SnT 2025 8 SEPTEMBER ONLINE DAY 9 TO 12 SEPTEMBER AT HOFBURG PALACE, VIENNA & ONLINE
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

P1.2-054

Attenuation of seismic waves in the Charlevoix seismic zone, southeastern Canada

Amir Mansour Farahbod and John F. Cassidy

Geological Survey of Canada

INTRODUCTION AND MAIN RESULTS

We investigate seismic attenuation characteristics of the Charlevoix seismic zone that is located ~100 km downstream from Quebec City and is the most seismically active region of eastern Canada. We determine Coda Q using 583 earthquakes (2.0 ≤ M ≤ 5.4) recorded at seven stations of the Canadian National Seismic Network from 1992 to 2022. We find that the highest Q_0 (Q at 1 Hz) values are at station A11 (e.g., Q_0 of 109), that is the farthest station from the 1663, M~7 earthquake (D=40 km). The lowest Q_0 values that we find are at station A16 (e.g., Q_0 of 72) that is the second closest station to the 1663 earthquake (D=16 km) after station A61 (D=10 km). Also, we find the lowest overall average Q_0 value of 72 at station A16. Based on global studies, Q_0 is lower in the vicinity of large earthquakes. Therefore, the low Q_0 values at station A16 may suggest that the 1663 earthquake is located slightly southeast of the catalog epicenter, considering high uncertainty associated with historic events. An average for all the data results in a Q relationship of $Q_C = 81f^{1.06}$ (2 Hz ≤ f ≤ 16 Hz) for the entire region.

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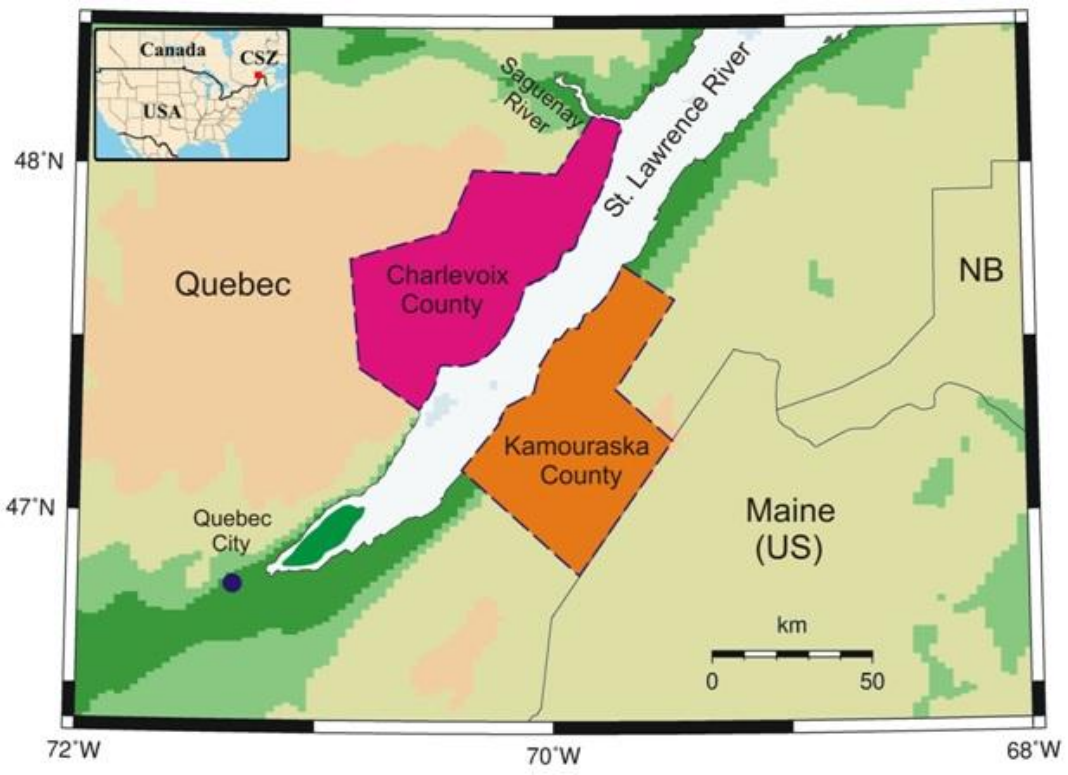
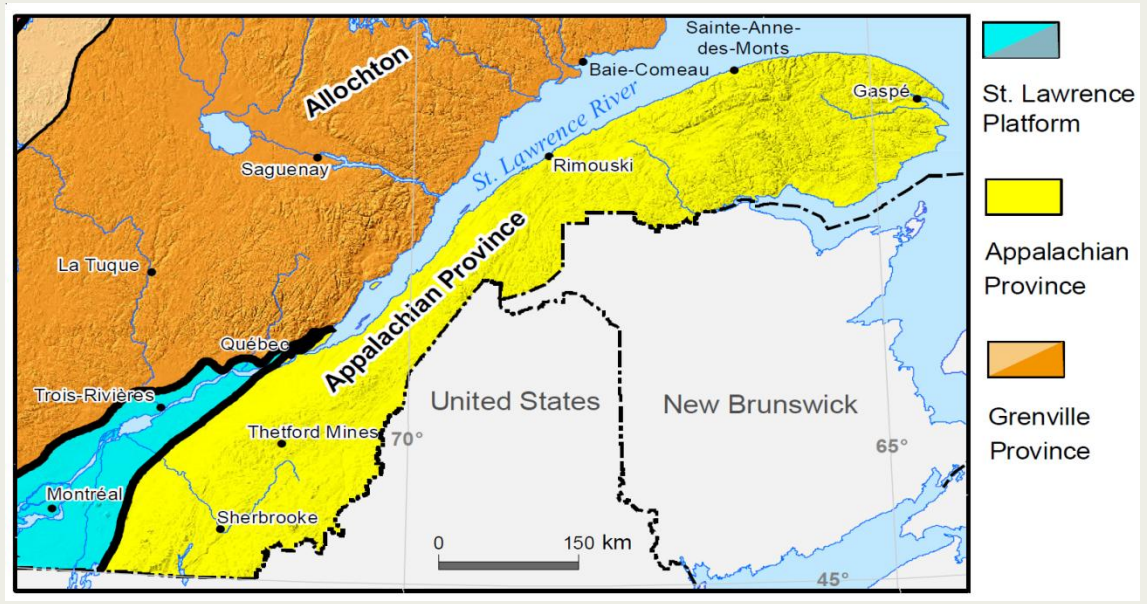
Charlevoix Seismic Zone

The Charlevoix Seismic Zone (CSZ) is the most seismically active region of eastern Canada (Nadeau et al., 2020). As most earthquakes occur under the St. Lawrence River, between Charlevoix County on the north shore and Kamouraska County on the south shore, this region is also often referred to as the Charlevoix-Kamouraska Seismic Zone. The CSZ is an area of contrasting topography. While the south shore is a gently rolling landscape, the north shore is a mixture of rugged highlands, plateau and valleys, separated by dramatic changes in elevation (Lamontagne, 1999). In addition, a Devonian meteorite impact (-350Ma) has shattered the plateau, creating a semi-circular depression 56 km in diameter (Lamontagne, 1999). The centre of the Crater is a 768 m high central peak, Mont des Eboulernents, which is surrounded by an interior plateau of up to 15 km radius, and by a peripheral depression of up to 27.5 km radius (Rondot, 1989).





Modified from the map of the great geological domains of Quebec, Ressources Naturelles Quebec, 2012.

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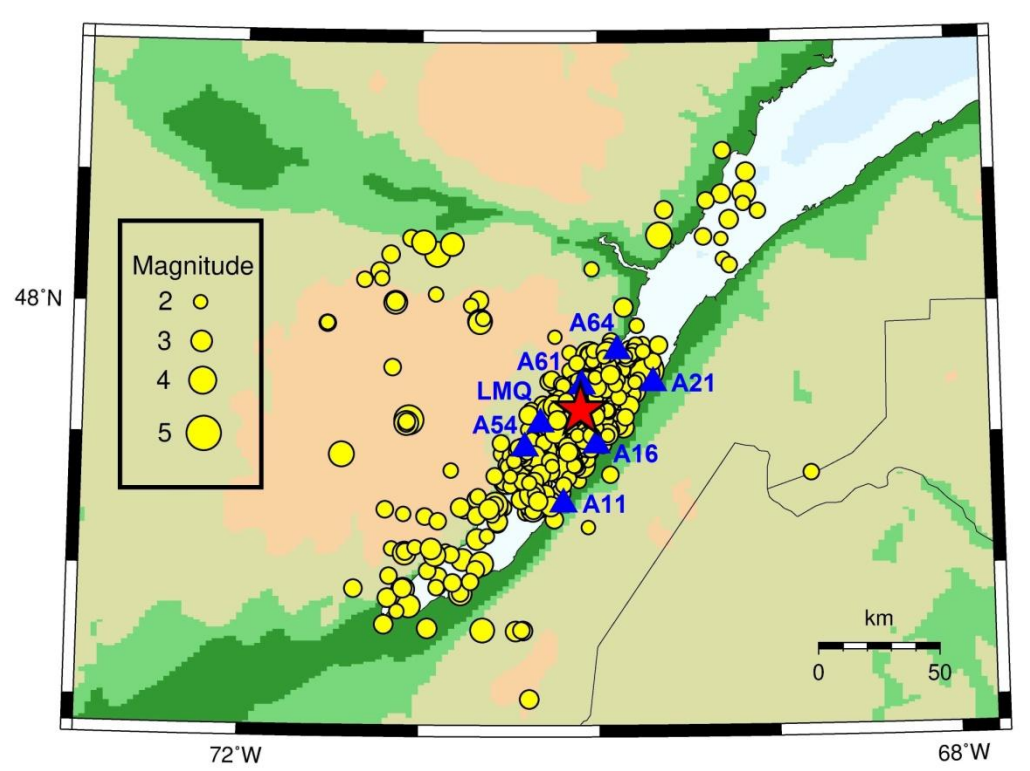
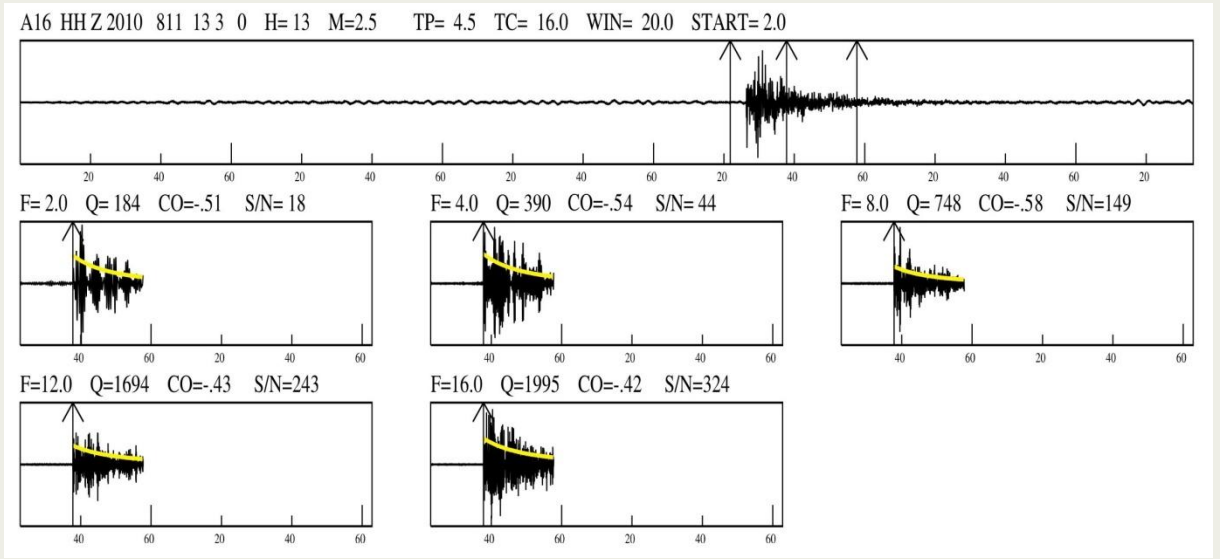
Methodology / Seismic data



For calculating Q_C we used seismic waveform data from seven CNSN sites in southeast Quebec from June 16, 1992 to December 26, 2021 (star: epicenter of the 1663, M~7 earthquake; Lamontagne et al., 2018). We used the computer program SEISAN [Havskov and Ottemöller, 2012] to calculate coda Q.



In this study we determine the coda Q factor using the single backscattering approximation, which explains the decay of earthquake coda under the assumption of weak isotropic scattering from homogeneously distributed heterogeneities [Aki & Chouet, 1975].

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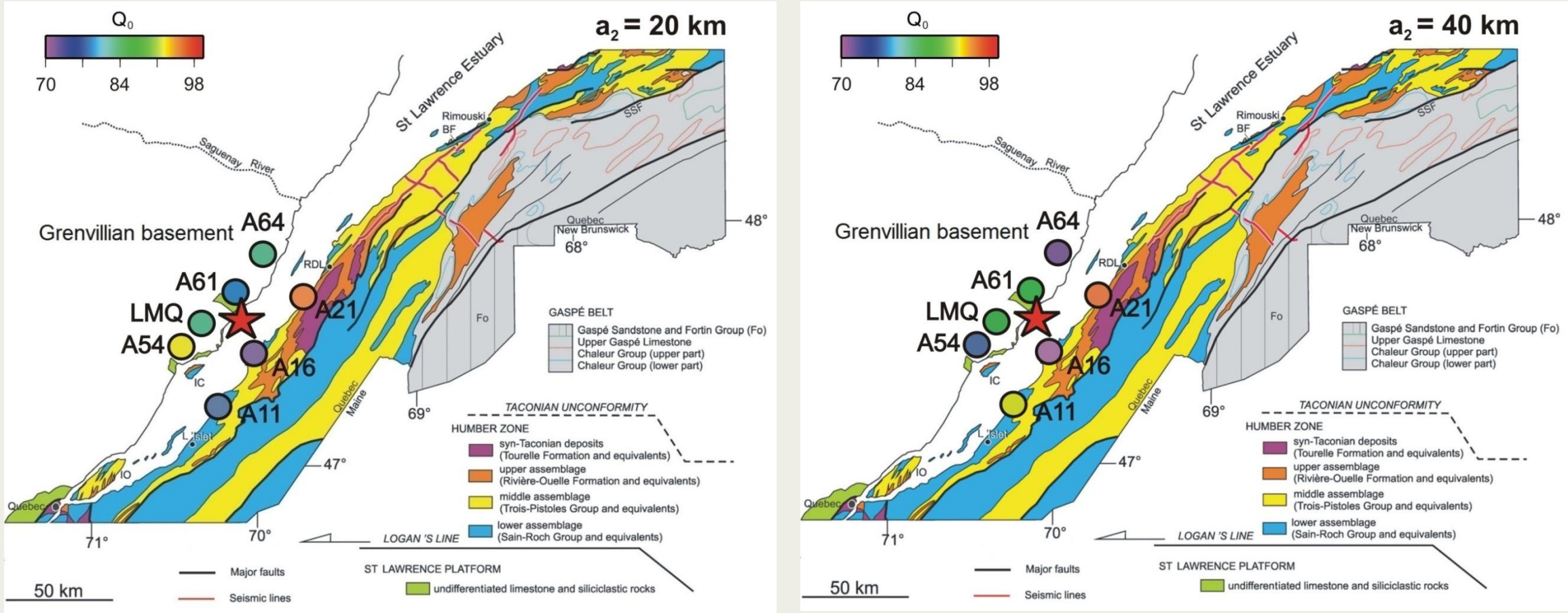
Results



The sampling volume is one-half of a three-dimensional ellipsoid, where a_2 is its semi-minor axis. Maps: Q_0 variations (shaded circles) at each seismic station, superimposed on the geological map of the region (modified after Pinet et al., 2013). Star represents the epicenter of the 1663 (M~7) earthquake.

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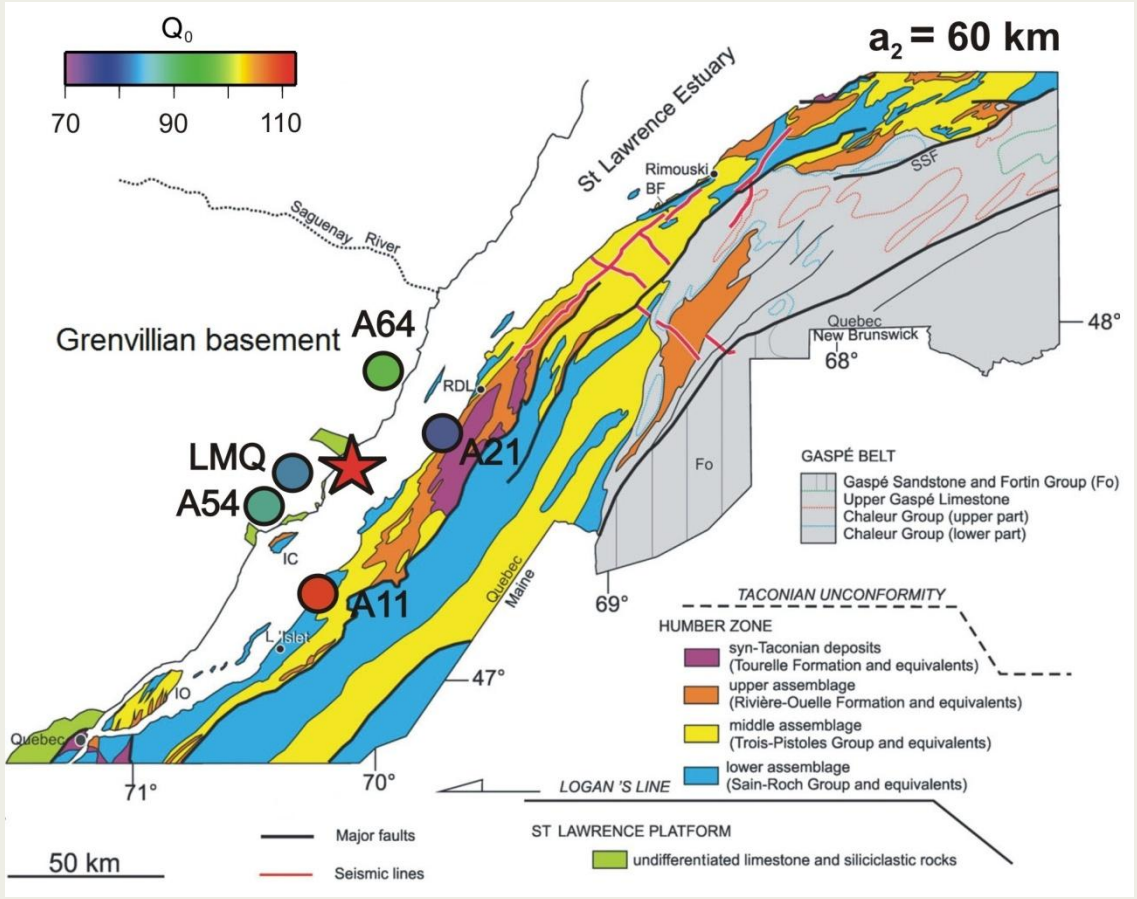

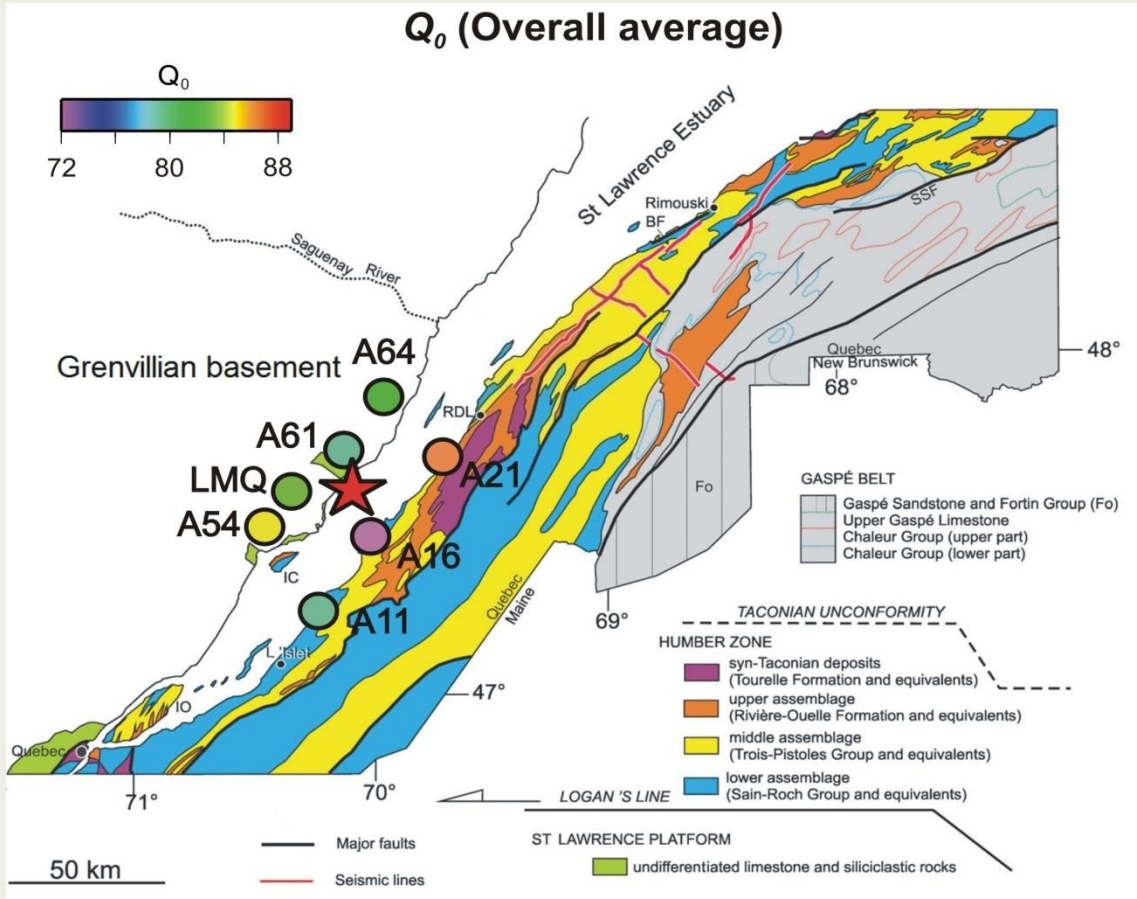

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Summary and conclusions

We investigated coda-wave attenuation from the southeast Quebec in the CSZ using the single scattering approximation on records from 7 stations of the regional Canadian National Seismic Network. Coda windows were selected to start at $t_C = 2t_S$ and were filtered at center frequencies of 2, 4, 8, 12 and 16 Hz. The lowest Q_0 of 72 (t_{lapse}=24 sec, station A16) was observed on the East Shore in the Appalachians province. Based on the location of the 1663 earthquake (Lamontagne et al., 2018), A16 is the second closest station to that event (D=16 km) after station A61 (D=10 km). The highest Q_0 values of 109 (t_{lapse}=36 sec, station A11) is in the Appalachians province at the farthest distance from the 1663 earthquake (D=40 km). Also the overall average of Q_0 is the lowest at Station A16 (e.g., Q0 of 72) and are the highest at station A21 (e.g., Q_0 of 88) which is the second farthest station from the 1663 earthquake (D=33 km). In general, we suggest that lower calculated Q_0 values at stations in the CSZ are primarily attributed to the proximity of the 1663 earthquake which is similar to findings of Jin and Aki (1988). This is in agreement with the findings of a recent study in the CSZ that indicates Charlevoix is still influenced by the stress changes imparted by the 1663 earthquake in the surrounding crust (Fereidoni, 2014).

We observe similar pattern of Q_0 variations at stations in the Appalachian province and the Grenville province. On the two sides of the St. Lawrence River, average Q_0 values are clearly indicate an increasing trend by distance from the 1663 earthquake. On the West Shore average Q_0 values are the lowest at A61 (e.g., Q_0 of 79) and higher at A64 (e.g., Q_0 of 81) in the north and at LMQ and A54 (e.g., Q_0 of 83 and 85, respectively) in the south. On the East Shore average Q_0 values are the lowest at A16 (e.g., Q_0 of 74) and higher at A21 (e.g., Q_0 of 88) in the north and at A11 (e.g., Q_0 of 79) in the south. In general, we expect higher Q_0 values at stations in the Grenville province rather than stations in the Appalachian province. But observation of the highest and, the lowest Q_0 values in the region on the East Shore (with younger deposits) and variation of Q_0 values as a function of distance from the 1663 earthquake epicenter may suggest that the event occurred further to the southeast than the given catalog location.

We determined the overall average Q_0 value of 81+/-1 at lapse times of 20 to 60 seconds for the entire region. This is slightly lower than 91+/-4 that was determined by Woodgold (1994) at lapse times of 20 to 40 seconds, due to the difference in the size of the two databases and different parameter settings.

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