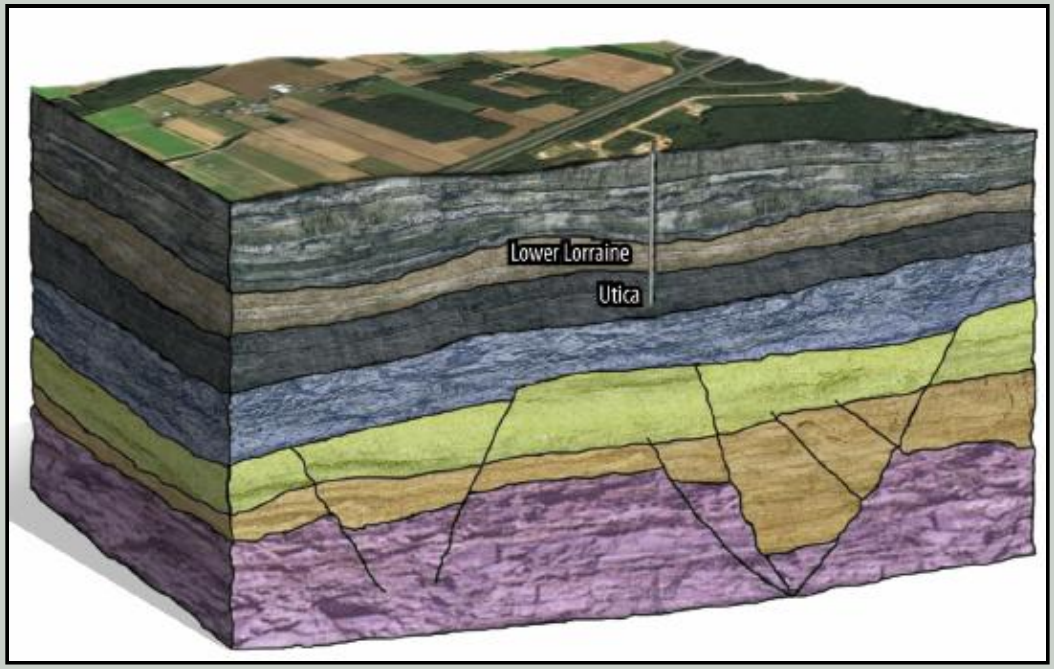
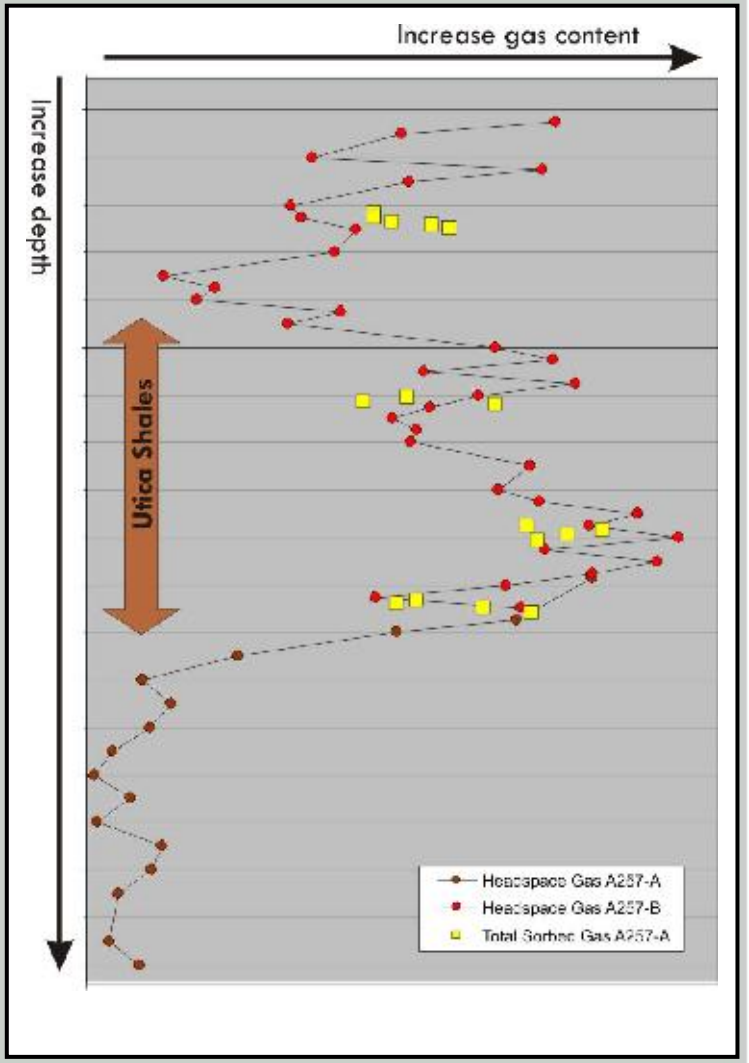
Shallow Shale Gas Exploration

- Drilled in 2008 - Core taken in four shale zones;
- Mud gas, Geojar and core analysis correlations;
- Hydrocarbon analysis : Gas rich in propane and butane, significant presence of light crude oil (37°API);
- Shale Gas Propane Frac Stimulation in Fall 2009 – First time in Eastern Canada.





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Utica Shales Propane Frac

- First Shallow fracture stimulation of the Utica Shales (depths 436.5 to 473.5 meters).
- Perforations with 1 m^3 of acid;
  Followed by injection of 61 tons of sand propelled by 251 000 L of propane;
- Production of 47 bbl oil and a gas flow (natural gas + propane) of 467 mcf/day – first 109 hours. Following this, the oil flow practically stopped and the average gas flow was 92 mcf/day. No sand or water was observed during the test;
- Demonstration that it is possible to adequately and safely frac the Shallow Utica Shales.

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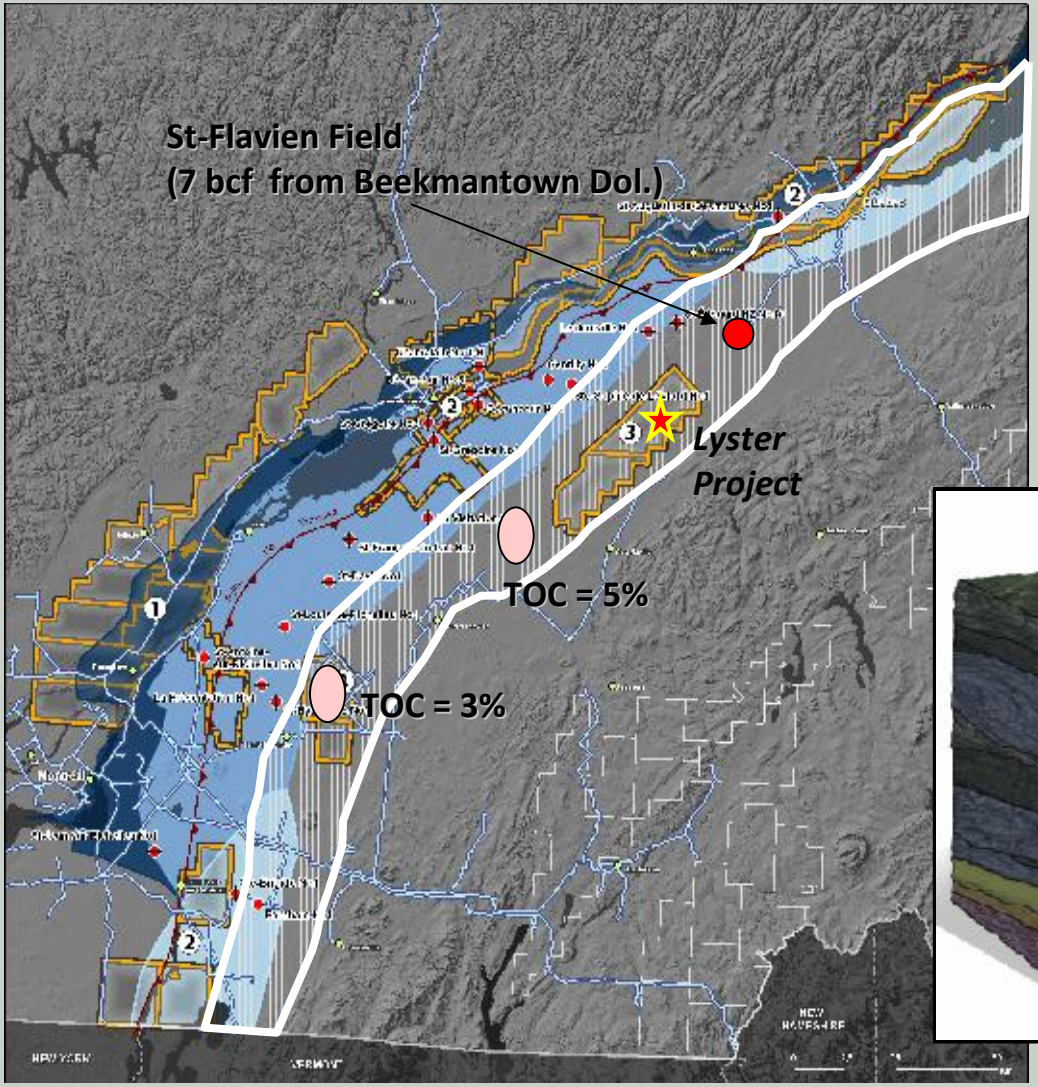
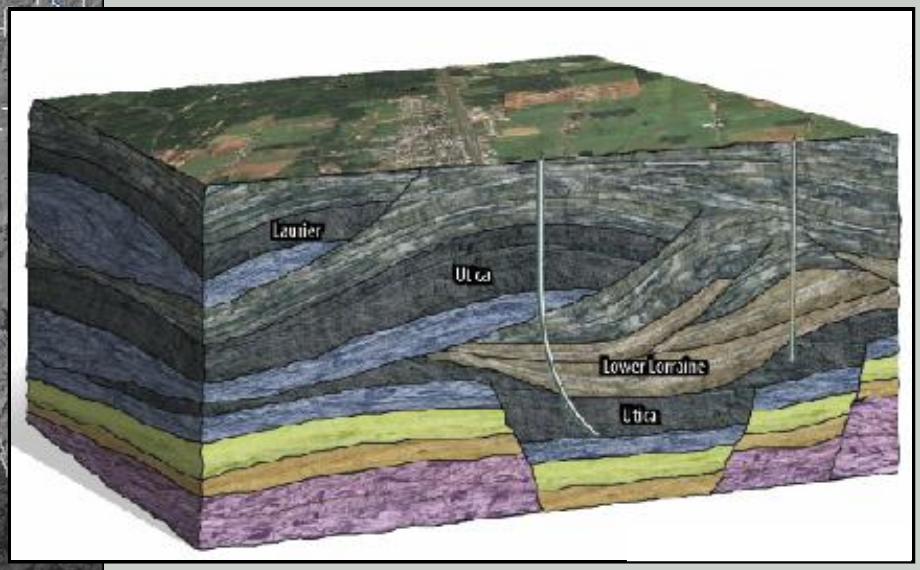
Overthrusted Shale Gas Play



- Several gas occurrences in well drilled in 70's-80's (*one producing field*);
- Thick sequence of overthrusted shales and carbonates;
- Shale units :
  - Laurier Black Shale >1000 m : 1% TOC
  - Utica & Lorraine



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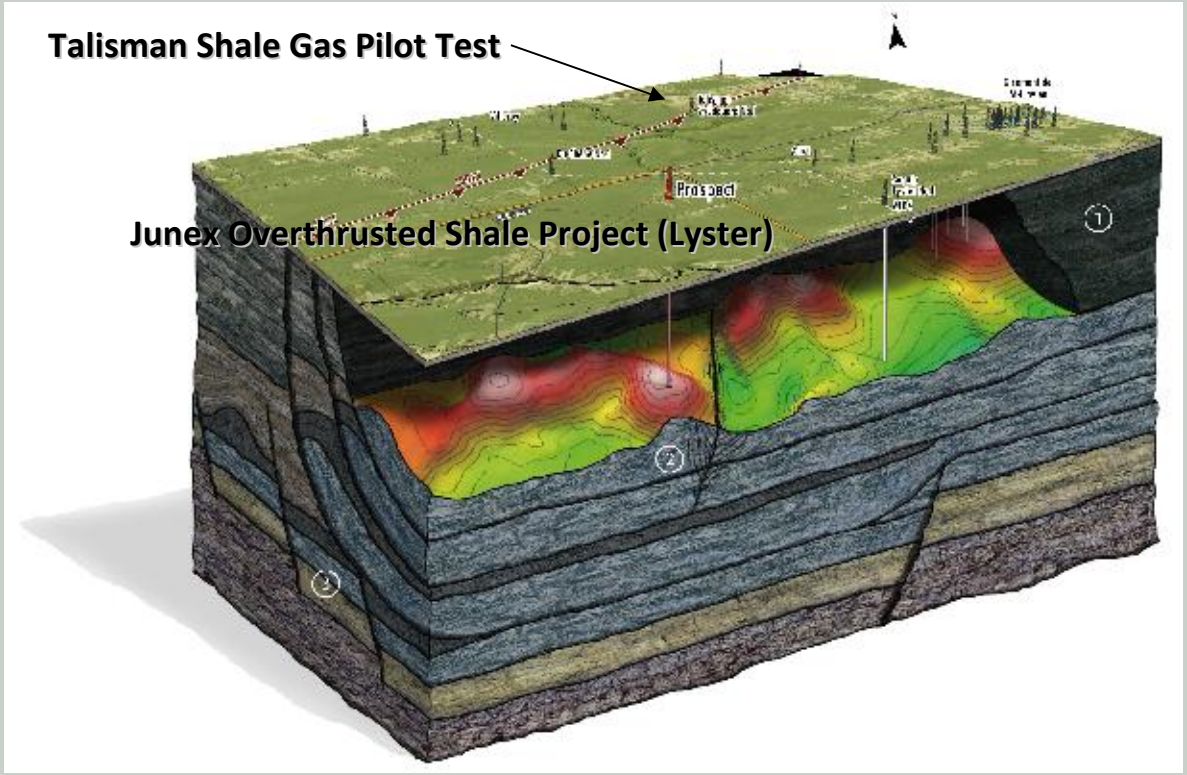
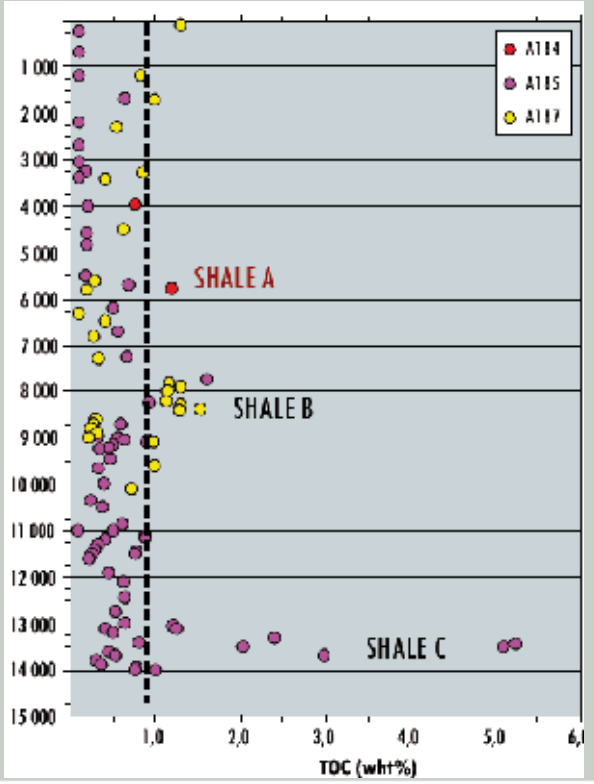
Overthrusted Shale Gas Play

- Shale units in the condensate to dry gas window;
- Good correlations between higher TOC Shales and mud gas shows;
- Lyster Project - Two wells planned in 2010 - Multi-target play :
  - Target 1 : Utica Shale (and equivalent thrusted shales)
  - Target 2 : Thrusted dolomitized/fractured carbonates
  - Target 3 : Deep Overpressurized Utica Shales



TOC(%) vs Depth(ft)



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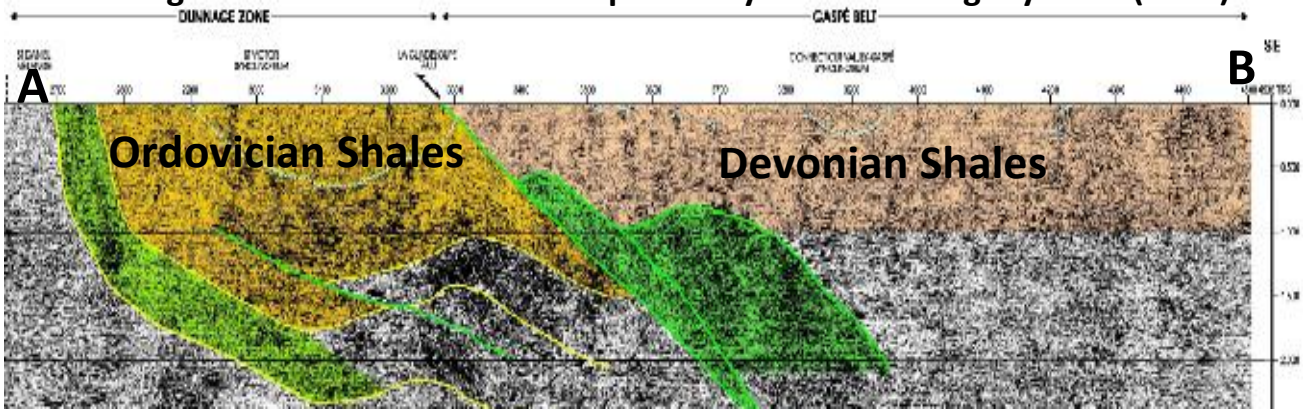
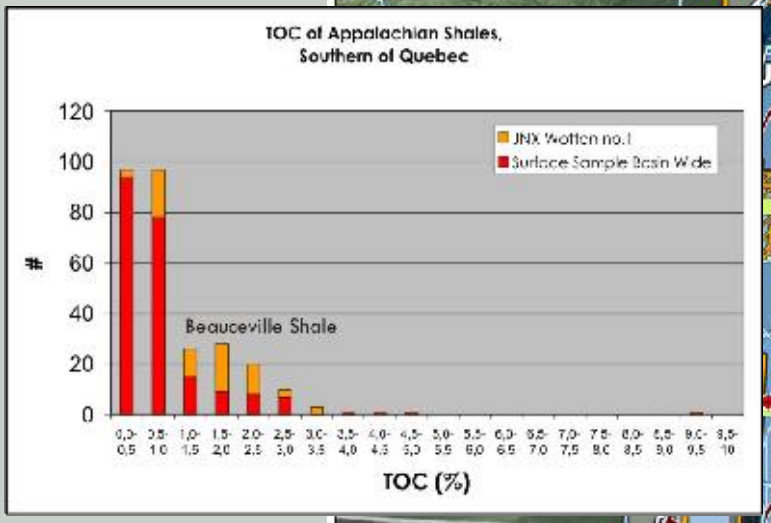
Appalachian Shale Gas Play

M2001 Regional Seismic Profile – Interpreted by GSC - Castonguay et al. (2003).





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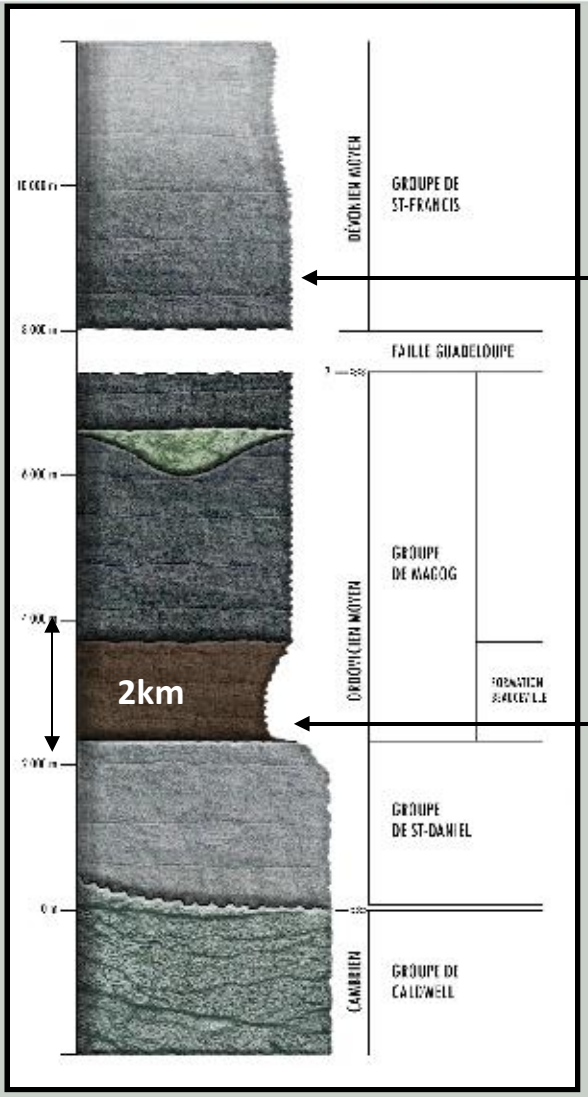
Appalachian Shale Gas Play

- Organic-rich shale;
- Dry gas window;
- Amorphous kerogen (Type II);
- Rapidly subsiding deep marine sedimentation;
- Good organic recovery;
- Bitumen particles are noted (some liquid hydrocarbon generation occurred);
- Pre-vitrinite time;
- Gas infrastructures;



Lower Devonian Shales
St-Francis Group
Poorly known stratigraphy

Middle Ordovician Shales
Beauceville Shale
Well recognized unit

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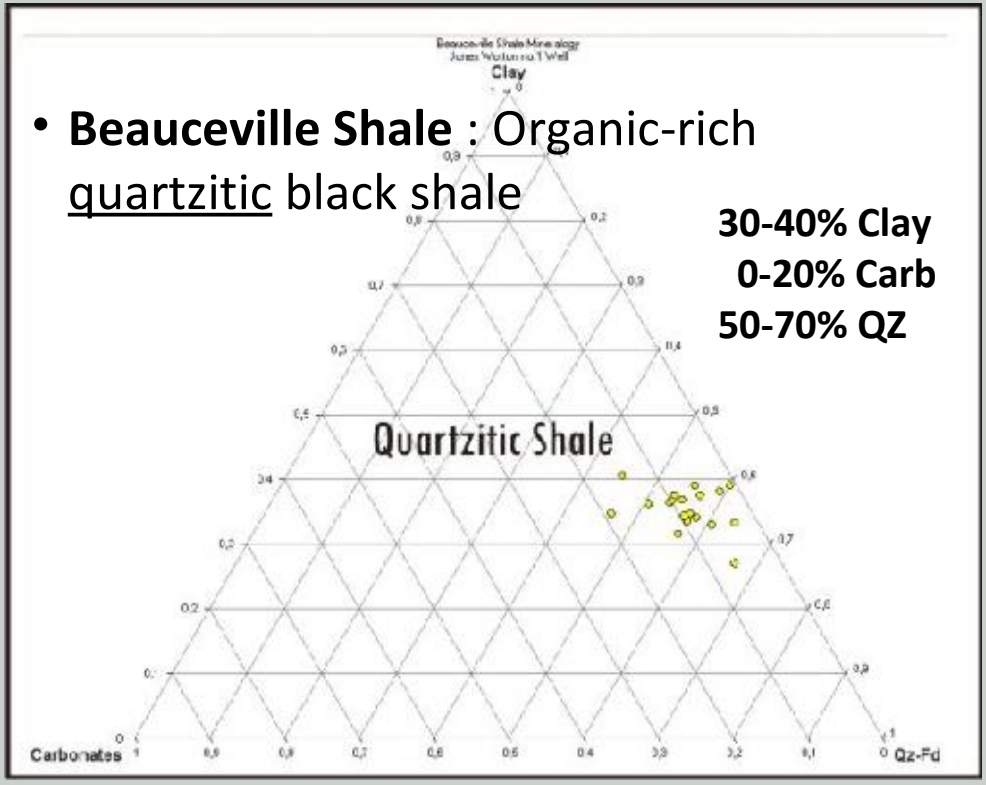
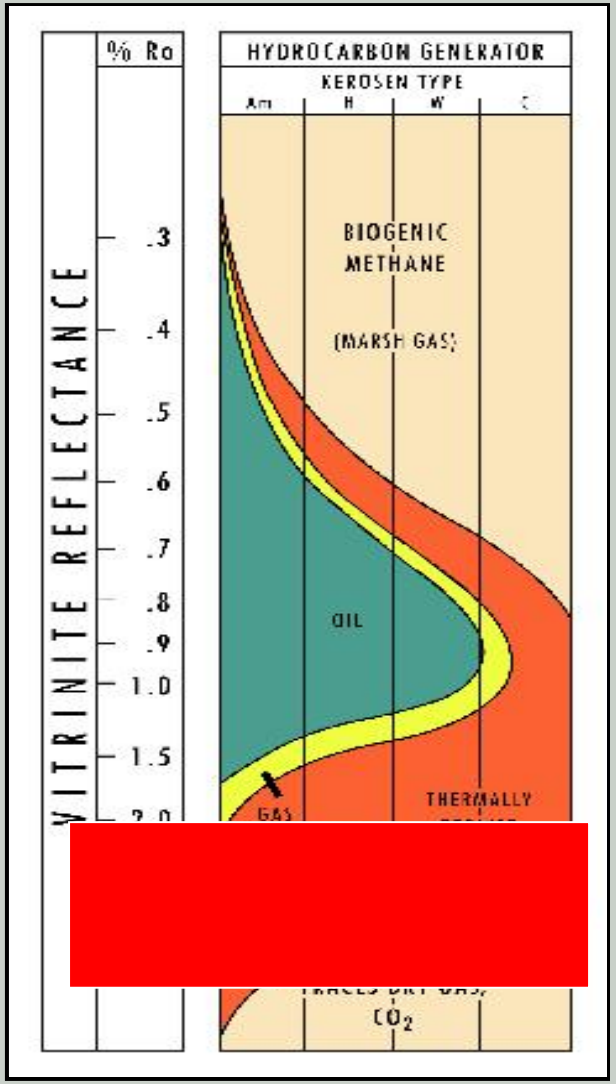
Appalachian Shale Gas Play

- **Beauceville Shale** : Organic-rich quartzitic black shale

30-40% Clay
0-20% Carb
50-70% QZ



ROUTINE CRUSHED CORE ANALYSES	Average	Variation
Density	2,62 g/cc	2,4@2,82
Gas Porosity	4,6%	0,7@9,6
Permeability	326 nD	46@749



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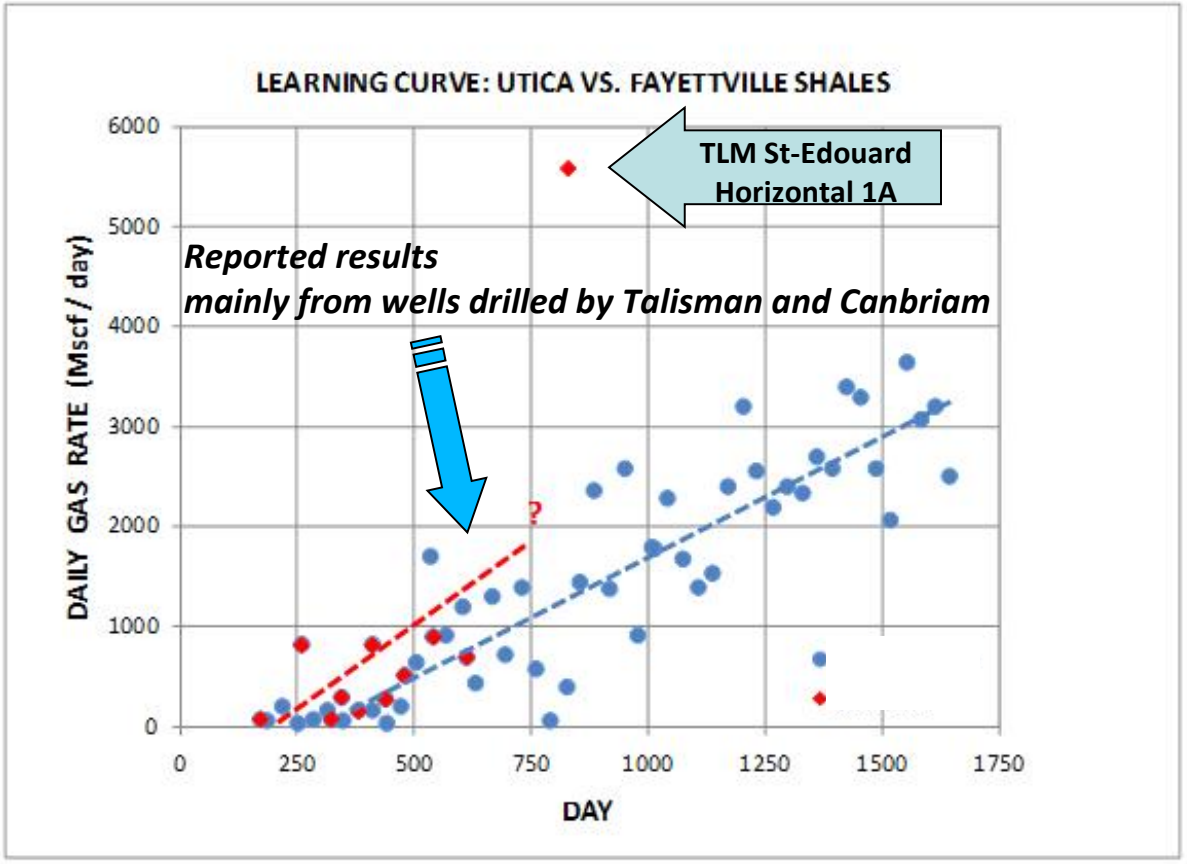
Learning curve

Recently reported results for various tests



Learning Curves Comparison between the Fayetteville and the Utica Shales
(Source: Web Sites of Companies Operating in Shale Gas Reservoirs, Questerre, Chan et al., 2010).

- *The results revealed indicate production potential comparable to those of other basins;*
- *Over the next year, the results from eight new wells should be made public.*

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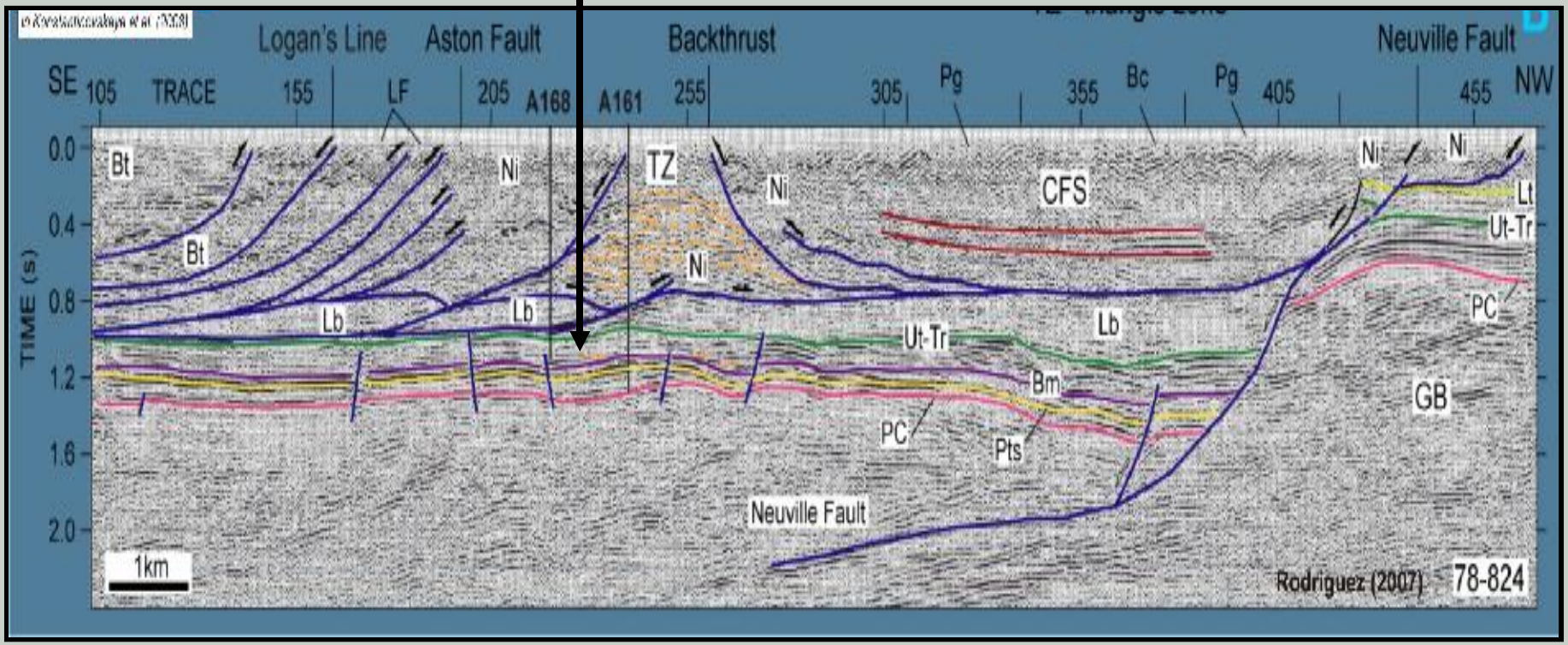
Pressure Gradient Variation

Talisman St-Edouard and Leclerville wells

12 MMcfd Initial Production

Overthrusted Shales



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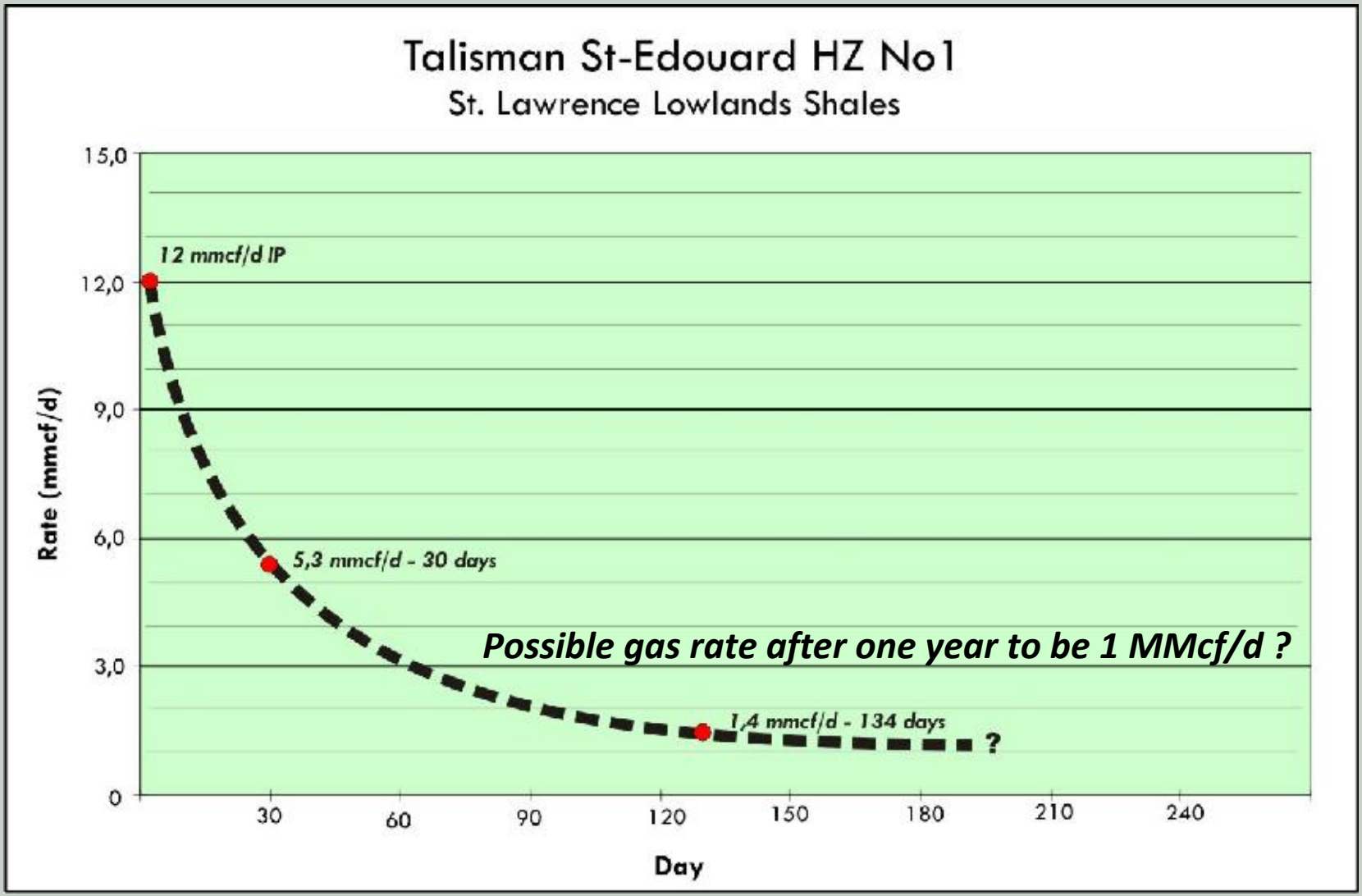
First long-term testing

Stimulated Horizontal Well - Deep Shale



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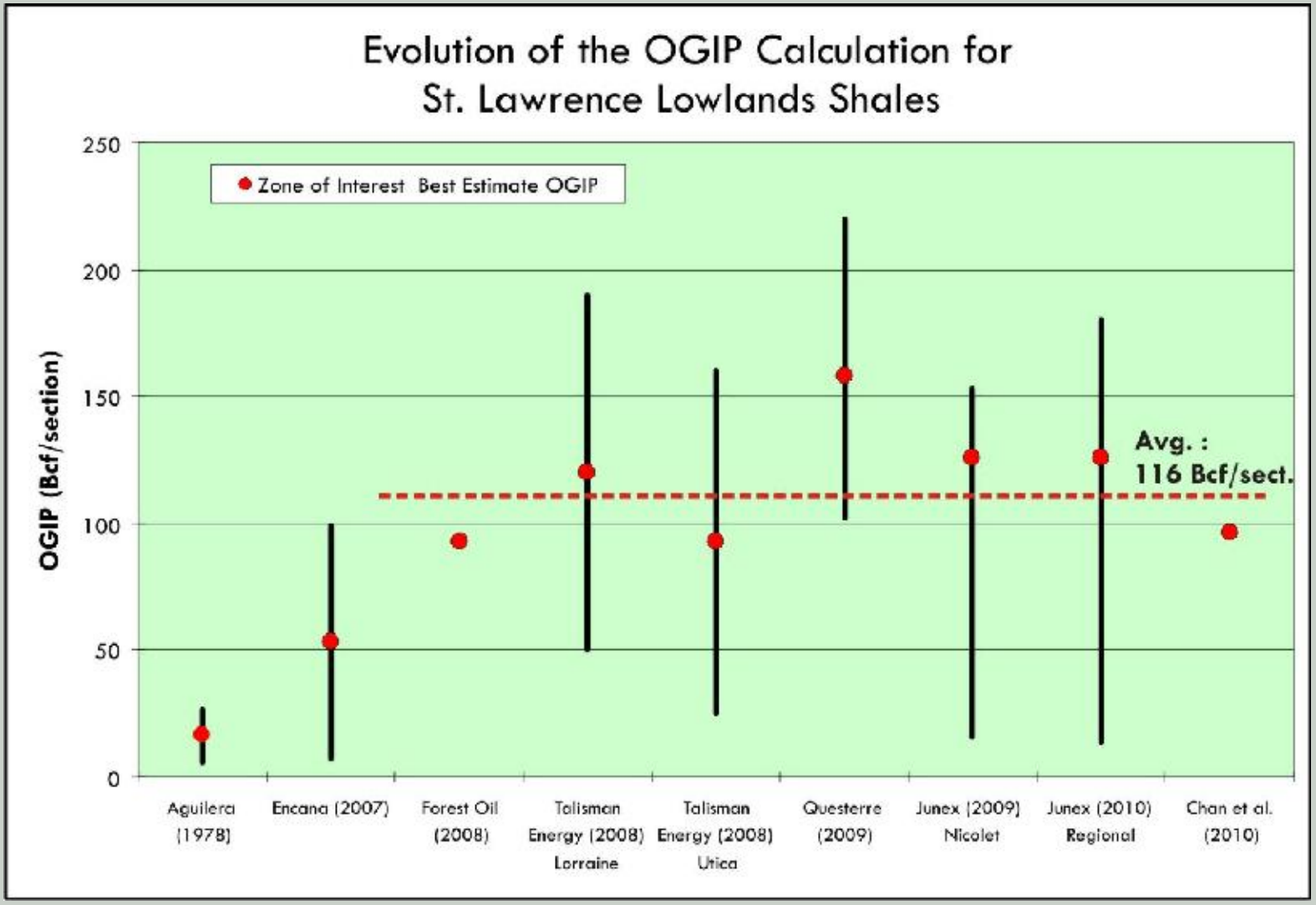
Utica Shale Medium to deep Play

Gas-in-place estimation



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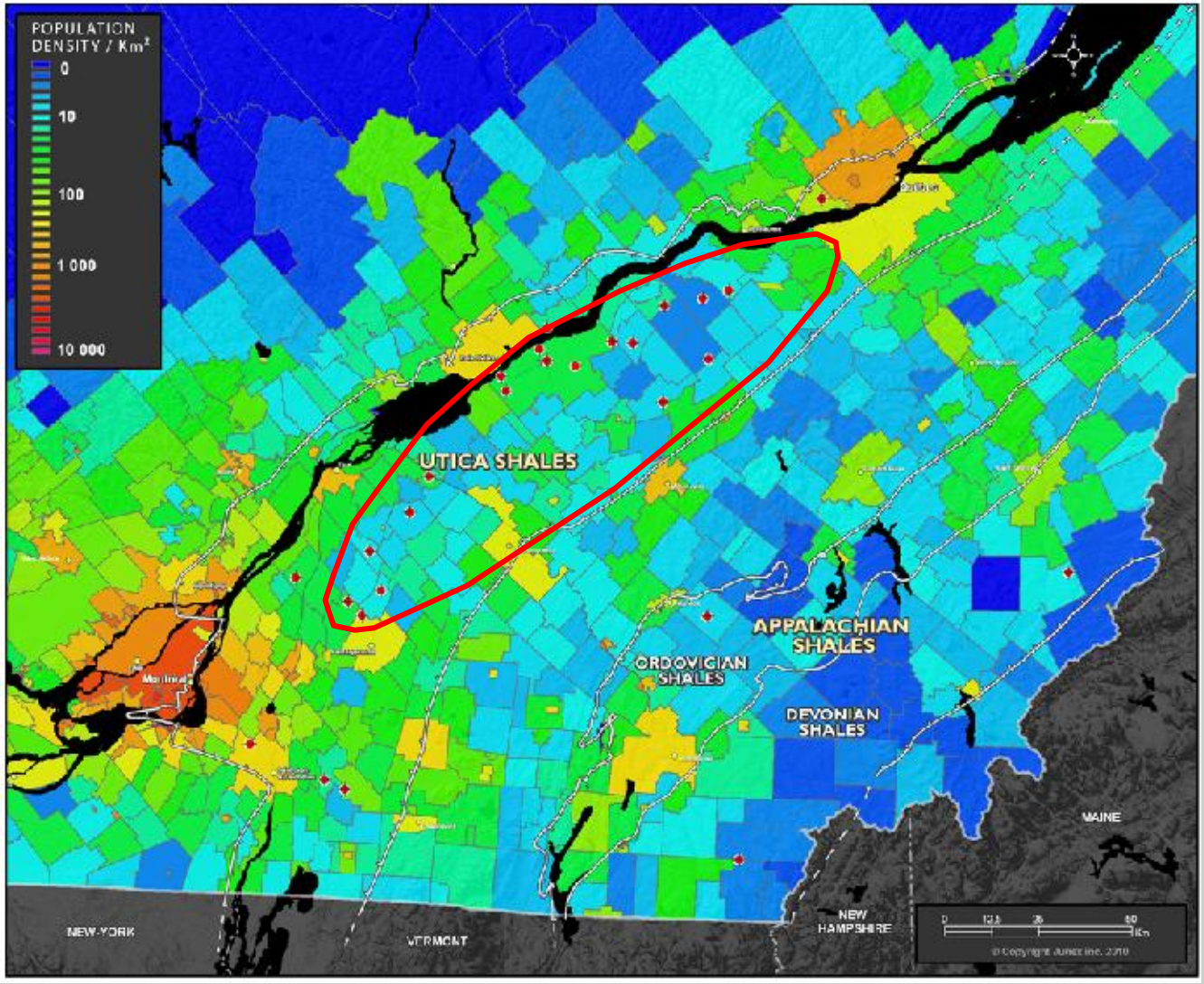
Land Management Challenges

Population density and shale gas exploration



- *GIS/Mapping tool help the land management of shale gas exploration;*
- *Main exploration activities occurred in area with less density of population (0 to 10 persons/ km²);*

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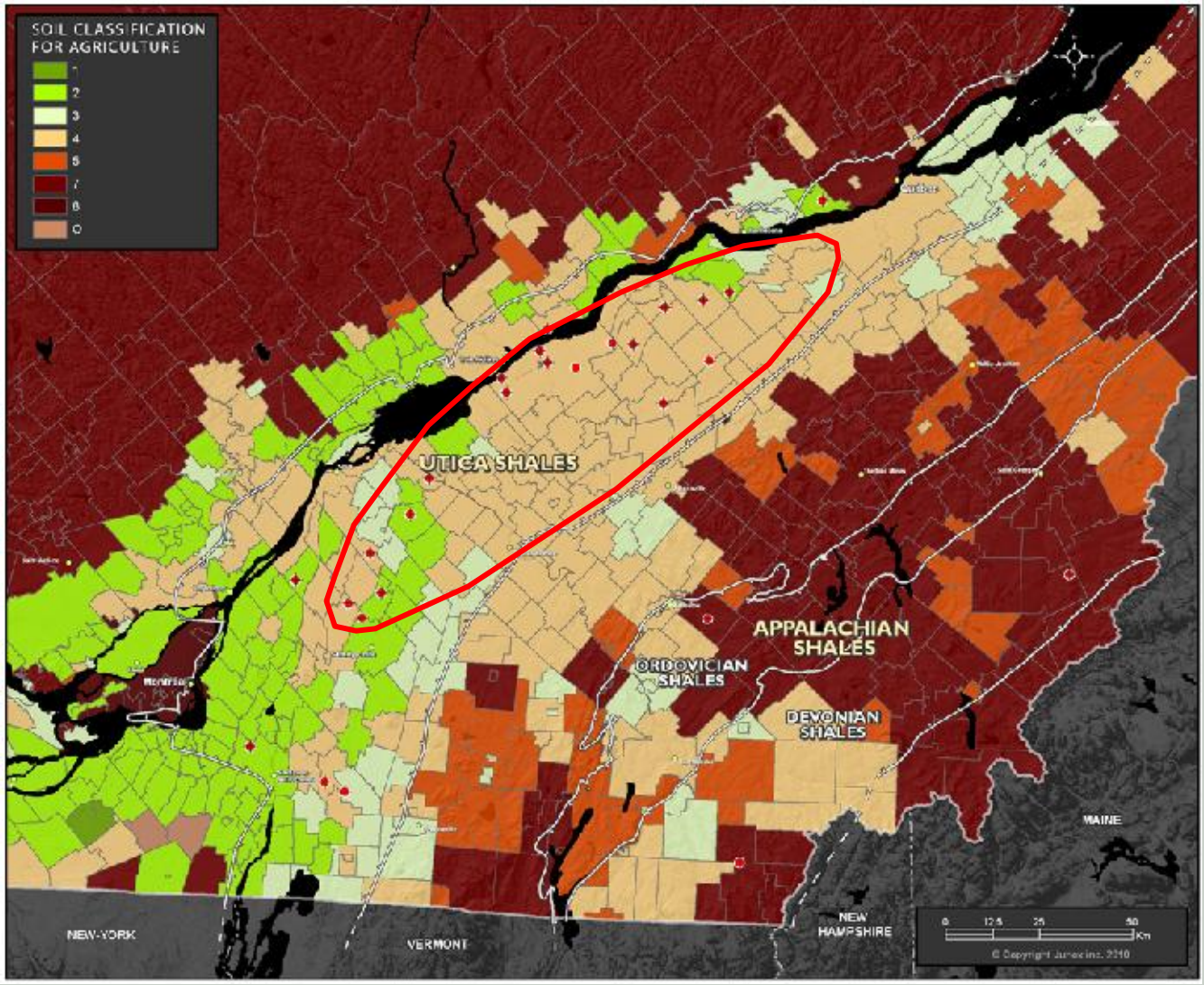
Land Management Challenges

Agriculture and shale gas exploration



- *Green colors (Class 1-2-3) represent the area with the highest soil potential for agriculture;*
- *Main exploration activities occurred in Class 4 area;*
- *Soils in Class 4 have very serious limiting factors that restrict the range of crops or require special conservation measures or have two disadvantages.*
- *Soils in Class 5 to 8 have less potential.*

Conclusions

1. The Shale Gas in Province of Québec are promising plays:
   - Widespread source of gas – Utica and Lorraine Shales;
   - Utica Shales : Proven fracturability in horizontal lateral : IP rate for 30 days exceed 5,000mcfd;
2. High potential Utica Shale Gas:
   - Estimated (average) OGIP for the most advanced area : 116 Bcf/section;
   - Pilot tests scheduled in 2011;
3. JUNEX is present in the heart of the action and develops new areas:
   - St Lawrence Lowlands :
     - Currently evaluating shale gas potential of the overthrusted play;
     - Continually analyzes data to identify new drill targets;
   - Appalachian Shales : geochemistry, seismic and strat-well;
4. Creation of the Quebec Oil and Gas Association (QOGA), and also, development of a Shale Research Consortium with the National Research Institute (INRS-GSC);
5. We shall have to work with population and keep them well informed of our progress to get social acceptability.

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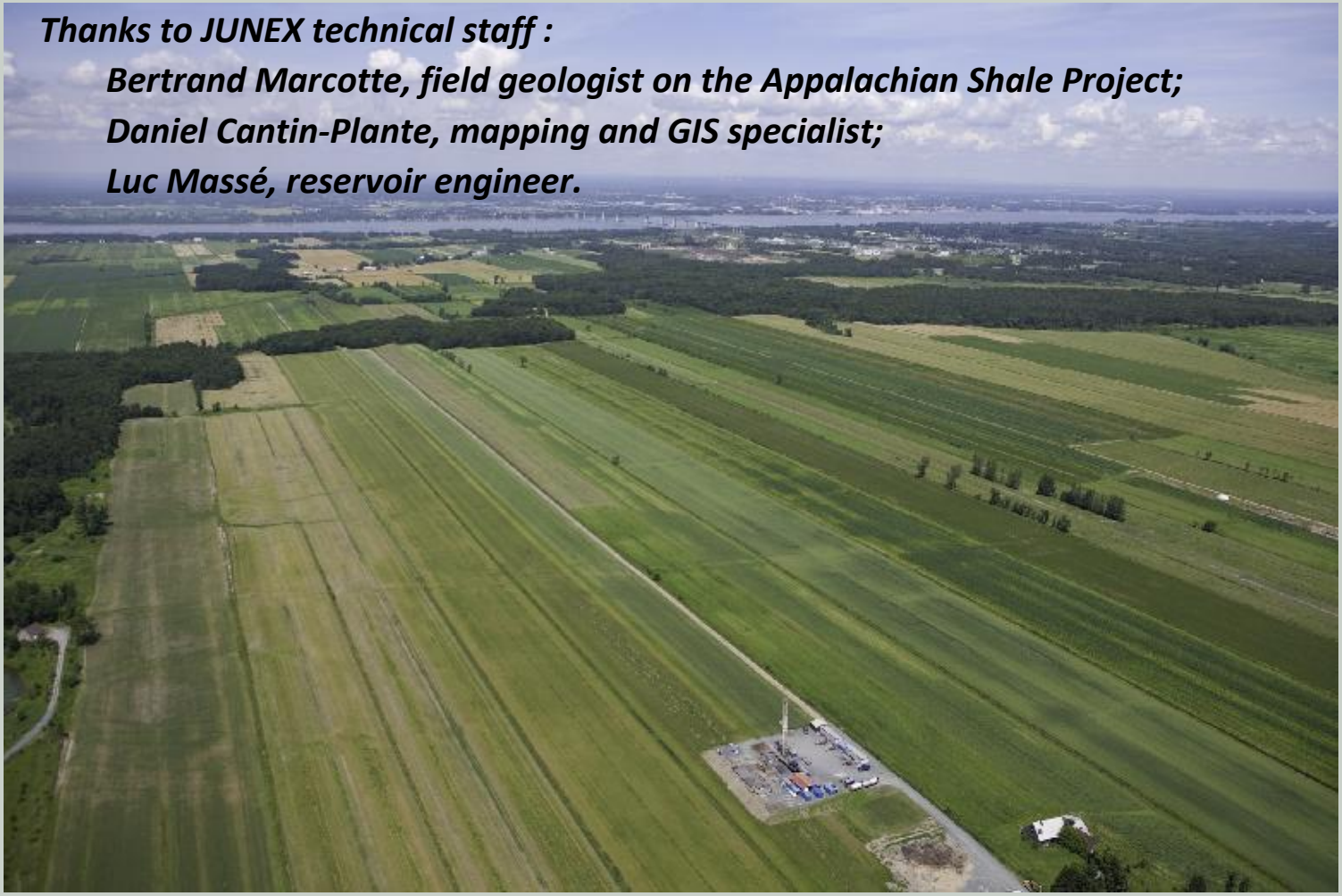

Source : JUNEX (2009)

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