Regional Geochemical Evaluation of the Ordovician Utica Shale Gas Play in Québec

Robert Thériault

Québec Ministry of Natural Resources and Wildlife

Ressources naturelles et Faune Québec

Outline of presentation

- **Geology of the Utica and Lorraine shales**
  - Regional setting
  - Shale gas fairways
  - Lithological characteristics
  - Isopach maps
- **Mineralogy of the Utica and Lorraine shales**
  - XRD data - Binary diagrams
  - XRD data - Well profiles
- **Geochemistry of the Utica and Lorraine shales**
  - Rock eval data
  - Isocontour maps (TOC, HI, TR, Index)
- **Conclusions**

Acknowledgements

Participating companies :

- Talisman Energy
- Forest Oil
- Junex
- Gastem
- Encana

Prov / Fed governments :

- GSC-Calgary
- GSC-Quebec (D. Lavoie)
- INRS (R. Bertrand)
- MRNF (S. Beauséjour; drafting)

→ **OVER 600 ROCK EVAL ANALYSES**

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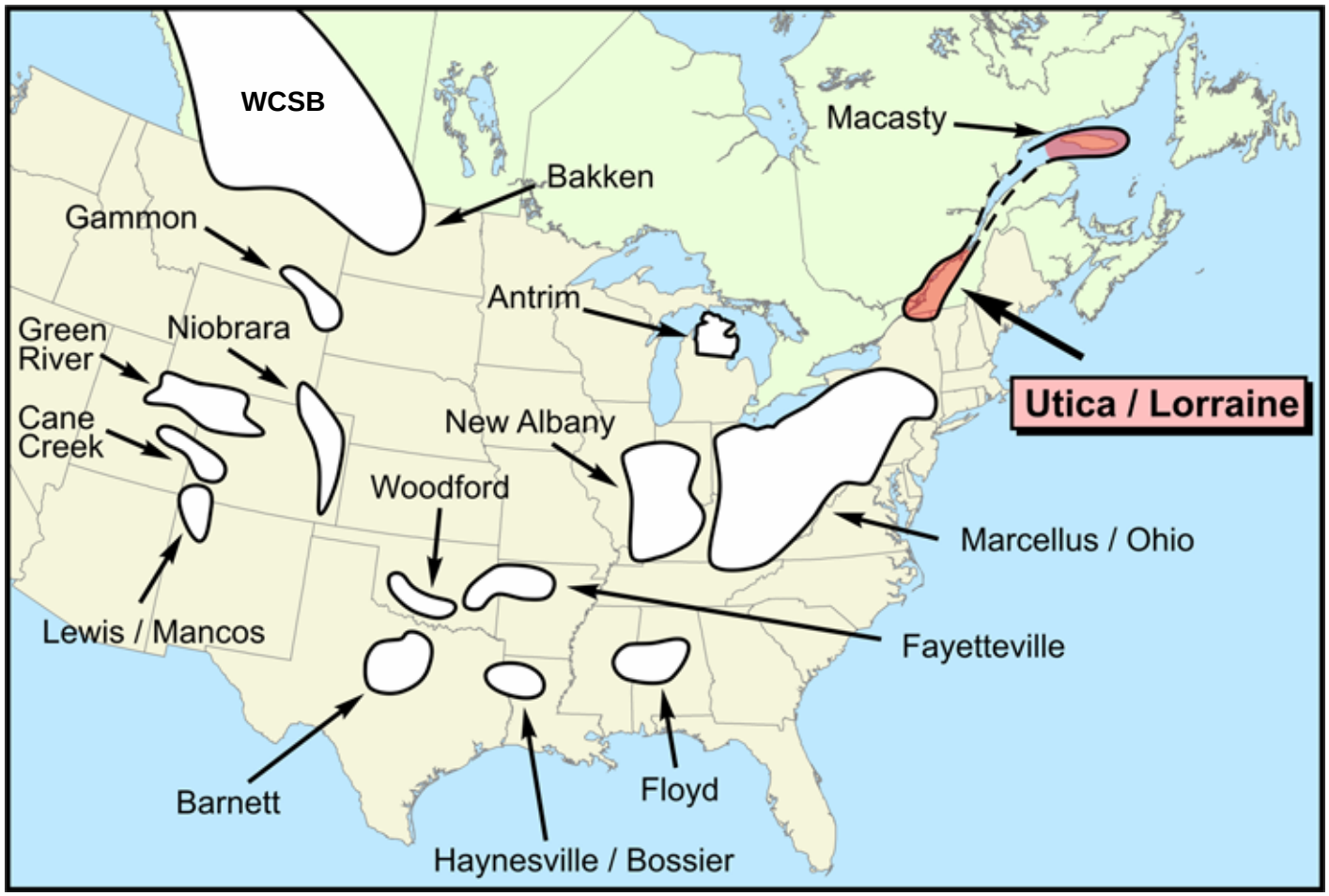
Shale plays in North America



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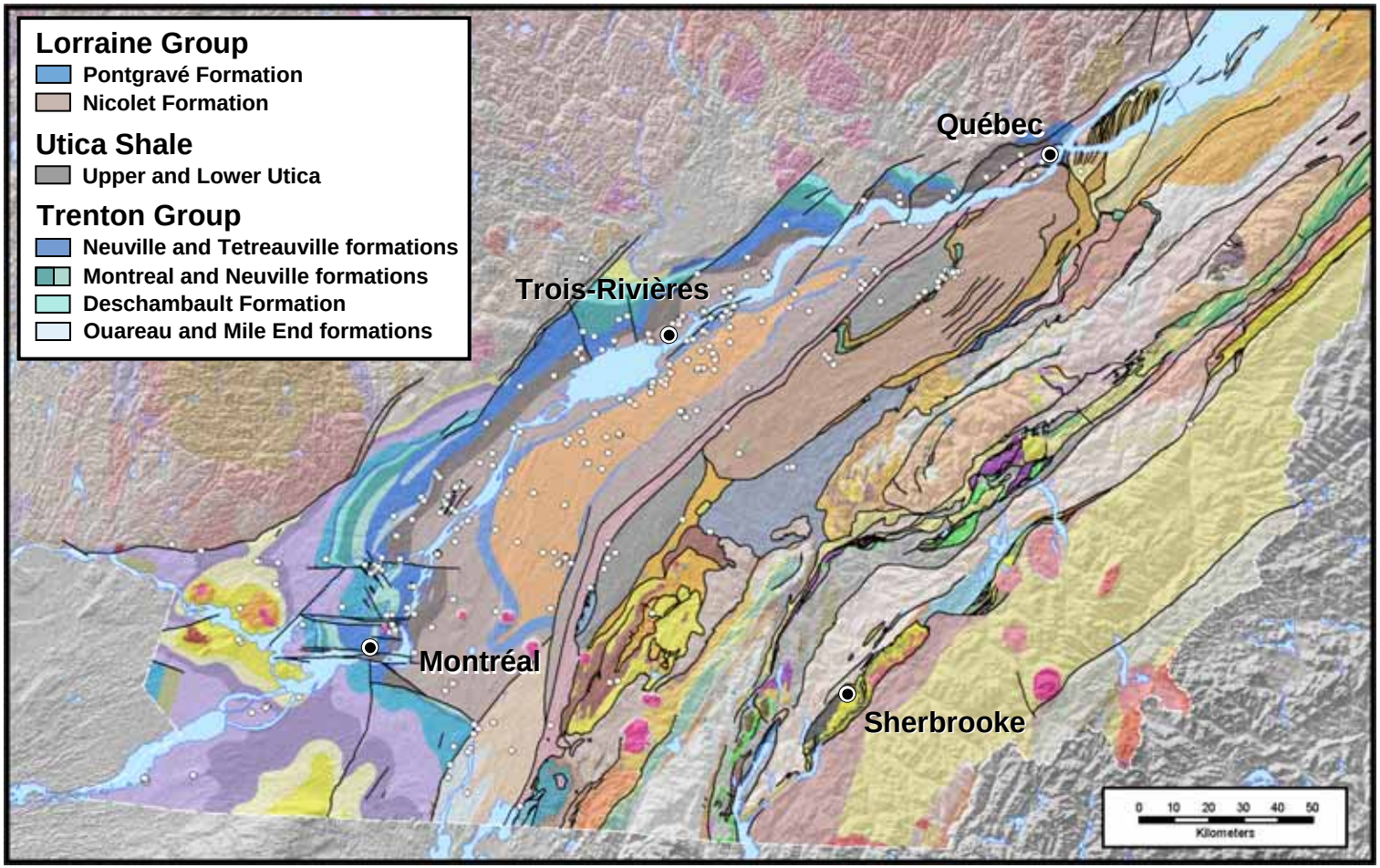
Geology of the St. Lawrence Lowlands



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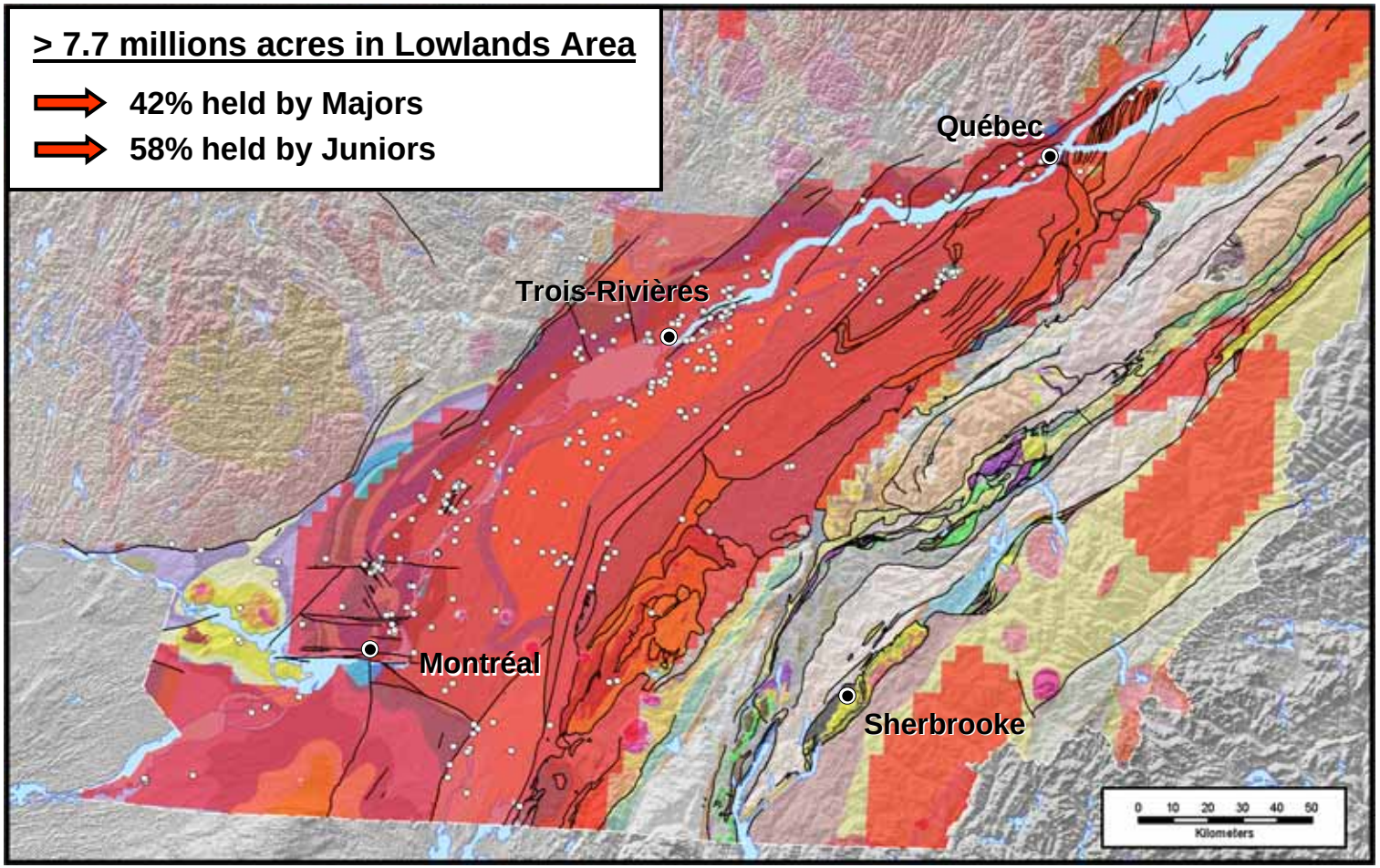
Exploration licences - Lowlands



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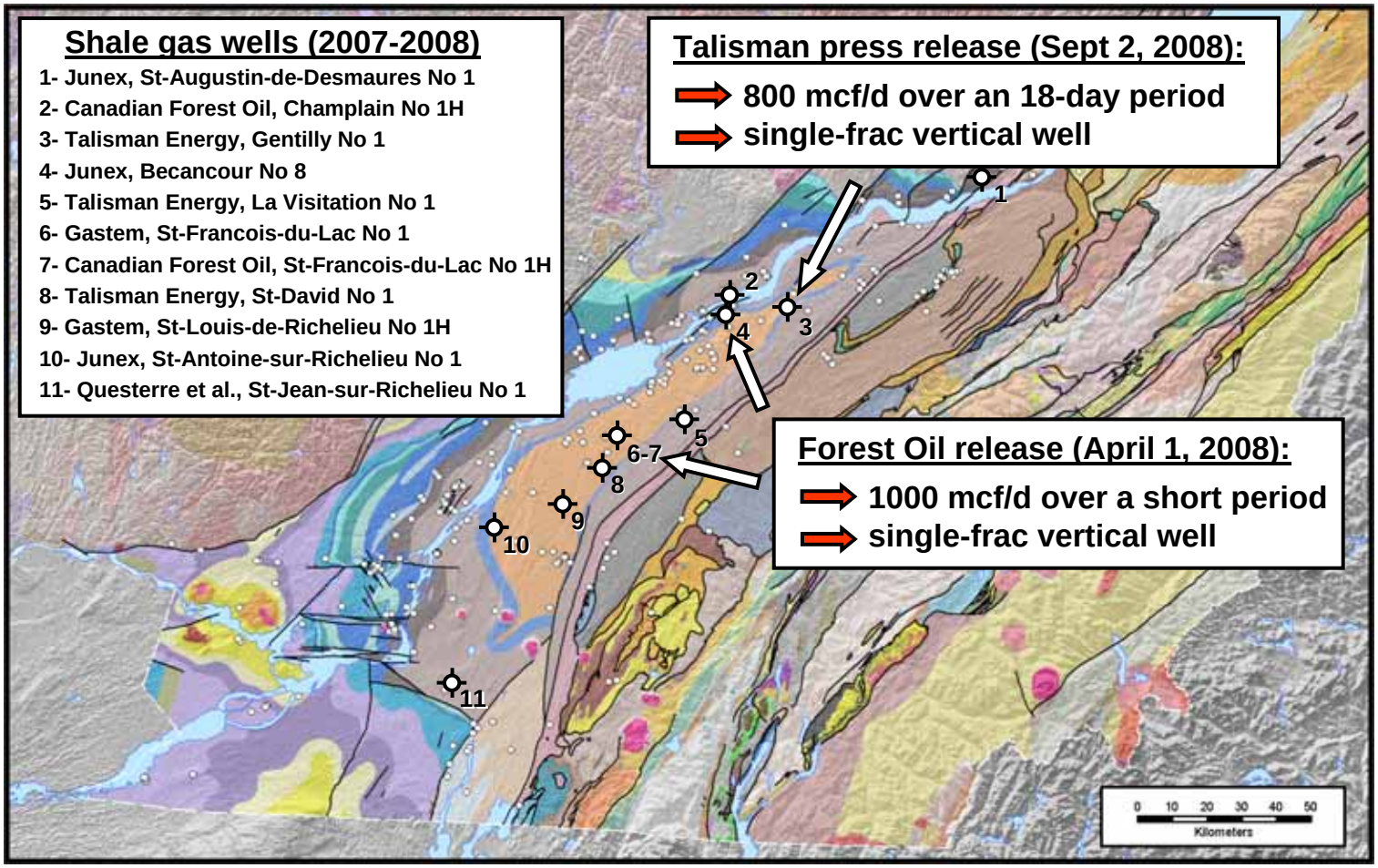
Shale gas wells - Lowlands



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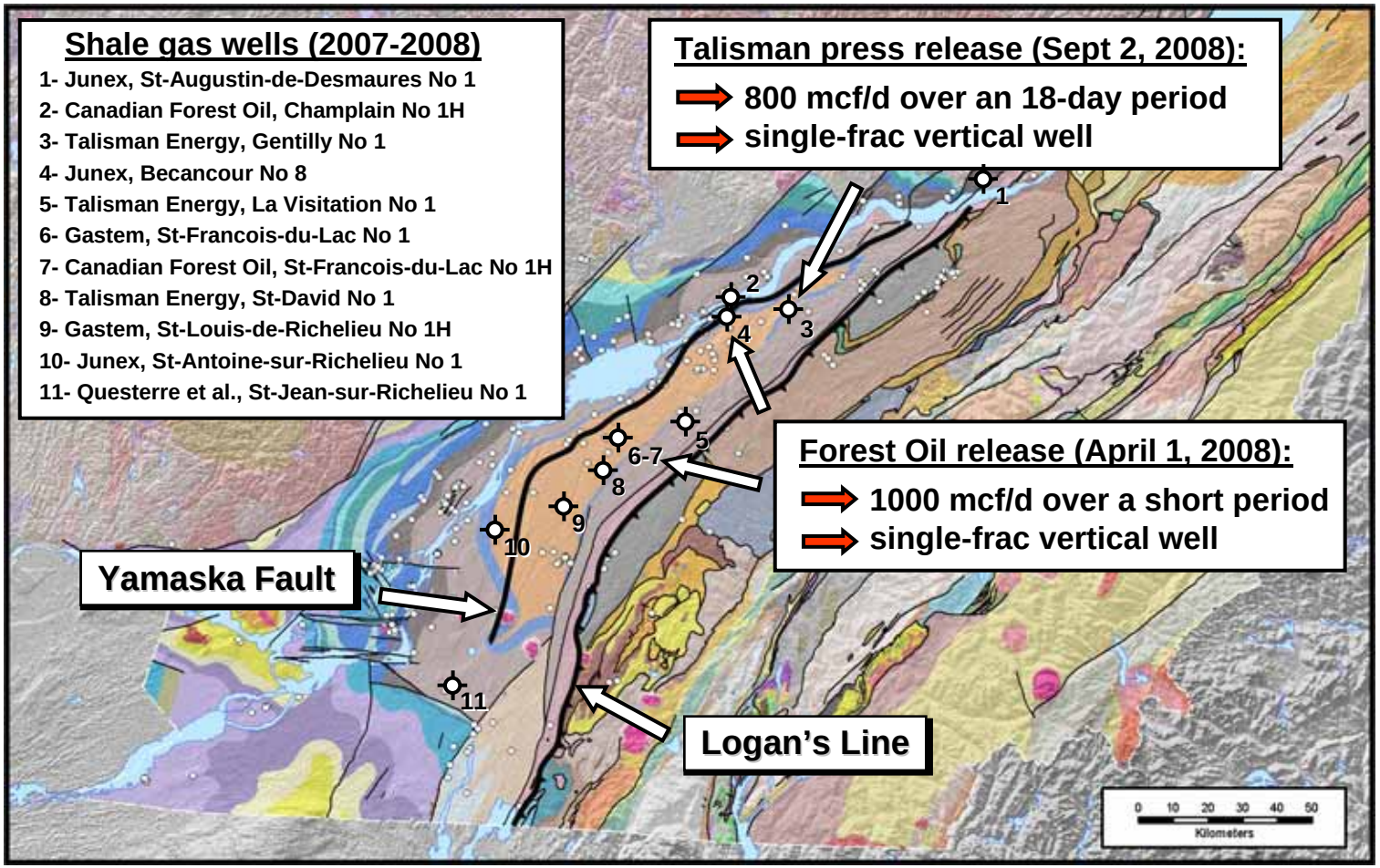
Shale gas wells - Lowlands



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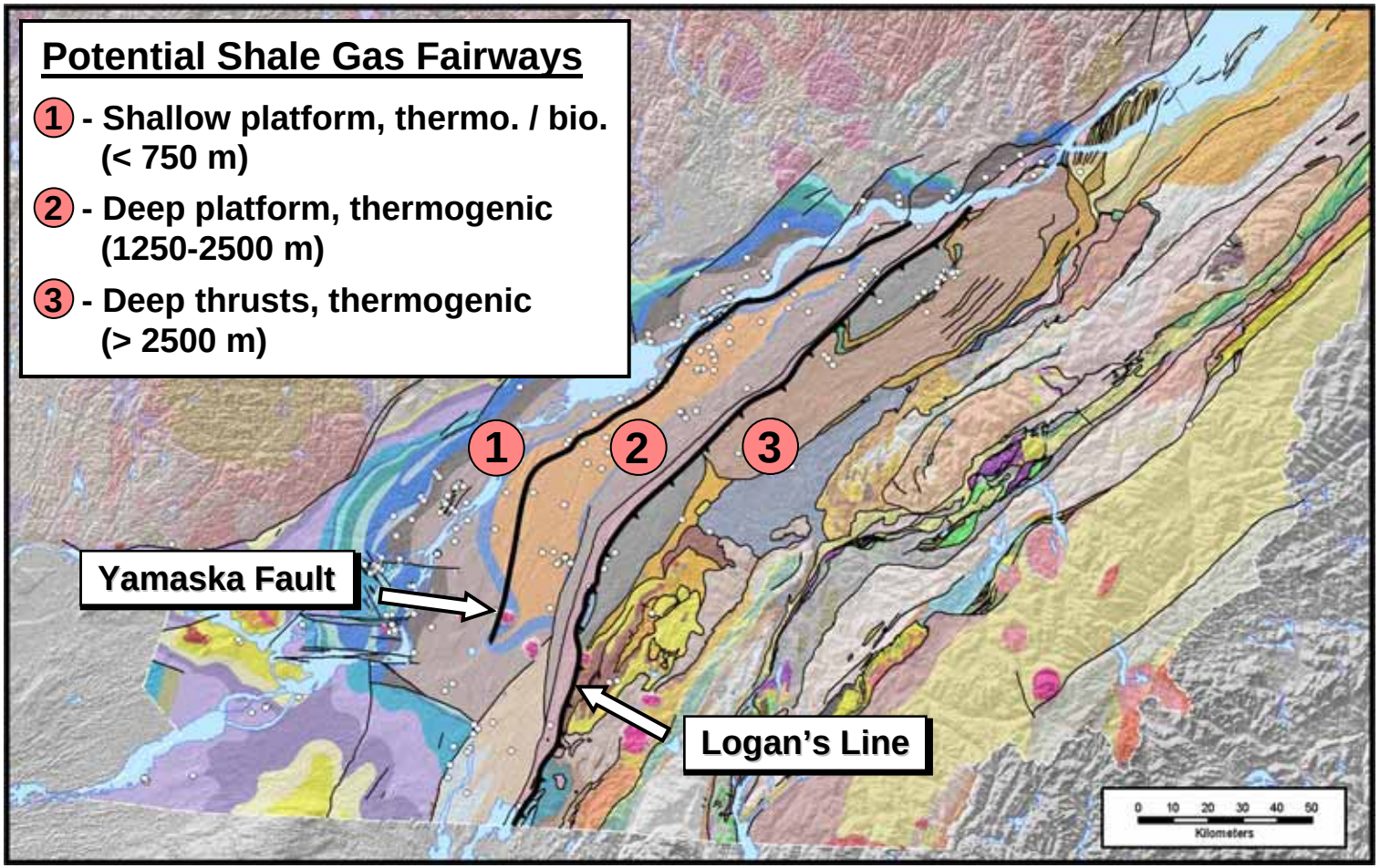
Potential shale gas fairways - Lowlands



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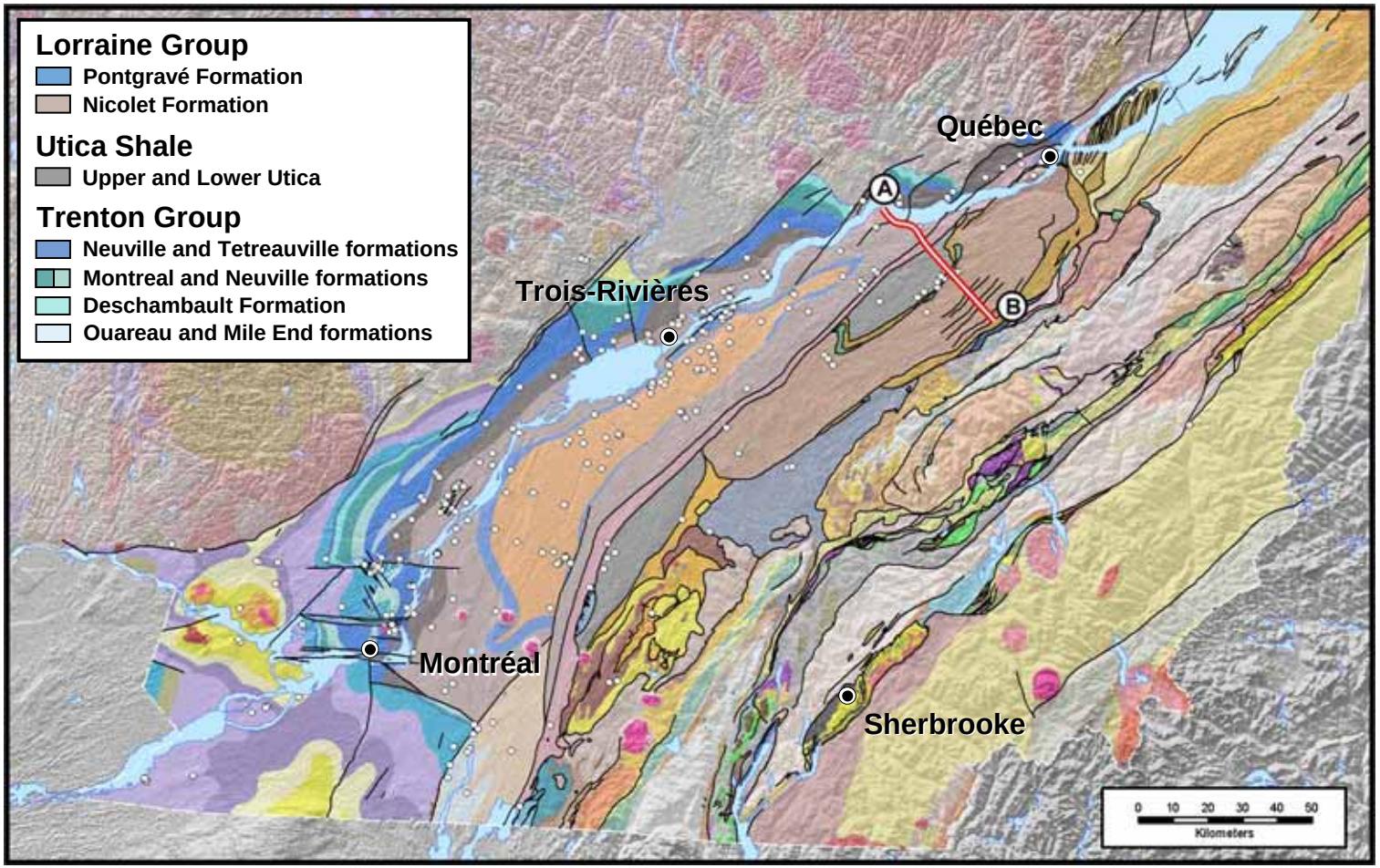
Seismic line M-2001



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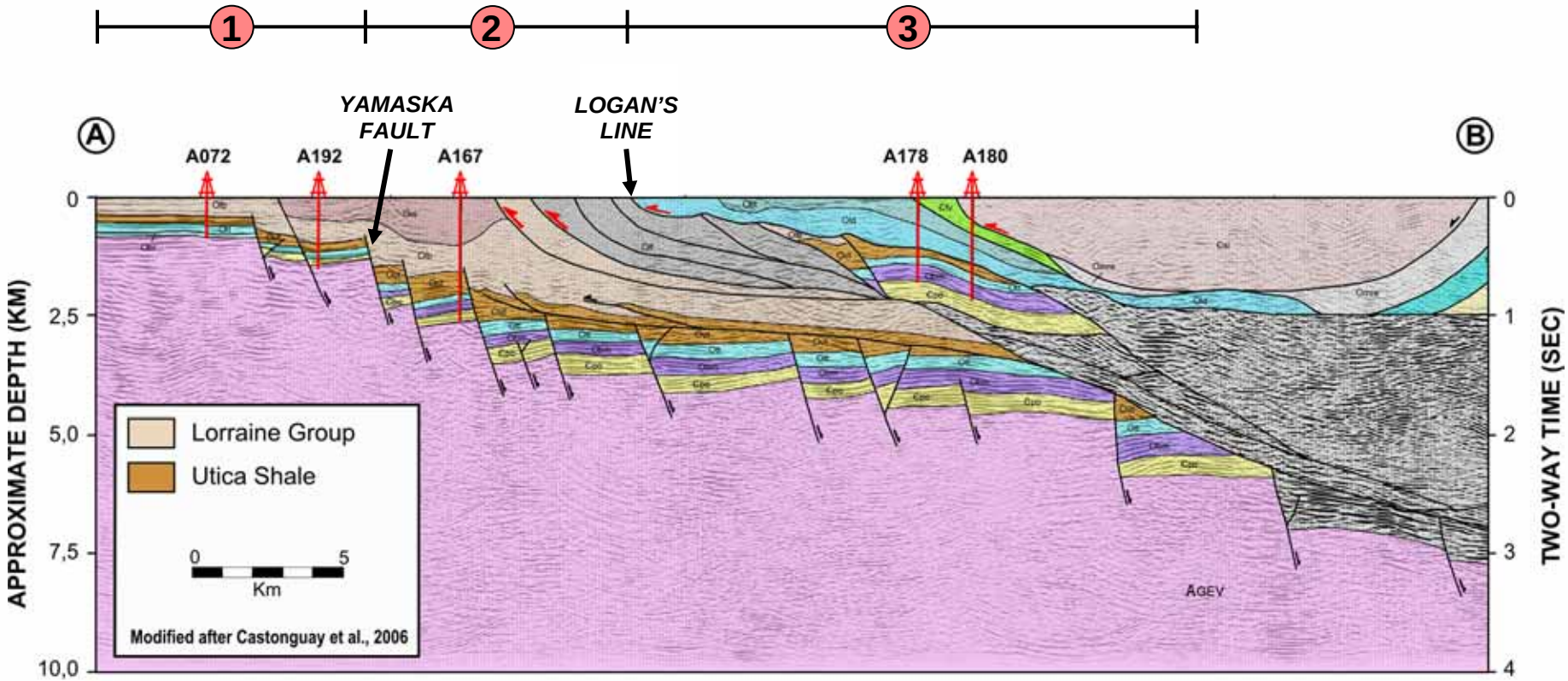
Seismic profile M-2001



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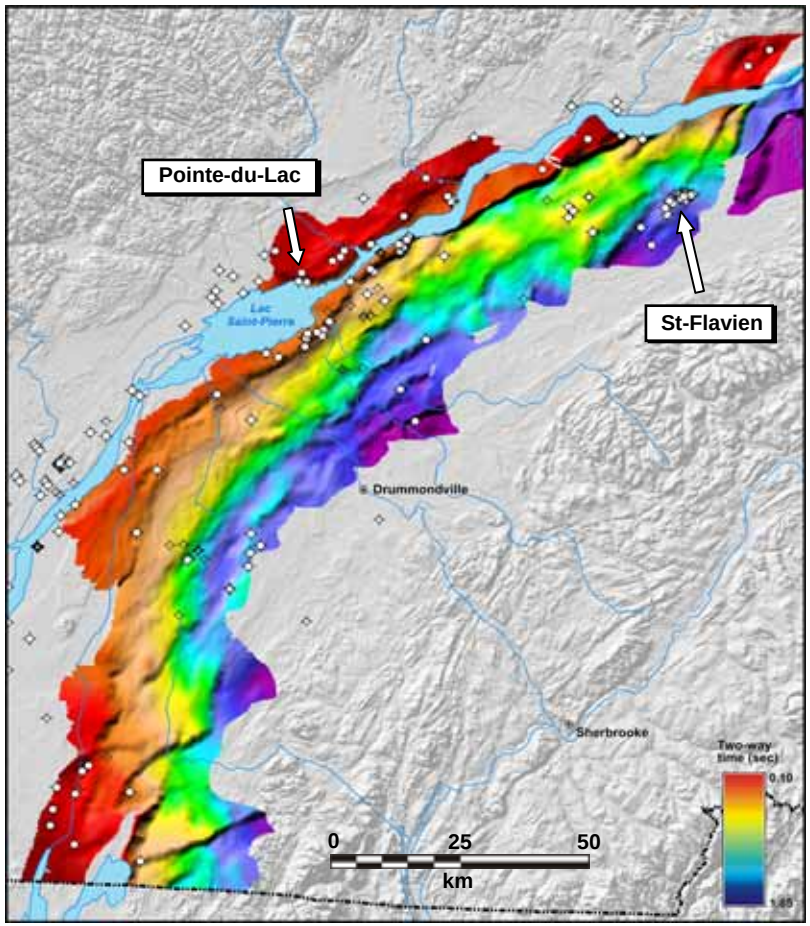
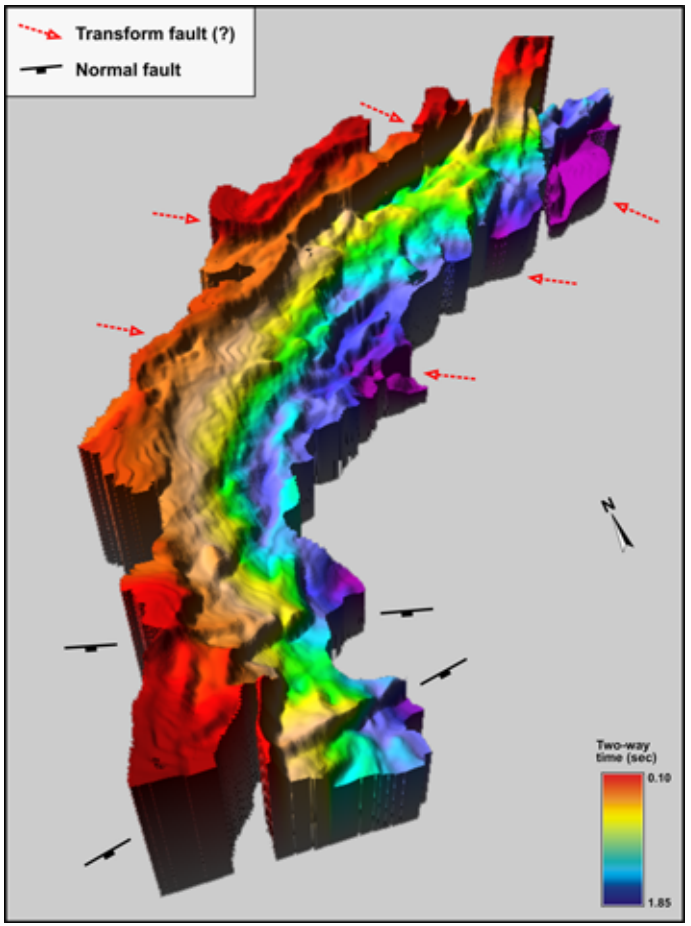
Time-structure map - Top of Trenton





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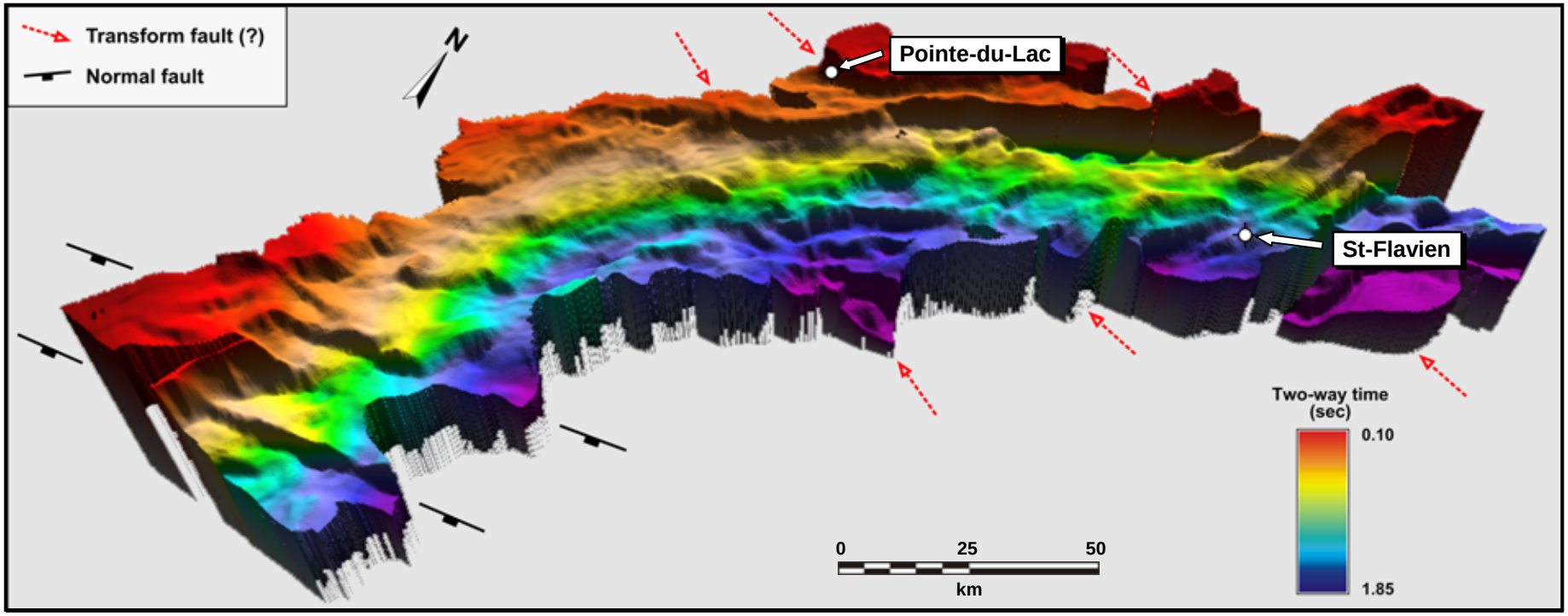
Time-structure map - Top of Trenton

View towards the NW



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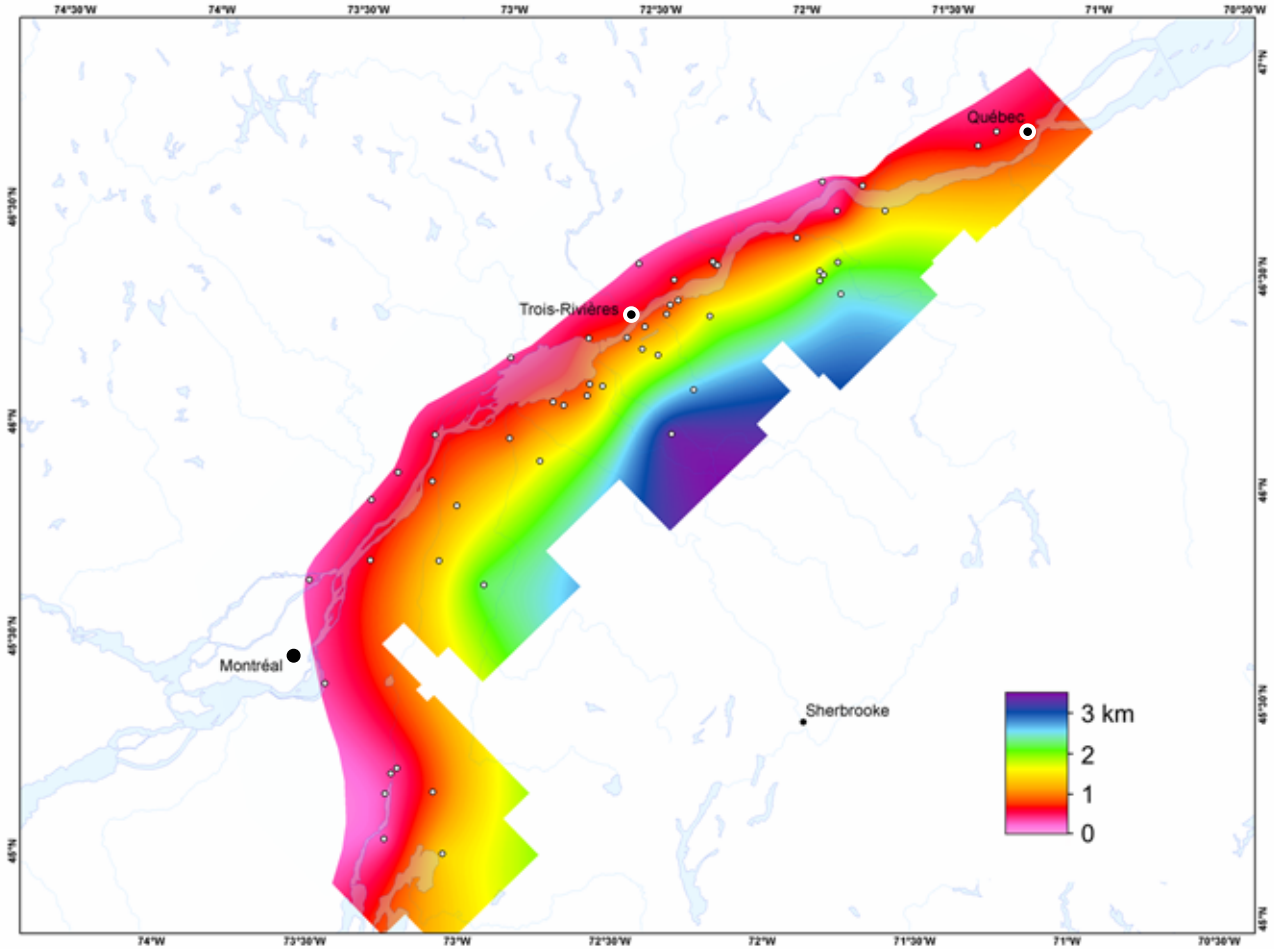
Depth contour map – Top of Utica Shale



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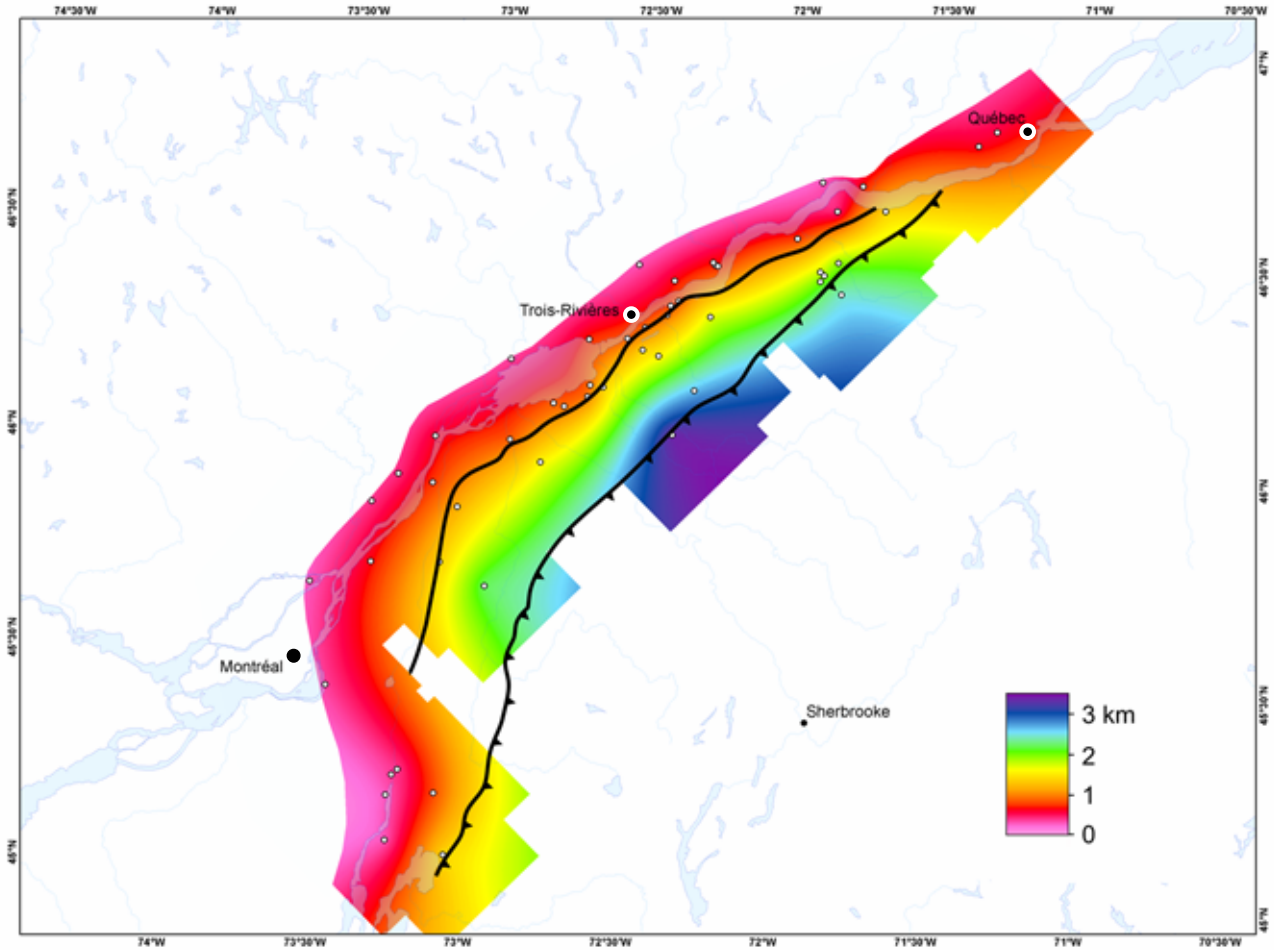

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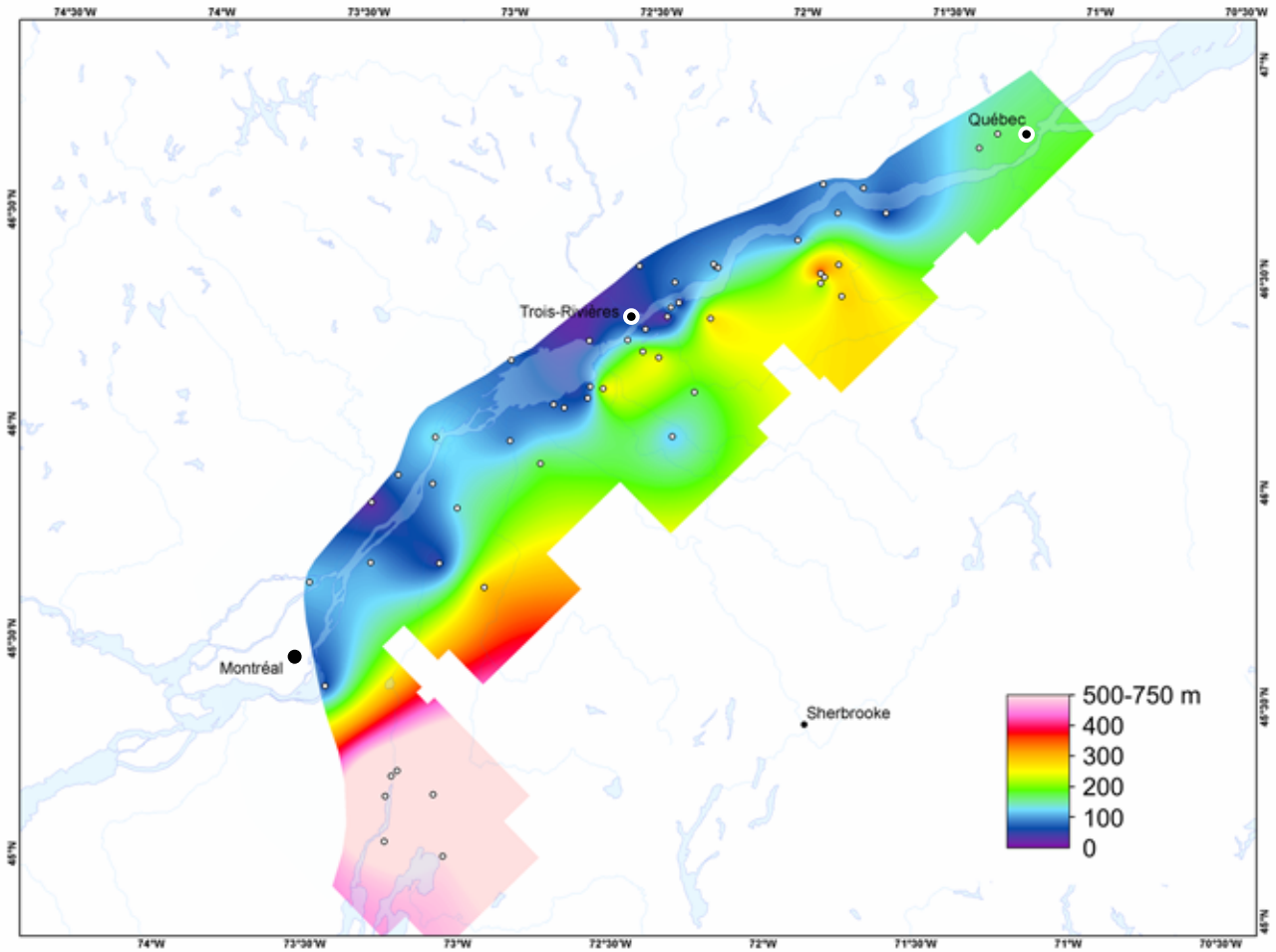
Isopach map – Utica Shale



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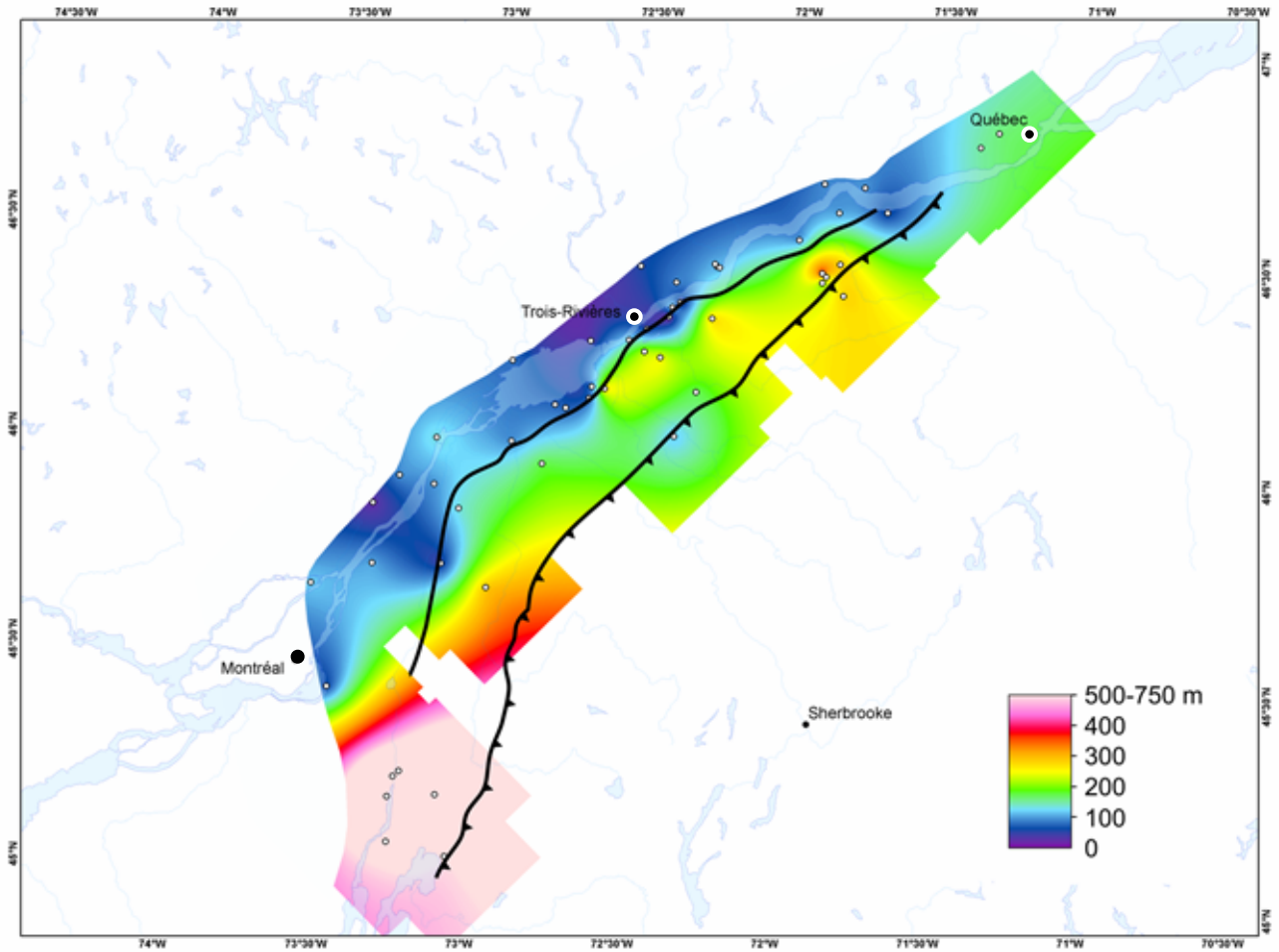

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Geology – Trenton / Utica contact

Jacques-Cartier River, Pont-Rouge

- Top of Trenton = 50 cm limestone bed
- Base of Utica = calcareous shale with limestone interbeds
- Gradual contact in the northern part of Québec Lowlands

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Geology – Lower Utica

Cap-Santé

- Calcareous shale
- Medium to dark grey
- Very common limestone interbeds

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Geology – Upper Utica

Jacques-Cartier River, Donnaconna

- Calcareous shale
- Medium to dark grey
- Few limestone and siltstone interbeds

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Geology – Lorraine Group

Montmorency Falls

- Non-calcareous, siliceous and argillaceous shale
- Medium to dark grey, with a brownish tinge
- Siltstone and sandstone interbeds

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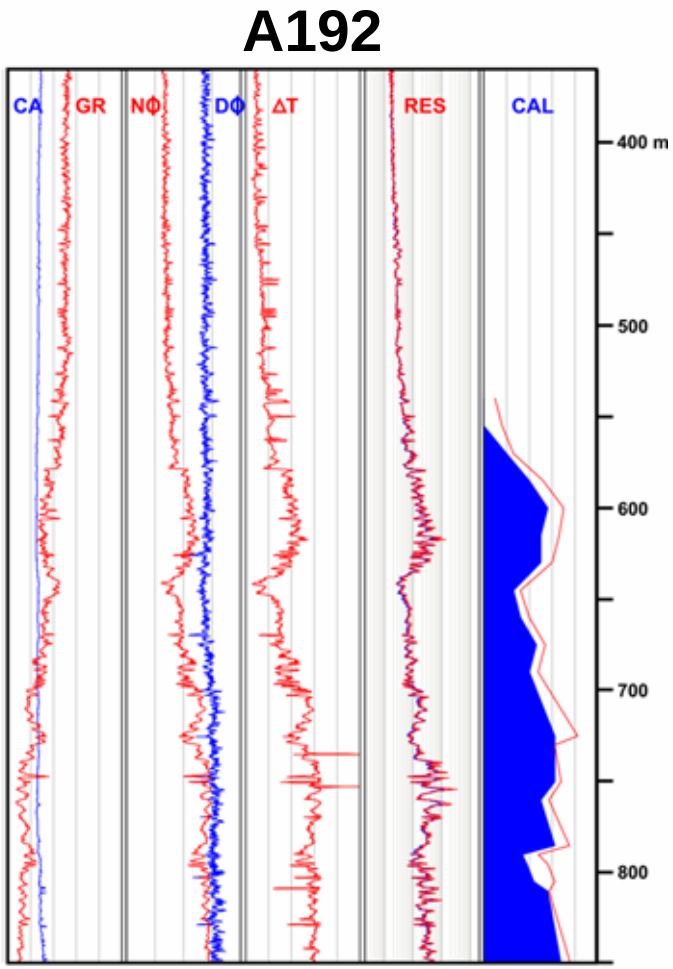
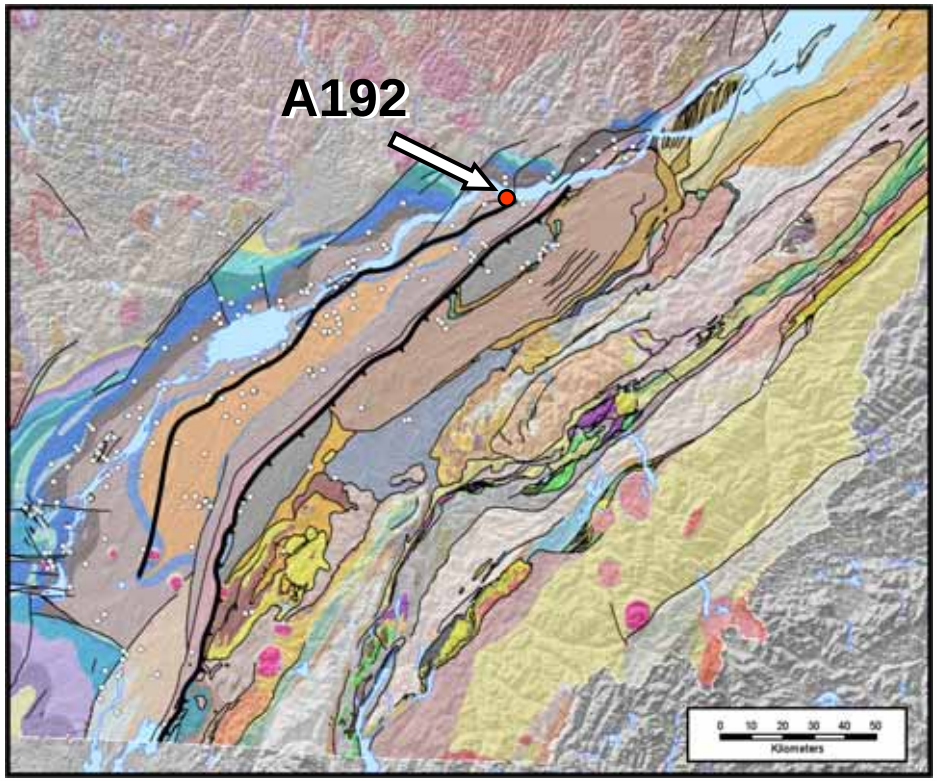
Well log data - SOQUIP, St-Croix No 1 Lotbiniere





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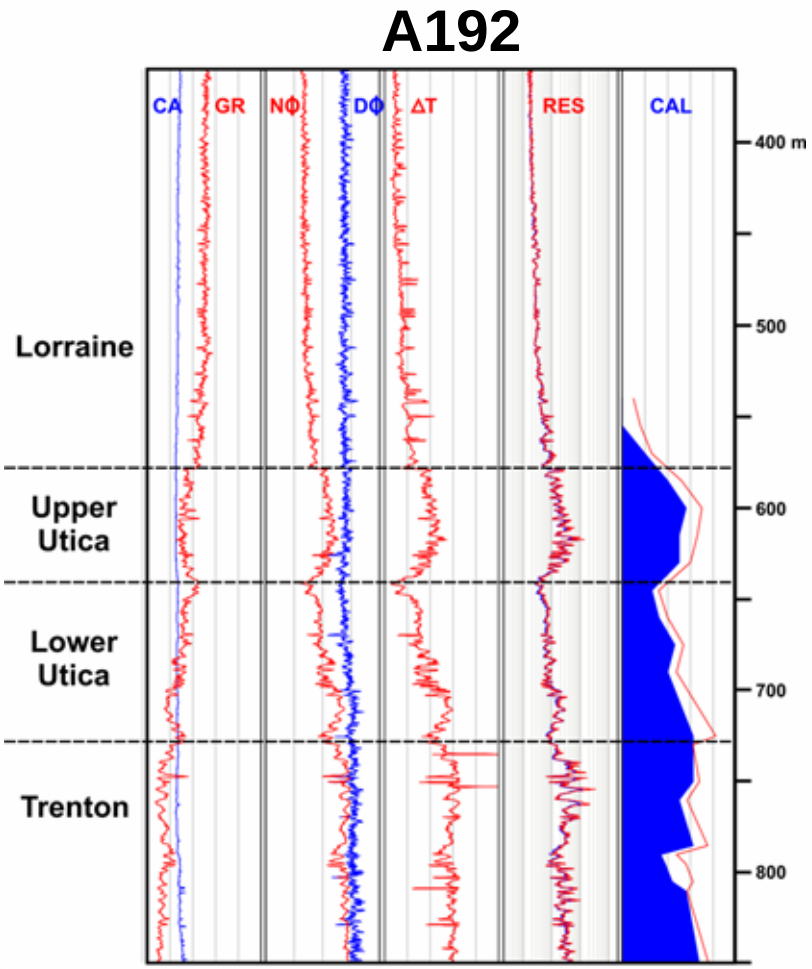

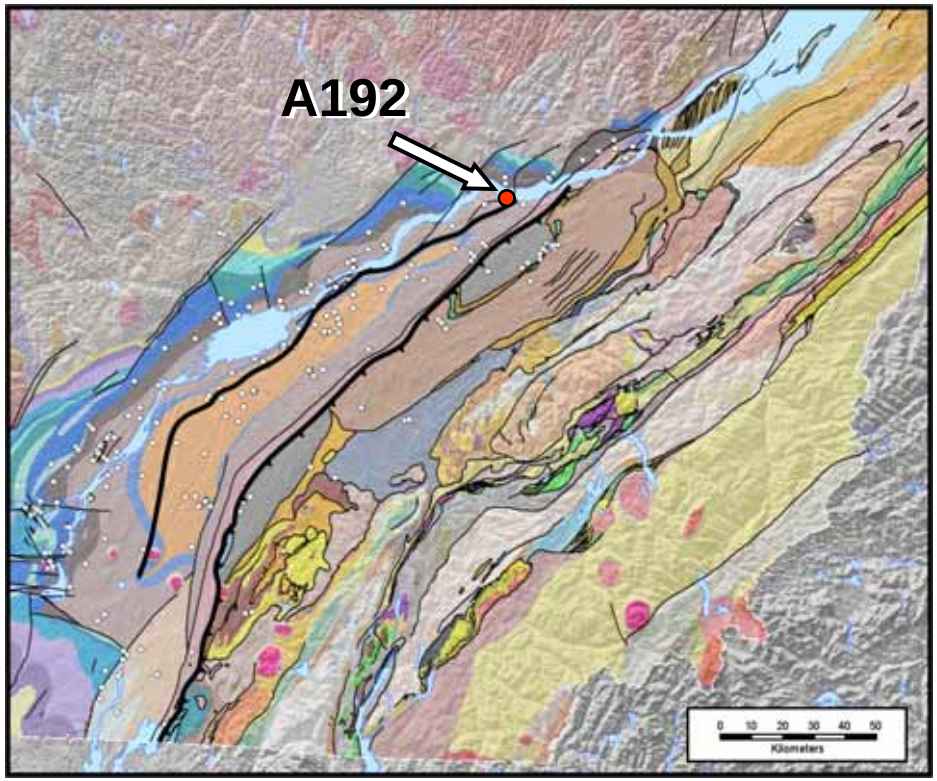

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Well log data - SOQUIP Laduboro, Nicolet No 1

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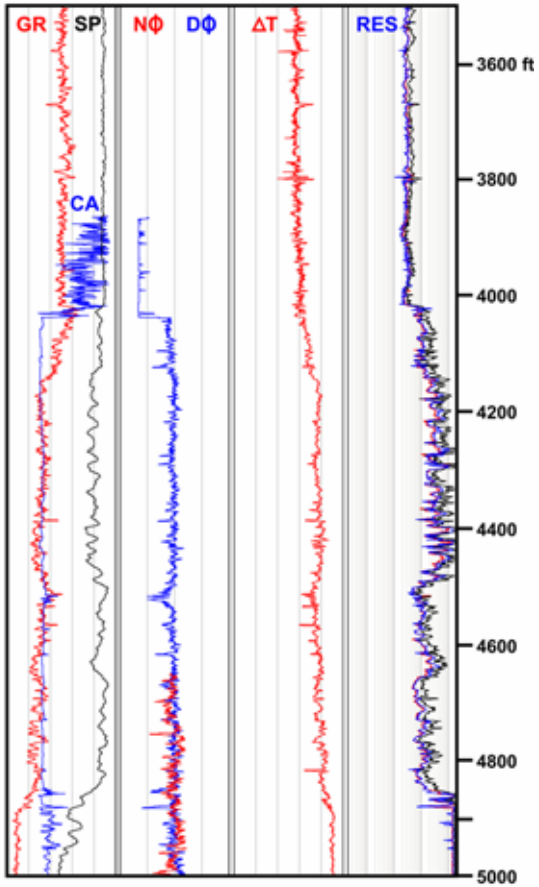

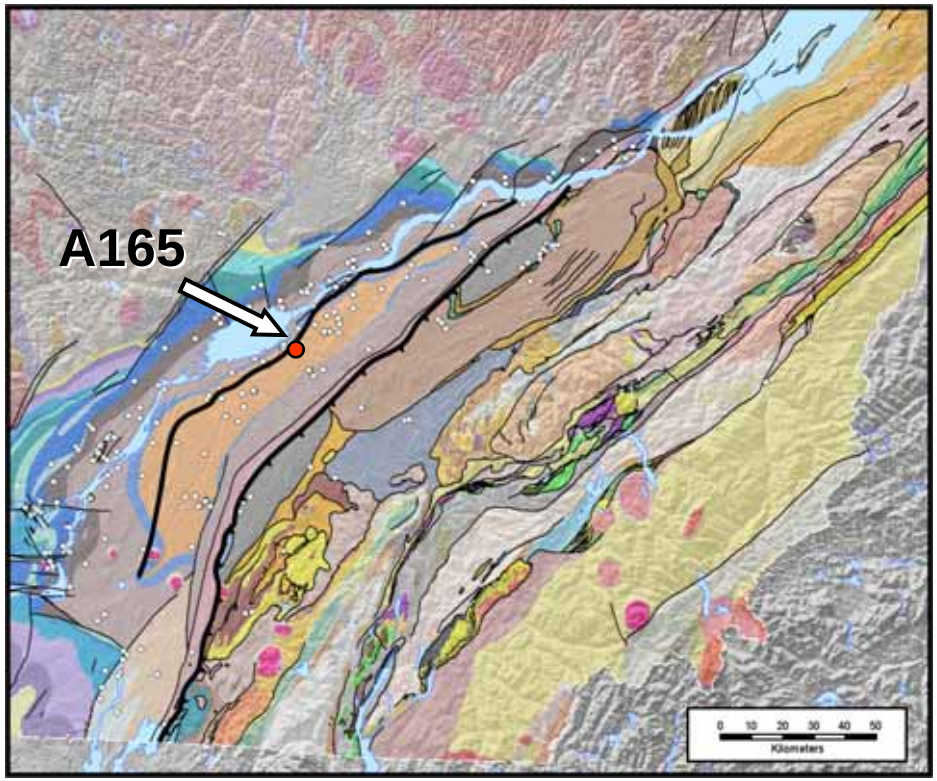

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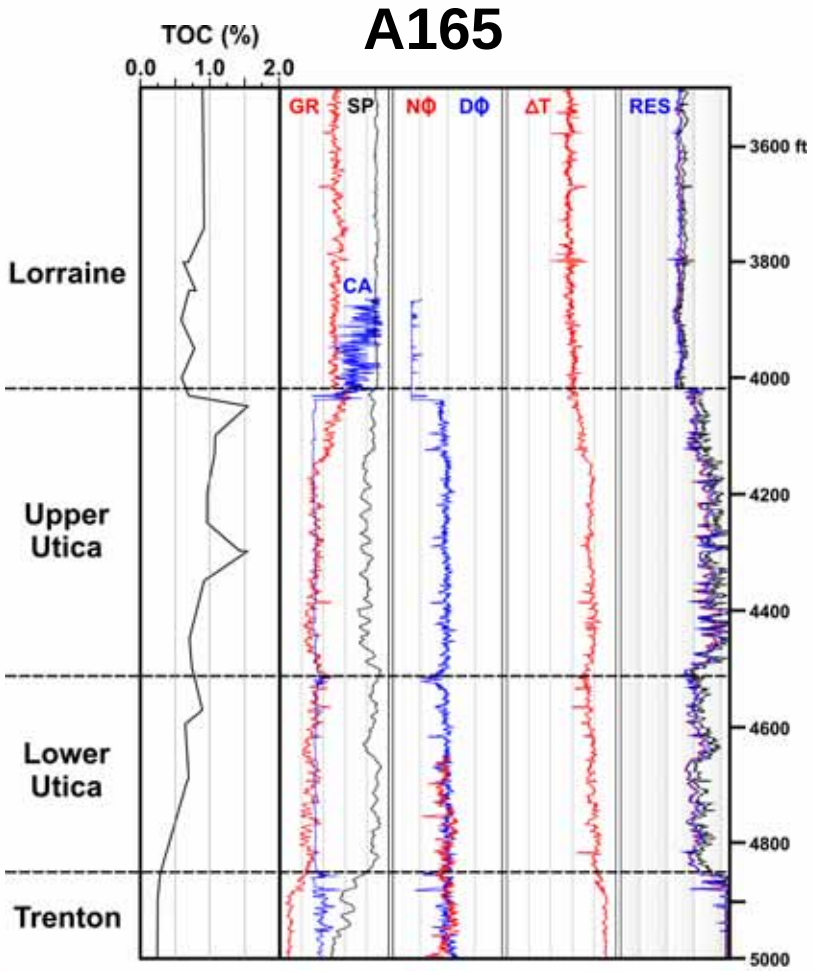

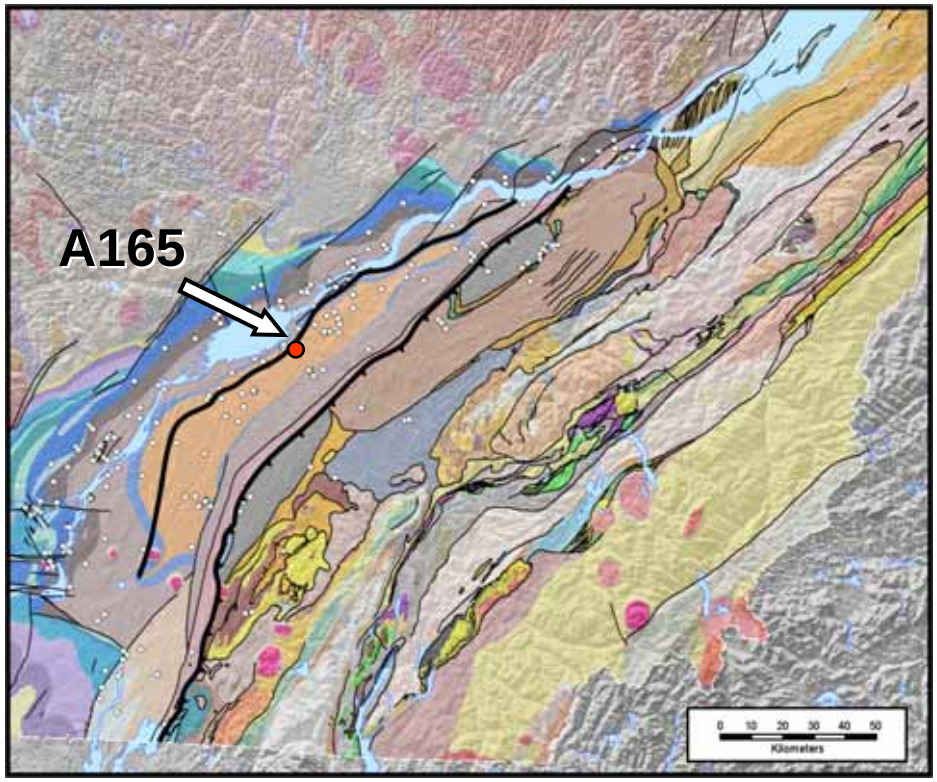

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Well log data - SOQUIP St-Thomas-d'Aquin No 1

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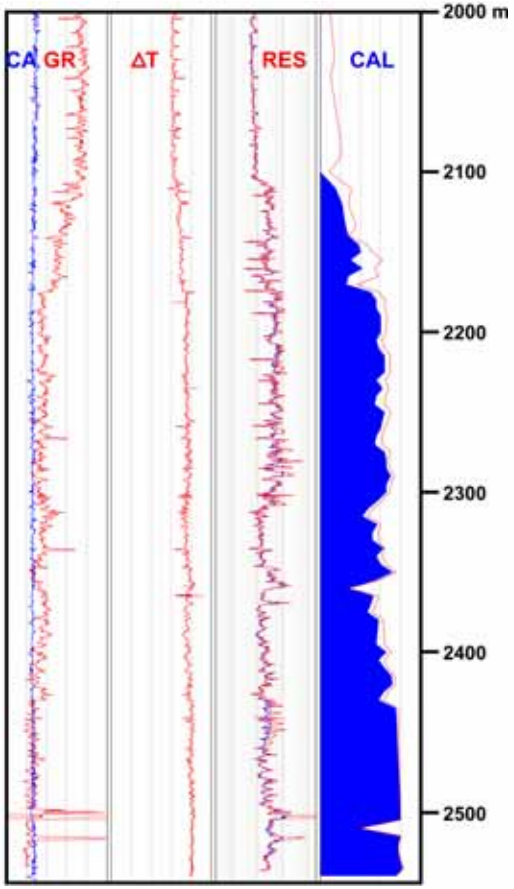

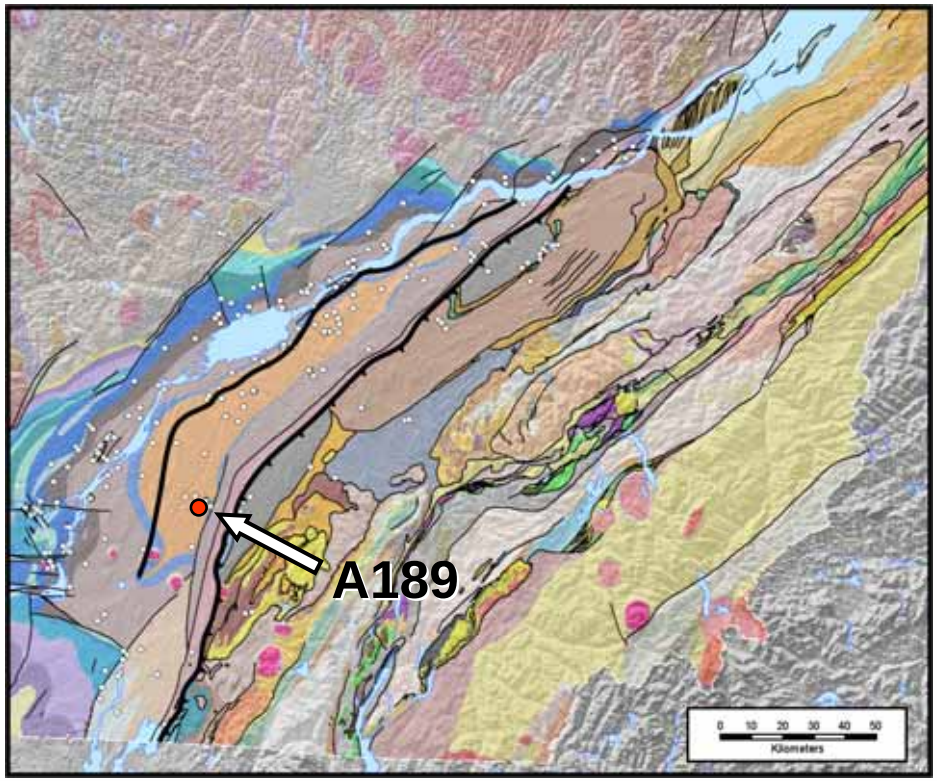

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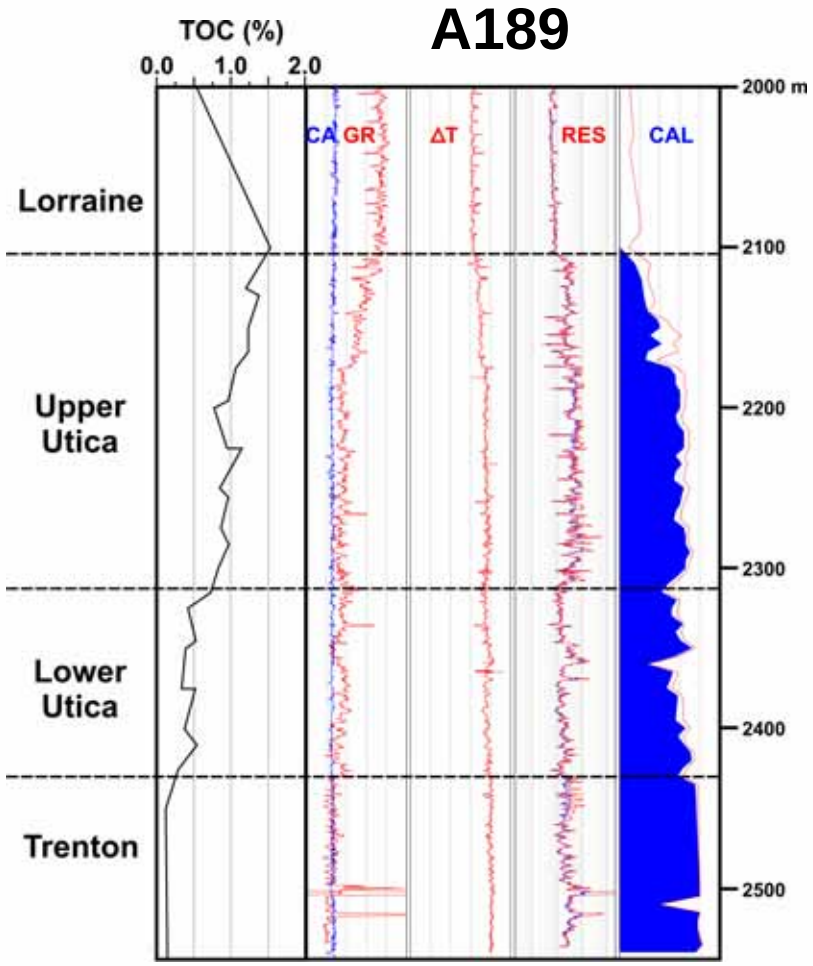

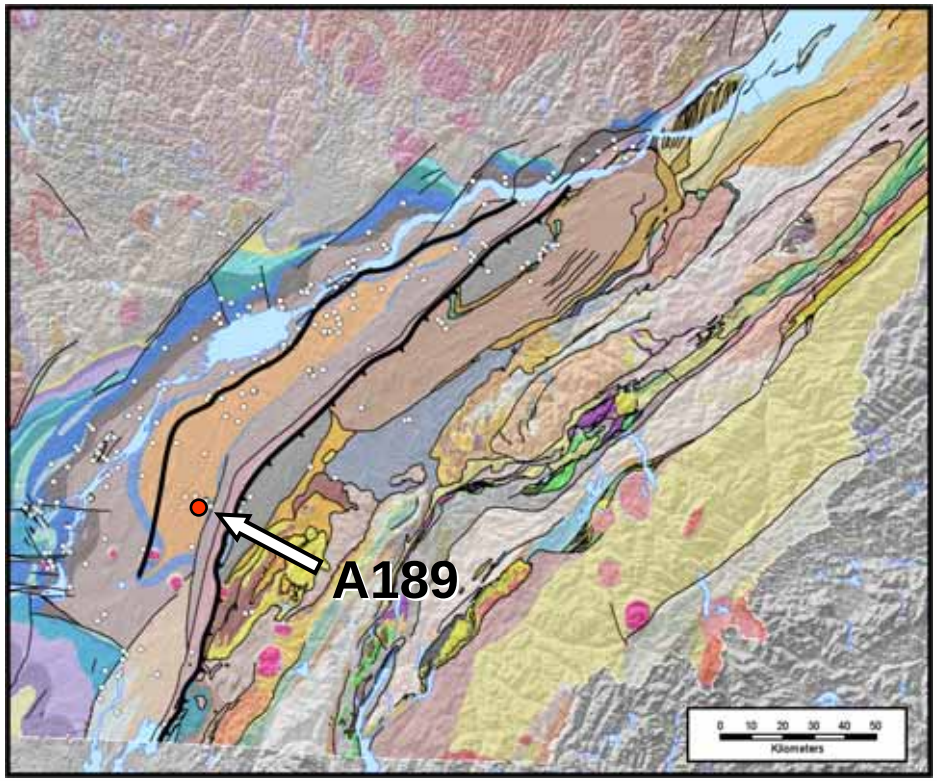

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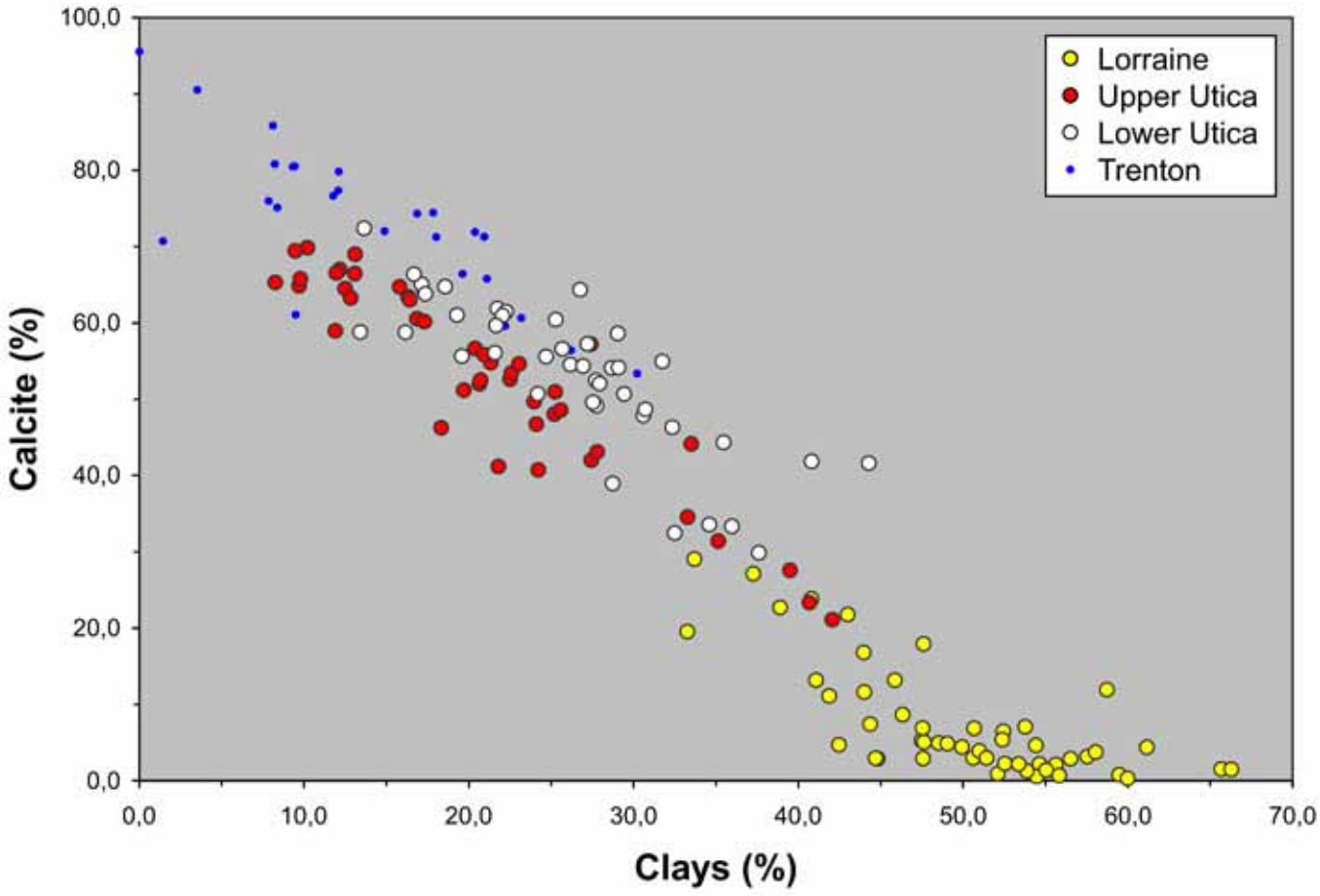
- Conclusions

Mineralogy - XRD data



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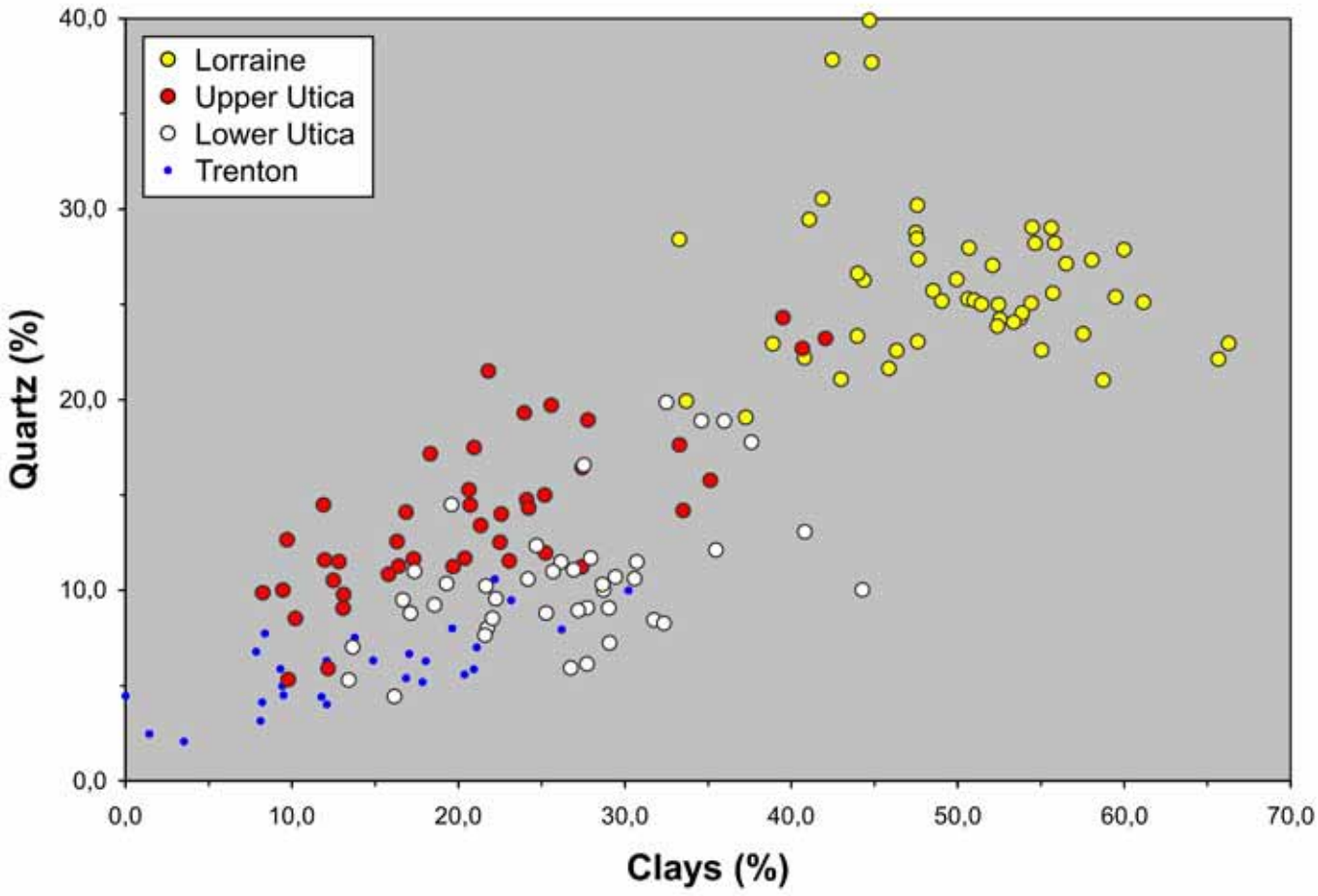

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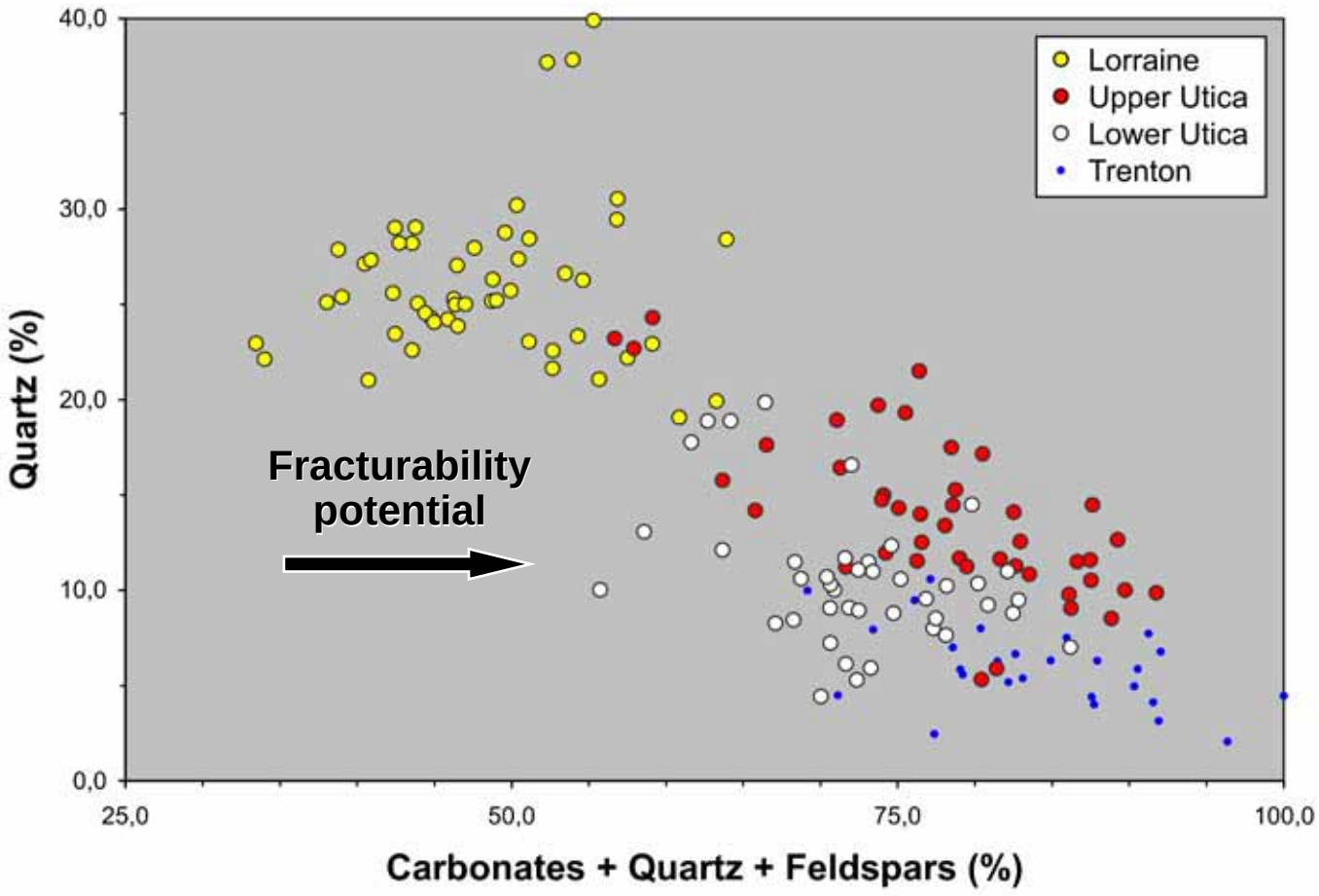
Mineralogy - XRD data



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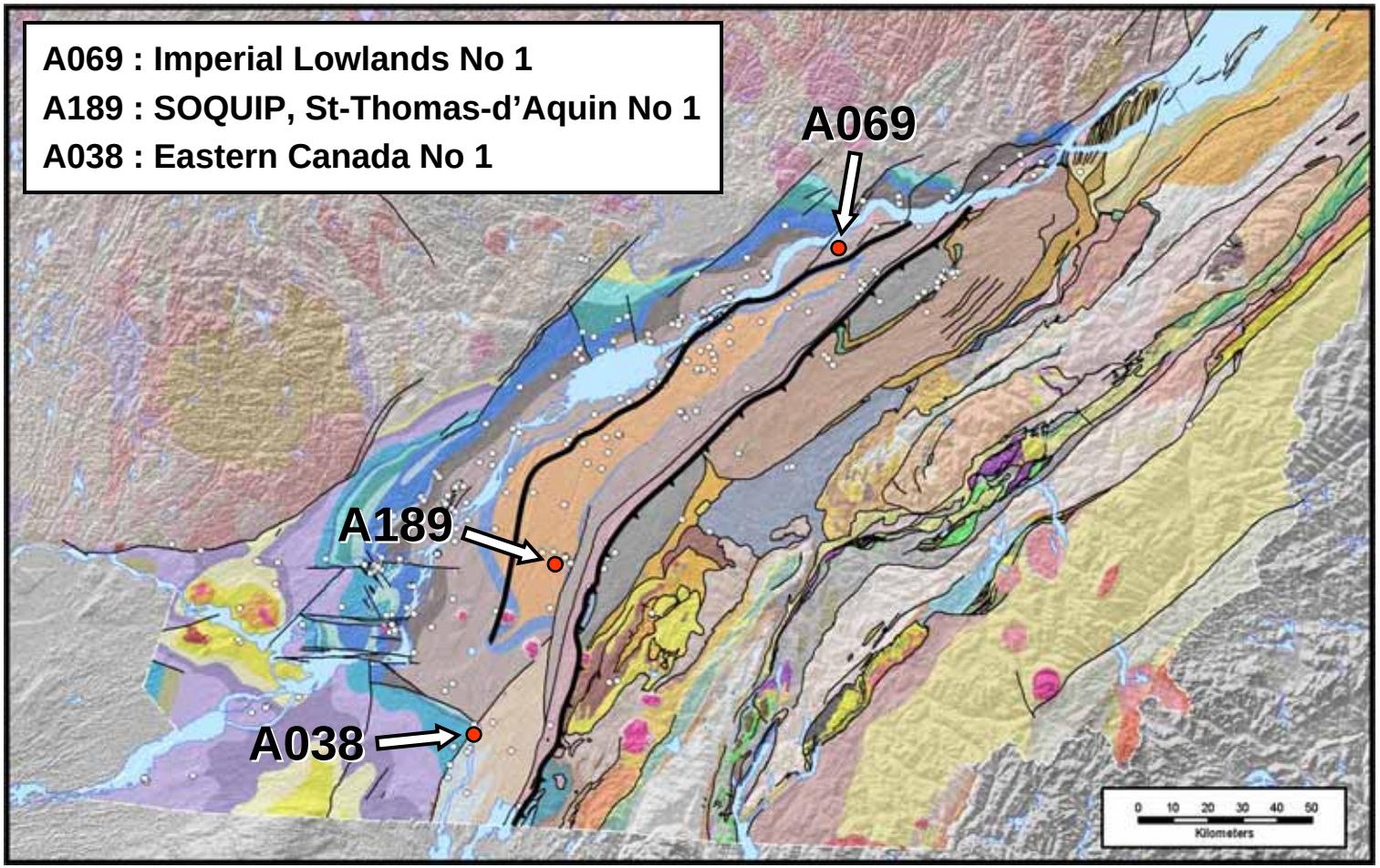

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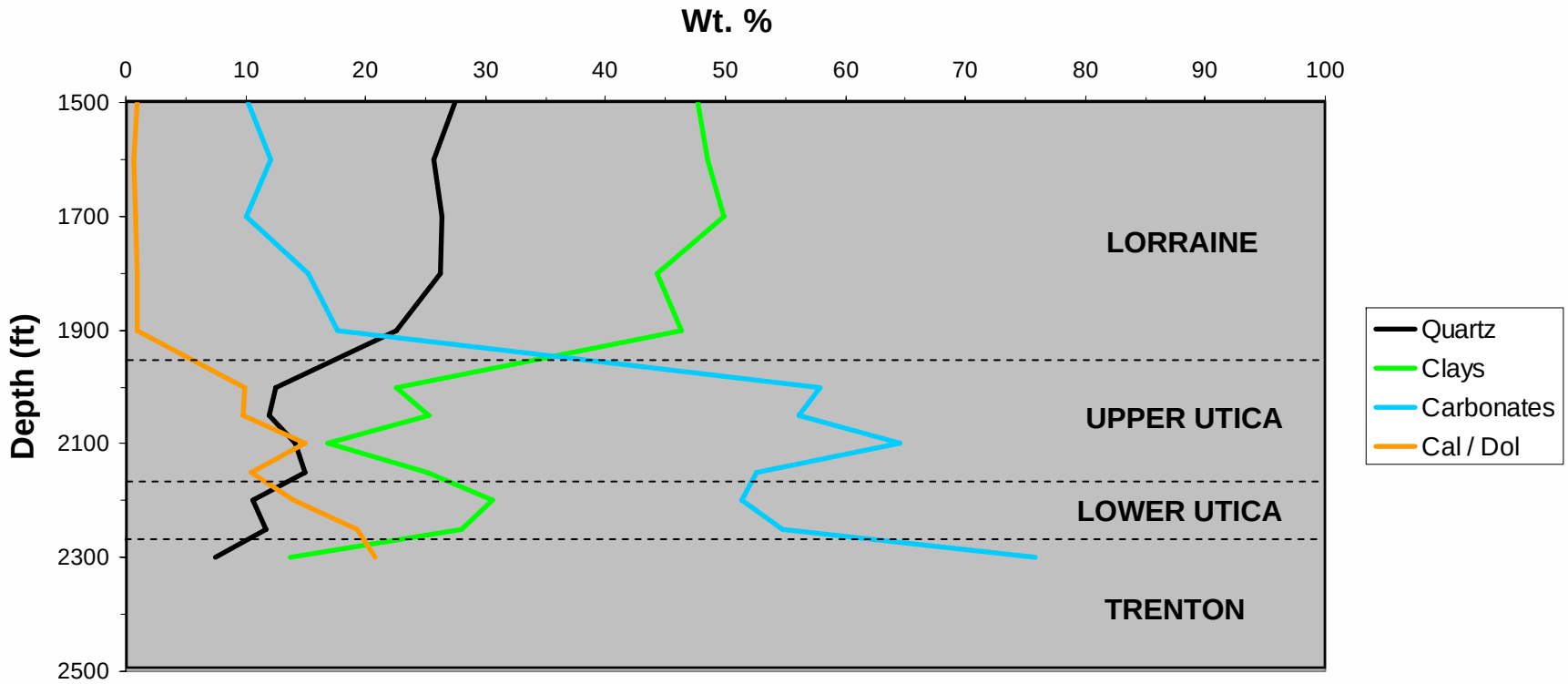
XRD data - Imperial Lowlands No 1 (A069)



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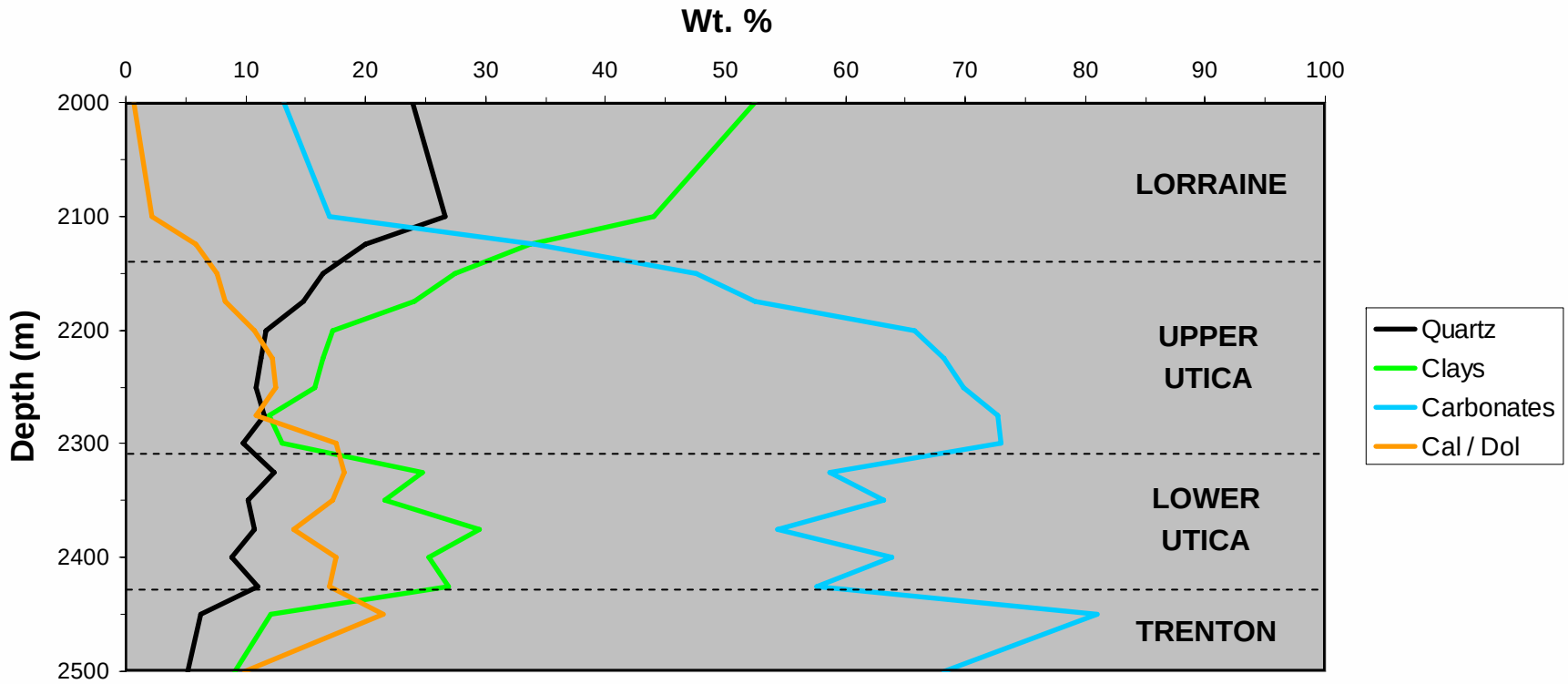
XRD data - SOQUIP, St-Thomas-d'Aquin No 1 (A189)



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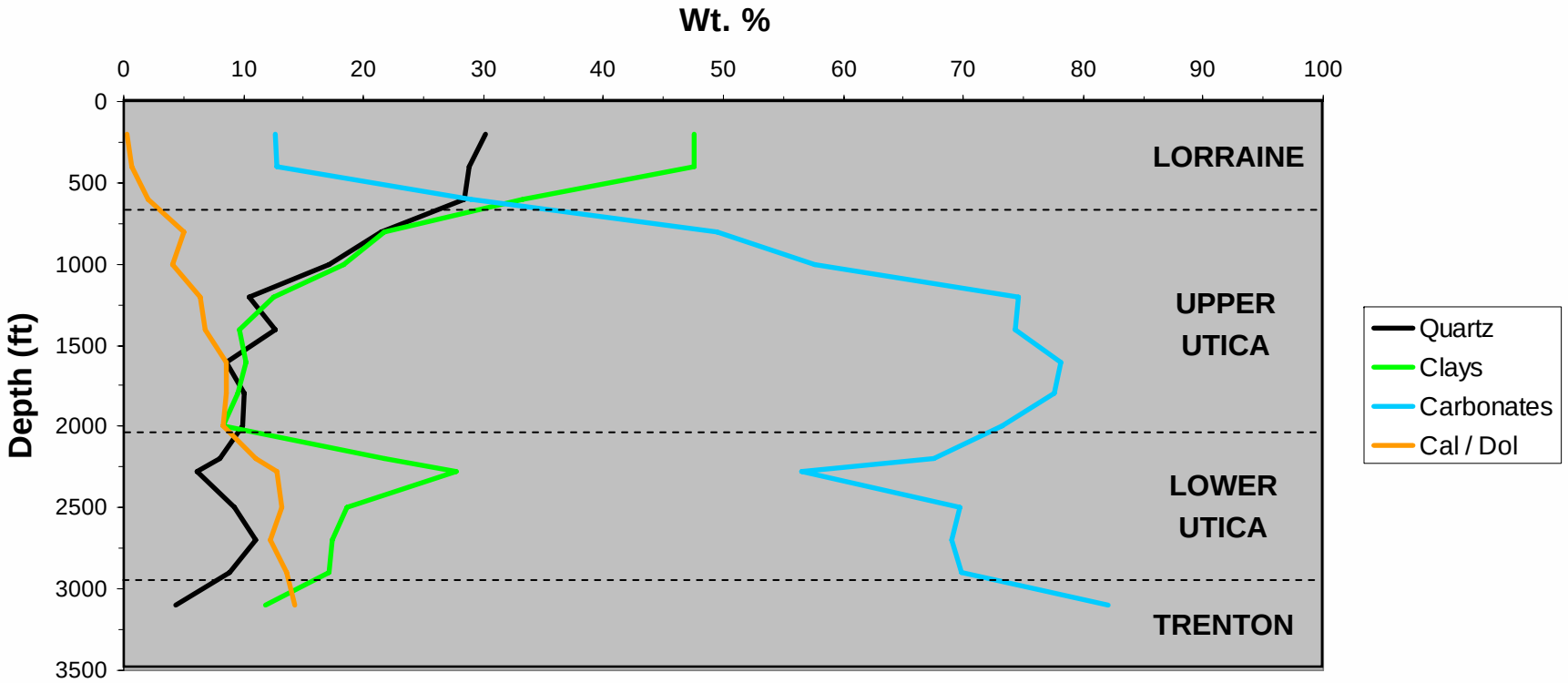

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Summary - XRD data (avg. values)

	LORRAINE	UPPER UTICA	LOWER UTICA
Clays*	50	20	25
Quartz	25	15	10
Calcite	5	50	50
Dolomite	5	5	5
Feldspars	10	5	5

* Clays = 65-85% Illite, 10-25% Chlorite, 5% Kaolinite

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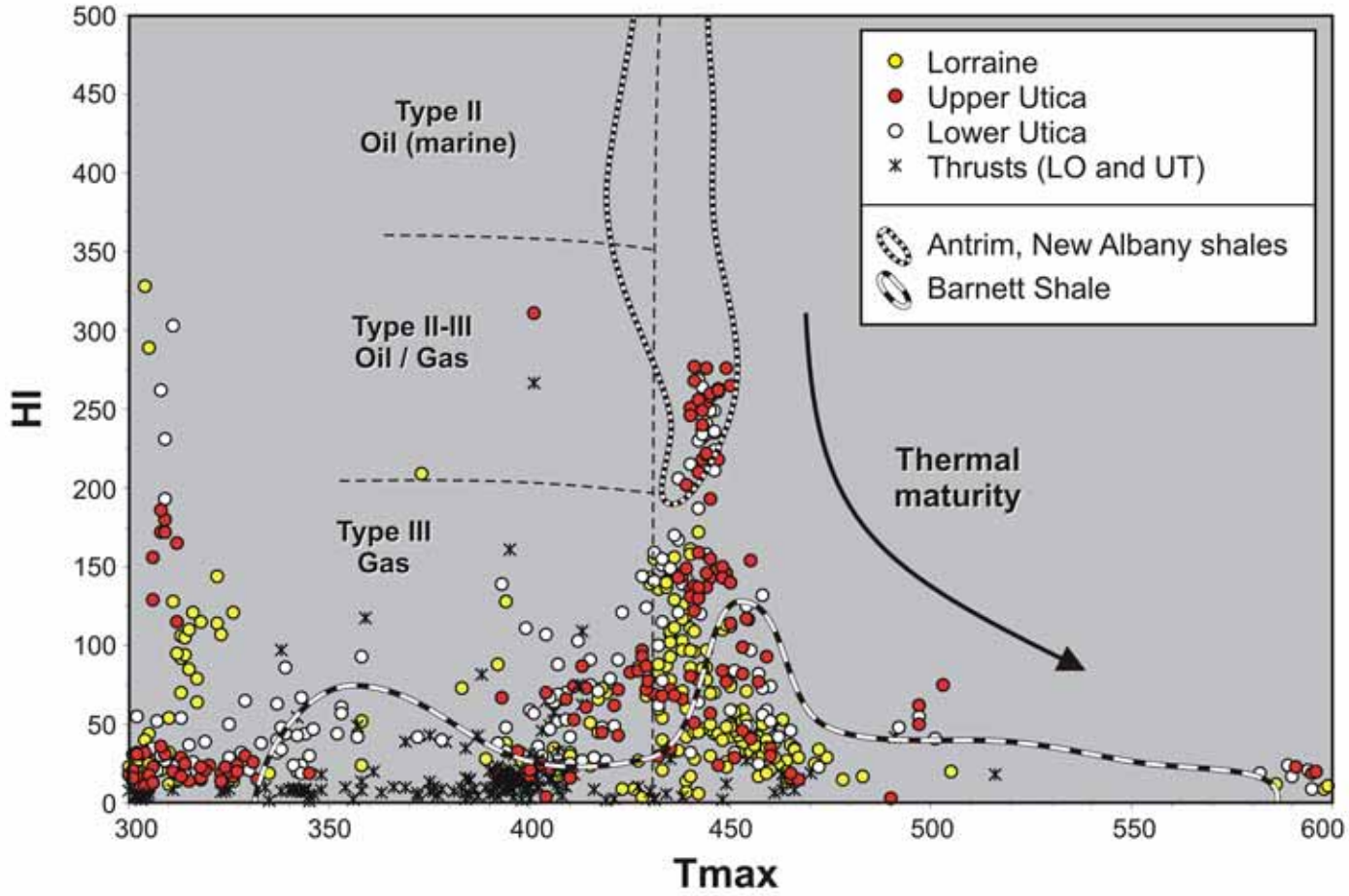
Geochemical study

Rock Eval samples

- 65 wells (cuttings and core)
- 53 outcrops
- Total of 1050 analyses (350 extra analyses from 22 new wells expected this month)

Geochemistry – Rock Eval



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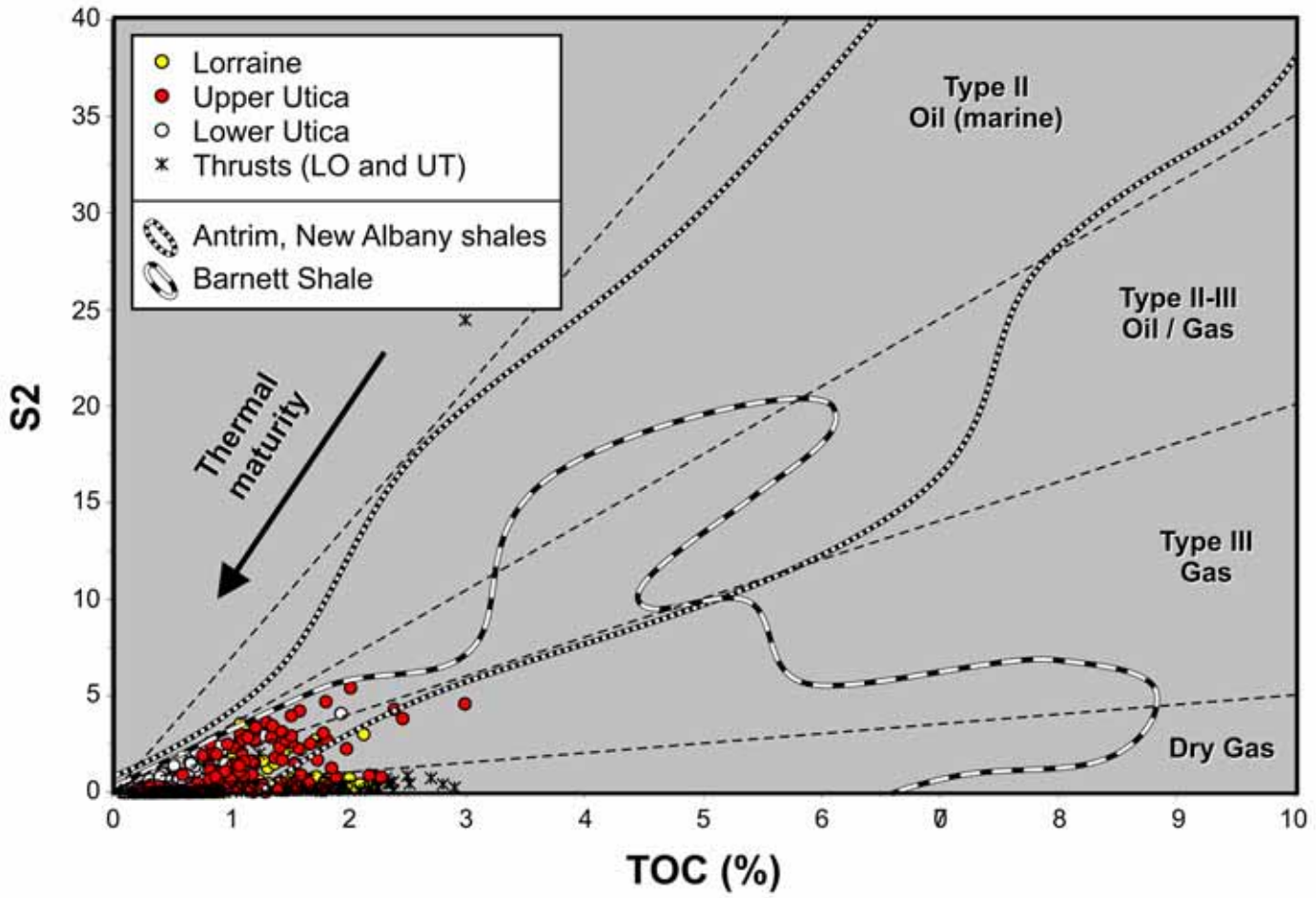
Geochemistry – Rock Eval



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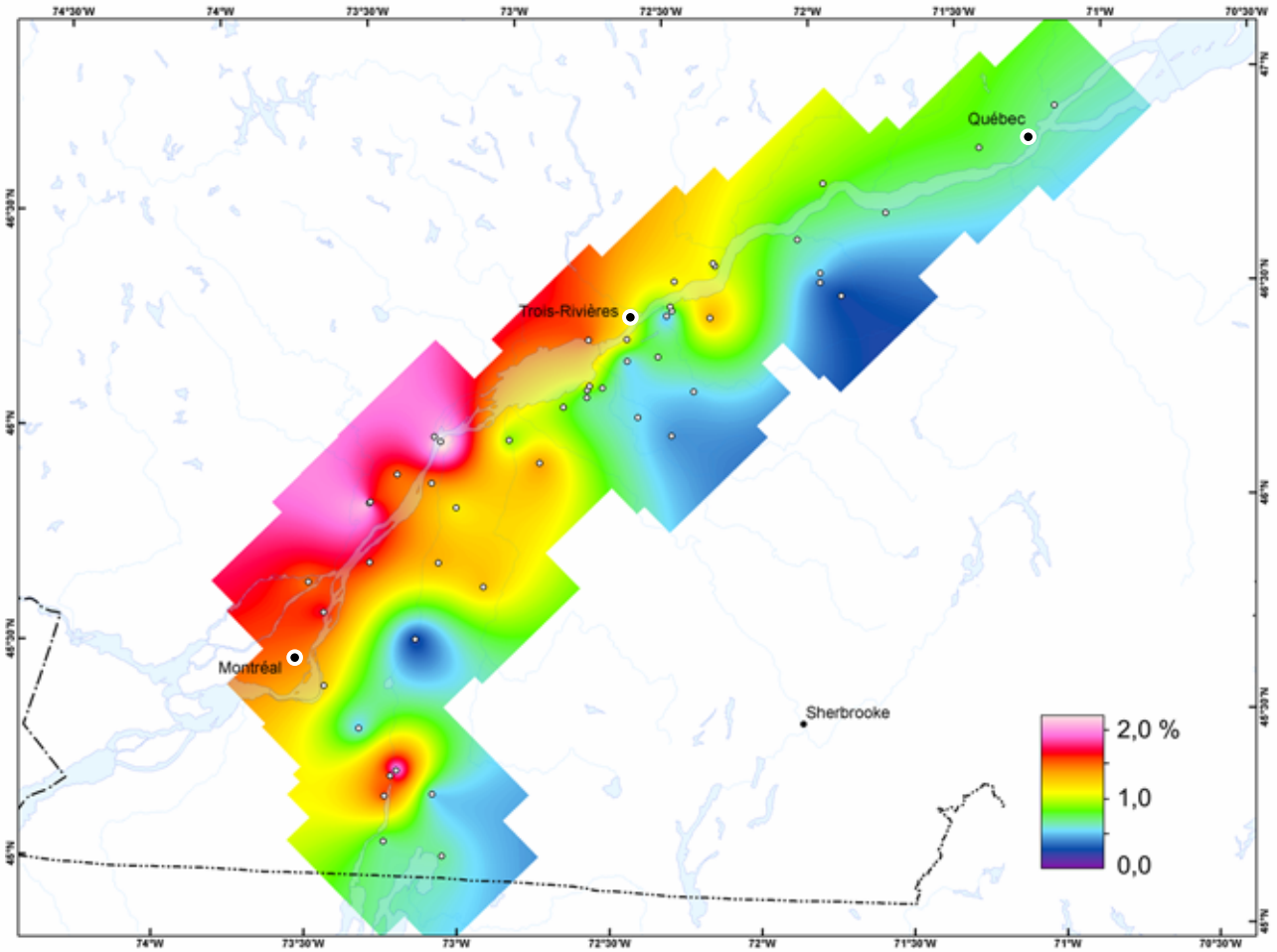
Average TOC - Lorraine



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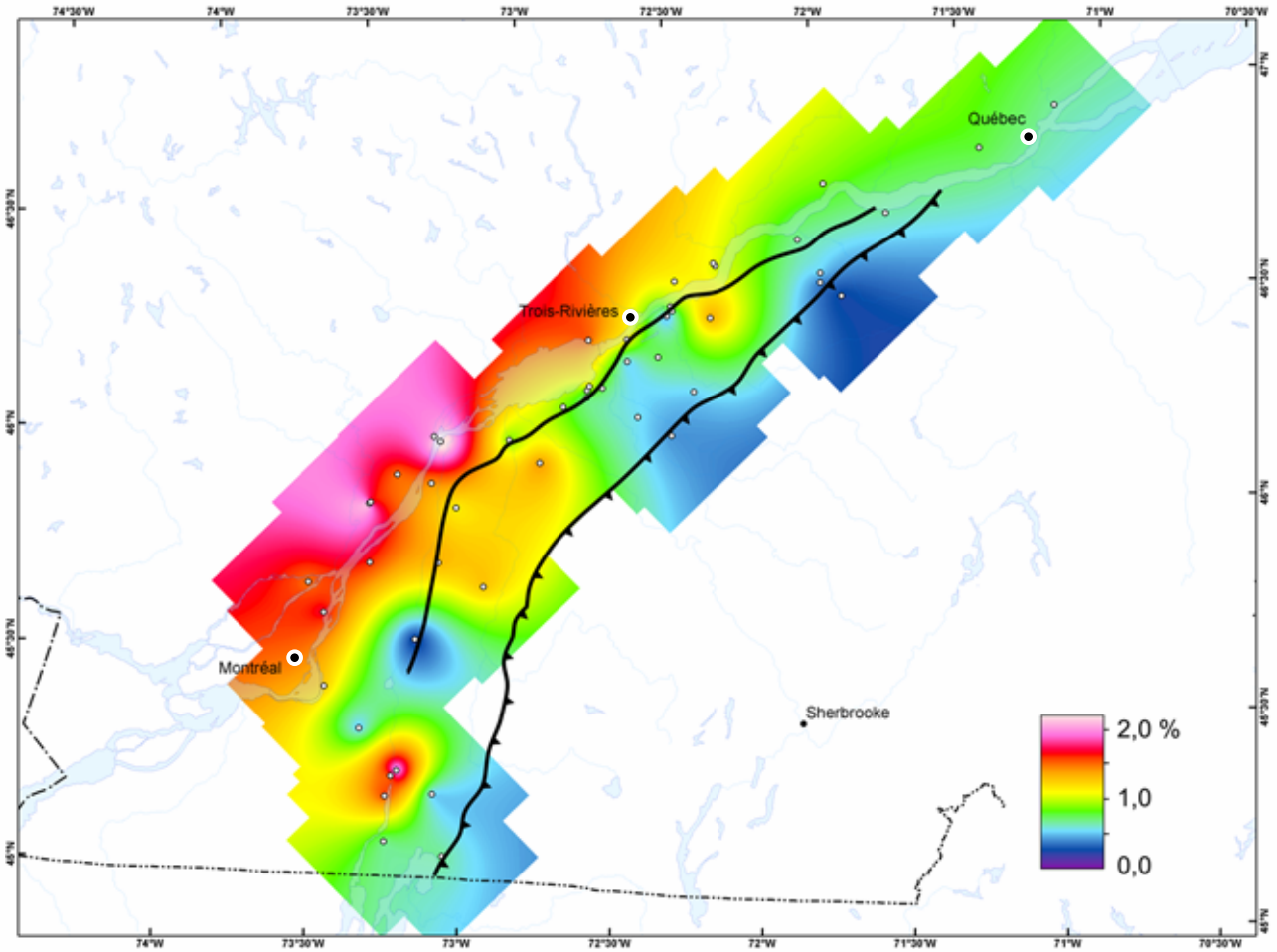
Average TOC - Lorraine



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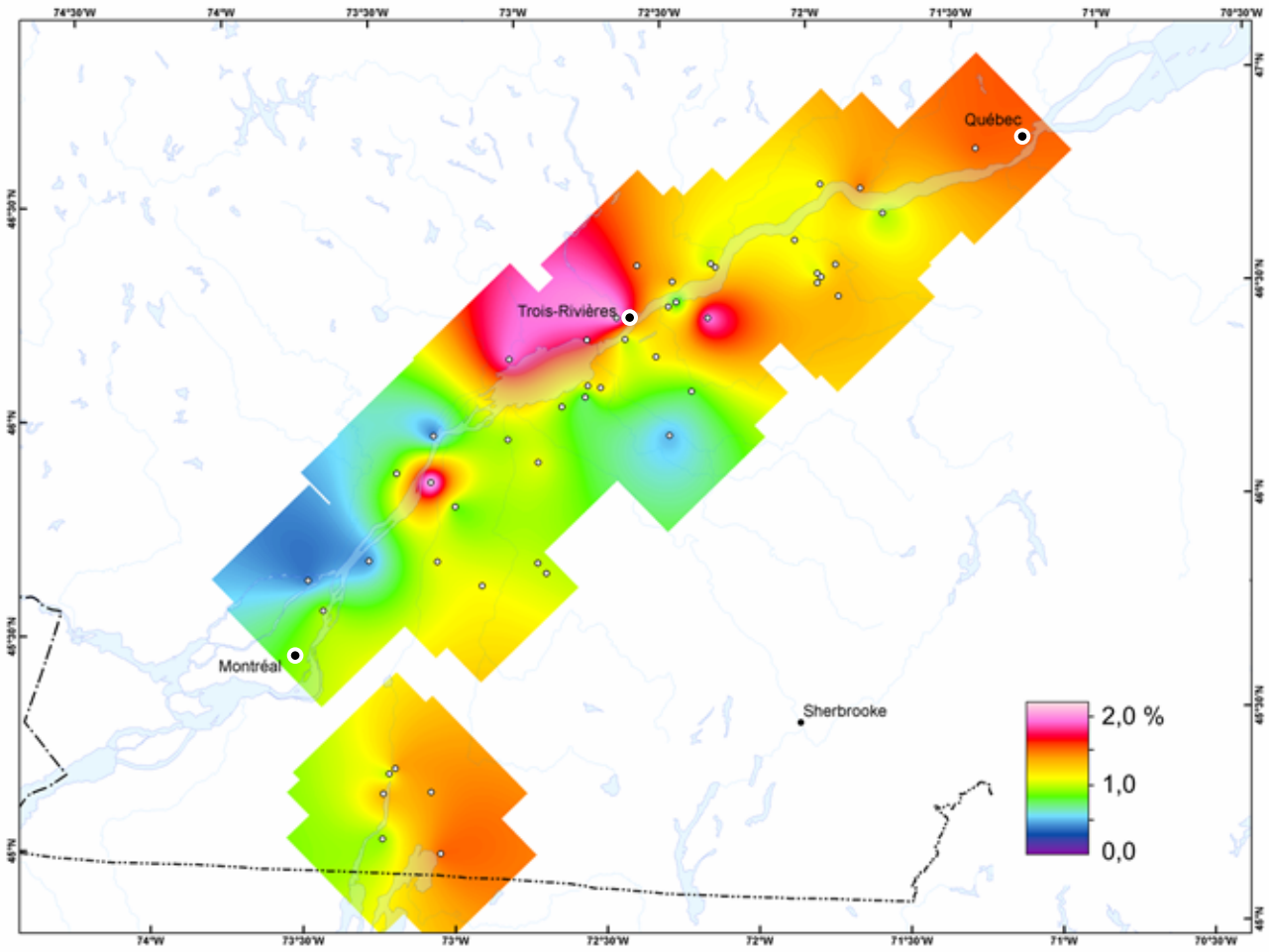
Average TOC – Upper Utica



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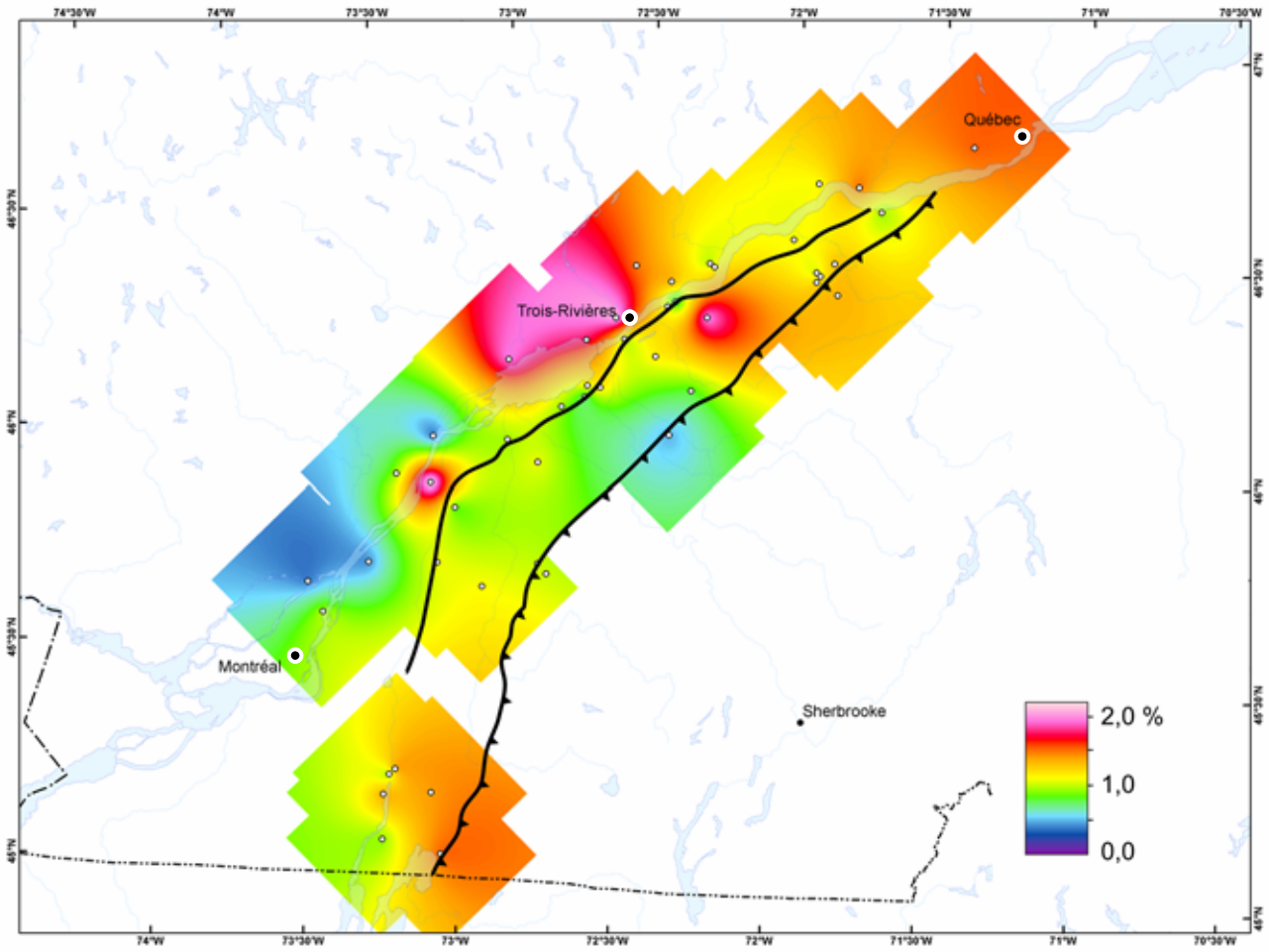

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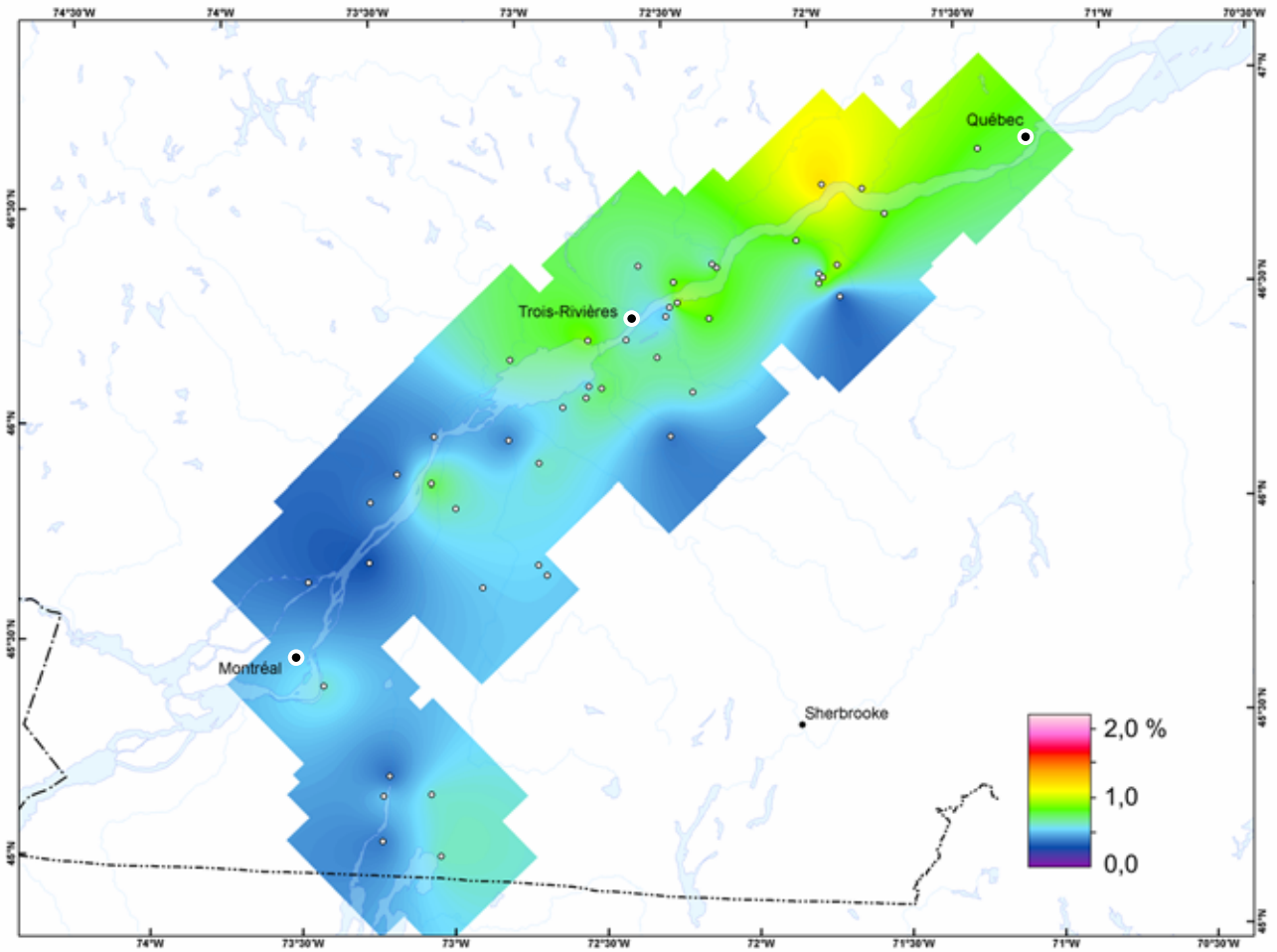
Average TOC – Lower Utica



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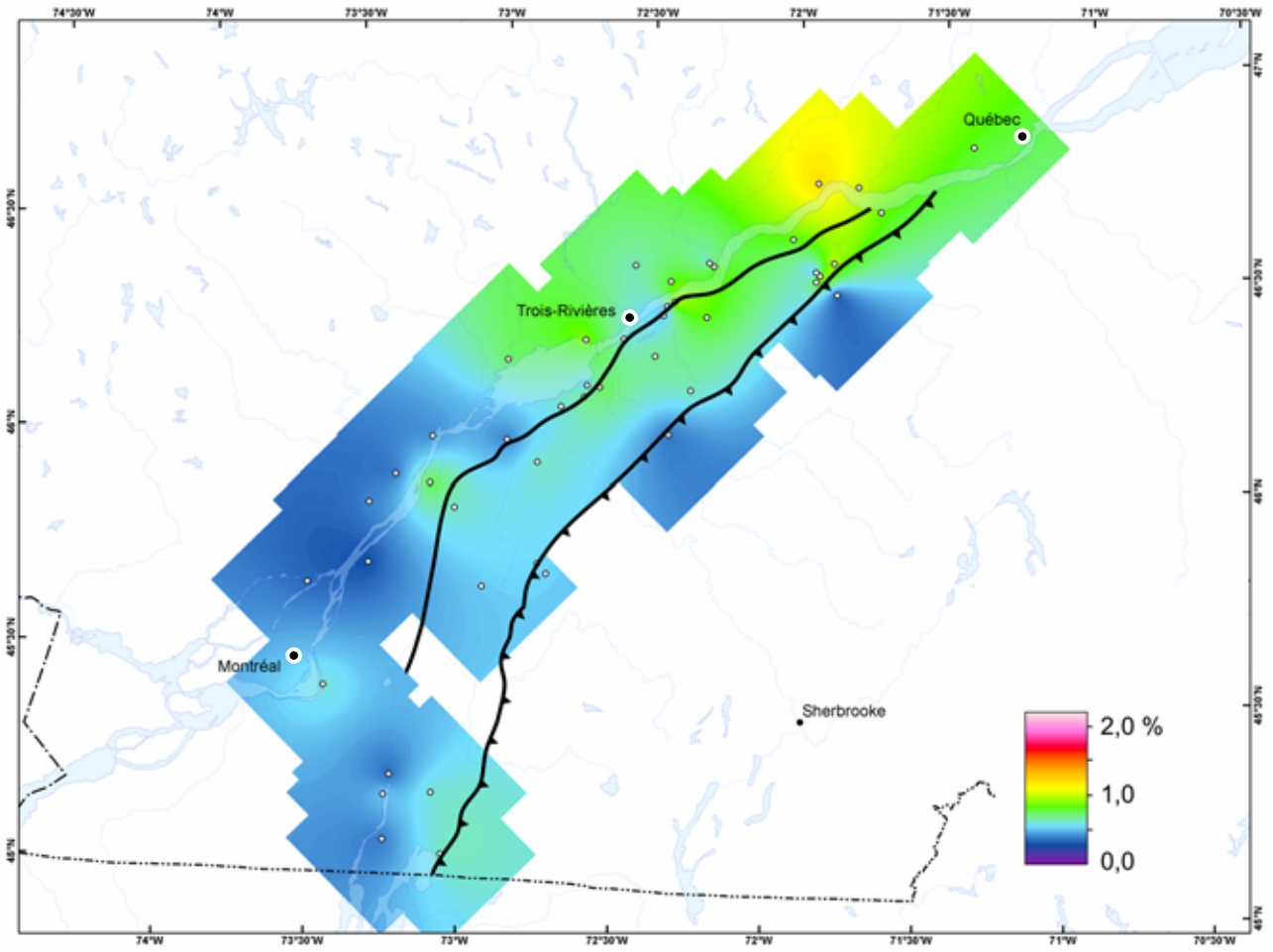

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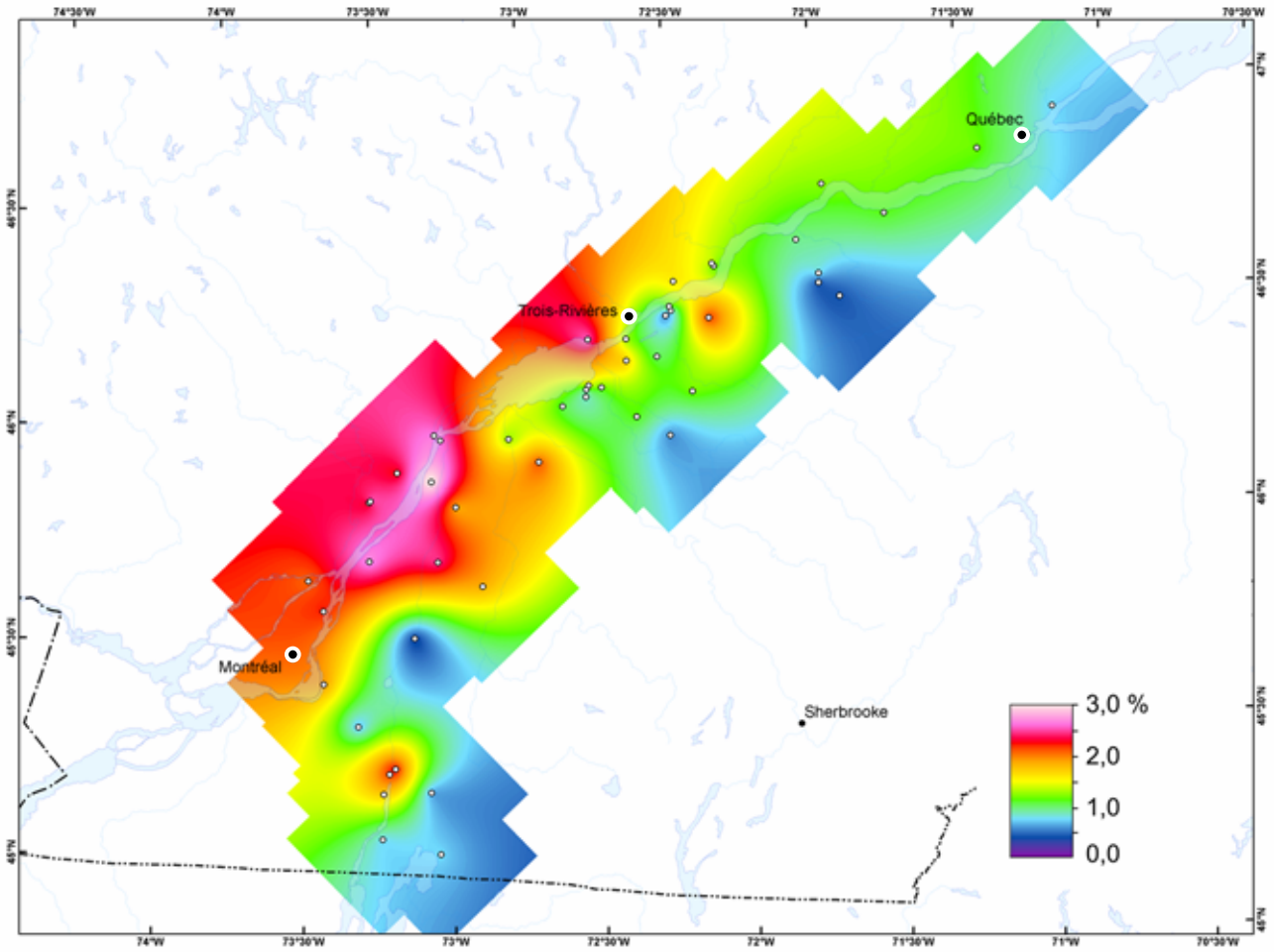
Maximum TOC - Lorraine



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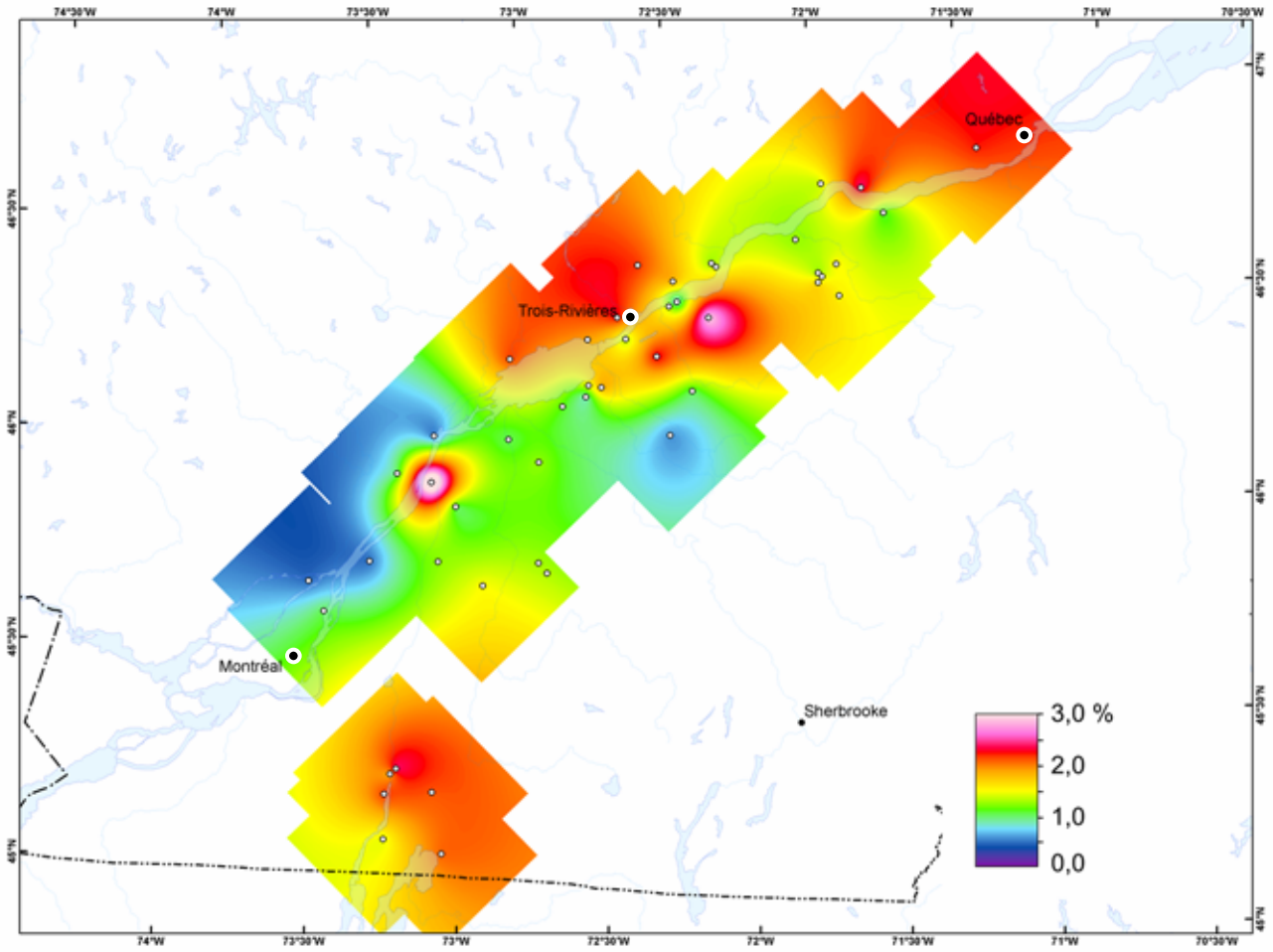
Maximum TOC – Upper Utica



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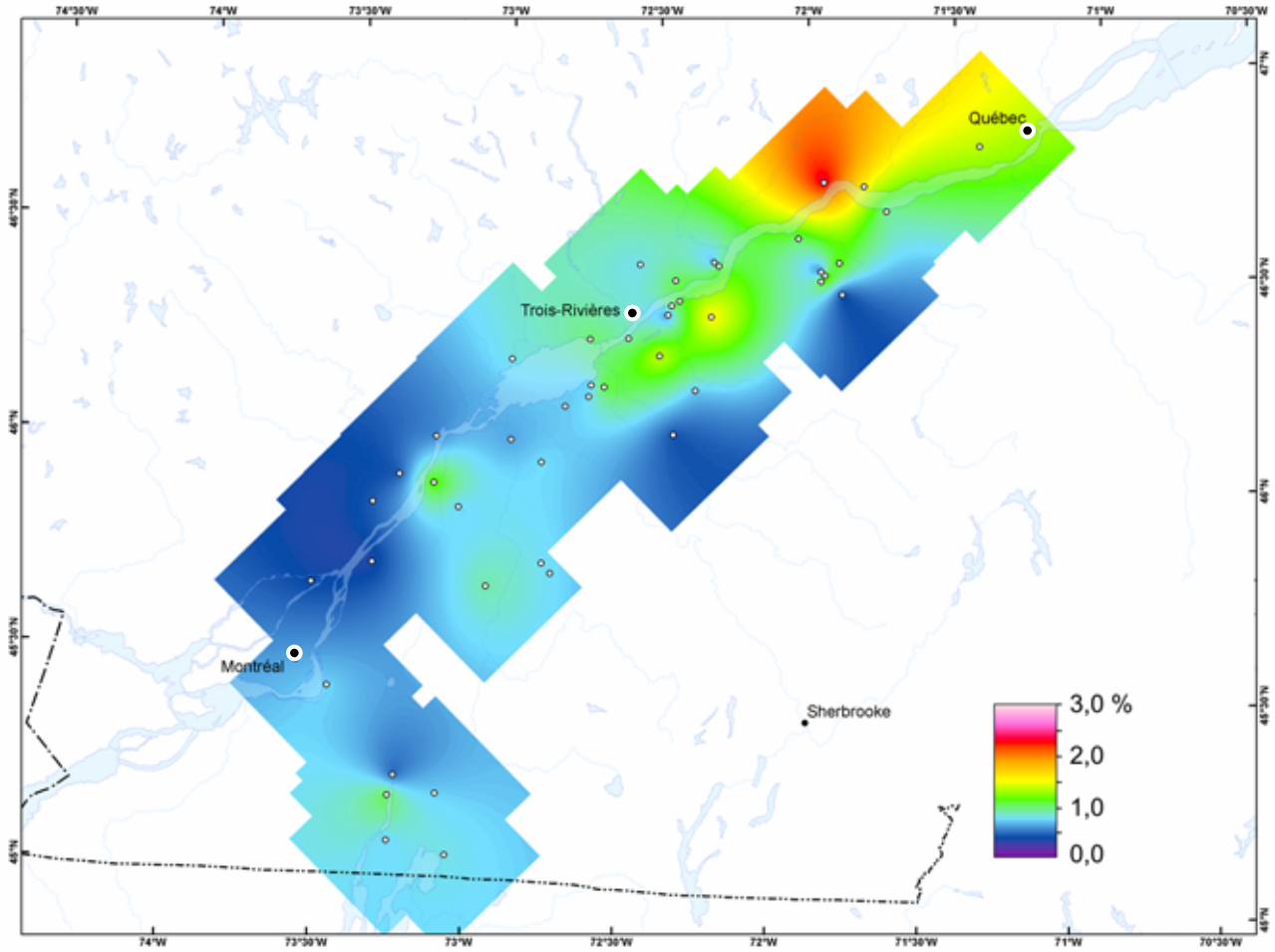
Maximum TOC – Lower Utica



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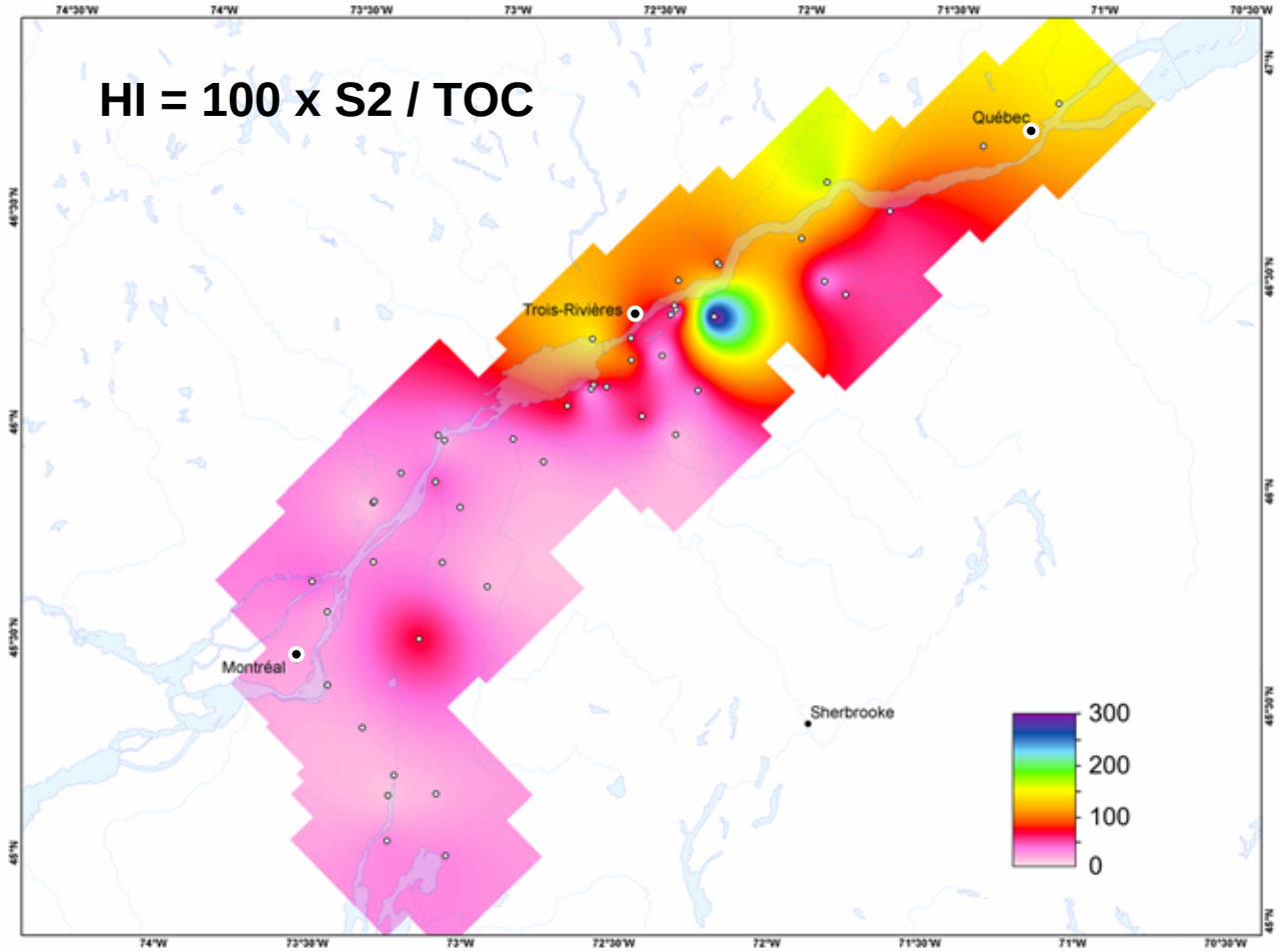
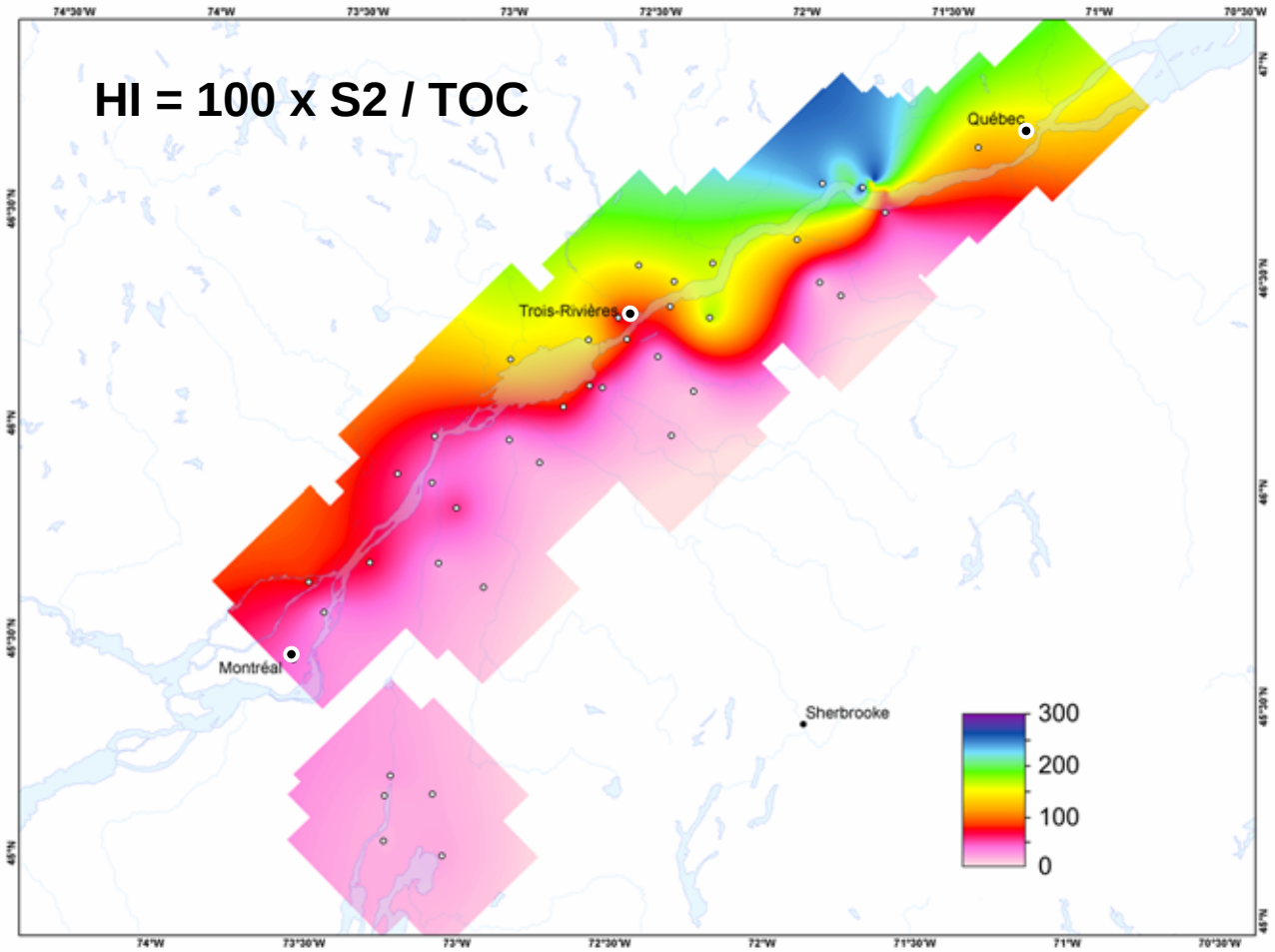
Hydrogen Index (HI) - Lorraine



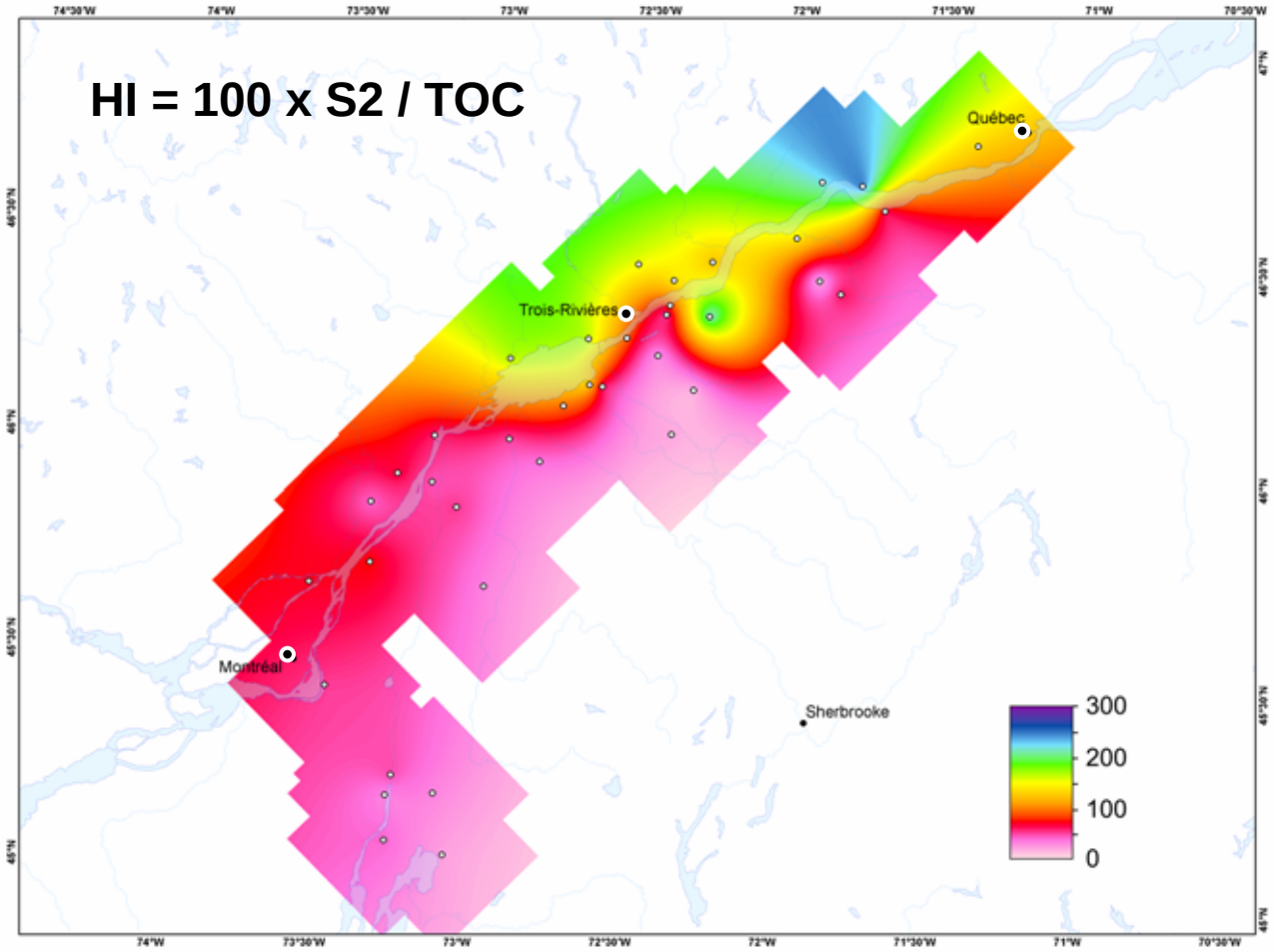
Ressources naturelles et Faune Québec

Hydrogen Index (HI) – Upper Utica



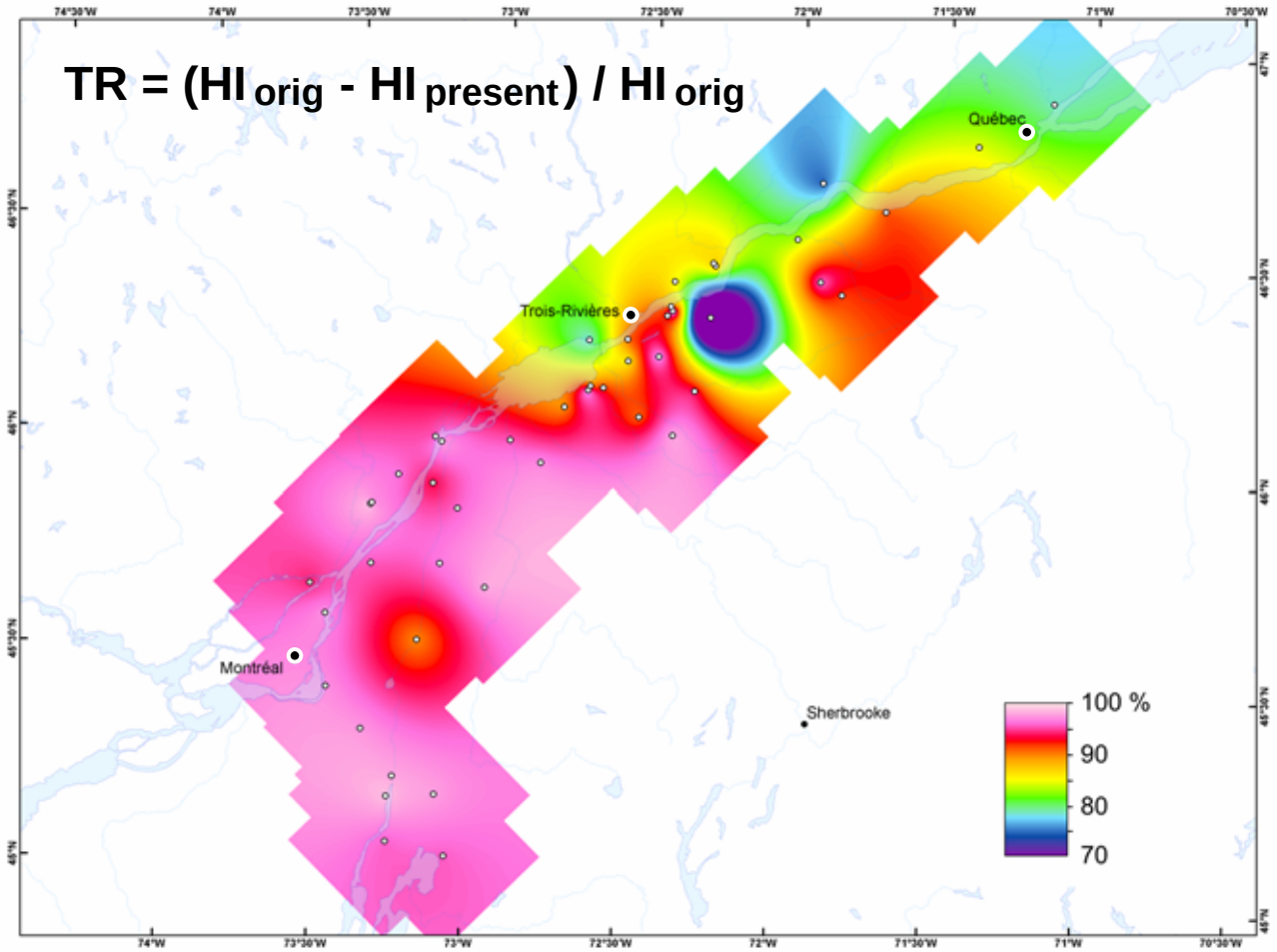
Ressources naturelles et Faune Québec

Hydrogen Index (HI) – Lower Utica



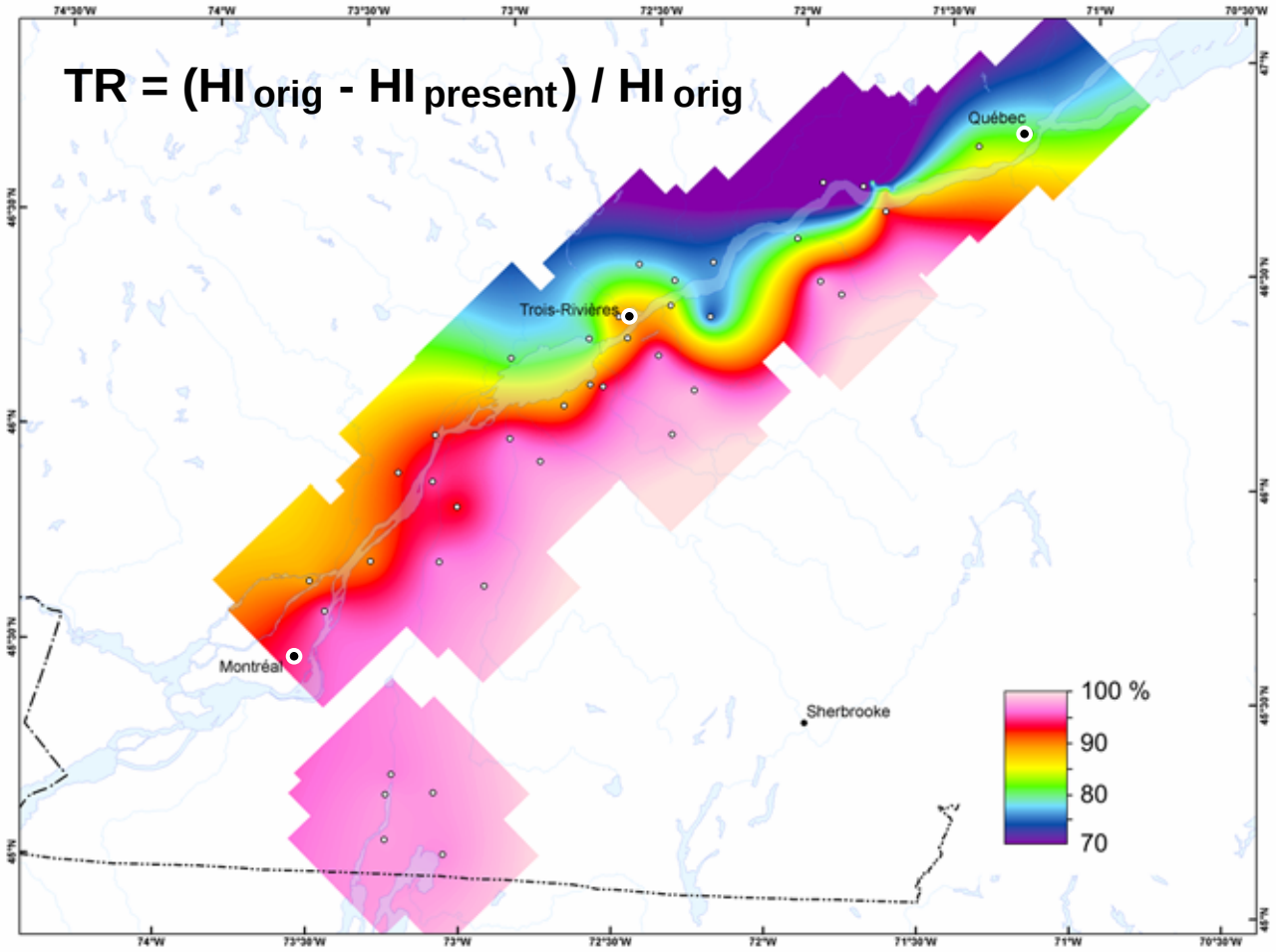
Ressources naturelles et Faune
Québec

Transformation Ratio (TR) - Lorraine



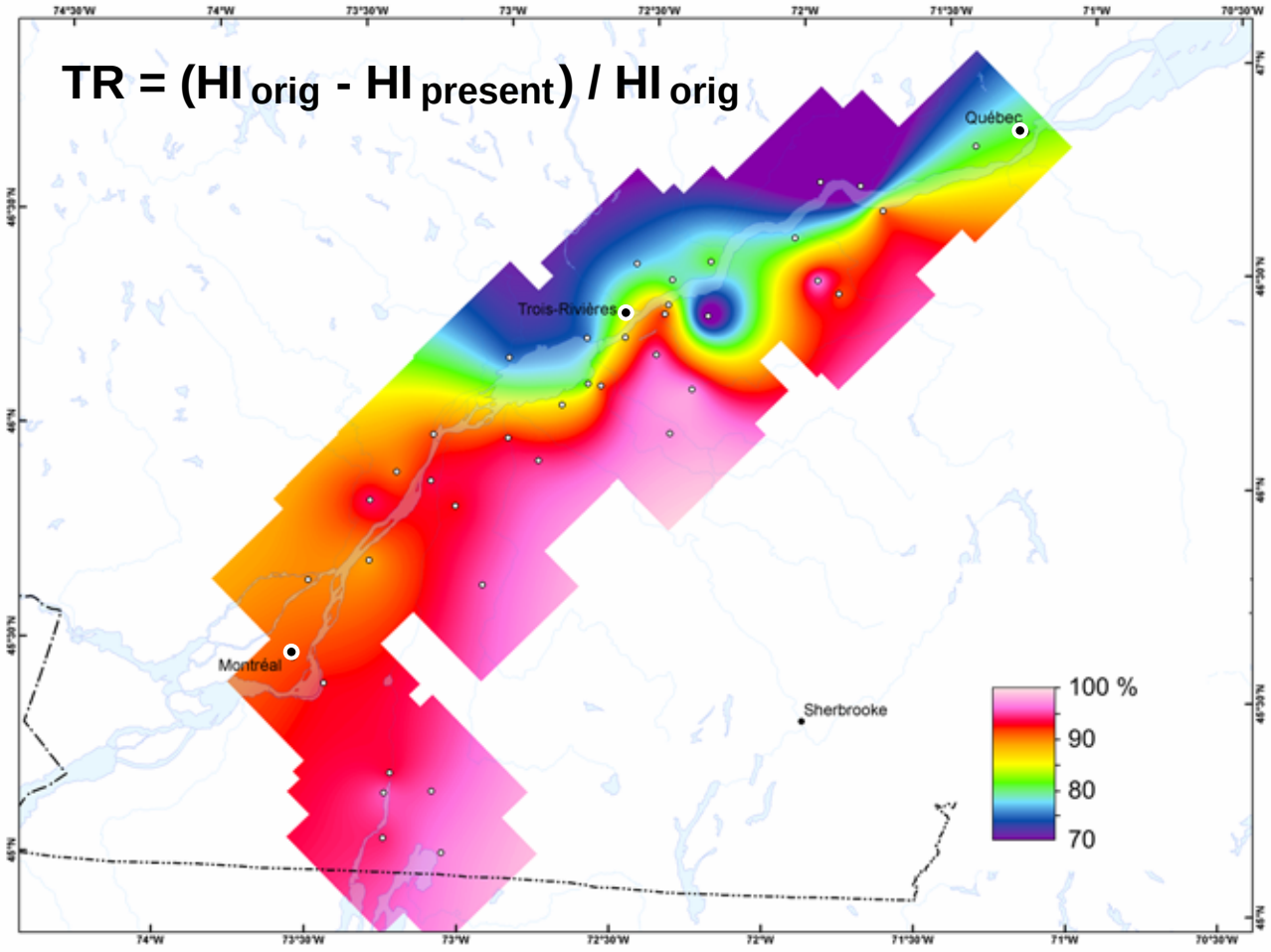
Ressources naturelles et Faune Québec

Transformation Ratio (TR) – Upper Utica



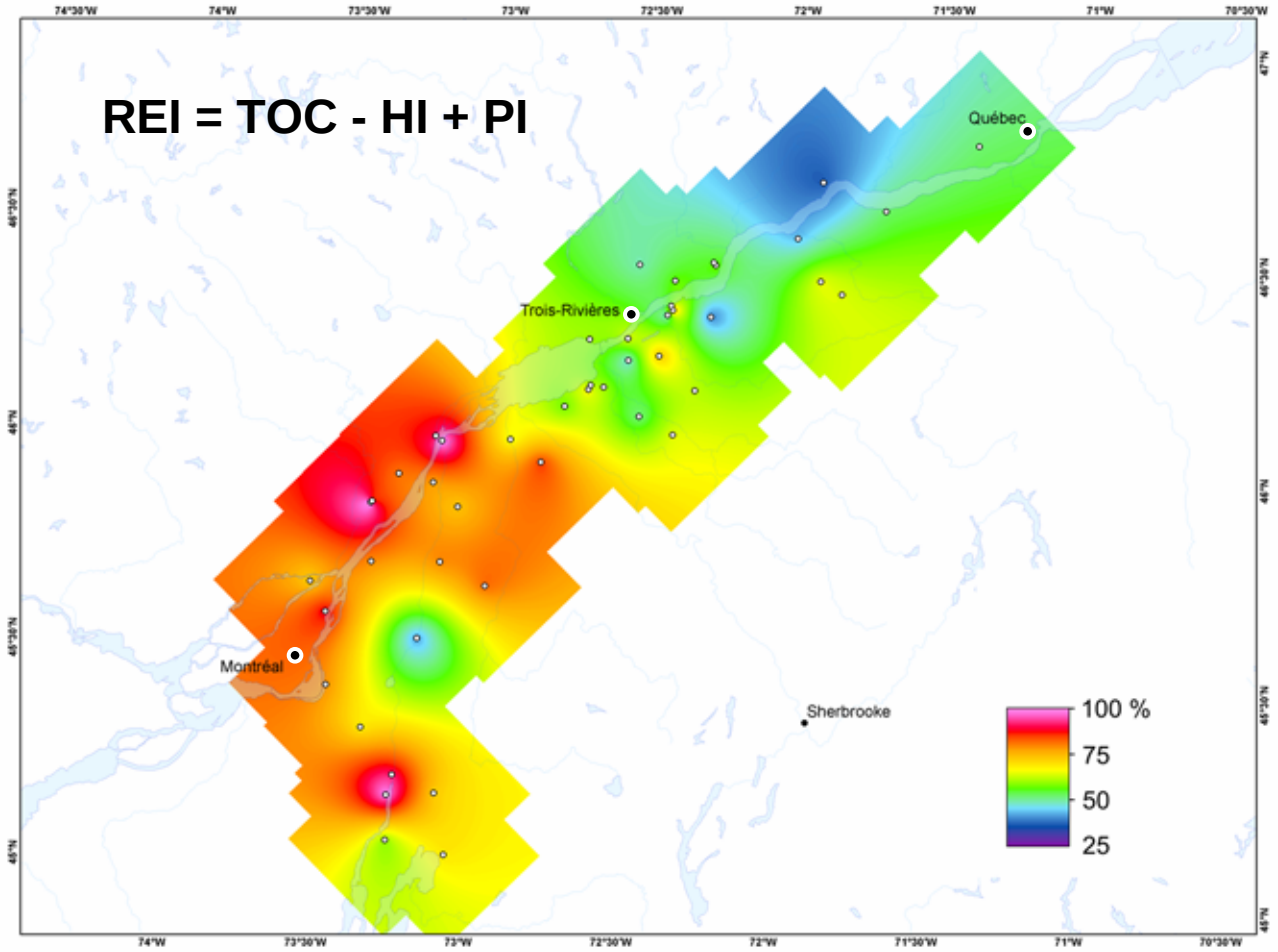
Ressources naturelles et Faune Québec

Transformation Ratio (TR) – Lower Utica



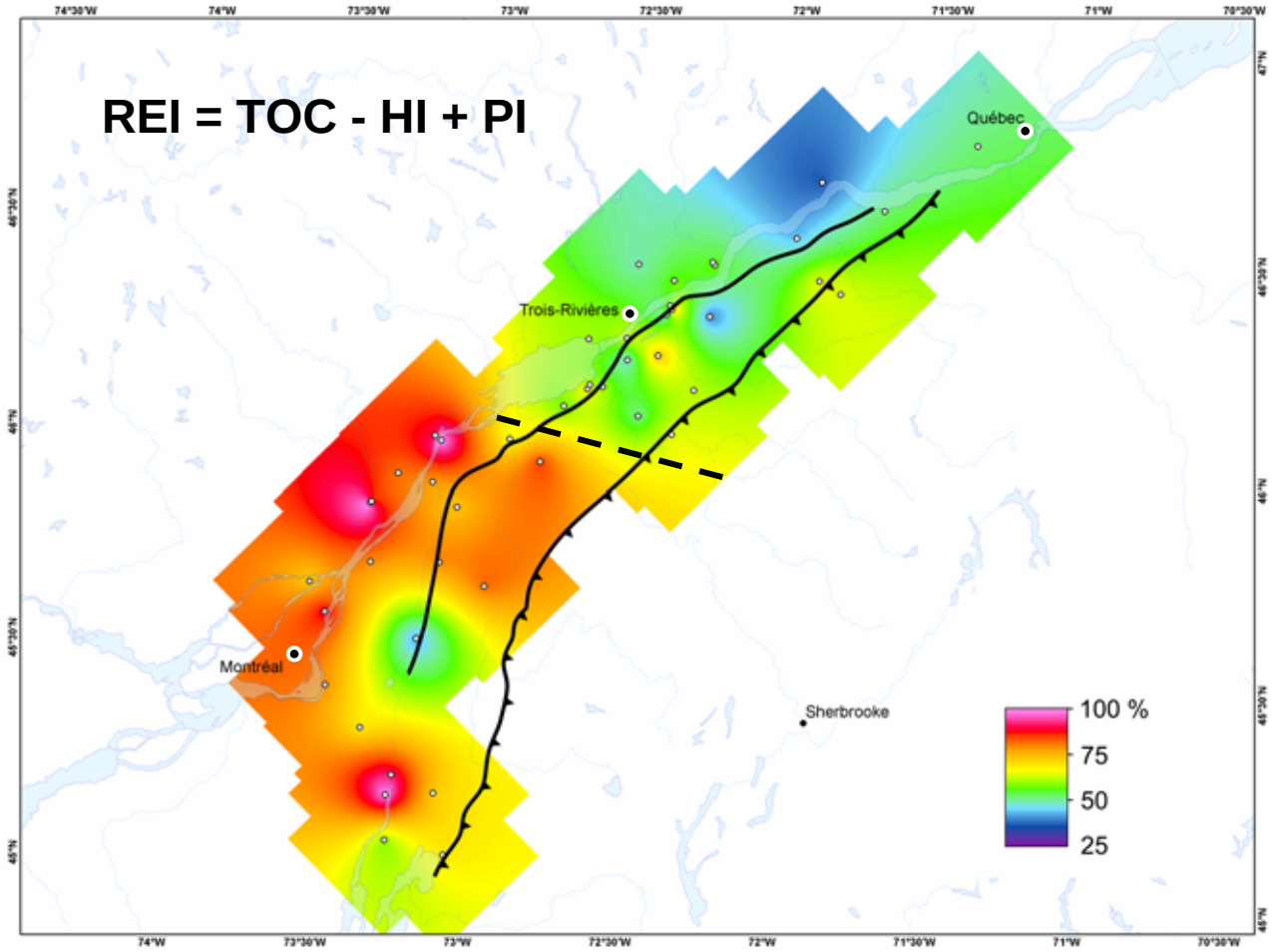
Ressources naturelles et Faune Québec

Rock Eval Index (REI) – Lorraine



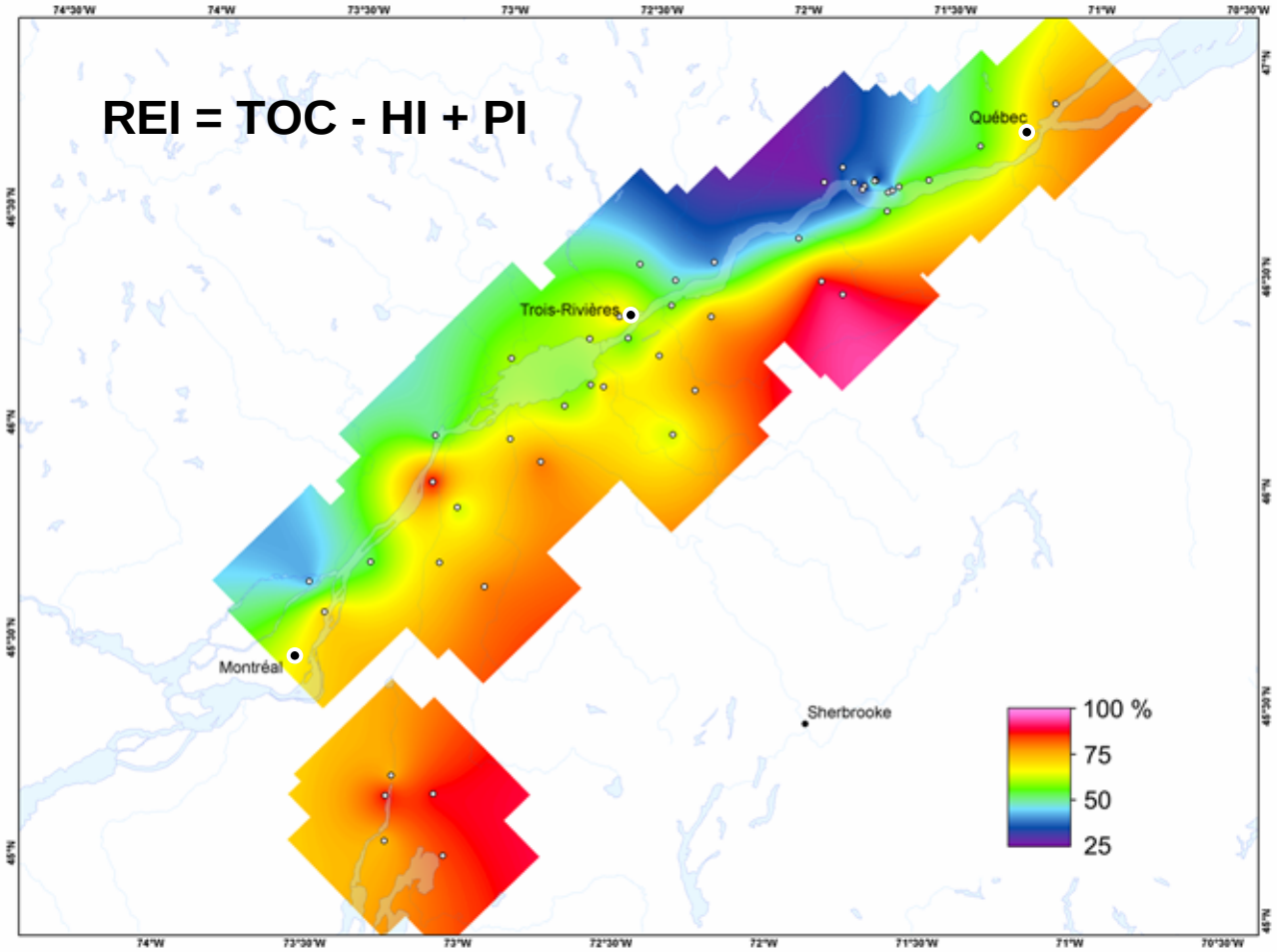
Ressources naturelles et Faune Québec

Rock Eval Index (REI) – Lorraine



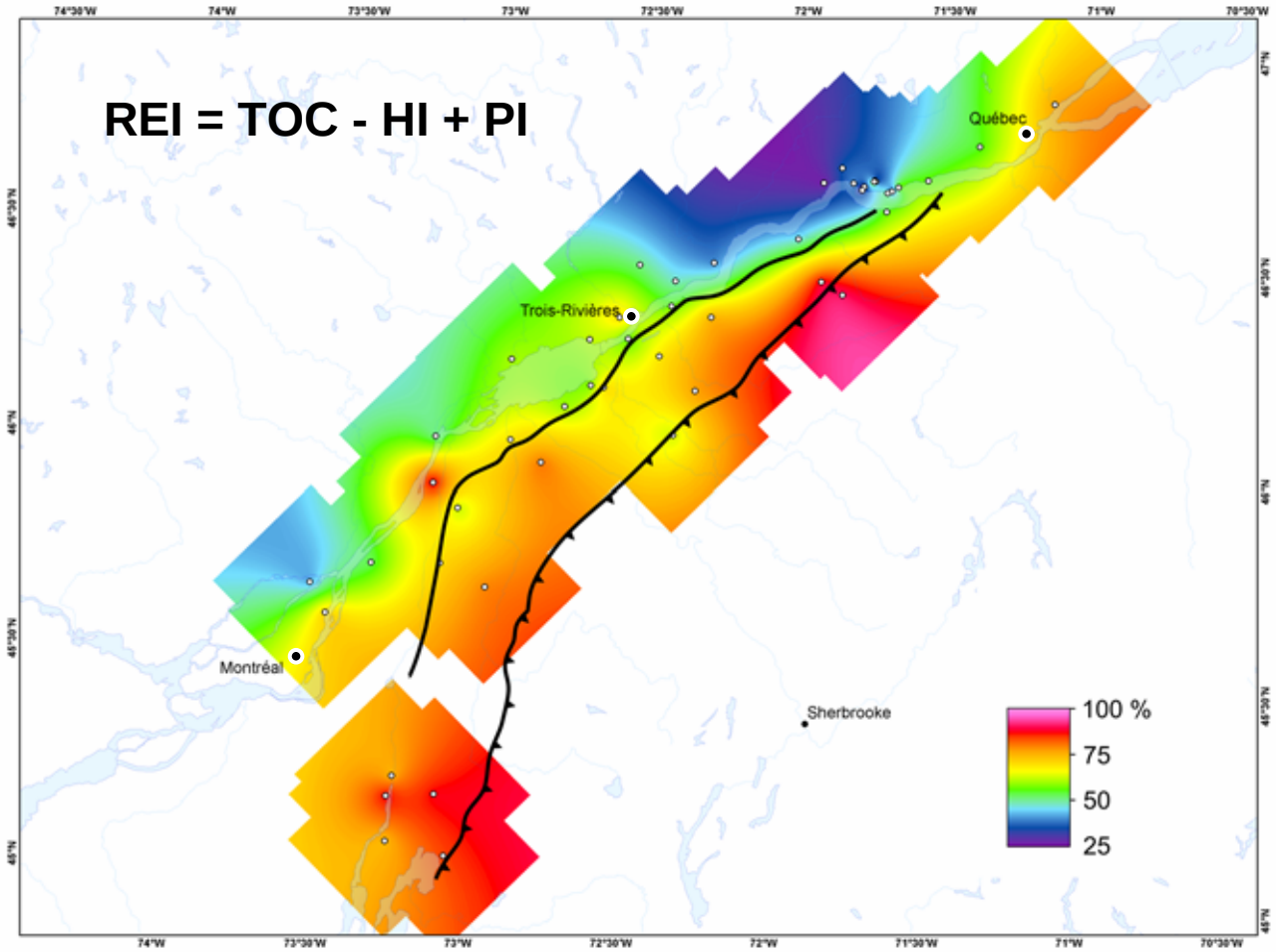
Ressources naturelles et Faune Québec

Rock Eval Index (REI) – Upper Utica



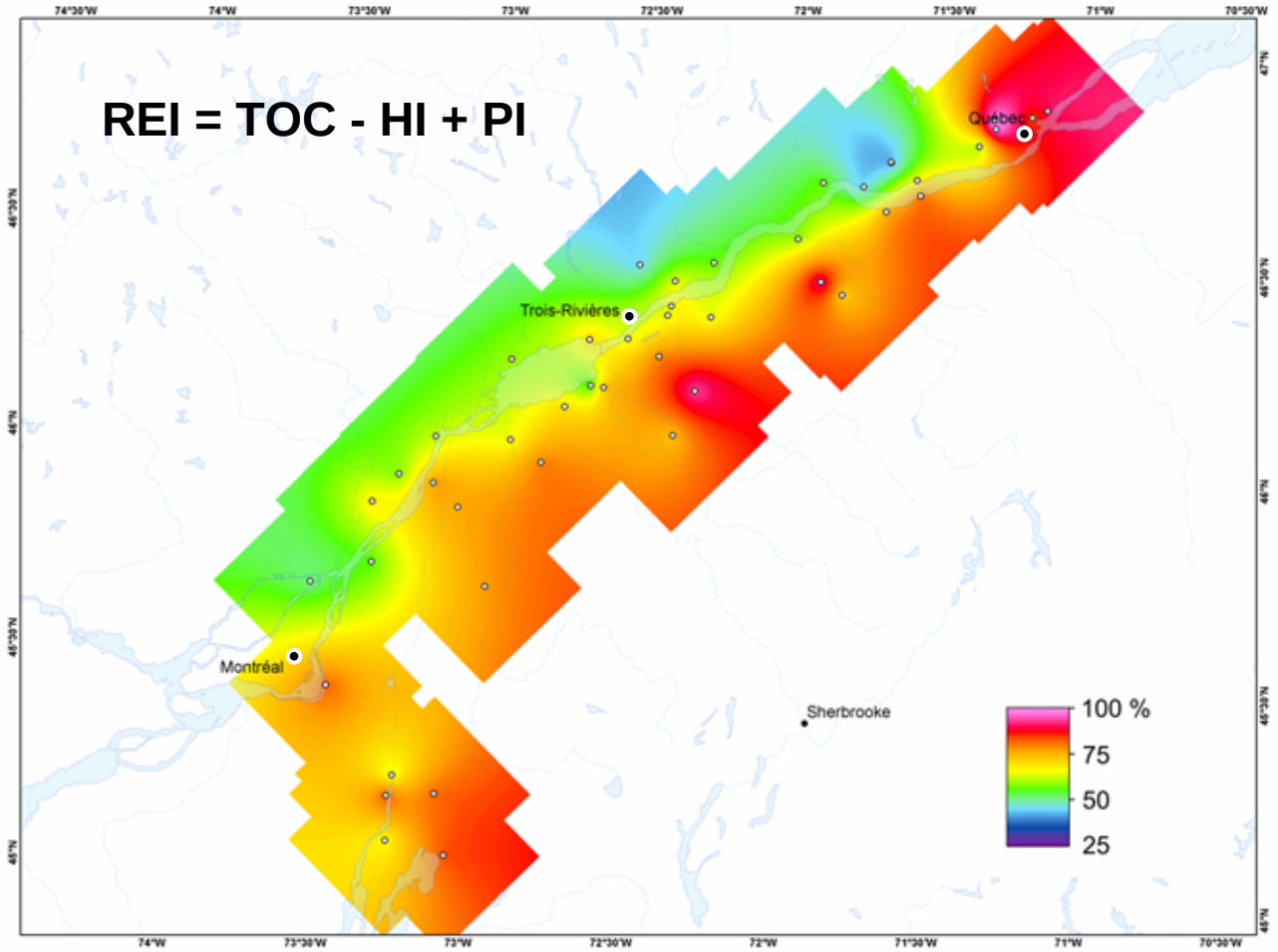
Ressources naturelles et Faune Québec

Rock Eval Index (REI) – Upper Utica



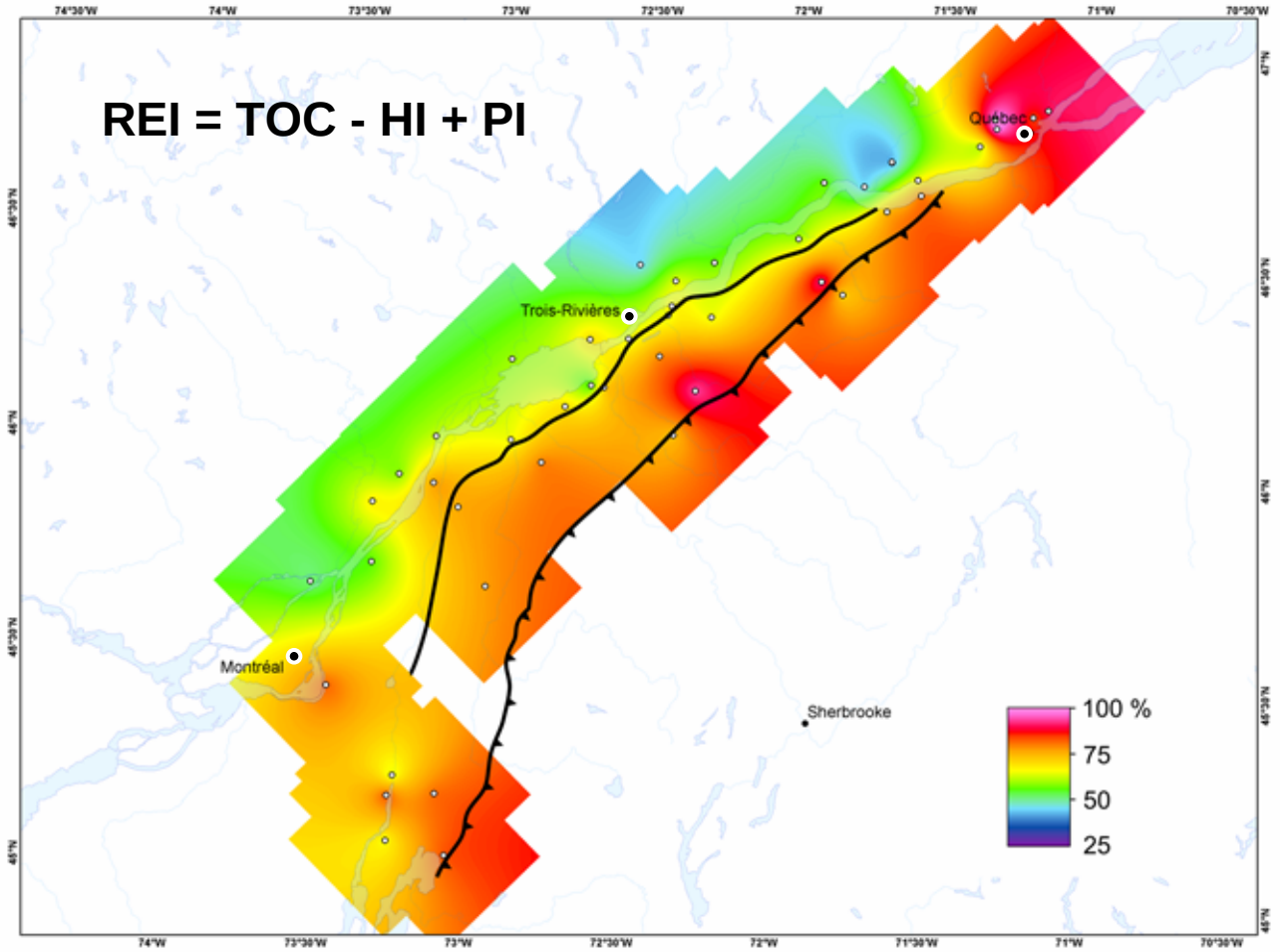
Ressources naturelles et Faune Québec

Rock Eval Index (REI) – Lower Utica



Ressources naturelles et Faune Québec

Rock Eval Index (REI) – Lower Utica



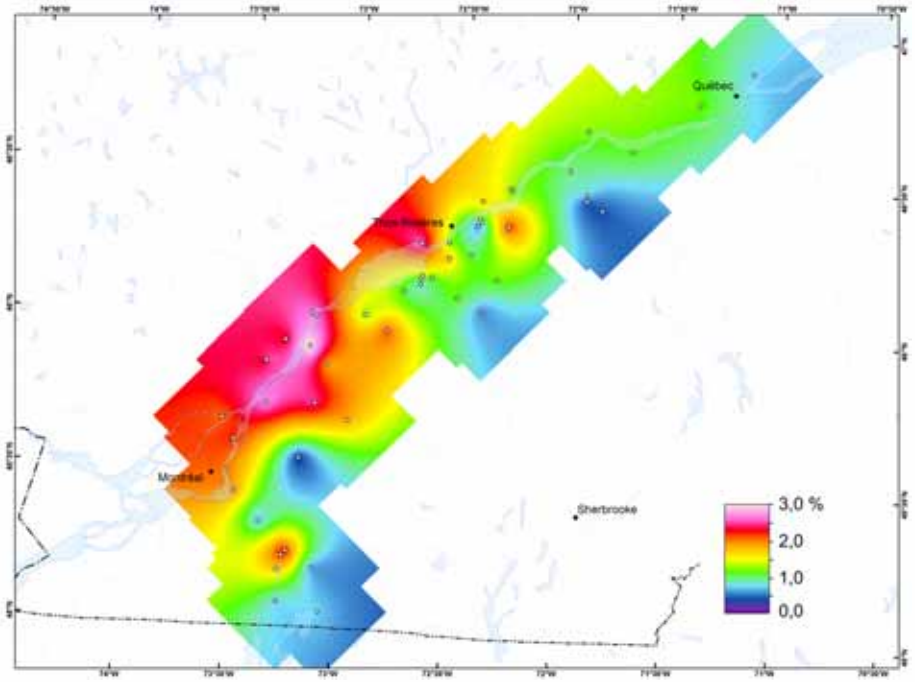
Ressources naturelles et Faune Québec

Summary - Rock Eval data (avg. values)

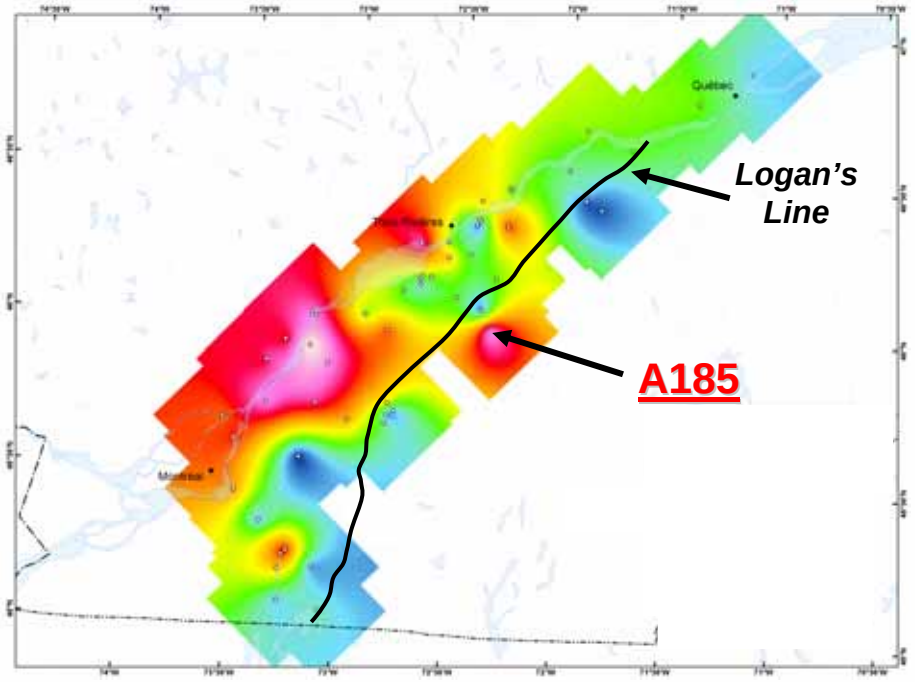
	LORRAINE	UPPER UTICA	LOWER UTICA
TOC	0.90%	1.21%	0.75%
S1	0.32	0.74	0.47
S2	0.40	0.92	0.57
HI	50	77	77
n	405	250	280

Maximum TOC - Lorraine (deep thrusts)

Max TOC - Lorraine (platform)



Max TOC - Lorraine (platform + thrusts)



Ressources naturelles et Faune Québec

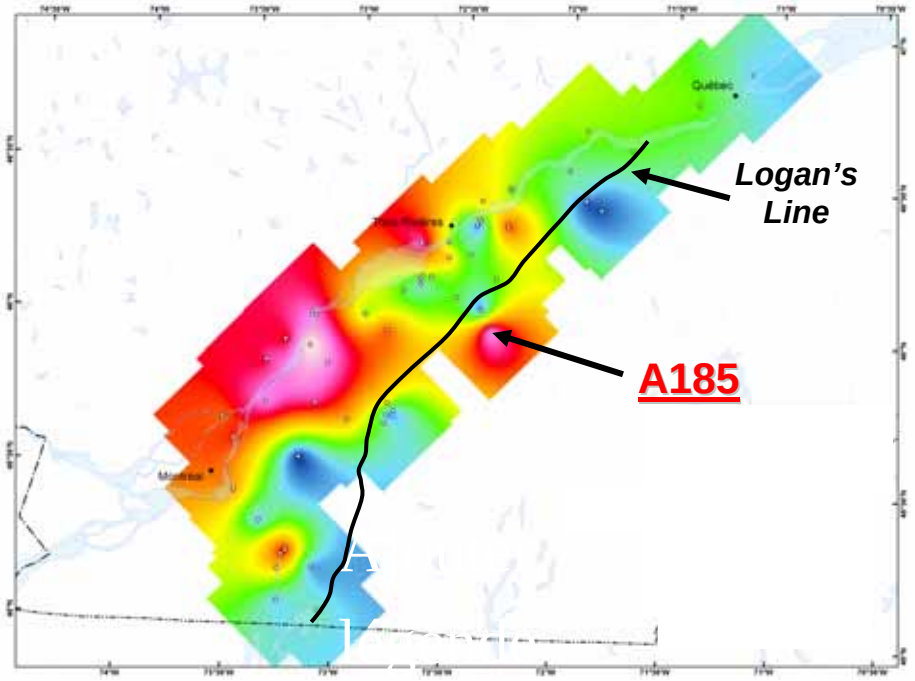
Maximum TOC - Lorraine (deep thrusts)

A185

Depth	TOC	HI
7750’	1.60%	49
13700’	2.99%	818

More rock eval analyses expected shortly from thrust sheets

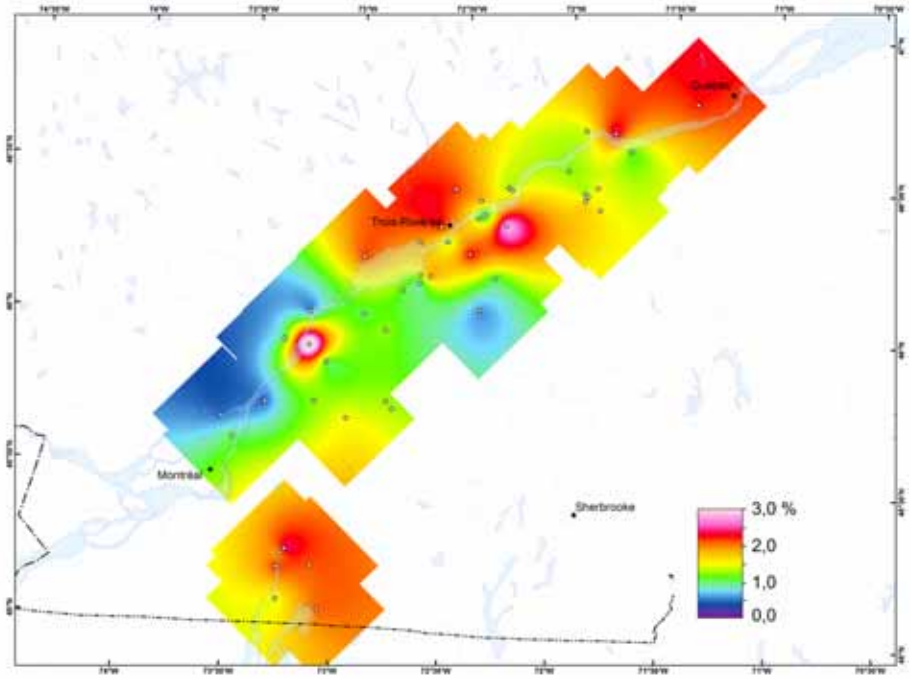
Max TOC - Lorraine (platform + thrusts)



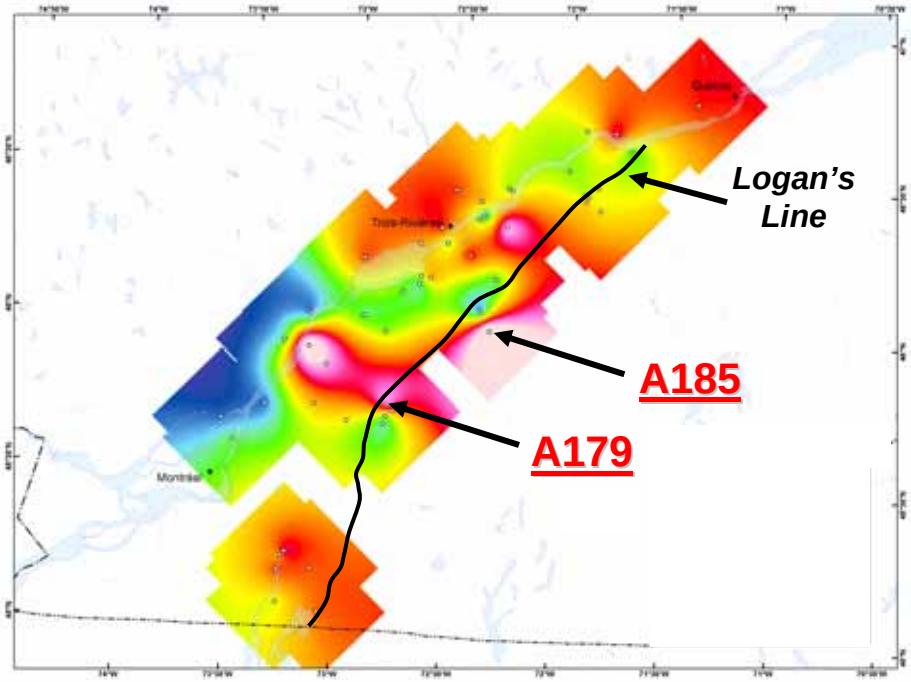
Ressources naturelles et Faune Québec

Maximum TOC - Upper Utica (deep thrusts)

Max TOC - Upper Utica (platform)



Max TOC - Upper Utica (platform + thrusts)



Ressources naturelles et Faune Québec

Maximum TOC - Upper Utica (deep thrusts)

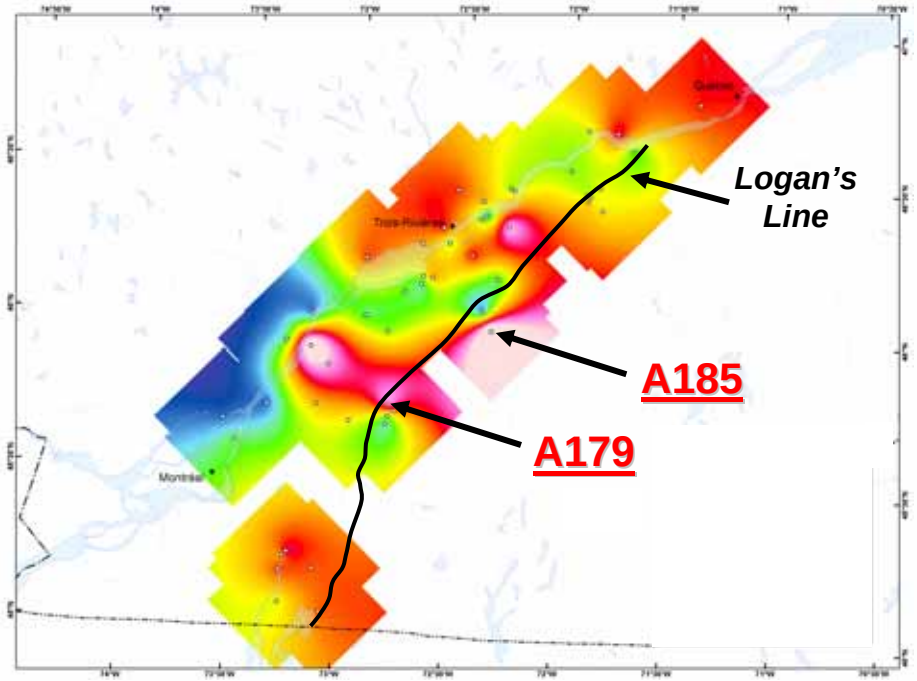
A185

Depth	TOC	HI
13500’	5.10%	807

A179

Depth	TOC	HI
4750’	2.38%	24
9250’	2.90%	12
9100-9600’ (>150 m)	2.00-3.00% (avg. 2.40%)	10-35 (avg. 20)

Max TOC - Upper Utica (platform + thrusts)



Ressources naturelles et Faune Québec

Conclusions

- **Three shale gas exploration fairways have been identified in the Utica / Lorraine sequence of the St. Lawrence Lowlands :**
  - **Shallow platform, biogenic/thermogenic play**
  - **Deep platform, thermogenic play**
  - **Deep thrusts, thermogenic play**
- **A fourth exploration fairway pertaining mainly to the Lorraine Group is present in the southern part of the Lowlands, being possibly related to the reactivation of E-W transform or normal faults originally formed during the Cambrian rifting of Laurentia**
- **Additional results are expected shortly, especially from the deeper, TOC-rich thrust sheets;**
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