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INTRODUCTION

Studies of reprocessed seismic reflection data are providing new insights into subsurface structure and tectonic evolution of the St Lawrence Platform and Quebec Appalachians. A key data-set currently being evaluated is a trio of seismic reflection profiles recorded in 1978 for the Government of Quebec (Ministère des Ressources Naturelles du Québec (MRNQ); Fig. 1). These data were originally acquired to promote petroleum exploration in the region. The seismic lines (M-2001, Fig. 2; M-2002, Fig. 3; M-2003, Fig. 4) represent a total of 270 line-km of data. Line M-2001 is the longest profile, extending across the full width of the Appalachian belt in southern Quebec. All three lines cross the St Lawrence platform and mapped surface position of the Appalachian structural front (Logan's Line). The seismic data were recorded using a Vibroseis source, 58-12 Hz sweep, 48 channels, and 12 fold coverage. The original processed sections were released in open file (by MRNQ) in 1979. Interpretations of line M-2001 were presented in several papers published in the 1980s. There have been no published descriptions of lines M-2002 or M-2003.

Post-stack reprocessing of MRNQ seismic data was conducted to determine if data quality could be improved by using modern seismic processing technology. The reprocessing was carried out at the Geological Survey of Canada, using a ProMAX™ seismic processing system. The input digital files were original, unfiltered stack data. Processing steps applied were bandpass filter, F-X deconvolution, dip scan (slant) stack, Kirchoff time migration, and (for line M-2001) trace amplitude equalization. Time migration was based on smoothed stacking velocities. The reprocessed data show significant improvements in quality of reflection images (Fig. 5). This poster presents preliminary interpretations of (reprocessed) seismic line M-2001 and observations from line 2003 and part of line 2002. The seismic sections presented here are migrated data, illustrated with variable intensity displays.

GEOLOGICAL SETTING

The Lower Paleozoic Laurentian continental margin in southern Quebec consists of the autochthonous St. Lawrence lowlands platform, the parautochthonous foreland fold and thrust belt, and the allochthonous Appalachian nappes. The Aston fault and Logan's Line mark the boundary between these tectonostratigraphic domains. The St. Lawrence platform is bounded to the north and underlain by Precambrian (Grenville) basement rocks. The Appalachian belt consists of: the internal and external Humber zones, distinguished by contrasting deformation and metamorphic characteristics; the oceanic and ophiolitic Dunnage zone; and the Silurian-Devonian Connecticut Valley-Gaspé Synclinorium (Gaspé Belt).

Stratigraphy

The St. Lawrence platform consists of Cambrian to Lower Ordovician siliciclastic strata of the Potsdam Group, overlain by Lower to Upper Ordovician carbonate strata of the Beekmantown, Chazy, Black River and Trenton groups. The platform succession is overlain by Upper Ordovician fine-grained siliciclastic strata of the Utica, Sainte Rosalie and Lorraine groups, which in turn are capped by the uppermost Ordovician Queenston Group. The Upper Ordovician clastics are syn-orogenic foreland deposits. The Humber zone in the area of the MRNQ lines consists of Cambrian to Ordovician continental margin rocks including the Oak Hill Group (rift-drift), the Caldwell Group and Bennett Schists (passive margin), Drummondville Oliststrome, and foreland-basin strata. The oceanic Dunnage zone contains ophiolitic complexes, volcanic rocks, melanges (St. Daniel Mélange), and syn-orogenic flysch deposits.

Structure

The St. Lawrence Platform developed as a continental rift zone and subsequent passive continental margin. The Humber zone formed in response to destruction of the outer continental margin during Middle to Late Ordovician accretion of oceanic terranes (a tectonic phase classically referred to as the Taconian Orogeny). The Taconian event in the Humber zone is manifested by northwest-directed thrust faulting, foreland-propagating nappe emplacement, and regional prograde metamorphism. Renewal of tectonic activity during the Silurian-Early Devonian resulted in backthrusting, extensional faulting, and retrograde metamorphism in the internal Humber zone. The Connecticut Valley-Gaspé Synclinorium developed in an extensional setting during this tectonic phase. The Humber and Dunnage zones and Gaspé Belt were variably deformed during the Middle to Late Devonian Acadian Orogeny.

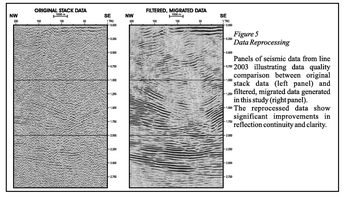
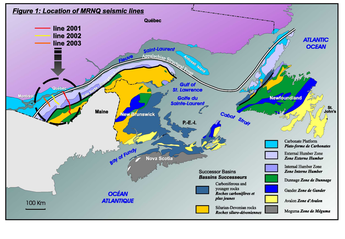


Figure 5
Data Reprocessing

Panels of seismic data from line 2003 illustrating data quality comparison between original stack data (left panel) and filtered, migrated data generated in this study (right panel).
- The reprocessed data show significant improvements in reflection continuity and clarity.



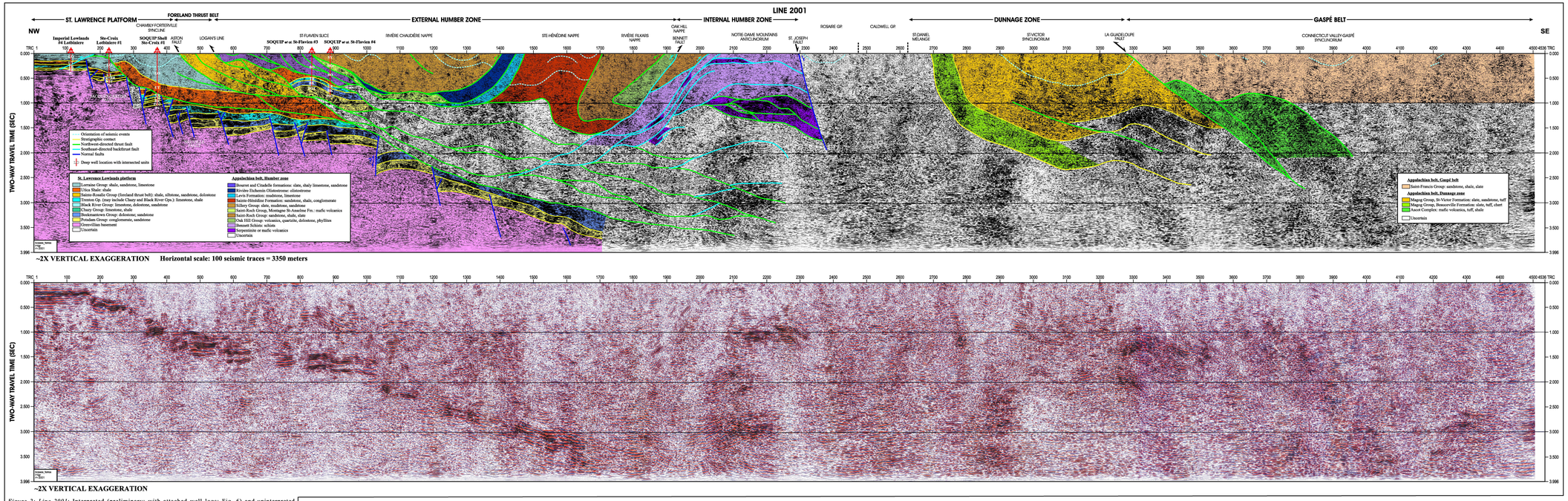
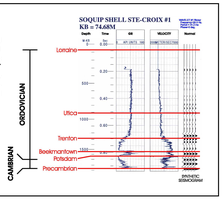


Figure 2; Line 2001: Interpreted (preliminary; with attached well logs; Fig. 6) and uninterpreted displays of (150 km-long) line 2001. The architecture of the Appalachian belt can be described in terms of structures and tectonostratigraphic domains: from northwest to southeast; the Chambly-Fortierville syncline; Logan's Line; the St. Flavien slice, a thrust sheet of platform carbonates (containing the only commercial gas field discovered in the region to date); the Chaudière, Sainte-Hénédine, Rivière Filkars, and Oak Hill thrust sheets (nappes); the Bennett fault (a backthrust fault); the Notre-Dame Mountains anticlinorium (NDMA) which forms the metamorphic core of the internal Humber zone; the St. Joseph fault, a SE-dipping normal fault; the St. Victor synclinorium (containing oceanic rocks of the Dunnage zone); and the Guadeloupe fault, an Acadian reverse fault that forms the margin of the Connecticut Valley-Gaspé synclinorium.

New observations from reprocessed line M-2001 include:
1) thrust and fold structures northwest of the mapped structural front, within the St. Lawrence platform, for example;
2) a possible incipient triangle zone structure located above a footwall ramp of the principal Appalachian décollement. In that scheme, the Chambly-Fortierville syncline may be viewed as fault ramp associated fold.
3) the surface location and sub-surface geometry of Logan's line are still, after reprocessing, a challenge to interpret. However, to the southeast in its footwall, the conspicuous Saint-Flavien structure is well-imaged. The latter is interpreted as a detached and folded sheet of platform sequence that was transported along a thrust fault, which progressed over a footwall ramp induced by a major step in the rifted margin geometry.
4) presence of both extensional and compressional structures within the platform, including southeast- and northwest-dipping faults, forming half-grabens.
5) platform overlap features, possibly related to fault inversion (e.g. tr. 1050).
6) shallow sub-horizontal décollement beneath Chaudière and Ste-Hénédine nappes
7) steep dipping margins of the NDMA, including NW-dipping footwall splays of the Bennett fault (marked by serpentinite slivers) and SE-dipping St. Joseph fault, which based on abrupt termination of strong reflector events below the NDMA (at seismic trace 2300 between 1.0 and 1.3 second) indicate that the fault reaches that depth.
8) geometry of stacked thrust wedges within the NDMA.
9) rotation of reflectors in hanging wall of La Guadeloupe fault, possibly indicating the early history of Siluro-Devonian extension, prior to Acadian thrusting.
10) the seismic imagery of the Connecticut Valley-Gaspé synclinorium displays significant differences of orientation depending of depth: Between shallow (0.6 sec) reflectors showing the synformal structure and deeper events that are mostly sub-horizontal. The decoupling of orientation may represent a major break or discontinuity, such as a décollement or an unconformity marking the base of the basin.

Figure 6; Synthetic Seismogram

Gamma ray and interval velocity log curves (with annotated stratigraphy), and seismic traces for the Ste-Croix No. 1 exploration well (see Fig. 2 for location). The synthetic traces display typical contrasts between low amplitude reflections of the upper Ordovician foreland succession (predominantly shale) and high amplitude reflections of the Cambro-Ordovician platform (carbonates and sandstones). This well tested a platform fault block at northwest end of line 2001.



Acknowledgments

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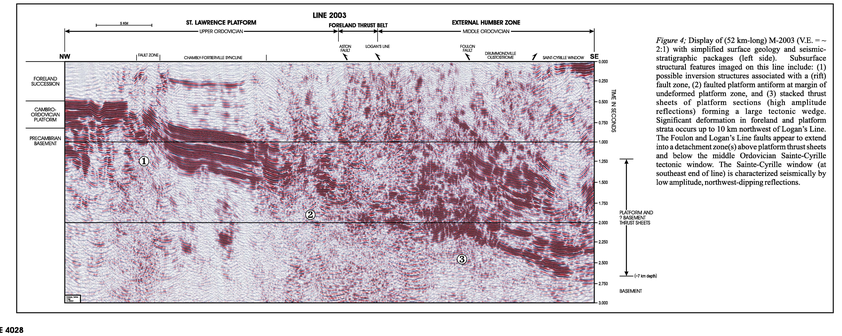

Figure 4; Display of (52 km-long) M-2003 (V.E. = ~ 2:1) with simplified surface geology and seismic-stratigraphic packages (left side). Subsurface structural features imaged on this line include: (1) possible inversion structures associated with a (rift) fault zone, (2) faulted platform antiform at margin of undeformed platform zone, and (3) stacked thrust sheets of platform sections (high amplitude reflections) forming a large tectonic wedge. Significant deformation in foreland and platform strata occurs up to 10 km northwest of Logan's Line. The Foulon and Logan's Line faults appear to extend into a detachment zone(s) above platform thrust sheets and below the middle Ordovician Sainte-Cyrille tectonic window. The Sainte-Cyrille window (at southeast end of line) is characterized seismically by low amplitude, northwest-dipping reflections.

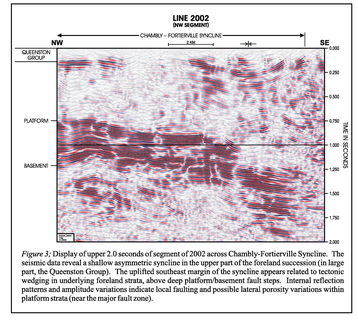

Figure 3; Display of upper 2.0 seconds of segment of 2002 across Chambly-Fortierville Syncline. The seismic data reveal a shallow asymmetric syncline in the upper part of the foreland succession (in large part, the Queenston Group). The uplifted southeast margin of the syncline appears related to tectonic wedging in underlying foreland strata, above deep platform/basement fault steps. Internal reflection patterns and amplitude variations indicate local faulting and possible lateral porosity variations within platform strata (near the major fault zone).

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STRUCTURAL ARCHITECTURE OF THE ST. LAWRENCE PLATFORM AND QUEBEC APPALACHIANS: INSIGHTS FROM REPROCESSED (MRNQ) SEISMIC REFLECTION DATA

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(contribution to the Geological Bridges of Eastern Canada through the NATMAP project – Architecture of Appalachian foreland and platform in Quebec, New Brunswick and Newfoundland)

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