AER/AGS Open File Report 2013-15

Alberta Energy Regulator

Alberta Earthquake Catalogue, Version 1.0: September 2006 through December 2010

AGS
ALBERTA GEOLOGICAL SURVEY

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Alberta Earthquake Catalogue, Version 1.0: September 2006 through December 2010

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Abstract

This report documents micro to moderate earthquakes located in Alberta during the period from September 2006 through December 2010. Our catalogue incorporates seismic waveform data from the Canadian Rockies and Alberta Network, the Alberta Telemetered Seismograph Network, the Canadian National Seismograph Network, the Montana Regional Seismic Network, and the United States Array Reference Network. The analyses were performed using the proprietary Antelope environmental monitoring software package (by Boulder Real Time Technology). Most of the recorded earthquakes in Alberta occur along the southeast-trending foreland belt on the eastern flank of the Canadian Rocky Mountains. We confirm the spatially clustered earthquakes that have been observed in past studies in the areas of Rocky Mountain House, Brazeau River, and Turner Valley. We document that the Brazeau River cluster persists during the time period of this study, whereas the Rocky Mountain House and Turner Valley regions have experienced a decrease in the number of recorded events. We also note a persistent but diffuse cluster of events, termed the Del Bonita cluster, near the Alberta-Montana border.

1 Introduction

Alberta is a prairie province bordering the eastern flank of the Rocky Mountains. Its geographic location is characterized by a transition from a relatively low-seismicity (Milne, 1970; Milne et al., 1978) intraplate regime to a more active foreland belt. It is also an area of active energy resource development, including coal, natural gas, conventional oil, and unconventional hydrocarbon resources. The federal government has monitored earthquakes in Canada since the late 1800s, and by 1950 had the capacity to detect earthquakes of magnitude 6 and larger throughout Canada. While there is no recorded evidence of any major destructive earthquake occurring in Alberta to date (Lamontagne et al., 2007), there have been hundreds of micro to moderate earthquakes from 1950 to 2006. The magnitudes of seismic events in Alberta tend to be between 0 (micro) and 6 (moderate) M_L (see Table A.1 for a classification of earthquake sizes based on magnitude; modified from Havskov and Ottemöller, 2010). Although there appears to be little threat from major earthquakes, it is important to understand the seismicity patterns within Alberta. There is evidence that in some cases earthquakes have been related to hydrocarbon production, such as fluid extraction, enhanced recovery methods, or wastewater injection (e.g., Davis and Frohlich, 1993; Horner et al., 1994; Segall, 1989; Simpson, 1986; Suckale, 2009 and 2010; British Columbia Oil and Gas Commission, 2012).

The first step to understanding seismicity in a region is to document the baseline seismicity. To that end, earthquake catalogues document seismic events over a period of time, usually listing the time of occurrence in Universal Coordinated Time (UTC), geographic location, magnitude, and type of event. A catalogue may document other parameters, such as polarity and focal mechanisms. Sometimes a catalogue will also indicate whether the event was felt or implicated in damage to private property or infrastructure. In Canada, the detection, location, and cataloguing of events and the archival of raw waveforms from Canadian seismic stations have been the purview of Earthquakes Canada (EC), a group within the Geological Survey of Canada (GSC). EC's archive of waveforms extends back to 1975, and its database of Alberta earthquakes is available from 1922 to present.

The completeness of a catalogue is affected by the number and distribution of reporting seismic stations. There are currently over 100 seismic stations within Canada owned and operated by the GSC. These stations are concentrated in seismically active regions. Two stations are located in the province of Alberta, near Edmonton and Waterton. The location of the Alberta stations (Figure 1; Table A.1), together with the stations in southeastern British Columbia and northern Montana, give a high degree of confidence that earthquakes of 2.0 M_L and greater can be located in the southwestern region of Alberta. There is less confidence that seismic events lower than 3.0 M_L will be detected and located in the areas of northern and eastern Alberta, in which there were no telemetered stations before 2010. The EC catalogue currently documents more than 800 earthquakes located in Alberta from 1922 to September 2006. The distribution of the Alberta earthquakes recorded in EC's database is shown in Figure 2.

This document lists the earthquakes in Alberta from late September 2006 through December 2010 and accompanies the release of a digital GIS dataset (Stern et al., 2013). The digital dataset contains an earthquake's epicentre in latitude and longitude, the estimated or fixed depth, origin time (in UTC), magnitude, nearest settlement, location algorithm used, and error ellipses. The locations of earthquakes are based on waveform data from five networks: the Canadian National Seismograph Network (CNSN), the Alberta Telemetered Seismograph Network (ATSN), the Canadian Rockies and Alberta Network (CRANE), the Montana Regional Seismic Network (MRSN), and the United States Reference Network (US-REF). The key difference between the Alberta Geological Survey (AGS) earthquake database and that of EC is the inclusion of data from the non-telemetered CRANE stations, which were previously unavailable. We anticipated that the addition of the CRANE data would allow us to locate events missed by the telemetered networks and reveal seismicity patterns not evident in the EC database.

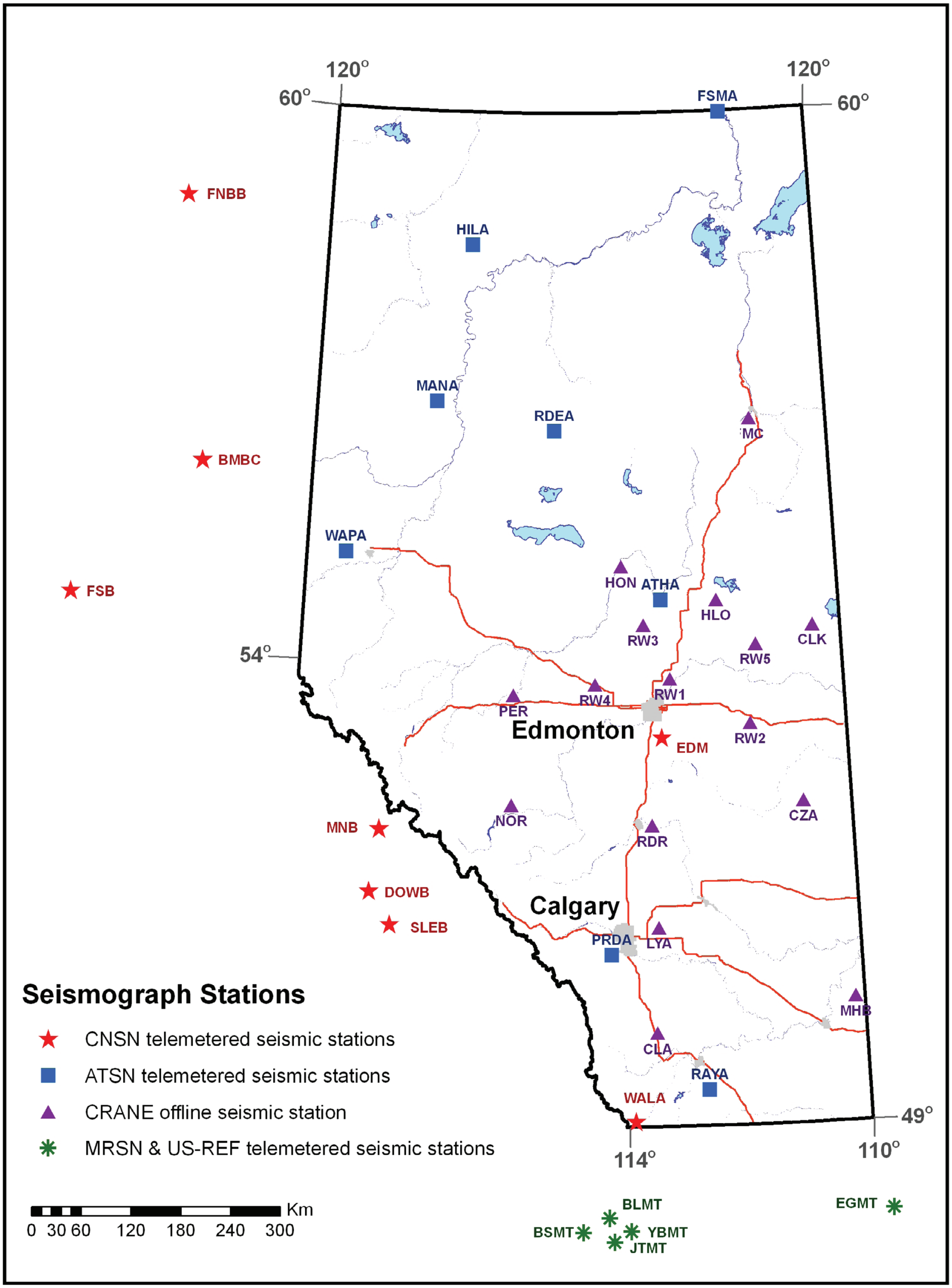

Figure 1. Seismograph stations in and around Alberta.

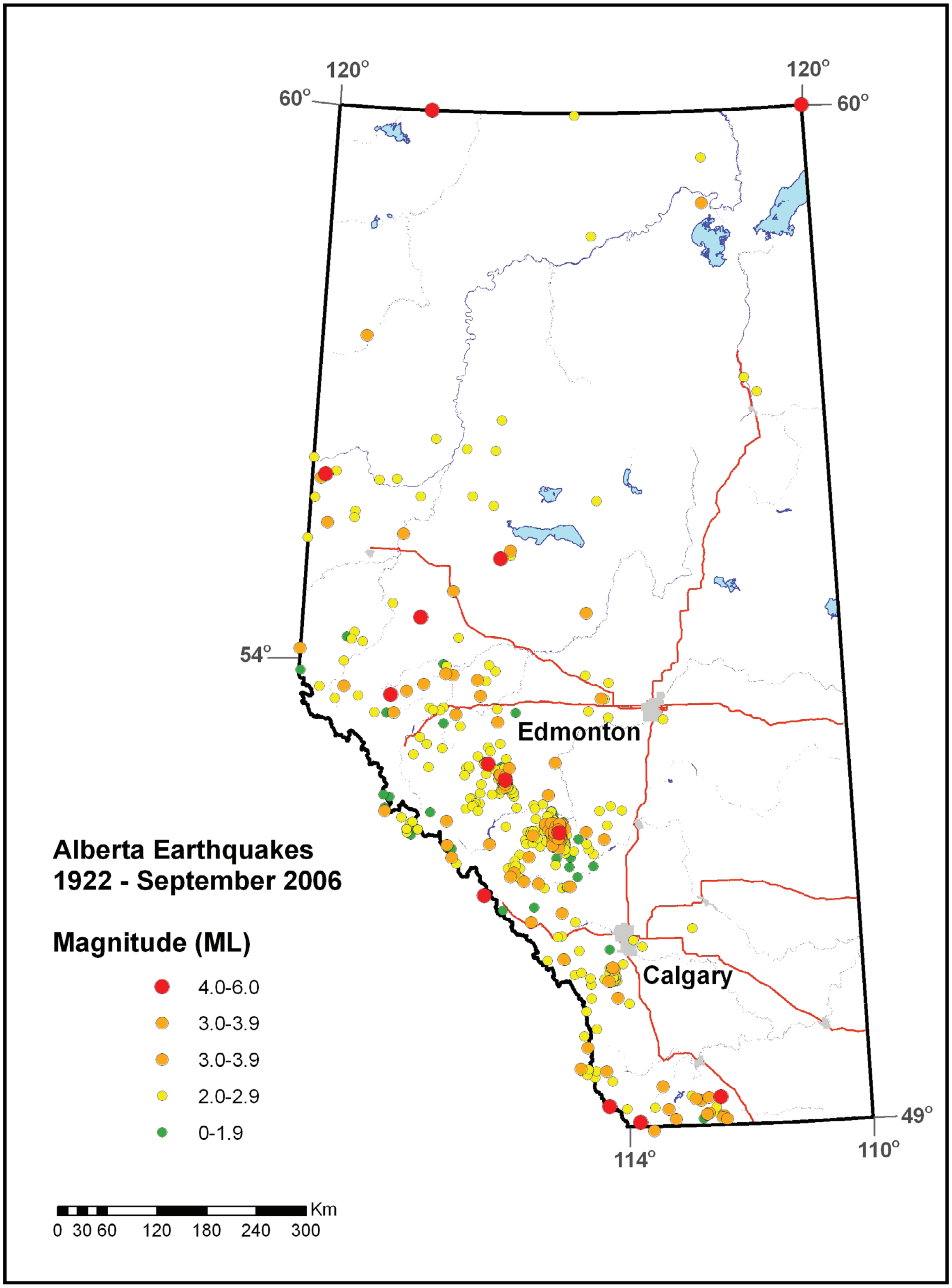

Figure 2. Alberta earthquakes recorded in Earthquake Canada's database from 1922 to September 2006 (Earthquakes Canada, 2011).

2 Seismic Stations

2.1 The Canadian National Seismograph Network Stations

The GSC operated a seismic station in Alberta at Banff (BAN) from 1955 to 1966 (Milne et al., 1978). A second station was installed in Alberta near Edmonton (EDM) in 1963. Two months before the station in Banff was decommissioned, a station was installed near Suffield (SES). Before the decommissioning of the Suffield station in 1993, the CNSN was modernized to digital seismographs (North, 1994) with a new station installed near Waterton (WALA). The GSC currently operates and maintains the two CNSN stations, EDM and WALA, in Alberta (North, 1994), as well as stations in British Columbia and the Northwest Territories. The B.C. stations are near Bull Mountain (BMBC), Downie Slide (DOWB), Fort Nelson (FNBB), Mount Dainard (MNB), and Sale Mountain (SLEB). We acquired the batch CNSN data from EC for the period from September 2006 through May 2010, with subsequent data from June 2010 acquired in near–real time.

2.2 The Alberta Telemetered Seismograph Network Stations

The Alberta Geological Survey scouted seven sites (Stern et al., 2011) for the ATSN stations that were installed by the University of Calgary (U of C) in 2009 through 2010. The northern stations are located near Grande Prairie (WAPA), Manning (MANA), High Level (HILA), and south of Fort Smith (FSMA). The southern stations are located near Medicine Hat (MEDA) and Raymond (RAYA). The U of C recommissioned a station near Priddis (PRDA) in 2009, installed an eighth station at Red Earth Creek (RDEA) in 2011, and installed a ninth at the University of Athabasca (ATHA) in 2012. The ATSN stations are affiliated with the Portable Observatories for Lithospheric Analysis and Research Investigation Seismicity (POLARIS) consortium (Eaton et al., 2005). We received the data from these stations in near–real time from EC.

2.3 The Montana Regional Seismic Network and the United States Reference Network Stations

In our analyses we used data from a subset of the US-REF stations operated by the United States Geological Survey (USGS) and a subset of the MRSN operated by the Montana Bureau of Mines and Geology. The US-REF stations referenced are located near Dagmar, Montana (DGMT); Eagleton, Montana (EGMT); and Newport, Washington (NEW). The MRSN stations referenced are near Jette Lake (JTMT), Swartz Lake (SWMT), Bassoo Peak (BSMT), Blacktail Mountain (BLMT), and Yellow Bay (YBMT). We downloaded the data from the US-REF and MRSN stations from the Incorporated Research Institutions for Seismology (IRIS) from September 2006 through June 2010, with subsequent data received in near–real time.

2.4 The Canadian Rockies and Alberta Network (CRANE)

The installation in central Alberta of a network of semi-permanent non-telemetered seismic stations by the University of Alberta (U of A) started in 2005 (Gu et al., 2009). Although the original purpose of the installations was for research using low-frequency teleseisms (Gu et al., 2011), by late 2006 there were enough stations for locating earthquakes occurring in west-central Alberta. The AGS began collaborations with the U of A in 2009 to support the densification of CRANE stations in Alberta. The CRANE stations are located near Claresholm (CLA), Czar (CZA), Fort McMurray (FMC), Hylo (HLO), Hondo (HON), Tudor (LYA), Medicine Hat (MHB), Nordegg (NOR), Peers (PER), Red Deer (RDR), and Redwater (RW1, RW2, RW3, RW4, RW5). Several stations not shown in Figure 1 were operated for a shorter period of time near Brule (BRU), Cold Lake (CLK), Red Earth Creek (REC), Joffre (JOF), and Dorintosh, Saskatchewan (DOR). The CRANE stations were operated by the U of A with the waveform data stored on site and collected twice yearly for analysis. We obtained the early CRANE data, spanning the time frame from September 2006 through 2009, via batch downloads from IRIS. Subsequent years were uploaded from the compact flash cards collected on the twice-yearly maintenance trips. We merged the CRANE data with the real-time data before processing and analysis.

3 Data Acquisition and Handling

3.1 Real-Time Data Automated System

We acquired and processed the real-time data using Antelope Environmental Data Collection Software (http://www.brtt.com; referred to as Antelope for the remainder of the report). We acquired the seismic waveforms (from the CNSN and ATSN stations) from EC through an object ring buffer (ORB) import using *orb2orb*.[1] Waveforms from IRIS (US-REF and MRSN) were obtained through the module *slink2orb*.

An automated client program, *orbdetect*, scrutinized the data packets within the ORB for the presence of seismic signals using a multi-frequency, short-term average window to long-term average window (STA/LTA) ratio to detect seismic arrivals. The automated module *orbassoc* further processed the data by associating the detections into events using a spatial grid search. A database of detections, arrivals, origins, and waveform pointer files was created by the *cdorb2db* module.

3.2 Offline Data

We obtained the waveform and header files of the offline data for CRANE, MRSN, and US-REF from IRIS. The CRANE station data for subsequent years are collected directly from the U of A's compact flash cards that are removed as part of the collaborative maintenance program for those stations. The CRANE flash cards are routinely collected in the spring and fall. We obtained CNSN data before startup of the Alberta Earthquake Studies Project (September 2006–June 2010) from EC in Canadian Archive format (Earthquakes Canada, 2012).

The offline data was processed using *dbdetect* to execute the STA/LTA detector and *dbgrassoc* to associate events and create arrivals and origins (similar to how the real-time data was processed). We merged the database tables of the offline waveforms with the tables generated by the real-time system before analyzing the events.

3.3 Data Analysis

We filtered the processed continuous waveform data with a 1–5 Hz band-pass filter and scanned the waveforms for missed events in six hour windows. P-wave arrivals or events that were visible on at least three stations were picked using *smartpick*. (Figure 3 is an example showing a map of reporting stations for a 2.5 M_L local earthquake event.) Where possible, P, Pn, Pg, S, Sn, Sg, Lg, or Rg arrivals were identified and used for location (see Figure 4 showing waveforms and picks of the same event). We adjusted the picks, assigned error bars, and located the events using *dbloc2* which uses the earthquake-location library GENLOC (Pavlis et al., 2004). The phase travel times are computed based on cn01, a 2-layer 1D model obtained from the Pacific Geoscience Centre, to maintain consistency with EC's

[1] The software package Antelope is not a single monolithic program, but is instead a collection of specialized libraries and scripts. Throughout this section we refer to the specific scripts we used. These are available to anyone who owns a copy of Antelope. For clarity, script names are italicized throughout.

database of western Canadian earthquake locations. Based on the location and time of day, the events were categorized as teleseisms (listed as qt), referring to earthquakes that occur very far away; regional earthquakes (qr), meaning earthquakes outside of Alberta but within 250 km of the border; blasts (qb), non-tectonic events; or local earthquakes (ql), referring to any tectonic event located within Alberta or up to 10 km outside of the provincial border. (The AGS catalogue described in this report only lists local earthquakes.)

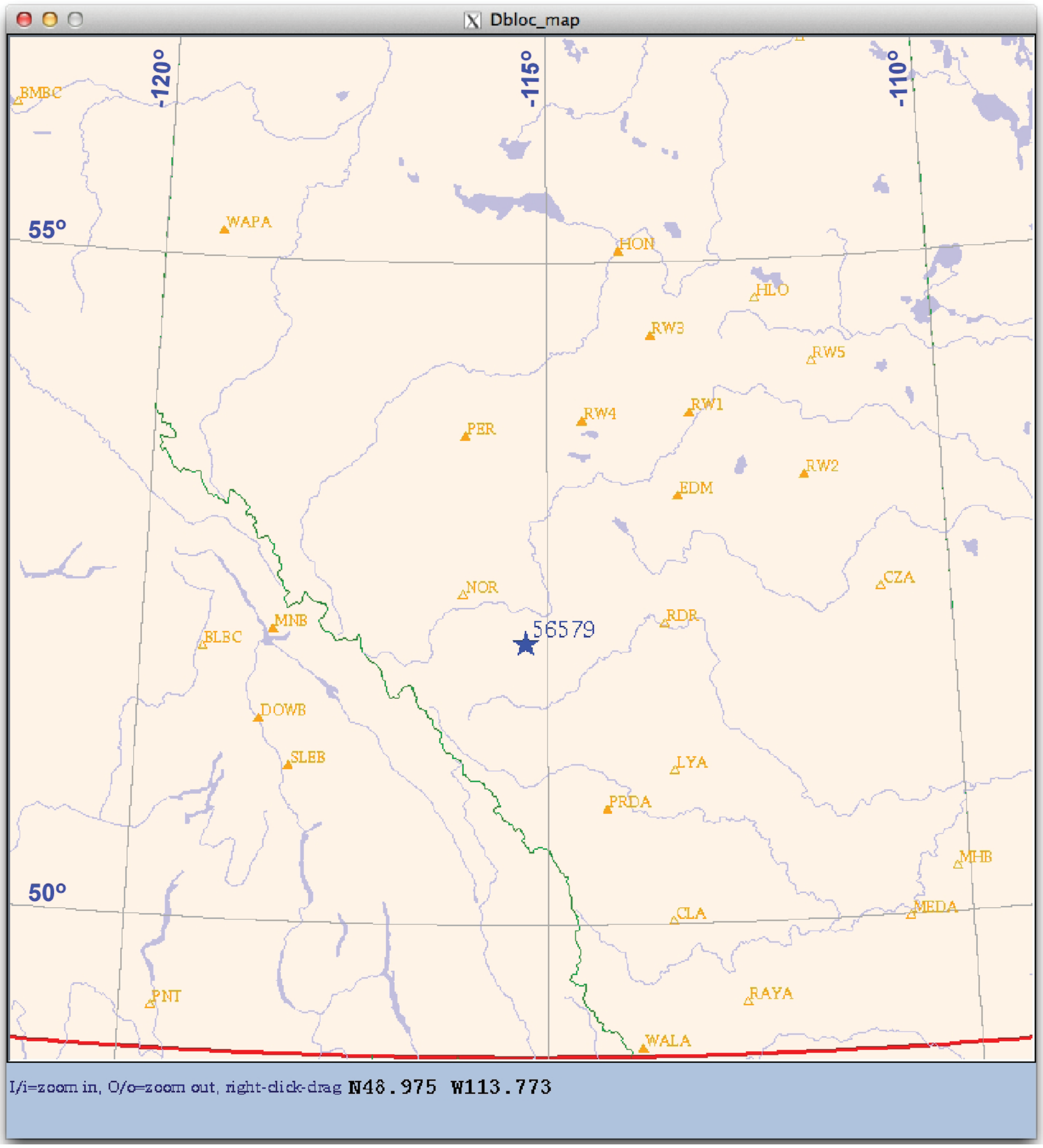

Figure 3. Map of reporting stations (generated by *dbloc2*) for a 2.5 M_L local earthquake on September 16, 2010. The blue star is the location of the event with its origin ID. The stations used in the GENLOC solution algorithm are shown as solid triangles. Non-reporting stations, either because the station was not in operation or the arrival signal was too weak, are shown as open triangles.

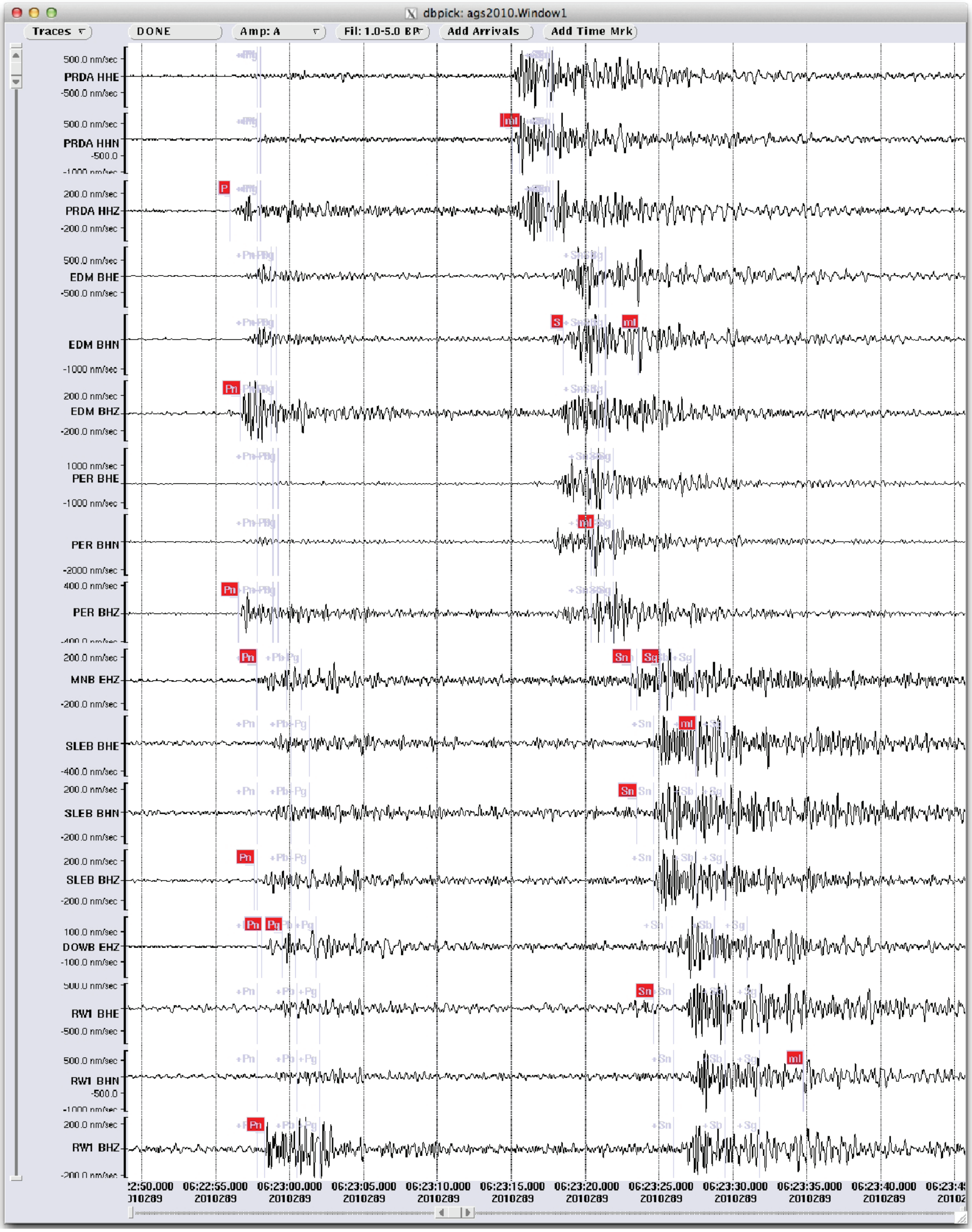

Figure 4. Window (generated by *dbpick*) showing the selection of waveforms (horizontal and vertical traces) and picks of the same local earthquake of Figure 3. The red flags depict the placement of the phase pick for P, Pn, S, and Sn. The red flag marked "ml" shows the portion of waveform used for local magnitude calculation. The silver vertical marks and labels are the predicted arrivals using the iasp91 global velocity model (Kennett and Engdahl, 1991; Kennett et al., 1995).

3.3.1 Locations

The surface coordinates (epicentre) of the seismic events are given in decimal degrees north of the equator for latitude and west of the prime meridian (through Greenwich, England) for longitude. The uncertainty of the horizontal locations varies from around 2 km to as much as 50 km (Schultz, R.J., Stern, V.H., Gu, Y.J., Seismicity and ambient noise recorded by CRANE; manuscript submitted for publication to Bulletin of the Seismological Society of America, 2013). The best-located events are generally in southern and southwestern Alberta with arrivals of seismic phases recorded on three or more seismic stations. Events occurring north of 55° latitude show large uncertainties due to the paucity of seismic stations available to record events.

The focal depth of the seismic event, when used with the surface coordinates, indicates the location of the event's hypocentre. Because the average distance between the real-time telemetered stations for the AGS virtual network is around 250 km (125 km with the addition of the non-telemetered CRANE stations), the distance from an earthquake to the nearest seismic station can be on the order of 50 km. This distance prohibits reliable depth determination for events in Alberta; therefore, the depths for events that are determined to be blasts are assigned 0 km and those for tectonic local earthquakes are fixed at 1, 3, or 5 km.

The origin time of each earthquake is given in UTC. The conversion to local time is UTC −7 hours (Mountain Standard Time) and UTC −6 hours (Mountain Daylight Time). Table A.3 lists the start and end of Daylight Saving Time (at 2 a.m.) for 2006 through 2010 in Alberta.

3.3.2 Magnitudes

The calculated magnitudes listed for the earthquakes in the accompanying digital GIS dataset (Stern et al., 2013) and Table A.2 quantify the relative size of the event. The local magnitude (M_L) calculations are based on the logarithm of the maximum amplitude of ground motion of the S-wave on broadband seismographs (see, for instance, Ristau et al., 2003 and 2005) plus a correction factor for the epicentral distance and depth. The magnitudes listed are an average of the values calculated from each reporting seismograph for an event. When a magnitude was not calculated, usually because response information on the seismograph was unavailable, a value of −999 was recorded. The uncertainty, depending on the number and variation of measurements as well as variations in local attenuation and geometrical spreading, can be as much as 0.50 M_L.

3.3.3 Error Ellipses

We provide in the digital dataset (Stern et al., 2013) the variance and covariance matrix and error ellipse for each event. The standard deviations for latitude, longitude, depth (see discussion above in Section 3.3.2), and origin time are given by the square root of the diagonal elements sxx, syy, szz, and stt. The standard error of observations is given as 'sdobs,' which is calculated from the square root of the sum of the squares of the time residuals divided by the number of degrees of freedom. The error ellipse is specified by the semi-major axis (smajax), semi-minor axis (sminax), strike, and depth at a 0.683 confidence level.

4 Blast Events

We labelled events that occurred at a location of known blasting during daytime hours as blasts (qb). Many of the events labelled as blasts had a signature in which the amplitude of the Pn arrival was similar or larger than the amplitude of the Sn or Lg wave. Some events that we labelled as blasts may have been local earthquakes; the reverse, however, is less likely. We obtained blast records for many of the quarries and surface coal mines in Alberta (Figure 5; Table A.5). We used the blast records to help constrain daytime events that were poorly located in regions near mines.

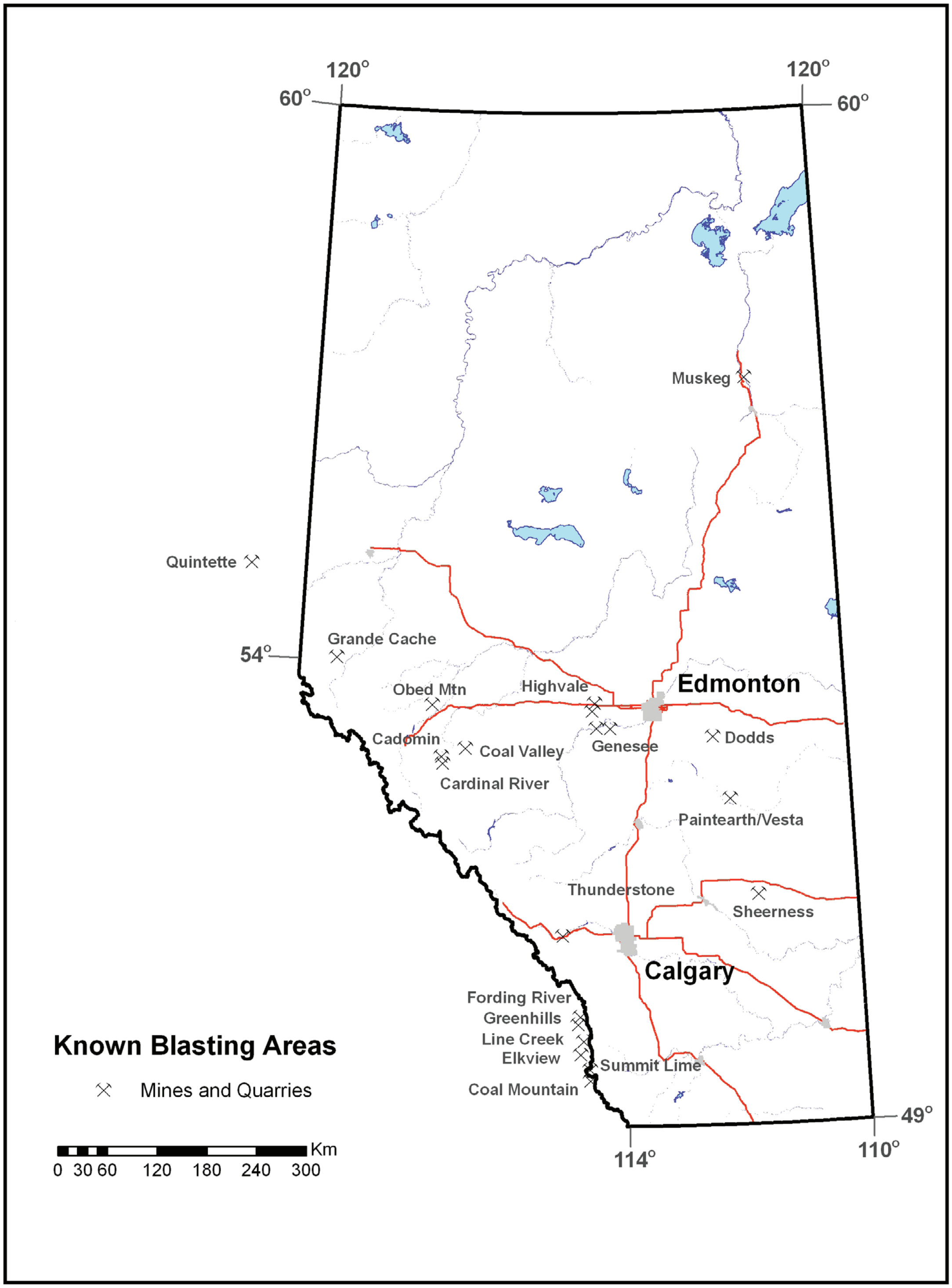

Figure 5. Areas of known blasting in Alberta and B.C. that have produced events which have been recorded on nearby seismograph networks.

5 Local Earthquakes

The vast majority of earthquakes in Alberta are located in the southeast-trending foreland belt along the eastern flank of the Rocky Mountains. This distribution is evident in both the 1922 to 2006 database of EC (Figure 2) and in the catalogue presented here (Figure 6; Table A.2). Spatially clustered groups of earthquakes are observed in the areas of Rocky Mountain House, Brazeau River, and Turner Valley (Baranova et al., 1999). A more diffuse cluster of earthquakes is also identified near the Alberta-Montana border, which we call the Del Bonita cluster.

Sustained changes in the number of earthquakes recorded per year can be observed in the frequency diagram of Figure 7. The first rise in recorded events occurs in 1963 (left-most white arrow). This rise is likely associated with the deployment of a CNSN station EDM in 1963 accompanying the previously installed Banff station (BAN) in 1955. The modest rise in recorded events after 2006 (right-most white arrow) is the result of increased capacity to detect and locate events from the deployment of the CRANE stations. The largest rise in recorded events occurred in 1976 (middle white arrow) and is largely restricted to the clustered events. The 1976 change in seismicity pattern is 10 years after the addition of a station near Mica Creek (MCC, 1966–1977; reinstalled as MCE, 1977–1981) and is not the result of an increase in network capacity (Baranova, 1999). The observed increase in 1976 prompted studies of the events southwest of Rocky Mountain House (Rebollar et al., 1982; Rebollar et al., 1982; and Wetmillar, 1986).

5.1 Rocky Mountain House

The apparent correlation between an increase in recorded seismic events in the area southwest of Rocky Mountain House (Figures 8 and 9) and the ramping up of gas production from the Strachan Leduc A Pool initiated a field campaign consisting of the installation of five single-component analogue seismographs by the Earth Physics Branch of the GSC (now known as Earthquakes Canada). The field survey (Wetmillar, 1986), lasting 23 days from September 16th to October 8th of 1980, recorded 146 local earthquakes, of which 67 were located. During the last week of the GSC's field campaign, the U of A installed a digital seismograph from October 1st through October 8th of 1980, recording 17 of the events (Rebollar et al., 1982; Wetmillar, 1986). Subsequent studies (Rebollar et al., 1982, 1984; Wetmillar, 1986; and Baranova et al., 1999) implicated the Strachan D3-A (Leduc reef complex) sour gas pool with the observed seismicity. The Rocky Mountain House region has sustained a total of 356 earthquakes recorded from the mid-seventies through 2010. It has, however, experienced a decline in seismicity after the last peak in 1988 (Figure 8). We recorded 11 events in this region from September 2006 through December 2010 compared to 6 events recorded in the EC catalogue for the same time period. We attribute the difference to the additional data from the CRANE stations.

5.2 Brazeau River

The Brazeau River cluster of events is northwest of the Rocky Mountain House cluster and 40 km southwest of the Brazeau Reservoir (Figure 9). A total of 93 events were recorded from 1964 through 2010. The majority of the earthquakes were smaller than a 2.5 M_L. The largest event, a 4 M_L, occurred on March 31, 1997. Seismicity in the Brazeau River region increased between 1994 and 2009 (Figure 10). We recorded 27 events in the catalogue for this region from September 2006 through December 2010 compared to 20 events recorded in the EC catalogue for the same time period.

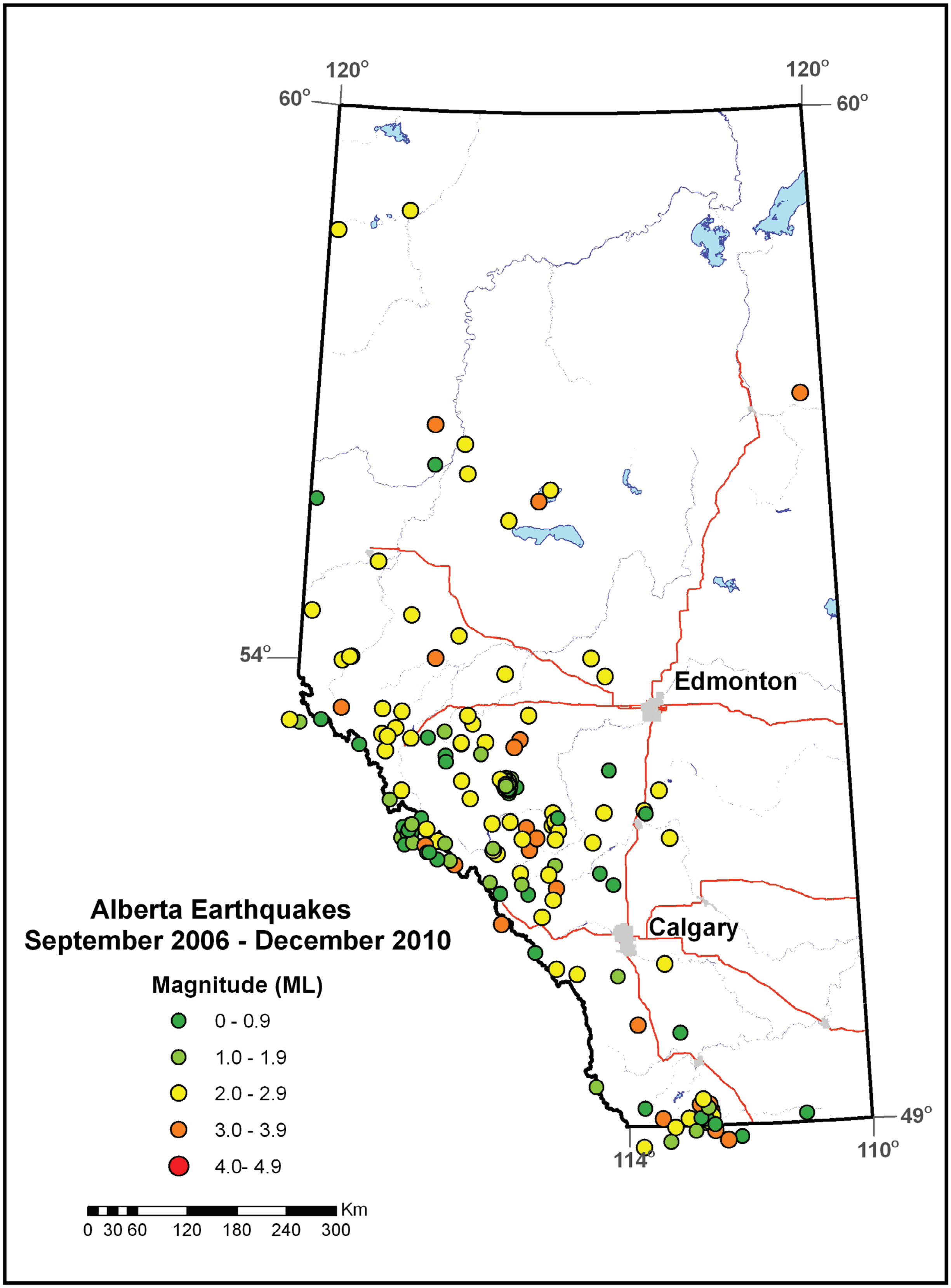

Figure 6. Alberta earthquakes from September 2006 through December 2010.

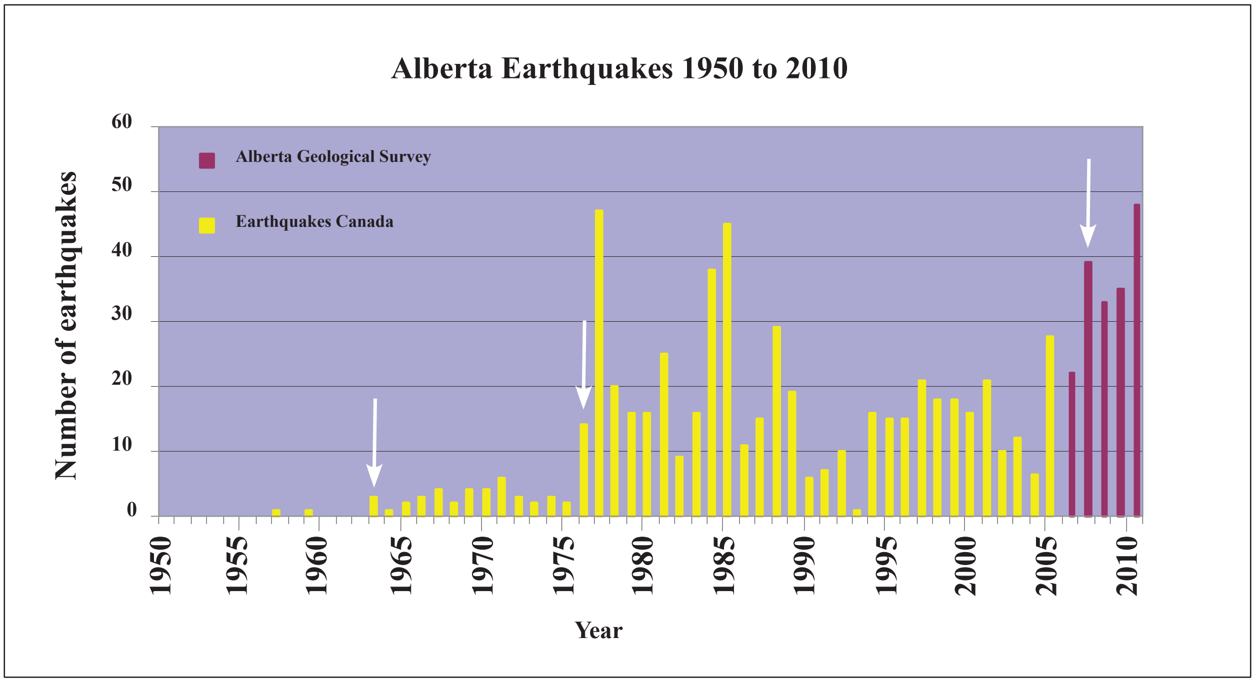

Figure 7. Alberta earthquakes 1950 through September 2006.

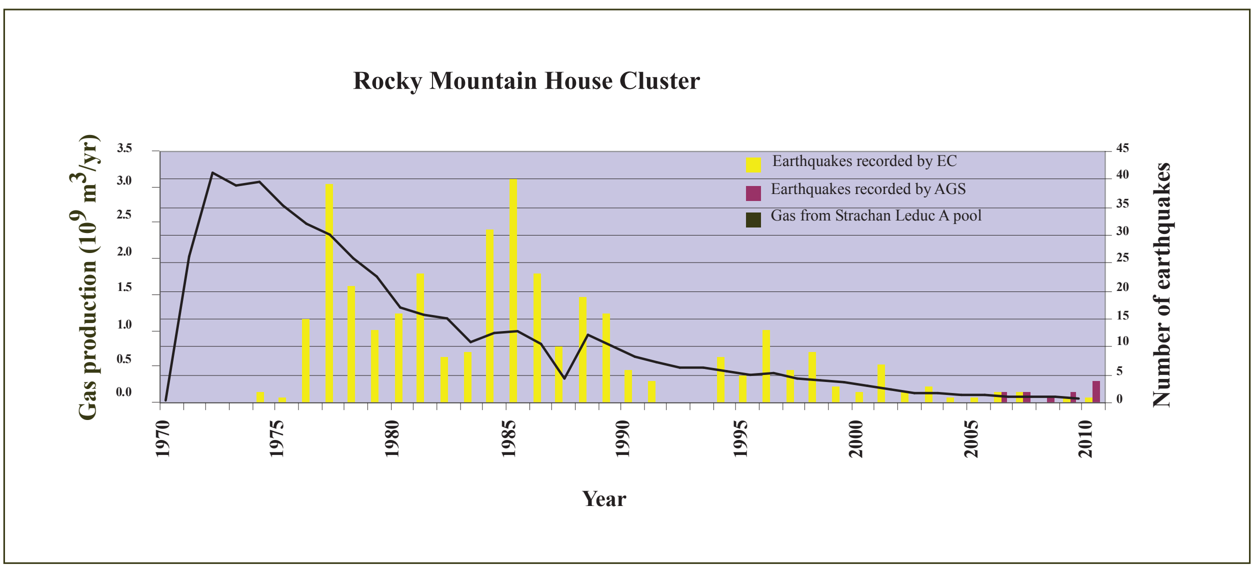

Figure 8. Frequency diagram of yearly earthquakes within a 40 km radius of the Strachan D3-A Pool compared to Strachan D3-A Pool yearly gas production (black solid line).

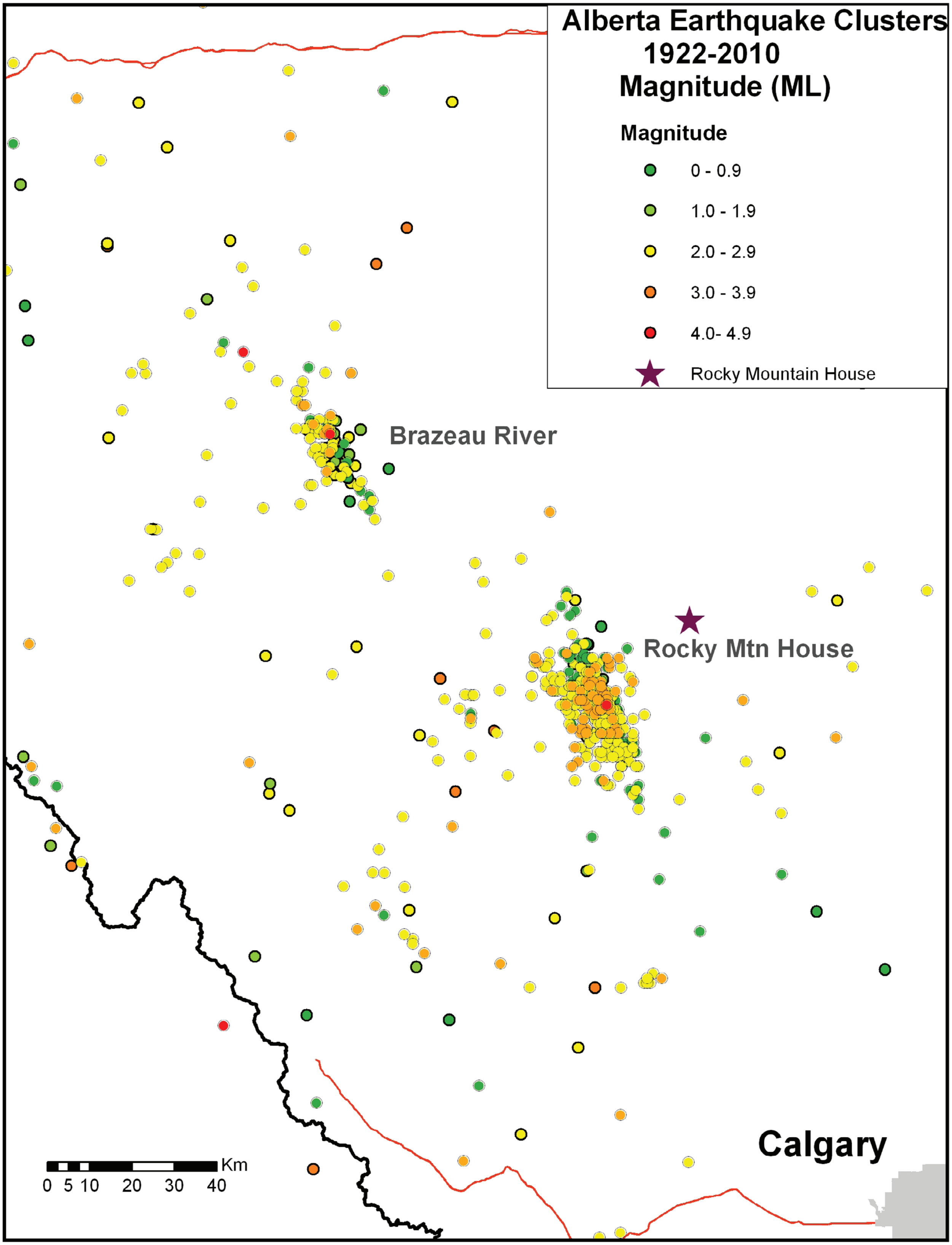

Figure 9. Rocky Mountain House and Brazeau River clusters of earthquakes 1922 to 2010.

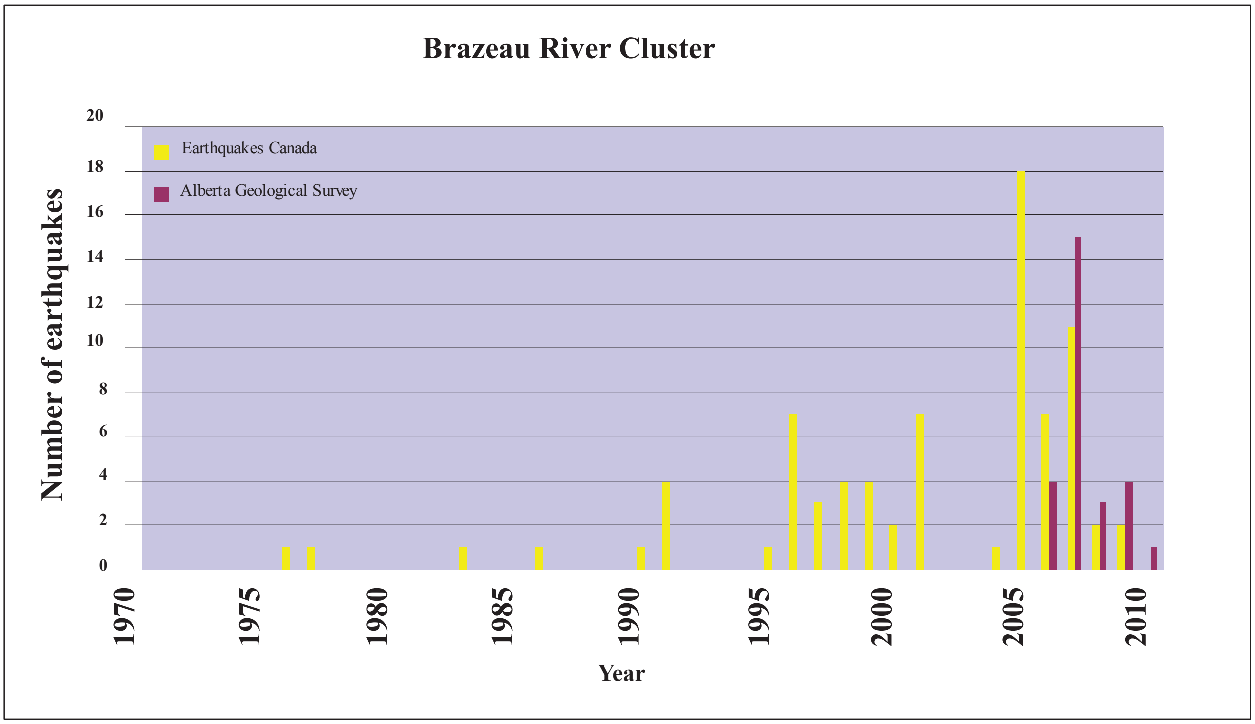

Figure 10. Frequency diagram of Brazeau River events 1970 to 2010.

5.3 Turner Valley

The Turner Valley cluster of earthquakes is located southwest of Calgary (Figure 11). After an initial modest spike in seismicity in the 1970s and again in the late 1980s, seismicity has dropped to less than two events per year (Figure 12). A total of 24 events were recorded, all but one between 1976 and 2001, and one in 2008. The magnitudes of the majority of the earthquakes were between 2 and 3 M_L, with the largest event, a 3.5 M_L, on June 18, 1991. Both the EC and AGS earthquake catalogues recorded one event between September 2006 and December 2010.

5.4 Del Bonita

The Del Bonita cluster near the Alberta-Montana border (Figure 11) has sustained sporadic events from the 1970s through 2010. There have been 29 events recorded during that period, with the largest event, a 4 M_L, recorded on December 30, 2006. We recorded 16 events in the AGS earthquake catalogue for this region from September 2006 through December 2010. A total of 8 events were recorded in the EC catalogue for the same time period. We attribute the observed increase in 2008 (Figure 13), at least partially, to the increasing density of seismic stations available for detecting events during the course of this study.

6 Summary

We provide in this report the detailed documentation for the first instalment of the Alberta earthquake catalogue during the time period from September 2006 through December 2010 (data in Table A.2 and available as digital dataset AER/AGS DIG 2013−0017 [Stern et al., 2013]). The pattern of seismicity for Alberta is not remarkably different from that obtained from the EC database in that most earthquakes occur along the foreland belt of the eastern Rocky Mountains with clusters of increased seismicity in three areas: Brazeau River, Del Bonita, and to a lesser degree Rocky Mountain House. This database, however, is more comprehensive as shown by the increased number of recorded earthquakes, particularly with the clustered events. The main findings of this work are as follows:

- The addition of the CRANE, ATSN, and MRSN stations was a major factor in enhancing the number of events detected.
- Rocky Mountain House (RMH) seismicity has decreased since the earlier studies by Wetmillar (1986), Rebollar et al. (1982, 1984), and Baranova et al. (1999).
- The decrease in RMH seismicity shadows a decrease in production volumes at the Strachan Leduc D−3A Pool, suggesting that the seismicity may be affiliated with hydrocarbon extraction activity.
- The Brazeau River and Del Bonita clusters are currently experiencing seismicity that merits further study.

Next steps for increasing the utility of the Alberta earthquake catalogue are to

- increase telemetered station density, focusing on regions of anthropogenic activity,
- improve velocity models used for location algorithms, and
- provide yearly updates of recorded events.

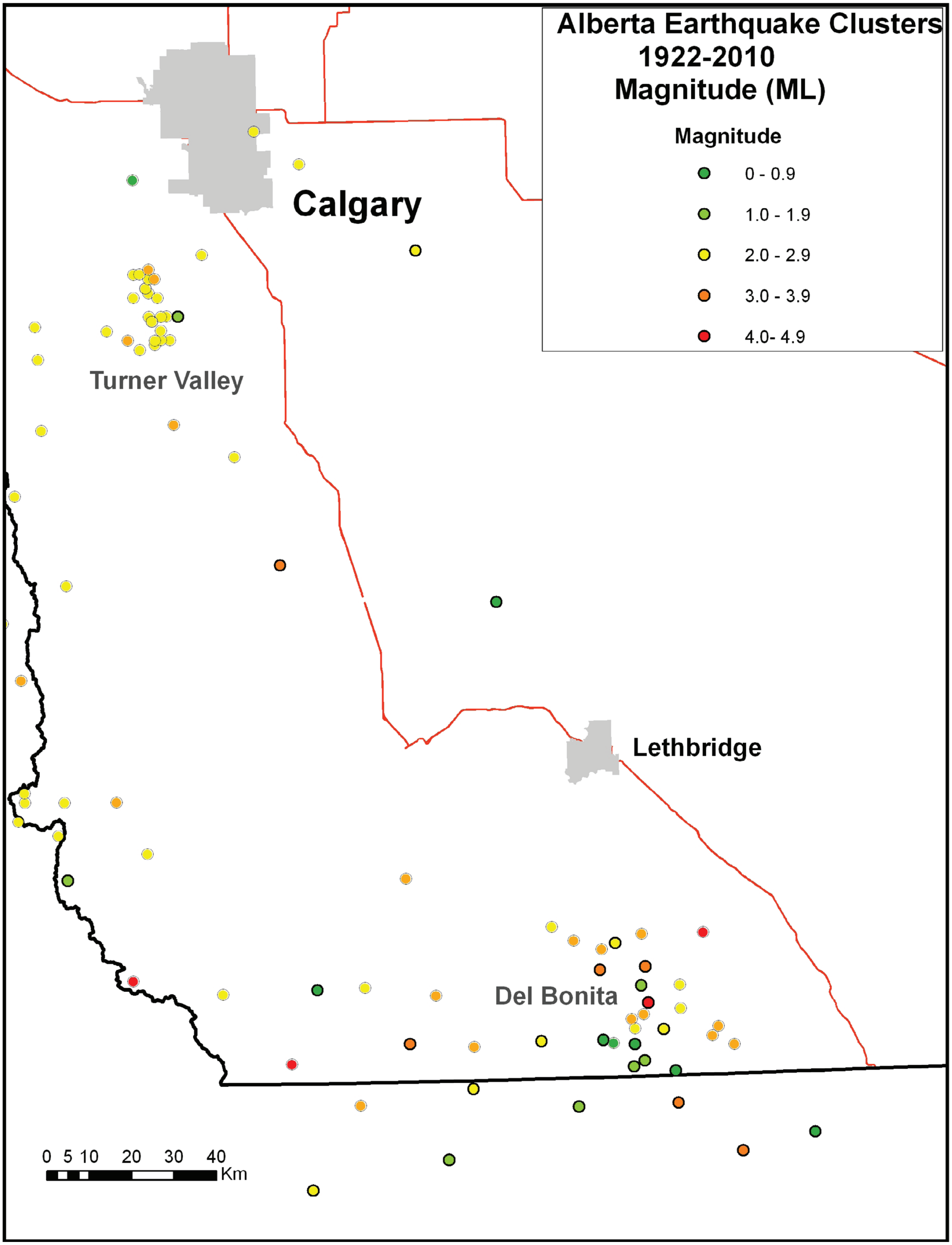

Figure 11. Turner Valley and Del Bonita clusters of earthquakes 1922 to 2010.

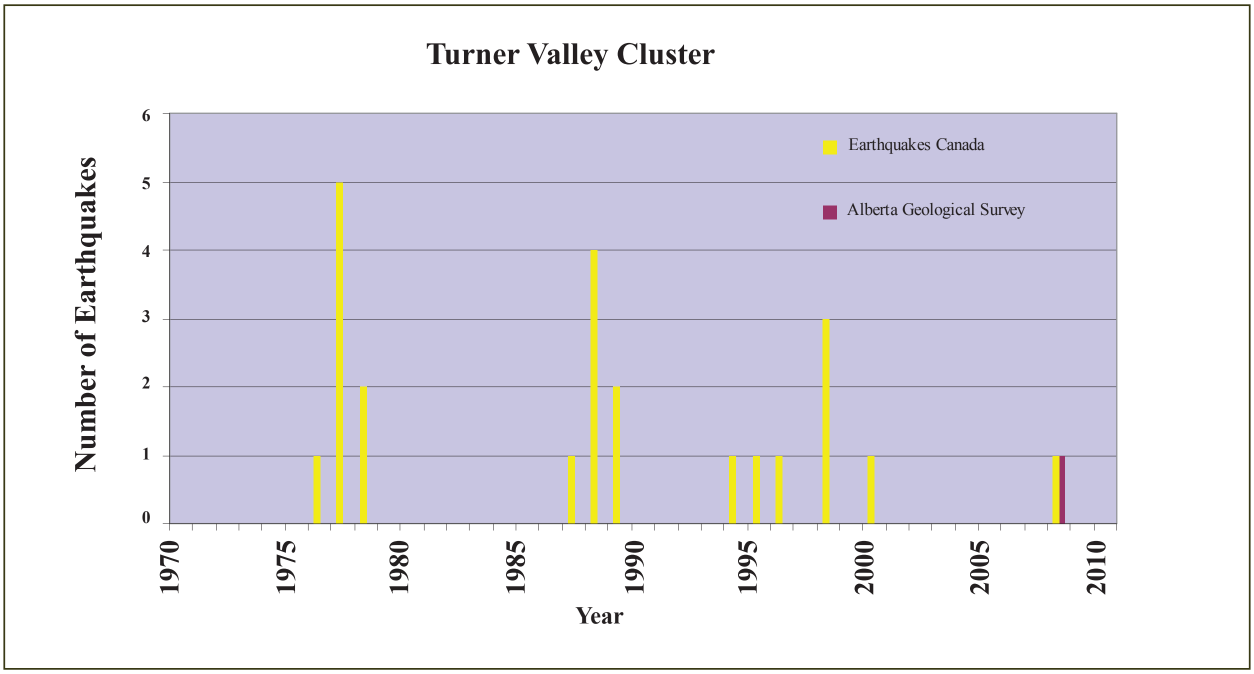

Figure 12. Frequency diagram of Turner Valley events 1970 to 2010.

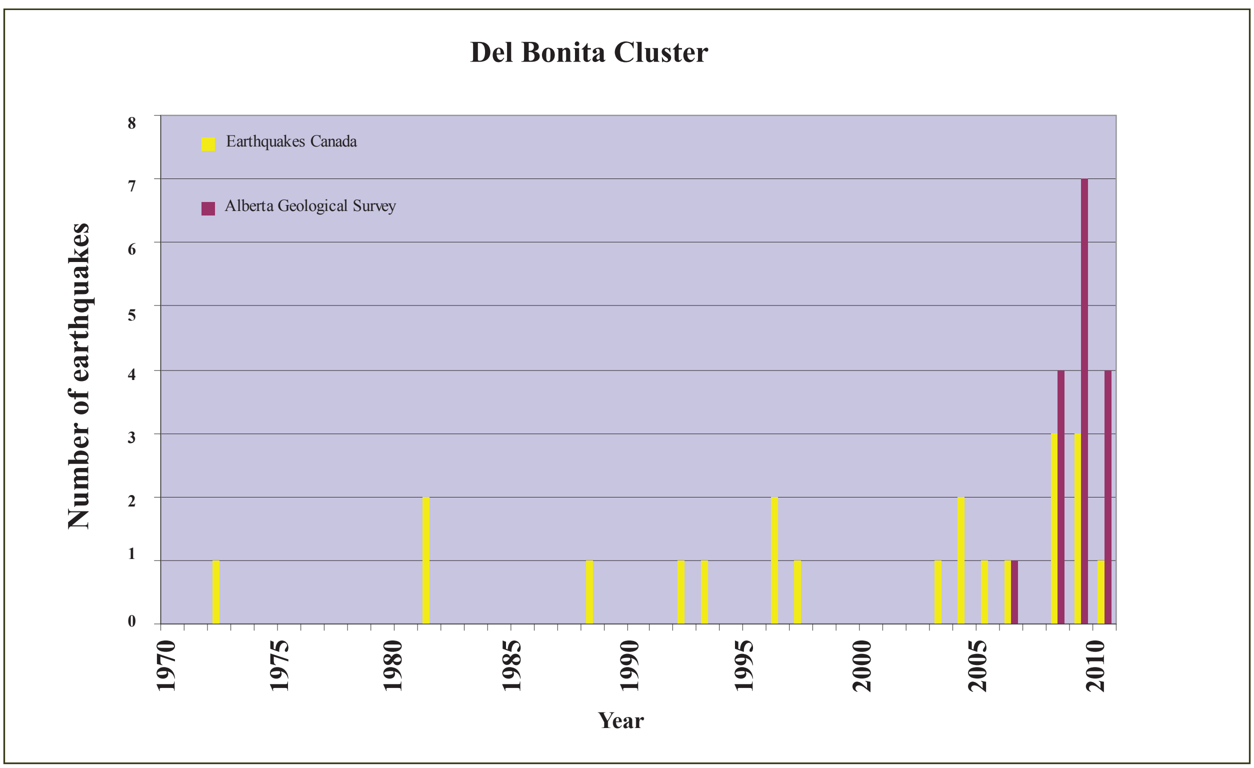

Figure 13. Frequency diagram of Del Bonita events 1970 to 2010.

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Appendix – Tables

Table A.1. Seismograph stations in Figure 1 or whose data are routinely collected for use in location algorithms.

Station	Latitude[1]	Longitude[1]	Location	Network[2]	On Date[3]	Off Date[3]	Status
ATHA	54.7137	−113.314	Athabasca, AB	ATSN	10/19/2012		OPEN
BAN	51.1717	−115.558	Banff, AB	CNSN	08/01/1955	09/19/1966	CLOSED
BLBC	52.0434	−119.241	Blue River, BC	CNSN	06/17/1997		OPEN
BLMT	48.0108	−114.363	Blacktail Mtn, MT USA	MRSN	03/11/2004		OPEN
BMBC	56.045	−122.131	Bull Mountain, BC	CNSN	01/30/1998		OPEN
BRU	53.32	−117.87	Hinton, AB	CRANE	10/02/2006		OPEN
BSMT	47.8513	−114.787	Bassoo Peak, MT USA	MRSN	11/01/1995		OPEN
CLA	50.01	−113.52	Claresholm, AB	CRANE	10/02/2006		OPEN
CLK	54.3848	−110.507	Cold Lake	CRANE	09/23/2011		OPEN
CZA	52.49	−110.86	Wainwright, AB	CRANE	08/31/2007		OPEN
DGMT	48.47	−104.196	Dagmar, MT USA	US-REF	00/00/1972		OPEN
DOR	54.22	−108.57	Dorintosh, AB	CRANE	10/26/2007	04/05/2010	CLOSED
DOWB	51.5183	−118.516	Downie Slide, BC	CNSN	12/01/1982		OPEN
EDM	53.2217	−113.35	Edmonton, AB	CNSN	04/19/1963		OPEN
EGMT	48.024	−109.755	Eagleton, MT USA	US-REF	00/00/1972		OPEN
FCC	58.7617	−94.0867	Fort Churchill, MB	CNSN	10/03/1994		OPEN
FMC	56.65	−111.5	Fort McMurray, AB	CRANE	11/16/2007		OPEN
FNBB	58.8904	−123.01	Fort Nelson, BC	CNSN	10/24/1999		OPEN
FSB	54.4767	−124.328	Fort St. James, BC	CNSN	04/30/1979		OPEN
FSMA	59.9862	−111.822	Fort Smith, AB	ATSN	09/12/2010		OPEN
HILA	58.55608	−117.02	High Level, AB	ATSN	10/19/2009		OPEN
HLO	54.7	−112.28	Hylo, AB	CRANE	05/05/2009		OPEN
HON	55.08	−114.05	Slave Lake, AB	CRANE	10/14/2006		OPEN
JOF	52.34	−113.51	Joffre, AB	CRANE	09/18/2006	05/24/2007	CLOSED
JTMT	47.7467	−114.283	Jette, MT USA	MRSN	11/01/1995		OPEN
LYA	51.1551	−113.473	Strathmore, AB	CRANE	10/02/2006		OPEN
MANA	56.85538	−117.637	Manning, AB	ATSN	10/17/2009		OPEN
MCC	52.0517	−118.585	Mica Creek, BC	CNSN	07/05/1966	06/03/1977	CLOSED

Station	Latitude[1]	Longitude[1]	Location	Network[2]	On Date[3]	Off Date[3]	Status
MCE	52.0033	−118.562	Mica Creek, BC	CNSN	06/04/1977	08/12/1981	CLOSED
MEDA	49.98148	−110.742	Medicine Hat, AB	ATSN	10/09/2009	08/09/2011	CLOSED
MHB	50.32	−110.16	Medicine Hat, AB	CRANE	05/10/2009		OPEN
MNB	52.1983	−118.383	Mount Dainard, BC	CNSN	10/29/1981		OPEN
NEW	48.263	−117.12	Newport, WA USA	US-REF	00/00/1972		OPEN
NOR	52.49143	−116.052	Nordegg, AB	CRANE	09/18/2006		OPEN
OVMT	47.06433	−112.997	Ovando Mtn., MT USA	MRSN	10/14/1996		OPEN
PER	53.68	−116.04	Edson, AB	CRANE	09/28/2006		OPEN
PNT	49.3167	−119.617	Penticton, BC	CNSN	01/01/1960		OPEN
PRDA	50.8674	−114.292	Priddis, AB	ATSN	11/13/2009		OPEN
RAYA	49.38627	−112.687	Raymond, AB	ATSN	08/09/2010		OPEN
RDEA	56.55117	−115.32	Red Earth Creek, AB	ATSN	06/08/2011		OPEN
RDR	52.2658	−114	Red Deer, AB	CRANE	09/14/2011		OPEN
REC	56.55	−115.28	Red Earth Creek, AB	CRANE	10/13/2006	06/01/2007	CLOSED
RW1	53.8529	−113.176	Coronado, AB	CRANE	10/15/2010		OPEN
RW2	53.3493	−111.746	Ranfurly, AB	CRANE	09/17/2010		OPEN
RW3	54.4415	−113.651	Meadowbrook, AB	CRANE	10/15/2010		OPEN
RW4	53.8006	−114.552	Glenevis, AB	CRANE	10/13/2010		OPEN
RW5	54.2043	−111.578	Ashmount, AB	CRANE	10/01/2010		OPEN
SES	50.396	−111.042	Suffield, AB	CNSN	00/00/1966	03/31/1993	CLOSED
SLEB	51.1672	−118.134	Sale Mountain, BC	CNSN	10/01/1985		OPEN
SWMT	47.5093	−113.999	Swartz Lake, MT USA	MRSN	09/15/2001		OPEN
ULM	50.25026	−95.875	Lac Du Bonnet, MB	CNSN	10/01/2004		OPEN
WALA	49.0586	−113.912	Waterton Lake, AB	CNSN	06/01/1992		OPEN
WAPA	55.18333	−119.254	Grande Prairie, AB	ATSN	10/15/2009		OPEN
YBMT	47.8633	−114.012	Yellow Bay, MT USA	MRSN	09/15/2001		OPEN
YKB3	62.4486	−114.605	Yellowknife, NT	CNSN	01/25/1989		OPEN
YKB6	62.5165	−114.605	Yellowknife, NT	CNSN	01/25/1989		OPEN
YKR1	62.4927	−114.946	Yellowknife, NT	CNSN	00/00/1962		OPEN
YKR2	62.4928	−114.896	Yellowknife, NT	CNSN	00/00/1962		OPEN
YKR4	62.4928	−114.8	Yellowknife, NT	CNSN	00/00/1962		OPEN

Station	Latitude[1]	Longitude[1]	Location	Network[2]	On Date[3]	Off Date[3]	Status
YKR9	62.4932	−114.556	Yellowknife, NT	CNSN	00/00/1962		OPEN
YKW3	62.5608	−114.616	Yellowknife, NT	CNSN	01/25/1989		OPEN

1 Latitude and Longitude are in decimal degrees.
2 Network code: ATSN is the Alberta Telemetered Seismograph Network, CNSN is the Canadian National Seismograph Network, CRANE is the Canadian Rockies and Alberta Network, MRSN is the Montana Regional Seismic Network, and US-REF is the USArray/American National Seismograph System Reference Network.
3 Dates are in the MM/DD/YYYY format.

Table A.2. Earthquakes located in Alberta, or within 10 km of the provincial border, from September 2006 through December 2010 (data from AER/AGS DIG 2013−0017 [Stern et al., 2013]).

Latitude[1]	Longitude[1]	Depth (km)[2]	Dtype[3]	Date & Time (UTC)[4]	Mag (M_L)[5]	Location[6]
49.1546	−112.685	18	f	12/30/2006 (364) 13:53:48.586	4.07	10 km NNE of Shanks Lake
52.7167	−116.12	1	f	10/21/2006 (294) 6:51:56.286	0.51	26 km NNW of Harlech
52.7107	−116.186	1	g	11/08/2006 (312) 19:05:10.366	2.9	27 km NW of Harlech
51.5206	−115.735	1	g	11/21/2006 (325) 8:05:06.369	−999	25 km WNW of Panther Mtn
52.2361	−115.25	1	g	12/01/2006 (335) 0:07:36.396	2.31	27 km SW of Rocky Mtn House
52.6887	−115.964	1	g	12/05/2006 (339) 8:00:33.891	0.77	21 km N of Harlech
52.7702	−116.065	1	g	12/06/2006 (340) 5:48:08.697	1.33	30 km NNW of Harlech
53.0168	−117.252	1	g	12/08/2006 (342) 5:54:20.639	−999	5 km ESE of Cadomin
52.6763	−116.153	6	f	10/21/2006 (294) 9:26:55.064	0.41	23 km NW of Harlech
52.3185	−115.267	1	g	12/01/2006 (335) 0:10:59.740	2.24	24 km WSW of Rocky Mtn House
51.199	−116.189	1	g	11/05/2006 (309) 19:08:42.880	3.66	9 km NE of Rockwall Peak
52.9435	−117.237	1	g	12/23/2006 (357) 13:24:29.403	−999	12 km SE of Cadomin
53.3617	−116.767	6	f	12/29/2006 (363) 21:13:09.925	2.38	3 km SSE of Weald
49.0951	−111.086	2	f	9/24/2006 (267) 5:26:23.368	−999	17 km NE of Aden
53.0449	−118.332	13	f	10/18/2006 (291) 0:47:50.782	2.22	25 km NW of Jasper
53.2923	−118.169	10	f	12/02/2006 (336) 20:56:46.432	2.33	48 km N of Jasper
52.6175	−116.099	2	f	2/26/2007 (057) 15:14:59.731	0.58	15 km NW of Harlech
52.2778	−115.316	1	g	3/19/2007 (078) 5:31:38.354	2.52	13 km WNW of Strachan
53.1482	−116.969	1	f	5/24/2007 (144) 4:14:43.462	3.26	5 km SE of Coalspur
52.673	−116.155	1	g	9/21/2007 (264) 1:53:27.510	2.74	23 km NW of Harlech
52.7026	−116.136	1	g	10/09/2007 (282) 3:07:19.428	1.96	25 km NW of Harlech

Latitude[1]	Longitude[1]	Depth (km)[2]	Dtype[3]	Date & Time (UTC)[4]	Mag (M_L)[5]	Location[6]
52.73	−116.146	1	g	10/16/2007 (289) 9:58:14.341	2.24	28 km NNW of Harlech
52.6475	−113.422	5	g	10/18/2007 (291) 23:26:55.610	2.72	11 km ESE of Ponoka
52.6571	−116.095	1	g	10/16/2007 (289) 8:10:28.407	2.07	18 km NW of Harlech
52.7136	−116.148	3	f	10/16/2007 (289) 11:33:46.892	0.8	26 km NW of Harlech
52.7883	−116.152	1	g	3/28/2007 (087) 5:57:48.766	1.64	33 km NW of Harlech
52.7301	−116.181	3	f	3/22/2007 (081) 9:24:09.885	2.3	28 km NW of Harlech
52.2733	−115.265	1	f	4/20/2007 (110) 11:38:26.429	1.77	17 km SW of Ferrier
58.9058	−118.348	1	g	5/23/2007 (143) 18:31:32.308	2.93	23 km NE of Habay
52.6941	−116.082	2	f	5/25/2007 (145) 23:09:58.347	2.02	22 km NNW of Harlech
52.1446	−117.836	5	g	6/07/2007 (158) 21:47:55.570	−999	82 km SSE of Jasper
52.0886	−114.605	1	g	8/14/2007 (226) 15:24:42.451	2.07	8 km NE of Crammond
52.6844	−116.117	1	f	10/20/2007 (293) 3:32:14.295	1.08	22 km NW of Harlech
52.1642	−117.798	1	g	11/01/2007 (305) 16:06:50.023	−999	81 km SSE of Jasper
51.838	−115.268	1	g	11/27/2007 (331) 2:27:02.506	1.5	35 km SW of Ricinus
52.2224	−117.795	1	g	12/28/2007 (362) 9:07:48.994	1.81	76 km SSE of Jasper
54.3132	−117.067	1	g	1/22/2007 (022) 7:22:36.644	2.95	20 km SW of Fox Creek
50.0127	−113.144	1	g	2/06/2007 (037) 11:39:11.178	−999	5 km NW of Barons
52.4281	−113.69	1	g	3/22/2007 (081) 20:12:27.905	2.41	5 km SE of Lacombe
53.274	−117.282	8	f	5/01/2007 (121) 0:47:42.594	1.64	24 km SE of Hinton
53.2275	−118.416	15	g	6/17/2007 (168) 14:51:21.588	2.22	30 km WNW of Devona
52.7359	−116.139	1	f	7/06/2007 (187) 19:02:32.679	3.03	27 km NW of Harlech
52.7537	−116.106	1	g	7/06/2007 (187) 19:06:05.924	2.54	29 km NNW of Harlech
52.7486	−116.156	2	f	7/08/2007 (189) 11:23:54.875	2.31	30 km NNW of Harlech
52.7142	−116.11	1	g	7/17/2007 (198) 16:52:21.550	2.06	25 km NNW of Harlech
49.4354	−114.562	4	f	7/20/2007 (201) 6:46:06.058	1.96	18 km SSW of Crowsnest Pass
52.0848	−117.343	8	f	7/25/2007 (206) 19:11:54.304	2.47	101 km SE of Jasper
50.8897	−115.603	1	g	8/09/2007 (221) 6:16:31.438	−999	27 km SW of Canmore
53.201	−118.312	3	f	8/14/2007 (226) 20:51:54.390	2.79	22 km WNW of Devona
53.1542	−116.969	1	g	9/28/2007 (271) 4:07:54.863	2.25	4 km SE of Coalspur
53.1891	−117.88	6	f	10/15/2007 (288) 21:04:22.314	2.75	3 km SE of Pocahontas
53.1999	−115.912	10	f	11/12/2007 (316) 20:16:40.113	3.76	34 km WSW of Cynthia

Latitude[1]	Longitude[1]	Depth (km)[2]	Dtype[3]	Date & Time (UTC)[4]	Mag (M_L)[5]	Location[6]
55.7314	−119.879	10	g	11/17/2007 (321) 0:32:15.991	−999	11 km SSE of Bay Tree
52.7206	−116.166	1	g	11/23/2007 (327) 12:48:35.788	0.61	27 km NNW of Harlech
52.3937	−113.66	0	f	12/28/2007 (362) 20:11:01.542	−999	10 km SE of Lacombe
49.2312	−112.691	24	f	1/03/2008 (003) 13:28:15.963	3.79	23 km NNE of Del Bonita
52.2425	−117.834	3	f	1/08/2008 (008) 6:28:10.006	2.26	72 km SSE of Jasper
51.8315	−117.033	1	g	10/23/2008 (297) 8:40:07.070	3.6	70 km NW of Lake Louise
52.1294	−113.252	1	g	3/21/2008 (081) 7:22:14.873	2.78	6 km NW of Lousana
49.0795	−113.459	19	f	1/12/2008 (012) 22:23:09.301	3.56	4 km SSE of Beazer
53.9101	−116.198	1	g	1/31/2008 (031) 9:14:37.195	2.9	15 km W of Shining Bank
51.5905	−115.239	1	g	2/03/2008 (034) 12:03:59.330	3.45	58 km SSW of Ricinus
52.512	−118.217	1	g	2/19/2008 (050) 4:28:31.114	1.89	42 km SSW of Jasper
52.6668	−116.106	1	g	3/23/2008 (083) 7:57:48.078	0.52	19 km NNW of Harlech
55.7902	−115.606	1	g	4/24/2008 (115) 14:53:08.659	3.03	13 km N of Atikameg
51.7518	−115.875	18	f	6/10/2008 (162) 9:51:30.494	2.18	40 km NE of Lake Louise
52.0988	−117.943	2	f	7/09/2008 (191) 9:09:39.328	2.01	86 km S of Jasper
52.2233	−117.955	14	f	7/22/2008 (204) 6:56:22.549	−999	73 km S of Jasper
50.63	−114.184	1	g	8/05/2008 (218) 7:58:47.714	1.83	6 km SE of Turner Valley
52.1097	−117.983	1	g	8/19/2008 (232) 7:52:17.576	1.23	84 km S of Jasper
52.1565	−117.886	4	f	8/20/2008 (233) 11:56:24.837	−999	79 km S of Jasper
54.5222	−119.821	5	f	11/06/2008 (311) 0:00:07.153	2.89	66 km SW of Wapiti
52.1926	−117.861	1	g	12/05/2008 (340) 12:55:12.646	−999	76 km S of Jasper
49.0792	−113.034	27	f	3/12/2008 (072) 18:34:57.505	2.97	3 km E of Owendale
52.0317	−117.921	11	f	7/07/2008 (189) 22:37:28.494	−999	93 km S of Jasper
52.7234	−116.137	1	g	2/06/2008 (037) 4:26:49.925	−999	26 km NNW of Harlech
51.9601	−116.29	1	f	1/13/2008 (013) 1:08:39.039	2.64	55 km NNW of Lake Louise
51.8729	−117.108	4	f	1/17/2008 (017) 9:44:34.577	1.8	77 km NW of Lake Louise
52.7619	−116.159	1	g	1/31/2008 (031) 18:42:43.592	1.75	31 km NW of Harlech
49.0197	−112.737	1	g	2/26/2008 (057) 10:01:57.796	1.87	4 km E of Del Bonita
51.8845	−117.336	27	f	3/04/2008 (064) 1:43:53.274	−999	92 km NW of Lake Louise
51.6482	−116.4	1	g	3/10/2008 (070) 0:08:08.485	1.32	27 km NW of Lake Louise
48.8692	−112.16	2	f	4/04/2008 (095) 2:10:16.403	−999	32 km S of Milk River

Latitude[1]	Longitude[1]	Depth (km)[2]	Dtype[3]	Date & Time (UTC)[4]	Mag (M_L)[5]	Location[6]
55.9144	−115.379	1	g	4/24/2008 (115) 16:14:55.264	2.77	16 km E of Atikameg
53.8932	−114.358	3	g	9/03/2008 (247) 16:49:23.939	2.44	4 km SW of Lac la Nonne
52.4131	−115.311	1	g	9/22/2008 (266) 21:37:48.510	2.51	17 km NW of Ferrier
51.9948	−116.36	2	f	11/04/2008 (309) 21:10:43.255	2.49	56 km SSW of Nordegg
53.4781	−118.065	1	g	11/09/2008 (314) 21:23:38.124	2.21	23 km NW of Brule
52.5507	−116.781	1	g	4/01/2009 (091) 13:01:35.481	2.74	49 km WNW of Nordegg
49.2272	−112.838	27	f	8/05/2009 (217) 10:08:10.755	3.16	35 km E of Cardston
51.4625	−115.295	5	f	12/08/2009 (342) 21:05:53.038	2.99	37 km NNE of Banff
50.6585	−114.88	1	g	3/06/2009 (065) 12:19:22.647	2.18	43 km W of Turner Valley
52.2444	−115.778	8	f	4/11/2009 (101) 8:20:34.289	3.2	44 km W of Strachan
56.8921	−110.443	1	g	11/21/2009 (325) 21:03:26.891	3.46	61 km ENE of Fort McMurray
54.0672	−117.488	1	f	8/10/2009 (222) 2:38:45.545	3	57 km SW of Fox Creek
48.9404	−112.597	13	f	9/29/2009 (272) 11:34:56.014	3.59	34 km ESE of Wiskey Gap
52.4112	−114.402	1	g	11/18/2009 (322) 10:01:32.229	2.69	6 km NNW of Eckville
54.0907	−114.618	2	f	2/05/2009 (036) 5:58:53.819	2.82	14 km WSW of Barrhead
52.325	−117.642	1	g	4/27/2009 (117) 1:33:23.981	0.9	68 km SSE of Jasper
49.0973	−112.638	6	f	8/05/2009 (217) 9:50:44.081	2.09	14 km NE of Del Bonita
52.2449	−115.214	1	g	8/18/2009 (230) 4:30:42.668	1.94	6 km SW of Strachan
52.0607	−117.21	1	g	9/01/2009 (244) 5:01:09.974	1.41	89 km SW of Nordegg
52.2087	−117.546	1	g	9/23/2009 (266) 5:16:12.725	2.18	83 km SSE of Jasper
52.0049	−115.721	4	f	12/28/2009 (362) 9:00:42.392	3.44	49 km SW of Strachan
52.6927	−116.166	6	f	12/01/2009 (335) 15:54:31.606	1.22	35 km NW of Harlech
56.3942	−117.062	1	g	2/19/2009 (050) 4:02:28.968	2.99	24 km NE of Peace River
52.7685	−116.251	1	g	12/01/2009 (335) 15:56:13.817	2.59	24 km NE of Harlech
56.1666	−117.632	1	g	1/06/2009 (006) 0:24:00.194	−999	19 km WSW of Peace River
53.3001	−119.914	10	f	1/08/2009 (008) 4:27:04.205	1.8	81 km SW of Grande Cache
53.3204	−120.094	5	f	1/08/2009 (008) 15:56:54.000	2.2	130 km WSW of Grande Cache
50.7622	−113.385	1	g	1/17/2009 (017) 21:01:25.954	2.39	40 km SE of Calgary
52.0575	−117.78	1	g	2/02/2009 (033) 21:56:41.338	1.3	93 km S of Jasper
49.067	−112.733	9	f	2/22/2009 (053) 11:55:48.523	−999	6 km NE of Del Bonita
49.0783	−112.834	11	f	2/22/2009 (053) 12:25:22.599	−999	6 km NNE of Del Bonita

Latitude[1]	Longitude[1]	Depth (km)[2]	Dtype[3]	Date & Time (UTC)[4]	Mag (M_L)[5]	Location[6]
49.0322	−112.702	1	g	2/22/2009 (053) 13:09:26.088	1.29	7 km E of Del Bonita
52.1343	−115.59	7	f	3/30/2009 (089) 15:20:35.981	3.72	33 km SW of Strachan
48.8343	−112.394	3	f	6/09/2009 (160) 15:21:29.966	3.05	36 km SE of Del Bonita
52.717	−116.102	2	f	6/21/2009 (172) 2:24:47.728	1.72	25 km NNW of Harlech
52.7221	−116.163	1	f	7/09/2009 (190) 7:35:58.997	1.86	28 km NNW of Harlech
52.0287	−117.559	2	f	11/03/2009 (307) 10:57:48.506	3.27	76 km W of Cline River
51.9553	−117.519	1	g	11/03/2009 (307) 12:41:57.702	0.7	75 km WSW of Cline River
51.9573	−117.488	1	g	11/03/2009 (307) 13:11:08.429	0.8	73 km WSW of Cline River
52.1907	−117.862	1	g	11/27/2009 (331) 2:50:53.425	0.7	95 km W of Cline River
49.1922	−112.706	14	f	1/01/2010 (001) 4:46:27.411	1.66	19 km NNE of Del Bonita
52.3207	−115.273	1	g	1/03/2010 (003) 13:42:27.211	2.62	12 km NW of Strachan
53.2021	−117.58	7	f	1/03/2010 (003) 21:52:15.283	−999	26 km NNW of Cadomin
51.6316	−115.848	1	g	1/14/2010 (014) 4:52:36.015	1.5	31 km NE of Lake Louise
49.2829	−112.787	27	f	2/19/2010 (050) 9:04:01.687	2.43	28 km N of Del Bonita
52.6181	−118.015	7	f	2/23/2010 (054) 9:49:21.698	2.28	29 km S of Jasper
52.2557	−117.807	5	f	2/28/2010 (059) 10:32:37.132	1.64	71 km SSE of Jasper
53.4684	−115.757	1	g	3/12/2010 (071) 4:48:00.739	2.88	16 km SSE of Carrot Creek
54.9811	−118.926	8	f	3/20/2010 (079) 23:39:43.951	2.9	13 km SE of Grande Prairie
54.5251	−117.958	1	g	3/21/2010 (080) 21:02:07.662	2.26	55 km SW of Little Smoky
51.7516	−114.481	1	g	3/27/2010 (086) 21:56:37.933	−999	25 km WSW of Olds
52.2116	−115.206	5	f	4/12/2010 (102) 16:28:41.891	2.42	6 km SW of Strachan
52.7017	−116.152	1	g	4/17/2010 (107) 20:37:51.336	1.46	24 km NNW of Harlech
52.2867	−116.382	1	g	5/09/2010 (129) 21:42:06.426	2.22	28 km SW of Nordegg
52.3102	−116.068	2	f	5/10/2010 (130) 14:38:39.203	2.04	17 km S of Nordegg
53.1667	−116.535	1	g	5/25/2010 (145) 4:25:28.431	2.04	20 km NE of Coal Valley
52.7422	−116.945	1	g	6/01/2010 (152) 6:14:51.770	2.26	40 km SE of Cadomin
54.0021	−119.202	1	g	6/02/2010 (153) 7:20:18.756	2.27	16 km NNW of Grande Cache
54.0446	−119.033	4	f	6/06/2010 (157) 9:19:28.395	2.52	20 km NNE of Grande Cache
53.4939	−118.418	5	g	6/17/2010 (168) 3:24:00.588	2.98	61 km SE of Grande Cache
54.0382	−119.076	5	f	6/18/2010 (169) 7:59:11.620	2.62	19 km N of Grande Cache
51.737	−115.376	3	f	7/15/2010 (196) 12:15:07.430	2.38	51 km W of Sundre

Latitude[1]	Longitude[1]	Depth (km)[2]	Dtype[3]	Date & Time (UTC)[4]	Mag (M_L)[5]	Location[6]
49.1967	−113.754	3	f	7/27/2010 (208) 18:46:24.100	−999	11 km SW of Parkbend
48.9813	−113.256	1	g	8/29/2010 (241) 22:15:00.959	2.98	12 km SW of Taylorville
48.7717	−113.78	1	g	8/29/2010 (241) 22:15:10.789	2.68	43 km SSW of Mountain View
48.9387	−112.918	1	g	8/29/2010 (241) 22:22:29.831	1.99	14 km SW of Del Bonita
52.0153	−116.358	1	g	9/03/2010 (246) 8:13:43.883	1.4	54 km SW of Nordegg
53.0412	−116.613	2	f	9/03/2010 (246) 16:25:56.899	1.4	14 km SE of Coal Valley
58.6521	−119.827	10	f	9/12/2010 (255) 10:03:44.885	2.52	30 km NW of Rainbow Lake
56.0722	−116.995	3	f	9/23/2010 (266) 1:49:36.133	2.79	8 km SW of Harmon Valley
55.5747	−116.18	1	g	10/03/2010 (276) 8:07:57.109	2.27	6 km SSW of Grouard
56.6001	−117.652	1	g	10/03/2010 (276) 8:08:53.202	3.47	7 km N of Dixonville
53.1227	−116.019	1	g	10/08/2010 (281) 20:14:23.691	3.17	59 km SE of Edson
52.1223	−115.269	1	g	10/16/2010 (289) 6:22:57.808	2.55	18 km SW of Strachan
48.8321	−113.341	15	f	10/25/2010 (298) 8:50:59.971	1.91	46 km SW of Del Bonita
52.3572	−115.221	1	g	10/29/2010 (302) 12:50:57.685	−999	13 km NNW of Strachan
52.8729	−114.309	1	g	11/01/2010 (305) 0:14:39.116	−999	14 km SW of Battle Lake
53.0952	−118.813	13	f	11/01/2010 (305) 21:28:56.102	−999	55 km NW of Jasper
53.4539	−116.871	1	g	11/02/2010 (306) 17:10:08.412	2.58	31 km SW of Edson
53.3469	−119.527	1	g	11/04/2010 (308) 17:20:27.098	−999	65 km SW of Grande Cache
51.5267	−116.219	1	g	11/15/2010 (319) 0:14:43.972	−999	8 km NNW of Lake Louise
50.7141	−115.238	2	f	11/15/2010 (319) 21:22:31.245	2.15	26 km SSW of Kananaskas Village
50.1002	−113.854	1	g	11/17/2010 (321) 23:37:42.442	3.44	8 km NNE of Lyndon
49.0086	−112.603	3	f	11/22/2010 (326) 15:38:10.801	−999	14 km ESE of Del Bonita
52.124	−115.846	3	f	12/15/2010 (349) 15:33:19.186	2.88	42 km SE of Nordegg
53.4881	−119.17	2	f	12/18/2010 (352) 18:15:18.792	3.13	44 km SSW of Grande Cache
51.2776	−115.488	10	f	12/22/2010 (356) 1:26:21.754	2.8	12 km NE of Banff
51.6268	−114.249	1	g	11/01/2010 (305) 20:25:32.580	−999	9 km SW of Didsbury

1 Latitude and Longitude are in decimal degrees.
2 Depths are poorly constrained and not accurate.
3 In most cases the depth was fixed and so indicated with a ‘g’; when allowed to be calculated by the genloc location algorithm, it is indicated with an ‘f’.
4 MAG refers to the magnitude or size of an event. A value of −999 is a null entry, indicating that a magnitude was not calculated.
5 The location of an event is given relative to the nearest city, town, or settlement.

Table A.3. Daylight Saving Time change dates for Alberta. Changes occur at 2 a.m.

Year	Start	End
2006	April 2nd	October 29th
2007	March 11th	November 4th
2008	March 9th	November 2nd
2009	March 8th	November 1st
2010	March 14th	November 7th

Table A.4. Earthquake magnitude classification.

Magnitude	Earthquake class	Effects of earthquakes	Recording of earthquakes
4 to 6	Moderate or Medium	Often felt, may cause minor damage	Readily recorded on distant near-surface seismographs
2 to 4	Small or minor	May be felt above 2.5 M_L	Readily recorded on regional near-surface
Less than 2	Micro	Usually not felt	Events above 1 M_L recorded on local near-surface seismographs.

Table A.5. List of known blast areas.

Mine	Province	Company[1]	Commodity mined	Records available[2]
Cadomin Quarry	AB	Lehigh Cement Company	Limestone	yes
Cardinal River (Cheviot)	AB	Teck Limited	Coal	yes
Coal Mountain	BC	Teck Limited	Coal	no
Coal Valley	AB	Sheritt International	Coal	yes
Dodds Coal Mine	AB	Dodds Coal Mining Co. Ltd.	Coal	no
Elkview	BC	Teck Limited	Coal	no
Exshaw	AB	Graymont	Limestone	yes
Fording River	BC	Teck Limited	Coal	yes
Genesee	AB	Sheritt International	Coal	no
Grande Cache	AB	Grande Cache Coal Corp.	Coal	yes
Greenhill	BC	Teck Limited	Coal	yes

Muskeg	AB	Hammerstone	Limestone	no
Highvale	AB	TransAlta Corporation	Coal	yes
Line Creek	BC	Teck Limited	Coal	no
Obed Mountain	AB	Sheritt International	Coal	yes
Paintearth / Vista	AB	Sheritt International	Coal	no
Quintette	BC	Teck Limited	Coal	no
Sheerness	AB	Sheritt International	Coal	no
Summit Lake	AB	Graymont	Limestone	no
Thunderstone	AB	Thunderstone Quarries	Rundle stone	yes

1 Company refers to the current ownership.
2 This indicates whether detailed records were made available by the companies.