

Potential hydrocarbon source rocks and thermal maturity of Paleozoic succession of Bas-Saint-Laurent, Québec

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Summary

A vast region localized in the lower St. Lawrence Valley was studied for its hydrocarbon source rock potential and thermal maturity (Fig. 1). Source rocks are present in both Paleozoic platform and Appalachians sedimentary units. The maturity of the platform units varies from the oil generation stage to the gas zone. The maturity of Appalachians successions covers a wide range from the oil stage to the end of the anchimetamorphism. Excellent to fair hydrocarbon source rocks are found in both domains.

Introduction

The identification of potential hydrocarbon source rocks and the thermal zonation in the sedimentary domains of Quebec have been a major research activity over the last three decades in the Cambrian-Ordovician St. Lawrence Platform and in the Cambrian to Devonian Appalachians. Detailed local and regional syntheses for various areas have been completed and used by the exploration and academic communities (Bertrand, 1990, 1991; Héroux and Bertrand, 1991; Bertrand and Malo, 2001; Bertrand *et al.*, 2003; Bertrand and Lavoie, 2006; Roy, 2008; Lavoie *et al.*, 2009).

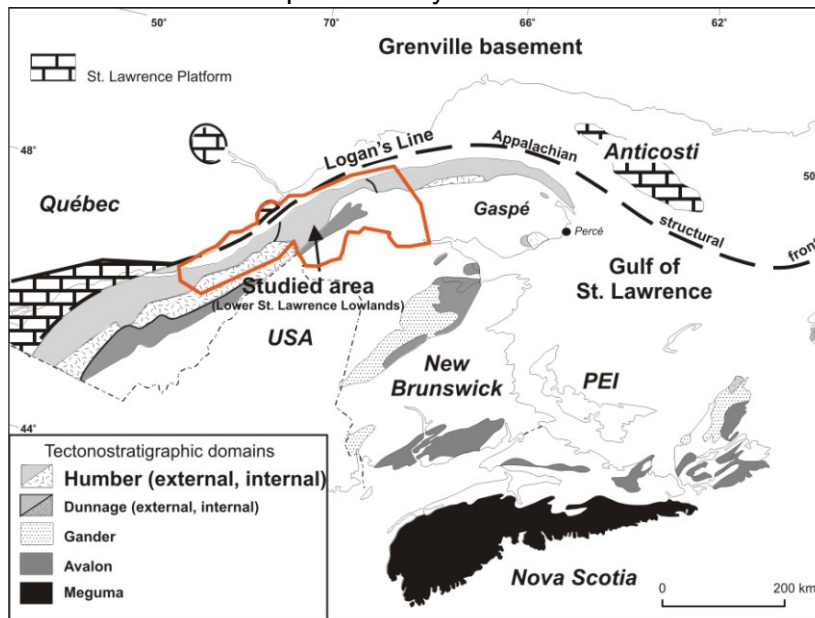


Figure 1. Studied area with the main tectonostratigraphic domains.

After all these years, the lower St. Lawrence Valley between Quebec City and the western end of Gaspé Peninsula, on both shores of the St. Lawrence River remained the last area to be covered by detailed organic matter studies (Fig. 1). This study presents the results of the latter research for the vast sector of Quebec Appalachians that constitutes the Bas-Saint-Laurent.

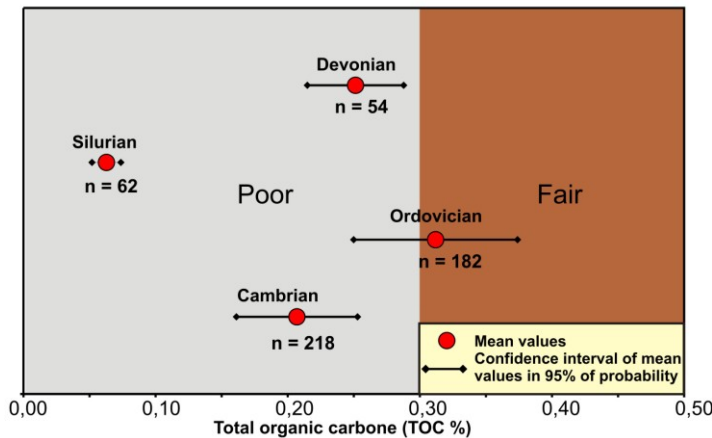


Figure 2. Relationship between TOC and age of the successions. n = actual analyses

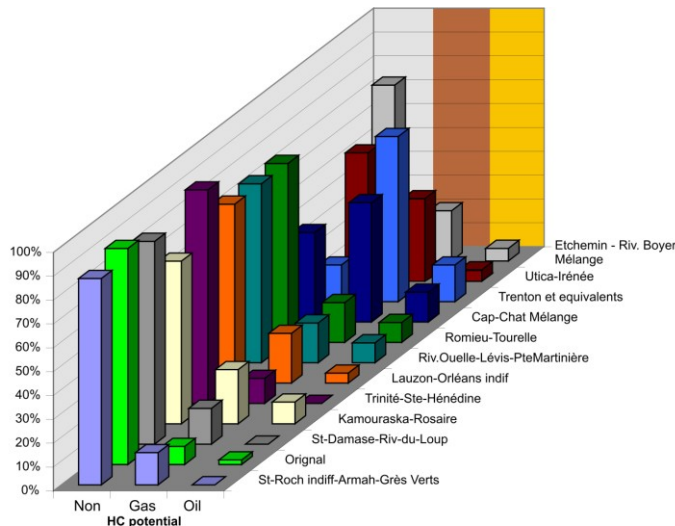


Figure 3. Proportions in every stratigraphic of rock having a potential for oil or gas.

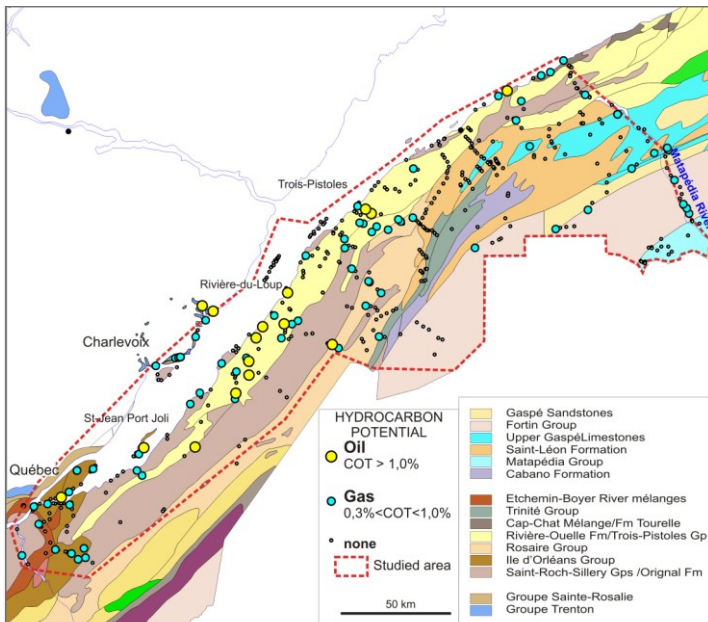


Figure 4. Geographical distribution of best potential hydrocarbon source rocks.

More than 500 Rock Eval and total organic carbon (TOC) analyses and nearly the same number of reflectance analyses were obtained in Cambrian to Devonian rock units of the Bas Saint-Laurent area between the Matapédia and Chaudière rivers. Almost all the stratigraphic units of this area were sampled.

Source rocks

Nearly 25% of the studied successions yielded TOC values higher than 0.3%. In the Appalachians successions, the richest stratigraphic units are Ordovician (Cap-Chat and Rivière Boyer River mélanges, Rivière Ouelle and Lévis formations) and Cambrian (Kamouraska and Lauzon formations). The poorest units are Silurian (Figures 2 and 3). In the autochthonous Ordovician platform, the richest successions belong to the Trenton and Utica groups.

The maximum TOC values in those Paleozoic successions vary between 1% and 3%. Maximum TOC values are similar in both Appalachians and platform successions. In the Trenton Group and in the Cap-Chat Mélange, significant hydrocarbon source rock potential is recognized in more than 50% of the collected samples (Figure 3). The potential for good hydrocarbon source rocks in other units does not exceed 30%.

The best potential source rocks are geographically restricted to: 1) the area between Trois-Pistoles and St-Jean Port-Joli on the southern shore of St. Lawrence River, 2) in Charlevoix areas (northern shore of the St. Lawrence

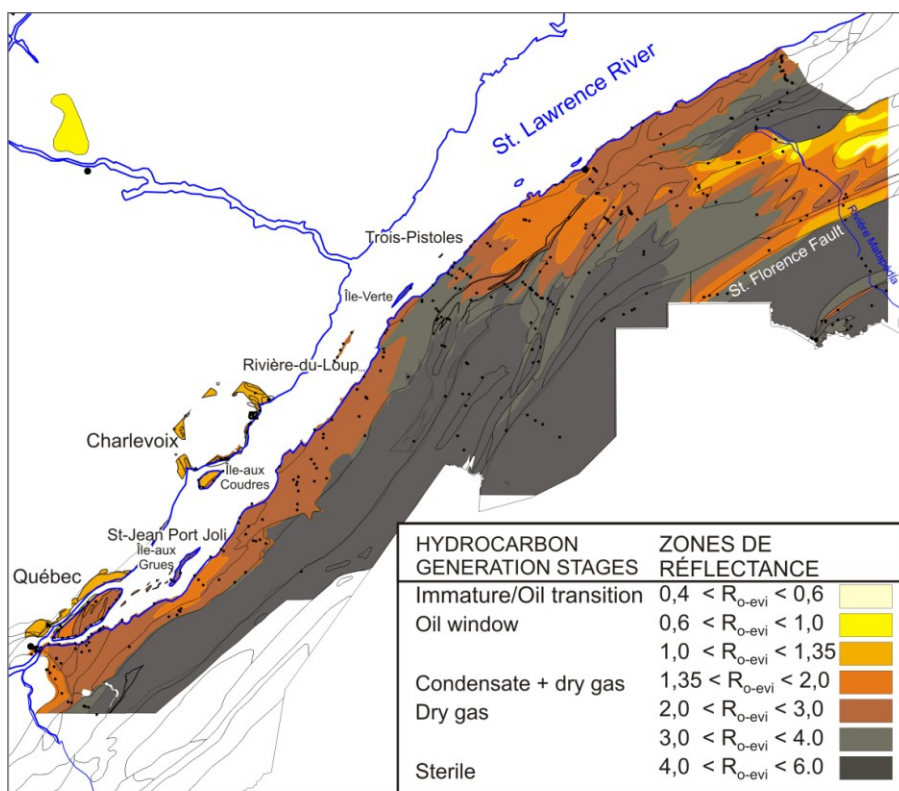


Figure 5. Thermal maturity based on estimated vitrinite reflectance (R_{o-evi}) and stages of hydrocarbon generation.

River), 3) in the Ile-Aux-Grues, and 4) in both shores of the St. Lawrence River in the Quebec City area (Figure 4).

Thermal maturity

At the regional scale, thermal maturation is highly variable, the oil window and condensate stages are found in Cambrian - Ordovician platform and Appalachian successions near Quebec City and nearby Charlevoix areas (Figure 5). On the southern shore of the St. Lawrence River, thermal maturation in coeval Appalachian units is higher reaching the dry gas zone with some local anomalies in the Île Verte

area (more mature) and Île-Aux-Grues (less mature – condensate) (Figure 5).

The Silurian and Devonian Appalachian units located north of the St. Florence Fault are characterized by a westward progressive increase in maturation from the oil window in the Matapédia Valley to the anchizone in the Témiscouata area. Rocks of the Lower Devonian Fortin Group, outcropping south of this fault, are invariably within the dry gas or the anchizone stage (Figure 5).

Conclusions

Considering their high level of thermal maturity, the actual hydrocarbon potential of these rocks is minimal. For the platform succession, some units that had a significant genetic potential are located in the Quebec City and Charlevoix areas, they now have reached the end of the oil window, Excluding local sectors as discussed above, the Appalachians Cambrian - Ordovician units are now overmature, up to the epizone stage, however, some units still contain up to 3% of residual TOC; this suggests that significant quantities of hydrocarbons were generated by these potential Appalachian source rocks during their thermal history.

References

Bertrand, R., 1990, Maturation thermique et histoire de l'enfouissement et de la génération des hydrocarbures du bassin de l'archipel de Mingan et de l'île d'Anticosti : Canadian Journal of Earth Sciences, 27, 731-741.
 Bertrand, R., 1991, Maturation thermique des roches-mères dans les bassins des basses-terres du Saint-Laurent et dans quelques buttes témoins au sud-est du Bouclier canadien : International Journal of Coal Geology, 19, 359-383.

Bertrand, R., Lavoie, D., and Fowler, M., 2003, Cambrian-Ordovician shales in Humber zone: thermal maturation and source rock potential: Canada: Bulletin of Canadian Petroleum Geology, 51, 213-233.

Bertrand, R., and Lavoie, V., 2006, Hydrocarbon source rocks and organic matter maturation of lower Paleozoic successions in the St. Lawrence Platform and in the external domain of the Québec Appalachians: GAC/MAC annual meeting, Montréal 2006, Program with abstracts.

Bertrand R., and Malo, M., 2001, Source rock analysis, thermal maturation, and hydrocarbon generation in the Siluro-Devonian rocks of the Gaspé Belt basin, Canada: Bulletin of Canadian Petroleum Geology, 49, 238-261.

Héroux, Y., and Bertrand, R., 1991, Maturation thermique de la matière organique dans un bassin du Paléozoïque inférieur, Basses-Terres du Saint-Laurent, Québec, Canada : Canadian Journal of Earth Sciences, 28, 1019-1030.

Lavoie, D., Dietrich, J., Pinet, N., Castonguay, S., Hannigan, P., Hamblin, T., and Giles, P.S., 2009, Hydrocarbon resource assessment, Paleozoic basins of eastern Canada, Open File 6174 : Geological Survey of Canada, 275 pages

Roy, S., 2008, Maturation thermique et potentiel pétrologène de la Ceinture de Gaspé, Gaspésie, Québec, Canada. Thèse de Ph.D., INRS-ETE, Université du Québec.