

Shale Gas Potential of the Quebec Sedimentary Basins*

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Abstract

Recent interest in unconventional gas resources has attracted several oil and gas explorers to sedimentary basins in Southern Quebec. The main target of this interest is the Middle Ordovician Utica Shale. Current knowledge of the area's geology led industry to subdivide the Shale-gas potential into different plays. JUNEX subdivided it into five different plays: 1) medium- to deep-depth thermogenic Shale gas; 2) shallow- to medium-depth thermogenic Shale gas; 3) overthrust Shale gas; 4) biogenic Shale gas; 5) Intra- Appalachians sub-basin Shale gas. To date, most operations have been performed in the medium-depth thermogenic Shale gas play (1000-2000 meters), located in the central part of the Saint Lawrence Lowlands. With OGIP estimates ranging from 25 to 350 Bcf per section, the play is definitely considered to be promising. However, other plays are also attractive and, over the past few years, JUNEX has worked intensively on the development of these new areas of exploration. They all have different potentials but also different economics and issues. Based on the exploration work realized by JUNEX over the past five years in Southern Quebec, the characteristics of the five plays, from a geological, geochemical, structural, and geophysical perspective, are reviewed. The five plays are described, based on the data available regarding the basin geology, shale mineralogy, organic-matter type, gas geochemistry, structural style, and infrastructure access. As a result, a new Shale gas potential map will be available for the Southern Quebec sedimentary basins.

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Shale Gas Potential of the Quebec Sedimentary Basins

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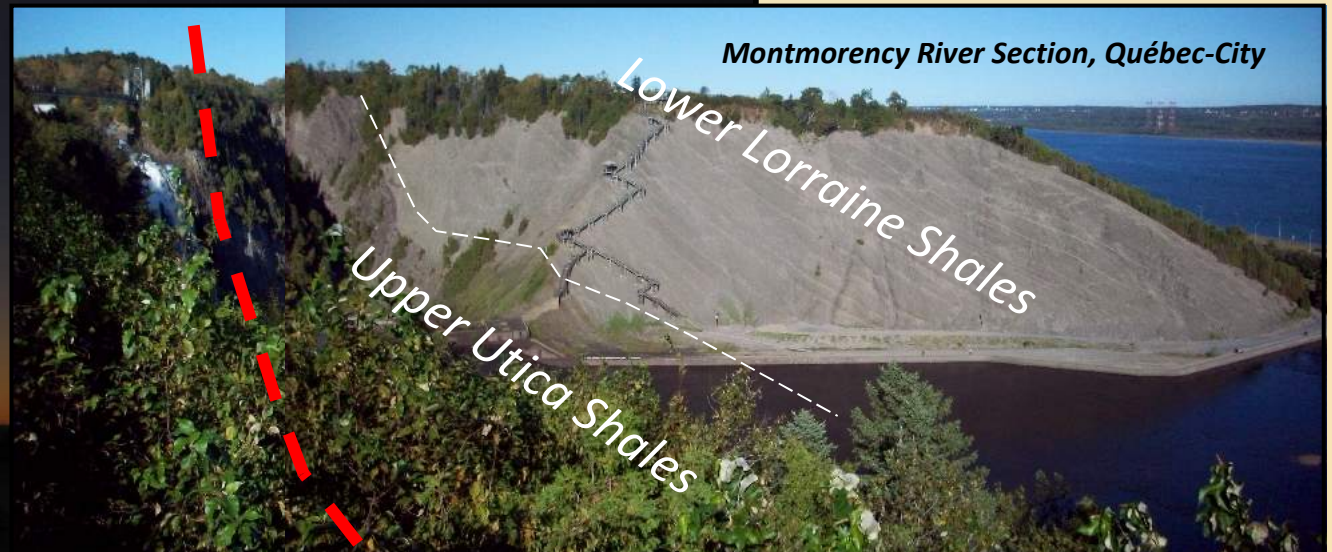
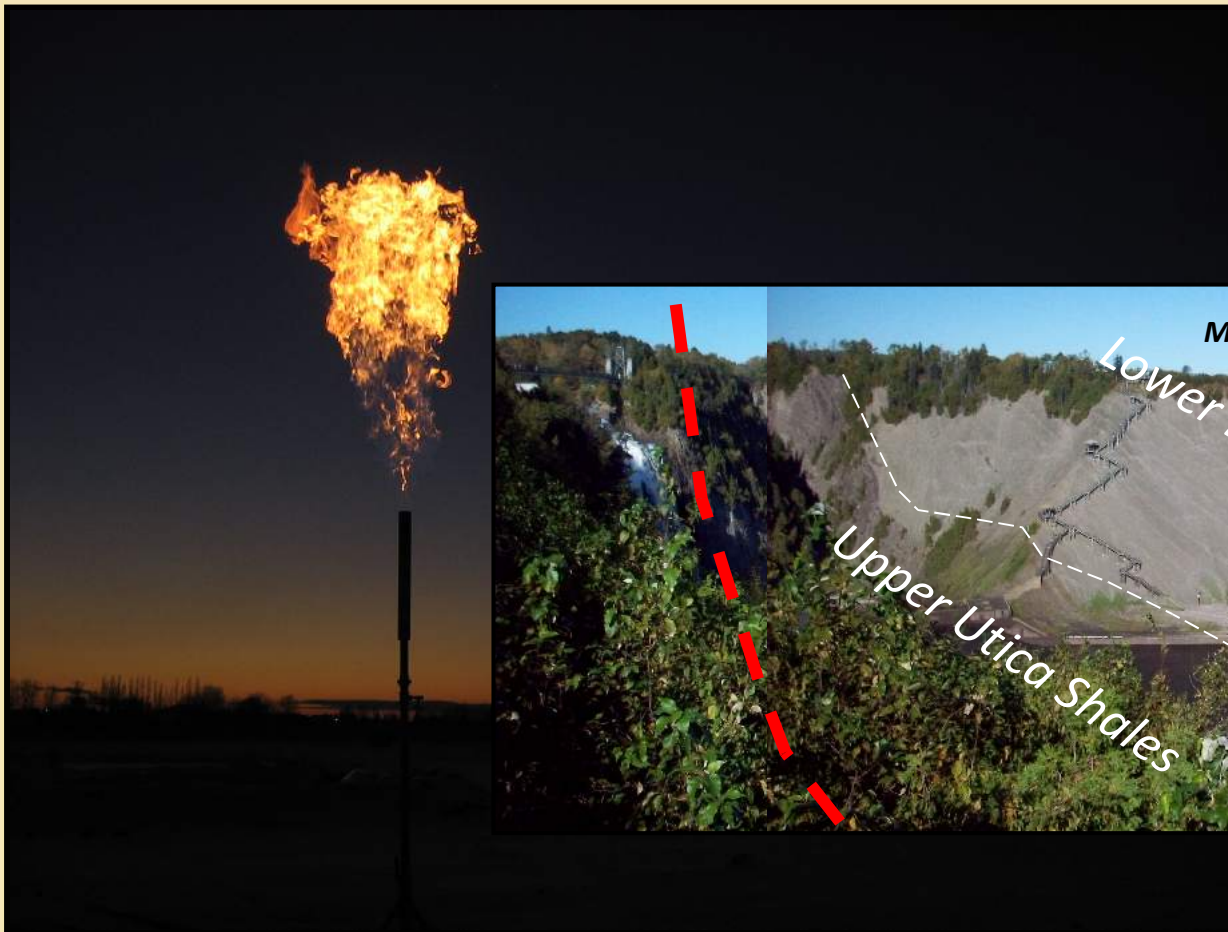
AAPG Eastern – Evansville, IN

September 21th, 2009

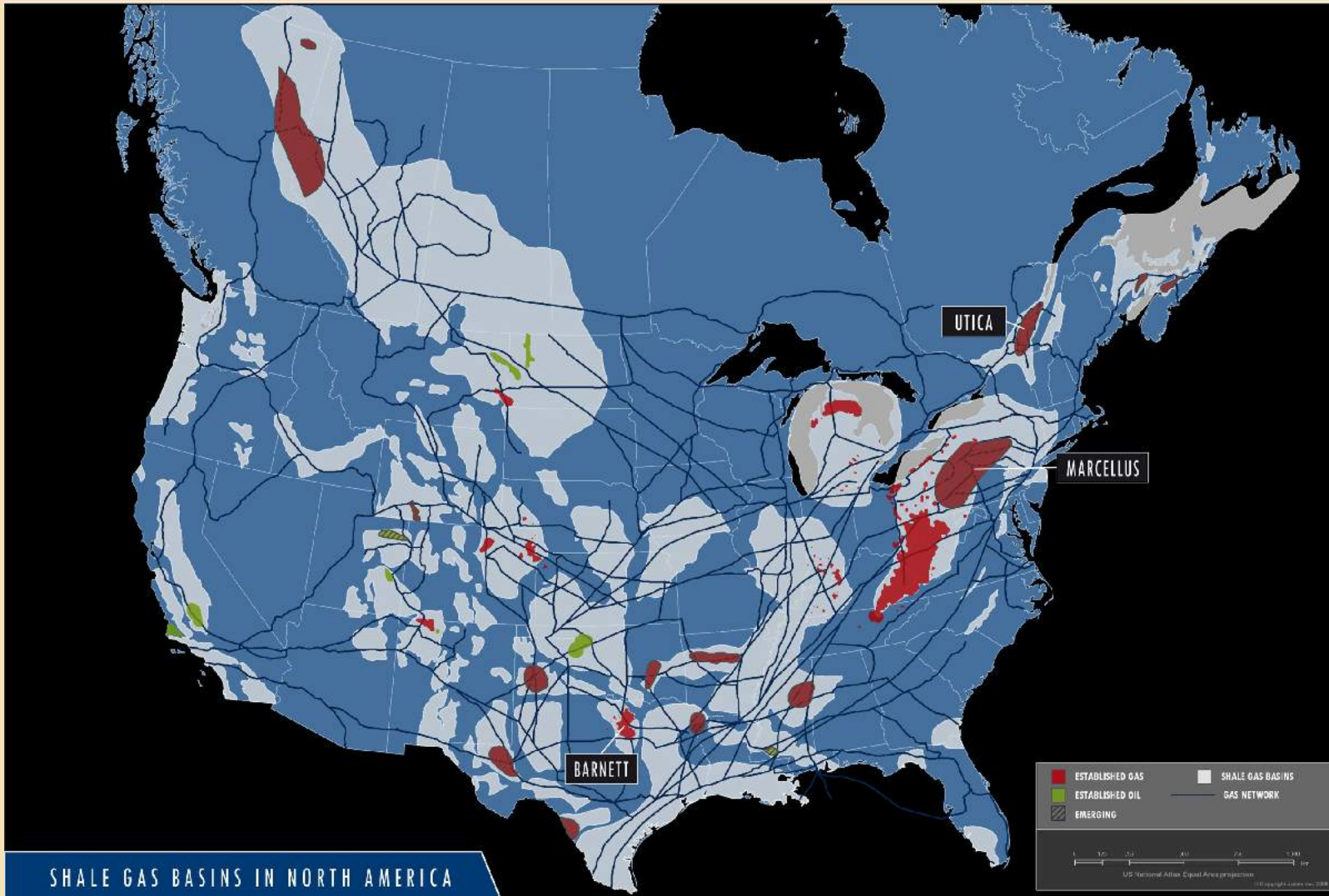
JUNEX

- JUNEX inc. is an O&G Exploration company founded in Québec City in March 1999
- Listed on the TSX Venture Exchange since June 2001;
- Diversified portfolio in every sedimentary basin in Quebec;
- Owns and operates two rigs equipped for testing with capacity of 2000 meters;
- Produced light oil in Gaspé, produced natural brine in Bécancour;
- Involved in CO2 sequestration project in Bécancour;
- Cash in hand : \$26.6 million, no debt;
- 2008-2009 objective : acquiring more data (from new wells) on the gas potential of the different shale sequences in Quebec. In other words : extending the area and the value of the shale gas plays.

Ordovician Shales gas of Saint Lawrence Lowlands

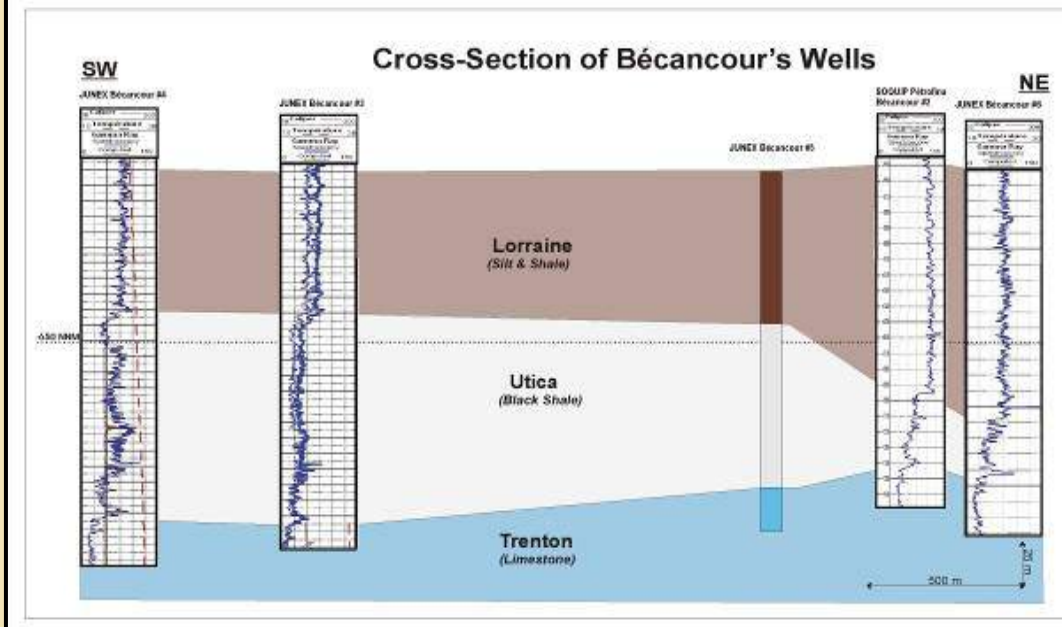
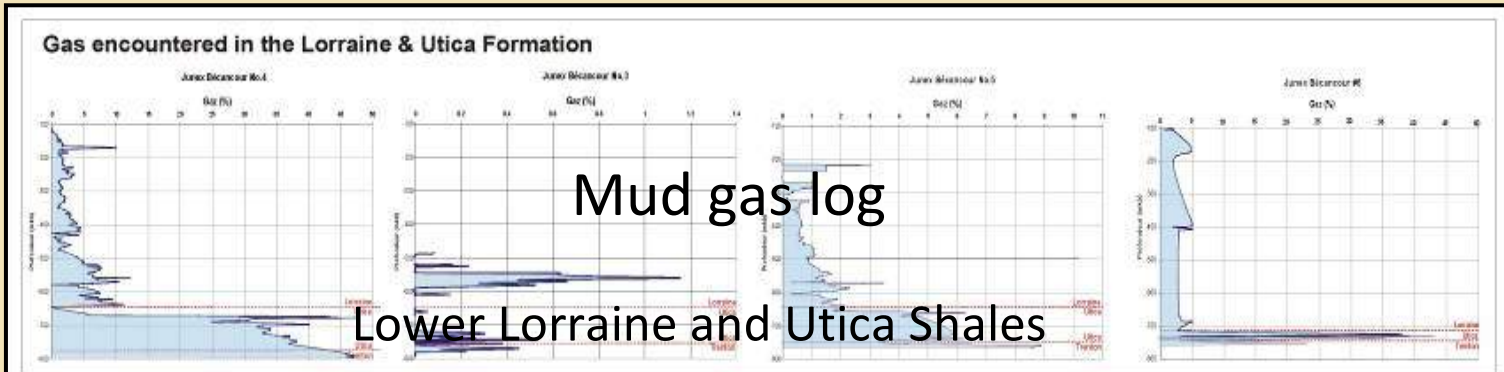


North American Shale Gas Basins



Utica Shale Gas – Where did it start?

Aguilera (1978) : Villeroy; and, JUNEX (2004) : Bécancour

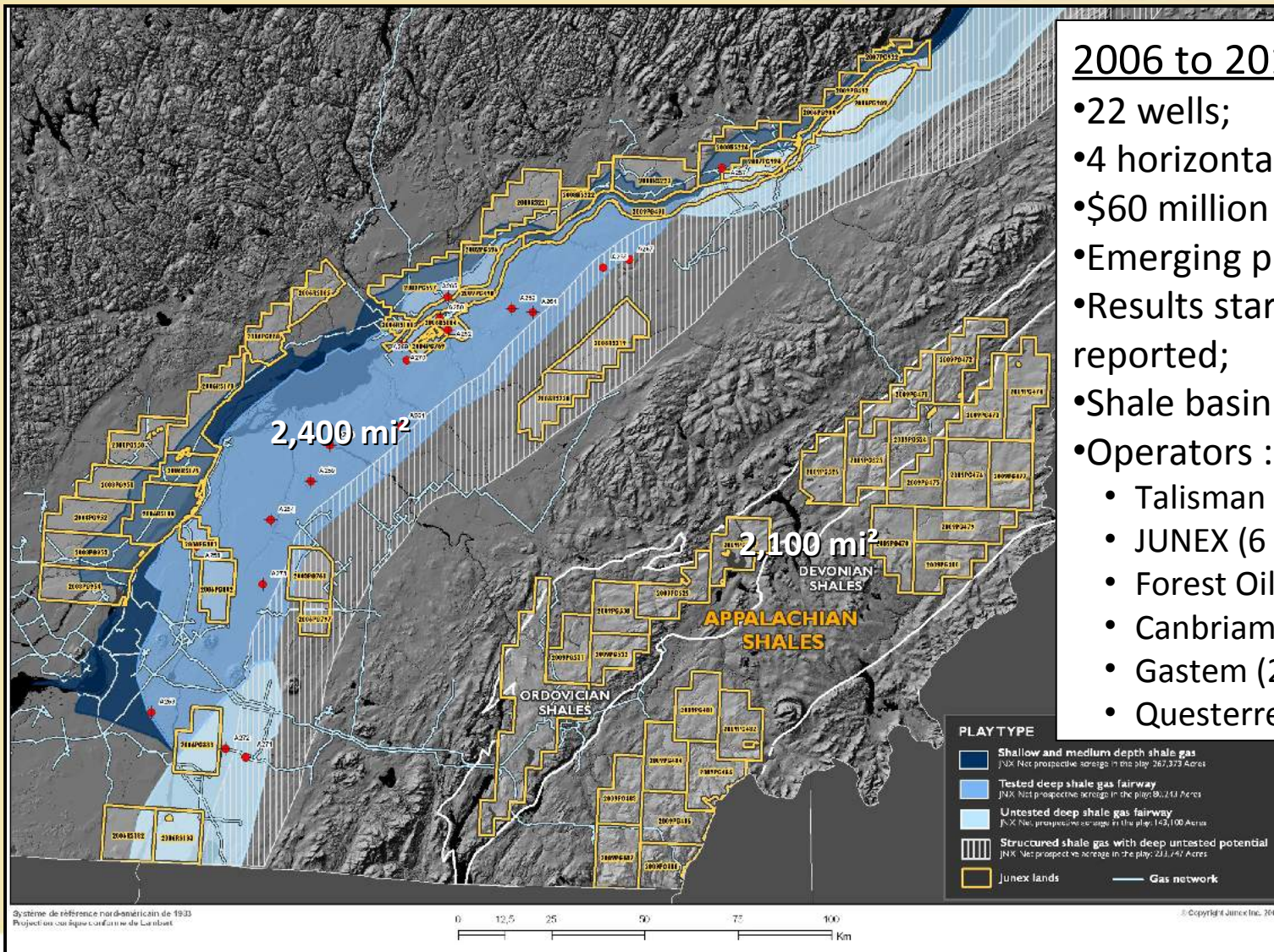


Bécancour's Field



JUNEX (2005)

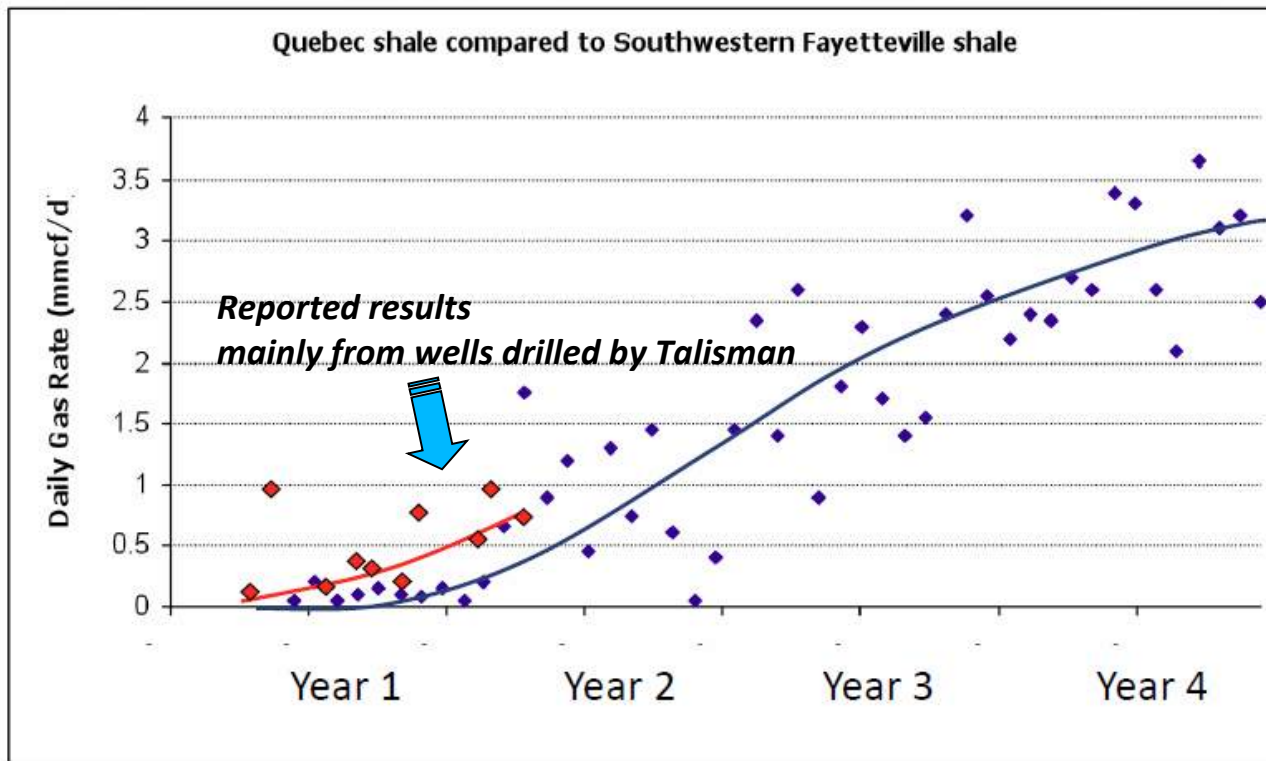
Shale gas play – Exploration activities



- 2006 to 2010**
- 22 wells;
 - 4 horizontal;
 - \$60 million (in 2008);
 - Emerging play;
 - Results starting to be reported;
 - Shale basin : 4500 mi²
 - Operators :
 - Talisman (7 wells)
 - JUNEX (6 wells)
 - Forest Oil (3 wells)
 - Cambrian (3 wells)
 - Gastem (2 wells)
 - Questerre (1 well)

Learning curve

Recently reported results for various tests



- *The results indicate production potential comparable to that of other basins;*
- *Over the next six months, the results from five new wells should be made public.*

◆ Quebec
 ■ Trend Line

Graph source : Questerre (2009)

◆ Southwestern
 ■ Trend Line

What we did

Shale Properties	Coring (Porosity, Permeability, Density)
GIP	Core analysis (Canister Desorption & Adsorption Isotherms), GeoJar
Gas geochemistry	Stable isotopes, Gas composition
Organic matter type	TOC/RE, Biomarkers, Kerogen thermal maturity
Rock mechanics	Compressive Strength - UCS, Elastic Modulus, Poisson's Ratio
Shale mineralogy	XRD, Thin-section, Shale Gas Log, Frac Fluid Sensitivity, Cap suction
Basin geology	<i>Regional-scale sedimentology model*</i>

** Project in progress*

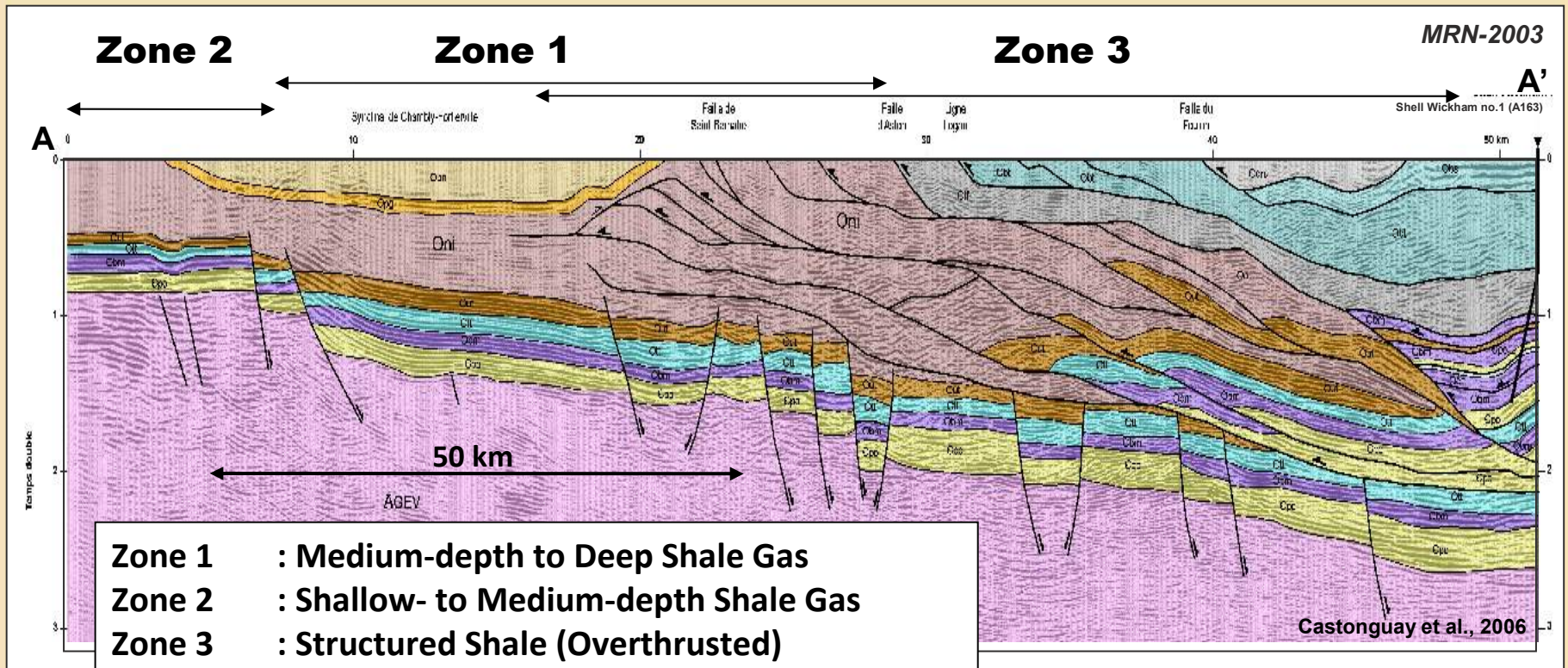
General properties...

JUNEX subdivided it into five different plays:

- 1) medium- to deep-depth thermogenic shale gas;
- 2) shallow- to medium-depth thermogenic shale gas;
- 3) overthrust shale gas;
- 4) biogenic shale gas;
- 5) intra-Appalachians sub-basin shale gas.

To date, most operations have been performed in the medium- to deep-depth thermogenic Shale gas play (1000-2000 meters), located in the central part of the Saint Lawrence Lowlands.

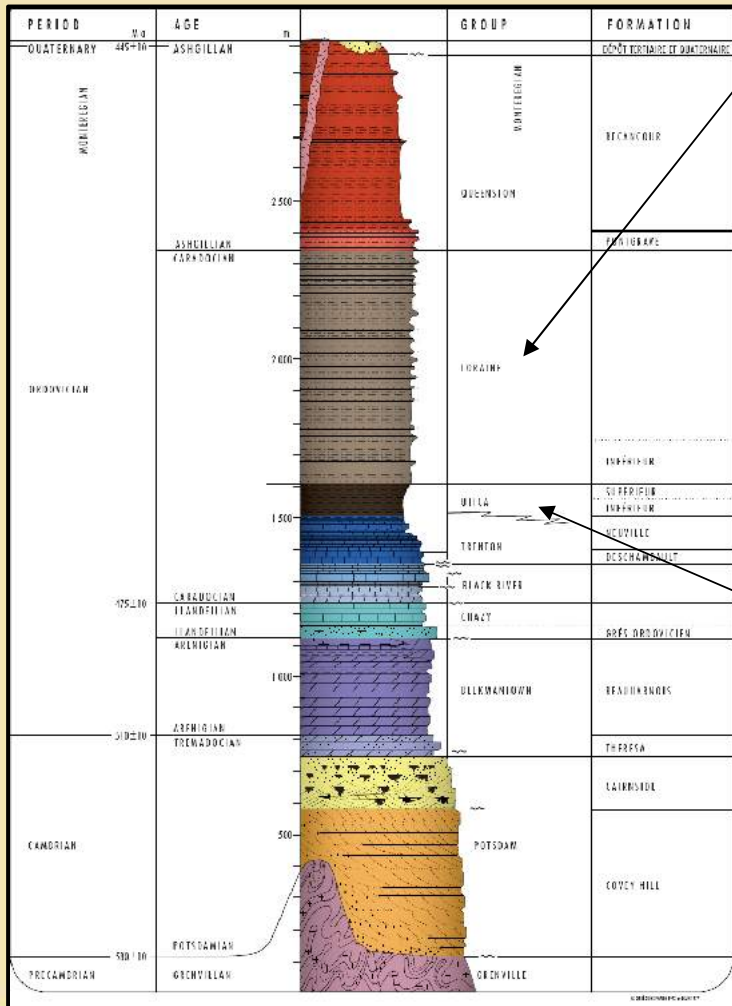
Five Shale Gas plays of the Quebec Sedimentary Basins



- Zone 1** : Medium-depth to Deep Shale Gas
- Zone 2** : Shallow- to Medium-depth Shale Gas
- Zone 3** : Structured Shale (Overthrust)
- Zone 4** : Biogenic Shale Gas *
- Zone 5** : Intra-Appalachian Basin Shale Gas *

* Not shown on figure

General Stratigraphy of Utica and Lorraine Shales



Lorraine :
 600 to 2000 m
 Arenaceous shales/siltstones
 Sandstone interbed

Lorraine average mineralogy :

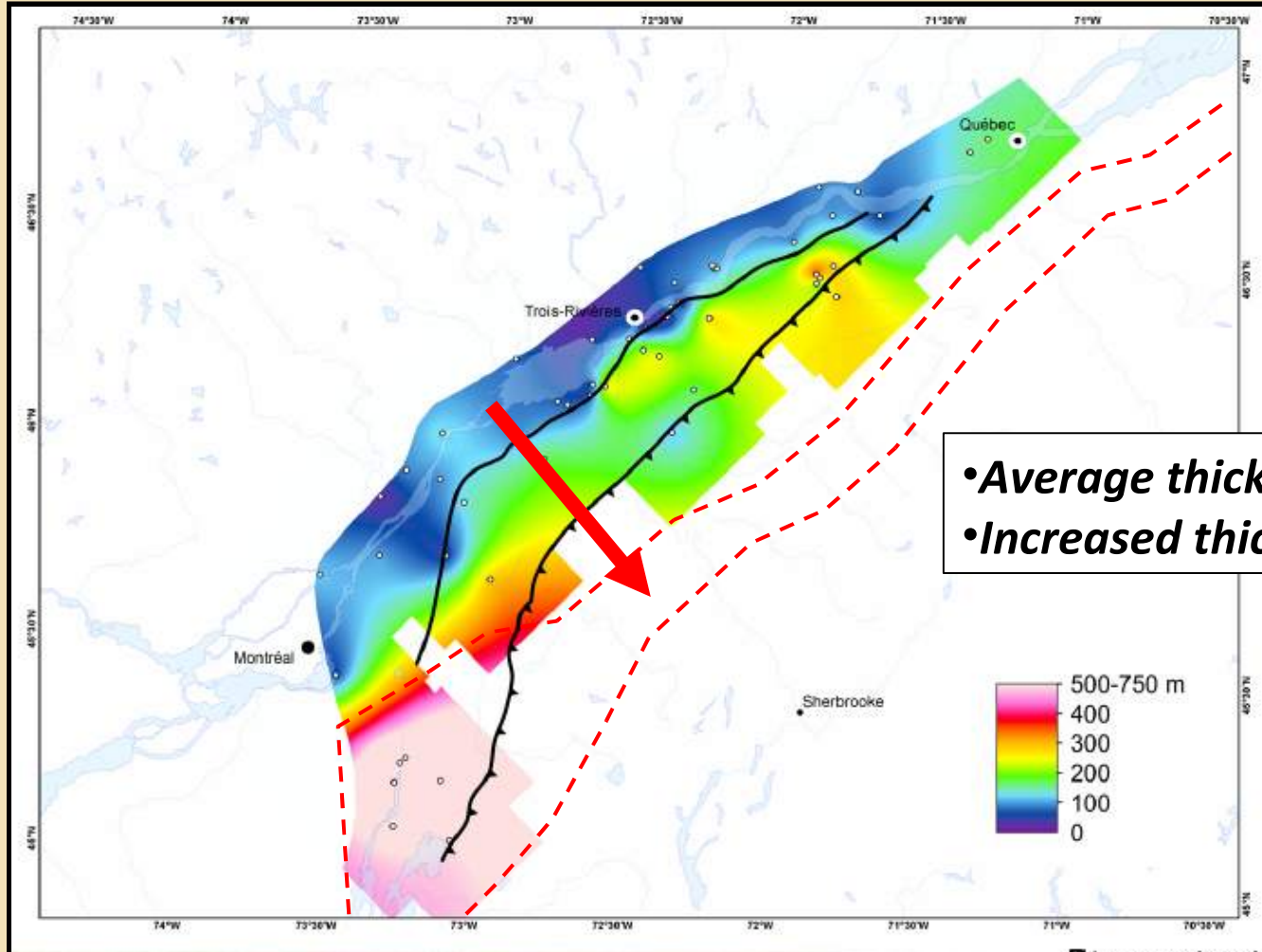
>50% Clay
 <10% Carb
 40% QZ

Utica :
 100 to 500 m
 Dark brown to black
 calcareous shale

Utica average mineralogy :

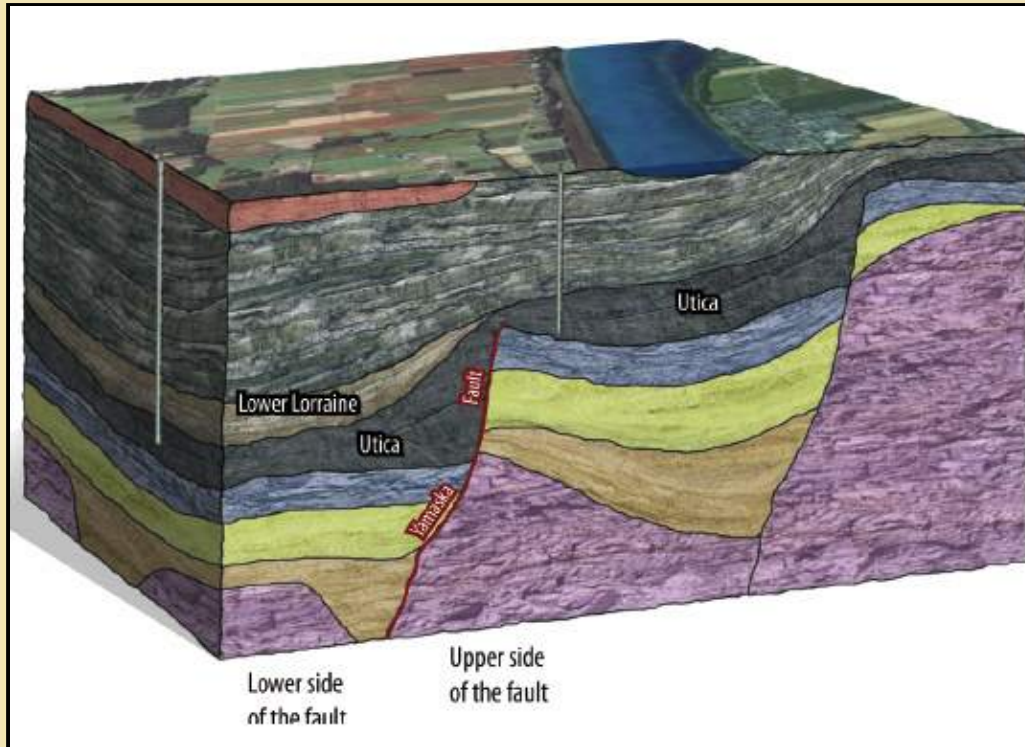
25% Clay
 60% Carb
 15% QZ

Utica Shale Thickness variation



- **Average thickness = 150m**
- **Increased thickness to SE**

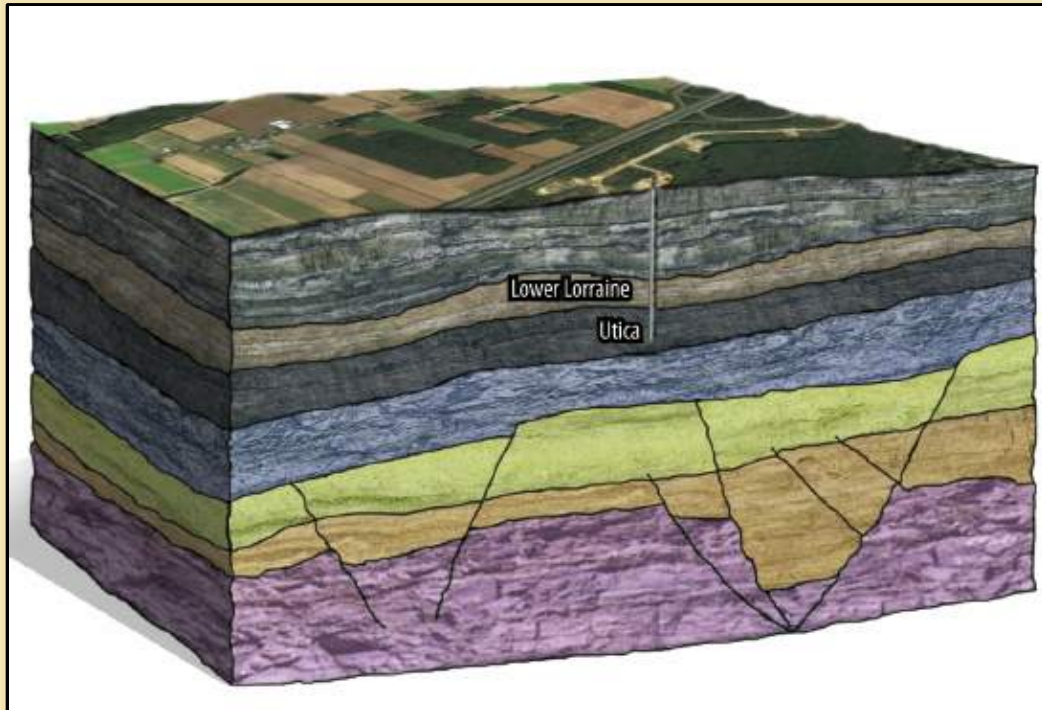
Medium depth to deep Shale Gas



Formation : Utica and Lorraine
 Depth : 500 to 2500 m
 Thickness : 150 to 400 m
 TOC : 0.5 to 2.5%
 Thermal Maturity : Condensate to Dry Gas
 Gas type : Thermogenic from Type II Kerogen
 GIP : 50 to 350 bcf/section *
 Current activity :
 10 wells tested;
 Only play with horizontal wells;
 Next well to be tested – JUNEX St-Augustin no.1

**Most obvious area to begin evaluation of potential.
 Low deformation, interesting depth and OGIP.**

Shallow to medium depth Shale Gas



Formation : Utica and Lorraine
 Depth : 100 to 500 m
 Thickness : 100 to 200 m
 TOC : 0.5 to 3.0%
 Thermal Maturity : Condensate to
 Dry Gas
 Gas type : Thermogenic from
 Type II Kerogen
 GIP : Currently under evaluation

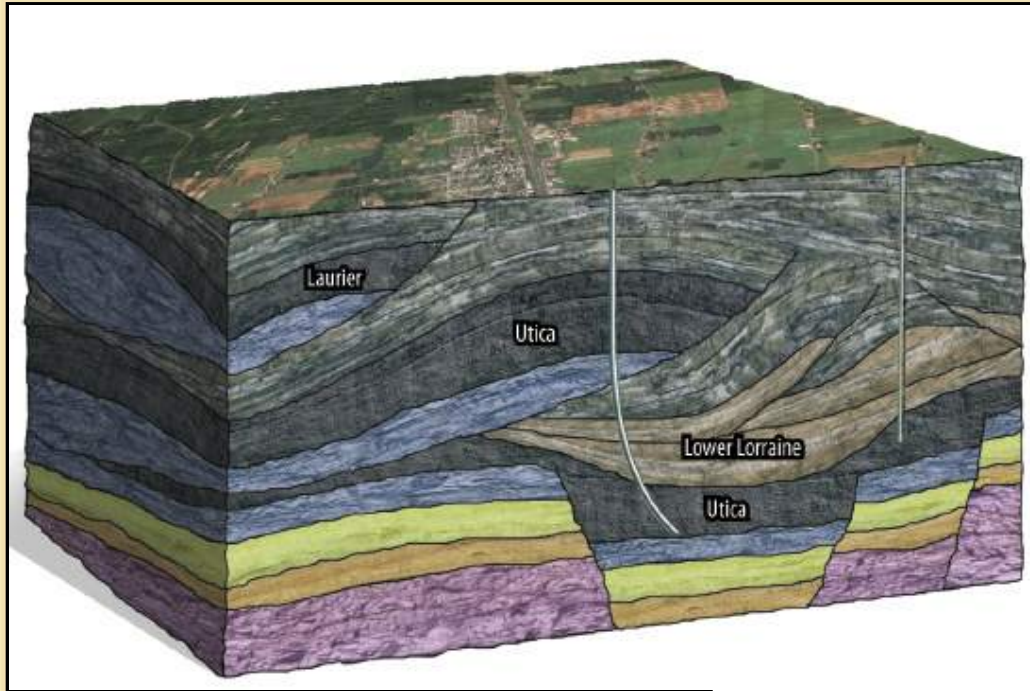
 Current activity :
 1 wells drilled (Questerre)
 No result available

**Area with the easiest access to pipeline
 and the lower drilling cost.**

Little work done to date.

Low deformation, shallow depth, and good TOC.

Overthrust Shale Gas



Formation : Utica and Laurier
 Depth : 500 to 3000 m
 Thickness : Several thrust zones of 100 to 400 m
 TOC : 0.5 to 5.0%
 Thermal Maturity : Condensate to Dry Gas
 Gas type : Thermogenic from Type II Kerogen
 GIP : No data available

Current activity :
 Seismic surveys were acquired in order to delineate exploration targets (for 2010).

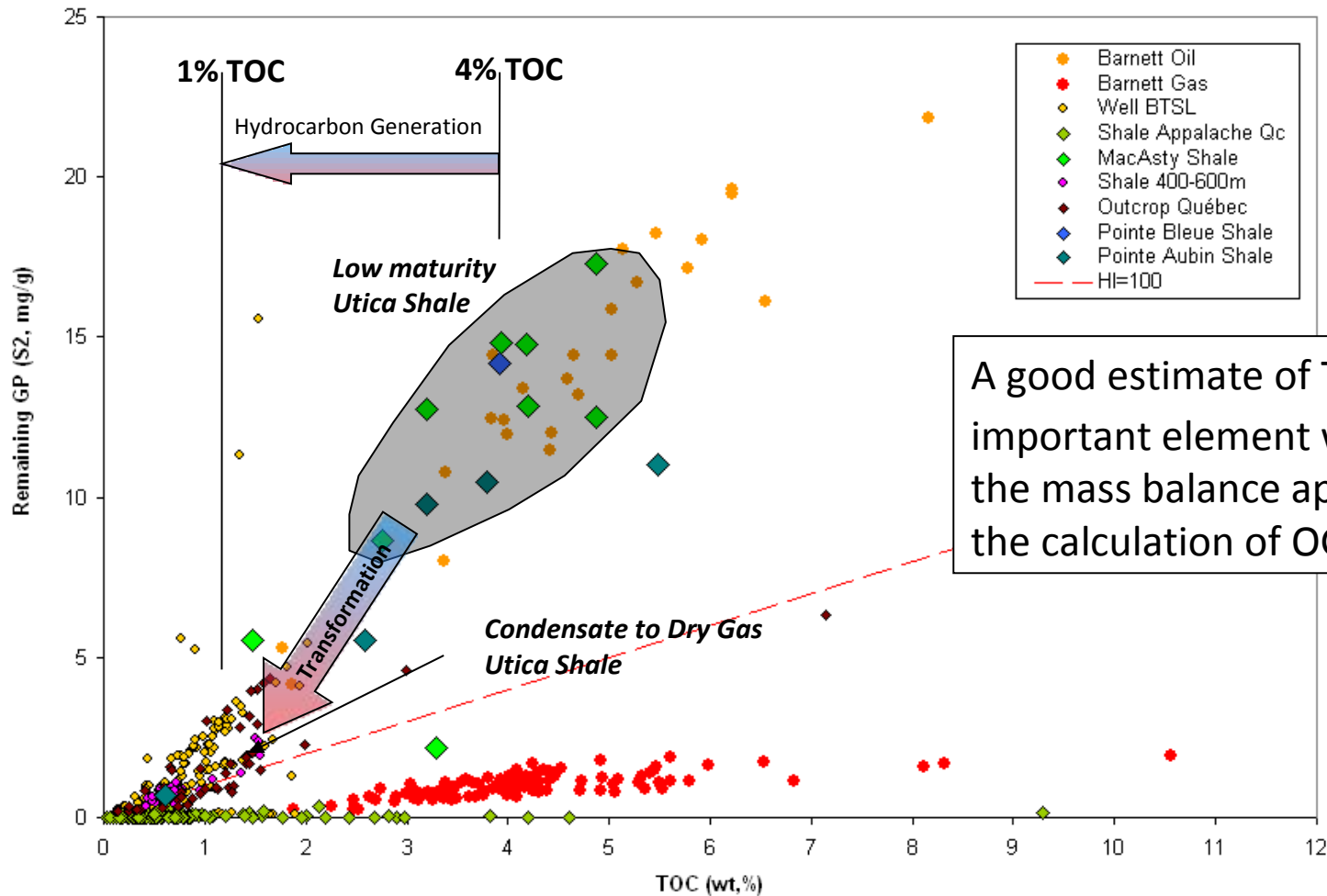
**Possibly the area with the highest OGIP.
 Higher drilling cost.**

**Deformed zone, shallow- to deep-depth shales thrust,
 and the highest TOC reported in the Lowlands.**

Discussion

<p>GIP</p>	<p>Increase depth = decrease porosity = same free gas deep of shallow Higher TOC = Higher sorbed gas content</p>
<p>TOC</p>	<p>TOC_{pd} is low at 1% but TOC_{original} about 3 to 5% = Good TR Locating TOC rich zone is important for sorbed gas</p>
<p>Maturity</p>	<p>Maturity hard to evaluate with vitrinite style measurement Stable isotopes indicate condensate to dry gas window No important variation at basin scale = erosion of 5000m</p>
<p>Porosity</p>	<p>Core measurement porosity is a concern : pressure release Use different tool : Shale gas log or CT-Scan</p>
<p>Play Potential</p>	<p>Three Shale plays have significant potential</p>
<p>Basin geology</p>	<p>Sedimentology of the shales is not well understood</p>

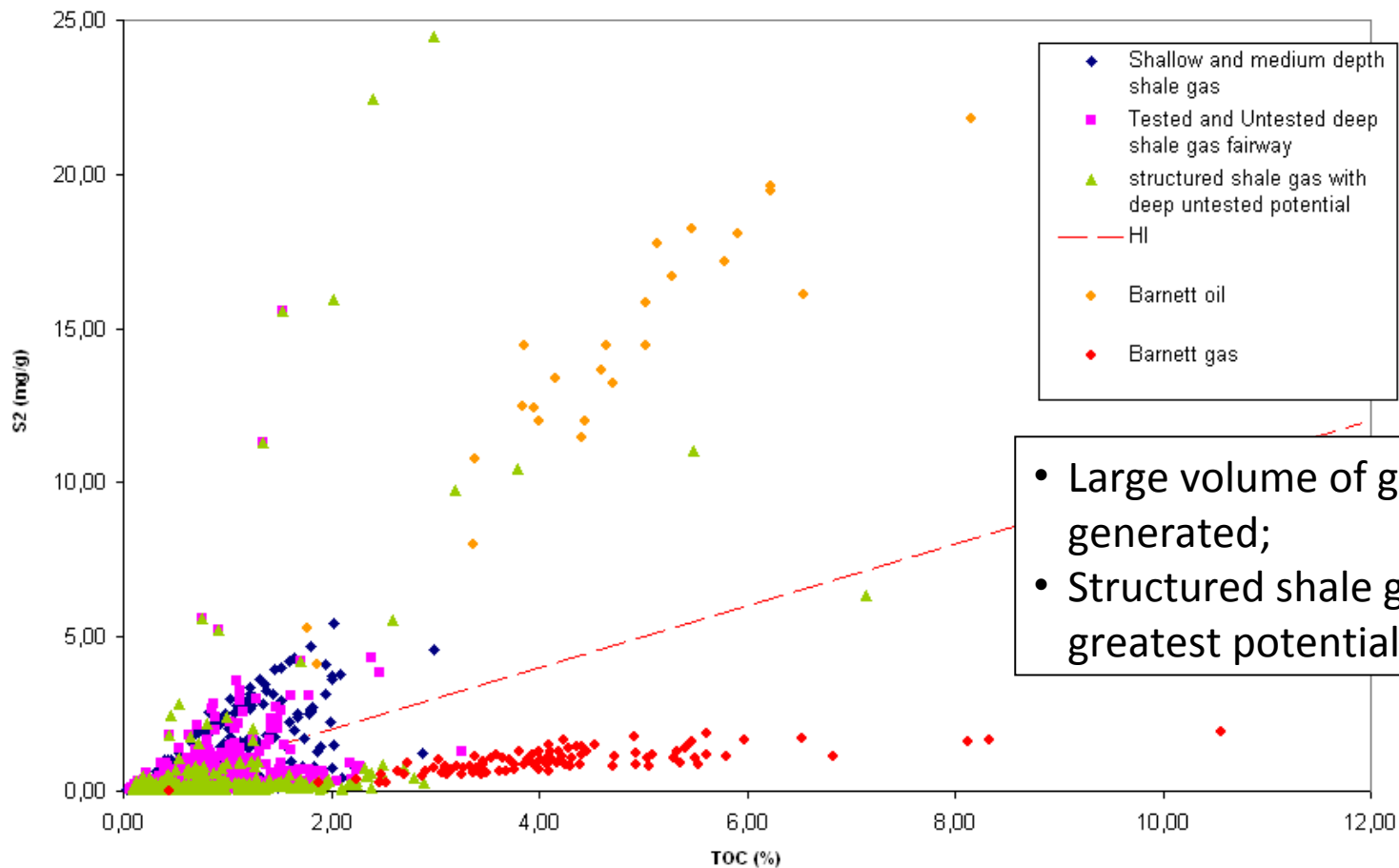
Present-day TOC vs Original TOC



A good estimate of TOC_{original} is an important element when using the mass balance approach for the calculation of OGIP

Gas Generation Potential

Three plays of the Saint Lawrence Lowlands



- Large volume of gas has been generated;
- Structured shale gas has the greatest potential.

Shale mineralogy and petrophysics

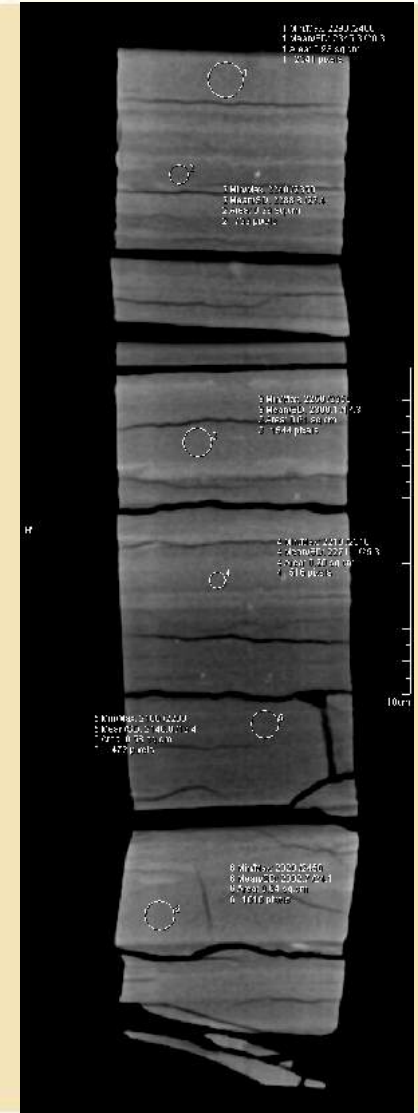
XRD and CT-Scan

Importance of mineralogy for :

- Geological setting ;
- Fracability measurement.

CT-Scan :

- Measure porosity;
- Characterize fracture network;
- Highlight sedimentary pattern.



Shale gas type

Isotopic characterization

In the Ordovician

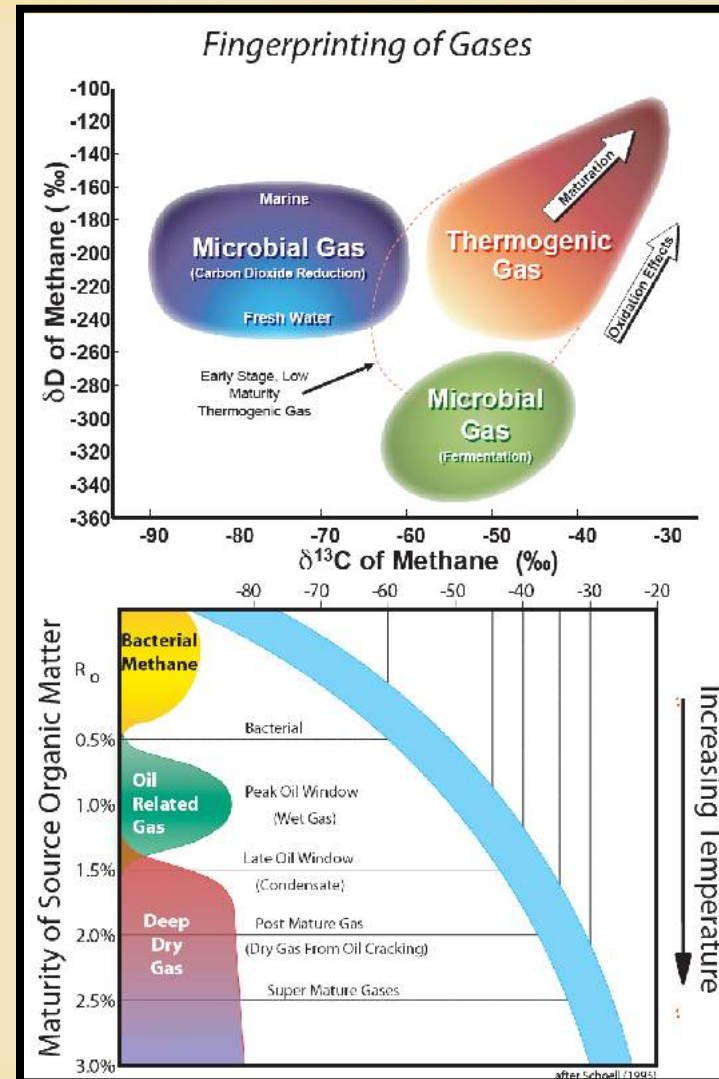
St. Lawrence Lowland basin :

- Mainly Thermogenic Dry Gas
- Type II Kerogen
- Same source rock
- Increase maturity

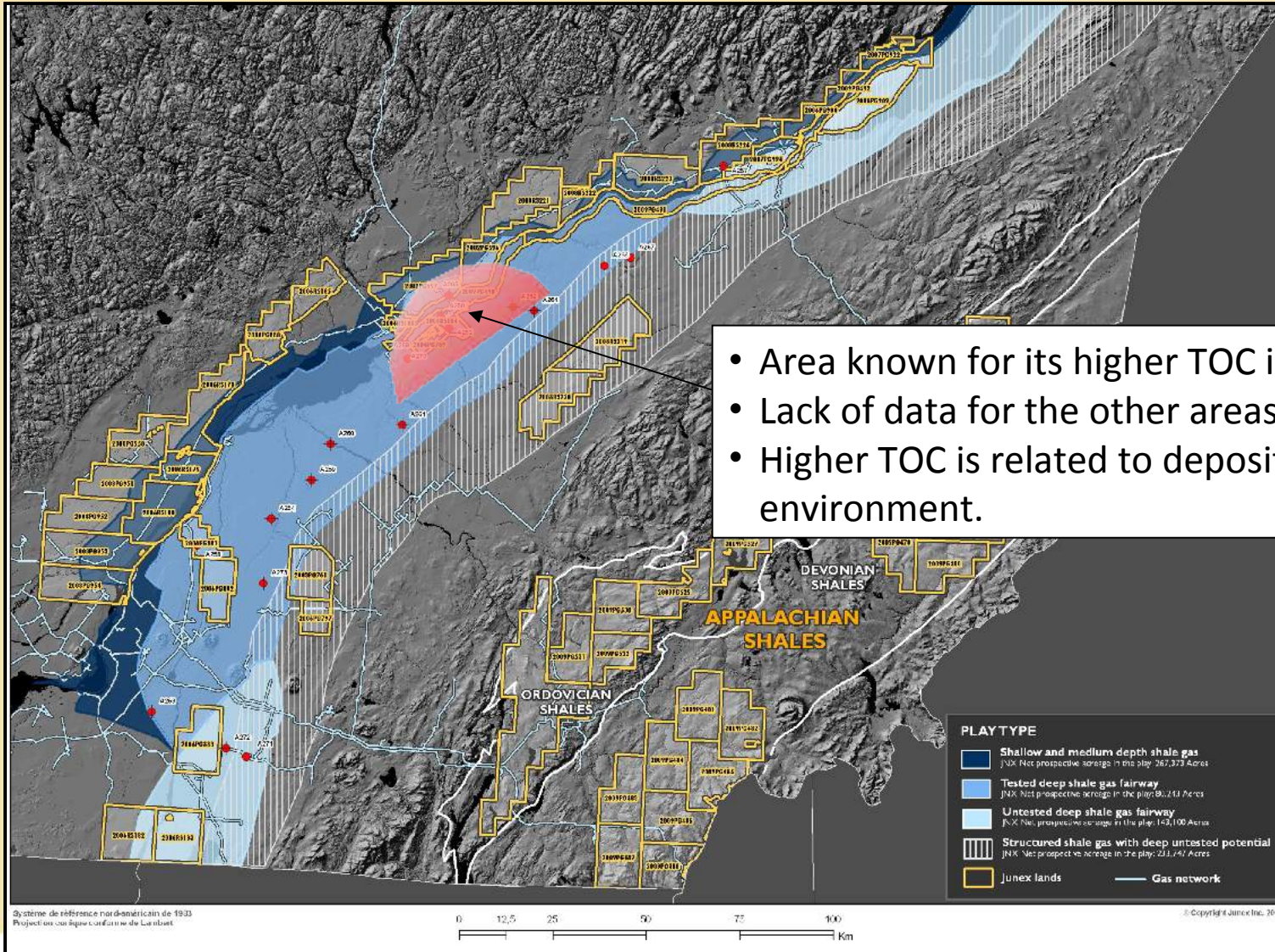
For « *pre-vitrinite time* » basin :

Isotope is presently the more accurate tool for maturity evaluation in Ordovician basin

Graph source : Isotech Laboratories website

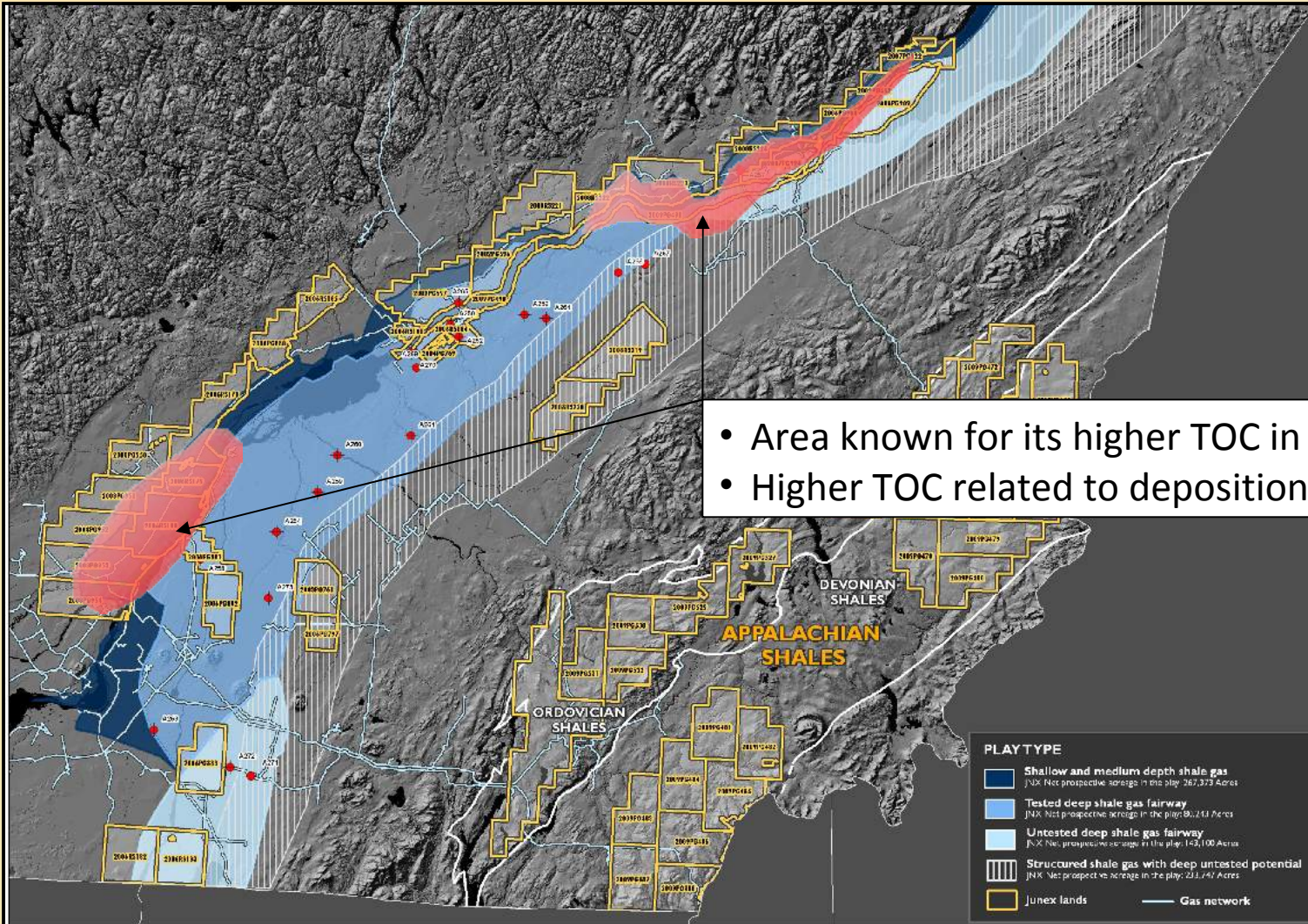


Medium depth to deep Shale Gas



- Area known for its higher TOC in the Utica;
- Lack of data for the other areas;
- Higher TOC is related to depositional environment.

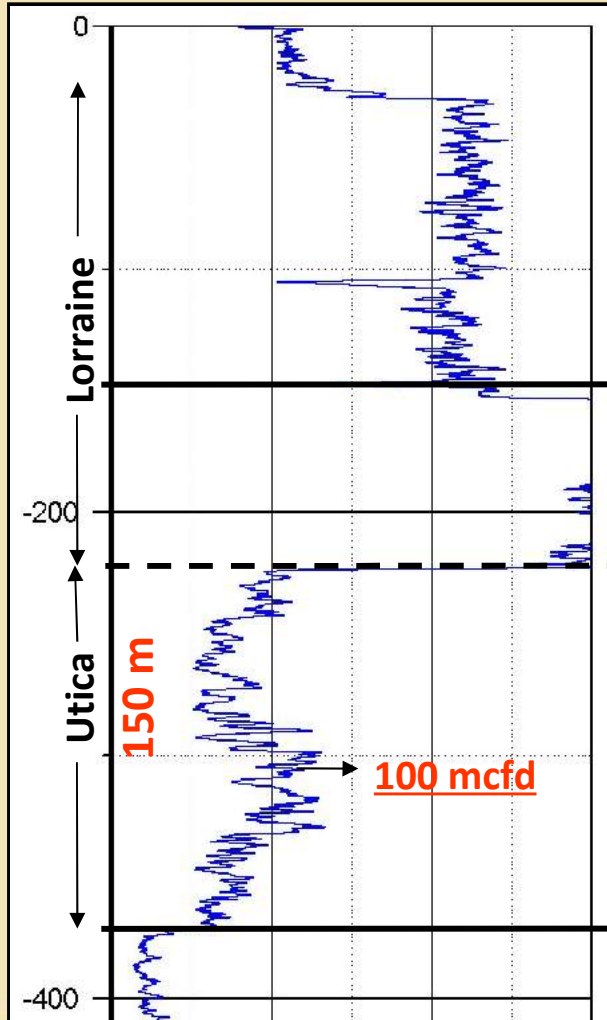
Shallow to medium depth Shale Gas



- Area known for its higher TOC in the shales;
- Higher TOC related to depositional environment

Ordovician versus Devonian Shales

A151 well, North Shore of Montreal



Similar depositional environment recorded on log

lower TOC gray shales

higher TOC QZ black shales

higher TOC CA black shales

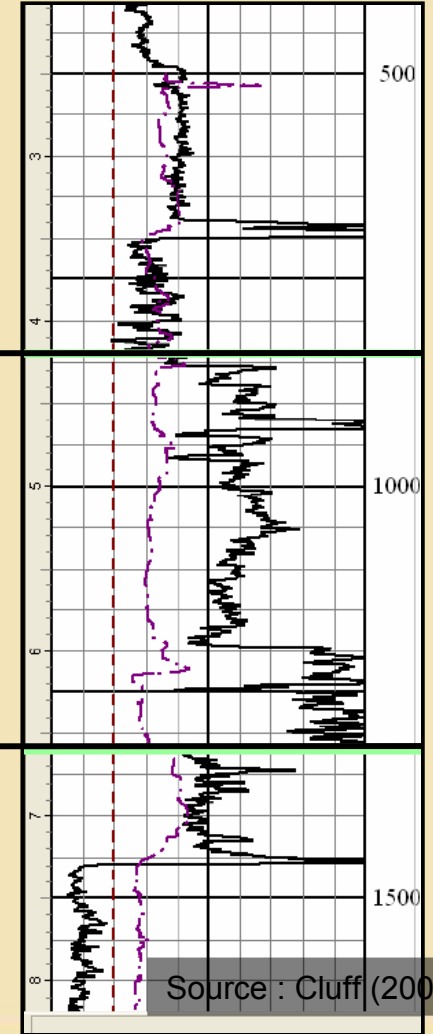
Ordovician Ls

lower TOC gray shales

higher TOC black shales

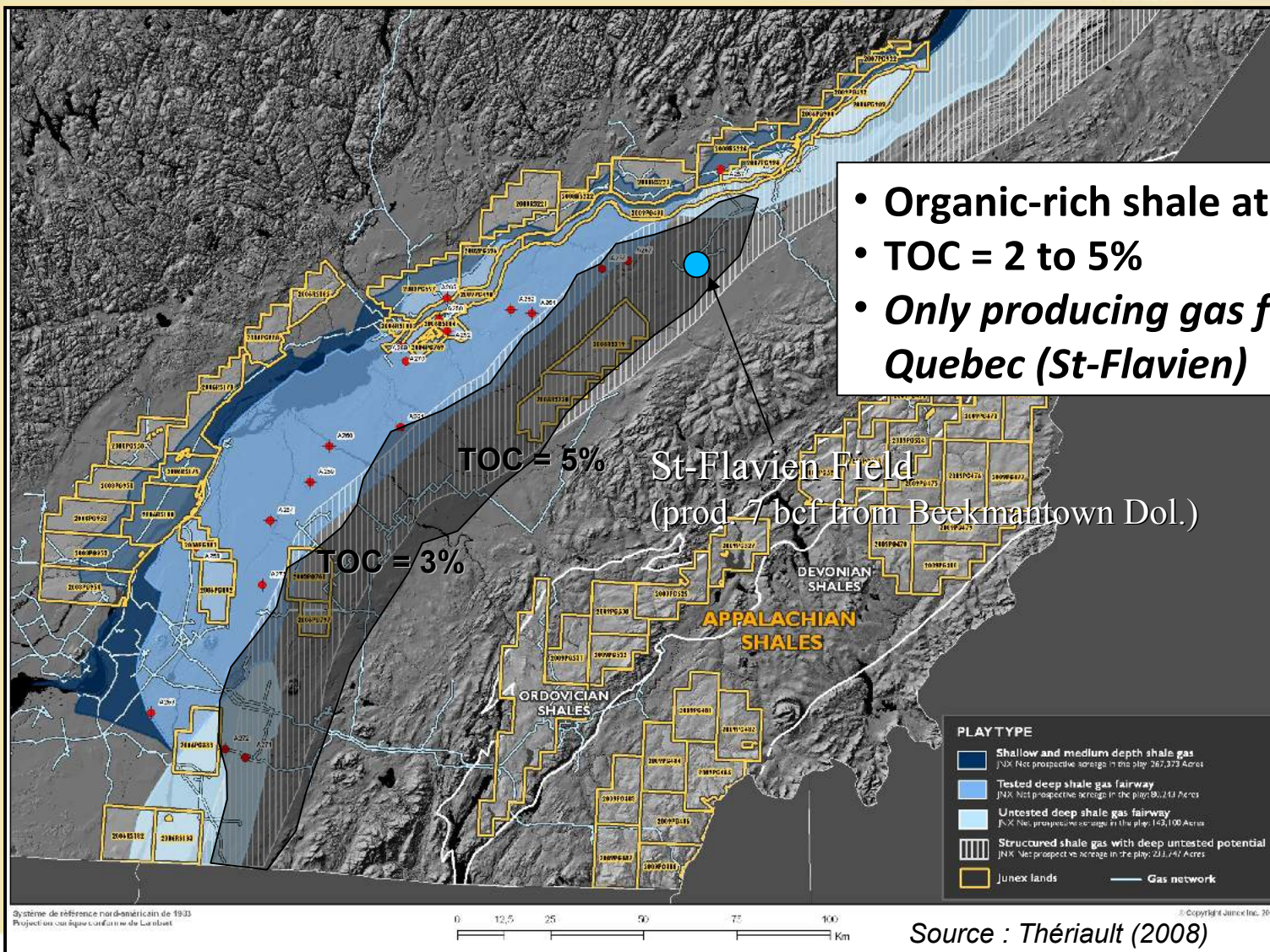
Devonian Ls

Huron Shale, Ohio



Source : Cluff (2009)

Overthrust Shale Gas

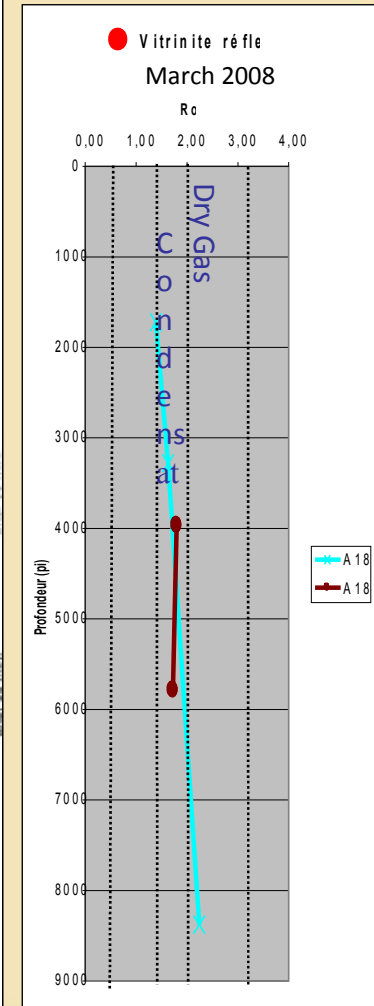
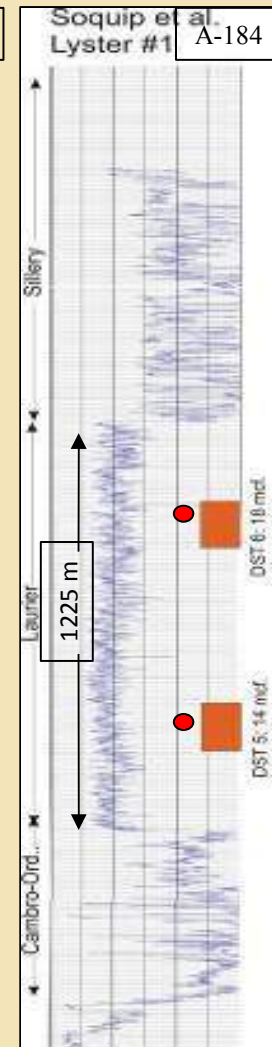
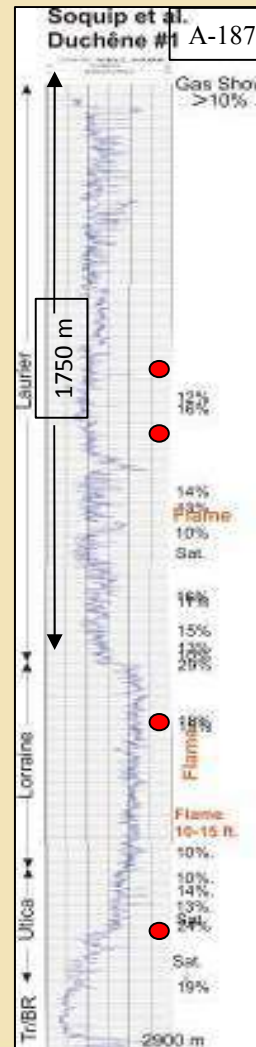


- Organic-rich shale at 2000m
- TOC = 2 to 5%
- *Only producing gas field in Quebec (St-Flavien)*

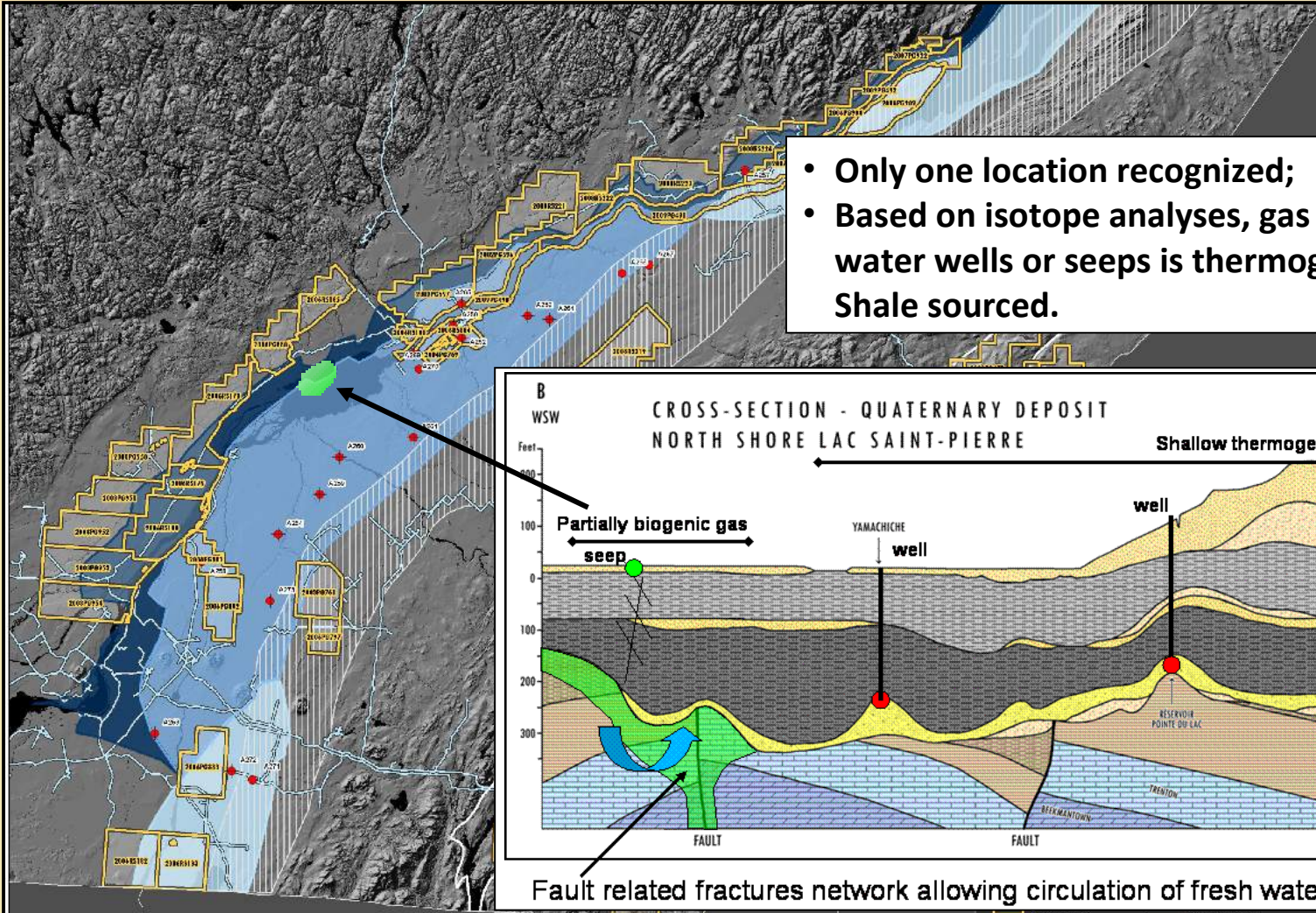
Overthrust Shale Gas

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

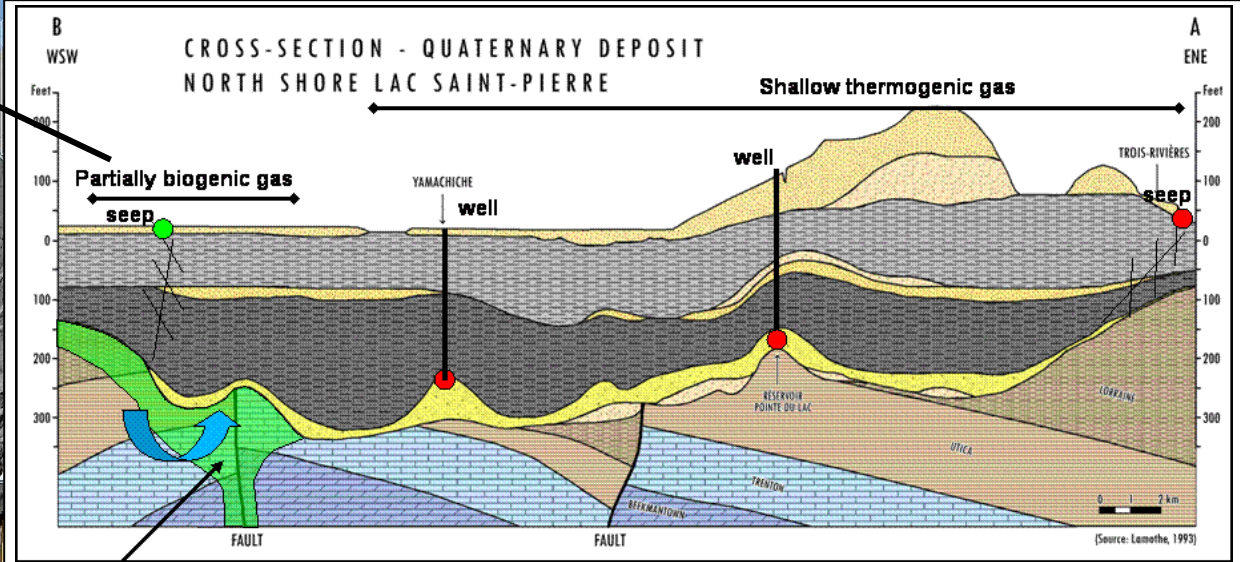
Recent seismic improved delineating the thrust



Biogenic Shale Gas



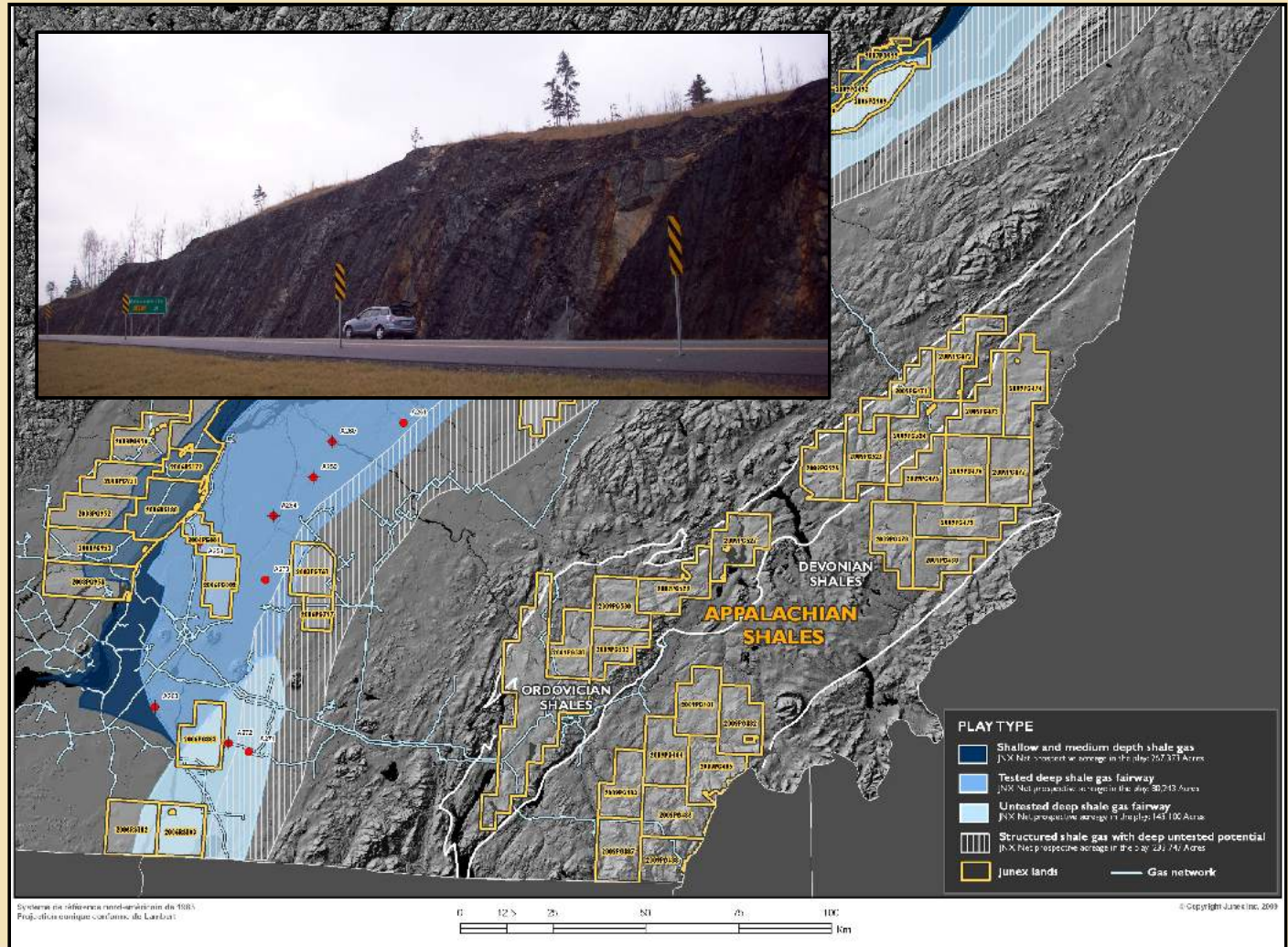
- Only one location recognized;
- Based on isotope analyses, gas found in other water wells or seeps is thermogenic Utica Shale sourced.



Fault related fractures network allowing circulation of fresh water

Intra-Appalachians sub-basin Shale gas

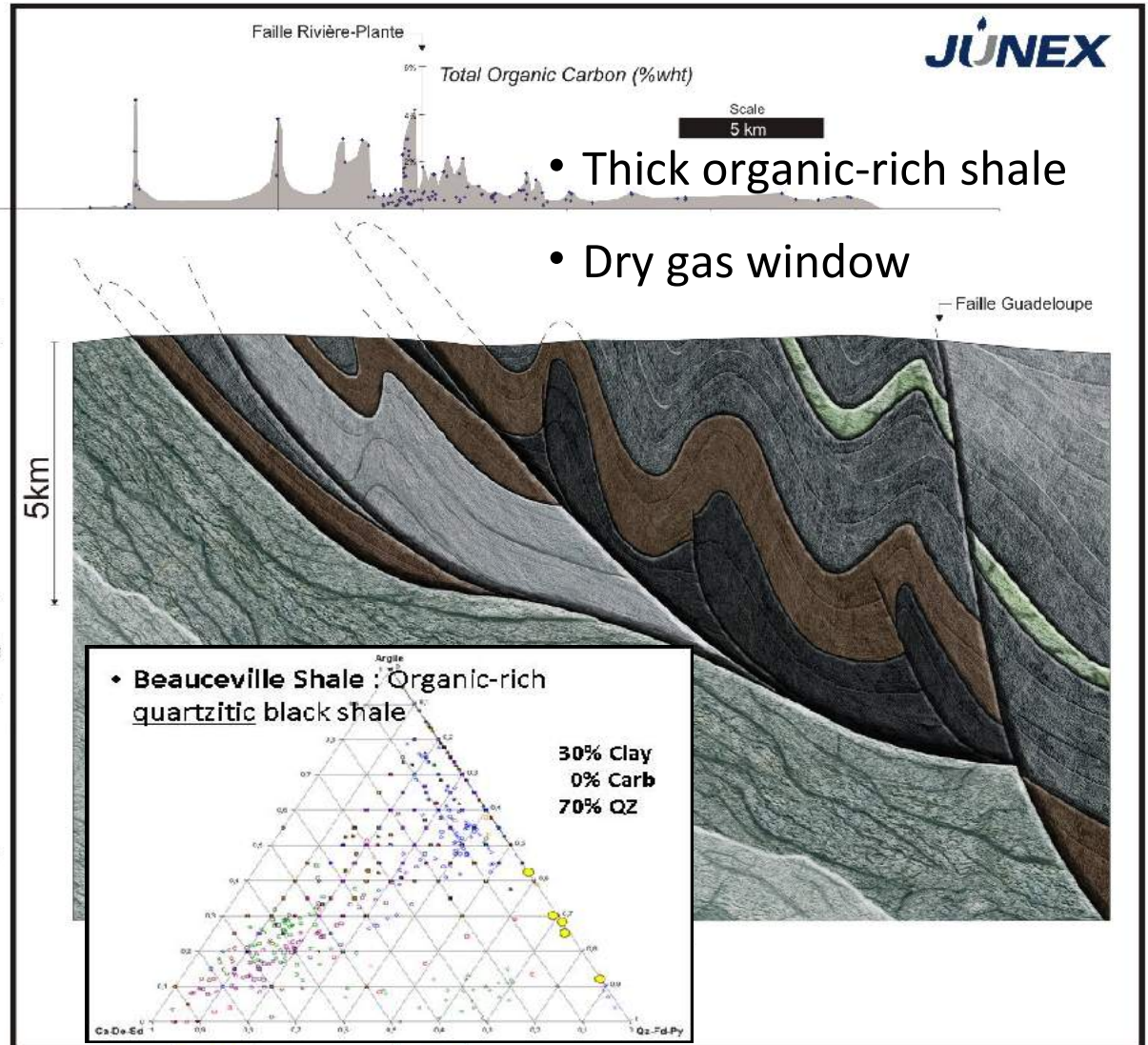
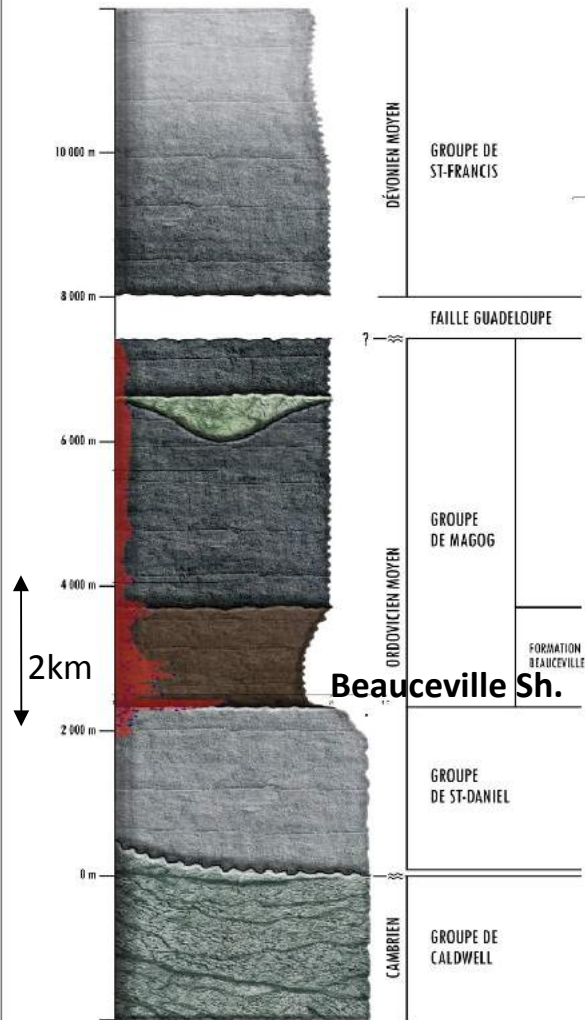
- Organic-rich shale
- Dry gas window
- Amorphous kerogen (Type II)
- Rapidly subsiding deep-marine sedimentation
- Good organic recovery
- Bitumen particles are noted (some liquid hydrocarbon generation occurred)
- Pre-vitrinite time



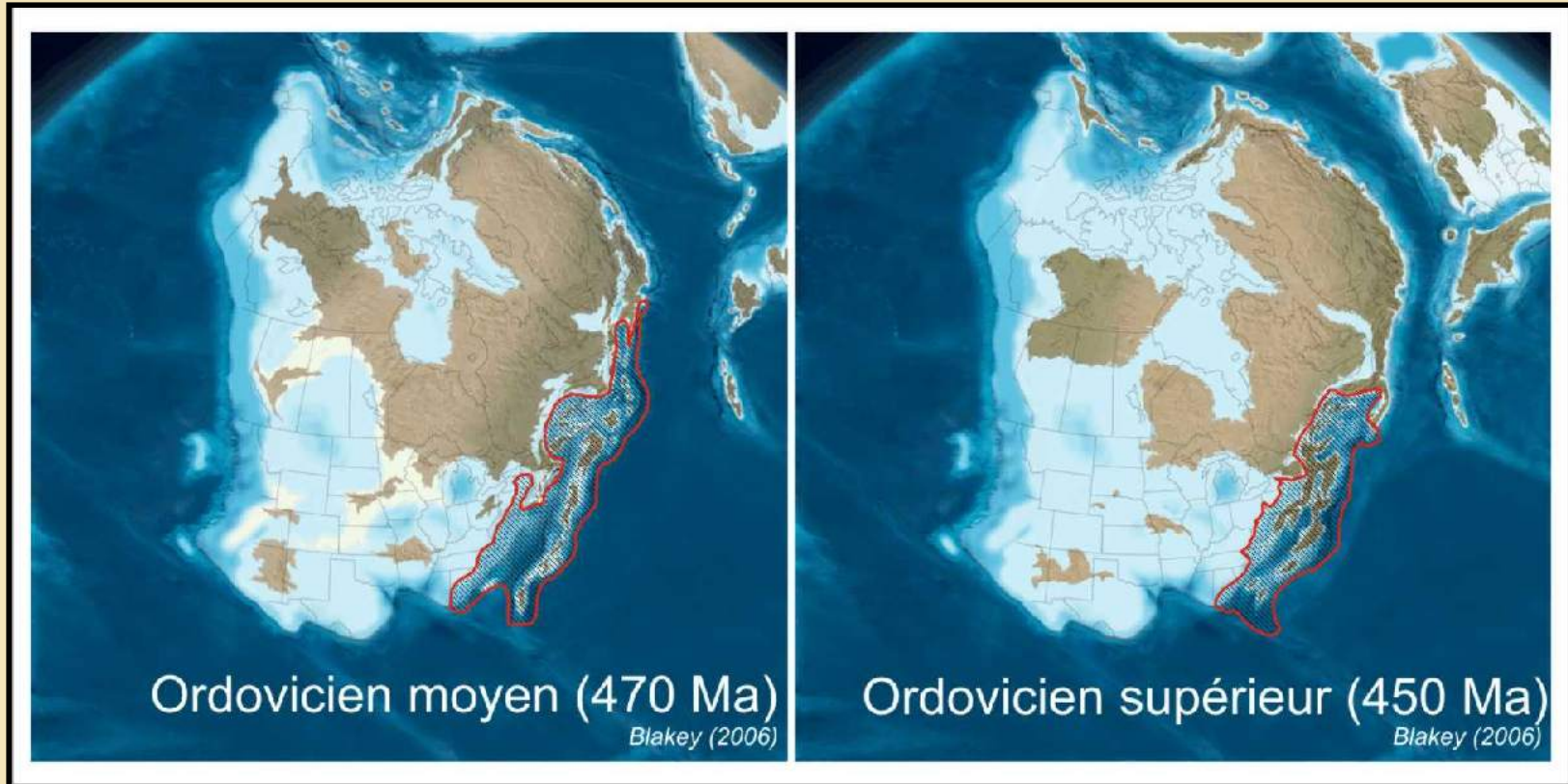
Intra-Appalachians sub-basin Shale gas

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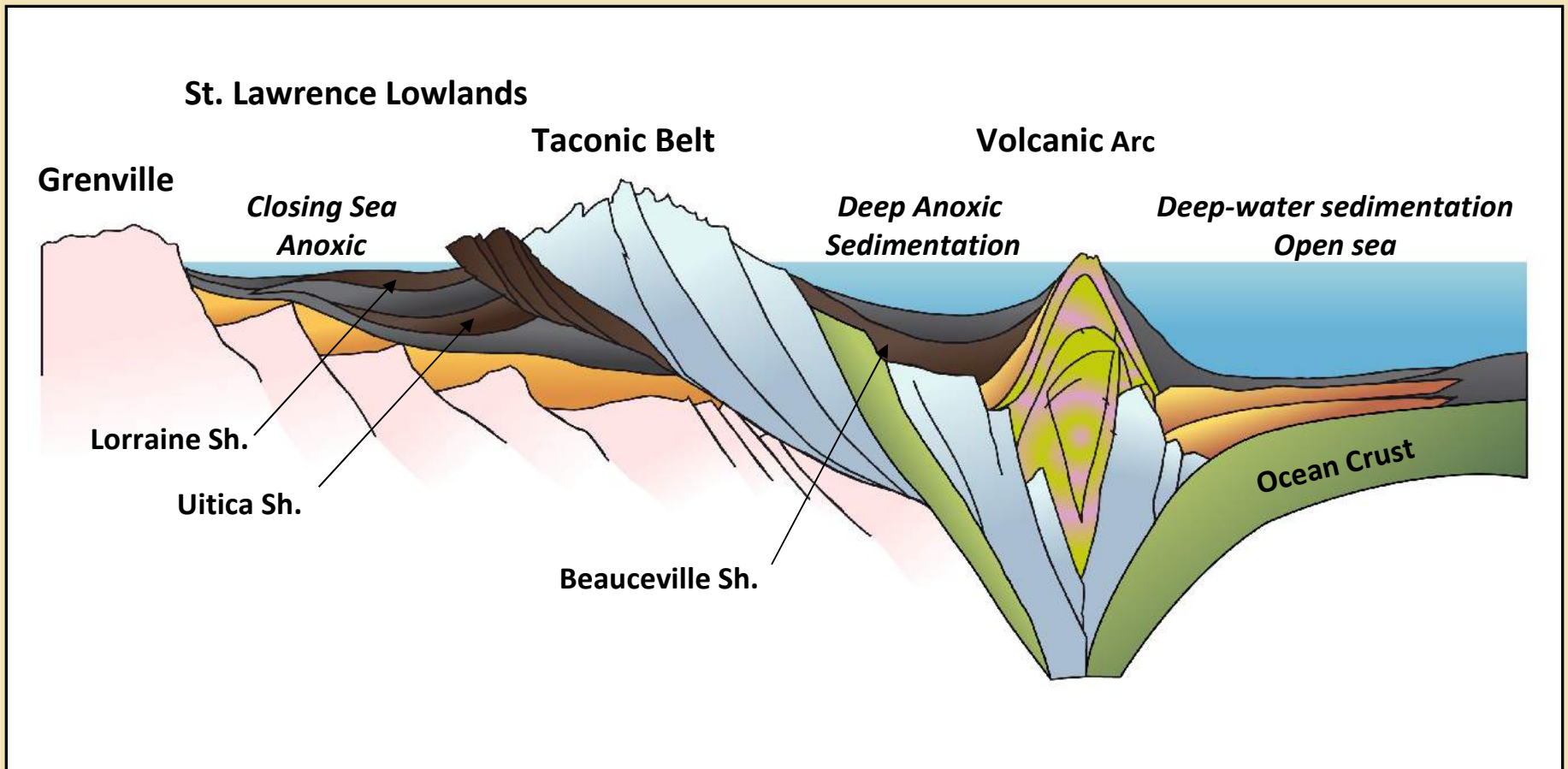


Quebec Ordovician Shale Depositional Environment Based on North America Paleogeography



Sedimentation Model

Eastern Canada – Middle to Late Ordovician time



Conclusions

1. The different Shale Gas areas in Province of Québec are promising plays:
 - Widespread source of gas – Utica;
 - Proven fracturability;
2. Presenting good potential but remains an emerging play:
 - OGIP from 50 to 300 Bcf/section;
 - Test rate from 100 mcf/d to 1000 mcf/d;
 - Pilot projects are the next step;
3. Coming year will be an important milestone;
4. JUNEX is present in the heart of the action and develops new areas:
 - Saint-Augustin Well : frac planned;
 - Appalachian Shales : seismic and Strat-Well
 - Other area of the Lowlands : data analysis underway to identify new drill targets;
 - Proactive about new technologies available;
5. Future results and companies' collaboration will have a positive impact on the learning curve and make the Québec Shale Gas Plays producing.



Foragaz Rig #2 drilling in Bécancour Area, Québec (September 2008)