THE POTSDAM COLLEGE SEISMIC NETWORK

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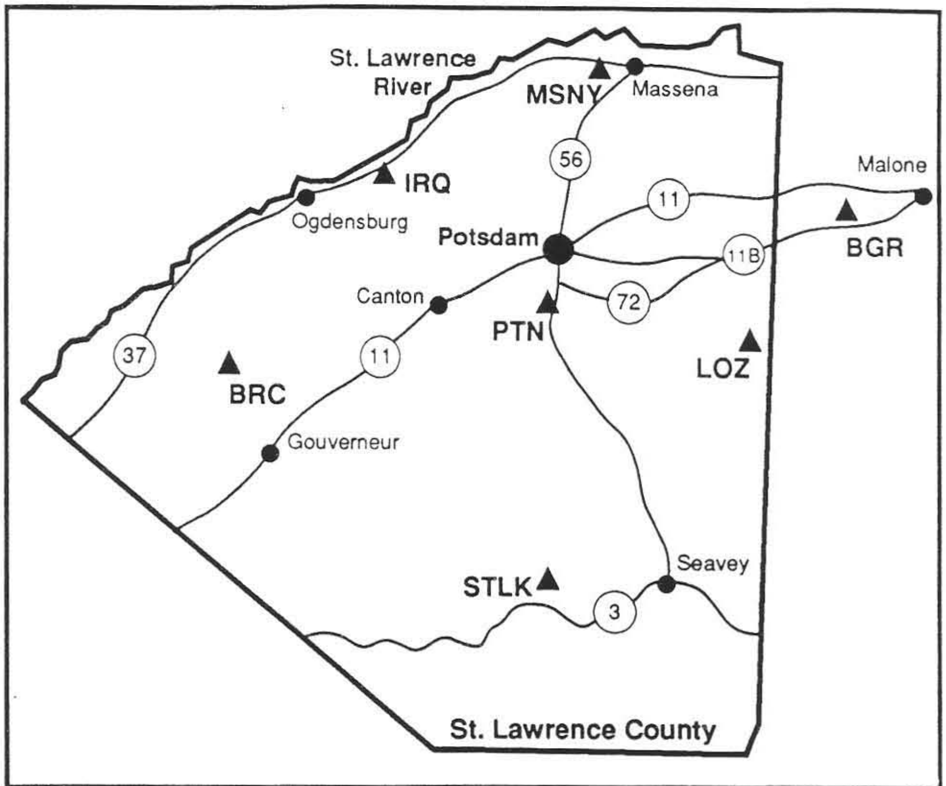
INTRODUCTION

The Potsdam Seismic Network consists of seven short period-vertical seismograph stations located in the St. Lawrence Valley in northwestern New York. All seven of the seismic field stations transmit the seismic signals to Potsdam College via FM narrow-band telemetry except the station at Star Lake (STLK) which is relayed through the Brasie Corners (BRC) station. The earthquakes recorded by the network are located by using two hypocentral location programs FASTHYPO (Hermann 1979) and HYPOINVERSE (Klein 1978) run on a Zenith personal computer. Analog data from the field stations is digitized and the digitized seismic signals fed directly into the SUN computer where the digital seismogram may be observed on the computer monitor. The program SUNPICK is used to pick the P and S phases and determine the arrival times used to locate the hypocenter.

During the past 5 years forty-eight local earthquakes have been recorded by the network. Most of the epicenters of the earthquakes are located in the St. Lawrence Valley just south of the Massena-Cornwall area. No surface evidence of any major fault is in this area nor has any noticeable ground displacement been observed however two faults of the Ottawa-Bonnechere graben, the Winchester Springs and Gloucester faults are inferred to cross the St. Lawrence River into the United States. The area also contains a possible extension of the Carthage-Colton Mylonite Zone, a major structural boundary that separates the Adirondack Highlands from the Lowlands. Most of the epicenters are located along the possible extension of the CCMZ and in the vicinity of the Gloucester and Winchester Springs faults.

HISTORY OF THE SEISMIC NETWORK

The Potsdam College Seismic Network consists of seven short period-vertical seismograph stations (Figure 1) located in the St. Lawrence Valley in northwestern New York. The first station (PTN) was installed in October 1971 as a joint venture between Potsdam College and the Lamont-Doherty Geological Observatory (LDGO) of Columbia University. LDGO installed the seismic field station sixteen kilometers south of Potsdam and telemetered the seismic signals to Potsdam College where they were recorded on a seismograph jointly purchased by the Potsdam College and Alcoa Foundations. The seismic signals were transmitted by telephone lines to LDGO at the Palisades, New York, for study



POTSDAM COLLEGE SEISMIC NETWORK

Seven short-period vertical seismograph stations in the St. Lawrence Valley

▲ BGR	Bangor
▲ BRC	Brasie Corners
▲ IRQ	Iroquois Dam
▲ LOZ	Lake Ozonia
▲ MSNY	Massena
▲ PTN	Potsdam
▲ STLK	Star Lake

Figure 1: Potsdam College Seismic Network

by the LDGO seismologists. This was the first seismograph station installed in northern New York.

During the succeeding years six more seismograph stations were installed in the area. In 1976 LDGO installed seismic field stations at the Long Sault Dam at Massena, and at Bangor, New York. The Gulf and Alcoa Foundations provided Potsdam College with grants to purchase seismographs to record from these two field stations. From 1983 to 1988 Potsdam College purchased seismic equipment to install three stations at Lake Ozonia (LOZ), Star Lake (STLK) and Brasie Corners (BRC). The funds for the installation of these stations were received from the New York State Power Authority and Alcoa Foundations. In 1988 Plattsburgh State College donated one seismograph to Potsdam College.

The Lamont-Doherty Geological Observatory of Columbia University provides much equipment and services for the operation of the network and is connected through internet to the seismic signals recorded by the network. The information from the network is also provided to the Geophysics Division of the Canadian Geological Survey so they may locate Canadian epicenters more accurately and calculate fault plane solutions.

In addition to detecting, recording and locating local earthquakes Potsdam College maintains a catalog of historical and recent seismicity in the northeastern United States and southeastern Canada. This catalog contains 3159 seismic events in the area between 39^{o} to 53^{o} north latitude and 58^{o} to 81^{o} west longitude and lists all the earthquakes that have occurred during the period 1534 through 1986. This earthquake catalog, published by Nottis (1983), serves as the core for the New York State Earthquake Hazard Reduction Program.

THE SEISMIC FIELD STATIONS

The detection of earthquakes occurs at the seven seismic field stations shown in Figure 1. All the seismometers are vertical short-period units which respond to the short-period seismic waves generated by local earthquakes. The seismometer is placed on bedrock inside a bottomless 55 gallon steel drum. The ground motion produced by the seismic waves is converted to an electrical signal and fed into a high-gain amplifier to increase the signal amplitude. This signal is frequency modulated by a voltage-controlled oscillator (VCO). The VCO frequency is now in the audible range and its output frequency changes in response to the change sensed by the seismometer. The signal is modulated to the FM radio transmitter and then transmitted to the receiving station at Potsdam College. The power output of the transmitter is 100-350 milliwatts. The frequency is usually in the UHF government experimental band.

Presently the network is converting its seismic field stations from batteries to solar energy. The solar-powered station consists of a silicon solar collecting panel that provides DC current to the regulator during the daylight hours. When sufficient current is available, a regulator recharges a battery. The battery supplies the energy that is needed to power the radio transmitter and amplifier. This results in significant financial savings.

THE SEISMIC RECORDING STATION

All seven of the seismic stations transmit the seismic signals to Potsdam College via FM narrow band telemetry except the station at Star Lake (STLK) which is relayed through the Brasie Corners station (BRC). Antennas and receivers on Raymond and Timerman Halls pick up the signals and feed them into discriminators. The discriminator removes the FM carrier wave and feeds the signal into the amplifier for amplification. The output from the amplifier is recorded on the helicorder or seismograph. The output from the discriminators also enters a SUN Computer which serves as an analog to digital converter.

The entire system is "locked on" to a satellite receiver which continuously monitors a GOES satellite which transmits time signals from the National Bureau of Standards at Washington, D.C. The clock displays the number of the day of the year, and hours, minutes and seconds in Universal Coordinated Time (UTC). Its accuracy is always within 12 milliseconds of true UTC time.

The Potsdam College Seismic Network short-period seismometers are best suited for the detection of local earthquakes. Local earthquakes are those with epicenters within 1000 kms from the seismic station. However, distant earthquakes (teleseisms) may also be recorded provided the magnitude of the earthquake is greater than 5 on the Richter Scale. Several teleseisms such as the Armenian, Loma Prieta and the more recent Landers, California earthquake have been recorded during the past few years. The teleseisms are too distant to locate the epicenter accurately by our closely spaced regional seismic network. Information about the teleseism is obtained quickly from the National Earthquake Information Center. Quick Epicenter Determinations (QED) are available to users having access to a modem and microcomputer by dialing the toll-free number 800-358-2663. The information provided by the NEIC and our seismogram of the quake are an excellent combination to understand and analyze the earthquake.

SEISMOGRAM ANALYSIS

The earthquakes recorded by the Potsdam Seismic Network are located by using the two hypocentral location programs FASTHYPO and HYPOINVERSE. The programs are run on a Zenith 159 computer with a hard disk and a SUN SPARC Workstation. These programs determine the location, depth and origin time by minimizing the difference between the observed and calculated travel times of the seismic phase arrivals for a specific crustal velocity model. For a particular earthquake the model most appropriate for the epicentral region of the quake is used. The arrival times of seismic phases are used as input to the computer programs. The times are read from the records of the network or are picked from the monitor screen of the SUN Workstation. A data sheet used to record seismogram measurements and input them into the computer is shown in Figure 2.

The magnitudes (Mc) of local earthquakes are calculated by using the signal duration (coda length) formula developed for New England (Chaplin 1980). An average magnitude

DATA SHEET (FASTHYPO on Zenith)

DATE OF EVENT ______________________________

Hours and minutes of event (UTC) ______________________

Type FAST when you see C

Type ø for geographic

Type 1 for Northern NY - Adirondack Model

Type 1 to input data at the terminal

Enter a title (up to 80 characters) ______________________

STA (capitals)	P Descrip.	P-WT	TP (Secs)	S Descrip.	S WT	TS (Secs)
PTN	IC '	'	'	E '	'	'
LOZ	IC '	'	'	E '	'	'
BRC	IC '	'	'	E '	'	'
STLK	IC '	'	'	E '	'	'
BGR	IC '	'	'	E '	'	'
MSNY	IC '	'	'	E '	'	'
IRQ	IC '	'	'	E '	'	'

When finished with station data, type STOP (capitals)

Figure 2: Data Sheet showing input to computer to locate hypocenter

value based on all available station observations is reported for each earthquake. The signal duration is the time from the P-wave arrival until the coda amplitude disappears into the background noise. The formula used in magnitude determination is:

$$Mc = 2.21 \text{ Log } T - 1.70,$$ where T is the signal duration in seconds.

An example of a calculation of the magnitude of the aftershock of the Goodnow Earthquake of October 7, 1983 is shown in Figure 3.

SUN WORKSTATION

The Potsdam Seismic Network contains a SUN SPARC Workstation for analysis of the earthquakes detected by the network. The analog data from the network is digitized, and the

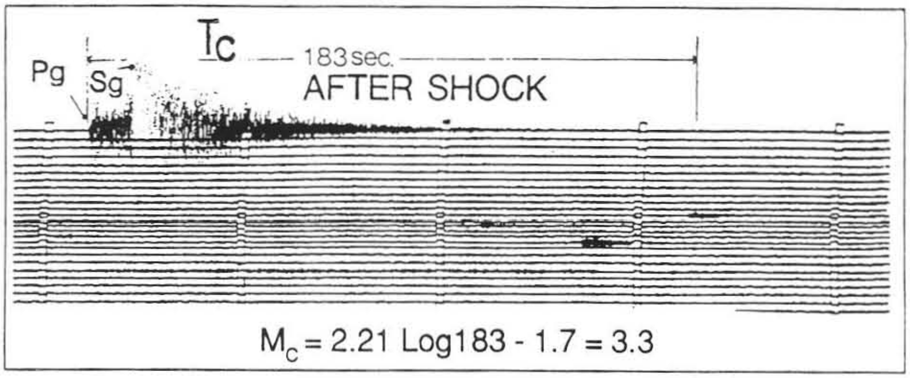


Figure 3: Seismogram showing magnitude calculation

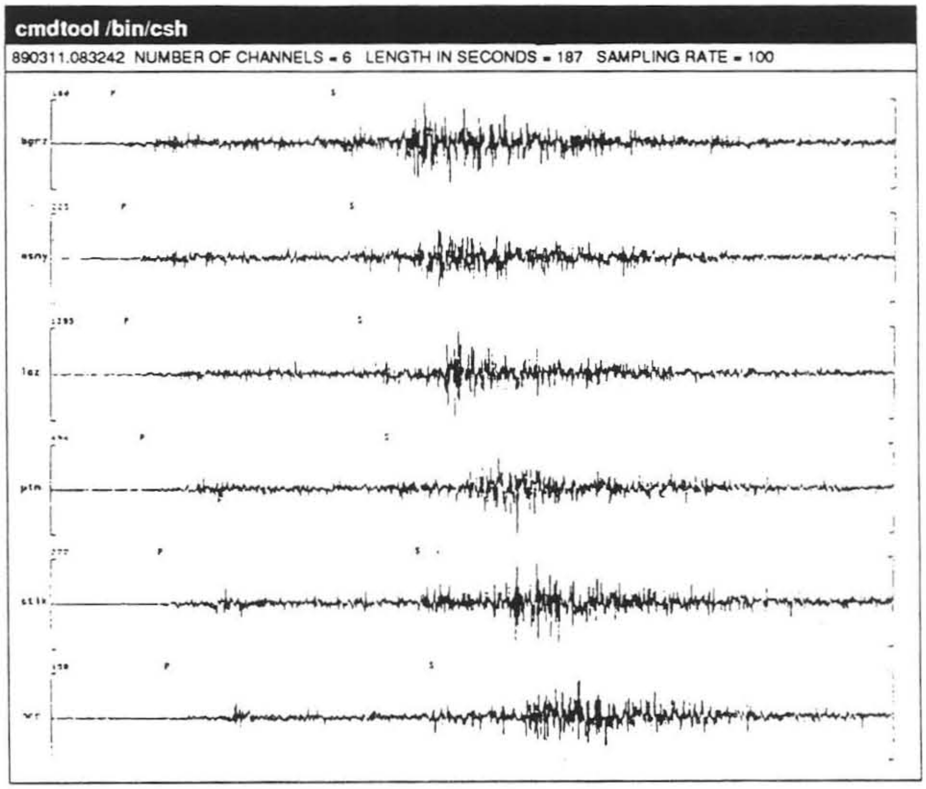


Figure 4: Digital seismogram of Charlevoix quake as seen on the SUN computer

digitized seismic signals are fed into the SUN computer for study. A typical digital seismogram of an earthquake with its epicenter located in the Charlevoix Region, Quebec, Canada, is shown in Figure 4. This earthquake occurred on March ll, 1989, at 08h:32m:42s UTC, so it is stored under the file number 890311.083242. The advantages of using the digitized seismogram are that the earthquake record may be modified so arrival times of P and S phases may be measured to l/100 of a second, and the record may be enhanced to show the

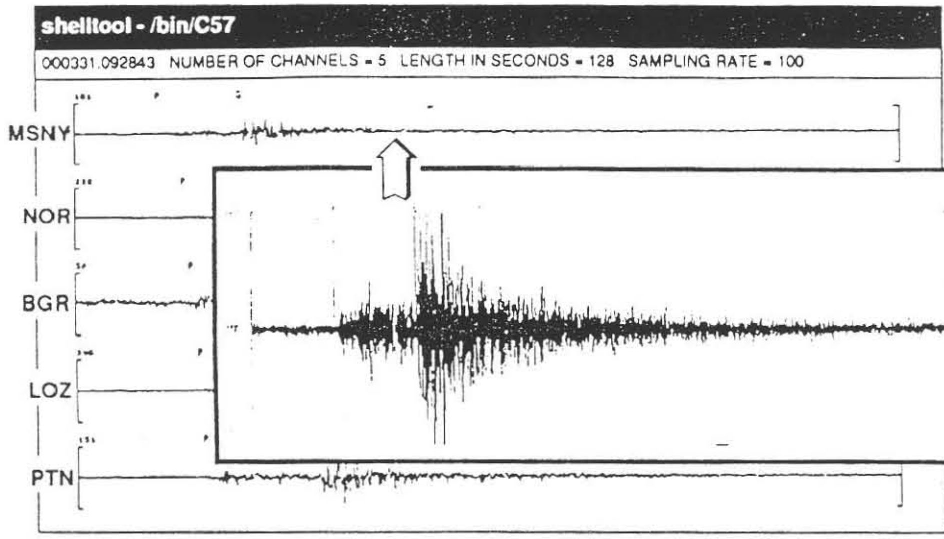


Figure 5: Digital seismogram of the earthquake recorded by the Massena (MSNY), New York stations. The enhanced output is shown in the inset

P and S phases more clearly. Figure 5 shows a local earthquake recorded by the Massena (MSNY) station before and after enhancement with the SUN computer. The program SUNPICK is used to pick the P and S phases and determine their arrival times. The arrival times of the P and S phases are used as input to HYPOINVERSE to locate the hypocenter of the earthquake. A printout of the seismic event is obtained by using a laserwriter configured with the SUN computer.

INTENSITY STUDIES

Intensity studies are conducted of all local earthquakes using the Modified Mercalli Intensity Scale. United States Geological Survey Earthquake Questionnaires are distributed to residents in the area through local newspapers. Evaluation of the responses from the residents enables the intensity at particular sites to be determined with the Modified Mercalli Intensity Scale. The intensity values are plotted and contoured to construct an isoseismal map of the earthquake.

SEISMOTECTONIC RELATIONS AND DATA

The Potsdam College Seismic Network is located in the heart of the most active seismic area in New York State. This belt of earthquakes is known as the Northern New York-Western Quebec seismic zone (Figure 6). Historic earthquake data indicate that the earthquake activity in this area has been persistent for over 400 years (Smith 1966). The largest earthquake in New York State occurred in this zone at Massena, New York, on September 5, 1944. This earthquake of Intensity VIII caused over $10,000,000 (current

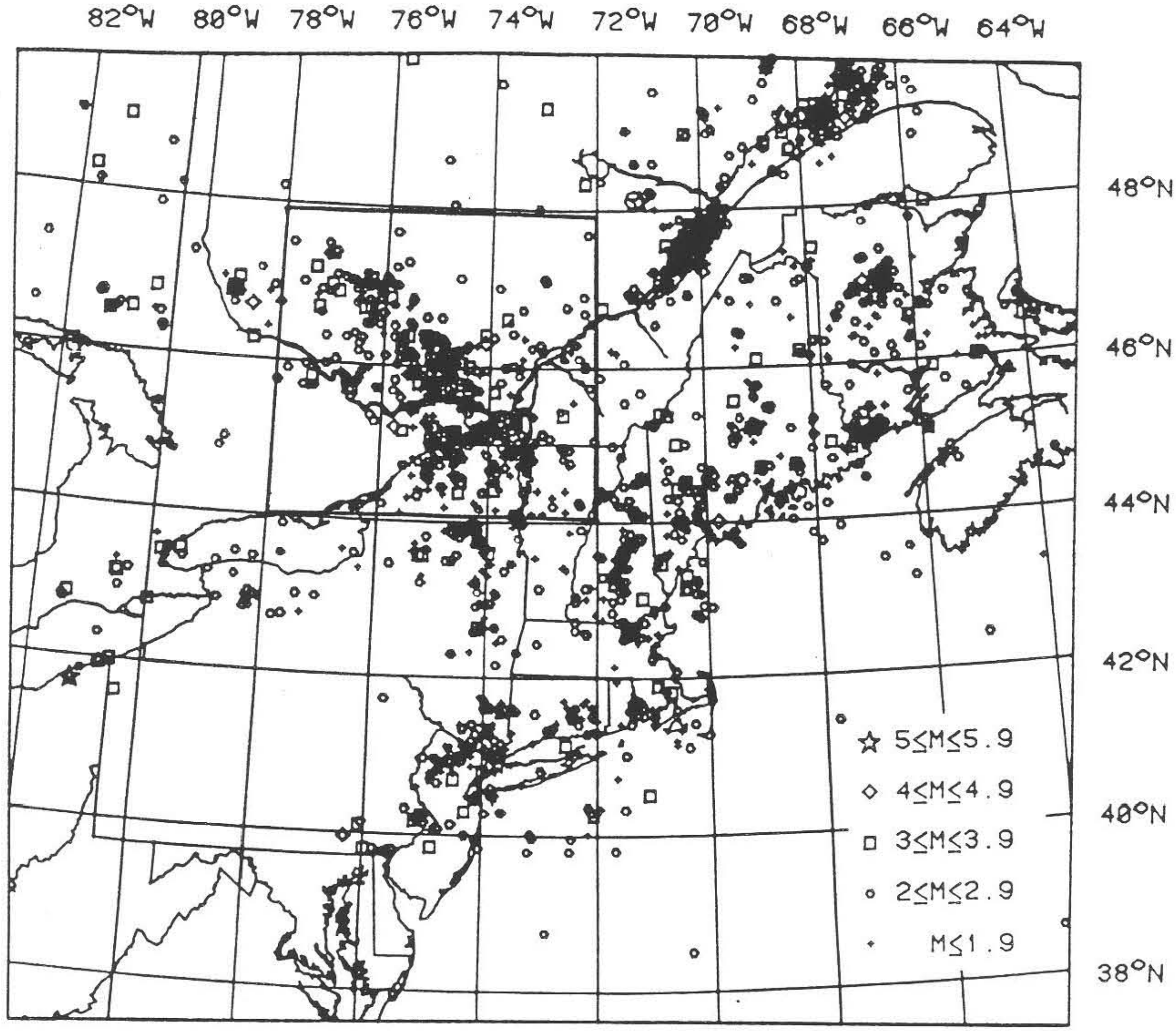


Figure 6: Earthquake epicenters in northeastern United States 1975 - 1989 (From Northeastern U.S. Seismic Report March 1992) (Northern New York - Western Quebec seismic zone is outlined)

dollars) in damage in the Massena-Cornwall area. The earthquake destroyed 90% of the chimneys in the Massena area and did extensive damage to schools and other buildings. It is likely that another damaging earthquake could occur in the area.

More recently, early in the morning of October 7, 1983, an earthquake of magnitude 5.2 and maximum Intensity VII on the Modified Mercalli Scale shook all of New York State and adjacent areas. The epicenter of this earthquake was located 20 km northeast of Blue Mountain Lake near Goodnow Mountain so it is known as the Goodnow Earthquake. Millions of dollars in damage would have resulted from this earthquake if its epicenter were located in an urban area.

Table 1. Distribution by zone of all known earthquakes New York State as a function of size (1720–1980).

	Number of Events				Total NY State
Zone	1	2	3	4	
III	12	113	31	15	171
IV	12	66	17	11	106
V	2	23	13	3	41
VI	3	6	2	0	11
VII	0	2	2	0	4
VIII	1	1	0	0	2
TOTAL	30	211	65	29	335

Magnitude and Intensity

The intensity and magnitude of an earthquake are not the same. Intensity *refers to how much damage was caused, as reported by the public; it is measured by the Modified Mercalli Scale. The intensity decreases as one moves farther from the epicenter.* Magnitude *is a relative measure of the true size of the earthquake in terms of how much energy is released. It is determined by the amplitude or period of the waves and is the same at different seismic stations.*

Figure 7: Shaded area indicates number of earthquakes of Intensities III through VIII occurring in the northern New York seismic zone

The number of earthquakes in New York State in various source regions is shown in Figure 7. These data show clearly that the northern New York area is most active seismically with 211 seismic events of a total of 335 for New York State. Diment, Urban and Revetta (1972) and Sbar and Sykes (1973) originally suggested that this seismic zone was part of a larger belt of seismicity extending from Boston, Massachusetts through Ottawa into Kirkland Lake, Ontario. Most of the earthquakes recorded by the Potsdam Seismic Network during the past 5 years have their epicenters located in this zone in the Cornwall, Ontario, Massena, New York area.

Table 1 shows a list of forty eight earthquakes recorded by stations in the network during the past five years and Figure 8 shows the distribution of these epicenters in the Cornwall-Massena area. The parameters of these earthquakes were determined from the Geophysics Division of the Canadian Geological Survey, the Northeastern United States Seismic Network Reports and the Potsdam State Seismic Network. The earthquake foci in this area are located well within the Precambrian basement rocks and fault plane solutions indicate reverse faulting along NNW or NW striking fault planes (Schlesinger-Miller, 1983). No surface evidence of any major fault is in this area nor has any noticeable ground displacement been observed (Berkey, 1945).

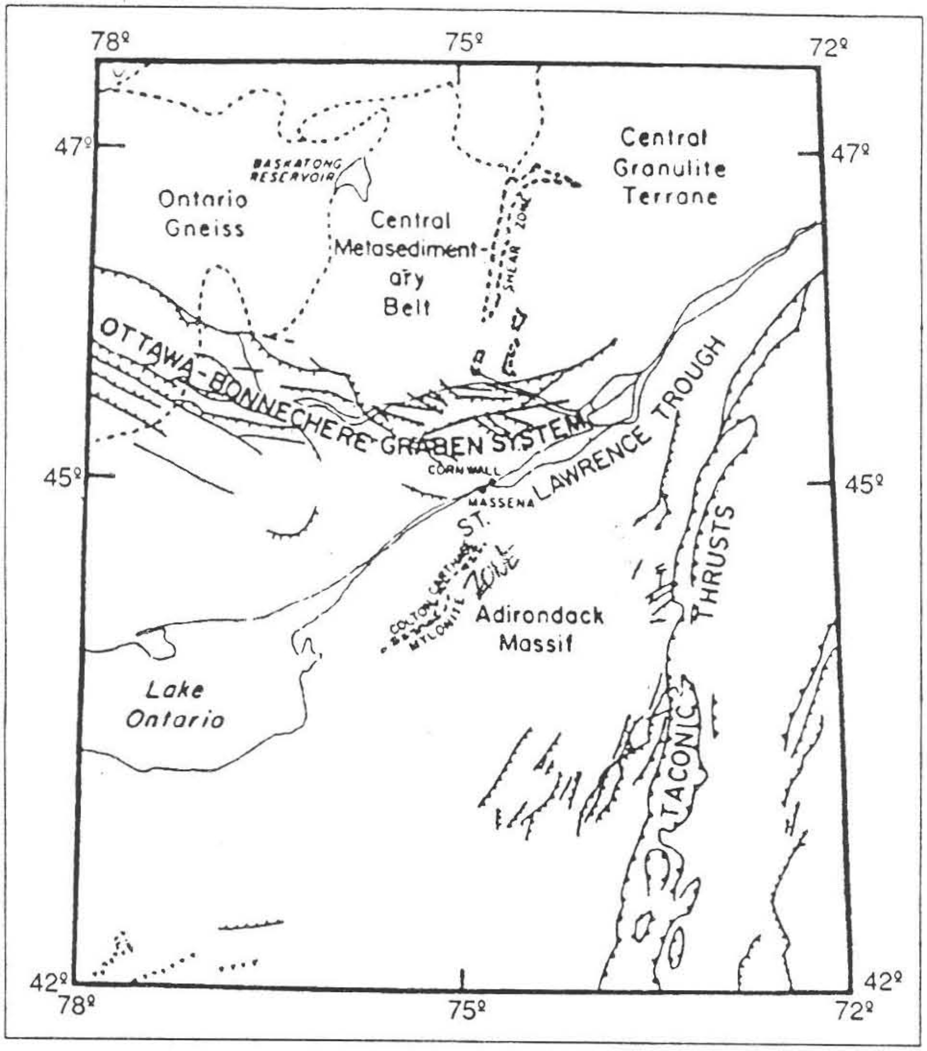


Figure 9: Generalized reference map from Tectonic Map of the United States (1944, 1962). Precambrian province boundaries are from Forsyth (1981).

The distribution of epicenters, both recent (1988-1992) and historical extends in an east-west or east-northwest direction. Comparison of the distribution of recent seismicity with historical earthquakes indicates the recent earthquakes occur in the same general area as the historical seismicity. The coincidence of recent and historical seismicity suggest some local geologic feature causing the earthquakes in the area. Two faults of the Ottawa-Bonnechere graben, the Winchester Springs and Gloucester faults are inferred to cross the St. Lawrence River into the United States in this area (Weston Geophysical 1985). Evidence of these fault extensions is based on limited outcrop and landform data correlated with similarity of VLF conductivity signatures over known faults in Canada. The earthquake epicenters in the

Another consideration is whether the earthquakes in the area are related to the Carthage-Colton Mylonite Zone. The CCMZ is a major structural boundary between the Adirondack Highlands and Northwest Adirondack Lowlands. This zone may continue northward under

Table 1 (Earthquakes recorded by Potsdam Seismic Network (1988 - 1992)

Date	Latitude North	Longitude West	Origin Time UTC	Magnitude	Comments
01/30/88	44°53.50'	75°3.23'	01:06:6.55	1.0	Louisville, N.Y.
02/12/88	44°42.44'	74°39.47'	11:41:34.14	1.7	Nicholville, N.Y.
02/13/88	45°12.10'	75°7.66'	02:11:35.93	2.1	Chrysler, Ontario, Canada
03/24/88	44°54.71'	73°25.47'	02:12:24:30		Chazy, N.Y.
04/02/88	44°32.64'	75°10.43'	10:00:22.33	1.9	Pyrites, N.Y.
04/26/88	44°57.00'	72°37.20'	19:42:10.20	2.3	U.S.A.-Quebec border
05/02/88	44°56.31'	74°48.86'	06:34:51.37	2.0	Helena, N.Y.
05/15/88	45°9.00'	75°36.00'	06:10:05.4	3.3	Vernon, Ontario, Canada
05/25/88	44°49.23'	74°58.16'	09:30:32.38	1.9	Raymondville, N.Y.
06/24/88	44°31.61'	74°37.76'	04:44:32.86	1.7	East of South Colton, N.Y.
08/09/88	45°23.05'	75°55.00'	16:5:950.59		Ottawa, Contario, Canada
08/09/88	45° 0.35'	74°59.00'	13:57:28.19	3.0	Ingleside, Ontario
08/09/88	44°59.77'	75° 0.11'	14:52:35:14	1.0	Ingleside, Ontario
08/10/88	44°32.00'	75° 3.26'	14:32:41.16		Near Potsdam, N.Y.
08/11/88	44°59.68'	74°59.78'	05:05:39.50	2.1	Ingleside, Ontario
08/28/88	43°57.17'	74°35.21'	09:10:19.63	1.7	Forked Lake, N.Y.
10/01/88	44°34.23'	75°23.71'	07:08:29.32	1.8	Rensselaer Falls, N.Y.
11/01/88	44°49.22'	74°46.21'	20:56:49.07	1.9	North Lawrence, N.Y.
11/08/88	44°52.16'	73°29.16'	07:23:9.58	1.5	Chazy, N.Y.
11/24/88	43°47.25'	74° 9.88'	16:11:28.84	2.3	East of Indian Lake, N.Y.
11/25/88	48°7.2'	71°10.8'	23:46:06	6.0	Saguenay Earthquake, Quebec, Canada
12/24/88	44°42.95'	73°26.07'	11:04:19.32	2.0	Plattsburgh, N.Y.
01/15/89	44°50.25'	73°39.97'	05:05:24.78	1.7	West Chazy, N.Y.
02/01/89	44°37.79'	74°59.82'	12:44:9.25	1.7	Hannawa Falls, N.Y.
02/03/89	44°45.48'	74°39.45'	04:21:3.67	1.9	West Bangor, N.Y.
02/08/89	44°31.63'	74°53.14'	21:05:7.43	1.7	South Colton, N.Y.
03/16/89	60°3.72'	70°3.36'	04:17:29.40	5.2	Baffin Island, Quebec, Canada
05/29/89	43°52.04'	76°10.42'	19:18:52.25	2.5	SW of Watertown, N.Y.
05/30/89	44°12.77'	75°34.87'	03:58:47.99	1.6	Antwerp, N.Y.
05/31/89	44°44.12'	74°18.68'	07:31:20.36	1.0	Mountain View, N.Y.
06/29/89	44°52.82'	74°21.42'	10:41:33.86	1.8	Malone, N.Y.
07/08/89	44°42.56'	74°31.09'	06:50:5.36	1.9	Dickenson Center, N.Y.
07/08/89	44°42.80'	74°29.72'	06:50:5.01	2.3	SW of Malone, N.Y.
11/16/89	47°12.60'	76°27.06'	09:24:06.86	3.7	Maniwaki, Quebec, Ontario
01/13/90	43°49.68'	75°30.84'	02:20	2.2	
03/03/90	45°7.68'	75°15.6'			
10/07/90	46°18.8'	75°11.7'	08:47:30.8	3.9	South of Mont-Laurier, Quebec
10/19/90	46°28.4'	75°35.5'	07:01:57.4	5.0	Mont-Laurier Region Quebec
11/15/90	47°7.68'	76°13.14'			Maniwake, Quebec, Canada
02/16/91	44°22.0'	75°1.8'	00:03:48.2	2.4	Adirondack Region
02/16/91	44°44.4'	74°8.7'	21:46:42.2	2.9	Chasm Falls, N.Y.
04/06/91	46°12'	76°48'	05:26	3.9	133 km NW Ottawa
05/16/91	44°20.64	75°05.7'	00:03:47.8	2.4	Russell, N.Y.
05/17/91	45°30'	74°24'	18:08	3.2	64 km West of Montreal, Quebec
06/16/91	47°0'	76°42'	16:46	4.2	198 km NW of Ottawa, Ontario
07/04/91	45°12'	73°48'	01:47	3.8	37 km SW of Montreal, Quebec
07/05/91	45°6'	73°58'	01:47:38.90	3.6	Ormstown, Quebec, Canada
07/08/91	45°33.48'	77°8.64'	10:08:14.9	3.4	Eganville, Ontario, Canada
08/22/91	45°52.8	75°7.2'	08:22:55.3	3.1	Cheneville, Quebec, Canada
01/05/92	44°49.86'	74°45.48'	22:36:12	3.1	Brasher Falls, N.Y.
03/31/92	45°5'	75°38'	10:45:21.01	3.0	Near North Gower, Ontario
04/17/92	44°53'	74°45'	01:38:31.59	2.9	4 km south of Helena, N.Y.
04/17/92	44°56'	74°44'	02:11:07.56	2.9	1 km north of Helena, N.Y.
04/19/92	44°54'	74°33'	09:39:30.25	3.0	Easter Sunday, Bombay, N.Y.

Table 1 (continued)

Date	Latitude North	Longitude West	Origin Time UTC	Magnitude	Comments
05/19/92	46°24'	74°54'	05:59:00	3.7	127 km northeast of Ottawa, Ontario
05/30/92	46°27'	74°57'	08:03:4.41	2.9	7 km NW of L'Annonciation, Quebec
06/01/92	45°17'	74°4.0'	12:01:4.80	2.4	2 km southwest of Les Cedres, Quebec
06/03/92	46°12'	75°0'	04:40:00	3.3	106 km northeast of Ottawa, Ontario
06/20/92	44°34'	75°2.6'	04:59:1.80	2.5	3 km southwest of Pierrepoint, N.Y. (near Carthage-Colton Mylonite Zone)
07/01/92	43°57'	74°14.2'	04:18:8.76	2.8	Epicenter located at Newcomb, N.Y. in (epicentral region of Goodnow Quake 10/7/83)
10/05/92	44°50'	74°40'	22:36:01.4	3.2	Brasher Falls, N.Y.
11/11/92	46°55.2'	75°138'	09:02:42.00	3.3	Mt. Laurier, Quebec, Canada
11/17/92	46°42'	74°54'	03:58:4.65	4.4	32 km NW of Hawkesbury, Ontario
12/16/92	44°46'	74°37'	23:24:59.38	2.6	Moira, N.Y.

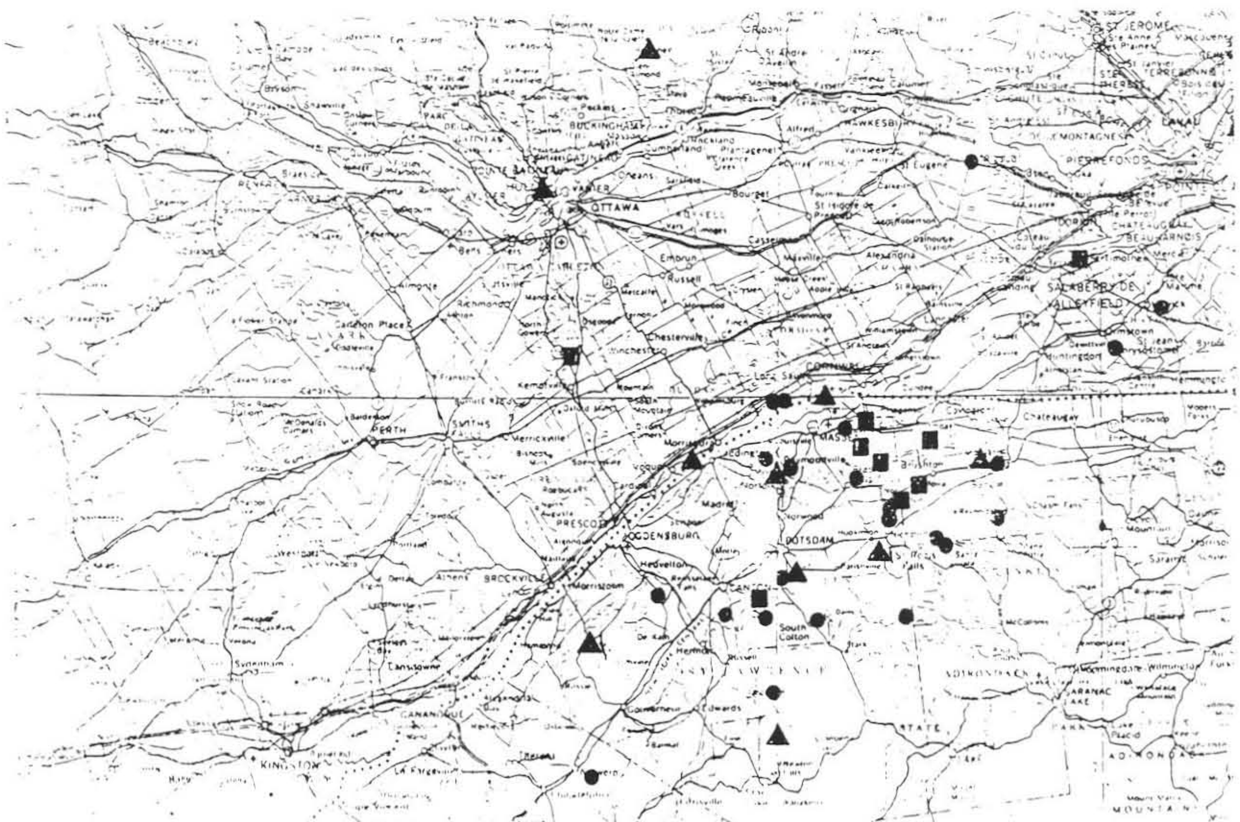


Figure 8: Earthquake epicenters recorded by Potsdam College Seismic Network (1988 - 1992)
Seismic Field Stations
Earthquake Epicenters 1992
Epicenters

the St. Lawrence Trough and connect with the north-northwest trending zone of mylonites north of the Ottawa River (Figure 9). These mylonite zones are believed to be contacts or fault zones between contrasting terrains (Buddington and Leonard 1962). If this zone is continuous the connection between them would pass directly beneath the Cornall-Massena area. Several earthquakes are aligned along the possible continuation of this zone.

SUMMARY AND CONCLUSIONS

The Potsdam College Seismic Network consist of 7 short period vertical seismographs located in the St. Lawrence Valley in northwestern New York. The network provides an important educational tool at the college and significant public service to the area. The network also provides information on the location of local earthquakes and their first motions for research in seismology. Most of the earthquakes recorded by the network occur in the northern New York-Western Quebec seismic zone. Forty eight local earthquakes have been recorded by the network during the past five years. Eighteen of these earthquakes had epicenters located in a northwest-southeast trending belt in the Massena-Cornwall area. These epicenters lie in the vicinity of two faults of the Ottawa-Bonnechere graben that are inferred to extend into the United States in the Massena, N.Y. area. A second belt of epicenters trends northeastward along the northern edge of the Frontenac axis and Adirondack Dome. Seven of the epicenters lie along the Carthage-Colton Mylonite Zone and a possible extension of it beneath the lower Paleozoic rocks in the Massena area.

WORKSHOP SCHEDULE

The workshop on the Potsdam Seismic Network will convene in the Geology Department at Potsdam College at 3:00 p.m., Friday, September 24, 1993. Participants should report to Room 120 in Timerman Hall to hear a slide talk and view a videotape about the seismic network. After the slide talk we will visit the Potsdam Seismic recording stations in the hallway of Timerman Hall to discuss the recording of the earthquakes. A field trip will be taken (transportation will be provided) to visit a seismic field station (PTN) to demonstrate how stations are installed, and operated. Finally we will return to Timerman Hall to locate a local earthquake by computer techniques. The workshop should be completed between 5:00 and 6:00 p.m. Several handouts will be given to participants including a booklet about the seismic network, a seismic report of earthquakes recorded during the past five years, a local earthquake exercise and a packet about earthquakes in New York State.

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