ANNALI DI GEOFISICA, VOL. XXXVII, N. 5, September 1994

The Canadian National Seismograph Network

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The Canadian National Seismograph Network currently consists of 5 very-broadband (VBB) and 15 broadband (BB) stations across Canada, supplemented by 6 short period (SP) stations. When it is completed by the end of 1995, a further 1 VBB, 12 BB and over 40 SP stations will have been added. Data from all sites are telemetered in real time to twin network acquisition, processing and archiving centres in Eastern and Western Canada. All data are continuously archived in SEED format on optical disk and access to the most recent three days of data is provided through a mail-based AutoDRM system. Continuous data from the VBB sites are sent to the FDSN Data Management Centre approximately one month after being recorded.

Network objectives

The resources available for seismology in Canada are limited and the Canadian National Seismograph Network (CNSN) has to satisfy a number of needs that, in order of priority for the Geological Survey of Canada (GSC), are as follows:

- monitor national seismicity in near-real time;
- provide data for research into the nature and causes of earthquakes in Canada;
- contribute to the assessment of global seismic activity;
- provide the Canadian contribution to nuclear test ban monitoring experiments;
- produce data from Canadian stations for seismological research worldwide;
- contribute continuous data to the Federation of Digital Seismograph Networks (FDSN).

These objectives are not always compatible and some compromises have had to be made, for example, current so-called very-broadband (VBB) systems do not cover the full range of frequencies necessary for local and regional seismicity, or for test ban monitoring, but with the resources available it has not yet been possible to equip VBB stations with supplementary high frequency sensors. The VBB sites have been installed with an average spacing of over 1500 km, while the broadband (BB) have generally national coverage, and the short period (SP) stations are concentrated in seismically active areas.

Seismograph stations

The VBB stations are equipped with Wielandt-Streckeisen STS-1 VBB seismometers, and the BB stations with Guralp CMG3-ESP or CMG3-T instruments. A 24-bit digitizer has been developed by the GSC to acquire the data from these sensors. Sampling is synchronised by input from

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Omega or GPS clocks, and for both BB and VBB CNSN sites the sampling rates are 40 per second. Finite Impulse Response (FIR) anti-alias filtering is employed to maximise the bandwidth and this allows the VBB and BB system response shapes to be identical to that of the seismometers to frequencies exceeding 15 Hz. The digitizer is quite similar in design and performance to others now on the market – in terms of performance it has low (less than 1 bit rms) noise, achieved at some expense in linearity (which is still better than 20 bits). It has internal (RAM) buffering capacity for up to 6 h of data – this will accommodate short losses of satellite-based communications due to solar transits and other factors, as well as brief outages of the network data acquisition systems. Apart from this RAM buffer there is no local data recording capability. A communications protocol has been developed to provide data retransmission, remote calibration, and timing verification. Data compression based on differencing and a bit-level encoding scheme is employed to minimise the communications bandwidth required, and at most CNSN sites one data sample can be compressed to less than 8 bits. During very large events the data will become less compressible and may accumulate in the digitizer buffer if the capacity of the communications link is temporarily exceeded. The data are sent in six second packets, each individually time tagged and with a CRC check.

Short period (SP) sites are equipped with Teledyne-Geotech S-13 seismometers. At most locations only a vertical component sensor has been installed, but some are three-component. Another 24-bit digitizer, with lower noise characteristics than that used for the BB and VBB instruments, has been developed to sample the SP data 100 times per second. The communications protocol, timing, data compression, and buffering are identical to those of the broad band digitizer. Both SP and BB sites are provided with a battery-backed Uninterruptible Power System (UPS) that will run the seismograph and telemetry systems for up to 6 h.

Telemetry

Very Small Aperture Terminal (VSAT) satellite links are used to relay the continuous data from the VBB and BB stations to the network data acquisition systems. Satellite links are cheaper than dedicated telephone links over distances greater than about 200 km and are the only viable means of communications to many of the more remote areas of Canada. All communications links are provided with a capacity sufficient to transfer 2 bytes per data sample (note that these two bytes are for the compressed differences, and thus easily accommodate actual data values exceeding 24 bits). A 2400 baud link suffices for a three-component, 40 sample/s broad band site. The SP stations use a mixture of radio, dedicated telephone, and satellite links; in many cases data from several sites are telemetered by radio to a concentration point and then transferred to a satellite link.

Data acquisition and processing

Twin Network Acquisition Systems (NAQSs) in Ottawa, Ontario and in Sidney, British Columbia, acquire, process and archive the data produced by the CNSN. Data from the VSAT-linked sites are received at a Master Earth Station in Toronto, where they are concentrated and sent over separate high-speed (128 Kbaud) satellite links to both Ottawa and Sidney. The data are processed and archived at both locations, providing enhanced overall CNSN reliability. If a data packet or packets are garbled or missing, the remote site is requested to retransmit the packets in question. The two separate satellite links used produce a delay of just under one second, but in addition to this, packet handling and FIR filtering delays are such that if the initial transmission is successful, the oldest data in a (6 s) packet will be just under 20 s old when it arrives in Ottawa. If retransmission is necessary (typically several packets per day for each station component) the data delay will be increased by at least 10 s, and is sometimes longer. Some SP stations with radio or telephone

telemetry only are received by just one of the two NAQS, but all VBB and BB data are acquired at both locations. Both NAQS are provided with UPS systems, supplemented by a diesel generator.

The NAQSs carry out signal detection and subsequent automatic location processing, and archive the continuous data on optical disk. They also maintain a 3-4 day ring buffer on magnetic disk, in order to satisfy requests for recent data as rapidly as possible. The continuous data from the whole network are archived in half-hour SEED volumes on Sony 12-inch WORM (Write Once – Read Many) platters that have a capacity of 6.4 Gbytes. At present each half-hour file is approximately 12 Mbytes and when the CNSN has been completed the anticipated daily archive volume is expected to be between 1.5 and 2 Gbytes. At the end of each data day, long period data streams sampled once per second are filtered from the BB and VBB data, and also archived on optical disk

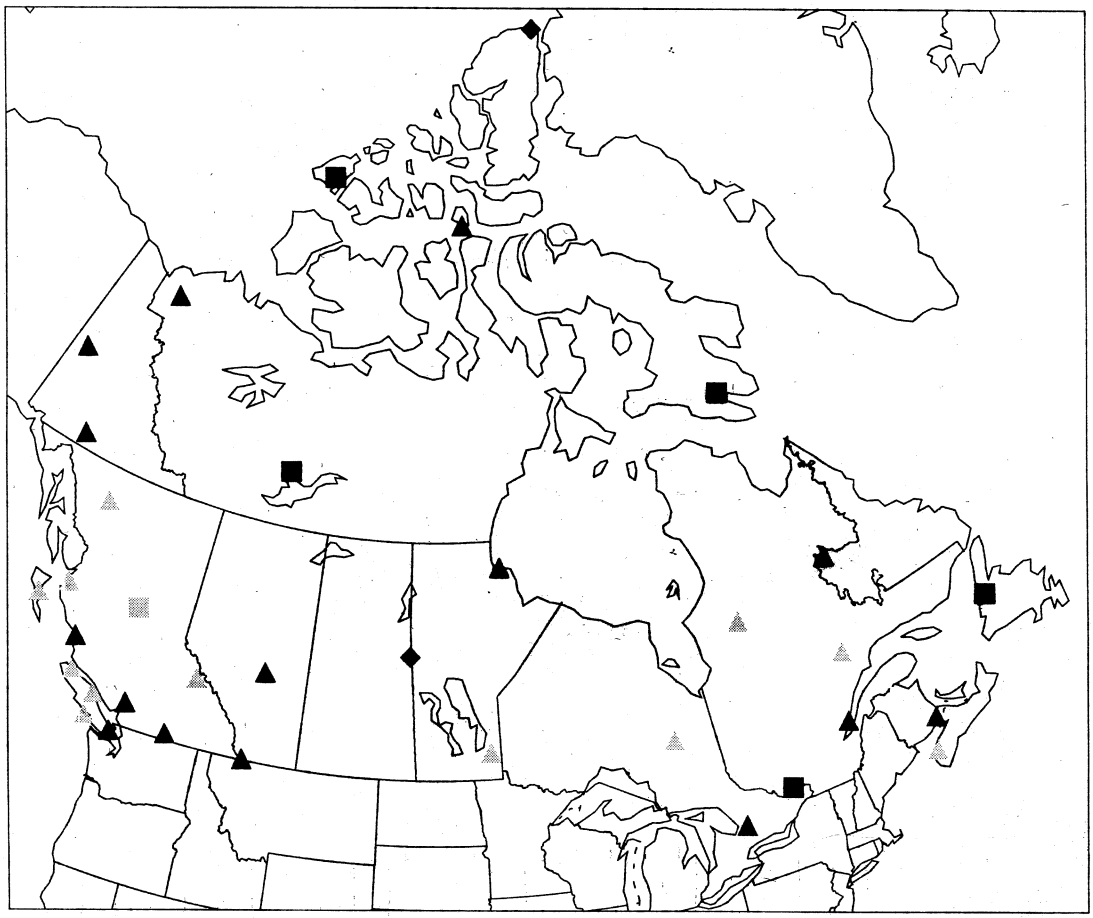

Fig. 1. Locations of the installed (by March 1994 – filled symbols) and planned (open symbols) broadband stations in Canada. CNSN VBB sites are denoted by squares and BB sites by triangles, and IRIS VBB sites by diamonds.

as network day SEED volumes. A separate archive is maintained for waveform data recorded from events in and near Canada.

Network configuration

Figure 1 shows the locations of present and planned CNSN BB and VBB stations. The SP sites that are largely concentrated in Southeastern and Southwestern Canada are not shown – there will be about 50 of these. All but one of the VBB stations have been installed, and to date 15 of the planned 27 BB stations are in place. Installation of the remaining VBB and BB sites, and most of the SP sites, will be completed by the end of 1995. Routine data capture and archiving started in April 1993, though a limited amount of data prior to this is available. Also shown on the map are the two IRIS VBB stations located in Canada.

Data access

Data from the VBB sites are sent on Exabyte tape in SEED format to the FDSN data management centre in Seattle, U.S.A., about one month after being recorded, starting in April 1993. Copies of the archive files (30 min SEED volumes for the entire network; LP network day SEED volumes) can be obtained upon request from the Ottawa data laboratory manager (shannon@seismo.emr.ca). Access to CNSN data in the on-line magnetic disk buffer (most recent 72 h) is provided through an internet mail-based system that is basically identical to the AutoDRM method developed in Switzerland (Kradolfer, 1993) that has been adopted as a standard by the FDSN. Requested waveform data is provided either as returned mail messages in the so-called GSE format (Group of Scientific Experts, 1990) or, via an anonymous ftp option, in SEED format. To learn how to use this method, send an internet mail message containing the following text lines:

BEGIN
GUIDE
EMAIL youraddress@yourplace
STOP

to autodrm@seismo.emr.ca, and the user guide will be mailed back to you.

REFERENCES

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