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Abstract

In this study we investigated coda-wave attenuation (Q_c) in the interior of British Columbia, with a focus on the Anahim Volcanic Belt (AVB) and specifically the Nazko Cone region using the single scattering approximation on records from short period and broadband stations of the regional Canadian National Seismic Network (CNSN) and POLARIS Network. Our dataset is comprised of 380 earthquakes recorded between 1999 and 2012 with magnitudes ranging from 1.6 to 3.9, depths from 0 to 36 km and epicentral distances of 15 to 100 km. This gives a total of 423 high signal to noise (S/N) traces (S/N≥5.0) useful for Q_c calculation (with a range of ellipse parameter, a_2, of 30 to 110) across the region. Coda windows were selected to start at $t_c = 2t_S$ (two times the travel time of the direct S wave), and were filtered at center frequencies of 2, 4, 8, 12 and 16 Hz. Although the dataset is relatively small, with substantial uncertainties, a consistent pattern emerges. We find that in the interior of BC, the lowest Q_0 values (e.g., Q_0 of 39) are in the vicinity of Nazko Cone, near the 2007 earthquake swarm. This sequence of more than 1000 earthquakes occurred at depths of 25-31 km and was interpreted as a magma injection at the base of the crust. Further, we find that all stations within the AVB show lower Q_0 values compared to other stations in the BC interior. Averaging all data in the AVB with a_2 of 30-50 km (UBRB, MCMB1, SULB, THMB) yields a low average Q_0 of 53, compared to an average Q_0 of 67 at other stations in the BC interior, and an average Q_0 of 70 for stations in the Cascadia subduction zone. Our results showing low Q_0 throughout the AVB (and the lowest Q_0 at Nazko Cone) provides additional support for the interpretation of magma injection into the lower crust during the Nazko earthquake sequence, fracturing of the crust, and high seismic attenuation.

Introduction

The central interior of British Columbia is a seismically quiescent area of the province. In more than 40 years of earthquake monitoring, few earthquakes have been detected or located in the vicinity of the Nechako basin [Cassidy et al., 2001]. As a result, seismic attenuation has never been studied in detail in the interior of British Columbia. However, a dense temporary POLARIS seismic array was operated in this region from 2006-2009 to map crustal structure (Cassidy et al., 2010), and in 2007 an earthquake swarm of more than 1000 events occurred near Nazko Cone in the AVB (Cassidy et al., 2011) (Figure 1).

This swarm represents the first significant recorded seismicity in the region. Most of the located events are microearthquakes ($M_L < 2.5$) and the largest had a magnitude of 3.9. In this study we use these new recordings from both permanent Canadian National Seismograph Network (CNSN) and temporary POLARIS seismic stations to evaluate, for the first time, coda Q attenuation through the interior of BC, including the AVB, and the southern Coast Mountains. We use the single scattering method (Sato, 1977) and determine the attenuation and frequency dependency for different travel paths in the study area. This study is complementary to similar studies in the more seismically active southwest corner of British Columbia (Farahbod et al., 2016; Zelt et al., 1999). We compare our results from the interior of British Columbia – focusing on the AVB and Nechako Basin, but extending from Whistler and Lillooet in the south to Fort St. James in the north (Figure 2) - with the coastal region, and discuss the implications of our new seismic attenuation results.

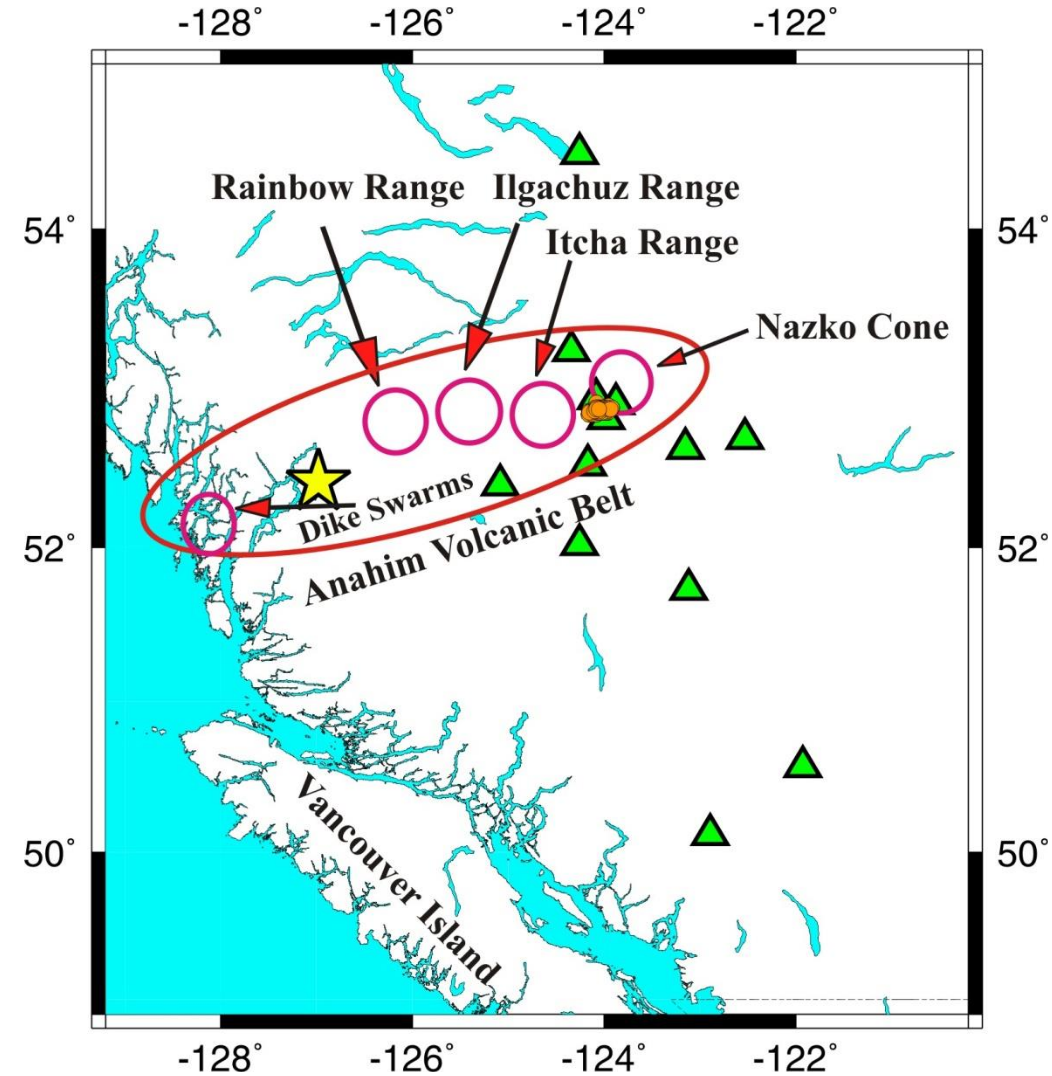


Figure 1: Map of the study area including the Anahim volcanic belt (AVB) which lies within the ellipse. The 2007 Nazko earthquake swarm is indicated by the orange circles, the 1942 earthquake swarm near Bella Coola is indicated by the yellow star. Seismographic stations which used in this study are indicated by the green triangles. The ages of volcanic centers of the Rainbow, Ilgachuz, and Itcha decrease from about 13 Ma for the Dike Swarms at the western end of the belt to 8 Ma for the Rainbow range, 5 Ma for the Ilgachuz range, 2.5 Ma for the Itcha range, and 0.01–0.34 Ma for the Nazko cone.

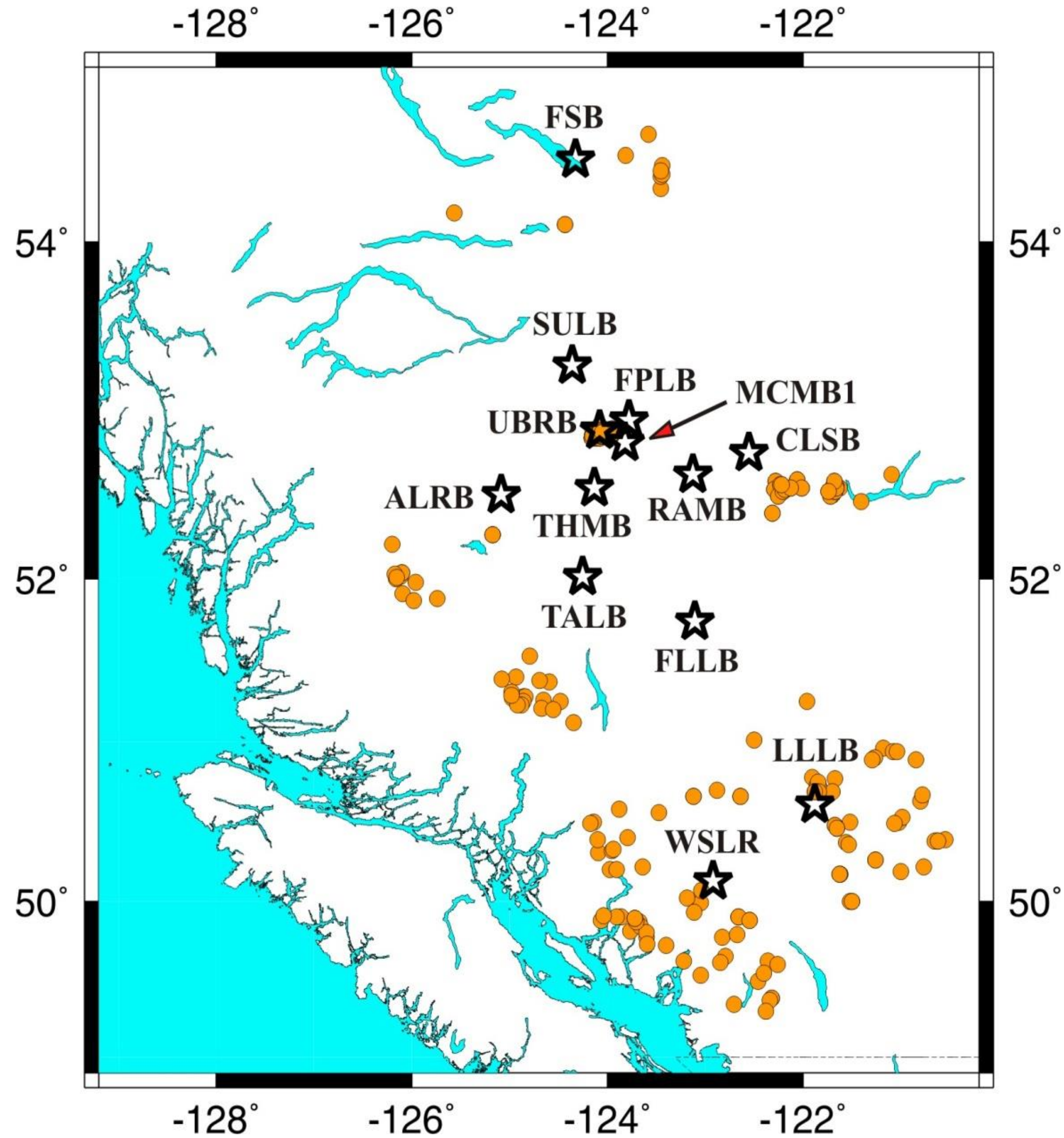


Figure 2: Map showing distribution of events (orange circles) and stations (stars) used in this study. All waveform data were collected from the Canadian National Seismic Network (CNSN) and POLARIS network. Note that the only permanent CNSN stations in this map area are FSB, LLLB, and WSLR.

Geology and tectonic setting

Our study area of south-central British Columbia focuses on the Nechako Basin region of the AVB, but also includes a region extending from near Whistler (WSLR) and Lillooet (LLLB) in the south to Fort St. James (FSB) in the north (Figure 2).

The AVB comprises a broad, east-northeasterly trending zone of alkaline to peralkaline intrusive and extrusive rocks that extends across the Coast Mountains and Interior Plateau (Figure 1). The western part of the belt is defined by dike swarms and subvolcanic plutons that are exposed in the vicinity of Bella Bella on the central British Columbia coast (Souther 1986). Three composite shield and dome complexes, the Rainbow, Ilgachuz, and Itcha ranges, form the central part of the belt (Souther and Clague 1987; Kuehn, 2014). The gently sloping flanks of these shield volcanoes merge with flat-lying basalt flows of the Chilcotin Group (Souther and Clague 1987). Nazko cone (Figure 1), located about 75 km west of Quesnel in central British Columbia, is believed to be the youngest and most easterly eruptive centre in the AVB (Figure 1).

Chilcotin basalts issued from numerous vents along a northwest-trending axis and are thought to be products of Late Miocene and Pliocene back-arc volcanism associated with subduction of the Juan de Fuca plate (Bevier 1983a, 1983b). The AVB has been interpreted as the trace of a hotspot (Bevier et al. 1979), a model consistent with an observed decrease in the age of volcanism from 10- 14 Ma in the west to about 4 Ma in the Itcha Range, the most easterly of the shield complexes (Souther 1986). Nazko cone is 80 km east-northeast of the Itcha Range, along the projected trend of the AVB. It is near the eastern margin of the area underlain by Chilcotin Group basalt, but its location and postglacial age suggest a closer affiliation with the AVB than with any other known Neogene or Quaternary tectonic feature (Souther and Clague 1987).

The southwest portion of the Coast Belt examined in this study consists mainly of granitic rocks of late Middle Jurassic to mid-Cretaceous age (Monger and Journeay, 1994). The Intermontane Belt is a region of complex geology comprising volcanic, sedimentary, and granitic rocks ranging in age from Paleozoic to early Cenozoic age (Monger and Price, 2002).

Seismicity

The Nechako basin area, the focus of this study, is one of the most seismically quiescent areas of British Columbia. Very few earthquakes have occurred here since 1965 when local monitoring began with a seismic station at Fort St. James (~180 km to the north of Nazko). Given the seismic station distribution (Milne et al., 1978), the magnitude completeness for this general area varies from about M 3 in 1970 to about M 1–2 in 2009 during the operating period of the POLARIS temporary seismic array (Cassidy et al., 2011). Seismicity in the area is generally concentrated within the Coast Mountains (from just north of Vancouver and extending to the northwest – as shown in Figure 2) and in the vicinity of the Rocky Mountains, to the east. Within the AVB, a previous earthquake swarm occurred near Bella Coola (about 200 km to the west of the Nazko sequence). This swarm (Figure 1) consisted of more than 40 felt earthquakes that occurred near Bella Coola between September 1940 and August 1943 (Milne, 1956).

Data

Digital records of local earthquakes were collected from the interior British Columbia (with a focus on the AVB and the site of the 2007-2008 Nazko events) from the Geological Survey of Canada (GSC). Three hundred and eighty earthquakes were selected from the Canadian catalogue for this study (Figure 2). They were all recorded between November 1999 and December 2011 by at least three seismic stations, had their epicenters located in the interior British Columbia region (~49º–55º N, ~120.5º– 126.5º W), epicentral distances between ~15 km and ~100 km, local magnitudes (M_L) ranging from 1.6 to 3.9 and focal depths reaching up to 36 km (Appendix 1). All records were from vertical short period and broadband seismometers and sampled at the rate of either 100 or 40 samples per second. We utilized data from 10 POLARIS seismic stations in the Nechako Basin (ALRB, CLSB, FLLB, FPLB, MCMB1, RAMB, SULB, TALB, THMB and UBRB – see Cassidy et al., 2010) and three CNSN stations in the neighboring regions (FSB, LLLB and WSLR). Frequency-magnitude distribution of selected earthquakes for each station is provided in Appendix 2. Maps of event-station configurations are provided for (a) reported and (b) selected earthquakes in a radius of 100 km around each seismic station (Appendix 3, Figures A3-12). In one case (FLLB) there were no located earthquakes near the station (Figure A3-4a).

The coda Q method and data selection

In this study, we determine the Q factor for the interior of British Columbia using the single backscattering method, which explains the decay of earthquake coda under the assumption of weak isotropic scattering from homogeneously distributed heterogeneities [Aki, 1969; Aki and Chouet, 1975; Sato 1977]. The coda waves are assumed to comprise S-to-S backscattered waves, which do not produce secondary scattering when encountering another scatterer and the measured coda Q, (Q_C) depends on both intrinsic and scattering attenuation [Aki and Chouet, 1975; Wu and Aki, 1988]. The coda wave amplitude at frequency f, and lapse time t (time from the event origin) is described by

$$A(f, t) = S(f)t^{-\nu}e^{-\pi ft/Qc} \qquad (1)$$

where S(f) is the source factor which is related to the earthquake's source spectrum and includes station site, backscattering, and source effects [Wu and Aki, 1988]. The geometrical spreading parameter ν is 1, 0.5 and 0.75 for body-wave scattering (this study), surface wave scattering, and diffusion, respectively [Aki and Chouet, 1975]. Equation (1) assumes that the source and receiver are at the same point, a good approximation only for signals at a lapse time, t, greater than 2 times the travel time of the direct S wave, t_S [Rautian and Khalturin, 1978; Sato, 1977]. Equation (1) for body-wave can be written as

$$\ln(A(f,t)t) = \ln(S(f)) - \pi ft/Q_C \qquad (2)$$

so that, Q_C can be obtained by linear regression of ln(A(f,t)t) on t over a coda time window at a constant frequency f. In practice, A(f,t) is obtained by bandpass-filtering the coda signal over a narrow passband centered on frequency f and fitting a time decay envelope to the filtered signal [Rautian and Khalturin, 1978]. When many decay curves are available for the same region, all data can be inverted simultaneously to obtain one Q value [Aki and Chouet, 1975; Havskov et al., 1989]. Obtaining one Q value for each decay curve and averaging Q^{-1} values gives the same result [Kwamme, 1985]. This latter method has the additional advantages of faster computation and the ability to check the fit to equation (2) to eliminate bad results [Havskov et al., 1989].

Assuming that the coda window starts at $t_1=2t_S$, the end time t_2 controls the maximum size of the volume sampled by the backscattered waves [Zelt et al., 1999]. The sampling volume is one-half of a three-dimensional ellipsoid, with the source and receiver as focal points, semimajor axis $a_1 = v_S t/2$ and semiminor axis $a_2 = (a_1^2 – R^2/4)^{1/2}$, where v_S is the average S-wave velocity (3.5 km/sec) and R is the station-event separation [Pauli, 1984]. For similar a_1 and a_2, the sampled volume is nearly a sphere and the maximum depth sampled is approximately given by $z_{max} = a_2 +d/2$, where d is the event depth [Havskov et al., 1989; Zelt et al., 1999].

Practically, to make meaningful comparisons of Q_C from different regions, it is important to make estimates of the volumes sampled by different stations. The average sampling volume can be determined by setting $t = (t_1 + t_2)/2$ in the equation for a_1 [Havskov et al., 1989]. Therefore, by varying t_2, it is possible to ensure that the volumes being sampled by each event-station combination are approximately the same [Zelt et al., 1999].

For calculating coda Q, we used waveform data from 13 short period and broadband vertical component seismograph stations of the Geological Survey of Canada and the POLARIS network (Figure 2) with flat frequency responses from 1 to 16 Hz.

For each event-station combination, we picked P-wave and S-wave arrivals (e.g., Figure 3) and relocated earthquakes considering a velocity model used for standard earthquake locations in this region. Then we calculated Q_C at five frequencies between 2 and 16 Hz using equation (2). The frequency dependence of Q_C can be expressed as $Q_C = Q_0 f^{\alpha}$ [Rautian and Khalturin, 1978]; Q_0 (Q_C at 1 Hz) and α are obtained by linear regression of log (Q_C) on log (f). For each station, Q_C is determined by averaging the calculated values from all events (see Appendix 4).

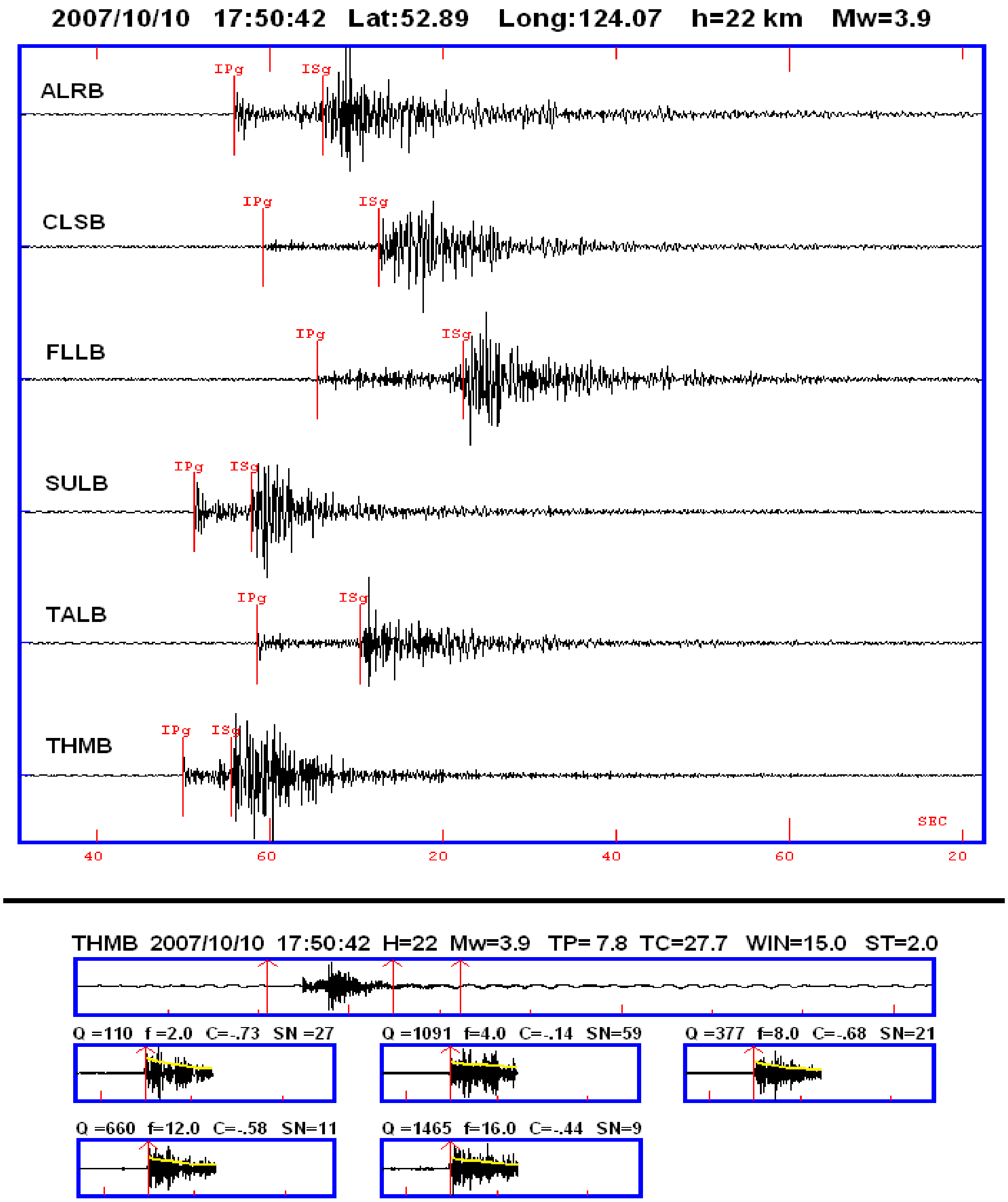


Figure 3: Data processing example for an earthquake recorded on October 10, 2007 in Nazko region. The first step is a visual inspection of available waveforms (top-left) and the selection of the closest stations to the event with the highest S/N ratio (top-right). In the bottom panel, the top trace is the original unfiltered waveform where the 3 vertical lines indicate (from left) origin time, start and end of coda window. Above the seismogram is first the station code, origin time, depth(h), magnitude (ML), P-wave travel time (TP, sec), start of coda window from the origin (TC, sec), window length (WIN, sec) and start of coda window in terms of S-wave travel time (t coda>ST*S- travel time). The amplitude decay corresponding to estimation parameters (f: frequency, C: correlation coefficient and S/N: signal to noise ratio) is shown by the yellow curve in the five filtered segment.

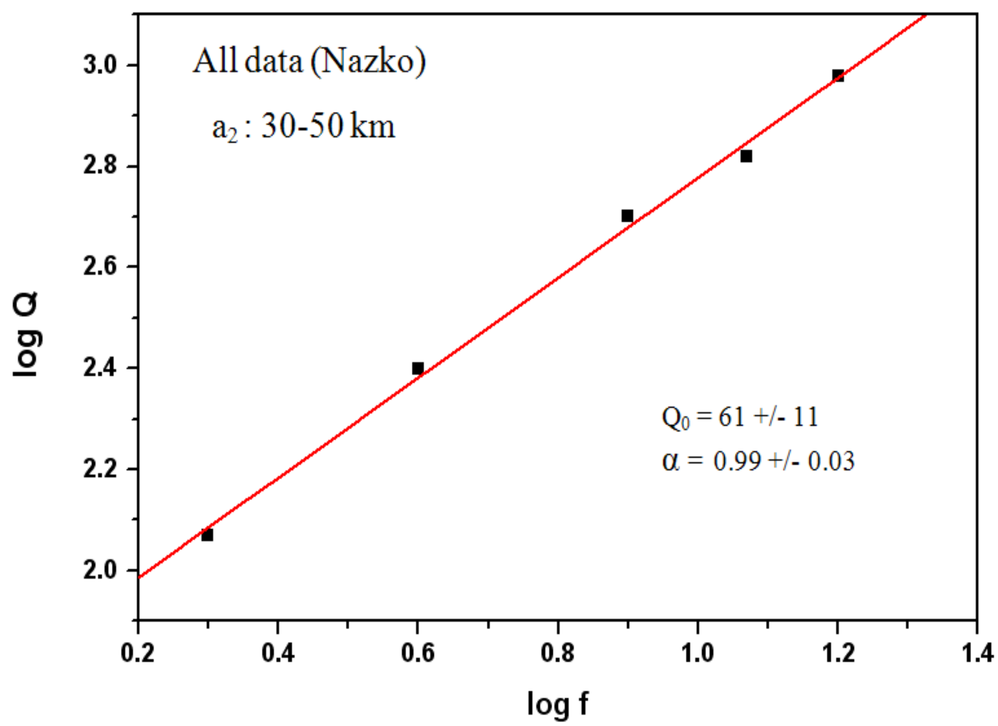
In general, Q increases with lapse time which likely is a result of including a greater volume of less complex upper mantle material in the sampling volume [Pauli, 1984; Zelt et al., 1999]. Therefore, in order to reduce sampling size and to ensure that approximately equivalent volumes are sampled at each station used to calculate Q, we fixed a_2 and average of maximum lapse time to specific values. These values are selected based on the location distribution of earthquakes around the stations.

In total, the dataset comprises 380 earthquakes recorded between 1999 and 2012 with magnitudes ranging from 1.6 to 3.9, depths from 0 to 36 km and distances from the seismograph station of 15 to 100 km. This gives a total of 423 high signal to noise traces (S/N≥5.0) useful for Q_C calculation; however the number of traces actually used for analysis depends on sampling size. The coda window length used in this study is 15 sec except for epicentral distances less than 30 km which is 10 sec.

We used the computer program SEISAN [Havskov and Ottemöller, 2008] to calculate coda Q. The program calculates Q for a series of events and stations at five frequencies (2, 4, 8, 12 and 16 Hz). On completion, the average values are calculated and a Q versus f curve is fit to the calculated values [Havskov and Ottemöller, 2008]. The program also plots the individual events and filtered coda windows (e.g., Figure 3).

Coda Q for earthquakes in the interior of BC

In order to make a regional comparison of Q over the study area, it is necessary to use the shortest possible event-station paths. This, rules out simply selecting all the data with the highest signal-to-noise ratio. In this study, we calculated coda Q at different stations by using different sets of ellipse parameter a_2 (30-110 km) and lapse time (17-70 sec) with maximum sampling depth between 44 km and 120 km. An average of all data in the Nazko region with a_2 between 30 km and 50 km gives a relationship of $Q_C = 61 f^{0.99}$ for frequencies in the 2- to 16- Hz range (Figure 4).



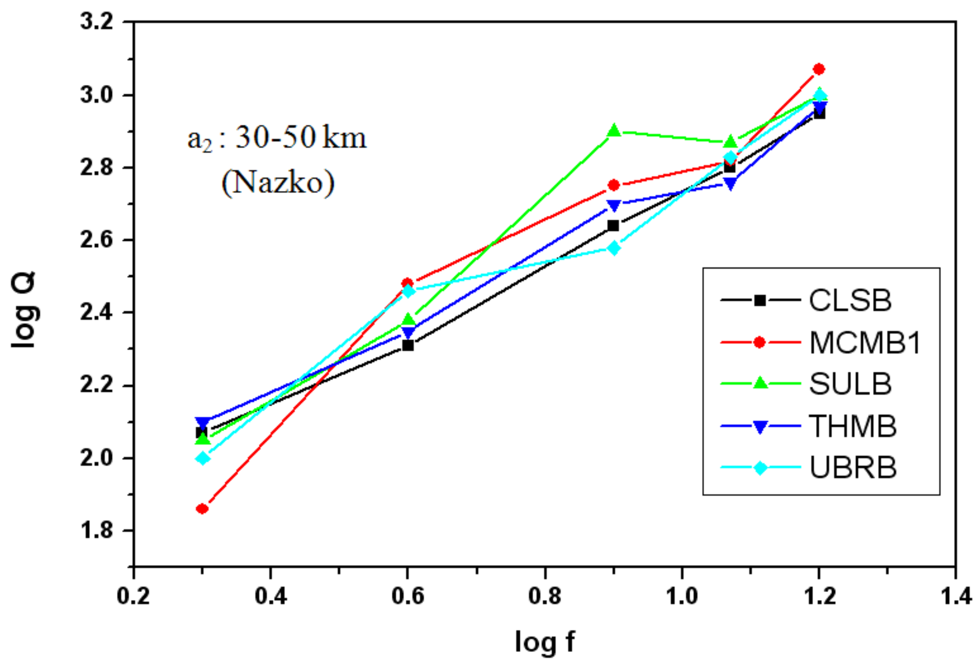


Figure 4: Q_0 and α values for all calculated Q values (top) and log-log plots showing variation of Q_C with frequency (2-16 Hz) and sampling volume size (a_2 = 30-50 km; average lapse times of 17-32 sec) at five stations in the Nazko region (bottom).

Q_0 values (coda Q at 1 Hz) generally allow a quantitative comparison from station to station and with other studies [e.g., Farahbod et al., 2016; Zelt et al., 1999; Havskov et al., 1989]. Therefore, we calculated the Q_0 values for each station for the smallest possible sampling volumes (Figures 5-8). Table 1 provides the Q_0 estimate (as well as time lag) for each station with five or more events (note that due to poor S/N and lack of data, there is not even a single Q estimate for stations FPLB and RAMB). It is noteworthy that all stations examined in this study exhibit low Q_0 values (39 – 109). Uncertainty in these Q_0 values ranges from 4 to 18 (as indicated on the maps by dotted circles with a diameter proportional to the error).

The lowest Q_0 values (highest attenuation) determined in this study (MCMB1 with a Q_0 of 39, and UBRB with a Q_0 of 54) are the stations that are closest to the Nazko Cone in the AVB. This is noteworthy, as the Nazko Cone is the youngest and most easterly volcanic cone in the AVB (Souther et al., 1987) and is nearest to the 2007 earthquake swarm (Figure 2) that was interpreted as injection of magma into the lowermost crust (Cassidy et al., 2011). Averaging all data in the AVB having a_2 between 30 km and 50 km and average lapse times between 17 s and 33 s (UBRB, MCMB1, SULB, THMB) yields a low average Q_0 of 53.

As can be seen in Table 1, all stations within the AVB show lower Q_0 values compared to other stations (at similar a_2 parameters) in the BC interior. For example, for a_2 of 30-35 km, the average Q_0 value for stations within the AVB is 46.5 compared to 57 for the station outside of the AVB. For a_2 of 45-55 km, the average Q_0 within the AVB is 59 compared to 71 outside the AVB, and for a_2 of 75-85, the average Q0 value for the station within the AVB is 79 compared to 97 for the stations outside the AVB.

Table 1. Average Q_0 and estimated uncertainties for different sampling volumes (a_2 parameter). Boldface denotes stations within the AVB. The numbers in brackets indicate the number of events used to compute Q_0 at each station.

Station	**Q_0 ± error a_2=30-35 km**	**Q_0 ± error a_2=45-55 km**	**Q_0 ± error a_2=75-85 km**	**Q0 ± error a_2=95-110 km**	**a_2 (km)**	**t_c (sec)**	**Z_{max} (km)**
UBRB	**54 ±17 (13)**				**30**	**17**	**44**
MCMB1	**39 ±13 (6)**				**33**	**20**	**47**
THMB		**63 ±12 (15)**			**45**	**28**	**59**
SULB		**55 ±9 (9)**			**50**	**33**	**66**
ALRB			**79 ±4 (9)**		**75**	**47**	**88**
CLSB	57 ±11 (5)				32	50	59
CLSB				78 ±16 (12)	95	60	111
FSB		69 ±15 (5)			55	35	59
LLLB		74 ±18 (5)			53	34	69
TALB			109 ±13 (11)		86	55	98
FLLB				91 ±21 (3)	110	70	120
WSLR			85 ±12 (6)		80	49	90

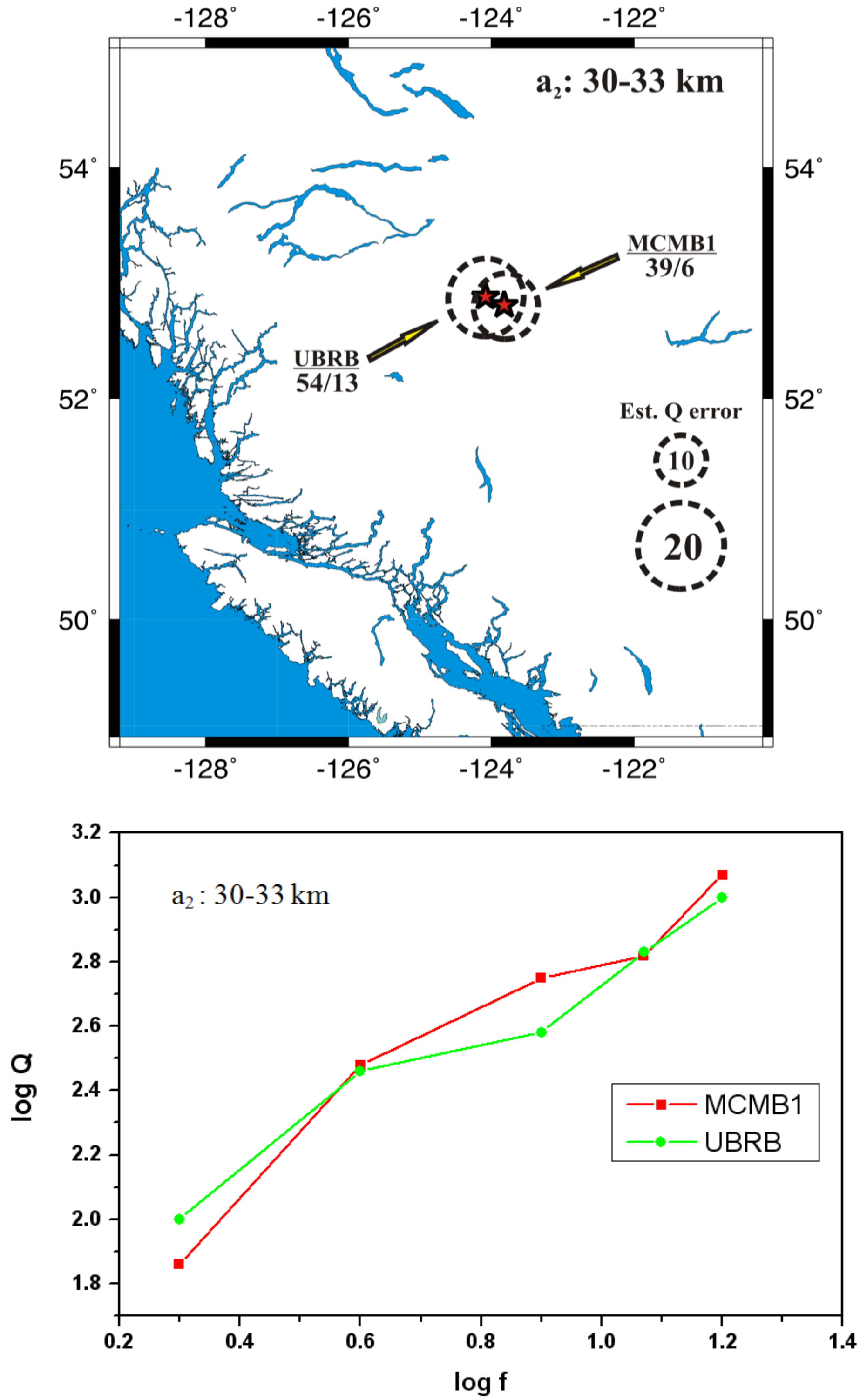
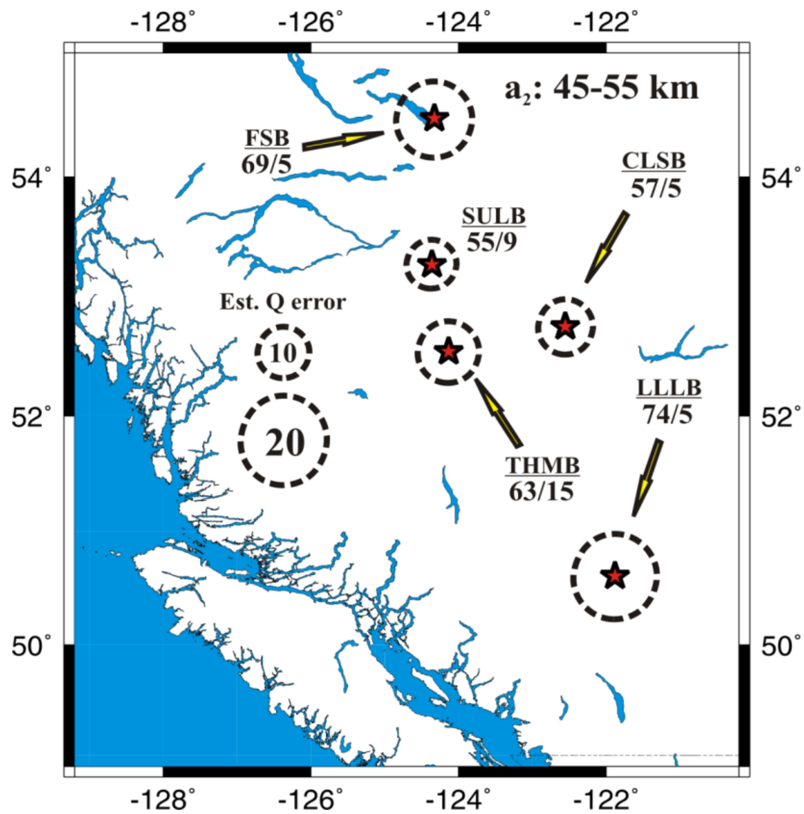


Figure 5: Q_0 variations throughout the interior of BC for sampling volumes with ellipse parameter a_2 between 30 and 33 km and lapse time between 17 and 20 seconds (top) and log-log plots showing variation of Q_C with frequency (bottom). Only stations with five or more events are shown. Numbers below station code are average Q_0 / number of events. Estimated errors in Q_0 values are indicated by dotted circles with diameter proportional to relative error (see Appendix 4).



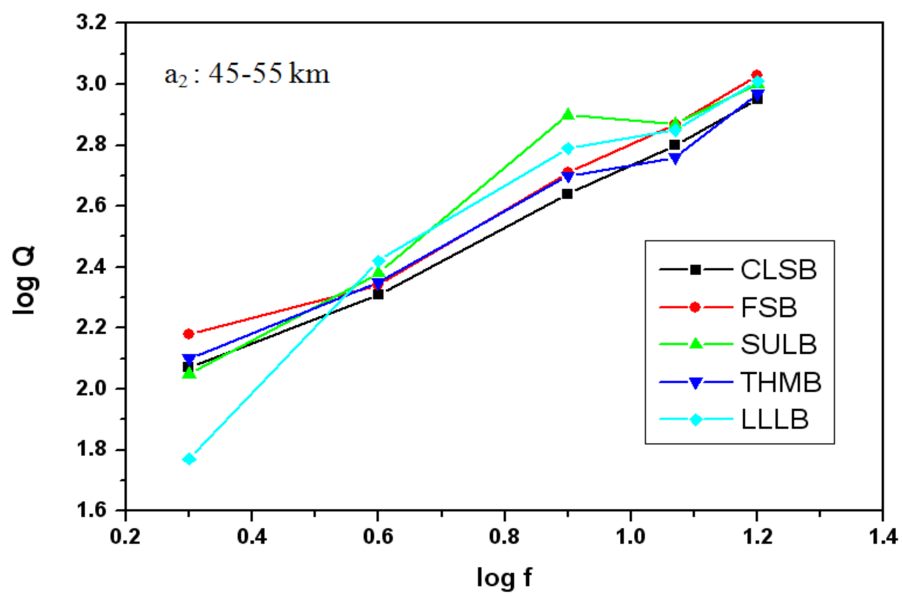
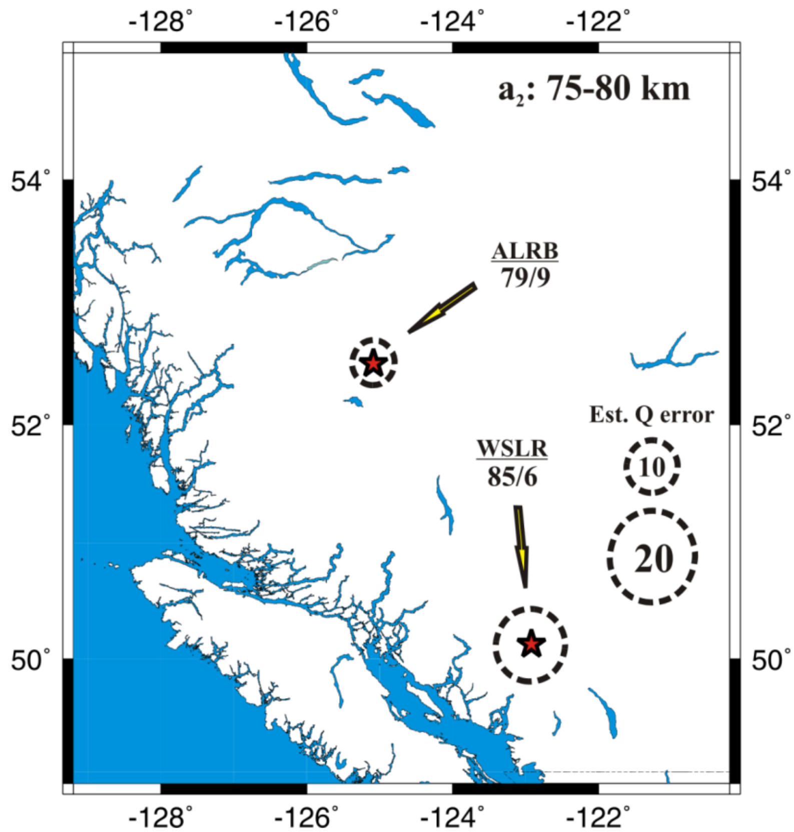


Figure 6: Q_0 variations throughout the interior of BC for sampling volumes with ellipse parameter a_2 between 45 and 55 km and lapse time between 28 and 35 seconds (top) and log-log plots showing variation of Q_C with frequency (bottom). Only stations with five or more events are shown. Numbers below station code are average Q_0 / number of events. Estimated errors in Q_0 values are indicated by dotted circles with diameter proportional to relative error (see Appendix 4).



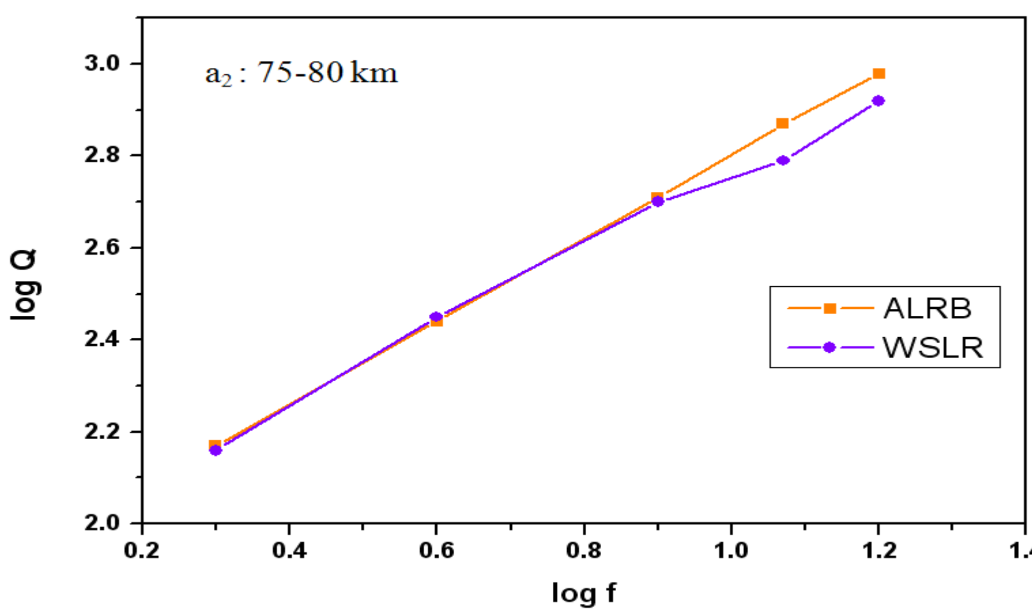


Figure 7: Q_0 variations throughout the interior of BC for sampling volumes with ellipse parameter a_2 between 75 and 80 km and lapse time between 47 and 49 seconds (top) and log-log plots showing variation of Q_C with frequency (bottom). Only stations with five or more events are shown. Numbers below station code are average Q_0 / number of events. Estimated errors in Q_0 values are indicated by dotted circles with diameter proportional to relative error (see Appendix 4).

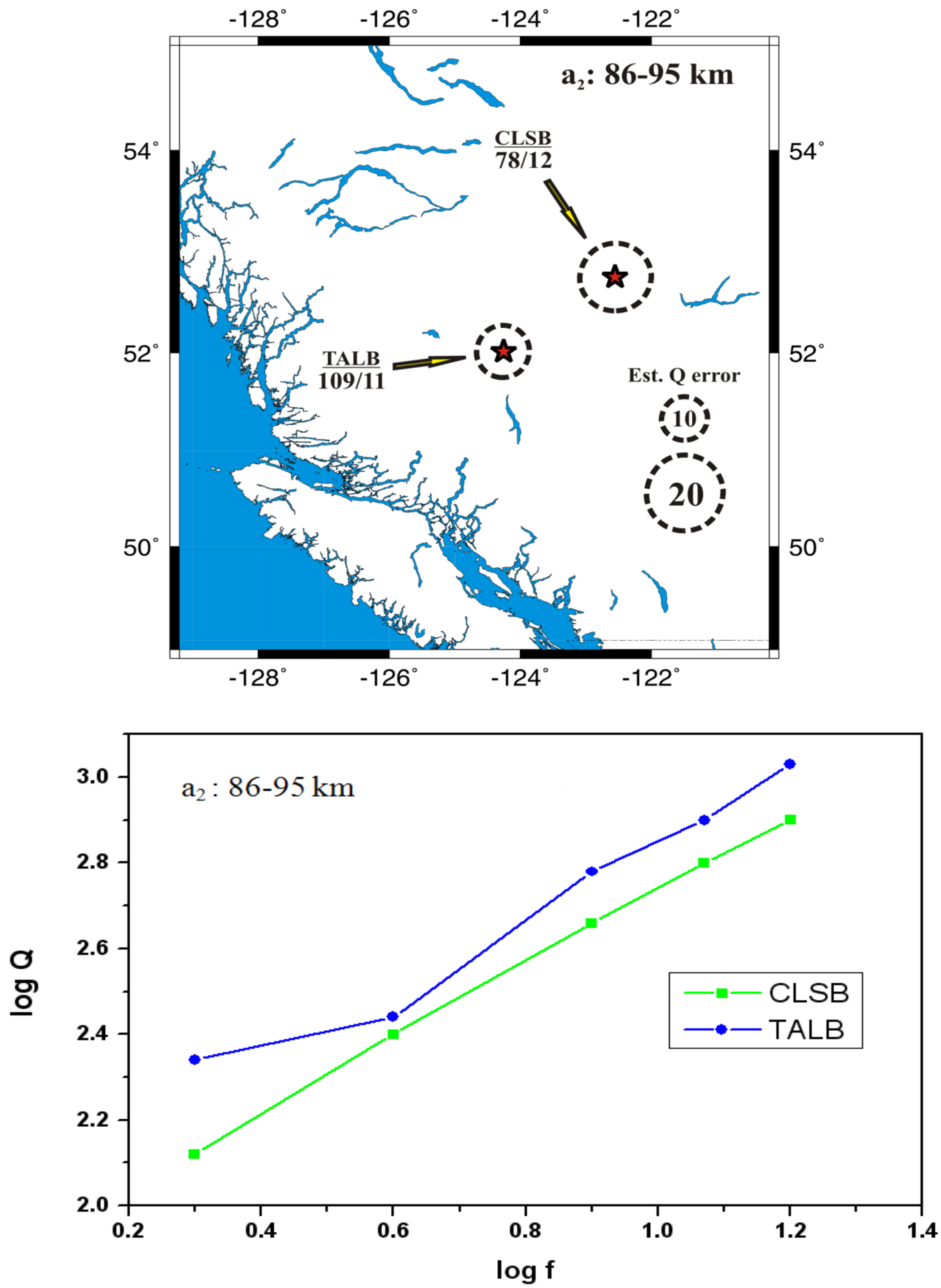


Figure 8: Q_0 variations throughout the interior of BC for sampling volumes with ellipse parameter a_2 between 86 and 95 km and lapse time between 55 and 60 seconds (top) and log-log plots showing variation of Q_C with frequency (bottom). Only stations with five or more events are shown. Numbers below station code are average Q_0 / number of events. Estimated errors in Q_0 values are indicated by dotted circles with diameter proportional to relative error (see Appendix 4).

Comparing our AVB results to Q_0 values across the northern Cascadia subduction zone (Farahbod et al., 2016) reveals a similar pattern. For all a_2 values, Q_0 is lower for stations within the AVB compared to those in the Cascadia subduction zone. For example, for a_2 of 30-35 km, the average Q_0 value for stations within the AVB is 46.5 compared to 69 for stations (a_2 of 40) in Cascadia. For a_2 of 45-55 km, the average Q_0 within the AVB is 59 compared to 70 in Cascadia, and for a_2 of 75-85, the average Q_0 value for the station within the AVB is 79 compared to 83 for stations in Cascadia.

Summary and conclusions

We investigated coda-wave attenuation in the interior of British Columbia, with a focus on the AVB (and especially the Nazko Cone region), using the single scattering approximation on records from short period and broadband stations of the regional Canadian National Seismic Network (CNSN) and POLARIS Network. In the Nazko region, the method was applied to more than 400 records of an unusual sequence of earthquakes mostly located at a depth between 25 and 31 km and within a radius of about 5 km. 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.

Despite this relatively small data set with significant uncertainties, some consistent patterns are observed. At all BC interior stations, low Q_0 values are obtained (<109) consistent with tectonically active regions (e.g., see Farrokhi et al., 2015). We find that in the interior of BC, the lowest Q_0 values (e.g., Q_0 of 39) are in the vicinity of Nazko Cone, near the 2007 earthquake swarm. These low Q_0 values are consistent with fractured rock (high attenuation) from magma intrusions. Further, we find that all stations within the AVB show lower Q_0 values compared to other stations in the BC interior. Considering all data in the AVB with a_2 of 30-50 km (UBRB, MCMB1, SULB, THMB) yields a low average Q_0 of 53, compared to an average Q_0 of 67 at other stations in the BC interior, and an average Q_0 of 70 for stations in the Cascadia subduction zone (Farahbod et al., 2016).

Acknowledgements

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Appendix 1

Earthquake parameters (note that "g" for depth indicates fixed (assigned) depth by analyst)

No.	Date yyyy/mm/dd	Origin Time hh:mm:ss	Lat. (N)	Long. (E)	Depth (km)	Mag.
1	1999/11/15	07:43:45	51.01	-122.50	0.0g	1.6ML
2	2000/02/05	13:40:39	50.38	-120.63	1.0g	1.7ML
3	2000/09/11	05:07:41	50.78	-121.91	5.8	2.1ML
4	2000/09/27	23:29:01	50.77	-121.67	1.0g	1.8ML
5	2000/10/23	21:21:00	50.50	-121.52	10.0g	1.6ML
6	2001/02/10	03:24:20	54.31	-123.45	10.0g	3.0ML
7	2001/05/22	08:16:24	50.37	-121.56	10.0g	1.9ML
8	2001/06/19	02:59:50	50.96	-121.18	1.0g	1.7ML
9	2001/07/08	22:12:22	50.36	-121.53	1.0g	1.6ML
10	2001/12/19	03:08:38	50.17	-121.62	3.7	2.0ML
11	2001/12/22	23:26:04	50.70	-122.88	5.0g	1.8ML
12	2002/08/30	08:44:42	54.62	-123.58	10.0g	2.5ML
13	2002/11/03	22:40:16	50.63	-120.80	1.0g	1.9ML
14	2002/11/04	03:34:44	50.67	-120.78	1.0g	1.6ML
15	2003/10/08	18:42:40	54.38	-123.45	5.0g	2.9ML
16	2003/12/02	15:16:38	54.44	-123.44	1.0g	1.7ML
17	2004/02/28	06:35:29	49.72	-123.40	1.0	1.9ML
18	2004/04/03	20:18:18	49.62	-123.22	10.3	1.8ML
19	2004/07/01	13:23:44	49.77	-122.83	3.3	1.8ML
20	2004/10/06	09:57:08	54.39	-123.44	1.0g	2.1ML
21	2005/02/21	13:11:55	49.62	-122.36	5.0g	1.9ML
22	2005/03/15	16:07:05	50.31	-124.09	1.0	1.6ML
23	2005/08/18	04:09:47	51.25	-121.96	10.0g	2.2ML
24	2005/10/08	00:19:53	50.69	-121.84	10.0g	1.9ML
25	2005/10/15	08:23:34	49.38	-122.32	1.0	1.8ML
26	2005/10/18	19:32:07	49.38	-122.32	1.0	2.5ML
27	2005/11/09	04:43:17	49.37	-122.34	3.4	2.3ML
28	2005/12/26	05:43:54	49.81	-123.77	1.0g	1.7ML
29	2006/01/10	06:07:01	54.41	-123.45	1.0g	1.9ML
30	2006/08/12	05:06:07	50.73	-121.86	5.3	1.6ML
31	2006/08/16	13:18:45	50.56	-123.47	1.0	1.8ML
32	2006/08/26	14:08:57	50.69	-121.70	1.4	1.7ML
33	2006/10/24	08:40:12	50.22	-120.77	1.0g	2.0ML
34	2006/12/15	10:37:49	49.79	-122.67	0.0	1.8ML
35	2006/12/30	17:49:23	49.30	-122.38	3.8	1.7ML

36	2007/03/09	21:30:23	50.48	-121.67	1.0g	2.0ML
37	2007/06/09	17:11:55	50.50	-124.14	1.0g	2.2ML
38	2007/06/09	19:38:08	50.50	-121.02	1.0g	1.9ML
39	2007/06/17	04:44:48	49.77	-123.60	6.0	1.7ML
40	2007/07/09	14:58:03	50.66	-122.64	0.0	2.1ML
41	2007/10/09	08:26:09	52.87	-124.04	30.2	1.8ML
42	2007/10/09	08:30:14	52.88	-124.05	30.1	1.6ML
43	2007/10/09	17:09:20	52.88	-124.03	29.0	1.8ML
44	2007/10/09	17:50:39	52.88	-124.05	28.8	2.0ML
45	2007/10/09	17:51:31	52.88	-124.08	27.6	2.0ML
46	2007/10/09	18:16:13	52.88	-124.05	28.6	2.1ML
47	2007/10/09	18:45:59	52.88	-124.04	28.3	1.9ML
48	2007/10/09	19:09:49	52.88	-124.03	29.2	1.6ML
49	2007/10/10	01:00:01	52.86	-124.14	31.2	1.8ML
50	2007/10/10	01:04:34	52.87	-124.13	30.2	1.8ML
51	2007/10/10	02:49:22	52.87	-124.02	22.6	1.9ML
52	2007/10/10	03:12:02	52.88	-124.07	28.5	1.9ML
53	2007/10/10	03:21:20	52.89	-124.06	23.9	1.9ML
54	2007/10/10	03:24:47	52.89	-124.07	25.9	2.3ML
55	2007/10/10	03:38:29	52.88	-124.08	25.3	2.0ML
56	2007/10/10	04:10:12	52.88	-124.05	28.9	1.9ML
57	2007/10/10	04:28:28	52.88	-124.04	26.7	1.7ML
58	2007/10/10	04:59:54	52.88	-124.07	24.3	2.3ML
59	2007/10/10	05:58:20	52.89	-124.05	28.7	1.7ML
60	2007/10/10	08:07:20	52.89	-124.06	24.6	1.8ML
61	2007/10/10	10:33:43	52.88	-124.06	28.6	1.9ML
62	2007/10/10	10:41:29	52.88	-124.02	28.0	1.6ML
63	2007/10/10	11:33:30	52.88	-124.06	24.4	2.4ML
64	2007/10/10	13:36:51	52.89	-124.02	26.0	1.9ML
65	2007/10/10	14:02:30	52.88	-124.08	24.7	2.3ML
66	2007/10/10	14:31:01	52.88	-124.03	27.9	1.6ML
67	2007/10/10	14:47:56	52.88	-124.08	28.3	1.7ML
68	2007/10/10	15:27:10	52.88	-124.06	27.4	1.6ML
69	2007/10/10	16:54:07	52.88	-124.02	27.5	1.6ML
70	2007/10/10	17:07:27	52.88	-124.05	28.8	1.8ML
71	2007/10/10	17:46:05	52.89	-124.06	22.9	2.4ML
72	2007/10/10	17:50:42	52.89	-124.07	22.3	3.9Mw
73	2007/10/10	22:25:47	52.87	-124.15	32.0	1.7ML
74	2007/10/10	22:51:45	52.88	-124.07	26.6	1.9ML
75	2007/10/11	00:54:45	52.88	-124.08	27.6	1.9ML
76	2007/10/11	00:59:56	52.88	-124.07	28.3	2.8ML

77	2007/10/11	04:07:50	52.88	-124.09	27.2	2.6ML
78	2007/10/13	08:12:16	52.88	-124.04	28.9	1.6ML
79	2007/10/13	09:28:03	52.88	-124.07	24.7	1.6ML
80	2007/10/14	08:34:46	52.86	-124.03	31.1	1.6ML
81	2007/10/14	09:57:16	52.86	-124.05	24.9	1.6ML
82	2007/10/14	10:33:35	50.90	-121.27	1.0g	2.0ML
83	2007/10/14	11:47:51	52.87	-124.06	28.5	2.0ML
84	2007/10/14	12:11:02	52.87	-124.07	30.2	1.6ML
85	2007/10/14	13:15:11	52.87	-124.07	31.0	1.6ML
86	2007/10/14	13:33:20	52.85	-124.16	29.7	1.7ML
87	2007/10/14	14:18:46	52.87	-124.03	30.2	1.6ML
88	2007/10/14	23:44:35	52.89	-123.99	28.5	1.6ML
89	2007/10/14	23:46:07	52.89	-123.99	29.5	1.7ML
90	2007/10/15	10:30:44	52.89	-124.06	32.0	1.6ML
91	2007/10/15	10:56:56	52.88	-124.05	30.5	1.7ML
92	2007/10/15	13:21:00	52.88	-124.05	30.9	1.6ML
93	2007/10/15	13:28:23	52.87	-124.05	22.1	1.7ML
94	2007/10/15	23:43:30	52.87	-124.07	28.0	1.6ML
95	2007/10/16	16:08:45	52.86	-124.03	30.3	1.6ML
96	2007/10/16	17:56:09	52.88	-123.95	25.9	1.6ML
97	2007/10/16	22:58:30	52.87	-124.04	30.1	1.6ML
98	2007/10/17	05:27:16	52.87	-124.03	30.5	1.8ML
99	2007/10/17	09:51:38	52.87	-124.08	30.9	1.8ML
100	2007/10/17	09:56:01	52.89	-123.92	31.0	1.7ML
101	2007/10/17	11:03:35	52.87	-124.06	30.0	1.7ML
102	2007/10/17	12:50:30	52.86	-124.12	30.5	1.9ML
103	2007/10/17	13:08:24	52.86	-124.12	29.0	1.6ML
104	2007/10/17	15:17:15	52.87	-124.11	31.1	1.9ML
105	2007/10/17	15:41:01	52.87	-124.09	30.6	1.7ML
106	2007/10/17	15:47:05	52.87	-124.07	30.1	1.8ML
107	2007/10/17	19:14:26	52.87	-124.09	31.4	1.6ML
108	2007/10/17	19:18:00	52.88	-124.01	31.9	1.8ML
109	2007/10/18	03:04:08	52.87	-124.06	30.0	1.7ML
110	2007/10/18	05:15:18	52.86	-124.00	30.6	1.8ML
111	2007/10/18	07:00:05	52.87	-124.06	29.4	1.9ML
112	2007/10/18	08:42:28	52.87	-124.06	28.7	1.6ML
113	2007/10/18	11:00:59	52.88	-124.05	29.4	1.6ML
114	2007/10/18	12:26:13	52.88	-124.04	29.8	1.6ML
115	2007/10/18	12:30:26	52.87	-124.05	24.5	1.6ML
116	2007/10/18	14:46:20	52.88	-124.05	28.2	1.6ML
117	2007/10/18	14:54:08	52.88	-124.04	28.5	1.7ML

118	2007/10/18	21:15:21	52.87	-124.08	29.2	1.8ML
120	2007/10/18	22:08:13	52.86	-124.00	30.2	1.7ML
121	2007/10/19	00:21:39	52.87	-124.05	30.5	1.7ML
122	2007/10/19	02:38:08	52.87	-124.07	30.2	1.7ML
123	2007/10/19	02:41:27	52.88	-124.05	28.8	1.7ML
124	2007/10/19	03:15:28	52.87	-124.06	28.7	1.8ML
125	2007/10/19	06:10:33	52.86	-123.98	30.6	1.6ML
126	2007/10/19	06:11:54	52.86	-123.96	30.0	1.6ML
127	2007/10/19	06:17:53	52.86	-124.05	31.0	1.7ML
128	2007/10/19	07:24:19	52.88	-124.03	27.0	1.9ML
129	2007/10/19	07:44:49	52.88	-124.06	28.7	1.9ML
130	2007/10/19	07:47:45	52.87	-124.02	29.3	1.8ML
131	2007/10/19	07:54:10	52.87	-124.05	28.8	1.8ML
132	2007/10/19	08:14:52	52.86	-124.04	31.7	1.6ML
133	2007/10/19	09:12:12	52.86	-124.04	30.9	1.8ML
134	2007/10/19	11:14:33	52.88	-124.03	28.6	1.8ML
135	2007/10/19	11:45:27	52.87	-124.04	28.4	1.8ML
136	2007/10/19	23:34:24	54.17	-125.57	0.0	2.5ML
137	2007/10/20	00:38:54	52.59	-122.28	0.0g	2.2ML
138	2007/10/20	03:39:24	52.88	-124.05	26.7	1.7ML
139	2007/10/20	08:29:42	52.87	-124.05	25.8	1.8ML
140	2007/10/20	11:59:41	52.88	-123.99	28.8	1.7ML
141	2007/10/20	12:35:34	52.87	-124.05	28.4	1.7ML
142	2007/10/20	17:43:41	52.88	-124.05	28.8	1.8ML
143	2007/10/20	20:11:17	52.88	-124.07	29.3	1.6ML
144	2007/10/20	22:15:47	52.86	-124.07	28.3	1.9ML
145	2007/10/20	22:50:00	52.87	-124.07	28.3	1.6ML
146	2007/10/21	01:46:47	52.87	-124.06	28.2	1.6ML
147	2007/10/21	05:21:24	52.88	-124.01	29.2	1.7ML
148	2007/10/21	07:36:26	52.87	-124.02	29.5	1.7ML
149	2007/10/21	13:50:56	52.88	-124.03	28.4	1.7ML
150	2007/10/21	14:38:17	52.87	-124.06	26.5	1.7ML
151	2007/10/21	22:03:03	52.87	-124.07	26.1	1.6ML
152	2007/10/21	22:10:34	52.86	-124.04	26.3	1.7ML
153	2007/10/22	00:40:58	52.87	-124.06	27.4	1.9ML
154	2007/10/22	00:53:04	52.87	-124.07	28.0	1.7ML
155	2007/10/22	03:37:51	52.88	-124.02	28.3	1.7ML
156	2007/10/22	03:49:16	52.88	-124.04	27.1	1.6ML
157	2007/10/22	04:17:59	52.88	-124.06	28.7	1.6ML
158	2007/10/22	05:05:15	52.87	-124.13	24.0	1.8ML
159	2007/10/22	05:30:02	52.87	-124.14	30.1	1.6ML

160	2007/10/22	06:15:27	52.87	-124.09	26.8	1.9ML
161	2007/10/22	06:21:34	52.87	-124.06	27.5	1.9ML
162	2007/10/22	06:36:19	52.87	-124.08	27.3	1.7ML
163	2007/10/22	06:50:10	52.87	-124.01	29.4	1.8ML
164	2007/10/22	06:56:05	52.88	-124.02	28.1	1.9ML
165	2007/10/22	07:12:46	52.88	-124.08	27.9	1.6ML
166	2007/10/22	07:19:44	52.89	-124.03	28.3	1.6ML
167	2007/10/22	07:22:09	52.88	-124.07	28.5	1.6ML
168	2007/10/22	07:30:59	52.87	-124.07	27.4	1.9ML
169	2007/10/22	08:13:30	52.88	-124.03	28.0	1.7ML
170	2007/10/22	08:44:10	52.88	-124.08	27.7	1.7ML
171	2007/10/22	08:51:10	52.87	-123.99	30.6	1.8ML
172	2007/10/22	09:19:04	52.88	-124.02	27.5	1.6ML
173	2007/10/22	10:04:25	52.88	-124.03	27.8	1.7ML
174	2007/10/22	10:13:48	52.89	-124.09	28.5	1.7ML
175	2007/10/22	11:51:22	52.88	-124.08	26.8	1.6ML
176	2007/10/22	12:01:15	52.88	-124.02	28.4	1.7ML
177	2007/10/22	13:00:28	52.88	-124.02	28.3	1.6ML
178	2007/10/22	13:09:47	52.88	-124.02	27.9	1.7ML
179	2007/10/22	13:13:55	52.87	-124.03	28.7	1.6ML
180	2007/10/22	13:20:24	52.88	-124.01	29.5	1.7ML
181	2007/10/22	13:33:59	52.88	-124.09	26.0	1.9ML
182	2007/10/22	13:41:19	52.88	-124.01	28.4	1.6ML
183	2007/10/22	14:21:42	52.88	-124.02	28.6	1.8ML
184	2007/10/22	17:52:54	52.88	-124.08	25.6	1.6ML
185	2007/10/23	00:52:31	52.87	-124.08	24.8	1.7ML
186	2007/10/23	03:13:47	52.87	-124.07	27.2	1.7ML
187	2007/10/23	03:31:49	52.88	-124.09	27.7	1.6ML
188	2007/10/23	08:55:37	52.87	-124.09	27.3	1.6ML
189	2007/10/23	12:13:00	52.88	-124.05	29.2	1.6ML
190	2007/10/23	14:01:15	52.89	-124.02	26.4	1.6ML
191	2007/10/23	14:02:40	52.88	-124.06	28.2	1.6ML
192	2007/10/23	14:08:02	52.88	-124.03	27.2	1.6ML
193	2007/10/23	14:26:14	52.88	-124.07	27.6	1.6ML
194	2007/10/23	15:53:45	52.88	-124.03	28.3	1.6ML
195	2007/10/23	17:08:07	52.88	-124.04	26.9	1.6ML
196	2007/10/23	22:30:15	52.90	-123.95	26.0	1.9ML
197	2007/10/23	22:46:51	52.88	-124.08	25.8	1.6ML
198	2007/10/24	01:06:30	52.85	-124.12	28.8	1.6ML
199	2007/10/24	01:10:04	52.87	-124.09	27.5	1.6ML
200	2007/10/24	03:51:52	52.87	-124.08	28.1	1.7ML

201	2007/10/24	05:05:00	52.86	-124.08	27.2	1.9ML
202	2007/10/24	05:40:44	52.87	-124.07	28.0	1.9ML
203	2007/10/24	06:17:09	52.86	-124.04	30.7	1.7ML
204	2007/10/24	06:34:10	52.89	-124.01	27.8	1.7ML
205	2007/10/24	07:25:19	52.88	-124.00	29.7	1.6ML
206	2007/10/24	07:36:54	52.86	-124.06	28.5	1.8ML
207	2007/10/24	08:30:57	52.92	-124.08	22.3	1.6ML
208	2007/10/24	12:16:01	52.88	-124.04	26.2	1.6ML
209	2007/10/24	13:28:02	52.89	-124.06	26.6	1.6ML
210	2007/10/24	16:13:53	52.87	-124.06	27.5	1.6ML
211	2007/10/25	01:52:25	52.87	-124.07	28.9	1.7ML
212	2007/10/25	12:29:26	52.89	-123.97	27.6	1.6ML
213	2007/10/26	20:11:45	52.87	-124.02	28.5	1.6ML
214	2007/10/26	23:02:28	52.88	-124.06	27.2	1.6ML
215	2007/10/27	05:44:13	52.89	-124.01	29.6	1.6ML
216	2007/10/27	07:57:38	52.87	-124.07	27.9	1.7ML
217	2007/10/27	11:06:42	52.87	-124.04	28.8	1.6ML
218	2007/10/27	14:10:13	52.87	-124.06	27.4	1.6ML
219	2007/10/27	14:23:46	52.87	-124.00	29.8	1.7ML
220	2007/10/27	14:41:24	52.87	-124.08	27.9	1.6ML
221	2007/10/27	14:45:06	52.88	-124.06	28.6	1.7ML
222	2007/10/27	16:06:22	52.88	-124.04	30.7	1.6ML
223	2007/10/27	16:12:05	52.88	-124.00	29.7	1.6ML
224	2007/10/27	16:20:30	52.87	-124.07	28.1	1.6ML
225	2007/10/27	18:24:58	52.88	-124.03	28.0	1.6ML
226	2007/10/27	21:07:14	52.88	-124.03	30.2	1.6ML
227	2007/10/28	19:15:44	52.88	-124.07	28.4	1.6ML
228	2007/10/28	20:17:09	52.87	-124.05	28.9	1.6ML
229	2007/10/30	01:28:34	52.85	-124.08	29.5	1.6ML
230	2007/10/30	04:28:29	52.88	-124.06	26.8	1.7ML
231	2007/10/30	15:04:53	52.87	-123.98	29.4	1.6ML
232	2007/10/30	18:08:39	52.86	-123.98	29.0	1.6ML
233	2007/10/30	18:14:32	52.86	-124.06	28.8	1.8ML
234	2007/10/31	02:16:56	52.87	-124.02	29.8	1.6ML
235	2007/10/31	02:36:50	52.88	-123.94	29.7	1.6ML
236	2007/10/31	03:14:46	52.87	-123.99	29.5	1.7ML
237	2007/10/31	04:39:22	52.87	-124.09	29.8	1.8ML
238	2007/10/31	05:03:33	52.87	-123.97	29.3	1.9ML
239	2007/10/31	10:33:57	52.86	-124.06	28.8	1.6ML
240	2007/10/31	16:19:47	52.88	-124.06	28.1	2.0ML
241	2007/10/31	16:53:51	52.86	-124.04	28.1	1.7ML

242	2007/11/01	04:04:47	52.87	-124.07	30.0	1.7ML
243	2007/11/01	12:50:21	52.86	-124.08	30.6	1.6ML
244	2007/11/02	02:30:36	52.87	-124.04	28.8	1.6ML
245	2007/11/02	02:42:22	52.87	-124.06	28.4	1.6ML
246	2007/11/02	08:50:55	52.86	-124.03	28.8	1.7ML
247	2007/11/02	09:39:41	52.86	-124.04	28.4	1.8ML
248	2007/11/02	11:09:00	52.88	-124.05	25.7	1.7ML
249	2007/11/02	11:53:35	52.86	-124.05	29.2	1.8ML
250	2007/11/02	12:56:46	52.86	-124.03	28.0	1.6ML
251	2007/11/02	13:50:44	52.86	-124.05	30.2	1.6ML
252	2007/11/02	14:59:58	52.87	-124.06	29.5	1.6ML
253	2007/11/02	17:11:24	52.86	-124.02	30.1	1.7ML
254	2007/11/03	06:56:08	52.00	-126.16	1.0g	2.5ML
255	2007/11/07	09:48:40	52.87	-124.05	29.1	1.7ML
256	2007/11/08	19:47:06	52.47	-121.41	1.0g	1.8ML
257	2007/11/09	19:04:58	52.88	-123.99	29.4	1.6ML
258	2007/11/09	23:35:30	52.56	-121.66	15.5	2.2ML
259	2007/11/13	20:38:27	52.63	-121.09	36.2	2.5ML
260	2007/11/13	23:30:41	52.51	-121.70	24.2	2.2ML
261	2007/11/14	04:01:50	52.02	-126.11	1.0g	2.3ML
262	2007/11/14	14:34:16	52.04	-126.10	1.0g	2.1ML
263	2007/11/14	19:58:23	52.54	-122.29	14.9	2.0ML
264	2007/11/15	19:21:11	52.50	-121.72	1.0g	2.3ML
265	2007/11/15	20:29:45	52.55	-121.63	5.0g	2.0ML
266	2007/11/16	00:03:49	52.57	-122.23	1.0g	2.1ML
267	2007/11/16	06:59:27	52.04	-126.10	1.0g	2.3ML
268	2007/11/16	13:40:07	52.88	-124.03	28.8	1.8ML
269	2007/11/16	14:03:57	52.88	-124.04	29.0	1.7ML
270	2007/11/22	14:24:58	52.03	-126.17	1.0g	2.2ML
271	2007/11/23	21:23:00	52.53	-122.21	12.7	2.1ML
272	2007/11/27	14:29:47	52.87	-124.11	31.4	1.8ML
273	2007/11/30	20:36:40	52.57	-121.69	14.8	2.1ML
274	2007/12/04	17:10:00	52.87	-124.06	28.6	1.8ML
275	2007/12/09	20:47:22	52.53	-121.67	18.2	2.2ML
276	2007/12/11	11:52:38	52.86	-124.05	29.3	1.6ML
277	2007/12/19	19:46:53	51.25	-124.48	10.0g	2.2ML
278	2007/12/20	23:43:08	52.88	-123.93	29.3	1.6ML
279	2007/12/21	02:27:50	52.87	-124.06	28.6	1.8ML
280	2007/12/21	06:42:07	52.87	-124.11	27.6	1.6ML
281	2007/12/21	21:01:17	52.60	-122.06	16.9	1.9ML
282	2007/12/22	00:17:59	52.55	-121.66	11.5	2.2ML

283	2007/12/25	03:05:56	49.65	-122.79	1.0g	1.9ML
284	2007/12/25	12:36:38	52.86	-124.15	25.7	1.9ML
285	2007/12/25	19:42:25	52.53	-121.67	1.0g	2.2ML
286	2007/12/27	20:35:40	52.55	-121.67	9.4	2.2ML
287	2007/12/28	23:35:57	52.50	-122.25	11.4	2.4ML
288	2008/01/21	14:58:42	51.26	-124.65	1.0g	1.7ML
289	2008/01/26	00:25:11	52.55	-122.01	13.6	1.7ML
290	2008/01/27	21:12:34	52.55	-121.66	14.6	2.0ML
291	2008/02/01	23:50:39	52.59	-121.68	1.0g	2.3ML
292	2008/02/02	01:04:14	52.53	-122.21	7.3	2.5ML
293	2008/02/03	00:17:58	52.54	-122.19	9.6	2.0ML
294	2008/02/03	20:15:43	52.55	-122.13	14.8	1.8ML
295	2008/02/04	05:48:48	52.89	-124.08	27.1	1.6ML
296	2008/02/10	09:04:34	51.21	-124.67	1.0g	2.0ML
297	2008/03/11	02:56:39	52.87	-124.10	27.6	1.8ML
298	2008/03/11	15:14:05	52.88	-124.08	27.8	2.0ML
299	2008/04/08	01:37:39	50.49	-124.17	5.0g	1.6ML
300	2008/05/15	13:45:53	52.88	-124.05	28.2	1.6ML
301	2008/05/21	12:18:58	50.58	-123.88	10.0g	1.7ML
302	2008/06/01	18:31:04	52.57	-122.22	14.6	2.3ML
303	2008/06/17	03:21:04	51.28	-124.86	1.0g	1.6ML
304	2008/07/22	04:26:02	52.01	-126.15	1.0g	1.9ML
305	2008/08/13	16:40:50	51.20	-124.55	10.0g	1.6ML
306	2008/09/11	00:48:02	49.90	-122.66	0.9	2.0ML
307	2008/10/01	15:23:17	51.28	-124.84	1.0g	2.6ML
308	2008/10/16	06:06:16	50.26	-121.26	1.0g	1.9ML
309	2008/10/16	09:50:36	50.26	-121.26	1.0g	1.8ML
310	2008/10/30	02:54:36	50.19	-121.00	1.0g	2.2ML
311	2008/11/21	21:07:58	49.49	-122.46	10.6	1.6ML
312	2008/12/23	20:49:02	49.90	-123.86	1.0g	1.9ML
313	2008/12/27	07:45:09	49.87	-123.67	4.6	1.6ML
314	2009/01/01	13:17:34	49.61	-122.85	1.0	1.6ML
315	2009/01/16	02:16:09	51.12	-124.35	9.4	2.3ML
316	2009/02/08	07:35:33	50.46	-121.65	1.9	1.7ML
317	2009/03/03	11:59:57	49.53	-123.05	0.0	1.8ML
318	2009/03/16	07:02:36	49.99	-123.07	1.0	1.7ML
319	2009/03/16	07:03:03	49.99	-123.05	1.0	1.6ML
320	2009/03/30	11:51:03	50.02	-123.19	1.0	1.7ML
321	2009/04/05	11:26:03	51.88	-125.74	1.0g	2.2ML
322	2009/04/23	10:19:13	50.32	-123.95	3.3	1.7ML
323	2009/05/31	16:08:44	52.53	-121.74	0.0	2.3ML

324	2009/06/06	06:15:49	52.27	-125.17	1.0g	2.3ML
325	2009/07/06	00:14:43	49.84	-123.66	2.3	2.2ML
326	2009/07/15	19:52:55	50.53	-120.99	10.4	1.8ML
327	2009/09/03	21:52:25	50.38	-120.65	22.2	2.1ML
328	2009/09/20	16:51:46	52.21	-126.20	5.0g	2.1ML
329	2009/10/01	12:31:51	50.40	-123.79	1.0g	1.7ML
330	2009/10/15	23:13:23	49.34	-122.71	1.0g	1.7ML
331	2009/11/16	06:40:09	50.89	-121.29	1.0g	1.8ML
332	2009/12/27	04:37:20	50.20	-123.97	5.0g	1.7ML
333	2010/01/11	11:13:21	50.73	-121.84	5.0g	2.1ML
334	2010/01/25	07:06:43	50.20	-123.91	6.0	1.6ML
335	2010/02/08	00:10:35	52.40	-122.31	5.0g	2.4ML
336	2010/02/20	05:15:30	51.40	-124.93	1.0g	1.6ML
337	2010/02/24	19:38:15	49.88	-124.07	1.0	1.6ML
338	2010/04/14	22:41:49	50.94	-121.08	5.0g	1.7ML
339	2010/04/27	19:40:45	50.00	-121.50	1.0g	1.7ML
340	2010/05/12	00:35:56	50.00	-121.52	1.0g	1.6ML
341	2010/05/13	23:35:48	50.00	-121.50	0.2	1.6ML
342	2010/06/11	12:48:35	50.66	-123.12	5.0	1.9ML
343	2010/07/09	07:32:30	51.91	-126.09	1.0g	2.2ML
344	2010/07/09	15:06:28	51.87	-125.98	1.0g	2.2ML
345	2010/08/25	02:13:15	50.07	-123.04	0.1	1.7ML
346	2010/09/01	04:04:38	51.37	-124.59	1.0g	1.8ML
347	2010/09/11	00:04:30	50.49	-121.07	10.0g	1.6ML
348	2010/09/17	06:10:56	49.60	-122.26	6.0	1.7ML
349	2010/09/22	21:09:07	49.80	-123.60	3.5	1.8ML
350	2010/10/04	08:50:06	50.33	-123.94	0.0	1.6ML
351	2010/10/11	07:53:53	51.27	-124.97	5.0g	2.4ML
352	2010/10/11	11:19:25	54.50	-123.81	1.0g	3.5ML
353	2010/10/28	19:03:00	49.90	-123.91	1.0g	1.7ML
354	2010/11/10	05:09:13	50.39	-120.55	1.0g	1.7ML
355	2010/11/11	21:56:05	49.73	-123.59	1.0g	1.8ML
356	2010/12/15	07:11:02	50.17	-121.63	1.0g	1.9ML
357	2010/12/18	03:54:15	50.69	-121.88	7.5	1.7ML
358	2011/01/06	18:34:03	49.88	-122.55	0.9	1.7ML
359	2011/02/16	07:54:41	50.75	-121.85	1.0g	1.6ML
360	2011/02/24	06:28:15	51.31	-124.98	1.0g	2.4ML
361	2011/03/05	06:48:53	51.38	-124.69	0.0	2.5ML
362	2011/03/20	11:32:28	50.22	-123.64	1.0g	1.8ML
363	2011/03/24	09:48:27	50.39	-124.10	1.0g	1.7ML
364	2011/04/27	04:57:07	50.38	-120.62	20.0g	2.5ML

365	2011/06/01	11:44:03	51.53	-124.79	1.0g	1.9ML
366	2011/06/30	08:17:28	54.10	-124.43	1.0g	3.3ML
367	2011/08/12	06:02:11	49.54	-122.40	19.5	3.3ML
368	2011/08/26	18:50:40	51.39	-125.08	1.0g	2.4ML
369	2011/09/18	16:33:21	49.91	-124.04	0.7	1.7ML
370	2011/09/21	13:18:10	49.87	-123.71	1.5	1.8ML
371	2011/09/25	20:59:08	49.93	-123.11	1.0g	1.7ML
372	2011/09/26	09:16:29	51.25	-124.86	1.0g	2.0ML
373	2011/09/28	09:49:47	51.23	-124.88	1.0g	2.4ML
374	2011/10/01	17:17:55	51.23	-124.92	1.0g	2.5ML
375	2011/10/02	14:38:20	51.29	-124.98	1.0g	2.5ML
376	2011/10/19	19:34:06	51.98	-125.96	1.0g	2.4ML
377	2011/11/09	08:09:52	50.94	-121.04	1.0g	1.7ML
378	2011/11/21	04:27:21	49.89	-123.72	0.0	1.6ML
379	2011/11/21	17:11:15	50.89	-120.85	10.0g	2.6ML
380	2011/11/25	20:39:02	49.89	-123.72	1.4	1.9ML

Appendix 2

Frequency-Magnitude of selected earthquakes per station

Station	Magnitude		
	1.6-1.9	2.0-2.9	3.0-3.9
ALRB	210	25	-
CLSB	52	22	-
FLLB	-	-	-
FPLB	169	2	-
FSB	2	4	3
LLLB	31	13	-
MCMB1	169	2	-
RAMB	212	34	1
SULB	209	14	2
TALB	213	27	1
THMB	209	15	1
UBRB	169	2	-
WSLR	47	7	1

Appendix 3

Maps of earthquakes within 100 km of each seismic station

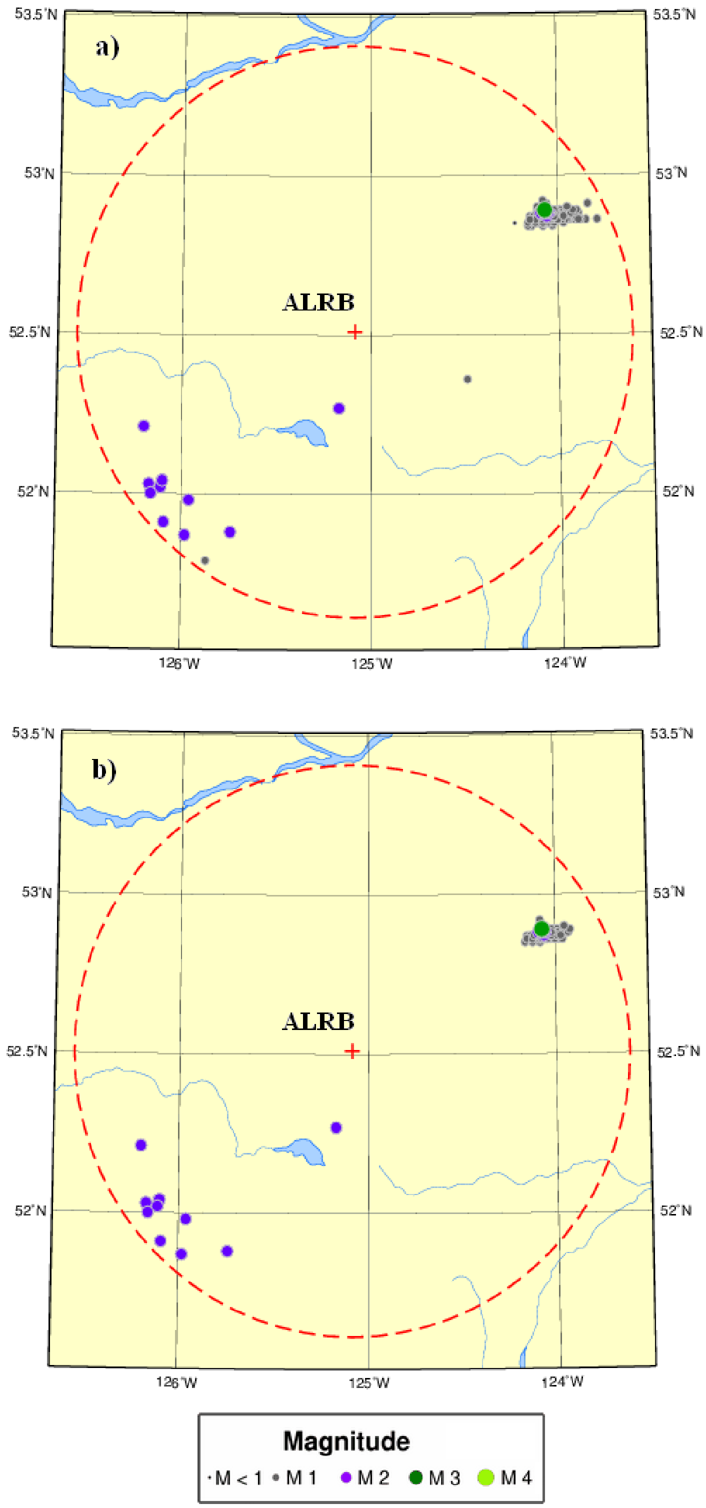


Figure A3-1: Map showing (a) distribution of reported events and (b) selected earthquakes in a radius of 100 km around station ALRB between 2007 and 2011.

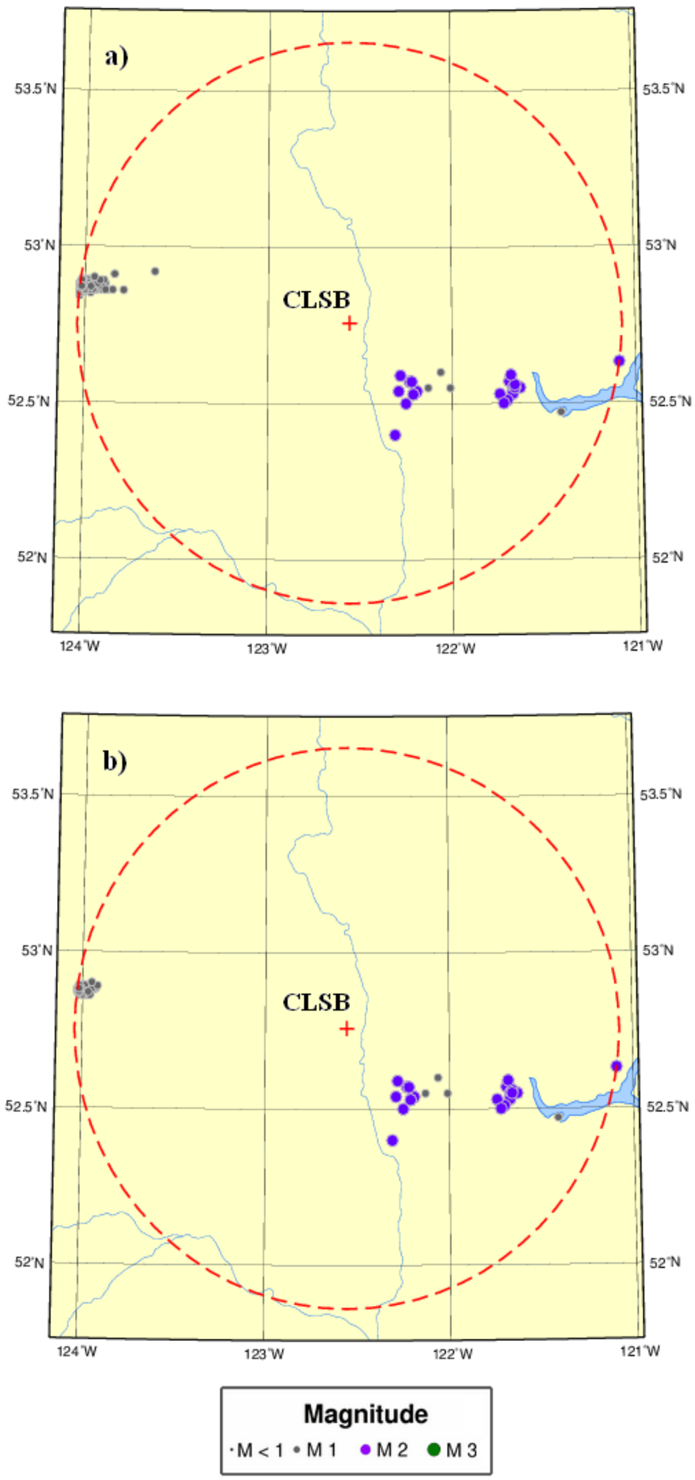


Figure A3-2: Map showing (a) distribution of reported events and (b) selected earthquakes in a radius of 100 km around station CLSB between 2007 and 2011.

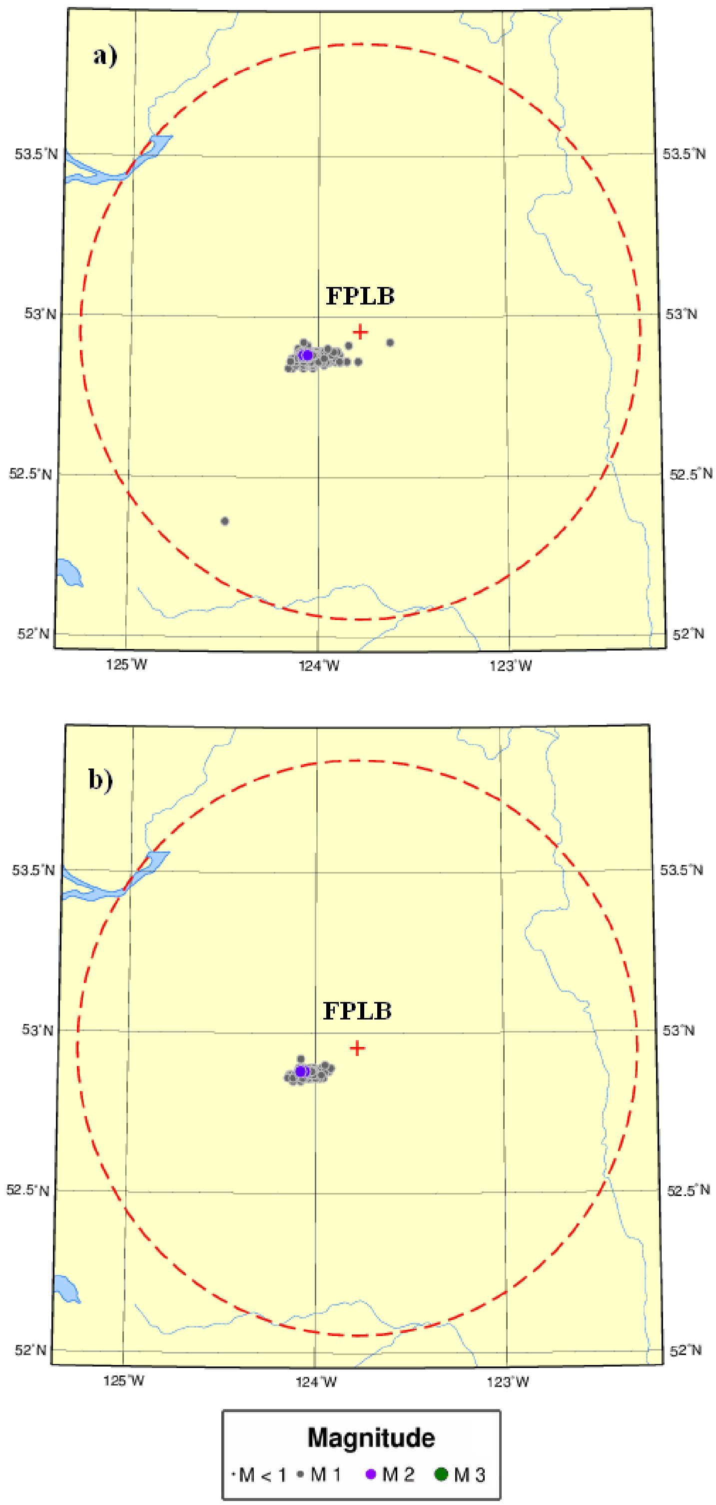


Figure A3-3: Map showing (a) distribution of reported events and (b) selected earthquakes in a radius of 100 km around station FPLB between 2007 and 2011.

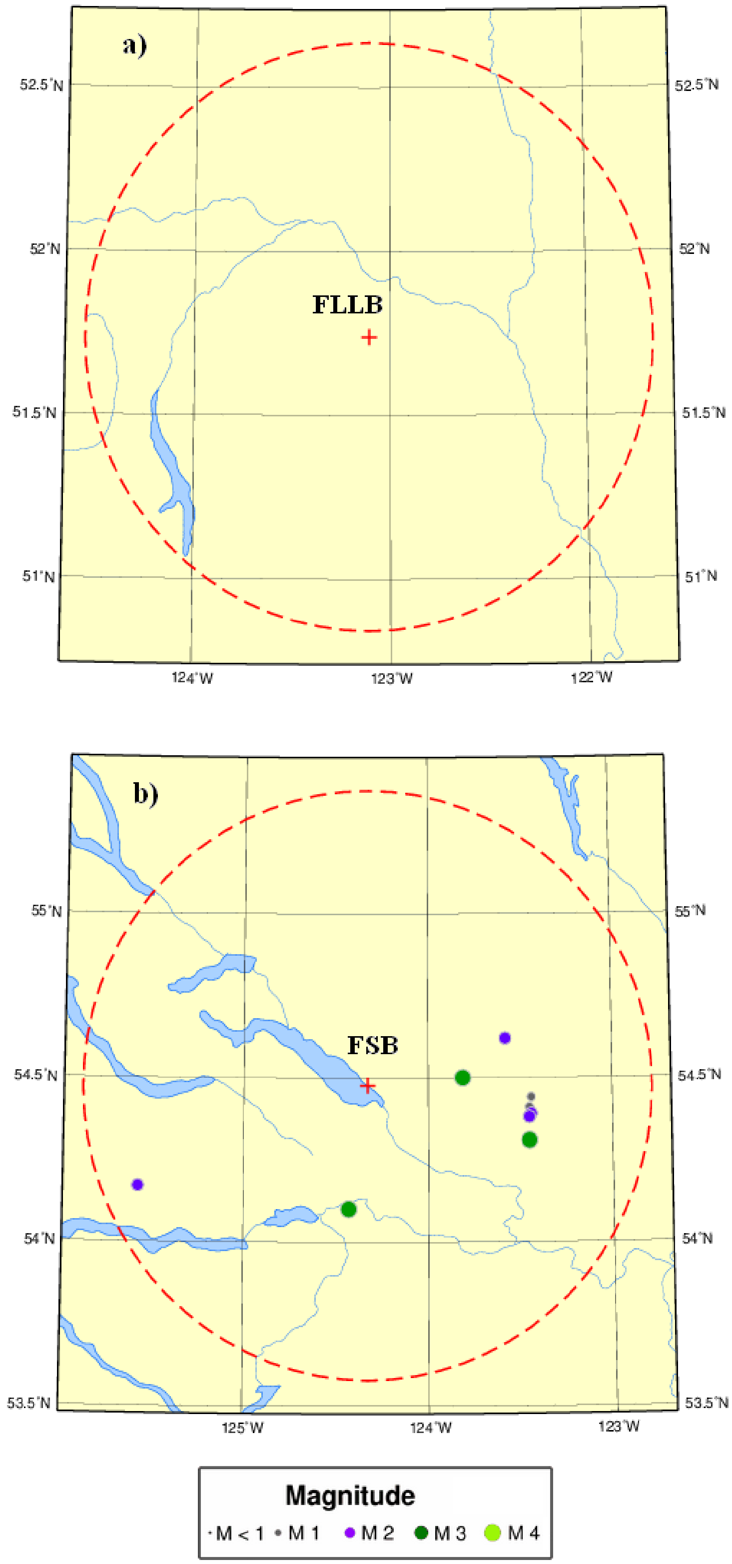


Figure A3-4: Map showing distribution of events in a radius of 100 km around (a) station FLLB (2007- 2010) and (b) station FSB (1996-2011).

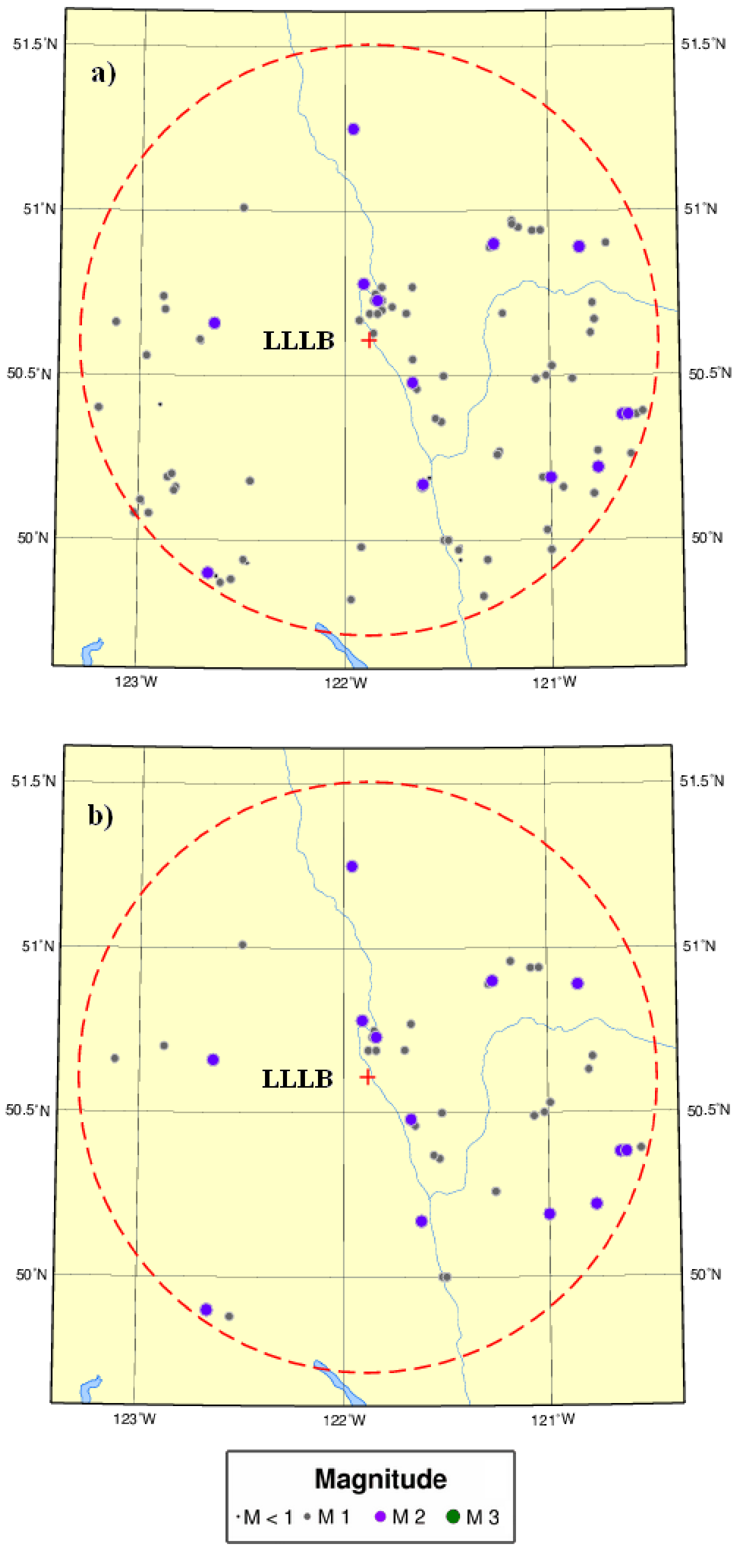


Figure A3-5: Map showing (a) distribution of reported events and (b) selected earthquakes in a radius of 100 km around station LLLB between 1998 and 2011.

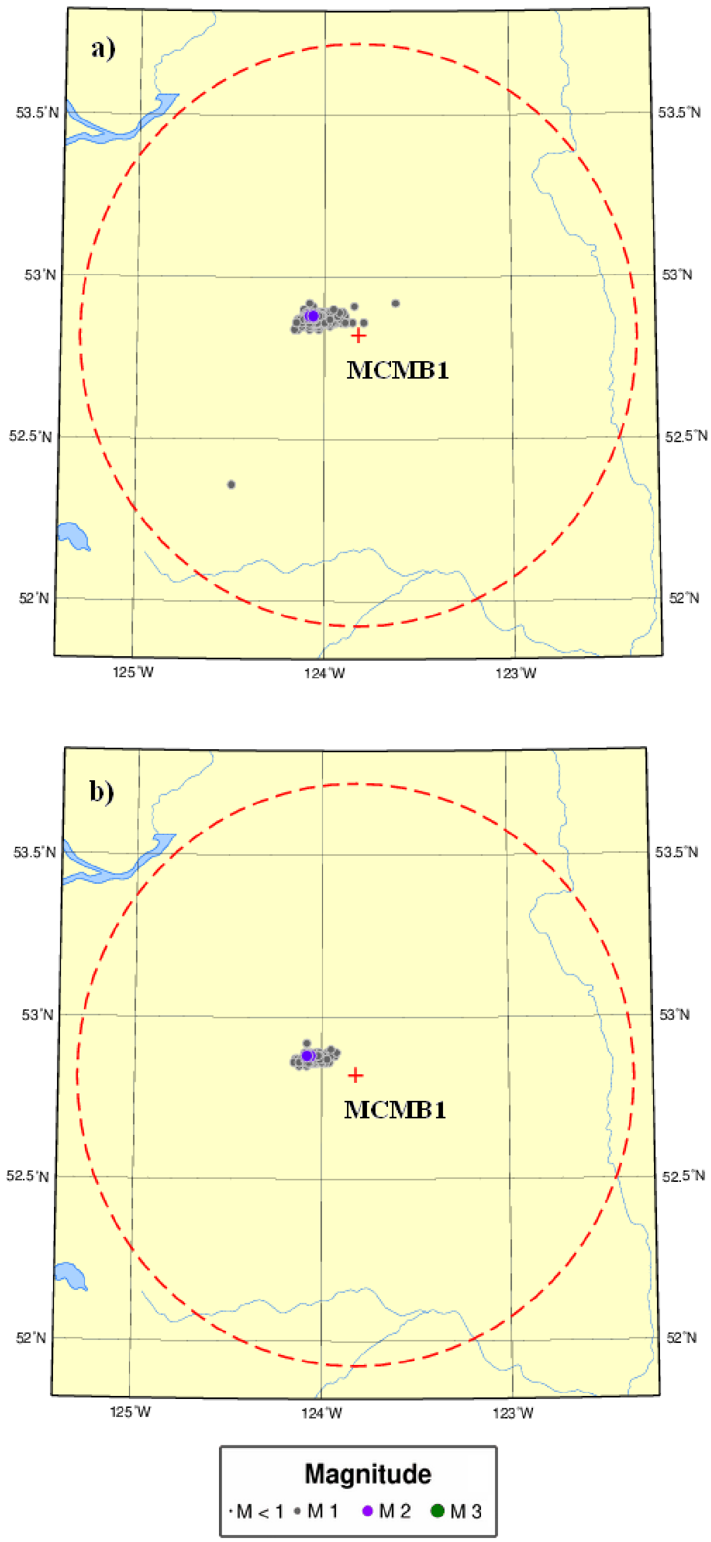
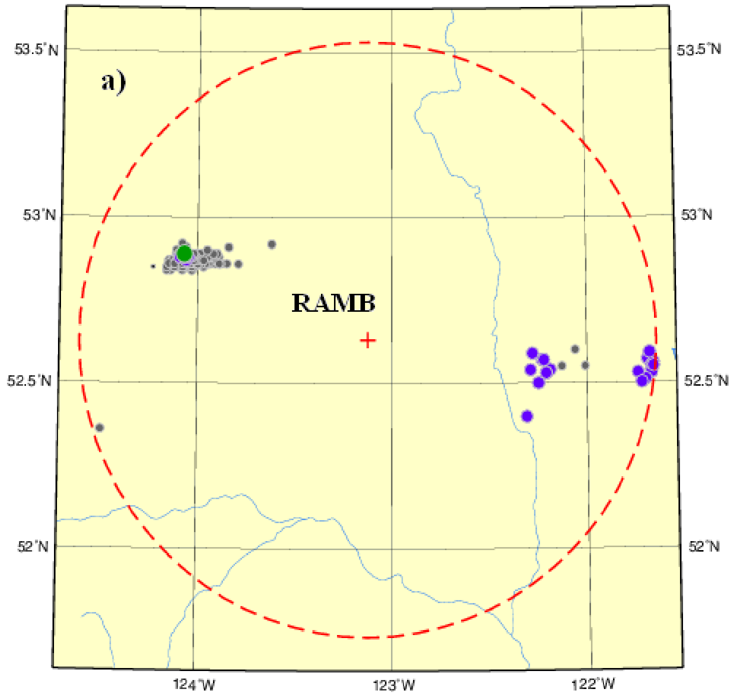


Figure A3-6: Map showing (a) distribution of reported events and (b) selected earthquakes in a radius of 100 km around station MCMB1between 2007 and 2011.



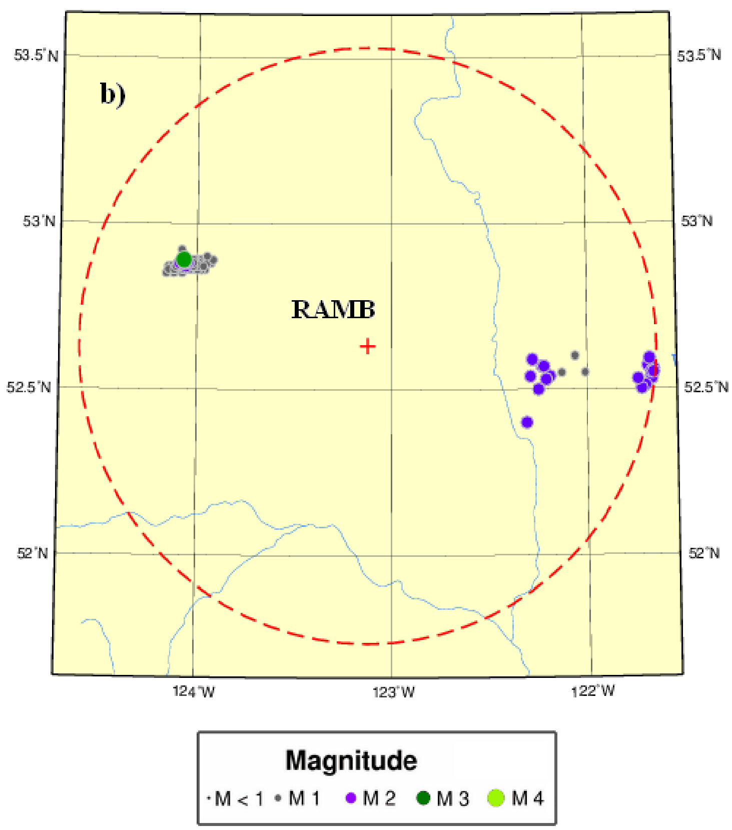


Figure A3-7: Map showing (a) distribution of reported events and (b) selected earthquakes in a radius of 100 km around station RAMB between 2007 and 2011.

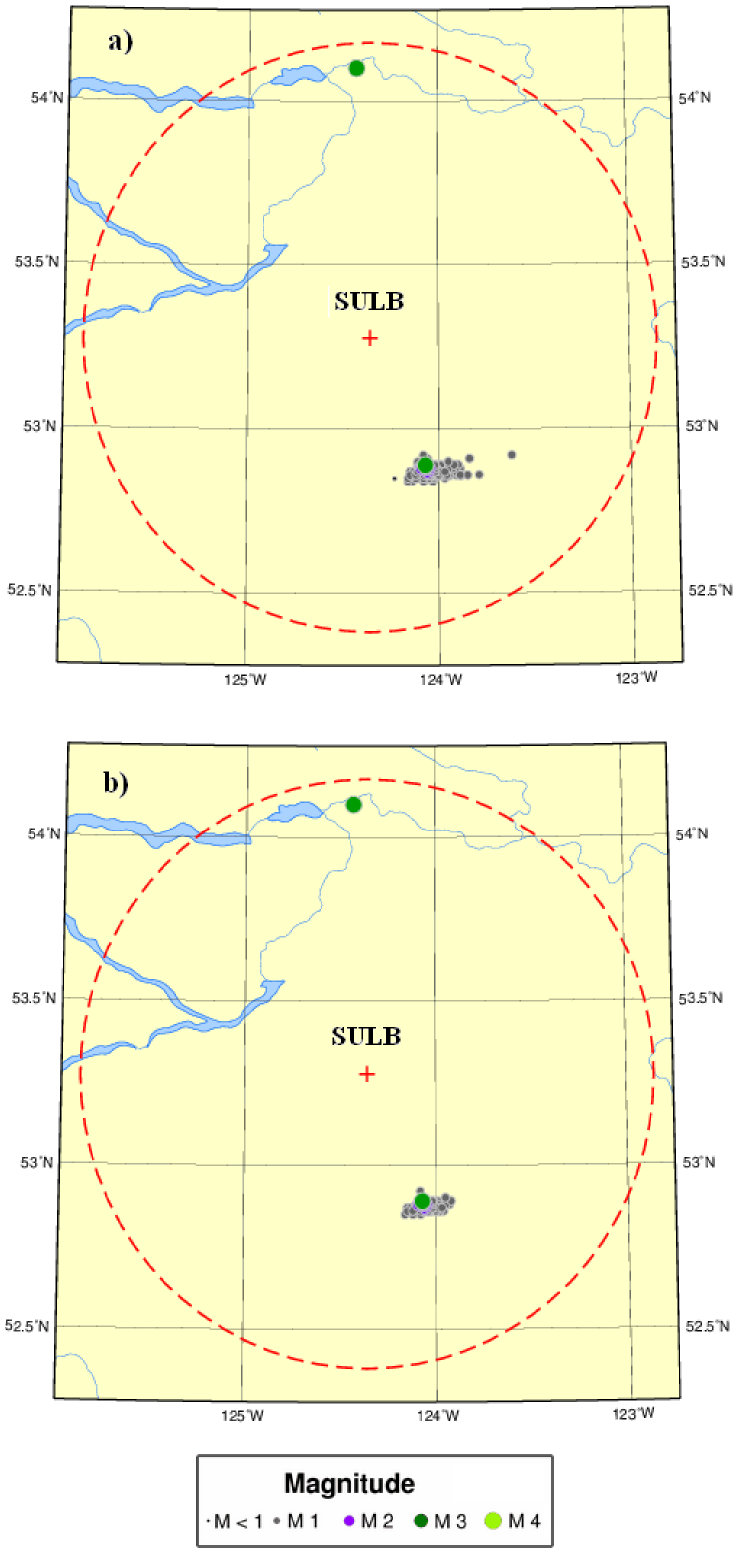
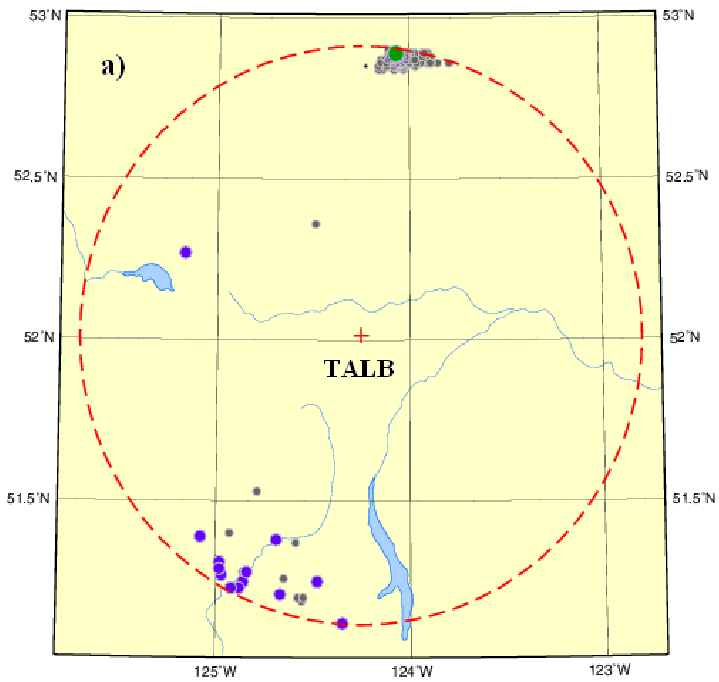


Figure A3-8: Map showing (a) distribution of reported events and (b) selected earthquakes in a radius of 100 km around station SULB between 2007 and 2011.



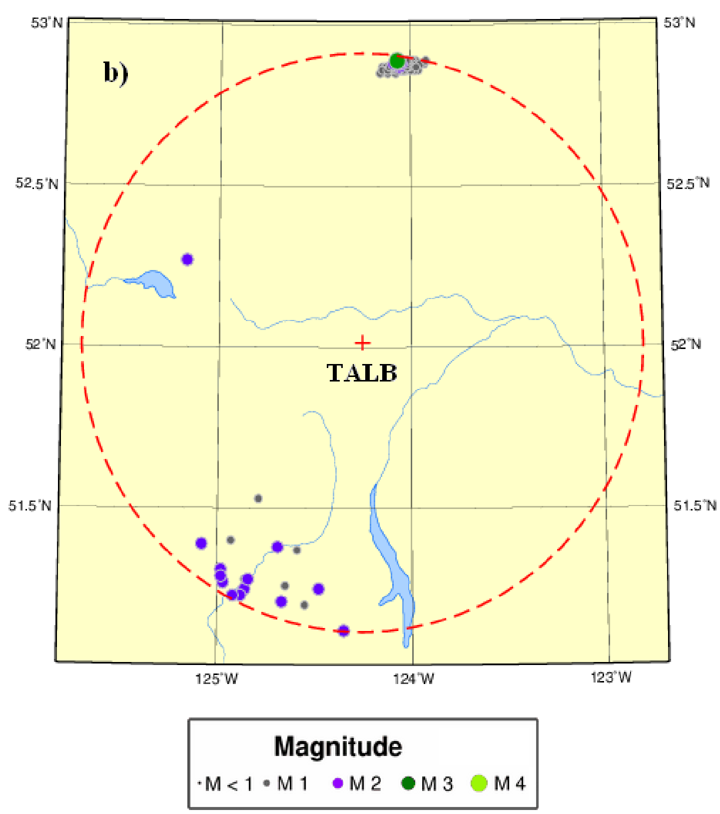


Figure A3-9: Map showing (a) distribution of reported events and (b) selected earthquakes in a radius of 100 km around station TALB between 2007 and 2011.

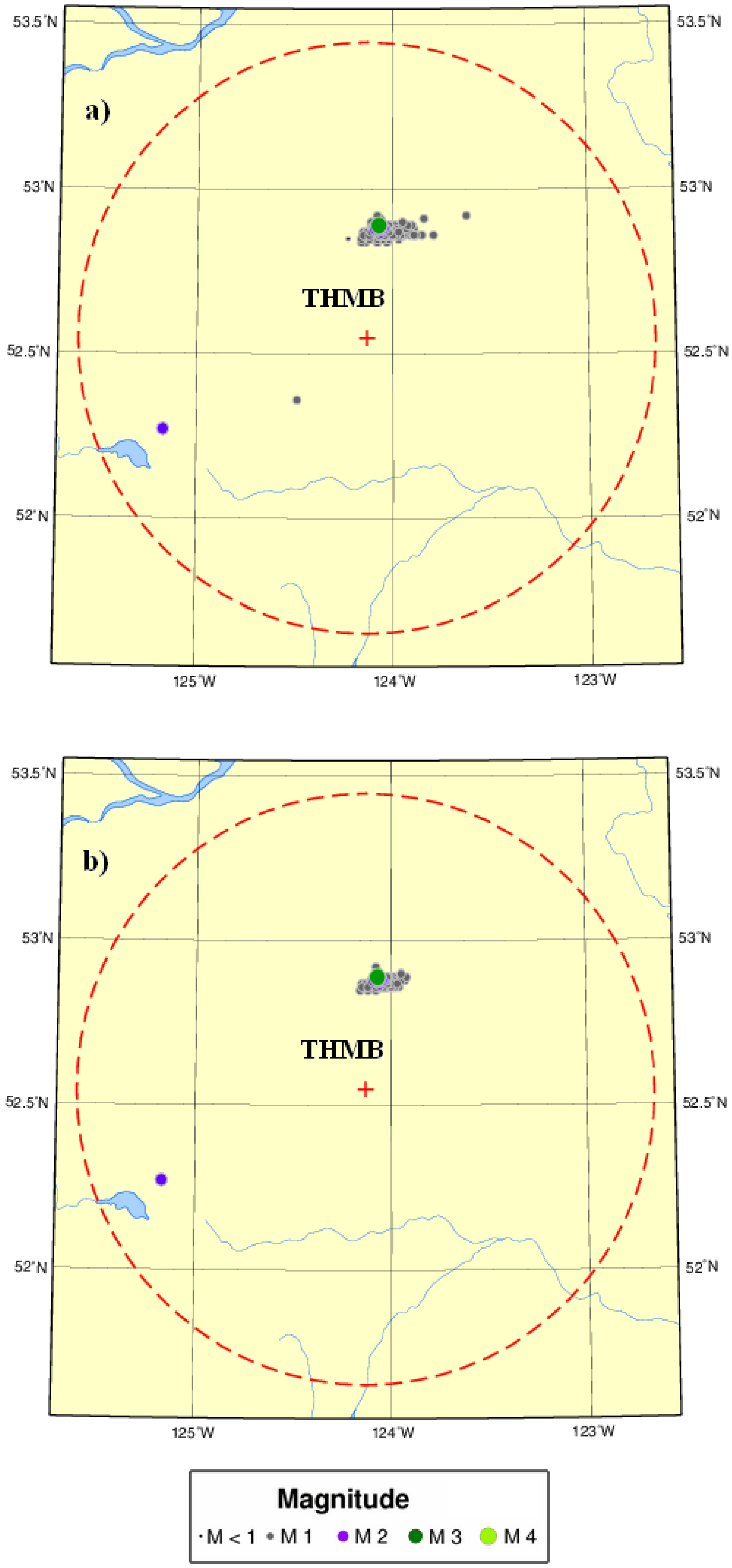


Figure A3-10: Map showing (a) distribution of reported events and (b) selected earthquakes in a radius of 100 km around station THMB between 2007 and 2011.

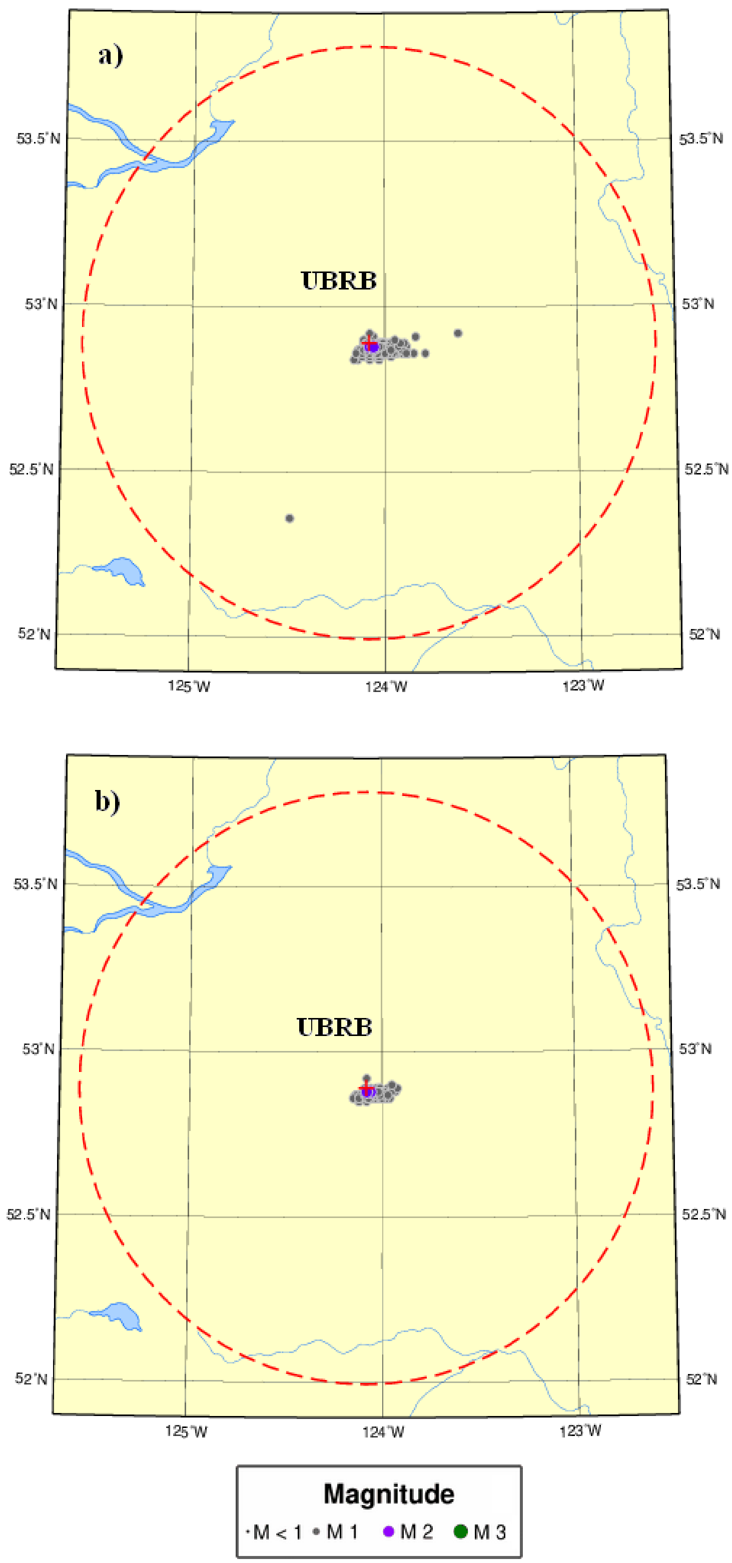


Figure A3-11: Map showing (a) distribution of reported events and (b) selected earthquakes in a radius of 100 km around station UBRB between 2007 and 2011.

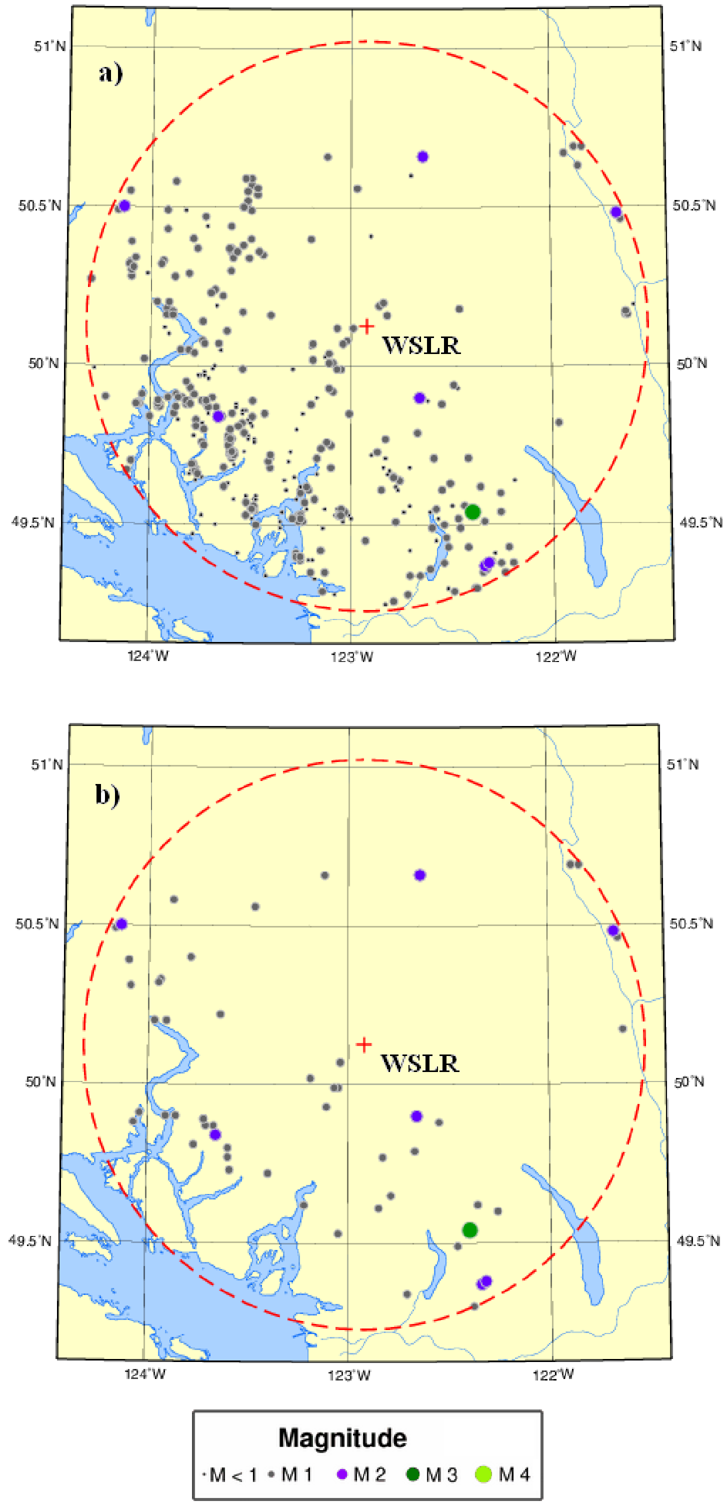


Figure A3-12: Map showing (a) distribution of reported events and (b) selected earthquakes in a radius of 100 km around station WSLR between 2003 and 2011.

Appendix 4

Coda Q and Frequency Dependence in the Interior of BC

Table A4-1
Coda Q estimates and Frequency Dependence at all seismographic stations

Station	Average Q_0, α, Z_{max}, a_2 and t_{lapse} values				
	Q_0 +/- error (number of events)	**α +/-error**	**Z_{max} (km)**	**a_2 (km)**	**t_{lapse} (Sec)**
ALRB	79+/-4 (9)	0.90+/-0.01	88	75	47
CLSB	57+/-11 (5)	0.98+/-0.04	59	32	50
CLSB	78+/-16 (12)	0.86+/-0.09	111	95	60
FLLB	91+/-21 (3)	0.69+/-0.18	120	110	70
FSB	69+/-15 (5)	0.96+/-0.10	59	55	35
LLLB	74+/-18 (5)	0.95+/-0.08	69	53	34
MCMB1	39+/-13 (6)	1.23+/-0.24	47	33	20
SULB	55+/-9 (9)	1.05+/-0.01	66	50	33
TALB	109+/-13 (11)	0.79+/-0.08	98	86	55
THMB	63+/-12 (15)	0.95+/-0.05	59	45	28
UBRB	54+/-17 (13)	1.02+/-0.11	44	30	17
WSLR	85+/-12 (6)	0.83+/-0.07	90	80	49

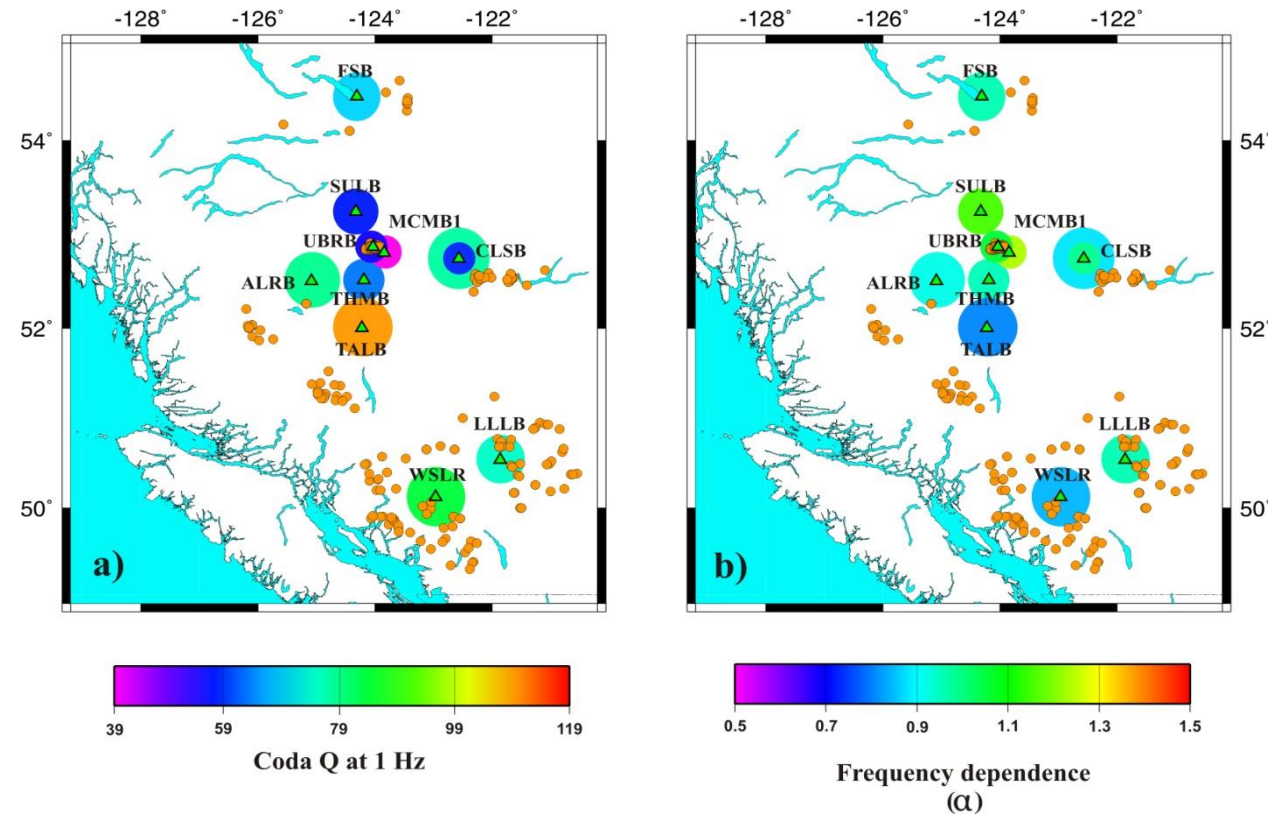


Figure A4-1: Map of: a) Q_0 variations and b) frequency dependence in the interior of British Columbia for sampling volumes with ellipse parameter a_2 between 30 and 95 km (average lapse time between 17 and 60 seconds) and earthquakes in this range, which were used for the calculation. Diameter of circles is proportional to the corresponding a_2 parameter and lapse time. Green triangles indicate GSC and POLARIS seismic stations. Only stations with five or more events are shown.

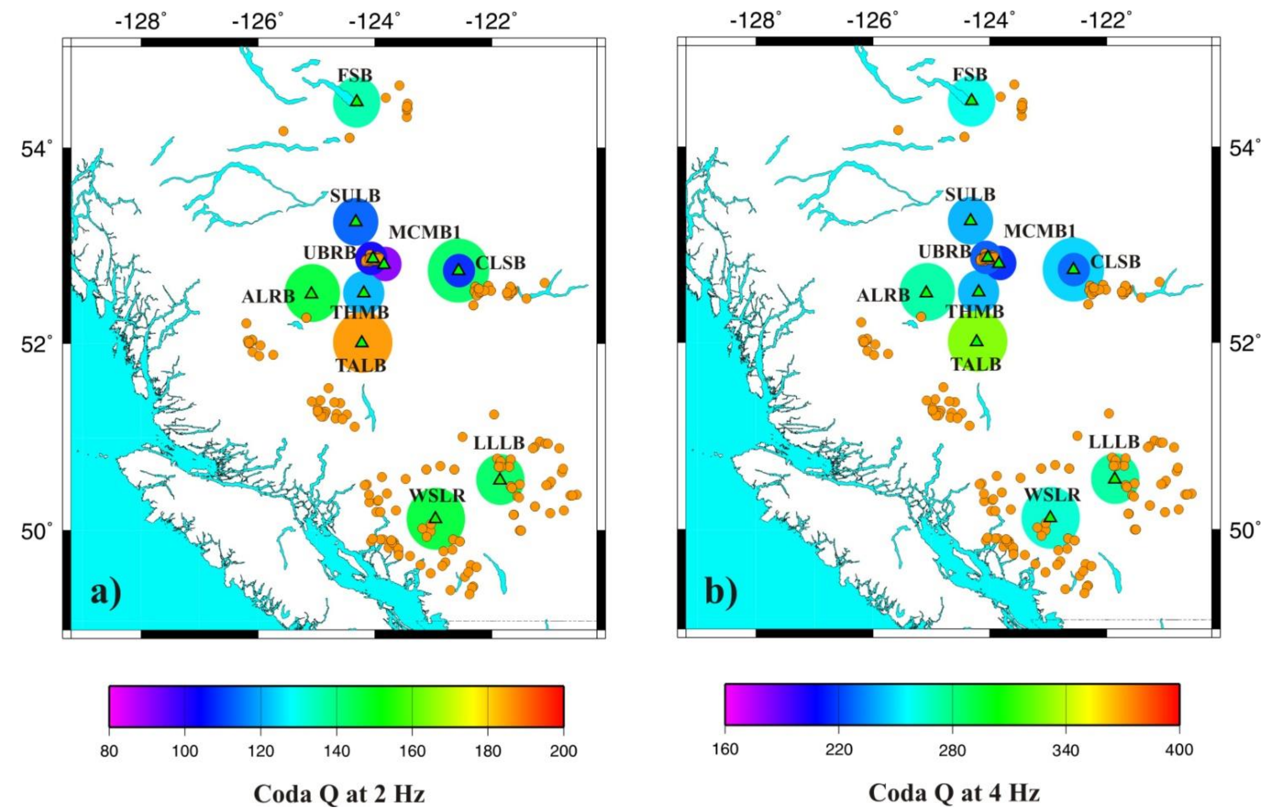


Figure A4-2: Map of coda Q variations at: a) 2 Hz and b) 4 Hz in the interior of British Columbia for sampling volumes with ellipse parameter a_2 between 30 and 95 km (average lapse time between 17 and 60 seconds) and earthquakes in this range, which were used for the calculation. Diameter of circles is proportional to the corresponding a_2 parameter and lapse time. Green triangles indicate GSC and POLARIS seismic stations. Only stations with five or more events are shown.

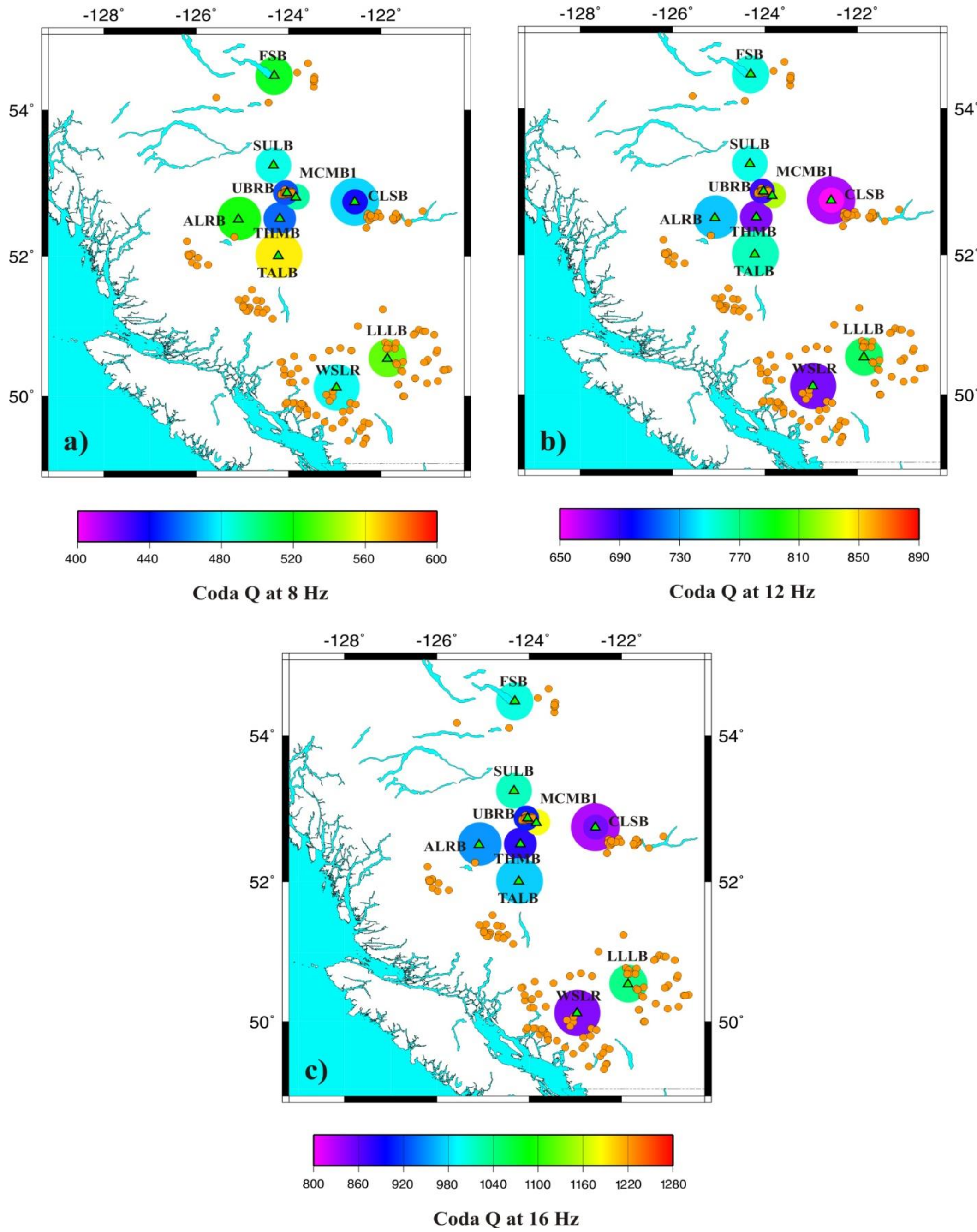


Figure A4-3: Map of coda Q variations at: a) 8 Hz, b) 12 Hz and c) 16 Hz in the interior of British Columbia for sampling volumes with ellipse parameter a_2 between 30 and 95 km (average lapse time between 17 and 60 seconds) and earthquakes in this range, which were used for the calculation. Diameter of circles is proportional to the corresponding a_2 parameter and lapse time. Green triangles indicate GSC and POLARIS seismic stations. Only stations with five or more events are shown.