IGNACE AREA MICROSEISMIC MONITORING PROJECT

ANNUAL EVENT SUMMARY REPORT (NOVEMBER 2020 - DECEMBER 2021)

APM-REP-01332-0340 **August 2022**

Nanometrics

NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

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Prepared for

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Revision Summary

Rev	Date	Authors	Comments
R1.0	2022-01-31	Danielle Mathieson	Initial issue
R1.1	2022-02-13	Jamie Conway, Krista Kaski, Danielle Mathieson	Updated with NWMO revisions
R1.2	2022-05-31	Emrah Yenier, Jamie Conway, Krista Kaski, Eugen Besoiu	Restructured the report to present information in a more logical order. Addressed outstanding NWMO questions and comments
R1.3	2022-07-01	Jamie Conway	Updated with NWMO and GRG revisions
R1.4	2022-07-15	Jamie Conway	Updated with NWMO comments
R1.5	2022-08-09	Jamie Conway	Updated with NWMO revisions

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Abbreviations

AOI: Area of interest for the Microseismic Monitoring Program to detect and quantify microseismicity approximately 50 km around the Revell Site in the Ignace area

APM: Adaptive Phased Management

CF: Characteristic function for trigger detection algorithm

IRIS: Incorporated Research Institutions for Seismology

Mc: Magnitude of completeness for the monitoring network

ML: Local magnitude scale

MSL: Mean sea level datum

NRCan: Natural Resources Canada

NWMO: Nuclear Waste Management Organization

Program: Microseismic monitoring program for the Ignace area

SNR: Signal to noise ratio

STA/LTA: Short-time average through long-time average trigger detection algorithm

Vp: Seismic propagation velocity of P-waves

Vs: Seismic propagation velocity of S-waves

WGS84: World Geodetic System (1984)

1. **Introduction**

The Nuclear Waste Management Organization ("NWMO") is responsible for implementing Adaptive Phased Management ("APM"), Canada's plan for the long-term management of used nuclear fuel. The ultimate objective of APM is the centralized containment and isolation of used nuclear fuel in a deep geological repository located at a safe site in an informed and willing host community. NWMO is committed to implementing the project in a manner that protects human health, safety, security and the environment, while fostering the long-term well-being of the community and region in which it is implemented.

The Microseismic Monitoring Program ("Program") in the Ignace area is part of Phase 2 Geoscientific Preliminary Field Investigations of the NWMO's APM Site Selection phase. The objective of the Program is to install a network of nine seismic stations (broadband seismometers) and provide continuous monitoring and reporting of earthquake activity for an Area of Interest ("AOI") around the potential repository area (i.e., Revell Site) located in the northwestern portion of the Revell batholith (Figure 1). The Program seeks to develop the ability to detect and quantify microseismicity within a predefined region approximately 50 km around the Revell Site in the Ignace area (Figure 2).

Nanometrics was contracted by NWMO for the implementation of the Program. Work activities that have been included in the Program are:

- Design of seismic monitoring network,
- Initial field assessments of station locations,
- Installation and maintenance of stations,
- Data acquisition, archiving and processing, and
- Annual cataloging of data and seismic events detected in the AOI.

This report is prepared by Nanometrics. It includes an annual summary of the Program for activities performed in 2021 regarding network operations, seismic data processing and event detection. An overview of work done for the derivation of a velocity model as well as the assessment of event location accuracy and network magnitude of completeness are also presented in this report.

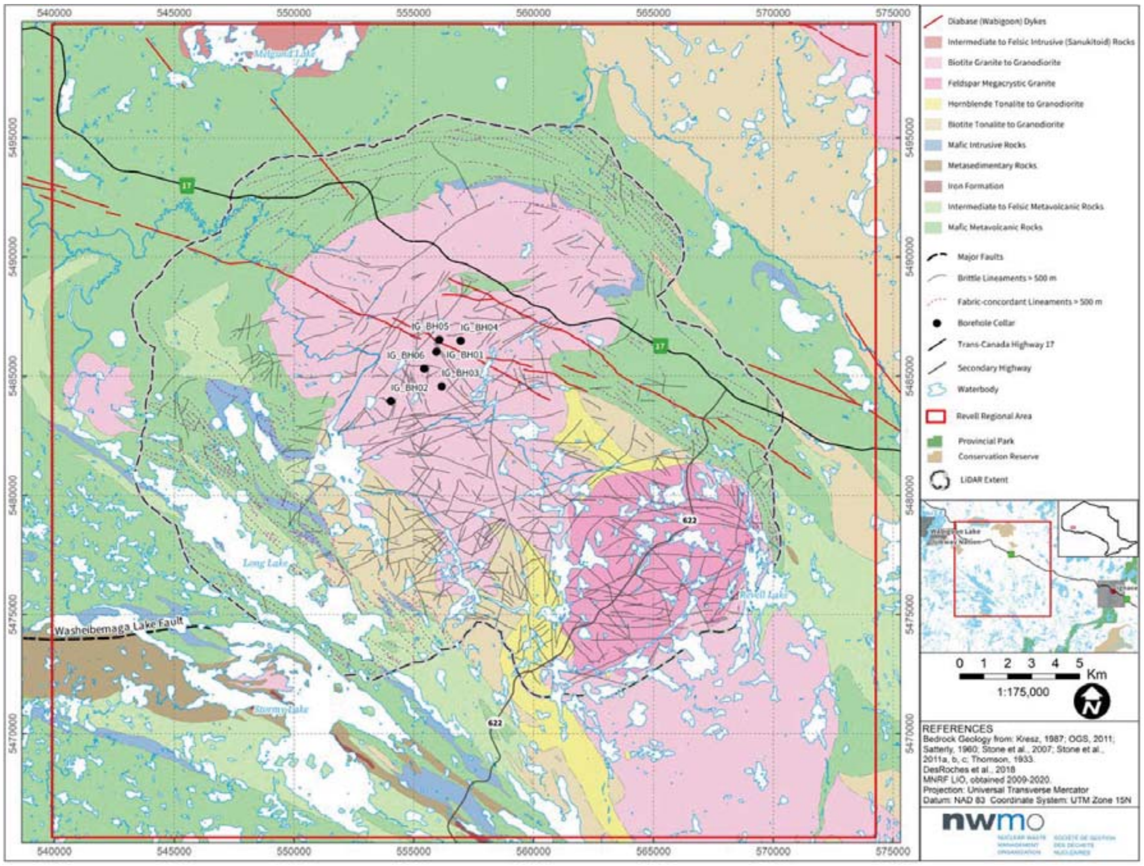

Figure 1. Bedrock map of the Revell Site. Black circles show the surface collar locations of drilled NWMO boreholes (Parmenter et al., 2020)

2. Network Operations

A summary of operational activities, including the installation and maintenance of the monitoring network as well as the statistics on the station state of health and data completeness are presented in this section.

2.1. Seismic Monitoring Network

NWMO seismic monitoring network consists of nine stations (broadband seismometers), all located inside the AOI. Seven of these stations stream data in real-time. Two stations (IG.SEI04 and IG.SEI08) record data in offline mode (i.e., no data transmission) due to lack of cellular connectivity in the area. Waveform data recorded at these two offline stations are collected with quarterly site visits and are incorporated into the data processing for detection of any additional earthquakes. The station locations are shown in Figure 2.

There are four additional stations from public seismic monitoring networks in the area:

- CN.ATKO, CN.EPLO, CN.SOLO from the Canadian National Seismograph Network, and
- US.EYMN from the United States National Seismic Network

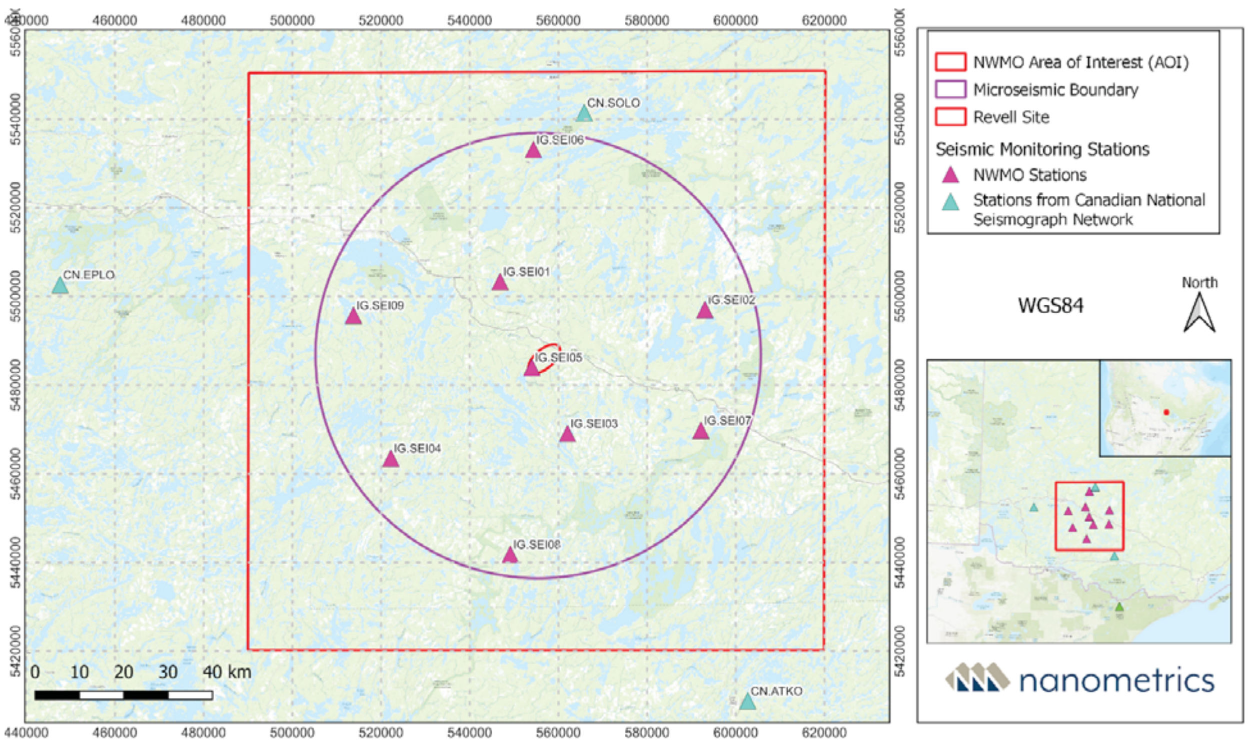

Figure 2. Locations of NWMO stations within the AOI. Public stations from national seismic networks incorporated into the Program are also shown. Microseismic Boundary represents the 50 km area around the Revell Site for microseismic monitoring. NWMO Area of Interest (AOI) represents the area defined by NWMO for detection, manual review and reporting of seismic activity.

These four public stations are also included in the Program. Their waveform data are streamed from the Incorporated Research Institutions for Seismology ("IRIS") and included in the data processing for event detection.

2.2. Operational Statistics and Maintenance Records

The first NWMO station (IG.SEI05) was installed close to one of the drilled boreholes, near the center of the network, on November 3rd, 2020. The site surveys for the remaining eight stations were completed in November 2020. However, they were installed in July 2021 after the completion of site selection and permitting. The monitoring network consisted of one NWMO station (IG.SEI05) and four public stations until then. Table 1 shows the installation dates for NWMO stations.

Table 1. Installation dates of NWMO stations

Station	Installation Date
IG.SEI05	2020-11-03
IG.SEI07	2021-07-05
IG.SEI02	2021-07-06
IG.SEI03	2021-07-07
IG.SEI08	2021-07-08
IG.SEI01	2021-07-09
IG.SEI06	2021-07-10
IG.SEI09	2021-07-11
IG.SEI04	2021-07-12

Table 2 shows a summary of station maintenance activities performed in 2021. Detailed station maintenance records were delivered to NWMO as they occurred and reference can be made to those documents for detailed descriptions. NWMO has taken the ownership of maintenance visits to replace drained batteries due to winter conditions.

Table 2. NWMO station maintenance details

Date	Station	Notes
2021-07-07	IG.SEI05	The high gain Centaur digitizer (SN: 6781) was replaced with a standard Centaur.
2021-12-14	IG.SEI02	New batteries were installed at the station, the old batteries were removed in order to be recharged.
2021-12-14	IG.SEI08	NWMO field personnel were trained to replace the batteries at the stations. The damaged guy wires were inspected and repaired. Additionally, since the station is not transmitting data in real-time, the data was retrieved and uploaded for processing.
2021-12-15	IG.SEI09	The batteries were replaced at the station. According to the site inspection, one of the guy wires was pulled, as result, the telescopic mast and the turnbuckle were bent. The bent section of the telescopic mast was removed, and the Omni antenna was reinstalled on the lower section of the mast.

2.3. Station State of Health Summary

Nanometrics actively monitors the state of health for streaming stations. If cellular connection to a station is lost temporarily (i.e., no data transmission), the station will continue recording data, as long as it maintains battery life. When the connection is restored, data transfer continues and the incomplete data is automatically filled, typically allowing for the continuation of 100% data collection. Stations were installed in remote areas and are working on batteries with the help of solar panels. No data can be recorded and transmitted when a station goes down due to low or no power. This is generally experienced in winter months when solar panels are covered with snow and batteries are not recharged. Table 3 shows the station data availability (in percent) from November 2020 to December 2021, on a monthly basis. Tables provided in Appendix A show data availability on a daily basis. Some short-term data losses were experienced for a few stations during winter. However, this did not have a notable impact on the overall network capability to detect earthquakes because a minimum of four operating stations are required to accurately locate earthquakes.

Table 3. Station data availability (in percent) from November 2020 to December 2021.

Station					November 2020	December 2020
IG.SEI05					100	100
	January 2021	February 2021	March 2021	April 2021	May 2021	June 2021
IG.SEI05	100	100	100	100	100	100
	July 2021	August 2021	September 2021	October 2021	November 2021	December 2021
IG.SEI01	100	100	100	100	62.8	55.6
IG.SEI02	100	100	100	100	54.1	73.1
IG.SEI03	100	100	100	100	83.6	84
IG.SEI04	100	100	100	100	96	100
IG.SEI05	100	100	100	100	100	100
IG.SEI06	100	100	100	100	67.8	78.9
IG.SEI07	100	100	100	100	100	100
IG.SEI08	100	100	100	83.3	100	100
IG.SEI09	100	100	100	100	88.8	88.8

3. Seismic Data Processing

An overview of seismic data processing workflow for the detection and characterization of seismic events is presented in this section.

3.1. Automatic Event Detection

Seismic monitoring stations continuously record ground vibrations generated by anthropogenic activities (e.g., mining/quarry blasts - discussed in Section 6) and natural phenomena, including earthquakes. The NWMO stations are equipped with highly sensitive seismometers that can detect vibrations well-below human perception. The recorded data are streamed to the Nanometrics Cloud Data Center in near real-time, for data processing.

The continuous waveform data acquired from each station is processed through a short-time-average through long-time-average ("STA/LTA") trigger detection algorithm. The algorithm predicts a characteristic function ("CF") of the signal based on continuously-moving short-time and long-time windows and declares a trigger when the CF exceeds a pre-set threshold. The automatic processing system declares an event when a minimum of four time-correlated seismic phase arrivals are picked at a minimum of four stations.

3.2. Manual Review

Not every automatic event detection would necessarily be associated with an earthquake. Event waveforms are reviewed by experienced analysts on a next day basis, in order to confirm if they are seismic activities. False positives (incorrect classification of random noise) and non-seismic event detections due to anthropogenic activities (discussed in Section 6) are removed. For confirmed seismic events, the review process also involves adjustment of automatic picks for seismic phase arrivals and peak amplitudes, if deemed necessary, in order to ensure the quality of event solution (origin time, hypocenter location and magnitude). Following the manual adjustment of phase and amplitude picks, seismic events are re-processed to determine the final event solutions.

Earthquake hypocenter locations are determined based on an 1D velocity model, which was derived from 3D velocity data provided by NWMO (reader is referred to Section 5 for details about velocity models).

Seismic events that fall outside of the AOI after manual review are not included in the Program. For example, Figure 3 shows waveforms obtained from an earthquake that occurred on September 17, 2021, located approximately 11km outside of the AOI. In comparison, Figure 4 shows waveforms obtained from an earthquake that occurred on August 4, 2021, located inside the AOI.

Event magnitudes are determined in terms of Richter local magnitude (“ML”) based on a model proposed by Hutton and Boore (1987). Seismic events detected within the AOI are posted to Nanometrics Athena seismicity web portal for NWMO to review.

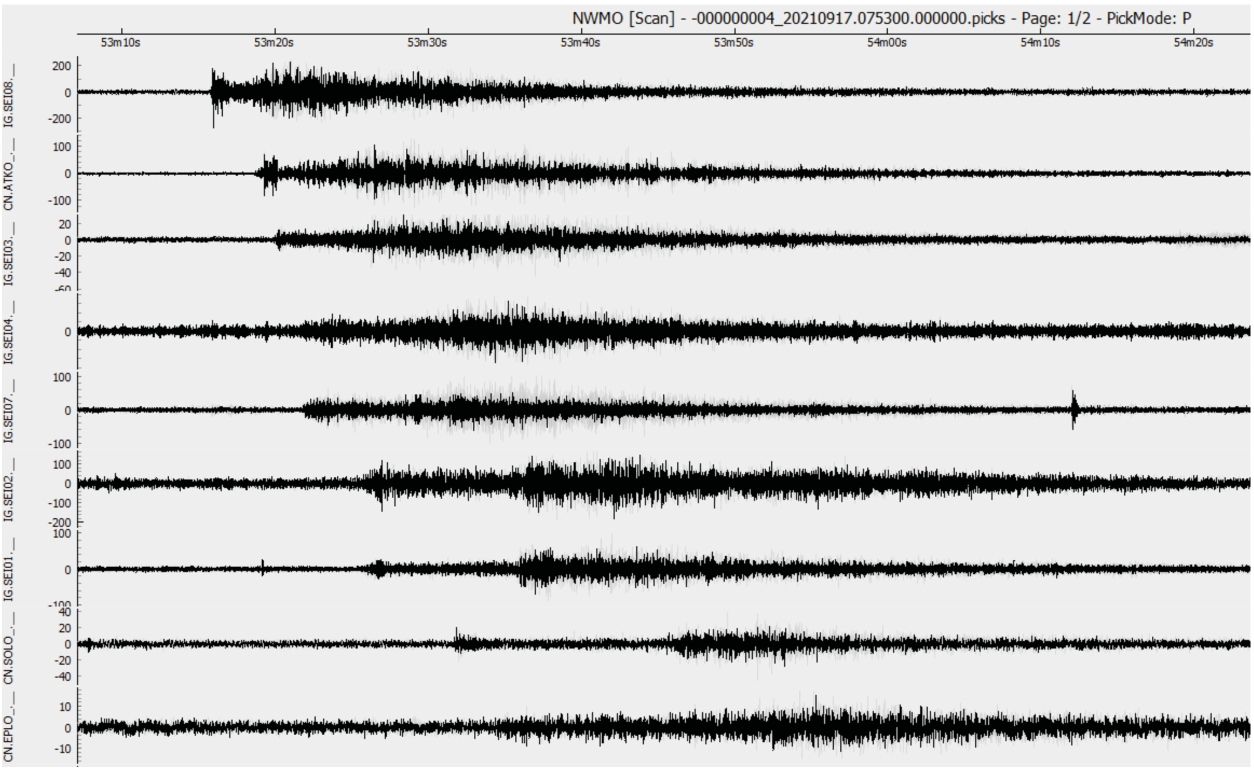

Figure 3. A seismic event detected on September 17th, 2021 that was located ~11 km outside of the AOI and was not included in the Program.

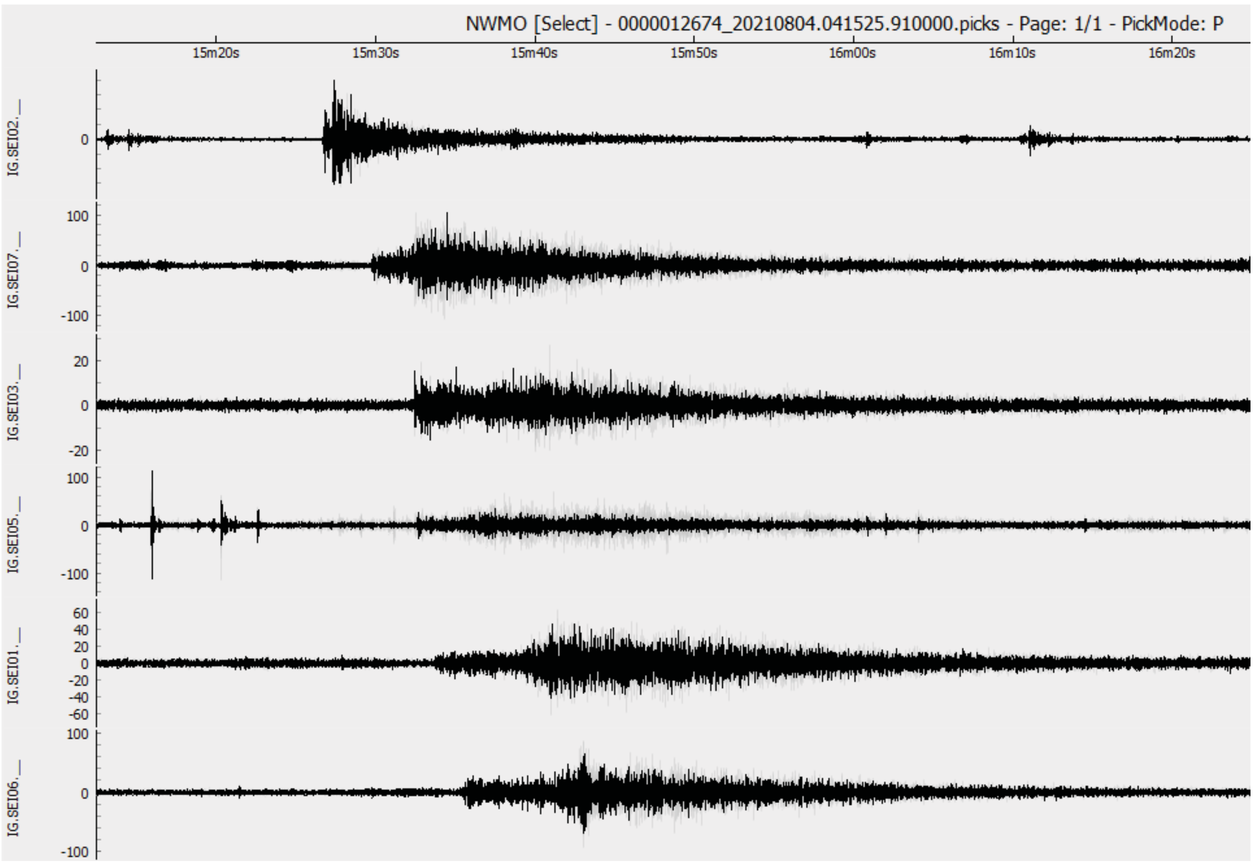

Figure 4. A seismic event detected on August 4th, 2021 that was located inside the AOI - included in the Program.

4. Network Performance

A summary of the network performance based on automatic event detections is provided in this section.

Automatic event detection is not bounded by the AOI to ensure no seismic events are missed due to automatic event location quality. This results in a large number of automatic event detections, with an average of ~1300 events per month. A total of 17,835 events were detected across the region from November 2020 to December 2021. Figure 5 shows the distribution of automatic event detections on a monthly basis.

The vast majority of these events were either false positives (incorrect detection of random noise) or anthropogenic activities (e.g., mining/quarry blasts - discussed Section 6). Several upticks in automatic event detections can be noted, such as in the month of March 2021. Common causes for such influxes of automatic detections are high wind patterns that cause increased vibrations at stations due to the shaking of trees and poles nearby. This can be noted in the months of December 2020, March 2021, and December 2021. An increase in automatic event detections also occurred in July 2021 and continued for the rest of the year due to the improved event detectability with the installation of the remaining stations.

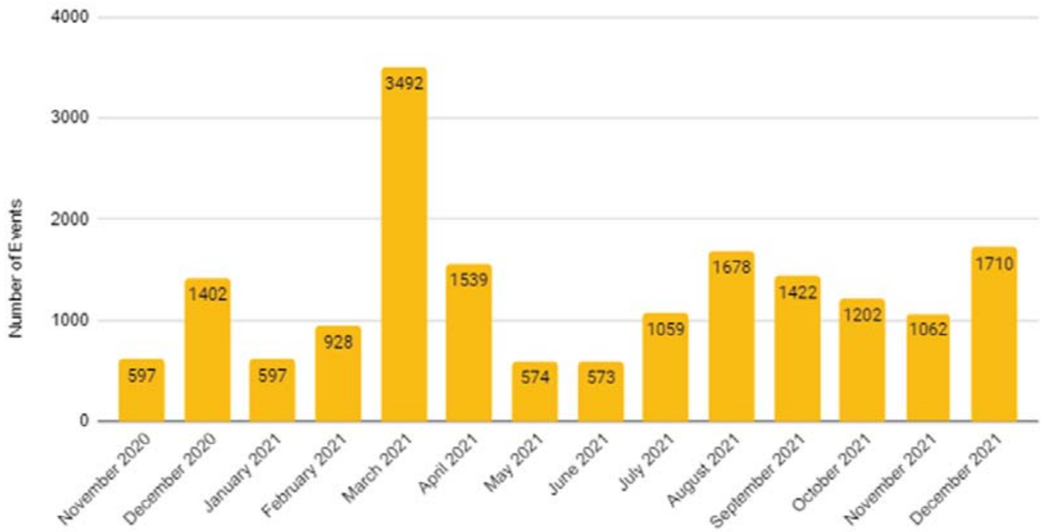

Figure 5. Rates of automatic event detections on a monthly basis

5. Seismic Velocity Model

A velocity model provides information on the seismic velocities present in the underlying geologic structure in an area (i.e. the speed with which seismic waves travel through the subsurface). Seismic velocity information allows for an estimation of distance between an event hypocenter and a recording station. Utilizing this information from several stations allows for the triangulation of earthquake hypocenters.

5.1. 3D Velocity Model

NWMO has provided a grid of P-wave velocity ("Vp") data for development of a 3D seismic velocity model for the AOI. The key steps involved in model building are as follows:

i. The provided velocity data is subsampled and smoothed
ii. 2D velocity layers are generated by interpolating the available data
    - S-wave velocities ("Vs") are estimated based on a constant Vs/Vp ratio of 1.75
    - The model is extended to a depth of 15 km assuming a constant velocity beyond the maximum depth of available velocity data (~4 km)
iii. Velocity layers are then merged and blended vertically
iv. Cross-validation is applied to remove outlier velocity data points
v. A 3D smoothing algorithm is applied to remove any sharp velocity contrasts

Figures 6 and 7 show Vp and Vs cross sections of the 3D velocity model, respectively.

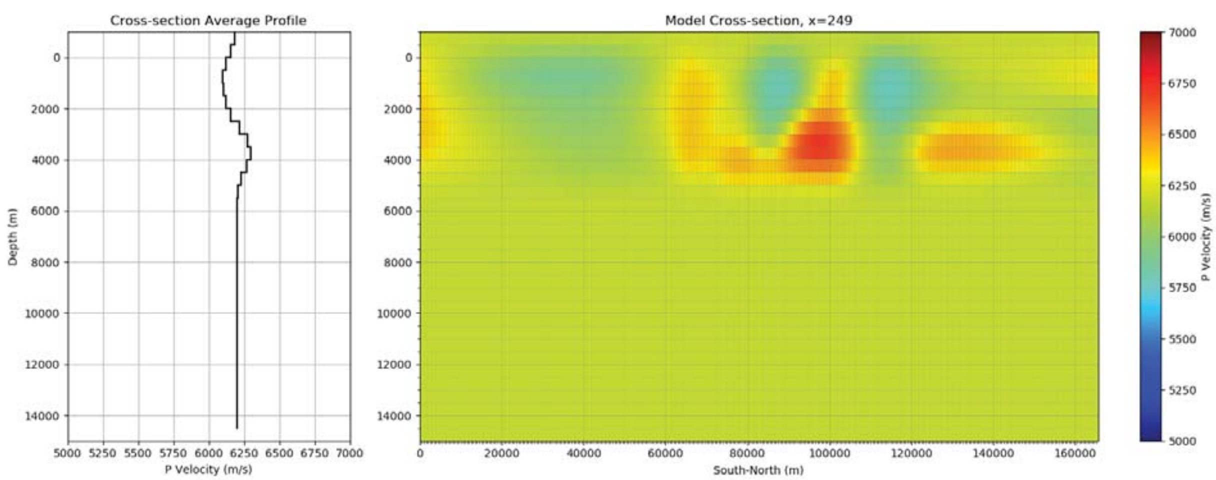

Figure 6. Vp cross-section of the 3D velocity model. The left panel displays a cross-section average profile, the right panel displays cross-section velocity.

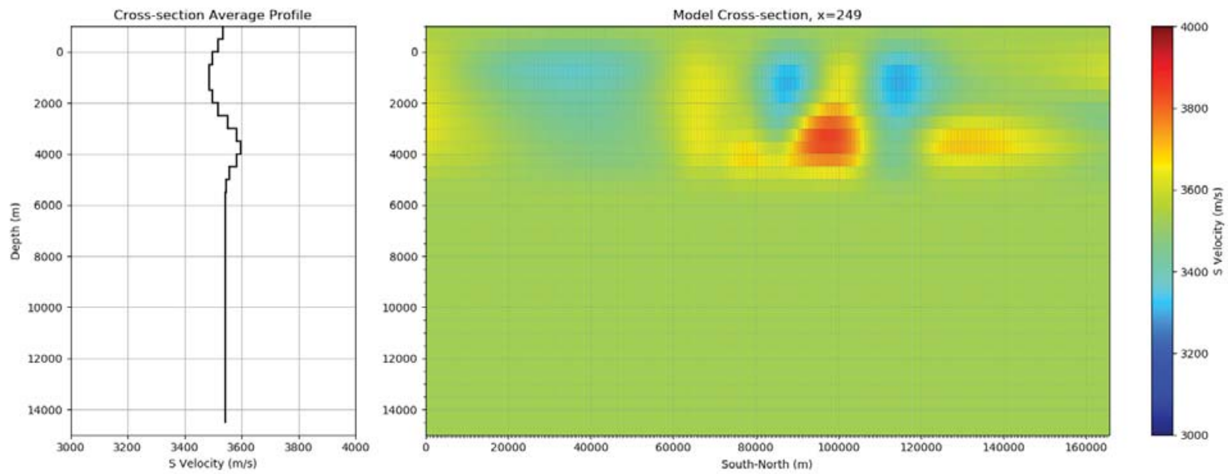

Figure 7. Vs cross-section of the 3D velocity model. The left panel displays a cross-section average profile, the right panel displays cross-section velocity.

The 3D velocity model is tested against seismic events detected within the AOI. It is observed that some events are unrealistically trapped in a medium above the surface due to some incompatibilities of the velocity model with observed seismic travel times. This suggests that the 3D velocity model requires some refinements before its integration with event processing and solution workflows. Therefore, it was agreed to use an average 1D velocity model until the re-assessment of the 3D velocity model with a larger earthquake dataset (~100 events within the AOI). The event locations will be re-calculated based on the 3D velocity model when it is finalized.

5.2. 1D Velocity Model

A simple 1D velocity model that captures the major velocity contrasts in the AOI is developed based on an averaging of the 3D velocity model. The 1D velocity model is temporarily used for locating seismic events until the 3D velocity model is finalized. Figures 8 and 9 show the 1D velocity model for Vp and Vs, respectively.

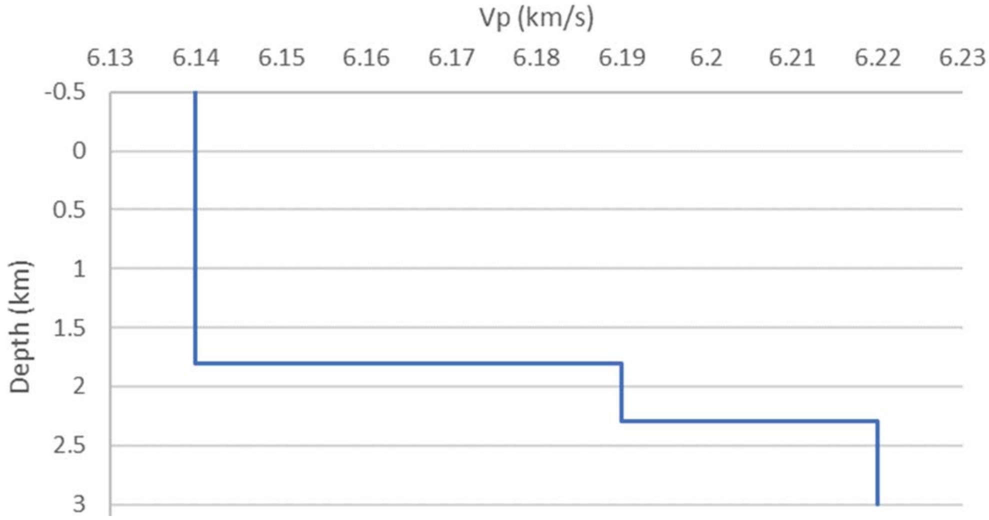

Figure 8. 1D velocity model for P waves. Top 3 km of the velocity model is shown for clarity. Vp attains a constant value of 6.22 km/s for depths greater than 3 km.

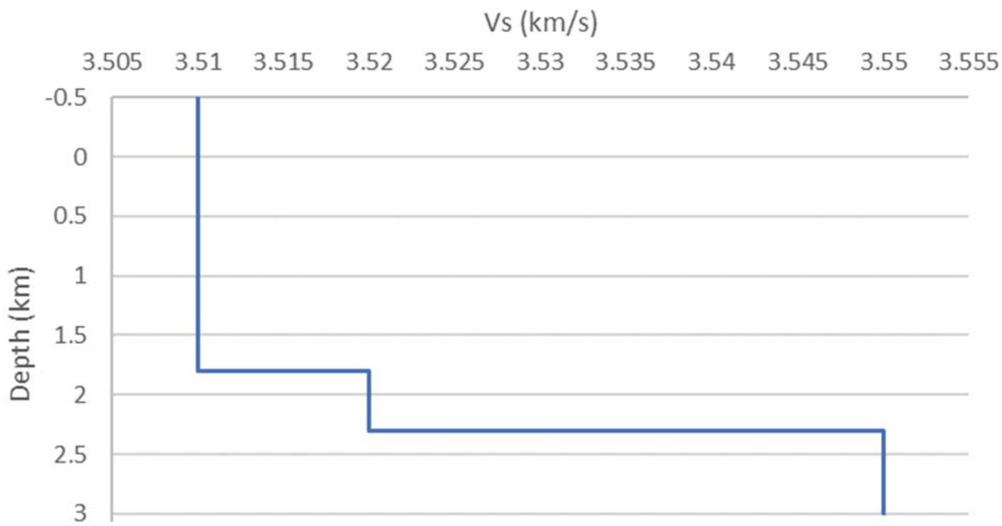

Figure 9. 1D velocity model for S waves. Top 3 km of the velocity model is shown for clarity. Vp attains a constant value of 3.55 km/s for depths greater than 3 km.

6. Seismic Activity within the AOI

This section provides a summary of earthquakes observed within the AOI from November 2020 to December 2021.

A total of 17 seismic events were observed within the AOI, with local magnitudes ranging from -0.13ML to 1.16ML. The largest event occurred on June 21, 2021. Figure 10 shows locations of seismic events observed within the AOI relative to the monitoring network and Table 4 provides a list of these events with their key seismological attributes. Earthquakes within the AOI attain depths ranging from 1.3 km to 7.0 km, with an average value of 4.5 km. The event depths were calculated based on 1D velocity model and will be reprocessed using a 3D velocity model when the model development is completed (discussed in Section 5). Waveforms obtained from these events are included in Appendix B.

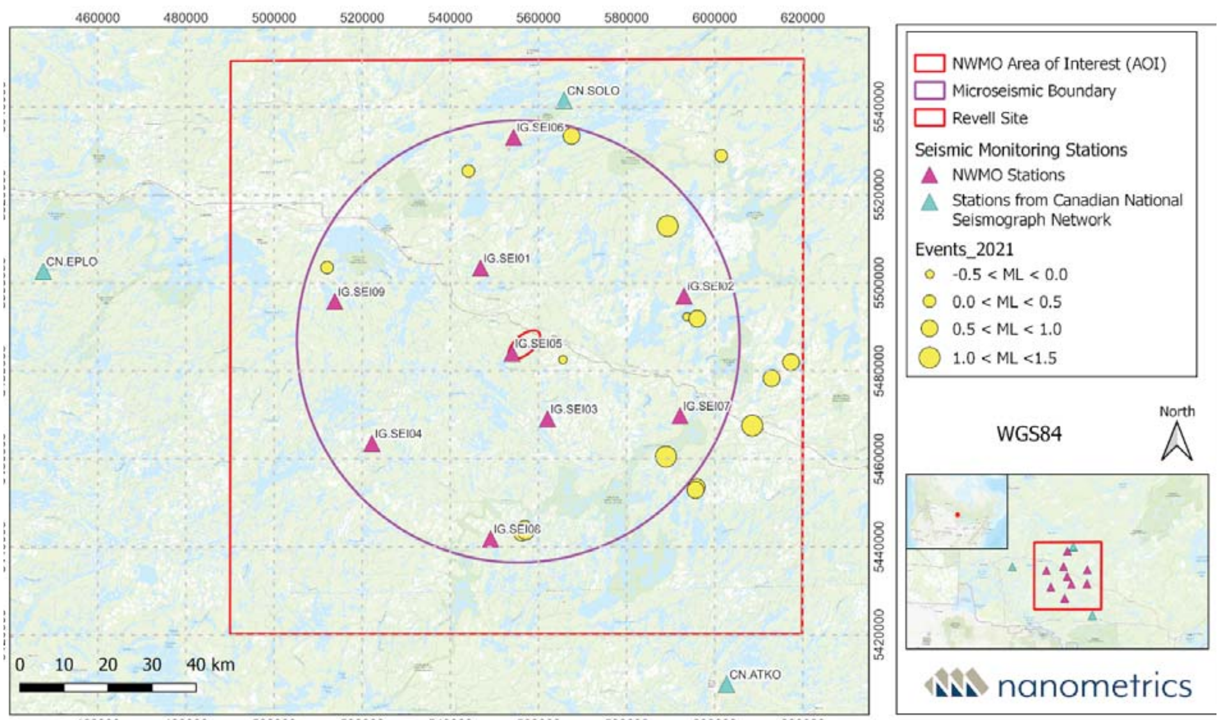

Figure 10. Seismic events observed within the AOI from November 2020 to December 2021.

Table 4. Earthquakes detected within the AOI from November 2020 to December 2021

Earthquake Origin Date and Time (UTC)	Latitude (WGS84)	Longitude (WGS84)	Depth (km)	Local Magnitude (ML)	Number of Stations with Phase Picks	Number of Phase Picks
2020-11-27 11:27:05	49.7618	-91.7595	5.5	1.04	4	8
2021-03-16 23:40:06	49.2908	-91.7765	3.5	1.10	5	10
2021-04-22 06:21:05	49.4470	-91.4418	3.5	0.68	5	10
2021-04-22 09:09:57	49.4790	-91.3798	3.5	0.75	5	8
2021-06-12 22:58:29	49.5715	-91.6712	7.0	0.63	4	6
2021-06-21 17:53:41	49.3510	-91.5053	4.9	1.16	5	6
2021-08-04 04:15:25	49.5762	-91.7033	1.6	-0.07	6	9
2021-08-08 04:02:10	49.4918	-92.0943	1.3	-0.13	5	9
2021-08-29 06:52:55	49.8795	-92.3858	6.7	0.14	10	13
2021-09-18 02:12:09	49.2215	-91.6862	3.9	0.75	11	22
2021-10-03 22:26:26	49.9037	-91.5863	3.0	0.33	10	18
2021-11-02 11:24:13	49.2272	-91.6818	6.7	0.71	12	21
2021-11-10 02:37:57	49.1417	-92.2163	3.1	0.78	12	21
2021-11-10 02:38:04	49.1465	-92.2195	7.0	0.94	5	6
2021-11-10 02:38:21	49.1392	-92.2283	7.0	0.75	8	10
2021-11-13 21:04:43	49.6837	-92.8330	2.9	0.45	9	18
2021-12-21 17:27:43	49.9490	-92.0587	5.6	0.79	7	9

Figure 11 shows the rate of seismic activity in each month. Note that the monitoring network consisted of one NWMO station (IG.SEI05) and four regional public stations until July 2021. The event detectability within the AOI has improved with the installation of the remaining eight NWMO stations in July 2021.

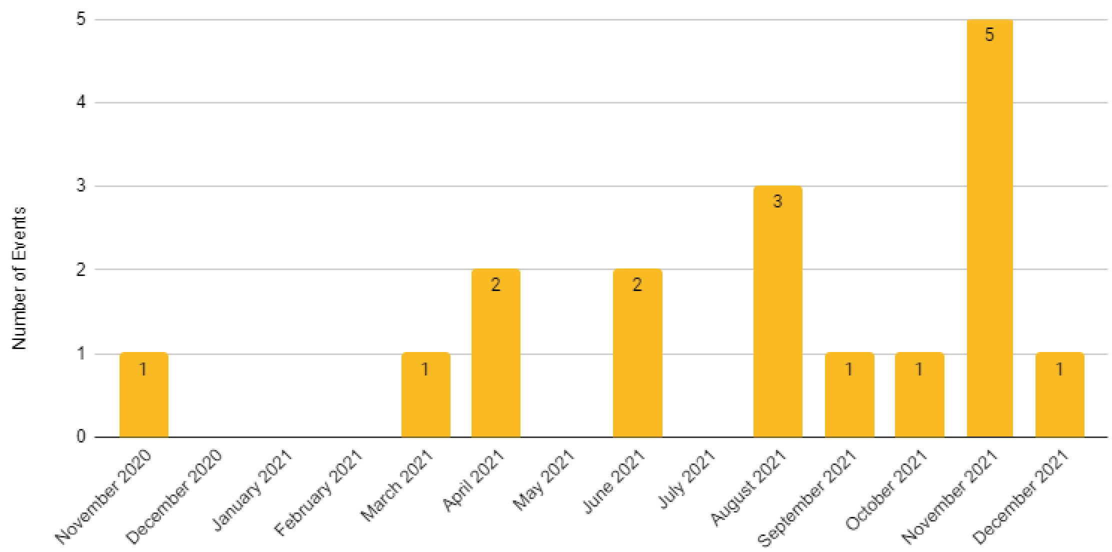

Figure 11. Number of seismic events observed within the AOI on a monthly basis

7. Anthropogenic Activity

There are several active mines and quarries located within 300 km of the NWMO network (the maximum distance that an event from a nearby anthropogenic source can be detected). Blasting activities at these mines and quarries are one of the major sources of events detected by the automatic processing system. In the manual review stage, non-seismic events, including mining/quarry blasts, are identified by experienced analysts by visual inspection of recorded waveforms in terms of presence and motion of seismic phases (P and S waves), Wood-Anderson simulated traces, and their correlated timing at multiple stations. The identified non-seismic events are removed subsequently.

Events detected by the Canadian National Seismograph Network are reviewed and categorized by Natural Resources Canada ("NRCan") depending on their sources. The historical event catalog is accessible from Earthquakes Canada website (https://www.earthquakescanada.nrcan.gc.ca). Figure 12 shows seismic and anthropogenic events identified by NRCan in the region from November 2020 to December 2021 (the event list is provided in Appendix C). The events associated with mining activities by NRCan are clustered around

- Rainy River, Red Lake and Lac des Iles mines in Canada, and
- Minntac and Peter Mitchell mines in the United States.

Most of these events are mining/quarry blasts. However, there are a few events that are labeled by NRCan as mining-induced seismic events (i.e., earthquakes occurred on critically stressed faults near mining sites due to stress perturbations of mining/quarrying activities). The mining-induced events are also included in the event list in Appendix C.

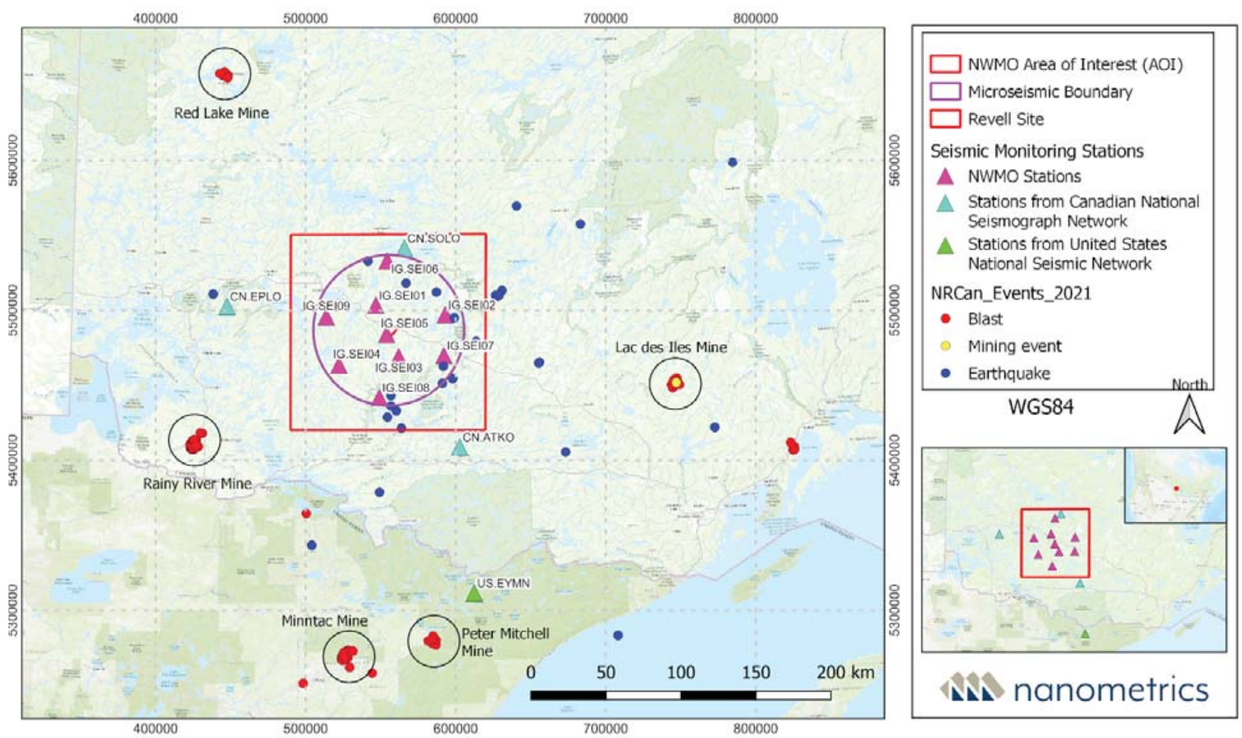

Figure 12. Seismic and mining events observed in the region by NRCan

8. Event Location Accuracy

In this section, the location accuracy of earthquakes within the AOI is investigated using synthetic events, in order to understand the effect of the velocity model complexity and the network density on the event location uncertainty. To this end, a number of distributed synthetic hypocenters with a specified depth and spacing are simulated. Travel time grids are generated for the velocity model using the Eikonal finite-difference method (Podvin et al., 1991). For each simulated event, synthetic P and S first arrivals with Gaussian-distributed timing errors are computed.

Simulated events are then located using a grid search algorithm to determine hypocentral probability density functions and maximum likelihood locations. The probability density function for each event accounts for P and S pick time uncertainties and an overall travel time uncertainty. Location uncertainty, σ, is calculated as the standard deviation of the hypocenter probability distribution for horizontal and vertical direction.

The 1D velocity model is used to model the location accuracy, considering all 13 stations (9 NWMO stations and 4 public stations). A timing error of 120 ms is assumed in this assessment. Figure 13 shows the modeled horizontal uncertainty of events detected by the monitoring network within the AOI. The minimum horizontal location uncertainty is estimated as 327.8 m, in the center of the NWMO array. This is applicable for events which are well recorded by most stations. Overall, the vertical uncertainty is expected to be higher than the horizontal uncertainty due to its higher sensitivity to the station proximity.

Accuracy event hypocenter locations depends on two key factors:

i. Azimuthal coverage and number of stations at which the timing of phase arrivals are identified accurately, and
ii. The compatibility of the velocity model used for locating events

The incorporation of the 3D velocity model into the event processing and solution workflow is expected to improve the event location accuracies.

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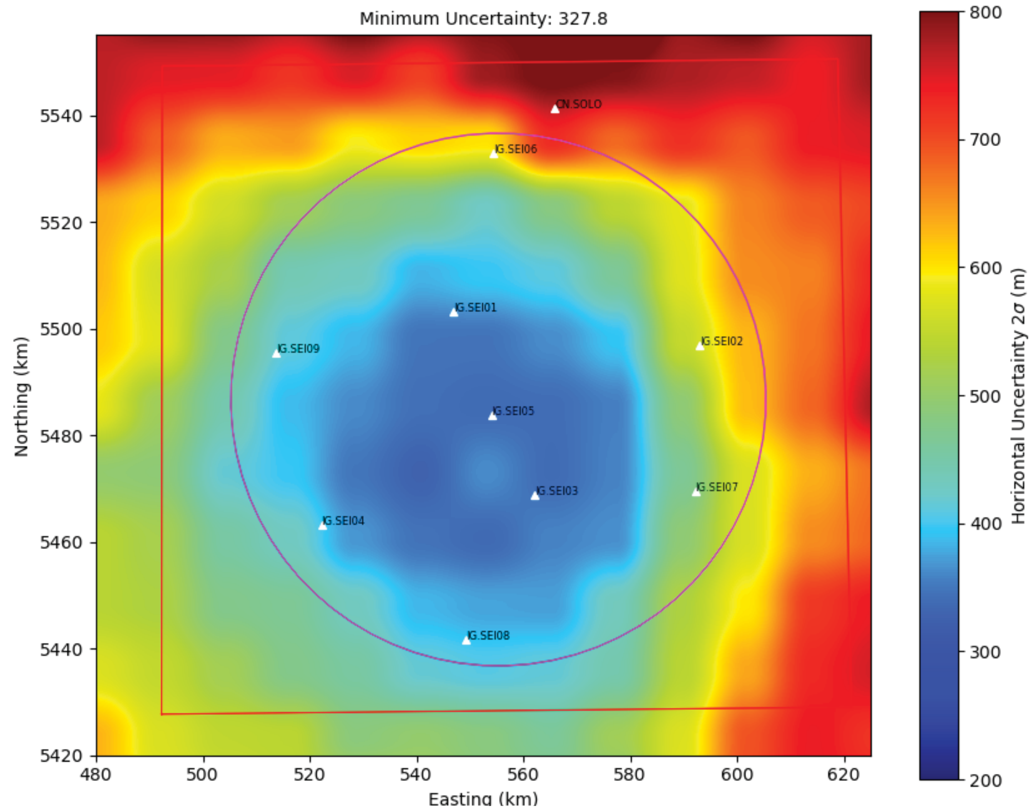

Figure 13. Modeled horizontal location uncertainty of events within the AOI

9. Magnitude of Completeness

Magnitude of completeness ("Mc") within the AOI is modeled for the NWMO network to understand the minimum magnitude above which all seismic events can be detected and located, given the current array geometry and the assumed velocity model, instrument noise floors, background noise model, and attenuation parameters. For an assumed event depth, Mc modeling measures the spectral amplitude levels at different stations following a waveform propagation modeling, taking into account seismic attenuation attributes and assuming a point-source model (Brune, 1970). This is performed for a large number of synthetic events with variable magnitudes across a gridded space. The event signal to noise ratios ("SNR") are measured at monitoring stations for each grid point, considering the mean noise level at each station of the network. The Mc at a grid point is determined as the minimum magnitude at which the estimated SNR on at least four stations satisfies a pre-set detectability threshold. Figure 14 shows the spatial variation of Mc within the AOI for the NWMO network. All seismic events down to magnitude of ~Mw1.0, on average, are expected to be detected by the array. Smaller earthquakes may still be detected and located but with a lower accuracy and completeness.

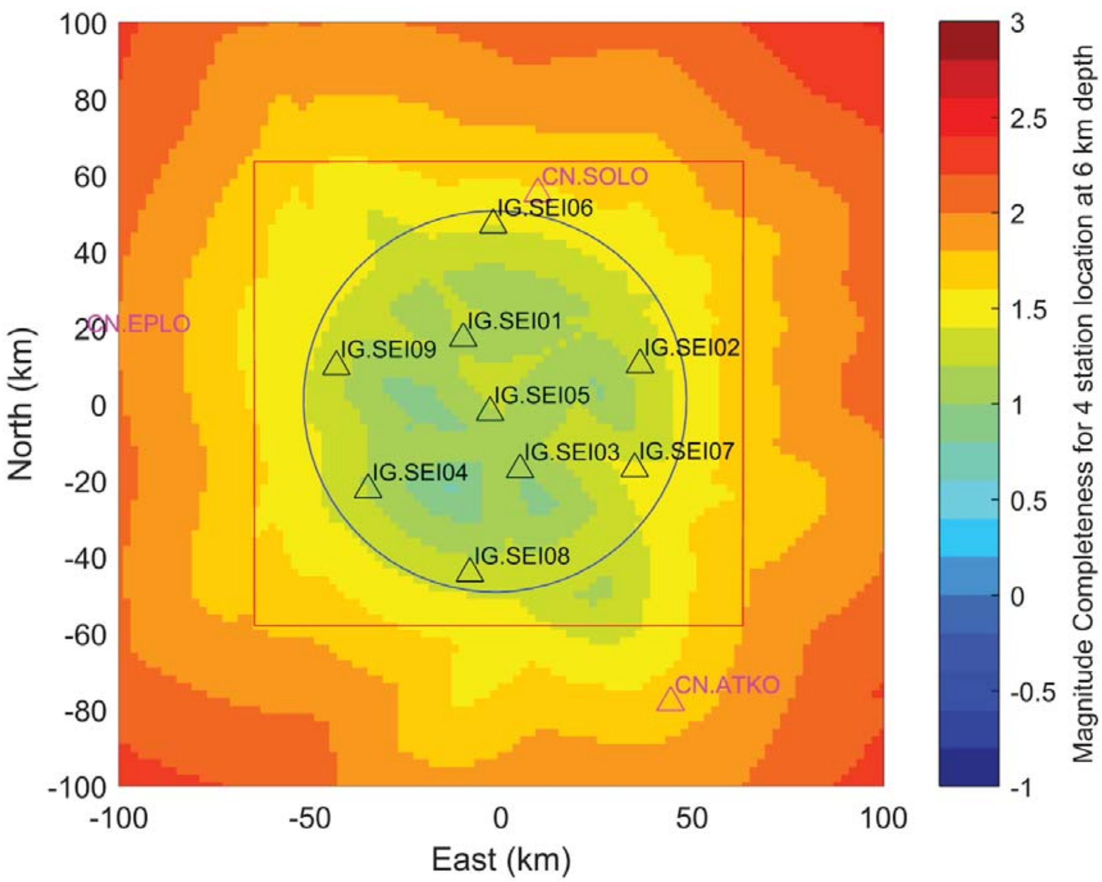

Figure 14. Magnitude of completeness (Mc) model of the NWMO network for events at a depth of 6 km. Blue circle represents the microseismic monitoring boundary (50 km radius around the Revell site) and the red square shows NWMO AOI. Black triangles represent locations of NWMO stations and pink triangles indicate the locations of public stations included in the Program.

10. Data Delivery

Nanometrics has delivered the monitoring data obtained from November 2020, when the first NWMO station was installed, to the end of calendar year 2021. The data has been uploaded to an SFTP server along with metadata, a data transmittal letter and the Annual Seismic Monitoring Report. The delivered data includes:

1. A catalog of earthquakes detected within the AOI (event origin date and time, hypocenter location, magnitude, location error ellipses etc.)
2. Seismic phase pick information in JSON-formatted files
3. Earthquake waveform data in miniSEED formatted files
4. Continuous raw waveforms delivered in form of 1-hour long miniSEED files for each station and channel

11. Summary

Nanometrics operates a seismic monitoring network in the Ignace area on behalf of NWMO, as part of the Microseismic Monitoring Program ("Program"). An annual overview of network operation activities and observed seismic activities are presented in this report.

The monitoring network consists of nine broadband seismograph stations within the AOI. The first station was installed on November 3rd, 2020 and the remaining eight stations were installed in July 2021 after the completion of site surveys and permitting. Four additional public stations located around the AOI are also incorporated into the Program.

Two stations (IG.SEI04 and IG.SEI08) record data in offline mode (i.e., no data transmission) due to lack of cellular connectivity in the area. All other stations stream data to the Nanometrics Data Center in the cloud in near real time. Waveform data recorded at offline stations are collected with periodic site visits and are incorporated into the data processing workflows. The acquired data are processed using an automatic event detection algorithm. The automatic processing system declares an event when a minimum of four time-correlated seismic phase arrivals are picked at a minimum of four stations. Event waveforms are reviewed by experienced analysts to identify those associated with seismic activities. A 1D velocity model was used for locating events. A modeling of event location accuracy indicated that the earthquakes detected within the AOI are estimated to have a minimum horizontal location uncertainty of ~330 m, considering the adopted 1D velocity model. The vertical uncertainty is expected to be higher than the horizontal uncertainty due to its higher sensitivity to the station proximity. A 3D velocity model is currently under development and event locations will be recalculated when it is completed.

From November 2020 to December 2021, a total of 17,835 automatic events were detected by the monitoring networks. The vast majority of these events were either false positives (incorrect classification of random noise) or anthropogenic activities (e.g., mining/quarry blasts). As a result of manual reviews, 17 earthquakes with local magnitudes ranging from -0.13ML to 1.16ML were identified within the AOI. These events attained depths ranging from 1.3 km to 7.0 km, with an average value of 4.5 km.

Magnitude of completeness (Mc) within the AOI is modeled for the NWMO network to understand the minimum magnitude above which all seismic events can be detected. This assessment suggests that earthquakes of magnitude M>1.0 within the AOI are expected to be detected by the array. Smaller earthquakes may still be detected and located but with a lower accuracy and completeness.

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Appendix A: Daily Station Data Availability

November 2020

Station	2020-11-01	2020-11-02	2020-11-03	2020-11-04	2020-11-05	2020-11-06	2020-11-07
IG.SEI05			81.2	100	100	100	100
	2020-11-08	2020-11-09	2020-11-10	2020-11-11	2020-11-12	2020-11-13	2020-11-14
IG.SEI05	100	100	100	100	100	100	100
	2020-11-15	2020-11-16	2020-11-17	2020-11-18	2020-11-19	2020-11-20	2020-11-21
IG.SEI05	100	100	100	100	100	100	100
	2020-11-22	2020-11-23	2020-11-24	2020-11-25	2020-11-26	2020-11-27	2020-11-28
IG.SEI05	100	100	100	100	100	100	100
	2020-11-29	2020-11-30					
IG.SEI05	100	100					

December 2020

Station	2020-12-01	2020-12-02	2020-12-03	2020-12-04	2020-12-05	2020-12-06	2020-12-07
IG.SEI05	100	100	100	100	100	100	100
	2020-12-08	2020-12-09	2020-12-10	2020-12-11	2020-12-12	2020-12-13	2020-12-14
IG.SEI05	100	100	100	100	100	100	100
	2020-12-15	2020-12-16	2020-12-17	2020-12-18	2020-12-19	2020-12-20	2020-12-21
IG.SEI05	100	100	100	100	100	100	100
	2020-12-22	2020-12-23	2020-12-24	2020-12-25	2020-12-26	2020-12-27	2020-12-28
IG.SEI05	100	100	100	100	100	100	100
	2020-12-29	2020-12-30	2020-12-31				
IG.SEI05	100	100	100				

January 2021

Station	2021-01-01	2021-01-02	2021-01-03	2021-01-04	2021-01-05	2021-01-06	2021-01-07
IG.SEI05	100	100	100	100	100	100	100
	2021-01-08	2021-01-09	2021-01-10	2021-01-11	2021-01-12	2021-01-13	2021-01-14
IG.SEI05	100	100	100	100	100	100	100
	2021-01-15	2021-01-16	2021-01-17	2021-01-18	2021-01-19	2021-01-20	2021-01-21
IG.SEI05	100	100	100	100	100	100	100
	2021-01-22	2021-01-23	2021-01-24	2021-01-25	2021-01-26	2021-01-27	2021-01-28
IG.SEI05	100	100	100	100	100	100	100
	2021-01-29	2021-01-30	2021-01-31				
IG.SEI05	100	100	100				

February 2021

Station	2021-02-01	2021-02-02	2021-02-03	2021-02-04	2021-02-05	2021-02-06	2021-02-07
IG.SEI05	100	100	100	100	100	100	100
	2021-02-08	2021-02-09	2021-02-10	2021-02-11	2021-02-12	2021-02-13	2021-02-14
IG.SEI05	100	100	100	100	100	100	100
	2021-02-15	2021-02-16	2021-02-17	2021-02-18	2021-02-19	2021-02-20	2021-02-21
IG.SEI05	100	100	100	100	100	100	100
	2021-02-22	2021-02-23	2021-02-24	2021-02-25	2021-02-26	2021-02-27	2021-02-28
IG.SEI05	100	100	100	100	100	100	100

March 2021

Station	2021-03-01	2021-03-02	2021-03-03	2021-03-04	2021-03-05	2021-03-06	2021-03-07
IG.SEI05	100	100	100	100	100	100	100
	2021-03-08	2021-03-09	2021-03-10	2021-03-11	2021-03-12	2021-03-13	2021-03-14
IG.SEI05	100	100	100	100	100	100	100
	2021-03-15	2021-03-16	2021-03-17	2021-03-18	2021-03-19	2021-03-20	2021-03-21
IG.SEI05	100	100	100	100	100	100	100
	2021-03-22	2021-03-23	2021-03-24	2021-03-25	2021-03-26	2021-03-27	2021-03-28
IG.SEI05	100	100	100	100	100	100	100
	2021-03-29	2021-03-30	2021-03-31				
IG.SEI05	100	100	100				

April 2021

Station	2021-04-01	2021-04-02	2021-04-03	2021-04-04	2021-04-05	2021-04-06	2021-04-07
IG.SEI05	100	100	100	100	100	100	100
	2021-04-08	2021-04-09	2021-04-10	2021-04-11	2021-04-12	2021-04-13	2021-04-14
IG.SEI05	100	100	100	100	100	100	100
	2021-04-15	2021-04-16	2021-04-17	2021-04-18	2021-04-19	2021-04-20	2021-04-21
IG.SEI05	100	100	100	100	100	100	100
	2021-04-22	2021-04-23	2021-04-24	2021-04-25	2021-04-26	2021-04-27	2021-04-28
IG.SEI05	100	100	100	100	100	100	100
	2021-04-29	2021-04-30					
IG.SEI05	100	100					

May 2021

Station	2021-05-01	2021-05-02	2021-05-03	2021-05-04	2021-05-05	2021-05-06	2021-05-07
IG.SEI05	100	100	100	100	100	100	100
	2021-05-08	2021-05-09	2021-05-10	2021-05-11	2021-05-12	2021-05-13	2021-05-14
IG.SEI05	100	100	100	100	100	100	100
	2021-05-15	2021-05-16	2021-05-17	2021-05-18	2021-05-19	2021-05-20	2021-05-21
IG.SEI05	100	100	100	100	100	100	100
	2021-05-22	2021-05-23	2021-05-24	2021-05-25	2021-05-26	2021-05-27	2021-05-28
IG.SEI05	100	100	100	100	100	100	100
	2021-05-29	2021-05-30	2021-05-31				
IG.SEI05	100	100	100				

June 2021

Station	2021-06-01	2021-06-02	2021-06-03	2021-06-04	2021-06-05	2021-06-06	2021-06-07
IG.SEI05	100	100	100	100	100	100	100
	2021-06-08	2021-06-09	2021-06-10	2021-06-11	2021-06-12	2021-06-13	2021-06-14
IG.SEI05	100	100	100	100	100	100	100
	2021-06-15	2021-06-16	2021-06-17	2021-06-18	2021-06-19	2021-06-20	2021-06-21
IG.SEI05	100	100	100	100	100	100	100
	2021-06-22	2021-06-23	2021-06-24	2021-06-25	2021-06-26	2021-06-27	2021-06-28
IG.SEI05	100	100	100	100	100	100	100
	2021-06-29	2021-06-30					
IG.SEI05	100	100					

July 2021

Station							
	2021-07-01	2021-07-02	2021-07-03	2021-07-04	2021-07-05	2021-07-06	2021-07-07
IG.SEI01							
IG.SEI02						87.8	100
IG.SEI03							70.7
IG.SEI04							
IG.SEI05	100	100	100	100	100	100	100
IG.SEI06							
IG.SEI07					59.8	100	100
IG.SEI08							
IG.SEI09							
	2021-07-08	2021-07-09	2021-07-10	2021-07-11	2021-07-12	2021-07-13	2021-07-14
IG.SEI01		70.7	100	100	100	100	100
IG.SEI02	100	100	100	100	100	100	100
IG.SEI03	100	100	100	100	100	100	100
IG.SEI04					17	100	100
IG.SEI05	100	100	100	100	100	100	100
IG.SEI06			99.3	100	100	100	100
IG.SEI07	100	100	100	100	100	100	100
IG.SEI08	29	100	100	100	100	100	100
IG.SEI09				98.2	100	100	100
	2021-07-15	2021-07-16	2021-07-17	2021-07-18	2021-07-19	2021-07-20	2021-07-21
IG.SEI01	100	100	100	100	100	100	100
IG.SEI02	100	100	100	100	100	100	100
IG.SEI03	100	100	100	100	100	100	100
IG.SEI04	100	100	100	100	100	100	100
IG.SEI05	100	100	100	100	100	100	100
IG.SEI06	100	100	100	100	100	100	100
IG.SEI07	100	100	100	100	100	100	100

IG.SEI08	100	100	100	100	100	100	100
IG.SEI09	100	100	100	100	100	100	100

	2021-07-22	2021-07-23	2021-07-24	2021-07-25	2021-07-26	2021-07-27	2021-07-28
IG.SEI01	100	100	100	100	100	100	100
IG.SEI02	100	100	100	100	100	100	100
IG.SEI03	100	100	100	100	100	100	100
IG.SEI04	100	100	100	100	100	100	100
IG.SEI05	100	100	100	100	100	100	100
IG.SEI06	100	100	100	100	100	100	100
IG.SEI07	100	100	100	100	100	100	100
IG.SEI08	100	100	100	100	100	100	100
IG.SEI09	100	100	100	100	100	100	100
	2021-07-29	2021-07-30	2021-07-31				
IG.SEI01	100	100	100				
IG.SEI02	100	100	100				
IG.SEI03	100	100	100				
IG.SEI04	100	100	100				
IG.SEI05	100	100	100				
IG.SEI06	100	100	100				
IG.SEI07	100	100	100				
IG.SEI08	100	100	100				
IG.SEI09	100	100	100				

August 2021

Station							
	2021-08-01	2021-08-02	2021-08-03	2021-08-04	2021-08-05	2021-08-06	2021-08-07
IG.SEI01	100	100	100	100	100	100	100

IG.SEI02	100	100	100	100	100	100	100
IG.SEI03	100	100	100	100	100	100	100
IG.SEI04	100	100	100	100	100	100	100
IG.SEI05	100	100	100	100	100	100	100
IG.SEI06	100	100	100	100	100	100	100
IG.SEI07	100	100	100	100	100	100	100
IG.SEI08	100	100	100	100	100	100	100
IG.SEI09	100	100	100	100	100	100	100
	2021-08-08	2021-08-09	2021-08-10	2021-08-11	2021-08-12	2021-08-13	2021-08-14
IG.SEI01	100	100	100	100	100	100	100
IG.SEI02	100	100	100	100	100	100	100
IG.SEI03	100	100	100	100	100	100	100
IG.SEI04	100	100	100	100	100	100	100
IG.SEI05	100	100	100	100	100	100	100
IG.SEI06	100	100	100	100	100	100	100
IG.SEI07	100	100	100	100	100	100	100
IG.SEI08	100	100	100	100	100	100	100
IG.SEI09	100	100	100	100	100	100	100
	2021-08-15	2021-08-16	2021-08-17	2021-08-18	2021-08-19	2021-08-20	2021-08-21
IG.SEI01	100	100	100	100	100	100	100
IG.SEI02	100	100	100	100	100	100	100
IG.SEI03	100	100	100	100	100	100	100
IG.SEI04	100	100	100	100	100	100	100
IG.SEI05	100	100	100	100	100	100	100
IG.SEI06	100	100	100	100	100	100	100
IG.SEI07	100	100	100	100	100	100	100
IG.SEI08	100	100	100	100	100	100	100
IG.SEI09	98.2	100	100	100	100	100	100

	2021-08-22	2021-08-23	2021-08-24	2021-08-25	2021-08-26	2021-08-27	2021-08-28
IG.SEI01	100	100	100	100	100	100	100

IG.SEI02	100	100	100	100	100	100	100
IG.SEI03	100	100	100	100	100	100	100
IG.SEI04	100	100	100	100	100	100	100
IG.SEI05	100	100	100	100	100	100	100
IG.SEI06	100	100	100	100	100	100	100
IG.SEI07	100	100	100	100	100	100	100
IG.SEI08	100	100	100	100	100	100	100
IG.SEI09	100	100	100	100	100	100	100
	2021-08-29	2021-08-30	2021-08-31				
IG.SEI01	100	100	100				
IG.SEI02	100	100	100				
IG.SEI03	100	100	100				
IG.SEI04	100	100	100				
IG.SEI05	100	100	100				
IG.SEI06	100	100	100				
IG.SEI07	100	100	100				
IG.SEI08	100	100	100				
IG.SEI09	100	100	100				

September 2021

Station							
	2021-09-01	2021-09-02	2021-09-03	2021-09-04	2021-09-05	2021-09-06	2021-09-07
IG.SEI01	100	100	100	100	100	100	100
IG.SEI02	100	100	100	100	100	100	100
IG.SEI03	100	100	100	100	100	100	100
IG.SEI04	100	100	100	100	100	100	100
IG.SEI05	100	100	100	100	100	100	100
IG.SEI06	100	100	100	100	100	100	100

IG.SEI07	100	100	100	100	100	100	100
IG.SEI08	100	100	100	100	100	100	100
IG.SEI09	100	100	100	100	100	100	100
	2021-09-08	2021-09-09	2021-09-10	2021-09-11	2021-09-12	2021-09-13	2021-09-14
IG.SEI01	100	100	100	100	100	100	100
IG.SEI02	100	100	100	100	100	100	100
IG.SEI03	100	100	100	100	100	100	100
IG.SEI04	100	100	100	100	100	100	100
IG.SEI05	100	100	100	100	100	100	100
IG.SEI06	100	100	98.9	100	100	100	100
IG.SEI07	100	100	100	100	100	100	100
IG.SEI08	100	100	100	100	100	100	100
IG.SEI09	100	100	100	100	100	100	100
	2021-09-15	2021-09-16	2021-09-17	2021-09-18	2021-09-19	2021-09-20	2021-09-21
IG.SEI01	100	100	100	100	100	100	100
IG.SEI02	100	100	100	100	100	100	100
IG.SEI03	100	100	100	100	100	100	100
IG.SEI04	100	100	100	100	100	100	100
IG.SEI05	100	100	100	100	100	100	100
IG.SEI06	100	100	100	100	100	100	100
IG.SEI07	100	100	100	100	100	100	100
IG.SEI08	100	100	100	100	100	100	100
IG.SEI09	98.2	100	100	100	100	100	100

	2021-09-22	2021-09-23	2021-09-24	2021-09-25	2021-09-26	2021-09-27	2021-09-28
IG.SEI01	100	100	100	100	100	100	100
IG.SEI02	100	100	100	100	100	100	100
IG.SEI03	100	100	100	100	100	100	100
IG.SEI04	100	100	100	100	100	100	100
IG.SEI05	100	100	100	100	100	100	100
IG.SEI06	100	100	100	100	100	100	100

IG.SEI07	100	100	100	100	100	100	100
IG.SEI08	100	100	100	100	100	100	100
IG.SEI09	100	100	100	100	100	100	100
	2021-09-29	2021-09-30					
IG.SEI01	100	100					
IG.SEI02	100	100					
IG.SEI03	100	100					
IG.SEI04	100	100					
IG.SEI05	100	100					
IG.SEI06	100	100					
IG.SEI07	100	100					
IG.SEI08	100	100					
IG.SEI09	100	100					

October 2021

Station							
	2021-10-01	2021-10-02	2021-10-03	2021-10-04	2021-10-05	2021-10-06	2021-10-07
IG.SEI01	100	100	100	100	100	100	100
IG.SEI02	100	100	100	100	100	100	100
IG.SEI03	100	100	100	100	100	100	100
IG.SEI04	100	100	100	100	100	100	100
IG.SEI05	100	100	100	100	100	100	100
IG.SEI06	100	100	100	100	100	100	100
IG.SEI07	100	100	100	100	100	100	100
IG.SEI08	100	100	100	100	100	100	100
IG.SEI09	100	100	100	100	100	100	100
	2021-10-08	2021-10-09	2021-10-10	2021-10-11	2021-10-12	2021-10-13	2021-10-14

IG.SEI01	100	100	100	100	100	100	100
IG.SEI02	100	100	100	100	100	100	100
IG.SEI03	100	100	100	100	100	100	100
IG.SEI04	100	100	100	100	100	100	100
IG.SEI05	100	100	100	100	100	100	100
IG.SEI06	100	100	100	100	100	100	100
IG.SEI07	100	100	100	100	100	100	100
IG.SEI08	100	100	100	100	100	100	100
IG.SEI09	100	100	100	100	100	100	100
	2021-10-15	2021-10-16	2021-10-17	2021-10-18	2021-10-19	2021-10-20	2021-10-21
IG.SEI01	100	100	100	100	100	100	100
IG.SEI02	100	100	100	100	100	100	100
IG.SEI03	100	100	100	100	100	100	100
IG.SEI04	100	100	100	100	100	100	100
IG.SEI05	100	100	100	100	100	100	100
IG.SEI06	100	100	100	100	100	100	100
IG.SEI07	100	100	100	100	100	100	100
IG.SEI08	100	100	100	100	100	100	100
IG.SEI09	98.2	100	100	100	100	100	100

	2021-10-22	2021-10-23	2021-10-24	2021-10-25	2021-10-26	2021-10-27	2021-10-28
IG.SEI01	100	100	100	100	100	100	100
IG.SEI02	100	100	100	100	100	100	100
IG.SEI03	100	100	100	100	100	100	100
IG.SEI04	100	100	100	100	100	100	100
IG.SEI05	100	100	100	100	100	100	100
IG.SEI06	100	100	100	100	100	100	100
IG.SEI07	100	100	100	100	100	100	100
IG.SEI08	100	100	100	100	83	0	0
IG.SEI09	100	100	100	100	100	100	100
	2021-10-29	2021-10-30	2021-10-31				

IG.SEI01	100	100	100				
IG.SEI02	100	100	100				
IG.SEI03	100	100	100				
IG.SEI04	100	100	100				
IG.SEI05	100	100	100				
IG.SEI06	100	100	100				
IG.SEI07	100	100	100				
IG.SEI08	0	0	0				
IG.SEI09	100	100	100				

November 2021

Station							
	2021-11-01	2021-11-02	2021-11-03	2021-11-04	2021-11-05	2021-11-06	2021-11-07
IG.SEI01	100	100	100	100	100	100	100
IG.SEI02	100	100	75.8	61.6	100	100	71.4
IG.SEI03	100	100	100	100	100	100	100
IG.SEI04	0	79	100	100	100	100	100
IG.SEI05	100	100	100	100	100	100	100
IG.SEI06	100	100	100	100	100	100	100
IG.SEI07	100	100	100	100	100	100	100
IG.SEI08	100	100	100	100	100	100	100
IG.SEI09	100	100	100	100	100	100	100
	2021-11-08	2021-11-09	2021-11-10	2021-11-11	2021-11-12	2021-11-13	2021-11-14
IG.SEI01	100	100	100	100	100	80.8	0
IG.SEI02	100	100	100	45.6	0	0	0
IG.SEI03	100	100	100	100	100	100	100
IG.SEI04	100	100	100	100	100	100	100
IG.SEI05	100	100	100	100	100	100	100

IG.SEI06	100	100	100	100	100	100	12.1
IG.SEI07	100	100	100	100	100	100	100
IG.SEI08	100	100	100	100	100	100	100
IG.SEI09	100	100	100	100	100	100	100
	2021-11-15	2021-11-16	2021-11-17	2021-11-18	2021-11-19	2021-11-20	2021-11-21
IG.SEI01	25.6	18.7	0	0	0	31.4	60.4
IG.SEI02	0	0	0	0	0	15.8	88
IG.SEI03	100	63.7	0	0	0	27.1	100
IG.SEI04	100	100	100	100	100	100	100
IG.SEI05	100	100	100	100	100	100	100
IG.SEI06	0	0	0	0	0	24	53.2
IG.SEI07	100	100	100	100	100	100	100
IG.SEI08	100	100	100	100	100	100	100
IG.SEI09	100	100	0	29.7	63.8	36.2	100

	2021-11-22	2021-11-23	2021-11-24	2021-11-25	2021-11-26	2021-11-27	2021-11-28
IG.SEI01	0	33.5	36.6	50	100	66.2	56.2
IG.SEI02	6.4	21.4	34.5	99.7	97.4	63.5	66.3
IG.SEI03	51.7	66.8	99.9	100	100	100	100
IG.SEI04	100	100	100	100	100	100	100
IG.SEI05	100	100	100	100	100	100	100
IG.SEI06	28.8	38.3	36.5	39.8	100	100	100
IG.SEI07	100	100	100	100	100	100	100
IG.SEI08	100	100	100	100	100	100	100
IG.SEI09	75	62.1	99.9	100	100	100	100
	2021-11-29	2021-11-30					
IG.SEI01	27.2	100					
IG.SEI02	89	87.3					
IG.SEI03	100	100					
IG.SEI04	100	100					
IG.SEI05	100	100					

IG.SEI06	100	100					
IG.SEI07	100	100					
IG.SEI08	100	100					
IG.SEI09	100	100					

December 2021

Station							
	2021-12-01	2021-12-02	2021-12-03	2021-12-04	2021-12-05	2021-12-06	2021-12-07
IG.SEI01	45.3	14.3	14.6	19	5.1	25.1	1.9
IG.SEI02	93.6	94.3	100	28.8	0.1	6.4	0
IG.SEI03	100	100	100	100	100	99.7	74
IG.SEI04	100	100	100	100	100	100	100
IG.SEI05	100	100	100	100	100	100	100
IG.SEI06	100	100	100	100	32.5	30.7	20.6
IG.SEI07	100	100	100	100	100	100	100
IG.SEI08	100	100	100	100	100	100	100
IG.SEI09	100	100	100	100	100	99.4	35
	2021-12-08	2021-12-09	2021-12-10	2021-12-11	2021-12-12	2021-12-13	2021-12-14
IG.SEI01	4	0	5.9	8.1	38.8	42.5	51.4
IG.SEI02	8.3	0	3.6	0.8	30.9	100	97.8
IG.SEI03	1.4	0	8.5	8.9	32.7	100	100
IG.SEI04	100	100	100	100	100	100	100
IG.SEI05	100	100	100	100	100	100	100
IG.SEI06	25.3	0	33.5	33.7	33.7	100	100
IG.SEI07	100	100	100	100	100	100	100
IG.SEI08	100	100	100	100	100	100	100
IG.SEI09	30.3	5.9	36.9	77.9	69.7	100	100
	2021-12-15	2021-12-16	2021-12-17	2021-12-18	2021-12-19	2021-12-20	2021-12-21

IG.SEI01	42.7	0	5.4	100	100	100	100
IG.SEI02	100	100	100	100	100	100	100
IG.SEI03	100	100	100	100	99.6	80.2	100
IG.SEI04	100	100	100	100	100	100	100
IG.SEI05	100	100	100	100	100	100	100
IG.SEI06	100	100	100	100	98.7	83.6	100
IG.SEI07	100	100	100	100	100	100	100
IG.SEI08	100	100	100	100	100	100	100
IG.SEI09	98.1	100	100	100	100	100	100

IG.SEI01	100	100	100	100	100	100	100
IG.SEI02	100	100	100	100	100	100	100
IG.SEI03	100	100	100	100	100	100	100
IG.SEI04	100	100	100	100	100	100	100
IG.SEI05	100	100	100	100	100	100	100
IG.SEI06	96.8	56	100	100	100	100	100
IG.SEI07	98.9	100	100	100	100	100	100
IG.SEI08	100	100	100	100	100	100	100
IG.SEI09	100	100	100	100	100	100	100
	2021-12-29	2021-12-30	2021-12-31				
IG.SEI01	100	100	100				
IG.SEI02	100	100	100				
IG.SEI03	100	100	100				
IG.SEI04	100	100	100				
IG.SEI05	100	100	100				
IG.SEI06	100	100	100				
IG.SEI07	100	100	100				
IG.SEI08	100	100	100				
IG.SEI09	100	100	100				

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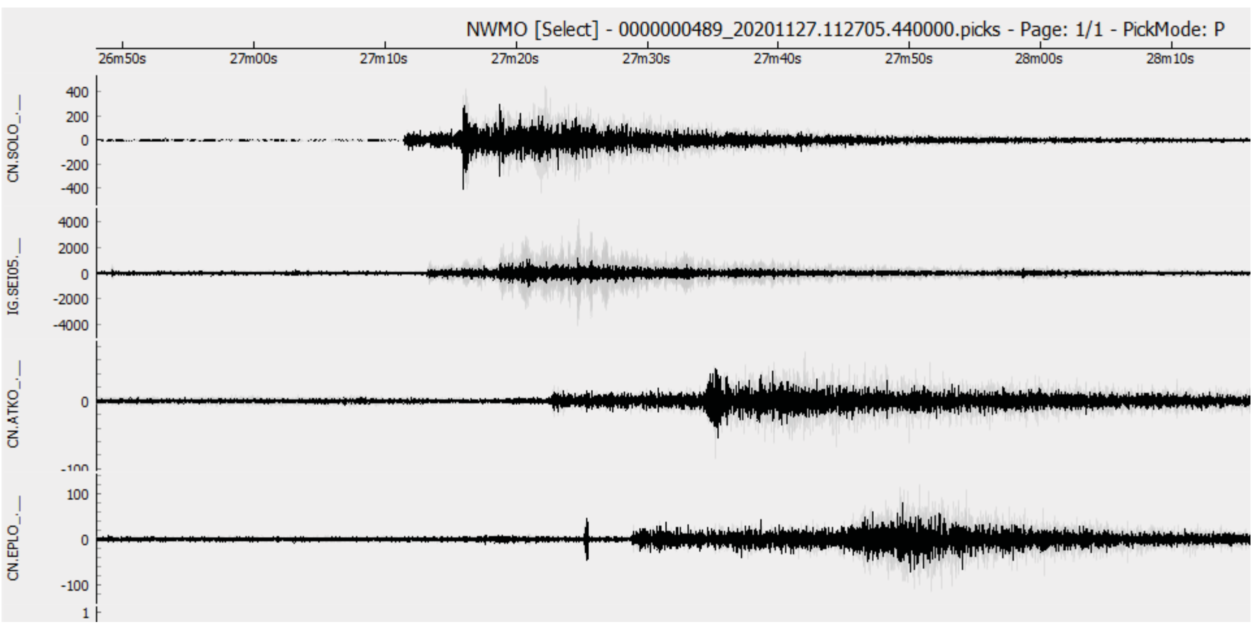
Appendix B: Waveforms of Earthquakes Detected within the AOI

This section displays the waveforms of seismic events detected within the AOI by the NWMO monitoring network. Waveforms are filtered with a 10 Hz bandpass unless otherwise specified.

Date: 2020-11-27
Time: 11:27:12 UTC
Latitude: 49.7618 ^{0}N
Longitude: 91.7595 ^{0}W
Depth: 5.53km
Magnitude: 1.04Ml



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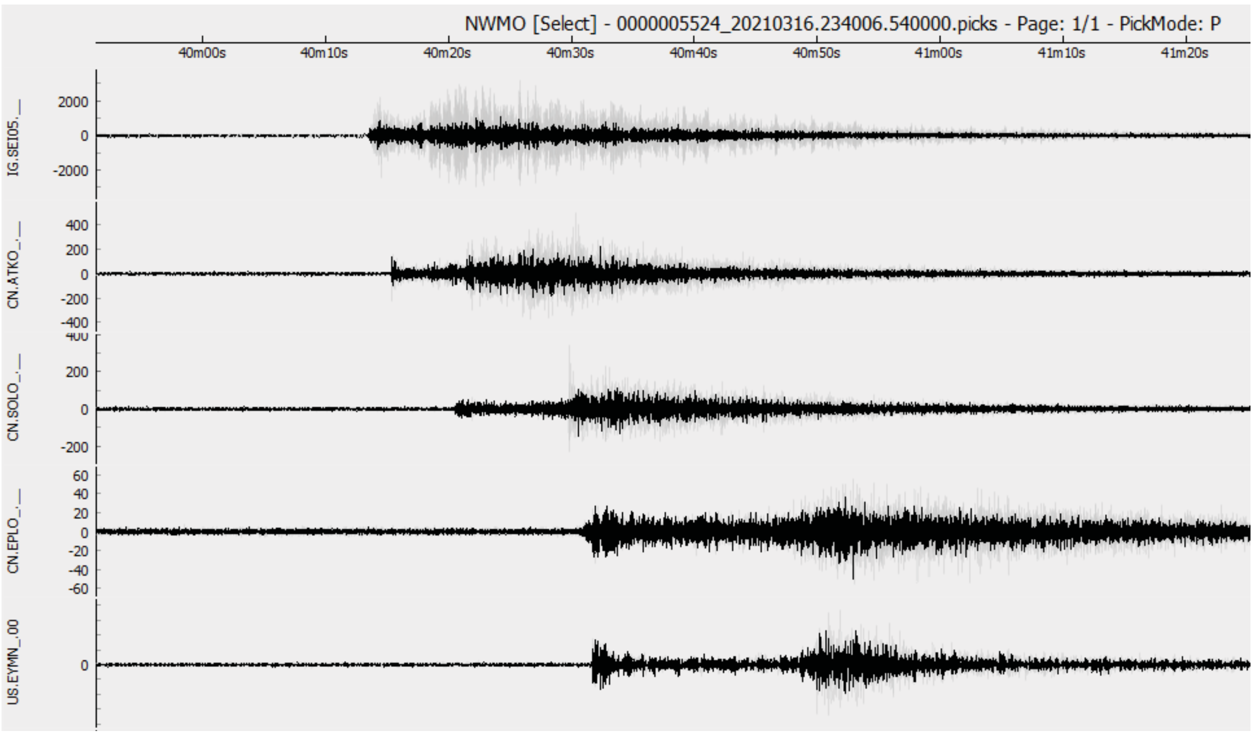
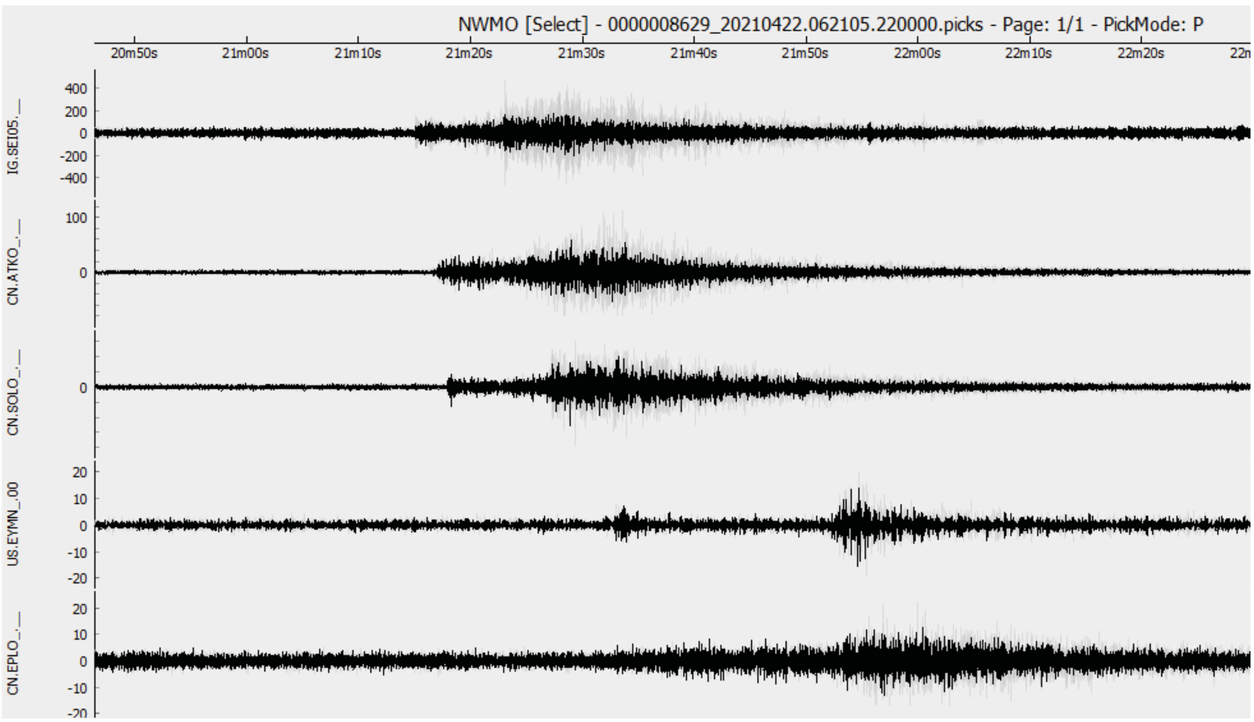
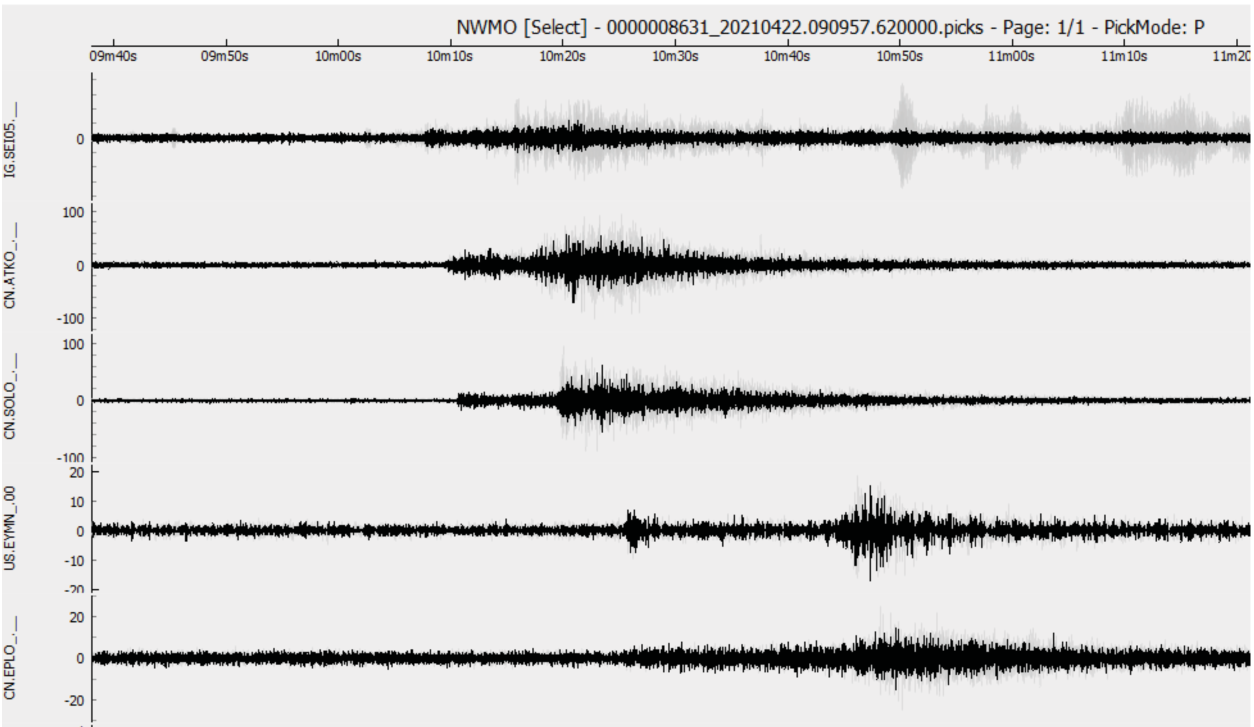
Date: 2021-03-16
Time: 23:40:06 UTC
Latitude: 49.2908 ^{0}N
Longitude: 91.7765 ^{0}W
Depth: 3.50km
Magnitude: 1.10Ml



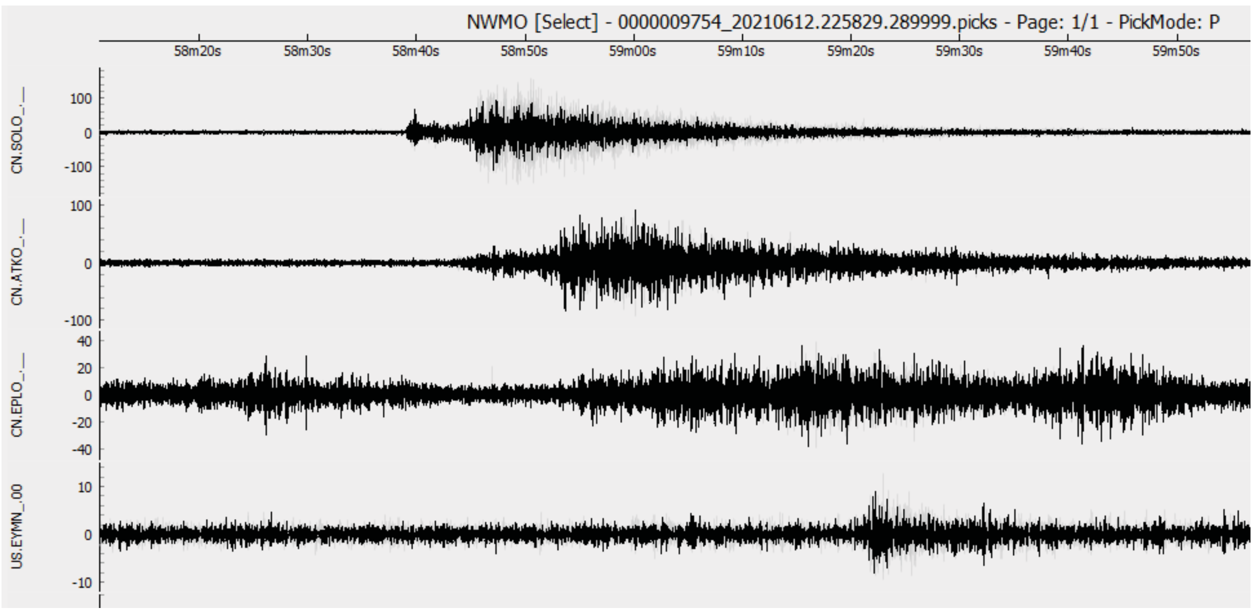
Date:	2021-04-22
Time:	06:21:05 UTC
Latitude:	49.4470 ^{0}N
Longitude:	91.4418 ^{0}W
Depth:	3.50km
Magnitude:	0.68Ml



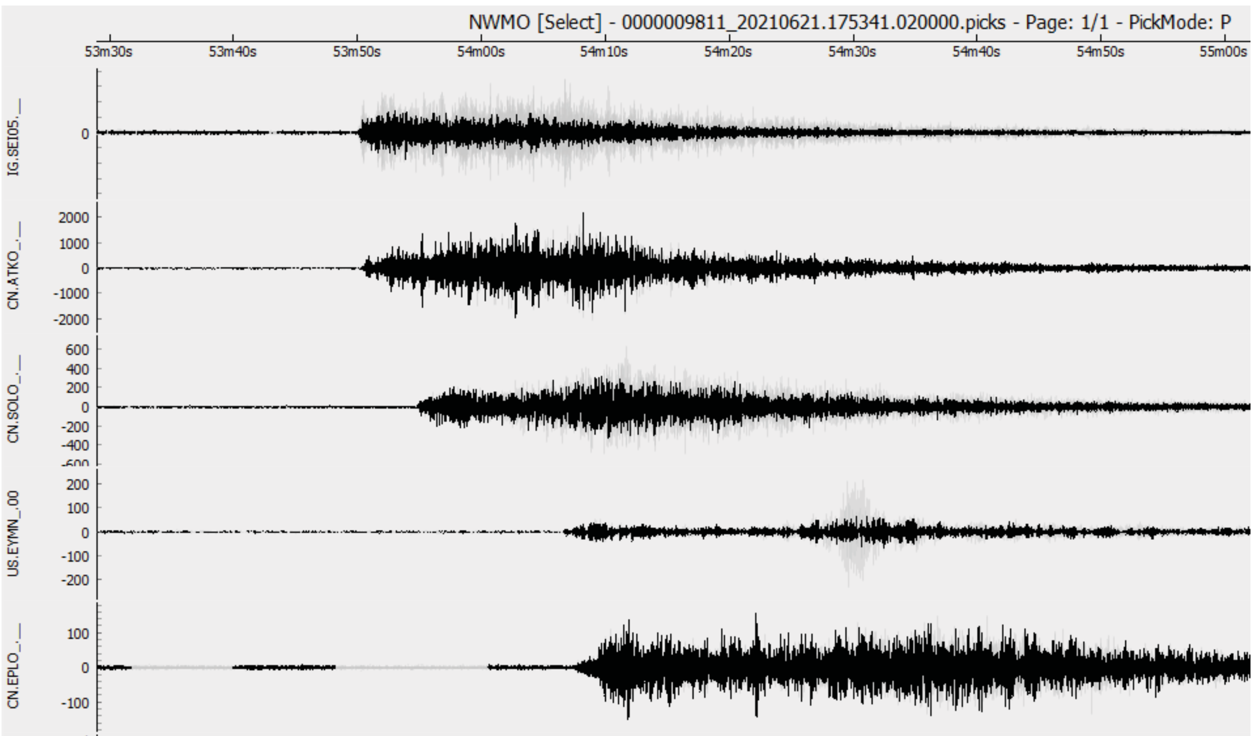
Date: 2021-04-22
Time: 09:09:57 UTC
Latitude: 49.4790 ^{0}N
Longitude: 91.3798 ^{0}W
Depth: 3.50km
Magnitude: 0.75Ml



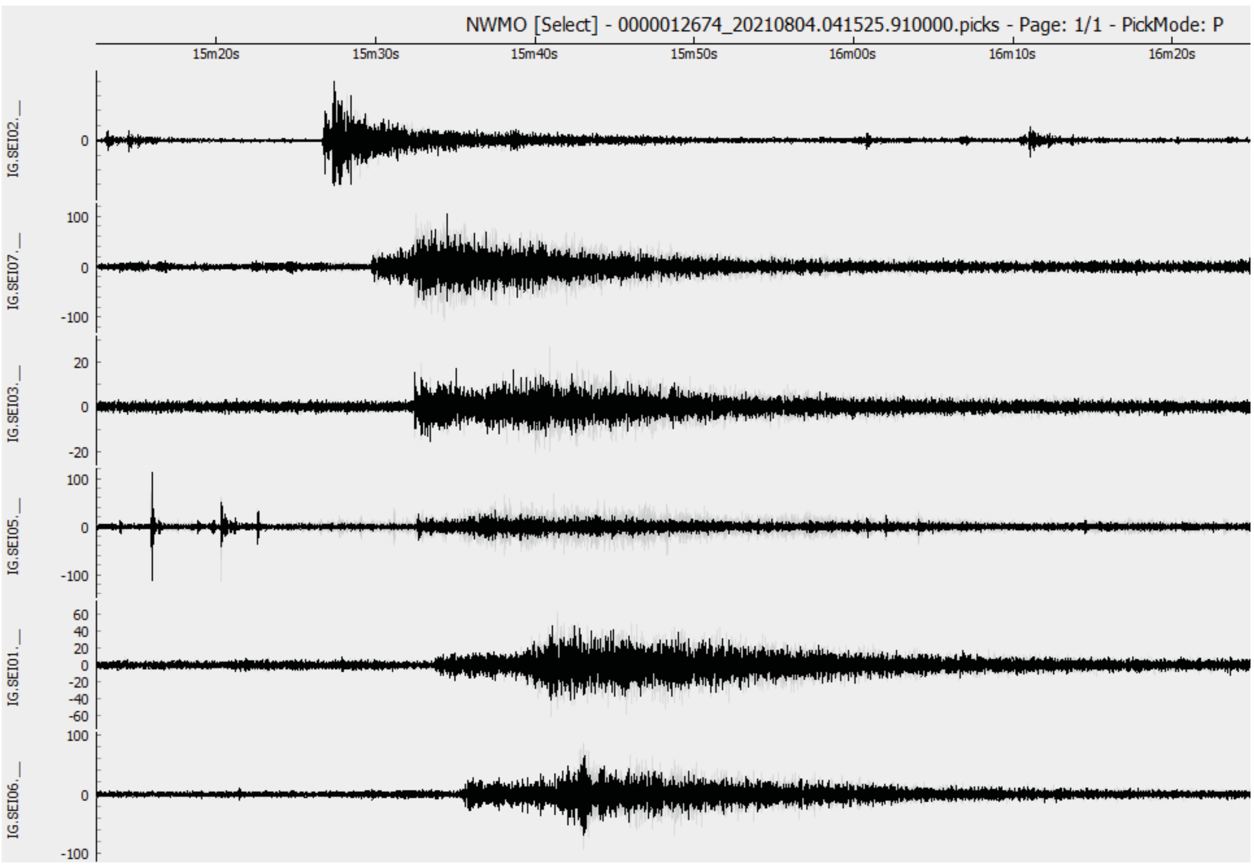
Date:	2021-06-12
Time:	22:58:29 UTC
Latitude:	49.5715 ^{0}N
Longitude:	91.6712 ^{0}W
Depth:	6.96km
Magnitude:	0.63Ml



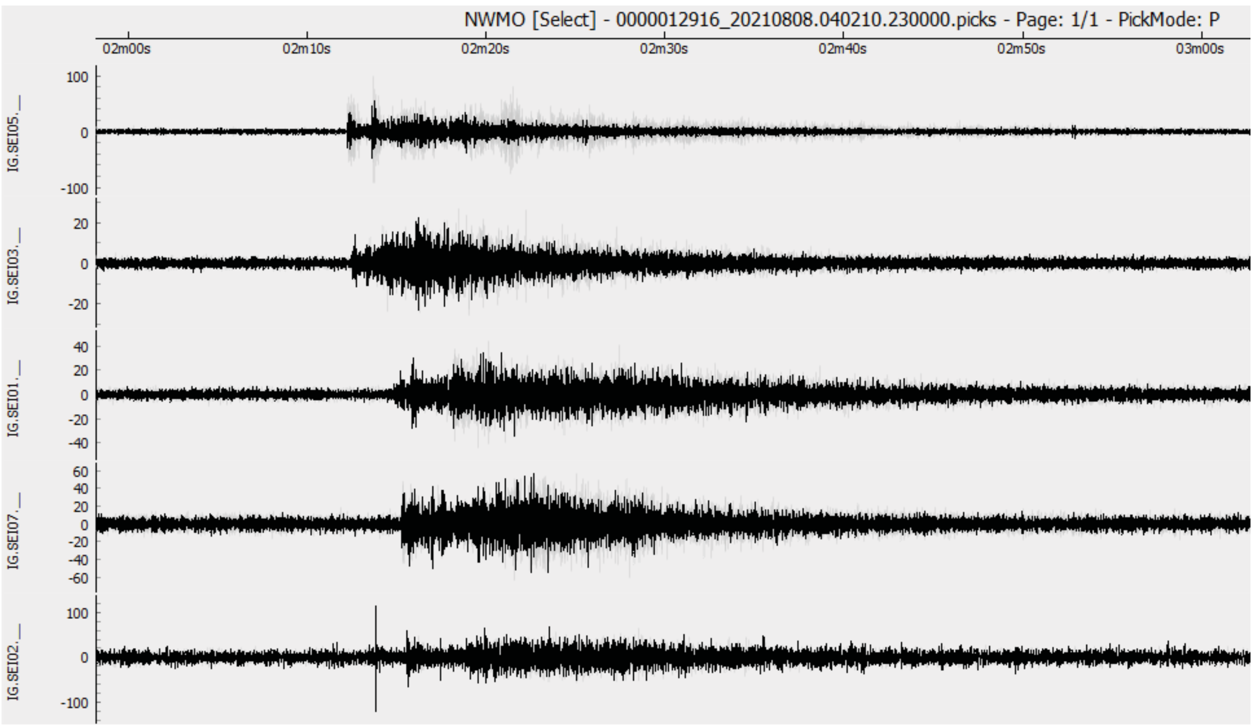
Date: 2021-06-21
Time: 17:53:41 UTC
Latitude: 49.3510 ^{0}N
Longitude: 91.5053 ^{0}W
Depth: 4.88km
Magnitude: 1.16Ml



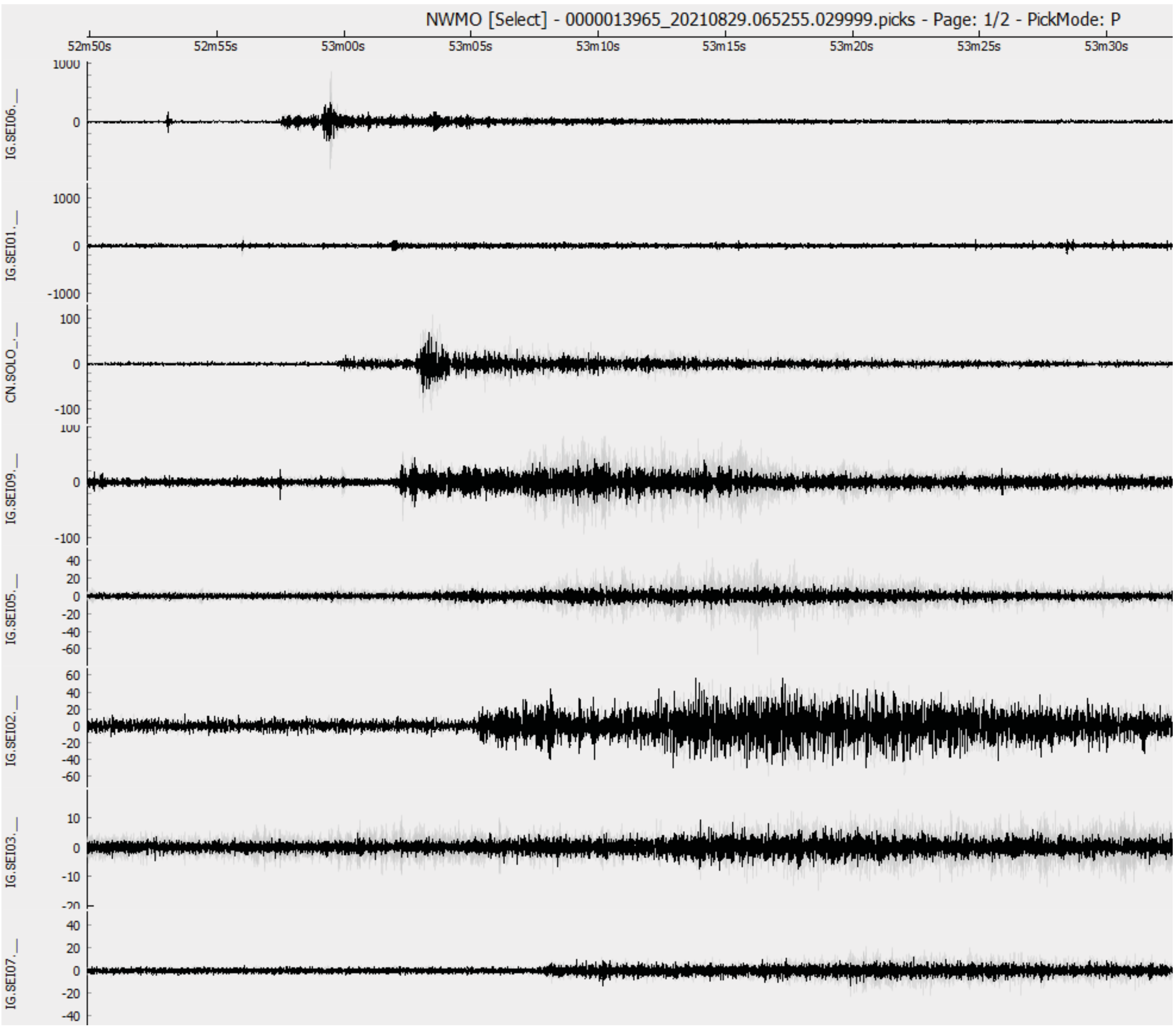
Date: 2021-08-04
Time: 04:15:25 UTC
Latitude: 49.5762 ^{0}N
Longitude: 91.7033 ^{0}W
Depth: 1.62km
Magnitude: -0.07Ml



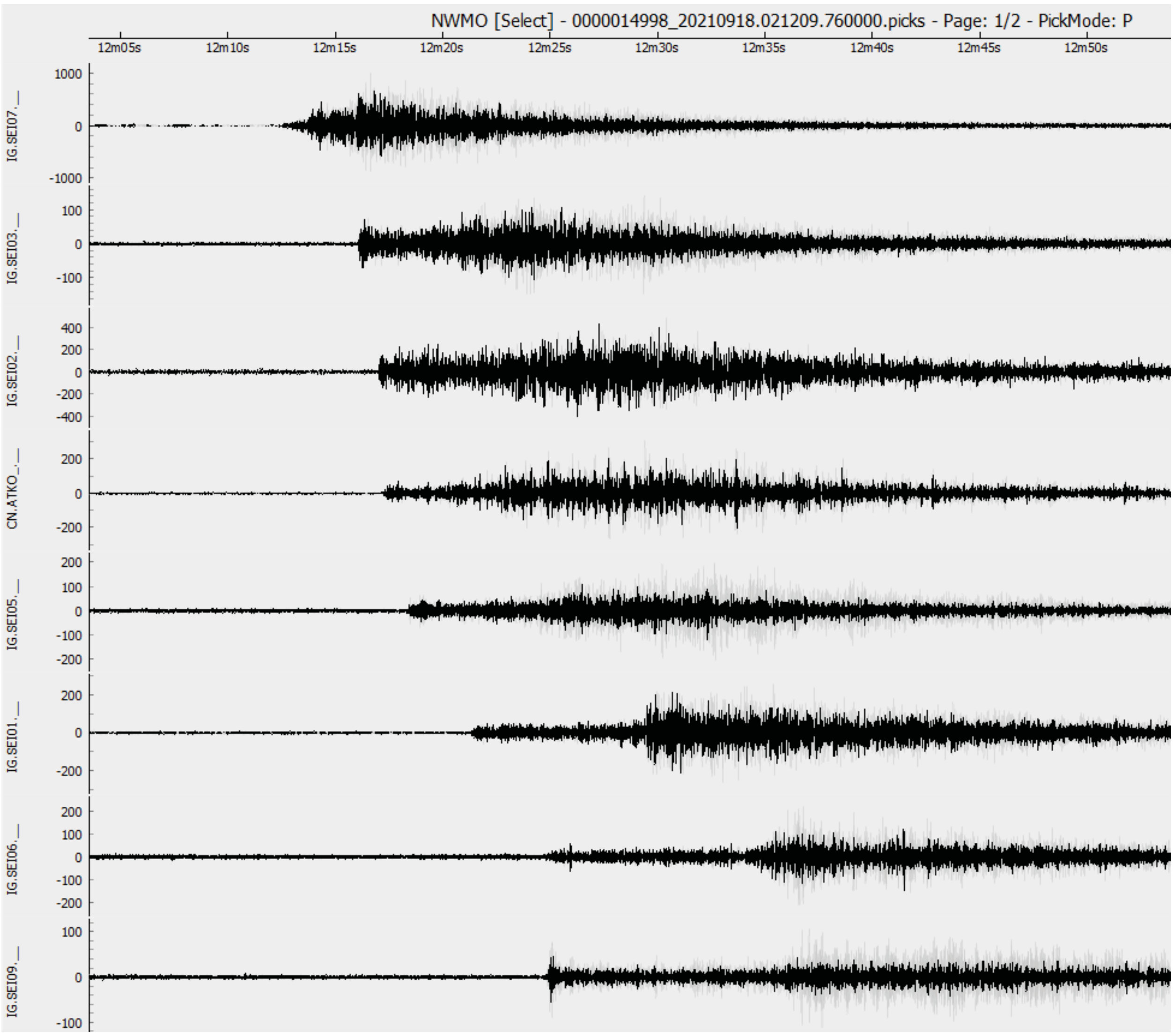
Date:	2021-08-08
Time:	04:02:10 UTC
Latitude:	49.4818 ^{0}N
Longitude:	92.0943 ^{0}W
Depth:	1.33km
Magnitude:	-0.13Ml



Date: 2021-08-29
Time: 06:52:55 UTC
Latitude: 49.8795 ⁰N
Longitude: 92.3858 ⁰W
Depth: 6.70km
Magnitude: 0.14Ml



Date: 2021-09-18
Time: 02:12:09 UTC
Latitude: 49.2215 ^{0}N
Longitude: 91.6862 ^{0}W
Depth: 3.94km
Magnitude: 0.75Ml



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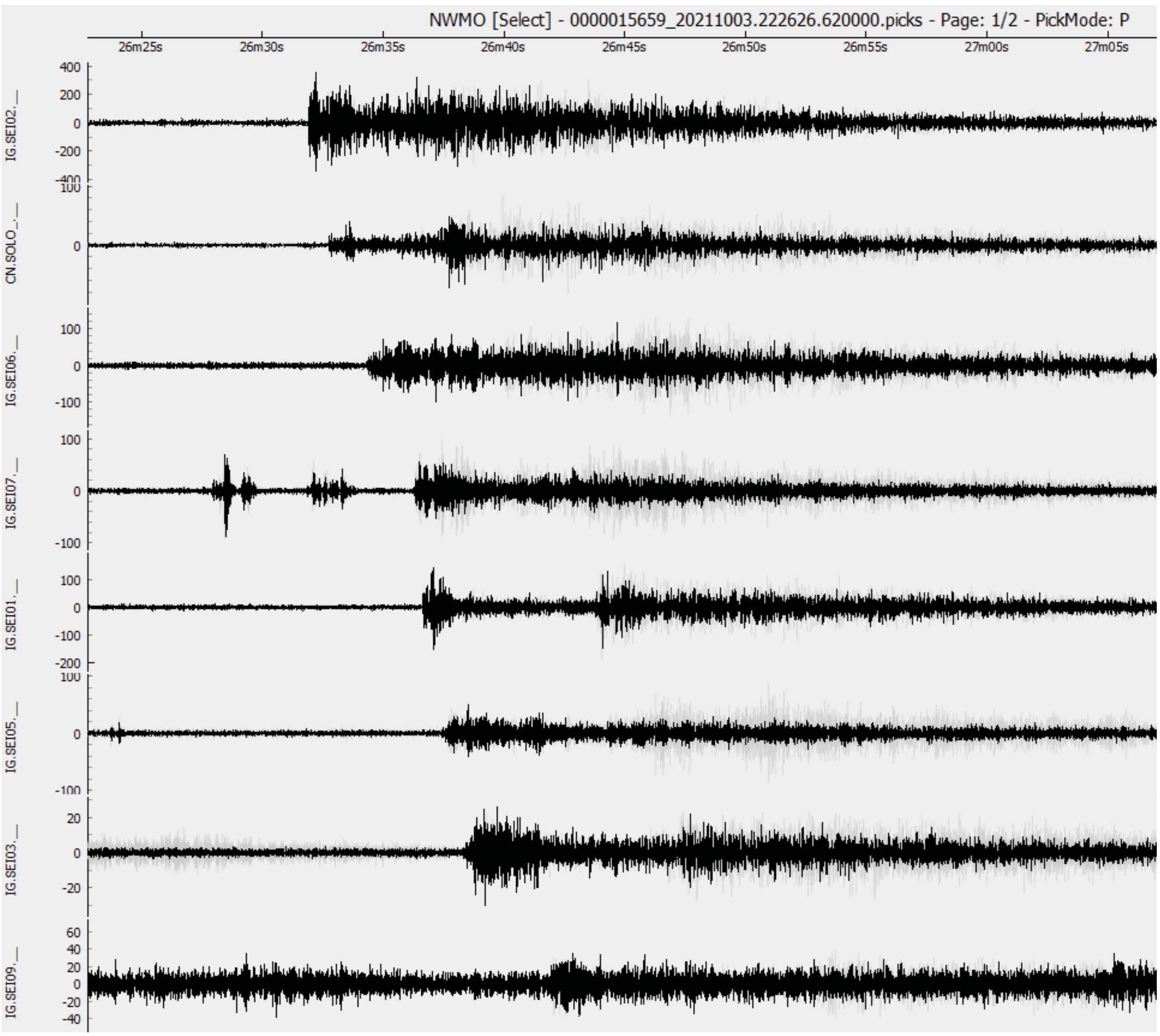
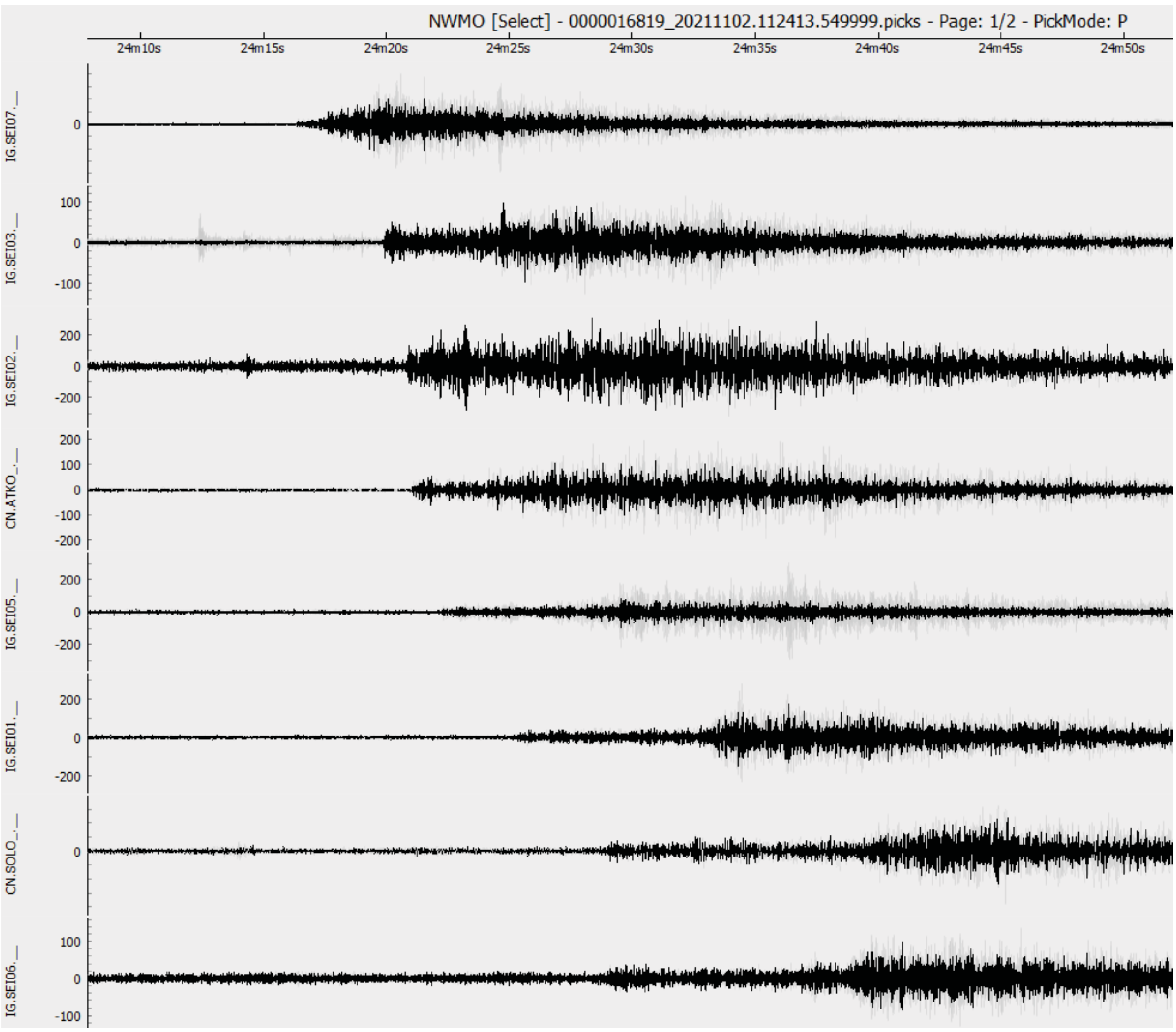
Date: 2021-10-03
Time: 22:26:26 UTC
Latitude: 49.9037 ^{0}N
Longitude: 91.5863 ^{0}W
Depth: 2.95km
Magnitude: 0.33Ml



Date:	2021-11-02
Time:	11:24:13 UTC
Latitude:	49.2272 ^{0}N
Longitude:	91.6818 ^{0}W
Depth:	6.71km
Magnitude:	0.71Ml



Date: 2021-11-10

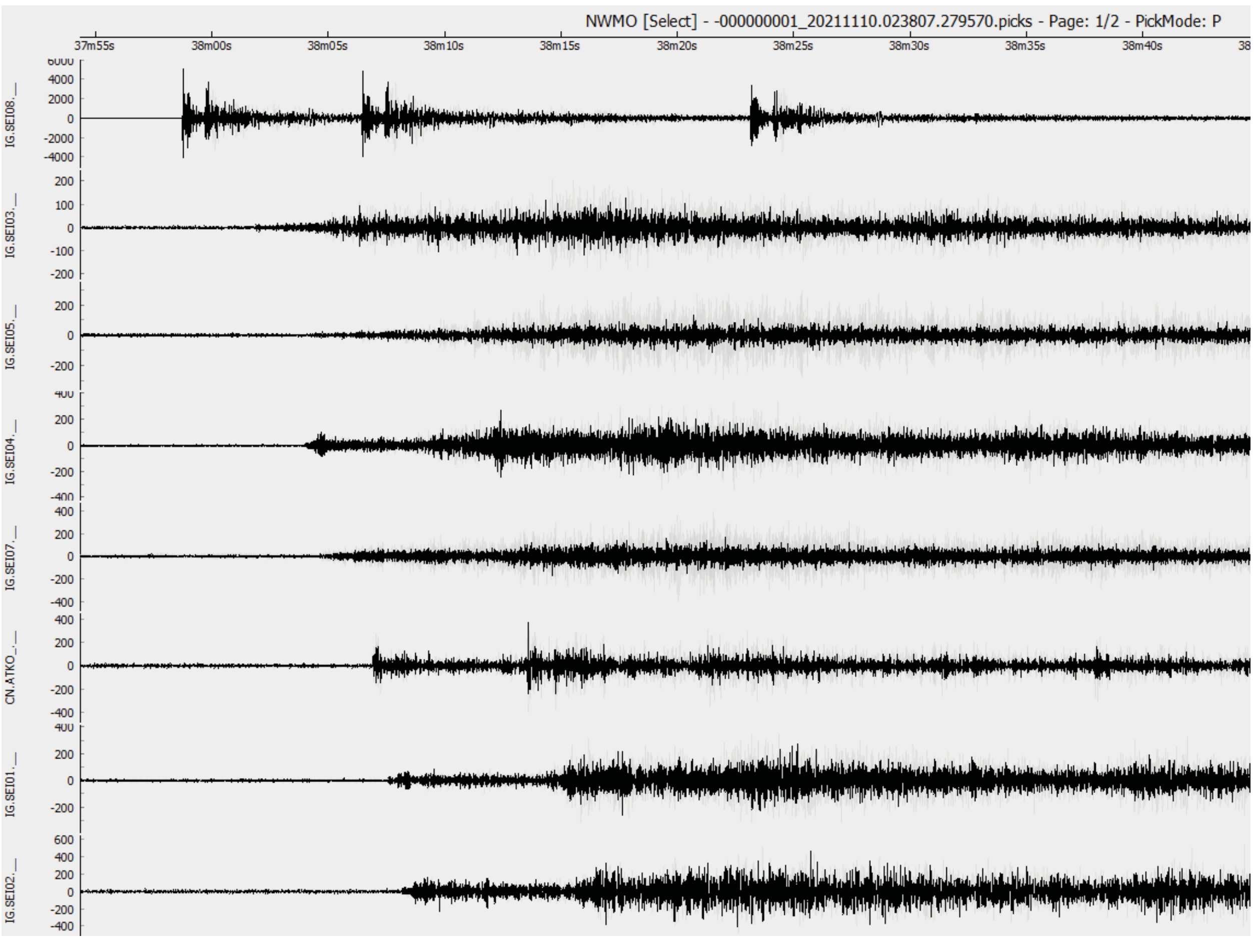
Time: 02:37:57 UTC

Latitude: 49.1417 ^{0}N

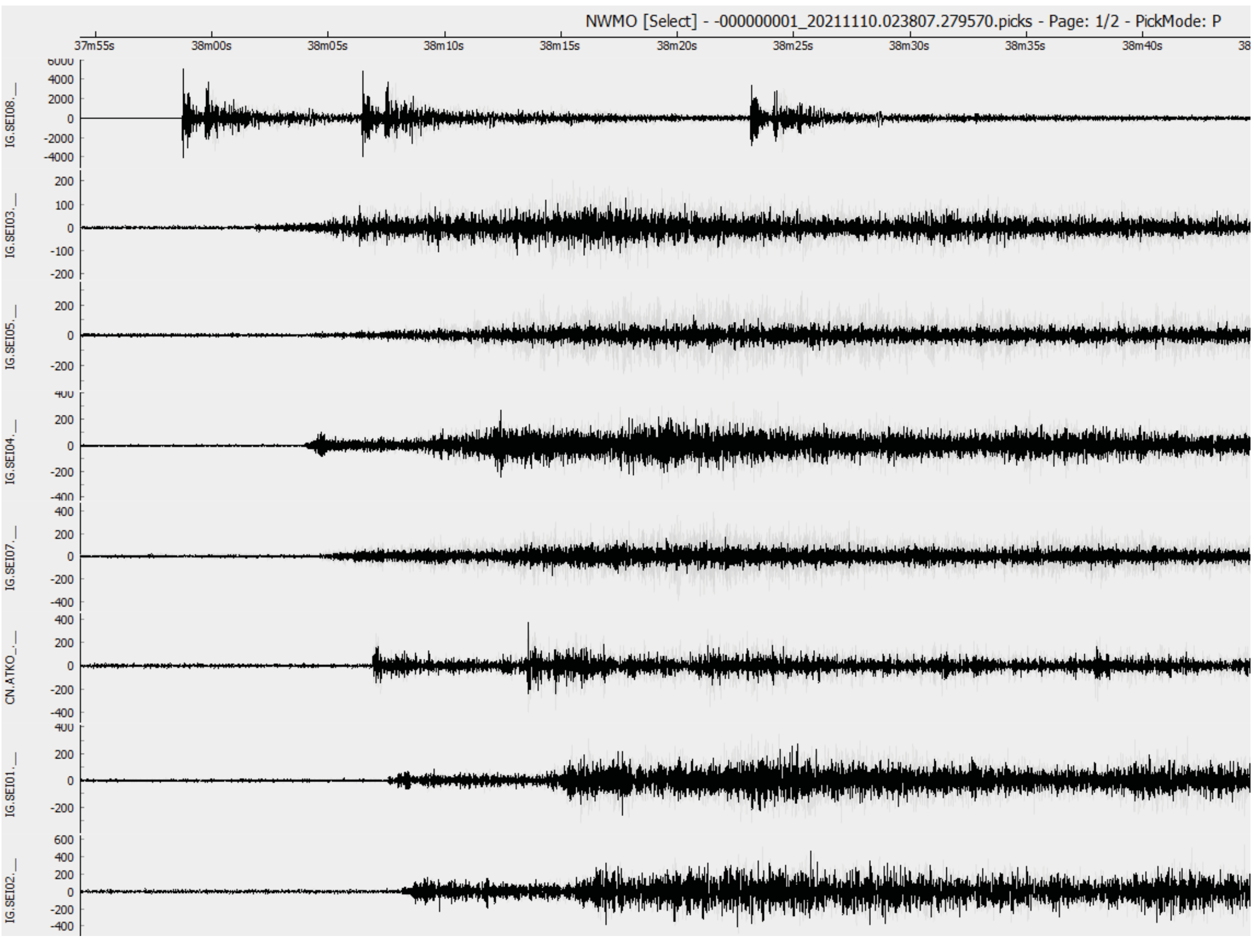
Longitude: 92.2163 ^{0}W

Depth: 3.14km

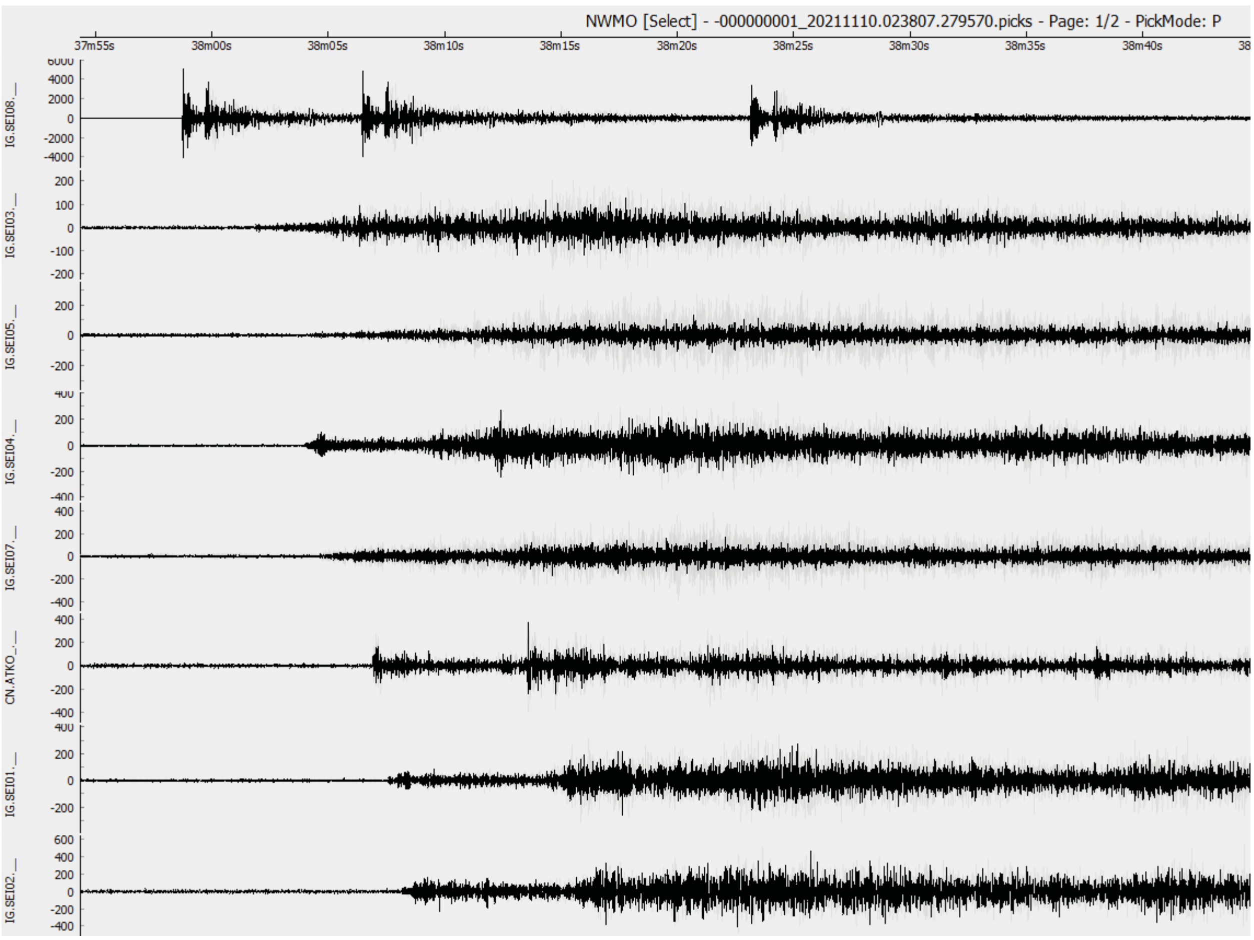
Magnitude: 0.78Ml



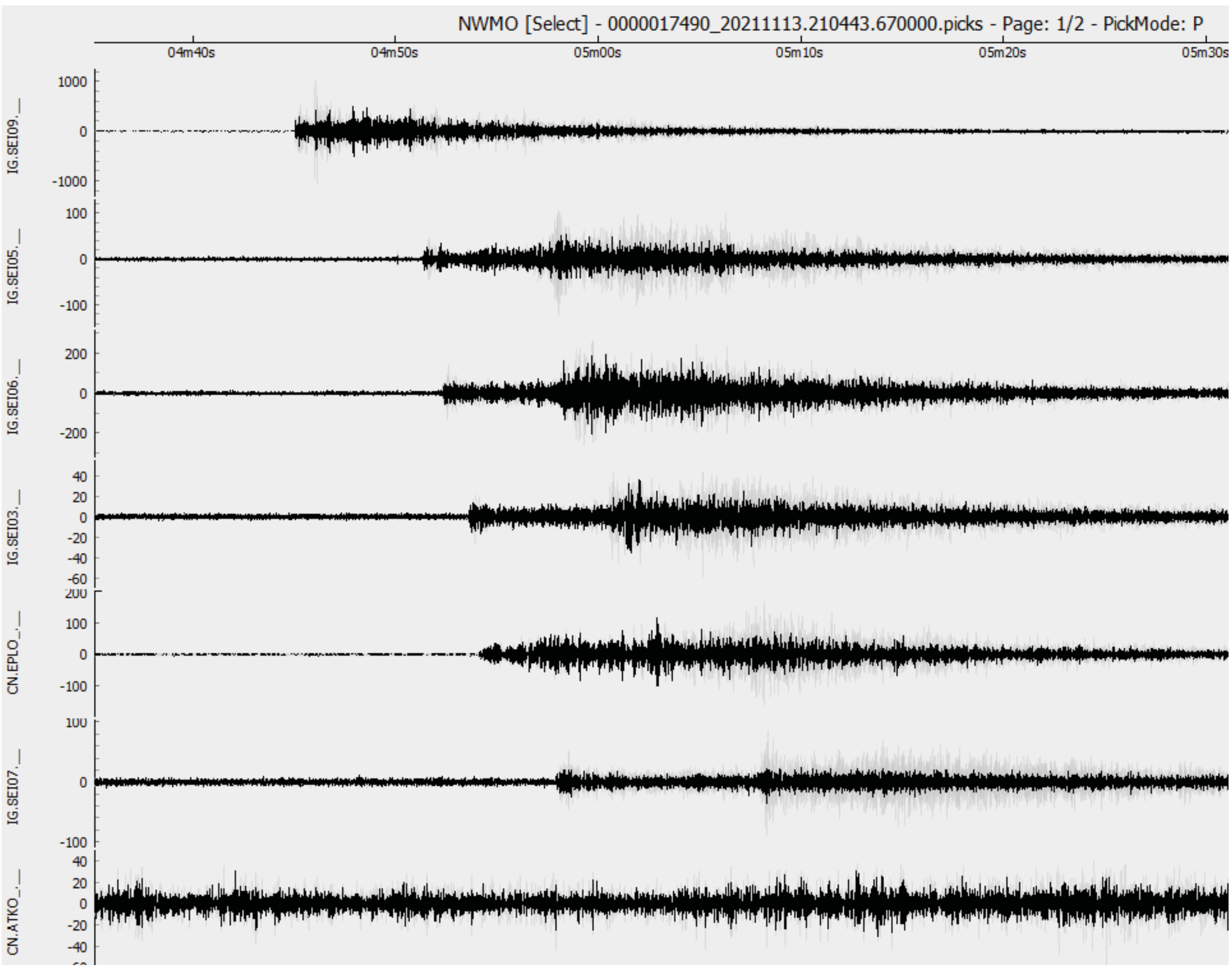
Date:	2021-11-10
Time:	02:38:04 UTC
Latitude:	49.1465 ^{0}N
Longitude:	92.2195 ^{0}W
Depth:	6.97km
Magnitude:	0.94Ml



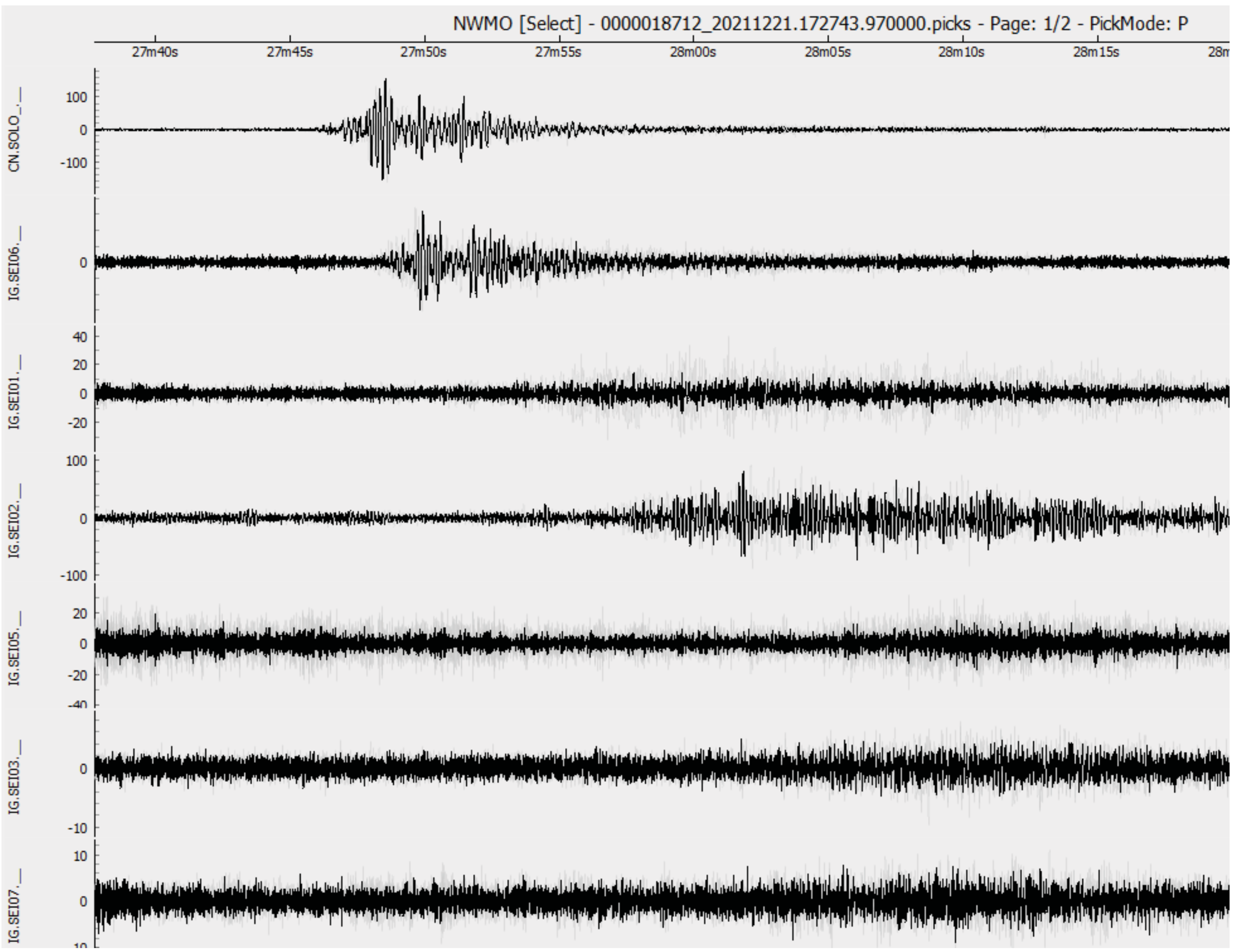
Date: 2021-11-10
Time: 02:38:21 UTC
Latitude: 49.1392 ^{0}N
Longitude: 92.2283 ^{0}W
Depth: 7.01km
Magnitude: 0.75Ml



Date:	2021-11-13
Time:	21:04:43 UTC
Latitude:	49.6837 ^{0}N
Longitude:	92.8330 ^{0}W
Depth:	2.88km
Magnitude:	0.45Ml



Date:	2021-12-21
Time:	17:27:43 UTC
Latitude:	49.9490 ^{0}N
Longitude:	92.0587 ^{0}W
Depth:	5.60km
Magnitude:	0.79Ml



Appendix C: NRCan Events (November 2020 - December 2021)

DateTime (UTC)	Lat	Long	Depth (km)	Mag	Description
2020-11-10T10:04	49.758	-91.181	2.0	2.7	67 km SE from Sioux Lookout, ON
2020-11-10T07:23	49.173	-89.618	0.0	2	Blast, Lac-des-Iles, ON
2020-11-12T10:50	49.17	-89.623	0.0	1.9	Blast, Lac-des-Iles, ON
2020-11-15T21:59	49.172	-89.619	0.0	1.8	Blast, Lac-des-Iles, ON
2020-11-15T17:05	48.911	-93.939	0.0	2.2	Blast, 53 km NW from Fort Frances, ON
2020-11-22T17:02	48.818	-94.044	0.0	2.3	Blast, 53 km NW from Fort Frances, ON
2020-11-27T11:27	49.755	-91.789	2.0	1.9	37 km S from Sioux Lookout, ON
2020-11-29T22:00	49.17	-89.624	0.0	1.8	Blast, Lac-des-Iles, ON
2020-11-30T11:01	49.165	-89.596	0.0	1.8	Blast, Lac-des-Iles, ON
2020-12-01T16:58	47.414	-93.021	0.0	2.4	Blast, Minnesota, U.S.
2020-12-03T15:59	47.612	-92.627	0.0	2.3	Blast, Minnesota, U.S.
2020-12-04T16:46	47.65	-91.88	0.0	2.8	Blast, Minnesota, U.S.
2020-12-05T22:50	49.18	-89.622	0.0	2	Blast, Lac-des-Iles, ON
2020-12-07T22:53	49.161	-89.65	0.0	1.9	Blast, Lac-des-Iles, ON
2020-12-21T21:00	48.858	-94.026	0.0	2.3	Blast, 54 km NW from Fort Frances, ON
2020-12-22T18:25	47.571	-92.641	0.0	2.6	Blast, Minnesota, U.S.
2020-12-23T22:54	49.175	-89.608	0.0	2	Blast, Lac-des-Iles, ON
2020-12-23T16:36	47.567	-92.624	0.0	2.7	Blast, Minnesota, U.S.
2020-12-24T06:19	49.17	-89.61	0.7	2.2	Mining related event, Lac-des-Iles, ON
2020-12-25T22:48	49.17	-89.612	0.0	1.7	Blast, Lac-des-Iles, ON
2020-12-26T10:54	49.167	-89.623	0.0	1.8	Blast, Lac-des-Iles, ON

2020-12-27T21:05	48.83	-94.047	0.0	2.3	Blast, 54 km NW from Fort Frances, ON
2020-12-28T10:55	49.169	-89.627	0.0	1.9	Blast, Lac-des-Iles, ON
2020-12-29T21:13	48.813	-94.034	0.0	2.2	Blast, 52 km NW from Fort Frances, ON
2020-12-30T17:00	48.857	-94	0.0	2.3	Blast, 53 km NW from Fort Frances, ON
2020-12-31T11:00	51.081	-93.772	0.0	2	Blast, NW of Red Lake, ON
2021-01-01T22:56	49.138	-89.644	0.0	2.1	Blast, Lac-des-Iles, ON
2021-01-02T12:19	49.167	-89.613	0.7	1.9	Mining related event,Lac-des-Iles, ON
2021-01-04T18:21	47.567	-92.661	0.0	2.8	Blast, Minnesota, U.S.
2021-01-06T22:55	49.169	-89.629	0.0	1.7	Blast, Lac-des-Iles, ON
2021-01-08T16:03	47.579	-92.651	0.0	2.5	Blast, Minnesota, U.S.
2021-01-14T21:59	49.16	-89.621	0.0	1.8	Blast, Lac-des-Iles, ON
2021-01-16T23:01	51.062	-93.742	2.2	2.1	Mining related event, Red Lake, ON
2021-01-21T21:05	48.834	-94.013	0.0	2.5	Blast, 52 km NW from Fort Frances, ON
2021-01-22T18:07	47.596	-92.637	0.0	2.5	Blast, Minnesota, U.S.
2021-01-23T21:07	48.815	-94.016	0.0	2.4	Blast, 51 km NW from Fort Frances, ON
2021-01-25T21:10	48.831	-93.973	0.0	2.4	Blast, 49 km NW from Fort Frances, ON
2021-01-29T11:08	49.176	-89.618	0.0	2	Blast, Lac-des-Iles, ON
2021-01-30T22:52	49.163	-89.622	0.0	2.2	Blast, Lac-des-Iles, ON
2021-02-02T17:31	47.577	-92.668	0.0	2.4	Blast, Minnesota, U.S.
2021-02-05T16:37	47.639	-91.843	0.0	2.9	Blast, Minnesota, U.S.
2021-02-14T17:08	48.838	-94.045	0.0	1.8	Blast, 54 km NW from Fort Frances, ON
2021-02-15T22:44	49.166	-89.63	0.0	1.6	Blast, Lac-des-Iles, ON
2021-02-16T00:19	48.891	-89.278	2.0	1.9	44 km NW from Mackenzie, ON
2021-02-17T21:05	48.815	-94.009	0.0	2.3	Blast, 51 km NW from Fort Frances, ON

2021-02-19T23:05	48.845	-94.05	0.0	2.3	Blast, 55 km NW from Fort Frances, ON
2021-02-20T22:52	49.157	-89.619	0.0	1.6	Blast, Lac-des-Iles, ON
2021-02-21T10:55	51.062	-93.773	0.0	2.1	Blast, W of Red Lake, ON
2021-02-23T23:19	49.174	-89.603	0.0	1.9	Blast, Lac-des-Iles, ON
2021-02-23T18:12	47.573	-92.656	0.0	2.4	Blast, Minnesota, U.S.
2021-02-23T03:41	49.812	-92.069	2.0	1.7	29 km S from Sioux Lookout, ON
2021-02-24T11:57	49.17	-89.61	0.8	1.8	Mining related event, Lac-des-Iles, ON
2021-02-28T22:49	49.183	-89.612	0.0	2	Blast, Lac-des-Iles, ON
2021-02-28T21:24	48.559	-92.332	2.0	1.7	57 km W from Atikokan, ON
2021-02-28T19:21	49.178	-89.619	0.0	1.9	Blast, Lac-des-Iles, ON
2021-03-04T16:34	47.474	-92.411	0.0	2.9	Blast, Minnesota, U.S.
2021-03-05T15:25	48.742	-88.573	0.0	2	Blast, 36 km NE from Mackenzie, ON
2021-03-07T10:49	49.172	-89.616	0.0	1.8	Blast, Lac-des-Iles, ON
2021-03-11T17:59	47.567	-92.661	0.0	2.4	Blast, Minnesota, U.S.
2021-03-13T21:03	48.824	-94.037	0.0	2.4	Blast, 53 km NW from Fort Frances, ON
2021-03-15T21:46	49.168	-89.613	0.0	2.1	Blast, Lac-des-Iles, ON
2021-03-15T20:01	48.815	-94.031	0.0	2.3	Blast, 52 km NW from Fort Frances, ON
2021-03-16T23:40	49.31	-91.737	2.0	2.1	13 km SSW of Ignace, ON
2021-03-18T09:49	49.172	-89.613	0.0	1.8	Blast, Lac-des-Iles, ON
2021-03-20T10:15	49.163	-89.625	0.0	1.9	Blast, Lac-des-Iles, ON
2021-03-25T17:27	47.584	-92.662	0.0	2.4	Blast, Minnesota, U.S.
2021-03-26T16:56	47.58	-92.649	0.0	2.3	Blast, Minnesota, U.S.
2021-03-26T08:38	49.724	-91.221	5.0	2.1	67 km SE from Sioux Lookout, ON
2021-03-26T08:10	49.729	-91.243	5.0	1.5	65 km SE from Sioux Lookout, ON

2021-03-26T07:49	49.729	-91.21	5.0	2	67 km SE from Sioux Lookout, ON
2021-03-27T18:03	48.751	-88.566	0.0	2.2	Blast, 37 km NE from Mackenzie, ON
2021-03-27T09:48	49.189	-89.617	0.0	1.7	Blast, Lac-des-Iles, ON
2021-03-28T20:02	48.82	-94.027	0.0	2.2	Blast, 52 km NW from Fort Frances, ON
2021-03-31T17:11	47.558	-92.682	0.0	2.3	Blast, Minnesota, U.S.
2021-04-01T15:02	48.731	-88.581	0.0	2.1	Blast, 35 km NE from Mackenzie, ON
2021-04-01T03:48	49.047	-92.172	5.0	1	52 km NW from Atikokan, ON
2021-04-01T03:46	49.075	-92.22	5.0	1.5	57 km NW from Atikokan, ON
2021-04-01T01:48	49.009	-92.254	5.0	1.3	55 km NW from Atikokan, ON
2021-04-03T21:50	49.174	-89.615	0.0	1.8	Blast, Lac-des-Iles, ON
2021-04-04T21:47	49.178	-89.619	0.0	1.8	Blast, Lac-des-Iles, ON
2021-04-08T00:11	49.321	-90.855	2.0	2.2	84 km NE from Atikokan, ON
2021-04-09T16:58	47.602	-92.647	0.0	2.4	Blast, Minnesota, U.S.
2021-04-17T09:50	49.174	-89.621	0.0	2	Blast, Lac-des-Iles, ON
2021-04-18T09:52	49.166	-89.621	0.0	1.8	Blast, Lac-des-Iles, ON
2021-04-19T17:04	47.558	-92.673	0.0	2.5	Blast, Minnesota, U.S.
2021-04-22T17:30	47.578	-92.638	0.0	2.7	Blast, Minnesota, U.S.
2021-04-22T09:09	49.453	-91.433	2.0	1.4	79 km SE from Sioux Lookout, ON
2021-04-22T06:21	49.456	-91.431	2.0	1.4	79 km SE from Sioux Lookout, ON
2021-04-24T21:50	49.169	-89.613	0.0	1.9	Blast, Lac-des-Iles, ON
2021-04-24T20:04	48.826	-94.001	0.0	2	Blast, 51 km NW from Fort Frances, ON
2021-04-25T21:48	49.169	-89.62	0.0	1.8	Blast, Lac-des-Iles, ON
2021-04-27T17:03	47.607	-92.581	0.0	2.8	Blast, Minnesota, U.S.
2021-04-30T20:08	48.824	-94.025	0.0	2.1	Blast, 52 km NW from Fort Frances, ON

2021-05-02T21:54	51.058	-93.784	0.0	2.1	Blast, W of Red Lake, ON
2021-05-02T20:09	48.848	-94.021	0.0	2.3	Blast, 53 km NW from Fort Frances, ON
2021-05-02T09:56	49.169	-89.609	0.0	2	Blast, Lac-des-Iles, ON
2021-05-09T21:49	49.169	-89.614	0.0	1.7	Blast, Lac-des-Iles, ON
2021-05-09T18:19	49.167	-89.613	0.8	2.3	Mining related event, Lac-des-Iles, ON
2021-05-10T20:06	48.839	-94.018	0.0	2.5	Blast, 53 km NW from Fort Frances, ON
2021-05-10T09:47	49.17	-89.619	0.0	1.7	Blast, Lac-des-Iles, ON
2021-05-11T09:04	49.172	-89.624	0.0	2	Blast, Lac-des-Iles, ON
2021-05-14T17:12	47.57	-92.68	0.0	2.5	Blast, Minnesota, U.S.
2021-05-15T20:06	48.856	-94.022	0.0	2.2	Blast, 54 km NW from Fort Frances, ON
2021-05-15T09:54	49.189	-89.626	0.0	1.6	Blast, Lac-des-Iles, ON
2021-05-16T22:03	49.175	-89.619	0.0	1.6	Blast, Lac-des-Iles, ON
2021-05-16T09:50	49.178	-89.616	0.0	1.6	Blast, Lac-des-Iles, ON
2021-05-23T16:04	48.854	-94.028	0.0	1.9	Blast, 54 km NW from Fort Frances, ON
2021-05-24T09:47	49.172	-89.621	0.0	1.8	Blast, Lac-des-Iles, ON
2021-05-25T09:42	49.179	-89.623	0.0	2	Blast, Lac-des-Iles, ON
2021-05-26T18:48	48.733	-88.569	0.0	2	Blast, 36 km NE from Mackenzie, ON
2021-05-27T15:42	47.668	-91.841	0.0	3	Blast, Minnesota, U.S.
2021-06-03T21:45	49.174	-89.616	0.0	1.8	Blast, Lac-des-Iles, ON
2021-06-04T09:47	49.171	-89.624	0.0	1.7	Blast, Lac-des-Iles, ON
2021-06-07T21:43	49.166	-89.624	0.0	1.9	Blast, Lac-des-Iles, ON
2021-06-07T20:04	48.851	-94.028	0.0	2.1	Blast, 54 km NW from Fort Frances, ON
2021-06-10T15:31	47.677	-91.865	0.0	2.3	Blast, Minnesota, U.S.
2021-06-11T09:47	49.176	-89.624	0.0	1.7	Blast, Lac-des-Iles, ON

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2021-06-12T22:58	49.599	-91.628	5.0	1.4	58 km SE from Sioux Lookout, ON
2021-06-13T20:07	48.846	-94.021	0.0	2.2	Blast, 53 km NW from Fort Frances, ON
2021-06-13T01:28	47.669	-90.225	18.0	1.7	106 km SW from Thunder Bay, ON
2021-06-17T03:08	50.142	-90.436	5.0	2.7	22 km SW from Allanwater Bridge, ON
2021-06-20T20:03	48.866	-94.018	0.0	2.1	Blast, 54 km NW from Fort Frances, ON
2021-06-21T17:29	47.577	-92.665	0.0	2.5	Blast, Minnesota, U.S.
2021-06-21T10:20	51.053	-93.744	0.0	2	Blast, Red Lake, ON
2021-06-21T09:46	49.186	-89.617	0.0	1.9	Blast, Lac-des-Iles, ON
2021-06-23T00:13	51.06	-93.74	1.0	1.9	Mining related event, Red Lake, ON
2021-06-24T15:47	47.692	-91.867	0.0	3	Blast, Minnesota, U.S.
2021-06-26T21:51	49.17	-89.614	0.0	1.9	Blast, Lac-des-Iles, ON
2021-06-26T20:08	48.871	-93.992	0.0	2.1	Blast, 53 km NW from Fort Frances, ON
2021-06-27T23:22	49.163	-89.607	0.0	2	Blast, Lac-des-Iles, ON
2021-06-27T09:48	49.158	-89.621	0.0	1.9	Blast, Lac-des-Iles, ON
2021-06-29T02:14	48.778	-90.64	2.0	1.7	72 km E from Atikokan, ON
2021-06-30T09:47	49.168	-89.621	0.0	1.5	Blast, Lac-des-Iles, ON
2021-07-01T17:09	47.575	-92.679	0.0	2.7	Blast, Minnesota, U.S.
2021-07-03T21:52	51.058	-93.772	0.0	2	Blast, W of Red Lake, ON
2021-07-03T09:48	49.172	-89.628	0.0	2	Blast, Lac-des-Iles, ON
2021-07-04T20:03	48.839	-94.036	0.0	2.4	Blast, 54 km NW from Fort Frances, ON
2021-07-06T09:07	49.178	-89.617	0.0	1.7	Blast, Lac-des-Iles, ON
2021-07-07T20:06	48.862	-94.021	0.0	2.5	Blast, 54 km NW from Fort Frances, ON
2021-07-07T17:16	47.564	-92.674	0.0	2.5	Blast, Minnesota, U.S.
2021-07-11T12:21	51.78	-92.01	18.0	2.1	130 km W from Pickle Lake, ON

2021-07-13T20:04	48.866	-94.02	0.0	2.4	Blast, 54 km NW from Fort Frances, ON
2021-07-13T09:45	49.163	-89.62	0.0	1.9	Blast, Lac-des-Iles, ON
2021-07-13T04:18	49.17	-89.61	0.9	1.9	Mining related event, Lac-des-Iles, ON
2021-07-14T18:01	48.433	-92.994	0.0	1.9	Blast, 35 km SE from Fort Frances, ON
2021-07-15T15:37	47.664	-91.911	0.0	2.9	Blast, Minnesota, U.S.
2021-07-17T21:57	48.866	-94.028	0.0	2.6	Blast, 55 km NW from Fort Frances, ON
2021-07-18T20:03	48.866	-94.007	0.0	1.9	Blast, 54 km NW from Fort Frances, ON
2021-07-19T21:42	49.164	-89.617	0.0	2	Blast, Lac-des-Iles, ON
2021-07-20T19:13	48.732	-88.566	0.0	2	Blast, 36 km NE from Mackenzie, ON
2021-07-21T17:00	47.55	-92.672	0.0	2.4	Blast, Minnesota, U.S.
2021-07-21T10:01	49.157	-89.627	0.0	2	Blast, Lac-des-Iles, ON
2021-07-24T07:24	50.262	-91.027	2.0	1.8	61 km W from Allanwater Bridge, ON
2021-07-25T09:54	51.062	-93.754	0.0	1.9	Blast, W of Red Lake, ON
2021-07-27T20:05	48.915	-93.957	0.0	2.2	Blast, 54 km NW from Fort Frances, ON
2021-07-28T22:05	49.172	-89.617	0.0	1.9	Blast, Lac-des-Iles, ON
2021-07-28T21:58	48.857	-94.019	0.0	2.1	Blast, 54 km NW from Fort Frances, ON
2021-07-29T17:16	47.59	-92.667	0.0	2.4	Blast, Minnesota, U.S.
2021-07-29T16:59	47.597	-92.657	0.0	2.4	Blast, Minnesota, U.S.
2021-07-29T15:18	47.581	-92.665	0.0	2.3	Blast, Minnesota, U.S.
2021-08-01T22:27	49.152	-89.626	0.0	1.7	Blast, Lac-des-Iles, ON
2021-08-01T15:59	48.872	-94.016	0.0	2.3	Blast, 55 km NW from Fort Frances, ON
2021-08-03T09:45	49.162	-89.611	0.0	1.8	Blast, Lac-des-Iles, ON
2021-08-05T17:01	47.601	-92.656	0.0	2.7	Blast, Minnesota, U.S.
2021-08-06T15:54	47.559	-92.648	0.0	2.4	Blast, Minnesota, U.S.

2021-08-07T22:00	51.047	-93.741	0.0	2	Blast, S of Red Lake, ON
2021-08-07T20:08	48.86	-94.023	0.0	2.3	Blast, 54 km NW from Fort Frances, ON
2021-08-12T15:28	47.672	-91.872	0.0	2.6	Blast, Minnesota, U.S.
2021-08-12T09:46	49.174	-89.62	0.0	1.8	Blast, Lac-des-Iles, ON
2021-08-14T22:09	51.059	-93.738	0.0	1.9	Blast, S of Red Lake, ON
2021-08-14T21:50	49.174	-89.636	0.0	1.7	Blast, Lac-des-Iles, ON
2021-08-15T21:49	49.195	-89.602	0.0	1.9	Blast, Lac-des-Iles, ON
2021-08-16T15:32	47.575	-92.635	0.0	2.2	Blast, Minnesota, U.S.
2021-08-17T17:17	47.592	-92.663	0.0	2.9	Blast, Minnesota, U.S.
2021-08-19T21:50	49.17	-89.613	0.0	1.7	Blast, Lac-des-Iles, ON
2021-08-21T09:46	49.168	-89.626	0.0	1.8	Blast, Lac-des-Iles, ON
2021-08-22T20:05	48.856	-94.018	0.0	2.1	Blast, 54 km NW from Fort Frances, ON
2021-08-23T10:00	51.059	-93.789	0.0	1.7	Blast, W of Red Lake, ON
2021-08-26T22:14	49.176	-89.599	0.0	2	Blast, Lac-des-Iles, ON
2021-08-29T06:52	49.947	-92.42	2.0	0.9	34 km SW from Sioux Lookout, ON
2021-08-30T16:01	48.864	-94.01	0.0	2.1	Blast, 54 km NW from Fort Frances, ON
2021-08-31T21:51	51.066	-93.76	0.0	1.8	Blast, W of Red Lake, ON
2021-08-31T09:42	49.169	-89.626	0.0	1.6	Blast, Lac-des-Iles, ON
2021-09-05T20:08	48.87	-94.01	0.0	2.1	Blast, 54 km NW from Fort Frances, ON
2021-09-06T09:43	49.168	-89.619	0.0	1.7	Blast, Lac-des-Iles, ON
2021-09-07T18:21	49.172	-89.62	0.0	2	Blast, Lac-des-Iles, ON
2021-09-07T09:53	51.047	-93.746	0.0	1.5	Blast, S of Red Lake, ON
2021-09-08T06:26	48.942	-92.127	5.0	1.6	43 km NW from Atikokan, ON
2021-09-10T09:52	49.158	-89.654	0.0	1.9	Blast, 3 km WSW of Lac des Iles Mine, ON

2021-09-16T00:23	49.17	-89.61	1.0	1.6	Mining event, Lac des Iles Mine, ON
2021-09-18T02:12	49.208	-91.748	5.0	1.5	24 km SSW of Ignace, ON
2021-09-21T08:51	49.317	-90.862	5.0	1.9	58 km E of Ignace, ON
2021-10-21T06:59	49.747	-93.855	2.0	1.9	39 km N of Whitefish Bay 32A, ON
2021-11-02T23:30	51.07	-93.816	0.0	1.9	Blast, 5 km WNW of Golden, ON
2021-11-02T11:24	49.235	-91.653	5.0	1.4	20 km S of Ignace, ON
2021-11-04T04:35	48.243	-92.944	2.0	2	53 km SE of International Falls, MN
2021-11-10T02:37	49.138	-92.22	2.0	1.7	51 km SW of Ignace, ON
2021-11-30T08:24	50.472	-88.988	5.0	2.3	18 km NNE of Whitesand, ON
2021-12-05T22:46	49.173	-89.641	0.0	2.4	Blast, 2 km W of Lac des Iles Mine, ON
2021-12-16T14:39	48.775	-88.597	0.0	2.1	Blast, 5 km WSW of Dorion, ON
2021-12-17T17:08	48.836	-93.996	0.0	2	Blast, 1 km ENE of Rainy River Mine, ON
2021-12-23T10:47	49.157	-89.58	0.0	2.1	Blast, 3 km ESE of Lac des Iles Mine, ON
2021-12-27T18:14	47.509	-92.61	0.0	2.5	Blast, 6 km WSW of Virginia, MN
2021-12-29T18:18	47.571	-92.657	0.0	2.6	Blast, 10 km WNW of Virginia, MN
2021-12-29T06:15	49.17	-89.61	1.1	2.1	Mining event, Lac des Iles Mine, ON

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