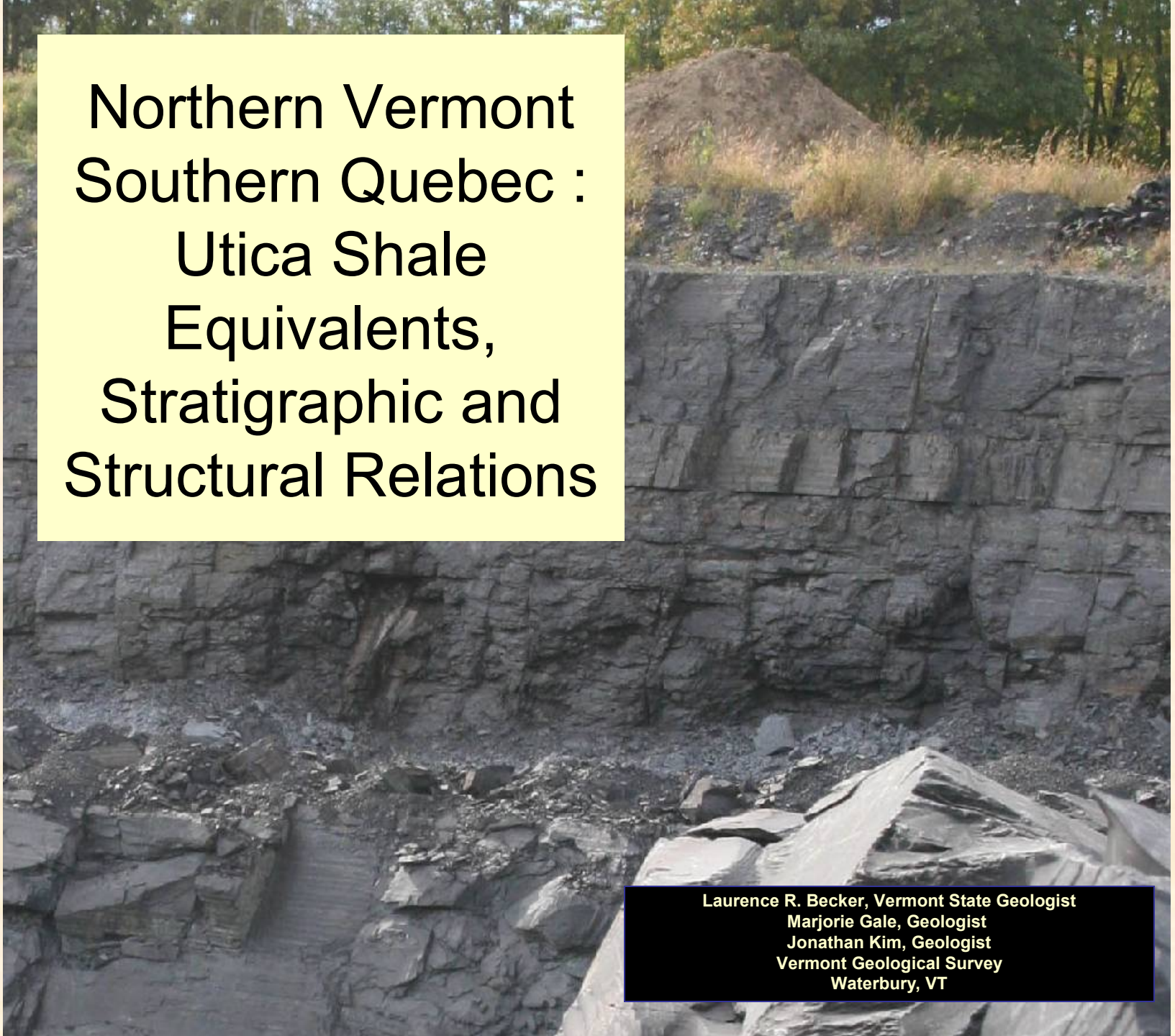
Northern Vermont Southern Quebec : Utica Shale Equivalents, Stratigraphic and Structural Relations



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Marjorie Gale, Geologist
Jonathan Kim, Geologist
Vermont Geological Survey
Waterbury, VT

Summary of Presentation

- Stratigraphic nomenclature in the Vermont Champlain Islands is consistent with Cambro-Ordovician units described in Noyan, Quebec

- A 1965 Alburg #1 American Petrofina log is correlated with Quebec seismic line Q118 as reported in Sejourne et.al. (2003)

- An idealized section from Fisher (1968) is employed in the correlation

Summary Continued:

- Black Stony Point is equivalent to Utica and black to dark gray to black Iberville likely compares to Lorraine rocks
- An interpreted cross section shows up to 1.8 km of thrust repeated shales
- Shales structurally overlie an autochthonous sequence and peripheral bulge normal faults beneath the flysch units
- Vermont stratigraphic and structural relations are consistent with Quebec fairway maps.

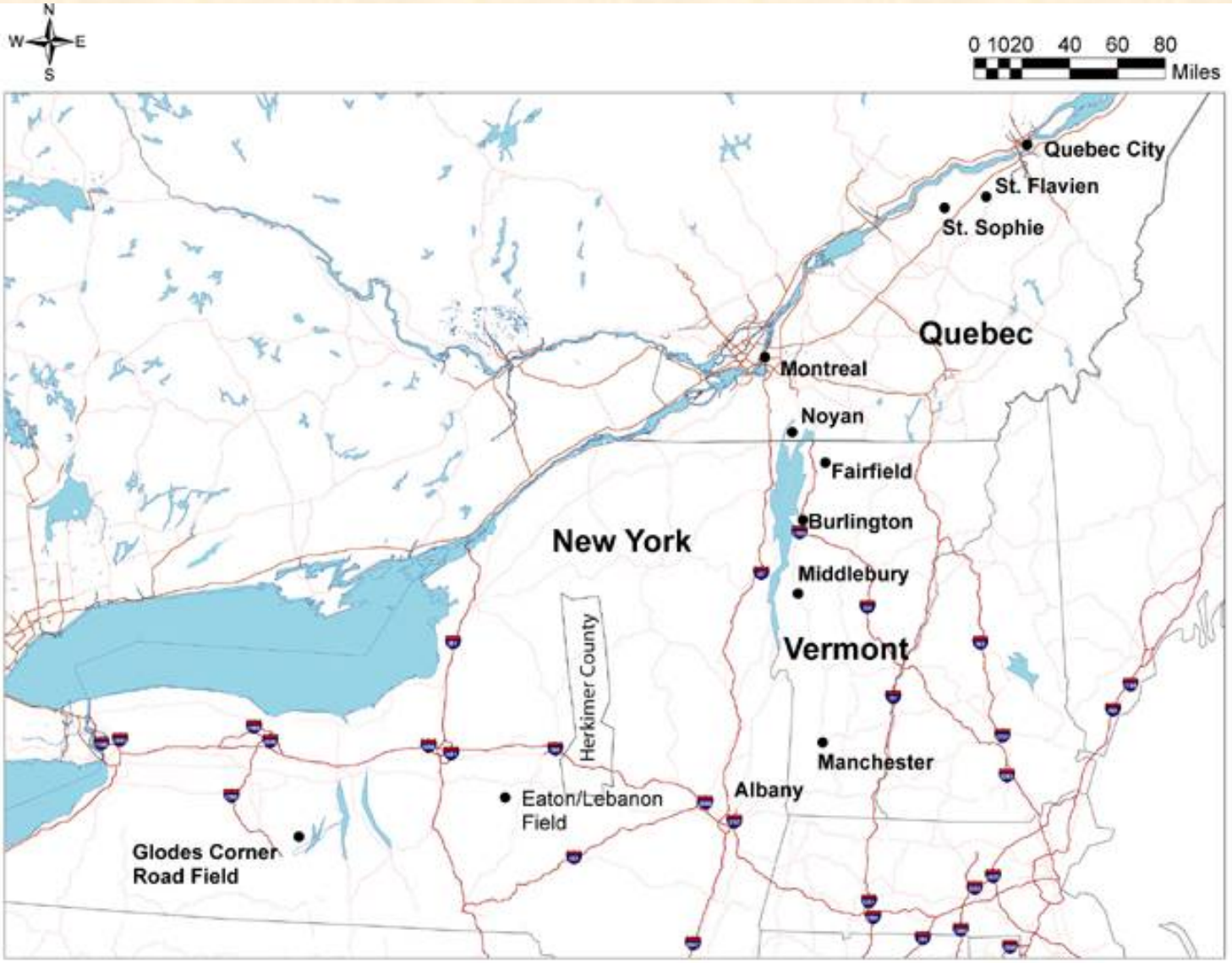


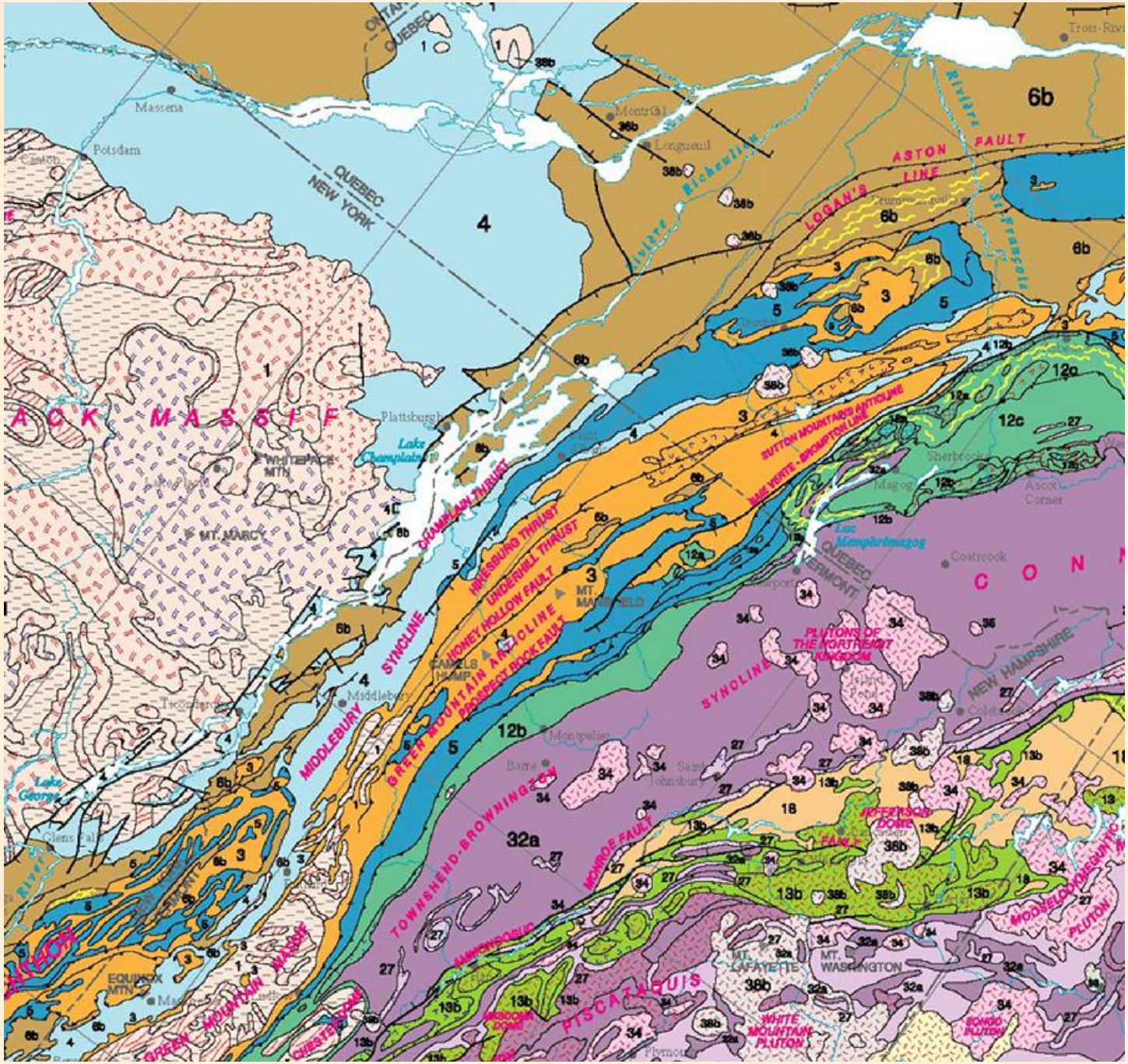
Figure 1: Location map of New York and Vermont and Quebec, Canada.

Regional Tectonics

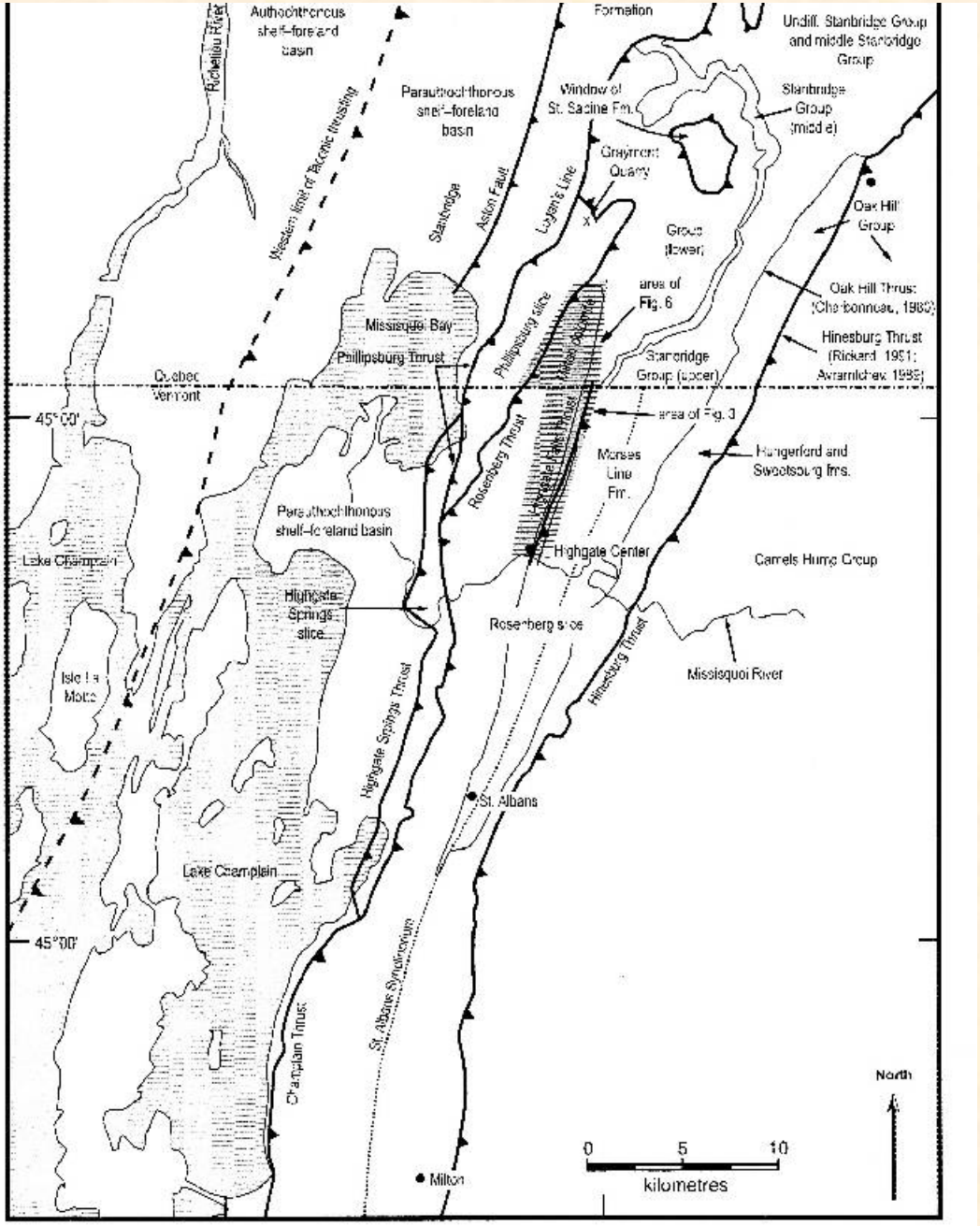
- Proterozoic rift faulting
- Drift and the formation of passive margin
- Initiation of subduction Late Cambrian
- Onset of normal faulting associated with the peripheral bulge - late Early Ordovician
- Initiation of Taconian (Middle Ordovician) thrusting and associated syn-orogenic deposition of shales
- Mesozoic normal faults

Regional Map

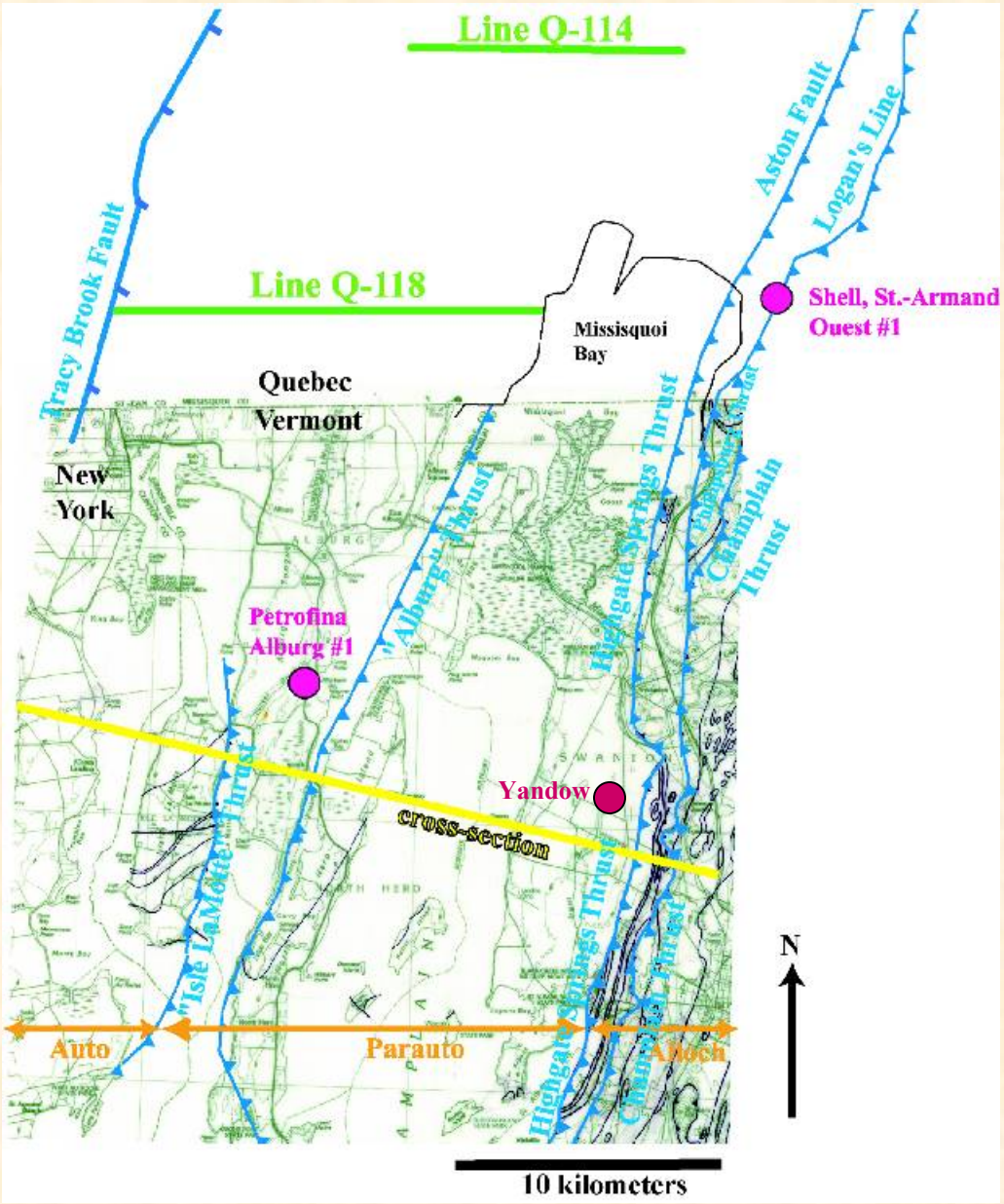
- **Autochthonous Domain – Grenville basement, platform rocks in NY and western Lake Champlain, and at depth in VT**
- **Para-autochthonous – Thrust faults in flysch on the Champlain Islands and west of the Highgate Springs thrust**
- **Allochthonous –**
  - **Lower Middle Cambrian to Middle Ordovician rocks on thrust upper plates**
  - **Highgate Springs Thrust /……Aston?**
  - **Champlain Thrust/Logan's Line including the Phillipsburg slice**



Hibbard, et.al.,2006

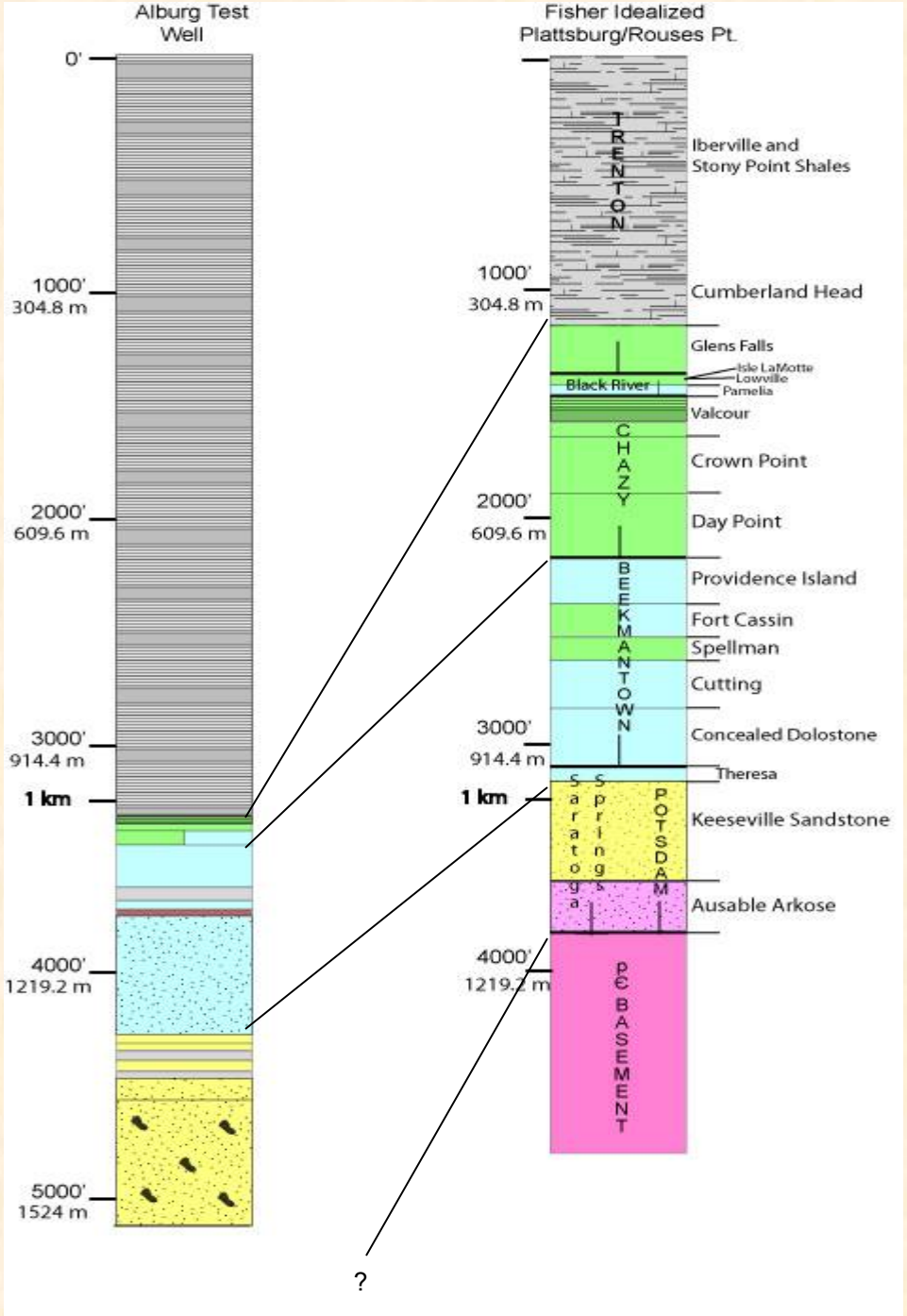


Schoonmaker and Kidd, 2007


Line Q-114
Line Q-118
Tracy Brook Fault
Aston Fault
Logan's Line
Shell, St.-Armand Ouest #1
Missisquoi Bay
Quebec
Vermont
New York
Alburg Thrust
Highgate Springs Thrust
Champlain Thrust
Petrofina Alburg #1
Isle LaMotte Thrust
Yandow
cross-section
Highgate Springs Thrust
Champlain Thrust
Auto
Parauto
Anoch
N
10 kilometers

Studies Referenced for Vermont Analysis

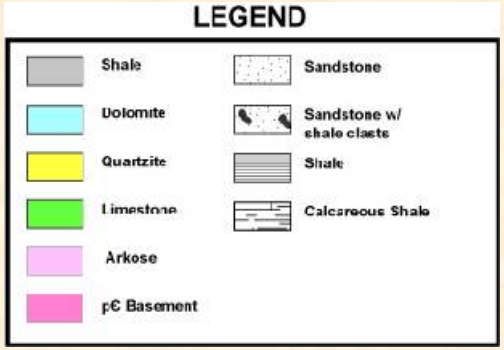
- Erwin, R.B., (1957) - Isle La Motte and South Hero Islands, VT
- Welby, C.W., (1961) - Central Champlain Valley, VT
- Fisher, D.W., (1968) - Plattsburgh and Rouses Point Quads, NY/VT
- Fisher, D. W.; Isachsen Y. W. and Rickard, L. V., (1970), New York State Map
- Mehrtens, C., Doolan,B, and Stanley, R. (1997), Lake Champlain North
- Junex/CCNMathews Press Release (2001) – Lacolle/Noyan Quebec
- Sejourne, S., Dietrich,J., and Malo, M. (2003) - Seismic Character of Southern Quebec Appalachians
- Wallach, J.L., and Mir Teledetection, (2004) Champlain Valley in NY



Alburg #1 Log

and

Fisher Stratigraphy (Idealized)



Alburg well compared to Fisher idealized

- Limestones very thin – Chazy, Black River -Trenton
- Beekmantown thickness similar to Fisher (Idealized)
- Potsdam thickness is similar but the Alburg well did not penetrate to basement
- Shale thickened by multiple thrust and/or by down dropped section filled in with flysch
- Limestones are thin due to thrust truncation or an upthrown block followed by erosion

Shale

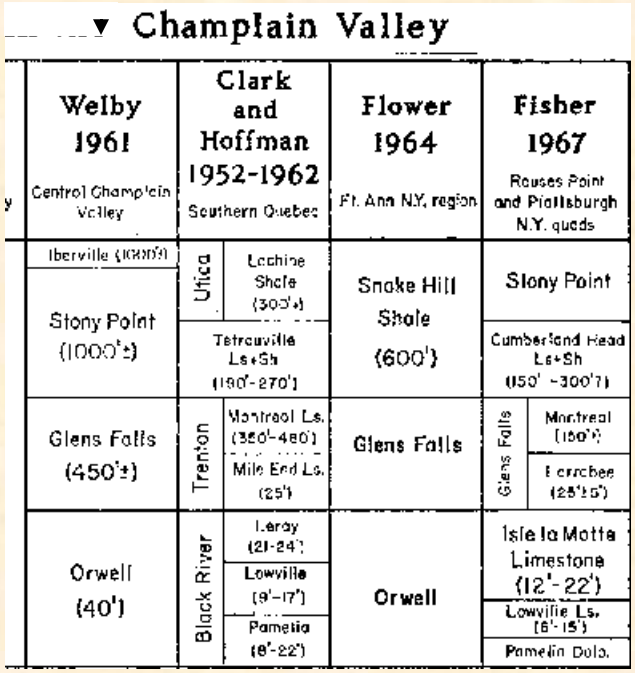
- Stony Point – Upper Ordovician, black, fissile, carbonaceous, calcareous shale (Fisher, Northern, VT)

- Iberville - Upper Ordovician, dark gray to black splintery fracturing noncalcareous shale (Fisher, Northern VT)

Shale – con't

- Stony Point – Also, limestone intervals, thin beds of black, calcitic dolostone or dolomitic limestone, some quartz, white calcite veins in rupture zones (Welby, Central VT)

- Mineralogy, TOC, Type of C, Tmax, Ro, HI, TR - Proposed to be studied



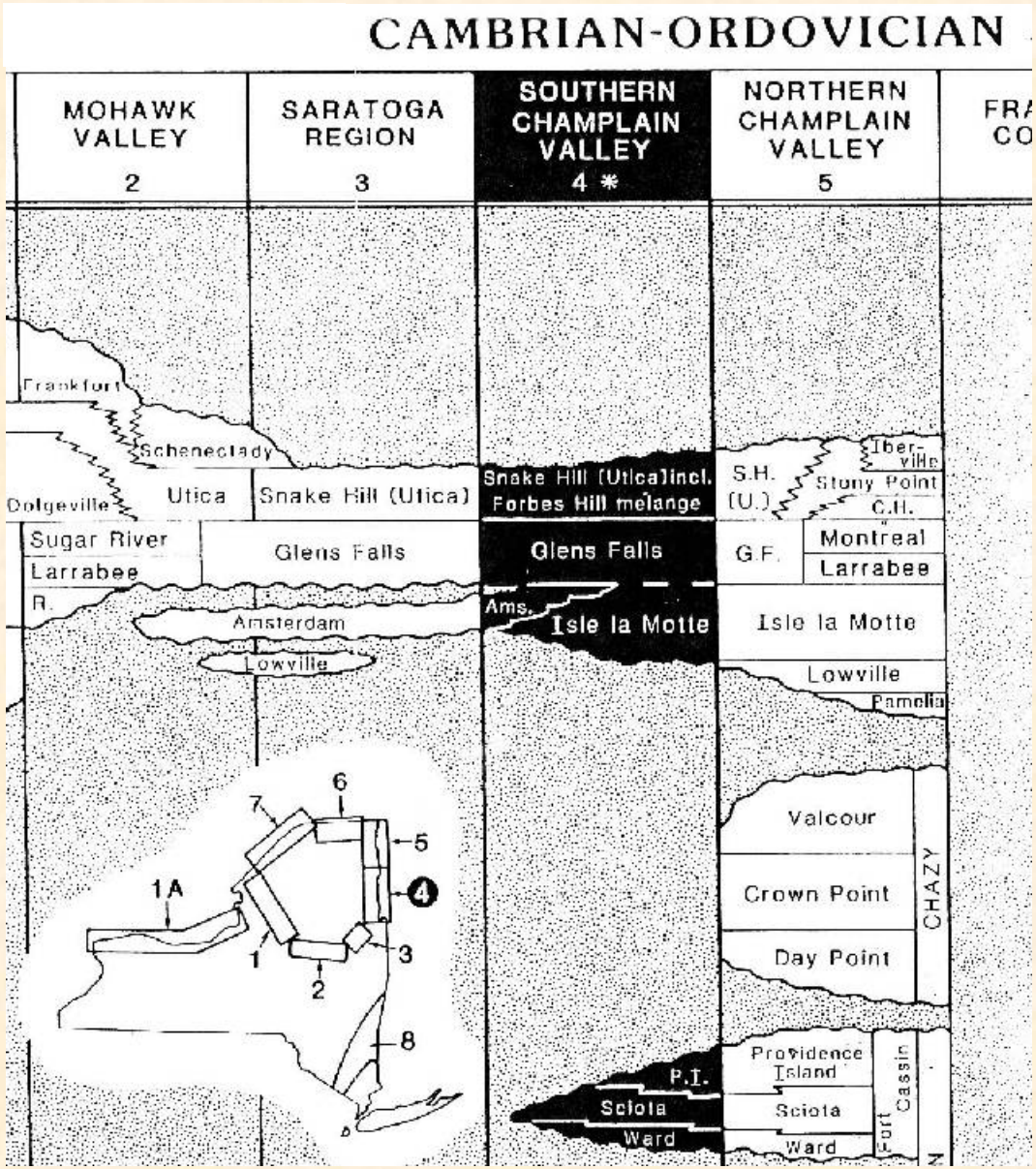
Fisher, D.W., (1968)

Special Bulletin No. 1

Vermont Geological Survey

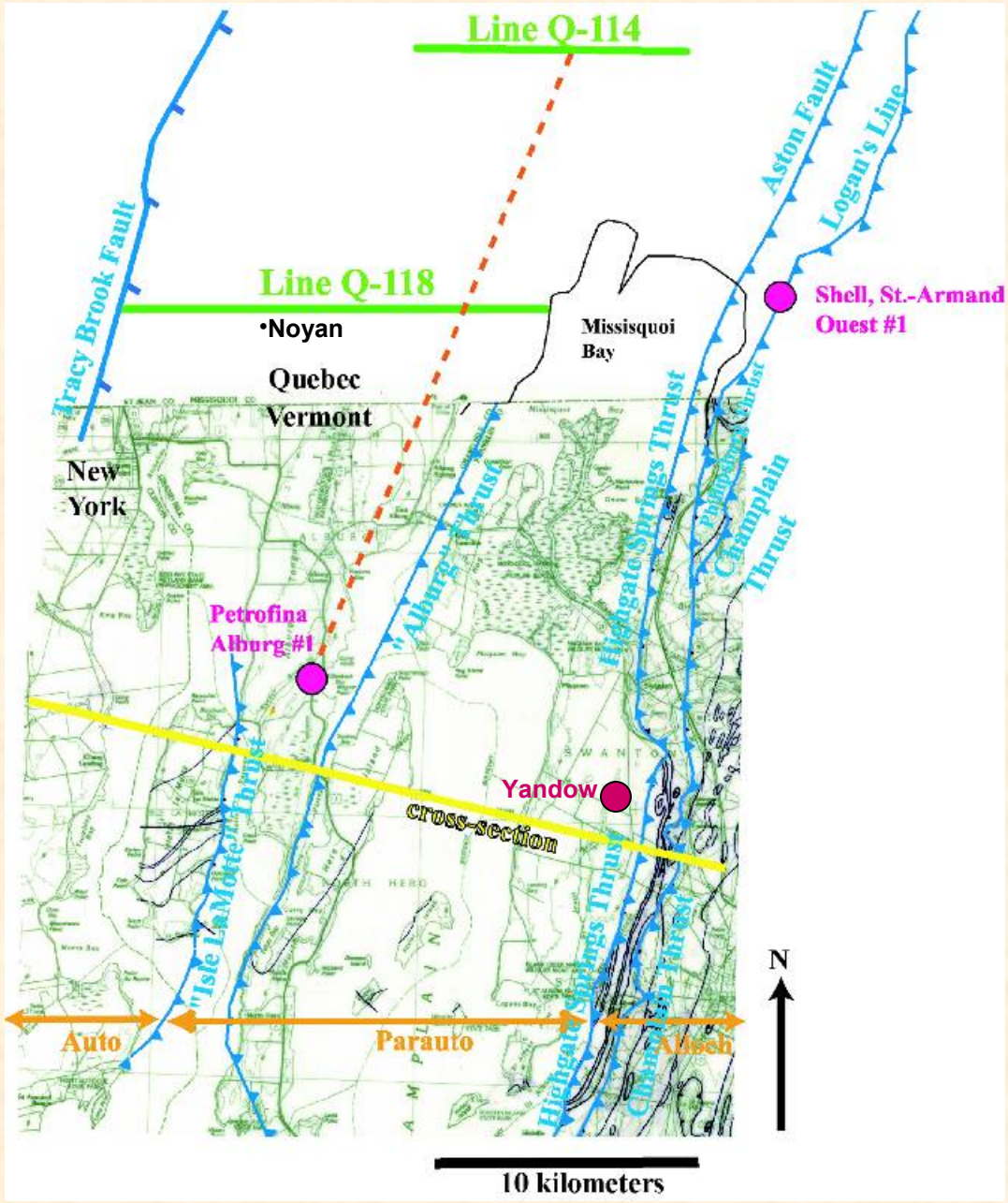
STONEY POINT

UPPER ORDOVICIAN



Fisher, D.W., New York State Geological Survey, (1981)

STONEY POINT – UPPER ORDOVICIAN


Line Q-114
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Petrofina Alburg #1
Yandow
cross-section
"Isle LaMotte" Thrust
Highgate Springs Thrust
Champlain Thrust
Auto
Parauto
Allochthon
N
10 kilometers

Seismic line Q118 – **Sejourne et al interpretation employs Globensky review of St. Armand #1 well to east**

- Flysch units (gray); Trenton – Black River (green); Chazy/Beekmantown (teal); Potsdam (yellow); and Basement (pink)
- Alburg well projected onto Q118 parallel to regional structure
- Hypothetical well shows seismic line interpretation of units
- Km scale from Globensky's comparison to seconds scale

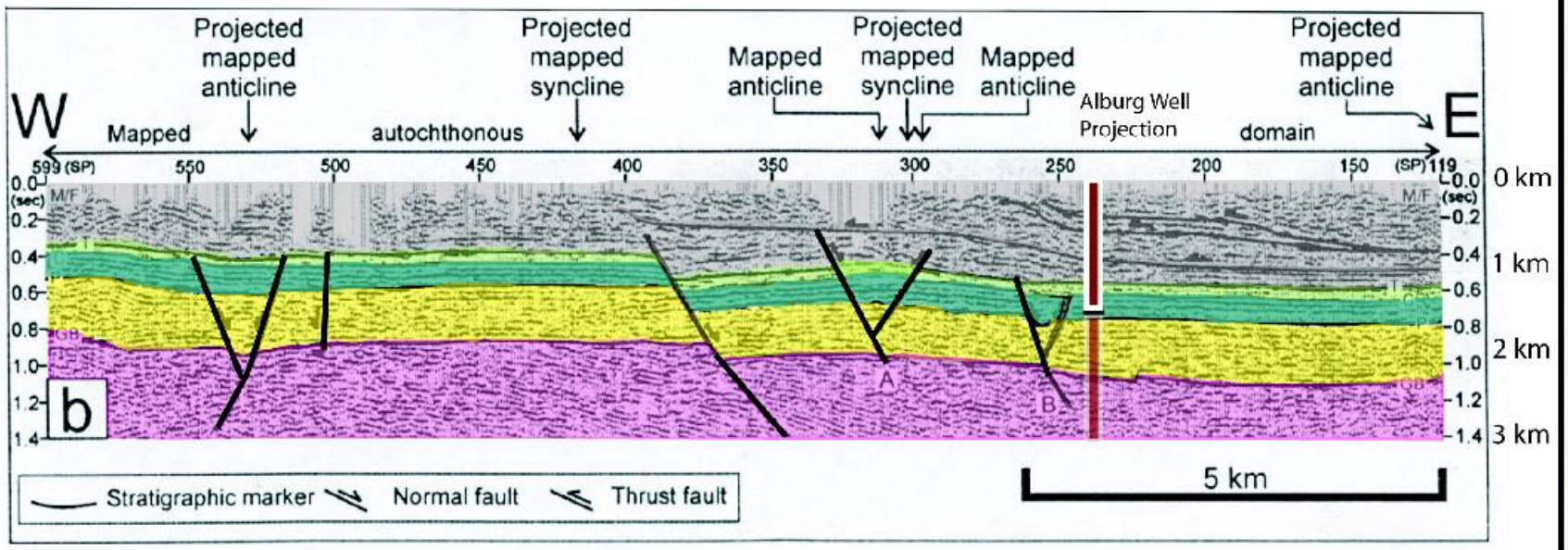
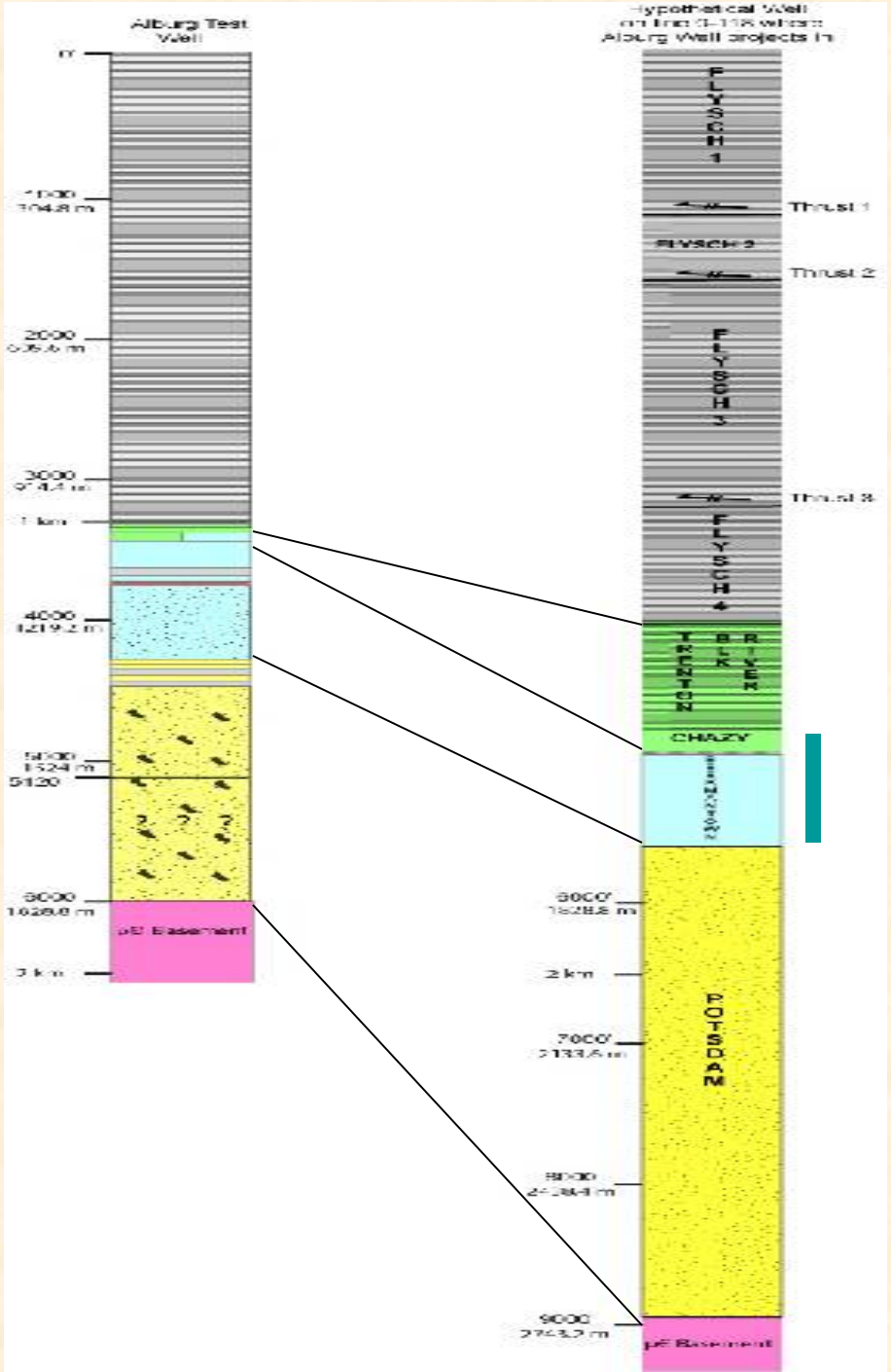


Fig. 5. (a) Migrated, multifold seismic line BHP Q-118. Box with dashed line indicates location of Figure 12. SP = Shot point. **(b)** Proposed structural interpretation. M/F = Undifferentiated molasse and flysch units, T = top of Trenton Group, C = top of Chazy Group, P = top of Potsdam Group, GB = top of Grenvillian basement, A = normal fault with associated rollover, B = normal fault referred to in Figure 11.

Modified from Sejourne et.al., 2003



Alburg #1 Log with Interpreted Potsdam Thickness

Hypothetical Well on Q118 Projecting in Alburg Well

LEGEND

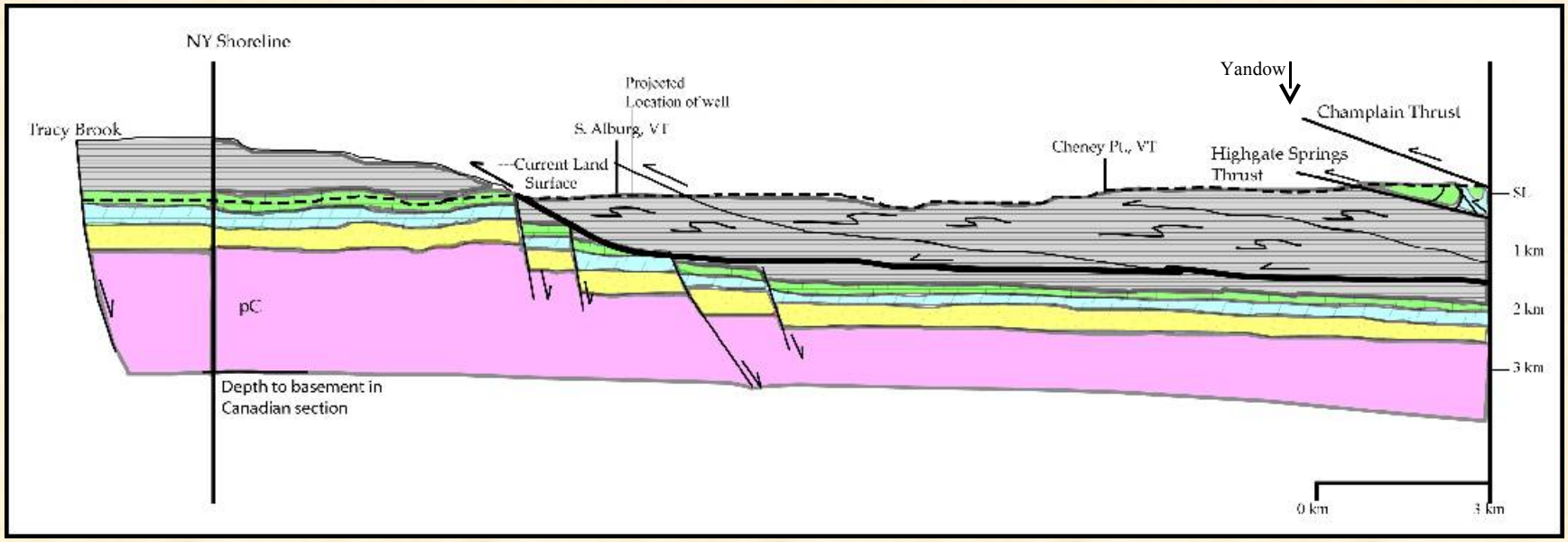
- Shale
- Sandstone
- Dolomite
- Sandstone w/ shale clasts
- Quartzite
- Shale
- Limestone
- Calcareous Shale
- Arkose
- pC Basement

Alburg #1 Log compared to Q118 Hypothetical

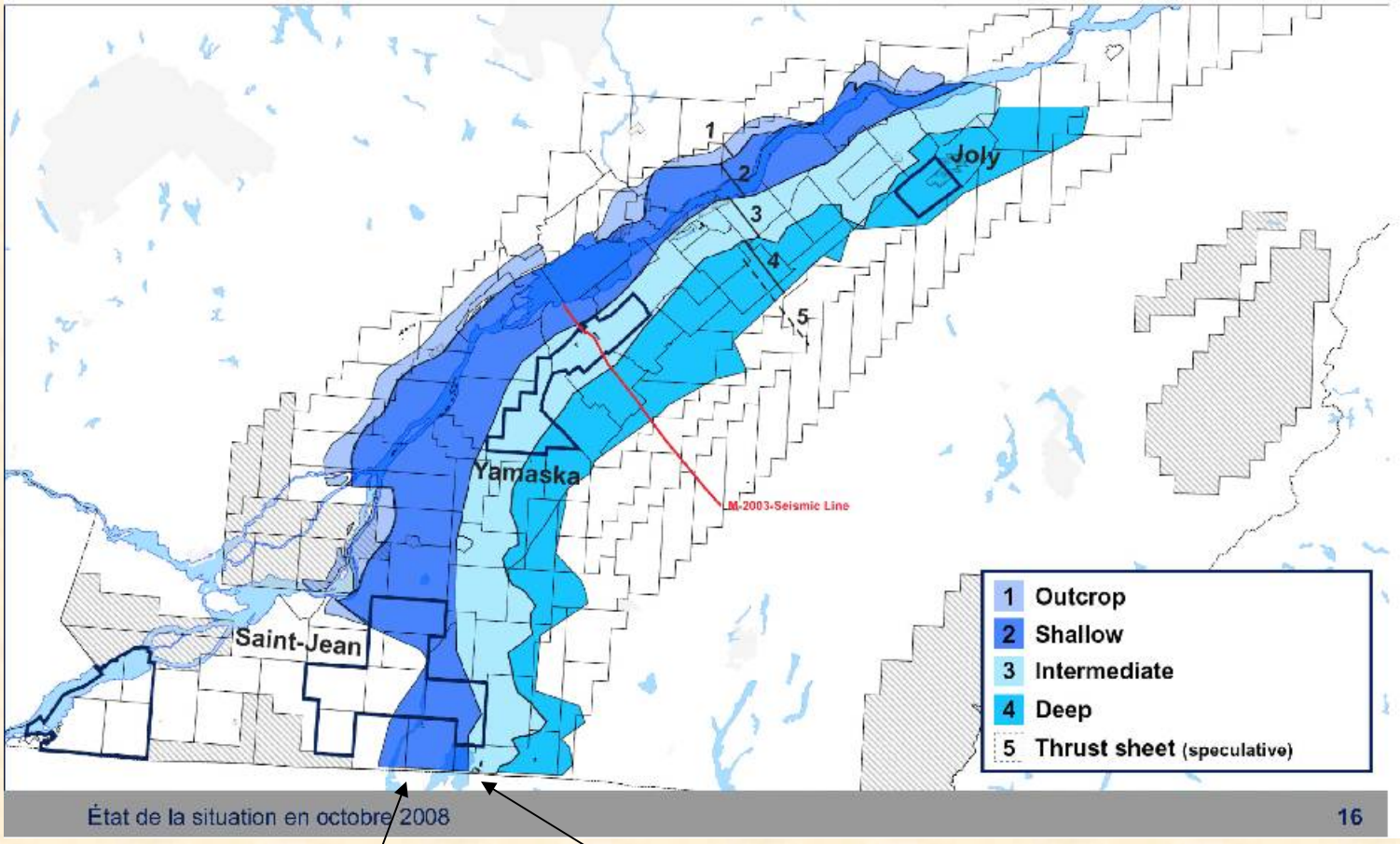
- Thickening of shales by thrusting is supported by mapping in Vermont and Q118 flysch
- Shale in south Alburg is thicker than Fisher idealized - 366 meters (1,200 feet)
- Shale thicker east and north of Alburg well
- Yandow well, 1,371 meters (4,500 ft) of shale to east of Alburg well supports

Cheney Point – Interpretive X Section

- Autochthonous domain on west side of x section
- Normal faults west of Alburg well dropped down basement to ~ 1820 meters (~6000')
- Could be more normal faults of varying ages
- East west normal faults are needed to drop to basement at ~ 2740 meters (~9000') on Q118
- Thickest repeated shales east side of x section - approximately 1.8 km
- Western most thrust is lowest in sequence of west directed thrusts in the shales



Le « fairway » des shales de l'Utica



État de la situation en octobre 2008

16

Champlain Islands

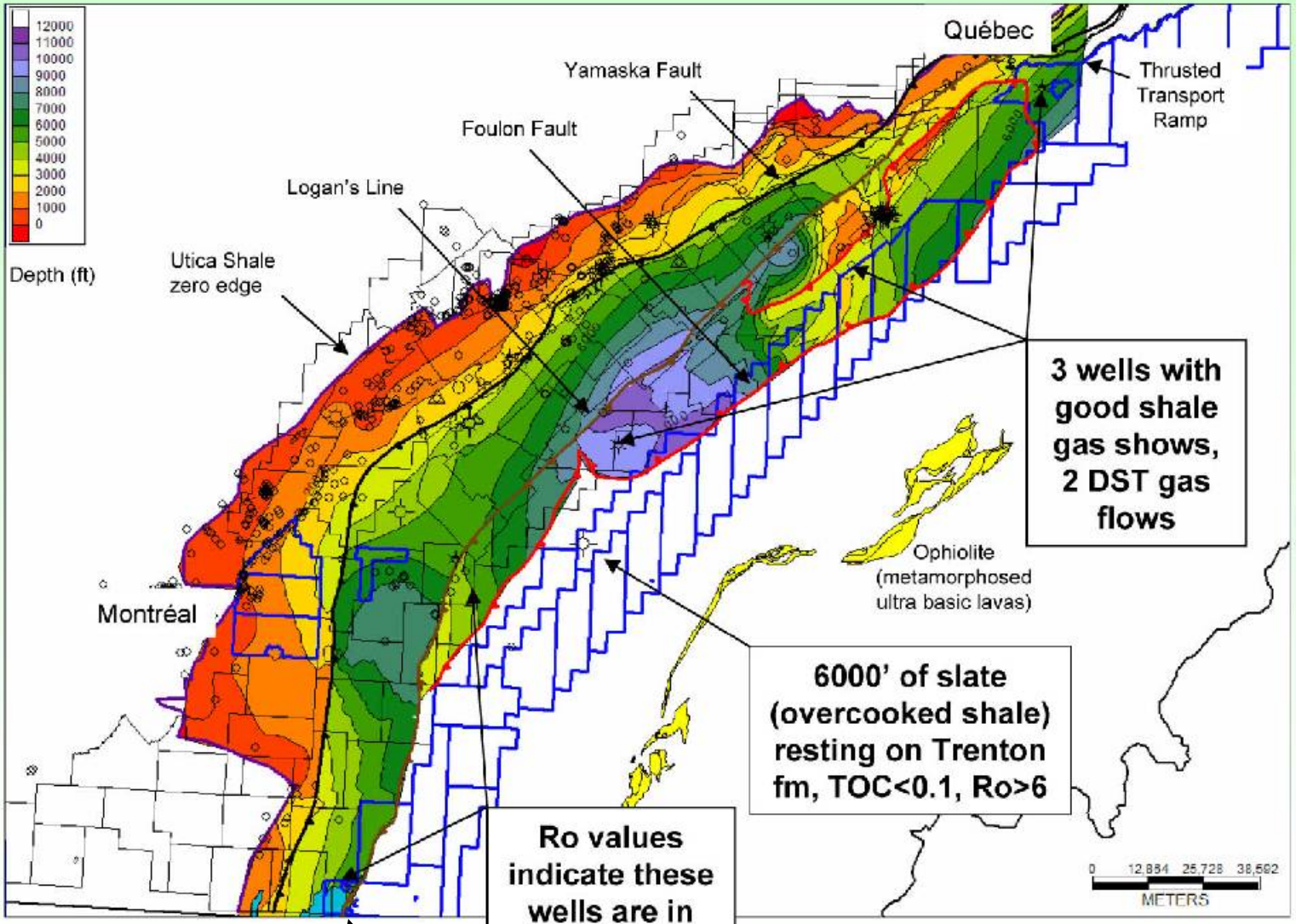
Vermont Border – Pipeline Enters

Depth to Base Utica Fm / Top Trenton Fm

MOLOPO

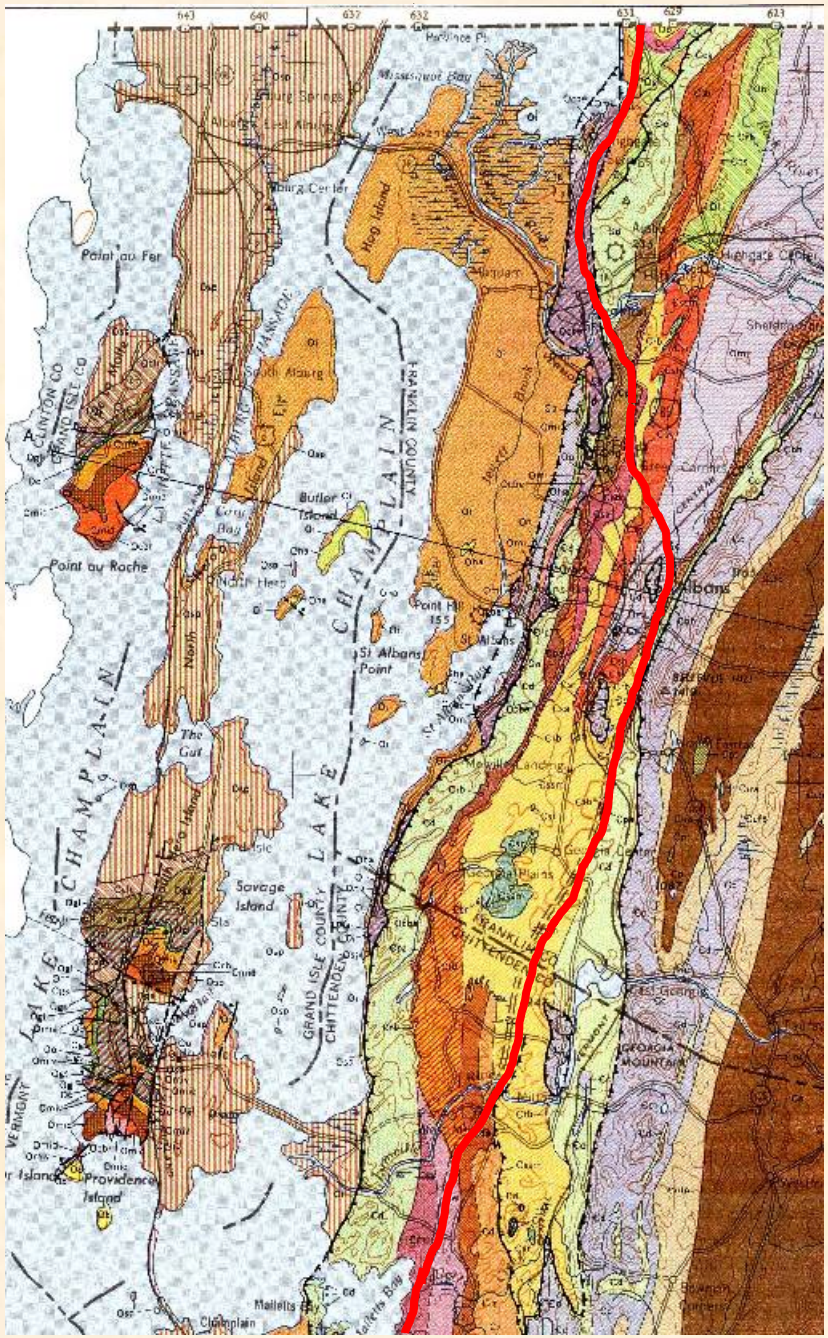
CANADA,

Nov 2008



Champlain Islands

Vermont Border –Pipeline Enters



Red Line:

General Location of Natural Gas Pipeline

Pipeline Capacity

Total System Capacity is 66,175 MMcfd

Conclusions

- Alburg Test Well
  - Contact between the flysch and thin carbonate section is interpreted as a thrust fault
  - Thinning of carbonates could be related to normal fault tectonics (Ordovician)
  - Shale thickened by multiple thrusts and/or by down dropped section – 1000 meters

- An interpreted cross section and Q118 indicate that depth to basement increases both to the north and east. Yandow well supports thickening of shale to east that is estimated to be up to 1.8 km. Thickest shale is in proximity to gas pipeline.

- Vermont stratigraphic and structural relations are consistent with Quebec fairway maps.