Potential CO_2 Geological Storage Sites for Carbon Capture and Storage (CCS) in Québec St. Lawrence Lowlands - A Preliminary Analysis

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Summary

The St. Lawrence Lowlands platform and frontal thrust slices of the Appalachian belt are prospective for CO_2 storage in the province of Québec. The thick (1500 to 3000 meters) sedimentary succession hosts two types of reservoirs: deep saline aquifers in the platform and gas reservoirs in the fold-thrust belt. The Potsdam, Beekmantown and Trenton groups are identified as the potential reservoir formations in the St. Lawrence Lowlands sedimentary succession. A preliminary analysis of selected storage sites is used to evaluate theoretical and effective capacities for CO_2 storage at the basin and reservoir scales.

Introduction

Interest for CCS is rapidly growing as it represents a short-to-medium-term solution for reducing anthropogenic CO_2 emissions in the atmosphere (IEA, 2008; IPCC, 2005). The technology for storing CO_2 in oil and gas reservoirs and in deep saline aquifers is now ready to be applied in the context of CCS (Bachu, 2008). Research for potential geological storage sites is thus going on worldwide where there are large sedimentary basins known as hosting geological reservoirs.

The objectives of the research project are to determine the potential capacity of CO_2 geological storage in Québec in order to evaluate the feasibility of CCS in the province. The St. Lawrence Lowlands is the current prospect area for CO_2 storage in the south part of Québec province where most of the large CO_2 emitters are located. The most advanced methodologies are used to identify the prospective CO_2 geological storage sites in Québec.

Geological setting

The Cambro-Ordovician platform sedimentary succession of the St. Lawrence Lowlands has a thickness of 1500 to 3000 meters and was unconformably deposited on the Precambrian bedrock (Globensky, 1987). The sedimentary succession is composed of sandstones of the Potsdam Group, dolomites of the Beekmantown Group and limestones of the Trenton, Black River and Chazy groups. They are overlain by the Utica Shale and the siltstones and shales of the Lorraine Group. SW-NE normal faults affect the succession which deepens toward the south-east (Castonguay *et al*., 2006). The Appalachian fold-thrust belt is limited by the Aston Fault and the Logan's Line, in between which we find parautochthonous parts of the platform sedimentary succession caught up in fault slices and displaced above rocks of the platform (figures 1 and 2).

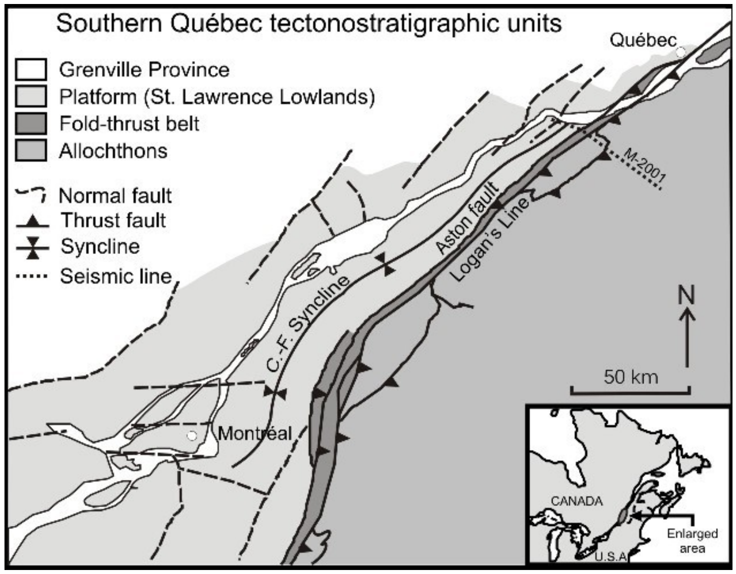

Figure 1: Southern Québec structural domains and location of the M-2001 seismic line (figure 2) (modified from Bertrand *et al.,* 2003).

Deep saline aquifers are found in the sedimentary succession of the platform, particularly in the Potsdam, Beekmantown and Trenton groups. The gas reservoirs, on the other hand, are known to be located in imbricated frontal thrust slices of the Appalachian fold-thrust belt (e.g. the Saint-Flavien reservoir, figure 2).

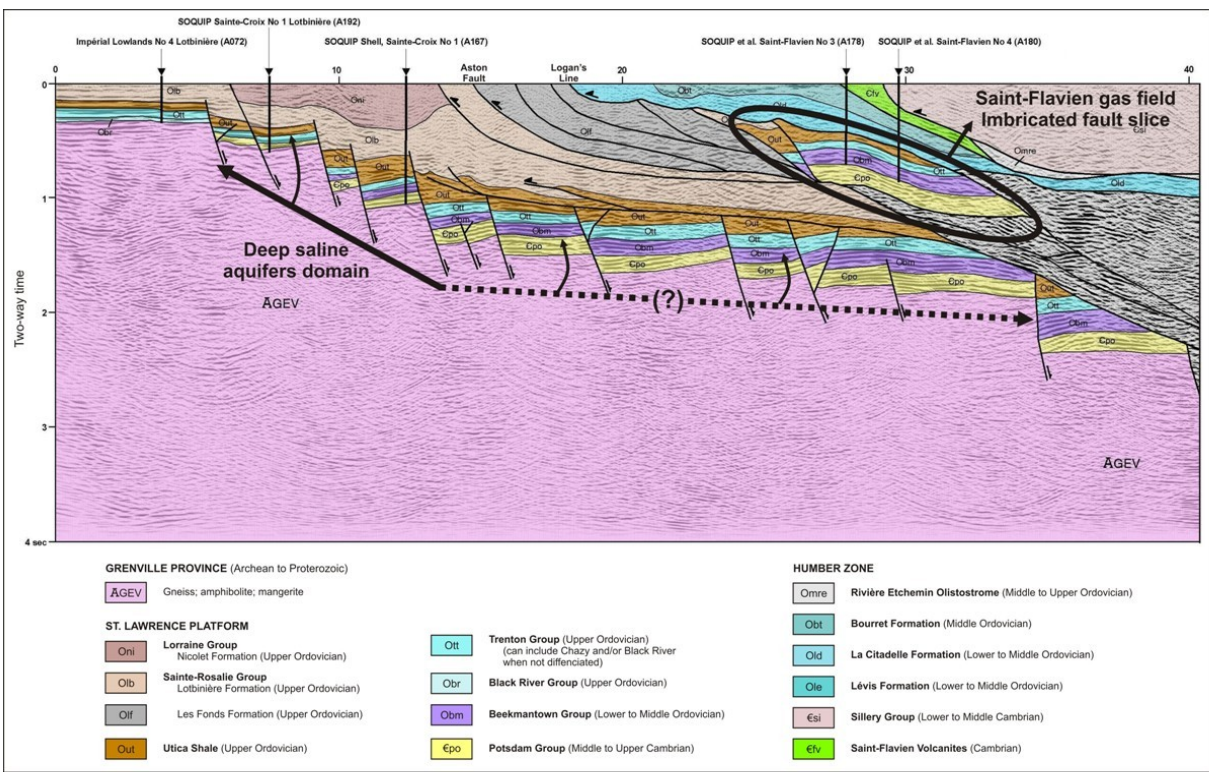

Figure 2: Architecture of the St. Lawrence Lowlands platform and the frontal part of the Appalachian fold-thrust belt, the two domains hosting potential CO_2 storage sites, on seismic line M-2001 (modified from Castonguay *et al.*, 2006).

Criteria for assessing CO2 storage sites

As not all the sedimentary basins are appropriate for CO_2 sequestration, a preliminary analysis must be conducted to evaluate their potential. Many geological and practical criteria must be taken into account in this assessment. Some of these criteria include depth, size, tectonic setting of the basin, fault occurrences, presence of an extensive vertical and horizontal seal (caprock), accessibility, infrastructures and proximity of large CO_2 sources (Bachu, 2003).

At the reservoir scale, the evaluation is more specific. The positive indicators include, among others, a depth of 1000 m to 2500 m, a reservoir thickness of at least 50 m, at least 20% of porosity and 300 mD of permeability, an unfaulted continuous caprock with a thickness of at least 100 m (Chadwick *et al.*, 2008).

In the case of the St. Lawrence Lowlands, a preliminary evaluation conducted by the chair on geological CO_2 sequestration at INRS is used to determine the potential of the basin and the reservoirs of the St. Lawrence Lowlands.

Preliminary analysis of the St. Lawrence Lowlands

The analysis of the criteria for assessing the potential of the St. Lawrence Lowlands basin shows many positive indicators for CO_2 geological sequestration. First of all, the basin extends over more than 10 000 km^2 which is a fairly good size and, most importantly,. it is covered by a extensive caprock that can exceed 1000 m of thickness (the Utica Shale and the Lorraine Group). The St. Lawrence Lowlands sedimentary units that may represent potential reservoir capacities for the CO_2 storage are located in sandstones of the Potsdam Group, dolomites of the Beekmantown Group, and more or less argillaceous limestones of the Trenton Group (including the thin Black River and Chazy groups). These sedimentary successions are found at depths of 1000 m to 2500 m within the platform and the imbricated thrust slices of the fold-thrust belt. The Potsdam Group is up to 750 m thick, its porosity is usually 6-12% and its permeability can be more than 10 mD and up to 200 mD in some thin layers. The Beekmantown dolomites are up to 450 m thick, they show porosities of 3-12%, exceptionally up to 18%, and good permeabilities varying from 45 mD to more than 250 mD. Finally, the Chazy-Black River-Trenton unit has a thickness of up to 375 m, lower porosities of 3-10% and permeability generally of the order of 1 mD but which can be more than 300 mD where saline aquifers are present.

Many practical criteria are positively evaluated such as: ease of access of the region, well developed infrastructures and several large CO_2 emitters located directly in the St. Lawrence Lowlands. Even if the porosities and permeabilities are lower than the positive indicators of Chadwick *et al.* (2008), the other good parameters still allow considering the St. Lawrence Lowlands units as potential CO_2 sequestration reservoirs.

Conclusions

The potential for CO_2 sequestration is evaluated in deep saline aquifers of the St. Lawrence Lowlands platform as well as in the gas reservoirs of the frontal trust slices of the Appalachian fold-thrust belt. The effective capacity of the St. Lawrence Lowlands is assessed at the basin-scale (Bachu *et al.*, 2007) with the ultimate objective to identify specific sequestration sites and evaluate their practical and matched capacities for CO_2 sequestration (local-scale and site-scale assessment; Bachu *et al.*, 2007).

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