The Silurian Sayabec Formation reservoir potential in the Lower St. Lawrence River area, Québec, Canada

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Context

Squatex has recently demonstrated interest for developing the oil and gas potential of the Lower St. Lawrence River area. The company drilled over 6000 meters of stratigraphic wells over the past 10 years. Several of them revealed oil or gas shows associated with naturally fractured zones, notably within the carbonate Silurian Sayabec Formation (Fm). This research project intended to assess the reservoir quality of sedimentary facies from this later lithostratigraphic unit in a prospective play, the Massé structure. Here we documented primary depositional facies and established a fine-scale stratigraphic framework.

The Massé structure

The Massé structure belongs to the northern part of the Connecticut Valley-Gaspé synclinorium. In this area, the Taconian unconformity separates the Cambro-Ordovician strata (to the north) and the Siluro-Devonian sucession (to the south; Malo and Bourque, 1993; Bourque et al., 1995). The Massé structure is limited by two normal faults and its sedimentary sequence was preserved with little amount of deformation and only local brecciation and/or fracturing occurrences.

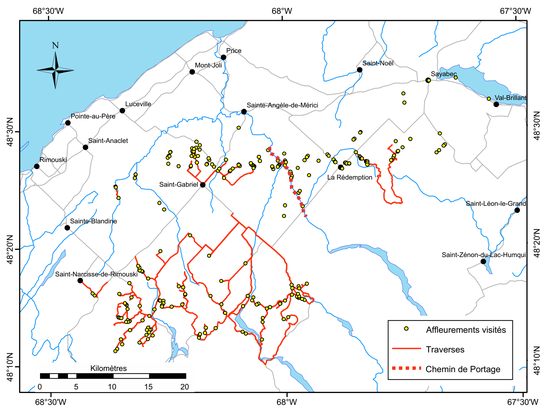

Figure 1 : Location map of the study area illustrating the 252 outcrop locations and cross-sections visited.

Methods

- **Mapping the Sayabec Fm** in the Massé structure area (Figure 1);
- **Sedimentologic, stratigraphic and structural** analysis at the outcrop scale;
- **Core logging** of Massé No.1, Massé No.2 and Portage wells (approx. 2 000 meters);
- **Petrography** of 54 thin sections from cores;
- **Integration** of wireline logs, seismic interpretations and core logging into a 3D database.

Fine-scale stratigraphy of the Sayabec Formation (Massé No. 2 well)

In the Massé structure area, the average thickness of the Sayabec Fm is 300 meters. The succession is mainly carbonate interbedded with silty and/or argillaceous layers or variable thickness. The interval revealed four levels of reservoir quality (Figure 2).

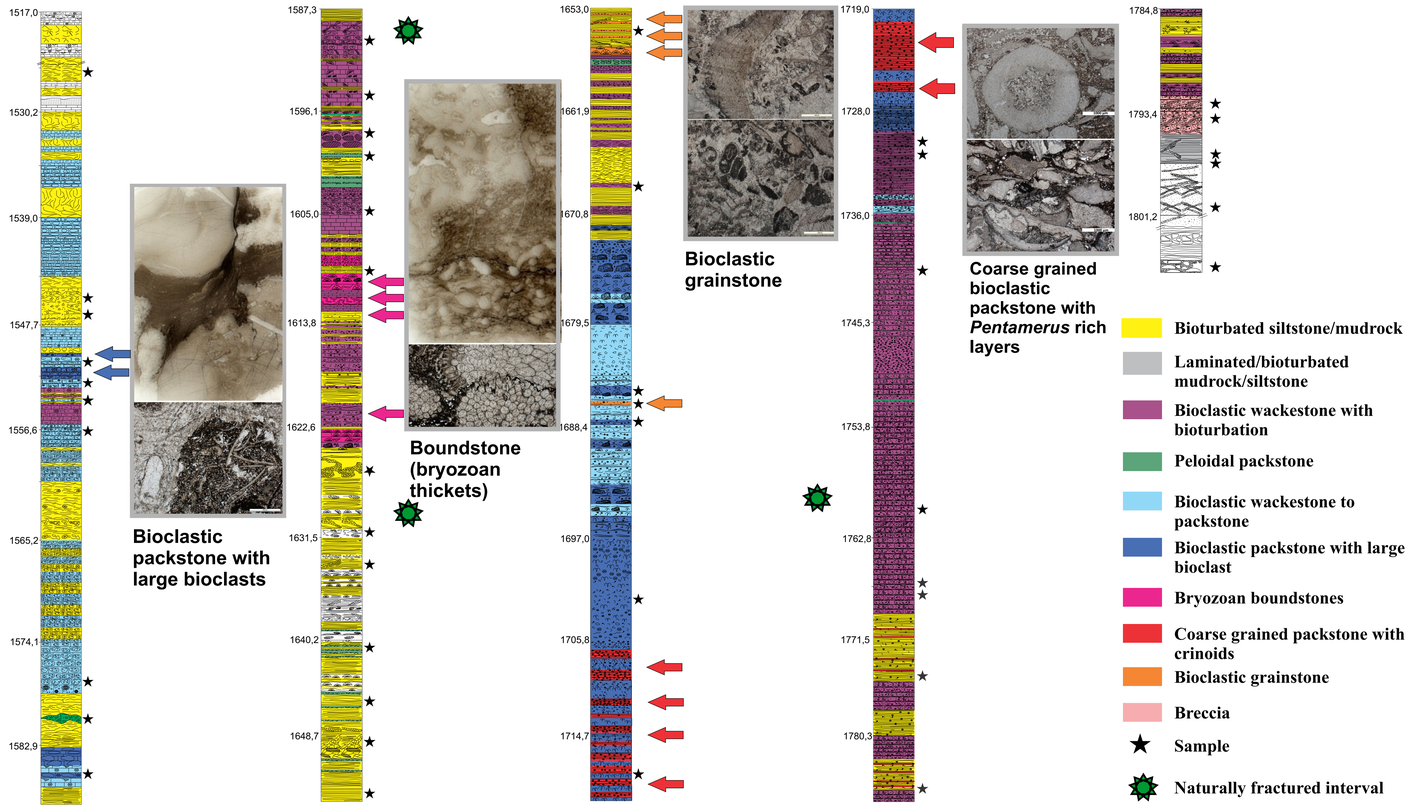

Figure 2 : Detailed stratigraphic log of the Sayabec Fm within Massé No.2 well. Reservoir quality intervals (red arrows) are associated with variable porosity types (intergranular, intragranular, moldic and vuggy). Permeability is potentially high due to the presence of naturally fractured intervals (green arrows).

Lateral variation - Massé No. 1

Massé no.1 has a distinctive 40 m thick interval of hydrothermal dolomite (HTD; Figure 3) where highly connected porosity is common. Pores are associated with fractures, dissolved bioclasts and vugs. Size of voids ranges from millimetric to pluricentimetric and shape varies from circular/pseudo circular to lenticular.

Figure 3 : Fractured and vug-bearing intervals within Massé No.1 well. Width of the picture is approx. 30 mm.

Lateral variation - HTD outcrop

At Saint-Cleophas the Sayabec Fm is exposed in a quarry on the southern flank of the Lac Matapedia Syncline (Figure 4). The 20 m thick brecciated dolostone section consists of replacive and pore-filling saddle dolomite of hydrothermal origin (Lavoie and Chi, 2001; Lavoie and Morin, 2004).

Figure 4 : Highly porous dolostone from the Sayabec Fm at the Saint-Cleophas quarry.

Reservoir analogs

The Sayabec Fm facies can be considered as analogous of hydrothermal dolomite reservoir facies of the Albion-Scipio and Stony Point fields in the Trenton–Black River Fms (Ordovician, Michigan basin, USA; Figures 5 and 6) or the Ladyfern gas field (Devonian, Slave Point Reservoir, British Columbia; Boreen and Colquhoun, 2001; Smith, 2006).

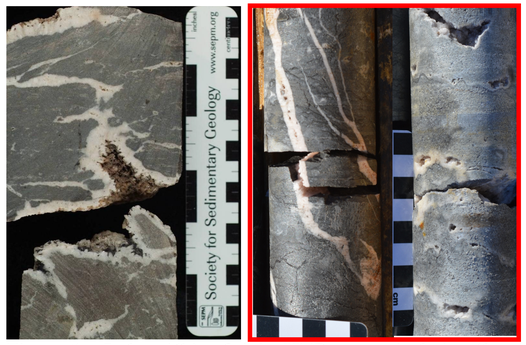

Figure 5 : Left - Albion-Scipio HTD reservoir facies (from Thornton and Grammer, 2011). Right - Fractured and vugs showing interconnected porosity within the Sayabec Fm carbonate facies.

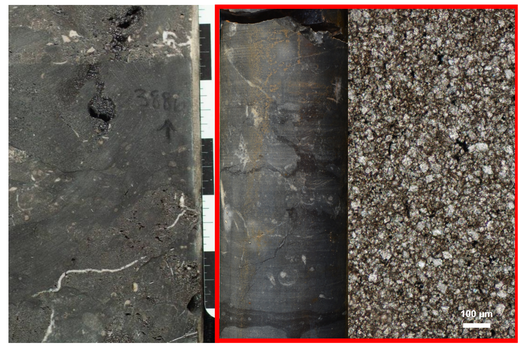

Figure 6 : Left - Albion-Scipio burrowed reservoir facies with variable size porosity at the cm-scale (from Thornton and Grammer, 2011). Right - Similar fine-grained burrowed facies with matrix locally replaced by microdolomite in the Sayabec Fm.

Future works

To improve our understanding of the Sayabec Fm reservoir potential, future works will focus on:

- geochemistry analyses of fractures-filling mineral phases;
- wireline log re-interpretations with new refined stratigraphic framework;
- acquisition of new seismic lines in the Massé structure;
- building a 3D geological model of the Sayabec Fm integrating all subsurface data available.

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References

Bourque, P.A., Brisebois, D., and Malo, M., 1995. Gaspé belt, In : Geology of the Appalachian-Caledonian Orogen in Canada and Greenland. H. Williams (ed). Geological Society of America, Geology of North America, v.F-1, p. 316-351.

Boreen, T., and Colquhoun, K. (2001). Ladyfern, NEBC: major gas discovery in the Devonian Slave Point Formation.

Davies, G. R., and Smith Jr, L. B. (2006). Structurally controlled hydrothermal dolomite reservoir facies: An overview. AAPG bulletin, 90(11), 1641-1690.

Lavoie, D., and Chi, G. (2001). The Lower Silurian Sayabec Formation in northern Gaspé: carbonate diagenesis and reservoir potential. Bulletin of Canadian Petroleum Geology, 49(2), 282-298.

Lavoie, D., and Morin, C. (2004). Hydrothermal dolomitization in the Lower Silurian Sayabec Formation in northern Gaspé-Matapédia (Québec): Constraint on timing of porosity and regional significance for hydrocarbon reservoirs. Bulletin of Canadian Petroleum Geology, 52(3), 256-269.

Malo, M., and Bourque, P. A. (1993). Timing of the deformation events from Late Ordovician to Mid-Devonian in the Gaspé Peninsula. Geological Society of America Special Papers, 275, 101-122.

Thornton, J. E., and Grammer, G. M. (2011). Prediction of Petrophysical Properties of Trenton-Black River (Ordovician) Reservoirs by Comparing Pore Architecture and Permeability to Sonic Velocity. ESAAPG abstract, AAPG Search and Discovery, 90142.