Annual Project Summary Report

The New England Seismic Network

USGS Award Number 01HQAG0022

PI John E. Ebel

Weston Observatory
Boston College
Department of Geology and Geophysics
381 Concord Rd.
Weston, MA 02493

Tel: 617-552-8300
Fax: 617-552-8388
Email: ebel@bc.edu
URL: http://www.bc.edu/westonobservatory

Project Summary

The operation of a regional seismic network to monitor earthquake activity in New England and vicinity is supported under this project. The purpose of this earthquake monitoring is to compile a complete database of earthquake activity in New England to as low a magnitude as possible in order to understand the causes of the earthquakes in the region, to assess the potential for future damaging earthquakes, and to better constrain the patterns of strong ground motions from earthquakes in the region. The New England Seismic Network (NESN) is operated by Weston Observatory of Boston College and in cooperation with the Earth Resources Laboratory of the Massachusetts Institute of Technology (MIT). This is a progress report for the time period from October 1, 2002 through September 30, 2003.

Regional Seismic Network Status

The New England Seismic Network is operated by Weston Observatory of Boston College in cooperation with the Earth Resources Laboratory at MIT. During the time period of this report, the Weston Observatory component of the network was comprised of 12 seismic stations (Figure 1). Eleven of the seismic stations are located within New England, while there is one station at Troy, NY.

At the beginning of the period of this report (October, 2002), all of the operating Weston Observatory stations were PC-based with on-site recording, three-component broadband sensors, and dial-up telephone telemetry or direct internet links to the central station at Weston Observatory. The sensors were CMG-40T feedback geophones with a flat response to ground velocity between roughly 30 Hz and 30 sec. The digitizers were Nanometrics 16-bit with gain-ranging, yielding effectively 136 db dynamic range. The sensor signals were being digitized at a rate of 100 samples per second per channel. The output from the digitizer was sent to a PC computer using OS/2, a multitasking operating system, at the digitizing site. The software controlling the stations stored the signals from the sensor in a continuous disk loop. Eight of the sites (BCX, BRY, EMMW, HNH, PQI, WES, WVL, and YLE) were available via internet connection to Weston Observatory, seven of which were also sending their data to the USGS NEIC in Golden, Colorado. Two stations (QUA2 in central Massachusetts and TRY at Troy, NY) were not operational at the beginning of the time period of this report due to communications problems at the sites.

At each station the signals from the seismometer were recorded on a local hard disk. The datastream from the digitizer was examined by a program that used a filter and STA/LTA scheme to test for possible events. When the STA/LTA threshold was exceeded, a notation of the time and duration of the exceedence is added to a text file on the recording computer. An analyst at Weston Observatory used this detection file from a station to determine the possible times at which events may have been contained on the remote disks. The analyst then used these times to send requests to the remote stations to send windows of waveform data back to Weston Observatory for analysis. The retrieved waveforms from all stations were analyzed and archived at Weston Observatory.

In the summer of 2003 the USGS provided to Weston Observatory five new systems from Refraction Technology, Inc. for digitizing and transmitting the seismic data at the remote stations. These systems use 24-bit digitization and RTP to USGS for data transmission. The CMG-40T sensors continued to be used as the sensing instruments at those sites. The sites where the new instrumentation was installed were BRY, FFD, HNH, QUA2 and WES. As of September 30, 2003, all of these sites with new equipment are now providing continuous seismic data, digitized at 40 samples/second, directly to the NEIC in Golden, CO, which in turn sends the continuous data to Weston Observatory via Earthworm. The new systems were needed because the old station equipment had become obsolete and could not be repaired or replaced if it broke down. Plans are being made with the USGS to replace more of the old PC-based digitizing systems at the other New England stations during FY2004.

During the time period covered by this report, Weston Observatory staff spent a great deal of time learning how to operate and make use of the seismic data being delivered by Earthworm. By the end of this reporting period, Weston Observatory was receiving continous data via Earthworm from its five new Reftek stations (BRY, FFD, HNH, QUA and WES), triggered data from its stations EMMW, PQI, WVL and YLE in New England, and continuous data from USNSN and USNSN-cooperative stations BINY, HRV, LBNH, and NCB. The data from these stations are now being used in a routine manner to check the times of possible event detections. While the implementation of Earthworm has speeded up the routine analysis of event detections by the regional seismic network, it has slowed the computation of event magnitudes when

earthquakes are analyzed. This is because the system response of the new Reftek stations in New England is not yet known, precluding those stations from being used for Lg magnitude determinations. Furthermore, the version of Earthworm's Waveviewer module currently being used at Weston Observatory does not provide a means to measure the amplitudes of the seismic signals it displays. These problems are being addressed at the present time.

One important development in the routine analysis of regional seismic network data at Weston Observatory is a new effort to implement a wavelet-transform based automated event detector and identifier. Such a system was initially created and tested by Gendron et al. (2000) for the PC-based regional seismic network stations operated by Weston Observatory. Unfortunately, the operation of that system had to be halted due to unresolveable conflicts with the station data acquisition systems. With the advent of the Earthworm system at Weston Observatory, a new effort was started to adapt and improve the Gendron et al. (2000) system to make use of the triggered and continuous data arriving via Earthworm. It was decided to implement this new system using Matlab, making it relatively platform independent (i.e., any computer running Earthworm and Matlab can run this system). An initial version of a wavelet-based automated event detector and identifier began being tested under routine operating conditions in August, 2003, and the bugs were still being worked out of the system as of the end of this reporting period. Nevertheless, initial results suggest that this system has the potential to become a very reliable event detector and identifier. To improve the reliability of the event identification, a second event identifier is being developed and implemented as part of the system (Zhu and Ebel, 2004; Ebel, 2004). Further development, improvement and testing of this new system will take place during the coming year. It is the long-term goal of this project to use this system not only for automated event detection and identification, but also for the computation of event locations and magnitudes in near real-time. The added information provided by the wavelet transform over that from simple STA/LTA systems is necessary to overcome the inherent limitations of a sparse, widely scattered regional seismic network such as that being operated by Weston Observatory in New England and vicinity.

In other network developments, we are continuing to work with the Maine Geological Survey to site a USNSN national backbone station in central Maine. An acceptable site has not yet been identified, although there are some possible candidates that must still be investigated.

Weston Observatory continues to cooperate with other regional network operators in northeastern North America (Lamont-Doherty Earth Observatory, the USGS NEIC, and the Canadian Geological Survey) in earthquake detection and analysis for events in the region. Event arrival time readings, waveforms, and hypocentral information are routinely exchanged between the Weston Observatory and these other groups. Weston Observatory continues to produce a quarterly seismic network bulletin for the New England area. That bulletin is produced in html format and is posted on the Weston Observatory web pages as soon as possible after the quarter ends. List of recents earthquakes are also maintained on the Weston Observatory web site, along with links to other important sites with earthquake information for the region.

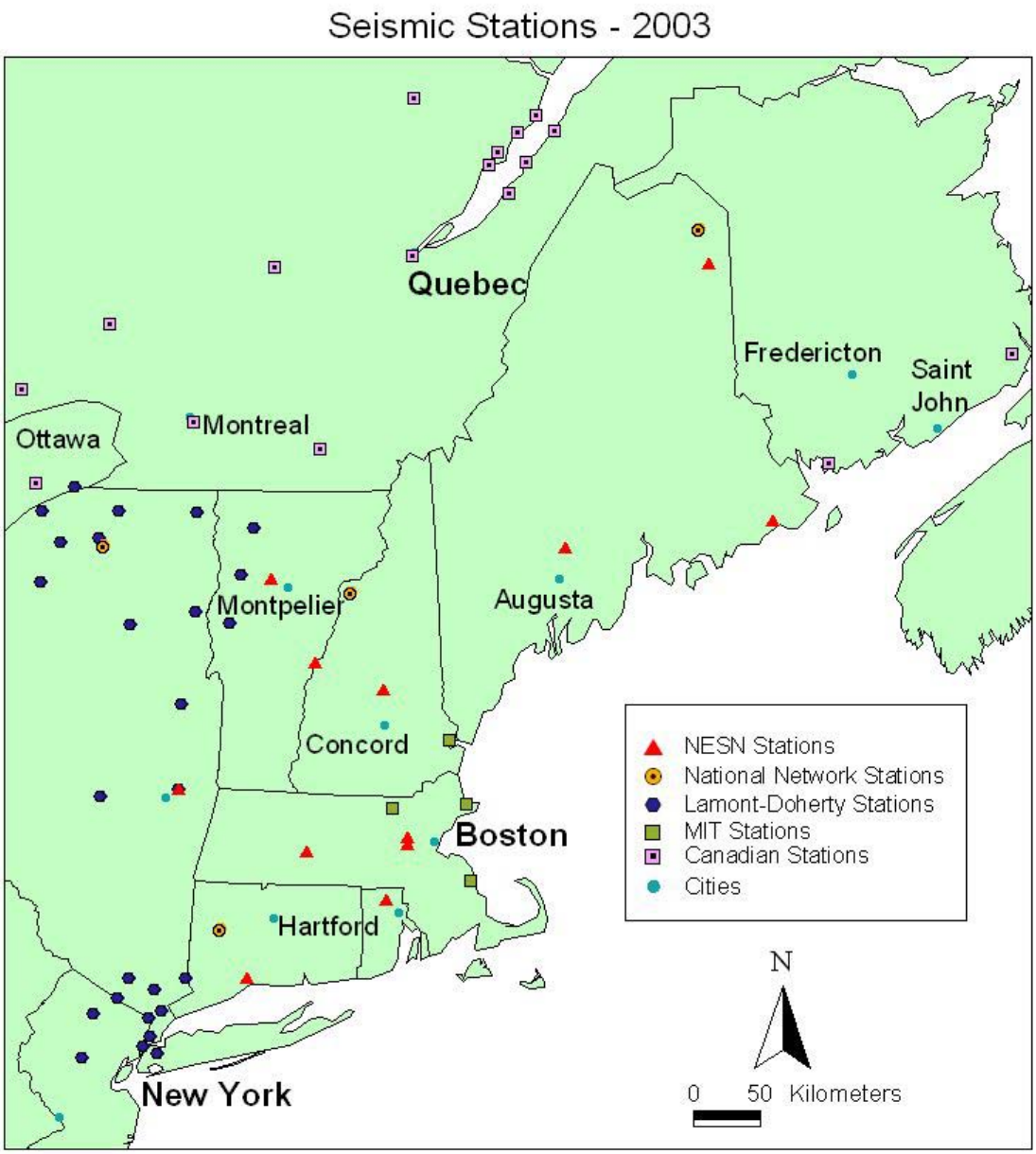

Figure 1. Stations of the Weston Observatory New England Seismic Network and other northeast networks from October 1, 2002 to September 30, 2003.

Accomplishments During the Report Period

Seismic Monitoring

The Weston Observatory NESN seismic stations detected a number of earthquakes from New England and vicinity from October 1, 2002 to September 30, 2003. A total of 18 local and regional earthquakes from New England and vicinity with magnitudes from 1.8 to 3.8 were detected and located by the network (Figure 2), some of which were locally felt. In addition to these events, some microearthquakes and suspected events, too small to be located, were detected by the network. The number of earthquakes during this reporting period is somewhat less than that from recent years.

The most significant earthquake detected during this reporting period was the Lg magnitude 3.6 earthquake that was centered in the Atlantic Ocean approximately 40 km northeast of Cape Ann, MA on July 22, 2003. According to the USGS "Did You Feel It?" web site, this earthquake was felt in northeastern Massachusetts, southeastern New Hampshire, and southernmost Maine. It was also felt in southeastern Massachusetts, although it was not reported felt in Boston or in the suburbs to the west. What makes this earthquake most interesting is that its felt area is similar to that reported for some of the aftershocks of the 1755 Cape Ann earthquake (mainshock magnitude estimated at about 6.0 to 6.3), suggesting that the 2003 event may have been centered in the same area as the 1755 shock. During the past 25 years several other earthquakes have been located in the same approximate area as the July, 2003 shock, lending support to the suggestion by Ebel et al. (2000) that some modern earthquake activity could be very late aftershocks of stronger earthquakes that took place hundreds of years ago.

Continuing a practice started in late 2002, Weston Observatory has a web site offering weekly estimates of the probability of a felt earthquake in New England. The temporal probability is based on the work of Ebel and Kafka (2002), while the spatial probability is based on research published by Kafka and Levin (2000) and Kafka (2002). A link called "Weekly Probability of Felt Earthquakes in New England" on the Weston Observatory web page (www.bc.edu/westonobservatory) shows the probability of a felt earthquake in New England for each upcoming 7-day period. Also shown on this web page is a map of those areas in New England that have about a 67% probability of being the epicenter of an earthquake of MLg >= 2.7 during the 7-day period. The number of hits on this web page indicates that there is a steady interest in this information.

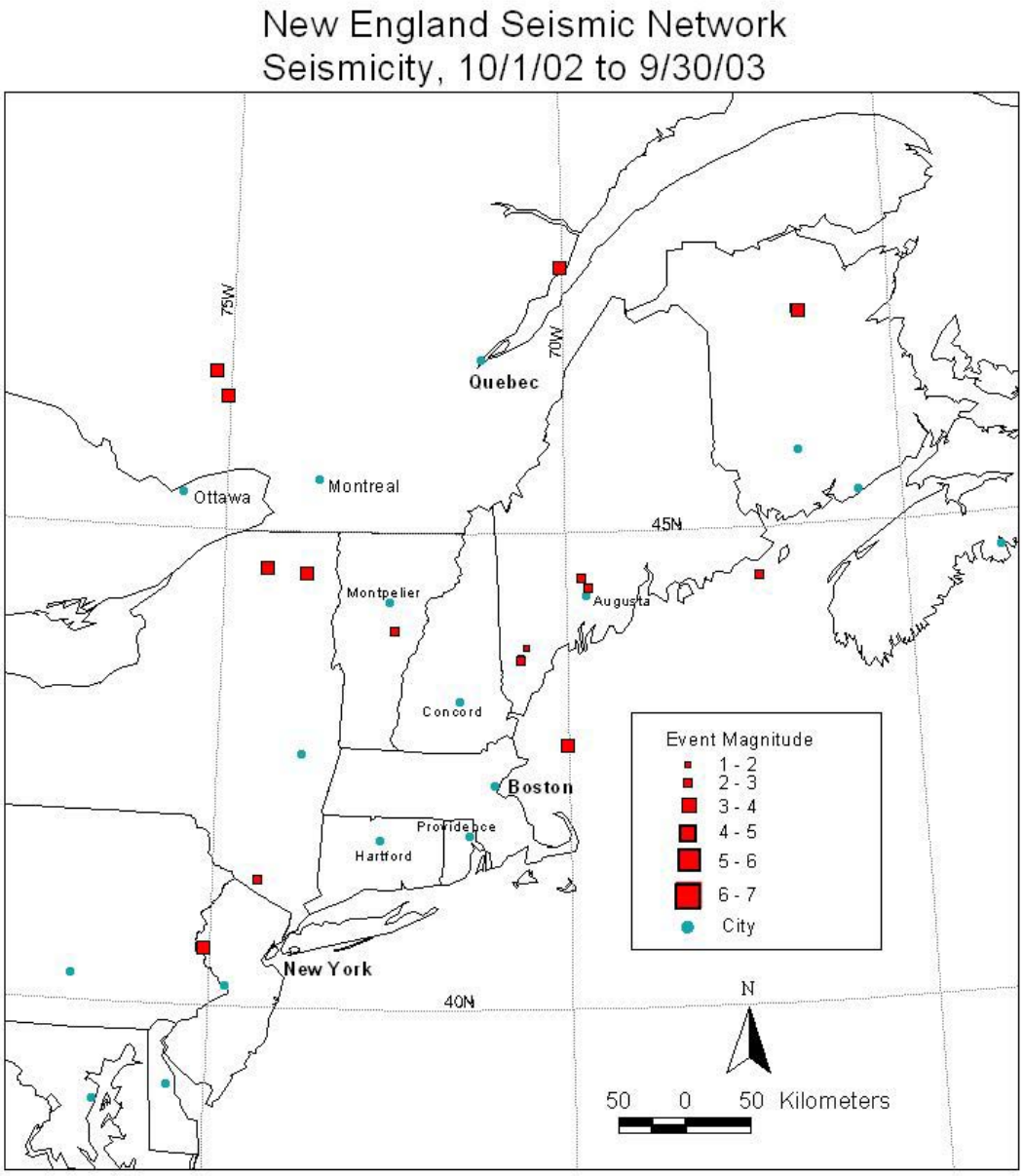

Figure 2. Seismicity of the northeastern U.S. and southeastern Canada detected by the Weston Observatory New England Seismic Network from October 1, 2002 to September 30, 2003.

Data Dissemination

Weston Observatory continues to archive the waveform data for the seismic stations which they are operating. Weston Observatory has the capability to convert the waveforms, routinely stored in Nanometrics format PC stations, to either ASCII, SAC or SEED format for external distribution. Weston Observatory has almost completed the process of developing the capabilities to deliver SEED waveforms of local events to the IRIS DMC. In addition, Weston Observatory is contributing hypocentral data to the CNSS composite catalog on a routine basis.

Weston Observatory maintains a web site with information about local earthquakes:

- http://www.bc.edu/westonobservatory

Currently available on the web page is the full catalog of northeastern earthquake activity to 2003 along with recent quarterly reports of the seismicity detected by the NESN. Weston Observatory attempts to regularly maintain and update its web pages with the latest information on earthquakes in the region.

Financial Report

During the time period of this report, the funding for this project was spent in accordance with the arrangements agreed upon in the cooperative agreement between Boston College and the USGS. For the current year of funding, less than 1% of the funding provided by the USGS has not been spent, and that is expected to be spent by the end of this year of the agreement period of work.

References

Ebel, J.E. (2004). Update on a Wavelet-Based Event Detector and Identifier at Weston Observatory, *Seism. Res. Lett.* **75**, in press.

Ebel, J.E., K.-P. Bonjer and M. Oncescu (2000). Paleoseismicity: Seismicity Evidence for Past Large Earthquakes, *Seism. Res. Lett.* **71**, 283-294.

Ebel, J.E. and A.L. Kafka (2002). A Non-Poissonian Element in the Seismicity of the Northeastern United States, *Bull. Seism. Soc. Am.* **92**, 2040-2046.

Gendron, P.A., J. Ebel and D. Manolakis (2000). Rapid Joint Detection and Classification with Wavelet Bases via Bayes Theorem, *Bull. Seism. Soc. Am.*, **90**, 764-774.

Kafka, A.L. (2002). Statistical Analysis of the Hypothesis that Seismicity Delineates Areas Where Future Large Earthquakes Are Likely to Occur in the Central and Eastern United States, *Seism. Res. Lett.* **73**, 992-1003.

Kafka, A.L. and S.Z. Levin (2000). Does the spatial distribution of smaller earthquakes delineate areas where larger earthquakes are likely to occur?, *Bull. Seism. Soc. Am.*, **90**, 724-738.

Zhu, L. and Ebel, J.E. (2004). Automated Seismic Signal Identification Algorithm for the New England Seismic Network Based on a Seismic Signal/Noise Ration (SNR) Spectral Model, *Seism. Res. Lett.* **75**, in press.